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Geotch03.pdf	12,633 KB	**Revised Final Oakland Shore Approach Geotechnical Site Characterization Report,** dated March 2001, prepared for Caltrans by Fugro-Earth Mechanics A Joint Venture Volume 1, Main Text and Appendices Volume-2A through Volume-4
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Earth Mechanics

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A JOINT VENTURE

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

VOLUME 1 - MAIN TEXT

Prepared for

CALIFORNIA DEPARTMENT OF TRANSPORTATION

March 2001

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March 5, 2001
Project No. 98-42-0058/EMI Project No. 98-145

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian
Contract Manager

Final Oakland Shore Approach Geotechnical Site Characterization
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. The majority of the Oakland Mole exploration was conducted as part of the Phase 2, Task 5 (final site characterization phase) studies of the referenced contract, although three cone penetration test (CPT) soundings were conducted as part of the earlier Phase 1, Task 3 work scope (preliminary site characterization) of the referenced contract.

The field exploration conducted on the Oakland Mole in the Spring and Fall of 1998 as part of the referenced contract included 25 soil borings (designated in the subsurface database created for the project as 98-51 through 98-75) and 9 CPT soundings (designated as 98-16 through 98-18 and 98-101 through 98-110 [several planned locations were abandoned due to electrical interference]). A total of 53 offshore tethered Seascout CPT soundings were conducted in December 1998 during seasonal high tides on the tidal flat to the north of the Oakland Mole. Fifteen all-terrain CPT soundings were conducted on the Tidal Flat to the north of the Mole in March 1999 during low tide conditions. Two trench and two pit excavations were conducted in April 1999. In Fall 2000, 11 marine Seacalf CPT soundings were performed in the vicinity of the Oakland Shore Approach to the west and northwest of the western tip of the Mole. The Seacalf CPTs were conducted as part of the Phase 3 field investigation program.

This Oakland Shore Approach Geotechnical Site Characterization report summarizes the field exploration for the Oakland Shore Approach and describes our interpretation of the geotechnical conditions based on the information collected from the exploration. Our present interpretations are based on the field data from the borings, the results of laboratory tests completed in the onshore laboratories, and the CPT soundings.

This report is provided in four volumes. Volume 1 provides the interpretational text and illustrations. Volume 2 contains 27 appendices that provide boring logs and test data from 25 land borings on the Oakland Mole and 2 marine borings offshore from the northwest tip of the Oakland Mole. Volume 3 contains the

results of the CPT soundings conducted on land, on the northern shore of the tidal flat, and offshore to the north and west of the Oakland Mole. Volume 4 contains four documents that include a preliminary study of approach fills at the Oakland Mole, studies on lateral spreading of fills at the Oakland Mole, findings from trench and pit excavations, and the advanced geotechnical laboratory studies conducted at the University of California at Berkeley.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

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SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CALTRANS CONTRACT 59A0053

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

VOLUME 1 - MAIN TEXT

MARCH 2001

Prepared For:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
Engineering Service Center
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Testing performed

No testing performed

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FUGRO-EM PROJECT MEMORANDA

- Preliminary Study of Approach Fills at Oakland Mole
- Studies on Lateral Spreading of Fills at Oakland Mole
- Findings From Trench and Pit Excavations on Oakland Mole (Updated

UNIVERSITY OF CALIFORNIA AT BERKELEY

- Geotechnical Testing for the East Bay Crossing of the San Francisco-Oakland Bay Bridge

EXECUTIVE SUMMARY

Project Background and Study Description

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture between Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract No. 59A0053.

Report Description and Intent

The purpose of this Oakland Shore Approach Site Characterization report is to provide a reference document and basis for future geotechnical reports addressing detailed foundation design and stability for the proposed approach and structures. Specifically, it: 1) documents the Phase 1 through 3 exploration activities and results, 2) presents the laboratory test results completed to date, 3) provides our interpretations of subsurface geotechnical conditions, 4) describes the analyses of anticipated pertinent site conditions, and 5) provides comments regarding ground stability issues pertinent to geotechnical design and construction of the Oakland Shore Approach.

The report is physically bound in four volumes. Volume 1 provides the interpretational text and illustrations. Volumes 2A and 2B contain 25 appendices that provide boring logs and boring-specific test data from each land boring as well as two marine borings drilled on the tidal flat to the north and northwest of the western tip of the Mole. Volume 3 contains three appendices that provide logs of cone penetration test (CPT) soundings, including: 1) land (truck-mounted and all-terrain-vehicle- [ATV-] mounted equipment) CPT soundings; 2) marine tethered Seascout CPT soundings on the tidal flat; and 3) marine Seacalf CPT soundings in the vicinity of the Oakland Mole. Volume 4 contains three additional documents including a summary of lateral spreading analyses, a memorandum discussing observations and findings from trench and pit excavations on the Mole, and a subcontract report from the University of California at Berkeley.

Area of Interest

This report addresses the subsurface conditions underlying the Oakland Shore Approach at the Oakland Mole. The Oakland Mole is a former shallow water/tidal flat area that was filled prior to the construction of the existing SFOBB in the 1930s. Two small northern extensions ("jughandles") were created in the 1950s and 1960s. The area included in this description is limited to the northern two-thirds of the Mole (from its western tip to a point approximately 800 meters to the east) and the adjacent tidal flat to the north. This portion of the Mole represents the

site of the proposed N6 alignment of the new bridge and approach, and includes portions of the existing Interstate 80 alignment.

Anticipated Mole Structures

The marine area of the Oakland Shore Approach structures extends about 300 meters from about Pier E17 through Pier E22. Farther to the east, alternative slab-on-pile-supported and fill-supported roadways were initially considered. The slab-on-pile structure was designed by TY Lin/M&N (and was carried through 65-percent design). Subsequent to the submittal of the 65-percent submittals, Caltrans selected the fill-supported roadway option for final design. Two alternative structures (designated "Long Structure Alternative" and "Short Structure Alternative") were also considered with differing abutment locations. Separate 85-percent design submittals were presented for each of those structures. Subsequently Caltrans decided that the 100-percent design will be for the Short Structure Alternative with a fill-supported roadway linking the structure to existing roads on the Oakland Mole. TY Lin/M&N is designing the Short Structure Alternative of the Oakland Shore Approach, and Caltrans is designing the fill-supported roadway.

The 85-percent drawings for the Short Structure Alternative show the following:

- Twin bridge and approach structures carrying separate east- and westbound traffic. Eastbound alignment is to the south of the westbound alignment. The westernmost tip of the Oakland Mole is south of about Station 84+00 of the new structures.
- The elevated pile-supported superstructures are shown to extend eastward, terminating at abutments at approximately Station 86+11 on the eastbound route and Station 86+42 on the westbound route.

Geotechnical Site Exploration

The site investigation program for the Oakland Shore Approach included:

a. 25 Land-Based Borings (Fall 1998)
   - 10 foundation borings
   - 14 pavement borings
   - 1 boring for proposed electrical substation location

b. 24 Land-Based CPT Soundings
   - Oakland Mole (truck-mounted equipment)
     - 2 seismic and 1 piezocone CPTs during Phase 1 (Spring 1998)
     - 3 seismic and 3 piezocone CPTs during Phase 2 (Fall 1998)

- Tidal flat along northern toe of Mole slope (ATV-mounted equipment; Winter 1999)
  - 2 seismic and 13 piezocone CPTs during Phase 2
  - Soil sample collection at 2 CPT locations

c. 2 Marine Borings Offshore From the Mole (Fall 1998)

d. 53 Tethered Seascout CPT Soundings on Tidal Flat (December 1998)

e. 2 Trench and 2 Pit Excavations (April 1999)

f. 11 Seacalf CPT soundings in the vicinity of the Oakland Shore Approach Structure (September 2000).

As described in the report, an extensive laboratory testing program was conducted as part of the site investigation.

General Subsurface Conditions

The subsurface conditions underlying the Oakland Mole and adjacent tidal flat include the following geologic features and strata:

- The existing Mole is composed primarily of poorly graded sands with variable amounts of rubble, cobbles, and rock. The fill is typically about 4.5 to 9 meters thick, but locally is as thick as 12.5 meters. The thickest fill section occurs over the location of a buried Young Bay Mud-filled paleochannel. The fill is generally dense above about elevation (El.) 0 mean sea level (MSL). In contrast, the fill is typically medium dense with loose layers below about El. 0 MSL. Standard penetration test (SPT) N-values in the submerged fill typically are between about 9 and 23.
- The Mole is underlain by about 5 to 15 meters of firm to stiff Young Bay Mud. The Young Bay Mud is normally consolidated (relative to the overburden pressure imposed by the Mole fill) beneath the 1930s' northern Mole extension, but slightly underconsolidated beneath the two more recent jughandle additions to the Mole.
- On the tidal flat to the north of the Mole where the Young Bay Mud has not been consolidated by the weight of the Mole fill, the top of the Young Bay Mud is about 0.5 to 2 meters higher than the surface of the Young Bay Mud beneath the Mole fill. That elevation difference is consistent with reported settlement of the Mole fill.
- The Young Bay Mud is overlain on the tidal flat by about 3 to 5 meters of sediments deposited during and since the construction of the northern extension of the Mole. Those tidal flat sediments locally include some or all of the following:
  - A locally continuous layer of sand that was probably deposited during the hydraulic placement of the lower submerged Mole fill.

  - A layer of very soft clay, subsequently referred to as "historical bay mud".
  - A layered deposit of sands and historical bay mud.
  - A surface "beach sand" layer in the western portion of the tidal flat.

- A distinct north-south-trending Young Bay Mud paleochannel crosses beneath the proposed new bridge alignment between the two jughandle additions to the Mole. The width of the paleochannel increases significantly and the paleochannel thalweg deepens to the north of the Mole. Between the jughandles, the base of the Young Bay Mud infill is at about El. -22 meters.

- The Young Bay Mud is underlain by layered sands and clays of the Merritt-Posey-San Antonio (MPSA) Formations except where removed by channeling. That sequence typically includes a distinct 3- to 5-meter-thick very dense sand (Merritt) layer. The MPSA Formations are generally present between about El. -8 and El. -20 meters. Locally, on the eastern flank of the Young Bay Mud-filled paleochannel, the very dense sand layer (or a separate sand layer with similar characteristics) within the sequence appears to be displaced about 5 meters downward.

- The layered MPSA Formations are underlain by Old Bay Mud (a thick sequence of very stiff to hard marine clays). Old Bay Mud includes a distinct crust at its surface as well as other deeper crust layers. The crusts are typically flat-lying and relatively continuous, although the crusts will be discontinuous where channels locally have eroded through the crust layers.

Geotechnical Stability Issues

The Oakland Mole is a hydraulic fill of variable density that is adjacent to a tidal flat and underlain by geologically Recent clay. The subsurface conditions have a number of implications regarding the stability of the Oakland Mole and new fill that might be placed to either raise or extend the Mole. The settlement and seismic stability of approach structures will be key elements in determining the types of approach structures and locating the transitions between different structures. Those settlement and seismic stability issues also will have a profound effect on the design and performance of any of the possible structure types.

Static stability issues include considerations of:

- Compression and settlement due to the weight of additional fill,
- Variations of total settlement due to variable thicknesses of the historical and Young Bay Muds, and the variations in the existing state of consolidation of the Young Bay Mud, and
- The time rate of settlement.

Seismic shaking may cause several potential problems:

- Liquefaction of the saturated fill,
- Ground surface settlement due to seismic shaking,
- Differential settlement and gapping between proposed bridge abutment or slab deck and adjacent ground,
- Cyclic degradation and loss of strength in the Young Bay Mud, and
- Lateral spreading or large lateral soil displacements if liquefaction or other strength degradation occurs behind the present slopes.

Preliminary discussions of those considerations are included in Section 6.0 of this report.

SECTION 1.0
INTRODUCTION

1.0 INTRODUCTION

This report is being provided to assist the California Department of Transportation (Caltrans) and its design team during the final design of the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project.

The study area is the site of the proposed northern alignment alternatives for the new bridge shore approach that extends from the western tip of the Oakland Mole to a point approximately 800 meters to the east. The site area is shown in Plates 1.1 and 1.2 and includes the existing I-80 alignment and the adjacent tidal flat to the north of the Mole.

The purpose of this report is to: 1) document the Phase 1 through Phase 3 exploration activities and results; 2) present the laboratory test results; 3) provide our interpretations of subsurface geotechnical conditions; 4) describe the analyses of anticipated pertinent site conditions; and 5) provide comments regarding ground stability and foundation considerations to aid geotechnical design and construction of the Oakland Mole Shore Approach.

The report is physically bound in four volumes. Volume 1 provides the interpretational text and illustrations. Volumes 2A and 2B contain 25 appendices that provide boring logs and boring-specific test data from each land boring as well as two marine borings drilled on the tidal flat to the north and northwest of the western tip of the Mole. Volume 3 contains three appendices that provide logs of cone penetration test (CPT) soundings including: a) land (truck-mounted and all-terrain-vehicle- [ATV-] mounted equipment) CPT soundings; b) marine tethered Seascout CPT soundings on the tidal flatland; and c) marine Seacalf CPT soundings in the vicinity of the Oakland Mole. Volume 4 contains three additional documents including a summary of lateral spreading analyses, a memorandum discussing observations and findings from trench and pit excavations on the Mole, and a subcontract report from the University of California at Berkeley.

1.1 BACKGROUND

1.1.1 Bridge and Route Description

The SFOBB carries 10 lanes of Interstate 80 traffic, five eastbound and five westbound, across San Francisco Bay. The bridge is bisected longitudinally by Yerba Buena Island, with the West Span(s) extending from San Francisco to Yerba Buena Island and the East Span(s) extending from Yerba Buena Island to Oakland. The existing bridge is a double-decked structure that was constructed in the 1930s.

1.1.2 Earthquake Damage and Retrofit Evaluation

During the 1989 Loma Prieta earthquake, the East Span(s) of the bridge suffered considerable damage, including the collapse of one span. Recognizing the vulnerability of the structure to future earthquake shaking, Caltrans embarked on a seismic retrofit program to upgrade the bridge. In the summer of 1995, Caltrans presented their retrofit strategy for the SFOBB East Span to the Seismic Advisory Board, who suggested replacement in lieu of retrofit.

Subsequently, Caltrans developed a 30-percent design of a continuous viaduct replacement structure. In 1996, that 30-percent design was presented to the Bay Bridge Design Task Force, who had been appointed by the Metropolitan Transportation Commission (MTC) to select a bridge type for the East Span replacement structure. The MTC and their task force then formed an Engineering and Design Advisory Panel (EDAP), who advised against Caltrans' proposed replacement bridge type.

1.1.3 Replacement Bridge

Following EDAP's recommendations, Caltrans contracted with a joint venture between TY Lin International and Moffatt & Nichol Engineers (TY Lin/M&N) to develop 30-percent designs for two alternative bridge types (Phase 1 design). The two bridge-type alternatives included a cable-supported Main Span offshore from Yerba Buena Island and a Skyway structure farther to the east, as well as the associated Yerba Buena Island transition structure(s) and Oakland Shore Approach structure(s). The locations of the various components of the chosen N6 alignment are shown on Plate 1.1. Alternative cable-supported main structures that were considered included single-tower or dual-tower, cable-stayed and self-anchored suspension bridge structures. The timing for the design project required that Caltrans and TY Lin/M&N submit 30-percent design-level schedule and cost estimates to EDAP and MTC by May 29, 1998.

In June 1998, EDAP and MTC selected the single-tower, self-anchored suspension bridge structures and haunched, concrete Skyway structures for final design. Final design of the chosen structure types and alignment was begun by the TY Lin/M&N team in late Fall 1998. The following table summarizes the submission dates for the various design submittals that have since been prepared. The last of the submittals for each component of the replacement bridge provides the basis for the structure descriptions presented in this report.

Design Submittal	Main Span	Skyway	Oakland Shore Approach
45%	January 1999	January 1999	January 1999
65%	August 1999	July 1999	August 1999
85%	In Preparation	February 2000	August 2000 (Long Structure) September 2000 (Short Structure)
100%		November 2000 (Draft)	In Preparation

1.2 N6 ALIGNMENT

1.2.1 Area of Interest

This report addresses the subsurface conditions underlying the Oakland Shore Approach at the Oakland Mole. The Oakland Mole is a former shallow water/tidal flat area that was filled prior to the construction of the existing SFOBB in the 1930s. The original Mole served as a roadway and railroad trackbed for a ferry terminal that extended into the bay to the west of the western end of the Mole. The Mole was then subsequently extended to the north during the construction of the SFOBB.

The area characterized in this report is primarily the northern two-thirds of the Mole, from its western tip to a point approximately 800 meters to the east, which includes the alignment of the existing SFOBB. The focus of the site exploration phase of the project was to develop the site characterization for the area being considered for the N6 alignment of the replacement bridge and its easternmost or Oakland Shore Approach (Plate 1.1). This alignment generally parallels the northern edge of the Oakland Mole, and includes areas on the existing Mole as well as overlying the tidal flat to the north of the Mole.

1.2.2 N6 Alignment Description

The N6 alignment, as received from TY Lin/M&N (2001) is shown on Plate 1.1. The proposed N6 alignment lies to the north of the existing alignment generally as follows:

- The proposed N6 alignment transitions from a double-decked structure at the tunnel portal on Yerba Buena Island to two, parallel, side-by-side structures north of the existing bridge.
- The maximum deviation between the alignments is to the east of existing Bridge Pier E4. At that point, the centerline of the N6 alignment is about 220 meters to the north of the centerline of the existing bridge alignment.
- From its point of curvature, the new alignment extends easterly to the Oakland Mole. The proposed alignment centerline is about 80 meters north of the existing bridge centerline at the point of curvature of the existing bridge at Pier E10.
- At the western end of the Oakland Mole, the proposed new alignment centerline is about 55 meters to the north of the existing bridge centerline.
- At its easternmost end, the N6 alignment is coincident with the existing at-grade SFOBB approach to the west of the toll plaza.

The N6 alignment structure is understood to include the following features:

- Twin bridge structures carrying separate east- and westbound traffic.
- A 70-meter-wide corridor for the new structures. The replacement bridge provides for five lanes of traffic in either direction and for a bike path along the eastbound structure.
- A total width of the corridor for the new structures of about 70 meters. The replacement bridge provides for 5 lanes of traffic in either direction, and a bike path along the eastbound structure.
- A transition structure extending 460 meters from the Yerba Buena Island Tunnel to the eastern tip of Yerba Buena Island.
- A self-anchored suspension cable, main-span signature structure extending 620 meters offshore the northeast tip of Yerba Buena Island.
- A four-frame Skyway structure extending approximately 2100 meters from the signature structure, eastward to the Oakland Shore Approach.
- An Oakland Shore Approach Structure extending about 700 meters form the Skyway structure to the north side of the Oakland Mole.
- An earthen fill transition from the Oakland Shore Approach Structure to the roadways leading to and from the existing bridge.

1.2.3 Oakland Shore Approach Structure

The marine area of the Oakland Shore Approach structure extends about 300 meters from about Pier E17 through Pier E22. Farther to the east, alternative slab-on-pile-supported and fill-supported roadways were initially considered. The slab-on-pile structure was designed by TY Lin/M&N (and was carried through 65-percent design). Subsequent to the submittal of the 65-percent submittals, Caltrans selected the fill-supported roadway option for final design. Two alternative structures (designated "Long Structure Alternative" and "Short Structure Alternative") were also considered with differing abutment locations. Separate 85-percent design submittals were presented for each of those structures. Subsequently, Caltrans decided that the 100-percent design will be for the "Short Structure" alternative with a fill-supported roadway linking the structure to existing roads on the Oakland Mole. The "short" Oakland Shore Approach structure is being designed by TY Lin/M&N while the fill-supported roadway is being designed by Caltrans.

As shown on the 85-percent design plans for the Short Structure Alternative, the proposed N6 alignment compares to the existing alignment as follows:

- At the westernmost tip of the Oakland Mole, the proposed new alignment centerline is about 50 meters to the north of the existing bridge centerline.
- At the easternmost end of the Short Structure Alternative, the eastbound structure of the N6 alignment essentially overlaps the existing SFOBB approach at just past existing Bent E32.

The 85-percent drawings for the Short Structure Alternative show the following:

- Twin bridge and approach structures carrying separate east- and westbound traffic. Eastbound alignment is to the south of the westbound alignment. The westernmost tip of the Oakland Mole is south of about Station 84+00 of the new structures.
- A total corridor width of about 70 meters for the new structures.
- The elevated pile-supported superstructures are shown to extend eastward, terminating at abutments at approximately Station 86+11 on the eastbound route and Station 86+42 on the westbound route.
- As the height of the bridge decreases, the pier spacing for the westbound alignment decreases from 64 meters between Piers E17 and E18 to 42 meters between Pier E22 and Abutment E23.
- Likewise, the pier spacing for the eastbound alignment decreases from 63.5 meters between Piers E17 and E18 to 41.7 meters between Pier E22 and Abutment E23.
- Piers E17 through E22 are supported by vertical 1.8-meter-diameter steel pipe piles.
- Abutment E23 is supported by vertical 0.61-meter-diameter, precast, prestressed octagonal concrete piles.
- The westbound Pier E18 footprint is rotated approximately 45 degrees relative to adjacent piers to avoid existing utility lines.

1.3 CALTRANS CONTRACT FOR GEOTECHNICAL AND GEOLOGICAL INVESTIGATIONS FOR THE PROJECT

To support their design efforts, Caltrans also has contracted with Fugro-Earth Mechanics (a joint venture between Fugro West, Inc., and Earth Mechanics, Inc.) to conduct geotechnical and geological investigations and studies for the replacement bridge. Caltrans Contract 59A0053, dated August 27, 1997, authorized those studies.

To date, six task orders have been issued under contract 59A0053. The six task orders include:

- Task Order No. 1 - Initial Site Characterization-Geophysical Surveys Phase with a Notice to Proceed issued January 6, 1998.
- Task Order No. 2 - Project Management and Coordination with a Notice to Proceed issued January 26, 1998.
- Task Order No. 3 - Preliminary Site Exploration and Testing with a Notice to Proceed issued January 26, 1998.
- Task Order No. 4 - Probabilistic Seismic Hazard Analysis Update and Preliminary Site Response Analysis with a Notice to Proceed issued May 19, 1998.
- Task Order No. 5 - Phase 2 Site Exploration and Characterization with a Notice to Proceed issued July 23, 1998.
- Task Order No. 6 - Pile Installation Demonstration Project Engineering/Monitoring with a Notice to Proceed issued December 23, 1998.

The Task Order No. 5 work scope included provisions for the final design phase of site exploration, testing, and characterization for the chosen bridge alignment and structures. The task order authorized the extensive marine exploration and land exploration programs on Yerba Buena Island and the Oakland Mole.

1.4 SITE INVESTIGATION

1.4.1 Project Datum

The horizontal and vertical datum specified by Caltrans (1997) for use on this project were as follows:

- Horizontal Datum: California Coordinate System Zone 3, NAD 1983 (meters)
- Vertical Datum: MSL Datum of 1929

Locations and elevations presented in this report are in reference to this project datum. The NGVD 29 datum is generally equivalent to mean sea level (MSL) datum, and is 0.942 meter above mean lower low water (MLLW) datum (e.g., to convert MLLW elevations to MSL elevations, *subtract* 0.942 meter from the MLLW elevation values).

1.4.2 Site Investigation Scope of Work

The site investigation programs conducted for the Oakland Shore Approach, as part of Caltrans Contract 59A0053, have included the following exploration and investigation activities:

a. 25 Land-Based Borings (Fall 1998)
   - 10 foundation borings
   - 14 pavement borings
   - 1 boring for proposed electrical substation location

b. 24 Land-Based CPT Soundings
   - Oakland Mole (truck-mounted equipment)
     - 2 seismic and 1 piezocone CPTs during Phase 1 (Spring 1998)
     - 3 seismic and 3 piezocone CPTs during Phase 2 (Fall 1998)
   - Tidal flat along northern toe of Mole slope (ATV-mounted equipment; Winter 1998)
     - 2 seismic and 13 piezocone CPTs during Phase 2
     - Soil sample collection at 2 CPT locations

c. 2 Marine Borings Offshore From the Mole (Fall 1998)

d. 53 Tethered Seascout CPT Soundings on Tidal Flat (December 1998)

e. 2 Trench and 2 Pit Excavations (April 1999)

f. 11 Seacalf CPT Soundings in the vicinity of the Oakland Shore Approach Structure (September 2000).

The locations of and designated numbers for those explorations are shown on Plate 2.1.

1.5 FINAL OAKLAND SHORE APPROACH SITE CHARACTERIZATION REPORT

1.5.1 Basis of Characterization

The interpretation of the subsurface conditions presented in this report is based primarily on the Fugro-EM site investigation activities conducted from January through April 1998 (Phase 1), September through November 1998 (Phase 2), and September and October 2000 (Phase 3). In addition to the above site investigation data, the following were also considered:

- Various previous borings completed from 1994 through 1996 for the Caltrans' retrofit studies
- Other historic drilling information

1.5.2 Integrated Approach and GIS Database

For the interpretations presented in this report, primary emphasis was placed on the site-specific conditions encountered in the 1998 borings and the 1999-2000 CPTs. The 1998 borings include extensive in situ and laboratory test data (on relatively undisturbed push samples), whereas the older borings include variable (and often limited) quantities of test data (on

comparatively disturbed driven samples). Testing on samples recovered from the 1998 borings together with the 1998 and 2000 in situ test data are the principal basis for the interpretations described herein. Other older data have generally been used to supplement the stratigraphic information provided in that new data.

The stratigraphy in the borings and CPTs has been compared and integrated with the interpreted stratigraphic relationships imaged by the adjacent marine-based explorations (borings, CPTs, and geophysical seismic reflection) performed for the marine portions of the project and presented in the Final Marine Geotechnical Site Characterization report (Fugro-EM, 2001d).

All of the new and past drilling data have been input into a Geographic Information System (GIS) to allow synthesis, comparison, analysis, and output of the data.

1.5.3 Report Organization

Main Text - Volume 1. The main text of the Revised Final Oakland Shore Approach Geotechnical Site Characterization report is composed of the following sections:

- Section 1.0 - Introduction
- Section 2.0 - Field Exploration
- Section 3.0 - Laboratory Testing
- Section 4.0 - Site Characterization
- Section 5.0 - Engineering Soil Properties
- Section 6.0 - Oakland Mole Stability Issues
- Section 7.0 - References

Various information is provided on illustrations that follow the main text.

Boring-Specific Appendices - Volumes 2A and 2B. The data and interpretations from each individual land boring are provided in Appendices 98-51 through 98-75. The boring-specific appendices for Borings 98-51 through 98-60 are contained in Volume 2A, while the remainder of the boring-specific appendices for Borings 98-61 through 98-75 are contained in Volume 2B. In addition, boring-specific appendices for two marine borings (98-39 and 98-44) are included at the end of Volume 2B. The appendices for the land borings generally include:

- Boring logs with soil test results
- In situ remote vane test data (Borings 98-51 through 98-60 only)
- Laboratory test results, including: summaries of test results, grain size curves, plasticity chart, stress-strain curves, consolidation test results, consolidated drained and undrained triaxial test results, R-value test results, and corrosion test results, as applicable

- Soil properties versus depth, including: plasticity index, liquidity index, soil sensitivity, ε_{50}, and preconsolidation pressure

The same information is included for the two marine borings, as are additional copies of the boring logs that include downhole CPT results and suspension wave logs.

CPT Data Appendices - Volume 3. The CPT sounding data are provided in Volume 3. Appendix A includes the data for the land (truck-mounted CPTs on the Mole and ATV-mounted CPTs at the toe of the Mole slope). Appendix B includes the data for the marine tethered Seascout CPTs on the tidal flat to the north of the Mole. Appendix C includes the data from the marine-based Seacalf CPT soundings performed in the vicinity of the Oakland Shore Approach structure. The CPT logs include cone tip resistance, friction sleeve resistance, pore pressure, computed friction ratio versus depth, and, for the seismic cone soundings, the data also includes the calculated shear wave velocity profile. In addition to the CPT data, correlations with undrained shear strength, preconsolidation stress, and relative density are included for the truck-mounted and ATV-mounted CPTs. Laboratory test results have been included where sampling was performed at two ATV-mounted CPT locations (99C-12 and 99C-14). The laboratory test results include: summaries of test results, grain size curves, plasticity charts, and plasticity index and liquidity index profiles. The Seacalf CPT sounding logs include estimates of undrained shear strength interpreted from CPT tip resistance for fine-grained layers.

Additional Reports - Volume 4. The Volume 4 appendices contain four additional documents including a memorandum presenting preliminary studies of approach fills at the Oakland Mole, a memorandum presenting studies on lateral spreading of fills at the Oakland Mole, a memorandum presenting observations and findings from trench and pit excavations on the Mole, and a subcontractor report from the University of California at Berkeley. The lateral spreading memorandum consists of a summary description of the methods and assumptions used in the analyses as well as results. The trench and pit excavation includes descriptions and findings from the excavation, trench logs, and photographs of the excavations. The subcontractor report from the University of California at Berkeley documents specialized cyclic simple shear and radial consolidation tests performed at the University of California at Berkeley laboratories.

1.6 RELATED REPORTS PREPARED BY FUGRO-EARTH MECHANICS

The flowchart presented on Plate 1.3 has been prepared to clarify and delineate the areas and issues addressed (or to be addressed) by the primary reports prepared (or to be prepared) for the project by Fugro-Earth Mechanics (2001a-h). As shown on Plate 1.3, the project submittals have generally been divided into: a) geotechnical site characterization reports, and b) foundation design reports.

The site characterization submittals consist of: a) marine, b) Oakland Shore Approach, and c) Yerba Buena Island reports. Final foundation reports will be prepared to address: a) the Yerba Buena Island transition structures and Main Span-Pylon, b) the Main Span-East Pier and Skyway Piers (E3 through E16), and c) the Oakland Shore Approach structures to the east of Pier E16. In general, foundation design recommendations and results are developed interactively and iteratively with the structural engineers. Since the design loads and foundation layouts are still being modified, the foundation reports for the Oakland Shore Approach and Yerba Buena Island transition structures and Main Span-Pylon are still in preparation. Design recommendations are typically being provided to the design team via memoranda and will be included in the final foundation reports.

The areas addressed by the various site characterization and foundation reports are shown on Plate 1.4. As shown on Plate 1.4, the delineation of areas addressed by the site characterization reports is generally based on the site investigation techniques used. In contrast, the areas addressed by the final foundation reports are based on: a) the subsurface conditions (as defined in the geotechnical site characterization reports), and b) the requirements of the various bridge and structural engineering teams. Consequently, the break-up of areas addressed in each of the foundation reports is somewhat different from the break-up of areas addressed in each of the site characterization reports.

Reports that represent the final submittal for a particular area or structure type are shaded gray on Plate 1.3. The interpretations and design recommendations presented in those reports generally supercede those presented in the preceding reports. Those reports also include all relevant data from the preceding reports.

Earth Mechanics

FUGRO

1835500 1836000 1836500 1837000 1837500 1838000 1838500 1839000 1839500 1840000

649000 648500 648000 647500 647000

TREASURE ISLAND

YERBA BUENA ISLAND

SKYWAY STRUCTURE

FRAME 1 FRAME 2 FRAME 3 FRAME 4

MAIN SPAN STRUCTURE

YBI TRANSITION STRUCTURE

OAKLAND SHORE APPROACH AREA

OAKLAND SHORE APPROACH STRUCTURE/FILL

OAKLAND MOLE

-5.0 -10.0 -15.0

LEGEND

N6 Alignment

San Francisco-Oakland Bay Bridge

Bathymetric Elevations from Phase 1 and Phase 3 Surveys, Meters Re. MSL 1929 (Caltrans, 1997)

Major (Interval = 5 Meters)

Minor (Interval = 1 Meter)

Pier Locations

N

100 0 100 200 Meters

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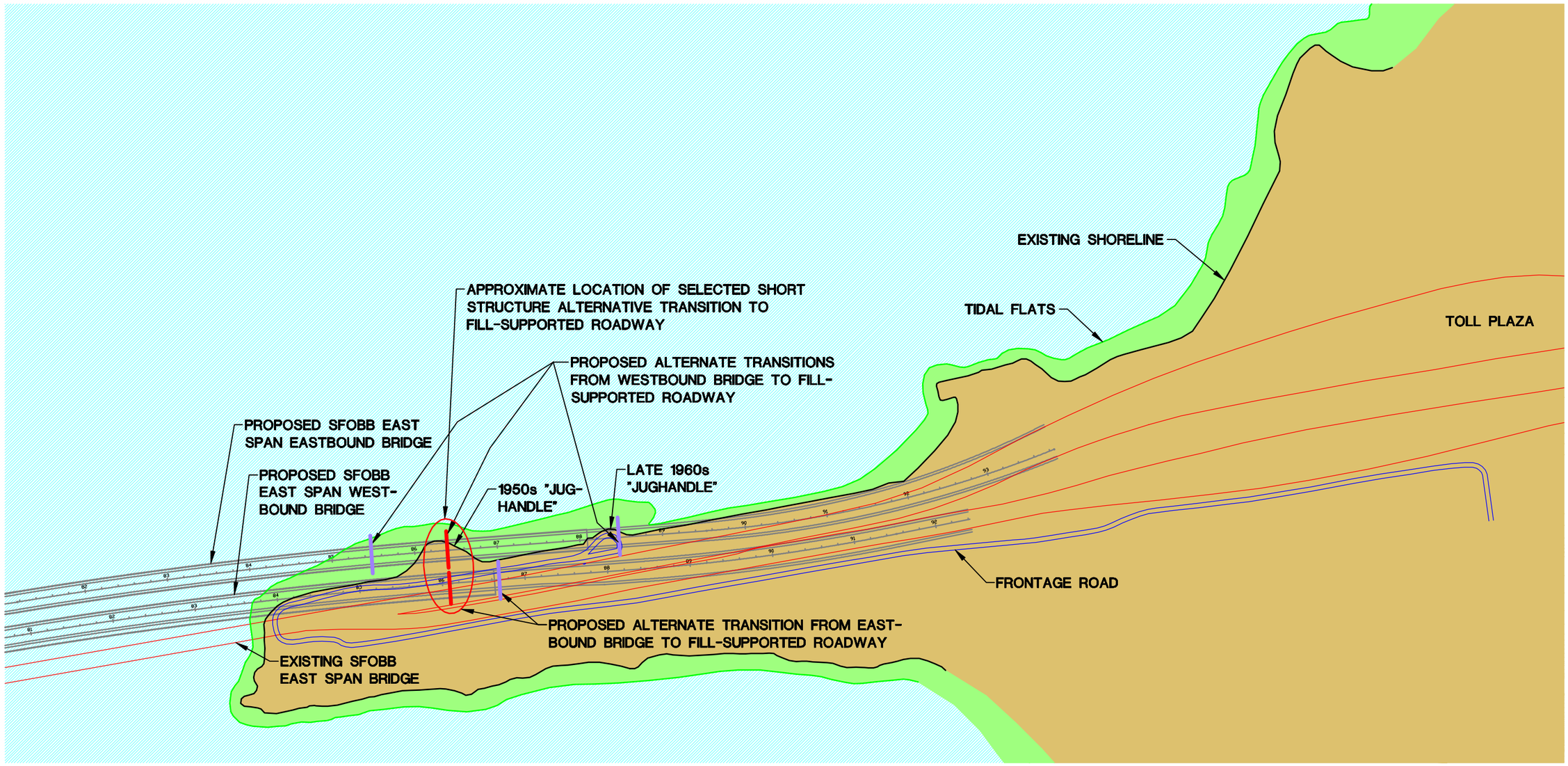
SITE VICINITY MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 1.1



NORTH

0 100 200 m

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SITE LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 1.2

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Earth Mechanics FUGRO

FUGRO-EM GEOTECHNICAL STUDY

Site Characterization Information

Onshore Site Characterization Reports

Oakland Shore Approach Site Characterization Reports

The Oakland Shore Approach report address the portions of the proposed N6 alignment that are on the Oakland Mole or within the tidal flat zone to the north of the Oakland Mole. The data provided are applicable to the structure-supported portion of the bridge at the west end of the mole, and to the fill-supported portions farther east.

Final Oakland Shore Approach Geotechnical Site Characterization - provides a detailed site characterization for the Oakland Mole and adjacent marine areas on the basis of Fugro-EM site investigations. Additionally, the report provides the results of liquefaction and lateral spread analyses performed in this area.

Vol 1 - Main Text and Illustrations
Vol 2A and 2B - By-boring Appendices
Vol 3 - CPT Sounding Appendix
Vol 4 - Additional Reports:
- Preliminary Study of Approach Fills
- Studies on Lateral Spreading of Fills
- Findings from Trench and Pit Excavation
- UC Berkeley Geotechnical Testing

3/5/01

Yerba Buena Island Site Characterization Reports

The Yerba Buena Island site characterization reports address the land-based structures at the west end of the N6 alignment. Those reports have/will address(ed) the Main Span-West Pier and various transition structures from the tunnel to the Main Span.

Phase 1 Subcontractor Reports
Vol 2 - NORCAL Geophysical Consultants, Inc. (Seismic Surveys - Yerba Buena Island)
COLOG, Inc. (BIPS Data - Yerba Buena Island)
Hughes Insitu Engineering, Inc. (Pressuremeter Testing)
6/24/98

Final Yerba Buena Island Geotechnical Site Characterization - documents the Fugro-EM site investigations. The report includes stratigraphic details and engineering properties of soil and rock for the design of structures on Yerba Buena Island. The report also documents the mapping and subsequent evaluation of shear zones observed on YBI. Draft 3/1/00

Note: Will be finalized when Main Span and Temporary Structure design is completed.

Marine Site Characterization Reports

The marine site characterization reports address portions of the proposed N6 alignment over the San Francisco Bay to the east of Yerba Buena Island and to the west of the Oakland Mole. These reports describe subsurface conditions beneath: a) the Main Span-Pylon; b) Main Span-East Pier; c) the various Skyway piers; and d) overwater portions of the Oakland Shore Approach structure to the west of the Oakland Mole.

Marine Geophysical Report

Final Marine Geophysical Survey - summarizes the Phase 1 2-D and 3-D geophysical surveys and the Phase 3 2-D geophysical survey. The report provides a number of structure contour maps and isopach (thickness) maps for the primary geologic units identified in the overwater portions of the project area. Also documented in this report are evaluations of offshore geologic structures identified in the Main Span area and the assessment of the recency of movements along offshore projection of shear zones mapped on YBI. 3/5/01

Marine Geotechnical Reports

Phase 1 Subcontractor Reports 6/24/98

Vol 1 -	Geovision	Borehole Geophysics
	Welenco, Inc.	Borehole Televiewer Logs
Vol 2 -	Hughes Insitu Engineering, Inc.	Pressuremeter Testing
Vol 3 -	Fugro South, Inc.	Resonant Column and Cyclic Direct Simple Shear Tests
	University of Texas at Austin	Dynamic Properties of Intact Soil Specimens
Vol 4 -	GeoTest Unlimited	Laboratory Rock Testing Program

Phase 2 Subcontractor Reports 3/5/01

Vol 1 -	Geovision	Borehole Geophysics
	Welenco, Inc.	Borehole Televiewer Logs
Vol 2 -	GeoTest Unlimited	Laboratory Rock Testin Program
Vol 3 -	Fugro West, Inc.	Seascout CPT soundings

Final Marine Geotechnical Site Characterization - summarizes the three phases of Fugro-EM site investigations performed in the overwater portions of the project area. The report provides detailed descriptions of the stratigraphy underlying the bridge alignment and also summarizes the engineering properties of the soil and rock encountered.
Vol 1 - Main Text and Illustrations
Vol 2A through 2H - By-boring and CPT sounding appendices 3/5/01

Foundation Design Information

Final Seismic Hazard Ground Motion Report - provides ground motion recommendations for the entire project. It includes probabilistic hazard studies, site response analyses, ARS design criteria, and multiple-support time histories. 2/28/01

Pile Installation Demonstration Project (PIDP) Geotechnical Report - documents the field activities during PIDP program and summarizes the results and conclusions derived from the data collected during that program. 3/5/01

Final Foundation Design Information Reports

Skyway and Main Span-East Pier

These reports provide foundation design recommendations and present construction considerations for the Main Span-East Pier (Pier E2) and Skyway Piers (E3 through E16). The reports are generally applicable to areas underlain by significant thicknesses of sediment where piers will be supported by batter, large-diameter, driven steel pipe piles.

Axial Pile Design and Drivability, Main Span-East Pier & Skyway Structures - provides pier-specific results of pile design for driven pile foundations under static axial loading conditions. The report also provides the results of pile drivability analyses and presents construction considerations for large-diameter pile foundations. 3/5/01

Lateral Pile Design, Main Span-East Pier & Skyway Structures - provides pier-specific results for the design of driven piles subject to static lateral loads. The report also presents a basis for the analysis of piles under dynamic lateral loading conditions. 2/28/01

Analysis and Design Procedures for Pile Foundations Supporting Temporary Towers - provides subsurface information and example calculations as guidance for the design of temporary tower foundations for the Skyway Structures. 3/5/01

Yerba Buena Island Structures and Main Span-Pylon Foundation

This report provides foundation design recommendations and presents construction considerations for the YBI approach structures (Bents W3 through W10a), temporary detour structures, and the Main Span-West Pier and -Pylon (Pier E1). The report is generally applicable to areas of onshore foundations or foundations supported in rock. In Preparation

Note: Will be finalized when Main Span and Temporary Structure design is completed.

Geotechnical Foundation Report for Structural Alternative, Oakland Shore Approach

Structural options (especially in marine areas) are being addressed by Fugro-EM. Nonstructural design concepts for the Oakland Shore Approach are being designed by Caltrans. No design recommendations are presented for those by Fugro-EM. This report provides foundation design recommendations and presents construction considerations for the structure-supported portions of the Oakland Shore Approach. Draft 7/31/00

Note: Will be finalized when Main Span and Temporary Structure design is completed.

FINAL FUGRO-EM REPORTS
SFOBB East Span Seismic Safety Project

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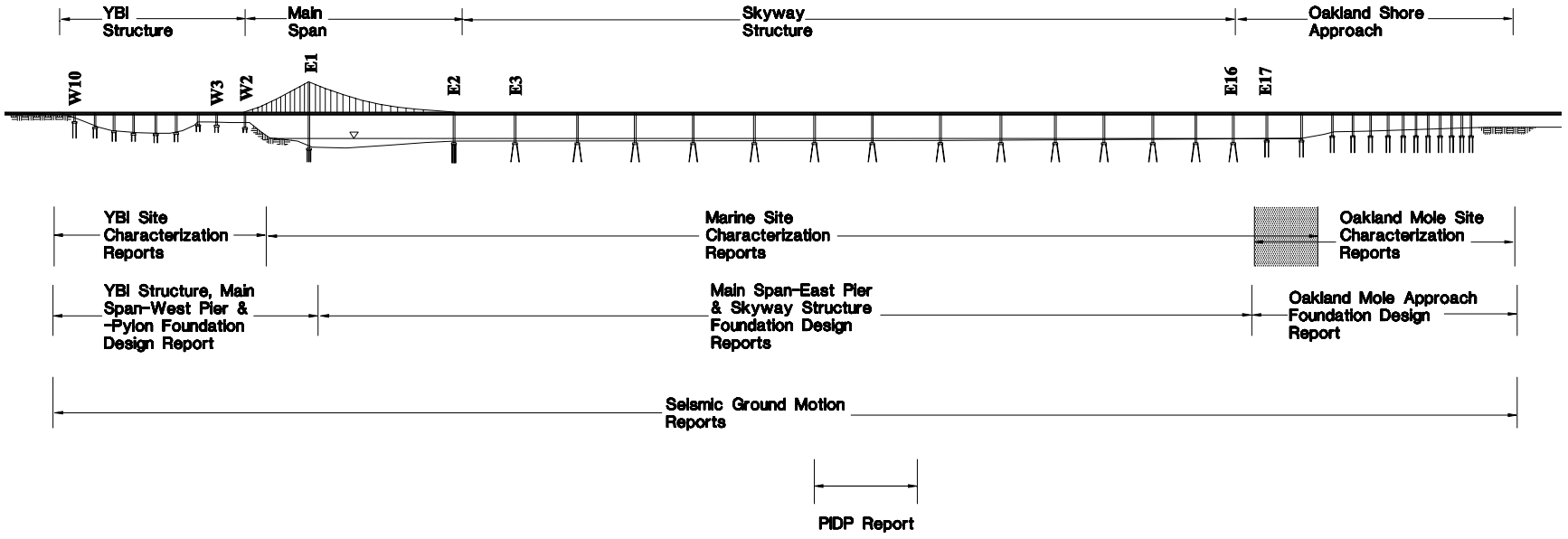


DELINEATION OF AREAS ADDRESSED BY FUGRO-EM REPORTS

SFOBB East Span Seismic Safety Project

PLATE 1.4

Earth Mechanics

FUGRO

SECTION 2.0

SECTION 2.0
FIELD EXPLORATION

2.0 FIELD EXPLORATION

2.1 GENERAL OVERVIEW

2.1.1 Purpose

The soil investigation program was performed to gather geotechnical data for design and construction of the Oakland Shore Approach for the new SFOBB East Span. The Oakland Shore Approach portion of the project generally includes a bridge structure, fill-supported roadway approaches to the new bridge, temporary detour roadways, and an electrical substation. As described in Section 1.0, the limits of the structural and fill-supported components of the Oakland Shore Approach have varied during design. However, it is understood from Caltrans that the 100-percent design will be for the "Short Structure" alternative with a fill-supported roadway linking the structure to existing roads on the Oakland Mole. Borings and CPT soundings were advanced to varying depths (depending on the geotechnical design issues in a given area) to characterize the soil stratigraphy and provide samples for classification and laboratory testing.

2.1.2 Previous Investigations

A series of borings were performed in the western 300 meters of the project site for the original construction of the Oakland Mole in the 1930s. In 1994, a series of borings and CPTs were conducted by Caltrans as part of the Oakland Bay Bridge Seismic Retrofit Program. This investigation included shear wave measurements, gamma ray, resistivity, and electric well logs. A permanent, deep, strong motion sensor was installed in Caltrans Boring B-4.

2.1.3 Current Investigation

Phase 1 - Scope. The Phase 1 investigation for the subject project included three land-based CPTs (designated as 98C-16 through 98C-18) conducted by Fugro Geosciences during Spring 1998. The CPT testing was performed to supplement the existing data and to provide preliminary site characterization of the Oakland Mole.

Phase 2 - Land Exploration. The Phase 2 investigation conducted on the Oakland Mole included 25 soil borings (designated as 98-51 through 98-75) and 6 CPT soundings (designated as 98C-101, 98C-102, 98C-104, 98C-105, 98C-109, 98C-110 [four planned locations, designated as 98C-103, 98C-106 through 98C-108, were abandoned due to electrical interference]). Phase 2 on-land Oakland Mole subsurface investigations were primarily conducted in Fall 1998. Trenches and test pits were excavated in April 1999. The locations of those explorations are shown on Plates 2.1a and 2.1b. A summary of the land-based exploration for the Oakland Mole approach is discussed below.

- **Foundation Borings** - Ten (10) relatively deep borings (98-51 through 98-60) were drilled to define subsurface conditions for foundation design. (Those borings were originally designated as B-1 through B-10.) The foundation borings were drilled to depths ranging from 36 to 71 meters.
- **Pavement and Electrical Substation Borings** - Fourteen (14) borings (98-61 through 98-74) were drilled for pavement design at locations selected by Parsons Brinckerhoff. (Those borings were originally designated as P-1 through P-14.) The pavement series borings were drilled to depths ranging from 7.5 to 25 meters. One additional boring (98-75) was added to the drilling program to investigate the subsurface conditions at the proposed electrical substation location. That boring was drilled to a depth of 31.1 meters.
- **CPT and Seismic CPT Soundings** - Six (6) CPT soundings were performed by Fugro Geosciences as part of the Phase 2 field exploration program, three of which included seismic velocity measurements. A total of 10 CPTs were attempted, but four could not be completed due to electrical interference and were abandoned.
- **Trench and Pit Excavations** - An investigation consisting of two exploratory trenches was conducted on the Oakland Mole for the purpose of visual inspection of subsurface ground conditions and buried rock dike materials for the design and construction of the new SFOBB East Approach. In addition, two pits were excavated in the beach areas at the north slopes to determine maximum excavation depths for the proposed fill construction.
- **Adjacent Phase 2 Marine Borings** - As part of the marine investigation (Fugro-EM, 2001d), Fugro also drilled two soil borings (98-39 and 98-44) on the tidal flat (see Plate 2.1a) off the present northwestern shore of the Oakland Mole.

Phase 2 - Tidal Flat Exploration. The new bridge and roadway alignments will overlie the existing tidal flat to the north of the Mole. Exploration of that shallow water and periodically exposed tidal flat required special equipment and techniques, which included:

- **Tethered Seascout CPTs** - Fifty-three (53) miniature cone Seascout CPTs were conducted in December 1998 during high tides to the north of the Mole. The soundings were conducted between about 15 and 110 meters to the north of the Mole. These CPT soundings typically extended to a penetration of 5 meters.
- **All-Terrain CPTs** - Fifteen (15) CPTs were conducted with an ATV-mounted CPT rig during low tide periods in March 1999 on the exposed tidal flat immediately to the north of the Mole. The CPT soundings were numbered 99C-1 through 99C-15. The ATV-mounted CPT soundings typically extended to a penetration of about 12 to 30 meters. Downhole seismic measurements were obtained in two of the ATV-mounted

CPT soundings (99C-13 and 99C-15). Samples also were obtained at two ATV-mounted CPT locations (99C-12 and 99C-14).

Phase 3 - Marine Seacalf CPT Program. The Phase 3 CPT operations consisted of a total of 77 CPT soundings performed along the N6 alignment, in the area north of Yerba Buena Island, and in the vicinity of the Oakland Shore Approach. The Phase 3 CPT operations were conducted between September 23 and October 6, 2000. The CPTs conducted in the vicinity of the Oakland Shore Approach included:

- Two (2) CPT soundings between Skyway Pier E16 and the Oakland Shore Approach Pier E17 where a temporary tower is planned to support the western-most section of the Skyway bridge deck prior to connecting the Skyway to the Oakland Shore Approach.
- Nine (9) CPT soundings along the alignment of the Oakland Shore Approach to refine the definition of the shallow stratigraphy in planned pier and anticipated falsework areas.

These CPT soundings were numbered 00C-64 to 00C-74 and their locations are shown on Plate 2.1a. The soundings in the vicinity of the Mole extended to penetrations ranging from 11 to 53 meters.

2.1.4 Organizational Roles

The following organizations have contributed to the execution of the Oakland Mole investigations:

- Fugro-EM provided definition of the onshore explorations program (with input relative to the pavement borings received from Parsons Brinckerhoff).
- CH2M Hill was tasked with logistical coordination of the land exploration, provided professional staff to log the land borings, and surveyed the locations of the land exploration.
- Pitcher Drilling Company drilled the borings.
- Spectrum Drilling predrilled and installed temporary casings.
- Fugro Geosciences conducted the CPT soundings.
- Fugro-EM personnel assisted in the field logistics, processed (tested and relogged) the samples on the offshore drilling barge, and conducted the in situ vane shear tests in 10 of the land borings.
- Integrated Wastestream Management performed soils disposal and Chromalab Environmental Services conducted environmental soils testing.

- CS Marine Constructors, Inc., supplied the barge from which the Seacalf CPT system was deployed.

2.2 LAND-BASED BORINGS

2.2.1 Overview

Boring Dates and Locations. The Phase 2 land borings included 25 borings drilled between September and November of 1998. Ten foundation borings (98-51 to 98-60) were located on the north side of the Oakland Mole, along the proposed N6 alignment. The 14 pavement borings (98-61 through 98-74) for roadway design were located on Interstate 80 with seven boreholes on or near the eastbound lanes and seven boreholes on the westbound lanes. Three boreholes (98-67 to 98-69) were moved from the inside eastbound shoulder to the inside westbound shoulder to accommodate traffic control considerations. Boring 98-75, for the proposed electrical substation, was located south of where the current eastbound lanes touch down on the Mole. The boring locations are shown on Plate 2.1.

Traffic Control Considerations. Many of the explorations required traffic control to close two lanes of the Interstate 80. The highway lane closures required encroachment permits from Caltrans and scheduling of the lane closures. The highway drilling operation was performed at night to minimize effects on daytime traffic. The allotted drilling time on westbound Interstate 80 was generally from 11:00 p.m. to 5:30 a.m. Borings in eastbound lanes also were drilled at night, but could remain closed until noon the following day. Borings that required consecutive days to drill were covered with a steel plate under the supervision of a Caltrans inspector.

Foundation Borings. The soil borings for the foundation design (Borings 98-51 through 98-60) consisted of a total of 10 deep boreholes that extended to depths of 35 to 70 meters. The purpose of these boreholes was to delineate the extent of the Mole fill, Young Bay Mud (YBM) and Merritt-Posey-San Antonio (MPSA) Formations, and to develop engineering properties for the fill, MPSA, YBM, and Old Bay Mud (OBM). Table 2.1 lists the boring locations and as-drilled penetration depths. Graphical boring logs are attached in Volume 2A.

Pavement and Electrical Substation Borings. Fourteen (14) shallow borings were drilled to shallower depths ranging from 8 to 23 meters for roadway pavement design (Borings 98-61 through 98-74). The borings were drilled to: 1) delineate the thickness of the fill and the top and, in some cases, the bottom of the Young Bay Mud layer; and 2) develop engineering properties of the fill and Young Bay Mud. Boring 98-75 was added at the end of this program and drilled to 31.1 meters for the design of the electrical substation.

Table 2.1 lists the boring locations and as-drilled penetration depths for the pavement and electrical substation boring locations. Graphical boring logs are attached in Volume 2B.

2.2.2 Drilling and Field Methods

The Phase 2 Oakland Shore Approach borings were drilled by Pitcher Drilling Company of Palo Alto, California, and were advanced by the rotary wash method using Failing 1500 drill-rigs with 124-mm (millimeter) drill bits.

The sampling process consisted of a combination of driven standard penetration test (SPT) and California liner sampling and pushed 76-mm tube samples. About two-thirds of the pushed tube samples were extruded in the field, while the remaining one-third were sealed in the tube (designated on the boring logs as "SAVE" tube samples).

In situ remote vane shear tests were conducted in the Young and Old Bay Mud deposits in the foundation borings (98-51 through 98-60). The in situ tests were conducted using Fugro's downhole Dolphin system. In situ vane shear tests were interspersed with the sampling, and the sampling interval was adjusted as required.

The samples collected from the land borings were classified and field tested, then transported to the marine drilling barge for further laboratory testing.

2.2.3 Sampling Methods and Intervals

Sampling Methods. SPTs as described in ASTM D1586 were performed through the fill material and in the Merritt Sand. At the top of the Young Bay Mud, a modified California sampler was used to collect clayey sand/sandy clay samples. The driven samplers were advanced using a standard SPT rope and cathead procedure. During the initial stages of the field exploration, driven California liner samples were occasionally taken in the Young and Old Bay Mud deposits. Due to the reduction in sample quality relative to the thin wall sampling procedures, the California liner sampling of the clay deposits was reduced or eliminated in the latter stages of the investigation.

Relatively undisturbed samples of the Young Bay Mud were collected using a 76-mm-OD (outside diameter), 72-mm-ID (inside diameter) Shelby tube sampler in accordance with procedures for Thin-Walled Tube Sampling of Soils (ASTM D1587). Shelby tube samples also were collected in the Old Bay Mud. About two-thirds of the pushed tube samples were extruded on the drill rig, while the remaining one-third were sealed in "SAVE" tubes.

In situ remote vane tests also were performed on the Young and Old Bay Mud deposits in the 10 foundation borings (98-51 through 98-60) using Fugro's downhole Dolphin remote vane system. The in situ vane shear tests were interspersed with the sampling.

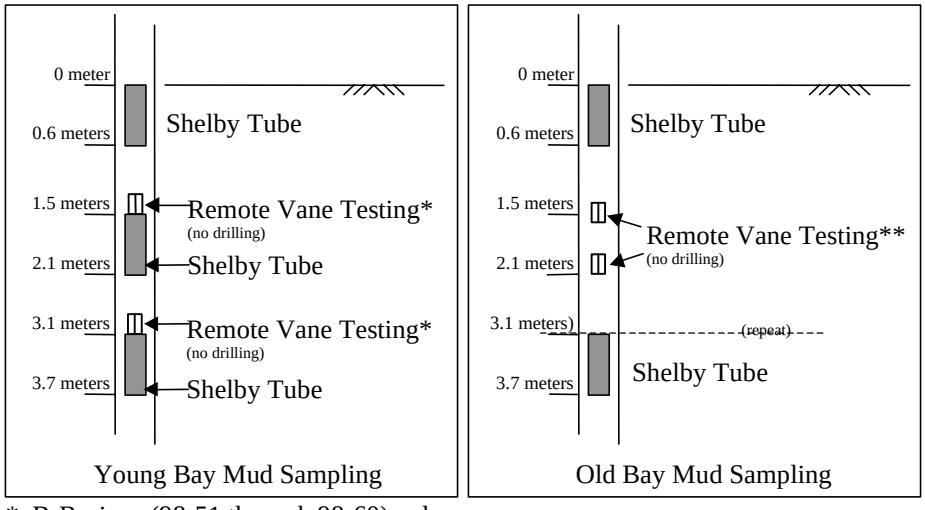
Sampling Intervals. The sampling schedule used for the pavement borings (98-61 to 98-75) was as follows:

- One bulk sample and two SPT samples within the upper 1.5 meters of the fill
- Pavement cores
- SPT samples at 1.5-meter intervals within the fill material
- Pushed Shelby tube sampler every 1.5 meters in the Young Bay Mud
- No in situ field tests
- At least one SAVE Shelby tube collected in the Young Bay Mud layer
- SPT samples at 1.5-meter intervals within the Merritt Sand
- Shelby tube samples every 1.5 meters in the Old Bay Mud

The sampling schedule for the foundation borings (98-51 through 98-60) was similar to that of the pavement borings, with the following differences:

- One SPT sample within the upper 1.5 meters
- No pavement core
- Every third Shelby tube sample saved in "SAVE" tubes
- Remote vane shear testing in both the Young and Old Bay Muds

The remote vane testing interval in the Young Bay Mud was to follow a Shelby tube sample by pushing the remote vane to the next 1.5-meter interval. In the Old Bay Mud, Shelby tube samples were followed by two remote vane tests pushed 1.5 to 2.1 meters below the previous tube sample. In each case, the remote vane was pushed to the test depth. The remote vane testing intervals are shown in the figure below.



* B-Borings (98-51 through 98-60) only

** In P-Borings (98-61 through 98-74), a Shelby tube sample was collected instead of the remote vane.

2.2.4 Soil Sample Preparation and Field Testing

The Shelby tube samples were extruded for immediate testing or sealed in "SAVE" tubes for later testing. The extruded Shelby tubes were cut into sections approximately 150 mm in length. The soil samples were visually classified in general accordance with ASTM D2487. Pocket penetrometer tests and Torvane tests were conducted on the samples to estimate shear strengths. The sections were wrapped in plastic film and aluminum foil, then placed in 150-mm-tall plastic tubes (quarts), capped, and labeled. The quarts were transferred to a laboratory located on the Fugro barge used for the marine drilling operation. The "SAVE" tubes were visually classified, and a bag sample was taken from the bottom 80 mm of the tube. The tubes then were sealed with O-ring seals, capped, labeled, and stored for subsequent laboratory testing.

The modified California sampler contained three 61-mm-diameter by 150-mm-long liners. Liners with intact soil samples were capped and stored for later testing. Liners that were not completely full and SPT samples from the split-spoon sampler were stored and labeled in plastic bags.

The samples collected from the land borings were transported to the laboratory on the marine drilling barge daily. The samples were relogged, and water content and unit weight measurements were conducted on each sample. Undrained shear strength measurements including miniature vane, Swedish fall cone, and unconsolidated-undrained (UU) triaxial shear tests were conducted on the clay samples. Approximately one-third of the clay samples were remolded (at their in situ water content) and undrained shear strength tests were conducted on the remolded specimen.

After the onboard testing was completed, the samples were transferred to the refrigerated trailer sample storage facility at the Fugro-EM field office. The samples were dispersed to the onshore laboratories, as appropriate. The "SAVE" tubes were transferred to Fugro's laboratory at Houston and the laboratory at the University of California at Berkeley for more detailed (consolidation and dynamic strength) laboratory testing.

2.2.5 In Situ Testing (Remote Vane)

The Dolphin remote vane was used to measure the in situ shear strengths of the Young and Old Bay Muds. Vane testing was generally not performed in hard clay strata where the in situ shear strength of the soils exceeds the measuring capacity of the vane. The vane testing also was not performed on highly stratified (interlayered clay and sand) soil profiles.

A schematic drawing showing the downhole Dolphin remote vane is presented on Plate 2.2. The downhole vane tests were performed immediately after the push sampling operation. The operational sequence for performing a downhole vane test involved attaching the remote vane to the drill rod, lowering the remote vane downhole, pushing the four-bladed vane to the desired test depth, and running the test.

The tests were run for approximately 3 minutes. At the end of the test, the drill string could be lowered to push the tool an additional 0.6 meter to perform the second test. At the end of the second test, the tool was pulled out of the soil formation. Once the tool was out of the borehole, the remote memory unit (RMU) was connected to a computer for the data retrieval procedure and to generate a "quickplot" of the torques developed. The undrained shear strength was then computed from the maximum vane blade torques and transducer/vane blade calibration factors. The maximum shear strength that can be measured by the Dolphin remote vane device is approximately 263 kilopascals (kPa). After the data retrieval procedure was completed, the RMU was reinitialized and prepared for the next test.

2.2.6 Elevation and Position

Ground elevations and coordinates of each boring location were determined by conventional land survey methods using a United States Geological Survey (USGS) control location on the Mole.

2.2.7 Borehole Abandonment and Soil Disposal

The borings were abandoned by backfilling the holes with cement grout. The pavement was patched with asphalt concrete at locations where existing pavement had been cored.

Environmental sampling (soil or water) was not required per instruction by the Caltrans Office of Structural Foundations, Sacramento, due to lack of environmental or hazardous waste reports for the Oakland Mole (Caltrans District IV, Environmental Planning - South).

Drilling cuttings, drill mud, and water from the borings were placed in a total of 59 Caltrans-approved, 208-liter (55-gallon) steel drums and stored in a secured Caltrans storage yard until disposal. All drums were opened and inspected by Integrated Wastestream Management, Inc. (IDM) of Milpitas. According to IDM, the mud had sedimented in the drums and water had risen to the top. The water and mud appeared uncontaminated by visual inspection. In October 1998, four (4) brass samples were extracted randomly from the mud in a total of 28 drums and composited in the certified laboratory of Chromalab Environmental Services, Inc. The Environmental Protection Agency (EPA) test results from a CAM 17 metals analysis indicated no major concentrations of contaminants. A total of 4,500 liters of water was removed from the muds and disposed of by Seaport Water Disposal Facility using a carbon-activated filtration/centrifuge system.

2.3 LAND-BASED CONE PENETRATION TESTING/SEISMIC CONE TESTING

CPT soundings were conducted by Fugro Geosciences on the Oakland Mole and in front of the toe of the Mole slope using truck-mounted and ATV-mounted CPT rigs, respectively. The CPT soundings were performed to: 1) help delineate the subsurface stratigraphy, 2) measure the in situ shear strengths of cohesive soils, and 3) estimate the relative density and frictional

characteristics of granular soils. Table 2.2 summarizes the CPT locations. The CPT sounding logs are provided in Volume 3.

2.3.1 On Land, Truck-Mounted CPT

Introduction. The Oakland Mole CPT soundings were conducted in two phases. The Phase 1 investigation (conducted in Spring 1998) consisted of two seismic CPT soundings (98-17 and 98-17) and one conventional piezocone sounding (98-16).

The Phase 2 program (conducted in Fall 1998) included six CPT soundings. The six Phase 2 soundings included three soundings with seismic velocity measurements and two piezocone CPTs. In addition to the six CPT soundings successfully conducted, four planned sounding locations (98C-103 and 98C-106 through 98C-108) were attempted, but then abandoned due to electrical interference. The CPT sounding locations are shown on Plate 2.1. Table 2.2 summarizes the CPT locations and penetration depths achieved. Logs of the CPT soundings are provided in Volume 3, Appendix A.

Field Operations. During Phase 1, CPT sounding 98C-16 was terminated at 17.4-meter depth after four attempts due to excessive deviation from vertical, which was believed to have been caused by the presence of boulders and cobbles in the upper zone of fill. The other two Phase 1 soundings were extended to between 48 and 53 meters.

Due to the expected difficulty of advancing the cone through the fill at the Phase 2 CPT locations, Spectrum Drilling predrilled through the fill material and lined the hole with steel casing. The casing then had an internal steel sleeve inside, and the annulus between the casing and steel pipe was filled with a neat cement mixture. The conventional CPT portion of each of the nine soundings was continuous below a depth of approximately 3 to 4.5 meters. Data acquired within the cased interval have been deleted from the CPT sounding logs.

Difficulties in advancing the cone through the steel pipe occurred when saturated sand, under a hydraulic gradient, flowed into the pipe thereby seizing the cone. To remedy this, Fugro Geosciences either washed the inside of the pipe to clean out the blockage or Spectrum Drilling returned to redrill the hole. Four of the CPT holes could not be advanced past the bottom of the fill due to an electrical charge interfering with the CPT instrumentation. Several attempts were made to mitigate the interference, including replacing the steel sleeve with a PVC sleeve and grounding the CPT rig, but the problem was not resolved. A photograph of the land-based CPT operation is shown on Plate 2.3.

2.3.2 Tidal Flat, ATV-Mounted CPT

Introduction. To further characterize the conditions on the shallow tidal flat sediments adjacent to the north toe of the Oakland Mole, an ATV-mounted CPT rig was mobilized. The all-terrain CPT soundings were conducted (in March 1999) to supplement the existing land data

and offshore tethered Seascout CPT soundings. The all-terrain CPT vehicle has low ground pressure tracks that allow it to be mobilized onto soft sediment terrain.

Two of the 15 ATV-mounted CPT soundings (99C-1 through 99C-15) included seismic CPT (shear wave velocity) measurements while the other 13 soundings were conventional piezocone CPTs. In addition, small-diameter sleeve samples were collected from two sounding locations (99C-12 and 99C-14). Plate 2.1 indicates the location of the CPT soundings conducted as part of Phase 2 of the referenced contract.

Field Operations. To access the tidal flat area to the north of the Oakland Mole, the CPT soundings were conducted during periods of low tides. CPT soundings 99C-3 through 99C-10 were conducted during seasonal low tides during the week of March 1 to March 5, 1999, which allowed access onto the exposed mudflats for several hours a day. The CPT work continued during the next period of low tides, the week of March 15 to March 19, 1999. Plate 2.4 shows a photograph of the all-terrain CPT vehicle on the beach just north of the Oakland Mole.

2.3.3 CPT System Equipment and Procedure

CPT System Equipment. The CPT system consists of a seismic wave source, a seismic cone penetrometer (which is a conventional electric piezocone with an additional section that contains a geophone array), and a recording unit (seismograph). Soundings were performed using a standard three-channel piezocone penetrometer that measures cone tip resistance, sleeve resistance, and pore water pressure.

A 66.75-kilonewton (kN) piezocone with an apex angle of 60 degrees, a base area of 15 square centimeters (cm^2), and a cylindrical sleeve area of 200 cm^2 was used. The pore water pressure measurements were taken immediately above the base of the piezocone (the filter is located 5 mm above the apex of the piezocone tip).

The CPT equipment was deployed from either a self-contained, 178-kN Fugro Geosciences truck on land or a Fugro Geosciences ATV-mounted rig on the tidal flat area. The vehicles contained a thrust mechanism to push the cone, a CPT recording unit, the seismograph, and other support equipment. The test equipment and procedures meet ASTM D5778-95 (ASTM, 1998) specifications. The truck was leveled and jacked up on four stabilizer pads to provide a stable reaction for the thrust of the cone.

The seismic wave source for generating shear waves consisted of a wooden beam anchored to the soil surface by the weight of one of the truck stabilizer pads and a swinging hammer that strikes the beam. The surface seismograph and downhole geophone array recorded the generated waves during interruptions in the CPT advancement.

Field Procedures. The penetration rate of the piezocone penetrometer was approximately 2 centimeters per second (cm/sec). During the test, measurements of piezocone tip resistance, sleeve friction, and pore water pressure were recorded simultaneously at about 1-second intervals.

The CPT system computer generated an instant "quickplot" of the data in the field that provided generalized information on the cone tip resistance, sleeve resistance, pore pressure, and rate of penetration. The CPT data were then processed and are presented in Volume 3. (For clarity, the plate number is the same as the designated sounding number [e.g., 98C-16].) The presentation of results from the CPTs consists of graphs showing tip resistance, sleeve friction, pore pressure, and friction ratio versus depth below the ground surface.

In tests with shear wave measurements, the CPT penetration was interrupted approximately every 1.5 meters in order to collect shear wave velocity data. The data are processed to calculate the average seismic wave velocities between individual test depths to produce a profile of average seismic wave velocities for contiguous depth intervals. Proprietary software assisted with digital filtering, amplitude scaling, event picking, velocity calculations, and data presentation.

At the completion of each boring, the CPT hole was grouted with a mixture of neat cement grout consisting of seven sacks of cement and one sack of gel per 26 liters of water. The mixture was pumped down the hole using a tremie pipe.

2.3.4 Elevation and Position

Ground elevations at and coordinates of each CPT sounding location were determined by conventional land survey methods using a USGS control location on the Mole.

2.4 TIDAL FLAT TETHERED SEASCOUT CPT TESTING

2.4.1 Introduction

Purpose of Soundings. Tethered Seascout CPT soundings were conducted to supplement existing land data and adjacent offshore boring data to further characterize the conditions of the shallow tidal flat sediments north of the Oakland Shore Approach. The Seascout was considered an ideal tool as it can be deployed from smaller vessels (e.g., geophysical survey vessels). Alternatives to using a CPT rig (e.g., drop coring, vibracoring, or jet probing) were considered unsatisfactory.

Seasonal high tides during the week of December 14 to 19, 1998, allowed access into otherwise unnavigable shallow water depths. Almost 100 Seascout CPT soundings were conducted along the N6 northern alignment. About half of the soundings were performed on the tidal flat north of the Oakland Mole. Fifty three (53) of those soundings were numbered

98C-446 to 98C-560, but are not sequential as some of the soundings were deferred. The remaining soundings (designated 98C-401 to 98C-445), were conducted along the proposed N6 alignment. Plate 2.1 shows the extent of the soundings included in this report. The interpreted conditions in the area are discussed in Section 4.0.

Description of Seascout CPT. Fugro's Seascout is a lightweight seafloor CPT system designed for tethered deployment from a modest-sized vessel. The Seascout CPT includes: a 2.4-meter-high triangular reaction frame with a 2-meter base dimension, a patented hydraulic thrust mechanism, a coiled CPT rod with spooling/straightening device, a miniature piezocone, and an associated data storage/processing computer. The weight of the Seascout frame in water is about 1,360 kilograms (kg).

As deployed at the tidal flat north of the Oakland Mole, the system has a maximum penetration of 5.2 meters. The lightweight design is based on a miniature cone penetrometer with a 100-square-millimeter (mm^2) cone base area rather than the conventional 1,000 mm^2. This results in a substantial reduction of thrust and reaction equipment requirements.

CPTs involve the in situ measurement of soil resistance to continuous penetration by cone-based push rods. The measurements comprise penetration depth, cone resistance, sleeve friction, pore pressure, and inclination from vertical. Use of the coiled CPT tube provides a continuous penetration push as opposed to a stroke-based penetration when using the more common 0.9-meter CPT rod segments.

2.4.2 In Situ CPT Sounding Methods and Equipment

Seascout Apparatus. Seascout apparatus consists of the following elements:

- **Thrust Machine** - Apparatus providing thrust to the coiled push rod system so that the required constant rate of penetration is controlled (underwater hydraulic power pack and patented wheeldrive thrust).
- **Reaction Equipment** - Reaction for the thrust machine (e.g., ballasted seabed frame, remotely operated vehicle, sled).
- **Coiled Push Rod System** - Thick-walled cylindrical tube used for advancing the penetrometer to the required test depth that is straightened upon penetration and coiled upon extraction.
- **Push Rod Casing** - Guide for the part of the push rod protruding above the soil and/or the push rod length exposed in water or soil so as to prevent buckling when the required penetration pressure increases beyond the safe limit for the exposed upstanding length of the push rod.
- **Piezocone Penetrometer** - Cylindrical terminal body mounted on the lower end of the push rods, including a cone, a friction sleeve, a filter, and internal sensing devices

for the measurement of cone resistance, sleeve friction, pressure, and (optionally) inclination.

- **Measuring System** - Apparatus and software, including sensors, data transmission apparatus, recording apparatus, and data processing apparatus.

Photographs taken during the deployment and subsequent retrieval of the Seascout are shown on Plates 2.5a and 2.5b.

Vessel. The SFOBB East Span Seismic Safety Project CPT soundings were conducted from the M/V *White Lightning*, a 15-meter workboat owned and operated by West Coast Sea Works. The Seascout was deployed off both the port and starboard sides of the vessel using a deck-mounted, hydraulically-operated crane. Station keeping was accomplished by "live-boating" over the location using vessel power. Soundings at the innermost locations closest to the Oakland Mole shoreline were conducted during flood tides when the maximum water depths allowed for safe boat-operating conditions.

Navigation. CPT locations were determined using Fugro's Differential Global Positioning System (DGPS), referenced to known base stations in the San Francisco Bay area. Coordinates calculated from the DGPS system are considered accurate to within about 1 meter. Coordinates for the CPT locations are reported relative to the California State Plane, Zone 3, NAD83 meters datum.

Procedure. The test procedure at each location included the following steps:

1. Positioning of vessel and Seascout at test location.
2. Lowering of Seascout frame to the mudline.
3. Advancement of the cone into the harbor bottom to the maximum 5.2-meter penetration or refusal.
4. Retraction of the cone rods and penetrometer.
5. Retrieval of the frame to the aft deck of the vessel, and moving to the next test location.
6. Data processing onboard the vessel.

All data were acquired digitally for subsequent computer-based processing (both on the vessel and later in the office) and presentation.

Due to the shallow water conditions, the soundings closest to the shoreline were conducted during peak high tides. Locally, those soundings were conducted within about 30 meters of the Oakland Mole dike in water depths of less than elevation (El.) -0.8 meter (MSL). During periods of flood tides, the Seascout was deployed so that the vessel drifted

towards the shoreline and away from the sounding area. During periods of slack tides, CPT soundings were conducted west of the Mole in deeper water.

Water Depth Measurement. Water depths at each CPT location were measured with a sounding tape and from marks fixed to the Seascout unit. These two methods enabled a check of the penetration of the Seascout unit itself into the seafloor. Where possible, the vessel's echo sounder was used as a cross-check. The measured water depths were corrected to MSL datum using the published tide charts for the nearby Matson Wharf.

2.4.3 Data Processing and Presentation of Results

The raw CPT sounding data were processed using proprietary processing algorithms (UNIPLOT) developed for offshore CPT data processing. For each sounding, logs of cone point resistance, sleeve friction, friction ratio, and pore pressure are presented in Volume 3. The friction ratio is defined as the ratio of the friction sleeve value to the cone point resistance. Logs of the Seascout CPT data are provided in Volume 3, Appendix B.

2.4.4 Standardization

CPTs provide correlation parameters (such as cone resistance) rather than properties (such as compressive strength). A high degree of CPT standardization is therefore important to allow the correlation and interpretation of the results. The standardization includes cone penetrometer geometry and rate of penetration. Layering and soil structure also contribute to significant differences between various cone sizes.

Cone Size. An important standardization item of the cone penetrometer geometry is the area of the cone base. Conventionally, this area is 1,000 mm^2. The International Reference Test Procedure for Cone Penetration Test prepared by ISSMFE (1989) permits deviations from the Reference Test (1,000 mm^2) under the following conditions:

- Explicit description, including a note on the graphs with the test results
- Tolerances for the cone base area to be adapted in direct proportion to the diameter
- Surface area of the sleeve to be adjusted proportionally with respect to the cross-sectional area of the cone

Although the 100 mm^2 Seascout cone penetrometer is not a conventional cone size, it meets the above-stated requirements of ISSMFE.

Rate of Penetration. The conventional rate of penetration for standard-sized CPTs is 20 ±5 millimeters per second (mm/sec). The Seascout rate of penetration is approximately 40 mm/sec. The selected higher penetration rate represents an estimated adjustment for cone penetrometer size. This adjustment relates to permeability (in particular, the transition zone between drained and undrained ground behavior during cone penetration). The higher

penetration rate possibly affects the tip resistance, sleeve friction, and pore pressure measurements, but with a limit of a few percent.

Significance of Layering and Soil Structure. Geotechnically, the results of a smaller cone penetrometer may differ from the 1,000-mm^2 cone penetrometer. Recognized factors that may contribute to differences include:

- Particle size of soil
- Soil layering
- Soil structure
- Density of loose granular sediments

The signature of a cone penetrometer may be affected where the D_{50} of a soil exceeds the equivalent of about six times the diameter of the cone penetrometer.

The loading response of a smaller cone penetrometer to soil layering is more rapid than that of a larger penetrometer. This relates to soil failure mechanisms in layered soils. Depending on ground conditions, the smaller cone penetrometer may show higher peak corrected cone tip resistance q_c values (see Section 5.2.2) and lower base values. In addition, the smaller cone is more sensitive to the presence of thin layers, whose resistance is averaged beneath a larger standard cone.

Soil structure may cause failure mechanisms to occur along zones of weakness. The larger penetrometer affects a larger mass of soil and thus a greater potential for soil structure effects. Therefore, the larger cone penetrometer may exhibit a lower cone resistance in structured soils.

Recent investigations of newly-placed granular hydraulic fill have shown that the cone resistances measured with the miniature cone are different than those measured with a standard-sized cone in loose to medium dense granular soils. The data show that the magnitude of those differences increases as the void ratio of the sediment increases.

2.4.5 Data Interpretation

Because of the factors discussed above, caution should be taken when interpreting the small-diameter Seascout CPT data. The Seascout uses a 100-mm^2 cone as compared to the 1,000-mm^2 "standard" cone. Cone type, cone size, scale, and rate effects can affect the measured tip and friction sleeve resistances and generated pore pressures. Plate 2.6 shows the difference in size and rate of penetration between the types of piezocones discussed.

Thus, the sounding results should be used as a qualitative indicator of subsurface conditions and quantitative empirical relationships should be used with caution. Only those

individuals experienced with the miniature cone should make the interpretation of soil parameters from the data.

2.5 EXCAVATIONS AND TRENCHES

On April 8 and 9, 1999, Earth Mechanics, Inc. (EMI) performed two trench and two pit excavations on the Oakland Mole. The trenches were performed for the purpose of visual inspection and verification of the location, extent, and composition of the pre-1950 rock dike presently buried beneath the existing northern edge of the Mole. The existence, location, and condition of the rock dike affects the design and construction of the proposed new SFOBB East Approach structures or fills. Per Caltrans' request, the two pits were excavated in the beach areas at the northern edge of the Mole. The purpose of these pits was to verify maximum unshored excavation depths and to determine whether removal of the (potentially liquefiable) beach sands was a feasible option. A memorandum documenting the trench and pit excavation program is included in Volume 4. The memorandum includes descriptions and findings from the excavations, trench logs, and photographs of the excavations.

2.5.1 Trench Excavations

The locations of the trenches are shown on Plates 2.1a and 2.1b. The locations were approximately in line with the visible northern edge of the Mole to the west and the east of the jughandles, reflecting the presumed location of a buried rock dike placed during the construction of part of the fill during the 1930s.

Trench 99T-1 was excavated on the western jughandle at the north edge of the existing Caltrans maintenance road pavement. Trench 99T-2 was cut inside the area circumscribed by the Caltrans road (the eastern jughandle), at approximately "W" Station 87+35. Both trenches were oriented in a north-south trend and were cut using a track-mounted excavator (Hyundai 290LC) with a 14.2-meter reach and a 0.6-meter-wide bucket. This rig was selected to cut pits in the adjacent beach areas between the jughandles. The materials excavated were temporarily stockpiled on plastic sheeting to prevent cross-contamination of underlying soils.

The trenches were backfilled with onsite soil and rock materials in lifts and compacted by tapping with the excavator bucket. Compaction led to some loss in total volume due to the loose consistency of original onsite soils, which was compensated for using soil borrowed from areas adjacent to the trench. At completion of the work, the original ground conditions were restored as well as possible.

2.5.2 Pit Excavations

Per Caltrans request, two pits were excavated in the tidal flat beach area between the two jughandles. The purpose of the pits was to verify how deep the cut would stay open unshored, and whether removal of the (potentially liquefiable) beach sands was a feasible option. The

locations are shown on the attached plan. The excavations were made by the long-reach excavator from onshore per National Environmental Policy Act Categorical Exclusion permit requirements.

2.6 ADJACENT OFFSHORE BORINGS

As part of the marine investigation (Fugro-EM, 2001d), two deep soil borings were drilled in the area (see Plate 2.1a) off the present north shore of the Oakland Mole. The two marine borings (98-39 and 98-44) were drilled in Fall 1998, immediately northwest and north of the western end of the Mole. The borings were respectively drilled to about 100- and 104-meter depths below the existing mudline.

To access those locations, the drilling barge was floated in at high tide and beached during low tide. The drilling methods, sampling procedures, and in situ and downhole geophysical testing methods and sequence are described in detail in Fugro-EM (2001d). By-boring appendices with lithographic logs with test data, CPT logs, and downhole geophysical logs for the two marine borings (98-39 and 98-44) are reproduced in Volume 2B of this report.

2.7 PHASE 3 MARINE CONE PENETRATION TESTING PROGRAM

2.7.1 Overview

The marine CPT operations were conducted using Fugro's Seacalf CPT system. The Seacalf unit was deployed over the bow of a barge supplied and operated by CS Marine Constructors, Inc., of Vallejo, California.

The locations of the marine CPT soundings are shown on Plate 2.2a. A summary of the dates of exploration, coordinates for each sounding, and depths of penetration achieved is provided in Table 2.3. The marine CPT program was conducted by Fugro between September 23 and October 6, 2000. Operations were conducted 24 hours per day. Photographs of the operations, barge, and Seacalf equipment are included on Plate 2.7.

2.7.2 Sounding Results

The results of the 9 marine CPT soundings performed in the vicinity of the Oakland Shore Approach are presented in Volume 3 of this report. All 77 of the Seacalf CPTs performed during the Phase 3 field operations are presented in Volume 2H of the Final Marine Site Characterization Report (Fugro-EM, 2000d). The CPT logs provide graphical plots versus depth showing: a) tip resistance in megapascals (MPa), b) sleeve friction in MPa, c) friction ratio in percent, and d) pore pressure readings in MPa. In addition, the sounding logs show the range of undrained shear strengths that are calculated from CPT cone tip resistances (corrected for unequal end area effects) based on cone bearing capacity factors (N_k) of 12 and 15.

2.7.3 Vessel

The marine CPTs were conducted from *Barge 32*, an approximately 33-meter by 9-meter barge that was supplied and crewed by CS Marine. The barge included a four-point anchor system and two spuds.

Fugro equipment was mobilized onboard Barge 32 at CS Marine's dock in Vallejo. The CPT barge was and pushed and positioned over the proposed sounding locations by the shallow draft tugboat *Mudcat*, which also served as an anchor assist boat. The tugboat was owned and operated by Westar, Inc.

Except where water depth prohibited the use of spuds, the barge was held on position using two spuds. Where water depth exceeded the capacity of the spuds or if the spuds were considered likely to impact existing underwater utility lines, the barges were held on position using a four-point anchor spread only. At several locations where anchors were used, it was possible to winch over to more than one test location using the same anchor spread.

2.7.4 Survey and Water Depth Measurements

Position and Navigation. A DGPS and integrated navigation software, owned and operated by Fugro, were used to position vessels at the specified drilling locations and to determine final X-Y coordinates of the vessels at those locations. Coordinates calculated from Fugro's DGPS system are considered accurate to within about 1 meter (3 feet). The actual locations of the Seacalf unit were calculated from: 1) the measured offsets of the unit from the DGPS receiver onboard the tugboat; and 2) the final heading of the barge. The DGPS also was used to position the barge's anchors.

Water Depth Measurements. Prior to deploying the Seacalf CPT unit, preliminary water depth measurements were made using a lead line and echo sounder. Those preliminary water depth measurements were required to make several field decisions (e.g., determining the length of cone rod to deploy during lowering of the Seacalf unit). However, due to relatively strong water currents, those measurements were considered somewhat approximate and the final mudline elevations reported were calculated from the 2000 multi-beam and tidal flat bathymetric survey data for the project.

2.7.5 Marine CPT Equipment and Procedure

Seacalf CPT System. The marine CPT soundings were performed using Fugro's 10-ton, wheel-drive tethered Seacalf CPT system. Deployed from a cantilevered frame off the bow of the barge, the Seacalf unit was lowered to and raised from the bay floor with a winch mounted to the barge deck.

With the Seacalf, the cone rod was advanced through the unit and into the soil by a system of four wheels that gripped the rod and pushed it into the soil at a controlled rate of 2 cm/sec. As the cone penetrated the seabed, the variations in cone tip resistance, sleeve friction, and dynamic pore pressure were continuously recorded. The results were displayed graphically and simultaneously recorded as the test progressed.

Cone Assembly. The basic construction of the cone assembly used in the marine CPT soundings is similar to that of the 15-cm^2 cone used for the conventional land CPT. Cone tip resistance, sleeve friction, and dynamic pore pressure were measured in all of the soundings. The pore pressure element was located at the base of the cone tip.

CPT Sounding Termination. CPT soundings were generally advanced until practical refusal to penetration was encountered. Practical refusal was typically due to either excessive deflection within the CPT cone rods or due to very high tip resistance. As the test progressed, the CPT operator monitored the cone resistance and its deviation from vertical. A test at a given location continued until a refusal criterion was met. For most soundings, the cone rod was first advanced through the relatively soft Young Bay Mud (YBM) strata until stiff clay layers or dense sand layers of the underlying units were encountered. To reduce the potential for rod buckling, casing was then advanced around the cone rods to provide lateral support in the relatively soft YBM layers. After setting the casing, the cone rod was again pushed until practical refusal was encountered.

Several of the CPT soundings performed in the Oakland Shore Approach area and to the north of Yerba Buena Island were located in extremely shallow water depths. To reduce the potential for grounding the barge and tug, CPT soundings at those locations were typically performed at high tide. In a few instances, this precluded the use of casing to increase test depth since it was necessary to move the barge before it was grounded during a falling tide. In those instances, testing was continued until practical refusal was encountered typically slightly below the base of the YBM.

Data Entry. Data collected from each sounding were processed immediately and entered into a database. The electronic databases were used to generate preliminary CPT sounding logs and to interpret soil properties using published and site-specific correlations with CPT data in the field. In addition to providing preliminary information in a timely manner to Caltrans and the design team, the data processing allowed for onboard data evaluation. For example, faulty data were easily identifiable, which allowed for replacement of equipment and retesting prior to demobilization of the barge.

Boring	Easting	Northing	Station Along "W-Line"	Offset from "W-Line" (m)	Ground Surface Elevation (m MSL)	Exploration Depth (m)
Foundation Design						
98-51 (B-1)	1838901	648233	84+35	56 RT	+1.2	70.7
98-52 (B-2)	1838962	648256	84+99	40 RT	+1.7	35.7
98-53 (B-3)	1839052	648267	85+90	37 RT	+3.6	35.7
98-54 (B-4)	1839080	648270	86+18	37 RT	+3.4	35.7
98-55 (B-5)	1839073	648301	86+14	5 RT	+2.0	61.6
98-56 (B-6)	1839212	648294	87+52	23 RT	+3.1	44.8
98-57 (B-7)	1839266	648307	88+07	14 RT	+3.5	46.3
98-58 (B-8)	1839287	648327	88+29	5 LT	+3.9	60.0
98-59 (B-9)	1839435	648325	89+77	9 RT	+3.5	38.7
98-60 (B-10)	1839546	648349	90+89	0	+3.4	46.3
Roadway and Substation Design						
98-61 (P-1)	1839130	648280	86+69	30 RT	+2.9	23.5
98-62 (P-2)	1839320	648302	88+60	23 RT	+3.6	23.0
98-63 (P-3)	1839479	648334	90+21	5 RT	+3.5	23.5
98-64 (P-4)	1839605	648362	91+50	2 LT	+3.5	23.5
98-65 (P-5)	1839704	648395	92+54	9 LT	+3.4	23.5
98-66 (P-6)	1839317	648260	88+54	65 RT	+3.1	8.1
98-67 (P-7)	1839462	648313	90+02	23 RT	+3.7	15.8
98-68 (P-8)	1839597	648340	91+38	18 RT	+3.7	9.6
98-69 (P-9)	1839677	648359	92+19	18 RT	+3.8	13.0
98-70 (P-10)	1839259	648242	87+95	78 RT	+3.0	25.0
98-71 (P-11)	1839449	648283	89+86	52 RT	+3.2	12.8
98-72 (P-12)	1839568	648300	91+02	52 RT	+3.1	8.1
98-73 (P-13)	1839666	648322	91+99	51 RT	+2.8	12.8
98-74 (P-14)	1839832	648345	93+57	80 RT	+2.9	7.2
98-75 (P-15)	1838987	648200	85+18	98 RT	+2.4	31.1

ON-LAND SOIL BORING LOCATIONS AND DEPTHS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

TABLE 2.1

Designation	Easting	Northing	Station Along "W-Line"	Offset from "W-Line" (m)	Ground Surface Elevation (m MSL)	Depth (m)	Velocity Logging with Seismic Cone	Soil Sampling
Phase 1, Spring 1998								
98-16	1838906	648241	84+12	9RT	1.5	17.3	No	No
98-17	1839051	648271	85+59	6LT	3.5	53.1	Yes	No
98-18	1839237	648298	87+47	20LT	3.2	50.0	Yes	No
Phase 2, Fall 1998								
98-101 (CPT-1)	1839011	648267	85+19	6LT	3.1	49.8	Yes	No
98-102 (CPT-2)	1839111	648300	86+52	9RT	2.1	50.2	Yes	No
98-104 (CPT-4)	1839304	648323	88+46	1RT	3.7	21.9	No	No
98-105 (CPT-5)	1839372	648313	89+13	16RT	3.6	39.1	No	No
98-110 (CPT-10)	1839489	648287	89+96	15RT	3.1	46.8	No	No
98-109 (CPT-9)	1839339	648260	88+45	26RT	3.0	48.9	Yes	No
Phase 2, All-Terrain (Spring 1998)								
99C-1	1838969	648274	85+08	23RT	-0.2	29.3	No	No
99C-2	1839037	648290	85+77	13RT	-0.6	12.1	No	No
99C-3	1839150	648311	86+91	1RT	0.1	15.5	No	No
99C-4	1839208	648316	87+50	1RT	-0.1	15.4	No	No
99C-5	1839262	648328	88+04	7RT	-0.1	15.5	No	No
99C-6	1839329	648333	88+72	7RT	-0.4	16.6	No	No
99C-7	1839384	648343	89+27	13RT	-0.6	19.8	No	No
99C-8	1839431	648353	89+75	19RT	-0.6	15.6	No	No
99C-9	1839496	648364	90+42	23LT	-0.7	15.0	No	No
99C-10	1839558	648374	91+06	23LT	-0.6	15.4	No	No
99C-11	1839139	648320	86+81	10LT	-0.4	24.4	No	No
99C-12	1839174	648323	87+16	10LT	-0.4	29.5	No	Yes
99C-13	1839205	648325	87+47	9LT	-0.4	22.6	Yes	No
99C-14	1839250	648329	87+92	9LT	-0.3	16.6	No	Yes
99C-15	1839014	648299	85+55	2LT	-0.4	11.7	Yes	No

NOTE: Electrical interference prevented data acquisition at planned CPT locations 98C-103 (CPT-3), 98C-106 (CPT-6), 98C-107 (CPT-7), and 98C-108 (CPT-8).

ON-LAND CPT LOCATIONS AND DEPTHS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

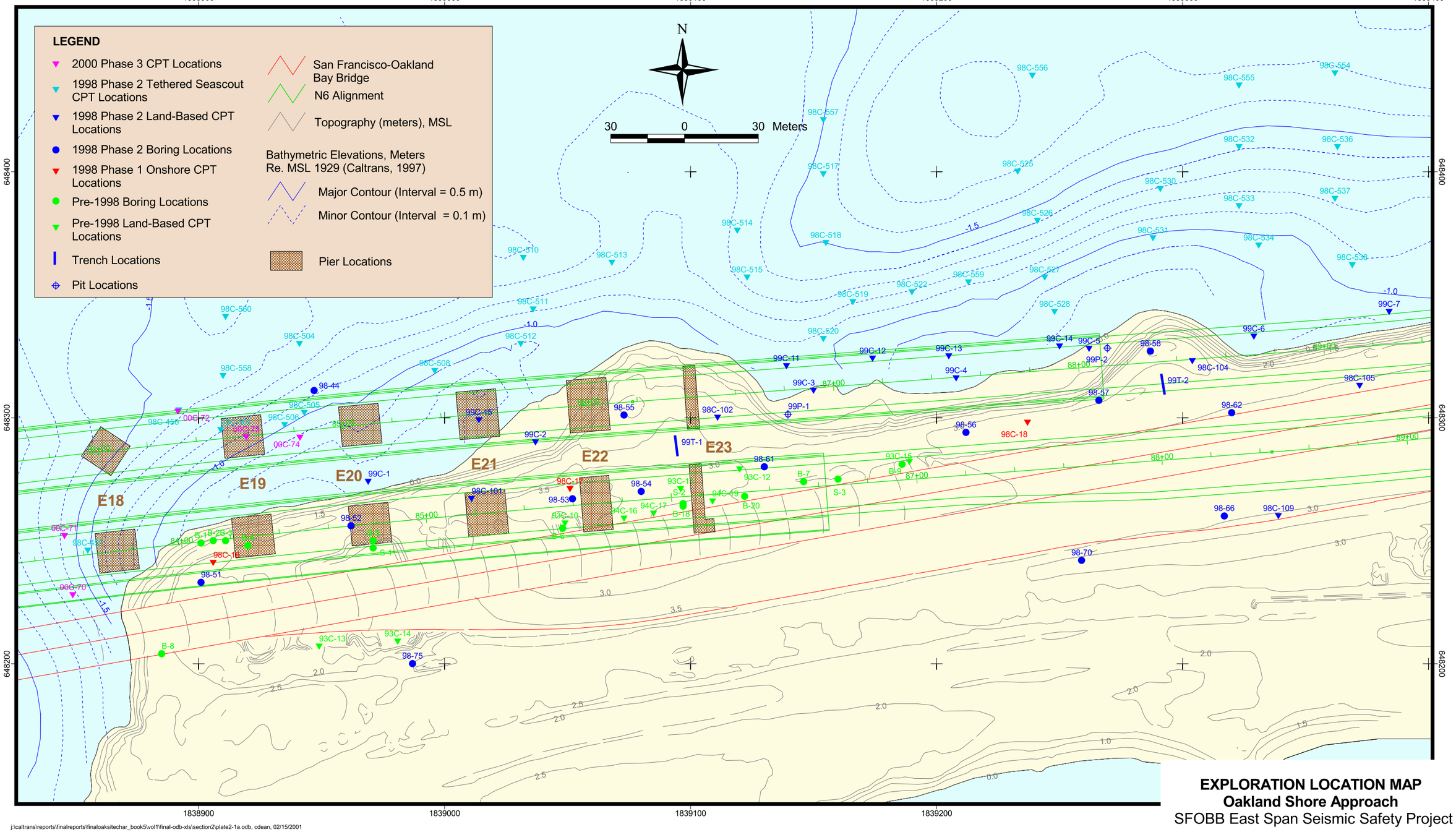
TABLE 2.2

Designation	Easting	Northing	Station	Offset (m)	Ground Surface Elevation (m MSL)	Depth (m)	Velocity Logging with Seismic Cone	Soil Sampling
September - October, 2000								
00C-64	1838758	648273	"W" Sta. 83+00	1 m Left	-2.9	50.0	No	No
00C-65	1838765	648233	"E" Sta. 82+79	1 m Right	-2.9	29.7	No	No
00C-66	1838780	648262	"W" Sta. 83+20	13 m Right	-2.6	25.1	No	No
00C-67	1838786	648232	"E" Sta. 83+0	4 m Right	-2.6	39.9	No	No
00C-68	1838806	648225	"E" Sta. 83+20	14 m Right	-2.4	42.2	No	No
00C-69	1838823	648249	"E" Sta. 83+40	8 m Left	-0.9	40.0	No	No
00C-70	1838848	648227	"E" Sta. 83+59	16 m Right	-1.6	11.9	No	No
00C-71	1838845	648251	"E" Sta. 83+59	8 m Left	-1.6	11.1	No	No
00C-72	1838891	648302	"W" Sta. 84+40	14 m Left	-1.4	51.4	No	No
00C-73	1838919	648292	"W" Sta. 84+59	No offset	-1.1	17.9	No	No
00C-74	1838941	648291	"W" Sta. 85+0	2 m Right	-0.9	12.7	No	No

MARINE-BASED SEACALF CPT LOCATIONS AND DEPTHS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO



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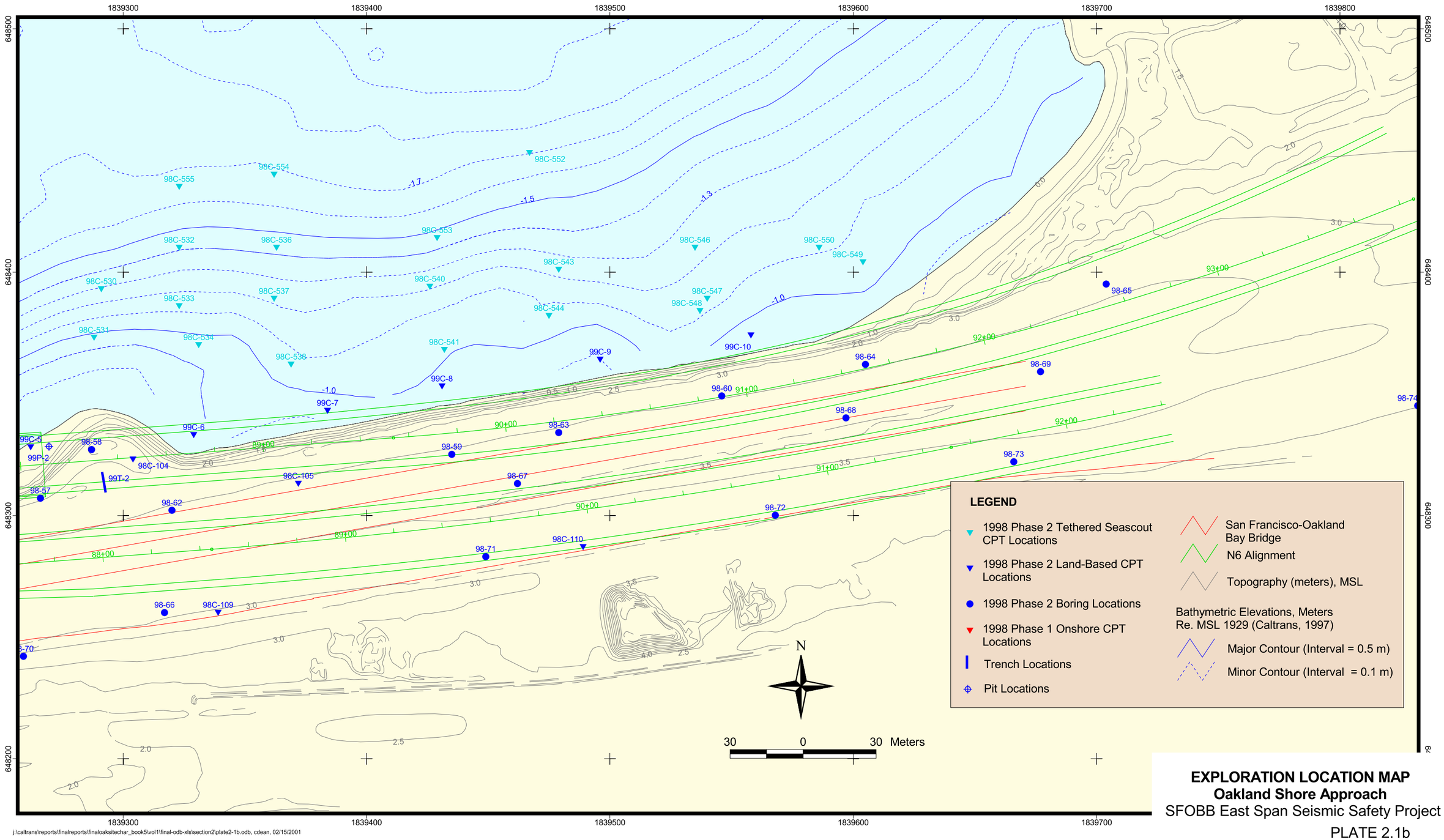
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1a

Earth Mechanics

FUGRO



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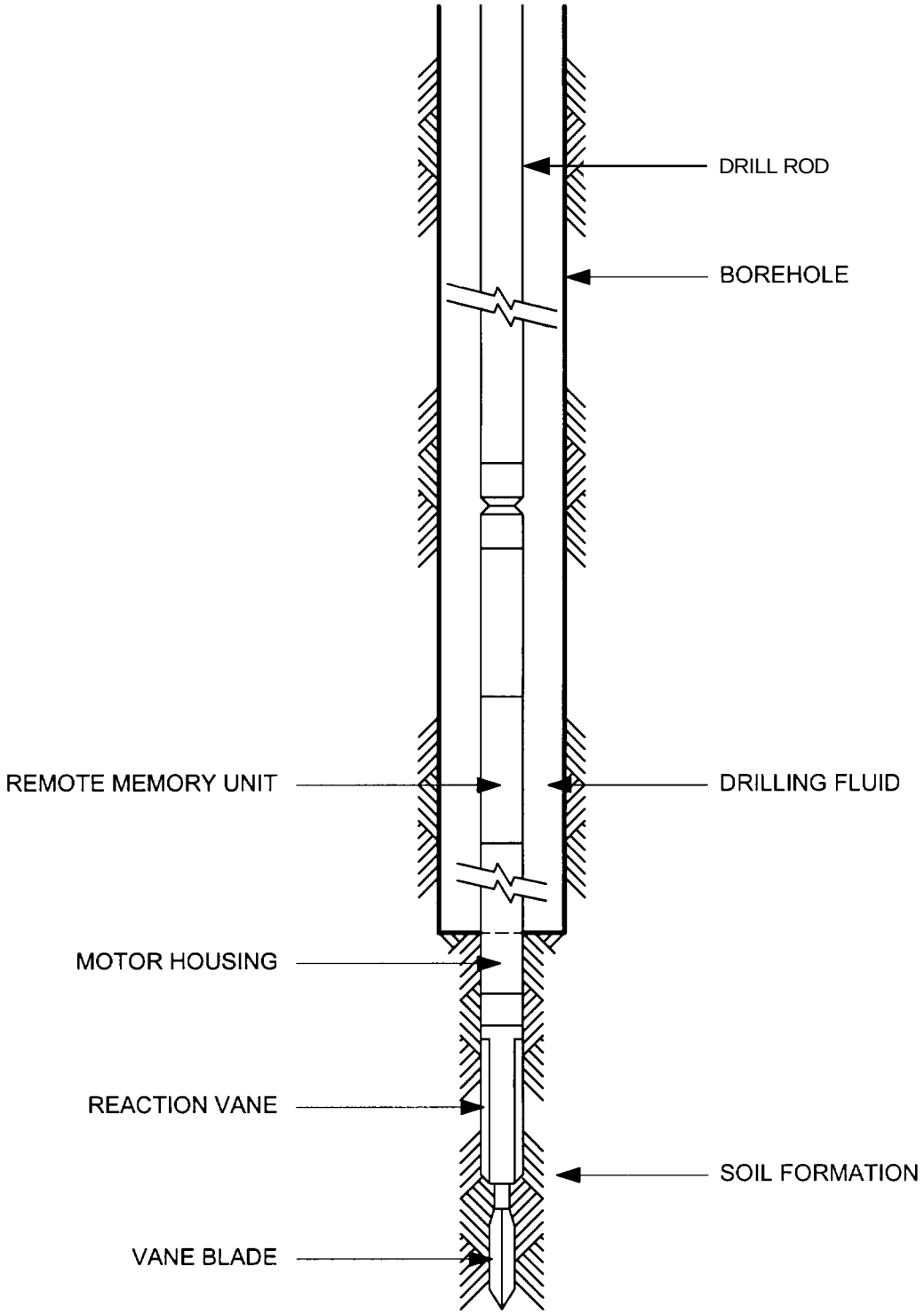
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1b



THE DOLPHIN DOWNHOLE REMOTE VANE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.2

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TRUCK-MOUNTED CPT OPERATIONS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.3

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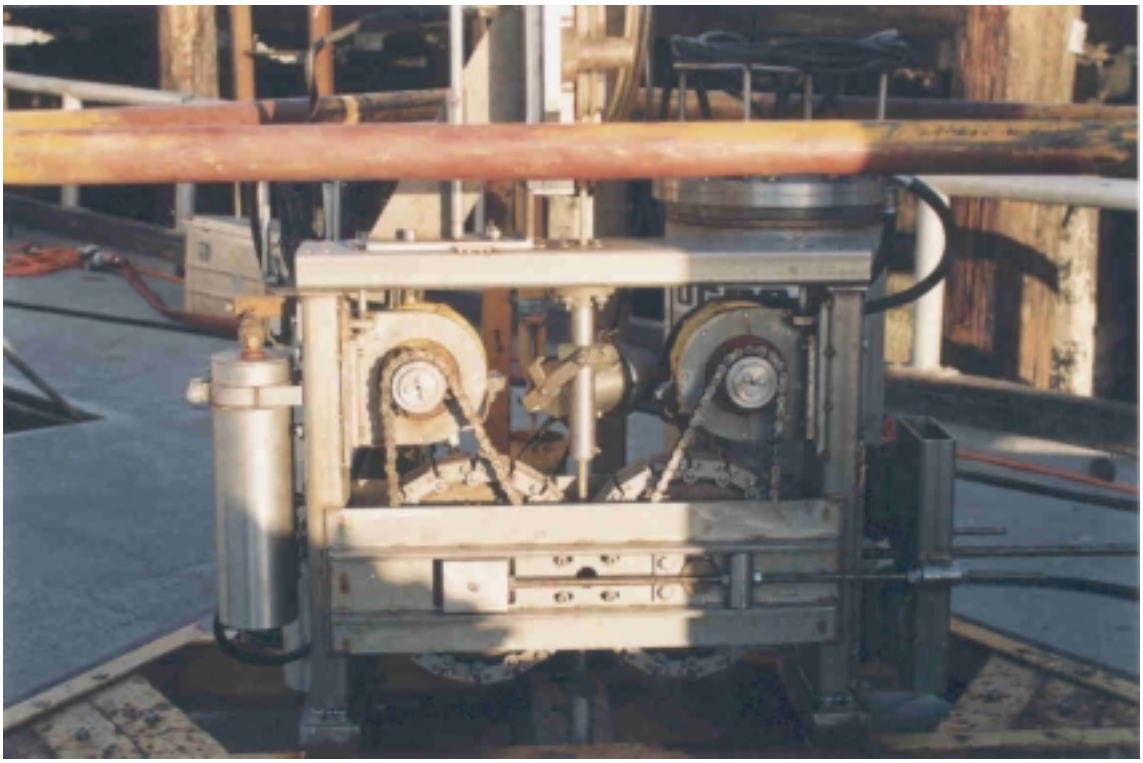
TRACK-MOUNTED CPT OPERATIONS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.4

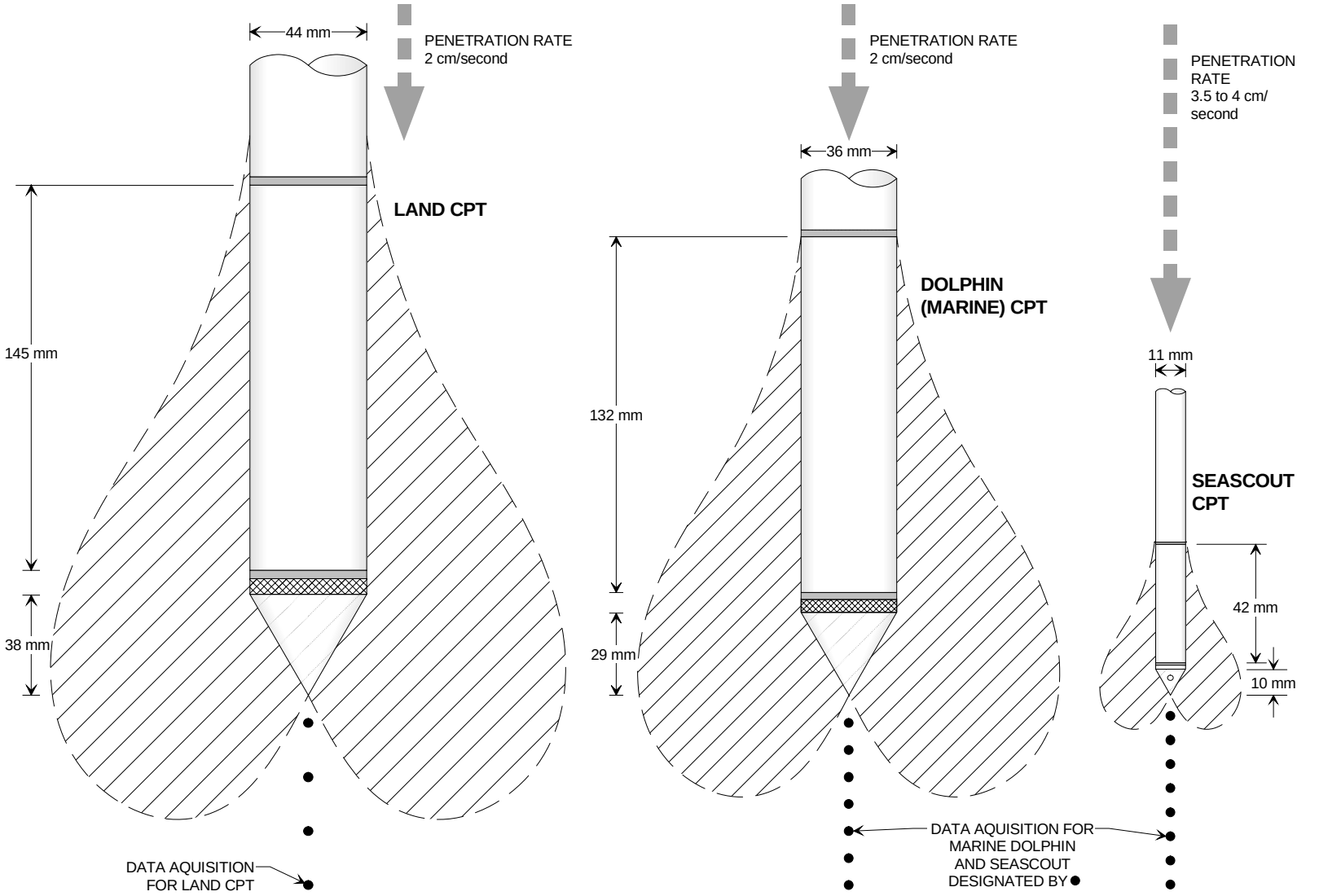
TETHERED SEASCOUT DEPLOYMENT
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.5a



TETHERED SEASCOUT RETRIEVAL
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.5b



LEGEND

Typical Zone of Influence

0 20 40
MILLIMETERS

COMPARISON BETWEEN LAND, DOLPHIN AND SEASCOUT CPTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 2.6

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

Barge 32 with Seacalf at San Francisco-Oakland Bay Bridge.

Seacalf being deployed from retractable cantilever frame.

SEACALF CPT OPERATIONS
Oakland Shore Approach
SFOBB East Span Replacement Project

PLATE 2.7a

Preparation for sounding with Seacalf in raised position.

SEACALF CPT OPERATIONS
Oakland Shore Approach
SFOBB East Span Replacement Project

PLATE 2.7b

SECTION 3.0
LABORATORY TESTING

3.0 LABORATORY TESTING

3.1 INTRODUCTION

The laboratory testing program for this study was performed in two phases. Visual classification, wet density determinations, water content determinations, and strength tests (including Torvane tests, pocket penetrometer tests, miniature vane tests, Swedish fall cone, and unconsolidated-undrained triaxial compression tests) were performed on the Fugro barge concurrently with the marine drilling and sampling operations. Additional laboratory soil testing was subsequently performed at Fugro's onshore soil mechanics laboratories in Ventura, California, and Houston, Texas. Dynamic testing was performed at the University of California at Berkeley. The onshore laboratory testing program included: classification tests (grain size, plasticity, organic content, specific gravity), consolidation tests, consolidated drained and undrained triaxial tests, cyclic direct simple shear tests, corrosion tests, and resistance value (R-value) tests.

The test procedures generally conformed to the applicable Caltrans and ASTM standards (ASTM, 1998). The following sections provide descriptions of the laboratory tests performed in the static laboratory soil testing program. The total numbers of laboratory tests that have been conducted are listed on Table 3.1. The results of most laboratory tests conducted on soil and rock samples are included in the individual boring-specific appendices provided in Volumes 2A and 2B. The report prepared by the University of California at Berkeley is included in Volume 4.

3.2 CLASSIFICATION TESTS

The method of classifying soils according to their engineering properties used in this study was ASTM Standard Test Method D2487, which is based on the Unified Soil Classification System. The classification tests performed for this project include tests for moisture content, unit weight, grain size distribution, Atterberg limits, organic content, and specific gravity. All of those data are tabulated on the Summary of Test Results provided in the boring-specific appendices (Volumes 2A and 2B), and most of the results also are plotted on the individual boring logs.

Tests for moisture content and unit weight of the soils were performed in general accordance with California Test 226. Plastic and liquid limits, collectively termed the Atterberg limits, were determined for selected cohesive soil samples and were performed in accordance with California Test 204. Wet densities of soil samples, where possible, were measured in the field by weighing soil samples of known volumes immediately after extrusion. Moisture content measurements for the above tests were from samples dried in an oven maintained at

approximately 110ºC. In the onshore laboratories, potentially organic samples were dried in an oven maintained at approximately 60ºC.

Specific gravity of soil tests were performed in accordance with California Test 209. Organic content tests to estimate the weight percentage of organic matter in potentially organic soils were performed in accordance with ASTM D2974.

The gradation characteristics of selected samples were estimated in general accordance with the sieve and hydrometer analysis procedures of California Tests 202 and 203, respectively. In general, sieve analysis (for sizes greater than the No. 200 sieve) were performed on primarily granular samples (sand and gravel), and hydrometer analysis was performed on primarily fine-grained samples (silt and clay). Several granular samples were tested for only the percent passing the No. 200 sieve.

3.3 SOIL SHEAR STRENGTH TESTS

3.3.1 Undrained Shear Strength

Six procedures were used in the laboratory investigation to determine the undrained shear strengths of the cohesive soils under various conditions. Undisturbed and residual shear strengths of cohesive soil samples were determined in the field with a motorized miniature vane device while the samples were still in the sample tubes. Remolded miniature vane tests, and undisturbed and remolded unconsolidated-undrained triaxial compression tests were performed in the field on selected samples after extrusion. Estimates of shear strength also were made in the field using a Torvane device, a fall cone device, and a hand-held pocket penetrometer. Additional unconsolidated-undrained triaxial compression tests were performed on selected cohesive soil samples in Fugro's Houston laboratory. Isotropically consolidated-undrained triaxial compression tests were performed on three samples in Fugro's Houston laboratory. The test procedures are described in the following paragraphs.

Torvane Test. In the Torvane test, a small hand-operated device (which consists of a metal disc with thin, radial vanes projecting from one face) is pressed against the flat surface of the soil until the vanes are fully embedded. The device is then rotated through a torsion spring until the soil is sheared. The device is calibrated to indicate the undrained shear strength of the soil directly from the rotation of the torsion spring.

Pocket Penetrometer Test. This test is performed by slowly pressing a small, flat-ended, cylindrical metal rod (6.35 mm in diameter) into the flat surface of the soil sample through a spring until it is embedded a predetermined distance. The resistance to penetration is recorded by the spring, which is calibrated to read the undrained shear strength of the soil based on spring compression.

Fall Cone Test. This test is performed by lowering a conical tool of known dimensions and weight so that the tip just makes contact with the flat surface of the soil sample. The tool is then released so that it penetrates below the surface of the sample under its own weight. The device is calibrated to indicate the undrained shear strength of the soil directly from the measured penetration of the cone. The maximum undrained shear strength that could be measured with the apparatus onboard the barge is approximately 215 kPa.

Miniature Vane Test. Miniature vane tests are performed in accordance with ASTM D4648. In performing the miniature vane test, a small, 4-bladed vane is inserted into an undisturbed or remolded cohesive specimen. Torque is applied to the vane through a calibrated spring activated by a motorized pulley and belt system, which causes the vane to rotate slowly until soil shear failure occurs. The undisturbed or remolded shear strength of the soil is computed from the torque transmitted by the calibrated spring by multiplying the net rotation, in degrees, by the spring calibration factor. The maximum undrained shear strength that could be measured with the miniature vane device used for this project is approximately 215 kPa.

In selected undisturbed miniature vane tests, residual shear strengths of very soft to firm clay soils also were measured by allowing the vane to continue rotating after the initial soil shear failure has occurred. The tests are terminated when the torque applied to the vane through the calibrated spring has reached a constant value. The residual shear strength, which represents the soil shear strength at large strain, is computed by multiplying the net rotation (in degrees) by the spring calibration factor.

Unconsolidated-Undrained Triaxial Compression Test. In this type of strength test, either an undisturbed or remolded test specimen is enclosed in a thin rubber membrane and subjected to a confining pressure at least equal to the computed effective overburden pressure. A confining pressure of about 830 kPa (the pressure limitation of the triaxial cell in the field laboratory) was used in the field for unconsolidated-undrained triaxial compression tests performed on samples encountered at deep penetration. The test specimen is not allowed to consolidate under the influence of this confining pressure prior to testing. The test specimen is then loaded axially to failure at a constant rate of strain without permitting drainage from the specimen. The undrained shear strength of the cohesive soil is computed as one-half the maximum observed deviator stress.

Undisturbed and remolded shear strengths determined by this type of test are tabulated on the Summary of Test Results in the boring-specific appendices (Volumes 2A and 2B). Values of ε_{50} from undisturbed unconsolidated-undrained triaxial compression tests, confining pressure, percent strain at failure, and type of failure are tabulated with the stress-strain curves in the boring-specific appendices.

Isotropically Consolidated-Undrained Triaxial Compression (CIUC) Test. Triaxial compression tests were performed to determine the stress-strain characteristics and the static

shear strength of a soil specimen under applied axial stresses. This test uses procedures recommend by ASTM D4767. Prior to setting up the test, the in situ effective vertical stress at the penetration of the sample was estimated on the basis of the interpreted unit weight profile at the boring location. The maximum past pressure that the sample had been subjected to was estimated from a consolidation test performed on a specimen from the same Shelby tube.

A cylindrical soil specimen was enclosed in a rubber membrane and placed inside a pressure chamber (triaxial cell). Tests were performed on specimens trimmed to 51.0-mm diameter (area = 20.27 cm^2) and a height of about 114 mm. The test specimens were saturated through back pressuring. Specimens were then isotropically consolidated in a drained state at a controlled rate of strain (about 0.3 percent per hour) to the assigned stresses, which are greater than or equal to the estimated maximum past pressure, thus inducing an overconsolidation ratio (OCR) of 1.0. Vertically or spirally oriented, 6-mm-wide, Whitman No. 54 filter strips placed at about 6-mm spacing provided radial drainage. The chamber pressure was kept constant and specimen drainage was not permitted during shear. A loading piston was advanced against the specimen cap at an applied rate of strain slow enough to produce approximate equalization of pore water pressure throughout the specimen at failure. The static stresses and pore water pressures, measured under undrained conditions, were used to express the measured strength parameters in terms of effective stress. Load, deformation, and pore water pressure measurements were recorded during loading using a data acquisition system.

Typically, a series of three tests were performed from each selected Shelby tube sample. One specimen was consolidated to approximately its effective overburden stress (typically close to the past maximum pressure in the Young Bay Mud). A second and third test were run on specimens consolidated to stress levels two and four times the estimated effective overburden pressure.

A summary of the estimated in situ stresses, consolidation stresses, and undrained shear strengths for the CIUC triaxial compression tests is presented on Table 5.1. Additionally, the following plots are provided for each test in the boring-specific appendices:

- Axial strain versus effective vertical stress during consolidation
- Shear stress (q) versus average effective stress (p') during undrained loading
- Shear stress, excess pore water pressure, and obliquity versus axial strain during undrained loading

3.3.2 Drained Strength Tests

Multi-stage, isotropically consolidated-drained (CIDC) triaxial compression tests were performed to evaluate the frictional characteristics of the granular materials encountered in the boring. The tests were performed on samples recovered using a 57-mm-ID, 74-mm-ID, and thin-walled Shelby tube or a modified California sampler with a 61-mm-ID brass liner. The test

specimen was trimmed down to a diameter of 51 to 71 mm, a height of 96 to 140 mm, and placed in a rubber membrane with saturated filter paper strips around the perimeter of the specimen.

During the consolidation phase, the test specimen was allowed to consolidate to one of three test-confining pressures. The Young Bay Mud samples were tested at confining stresses ranging from the interpreted in situ vertical effective stress to approximately five to eight times the interpreted in situ vertical effective stress. Due to the relatively low confining stresses, it was considered relatively difficult to test these samples at stresses less than the in situ vertical stresses. The Old Bay Mud/Upper Alameda Marine (OBM/UAM) samples were tested at stresses ranging from approximately half the interpreted in situ vertical effective stress to approximately four times the interpreted in situ vertical effective stress.

After the consolidation phase for the lowest confining pressure was completed and with the drainage line remaining open, the test specimen was sheared by increasing the axial load at a constant strain rate using a 44.5-kN Wykham-Farrance compression frame. The axial load was monitored by a load cell, deformation was measured by an LVDT, and volume change readings were taken with a calibrated burette. The load and deformation readings were continuously recorded by an IBM-compatible data logger.

The above procedures were repeated for two higher confining pressures. For the first two loading stages, the specimen was sheared until failure was indicated by a decrease in load, or 5 percent strain, whichever occurred first. After reconsolidation to a higher confining stress for the third stage, the sample was sheared to failure.

Isotropically consolidated-drained triaxial (CIDC) test results, including friction angle, are summarized in Table 5.3. Additionally, plots of stress versus strain, volumetric strain versus axial strain, and Mohr diagrams for the individual tests are presented in the boring-specific appendices (Volumes 2A and 2B).

3.4 CONSOLIDATION TESTS

3.4.1 Incremental Consolidation Tests

Incremental consolidation tests were performed on selected high-quality cohesive samples to investigate the stress history of the soils at the boring location. The tests were performed in accordance with the recommendations of ASTM D2435. The consolidation test specimens were trimmed into 63.4-mm-ID stainless steel rings. The trimmed test specimen and ring were then placed in a specially designed cell where the base of the test specimen was sealed from the fluid (water) and the top of the test specimen was exposed to the fluid. A porous stone was placed on top of the test specimen and the loading ram was brought into contact with the porous stone. As the test specimen was compressed during loading, the pore fluid drained from the sample through the porous stone. The setup of the test specimen into the cell was performed

with the entire cell under water so that there was no air trapped in the system that would affect the pore pressure response during loading.

After the cell was fully assembled, it was placed in a loading frame where the test specimen would be saturated before loading. Vertical loads were added in increments that usually doubled the previous load, yielding a load increment ratio of two. Each load increment was held for a period t_{100} (primary consolidation) determined by the logarithm of time method. The data readings were used to compute the vertical strain, vertical pressure, and coefficient of consolidation. Loading was continued until the effective stress applied was greater than the maximum past pressure applied to the test specimen, and the virgin compression portion of the consolidation curve was well defined. At that point, the test specimen was unloaded and then reloaded. The test specimen was rebounded again at the end of the test to produce a second rebound curve.

3.4.2 Controlled-Rate-of-Strain (CRS) Consolidation Test

CRS consolidation tests were performed in general accordance with ASTM D4186 on selected samples from the two adjacent marine borings (98-39 and 98-44). CRS consolidation test specimens were trimmed into 63.5-mm-ID stainless steel rings. The trimmed test specimen and ring were placed in a specially designed cell. The base of the test specimen was sealed from fluid (water) and the top of the specimen was exposed to the fluid. A porous stone was placed on top of the test specimen and the loading ram was brought into contact with the porous stone. As the test specimen was compressed during loading, the pore fluid drained from the top of the sample through the porous stone. A pressure transducer was connected to the bottom of the specimen, through the test cell, to measure the excess pore pressure during loading.

After the cell had been fully assembled, it was placed in a loading frame where the test specimen was saturated after a small setting load had been applied (to prevent swelling). The rate-of-strain was selected to produce a minimum excess pore pressure of 21 kPa and to limit the ratio of maximum excess pore pressure to applied vertical pressure to less than 15 percent (more commonly 10 percent). A limit of 10 to 15 percent was selected to obtain more reliable compressibility and rate of consolidation coefficients. The pore pressure ratio was continuously monitored during the first stage of loading, and the rate of strain was automatically adjusted to keep the pore pressure ratio within the above limits. Loading was continued until the applied effective stress was greater than the estimated maximum past pressure applied to the test specimen and the virgin compression portion of the consolidation curve was well defined. The sample was loaded to between 20 and 30 percent strain, and then rebounded to produce a rebound curve.

A summary of the consolidation test results is presented in Table 5.4. Individual test results are presented in the boring-specific appendices (Volume 2) as curves of void ratio versus

effective vertical pressure. Also plotted with these curves is the computed coefficient of consolidation at each effective vertical pressure.

3.5 ADDITIONAL LABORATORY TESTING

3.5.1 R-Value Testing

The R-value tests were performed on bulk samples of pavement subgrade material obtained from selected pavement series borings (98-65, 98-68, 98-69, and 98-72). The tests were performed in accordance with California Test 301 by BTC Laboratories, Inc., Ventura, California.

The R-value is a parameter used in the design of flexible pavement sections. The test consists of four basic steps:

1. Compaction of three samples at different moisture contents in a 100-mm-ID, by 127-mm-tall mold using a mechanical compactor.
2. An exudation pressure test is performed. An increasing pressure is applied to the compacted sample. When enough moisture is expelled from the sample to turn on five moisture indicating lights on the exudation device, the pressure is recorded as the exudation pressure.
3. A swell pressure test is performed by adding 200 mL of water to the top of the mold and measuring the expansion pressure after 16 to 24 hours.
4. A stabilometer test is performed where the induced lateral pressure is measured under an applied vertical pressure of 110 kPa. The R-value is then determined from an empirical formula presented in California Test Method 216.

The results of the R-value testing are presented in the Summary of Test Results and as plots of exudation pressure versus R-value in Volume 2B.

3.5.2 Corrosion Testing

Corrosion testing was performed by Health Science Associates, Los Alamitos, California. The corrosion testing followed California Test Methods 532 and 643. A series of four tests were run, including Resistivity (ohms/cm), pH, Chloride Content (parts per million [ppm]), and Sulfate Content (ppm). Corrosivity test results are presented in the by-boring appendices provided in Volumes 2A and 2B.

3.6 UNIVERSITY OF CALIFORNIA AT BERKELEY TESTING

Sealed "SAVE" tube samples from six locations were delivered to the University of California at Berkeley to conduct a series of special cyclic simple shear and consolidation tests.

The methods and results of that testing program are described and presented in UC Berkeley (1999), which is provided in Volume 4.

3.6.1 Simple Shear Testing

The purpose of the simple shear testing was to investigate the possible effects of large cyclic straining (such as might be caused by a significant seismic event) on the subsequent stress-strain properties of the soil. To assess this directly, pairs of specimens from a given sampling tube were tested. One of the specimens was sheared monotonically, while the other specimen was first cyclically loaded at a specified strain amplitude and number of cycles, and then monotonically sheared without allowing the pore pressures from the cyclic loading to dissipate. Cyclic loading consisted of 25 strain-controlled cycles at a frequency of 0.2 Hertz (Hz), with single amplitude shear strains ranging from 1 to 3 percent. A total of six sets of two or three specimens were tested.

3.6.2 Consolidation Testing

Six special consolidation tests were performed at the University of California at Berkeley to investigate the rate of consolidation that could be expected when pore pressures are allowed to dissipate horizontally, as would be the case after the installation of wick drains. Rather than conventional oedometer tests (which are designed to consolidate horizontal slices of a tube sample using vertical drainage), the tests used a modified triaxial test apparatus to measure the consolidation response of large cylindrical specimens to isotropic increases in stress.

Test	Number of Tests by Boring																										Totals
	98-51	98-52	98-53	98-54	98-55	98-56	98-57	98-58	98-59	98-60	98-61	98-62	98-63	98-64	98-65	98-66	98-67	98-68	98-69	98-70	98-71	98-72	98-73	98-74	98-75	98-39	98-44	
Index Tests																												
Atterberg Limits	22	13	9	9	19	17	15	19	13	15	11	7	11	9	9	--	4	4	2	8	6	1	4	--	10	34	33	304
Unit Weight	13	8	8	6	19	8	10	12	10	10	7	8	9	8	8	--	4	1	1	5	4	2	3	--	6	35	34	239
Water Content	31	20	21	19	30	29	23	27	22	25	19	17	20	18	18	5	12	10	10	19	11	6	9	5	21	51	48	546
Percent Passing #200	4	4	5	3	--	5	2	6	2	3	4	5	1	--	5	--	3	3	2	3	3	1	3	--	4	--	2	73
Sieve Analysis	3	2	3	3	2	3	5	4	3	2	8	5	4	3	1	3	3	4	4	4	--	3	2	2	6	6	3	91
Hydrometer	--	--	--	2	1	2	--	--	1	--	7	1	4	2	1	1	1	--	--	--	--	2	--	--	3	7	4	39
Specific Gravity	2	3	3	3	3	3	5	4	4	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32
Consolidation Tests																												
CRS Consolidation	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	3	7
Incremental Consolidation	7	1	2	4	5	3	4	4	2	2	6	3	4	3	7	--	1	--	1	3	2	--	4	--	4	4	5	81
Radial Consolidation	--	--	--	--	--	--	1	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4
Shear Strength Tests																												
Miniature Vane - Residual	--	--	1	--	--	--	--	--	2	1	1	--	2	1	--	--	--	--	--	--	--	--	1	--	--	9	6	24
Miniature Vane - Remolded	2	1	--	2	5	3	1	2	4	1	2	3	3	3	2	--	2	--	1	1	3	1	4	--	--	1	4	51
Miniature Vane - Undisturbed	14	7	9	10	17	11	15	14	8	13	6	6	6	8	5	--	4	--	2	5	4	1	3	--	7	24	29	228
Torvane	13	11	9	15	18	17	7	19	12	13	10	12	7	13	9	--	9	1	4	10	5	2	8	--	6	23	23	276
Pocket Penetrometer	9	1	2	2	10	9	6	11	--	5	2	2	4	2	3	--	--	--	--	1	--	--	--	--	5	22	24	120
Swedish Fall Cone	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	1	9	4	18
UU-Triaxial - Undisturbed	11	3	3	4	9	5	9	9	3	6	5	5	2	4	3	--	2	--	1	3	1	--	2	--	4	16	17	127
UU-Triaxial - Remolded	4	4	5	2	4	4	5	4	3	3	1	2	2	3	2	--	--	--	--	2	--	--	--	--	4	7	6	67
ICUC-Triaxial	--	--	--	--	--	--	1	--	--	--	--	--	--	1	--	--	1	--	--	--	--	--	--	--	--	--	--	3
ICDC-Triaxial	--	--	--	--	--	--	--	--	*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0
Remote Vane	19	13	7	12	18	8	11	14	13	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7	2	139
Direct Shear	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
Monotonic Direct Simple Shear		2	--	--	3	2	--	--	2	3	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15
Cyclic Direct Simple Shear	--	1	--	--	1	1	--	--	1	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6
Other Tests																												
Corrosivity	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	1	--	--	1	--	--	1	--	--	--	--	--	5
R-Value	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	1	1	--	--	1	--	--	--	--	--	5
Compaction (CA 216)	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	1	1	--	--	1	--	--	--	--	--	5
Sand Equivalent	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1	1	--	--	1	--	--	--	--	--	4

* Test in progress.

SUMMARY OF LABORATORY TESTING PROGRAM
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

TABLE 3.1

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SECTION 4.0
SITE CHARACTERIZATION

4.0 SITE CHARACTERIZATION

4.1 SITE HISTORY

4.1.1 Mole Key

The original Key System Mole was constructed (filled) on a former shallow water tidal flat prior to the construction of the existing SFOBB in the 1930s. The original Key System Mole served as a roadway and railroad trackbed for a ferry terminal that extended into the bay to the west of the western end of the Mole (see Plate 4.1).

4.1.2 Northern Mole Extension

Based on Trask and Rolston (1961), the construction of a northern extension to the then existing Key System Mole started on January 8, 1934. The approximate location of the original Mole key and the 1930s-circa northern extension relative to the existing Mole are shown on Plates 4.1 and 4.2. (Note that the historical overlay has been obtained from a small-scale, page-size drawing Caltrans [1932].)

To allow for the construction of the approaches to the current bridge, the westerly 610 meters (approximately from the existing western tip of the Mole to the proposed westbound Stations 89+00 to 90+00) were constructed first. Within this westerly segment of the northern extension, the historical documentation suggests that the fill was placed directly on the bay bottom. East of this limit, work reportedly began with the dredging of about 3 meters of the Young Bay Mud (YBM) from the bay bottom. The current investigation suggests that YBM was excavated around westbound Station 89+00, but does not appear to have been excavated east of westbound Station 89+50. Material for the northern extension fill was dredged from the Oakland Outer Harbor.

The Caltrans annual progress report reports for construction of the existing SFOBB (Caltrans, 1934) indicate that the northern extension fill was built in three stages:

1. The first-stage fill was placed hydraulically without containment up to about El. ±0 MSL. Upon completion of the first-stage fill, a temporary 1.2-meter-high bulkhead was constructed during periods of low tide. This bulkhead served the dual purpose of reducing the amount of rock needed to retain further fill and retaining the second stage of the fill.
2. The second stage fill was placed to about El. +1.2 meters MSL and served as a roadway for the operation of the rock contractor. Core rock was moved into position beyond the temporary bulkhead to an elevation slightly above El. +1.2 meters MSL. Face rock was then placed on the exposed face and the remainder of the core rock

was placed to between El. +3 and El. +3.7 meters MSL. This roughly shaped wall was then backed with sand to prevent excess leakage through it during the pumping of the third-stage fill.

3. The final stage was placed to an elevation sufficiently above the grade line of El. +3 meters MSL to allow for the anticipated settlement and consolidation that the fill would experience in the years to come. The remainder of the face rock was then placed by dumping from the top of the fill. The dredged fill was completed on December 28, 1934, with a total of approximately 2.9 million cubic meters having been pumped.

Post-Extension Modifications. As recorded on aerial photos, the northern side of the Oakland Mole has undergone several changes since construction of the northern extension. Significant changes on the northern portion of the Mole were observed in historical photographs as follows:

- By the late 1940s, the mudflat area to the north and northwest of the current Toll Plaza had been filled.
- By 1957, the northern edge of the Mole near the western tip (where early photos from 1936 show a docking pier) had been filled out to the north to form a new "pad" measuring approximately 30 by 60 meters. The western fill knob, subsequently referred to as the "western jughandle" in this report, is at proposed westbound Station 86+20.
- A second smaller filled area, located on the northern edge of the Mole farther to the east, was created by the late 1960s and is currently used as a "jughandle" traffic turnaround for the Caltrans maintenance road. The eastern knob (referred to as "eastern [turnaround] jughandle" in this report) and is at proposed westbound Station 88+30.
- By 1963, the portion of the western end of the Mole located beneath the SFOBB was extended to the west by approximately 90 meters.

Since approximately 1969, the geometry of the northern side of the Mole has remained basically unchanged.

Failure of Mole Fill. In the winter of 1947-1948, the underlying mud failed during the construction of the Mole fill to the north of the Toll Plaza. At the time of failure, the fill sank at least 6 meters. The mud reportedly thrust itself upward in places through the previous sand fill.

Settlement of Existing Fill. Plate 4.3 shows fill settlement along the Mole at 1, 5, and 20 years after construction. It appears that the settlement varies almost directly with the thickness of the underlying Young Bay Mud. After 20 years, the average settlement is approximately 10 percent of the thickness of Young Bay Mud. The total settlement could have

been more than that shown on Plate 4.3 since the settlement incurred during fill placement was not recorded and long-term (post-20-year) data are not available.

Since most of the filling occurred decades ago, primary settlement of the underlying Young Bay Mud has likely occurred, thus minimizing the possibility of significant future long-term settlement under the existing stress state. In addition, the Young Bay Mud underlying the fill will be stronger than its nearby marine counterpart due to consolidation under the weight of the Mole fill.

4.2 TOPOGRAPHY

The Oakland Mole is relatively flat except near the shoreline. Ground surface elevations on the Mole are typically between about El. +1.5 and El. +3.5 meters. In the western 150 meters, however, the ground surface slopes slightly to the west. In addition, as shown on Plate 4.3, the ground surface on the western jughandle is lower and slopes northward. Beyond and west of the toe of the western jughandle, there is an intermittently exposed, northwesterly-sloping beach.

4.3 BATHYMETRY

A bathymetric survey of the shallow tidal flat areas to the north and west of the Oakland Mole was conducted on August 23 and 24, 2000. A description of the survey equipment and procedures is presented in Appendix E of the Final Marine Geophysical Survey (Fugro-EM, 2001c). Bathymetric contours are shown on Plate 4.4.

The tidal flat to the north and west of the Mole extends from the toe of the northern and western Mole slopes to form a broad platform with a surface elevation of between about El. 0 and El. -1.3 meters. At low tide along the toe of the Mole, there is a strip of emergent land, the width of which decreases to the east. Locally, the emergent land strip is largest on the western sides of the jughandles. The extent of this emergent land generally corresponds to the El. -1.0 meter (MSL) contour (approximately MLLW elevation), which roughly parallels the Mole shoreline about 10 to 30 meters north of the toe of the Mole. The El. -1.3 meter (MSL) contour, which approximately corresponds to the lowest tide levels, typically runs about 50 meters north from the toe of the Mole. At the western jughandle, however, this contour deviates to the north to form a relatively shallow nob that extends approximately 100 meters from the jughandle shoreline.

Of the proposed overwater piers in the vicinity of the Oakland Shore Approach (Piers E17 and E18 Eastbound and Westbound, and Piers 19 through 20 Westbound), the bathymetry data show that Piers E20 and E21 Westbound will be exposed during most low tide cycles. It is likely that Piers E19 Westbound and E18 Eastbound will only be exposed during extreme low tide periods.

Local topographical variation on the tidal flat occurs as local features whose relief is greater than the general slope or changes on the tidal flat. These features are likely due to the ongoing, dynamic coastal and beach erosional and depositional processes around the tidal flat areas of the Mole. The bathymetry, therefore, is likely subject to seasonal variations.

A comparison of the current bathymetry on the tidal flat and the bathymetry shown on the Caltrans' 1933 map shows that the water depth has decreased to the north of the Mole. Those data show that the current bathymetry is as much as 2.2 meters shallower than the bathymetry prior to construction of the Mole extension. Review of the Seascout CPT sounding results suggests that the additional sediment accumulated on the tidal flat includes: a) sands that were deposited below water prior to the construction of the northern perimeter containment structure (during the northern Mole extension fill), b) very recent fine-grained sediments (subsequently referred to as "historical bay mud"), and c) a local surface sand layer.

4.4 GENERAL SUBSURFACE SOIL CONDITIONS

4.4.1 Stratigraphic Sequence Under Mole

The present subsurface site soils consist of the following sequence of major units (in descending order):

- Granular fill
- Soft to stiff clay (Young Bay Mud [YBM])
- Dense sand with layers of stiff sandy clay (Merritt-Posey-San Antonio [MPSA] Formations)
- Stiff to very stiff clay (Old Bay Mud [OBM])
- Very stiff to hard marine clays (Upper Alameda Marine [UAM] Formation)
- Dense to very dense alluvial sands (Lower Alameda Alluvium [LAA] Formation)

This sequence of marine and alluvial sediments unconformably overlies bedrock of the Franciscan Formation.

4.4.2 Stratigraphic Relationships

Longitudinal and transverse stratigraphic cross sections were constructed to assist with geologic characterization. The locations and orientation of those sections are shown on Plate 4.5 and a key to the symbols used on the cross sections is included on Plate 4.6. The cross sections are provided on Plates 4.7 through 4.12.

The following list summarizes the locations and data presented on the cross sections:

Plate No.	Section Designation	Location (see Plate 4.5 for cross section locations)	Data Shown on Cross Section
4.7a	M1-M1'	N6 Eastbound Alignment, Marine Areas, Piers E16 through E18 Eastbound	S_u and q_c
4.7b	M2-M2'	N6 Westbound Alignment, Marine Areas, Piers E16 through E19 Westbound	S_u and q_c
4.7c, 4.7d	A-A' through B-B'	Approximately the N6 Eastbound Alignment, Mole Areas	S_u and q_c
4.7e, 4.7f	A1-A1' through B1-B1'	Approximately the N6 Westbound Alignment, Mole Areas	S_u and q_c
4.8	C-C'	Perpendicular to Alignment - Approximately at Pier E20	S_u and q_c
4.9	D-D'	Perpendicular to Alignment - Between East and West Jughandles, Approximately "W" Station 87+10	S_u and q_c
4.10	E-E'	Perpendicular to Alignment - Approximately "W" Station 87+90	S_u and q_c
4.11	F-F'	Perpendicular to Alignment - Approximately "W" Station 89+90	S_u and q_c
4.12	A-A'	Approximately the N6 Eastbound Alignment, Mole Areas	q_c and Vs

The cross sections provide graphical representations of the soil units, measured cone tip resistance, and measured and calculated undrained shear strengths. The measured undrained shear strengths include in situ measurements from the remote vane shear tests and laboratory test results. Undrained shear strengths calculated from the measured CPT tip resistances (corrected for unequal end area and overburden effects) also are shown. Those calculated shear strengths are based on a bearing capacity factor (N_k) with a range of 12 to 15.

The variations in the stratigraphic sequence and thickness of strata as illustrated on the cross sections include the following:

- A distinct Young Bay Mud paleochannel crosses beneath the proposed new bridge alignment between about exploration locations 98C-54 and 98C-18 (approximately between proposed eastbound Stations 86+00 and 88+00). The paleochannel is interpreted to be a north-south-trending tributary to the east-west-trending paleochannel that crosses San Francisco Bay to the north of the existing East Span alignment. The ATV-mounted CPT soundings on the tidal flat to the north of the Mole suggest that the width of the paleochannel increases significantly to the north. Those data also suggest that the thalweg of the paleochannel deepens rapidly to the north.

- An additional east-west-trending tributary channel that begins just west of proposed Pier location E17 and deepens to the west was delineated based on the Phase 3 field investigation. The western edges of the Eastbound and Westbound Piers E17 appear to lie on the flank of this channel.

- The continuity of the MPSA Formations is interrupted where the Young Bay Mud-filled paleochannel is incised through the MPSA Formations. The CPT data suggest that MPSA sand layers generally are not present within that particular tributary paleochannel.
- The base of the fill is deeper and the thickness of the fill is greater where the Young Bay Mud paleochannel has incised into and through the MPSA Formations. This is due to the differential settlement of the greater thickness of Young Bay Mud clay within the paleochannels.
- Except where removed by channeling, the MPSA Formations frequently include a distinct 3- to 5-meter-thick very dense sand (Merritt) layer. The sand layer is often overlain by a limited thickness of clayey sand (or sandy clay) and is underlain by variable amounts of stiff to very stiff clay and sandy clay. The MPSA Formations are generally present between about El. -8 and El. -20 meters. Locally, on the eastern flank of the Young Bay Mud paleochannel, the very dense sand layer (or a separate sand layer with similar characteristics that was probably deposited inside an older paleochannel) within the sequence appears to be displaced about 5 meters downward.
- The Old Bay Mud includes a distinct crust at its surface. The data provide direct evidence of other deeper crust layers. The crusts are typically flat-lying and relatively continuous, although the crusts will be discontinuous where channels locally have eroded through the crust layers.

4.4.3 Tidal Flat Sediments

Mudline elevations to the north of the Mole are typically higher than the top of the Young Bay Mud beneath the Mole. This is due to the consolidation of the Young Bay Mud beneath the Mole under the weight of the Mole fill. Examination of the data suggests that the difference in elevation between the top of the Young Bay Mud under the tidal flat and beneath the Mole fill is between 0.5 and 2 meters. That magnitude of elevation difference is consistent with the reported settlement of the Mole fill.

To the north of the Mole, the Young Bay Mud sediments are overlain by sediments deposited during and since the construction of the northern extension of the Mole. Those tidal flat sediments locally include some or all of the following sediments:

- A locally continuous layer of sand that was probably deposited during the hydraulic placement of the lower submerged Mole fill, but prior to construction of the containment structure for the subsequent upper fill lifts.
- A layer of very soft clay that is subsequently referred to as the "historical bay mud" in order to differentiate that layer from the geologically-recent Young Bay Mud.
- A layered deposit of the sands and historic mud.

A surface sand in the western portion of the tidal flat, subsequently referred to as the "beach sand" layer.

4.5 GEOLOGIC AND CULTURAL FEATURES

4.5.1 Mole Fills

The northern portion of the Oakland Mole consists of primarily hydraulic (not engineered) fill placed during bridge construction in the 1930s. That fill predominantly consists of granular, poorly graded sand with silt and silty fine sand. The fill includes variable amounts of debris, rubble, cobbles, boulders, and shore protection riprap. The thickness of the fill typically varies from 4.5 to 9.0 meters. Locally, the fill is as thick as 12.5 meters.

Fill extends beyond the 1930s' northern extension at the present western and eastern "jughandles" (see Plate 1.2). Those subsequent fills consist of similar sands that locally extend northward and create beach areas at the toe of the existing slopes. These areas probably also contain rock of the former extended Mole dike. The present slopes of the Mole are protected by a blanket of riprap.

4.5.2 Buried Rock Dikes

The northern portion of the Mole is believed to be underlain by the buried remnants of at least two prior east-west-trending rock dikes. A 1932 Caltrans map shows the alignment of the northern edge of the original Mole (or key) as well as the proposed Mole extension to the north (see Plate 4.2). Several borings that penetrated gravel and rock appear to approximately correlate to the locations of the northern edge of the original and extended Mole as shown on the 1933 map.

Trench excavations conducted in April 1999 verified the existence of pre-1950 rock dikes buried beneath the existing east and west jughandles. The trench locations are provided on Plates 2.1a and 2.1b. The dikes are approximately in line with the existing shoreline on either side of the jughandles. The dike was found to be approximately 0.9 meter below the existing ground surface at the trench locations. The dike thicknesses were measured to be about 3 meters at the eastern jughandle and about 2.4 meters at the western jughandle. The excavation revealed the dike to be covered with angular and rounded riprap 0.6 to 1.2 meters in size. The dike core materials were composed of round to angular cobbles, 300 to 600 mm in size, with smaller cobbles and gravel filling the voids. Further detail from the trench excavations can be found in the memorandum included in Volume 4.

4.5.3 Tidal Flat to the North of the Mole

The data suggest that the Young Bay Mud, Merritt-Posey-San Antonio, and Old Bay Mud strata (see below) continue to the north of the Mole. The CPT soundings show that up to

several meters of sand and clay, collectively defined as the tidal flat sediments, overlie the Young Bay Mud immediately to the north of the Mole edge. The data suggest that the surface sand layer is discontinuous and decreases in thickness to the north and east.

4.5.4 Paleochannels

The stratigraphic sequence described in Section 4.4.1 is generally present under most of the site, although some formations have been locally eroded and complicated by various episodes of channeling. A main Young Bay Mud-infilled, east-west-trending paleochannel crosses San Francisco Bay to the north of the existing East Span alignment and is joined by several tributary paleochannels along the proposed SFOBB alignment. One north-south-trending tributary paleochannel (referred to hereafter as the tributary Mole paleochannel) crosses beneath the proposed new bridge alignment on the Mole approximately between boring locations 98-54 and 98-18 (at approximately westbound Stations 86+50 to 87+70).

The CPT data suggest that this paleochannel is filled with Young Bay Mud and that the channel appears to be incised through the Merritt-Posey-San Antonio Formations. With the exception of one relatively continuous 1- to 1.5-meter-thick sand layer, no other continuous sand seams or layers are observed from the available data within this channel.

In the vicinity of the Oakland Shore Approach, there is another Young Bay Mud-infilled paleochannel that lies in a southeast-northwest-trending tributary channel between proposed Piers E17 and E18 and runs west, eventually veering north to meet the main east-west-trending paleochannel.

4.5.5 Description of Stratigraphic Units

Fill. The Mole fill consists predominantly of poorly graded fine sand with silt to silty fine sand. The sands are generally dense above groundwater and medium dense with loose layers below groundwater.

The fill was dredged from the outer Oakland Harbor during the construction and subsequent extension of the Mole in the 1930s. Similarities in grain size characteristics suggest that the primary source of the Mole fill is the Merritt Sand deposits, a unit of the Merritt-Posey-San Antonio Formations. The data show that the fill is slightly coarser, with less fines than the average grain size of the Merritt Sand. That observation is considered to be consistent with the unconfined hydraulic placement of much of the Mole extension fill. The fill sands typically include about 5 to 14 percent fines. Local layers, however, include up to about 30 percent fines.

The thickness of the fill generally varies from 4.5 to 9.0 meters, but is as thick as 12.5 meters near the location of CPT 98C-105. The location of 98C-105 appears to correspond to the location where the Young Bay Mud was apparently excavated prior to the placement of the fill in the 1930s. The bottom of the fill typically ranges from El. -3.5 to El. -8.8 meters. The base of

the fill is deeper and the thickness of the fill greater where the Mole overlies a buried paleochannel. This is primarily due to the additional fill that was placed to compensate for the consolidation settlement of the thicker layers of compressible Young Bay Mud within the paleochannel.

The fill includes variable amounts of debris, rubble, cobbles and boulders, and shore protection riprap. The northern portion of the Mole is also believed to be underlain by buried remnants of the prior east-west-trending rock dikes that served as the edge of the original Key System Mole. In addition, former rock dikes placed before 1950 were left in place in the two jughandle areas. The dikes are approximately in line with the visible slopes east and west of the jughandles.

Tidal Flat Sediments. The tidal flat sediments to the north of the Mole consist of a sequence of Recent sand and very soft clay historical bay mud deposits overlying the Young Bay Mud. A deposit of surface beach sand extends along the northern shore of the Mole between the jughandles and to the west of the western jughandle. The beach sand is up to 1 meter thick at the shoreline. The data suggest that the surface sand layer is discontinuous and decreases in thickness to the north. The beach sand is generally thicker and extends farther north in the western portion of the tidal flat. Local variations in the beach sand thickness are likely due to littoral drift and other beach environment processes. Plate 4.13 shows the approximate beach sand thickness encountered in the tethered Seascout and ATV-mounted CPT soundings.

Throughout the tidal flat area to the north of the Mole and underlying the beach sand (where present) is historical bay mud that is comprised of very soft clay with interspersed seams and layers of sand. A comparison of the current bathymetry on the tidal flat and the bathymetry shown on a 1933 Caltrans map (provided in Volume 4) suggests that the historical bay mud has been deposited since the construction of the bridge in the 1930s. The historical bay mud deposits appear to be 0.3 to 3.0 meters thick.

A locally continuous layer of sand underlies the historical bay mud along the northern Mole shoreline between the jughandles and to the east of the eastern jughandle. This sand was likely deposited during the hydraulic placement of the lower submerged fill. The lower submerged fill was placed prior to the construction of the containment structure for the upper Mole fill of the northern Mole extension constructed in the 1930s. The sand layer is evident in many of the Seascout CPT soundings immediately north of the Mole and extends as far as 120 meters north of the Mole shoreline. The sand layer is as much as 1.5 meters thick at the northern shore of the Mole and thins northward. Plate 4.14 shows the approximate thickness of fill sand encountered in tethered Seascout and ATV-mounted CPT soundings. Plate 4.15 provides a schematic cross section through the northern tidal flats and Mole, and shows the relationship of the sand and historical bay mud deposits that overlie the Young Bay Mud.

Throughout the tidal flat area, the sequence of Recent sands and soft clays is underlain by the Young Bay Mud deposits. The tethered Seascout and ATV-mounted CPT data show that the top of the Young Bay Mud typically ranges in elevation from El. -3.5 to -5.0 meters.

Young Bay Mud (YBM). The Mole fill and tidal flat are underlain by a soft to stiff, Holocene-age marine clay deposit referred to as Young Bay Mud. Those compressible clay sediments have consolidated under the weight of the Mole fill since the 1930s.

The base of the Young Bay Mud typically occurs, where encountered in the borings, at about El. -9.5 to El. -14.5 meters throughout the site. In the paleochannel area (approximately Stations 86+50 to 87+70), the Young Bay Mud thickens and extends approximately El. -24.5 meters at the deepest point.

The deposits encountered in the tidal flat area farther to the north of the Mole predominantly consist of very soft to stiff clay with silt, sand, and shells deposited after construction was completed (around 1934). Seascout CPT data suggest abundant thin seams of silt, sand, or shells at various depths within the Young Bay Mud.

The data on the Mole and adjacent tidal flat confirm that the consolidation of the Young Bay Mud varies with the presence or absence of fill as well as with the age of the overlying fill. Beneath the northern Mole extension, the Young Bay Mud appears to be normally consolidated under the weight of the 1930s' fill. Beneath the more recent jughandle extensions, however, the data suggest that the Young Bay Mud is slightly underconsolidated relative to the weight of the 1950s' and 1960s' fill. The degree of underconsolidation in the Young Bay Mud at those locations appears to increase with depth. To the north of the Mole, the CPT data suggest that the upper portion of the Young Bay Mud is slightly overconsolidated relative to the much lower stress state that is present in the unfilled areas.

Merritt-Posey-San Antonio (MPSA) Formations. Beneath the Young Bay Mud, a layered sequence of sands and clays is present over portions of eastern San Francisco Bay. The term "Merritt-Posey-San Antonio (MPSA) Formations" is preferred over the more simplified designation of Merritt Sand in recognition of the layered and interbedded characteristics of the sequence.

The MPSA Formations include dense to very dense sand with layers of stiff to very stiff sandy clay and clay that underlie the Young Bay Mud throughout most of the site area. Except where removed by channeling, this sequence frequently includes a distinct 3- to 4.5-meter-thick, very dense sand (Merritt) layer. This sand layer is often overlain by a limited thickness of clayey sand (or sandy clay) and is underlain by variable amounts of stiff to very stiff clay and sandy clay with sand layers.

The MPSA Formations are generally present between about El. -7.6 and El. -19.8 meters. Locally, on the eastern flank of the Young Bay Mud paleochannel, the very dense sand layer (or

a separate layer of similar characteristics) within the sequence appears to be displaced about 5 meters downward.

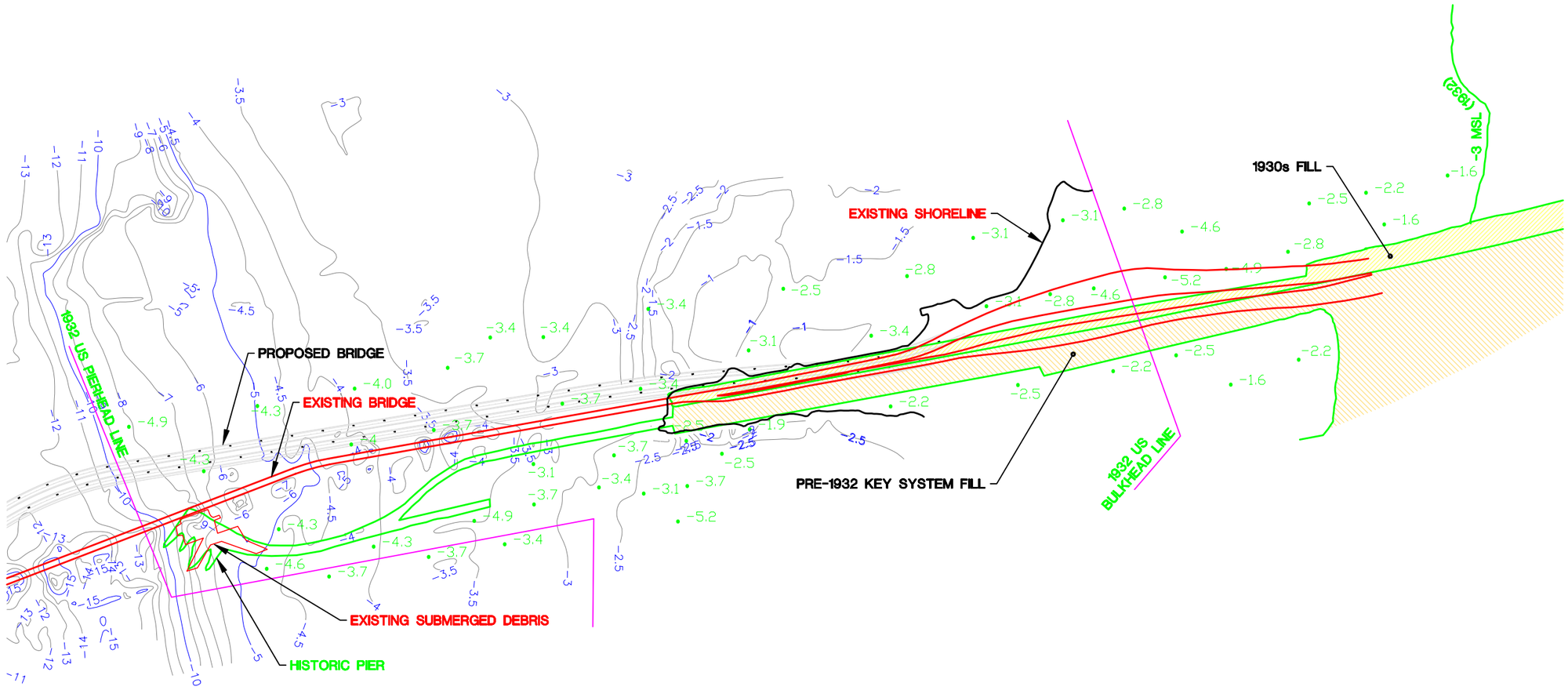
Two deep marine borings at the western tip of the Mole, ATV-mounted CPT soundings, and Seacalf CPT soundings all show that the MPSA Formations continue to the north of the Mole.

Old Bay Mud/Upper Alameda Marine Sediments. The Old Bay Mud/Upper Alameda Marine sequence (OBM/UAM) is an older marine stratum that underlies the entire site and its surrounding area. The OBM/UAM consist primarily of very stiff to hard fat clay and includes a distinct crust at its surface. Because the composition and geotechnical properties of the two units are similar and the definition of the interface between the two formations is tenuous, the two formations have been discussed and mapped as one combined sequence of sediments. Except where eroded by channeling, the top of the sequence typically is present from about El. -18 to El. -25 meters. The data provide evidence of other deeper crust layers. The crusts are typically flat-lying and relatively continuous, although locally the crusts will be discontinuous where channels have eroded through the crust layers.

Lower Alameda Alluvial Sediments. The Upper Alameda Marine sediments are underlain by dense to very dense alluvial sands with hard lean clay layers that are referred to as the Lower Alameda Alluvial (LAA) Formation. These primarily dense, granular sediments overlie the Franciscan Formation bedrock. The top of the LAA was encountered at about El. -75 meters in nearby marine Boring 98-44. The characteristics of the LAA are discussed in greater detail in the Final Marine Geotechnical Site Characterization Report (Fugro-EM, 2001d).

Bedrock. The Jurassic/Cretaceous-age Franciscan Formation forms the bedrock that underlies the Alameda Formation. Bedrock gently slopes to the east-southeast and was encountered at El. -135 meters (approximately 131.5 meters below existing top grade) at the western tip of the Mole and at El. -150 meters (approximately 146.5 meters below existing grade) at the Toll Plaza, which is located east of the subject project site.

For the Phase 1 and Phase 2 investigations (see Section 2.1), borings were not advanced to bedrock because deep foundations for the Oakland Shore Approach structures are not anticipated to reach bedrock. Bedrock was encountered by Caltrans (Caltrans, 1994) in three test borings at the western tip of the Mole and in one boring at the present Toll Plaza location as part of the Oakland Bay Bridge Seismic Retrofit program. According to those borehole logs and the marine boring logs by Fugro (see Volume 2), bedrock consists of weathered (brown/olive-colored) to fresh (dark gray-colored) sandstone with laminated interbeds of black-colored siltstone, claystone, and shale. The top of the bedrock includes varying degrees and depths of weathering.



LEGEND

-5.2 1930s Bathymetry, meters (MSL)

10 / 11 1997 Bathymetry Contours, meters (MSL)

NORTH

0 300 600 m

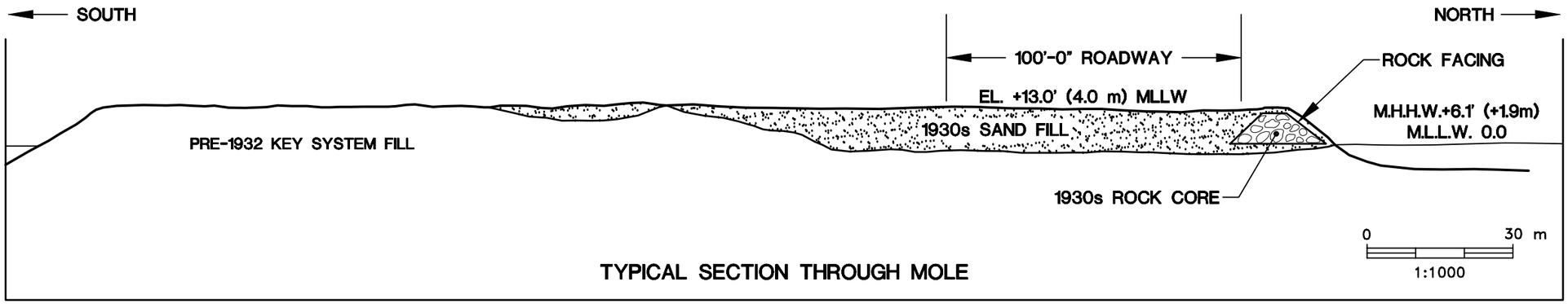
1:15,000

MORPHOLOGY OF OAKLAND MOLE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

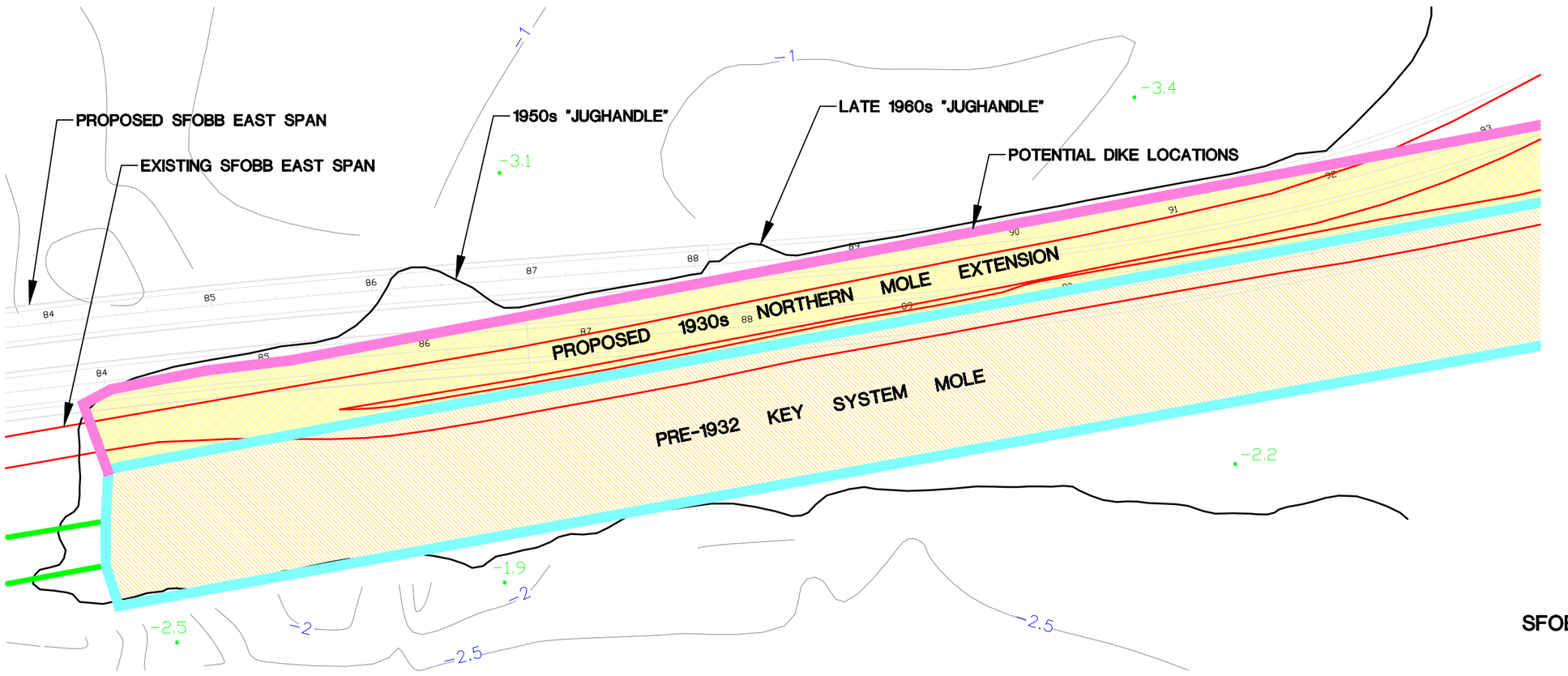
PLATE 4.1

9842\0058mole.dwg(0.2-8),ps,0058mole.pcp

Earth Mechanics FUGRO



TYPICAL SECTION THROUGH MOLE



LEGEND

- -5.2 1930s Bathymetry
- 10 / 11 1997 Bathymetry Contours

NOTE: Historical overlay was obtained from a small-scale page-size drawing in Caltrans (1932).

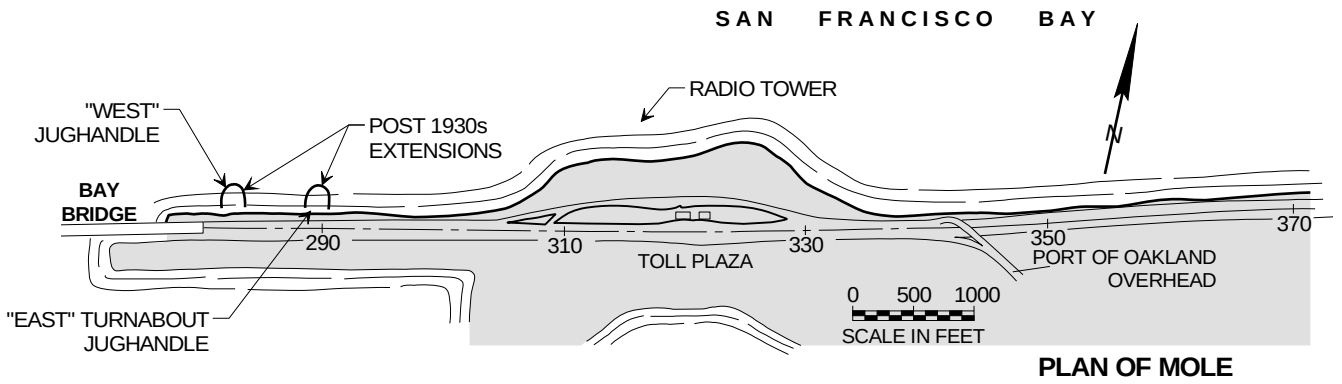
NORTH

0 90 m
1:3000

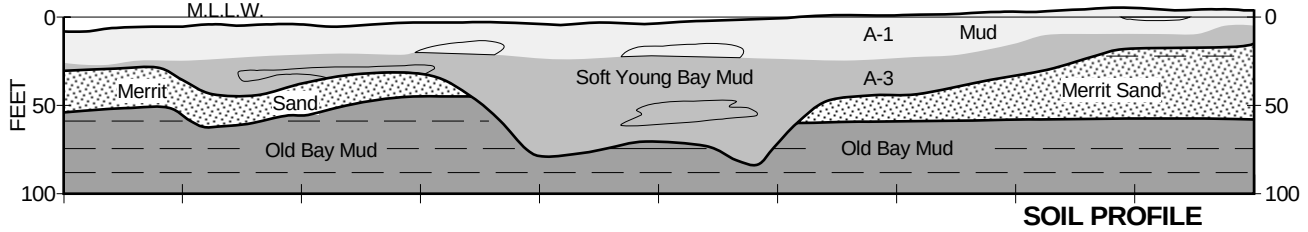
NORTHERN EXTENSION OF KEY SYSTEM MOLE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 4.2

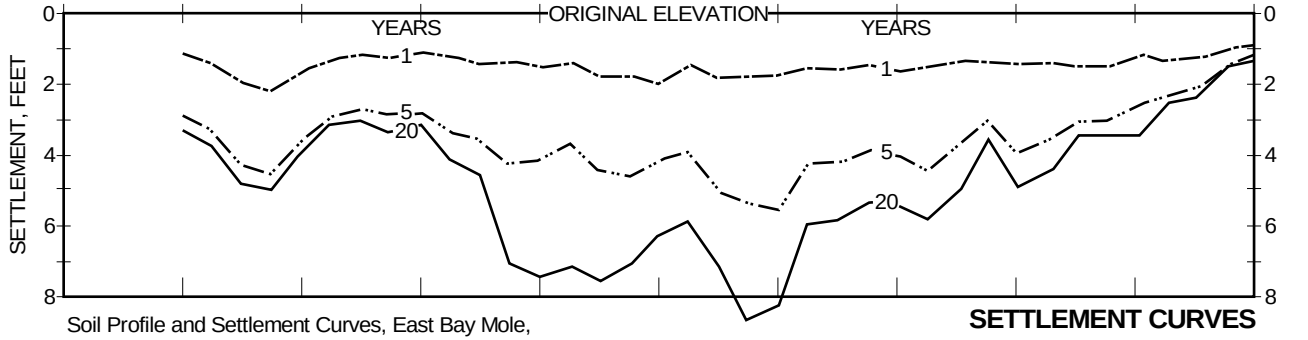
9842\0058mole.dwg(0,2-,3,8-14),ps,0058mole.pcp



PLAN OF MOLE



SOIL PROFILE



SETTLEMENT CURVES

Soil Profile and Settlement Curves, East Bay Mole, San Francisco-Oakland Bay Bridge (from Caltrans).

OAKLAND MOLE HISTORIC SETTLEMENT PROFILE

Oakland Shore Approach

SFOBB East Span Seismic Safety Project

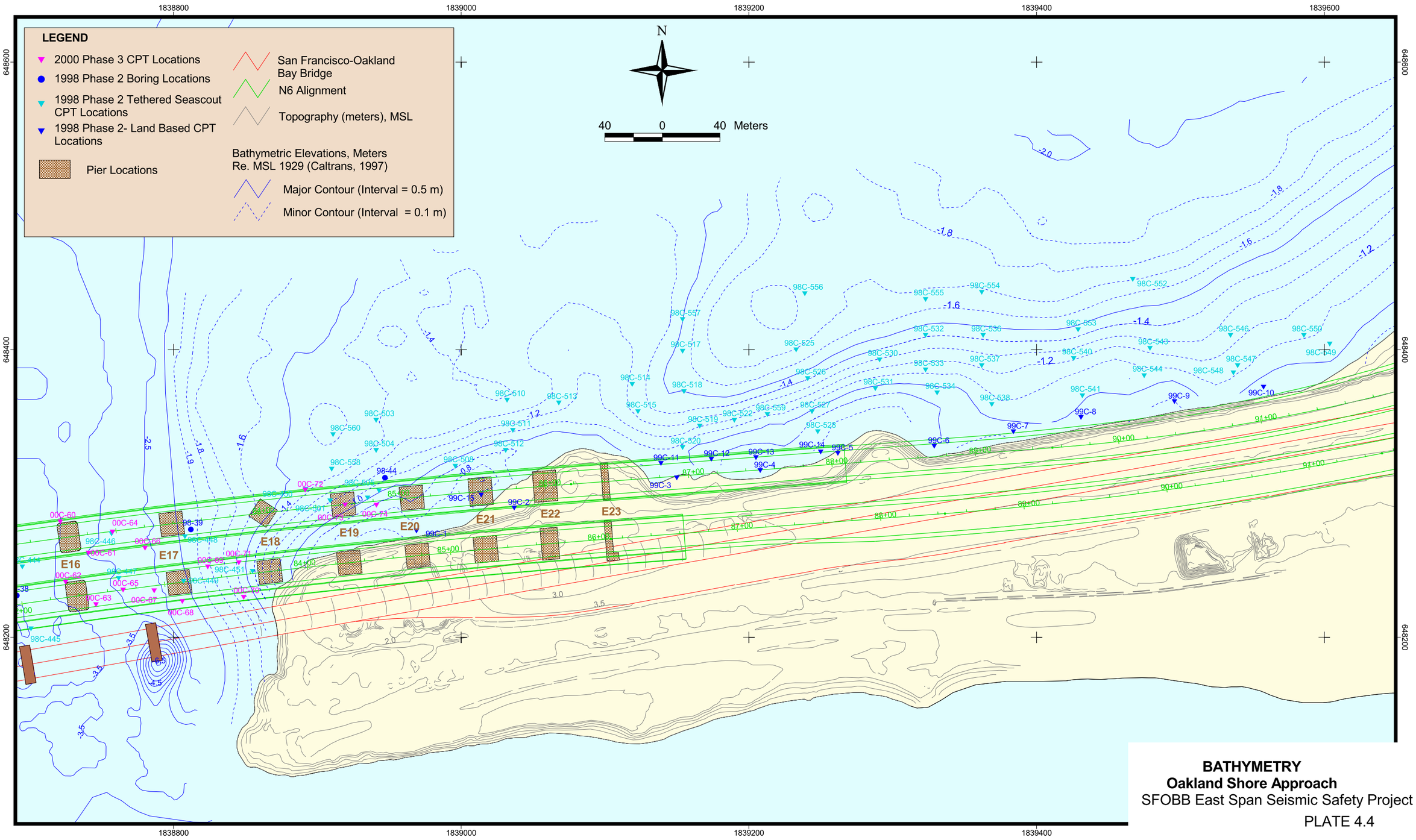
PLATE 4.3

Earth Mechanics

FUGRO

Earth Mechanics

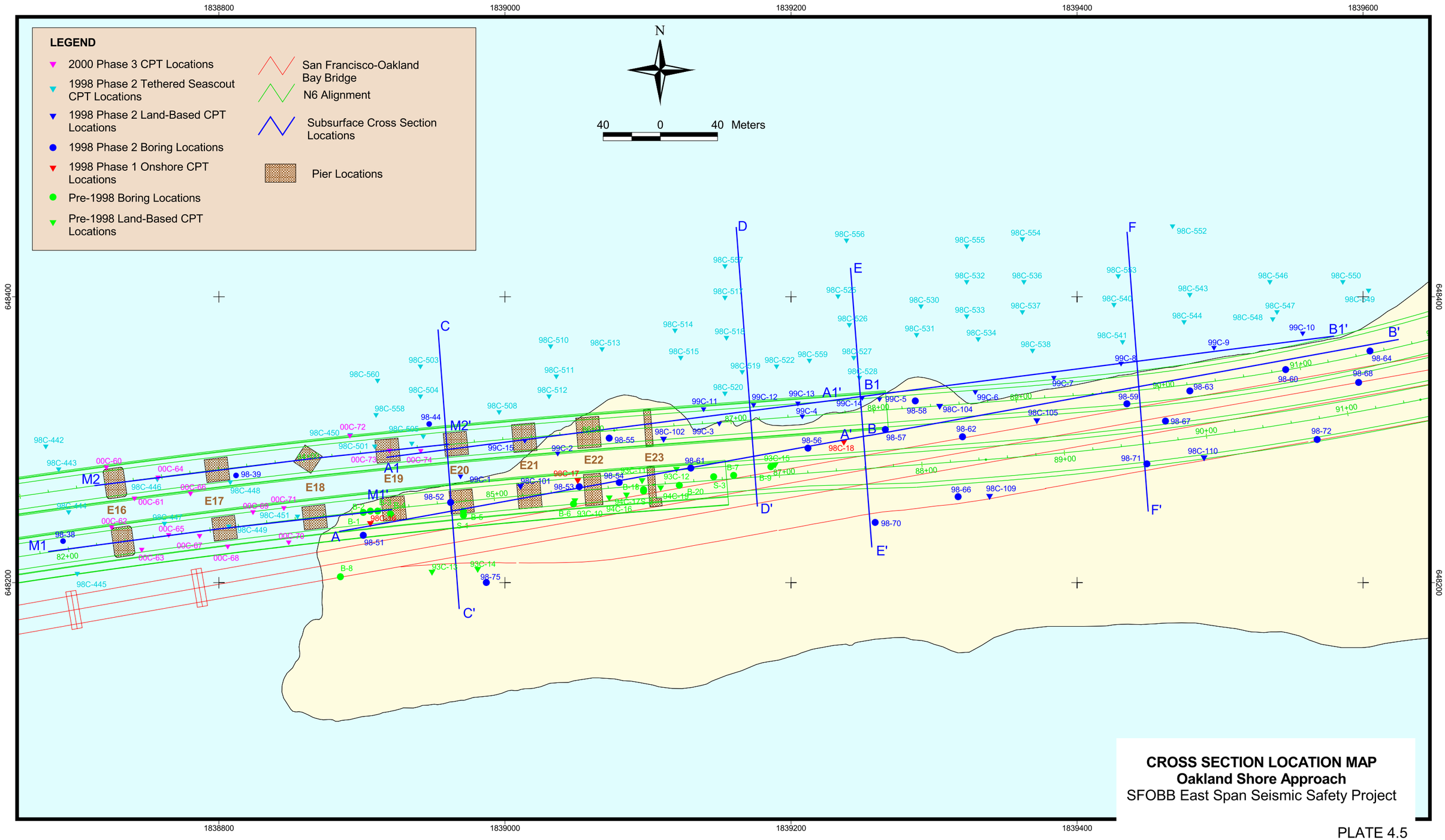
FUGRO



BATHYMETRY
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 4.4

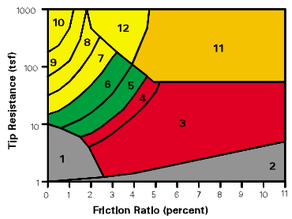
Earth Mechanics

FUGRO



CROSS SECTION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 4.5



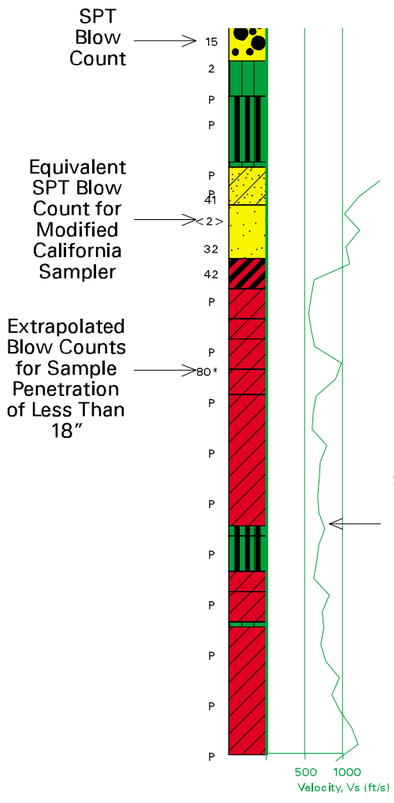
Zone	Soil Behavior Type	U.S.C.S.
1	Sensitive Fine-grained	OL-CH
2	Organic Material	OL-OH
3	Clay	CH
4	Silty Clay to Clay	CL-CH
5	Clayey Silt to Silty Clay	MH-CL
6	Sandy Silt to Clayey Silt	ML-MH
7	Silty Sand to Sandy Silt	SM-ML
8	Sand to Silty Sand	SM-SP
9	Sand	SW-SP
10	Gravelly Sand to Sand	SW-GW
11	Very Stiff Fine-grained *	CH-CL
12	Sand to Clayey Sand *	SC-SM

* overconsolidated or cemented

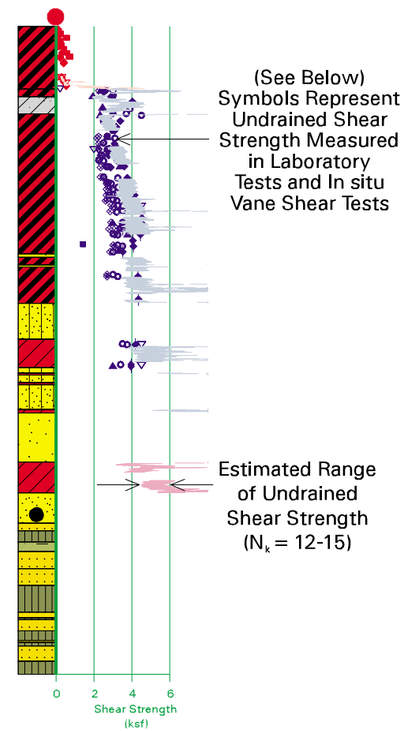
CPT CORRELATION CHART (Robertson and Campanella, 1984)

KEY TO CROSS SECTIONS

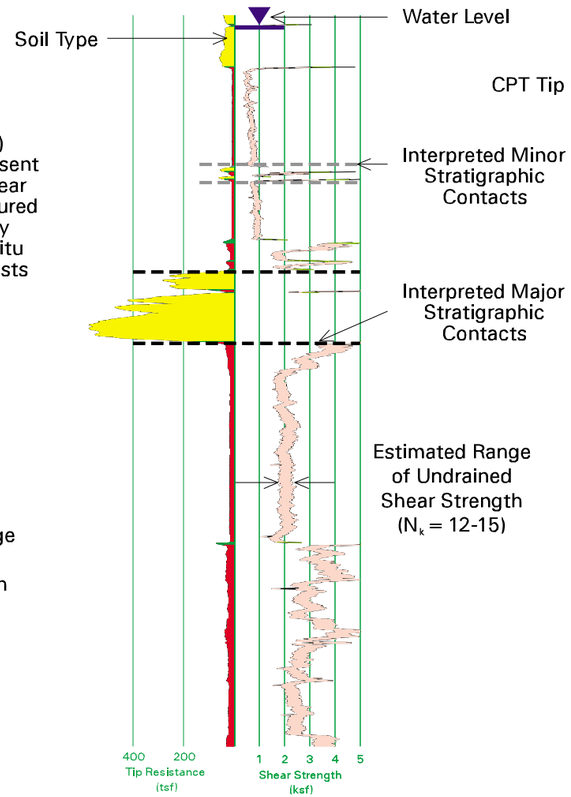
- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- GRAVEL with sand (GP or GW)
- GRAVEL with clay (GP-GC)
- Clayey GRAVEL (GC)
- GRAVEL with silt (GP-GM)
- Silty GRAVEL (GM)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- SAND with gravel (SP or SW)
- SAND with clay (SP-SC)
- Clayey SAND (SC)
- SAND with silt (SP-SM)
- Silty SAND (SM)
- Fat CLAY (CH)
- Sandy fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Silty CLAY (CL-ML)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Clayey SILT (ML/CL)
- Highly Plastic ORGANICS (OH)
- Low plasticity ORGANICS (OL)
- SANDSTONE (Rx)
- SILTSTONE (Rx)
- CLAYSTONE (Rx)
- Interbedded Rock Strata (Rx)
- CONGLOMERATE (Rx)
- Rock Fragments
- PAVEMENT



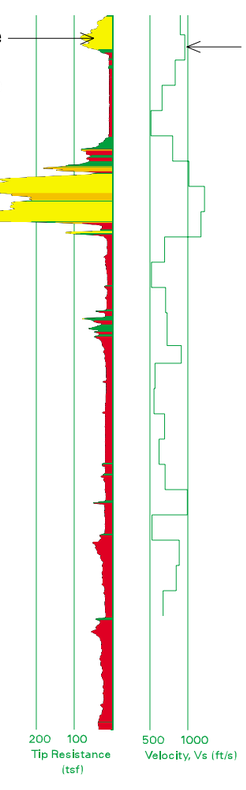
SOIL BORING
LITHOLOGY WITH
SHEAR WAVE VELOCITY



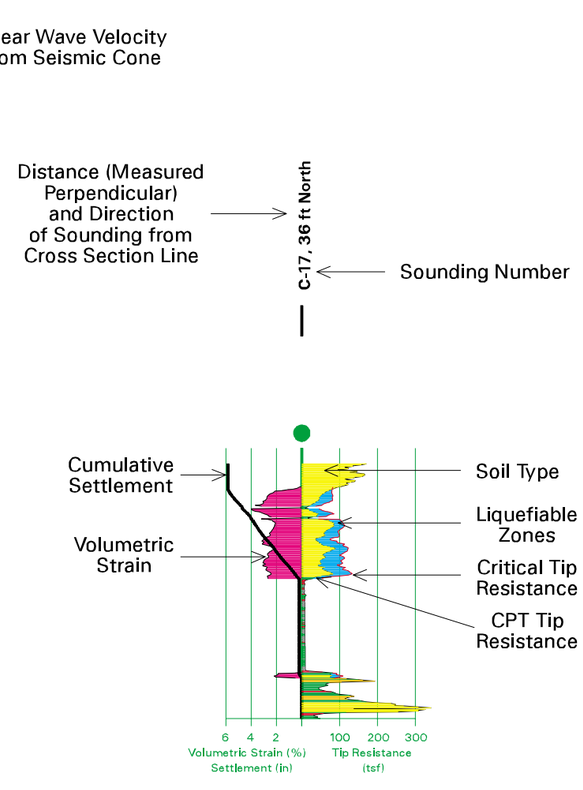
SOIL BORING
LITHOLOGY WITH
UNDRAINED SHEAR STRENGTH



CPT SOUNDING
WITH UNDRAINED SHEAR STRENGTH
AND INTERPRETED LITHOLOGY



CPT SOUNDING
WITH SHEAR WAVE
VELOCITY



CPT SOUNDING
WITH LIQUEFACTION
EVALUATION

Key to Undrained Shear Strength Symbols

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

Metric Conversions:

tsf = 0.0958 MPa
ksf = 47.9 KPa
ft/s = 0.3048 m/s
foot = 0.3048 m
inch = 2.54 cm

KEY TO CROSS SECTIONS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

M1 S82W

98-38, 19 m, North

00C-62, 35 m, North

Pier 16E

00C-63, 25 m, South

00C-65, 0 m, North

00C-67, 11 m, South

N82E

Pier 17E

00C-68, 43 m, South

S84W

00C-69, 28 m, North

00C-70, 50 m, South

Pier 18E

98-51, 52 m, South

M1' N84E

MEDIUM DENSE SAND

FILL

YBM

VERY SOFT TO FIRM CLAY

MPSA

VERY DENSE SAND

OBM

STIFF TO HARD CLAY

UAM

LAA

Tip Resistance (tsf) Shear Strength (ksf)

Shear Strength (ksf)

Elevation (feet)

Elevation (meters)

0, -50, -100, -150, -200, -250

0, -10, -20, -30, -40, -50, -60, -70

40ft

60ft

GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from CPT soundings, borings, and seismic reflection survey data. Conditions vary both along and perpendicular to the section line.

2) Refer to Key to Cross Sections (Plate 4.6) for descriptions of boring and CPT data shown above.

SHEAR STRENGTH SYMBOLS

- ▲ Unconsolidated Undrained (UU)
- □ Unconfined Compression (UC)
- ⊗ Pocket Penetrometer (PP)
- ⊕ Torvane (TV)
- ◆ Miniature Vane (MV)
- ◇ Remote Vane (RV)
- \+ Strength Exceeds Capacity of Measuring Device

KEY TO GEOLOGIC UNITS

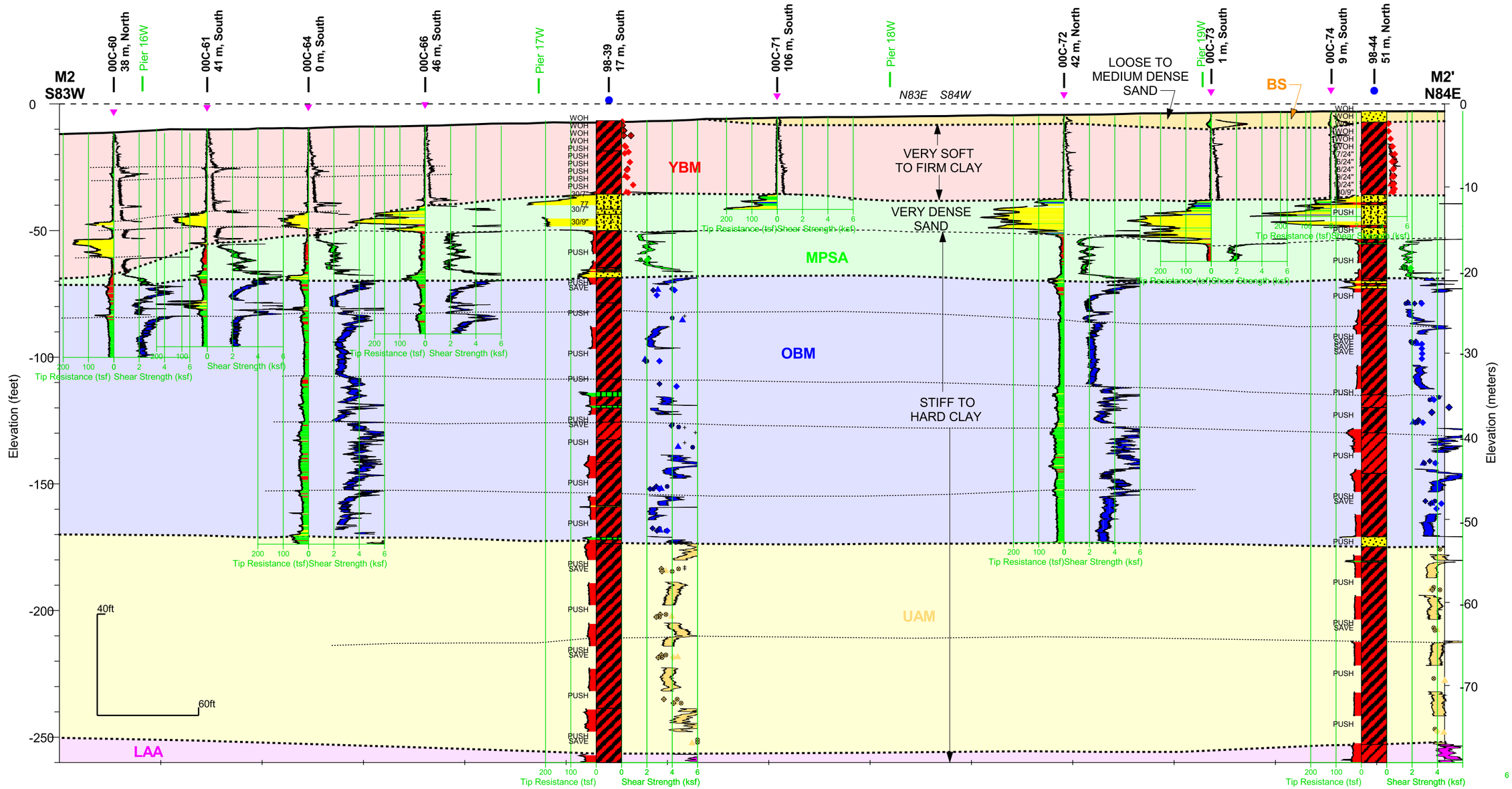
FILL	Fill/Buried Sand Fill	OBM	Old Bay Mud
YBM	Young Bay Mud	UAM	Upper Alameda Marine
MPSA	Merritt-Posey-San Antonio Formations	LAA	Lower Alameda Alluvial

SUBSURFACE CROSS SECTION M1-M1'
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project

PLATE 4.7a

Earth Mechanics

FUGRO



GENERAL NOTES:

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2) Refer to Key to Cross Sections (Plate 4.6) for descriptions of boring and CPT data shown above.

SHEAR STRENGTH SYMBOLS

- ▲ Unconsolidated Undrained (UU)
- □ Unconfined Compression (UC)
- ⊗ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ◇ Remote Vane (RV)
- \+ Strength Exceeds Capacity of Measuring Device

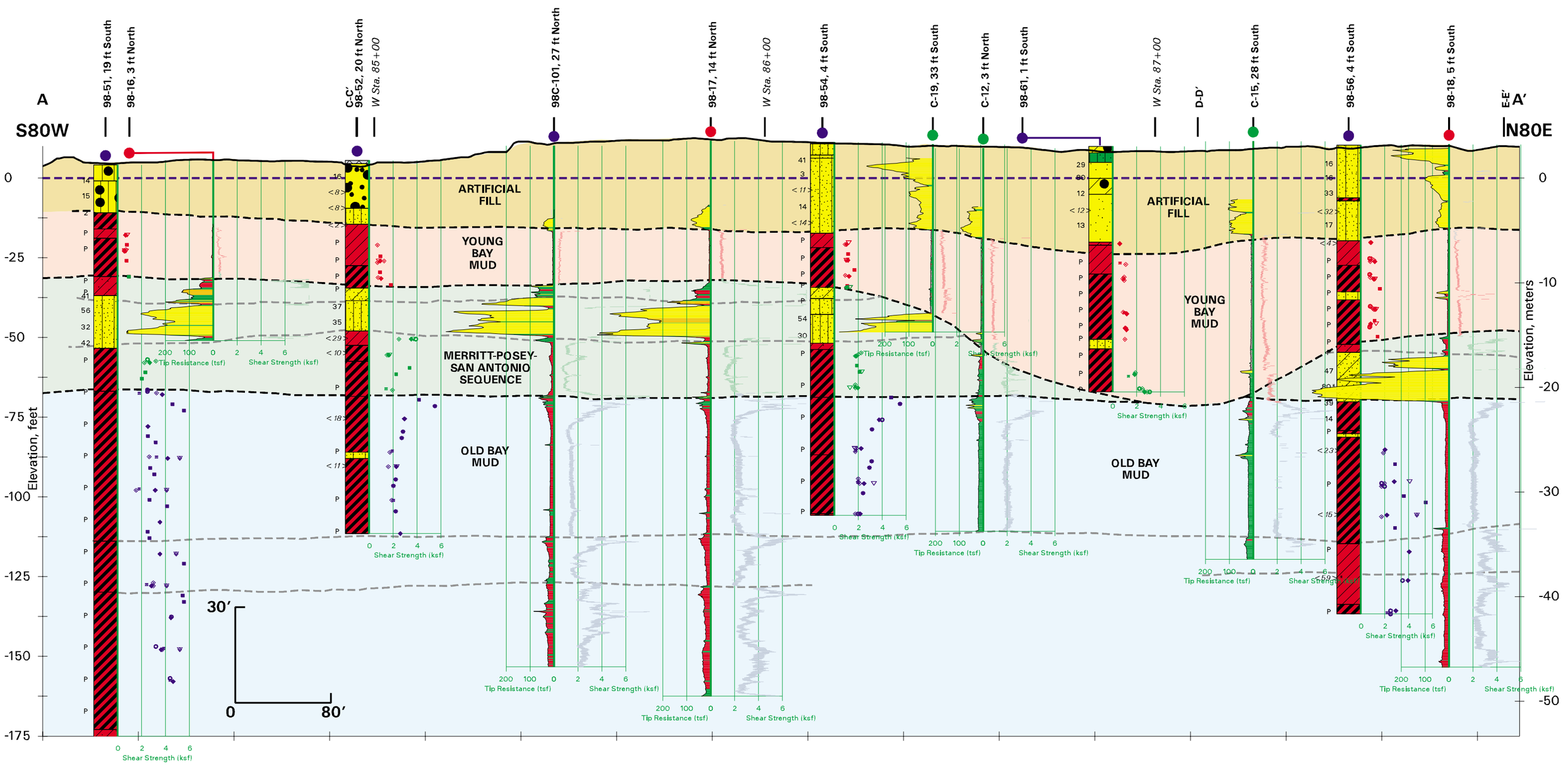
KEY TO GEOLOGIC UNITS

BS	Beach Sand	OBM	Old Bay Mud
YBM	Young Bay Mud	UAM	Upper Alameda Marine
MPSA	Merritt-Posey-San Antonio Formations	LAA	Lower Alameda Alluvial

SUBSURFACE CROSS SECTION M2-M2'
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project

PLATE 4.7b

Earth Mechanics FUGRO



GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.

2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.

3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.

4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION A-A'
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project

PLATE 4.7c

Earth Mechanics

FUGRO

B

S80W

W Sta. 88+00

98-57, 7 ft North

98-58, 59 ft North

98C-104, 36 ft North

98-62, 41 ft South

W Sta. 89+00

98C-105, 36 ft South

98-59, 34 ft South

F-F′

W Sta. 90+00

98-67, 89 ft South

98-63, 31 ft South

98-60, 22 ft South

W Sta. 91+00

98-68, 81 ft South

98-64, 14 ft South

B′

N80E

ARTIFICIAL FILL

YOUNG BAY MUD

MERRITT-POSEY-SAN ANTONIO SEQUENCE

OLD BAY MUD

Elevation, feet

0
-25
-50
-75
-100
-125
-150
-175

Elevation, meters

0
-10
-20
-30
-40
-50

Tip Resistance (tsf) Shear Strength (ksf)

Shear Strength (ksf)

30′

0

80′

GENERAL NOTES:

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2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.

3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.

4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

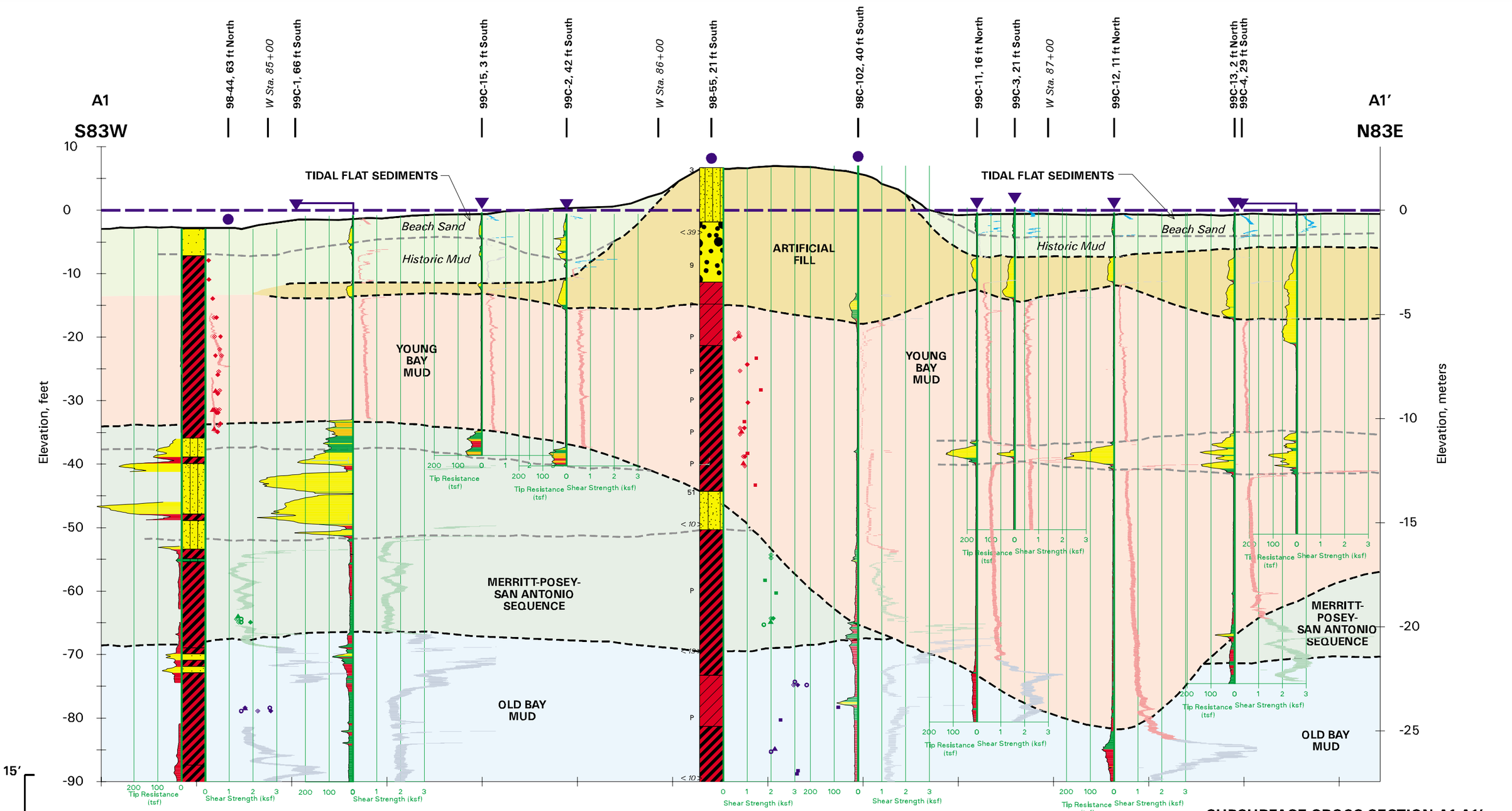
UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION B-B′
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project

PLATE 4.7d

Earth Mechanics FUGRO



GENERAL NOTES:

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2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

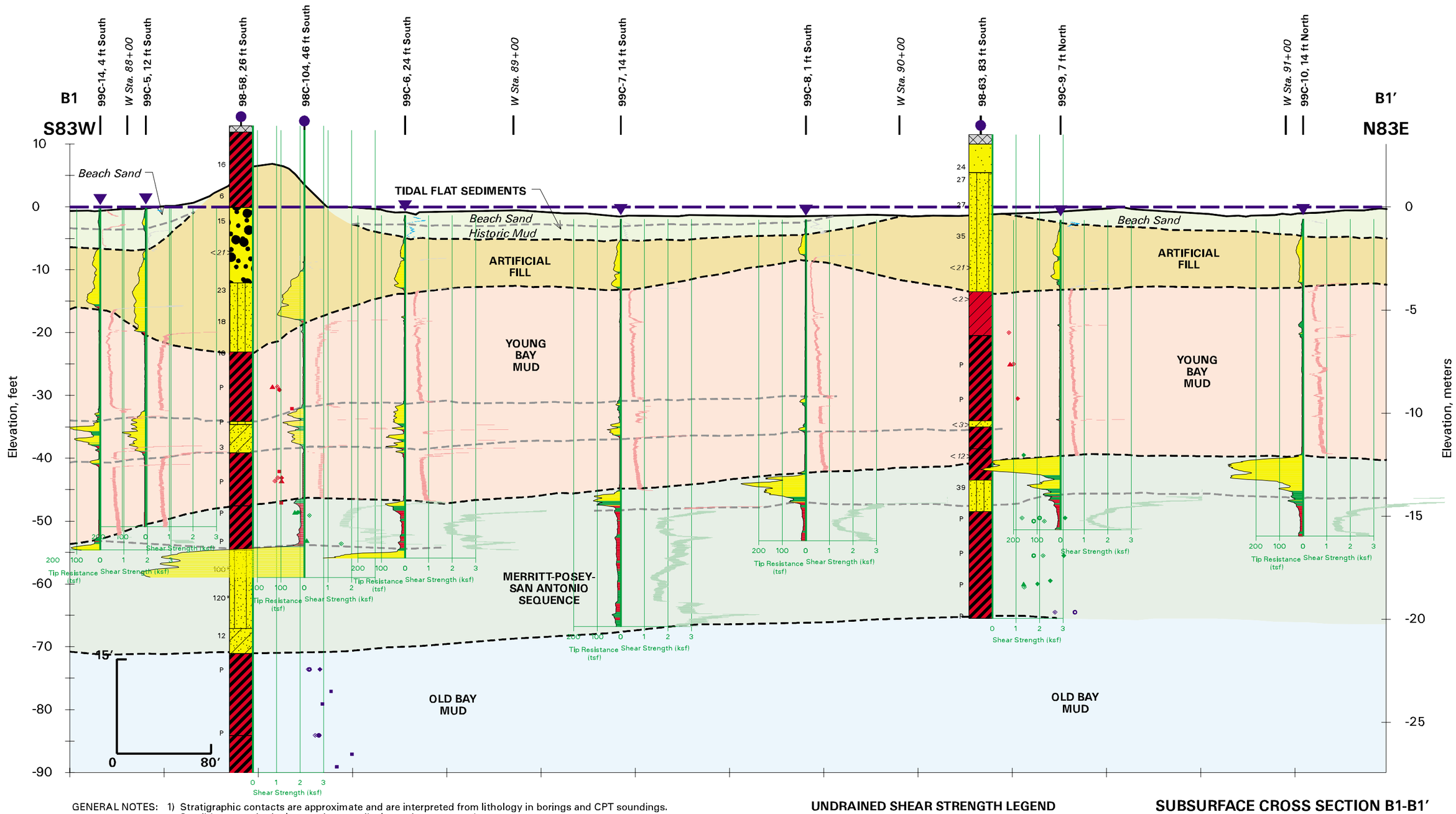
- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- | Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)

15′
0
80′

SUBSURFACE CROSS SECTION A1-A1′
With Undrained Shear Strength and CPT Tip Resistance
SFOBB East Span Seismic Safety Project

PLATE 4.7e

Earth Mechanics FUGRO



GENERAL NOTES:
1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

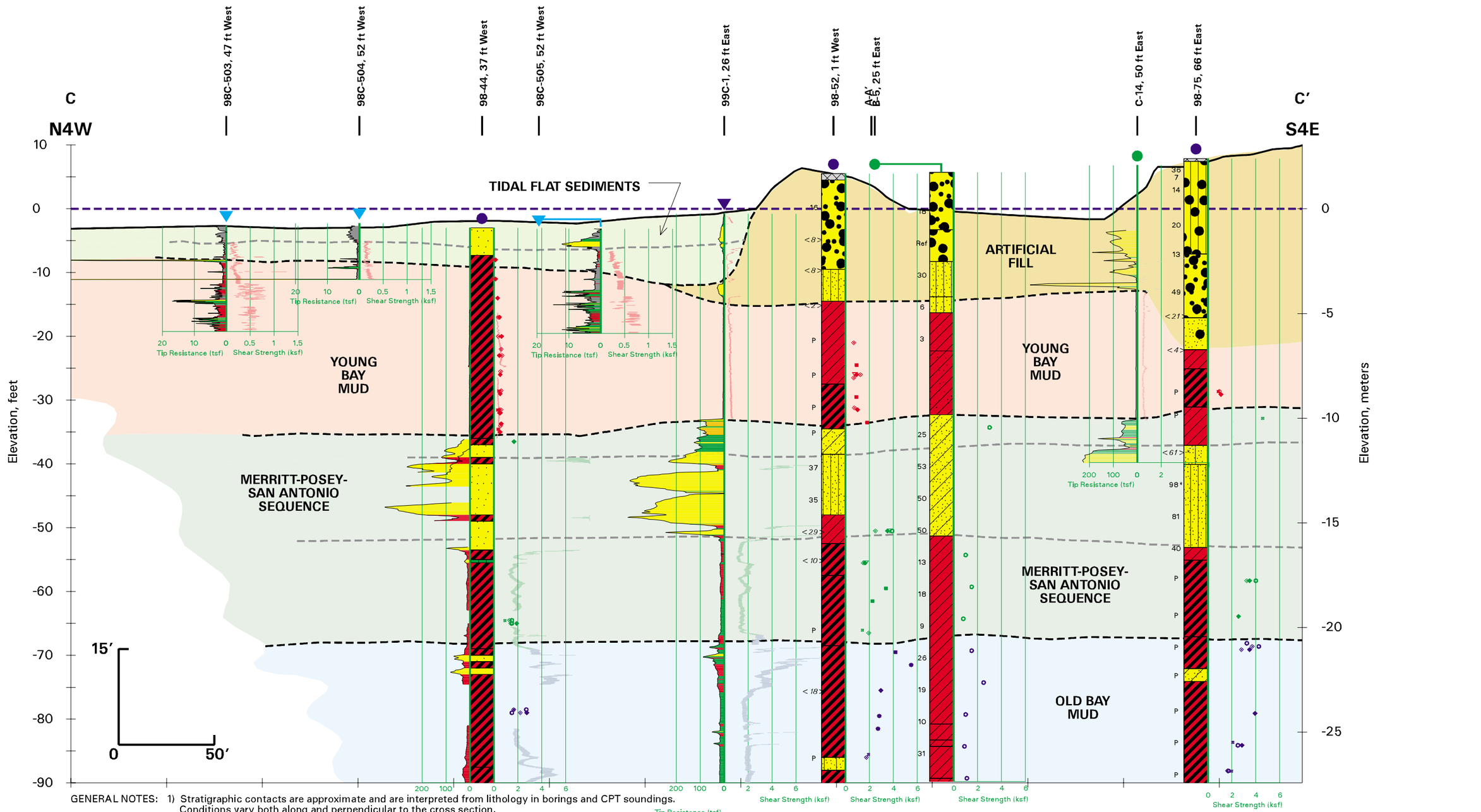
UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- | Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)

SUBSURFACE CROSS SECTION B1-B1′
With Undrained Shear Strength and CPT Tip Resistance
SFOBB East Span Seismic Safety Project

PLATE 4.7f

Earth Mechanics FUGRO



GENERAL NOTES:

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2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION C-C′
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project

PLATE 4.8

Earth Mechanics FUGRO

D
N4W

98C-557, 33 ft West
98C-517, 38 ft West
98C-518, 42 ft West
98C-519, 11 ft West
98C-520, 54 ft West
99C-12, 9 ft East
A-A'
C-15, 49 ft East
B-9, 38 ft East

D'
S4E

TIDAL FLAT SEDIMENTS
ARTIFICIAL FILL
YOUNG BAY MUD
OLD BAY MUD

Tip Resistance (tsf)
Shear Strength (ksf)

Elevation, feet
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90

Elevation, meters
0
-5
-10
-15
-20
-25

15′
0
50′

GENERAL NOTES:
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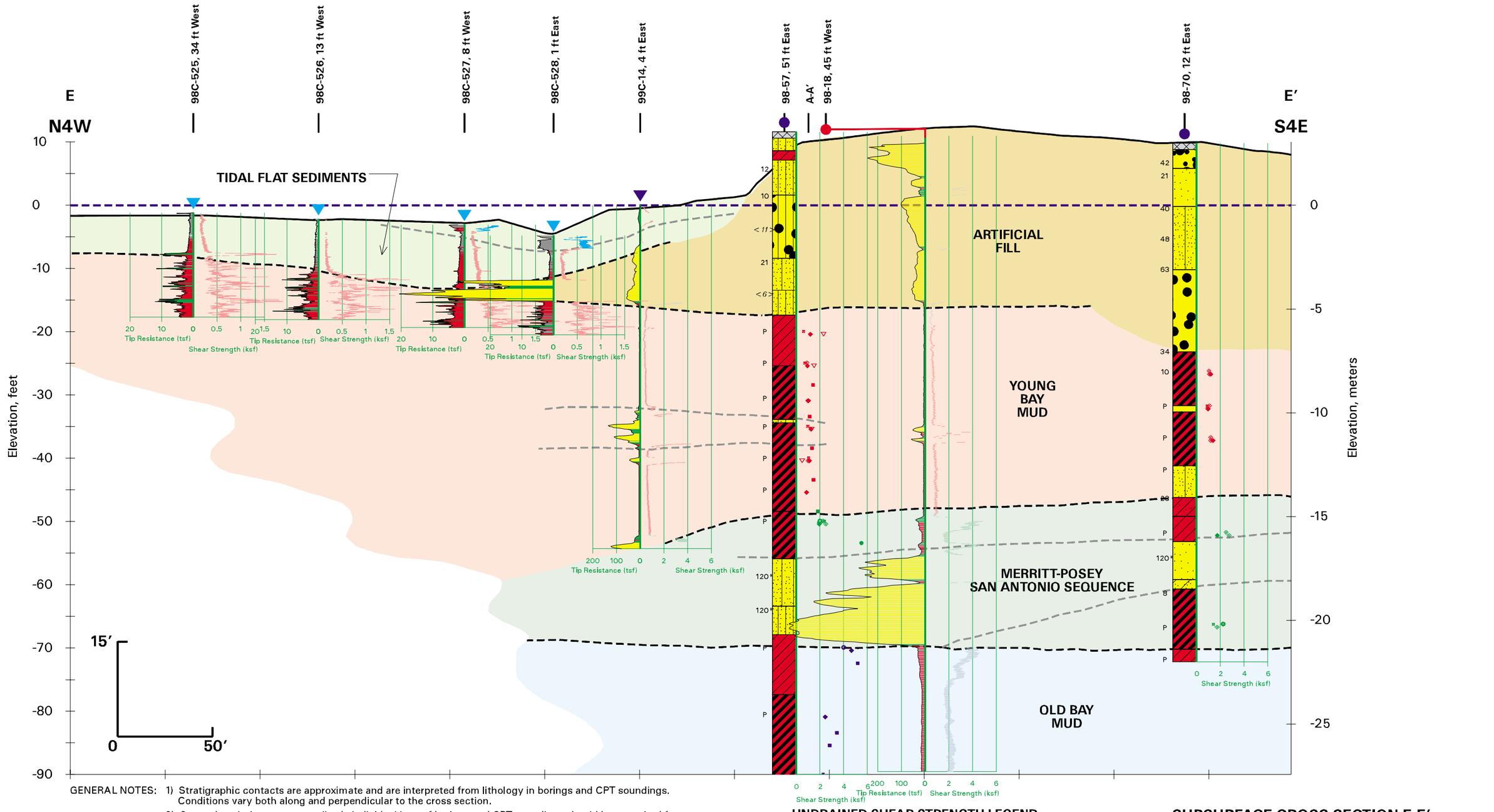
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION D-D′
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project
PLATE 4.9



GENERAL NOTES:
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2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION E-E′
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project
PLATE 4.10

Earth Mechanics FUGRO

F

N4W

98C-553, 28 ft West

98C-540, 43 ft West

98C-541, 31 ft West

99C-8, 36 ft West

B-B′

98-59, 30 ft West

98-67, 55 ft East

98-71, 5 ft East

F′

S4E

TIDAL FLAT SEDIMENTS

ARTIFICIAL FILL

YOUNG BAY MUD

MERRITT-POSEY SAN ANTONIO SEQUENCE

OLD BAY MUD

Tip Resistance (tsf)

Shear Strength (ksf)

Elevation, feet

Elevation, meters

10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90

-5
-10
-15
-20
-25

15′
0
50′

GENERAL NOTES:

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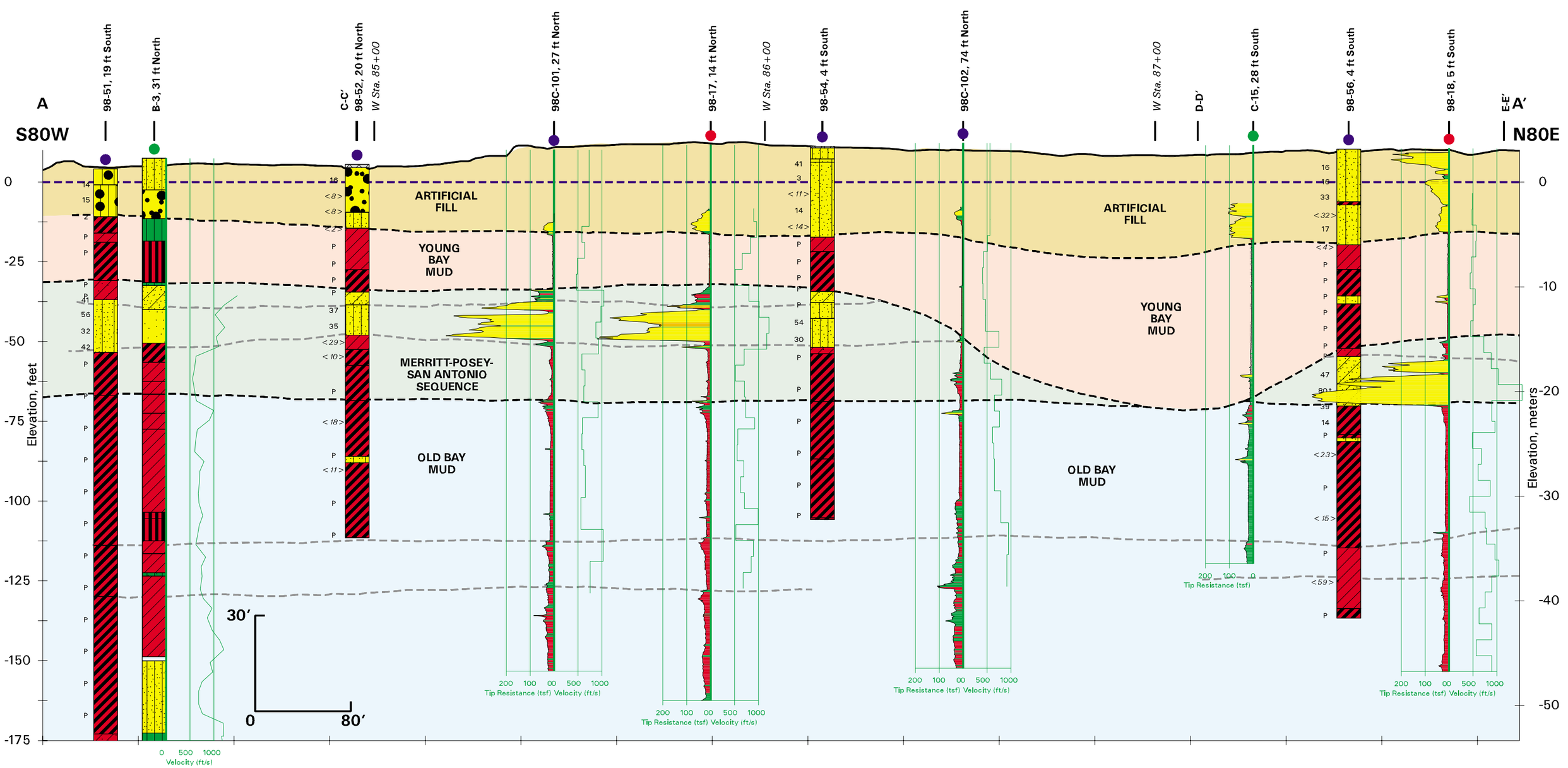
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

UNDRAINED SHEAR STRENGTH LEGEND

- ▲ Unconsolidated Undrained (UU)
- △ Unconfined Compression (UC)
- ○ Pocket Penetrometer (PP)
- ◈ Torvane (TV)
- ◆ Miniature Vane (MV)
- ■ Remote Vane (RV)
- ▽ Fall Cone (FC)

SUBSURFACE CROSS SECTION F-F′
With Undrained Shear Strength
SFOBB East Span Seismic Safety Project
PLATE 4.11

Earth Mechanics FUGRO



GENERAL NOTES:

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2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.

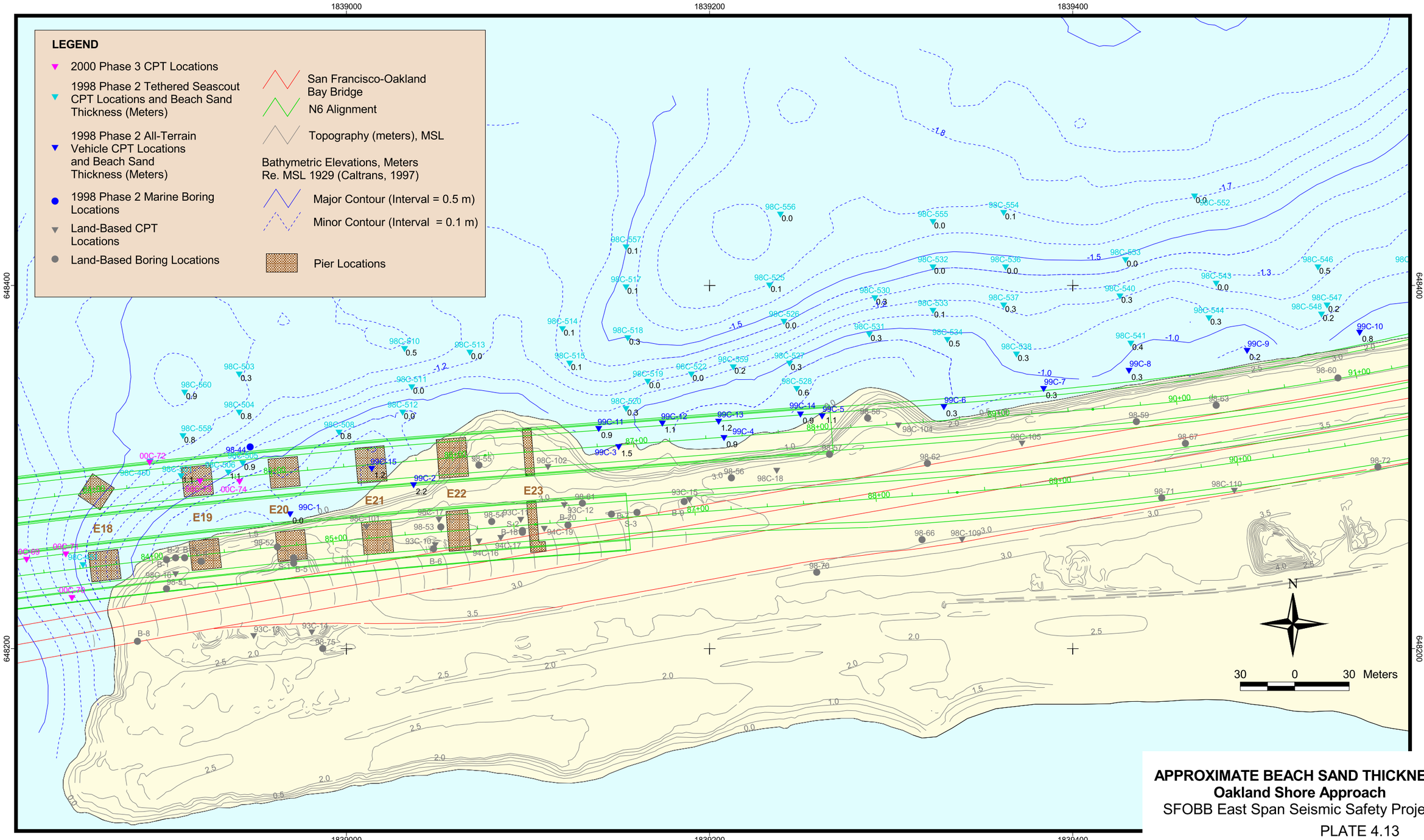
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.

4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

SUBSURFACE CROSS SECTION A-A′
With Shear Wave Velocity
SFOBB East Span Seismic Safety Project
PLATE 4.12

Earth Mechanics

FUGRO



APPROXIMATE BEACH SAND THICKNESS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 4.13

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Earth Mechanics

FUGRO

LEGEND

- 2000 Phase 3 CPT Locations
- 1998 Phase 2 Tethered Seascout CPT Locations and Buried Sand Thickness (Meters)
- 1998 Phase 2 All-Terrain Vehicle CPT Locations and Buried Sand Thickness (Meters)
- 1998 Phase 2 Marine Boring Locations
- Land-Based CPT Locations
- Land-Based Boring Locations
- San Francisco-Oakland Bay Bridge
- N6 Alignment
- Topography (meters), MSL

Bathymetric Elevations, Meters
Re. MSL 1929 (Caltrans, 1997)

- Major Contour (Interval = 0.5 m)
- Minor Contour (Interval = 0.1 m)
- Pier Locations

1839000 1839200 1839400

648400 648200

N

30 0 30 Meters

APPROXIMATE BURIED SAND THICKNESS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 4.14

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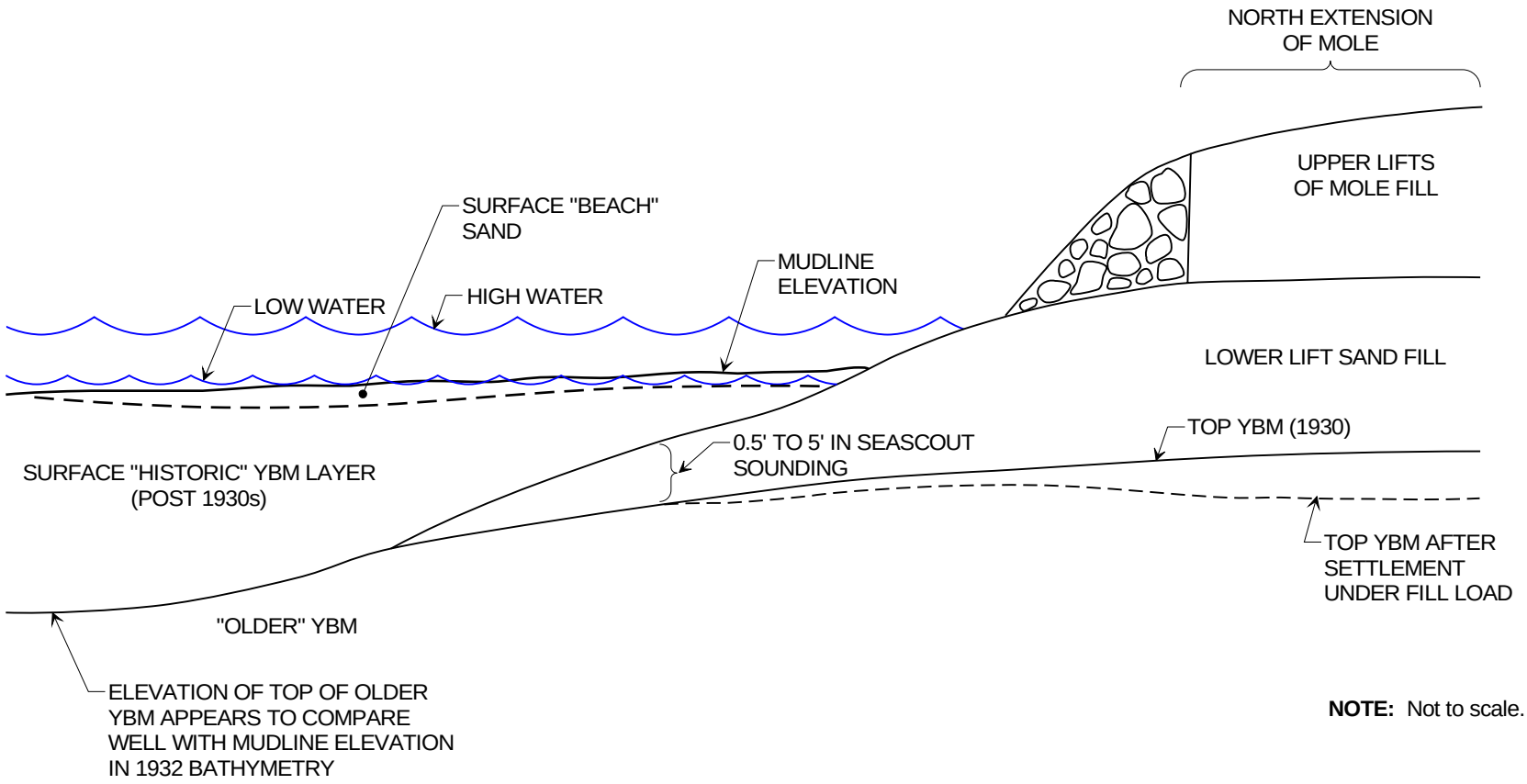

SIMPLIFIED CROSS-SECTION THROUGH
NORTHERN TIDAL FLAT AND OAKLAND SHORE APPROACH
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 4.15

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

Earth Mechanics

FUGRO

1838800 1839000 1839200 1839400

648400

LEGEND

- ▼ -16.5* 2000 Phase 3 CPT Locations
- ▼ -14.3* 1998 Phase 2 Land-Based CPT Locations
- ● -15.5* 1998 Phase 2 Boring Locations
- ▼ -9.8* 1998 Phase 1 Onshore CPT Locations
- ● -16.7* Pre-1998 Boring Locations
- ▼ -11.2* Pre-1998 Land-Based CPT Locations

* Elevation (m) of Base of Young Bay Mud in Exploration

NR = Exploration did not reach base of Young Bay Mud

N6 Alignment

San Francisco-Oakland Bay Bridge

Contours (m) of Base of Young Bay Mud

Contour Interval = 5 m

Contour Interval = 2.5 m

Note: Contours were developed from interpreted contacts in geotechnical explorations.

E16 Pier Locations and Number

Elevation (m) of Base of Young Bay Mud

- -7.5 to -10
- -10 to -12.5
- -12.5 to -15
- -15 to -17.5
- -17.5 to -20
- -20 to -22.5
- Deeper than -22.5

N

40 0 40 Meters

E16 E17 E18 E19 E20 E21 E22 E23

OAKLAND MOLE

648200

BASE OF YOUNG BAY MUD CONTOURS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 4.16

SECTION 5.0
ENGINEERING SOIL PROPERTIES

5.0 ENGINEERING SOIL PROPERTIES

5.1 CLASSIFICATION PROPERTIES AND UNIT WEIGHT OF SEDIMENTS

5.1.1 Classification Properties of Fine-Grained Sediments

In the vicinity of the Oakland Mole, marine clay sediments compose about 75 to 90 percent of the stratigraphic sequence that lies above the deep Lower Alameda Alluvial sediments. The fine-grained sediments are composed primarily of fat clay with lesser amounts of lean clays.

Plasticity. Consistent with the marine characterization program, the sediments comprising most of the Young Bay Mud (YBM), Old Bay Mud (OBM), and much of the Upper Alameda Marine (UAM) sequences are predominantly fat clays. Lower plasticity lean clay layers within those strata are predominantly encountered in crustal, overconsolidated zones. Outside of these crustal zones, the liquid limits of the fat clay sediments are generally similar.

The Atterberg limits for the sediments from the borings plot above the A-line of the plasticity chart, as shown on Plate 5.1. The liquid limits of the clay sediments typically range from about 40 to 82, and approximately 65 percent of the test specimens had a liquid limit of more than 50. The Young Bay Mud was typically less plastic and plots closer to the A-line of the plasticity chart than the Old Bay Mud. The upper few meters of the Young Bay Mud are typically siltier than the underlying clay deposits and tend to have a lower liquid limit. The plasticity index typically ranges from about 18 to 55.

Liquid limit and plasticity index data are plotted versus elevation by formation on Plates 5.2 and 5.3, respectively. The typical ranges of soil plasticity are summarized as follows:

- **Young Bay Mud** - A liquid limit of 40 to 70 and a plasticity index of 18 to 42. There is a noticeable trend of increasing plasticity with depth, due to generally decreasing silt content with depth.

  The liquid limit and plasticity index of several Young Bay Mud samples collected at all-terrain CPT locations along the foot of the Mole were similar to the sediments recovered from the land borings. The liquid limit of the Young Bay Mud underlying the tidal flat was generally higher than that encountered in land borings and ranged from 50 to 90.

- **Clay Layers in the Merritt-Posey-San Antonio (MPSA) Formations** - A liquid limit of 35 to 75 and a plasticity index of 25 to 50. The large range in plasticity within the MPSA Formations is due to the presence of both fat clays and sandy lean clays. The sandy clays typically have a liquid limit of 35 to 45 and a plasticity index

of 25 to 35. The fat clays are generally similar to the clay layers within the Young and Old Bay Muds.

- **Old Bay Mud/Upper Alameda Marine (OBM/UAM) Sediments** - Typically the OBM/UAM sediments have a liquid limit of 55 to 90 and a plasticity index of 35 to 60, with crust layers having a liquid limit of 35 to 45 and plasticity index of 20 to 30.
- **Tidal Flat Sediment** - The liquid limits and plasticity index of samples of historical bay mud collected at ATV-mounted CPT locations underlying the tidal flat to the north of the Mole were generally similar to the Young Bay Mud. The liquid limits were 62 and 92 with plasticity indexes of 38 and 55.

Grain Size. The grain-size characteristics of the fat clay, which comprises the majority of the Young Bay Mud and Old Bay Mud/Upper Alameda Marine sediments, show that: a) the percent minus the No. 200 sieve typically exceeds 85 percent, and b) the percent of clay-size particles that are finer than 0.002 mm generally ranges from about 30 to 55 percent. Lean clay layers within the Young Bay Mud typically contain about 15 to 30 percent clay-size particles that are finer than 0.002 mm. Those results are generally comparable to the results from the marine investigation and characterization program. The grain size of the historical bay mud underlying the tidal flat to the north of the Mole is judged to be generally similar to the fat clays and Young Bay Mud grain size properties. A sample of historical mud collected at an all-terrain CPT location shows that: a) the percent minus the No. 200 sieve exceeds 75 percent, and b) the percent of clay-size particles that are finer than 0.002 mm is about 22 percent. The typical ranges of grain size for the fat and lean clays from the Young and Old Bay Muds are shown on Plate 5.4.

5.1.2 Classification Properties of Granular Sediments

Granular soils were encountered down to the maximum depth explored in the Mole borings: a) as the artificial fill that comprises the majority of the top several meters of the subsurface, b) within the Merritt-Posey-San Antonio Formations as Merritt Sand, and c) as layers within the Old Bay Mud and Upper Alameda Marine sediments. Poorly-graded fine sand with silt and silty fine sand layers also are locally present above the Young Bay Mud on the tidal flat to the north of the Mole.

Typical grain-size characteristics of the granular materials are shown on Plate 5.4, the fines content data are plotted on Plate 5.5, and the mean grain size (D_{50}) data are plotted on Plate 5.6. The grain-size characteristics are summarized as follows:

- **Artificial Fill** - The fill typically consists of poorly graded fine sand with silt and silty fine sand with shell fragments. The poorly graded fine sand with silt and silty fine sand typically contain 5 to 14 percent finer than the No. 200 sieve and have a mean grain size of about 0.22 to 0.3 mm. Less prevalent, siltier layers contain up to

30 percent finer than the No. 200 sieve and have a mean grain size of between 0.12 and 0.22 mm.

- **Gravel and Rock in Artificial Fill** - The fill locally includes layers, pockets, and zones of gravel with sand, cobbles, and rubble. Riprap, cobbles, and gravel are present at the locations of buried rock dikes that were constructed during the placement of the Mole fill during the 1930s. Observations in the trench excavations indicate that the rock dike consists of a facing of angular and rounded riprap and quarry-run size round and angular cobbles. The face rock ranged from 0.6 to 1.2 meters in size and the core material ranged from 300 to 600 mm in size with small angular gravel filling the voids.
- **Merritt-Posey-San Antonio Formations -** The Mole investigation borings suggest that the sands within the MPSA Formations are typically poorly graded fine sand to silty fine sand with 6 to 25 percent finer than a No. 200 sieve and a mean grain size of about 0.18 to 0.26 mm.
- **Sand and Silt Layers in Old Bay Mud and Upper Alameda Marine -** In the sequence of primarily marine clays, sand layers were typically poorly graded fine sand with silt or silty fine sand with 5 to 15 percent finer than a No. 200 sieve.
- **Tidal Flat Sands -** Poorly-graded fine sand with silt and silty fine sand are locally present above the Young Bay Mud on the tidal flat to the north of the Mole. Grain size tests on a limited number of samples suggest that those tidal flat sands typically contain 4 to 10 percent finer than the No. 200 sieve and a have a mean grain size of about 0.2 to 0.25 mm.

5.1.3 Water Content and Unit Weights

Water Content. The measured water content data are summarized on Plate 5.7. The typical range of water content data are summarized as follows:

- **Artificial Fill** - Water content of the sand fill above the water table ranges from 4 to 13 percent. Below the water table, the water content of the fill is typically between about 15 to 26 percent. In the transition zone between the emergent and submerged fill, the water content typically ranges from 10 to 24 percent.
- **Tidal Flat Sediments** - The available water content data of the historical bay mud on the tidal flat to the north of the Mole typically ranges from about 40 to 100.
- **Young Bay Mud Beneath Mole** - The measured water content of the Young Bay Mud (YBM) beneath the Mole typically ranges from about 32 to 62 percent. Water content of up to 80 percent exists in local layers. The water content is frequently near the liquid limit. The water content is generally lower than the YBM data from the marine samples, where the water content generally ranges from 40 to 100 percent.

The difference is due to the consolidation of the YBM under the weight of the fill and the increased silt content in the upper few meters of the YBM underlying the Mole.

- **Young Bay Mud Beneath Tidal Flat** - Samples collected from the top 3 meters of Young Bay Mud to the north of the Mole indicate the water content typically ranges from about 65 to 75 percent.
- **Merritt-Posey-San Antonio Formations -** The water content in the Merritt Sand typically ranges from 20 to 32 percent, which is comparable to the marine characterization results. Water content of the fine-grained layers of the sequence typically is between 38 and 55 percent.
- **Old Bay Mud/Upper Alameda Marine Sediments** - Water content in the OBM/UAM sediments generally ranges from 35 to 55 percent. Lower values were measured in crustal zones and zones with a higher sand content. Although the water content has significant variability due to the presence of crust layers, there is a trend of decreasing water content with depth. The occasional granular layers generally have a water content of about 18 to 25 percent. This compares favorably with the results from the marine site characterization program where water content within the OBM/UAM sediments typically ranged from approximately 40 to 60 percent.

Unit Weights. The measured total unit weights are summarized on Plate 5.8. The typical range of unit weight data are summarized as follows:

- **Artificial Fill** - The total unit weights of the submerged fill ranges from 19.5 to 20.5 kilonewtons per cubic meter (kN/m^3). Unit weights as high as 21.8 kN/m^3 were measured in the fill.
- **Recent Young Bay Mud** - The total unit weights of the Young Bay Mud are generally between 16.4 and 18.4 kN/m^3, and generally decrease in depth due to the decreased silt and sand content.
- **Merritt-Posey-San Antonio Formations** - Total unit weights of the Merritt Sand range from 18.5 to 20.6 kN/m^3. The data compare favorably with the marine site characterization, where the unit weights of granular layers are generally between 18.6 and 20.2 kN/m^3. Unit weights within the fine-grained portions of the sequence typically range from 16.2 to 18.0 kN/m^3.
- **Old Bay Mud/Upper Alameda Marine Sediments -** Total unit weights in the OBM/UAM sediments range from 16.4 to 19.4 kN/m^3. The unit weights have significant variability due to the presence of crust layers, but there is a trend of increasing unit weight with depth. The occasional granular layers generally have submerged unit weights in excess of 19.4 kN/m^3.

5.2 CONSISTENCY AND SHEAR STRENGTH OF FINE-GRAINED SEDIMENTS

5.2.1 Undrained Shear Strengths From Laboratory and Remote Vane Testing

Both undrained shear strength measurements from laboratory tests on samples collected from land borings and in situ remote vane tests conducted in the land borings are summarized on Plates 5.9 through Plate 5.12. Plate 5.9 is a summary of all shear strength data plotted by test type. Plates 5.10 through 5.12 show shear strength data plotted by boring for the western, central, and eastern portions of the explored area of the Mole.

Some of the laboratory tests were conducted on driven samples. Examination of the data clearly shows that those test results are lower than the results of tests conducted on pushed samples or in situ vane shear tests. Those disturbance effects were recognized when formulating these interpretations of the in situ undrained shear strengths of the various sediments. In addition, the undrained shear strengths from laboratory miniature vane and in situ remote vane tests shown on Plates 5.9 through 5.12 include some tests on clay samples with sand seams and shells. The possibility that those test results, where sand seams are present within the test depth or specimen, may overestimate the strength also has been considered in these interpretations of the typical undrained shear strengths.

5.2.2 Undrained Shear Strengths Interpreted From CPT Testing

Undrained shear strengths have been estimated from the CPT measurements using the following expression:

$$S_u = (q_c - \sigma_{vo}) / N_k$$

Where: S_u = Undrained shear strength, kPa
q_c = Corrected cone tip resistance, kPa
σ_{vo} = Estimated in situ total vertical stress, kPa
N_k = Empirical cone bearing factor

Undrained shear strengths interpreted from CPT tip resistances are plotted on Plate 5.13. The data presented on Plate 5.13 are based on an empirical cone bearing capacity factor (N_k) of 12. The undrained shear strengths are calculated from tip resistances that are corrected for unequal cone end area effects.

Although the CPT data were filtered to exclude non-cohesive strata shown on the boring logs, the data presented on Plate 5.13 include scattered data points in thin sand seams and layers (plotting higher than the trend). Those abnormal test results were discounted when typical undrained shear strengths were interpreted.

5.2.3 Isotropically Consolidated-Undrained Triaxial Compression (CIUC) Results

Three series of CIUC tests were performed on Young Bay Mud samples. In each test series, three samples were consolidated to consecutively higher stress levels before being sheared in compression. Typically, one sample was consolidated to approximately the effective overburden pressure, while the second and third samples were consolidated to pressures approximately two and four times the effective overburden stress.

The results of the CIUC testing are summarized in Table 5.1. The measured undrained strengths of the samples consolidated to the effective overburden pressures ranged from 34 to 43 kPa, which is slightly higher than the undrained shear strength found in the field, laboratory, and CPT testing in the same borings. As expected, the results show that the undrained strength increases with increasing consolidation stress.

5.2.4 Variability of Undrained Shear Strength Measurements

Statistical evaluations of the variations in different types of undrained shear strength measurements were conducted to evaluate the results of the Mole data. A summary of the observations and conclusions is presented below.

Driven Samples, Pushed Samples, and In Situ Measurement Comparison. The undrained strength data from the Mole exploration plotted versus elevation (Plate 5.9) were evaluated by test type. The following observations are made relative to the differences among the laboratory vane test data on driven and pushed samples and the in situ vane testing data:

- The in situ remote vane measurements are consistently greater than the laboratory measurements on the samples.
- The laboratory measurements on the driven samples are consistently the lowest of the three measurements.
- The ratio of the laboratory miniature vane test measurements on pushed samples to the in situ vane results is less in the firm to stiff Young Bay Mud than in the stronger clay layers in the Merritt-Posey-San Antonio Formations or the Old Bay Mud.
- The difference between the laboratory measurements on the lower quality, driven modified California samples and the higher quality push samples is greater in the very stiff to hard Old Bay Mud than the soft to stiff Young Bay Mud.
- The ratio of laboratory measurement to in situ measurement is summarized below:

	Driven Samples	Pushed Samples
Young Bay Mud	0.4 to 0.7	0.6 to 0.85
Merritt-Posey-San Antonio Clay Layers	0.5 to 0.8	0.7 to 0.9
Old Bay Mud	0.65 to 0.8	0.75 to 0.95

The above observations are consistent with the sensitivity and potential for disturbance of the softer Young Bay Muds.

Comparison of Measurements From Different Test Types. In addition to evaluating the effect of different sampling procedures, the differences between different types of tests were also evaluated. To evaluate the data, cumulative frequency distributions of the different types of measurements were prepared for both the Young and Old Bay Muds. In addition, the cumulative frequency distributions were computed for the interpreted undrained shear strengths from the land CPT data based on an assumed N_k of 12. The cumulative frequency plots for the Young and Old Bay Muds are presented on Plates 5.14 and 5.15, respectively.

The following observations are made relative to the differences among the various types of measurements:

- In the firm to stiff Young Bay Mud, the CPT data and remote vane data suggest that about 10 percent of those measurements are affected by sand seams.
- After deleting that 10 percent of the data from the Young Bay Mud distributions and removing the measurements on driven samples from the data, the remaining data suggest that:
  - The ratio of unconsolidated-undrained triaxial test results to in situ vane results is about 75 percent.
  - The ratio of laboratory miniature vane results to in situ vane results is about 90 percent.
- In the very stiff Old Bay Mud, data from the CPT soundings, UU triaxial tests, and remote vane tests suggest that about 30 to 40 percent of those measurements are either in hard crust layers or affected by sand seams. Because laboratory miniature vane shear tests were frequently not performed in the hard crust layers, that data does not contain those higher strength layers.
- After the measurements in the crust and on driven samples are removed from the data, the Old Bay Mud distributions suggest that:
  - The ratio of unconsolidated-undrained triaxial test results to in situ vane results is about 80 percent.
  - The ratio of laboratory miniature vane results to in situ vane results is about 100 percent.

The cumulative frequency distributions also can be used to determine an appropriate N_k value for interpreting undrained shear strength from the CPT data. As noted earlier, recognizing that some of the unconsolidated-undrained triaxial measurements will underestimate the in situ shear strength and that some of the in situ vane tests may overestimate the undrained shear strength in layers with sand seams, N_k in the range of 10 to 13 for Young Bay Mud and 11 to 14 for Old Bay Mud appear applicable. Therefore, the interpreted undrained shear strengths based

on an N_k of 12 and plotted on Plate 5.13 are likely to be a slightly conservative estimate. The range of interpreted undrained shear strengths shown on the cross sections based on an N_k range of 12 to 15 are similarly slightly conservative.

5.2.5 Spatial Variability of Undrained Strength

Beneath the Mole. Plates 5.10 through 5.12 show undrained shear strengths by borings grouped in the western, central, and eastern portions of the Mole. As shown, the undrained shear strengths are generally similar throughout the Mole exploration area. With two exceptions, no significant spatial variations are observed.

The first exception is in the Young Bay Mud in the western portion of the site. In that area, the undrained shear strengths in the Young Bay Mud typically range from 23 to 60 kPa. In comparison, a range of 28 to 70 kPa appears to be more representative of the central and eastern areas. The lower undrained shear strengths in the western Mole area are interpreted to be due to: 1) lower overburden stresses (Borings 98-51 and 98-52) due to thinner fill sections, and 2) a thinner and younger fill section at Boring 98-55 on the western jughandle. As described subsequently, the consolidation data suggest that the Young Bay Mud is not fully consolidated under the weight of the more recent fill at that jughandle location.

The second exception is in the central area where the Young Bay Mud is thicker in the paleochannel. The data suggest that within the deeper portion of the paleochannel fill, the rate of increase in undrained shear strength with depth is less than elsewhere within the Young Bay Mud.

Differences Between Young Bay Mud Beneath the Mole and Adjacent Marine Areas The interpreted undrained shear strengths from the CPT data on the Mole and at the toe of the Mole slope are shown on Plates 5.16a and 5.16b. The results indicate that the undrained strengths of the Young Bay Mud measured on the tidal flats north of the Mole are typically 15 to 25 kPa lower than the shear strength beneath the Mole (Plate 5.16a). The higher shear strength beneath the Mole is primarily due to the consolidation of Young Bay Mud under the weight of the fill. The differences in undrained shear strength at the western end of the Mole and the western jughandle are quite small due to the relatively thin fill thicknesses at those locations (see Plate 5.16b). Similarly, lower shear strengths were computed from Seacalf CPT data in Young Bay Mud layers in areas to the north and west of the Mole than were measured in Young Bay Mud layers beneath the Mole. In general, the undrained shear strengths computed from Seacalf and ATV-mounted CPT data compare favorably. However, the undrained shear strengths from the Seacalf CPTs were typically slightly lower than undrained shear strengths measured from ATV-mounted tidal flat CPTs. This difference is attributed to the fact that the Seacalf CPTs generally encountered lesser thicknesses of sand overburden than the ATV-mounted CPTs. In areas of thicker sand overburden, the Young Bay Mud has likely consolidated to somewhat higher stresses and consequently has a higher undrained shear strength.

5.2.6 Summary of Undrained Strength

The consistency and undrained shear strength of fine-grained sediments is summarized as follows:

- **Young Bay Mud Beneath the Mole** - The Young Bay Mud beneath the Mole is typically firm to stiff with an undrained shear strength that increases with depth. The undrained shear strength typically ranges from 20 to 40 kPa at the top of the layer, and increases to about 35 to 60 kPa at the base of the layer. Where the paleochannel exists, the clay increases in strength with additional depth, albeit at a more gradual rate of increase. At the thalweg of the paleochannel, the interpreted undrained shear strength is 43 to 60 kPa.
- **Historical Bay Mud and Young Bay Mud Beneath the Adjacent Marine Areas** - The historical mud is typically very soft to soft with undrained shear strength (interpreted from CPT tip resistances) ranging from less than 5 to 20 kPa. As discussed above, the undrained shear strength of the Young Bay Mud beneath the tidal flat and the marine areas to the west of the Mole is less than the Young Bay Mud underlying the fill. The CPT data suggests that the undrained strength of the Young Bay Mud beneath these adjacent marine areas increases with depth from 15 to 35 kPa at the top of the layer to about 40 to 75 kPa at the bottom of the layer.
- **Clay Layers Within the Merritt-Posey-San Antonio Formations** - Clay layers within the MPSA Formations typically are stiff to very stiff sandy clay and clay with undrained shear strengths typically between about 60 and 120 kPa.
- **Old Bay Mud/Upper Alameda Marine Sequence** - These marine clays are generally very stiff to hard with shear strengths increasing from approximately 80 to 150 kPa near the top of the sequence to about 150 to 200 kPa at El. -69.5 meters where Boring 98-51 terminated. The adjacent marine Boring 98-44 reached the base of the OBM/UAM sequence at approximately El. -76.8 meters where the undrained shear strengths ranged from 144 to 215 kPa. The sequence includes several crust layers, generally including one at the top, where the undrained shear strengths are at least 25 to 70 kPa higher than the adjacent layers.

5.2.7 Effect of Cyclic Loading on Undrained Shear Strength of Young Bay Mud

A series of six pairs of simple shear tests (UC Berkeley, 1999 [reproduced in Volume 4]) were conducted to evaluate the effect of cyclic loading on the undrained shear strength of the Young Bay Mud. The test results are summarized in Table 5.2.

The test results suggest that for the range of cyclic shear stress amplitudes tested (single amplitude shear strains of from 1 to 3 percent), the ratio of the undrained shear strength after 25 cycles of load to the undrained shear strength prior to cyclic loading ranges from about 85 to 100

percent. The results did, however, show a significant degradation in the low strain shear modulus.

5.2.8 Strain Rate Effects

The undrained shear strength is affected by the rate of strain. Tests at different strain rates were conducted as part of the marine site characterization (Fugro-EM, 2001d). Those test results suggest that the undrained shear strength of the clay sediments beneath the project site generally increases by about 10 to 12 percent per log cycle of strain rate.

Idriss (1991) studied the stress-strain-strength behavior of clays under earthquake and wave loading conditions to understand strain-rate effects. Two frequencies (1 Hz and 0.05 Hz) were used to conduct cyclic loading in a laboratory. As reported in Idriss (1991), the cyclic shear stress with a 1 Hz frequency was about 68 percent higher than the static shear stress at 2-percent shear strain for Icy Bay Mud from Alaska. Even with a 0.05 Hz frequency, the tests show a 46-percent increase over the static shear stress.

Based on those studies, it is believed that strain-rate effects are inherent in the University of California at Berkeley cyclic simple shear tests because they were conducted with a loading frequency of 0.2 Hz. However, only a limited number of cyclic tests were conducted for the Young Bay Mud; thus, it is not possible to quantitatively assess the strain-rate effects from the University of California at Berkeley set of tests. A 40-percent increase from the static shear strength is proposed to account for strain-rate effects in the Young Bay Mud for the purpose of analysis of ground stability and lateral spreading issues.

5.2.9 Sensitivity and ε_{50}

Soil Sensitivity. Soil sensitivity is defined as the ratio of the undrained shear strength of an undisturbed sample to the shear strength of a remolded sample. This ratio is important in the prediction of soil resistance to pile driving. The ratio also can be used to evaluate possible disturbance of abnormally low values of undrained shear strength.

The sensitivities calculated from laboratory tests on samples from the Mole exploration borings are shown on Plate 5.17. The sensitivity is typically between about 2 and 4 in the Young Bay Mud and the upper 10 meters of the Old Bay Mud/Upper Alameda Marine sequence. Occasional lower sensitivities are inferred to suggest that the measurements of undisturbed shear strength have been adversely affected by sample disturbance. Most of those values were obtained in tests conducted on driven samples. Occasional higher sensitivities may be spurious, due to the presence of sand seams and shells in vane shear test specimens.

A range of 1.5 to 2 is more typical of the sensitivity of the clay layers in the Merritt-Posey-San Antonio Formations and the lower portion of the Old Bay Mud/Upper Alameda Marine sequence.

Sensitivity data also were analyzed from the remote vane testing conducted in the foundation borings (98-51 to 98-60). Sensitivity was taken as the peak undrained shear strength divided by the residual strengths (remote vane data are provided in the Volume 2 by-boring appendices). The sensitivities from the remote vane data form a relatively narrow band and typically range from 1.5 to 2.5 in the Young Bay Mud and Old Bay Mud sequences. These sensitivity estimates are generally less than the sensitivity calculated from the laboratory data. The lower values from the remote vane data may be due to the fact that remote vane residual shear strengths are not indicative of the completely remolded state achieved in the laboratory testing.

ε_{50} Value. The ε_{50} value is defined as the strain at 50 percent of the failure stress. The ε_{50} strain is used in the formulation of p-y curves for prediction of the lateral load-deflection response of pile foundation. Measured ε_{50} strains (as shown on Plate 5.18) typically range from 0.5 to 2.5 percent.

The following table summarizes the measured ε_{50} strains, the comparable values typically used (when high quality test data are not available) in conjunction with the methods of API RP 2A (1993), and the recommended ε_{50} values for p-y analyses:

Material	Typical Measured ε_{50} Strains (%)	Typical API Value (%)	Suggested ε_{50} Strain for p-y Formulation (%)
Soft to Firm Young Bay Mud	0.6 to 2.4	1 to 2	1.0
Firm Clay Layers in Merritt-Posey-San Antonio	0.5 to 3	1	0.75
Very Stiff (Old Bay Mud) Clay	0.5 to 2.5	0.5	0.5
Very Stiff to Hard (Upper Alameda Marine) Clay	0.5 to 2	0.5	0.5

The above interpretation of the representative ε_{50} strains for use in p-y formulation recognizes that the sampling process can lead to a softening of the stress-strain response, but not a stiffening.

5.3 DENSITY AND CONDITION OF GRANULAR SEDIMENTS

As noted previously, granular soils were encountered: a) as artificial fill that comprises the majority of the Mole, b) as thin layers within the Young Bay Mud and paleochannel clays, c) within the Merritt-Posey-San Antonio Formations, d) as layers within the Old Bay Mud and Upper Alameda Marine sediments, and e) within the tidal flat sediments to the north of the Mole.

5.3.1 Relative Density

Relative density (D_r) is defined as the ratio of the difference of the in situ void ratio and the maximum void ratio to the difference of the maximum and minimum void ratios. Relative density is a useful parameter in determining the frictional characteristic of granular soil and is

indicative of a soil's resistance to settlement and liquefaction. An assessment of relative density of granular soils encountered in the soil borings was carried out using correlations with CPT cone tip resistance and SPT blow count measurements.

CPT Cone Tip Resistance. Relative density from the CPT measurements was estimated using an empirical expression recommended by Robertson and Campanella (1989), and is given below:

$$D_r = [1/2.41]\ln[q_c/(157*(\sigma'_{vo})^{0.55})]$$

where: D_r = Relative density, decimal
q_c = Cone tip resistance, kPa
σ'_{vo} = Estimated in situ effective vertical stress, kPa

The above expression is based on studies originally performed by Schmertmann (1976) and later modified by Baldi et al. (1986). The expression has some limitations, including:

- Applies only to normally consolidated (coefficient of lateral earth pressure at rest of 0.45), moderately compressible, uncemented, unaged quartz sands with about 5 percent mica by volume.
- Is limited to an in situ effective vertical stress of about 500 kilonewtons per square meter (kN/m^2) (10 kips per square foot [ksf]).

It is noted that overburden stresses within the Upper and Lower Alameda sequences are generally in excess of the range used to generate the referenced correlation between tip resistance, overburden stress, and relative density. For the marine site characterization where cone data is available from the Alameda sequences, the expression was extrapolated for use at higher in situ effective vertical stresses.

Where appropriate, a correction has been applied to the measured q_c values to allow for fines content, using the correction procedure proposed by Robertson and Campanella (1989).

Cone tip resistance (q_c) values that have been calculated for relative densities of 15, 35, 65, 85, and 100 percent using the above expression are plotted on Plate 5.19. The average measured q_c values from field CPT data also are plotted on Plate 5.19 with the corresponding in situ σ'_{vo}, which is computed from an interpreted unit weight profile.

Blow Count Data. Relative density also can be estimated from a number of correlations with SPT blow counts in granular soils. A plot of normalized (to an overburden pressure of 95.8 kPa [1 ton per square foot]) N_1-values versus elevation sand deposits is shown on Plate 5.20.

A simple and often used correlation was presented by Terzaghi and Peck (1967). The correlation provides an approximation of the relative density for ranges of blow counts. The correlations are provided in the table below:

SPT N-value (blows/foot)	Relative Density	D_r (%)
0 to 4	Very loose	0 to 15
4 to 10	Loose	15 to 35
10 to 30	Medium Dense	35 to 65
30 to 50	Dense	65 to 85
> 50	Very Dense	85 to 100

Another correlation between blow count and relative density was presented by Kulhawy and Mayne (1990) and is given below:

$$D_r = \left[(N_1)_{60} / (60 + 25 \log D_{50})\right]^{0.5}$$

where: D_r = Relative density, decimal
$(N_1)_{60}$ = Normalized SPT blow count with 60-percent energy correction
D_{50} = Mean grain size, mm

In the above expression, D_{50} was taken to be 0.22 mm in the fine sands with silt and silty fine sand (which comprise the majority of the fill) and the Merritt Sand within the Merritt-Posey-San Antonio Formations. A plot of relative density versus elevation from SPT blow count data is presented on Plate 5.21.

Conclusions. Our interpretation of the typical density of the granular layers or strata are as follows:

- **Emergent Artificial Fill** - Above the water table, the fill is generally medium dense to dense with average SPT N-values ranging from 15 to 45 and measured cone tip resistances of between 6 and 29 MPa. The estimated relative density ranges from 65 to over 85 percent.
- **Submerged Hydraulic Fill** - Below the water table, the fill is generally loose to medium dense with SPT N-values ranging from 4 to 25 and measured cone tip resistances of between 1 and 10 MPa. The interpreted average N-value is about 15. The relative density is interpreted to range from 35 to 65 percent. In CPT sounding 98C-105, the fill encountered below El. -3 meters is dense to very dense. The measure cone tip resistances are over 20 MPa with an interpreted relative density of about 85 to 90 percent.

- **Tidal Flat Sediments** - The granular layers within the tidal flat sediments generally consist of a relatively thin surface layer of beach sand (up to 1 meter thick) and a locally continuous layer of sand along the northern Mole shoreline, which was likely deposited during the hydraulic placements of the lower submerged Mole fill (buried fill). The beach sand is generally loose to medium dense with relative densities ranging from 30 to 65 percent and measured cone tip resistances generally under 2.5 MPa. The buried fill is generally medium dense with relative densities varying from 40 to 70 MPa and measured cone tip resistances ranging from 2 to 5 MPa.
- **Sand Layers in Young Bay Mud** - A continuous sand layer measuring 0.3 to 1.5 meters thick is present in the Young Bay Mud between Borings 98-56 and 98-62, beginning along the eastern margin of the paleochannel. The sand layer is located approximately in the middle of the Young Bay Mud deposit at an elevation of approximately El. -10.5 meters. The CPT data indicate that this layer is dense with tip resistances ranging from 12 to 15 MPa. The relative density is interpreted to range from 65 to 70 percent.
- **Merritt-Posey-San Antonio Formations** - The Merritt Sand is generally dense to very dense with SPT N-values that range from 30 to greater than 50, and measured cone tip resistances of between 11.5 and 33.5 MPa. The interpreted relative density range is from 85 to over 100 percent.
- **Sand Layers in Old Bay Mud and Upper Alameda Marine** - Sand layers in the Old Bay Mud and Upper Alameda Marine sequences were encountered in the Mole exploration (Borings 98-51 and 98-52). The marine geotechnical site characterization (Fugro-EM, 2001d) indicates that these sand layers are generally dense to very dense with relative densities in excess of 75 percent, SPT N-values in excess of 50, and measured cone tip resistances of 20 to 45 MPa.

5.3.2 Drained Strength

Laboratory Data. Limited laboratory testing was performed to assess the frictional characteristics of the granular sediment encountered in the Mole explorations**.** A direct shear test was performed in the fine sand fill in Boring 98-63. The sample was obtained from a modified California liner sampler that was driven with a 63-kilogram hammer. Plots of the direct shear test are presented in the boring-specific appendices (Volume 2).

The direct shear test indicated an effective cohesion of 24 kPa and an effective friction angle of approximately 40 degrees. It is unlikely that the fill deposits are cemented and the apparent effective cohesion is interpreted to indicate non-linearity of the failure envelope with some reduction in effective friction angles at the higher confining stresses.

In addition, one isotropically consolidated-drained triaxial compression (CIDC) test was performed on a sample of fine sand fill from Boring 98-59. The sample also was obtained from

a modified California liner sample. Results are plotted in the boring-specific appendices (Volume 2A) and summarized in Table 5.3. The CIDC test indicated an effective cohesion of 10 (0.2 ksf) and an effective friction angle of approximately 47 degrees.

To assist in the interpretation of the drained strength of granular sediments, a total of 32 CIDC tests were performed on samples recovered from the 1998 marine borings. The test specimens included: 16 samples from sand layers in the Young Bay Mud, 7 samples from the Merritt-Posey-San Antonio Formations, 9 samples from sand layers in the Old Bay Mud/Upper Alameda Marine sequence, and 5 samples from the Lower Alameda Alluvial sequence. The test specimens were generally obtained from 54-mm-diameter tube samples driven with a 79-kilogram downhole hammer. Other specimens were obtained from 72-mm-diameter push samples.

A summary of the CIDC test results along with the results of classification tests performed on the specimen are presented in the Final Marine Geotechnical Site Characterization report (Fugro-EM, 2001d). Plots of consolidated-drained triaxial test results are presented in the boring-specific appendices.

Effective cohesion ranging from approximately 10 to as high as 150 kPa were interpreted from CIDC test results performed on sand samples from the Young Bay Mud, Merritt-Posey-San Antonio Formations, and Upper Alameda Marine sediments. While it is possible that these sediments may be slightly cemented, the apparent effective cohesion is interpreted to indicate non-linearity of the failure envelope with some reduction in effective friction angle at the higher confining stresses. Interpreted effective friction angle values were calculated by assuming no effective cohesion and considering only the failure stresses at the confinement that most closely approximated the in situ stresses. The laboratory data on marine boring samples and CPT test data indicate that the interpreted effective friction angle ranges from 34 to 40 in the sand layers within the Young Bay Mud, from 39 to 45 degrees in the Merritt-Posey-San Antonio Formations, and from 35 to 42 degrees in the Lower Alameda Alluvial sediments.

CPT Cone Tip Resistance. To supplement the laboratory test data, effective friction angles in the granular strata also were estimated using in situ CPT q_c data and the empirical expression recommended by Kulhawy and Mayne (1990):

$$\phi' = 17.6 + 11.0 \log \left[\frac{q_c / p_a}{\left(\sigma'_{vo} / p_a \right)^{0.5}} \right]$$

where: ϕ' = Effective friction angle
q_c = Measured cone tip resistance

σ'_{vo} = Effective overburden pressure
p_a = Atmospheric pressure

Cone tip resistance (q_c) values were calculated for ϕ' of 35°, 37.5°, 40°, 42.5°, and 45°, using the above expression, and are plotted versus effective vertical stress on Plate 5.22 along with the measured cone tip resistances (corrected for fines as described above).

Conclusions. Our interpretation of the typical frictional characteristics for those granular layers or strata are as follows:

- **Artificial Fill** - Above the water table, the effective friction angle of the fill is interpreted to range from approximately 40 to 45 degrees. Below the water table, the effective friction angle is interpreted to range from approximately 36 to 47 degrees. In CPT sounding 98C-105, the effective friction angle of the fill encountered below El. -3 meters is interpreted to be about 42 degrees.
- **Merritt-Posey-San Antonio Formations** - The effective friction angle of the Merritt Sand interpreted from the CPT data ranges from approximately 40 to 45 degrees, which is in general agreement with the data from the marine investigation.

5.4 CONSOLIDATION AND COMPRESSIBILITY PROPERTIES OF SEDIMENTS

5.4.1 State of Consolidation

Basis of Interpretation. The stress history of a soil formation can be evaluated by comparing the preconsolidation stresses with the existing overburden stresses. Preconsolidation stresses were estimated from 67 incremental consolidation tests. Those tests were performed (primarily) on relatively undisturbed SAVE tube samples and samples from Shelby tubes that were extruded in the field and stored in plastic quarts. Consolidation test results are presented in the boring-specific appendices (Volume 2). Table 5.4 summarizes the interpretations made from those tests and provides data from index tests performed on those samples.

The preconsolidation pressures (maximum past pressures) are interpreted from the consolidation test results using the Casagrande (1936) procedure and the Work Per Unit Volume Method proposed by Becker et al. (1987). Preconsolidation pressures also were estimated from CPT data using the following empirical correlation (Kulhawy and Mayne, 1990):

$$\sigma'_p = 0.33 (q_c - \sigma'_{vo})$$

where: σ'_p = Preconsolidation pressure
q_c = Cone tip resistance
σ'_{vo} = Effective overburden pressure

Preconsolidation data from the laboratory and CPT data from the land exploration are presented on Plate 5.23. The data are plotted versus effective vertical stress and show lines of constant OCR (which is the ratio of the preconsolidation pressure to the in situ effective overburden pressure). OCRs for all the laboratory data are plotted versus elevation on Plate 5.26. Similar data from the tidal flat CPTs and marine Borings 98-39 and 98-44 are provided on Plates 5.24 and 5.25. The preconsolidation stresses interpreted from CPT data generally agree favorably with those interpreted from the consolidation tests and can be used to extrapolate the state of consolidation between consolidation tests.

Interpretation. Out interpretation of the typical state of consolidation for the sediment underlying and adjacent to the Mole are as follows:

- **Young Bay Mud -** The laboratory test results indicate that the Young Bay Mud is generally normally consolidated with respect to the stresses imposed by the 1930s fill. The interpreted OCR values in the Young Bay Mud generally range from about 0.9 to 1.3 in the areas outside of the paleochannel. In the deeper portions of the paleochannel that cross beneath the Mole, the OCR of the lower portion of the Young Bay Mud is more typically about 0.8 to 1.1, which suggests that the deeper Young Bay Mud present within the lower section of the paleochannel may be slightly underconsolidated. This would indicate that these areas of the Mole may still be experiencing additional settlement due to the weight of the existing Mole fill.

  Beneath the western jughandle, the preconsolidation stresses interpreted from CPT sounding 98C-102 suggest that the Young Bay Mud sediments underlying that newer fill are underconsolidated. At that location, an OCR of about 0.6 to 0.8 is interpreted. The lower OCR agrees with the lower shear strength measurements from adjacent Boring 98-55 and may be due to relatively more recent filling of the jughandle area. The consolidation test run on a Young Bay Mud sample from Boring 98-55 indicates an OCR of 1.4, which matches the preconsolidation stress in the CPT sounding 98C-102 data at the same elevation. Interpreted CPT data (98C-104) and laboratory test data indicate that the Young Bay Mud underlying the eastern jughandle may also be slightly underconsolidated with an OCR ranging from 0.8 to 1.1.

- **Young Bay Mud Beneath the Tidal Flat -** Offshore from the Mole, the consolidation data from adjacent marine Borings 98-39 and 98-44 suggest that the Young Bay Mud is normally consolidated with an OCR of around 1. This is consistent with the data from the rest of the characterization where the OCR in the Young Bay Mud typically ranges from 0.9 to 2.0. The interpretation of the OCR from the ATV-mounted CPTs on the tidal flat indicate that the Young Bay Mud underlying the tidal flat is normally to slightly overconsolidated with OCRs typically decreasing from 2 to 3 at the top of the sequence to approximately 1.0 to 1.8 at the bottom of the sequence (see Plate 5.24). The higher OCR, however, does not necessarily represent overconsolidation. Due to the relatively low overburden

pressures at the top of the Young Bay Mud sequence, the estimated past pressures are only on the order of 40 to 80 kPa in excess of the estimated vertical overburden pressure.

- **Merritt-Posey-San Antonio Formations and Old Bay Mud/Upper Alameda Sequence** - The clay layers within the Merritt-Posey-San Antonio Formations, the Old Bay Mud, and the Upper Alameda Marine sediments are generally overconsolidated. Beneath the Mole, the OCR of the clay layers in the Merritt-Posey-San Antonio (MPSA) Formations is typically between about 1.2 and 2.5. The interpreted OCR typically ranges from about 2.5 to 3.5 in the various crust layers within the Old Bay Mud and top of the Upper Alameda Marine sediments. Below the crust layers, the interpreted OCR of the Old Bay Mud and top of the Upper Alameda Marine sediments typically ranges from about 1.3 to 1.8. The CPT data also show that the preconsolidation stresses in the crustal zones of the Old Bay Mud sequence are up to 500 kPa greater than the preconsolidation pressures in the rest of the sequence.

  The preconsolidation pressures in the MPSA, Old Bay Mud, and Upper Alameda Marine interpreted for the sediments beneath the Mole are similar to the values interpreted from the marine borings. The OCRs of those sediments, however, are lower beneath the Mole than beneath the San Francisco Bay farther to the west. The lower OCR is attributable to the additional stresses imposed by the weight of the Mole fill. Because those additional stresses likely did not exceed the preconsolidation pressure of the older deposits, it is logical to assume that the majority of the settlement that occurred below the Mole was due to consolidation of the Young Bay Mud.

- **Clay Layers Within the Lower Alameda Alluvial Sediments** - The marine geotechnical site characterization (Fugro-EM, 2001d) indicated that the OCRs tended to reduce with depth and are on the order of 1 to 2 at the base of the Lower Alameda Alluvial sequence. Although the majority of the sediments appear to have OCRs on the order of 2 to 3, overconsolidated crustal zones with OCRs on the order of 3 to 5 are common within these sequences. The relatively low OCRs at greater depths are not strictly indicative of normal or light overconsolidation, since the interpreted maximum past pressures are on the order of 300 to 800 kPa higher than the estimated overburden stresses.

5.4.2 Compressibility

Undisturbed Samples. The compression (C_{ec}) and recompression (C_{er}) ratios interpreted from consolidation tests are summarized on Table 5.4 and plotted on Plate 5.27.

The compression ratios for the primarily fat clays of the Young Bay Mud sequence range from approximately 0.12 to 0.30. The majority of the data for the Young Bay Mud are between

approximately 0.14 and 0.25. In the Old Bay Mud and Upper Alameda Marine sequences, the compression ratios for the primarily fat clays range from approximately 0.12 to 0.35.

Recompression ratios were estimated for tests on samples that included an intermediate rebound/recompression loop. The recompression ratios are generally between about 0.01 and 0.04.

Remolded Consolidation Tests. Two series of incremental consolidation tests were conducted on samples that were remolded at their natural water content and at their natural water content plus 5 to 8 percent. Plate 5.28 shows the results of a series of tests performed on Young Bay Mud samples taken from Boring 98-73, where a series of four incremental consolidation tests were run on samples between 7.9 and 9.4 meters. Three tests were run on a sample obtained from a driven modified California sampler, one from the extruded sample, and two remolded tests at water contents of 40 percent (natural water content) and 48 percent. The fourth test was run on a relatively undisturbed push tube sample. The results on Plate 5.28, show the effects of increasing sample disturbance and illustrates the effects of remolding on the compressibility of the Young Bay Mud. At a load of 120 kPa (near the preconsolidation stress), the driven sample and the sample remolded at a water content of 40 percent strained approximately 200 to 250 percent more than the relatively undisturbed sample. The sample remolded at a water content of 48 percent strained approximately 500 percent more than the relatively undisturbed sample. The results of the remolded consolidation tests are summarized in Table 5.4.

5.4.3 Coefficient of Consolidation

Vertical Samples. The coefficient of consolidation (c_v) was estimated from incremental consolidation tests. The coefficient of consolidation is generally highest in the overconsolidated range prior to the load reaching the preconsolidation pressure, and then decreases as the loading reaches and exceeds the preconsolidation pressure. The measured c_v values at the interpreted effective overburden pressure (which are typically between the c_v values in the overconsolidated range and those in the normally consolidated range) are plotted on Plate 5.29.

In general, the c_v values ranged from approximately 1 to 40 square meters per year (m^2/yr), although some values over 100 m^2/yr were calculated at stresses lower than the interpreted preconsolidation stress and along the intermediate reloading loops. At the effective overburden stress, approximately two-thirds of the c_v values are between 1 and 10 m^2/yr. In the normally consolidated range, at loads greater than the preconsolidation stress, the c_v data range from approximately 1 to 15 m^2/yr, but are typically less than 5 m^2/yr.

Multi-Oriented Samples. For Phase 2 of the marine geotechnical site characterization program (Fugro-EM, 2001d), a series of 14 multi-orientation consolidation tests were performed. In each series of tests, either two or three consolidation tests were performed from the same sample with the only variable being the orientation of the trimmed sample. In the two-test series,

the central axis of the specimen was either parallel or perpendicular to the axis of the boring (i.e., the specimen's orientation was vertical or horizontal, respectively). In the three-test series, an additional specimen with a 45-degree orientation also was tested.

The multi-orientation testing indicated that in the normally consolidated range of loading, the ratio of the horizontal c_v to the vertical c_v ranged between about 1 and 5 with an average value of approximately 2. The ratio of the 45-degree c_v to the vertical c_v ranged between 0.5 and 2.4 with an average of 1.1, indicating that the change in c_v with specimen orientation is relatively minor until there is a 90-degree change in orientation. This is consistent with the interpretation that the differences in c_v are primarily attributable to minor layering of the sediments.

Radial Consolidation Tests. Radial consolidation tests were performed by the University of California at Berkeley (1999) on conventional Shelby tube samples of the Young Bay Mud to evaluate the time rate of radial consolidation under applied isotropic stress increments with radial drainage. The procedures, method of interpretation, and results of these tests are discussed in Volume 4.

Two samples from depths of approximately 10 and 12 meters were tested under both convergent flow (towards the sample) and divergent flow (outward from the sample) conditions. The rates of consolidation for convergent flow and divergent flow were 1.8 and 3.6 m^2/yr and 0.3 and 1 m^2/yr, respectively. These c_v values are similar to the horizontal c_v measured in the multi-orientation consolidation tests discussed above. The lower rates from divergent flow were subsequently discounted due to technical difficulties encountered in the laboratory in maintaining a free-draining boundary on the circumference of the soil sample. As a result, the higher rates for convergent flow (with an average rate of about 2.7 m^2/yr) are considered more representative of horizontal radial flow conditions, such as those that would occur around a drainage well or wick drain.

5.5 SHEAR WAVE VELOCITY OF SEDIMENTS

Downhole shear wave velocities (Vs) were measured in five seismic CPTs (98C-17, 98C-18, 98C-101, 98C-102, and 98C-109) on the Mole and in two seismic CPTs (99C-13 and 99C-15) on the tidal flat to the north of the Mole. The measured Vs data are plotted versus elevation on Plate 5.30 and are also shown on the CPT logs in Volume 3. Only a limited amount of shear wave velocity data were obtained in the Mole fill due to the necessity of predrilling through the rubble in the fill.

The Vs data as measured in the different soil layers are summarized below:

- **Mole Fill Below El. 0** - Variable Vs between about 150 and 280 meters per second (m/sec).

- **Young Bay Mud Beneath Mole** - Vs typically between about 130 and 180 m/sec, with locally higher measurements at the top of the Young Bay Mud in some locations and in the bottom of the paleochannel in others.
- **Young Bay Mud Beneath Tidal Flat** - Vs data from two seismic CPTs (98C-13 and 98C-15) indicate that Vs is typically between about 100 and 160 m/sec, with lower measurements at the top of the sequence ranging from 60 to 80 m/sec.
- **Merritt-Posey-San Antonio Formations** - Variable Vs between 140 and 350 m/sec due to layered nature of sequence. In primarily clay zones, the Vs is typically less than 230 m/sec, while in dense sand layers the Vs is typically in excess of 260 m/sec.
- **Old Bay Mud** - In the Old Bay Mud, the Vs measurements tend to increase with depth. At the top of the layer (about El. -20 meters), the Vs typically ranges from about 180 to 230 m/sec. At about El. -35 meters, the Vs measurements are typically about 200 to 250 m/sec. Vs values of 280 to 320 m/sec were obtained in crust layers.

The shear wave velocities, obtained from the seismic CPTs, generally correlate favorably with the different strata identified from the CPT and boring explorations.

The Vs values in the Young Bay Mud under the Mole are slightly higher than those found in the marine investigation. This is due to the Young Bay Mud under the Mole being more consolidated due to the overlying fill and the higher silt content in the upper several meters of the sequence. The maximum Vs values in the Merritt Sand also are slightly higher than those from the marine investigation (Fugro-EM, 2001d). The Vs values in Old Bay Mud generally fall within the range of values found in the marine investigation.

Shear wave velocity data also are available from a previous Caltrans boring (B-1) located near the western end of the Mole. Those Vs data were collected in the Merritt Sand and underlying Old Bay Mud. No data were available in the Young Bay Mud. The Vs for the Merritt Sand was about 305 to 460 m/sec, which compares well with the seismic CPT results. Measured Vs values in the Old Bay Mud ranged from about 180 to 335 m/sec and generally increased with depth.

5.6 CYCLIC PROPERTIES OF YOUNG BAY MUD

5.6.1 Test on Mole Boring Samples

A total of six soil samples extruded from Shelby tubes collected within the Young Bay Mud were tested to investigate the stress-strain behavior under large cyclic strain and the post-earthquake properties at the University of California at Berkeley. The purpose of this program was to understand the stress-strain behaviors before and after an earthquake. One of the specimens was sheared monotonically from a virgin state, while the other was cyclically loaded to a specified strain amplitude and number of cycles and then monotonically sheared without

allowing the specimen to reconsolidate. The results of those tests are presented in the University of California at Berkeley report (1999) reproduced in Volume 4.

5.6.2 Tests on Phase 1 Marine Boring Samples

In addition to the dynamic tests conducted at UC Berkeley on selected SAVE tube samples from the Mole borings, dynamic tests were conducted on Young Bay Mud samples during the Phase 1 preliminary site investigation phase. During Phase 1, dynamic tests were conducted on both Young Bay Mud and Old Bay Mud samples at Fugro's Houston laboratory and at the University of Texas at Austin. Those tests included Resonant Column, Torsional Shear, and Cyclic Simple Shear tests. Our interpretation of the test results is provided in the Final Marine Geotechnical Site Characterization report (Fugro-EM, 2001d). The test results are provided in reports by Fugro South (1998) and the University of Texas at Austin (1998), which are reproduced in Volume 4 of the Phase 1 Subcontractor reports (Fugro-EM, 1998).

Boring Number	98-57			98-64			98-67		
Sample Number	**20A**	**20B**	**20B**	**13A**	**13B**	**13C**	**12A**	**12B**	**12C**
Penetration									
meters	16.9	17.1	17.2	11.0	10.9	10.7	11.1	11.0	10.8
feet	55.6	56.0	56.4	36.2	35.6	35.2	36.5	36.0	35.6
Unit	YBM	YBM	YBM	YBM	YBM	YBM	YBM	YBM	YBM
Moisture Content (%)									
Initial, W_0	53	49	53	45	44	45	52	46	45
Final, W_f	50	38	37	42	39	33	47	38	33
Atterberg Limits									
Liquid Limit, LL	57	57	57	43	43	43	53	53	53
Plastic Limit, PL	22	22	22	21	21	21	23	23	23
Initial Total Unit Weight, $\gamma_{t,0}$									
kN/m^3	16.7	16.8	16.5	17.4	17.4	17.4	16.8	17.4	17.4
pcf	107	107	105	111	111	111	107	111	111
Interpreted In Situ Preconsolidation Stress, σ'_p									
kPa (Casagrande Method, 1936)	158	158	158	144	144	144	153	153	153
ksf	3.3	3.3	3.3	3.0	3.0	3.0	3.2	3.2	3.2
Interpreted In Situ Preconsolidation Stress, σ'_p									
kPa (Work per Unit Volume, Becker et al, 1987)	148	148	148	141	141	141	158	158	158
ksf	3.1	3.1	3.1	3.0	3.0	3.0	3.3	3.3	3.3
Estimated In Situ Effective Vertical Stress, σ'_{v0}									
kPa	182	182	182	137	137	137	141	141	141
ksf	3.8	3.8	3.8	2.9	2.9	2.9	2.9	2.9	2.9
Estimated In Situ Overconsolidation Ratio, OCR									
OCR - Casagrande Method	0.9	0.9	0.9	1.0	1.0	1.0	1.1	1.1	1.1
OCR - Becker Method	0.8	0.8	0.8	1.0	1.0	1.0	1.1	1.1	1.1
Estimated In Situ Coeff. of Horizontal Stress (k_o)	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
Pre-Shear Effective Stress, σ'_{vc}									
kPa	177	383	766	134	240	479	134	240	479
ksf	3.7	8.0	16.0	2.8	5.0	10.0	2.8	5.0	10.0
Measured Undrained Shear Strength (S_u)									
kPa	87	145	262	78	109	179	71	102	181
ksf	1.8	3.0	5.5	1.6	2.3	3.7	1.5	2.1	3.8
Failure Strain, ε_f (%)	2.9	4.8	6.2	3.8	4.7	6.5	3.5	7.3	6.3
Undrained Strength Ratio									
Su/σ'_{vc}	0.49	0.38	0.34	0.59	0.46	0.37	0.53	0.43	0.38
Su/σ'_m [$s'_m = (\sigma'_{vc}+2*\sigma'_{hc})/3$]	1.47	1.14	1.03	1.76	1.37	1.12	1.58	1.28	1.13
Undrained Shear Strength at In Situ Stresses									
kPa	89	69	62	80	62	51	74	60	53
ksf	1.9	1.4	1.3	1.7	1.3	1.1	1.5	1.3	1.1
Effective Cohesion									
kPa	13			12			15		
ksf	0.3			0.3			0.3		
Estimated Effective Friction Angle (ϕ') [degrees]	30			33			32		

SUMMARY RESULTS OF
CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TESTING
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Boring No.	Sample Pair	Depth (m)	Static Shear Strength (Pre-Cyclic) (kPa)	Cyclic Strain (%)	Initial Cyclic Stress (kPa)	Final Cyclic Stress @ 25th Cycle (kPa)	Static Shear Strength (Post Cyclic) (kPa)
98-55	1	10.98	45	1	40	33	42
98-52	2	10.98	50	2	52	33	50
98-59	3	9.15	47	1	45	33	56
98-60	4	10.98	48	1.5	45	33	48
98-56	5	18.60	72	3	73	45	60
98-62	6	12.50	51	3	52	33	47

SUMMARY OF CYCLIC SHEAR TESTING PROGRAM ON YOUNG BAY MUD
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Boring Number	**98-59**
Sample Number	**4**
Penetration	
meters	6.4
feet	21.0
Strata Designation	Artificial Fill
Moisture Content (%)	
Initial, W_o	22
Gradation	
-200 (%)	8
D_{50} (mm)	0.23*
Wet Unit Weight	
kN/m^3	20.2
pcf	128
Dry Unit Weight	
kN/m^3	16.6
pcf	105
Effective Cohesion	
kPa	10
ksf	0.2
ϕ' (degrees)	47
In Situ Effective Overburden	
kPa	97
ksf	2.0
Test Confining Stresses	
kPa	28
ksf	0.6
kPa	55
ksf	1.2
kPa	110
ksf	2.3
ϕ' (degrees) -at σ'_{vo} & c' = 0	48

SUMMARY OF CONSOLIDATED-DRAINED TRIAXIAL TEST RESULTS
Boring 98-59
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

TABLE 5.3

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Boring Number	98-51	98-51	98-51	98-51	98-51	98-51	98-51	98-52	98-53	98-53
Sample Number	10	24	32	39	47	54	62	36	12	28
Penetration										
meters	10.9	24.8	33.8	42.9	49.2	61.5	70.3	35.5	11.2	29.5
feet	35.9	81.4	111.0	140.6	161.3	201.6	230.7	116.4	36.6	96.6
Unit	YBM	YBM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	YBM	OBM/UAM
Moisture Content (%)										
Initial, W_0	49	46	46	26	38	48	42	44	45	57
Final, W_f	31	37	39	22	36	46	42	35	32	46
Atterberg Limits										
Liquid Limit, LL	50	66	66	42	76	79	68	64	48	77
Plastic Limit, PL	21	25	27	19	27	27	27	24	20	24
Initial Total Unit Weight, $\gamma_{t,0}$										
kN/m^3	17.1	17.3	17.3	19.3	18.3	17.3	17.7	17.7	17.5	16.6
pcf	109	110	110	123	116	110	113	113	111	106
Void Ratio										
Initial, e_0	1.35	1.28	1.28	0.77	1.03	1.31	1.17	1.19	1.23	1.55
Final, e_f	0.86	1.00	1.04	0.59	0.97	1.24	1.15	0.94	0.89	1.25
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Casagrande Method, 1936)	139	407	623	575	1150	719	814	503	168	479
ksf	2.9	8.5	13.0	12.0	24.0	15.0	17.0	10.5	3.5	10.0
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Work per Unit Volume, Becker et al, 1987)	134	383	584	589	1178	671	790	489	168	450
ksf	2.8	8.0	12.2	12.3	24.6	14.0	16.5	10.2	3.5	9.4
Estimated Effective Vertical Stress, σ'_{v0}										
kPa	109	243	321	399	458	560	630	321	145	301
ksf	2.3	5.1	6.7	8.3	9.6	11.7	13.2	6.7	3.0	6.3
Overconsolidation, OCR										
OCR - Casagrande Method	1.3	1.7	1.9	1.4	2.5	1.3	1.3	1.6	1.2	1.6
OCR - Becker Method	1.2	1.6	1.8	1.5	2.6	1.2	1.3	1.5	1.2	1.5
Compression Index, C_c	0.56	0.64	0.77	0.26	0.65	0.73	0.66	0.65	0.47	0.48
$C_{e,c}$	0.24	0.28	0.34	0.15	0.32	0.32	0.30	0.30	0.21	0.19
Swelling Index, Cs	0.08	0.13	0.12	0.05	0.13	0.16	0.15	0.12	0.05	0.14
Ce,s	0.03	0.06	0.05	0.03	0.06	0.07	0.07	0.05	0.02	0.06
Recompression Index, C_r	-	-	-	-	-	-	-	-	0.06	-
$C_{e,r}$	-	-	-	-	-	-	-	-	0.03	-
Coefficient of Consolidation, C_v (at σ'_{v0})										
m^2/year (square root of time method)	6.1	13.0	37.0	97.6	42.0	6.3	5.3	9.6	12.9	9.2
ft^2/year (square root of time method)	65.67	139.94	398.30	1050.66	452.13	67.82	57.05	103.34	138.87	99.04

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4a

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

Boring Number	98-54	98-54	98-54	98-54	98-55	98-55	98-55	98-55	98-55	98-55
Sample Number	13a**	13b	26	35	17	26	39	47	55	63
Penetration										
meters	12.9	12.9	26.3	35.5	14.0	21.5	34.0	43.1	52.3	61.4
feet	42.2	42.4	86.4	116.4	46.0	70.5	111.4	141.5	171.5	201.5
Unit	YBM	YBM	OBM/UAM	OBM/UAM	YBM	MPSA	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM
Moisture Content (%)										
Initial, W_0	54	55	23	48	36	44	48	31	16	43
Final, W_f	38	43	21	18	36	32	38	25	14	34
Atterberg Limits										
Liquid Limit, LL	59	59	37	48	71	50	63	51	31	68
Plastic Limit, PL	22	22	13	18	29	22	25	21	13	25
Initial Total Unit Weight, $\gamma_{t,0}$										
kN/m^3	16.7	16.7	20.0	17.9	17.1	15.9	17.2	18.5	20.6	17.6
pcf	106	106	127	114	109	101	110	118	131	112
Void Ratio										
Initial, e_0	1.49	1.51	0.65	1.08	1.13	1.20	1.32	0.91	0.51	1.19
Final, e_f	1.02	1.16	0.58	0.71	0.59	0.86	1.02	0.68	0.38	0.93
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Casagrande Method, 1936)	168	172	685	316	196	378	503	1054	790	719
ksf	3.5	3.6	14.3	6.6	4.1	7.9	10.5	22.0	16.5	15.0
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Work per Unit Volume, Becker et al, 1987)	153	172	651	311	206	354	493	1059	771	699
ksf	3.2	3.6	13.6	6.5	4.3	7.4	10.3	22.1	16.1	14.6
Estimated Effective Vertical Stress, σ'_{v0}										
kPa	151	151	265	331	139	201	297	374	455	522
ksf	3.1	3.1	5.5	6.9	2.9	4.2	6.2	7.8	9.5	10.9
Overconsolidation, OCR										
OCR - Casagrande Method	1.1	1.1	2.6	1.0	1.4	1.9	1.7	2.8	1.7	1.4
OCR - Becker Method	1.0	1.1	2.5	0.9	1.5	1.8	1.7	2.8	1.7	1.3
Compression Index, C_c	0.57	0.75	0.21	0.41	0.62	0.44	0.70	0.30	0.16	0.47
$C_{e,c}$	0.23	0.30	0.13	0.20	0.29	0.20	0.30	0.16	0.10	0.21
Swelling Index, Cs	0.07	0.08	0.06	0.08	0.09	0.05	0.12	0.06	0.05	0.13
Ce,s	0.03	0.03	0.04	0.04	0.04	0.02	0.05	0.03	0.04	0.06
Recompression Index, C_r	-	-	-	-	0.06	-	-	-	-	-
$C_{e,r}$	-	-	-	-	0.03	-	-	-	-	-
Coefficient of Consolidation, C_v (at σ'_{v0})										
m^2/year (square root of time method)	5.4	12.0	19.2	7.1	2.5	14.8	20.5	47.0	30.8	2.1
ft^2/year (square root of time method)	58.13	129.18	206.69	76.43	26.91	159.32	220.68	505.95	331.56	22.61

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4b

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

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Boring Number	98-56	98-56	98-56	98-57	98-57	98-57	98-57	98-58	98-58	98-58
Sample Number	17b**	17a	47	20	30	38	46	11	17	36
Penetration										
meters	13.8	13.9	38.6	17.2	28.1	37.0	46.0	12.5	16.9	32.5
feet	45.4	45.5	126.8	56.5	92.2	121.4	151.0	41.0	55.5	106.5
Unit	YBM	YBM	OBM/UAM	YBM	OBM/UAM	OBM/UAM	OBM/UAM	YBM	YBM	OBM/UAM
Moisture Content (%)										
Initial, W_0	53	59	28	52	49	20	52	47	53	52
Final, W_f	36	41	24	36	39	17	49	41	28	43
Atterberg Limits										
Liquid Limit, LL	55	55	50	57	66	44	82	59	70	72
Plastic Limit, PL	24	24	19	22	25	61	25	28	28	23
Initial Total Unit Weight, $\gamma_{t,0}$										
kN/m^3	16.9	16.6	19.2	16.7	17.1	20.4	16.8	17.0	16.8	17.0
pcf	108	106	123	107	109	130	107	108	107	108
Void Ratio										
Initial, e_0	1.43	1.57	0.79	1.45	1.34	0.59	1.43	1.28	1.41	1.42
Final, e_f	0.98	1.08	0.65	0.97	1.04	0.48	1.32	0.61	0.92	1.17
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Casagrande Method, 1936)	148	177	766	158	378	671	719	163	153	527
ksf	3.1	3.7	16.0	3.3	7.9	14.0	15.0	3.4	3.2	11.0
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Work per Unit Volume, Becker et al, 1987)	144	180	790	148	364	623	675	172	163	503
ksf	3.0	3.8	16.5	3.1	7.6	13.0	14.1	3.6	3.4	10.5
Estimated Effective Vertical Stress, σ'_{v0}										
kPa	158	158	349	182	283	354	429	153	188	325
ksf	3.3	3.3	7.3	3.8	5.9	7.4	9.0	3.2	3.9	6.8
Overconsolidation, OCR										
OCR - Casagrande Method	0.9	1.1	2.2	0.9	1.3	1.9	1.7	1.1	0.8	1.6
OCR - Becker Method	0.9	1.1	2.3	0.8	1.3	1.8	1.6	1.1	0.9	1.5
Compression Index, C_c	0.51	0.69	0.35	0.58	0.67	0.20	0.95	0.55	0.51	0.87
$C_{e,c}$	0.21	0.27	0.20	0.24	0.29	0.13	0.39	0.24	0.21	0.36
Swelling Index, Cs	0.08	0.08	0.08	0.09	0.13	0.06	0.19	0.09	0.12	0.14
Ce,s	0.03	0.03	0.05	0.04	0.06	0.04	0.08	0.04	0.05	0.06
Recompression Index, C_r	-	-	-	-	-	-	-	0.07	0.05	-
$C_{e,r}$	-	-	-	-	-	-	-	0.03	0.02	-
Coefficient of Consolidation, C_v (at σ'_{v0})										
m^2/year (square root of time method)	12.6	12.0	22.0	4.6	6.2	11.0	3.9	1.9	1.5	25.5
ft^2/year (square root of time method)	135.64	129.18	236.83	49.52	66.74	118.41	41.98	20.45	16.15	274.51

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4c

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

Boring Number	98-58	98-58	98-58	98-59	98-59	98-60	98-60	98-61	98-61	98-61	98-61
Sample Number	46	55	63	28	38	33	40	16 rt	16	304	24
Penetration											
meters	41.7	50.7	59.9	26.4	38.5	34.1	43.3	14.1	14.1	17.1	20.1
feet	136.8	166.3	196.5	86.7	126.3	112.0	142.0	46.3	46.4	56.0	65.8
Unit	OBM/UAM	OBM/UAM	OBM/UAM	YBM	OBM/UAM	OBM/UAM	OBM/UAM	YBM	YBM	YBM	MPSA
Moisture Content (%)											
Initial, W_0	43	18	45	48	37	46	21	53	41	48	40
Final, W_f	38	19	41	40	26	37	22	35	30	34	39
Atterberg Limits											
Liquid Limit, LL	74	44	76	71	55	62	43	37	37	65	81
Plastic Limit, PL	24	17	27	28	21	22	16	19	19	26	31
Initial Total Unit Weight, $\gamma_{t,0}$											
kN/m^3	17.1	20.7	17.4	17.2	18.1	17.3	20.3	16.8	17.7	16.7	18.2
pcf	109	132	111	110	115	110	129	107	113	106	116
Void Ratio											
Initial, e_0	1.26	0.54	1.24	1.32	1.03	1.27	0.60	1.45	1.15	1.49	1.06
Final, e_f	1.09	0.51	1.10	1.09	0.70	1.00	0.59	0.95	0.81	0.80	1.05
Interpreted Preconsolidation Pressure, σ'_p											
kPa (Casagrande Method, 1936)	455	1102	742	340	642	484	671	172	141	180	354
ksf	9.5	23.0	15.5	7.1	13.4	10.1	14.0	3.6	3.0	3.8	7.4
Interpreted Preconsolidation Pressure, σ'_p											
kPa (Work per Unit Volume, Becker et al, 1987)	441	1054	685	354	632	489	666	168	137	177	366
ksf	9.2	22.0	14.3	7.4	13.2	10.2	13.9	3.5	2.9	3.7	7.7
Estimated Effective Vertical Stress, σ'_{v0}											
kPa	393	460	537	268	361	338	421	163	163	186	212
ksf	8.2	9.6	11.2	5.6	7.5	7.1	8.8	3.4	3.4	3.9	4.4
Overconsolidation, OCR											
OCR - Casagrande Method	1.2	2.4	1.4	1.3	1.8	1.4	1.6	1.1	0.9	1.0	1.7
OCR - Becker Method	1.1	2.3	1.3	1.3	1.8	1.4	1.6	1.0	0.8	1.0	1.7
Compression Index, C_c	0.68	0.17	0.78	0.68	0.52	0.72	0.21	0.58	0.37	0.76	0.35
$C_{e,c}$	0.30	0.11	0.35	0.29	0.26	0.32	0.13	0.24	0.17	0.31	0.17
Swelling Index, Cs	0.14	0.04	0.14	0.16	0.08	0.11	0.07	0.11	0.05	0.10	0.15
Ce,s	0.06	0.03	0.06	0.07	0.04	0.05	0.04	0.05	0.02	0.04	0.08
Recompression Index, C_r	-	-	-	-	-	-	-	0.06	-	-	-
$C_{e,r}$	-	-	-	-	-	-	-	0.02	-	-	-
Coefficient of Consolidation, C_v (at σ'_{v0})											
m^2/year (square root of time method)	2.9	7.0	6.0	3.9	23.0	13.8	2.9	4.5	2.6	6.9	1.1
ft^2/year (square root of time method)	31.22	75.35	64.59	41.98	247.59	148.56	31.22	48.44	27.99	74.71	11.84

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4d

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

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Boring Number	98-61	98-61	98-62	98-62	98-62	98-63	98-63	98-63	98-63	98-64	98-64	98-64	98-65	98-65	98-65	98-65
Sample Number	24c	24d**	15	25 rt	25	9	18	30rt	30	13	13rt	29	9a	9b#	9c##	10 rt
Penetration																
meters	20.0	19.9	12.7	16.9	16.9	7.9	12.7	20.2	20.3	11.1	11.1	20.3	9.6	9.6	9.6	11.1
feet	65.7	65.3	41.5	55.5	55.5	26.0	41.5	66.4	66.5	36.5	36.3	66.5	31.5	31.5	31.5	36.4
Unit	MPSA	MPSA	YBM	YBM	YBM	YBM	YBM	MPSA	MPSA	YBM	YBM	YBM	YBM	YBM	YBM	YBM
Moisture Content (%)																
Initial, W_0	35	33	53	56	58	57	40	26	25	43	46	31	62	62	69	34
Final, W_f	35	34	39	37	41	26	26	21	21	29	31	26	-	-	-	21
Atterberg Limits																
Liquid Limit, LL	81	81	51	58	58	42	42	42	42	43	43	60	74	74	74	41
Plastic Limit, PL	31	31	24	22	22	22	18	17	17	21	21	17	29	29	29	19
Initial Total Unit Weight, $\gamma_{t,0}$																
kN/m^3	18.8	18.8	16.8	16.5	16.5	18.5	18.0	20.1	20.3	17.8	17.5	19.3	16.5	16.2	15.6	18.2
pcf	120	120	107	105	105	118	115	128	129	113	111	123	105	103	99	116
Void Ratio																
Initial, e_0	0.94	0.90	1.45	1.55	1.57	1.56	1.09	0.69	0.65	1.16	1.25	0.83	1.65	1.65	1.85	0.98
Final, e_f	0.94	0.90	1.08	0.99	1.11	0.74	0.72	0.54	0.55	0.77	0.85	0.71	1.00	0.94	1.03	0.61
Interpreted Preconsolidation Pressure, σ'_p																
kPa (Casagrande Method, 1936)	354	292	163	117	101	115	105	527	436	144	153	292	81	-	-	139
ksf	7.4	6.1	3.4	2.5	2.1	2.4	2.2	11.0	9.1	3.0	3.2	6.1	1.7	-	-	2.9
Interpreted Preconsolidation Pressure, σ'_p																
kPa (Work per Unit Volume, Becker et al, 1987)	350	297	172	139	101	129	108	479	438	141	153	283	96	-	-	144
ksf	7.3	6.2	3.6	2.9	2.1	2.7	2.3	10.0	9.2	3.0	3.2	5.9	2.0	-	-	3.0
Estimated Effective Vertical Stress, σ'_{v0}																
kPa	212	212	153	183	183	116	151	214	214	137	139	209	122	122	122	132
ksf	4.4	4.4	3.2	3.8	3.8	2.4	3.2	4.5	4.5	2.9	2.9	4.4	2.6	2.6	2.6	2.8
Overconsolidation, OCR																
OCR - Casagrande Method	1.7	1.4	1.1	0.6	0.5	1.0	0.7	2.5	2.0	1.0	1.1	1.4	0.7	-	-	1.1
OCR - Becker Method	1.7	1.4	1.1	0.8	0.5	1.1	0.7	2.2	2.0	1.0	1.1	1.4	0.8	-	-	1.1
Compression Index, C_c	0.31	0.29	0.61	0.48	0.46	0.41	0.33	0.25	0.21	0.39	0.48	0.28	0.60	0.52	0.72	0.27
$C_{e,c}$	0.16	0.15	0.25	0.19	0.18	0.16	0.16	0.15	0.13	0.18	0.21	0.15	0.23	0.20	0.25	0.14
Swelling Index, Cs	0.13	0.12	0.12	0.09	0.09	0.05	0.06	0.07	0.07	0.08	0.05	0.09	0.11	0.10	-	0.05
Ce,s	0.07	0.06	0.05	0.04	0.03	0.02	0.03	0.04	0.04	0.04	0.02	0.05	0.04	0.04	-	0.02
Recompression Index, C_r	0.07	0.11	-	0.05	-	0.05	-	0.05	-	-	0.06	-	0.09	0.06	0.08	0.03
$C_{e,r}$	0.04	0.06	-	0.02	-	0.02	-	0.03	-	-	0.03	-	0.04	0.02	0.03	0.01
Coefficient of Consolidation, C_v (at σ'_{v0})																
m^2/year (square root of time method)	12.0	-	8.3	2.5	2.3	8.2	3.5	4.1	4.0	7.1	7.5	1.5	1.3	1.1	1.2	6.0
ft^2/year (square root of time method)	129.18	-	89.35	26.91	24.76	88.27	37.68	44.14	43.06	76.43	80.74	16.15	13.99	11.84	12.92	64.59

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4e

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

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Boring Number	98-65	98-65	98-65	98-67	98-69	98-70	98-70	98-70	98-71	98-71	98-73	98-73	98-73	98-73	98-75
Sample Number	10	15	15 rt	12	9	303	312	325	14rt	14	7##	8a	8b#	9	8
Penetration															
meters	11.2	13.9	13.9	11.2	11.0	11.0	15.7	24.9	11.2	11.2	7.9	8.1	8.1	9.5	11.0
feet	36.6	45.5	45.5	36.8	36.0	36.0	51.7	81.6	36.6	36.8	26.0	26.5	26.5	31.0	36.0
Unit	YBM	YBM	YBM	YBM	YBM	YBM	MPSA	MPSA	YBM	YBM	YBM	YBM	YBM	YBM	YBM
Moisture Content (%)															
Initial, W_0	37	56	58	49	45	46	22	25	36	37	48	40	39	39	32
Final, W_f	25	37	39	34	8	-	16	21	25	25	25	-	-	28	20
Atterberg Limits															
Liquid Limit, LL	41	56	56	53	55	59	Sand	44	35	35	51	44	44	48	32
Plastic Limit, PL	19	24	24	23	29	23		20	18	18	24	24	24	24	16
Initial Total Unit Weight, $\gamma_{t,0}$															
kN/m^3	18.1	16.6	16.5	17.2	17.3	18.2	20.7	20.0	18.4	18.4	17.0	17.9	18.1	17.9	18.9
pcf	116	106	105	109	110	116	132	128	117	117	108	114	115	114	120
Void Ratio															
Initial, e_0	1.03	1.54	1.57	1.33	1.26	1.26	0.58	0.68	0.99	1.00	1.29	1.08	1.02	1.06	0.88
Final, e_f	0.68	1.02	1.06	0.94	0.52	0.80	0.48	0.56	0.68	0.68	0.61	0.62	0.58	0.66	0.57
Interpreted Preconsolidation Pressure, σ'_p															
kPa (Casagrande Method, 1936)	153	134	153	153	158	168	-	637	201	220	-	101	-	115	259
ksf	3.2	2.8	3.2	3.2	3.3	3.5	-	13.3	4.2	4.6	-	2.1	-	2.4	5.4
Interpreted Preconsolidation Pressure, σ'_p															
kPa (Work per Unit Volume, Becker et al, 1987)	158	141	163	158	153	172	-	599	206	235	-	120	-	120	249
ksf	3.3	3.0	3.4	3.3	3.2	3.6	-	12.5	4.3	4.9	-	2.5	-	2.5	5.2
Estimated Effective Vertical Stress, σ'_{v0}															
kPa	132	149	149	141	143	147	182	269	133	133	105	105	105	115	142
ksf	2.8	3.1	3.1	2.9	3.0	3.1	3.8	5.6	2.8	2.8	2.2	2.2	2.2	2.4	3.0
Overconsolidation, OCR															
OCR - Casagrande Method	1.2	0.9	1.0	1.1	1.1	1.1	-	2.4	1.5	1.7	-	1.0	-	1.0	1.8
OCR - Becker Method	1.2	0.9	1.1	1.1	1.1	1.2	-	2.2	1.6	1.8	-	1.1	-	1.0	1.8
Compression Index, C_c	0.28	0.58	0.61	0.54	0.57	0.47	0.14	0.21	0.29	0.30	0.28	0.28	0.28	0.33	0.26
$C_{e,c}$	0.14	0.23	0.24	0.23	0.25	0.21	0.09	0.12	0.15	0.15	0.12	0.14	0.14	0.16	0.14
Swelling Index, Cs	0.05	0.17	0.10	0.09	-	0.08	0.01	0.05	0.27	0.02	0.06	0.05	0.05	0.06	0.02
Ce,s	0.02	0.07	0.04	0.04	-	0.04	0.01	0.03	0.14	0.01	0.02	0.03	0.02	0.03	0.01
Recompression Index, C_r	-	-	-	0.03	0.05	0.04	0.01	0.02	0.03	-	0.03	0.04	0.03	0.03	0.03
$C_{e,r}$	-	-	-	0.01	0.02	0.02	0.01	0.01	0.01	-	0.01	0.02	0.02	0.01	0.01
Coefficient of Consolidation, C_v (at σ'_{v0})															
m^2/year (square root of time method)	6.7	3.6	10.0	8.2	4.0	2.4	56.0	4.7	14.00	22.7	3.0	10.5	3.6	6.5	1.5
ft^2/year (square root of time method)	72.13	38.75	107.6	88.27	43.06	25.84	602.84	50.60	150.71	244.36	32.19	113.03	38.75	69.97	16.15

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

TABLE 5.4f

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

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Boring Number	98-75	98-75	98-75	98-39	98-39	98-39	98-39	98-39	98-39	98-39
Sample Number	20	27	34	5	10	36a	50a	63a	71	80
Penetration										
meters	21.8	26.4	31.0	3.0	4.9	20.9	37.4	54.6	64.6	75.5
feet	71.6	86.6	101.6	10.0	16.0	68.5	122.6	179.1	212.0	247.7
Unit	MPSA	OBM/UAM	OBM/UAM	YBM	YBM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	LAA
Moisture Content (%)										
Initial, W_0	62	34	50	57	31	45	23	79	41	20
Final, W_f	48	28	40	-	23	43	24	74	36	19
Atterberg Limits										
Liquid Limit, LL	38	61	70	46	33	70	41	81	61	66
Plastic Limit, PL	14	20	22	22	17	25	17	26	26	17
Initial Total Unit Weight, $\gamma_{t,0}$										
kN/m^3	16.3	18.5	16.8	15.4	17.9	17.4	20.1	16.5	17.8	19.9
pcf	104	118	107	98	114	111	128	105	113	127
Void Ratio										
Initial, e_0	1.68	0.95	1.40	1.54	1.00	1.23	0.64	1.93	1.13	0.63
Final, e_f	1.29	0.75	1.09	-	0.58	1.18	0.65	1.68	1.00	0.54
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Casagrande Method, 1936)	326	575	460	53	86	479	853	862	623	1557
ksf	6.8	12.0	9.6	1.1	1.8	10.0	17.8	18.0	13.0	32.5
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Work per Unit Volume, Becker et al, 1987)	335	560	450	56	91	465	877	833	671	1533
ksf	7.0	11.7	9.4	1.2	1.9	9.7	18.3	17.4	14.0	32.0
Estimated Effective Vertical Stress, σ'_{v0}										
kPa	250	278	311	19	31	160	300	455	536	637
ksf	5.2	5.8	6.5	0.4	0.6	3.3	6.3	9.5	11.2	13.3
Overconsolidation, OCR										
OCR - Casagrande Method	1.3	2.1	1.5	2.8	2.8	3.0	2.8	1.9	1.2	2.4
OCR - Becker Method	1.3	2.0	1.4	2.9	3.0	2.9	2.9	1.8	1.3	2.4
Compression Index, C_c	0.97	0.38	0.79	0.76	0.27	0.66	0.18	1.20	0.47	0.24
$C_{e,c}$	0.36	0.20	0.33	0.30	0.13	0.29	0.11	0.41	0.22	0.15
Swelling Index, Cs	0.17	0.14	0.14	0.09	0.03	0.13	0.05	0.17	0.18	0.05
Ce,s	0.06	0.07	0.06	0.04	0.01	0.06	0.02	0.07	0.08	0.02
Recompression Index, C_r	0.03	0.01	0.01	-	-	-	-	-	-	-
$C_{e,r}$	0.01	0.01	0.01	-	-	-	-	-	-	-
Coefficient of Consolidation, C_v (at σ'_{v0})										
m^2/year (square root of time method)	10.8	16.0	12.0	17.0	17.5	-	-	-	2.0	3.5
ft^2/year (square root of time method)	116.26	172.24	129.18	183	188	-	-	-	22	38

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

TABLE 5.4g

Earth Mechanics

FUGRO

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Boring Number	98-39	98-44	98-44	98-44	98-44	98-44	98-44	98-44	98-44	98-44
Sample Number	106a	16	36a**	36b	50a**	50b	54	68	79	90
Penetration										
meters	99.0	5.0	9.3	9.3	28.5	28.5	29.8	47.7	63.0	81.2
feet	324.6	16.5	30.4	30.5	93.5	93.6	97.7	156.6	206.5	266.3
Unit	LAA	YBM	YBM	YBM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	OBM/UAM	LAA
Moisture Content (%)										
Initial, W_0	20	39	59	60	46	50	47	46	49	18
Final, W_f	21	29	39	39	35	41	35	42	39	15
Atterberg Limits										
Liquid Limit, LL	45	42	53	53	70	70	56	76	67	29
Plastic Limit, PL	17	22	21	21	28	28	23	26	23	17
Initial Total Unit Weight, $\gamma_{t,0}$										
kN/m^3	20.5	18.4	16.3	16.3	17.4	17.1	17.2	17.3	16.9	20.3
pcf	130	117	104	104	111	109	109	110	108	129
Void Ratio										
Initial, e_0	0.58	1.19	1.61	1.64	1.26	1.36	1.30	1.27	1.38	0.56
Final, e_f	0.58	0.79	1.08	1.06	0.93	1.09	0.94	1.13	1.05	0.43
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Casagrande Method, 1936)	1485	-	67	62	479	407	393	766	958	1389
ksf	31.0	-	1.4	1.3	10.0	8.5	8.2	16.0	20.0	29.0
Interpreted Preconsolidation Pressure, σ'_p										
kPa (Work per Unit Volume, Becker et al, 1987)	1542	-	77	65	474	455	407	790	1035	1533
ksf	32.2	-	1.6	1.4	9.9	9.5	8.5	16.5	21.6	32.0
Estimated Effective Vertical Stress, σ'_{v0}										
kPa	881	37	64	64	227	227	236	387	501	647
ksf	18.4	0.8	1.3	1.3	4.7	4.7	4.9	8.1	10.5	13.5
Overconsolidation, OCR										
OCR - Casagrande Method	1.7	-	1.0	1.0	2.1	1.8	1.7	2.0	1.9	2.1
OCR - Becker Method	1.8	-	1.2	1.0	2.1	2.0	1.7	2.0	2.1	2.4
Compression Index, C_c	0.23	0.29	0.59	0.58	0.58	0.66	0.63	0.82	1.07	0.16
$C_{e,c}$	0.14	0.13	0.23	0.22	0.26	0.28	0.28	0.36	0.45	0.10
Swelling Index, Cs	0.10	4.11	3.06	3.06	4.70	6.46	4.23	7.87	4.94	0.99
Ce,s	0.04	0.04	0.03	0.03	0.04	0.06	0.04	0.07	0.04	0.01
Recompression Index, C_r	-	-	-	-	-	-	-	-	-	-
$C_{e,r}$	-	-	-	-	-	-	-	-	-	-
Coefficient of Consolidation, C_v (at σ'_{v0})										
m^2/year (square root of time method)	-	8.0	3.5	3.6	24.0	21.5	6.0	-	-	43.0
ft^2/year (square root of time method)	-	86	38	39	258	231	65	-	-	463

* Sample trimmed at 45 degree angle, representing in situ loading at 45 degree angle.

** Sample trimmed vertically, representing horizontal in situ loading.

sample remolded at natural water content

sample remolded at natural water content plus 5 to 8%

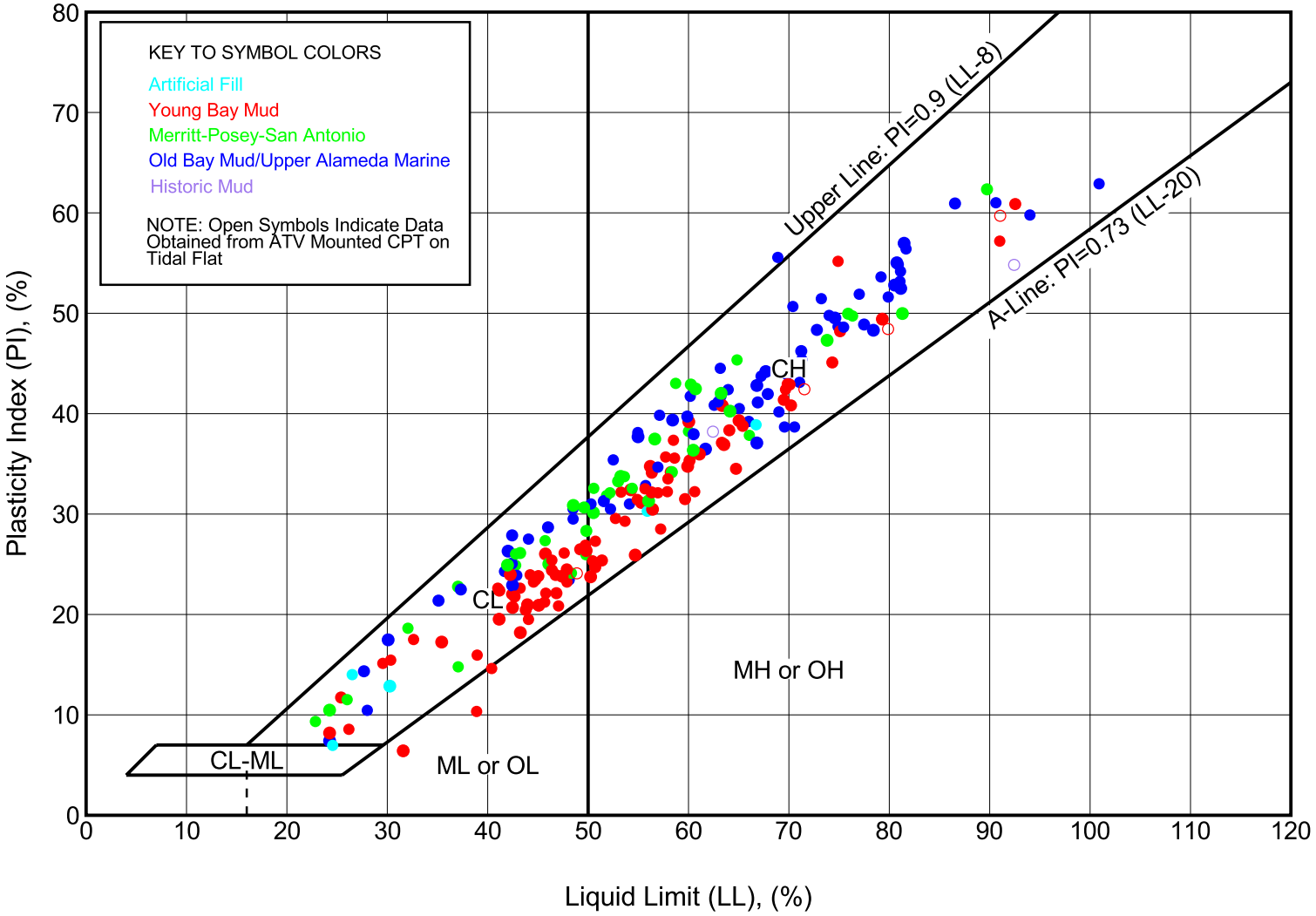
TABLE 5.4h

SUMMARY OF CONSOLIDATION TEST RESULTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

I:\WP\2001\1998-005\098-0058\Mole\8-sec5tbls.doc



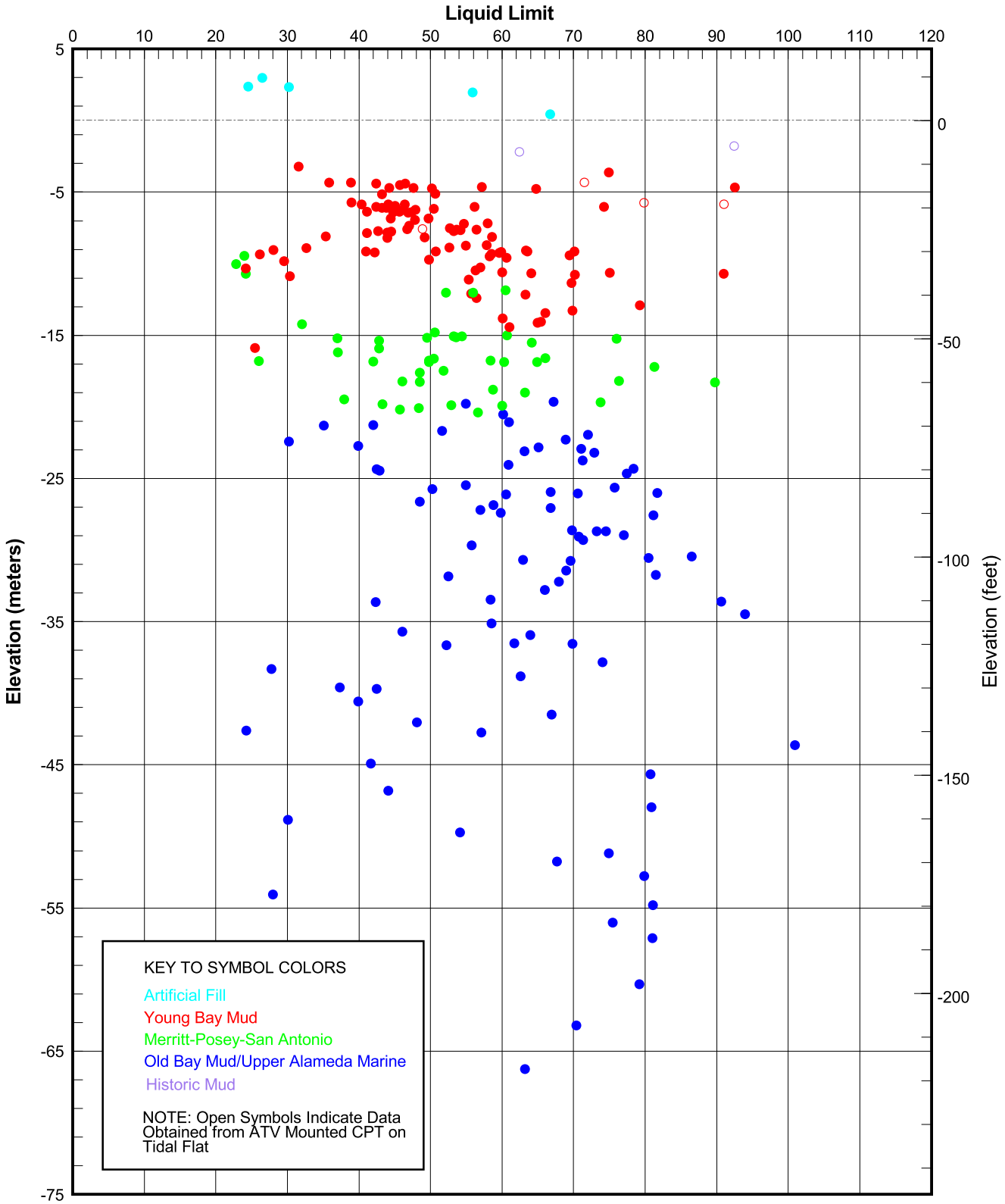
PLASTICITY CHART
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.1

SFOBB Task Order No. 5
Project No. 98-42-0058

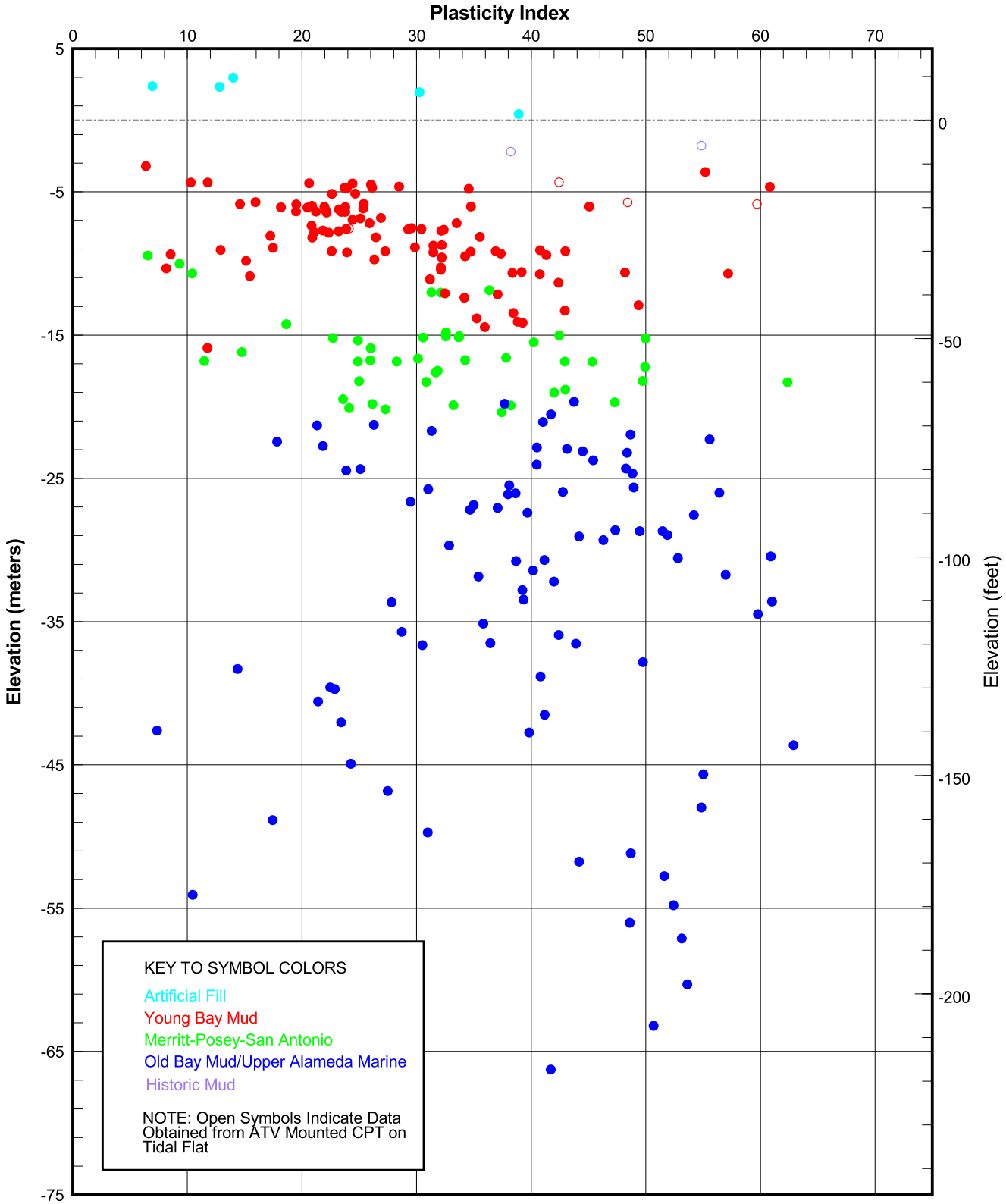
Earth Mechanics

FUGRO



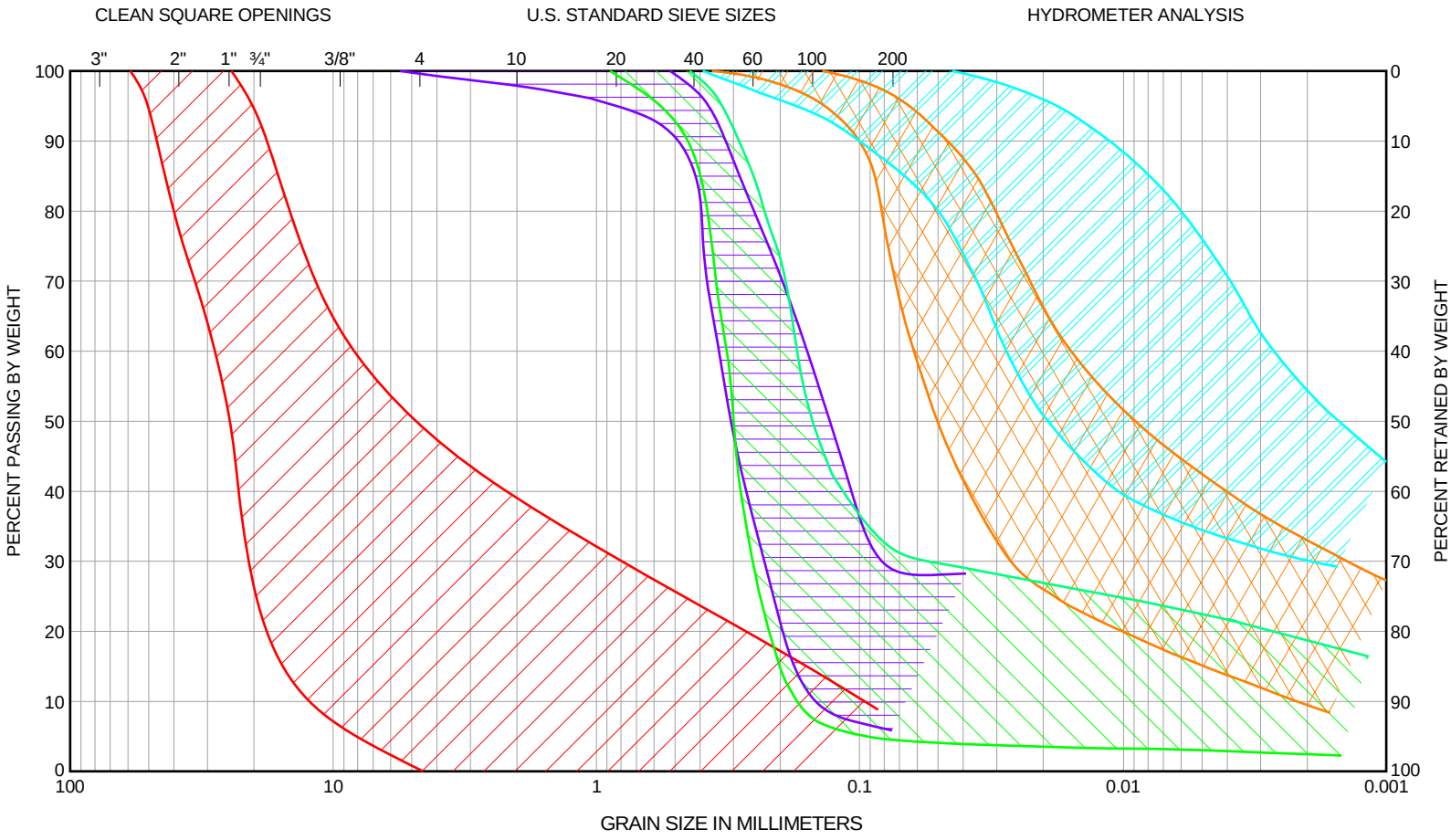
LIQUID LIMIT PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.2



PLASTICITY INDEX PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.3



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

Typical Range: Merrit Sand in Merrit-Posey-San Antonio Formation

Typical Range: Fine Sands in Artificial Fill

Typical Range: Gravel in Artificial Fill

Typical Range: Lean Clay in Young Bay Mud, Old Bay Mud and Upper Alameda Sediments

Typical Range: Fat Clay in Young Bay Mud, Old Bay Mud and Upper Alameda Sediments (From Marine Characterization)

TYPICAL GRAIN SIZE DISTRIBUTION CURVES

Oakland Shore Approach

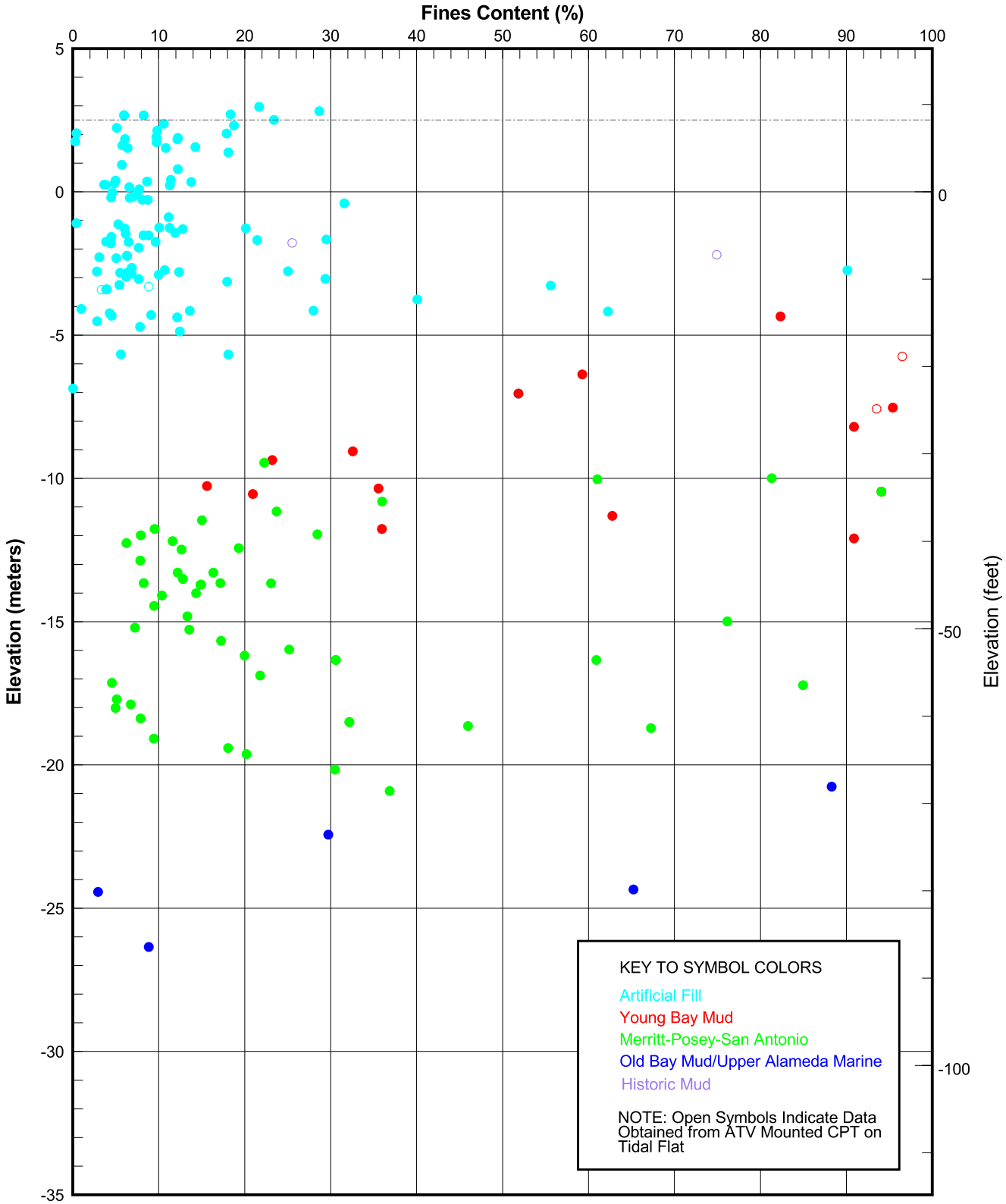
SFOBB East Span Seismic Safety Project

PLATE 5.4

SFOBB Task Order No. 5
Project No. 98-42-0058

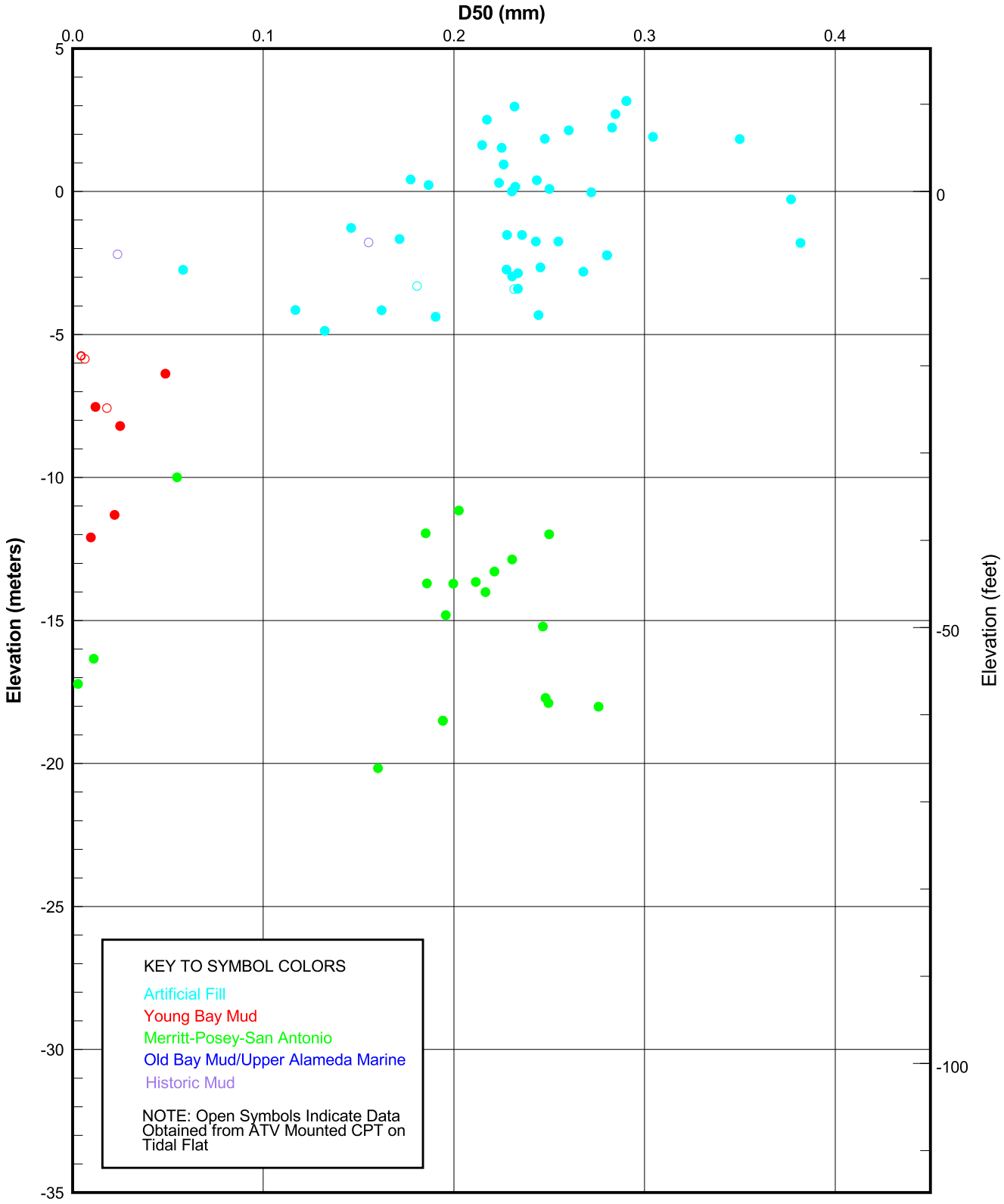
Earth Mechanics

FUGRO



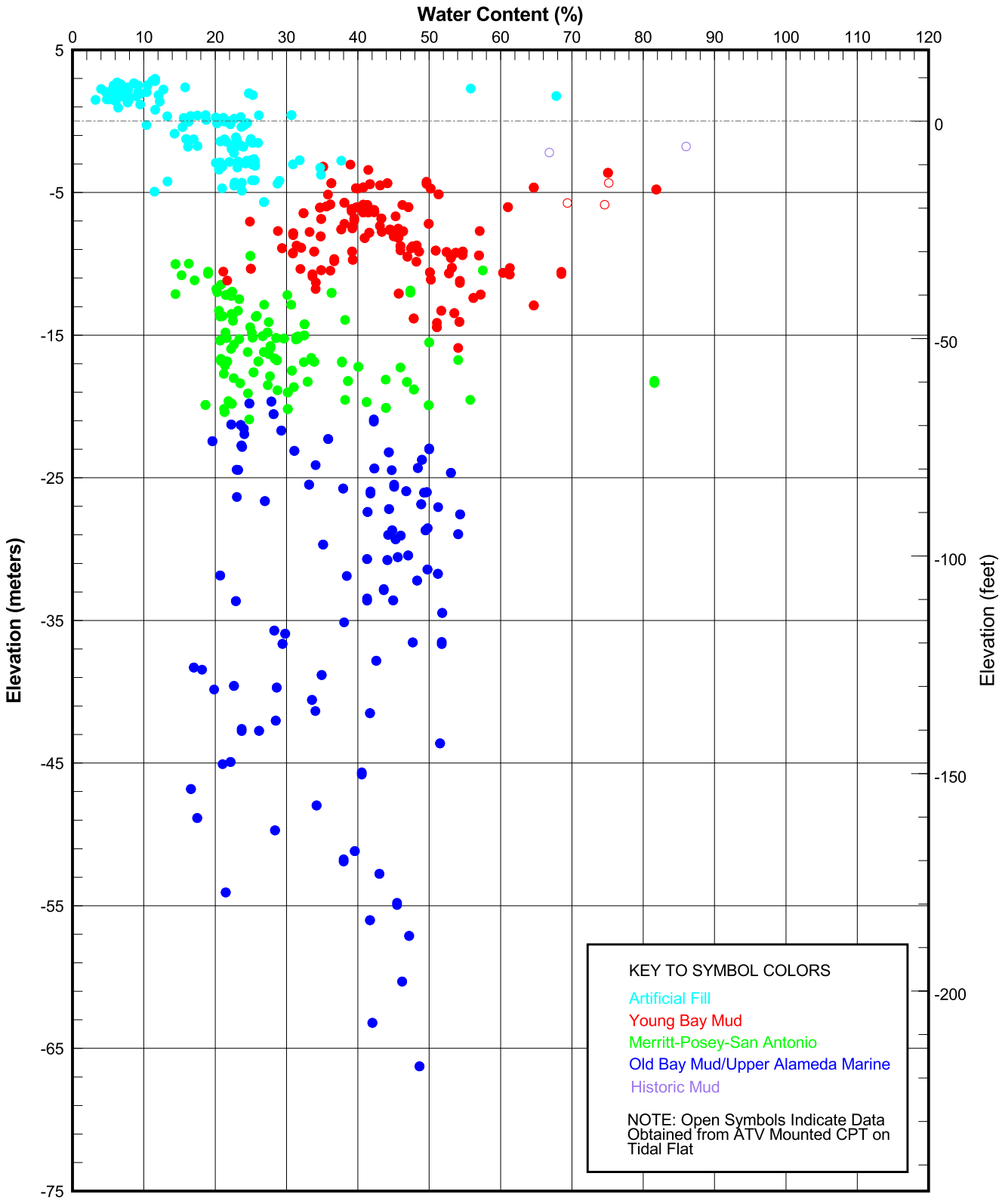
FINES CONTENT PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.5



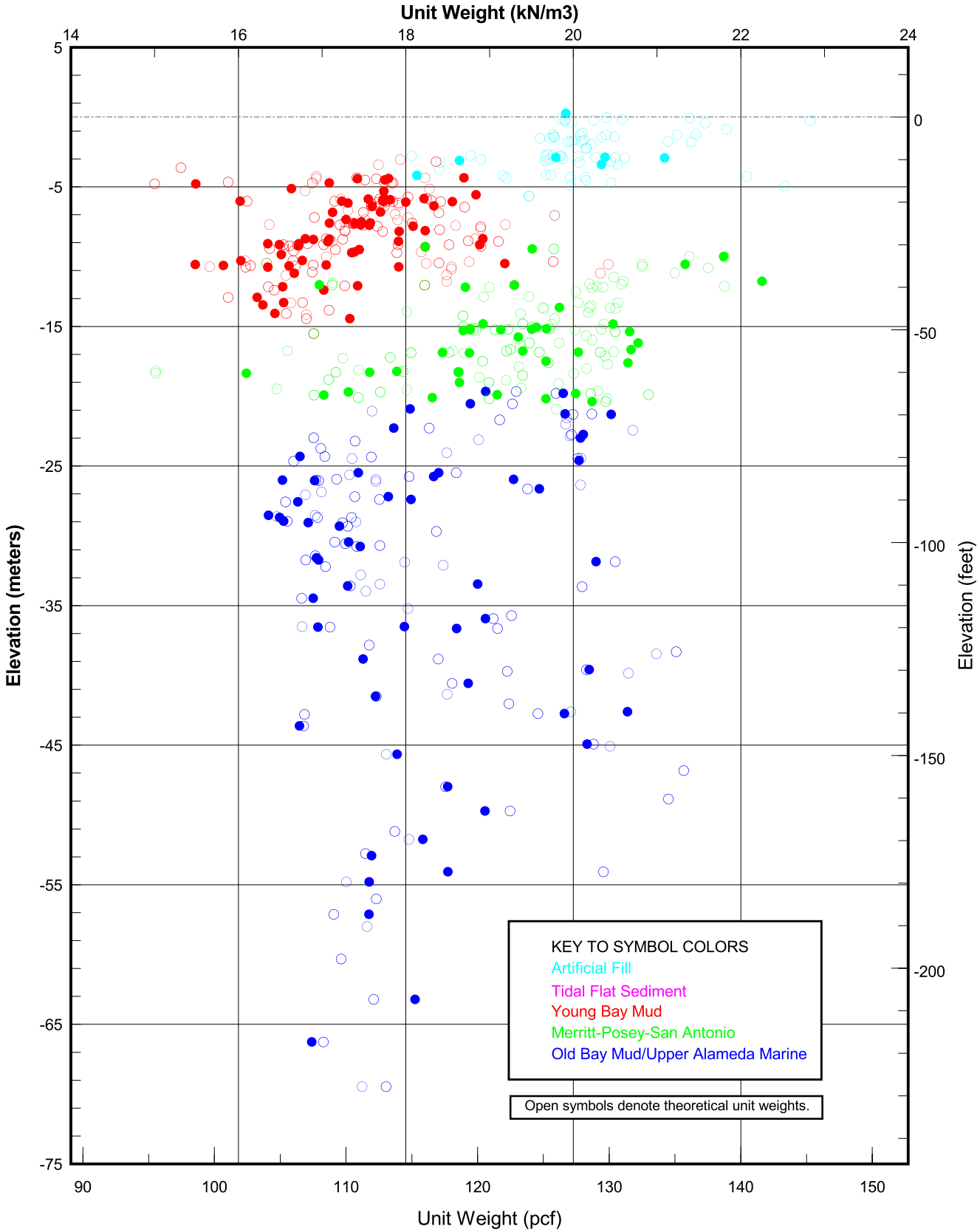
D50 PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.6



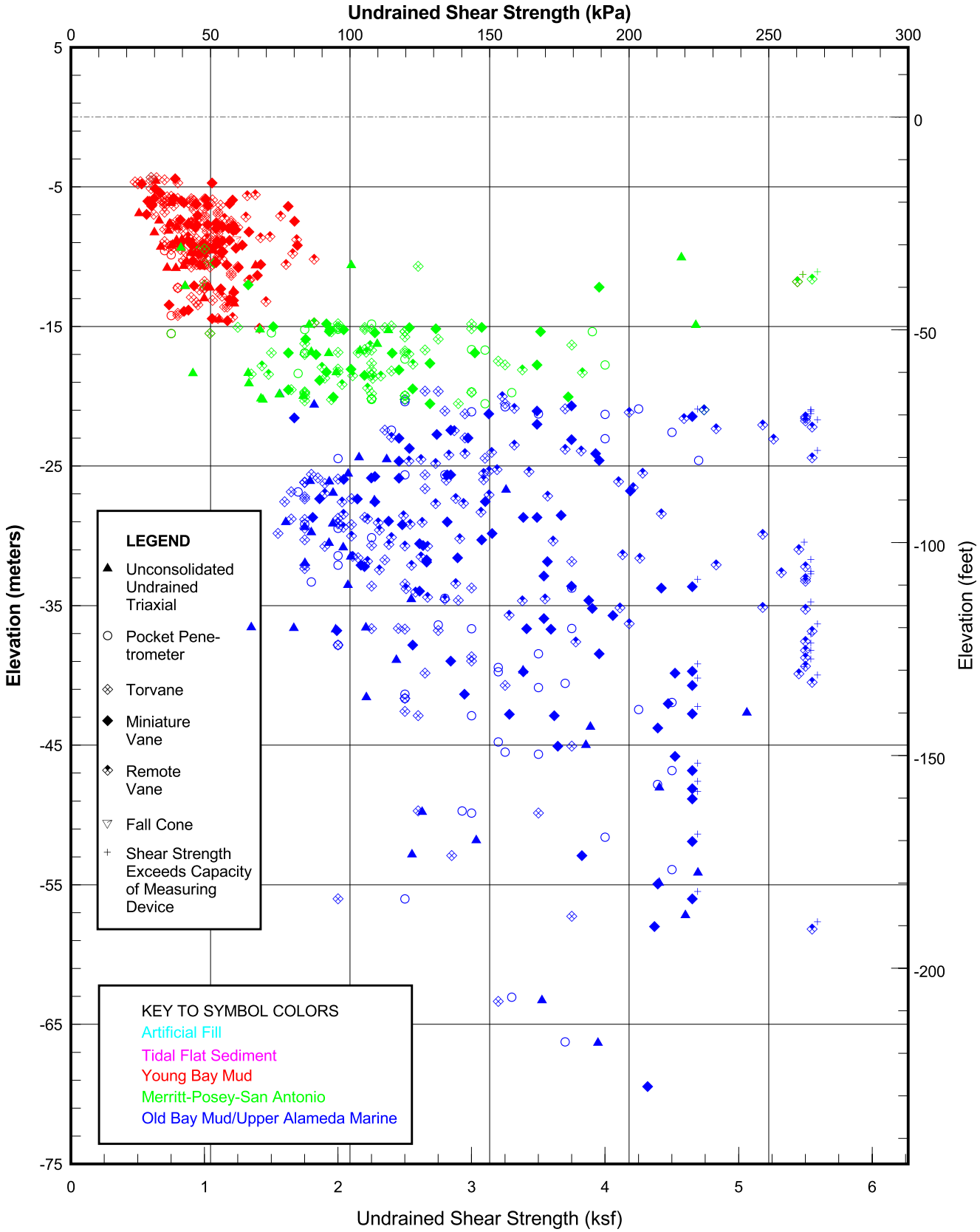
WATER CONTENT PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.7



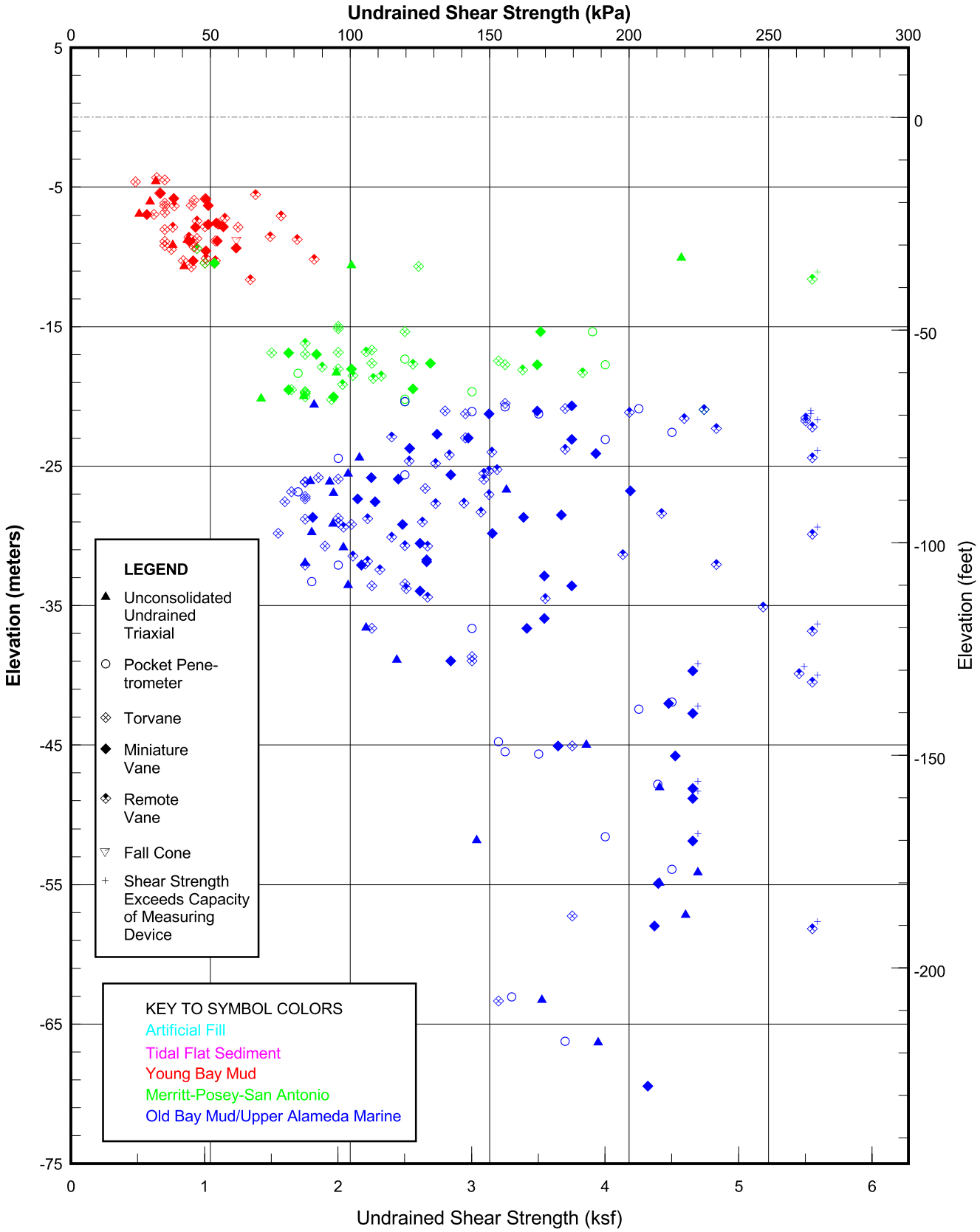
UNIT WEIGHT PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.8



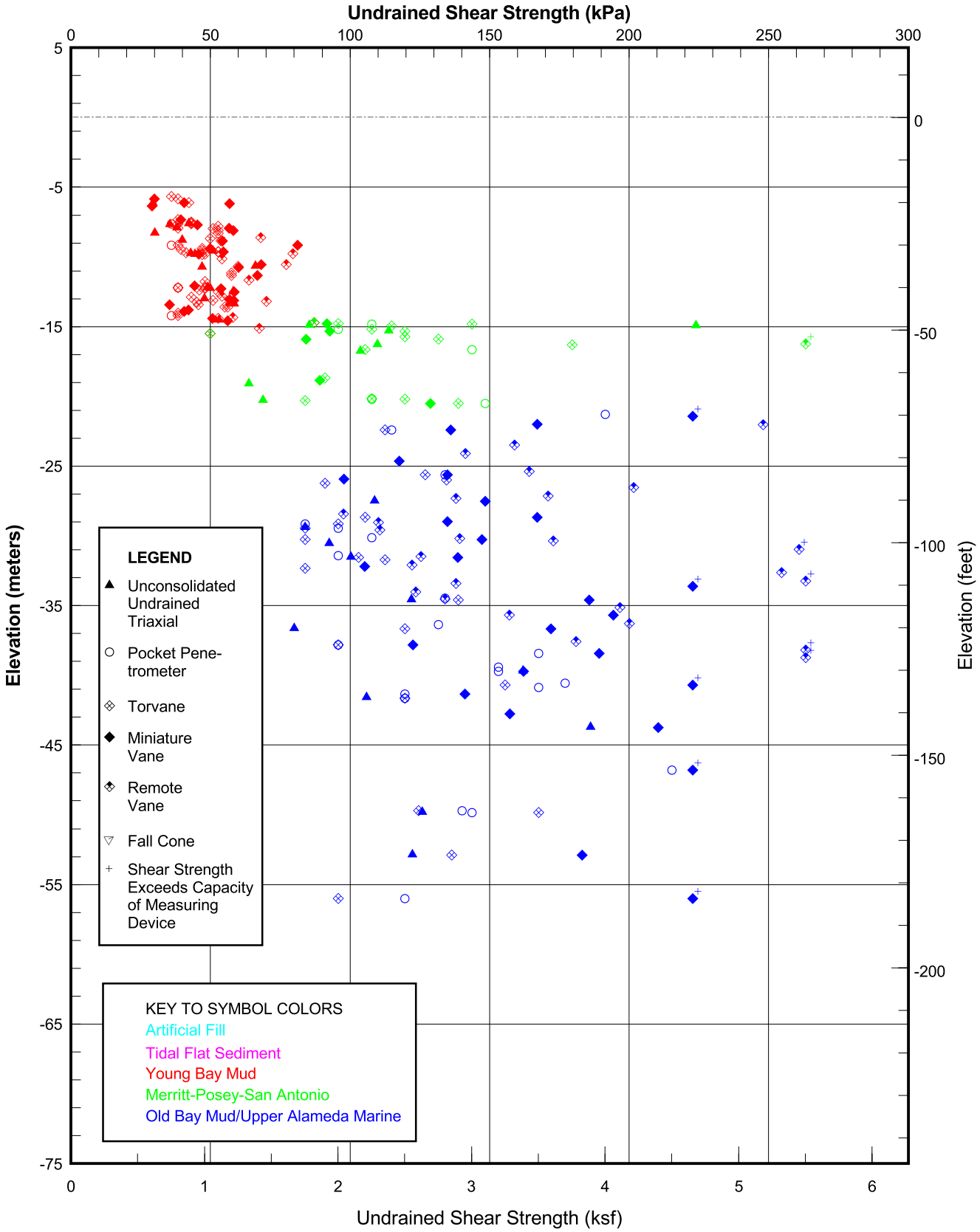
UNDRAINED SHEAR STRENGTH PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.9



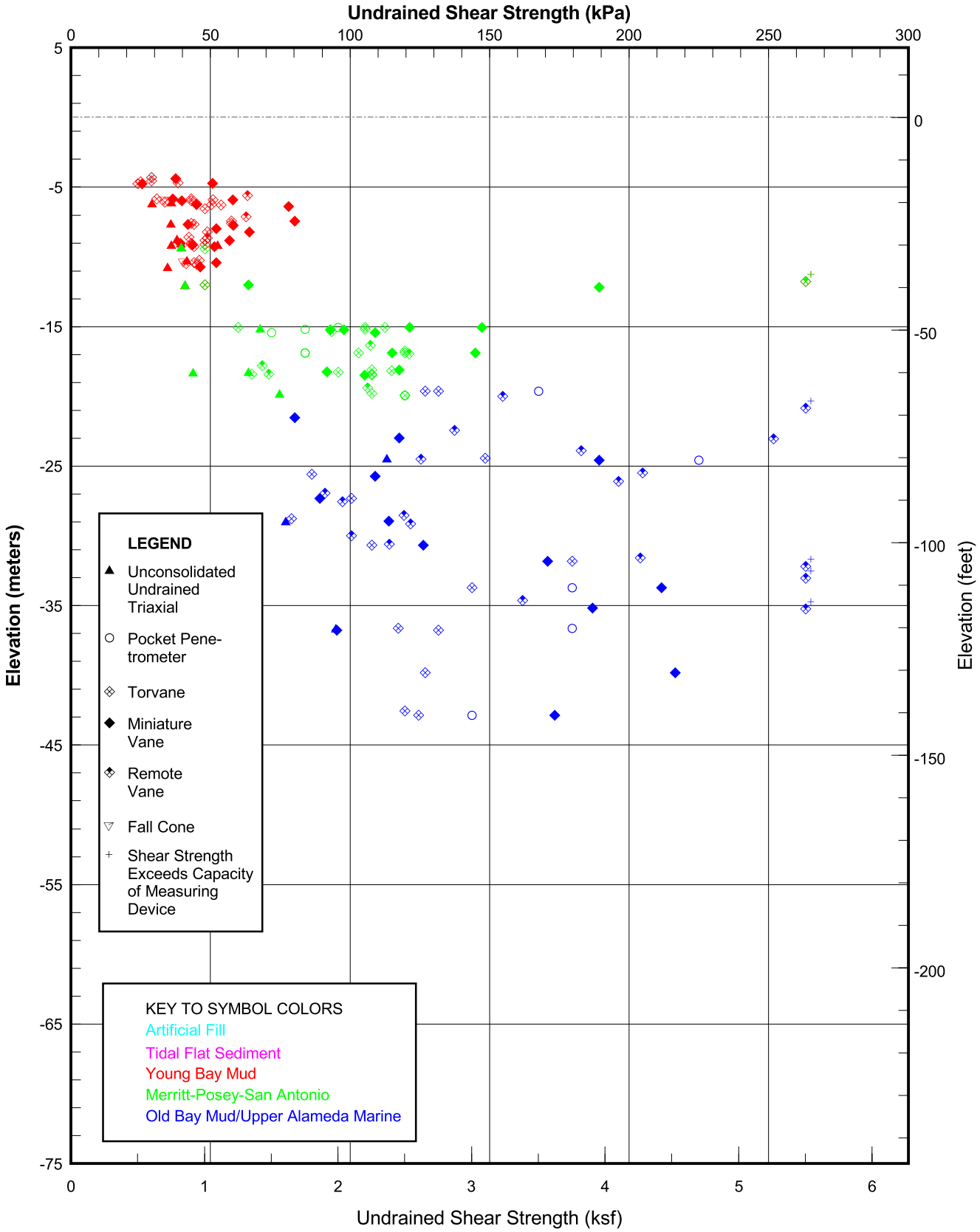
UNDRAINED SHEAR STRENGTH PROFILE FOR WESTERN PORTION OF MOLE
Borings 98-51, 98-52, 98-53, 98-54, 98-55, and 98-75
SFOBB East Span Seismic Safety Project

PLATE 5.10



UNDRAINED SHEAR STRENGTH PROFILE FOR CENTRAL PORTION OF MOLE
Borings 98-56, 98-57, 98-58, 98-61, 98-62, 98-66, and 98-70
SFOBB East Span Seismic Safety Project

PLATE 5.11

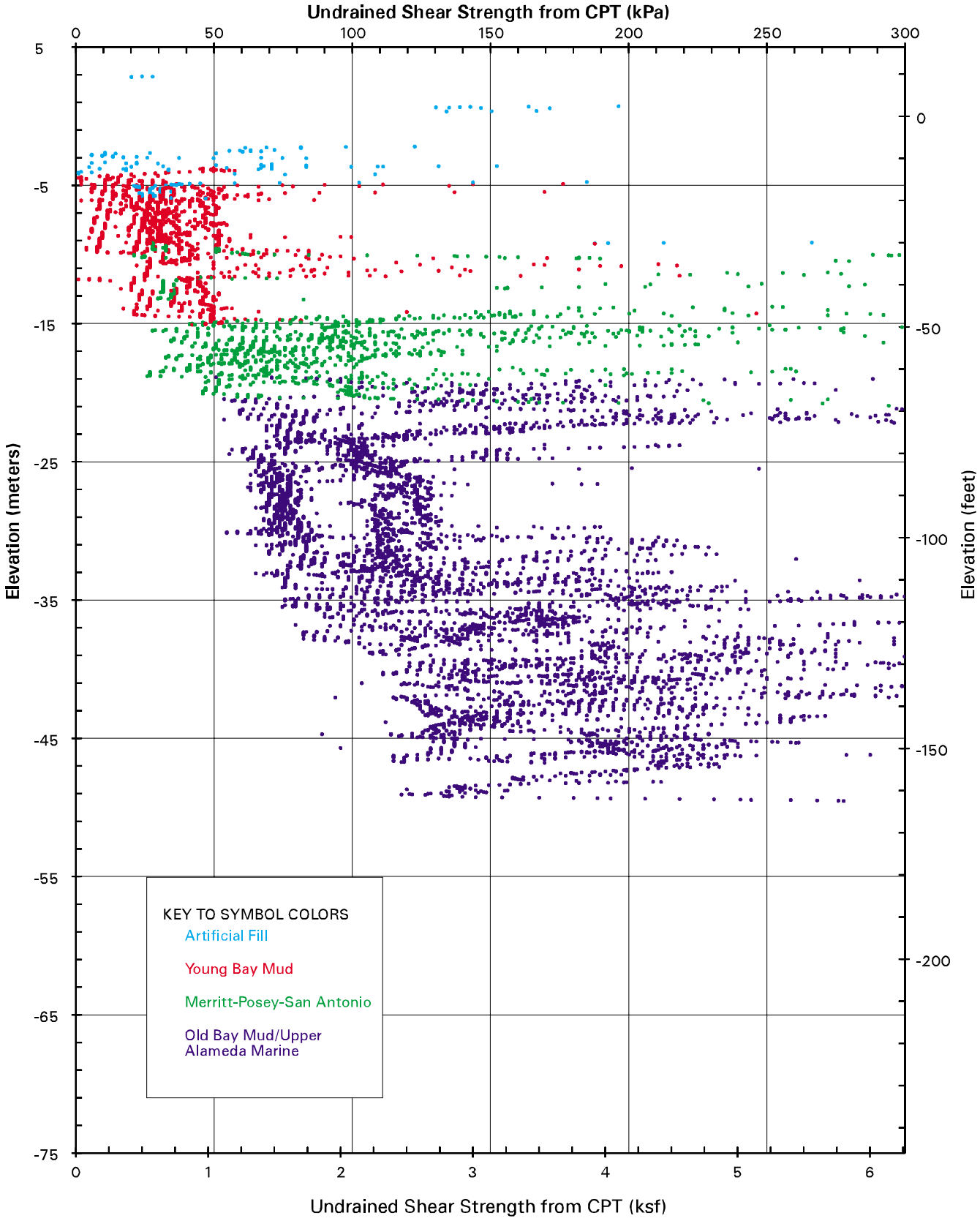


UNDRAINED SHEAR STRENGTH PROFILE FOR EASTERN PORTION OF THE MOLE
Borings 98-59, 98-60, 98-63, 98-64, 98-67, 98-71, and 98-72
SFOBB East Span Seismic Safety Project

PLATE 5.12

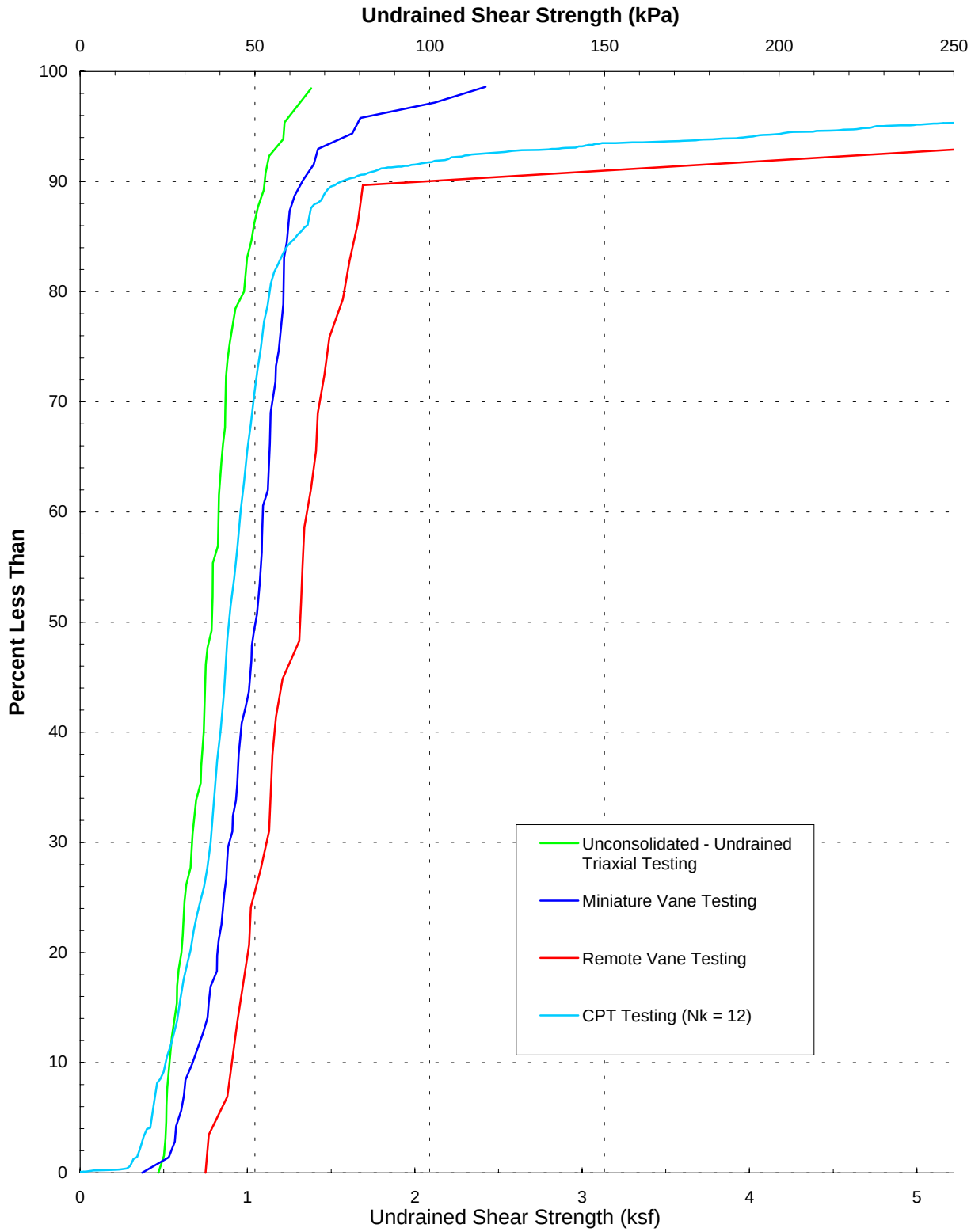
Earth Mechanics

FUGRO

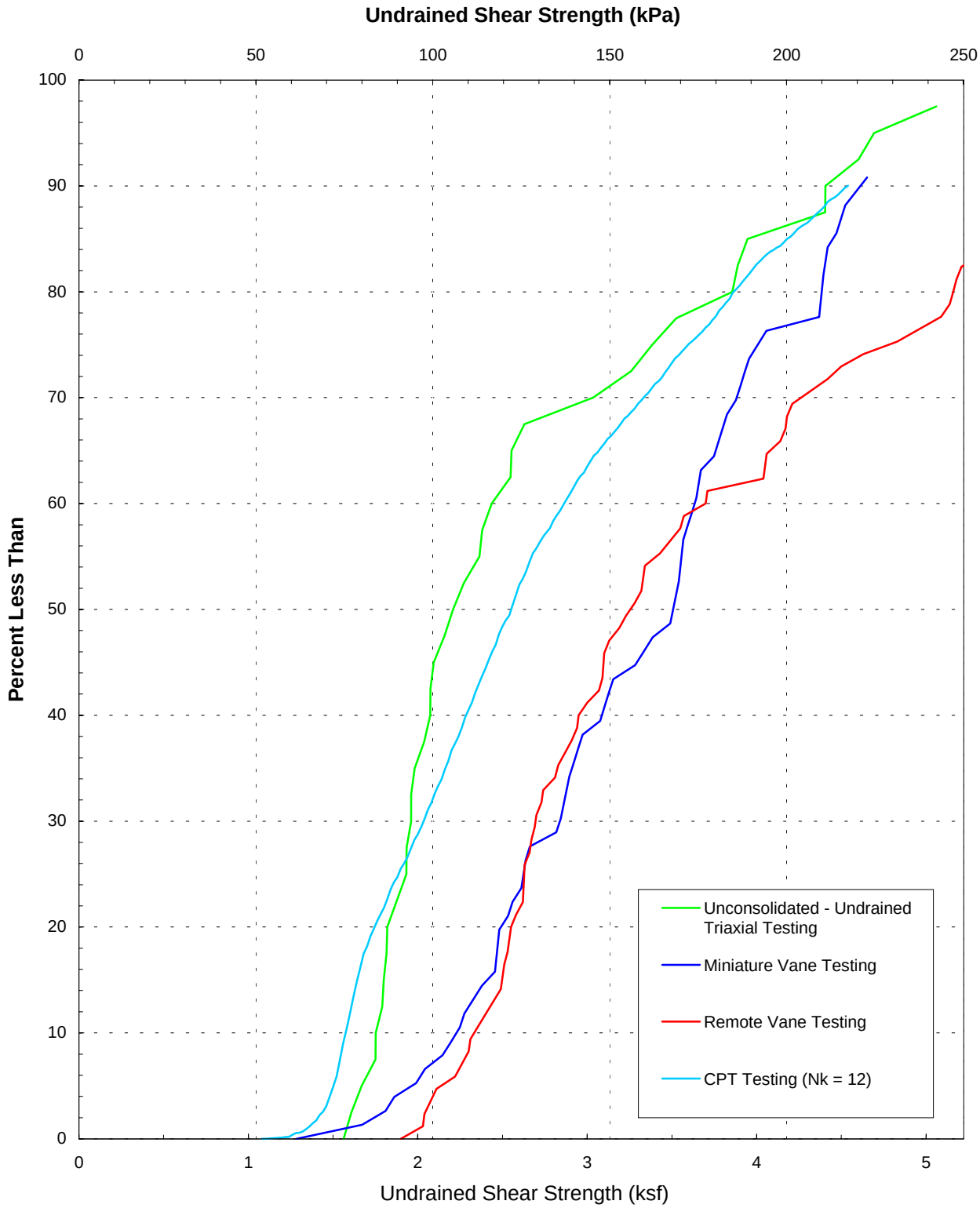


UNDRAINED SHEAR STRENGTH PROFILE FROM CPT TIP RESISTANCE ($N_k = 12$)
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.13

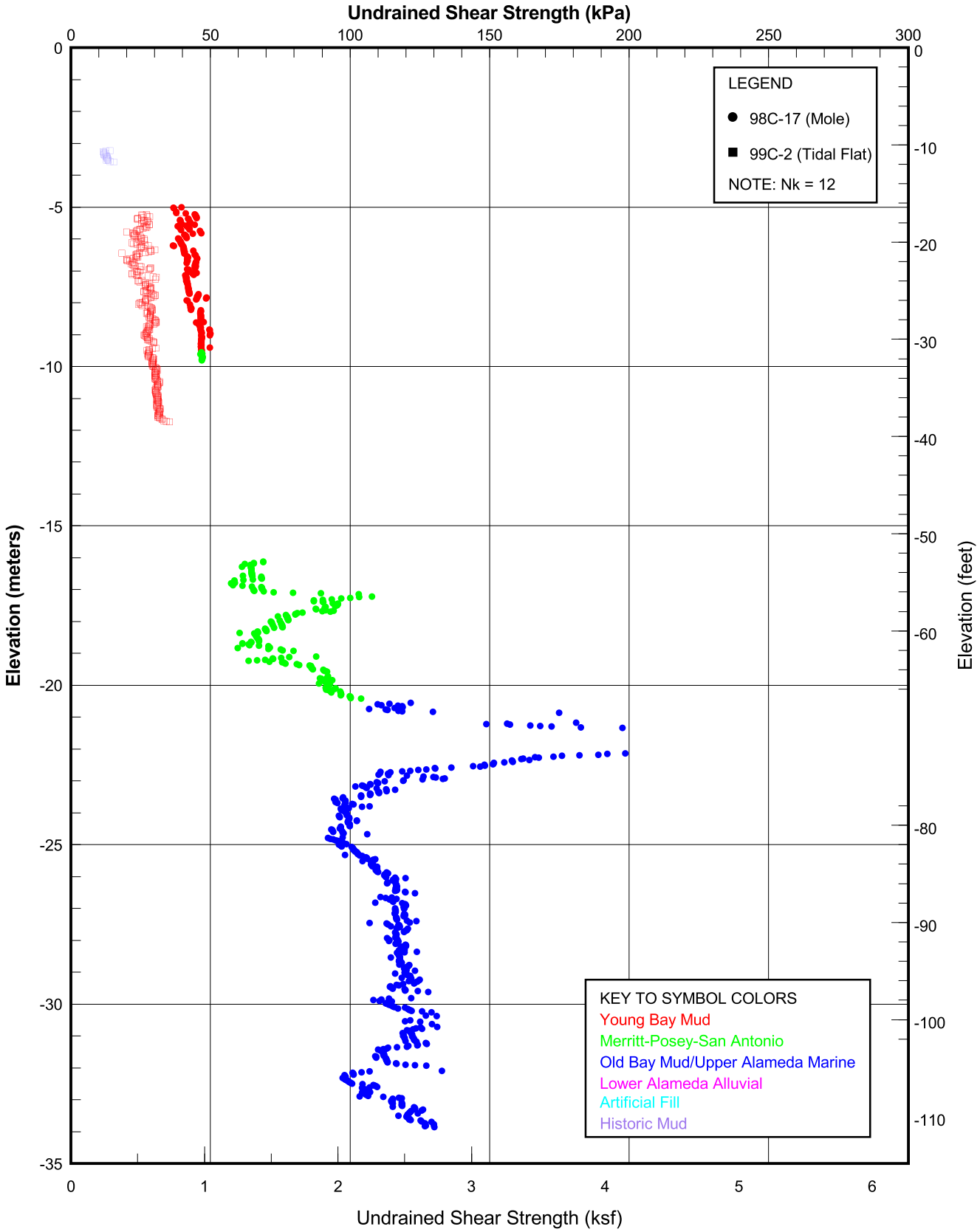


CUMULATIVE FREQUENCY OF UNDRAINED SHEAR STRENGTH
YOUNG BAY MUD
Oakland Shore Approach
SFOBB East Span Seismic Safety Project



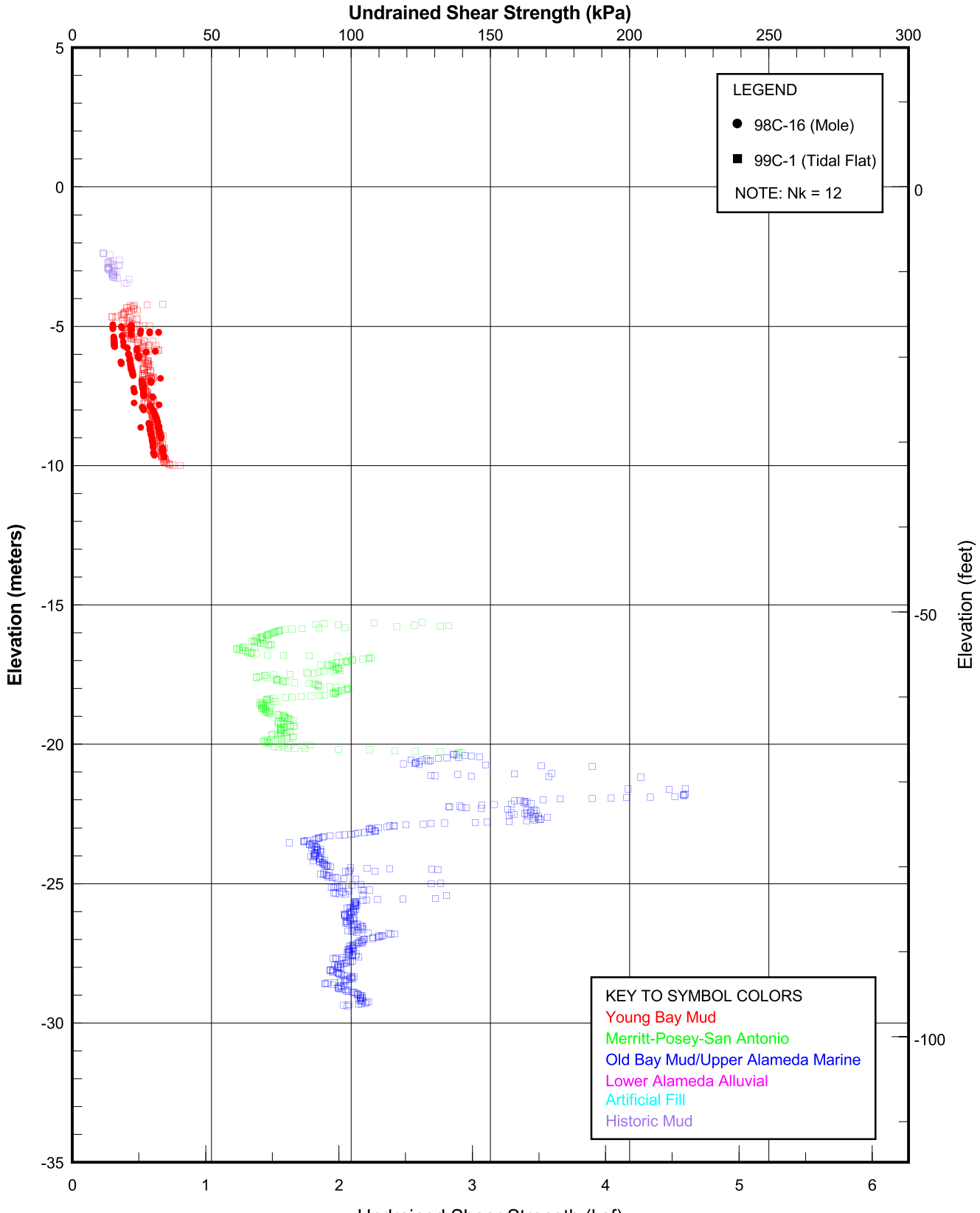
CUMULATIVE FREQUENCY OF UNDRAINED SHEAR STRENGTH
OLD BAY MUD
Oakland Shore Approach
SFOBB East Span Seismic Safety

PLATE 5.15



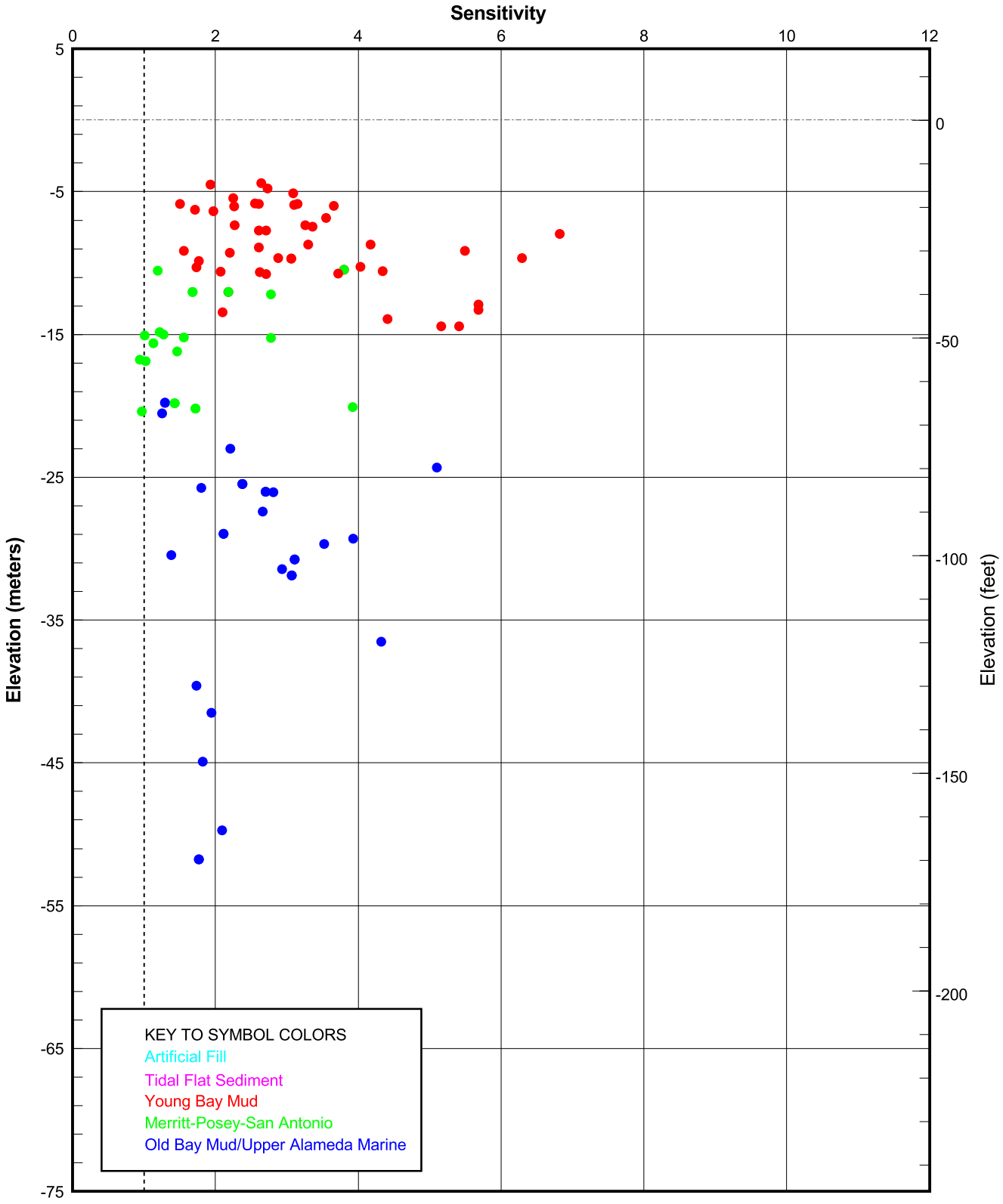
UNDRAINED SHEAR STRENGTH FROM CPT DATA ON THE MOLE AND TIDAL FLAT
Soundings 98C-17 and 99C-2
SFOBB East Span Seismic Safety Project

PLATE 5.16a



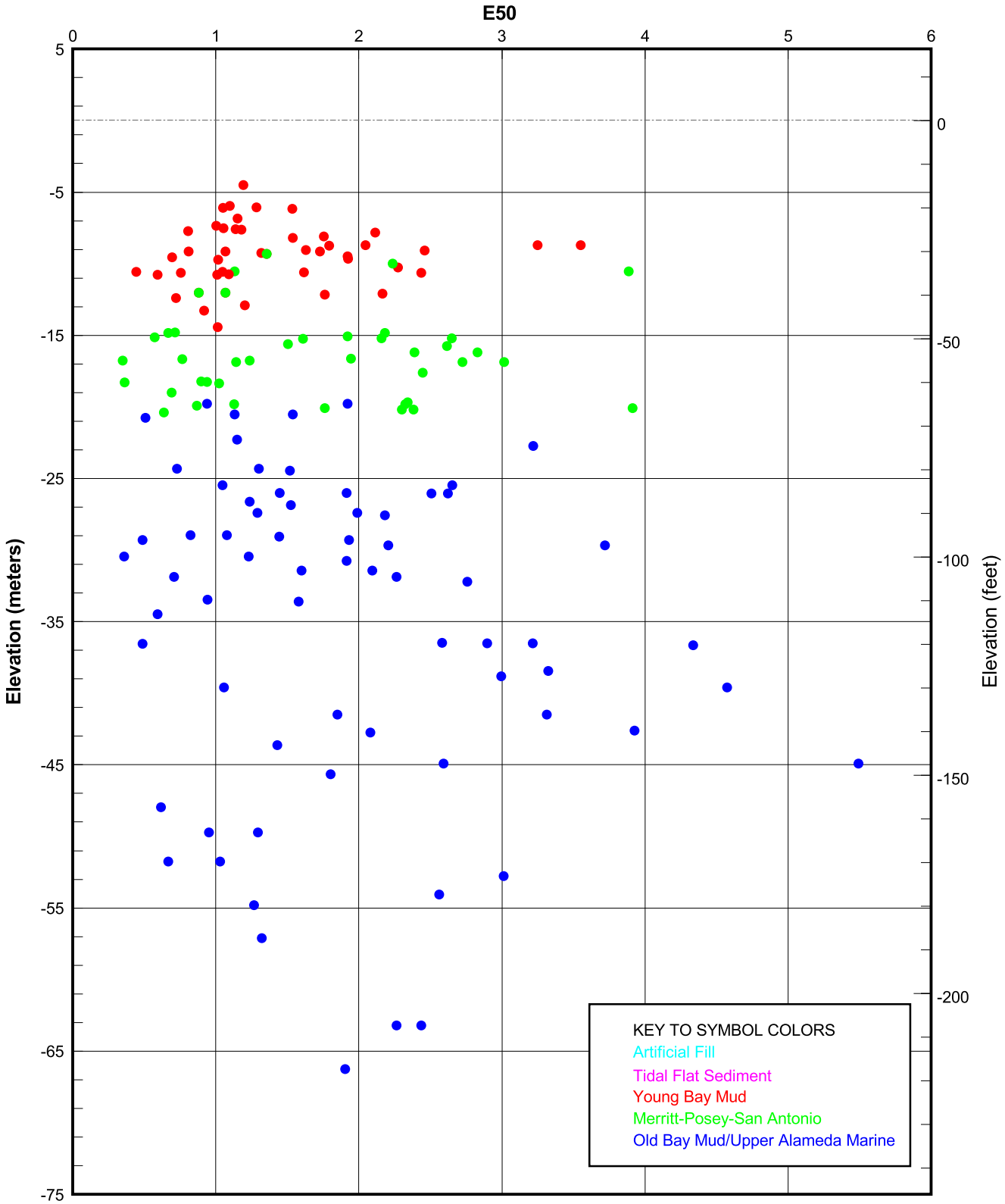
UNDRAINED SHEAR STRENGTH PROFILE
Borings 98C-16 and 99C-1
SFOBB East Span Seismic Safety Project

PLATE 5.16b



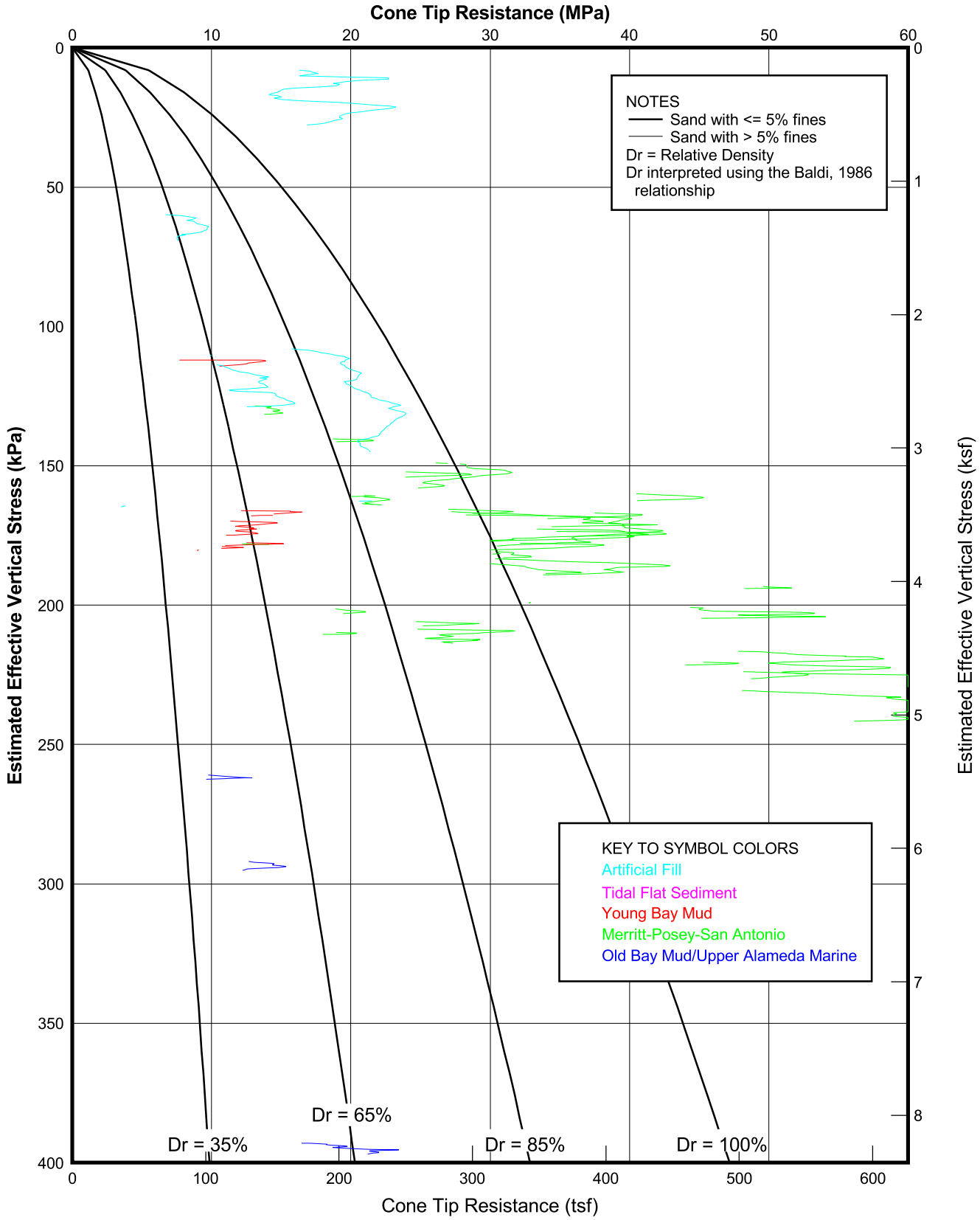
SENSITIVITY PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.17



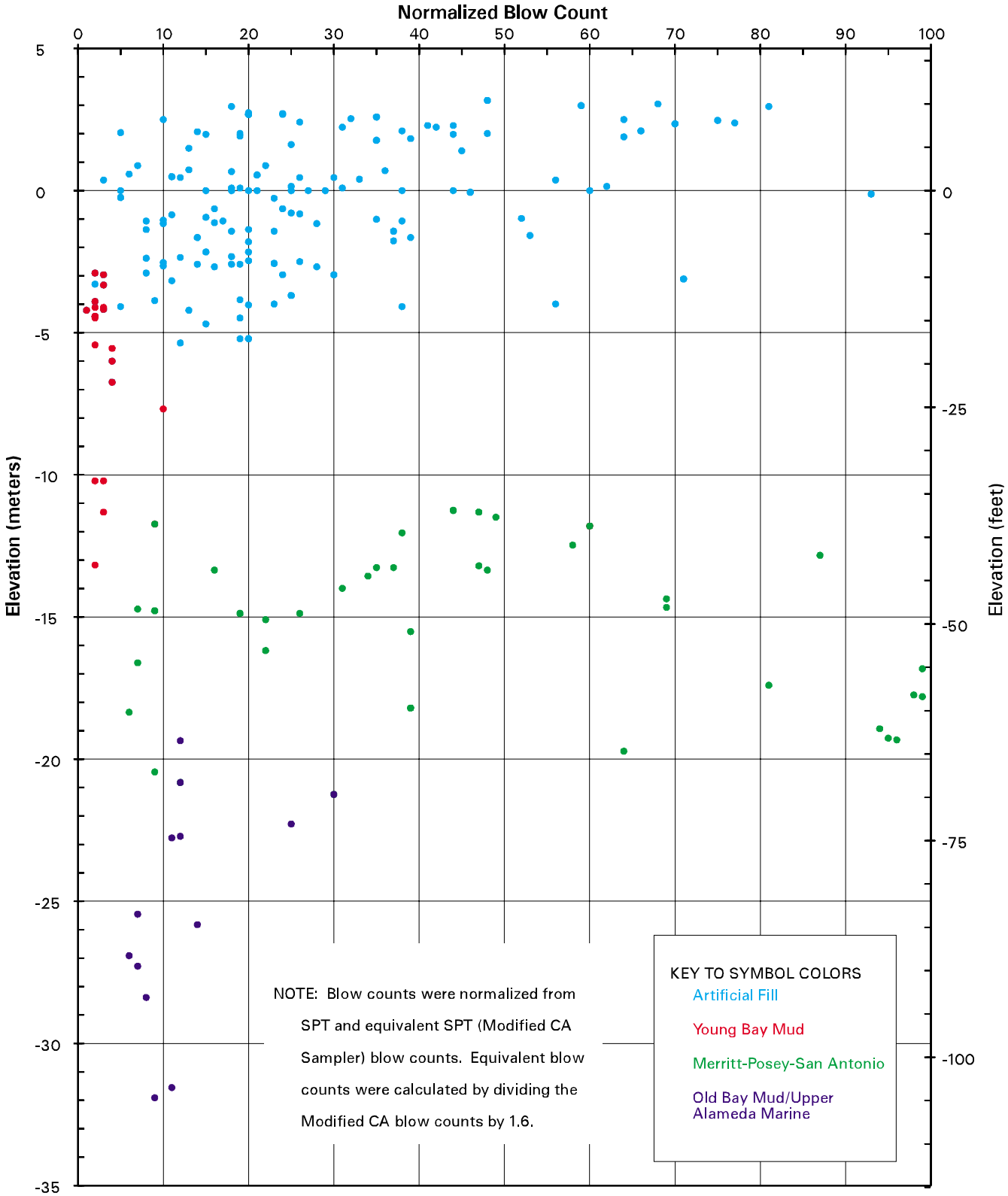
E50 PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.18



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.19



NORMALIZED BLOW COUNT PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.20

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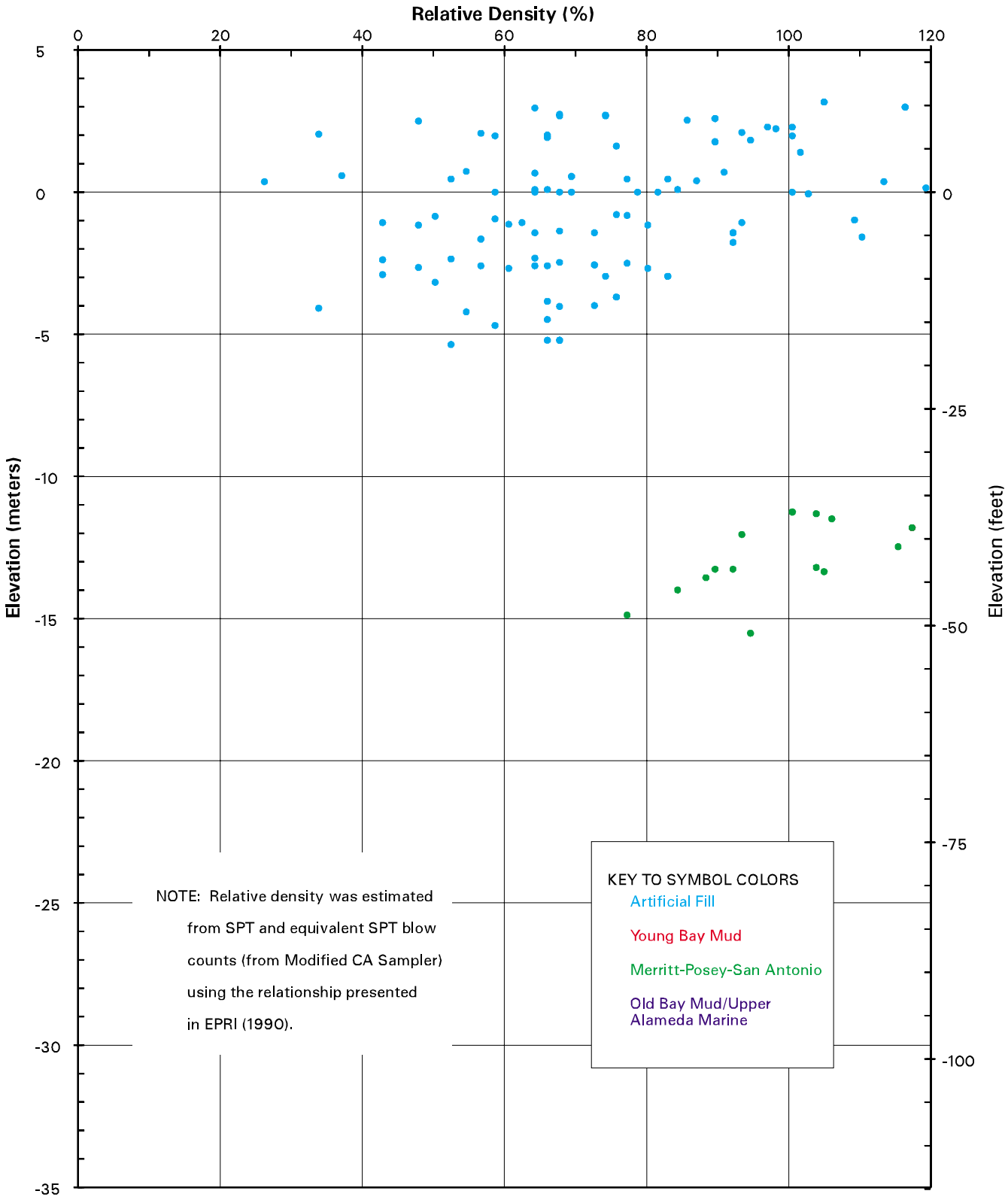

RELATIVE DENSITY PROFILE INTERPRETED FROM BLOW COUNTS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.21

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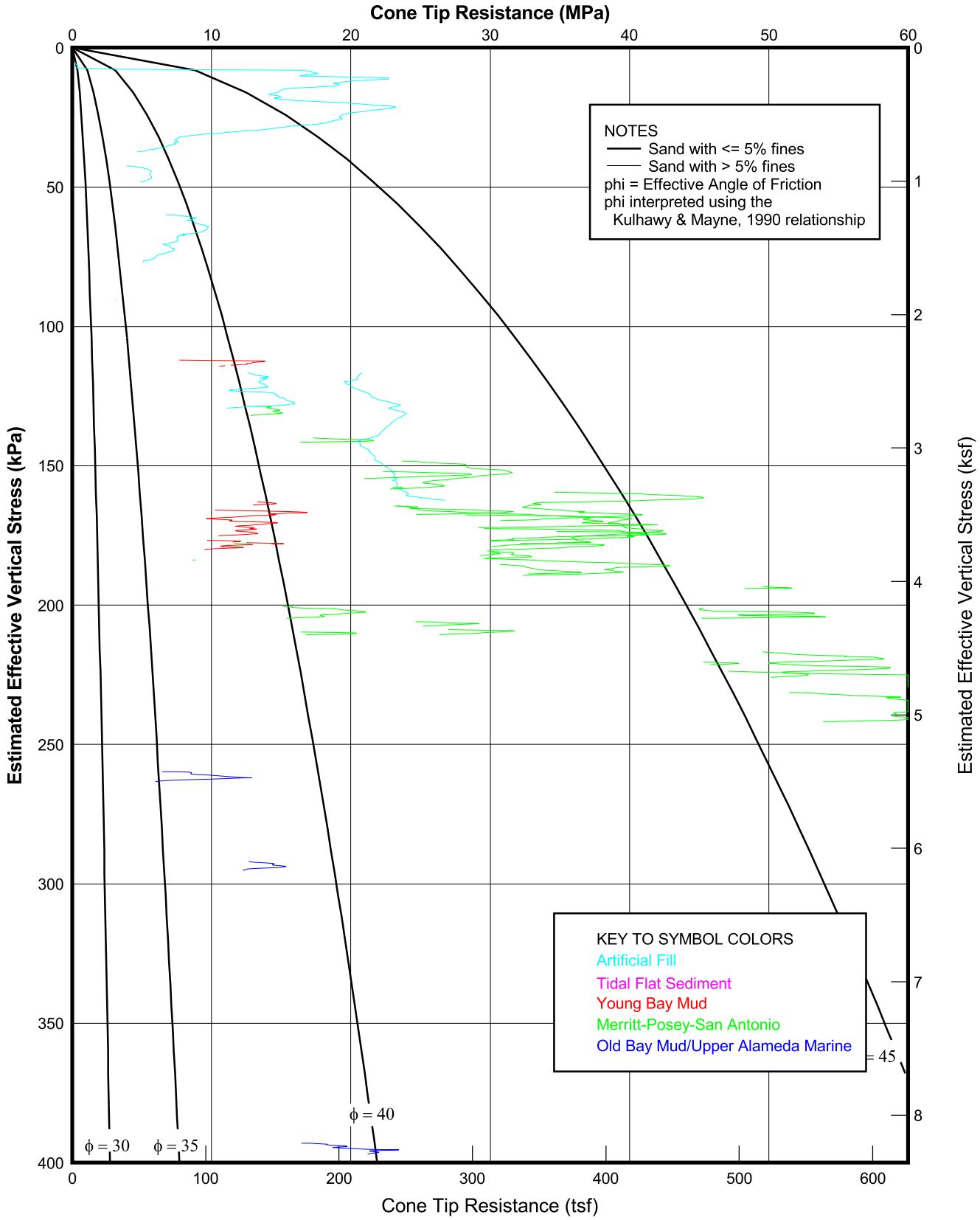
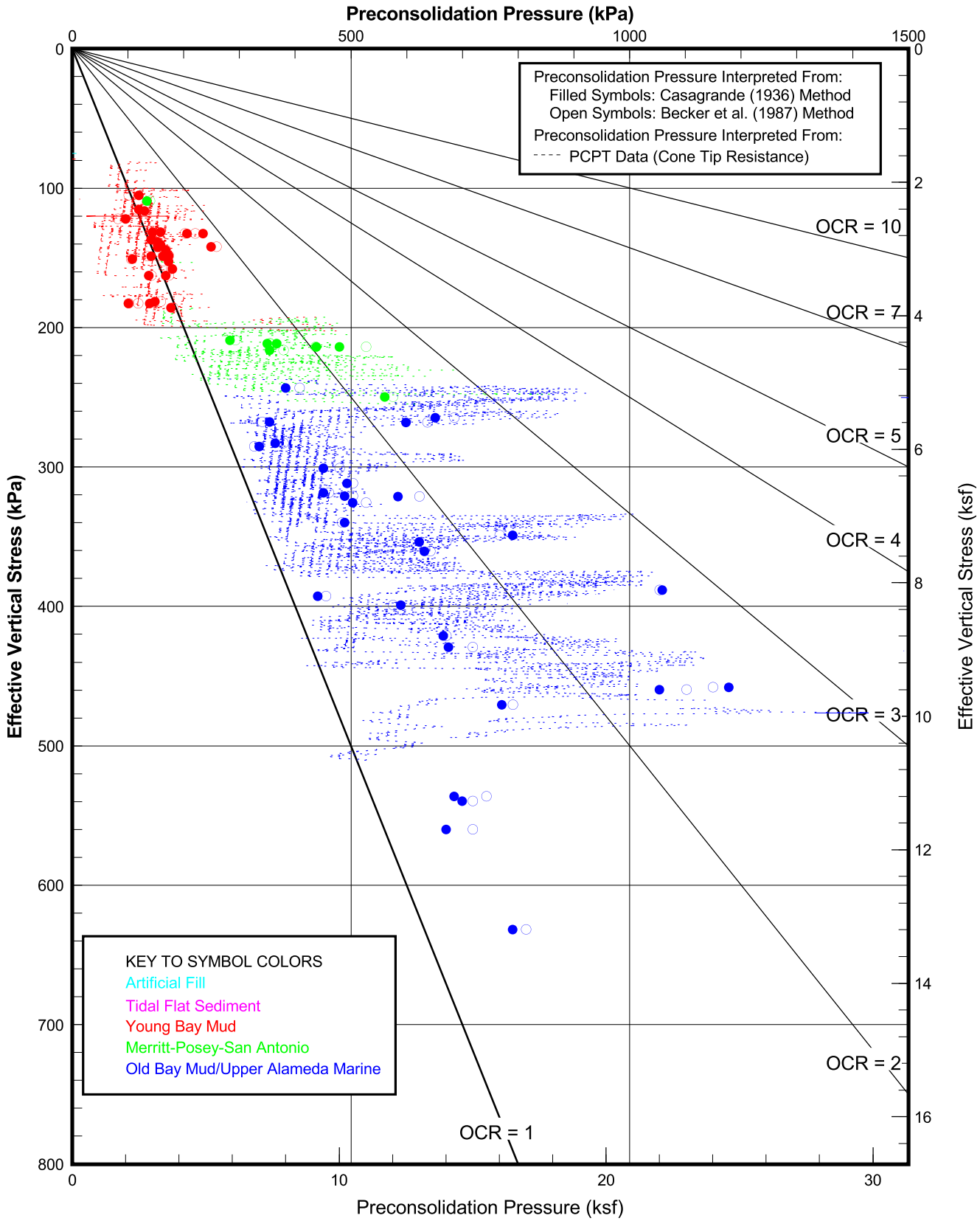


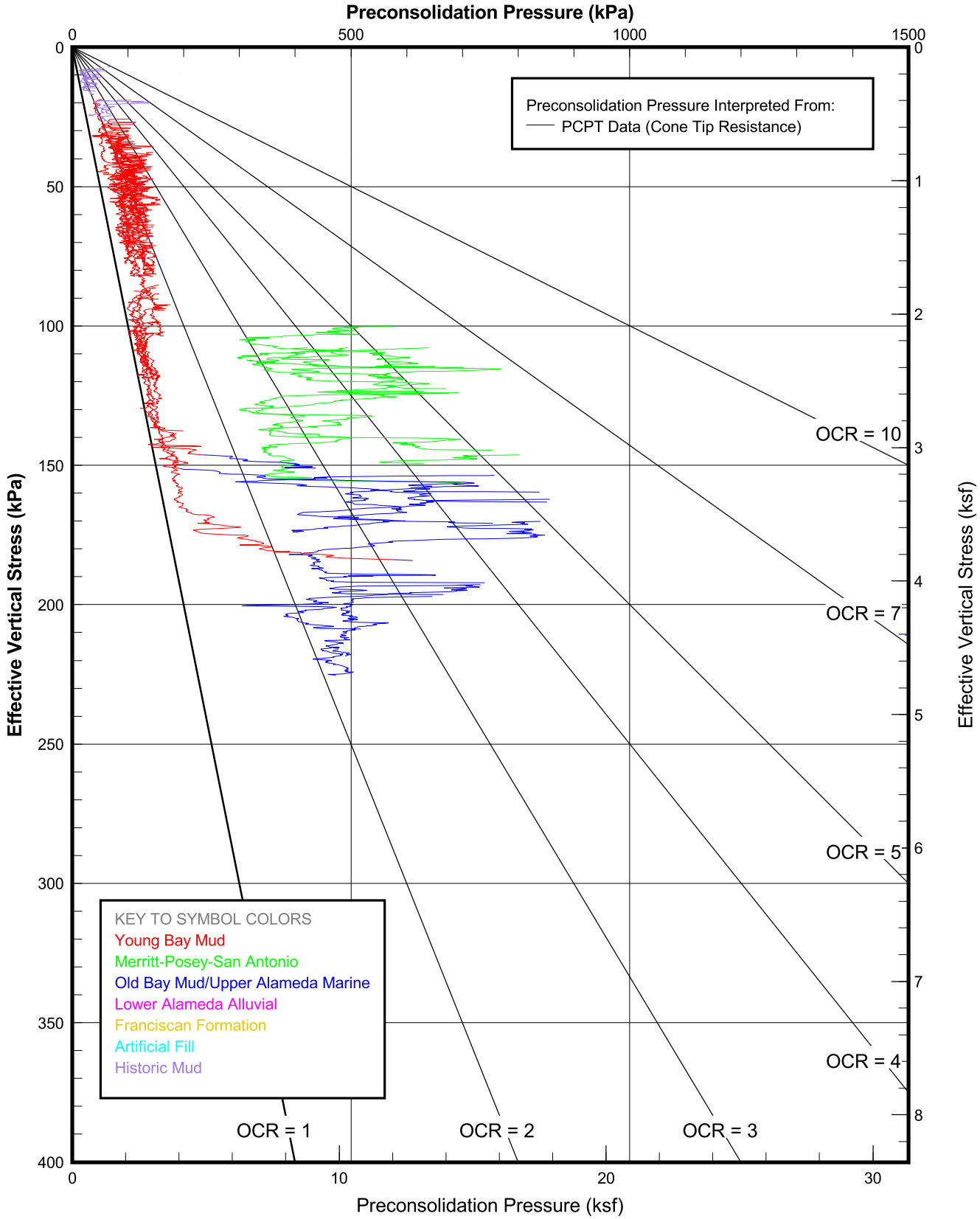
EFFECTIVE ANGLE OF FRICTION INTERPRETED FROM CPT DATA
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.22



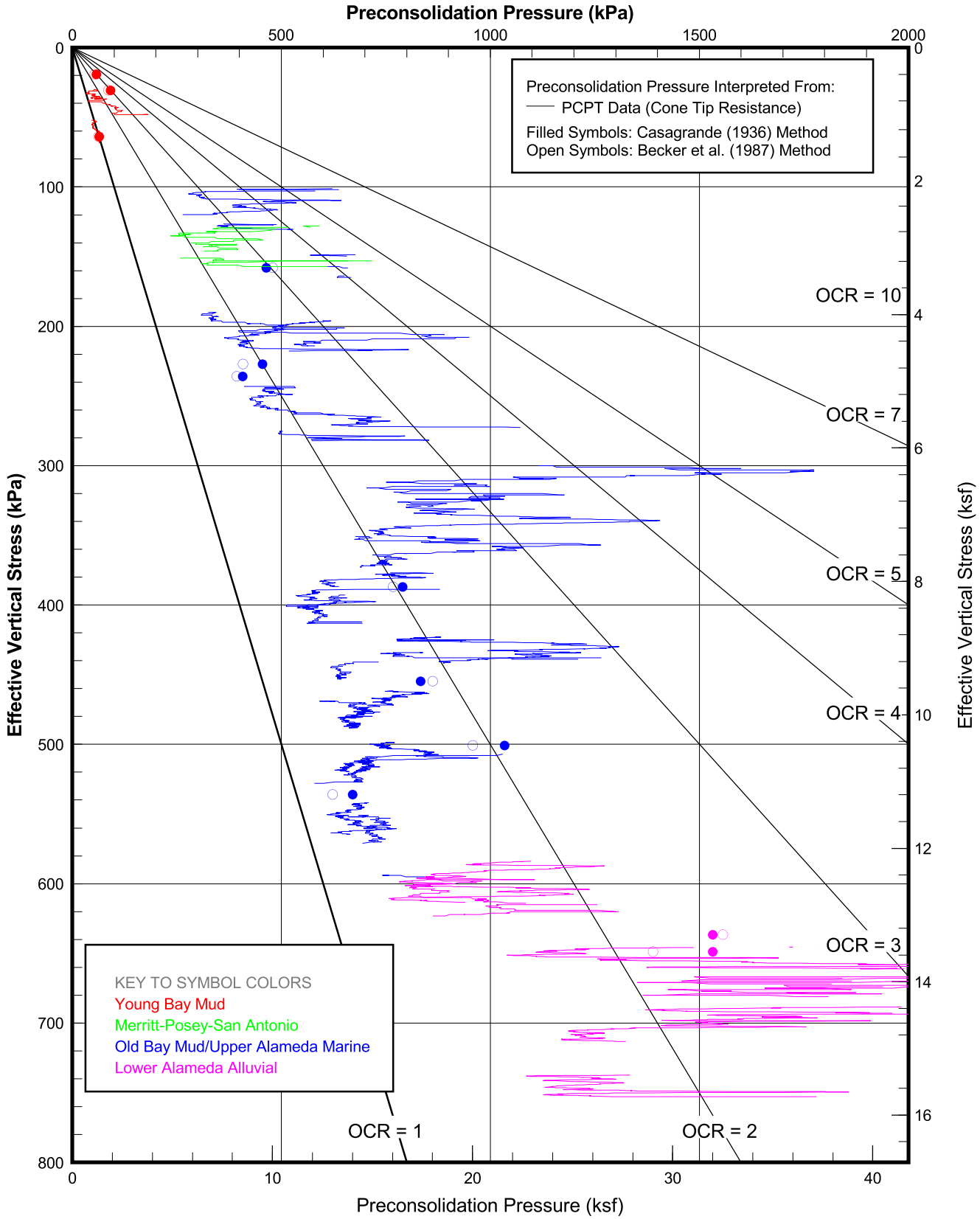
PRECONSOLIDATION STRESS INTERPRETED FROM CPT AND LABORATORY DATA
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.23



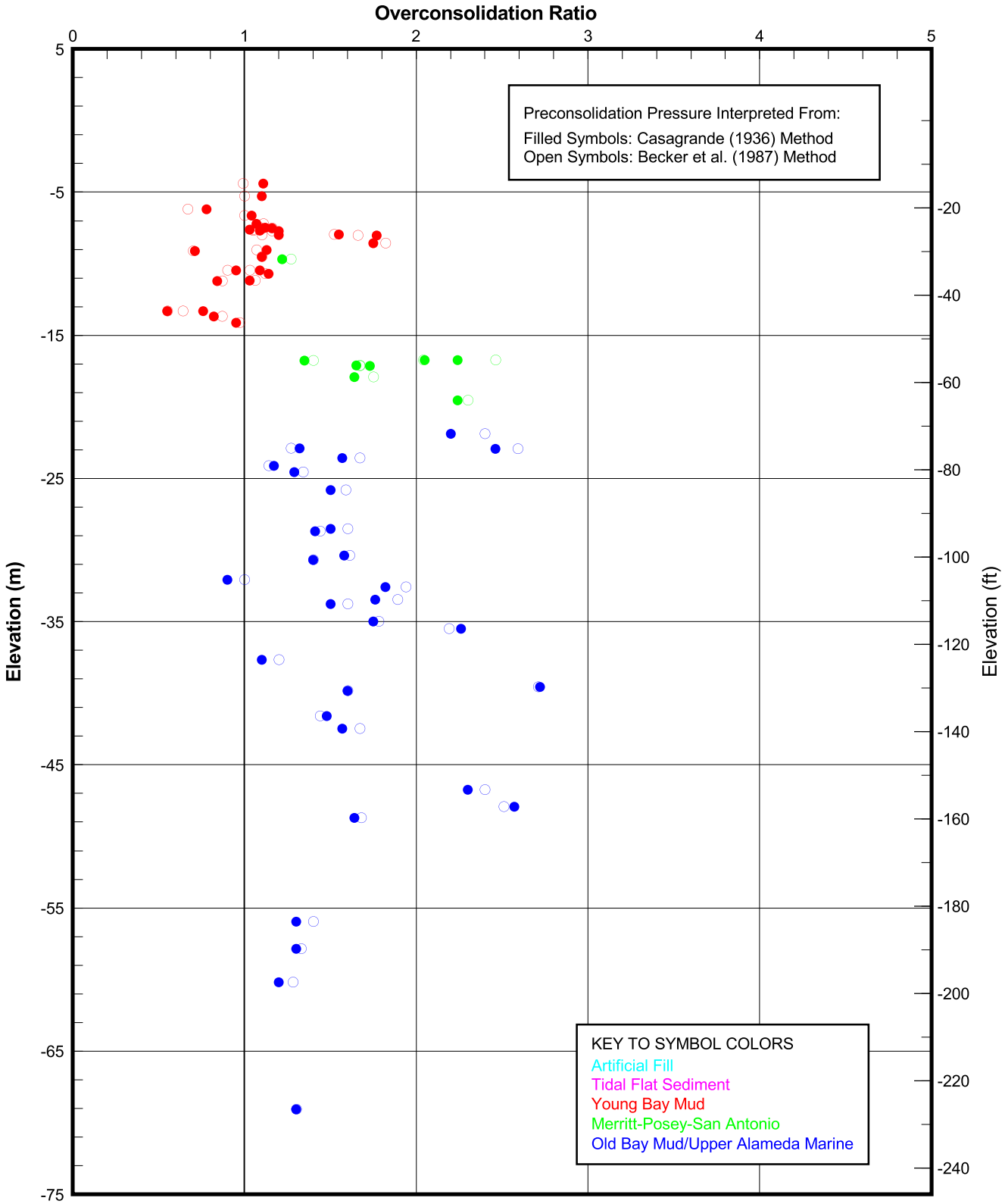
PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA
Borings 99C-1 through 99C-15
SFOBB East Span Seismic Safety Project

PLATE 5.24



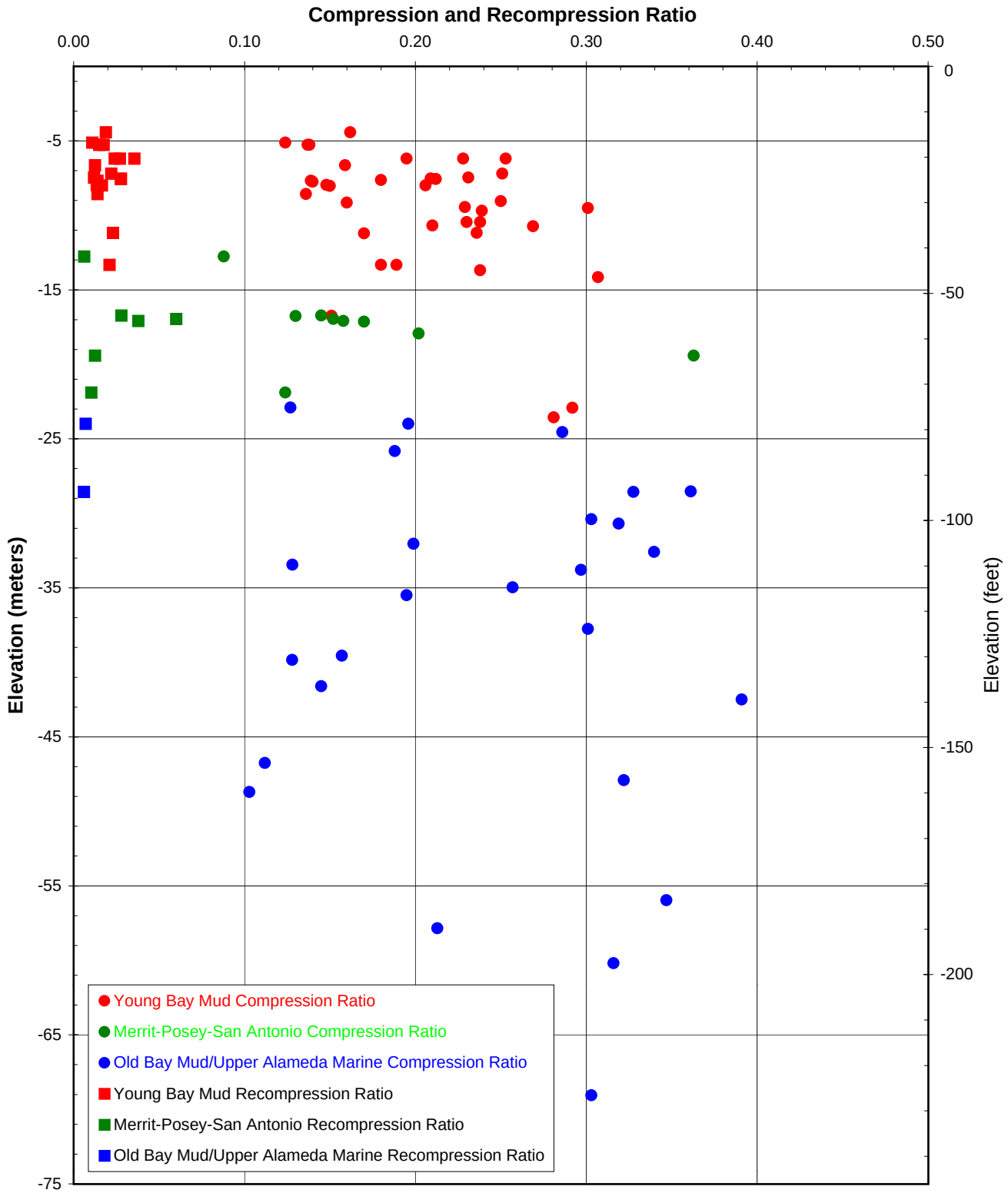
PRECONSOLIDATION STRESS FROM CPT AND LABORATORY DATA
Marine Borings 98-44 and 98-39
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.25



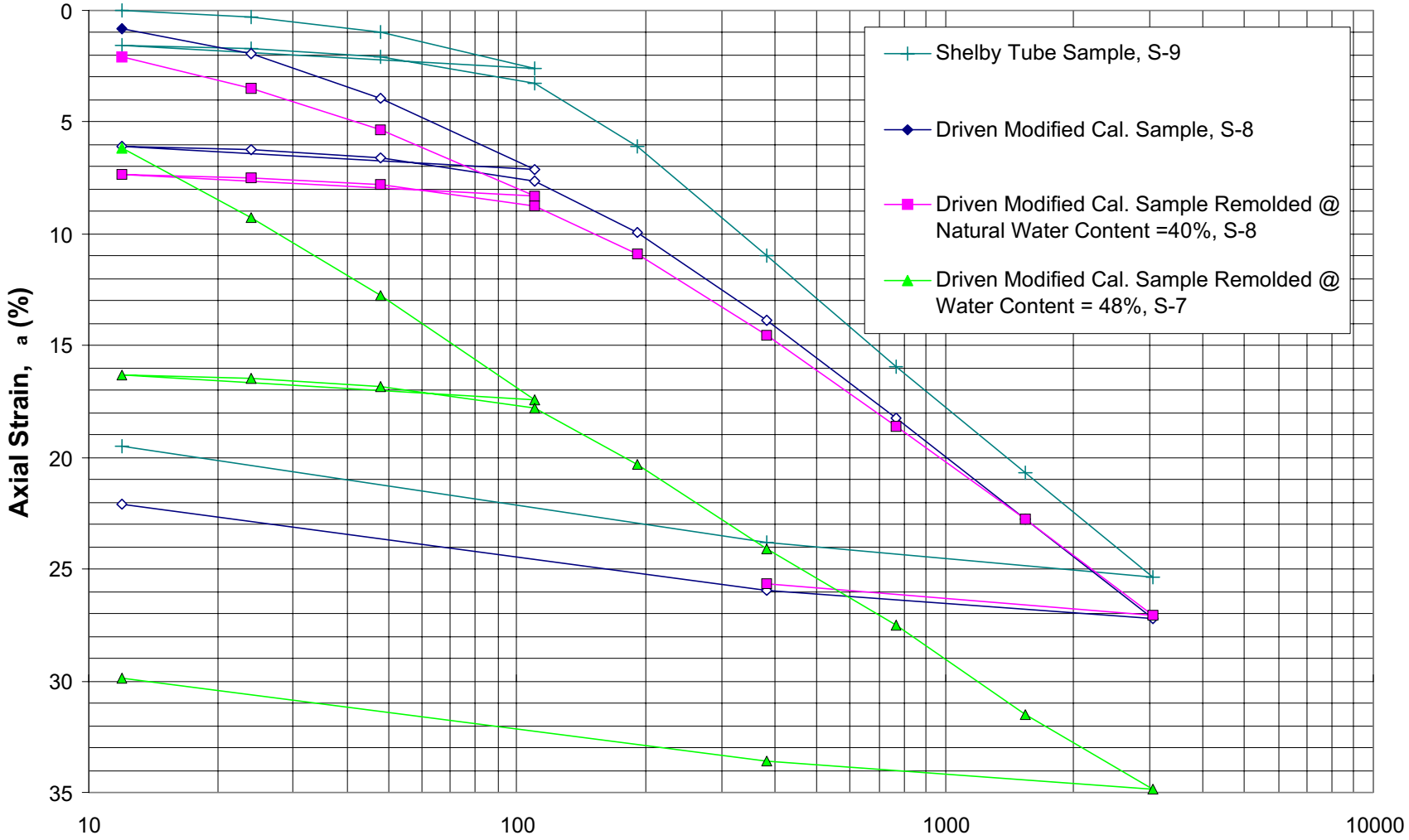
OVERCONSOLIDATION RATIO INTERPRETED FROM LABORATORY DATA
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.26



COMPRESSION AND RECOMPRESSION RATIO PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

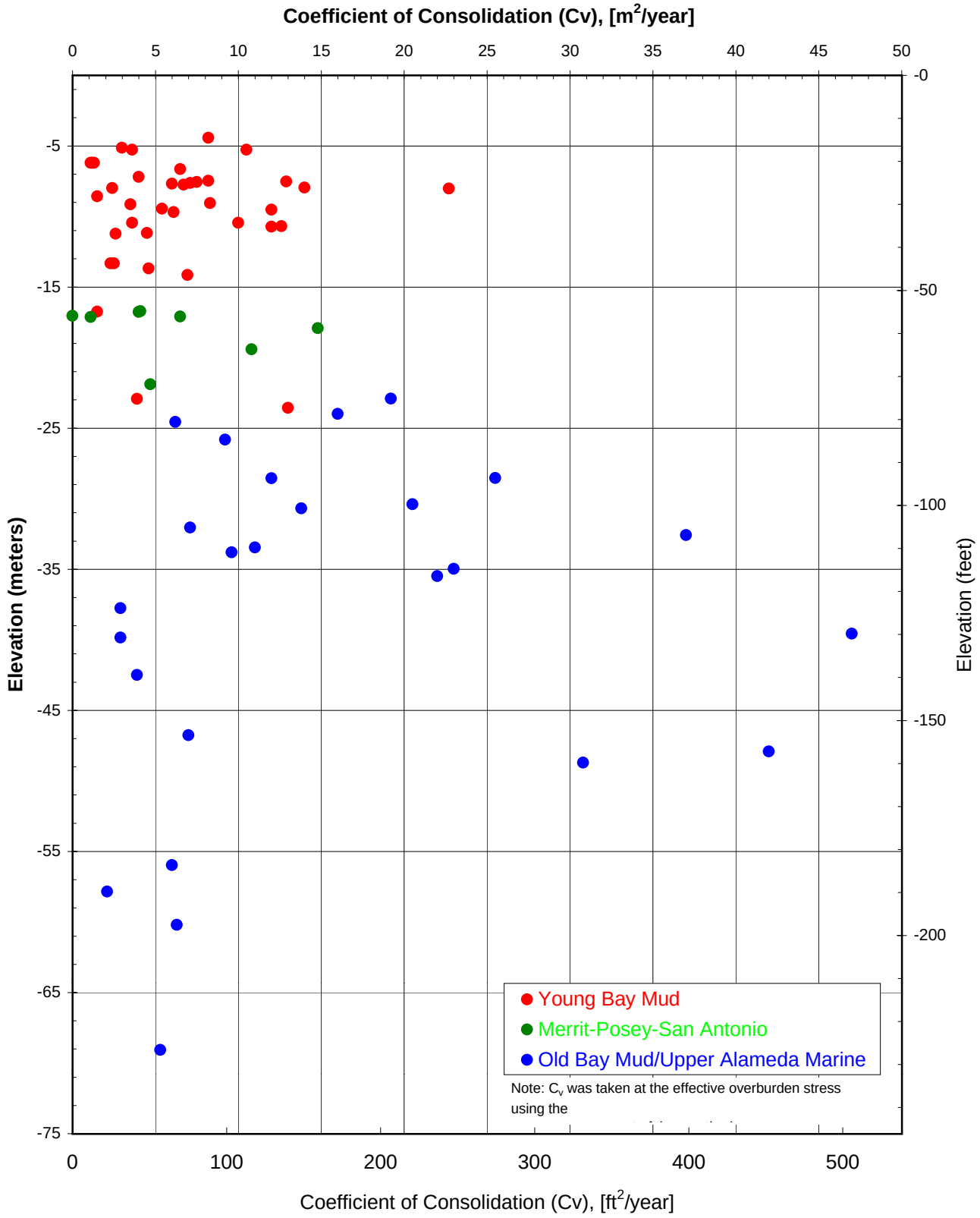
PLATE 5.27



REMOLDED CONSOLIDATION TEST RESULTS
Boring 98-73; Sample 7 - Depth: 26 ft, Sample 8 - Depth: 26.5 ft, Sample 9 - Depth: 31 ft
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

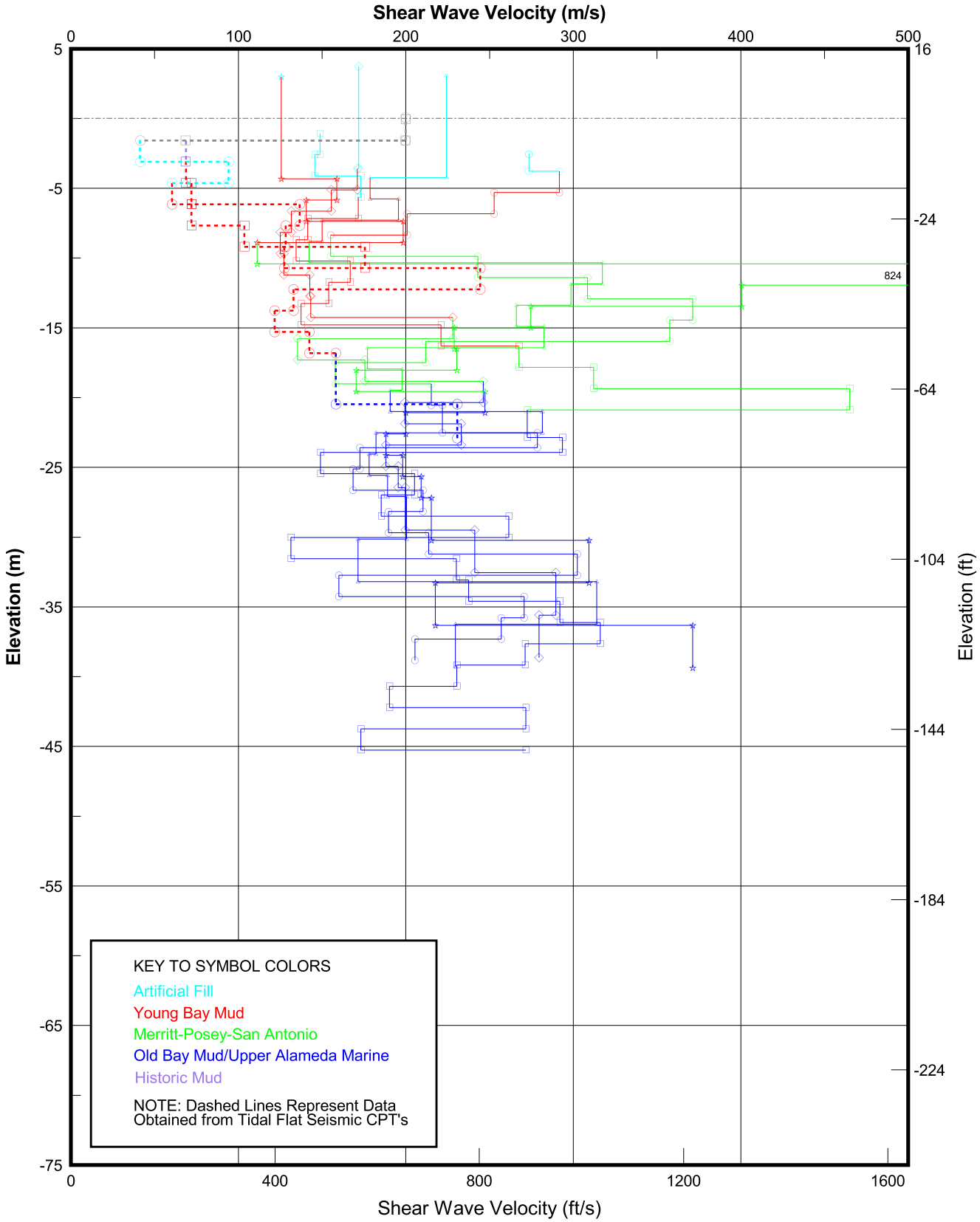
Earth Mechanics

FUGRO



COEFFICIENT OF CONSOLIDATION PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.29



SHEAR WAVE VELOCITY PROFILE
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

PLATE 5.30

SECTION 6.0
OAKLAND MOLE STABILITY ISSUES

6.0 OAKLAND MOLE STABILITY ISSUES

6.1 INTRODUCTION

6.1.1 Description of Anticipated New Approach Fills

As described in Section 1.0, the limits of the structural and fill-supported components of the Oakland Shore Approach have varied during design. However, Caltrans has indicated that the 100-percent design will be for the Short Structure Alternative with a fill-supported roadway linking the structure to existing roads on the Oakland Mole.

The approximate location of the transition from the Short Structure Alternative to the new fill sections is shown on Plate 1.2. Along the eastbound alignment, the fill section is anticipated to begin at about eastbound Station 86+11. In that area, the eastbound alignment is underlain by the existing 1930-circa northern extension of the Mole. At the eastbound abutment, the proposed roadway surface is anticipated to be at about El. +6.9 meters, which would require up to about 4 meters of new approach fill. Along the westbound alignment, it is understood that the bridge abutment is to be located on the western jughandle at westbound Station 86+42. At the westbound abutment, the proposed roadway surface is anticipated to be at about El. +6.8 meters, which would require up to about 5 meters of new approach fill. East of the transition, the northern edge of the new fill section will extend out onto the existing tidal flat to the north of the Mole.

6.1.2 Overview of Subsurface Conditions

The Oakland Mole is a filled area consisting primarily of granular soils with high groundwater overlying Young Bay Mud. The lower, submerged portion of the granular fill is typically loose to medium dense. As shown on Plate 4.7 and described in Section 4.0, both the existing fill and underlying Young Bay Mud are thickest where the Mole overlies a buried Holocene paleochannel between the western and eastern jughandles.

As discussed in Section 5.0, the Young Bay Mud is essentially normally consolidated under the weight of the 1930s' northern Mole extension fill. Under the newer jughandles that extend farther to the north, however, the test data show the Young Bay Mud to be underconsolidated under the weight of the more recently placed fill.

To the north of the Oakland Mole, the exploration shows that the geologically Recent Young Bay Mud is overlain by 2 to 5 meters of very recent tidal flat sediments. The overlying, post-1930s sediments include local accumulations of beach sand and very soft clay (historical bay mud). Underlying those surface materials, there is a semicontinuous layer of sand that was deposited during the construction of the northern Mole extension in the 1930s.

6.1.3 Implications of Subsurface Conditions

The subsurface conditions have a number of geotechnical implications for the stability of the Oakland Mole and any new fill that might be placed to either raise or extend the Mole. The stability issues include both settlement and seismic performance considerations.

Static stability issues include considerations of:

- Compression and settlement due to the weight of additional fill;
- Variations of the total settlement due to the variable thicknesses of both the historical and Young Bay Muds, and the variations in the existing state of consolidation of the Young Bay Mud; and
- The time rate of settlement.

There is potential for seismic shaking to cause several problems, including:

- Liquefaction of the saturated fill;
- Ground surface settlement due to seismic shaking;
- Differential settlement and gapping between the proposed bridge abutment or slab deck and adjacent ground;
- Cyclic degradation and loss of strength in the Young Bay Mud; and
- Lateral spreading or large lateral soil displacements if liquefaction or other strength degradation occurs behind the present slopes.

6.2 SETTLEMENT CONSIDERATIONS

6.2.1 Sources and Implications

Ground settlements will result from volume change in compressible soils due to the primary consolidation under the weight of the existing fill, consolidation under the weight of new fill, and secondary consolidation (creep) under the existing and/or additional stresses. The effects of ground settlement include: a) pile downdrag, b) gapping and related movement, c) damage to roadway pavements and foundations, and d) damage to structures as a result of differential settlements.

Where the existing ground surface of the Mole will be raised, significant short-term and long-term ground settlements are expected as a result of consolidation of the Young Bay Mud. Some additional settlement also may be realized due to consolidation in the deeper clay layers in the Merritt-Posey-San Antonio Formations and the underlying Old Bay Mud. Because the test data suggest that the Young Bay Mud is underconsolidated beneath the jughandle extensions, the

settlement due to the placement of additional fill is anticipated to be greater beneath those newer fill areas. Short-term ground settlement also could occur in the Mole fill in the areas underlain by rock dikes or riprap, rubble, debris, and where underground voids and burrows exist in the fill.

The settlements beneath new fill to the north of the existing Mole will be influenced by the same factors described above. However, to the north of the existing Mole, the thickness of new fill will be much greater than that required to raise the existing Mole to the same elevation. Further, the underlying Young Bay Mud to the north of the existing mole is consolidated to a much lower stress state than it is beneath the Mole. Therefore, the settlements beneath the new fill to the north of the existing Mole will be larger. Additional settlements also should be expected due to the consolidation of the historical bay mud layer.

6.2.2 Historical Settlement of 1930s Northern Mole Extension

Historical settlement measurements (Caltrans, 1933) following construction of the northern Mole extension in the 1930s are reproduced on Plate 4.3. As shown, those records indicate that:

- Outside of the paleochannels, as much as 1 meter of settlement occurred within the first 5 years, but little additional settlement occurred afterwards.
- Above the paleochannel to the west of the turnaround jughandle, about 1.5 meters of settlement occurred within the first 5 years, and about 0.1 to 0.2 meter of additional settlement occurred over the next 15 years.
- In the radio tower area farther to the east, about 1.5 to 2 meters of settlement occurred in the first 5 years over the deeper paleochannel present at that location, and as much as 1 meter of additional settlement occurred over the next 15 years.

The historical data illustrate that the total settlement will be proportional to the thickness of the Young Bay Mud, and the rate of settlement will be inversely proportional to the thickness of the Young Bay Mud.

6.2.3 Predicted Total Settlement Due to New Fill

A preliminary assessment of potential settlement due to the weight of new fill (reproduced in Volume 4) was conducted to assist in a cost comparison of the slab-on-pile versus the fill-supported slab roadway options. This assessment is presented in Volume 4. Caltrans will conduct further studies to finalize the design of the new approach fill. The preliminary settlement assessment for the new fill included:

- Research on construction of the existing Mole,
- Review of settlement history of the existing Mole,

- Review of the failure of the existing Mole during construction,
- Consideration of the construction sequence,
- Settlement analyses for the new fill along the eastbound alignment, and
- Settlement analyses for the new fill along the westbound alignment.

Based on the historical settlement data, total ground settlement from new approach fill being placed on existing soils north of the present slopes (up to El. +4 meters) will be on the order of 10 percent of the underlying Young Bay Mud thickness. The primary conclusions drawn from the study are as follows:

- For an assumed 5.5 meters of new fill on the new westbound alignment, the maximum ultimate settlement is anticipated to be about 1.5 meters.
- Along the northern edge of the existing westbound roadway, the maximum additional settlement is expected to be on the order of 0.15 meter.
- The ultimate settlement at the abutment fill for the new eastbound approach is expected to be about 0.6 meter.
- Secondary settlements are estimated to be on the order of about 6 mm per year.
- The use of lightweight fill may be a feasible option for the proposed eastbound abutment backfill and approach embankment.

Detailed evaluations and design of fill-supported roadway sections on the Mole are being performed by Caltrans.

6.2.4 Time Rate of Settlement Considerations

According to historical settlement measurements (refer to Volume 4), a settlement period of over 15 years would be required to achieve 90-percent consolidation in the Young Bay Mud. Based on preliminary studies (presented in Volume 4), the settlement period potentially can be reduced to less than 1 year using a wick drain design based on 1-meter, on-center spacing. The selection and design of appropriate ground improvement (drainage) methods (including wick drain systems) and construction sequences are being performed by Caltrans.

6.3 SOIL LIQUEFACTION

6.3.1 Definition

Liquefaction is the loss of strength that can occur in a loose, saturated sand during (or immediately following) seismic shaking. As loose granular soils are shaken, their tendency to contract and compress leads to the development of positive pore pressures. If the intensity or duration of the shaking is great enough, the buildup in pore pressure can produce a significant loss of shear strength. If the shaking continues after the onset of liquefaction, liquefaction can

produce a number of ground effects (e.g., sand boils, settlement, lurching, and lateral deflection). Liquefaction also can cause a loss of axial capacity of shallow or deep (due to downdrag) foundations, loss of lateral pile capacity, and lateral ground spreading.

The susceptibility of a granular soil to liquefaction is a function of the gradation, density, and fines content of the soil. Susceptibility to liquefaction decreases with respective increases in: a) distribution of grain size, b) soil density, c) fines content, and d) clay-size fraction of the fines. The susceptibility to liquefaction also tends to decrease as a function of the age of the deposit.

6.3.2 Method of Evaluation

Overview. Evaluation of the liquefaction susceptibility of coarse-grained layers and deposits primarily was based on the empirical procedure recommended by the National Center for Earthquake Engineering Research (NCEER, 1997). In the NCEER procedure, potentially liquefiable soil strata are identified as being those layers that are relatively loose, submerged granular sediments. Soil strata above the assumed groundwater level were considered not susceptible to liquefaction.

NCEER recommendations were used to compute liquefaction susceptibility using both boring SPT and CPT data. The available cyclic shear resistance of the potentially liquefiable strata encountered (based on the normalized SPT N-value or CPT tip resistance) was compared to the estimated cyclic shear stress that would be induced by a given earthquake. The estimated factor of safety against liquefaction is the ratio of the available cyclic shear resistance to the induced cyclic shear stress.

The estimated factors of safety against liquefaction at various depths are a function of the estimated overburden pressure at that depth. In general, higher factors of safety against liquefaction are calculated for higher overburden pressures. We note that most of the liquefaction analyses were performed using the existing Mole geometry and a groundwater level at El. 0 meter MSL. Several analyses, however, also were conducted for the assumed new ground surface elevation. When the profiles of the new fill sections are finalized, additional evaluations should be performed to check the validity of the results presented below.

Boring SPT Data. For use with the NCEER procedure, sample depths, fines contents, soil unit weights, and field SPT N-values were interpreted and summarized from the borings. The SPT data were then normalized to an overburden pressure of 0.1 MPa and corrected for fines content. Because the SPT sampling procedure consisted of a standard rope and cathead SPT hammer, the energy delivered to the sampler was assumed to be consistent with the conventional 60-percent efficiency for the SPT sampling procedure.

For this evaluation, sublayers were identified at each boring location. Typically, the overall stratigraphic description was obtained from the descriptions presented on the logs, and

sublayers were created on the basis of SPT blow counts and fines contents. Usually, one sublayer was created for each sample obtained in the boring and that layer was assigned the blow count associated with the sample. A fines content value was assigned to each of those sublayers on the basis of either laboratory tests performed on the sample or the nearest fines content measurement considered to be representative of the sublayer. Unless bounded by one of the stratigraphic layers shown on the boring logs or the estimated groundwater table, sublayer boundaries were selected midway between adjacent samples.

CPT Data. Liquefaction susceptibility also was calculated using the NCEER procedure based on the CPT tip resistance. For those analyses, the measured tip resistances were corrected for fines content using the procedures suggested in NCEER (1997) and normalized to an overburden pressure of 0.1 MPa.

6.3.3 Earthquake Ground Motion Assumed for Analyses

The seismic hazard analyses for the project (Fugro-EM, 2001g) have defined the following design earthquakes: a) a magnitude 7.5 event on the Hayward fault, and b) a magnitude 8 event on the San Andreas fault. Either of those two events is capable of producing a peak horizontal ground acceleration (PGA) on rock of at least 0.52g. The preliminary liquefaction analyses results presented subsequently assumed that an earthquake magnitude of 7.5 produced a PGA of 0.52g at the Oakland Mole. In addition, a limited number of analyses were conducted using lesser ground motions to evaluate the threshold ground motions that might be expected to produce liquefaction at the Mole.

6.3.4 Presentation of Results

Using the NCEER (1997) procedure, liquefaction analyses were performed for the borings and CPTs along longitudinal cross sections A-A' and B-B' as well as perpendicular cross sections C-C' and E-E' (the locations of which are shown on Plate 4.5; the geologic cross sections are included in Section 4.0). The results of the analyses of a magnitude 7.5 earthquake producing a PGA of 0.5g are shown on Plates 6.1 through 6.4. A key to the symbols used on the liquefaction analyses cross sections is provided on Plate 4.6.

Also shown on each plate is the respective equivalent PGA that would likely induce similar levels of cyclic shear stress for earthquake magnitudes of 6.0, 6.5, and 7.0. The equivalent PGAs were estimated using the Idriss Magnitude Scaling Factors (as recommended by the NCEER [1997] committee as a lower bound).

On the liquefaction analyses cross sections, the tip resistance and SPT N-values (or equivalent N-values [blow count divided by 1.6] for the California modified sampler) are shown as yellow bars to the right of the axis for each boring and CPT location. Also shown on each plot are the estimated SPT blow count and CPT tip resistance (red line) that would be required (based on NCEER, 1997) to prevent the occurrence of liquefaction for the assumed earthquake

magnitude and PGA. In general, layers and zones where the SPT or tip resistance required to preclude the occurrence of liquefaction is less than the normalized measured tip resistance are considered liquefiable. Where the resistance required to prevent liquefaction is less than the measured resistance, the zone that represents the deficiency is shaded blue.

6.3.5 Conclusions

Submerged Fill. As described in Section 5.0, the saturated granular Mole fill is generally loose to medium dense. The N_1-values in the submerged fill typically are between about 9 and 23, and average about 14.

The analyses results indicate that liquefaction of the Mole fill beneath the water table (El. 0 meter MSL) is likely to occur under the design seismic conditions. As shown on Plates 6.1 through 6.4, about 3.5 to 5 meters of the fill appear to be liquefiable under the analyzed ground motions. As shown, the measured resistances are typically about one-third to two-thirds of the resistances required to prevent liquefaction. The cross sections suggest that the liquefiable submerged fill layers are generally continuous beneath the Mole. The analyses results also show that the layer of sand placed to the north of the Mole during the 1930s Mole construction also is liquefiable.

Although not presented, analyses for other levels of ground shaking suggest that localized zones of the submerged fill are likely to experience liquefaction during a magnitude 7.5 earthquake at a PGA of about 0.2g. The analyses also suggest that widespread liquefaction will begin to occur during a magnitude 7.5 earthquake at a PGA of about 0.25 to 0.3g.

Those results are considered generally consistent with historical observations following the 1939 and 1981 (Loma Prieta) earthquakes, which probably produced PGAs of about 0.2 to possibly 0.3g at the site. Following the 1981 Loma Prieta event, sand boils and other ground deformations were observed to the east of the project site at the Toll Plaza. Documented records of those two historic earthquakes, however, show no reports of damage to the bridge or roadways in that area.

Native Merritt Sand. Merritt Sand is typically dense to very dense sand with an uncorrected SPT N-value of from 30 to more than 50 blows per 0.3 meter. As shown on Plates 6.1 through 6.4, the evaluation suggests that the Merritt Sand layer is unlikely to liquefy under the design seismic shaking.

6.4 GROUND SETTLEMENT DUE TO EARTHQUAKE SHAKING

Ground settlement (and other ground effects) during seismic shaking can occur due to: a) liquefaction, b) lateral spreading, and c) the compression of loose fill with rubble, voids, animal burrows, or other similar conditions. Settlements due to liquefaction and/or in loose, dry fill can be estimated using empirical procedures. Those estimates are based on level ground

conditions and are described below. Because the Mole is adjacent to a slope and lateral spreading is a significant possibility, the total ground settlements should be expected to be larger than estimated below for level ground conditions. Earthquake-induced settlement can cause downdrag on deep foundations, distress to pavements, gaps between ground support pavements and approach slab or abutments, and structural damage to structures founded on shallow foundations on or within the fill.

6.4.1 Liquefaction-Induced Settlement

The liquefaction cross sections provided on Plates 6.1 through 6.4 show an estimate of vertical ground settlement that may occur due to liquefaction-induced settlement. These estimates are based on the measured SPT N-values and CPT tip resistances, factors of safety against liquefaction calculated using the NCEER (1997) procedure, and the methods presented in Ishihara and Yoshimine (1992). Using the Ishihara and Yoshimine (1992) method, volumetric strains were estimated that could occur within submerged layers due to dissipation of seismically-induced pore pressures. The estimated volumetric strains associated with liquefaction are shown by the purple shading to the left of the line representing the boring and CPT locations on the liquefaction analyses cross sections.

The estimated volumetric strains were then used in conjunction with the corresponding layer thicknesses to evaluate the magnitude of seismically-induced settlements at the boring locations. The settlements below any elevation are shown by the thick black line to the left of the line representing the boring and CPT locations on the liquefaction analyses cross sections.

As shown on Plates 6.1 through 6.4, this analysis suggests that the liquefaction-induced ground settlement on the existing Mole will be on the order of 0.1 to 0.15 meter and may occur over wide areas. Large differential settlements should be expected. Differential settlement also may be as much as total settlement.

It should be noted and emphasized that the estimated liquefaction settlements are based on empirical procedures for level ground. Those estimates, therefore, do not consider the possible effects created by the adjacent Mole slope nor the possibility of lateral spreading, which would increase the amount of settlement in the graben area behind the slope. For those reasons, the estimated settlements shown on Plates 6.1 through 6.4 and discussed above are probably lower bound estimates of the settlements that will be realized during seismic shaking at the site.

6.4.2 Seismically-Induced Settlement of Dry Fill

Earthquake shaking also can result in seismically-induced settlement of relatively loose, dry, granular materials. However, the upper fill is generally dense, and therefore settlement of the dry fill is expected to occur primarily in the areas where voids exist in the dry, upper Mole fill. Except in those areas underlain by local voids or loose zones, the settlement of the dry fill

should be significantly less than the settlement due to liquefaction of the underlying submerged fill.

6.5 SEISMICALLY-INDUCED STRENGTH DEGRADATION OF YOUNG BAY MUD

The design earthquake is expected to generate multiple cycles of strong ground shaking. Young Bay Mud is a moderately sensitive clay (sensitivity ranges from about 2 to 5). The in situ remote vane test data show that shear strains of 20 to 30 percent are required to degrade the strength to a residual value. At large strains where soil remolding could occur, the strength of Young Bay Mud could be two to five times lower than its peak undrained static shear strength. If the Young Bay Mud layer is on a slope, such a loss of strength could contribute to lateral (downslope) movements.

The potential for cyclical strains produced by earthquake shaking to reduce the undrained strength of Young Bay Mud was evaluated by conducting a series of static and cyclic simple shear tests at the University of California at Berkeley. Those tests, whose results are provided in Volume 4 (UC Berkeley, 1999), included monotonically loaded static strength measurements after cyclic loading (25 cycles at a single amplitude shear strain of between 1 and 3 percent). The results indicate that although the shear modulus is reduced, the strength degradation due to seismic loading is about 10 to 15 percent.

Thus, it appears likely that the potential for significant strength degradation of Young Bay Mud during earthquake shaking is relatively low unless the seismic shaking produces a large strain slope-type failure. Since the test results indicate that degraded shear strength due to cyclic shear strains will be only slightly smaller than the undisturbed shear strength, the evaluation of slope-type failure mechanisms can be made based on static undrained shear strengths rather than remolded shear strengths.

6.6 LATERAL SPREADING

Lateral spreading is a phenomenon where large lateral soil movements (up to several meters) can occur if soils liquefy or otherwise lose strength, and there is sufficient degree of ground slope such that the slope becomes unstable. Slopes over much of the Oakland Mole range from about 0 to 2 degrees but can be steeper locally, particularly at the water's edge where they are about 15 to 20 degrees.

Lateral ground spreading induced by soil liquefaction or soil strength loss can result in an unstable slope and large lateral ground movement. This phenomenon can cause reduction and loss of soil support for foundations and roadways. Lateral spreading also can result in both loss of support for and large lateral loads and forces on abutments, piles, pile caps, and other buried structures (e.g., pipelines, utility conduits). The amount of relative movement required to induce

large forces is usually small (less than 0.5 meter). Forces are usually applied in one direction and are not cyclic in nature.

Mitigation against the effects of lateral spreading is usually accomplished in one of three ways:

1. Improve the ground to strengthen the soil, or provide better drainage and minimize the potential for lateral spreading. Ground improvement may include: a) soil replacement, soil densification by vibroflotation, compaction, or similar methods; or b) soil stabilization by the introduction of grout, soil-cement mixing, stone columns, or similar methods.
2. Design the foundation system to resist the applied loads at acceptable displacements.
3. Design new fills for acceptable displacements.

Ground improvement methods usually require that the area extent and depth of the soil mass involved be relatively well defined, and that an evaluation be made of the area of influence to be improved. The design of a foundation system to resist applied forces also requires knowledge of the extent and depth, but a uniform design could be used throughout an area prone to lateral spreading without the need to pinpoint the boundaries of spreading. For example, a single pile type and size (diameter, wall thickness, yield strength) could be specified for all the foundations in an area where lateral spreading may occur, as well as beyond the expected boundaries of lateral spreading.

The issues related to lateral spreading have been evaluated by Fugro-EM, Caltrans, and the Seismic Peer Review Panel. A summary description of the methods and assumptions used in the analyses as well as the analyses results are presented in a report in Volume 4 and in the Oakland Shore Approach Foundation Report (Fugro-EM, 2000). The purpose of the studies was to ascertain the effects of lateral spreading on proposed pile foundations and approach fill alternatives.

Earth Mechanics FUGRO

A S80W — A′ N80E

98-51, 19 ft South | 98-16, 3 ft North | C-C′ 98-52, 20 ft North | W Sta. 85+00 | 98C-101, 27 ft North | 98-53, 3 ft North | W Sta. 86+00 | C-17, 35 ft South | C-19, 33 ft South | C-12, 3 ft North | 98-61, 1 ft South | W Sta. 87+00 | D-D′ | C-15, 28 ft South | 98-56, 4 ft South | 98-18, 5 ft South | E-E′

ARTIFICIAL FILL

YOUNG BAY MUD

MERRITT-POSEY-SAN ANTONIO SEQUENCE

OLD BAY MUD

15′ / 0 / 80′

Elevation, feet: 10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90

Elevation, meters: 0, -5, -10, -15, -20, -25

Volumetric Strain (%) Settlement (in) | Tip Resistance (tsf) | Blow Counts

GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

SUBSURFACE CROSS SECTION A-A′
With Liquefaction Evaluation
Magnitude = 7.5, Acceleration = 0.52
SFOBB East Span Seismic Safety Project

PLATE 6.1a

Earth Mechanics FUGRO

B S80W — B′ N80E

W Sta. 88+00 | 98-57, 7 ft North | 98-58, 59 ft North | 98C-104, 36 ft North | 98-62, 41 ft South | W Sta. 89+00 | 98C-105, 36 ft South | 98-59, 34 ft South | F-F′ | W Sta. 90+00 | 98-67, 89 ft South | 98-63, 31 ft South | 98-60, 22 ft South | W Sta. 91+00 | 98-68, 81 ft South | 98-64, 14 ft South

Elevation, feet: 10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90

Elevation, meters: 0, -5, -10, -15, -20, -25

ARTIFICIAL FILL

YOUNG BAY MUD

MERRITT-POSEY-SAN ANTONIO SEQUENCE

OLD BAY MUD

15′ / 0 / 80′

Volumetric Strain (%) Settlement (in) | Tip Resistance (tsf) | Blow Counts

GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

SUBSURFACE CROSS SECTION B-B′
With Liquefaction Evaluation
Magnitude = 7.5, Acceleration = 0.52
SFOBB East Span Seismic Safety Project
PLATE 6.1b

Earth Mechanics FUGRO

C N4W — C′ S4E

98C-503, 47 ft West | 98C-504, 52 ft West | 98C-505, 52 ft West | 99C-1, 26 ft East | 98-52, 1 ft West | A-A′ B-5, 25 ft East | C-14, 50 ft East | 98-75, 66 ft East

TIDAL FLAT SEDIMENTS

ARTIFICIAL FILL

YOUNG BAY MUD

MERRITT-POSEY-SAN ANTONIO SEQUENCE

OLD BAY MUD

Tip Resistance (tsf)

Volumetric Strain (%) Settlement (in)

Blow Counts

Elevation, feet: 10, 0, -10, -20, -30, -40, -50, -60, -70, -80, -90

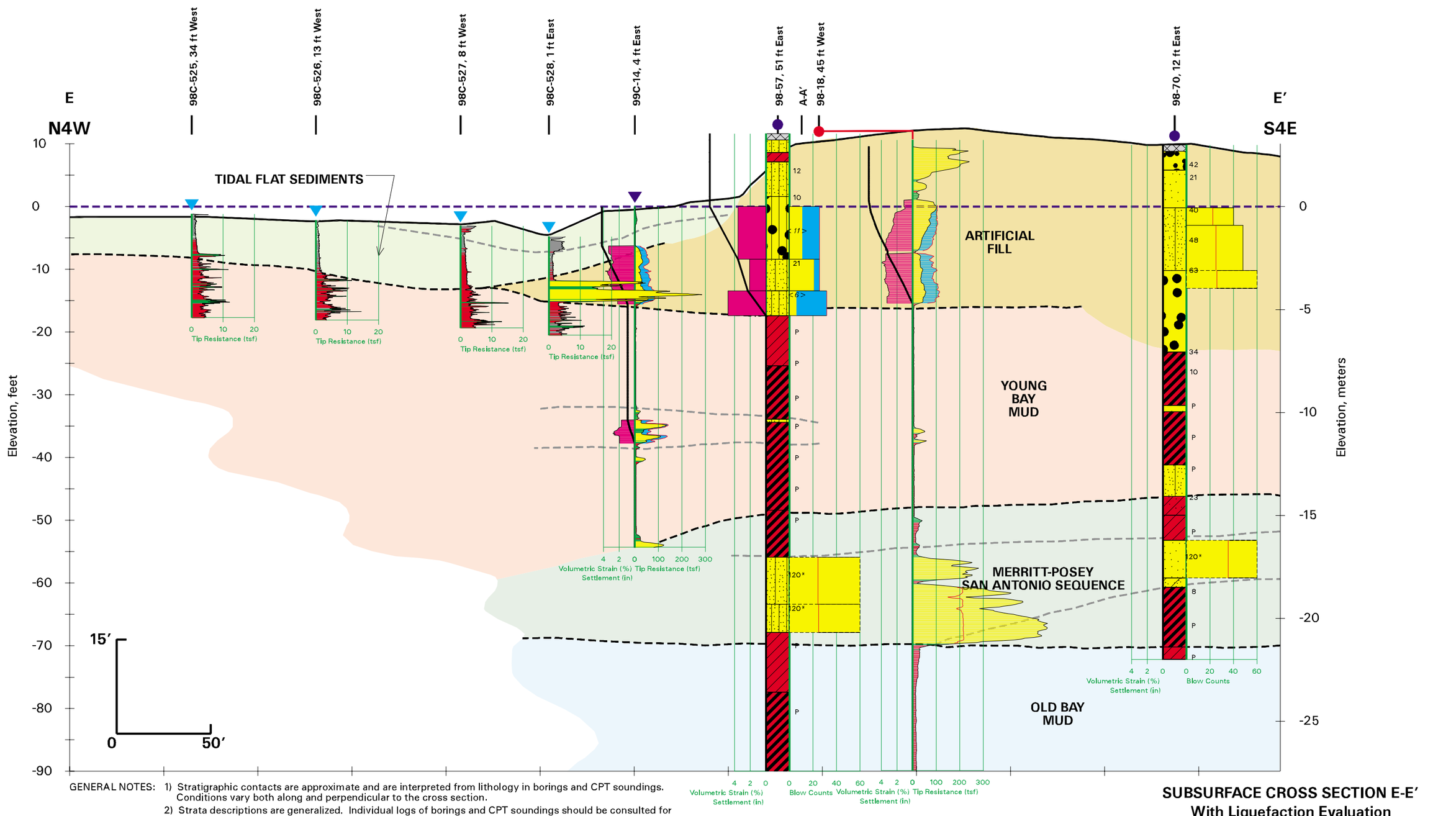
Elevation, meters: 0, -5, -10, -15, -20, -25

15′ / 0 / 50′

GENERAL NOTES:

1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

SUBSURFACE CROSS SECTION C-C′
With Liquefaction Evaluation
Magnitude = 7.5, Acceleration = 0.52
SFOBB East Span Seismic Safety Project
PLATE 6.2



GENERAL NOTES:
1) Stratigraphic contacts are approximate and are interpreted from lithology in borings and CPT soundings. Conditions vary both along and perpendicular to the cross section.
2) Strata descriptions are generalized. Individual logs of borings and CPT soundings should be consulted for details.
3) Refer to Key to Cross Sections (Plate 4.6) for details of data plotted on cross-sections. Note that lithologies for pre-1998 boring and CPT logs are as shown on Caltrans' Log of Test Boring Sheets.
4) The CPT lithologies are based on the empirical correlation between tip resistance and friction ratio (Robertson and Campanella, 1984) shown on Plate 4.6.

SUBSURFACE CROSS SECTION E-E′
With Liquefaction Evaluation
Magnitude = 7.5, Acceleration = 0.52
SFOBB East Span Seismic Safety Project
PLATE 6.3

SECTION 7.0
REFERENCES

7.0 REFERENCES

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REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

VOLUME 2A - APPENDICES
(Land Borings 98-51 through 98-60)

Prepared for

CALIFORNIA DEPARTMENT OF TRANSPORTATION

March 2001

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March 5, 2001
Project No. 98-42-0058/EMI Project No. 98-145

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian
Contract Manager

Final Oakland Shore Approach Geotechnical Site Characterization
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. The majority of the Oakland Mole exploration was conducted as part of the Phase 2, Task 5 (final site characterization phase) studies of the referenced contract, although three cone penetration test (CPT) soundings were conducted as part of the earlier Phase 1, Task 3 work scope (preliminary site characterization) of the referenced contract.

The field exploration conducted on the Oakland Mole in the Spring and Fall of 1998 as part of the referenced contract included 25 soil borings (designated in the subsurface database created for the project as 98-51 through 98-75) and 9 CPT soundings (designated as 98-16 through 98-18 and 98-101 through 98-110 [several planned locations were abandoned due to electrical interference]). A total of 53 offshore tethered Seascout CPT soundings were conducted in December 1998 during seasonal high tides on the tidal flat to the north of the Oakland Mole. Fifteen all-terrain CPT soundings were conducted on the Tidal Flat to the north of the Mole in March 1999 during low tide conditions. Two trench and two pit excavations were conducted in April 1999. In Fall 2000, 11 marine Seacalf CPT soundings were performed in the vicinity of the Oakland Shore Approach to the west and northwest of the western tip of the Mole. The Seacalf CPTs were conducted as part of the Phase 3 field investigation program.

This Oakland Shore Approach Geotechnical Site Characterization report summarizes the field exploration for the Oakland Shore Approach and describes our interpretation of the geotechnical conditions based on the information collected from the exploration. Our present interpretations are based on the field data from the borings, the results of laboratory tests completed in the onshore laboratories, and the CPT soundings.

This report is provided in four volumes. Volume 1 provides the interpretational text and illustrations. Volume 2 contains 27 appendices that provide boring logs and test data from 25 land borings on the Oakland Mole and 2 marine borings offshore from the northwest tip of the Oakland Mole. Volume 3 contains the

results of the CPT soundings conducted on land, on the northern shore of the tidal flat, and offshore to the north and west of the Oakland Mole. Volume 4 contains four documents that include a preliminary study of approach fills at the Oakland Mole, studies on lateral spreading of fills at the Oakland Mole, findings from trench and pit excavations, and the advanced geotechnical laboratory studies conducted at the University of California at Berkeley.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO-EARTH MECHANICS, A Joint Venture

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SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CALTRANS CONTRACT 59A0053

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

VOLUME 2A - APPENDICES
(Land Borings 98-51 through 98-60)

MARCH 2001

Prepared For:

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For boring-specific appendix plate numbers, please refer to the chart on the next page.

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Testing performed

No testing performed

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VOLUME 2
INDIVIDUAL BORING DATA AND ANALYSES APPENDICES

The exploration program for the site characterization of the Oakland Shore Approach of the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project included 25 onshore borings (10 with in situ testing), approximately 24 land-based cone penetration test (CPT) soundings, 53 marine tethered Seascout CPT soundings, and 11 marine Seacalf CPT soundings. In addition, 2 marine borings, which were performed in the shallow water tidal flat to the north and northwest of the Mole, are relevant to the characterization of the Oakland Shore Approach of the bridge. A description of the marine exploration program is provided under separate cover in the Final Marine Geotechnical Site Characterization report[1].

GEOTECHNICAL SITE CHARACTERIZATION SYNOPSIS - VOLUME 1

A general description of the Task Order No. 5, Final Oakland Shore Approach Geotechnical Site Characterization work scope is provided in Section 1.0 of Volume 1. A description of the land exploration program (drilling and CPT testing), tethered Seascout CPT program (including equipment used and field procedures), and marine Seacalf CPT program is presented in Section 2.0. Section 3.0 includes a description of the laboratory testing equipment and procedures. The locations of the borings and CPT soundings are provided on Plate 2.1 (included in this volume for reference), and a summary of the details of the individual exploration locations and depths is provided in Table 2.1 of Volume 1.

INDIVIDUAL BORING APPENDICES - VOLUMES 2A & 2B

Individual boring appendices are provided for each of the 27 borings (25 land borings and 2 marine borings). Each boring appendix includes boring logs and various in situ, downhole, and laboratory data.

Boring Appendices Collation and Plate Number Guide

A table is provided at the end of the Volume 2 Table of Contents that shows the plate titles and numbers included in each boring-specific appendix. The individual appendix plates are numbered with the boring number and a sequential number (e.g., 98-51.4, 98-51.5a, etc.).

[1] Fugro-Earth Mechanics (2001), *Final Marine Geotechnical Site Characterization, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Volume 1*, FWI Job No. 98-42-0054, prepared for California Department of Transportation, March 5.

Key to Terms and Symbols Used on the Boring Logs

A description of the terms and symbols used on the logs is provided on Plates A1a through A1c that follow this introductory text.

Land Boring Logs

The boring logs for each boring provide: lithology descriptions, sampling depths, descriptions of the soil characteristics, and plotted in situ, remote vane, and laboratory test data.

Sampler types are shown on the Key to Terms and Symbols Used on Logs (Plates A1a through A1c). The following nomenclature applies to the information in the blow count column of the log: a) "PUSH" denotes thin-wall tube pushed samples; b) "WOH" denotes samplers advanced by the weight of the drill string; and c) numerical values indicate either standard penetration test (SPT) N-values or California modified sampler blow counts. Additional description of the blow count and sampler nomenclature is provided on Plates A1a through A1c.

The center column of the log provides water content, plastic limit, liquid limit, percent passing the number 200 sieve, and density measurements (presented as total unit weights). In addition to the direct measurements of density, below El. 0 (mean sea level [MSL]) the logs show the theoretical unit weight based on the measured water content, an assumed specific gravity of 2.7, and an assumed 100-percent saturation.

The right-hand column presents the results of the undrained shear strength measurements conducted on samples recovered from the borings as well as in situ, remote vane measurements. Undrained shear strengths measured on remolded samples are also included in the plotted data.

Marine Boring Logs

The boring logs for each marine boring provide lithology descriptions, show sampling depths, contain descriptions of the soil and provide plotted remote vane, laboratory, and downhole geophysical test data. The appendices include three single-page boring logs (the data for the entire depth of the borings are shown on one page) that show geotechnical test data, downhole geophysical data, and CPT data, respectively. In addition to the single-page logs, multiple-page logs that show geotechnical test data and CPT data are provided at an expanded depth scale. Also included in the marine boring appendices is a geotechnical test data log of the near-surface sediments with an expanded undrained shear strength scale.

Geotechnical Test Data Logs. Sampler types are shown on the Key to Terms and Symbols Used on Logs (Plates A1b and A1c). The following nomenclature applies to the information in the blow count column of the log: a) "PUSH" denotes thin-wall tube samples pushed with the weight of the drill pipe; b) "WOH" denotes liner samplers advanced by the

weight of the down-hole hammer; c) values such as 18 designate either SPT N-values or California modified sampler; d) 50/7.5 centimeters (cm) is an SPT N-value; and e) 30/60 cm is a downhole, wireline hammer blow count. Additional description of the blow count and sampler nomenclature is provided on Plates A1b and A1c.

The center column of the log provides water content, plastic limit, liquid limit, percent passing the number 200 sieve, and density measurements (presented as submerged unit weights). In addition to the direct measurements of density, the logs also show the theoretical submerged unit weight based on the measured water content, an assumed specific gravity of 2.7, and an assumed 100-percent saturation.

The right-hand column presents the results of the undrained shear strength measurements conducted on samples recovered from the borings as well as the strengths measured in situ using the Halibut and Dolphin remote vane tools. The range of undrained shear strengths that are calculated from CPT cone tip resistances (corrected for unequal end area effects) also are shown based on cone bearing capacity (N_k values) of 12 and 15. Undrained shear strengths measured on remolded samples also are included in the plotted data.

CPT Logs. The in situ CPTs were conducted downhole using the Dolphin system. This downhole in situ tool has a maximum stroke (or test length) of 3 meters. Data are acquired in 3-meter-long increments or until the CPT meets refusal. The CPT intervals were interspersed with soil sampling. The CPT intervals are shown on the right of the logs for those borings.

The CPT logs for each boring with CPT data provide graphical plots of the data versus depth below mudline (or bay bottom). Data that are shown include: a) tip resistance in megapascals (MPa), b) sleeve friction in MPa, c) excess pore pressure readings in MPa, and d) friction ratio in percent.

Downhole Geophysical Logs. The geophysical tests for Borings 98-39 and 98-44 included compression and shear wave velocity (Vp and Vs, respectively) measurements. The data from those downhole measurements are provided on a separate downhole geophysical log that presents the measured downhole geophysical data.

Laboratory Test Results

The offshore and onshore laboratory test results are incorporated in the individual boring appendices. In addition to the test data plotted on the geotechnical test data logs, the appendices include the following information (where relevant):

- Remote vane test data
- Tabulated summary of test results

- Grain size distribution curves
- Plasticity chart showing the Atterberg limit data
- Plotted stress-strain curves from unconsolidated-undrained (UU) triaxial compression tests
- Plotted consolidation test results including axial strain and coefficient of consolidation versus effective vertical stress
- Plotted consolidated-undrained triaxial compression test results including consolidation curves, stress path, stress-strain curves, pore water pressure-strain curves, and obliquity-strain curves
- Plotted consolidated-drained triaxial compression test results including stress-strain curves and Mohr circles
- R-value test data (land borings)
- Corrosion testing results (land borings)

In addition to the static test results presented herein, the results of cyclic tests conducted on samples of Young Bay Mud recovered from the land borings are provided under separate cover in Volume 4.

Soil Property Profiles

Where data are available, the following soil properties are plotted versus depth:

- Plasticity Index (Liquid Limit minus Plastic Limit)
- Liquidity Index ([water content minus Plastic Limit] divided by Plasticity Index)
- Soil Sensitivity (undisturbed shear strength divided by remolded shear strength)
- ε_{50} (strain at 50 percent of the failure stress in UU triaxial tests)
- Preconsolidation Pressure - The interpreted preconsolidation pressure profiles show interpreted preconsolidation pressures from consolidation tests and estimated preconsolidation pressures from the in situ CPT data. Also shown on those plots are the calculated effective overburden pressure and isochrones of calculated overconsolidation ratios (OCR).
- Relative Density from CPT test data (marine borings)

CONE PENETRATION DATA SYNOPSIS – VOLUME 3

CPT soundings were performed on land using full-sized cones deployed from truck-mounted and all-terrain-vehicle- (ATV-) mounted cone penetration test (CPT) rigs. Tethered Seascout CPT soundings were performed over water using a miniature cone deployed from a workboat to the north of the Mole. Marine Seacalf soundings were performed using Fugro's wheel drive CPT system deployed from a barge.

Logs of the CPT soundings including graphical plots of tip resistance, sleeve friction, pore pressure, and seismic velocity measurements (where relevant) are presented in Volume 3 of this report. In addition to the CPT data, correlations with undrained shear strength, preconsolidation stress, and relative density are included for the track-mounted and ATV-mounted CPT soundings. Laboratory test results have been included for two ATV-mounted CPT locations (99C-17 and 99C-14) where sampling was performed. The Seacalf CPT sounding logs include estimates of undrained shear strength interpreted from CPT tip resistance for fine-grained layers.

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SOIL TYPES

- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- GRAVEL with sand (GP or GW)
- GRAVEL with clay (GP or GW)
- Clayey GRAVEL (GC)
- GRAVEL with silt (GP or GW)
- Silty GRAVEL (GM)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- SAND with gravel (SP or SW)
- SAND with clay (SP-SC)
- Clayey SAND (SC)
- Silty SAND (SM)
- SAND with silt (SP-SM)
- Fat CLAY(CH)
- Sandy fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Silty CLAY (CL-ML)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)
- Low plasticity ORGANICS (OL)
- SANDSTONE (Rx)
- SILTSTONE (Rx)
- CLAYSTONE (Rx)
- Interbedded Rock Strata (Rx)
- CONGLOMERATE (Rx)
- PAVEMENT

SAMPLERS

- Thin Walled 7.5 cm Tube
- Offshore Liner
- SPT
- Bulk Bag
- 5.7 cm Driven Tube
- Modified California Liner
- Rock Core (Interior symbol represents percent recovery)

CLASSIFICATION TESTS AND BLOW COUNTS

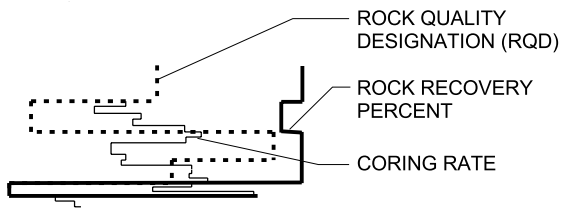
- ■ PERCENT PASSING 0.075 mm SIEVE
- ● WATER CONTENT (%)
- □ TOTAL UNIT WEIGHT (kN/m^3)
- ○ THEORETICAL TOTAL UNIT WEIGHT (kN/m^3)

PLASTIC LIMIT LIQUID LIMIT

+----------+

- ⬟ EQUIVALENT SPT BLOW COUNT

ROCK QUALITY AND CORING RATE



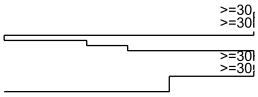
STRENGTH TESTS

- ⊗ POCKET PENETROMETER
- ⊕ TORVANE
- ◇ REMOTE VANE
- ◆ MINIATURE VANE (◈ RESIDUAL VANE)
- ▲ UNCONSOLIDATED UNDRAINED TRIAXIAL
- ▽ SWEDISH FALL CONE
- ▣ UNCONFINED COMPRESSION (SOIL)
- ◎ POINT LOAD TEST (INTACT SPECIMEN)
- ◍ POINT LOAD TEST (ALONG WEAK PLANE)
- ■ UNCONFINED COMPRESSION (ROCK)

△◇ (Open symbols indicate remolded tests)
+ Strength Exceeds Capacity of Measuring Device

PCPT (Nk = 12 to 15)

FRACTURE DENSITY



KEY TO TERMS AND SYMBOLS USED ON LAND BORING LOGS

SFOBB East Span Seismic Safety Project

PLATE A1a

Earth Mechanics

FUGRO

SOIL TYPES

- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- GRAVEL with sand (GP or GW)
- GRAVEL with clay (GP or GW)
- Clayey GRAVEL (GC)
- GRAVEL with silt (GP or GW)
- Silty GRAVEL (GM)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- SAND with gravel (SP or SW)
- SAND with clay (SP-SC)
- Clayey SAND (SC)
- Silty SAND (SM)
- SAND with silt (SP-SM)
- Fat CLAY(CH)
- Sandy fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Silty CLAY (CL-ML)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)
- Low plasticity ORGANICS (OL)
- SANDSTONE (Rx)
- SILTSTONE (Rx)
- CLAYSTONE (Rx)
- Interbedded Rock Strata (Rx)
- CONGLOMERATE (Rx)
- PAVEMENT

SAMPLERS

- Thin Walled 7.5 cm Tube
- Offshore Liner
- SPT
- Bulk Bag
- 5.7 cm Driven Tube
- Modified California Liner
- Rock Core (Interior symbol represents percent recovery)

CLASSIFICATION TESTS AND BLOW COUNTS

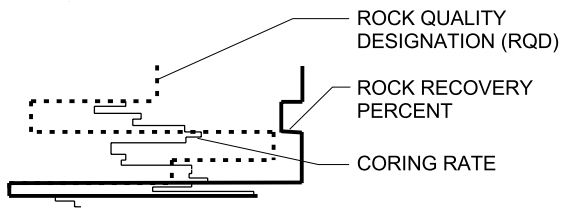
- ■ PERCENT PASSING 0.075 mm SIEVE
- ● WATER CONTENT (%)
- □ SUBMERGED UNIT WEIGHT (kN/m^3)
- ○ THEORETICAL SUBMERGED UNIT WEIGHT (kNm^3)

PLASTIC LIMIT LIQUID LIMIT

+----------+

⬠ EQUIVALENT SPT BLOW COUNT

ROCK QUALITY AND CORING RATE



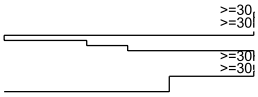
STRENGTH TESTS

- ⊗ POCKET PENETROMETER
- ⊕ TORVANE
- ◇ REMOTE VANE
- ◆ MINIATURE VANE (◈ RESIDUAL VANE)
- ▲ UNCONSOLIDATED UNDRAINED TRIAXIAL
- ▽ SWEDISH FALL CONE
- ▣ UNCONFINED COMPRESSION (SOIL)
- ◎ POINT LOAD TEST (INTACT SPECIMEN)
- ◍ POINT LOAD TEST (ALONG WEAK PLANE)
- ■ UNCONFINED COMPRESSION (ROCK)

△◇ (Open symbols indicate remolded tests)
+ Strength Exceeds Capacity of Measuring Device

PCPT (Nk = 12 to 15)

FRACTURE DENSITY



KEY TO TERMS AND SYMBOLS USED ON MARINE BORING LOGS

SFOBB East Span Seismic Safety Project

PLATE A1b

TUBE AND LINER SAMPLERS

WOH	Liner sample advanced with the weight of an 80 kg hammer.
PUSH or SAVE	Pushed thin-walled 7.5cm-tube.
15/60cm	Number of blows required to produce the indicated penetration using a 5.7 cm tube sampler. The sampler was driven with an 80 kg downhole hammer dropped approximately 1.5 m.

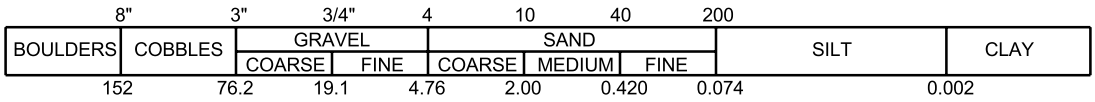
SPT AND MODIFIED CALIFORNIA LINER SAMPLERS

Samplers were driven with a 63.5 kg hammer dropped approximately 760 mm.

20	Number of blows to produce 30 cm of penetration after the initial 15 cm of seating.
86/28cm	Number of blows required to produce the indicated penetration after an initial 15 cm seating.
Ref/8cm	50 blows produced the indicated penetration during the initial 15 cm interval.

SOIL GRAIN SIZE

U.S. STANDARD SIEVE



SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, kPa
Very Soft	less than 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very Stiff	100 to 200
Hard	greater than 200

DENSITY OF GRANULAR SOILS

Descriptive Term	Relative Density (%)*
Very Loose	less than 15
Loose	15 to 35
Medium Dense	35 to 65
Dense	65 to 85
Very Dense	greater than 85

*Estimated from sampler driving record and PCPT tip resistance.

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the ease of breaking along these planes.
Fissured	Containing shrinkage or relief crack, often filled with fine sand or silt, usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 3 mm thick extending through the sample.
Seam	Inclusion 3 mm to 75 mm thick extending through the sample.
Layer	Inclusion greater than 75 mm thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil types.
Interlayered	Soil sample composed of alternating layers of different soil types.
Intermixed	Soil sample composed of pockets of different soil types and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.

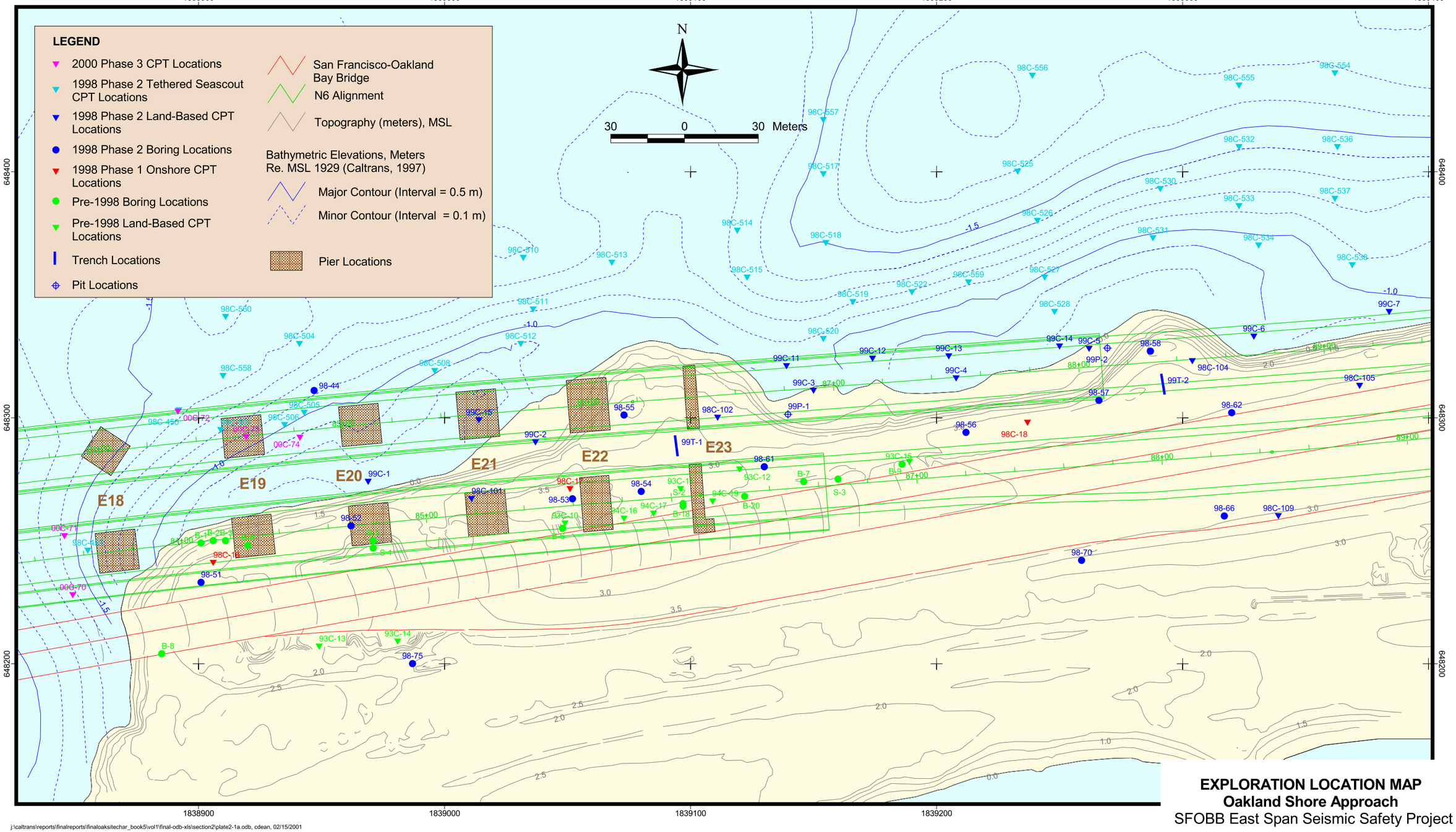
KEY TO TERMS AND SYMBOLS USED ON LOGS

SFOBB East Span Seismic Safety Project

Field6.apr,Fld.MetricKey2, CBD, 10/33/YY
j:\caltrans\reports\molesitechar\vol2\mole\vol_2a\odb\8.5x11\platea1c.odb

Earth Mechanics

FUGRO



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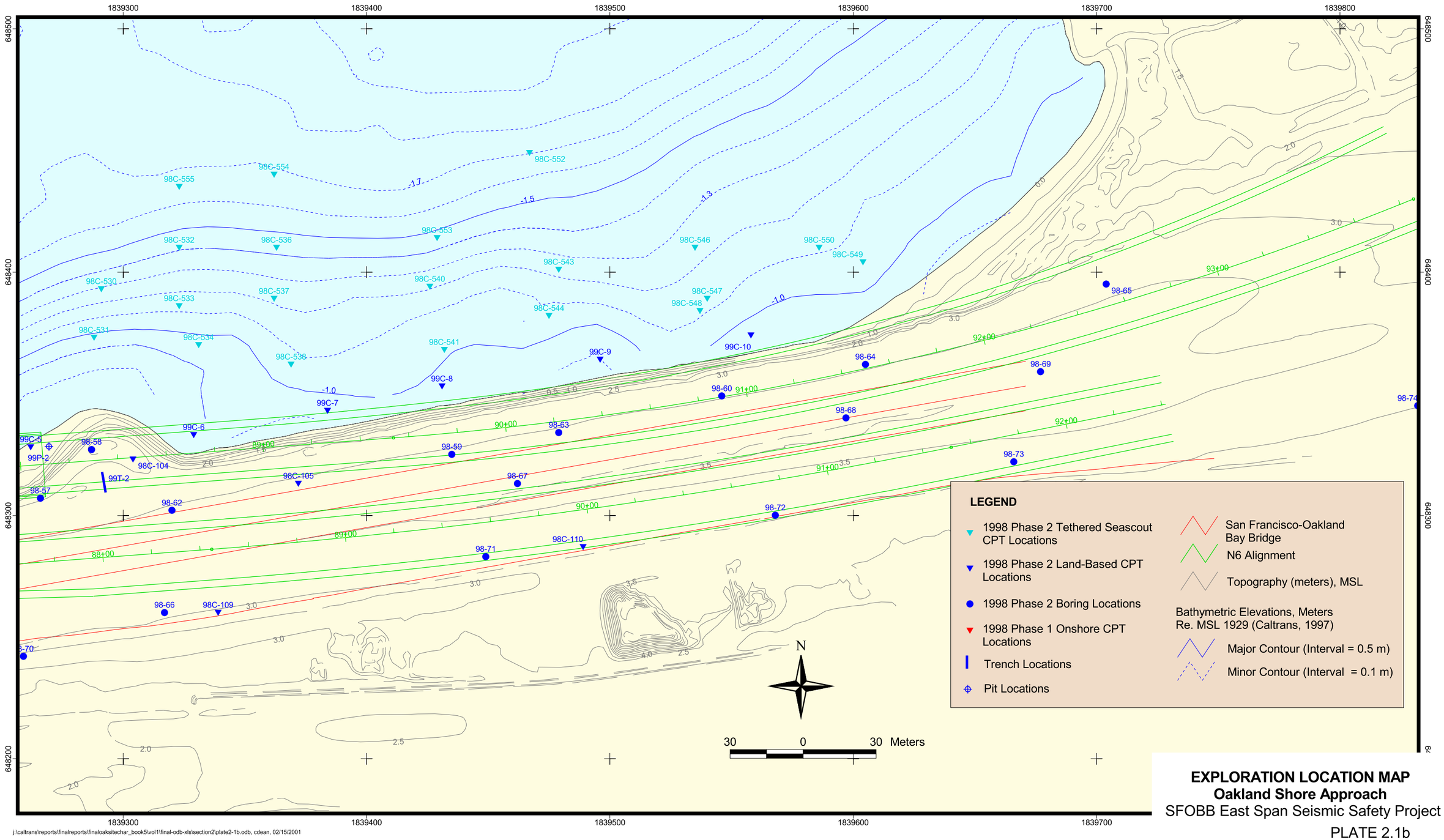
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1a

Earth Mechanics

FUGRO



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EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1b

LAND BORING 98-51

PROJECT NO:	98-42-0058	**START DATE:**	10/20/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-51 (17m right of E. Sta. 84+06)	**COMPLETION DATE:**	10/22/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838901 N648233
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 1.2m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
0	0	BAG	Silty GRAVEL with sand (GM), medium dense to dense, brown (1.5m) ▽(1.2m)	I
-2	2	14	Fine GRAVEL with silt and sand (GW-GM), medium dense, brown	II
	4	15	-fine to coarse sand with gravel, at 1.7m (4.6m)	
-4	6	2	Fat CLAY (CH), firm, olive gray	III
		PUSH	- with shell fragments	
-6	8	PUSH	-dark gray, with silt partings, at 4.6m	
-8	10	NR	-with silt pockets, 6.1m to 8.2m	
			-lean clay, 6.1m to 7.0m (10.7m)	
-10	12	SAVE	Sandy Lean CLAY (CL), very stiff, greenish gray	IV
		PUSH	-intermixed sand and clay, at 12.2m (12.5m)	
-12	14	41	Fine SAND with silt (SP-SM), dense to very dense, brownish yellow	V
		56	-with many clay pockets and seams, at 12.5m	
-14	16	32	-greenish gray below 15.2m	
			-mottled with yellowish brown, at 15.2m	
-16	18	42	-with many clay pockets at 17.1m (17.5m)	
		PUSH	Fat CLAY (CH), very stiff, greenish gray	VI
-18	20		-with black organic pockets and silt pockets, at 18.6m (21.6m)	
-20	22	PUSH	Fat CLAY (CH), very stiff, greenish gray	VII
			-with silt pockets, and a few calcareous nodules, at 21.3m	
-22	24			
		SAVE		
-24	26			
-26	28	PUSH	-with silt seams and partings and a few shell fragments, at 27.7m	
-28	30			
		PUSH	-with silty fine sand pockets and partings, at 30.8m	
-30	32			
-32	34	SAVE	-with a few silt pockets at 33.8m (36.0m)	
-34	36			
		PUSH	Fat CLAY (CH), very stiff, greenish gray	VIII
-36	38		-with silt pockets, desiccated pockets and organic pockets, at 36.6m	
-38	40	PUSH	-interlayered, greenish gray and olive gray, with silt partings and pockets, at 39.9m (40.8m)	
-40	42		Fat CLAY (CH), hard, greenish gray	
		SAVE		
-42	44			
-44	46	PUSH	-with silt pockets and partings, at 46.0m	
-46	48			
		PUSH	-with brownish yellow mottling and slickensides, at 49.1m	
-48	50			
-50	52	SAVE		
-52	54		-sandy lean clay, 53.9m to 56.4m	IX
		PUSH	-with sand seams and a trace of gravel, at 55.2m	
-54	56		-sand layer, 56.4m to 56.7m	
-56	58	PUSH	-with shell fragments at 58.2m	
-58	60			
-60	62	SAVE		
-62	64	PUSH		
-64	66			
-66	68	PUSH	-with many silt pockets at 67.4m	
-68	70			
		SAVE	-with organic pockets at 70.4m	
-70	72		TOTAL DEPTH: 70.7m BACKFILLED WITH: Cement Grout	
-72	74			

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-51.1

LOG OF BORING AND TEST RESULTS

BORING 98-51

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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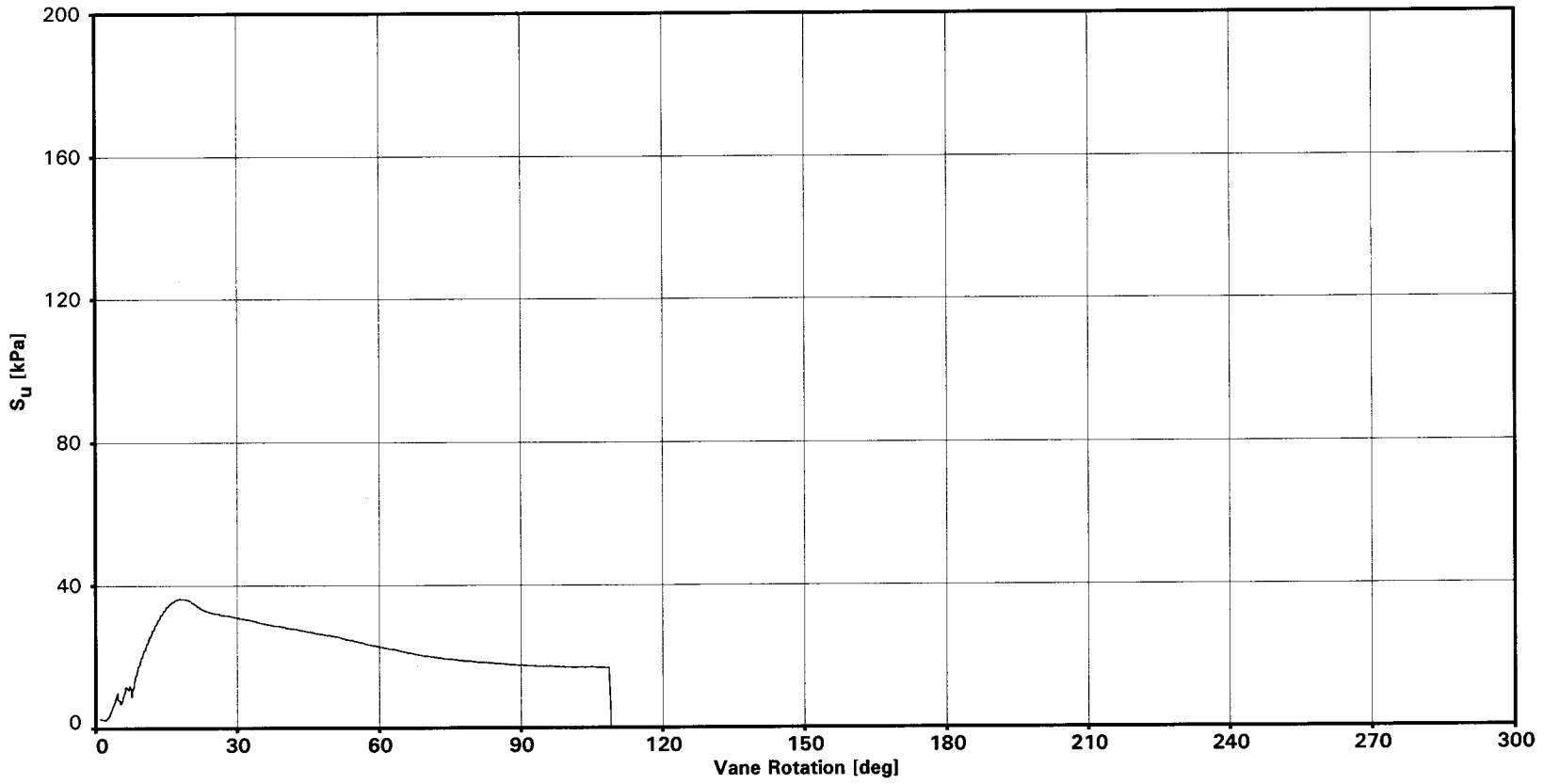
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 9.1m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

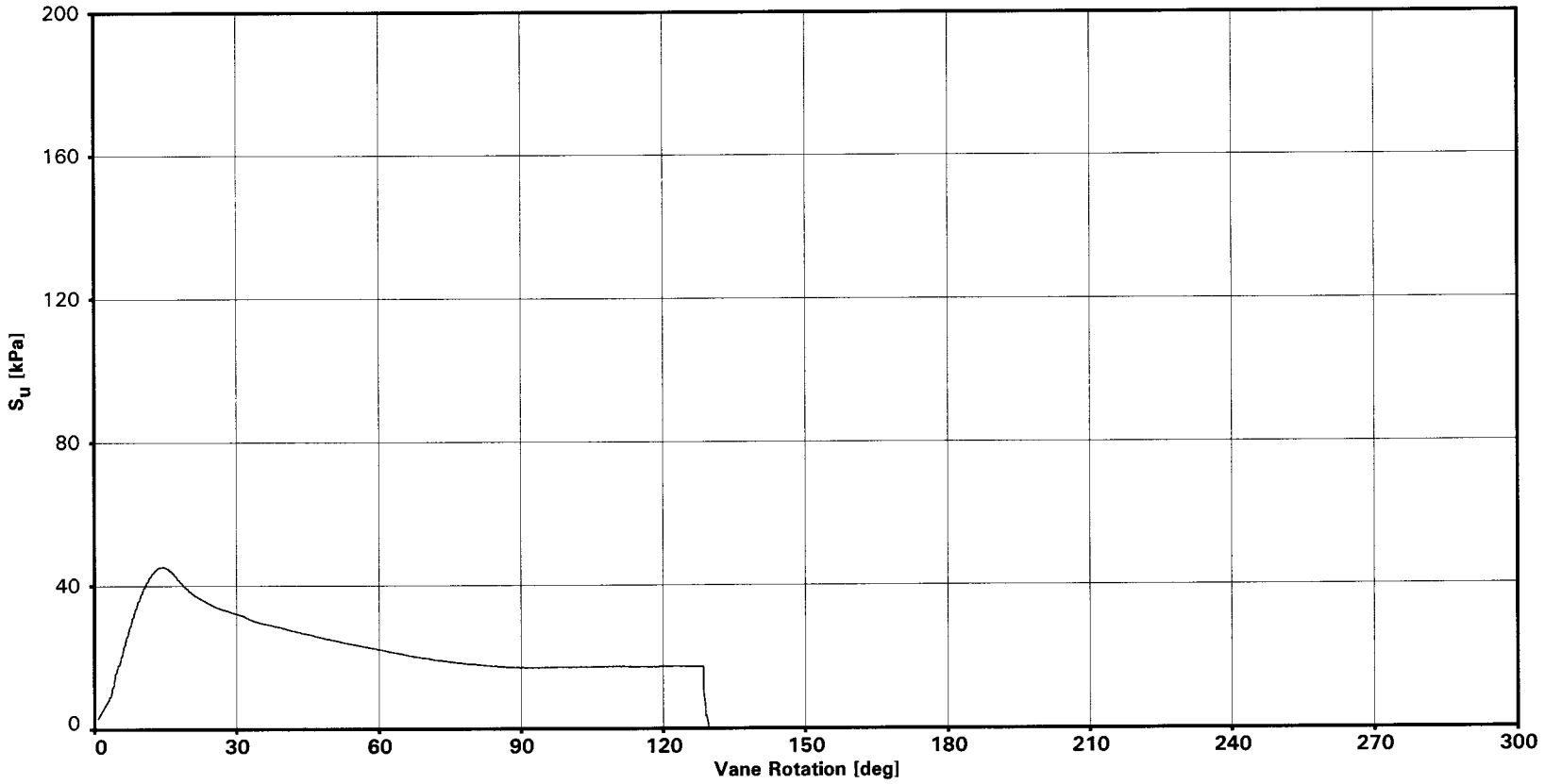
FUGRO

PLATE 98-51.2a

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 10.7m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

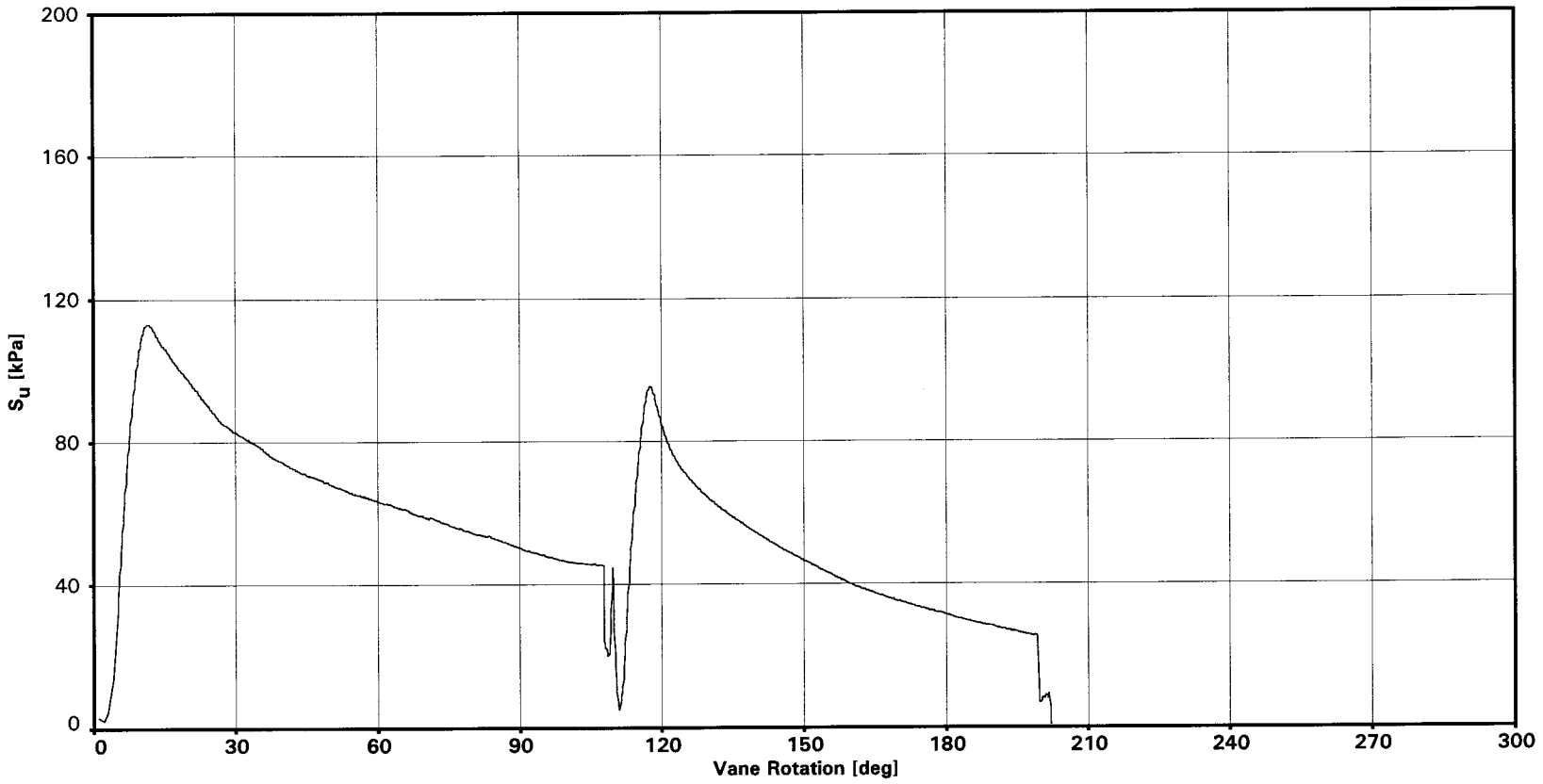
FUGRO

PLATE 98-51.2b

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 19.8m and 20.4m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

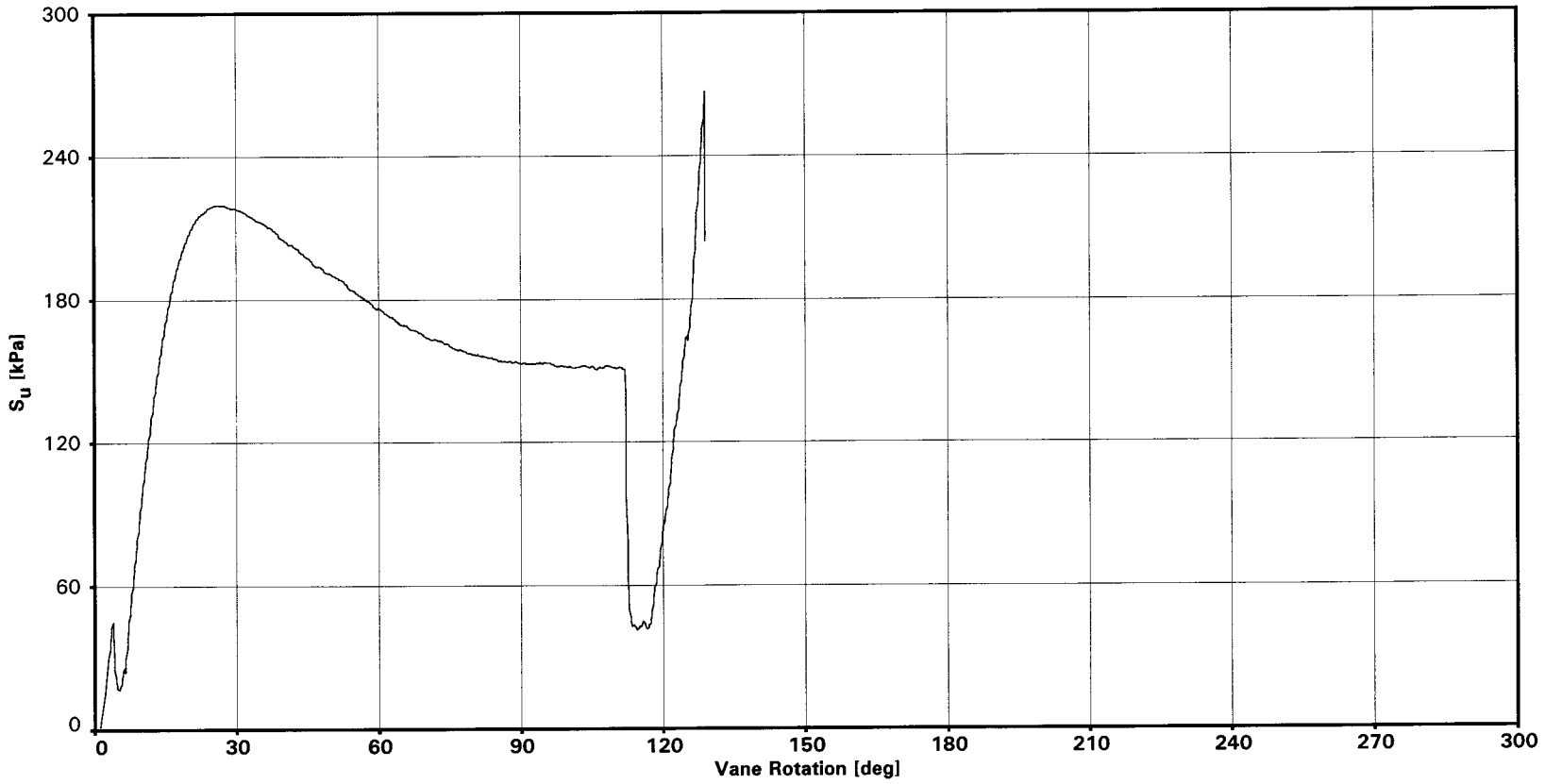
FUGRO

PLATE 98-51.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 22.9m and 23.5m
Boring 98-51
SFOBB East Span Seismic Safety Project

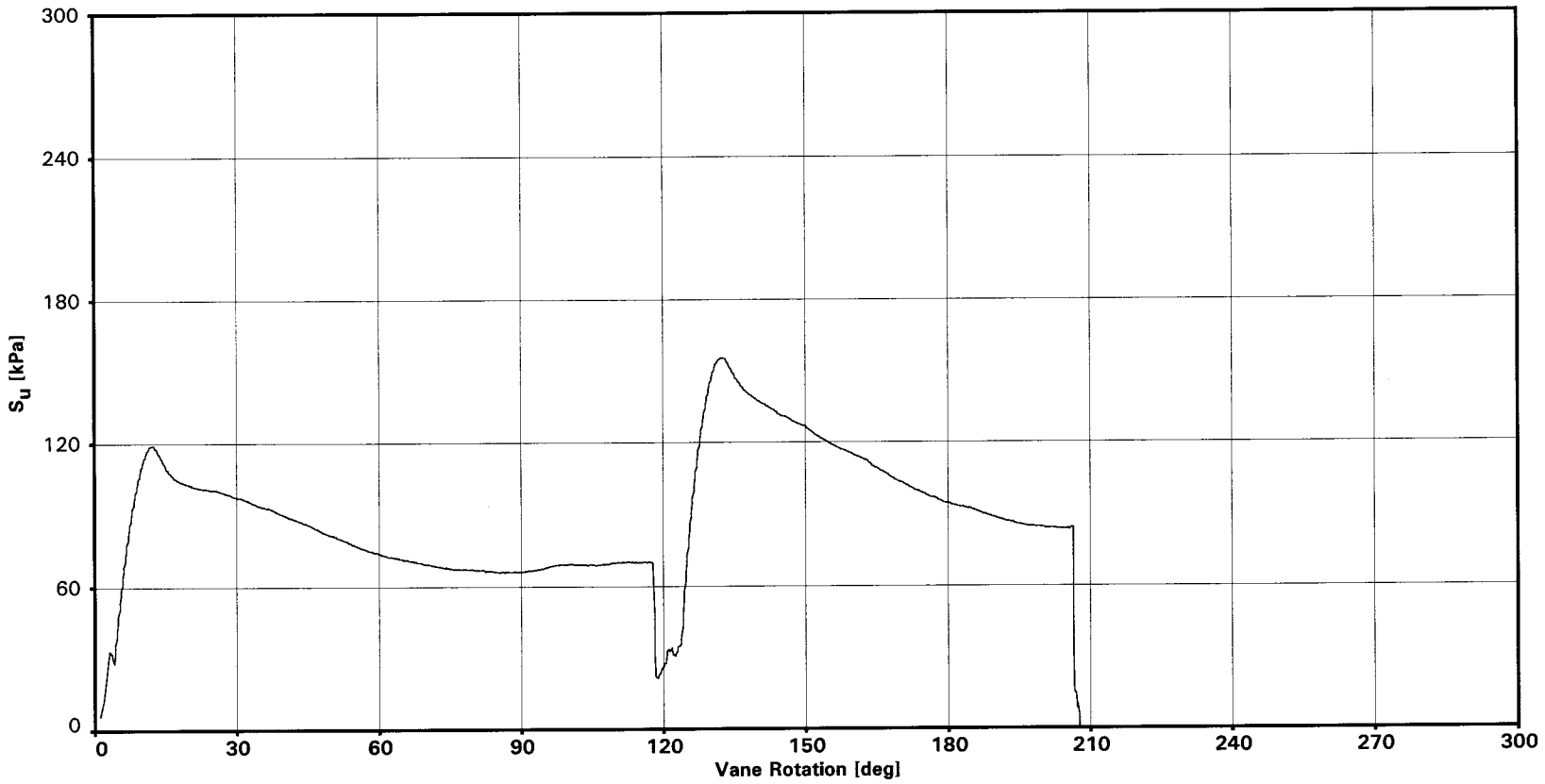
Earth Mechanics

FUGRO

PLATE 98-51.2d

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 25.9m and 26.5m
Boring 98-51
SFOBB East Span Seismic Safety Project

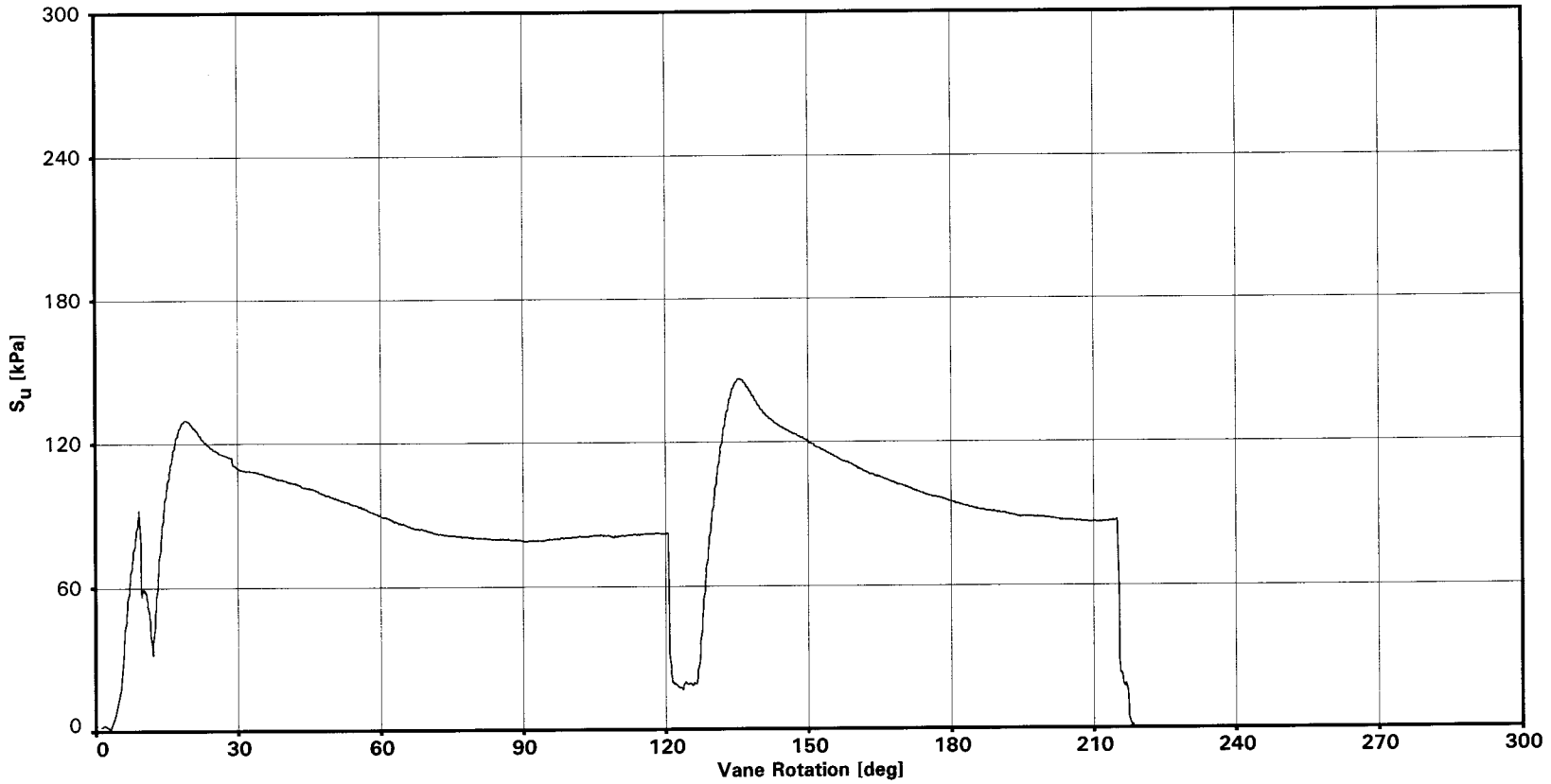
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 29.0m and 29.6m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

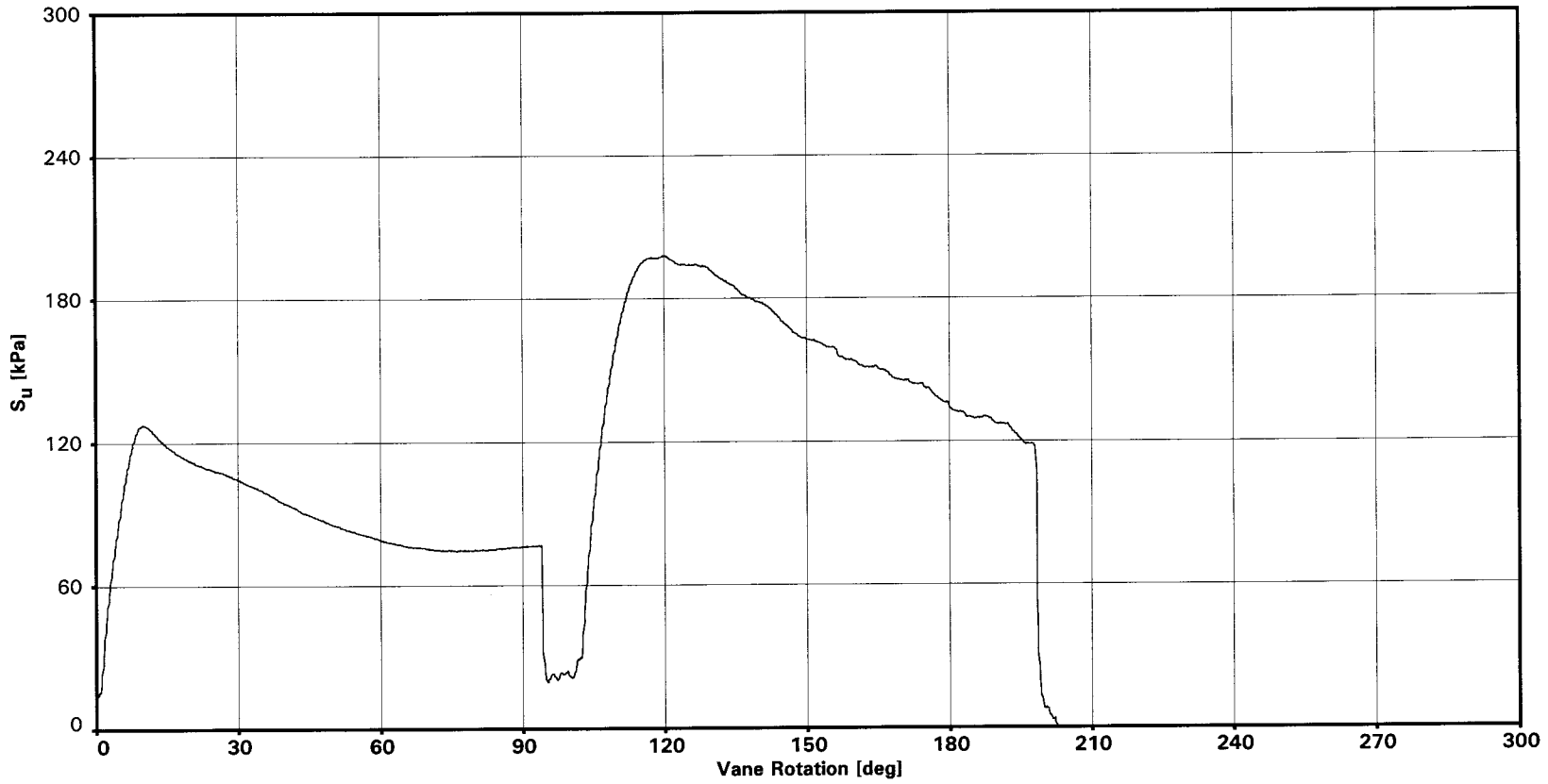
FUGRO

PLATE 98-51.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 32.0m and 32.6m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

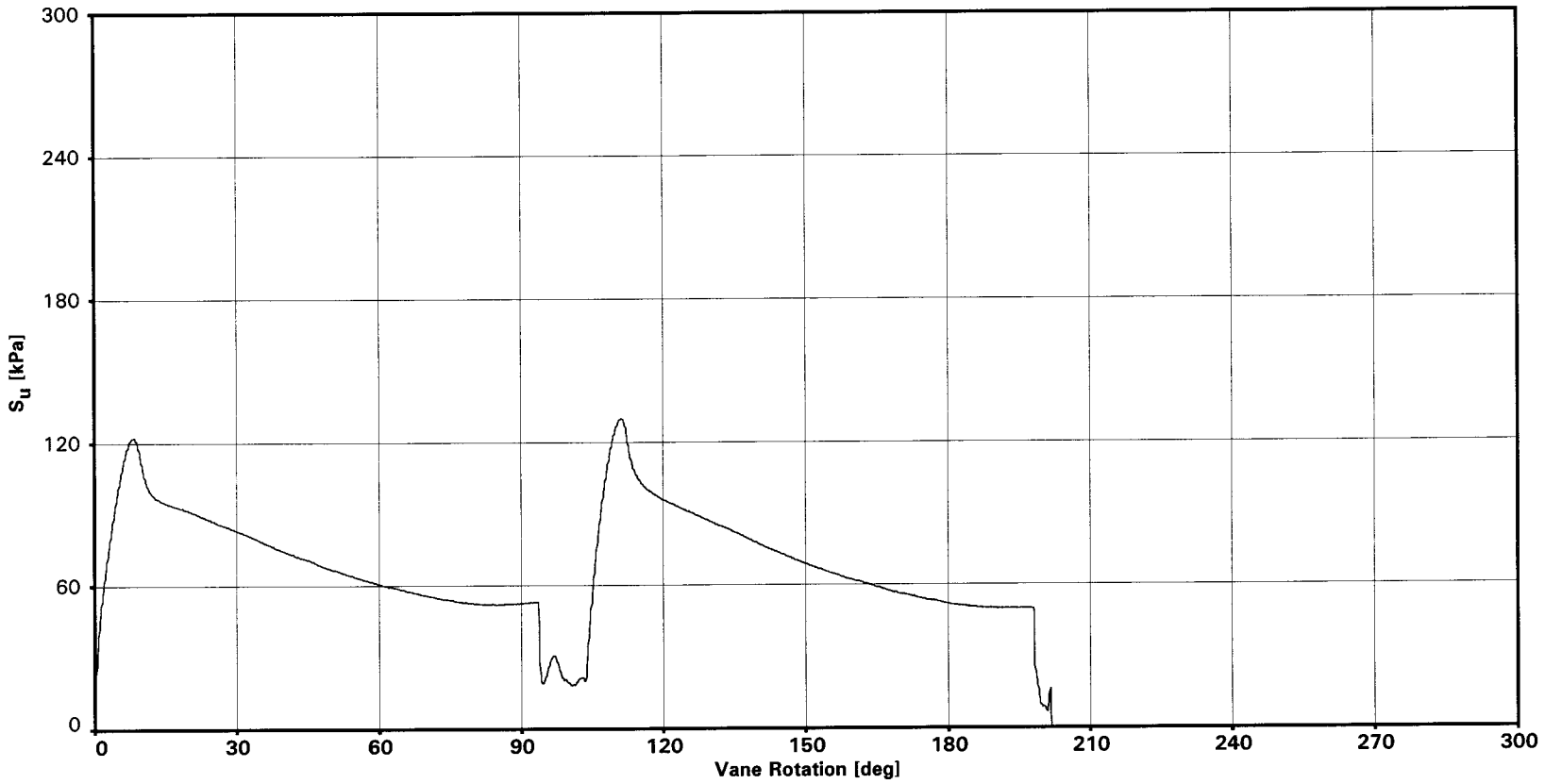
FUGRO

PLATE 98-51.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 35.1m and 35.7m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

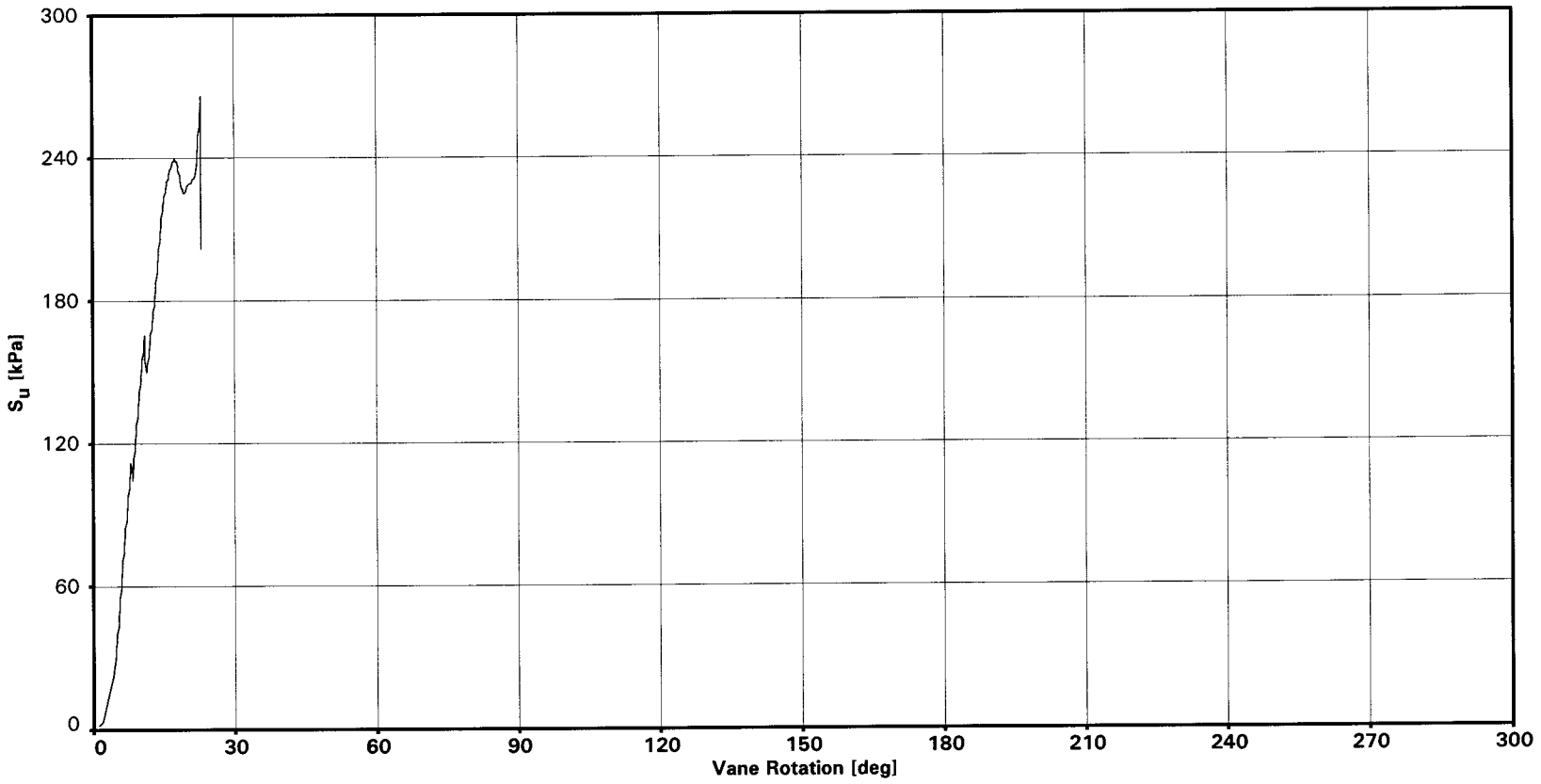
FUGRO

PLATE 98-51.2h

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 38.1m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

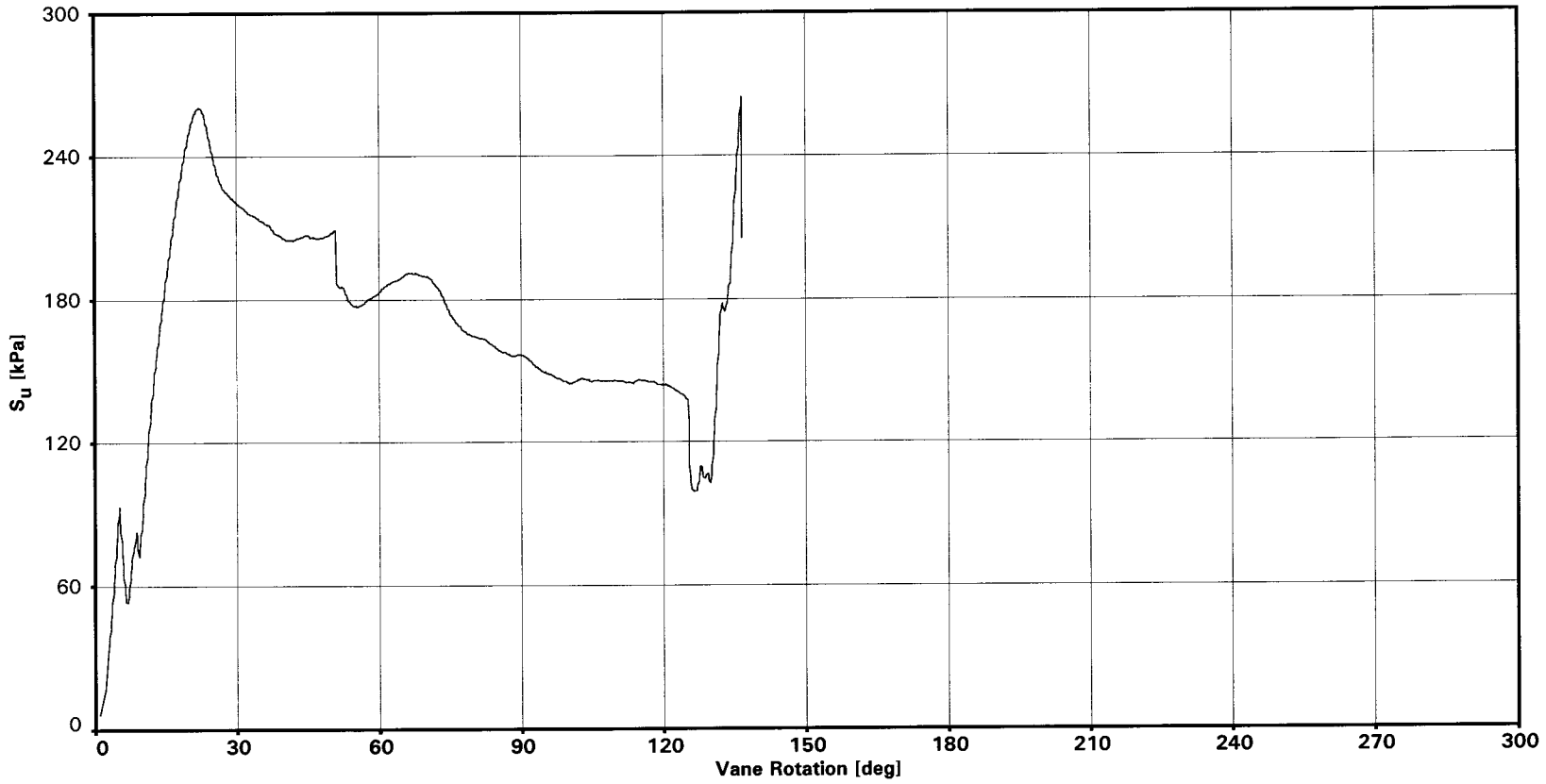
FUGRO

PLATE 98-51.2i

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 41.1m and 41.8m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

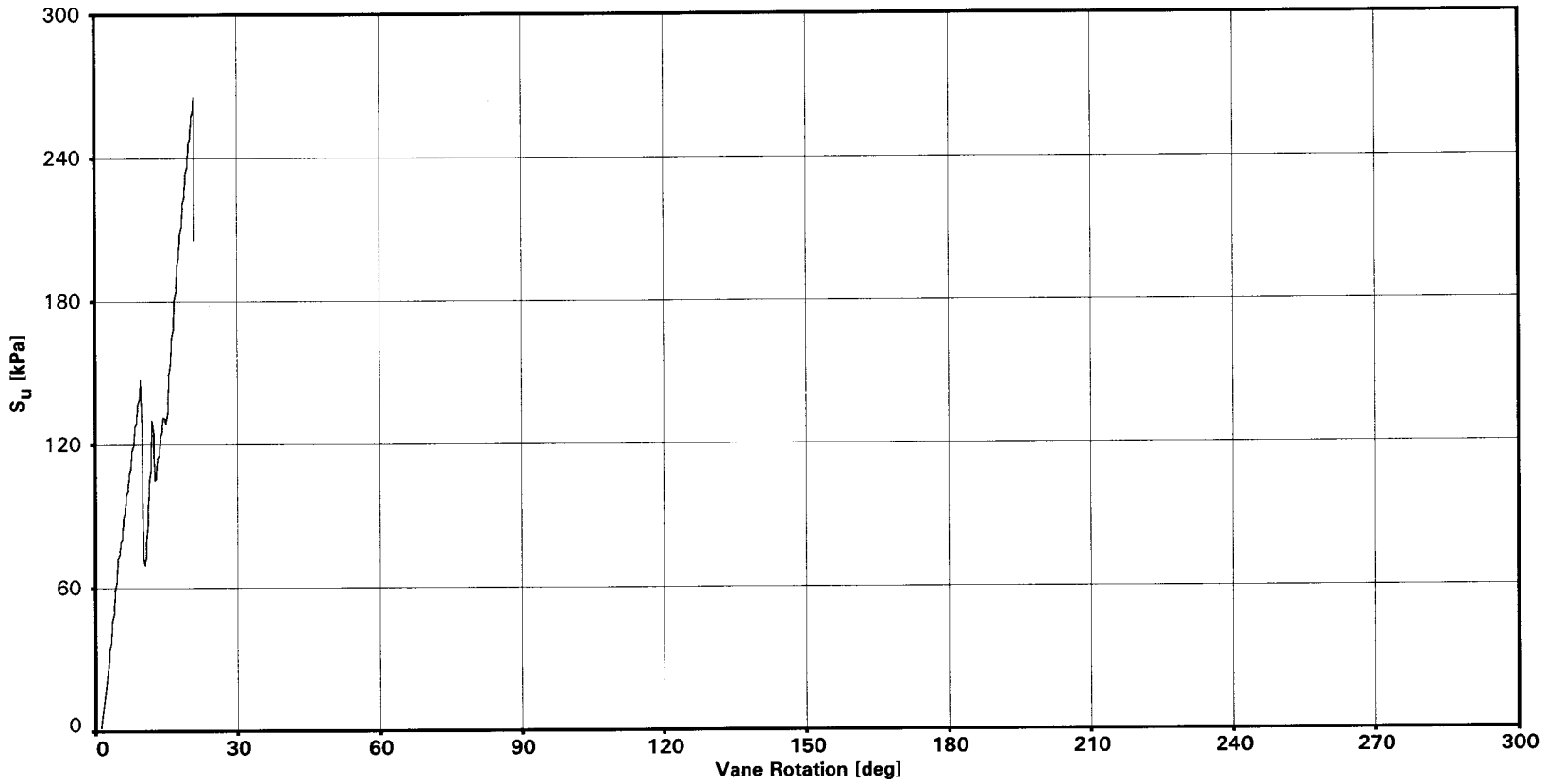
FUGRO

PLATE 98-51.2j

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 59.4m
Boring 98-51
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-51.2k

98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.7	1	15																									
3.2	2	22					8																				
4.9	3	75	75	20	1.00																						
6.4	4	36	43	21	0.67																						2.75
6.6	5					17.7																					
6.7	6							31.6			32.0	14.2															
7.6	400													36.9													
8.1	8	43	50	23	0.76	17.1		33.5			27.1	6.9			24.4		1.2										
8.2	9							29.7																			
9.1	401													36.4													
10.7	402													45.0													
11.2	10	47	50	21	0.88																					C	
11.3	11	14	23	14	0.10		61																				
12.4	12	17					24																				
12.7	13	21					15																				

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-51.3a

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98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
14.1	14	31					8																				
15.7	15	25					9																				
17.2	16	22					25																				
18.6	17								119.7																		
18.7	18	31	52	20	0.34	19.7		153.2																			2.71
18.9	19							107.7			128.7																
19.8	403													111.1													
20.4	404													97.2													
21.5	20								119.7																		
21.6	21								119.7																		
21.8	22	28	60	18	0.23	18.8		155.6							87.1	70.0	1.1										
21.9	23										179.5																
22.9	405													219.8													
23.5	406													265.7+													
24.9	24	45	66	25	0.50																					C	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-51.3b

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98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
25.0	25	49	71	26	0.51						121.3																
25.9	407													121.1													
26.5	408													152.7													
27.9	27	27	48	19	0.27	19.6		126.9							156.0		1.2										
28.0	28										200.5																
29.0	409													130.7													
29.6	410													147.0													
30.9	30	35	56	23	0.37										86.2	24.5	3.7										
31.1	31							74.2			151.0																
32.0	411													127.8													
32.6	412													197.7													
34.0	32	44	66	27	0.43																					C	
34.1	33										169.5																
35.1	413													120.2													
35.7	414													127.8													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.3c

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

c:\snfco-oak\odb\8.5x11\98-51sumc.odb

98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
37.2	35	30	64	22	0.19	18.9					169.5																
38.1	415													265.7+													
39.9	36							143.6																			
40.1	37	35	63	22	0.32	17.5									116.7		3.0										
40.2	38							143.6			136.1																
41.1	416													260.9+													
41.8	417													265.7+													
43.2	39	26	42	19	0.29				215.5																	C	
43.3	40	28	48	25	0.16						214.1																
46.0	41								153.2																		
46.2	42	22	42	17	0.20	20.2									184.6	101.2	2.6										
46.3	43	21						179.6			174.5																
49.1	44								210.3																		
49.2	45	34	81	26	0.15	18.5									211.0		0.6										
49.4	46										222.8+																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-51.3d

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98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
52.3	47	37	76	27	0.21																					C	
52.4	48	40	75	26	0.27																						
55.2	49								215.5																		
55.3	50	21	28	18	0.38	18.5									224.7		2.6										
58.4	52	47	81	28	0.36	17.6									220.3		1.3										
58.5	53							179.6																			
59.4	418													265.7+													
61.5	54	46	79	27	0.36																					C	
61.6	55	46	79	26	0.38																						
64.3	56								158.0																		
64.5	57	42	70	20	0.44	18.1									168.9	57.3	2.4										
64.6	58							153.2																			
67.5	61	49	63	22	0.65	16.9			177.2						188.9		1.9										
70.6	62	31	68	27	0.11																					C	
70.7	63	41	71	18	0.43						206.7																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-51.3e

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98-51		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
70.7	63	43																									

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.3f

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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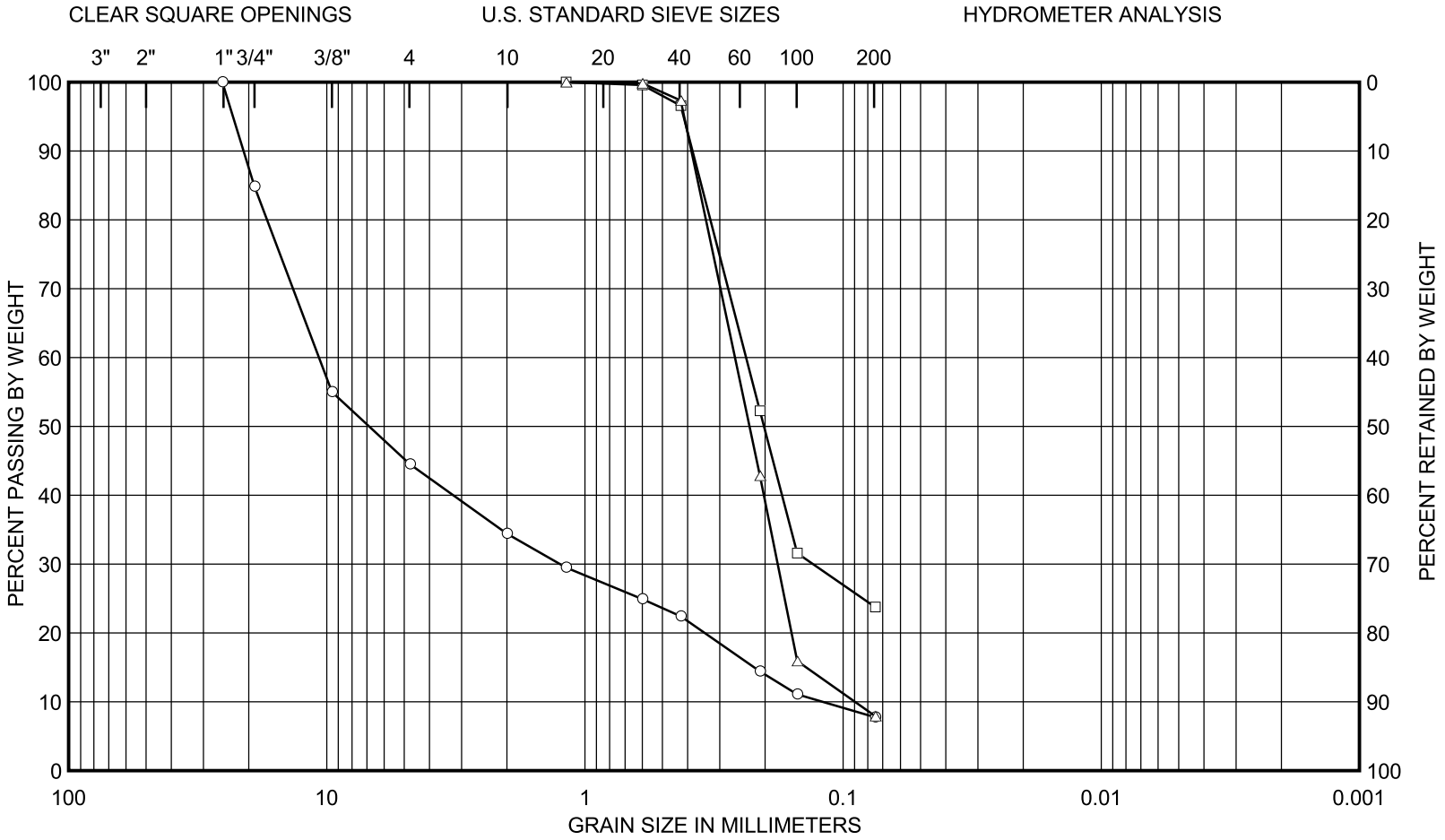

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.2	○—○	FINE GRAVEL (GW-GM) with silt, fine to coarse sand, and coarse gravel	1.2	89.3	6.8
12	12.4	□—□	FINE SAND (SP) with many large clay pockets			0.20
14	14.1	△—△	FINE SAND (SP-SM) with silt	1.4	2.9	0.23

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-51
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-51.4

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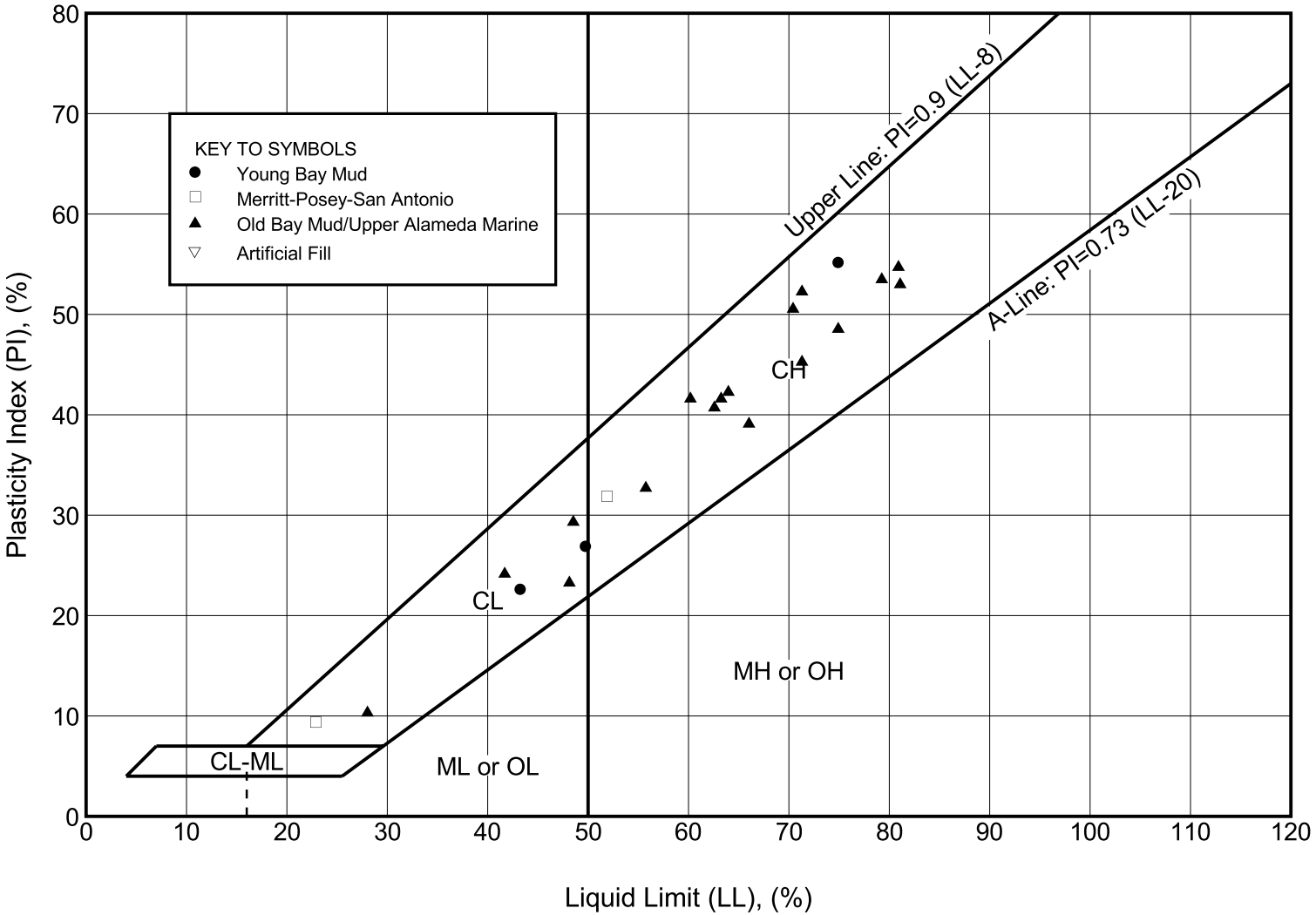


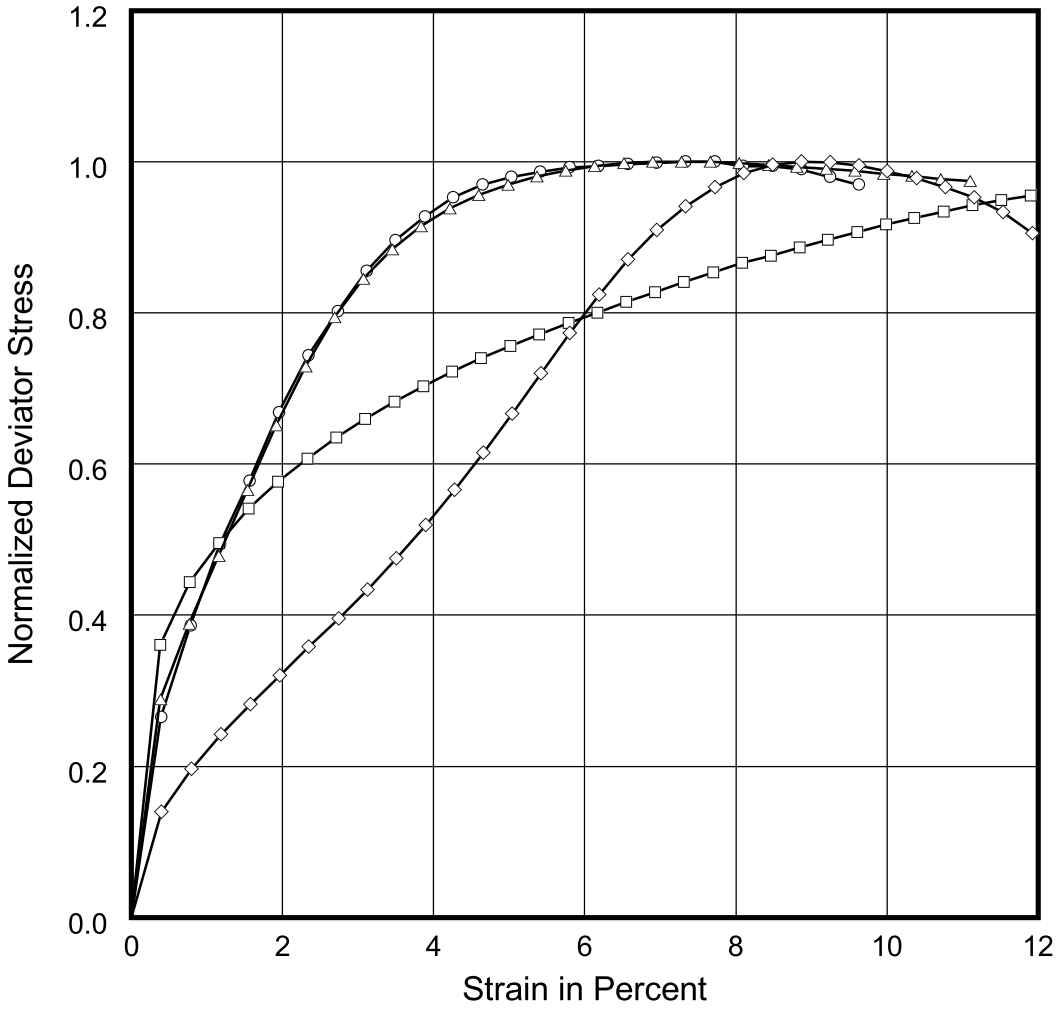
PLASTICITY CHART
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.5

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO



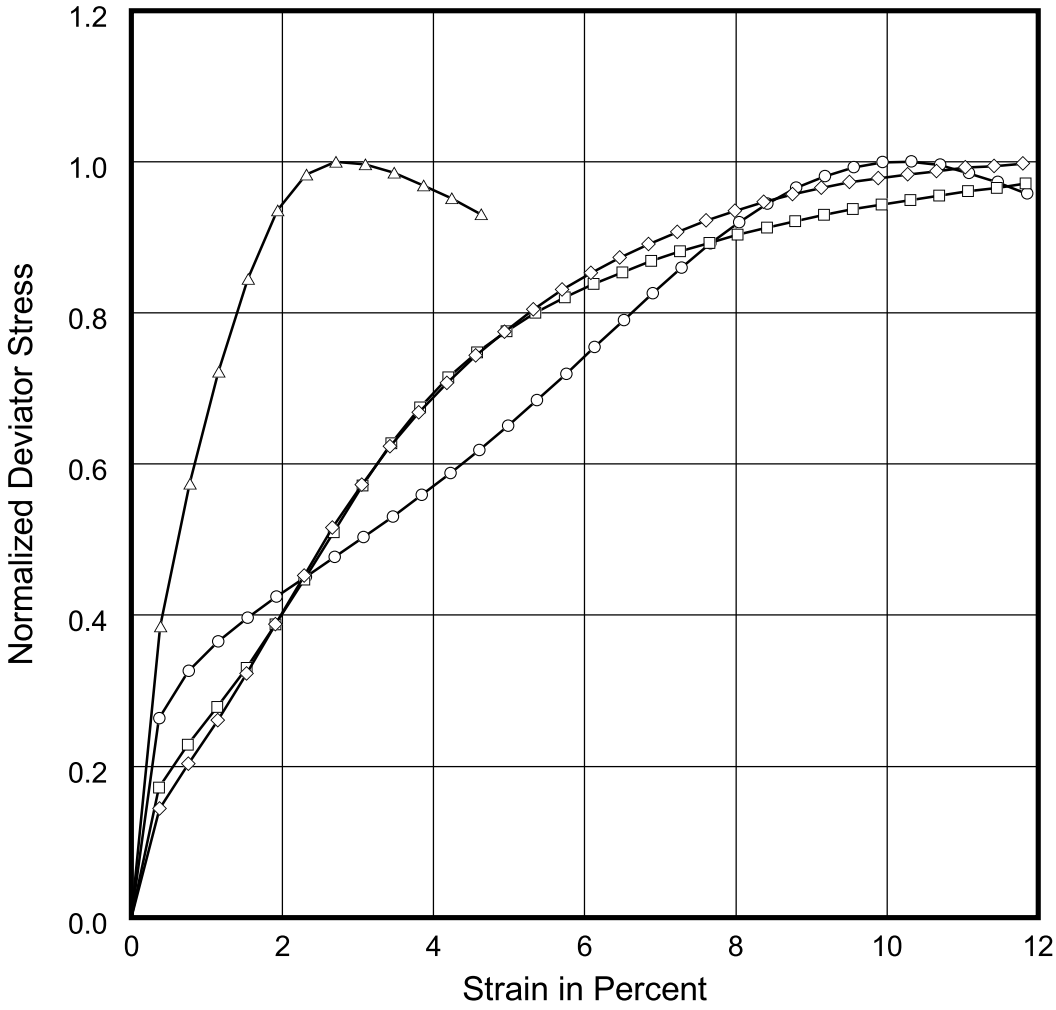
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	8	8.1	UU	172	49	1.2
□	22	21.8	UU	758	174	1.1
△	27	27.9	UU	862	312	1.2
◇	30	30.9	UU	931	172	3.7

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.6a



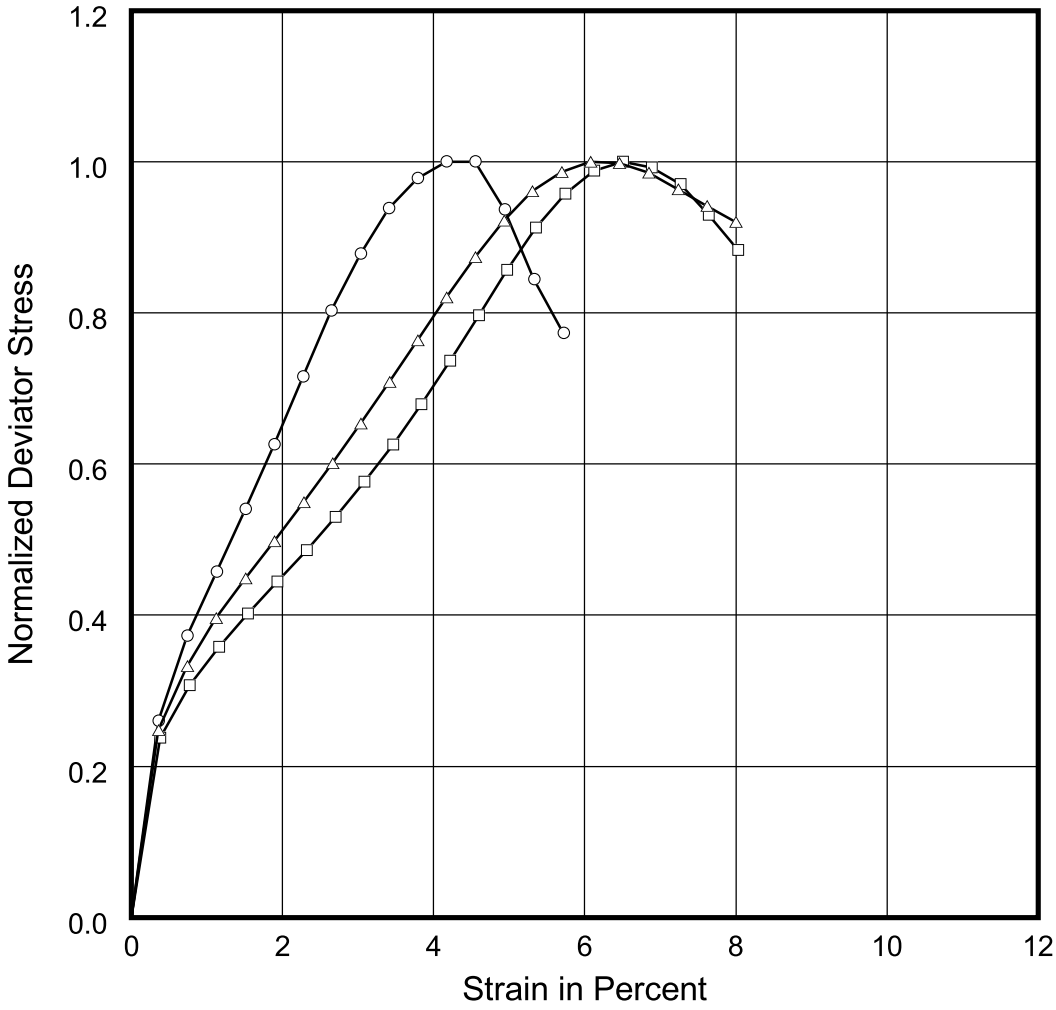
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	37	40.1	UU	1103	233	3.0
□	42	46.2	UU	1207	369	2.6
△	45	49.2	UU	1275	422	0.6
◇	50	55.3	UU	1379	449	2.6

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.6b



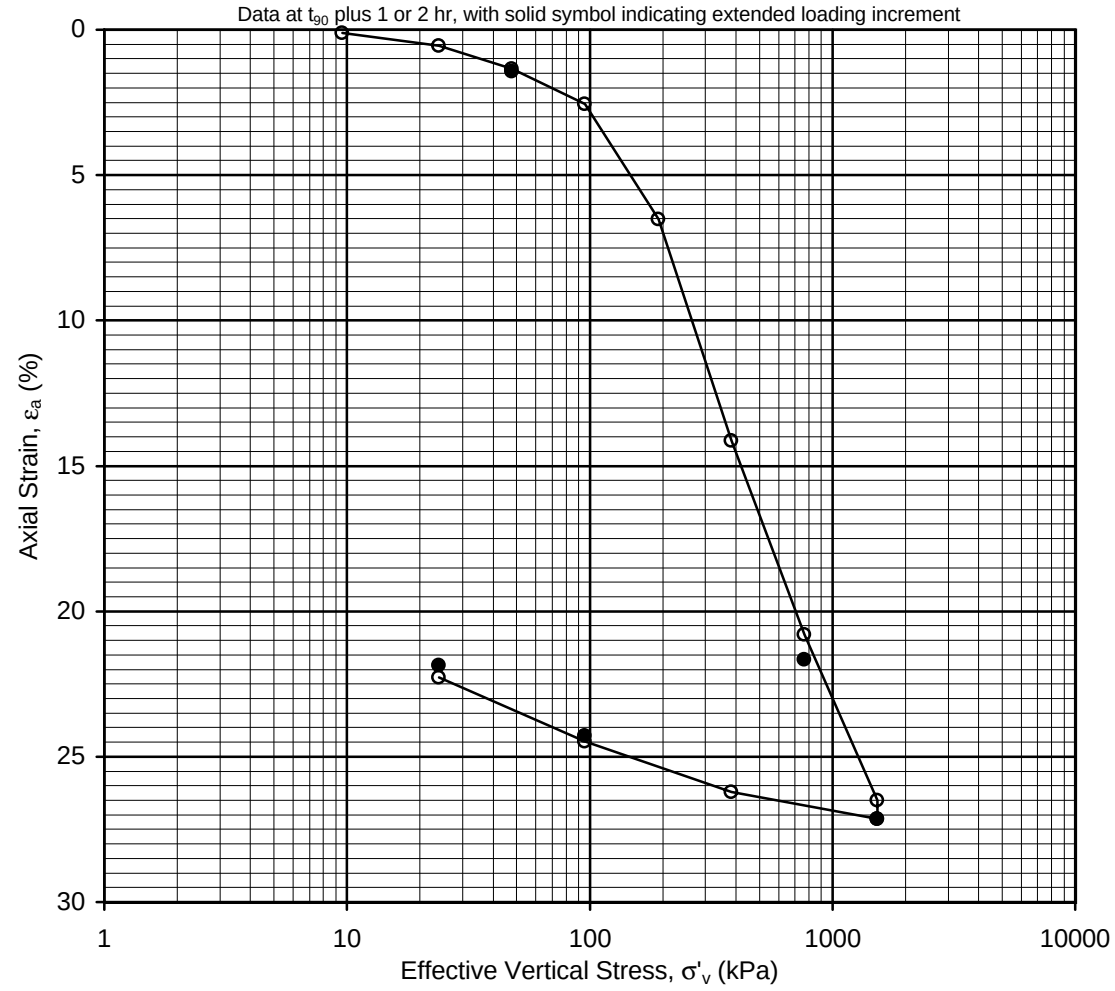
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○——○	52	58.4	UU	1448	441	1.3
□——□	57	64.5	UU	1551	338	2.4
△——△	61	67.5	UU	1620	378	1.9

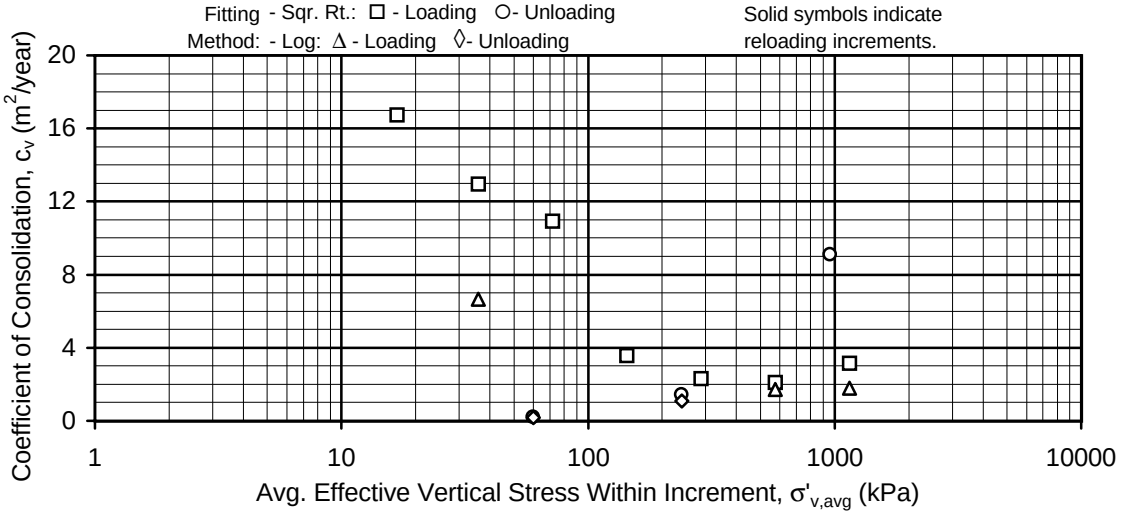
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-51
SFOBB East Span Seismic Safety Project

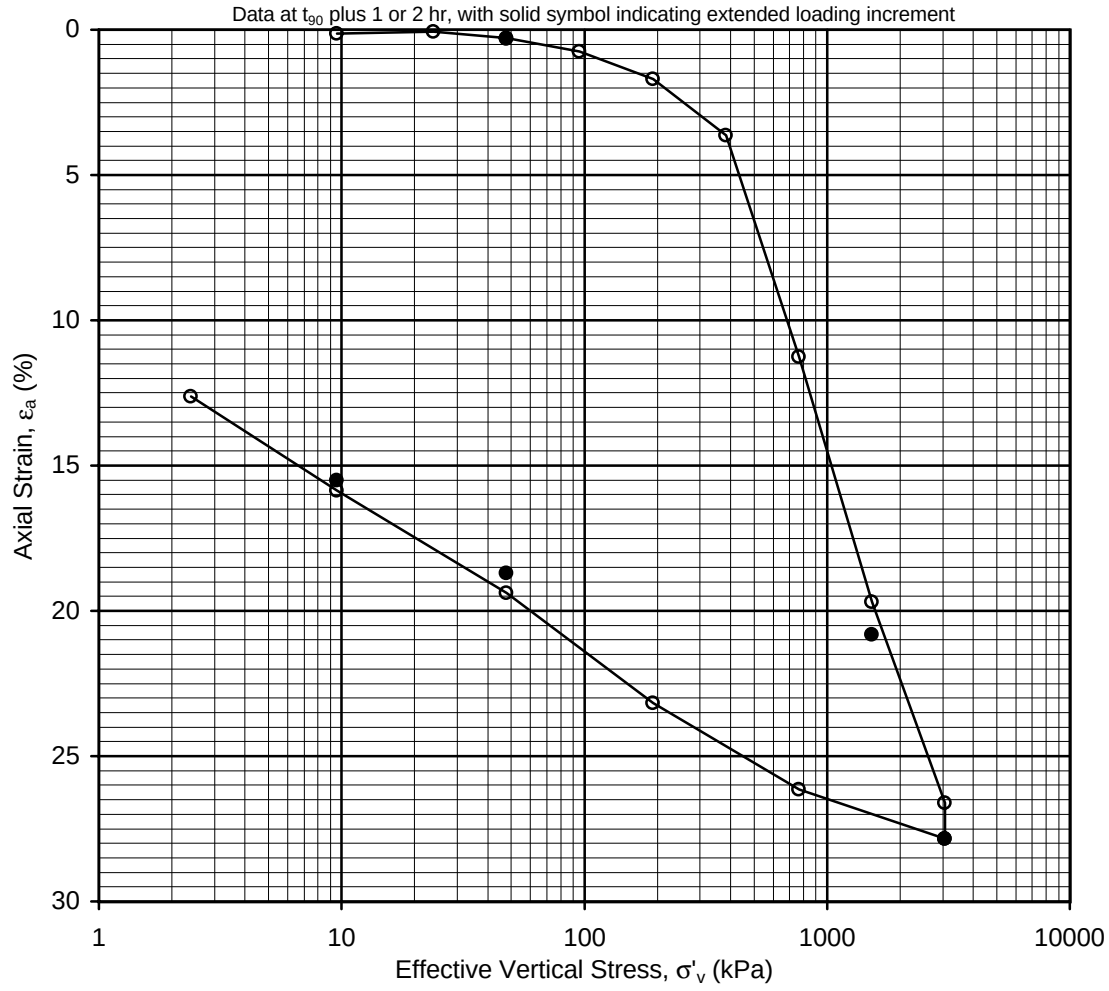
PLATE 98-51.6c

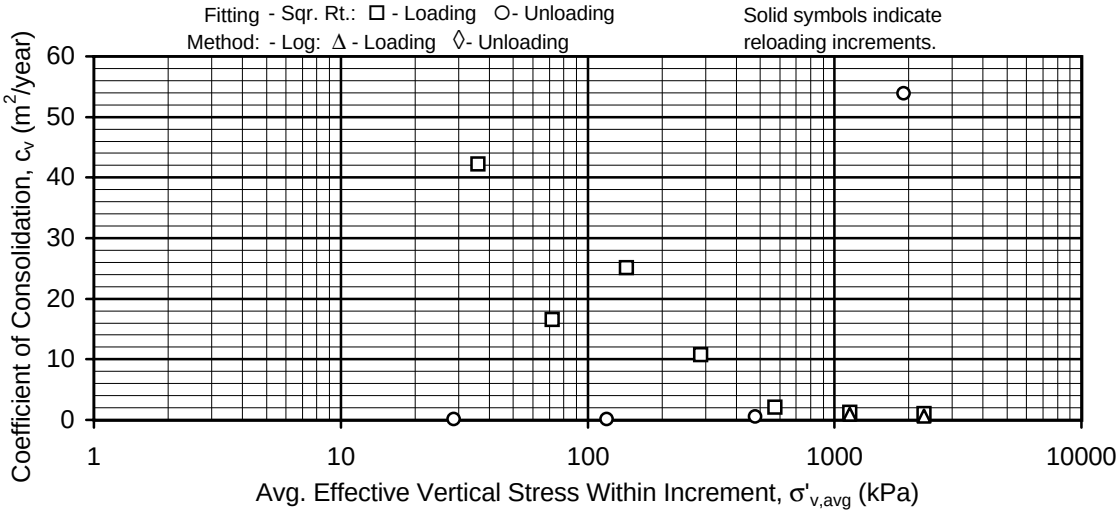




INCREMENTAL CONSOLIDATION TEST RESULTS

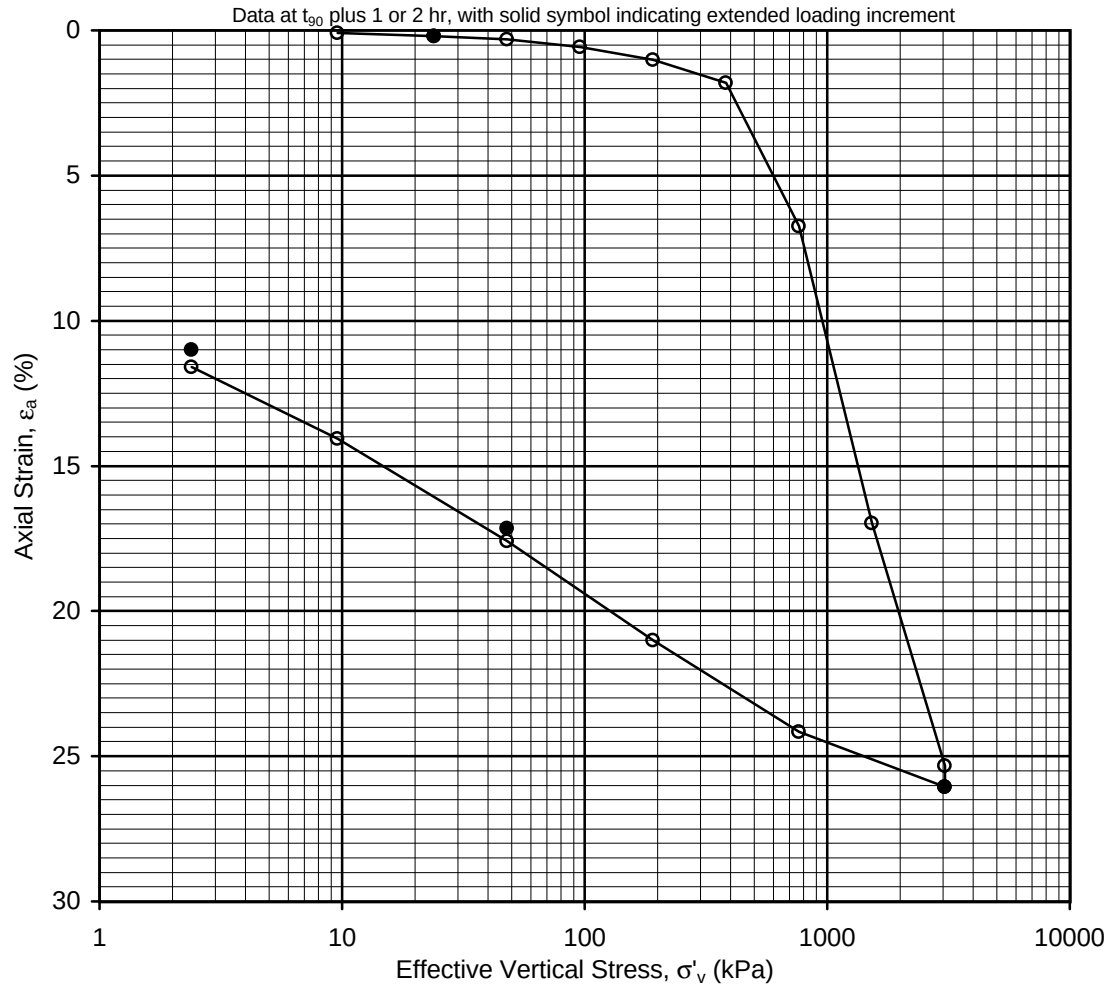
Sample No. 10 - Depth: 10.9m
Boring 98-51
SFOBB East Span Seismic Safety Project

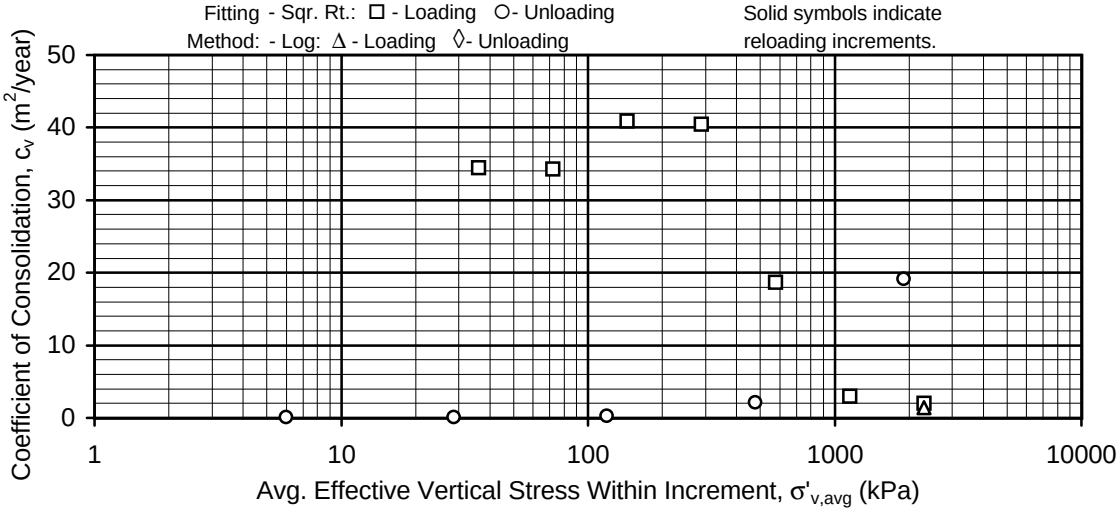




INCREMENTAL CONSOLIDATION TEST RESULTS

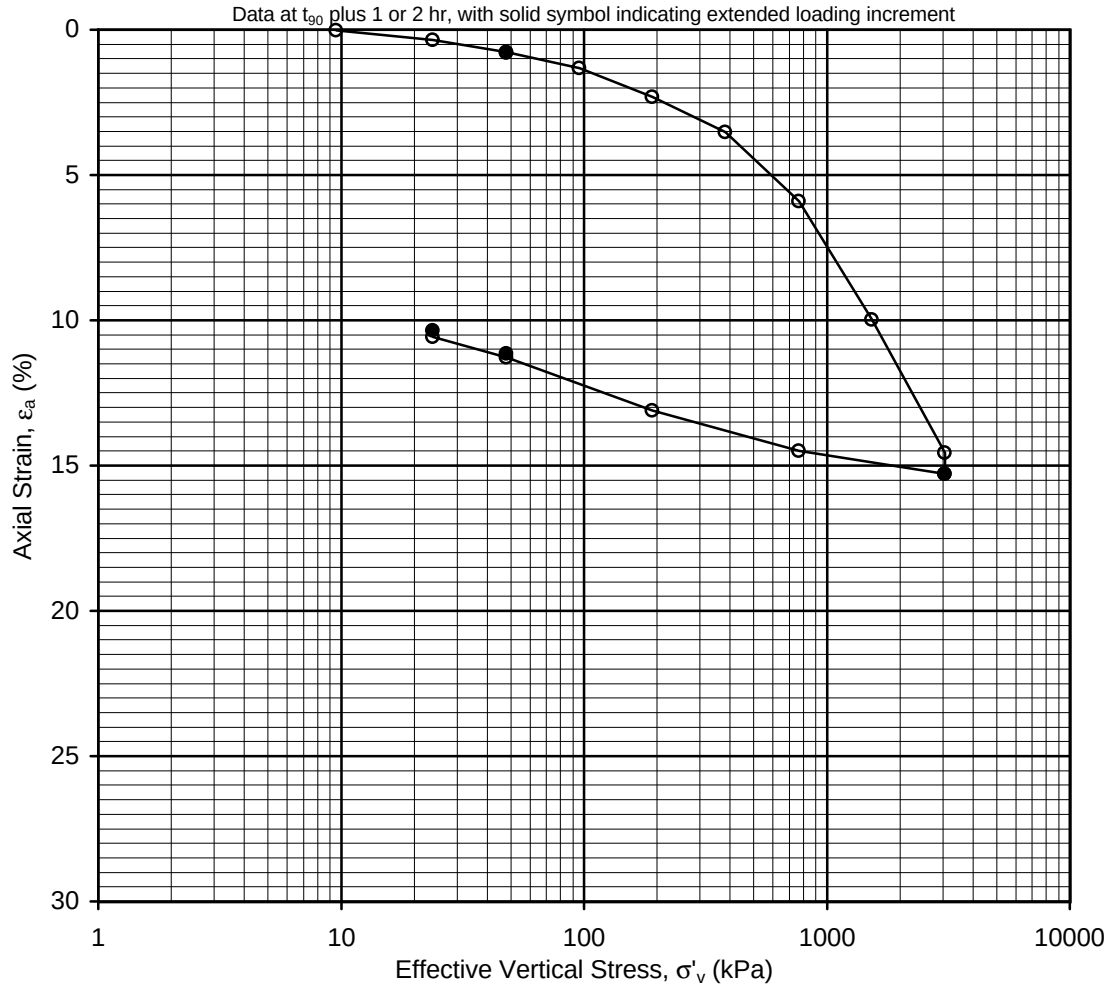
Sample No. 24 - Depth: 24.8m
Boring 98-51
SFOBB East Span Seismic Safety Project

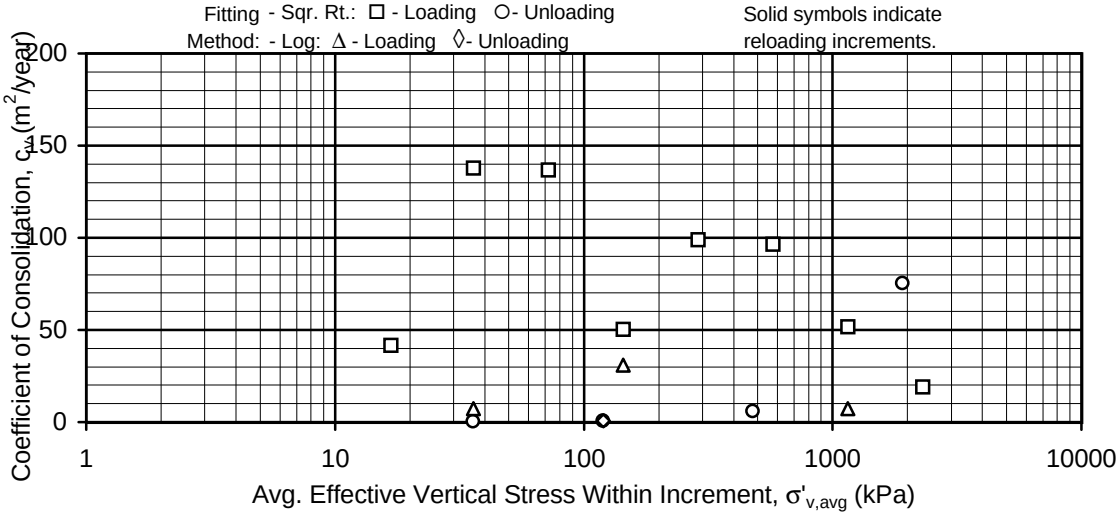




INCREMENTAL CONSOLIDATION TEST RESULTS

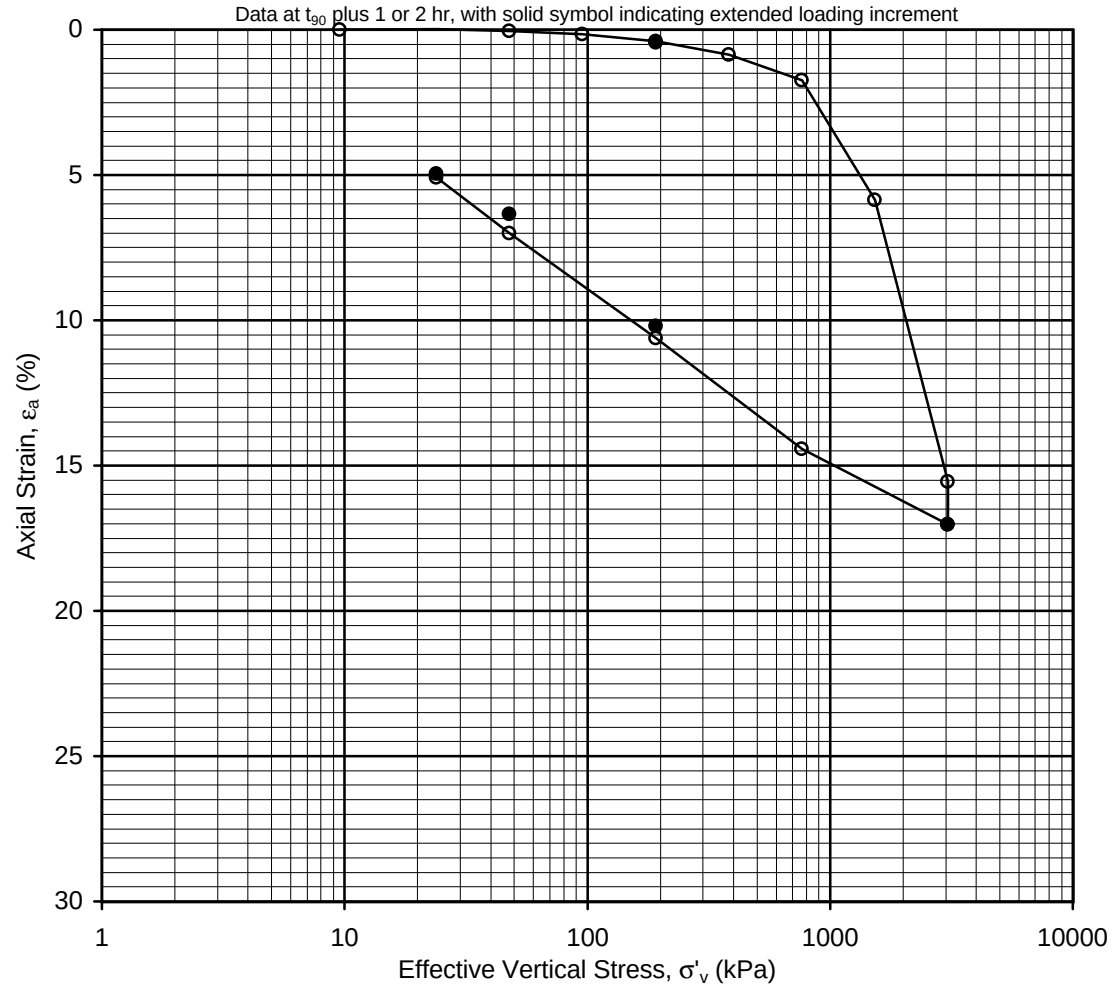
Sample No. 32 - Depth: 33.8m
Boring 98-51
SFOBB East Span Seismic Safety Project

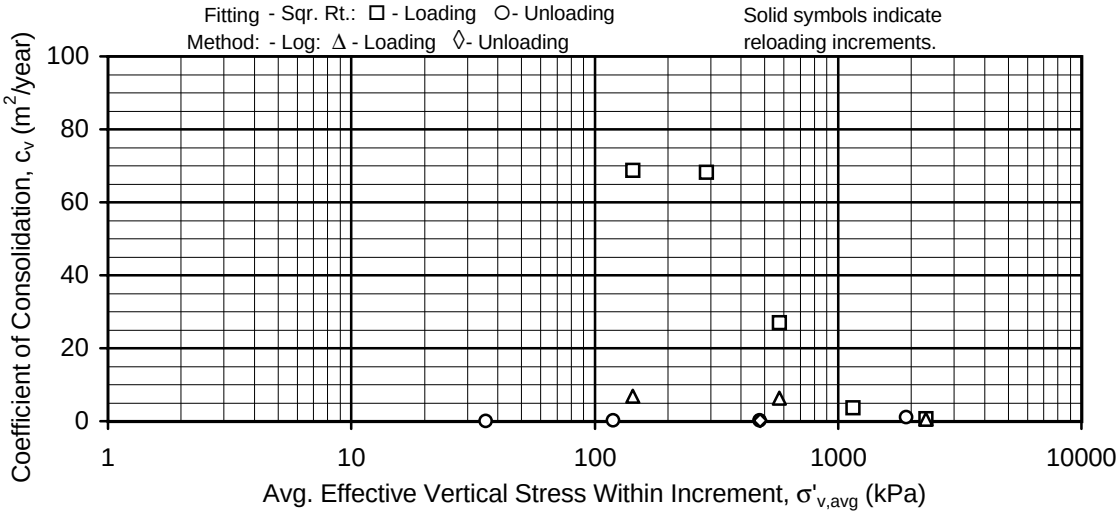




INCREMENTAL CONSOLIDATION TEST RESULTS

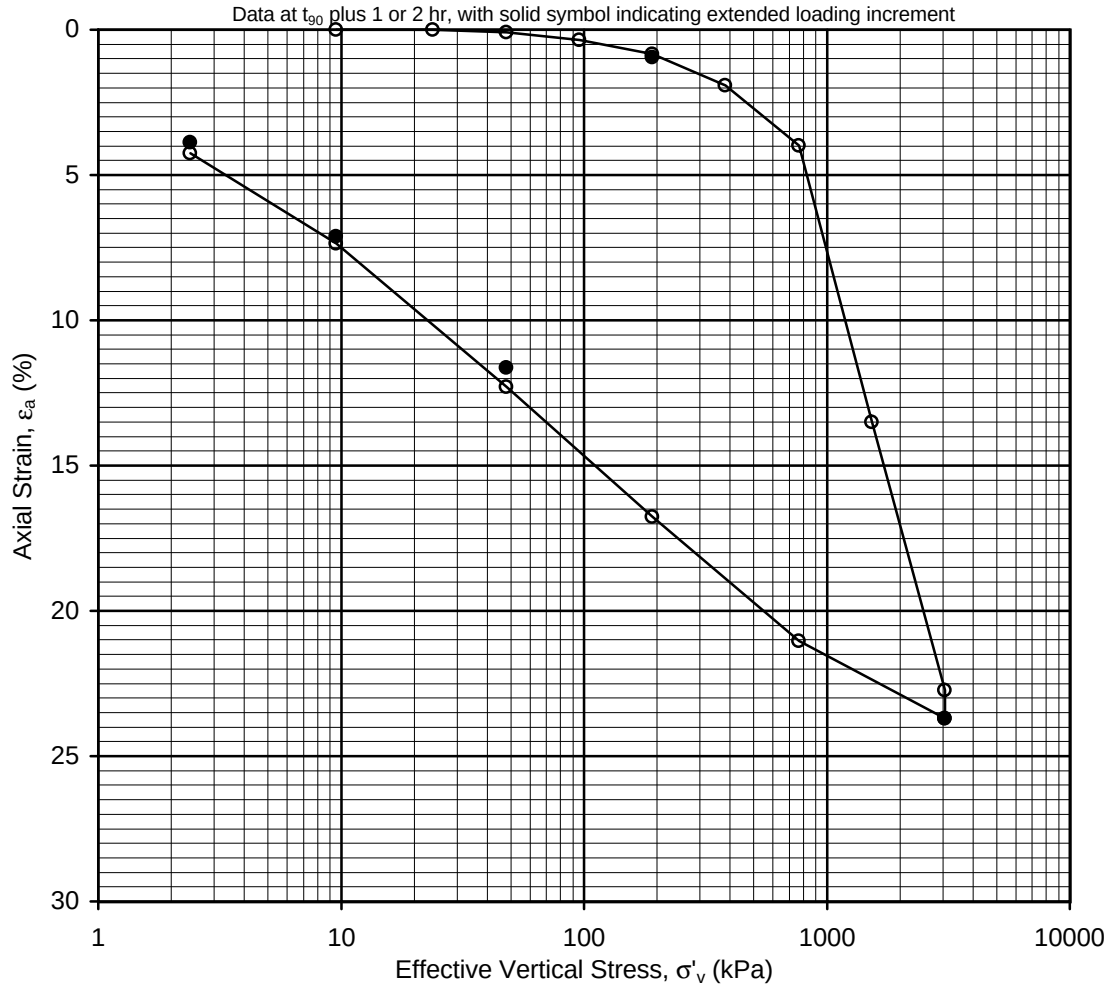
Sample No. 39 - Depth: 42.9m
Boring 98-51
SFOBB East Span Seismic Safety Project

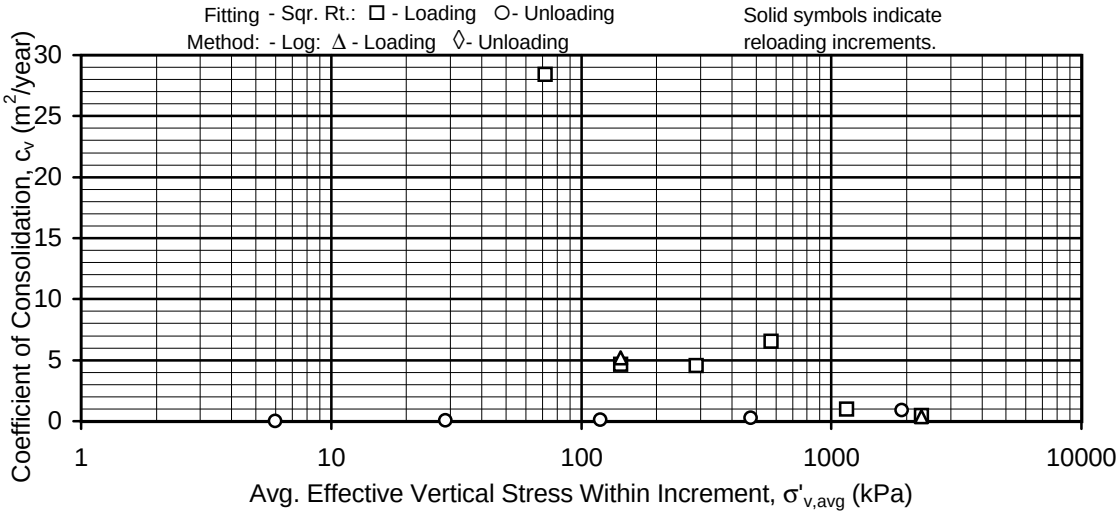




INCREMENTAL CONSOLIDATION TEST RESULTS

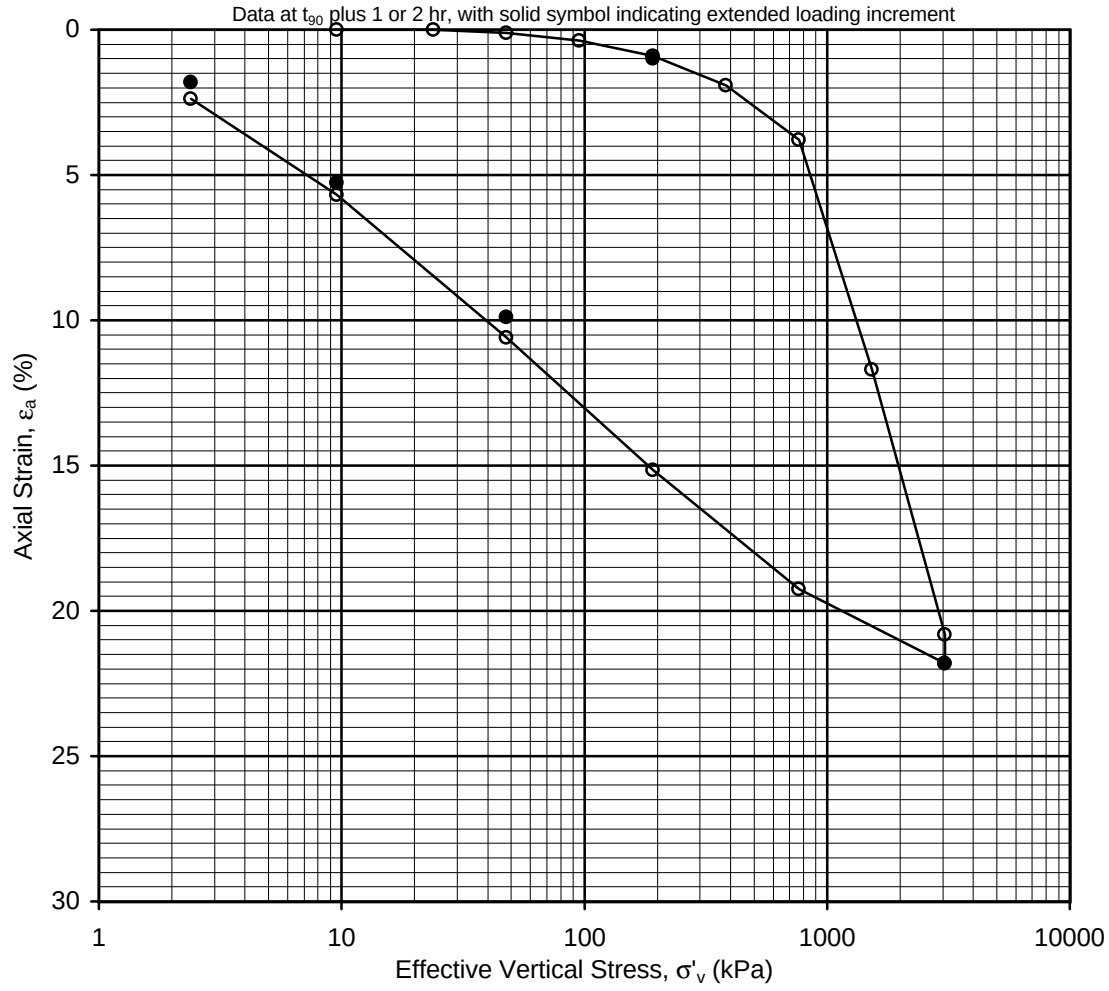
Sample No. 47 - Depth: 49.2m
Boring 98-51
SFOBB East Span Seismic Safety Project

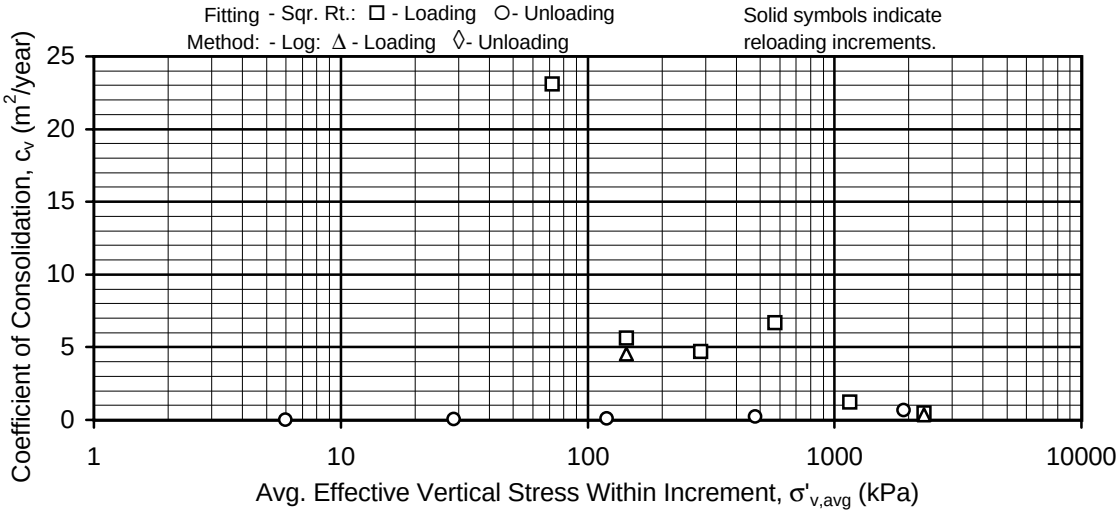




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 54 - Depth: 61.5m
Boring 98-51
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

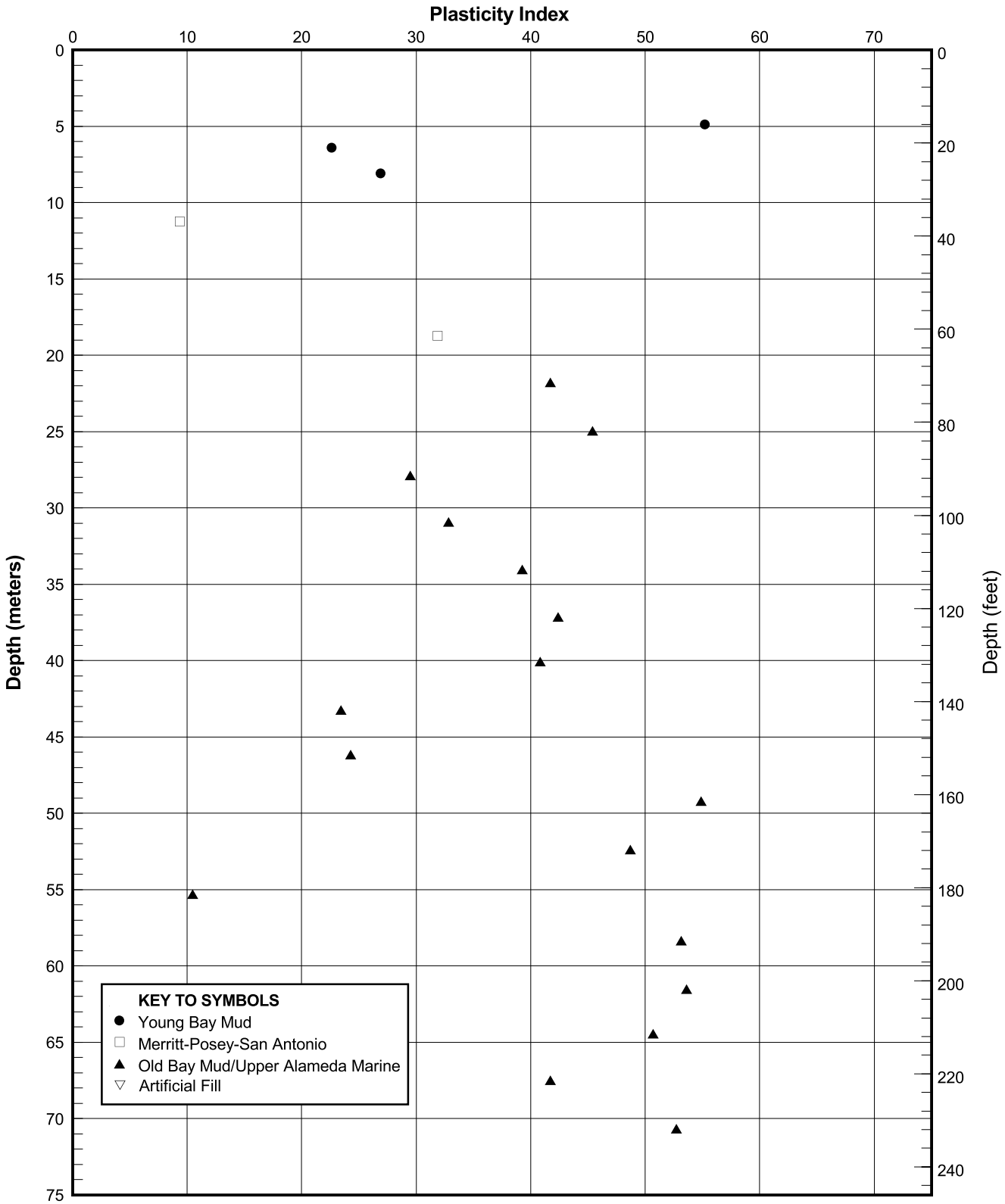
Sample No. 62 - Depth: 70.3m
Boring 98-51
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

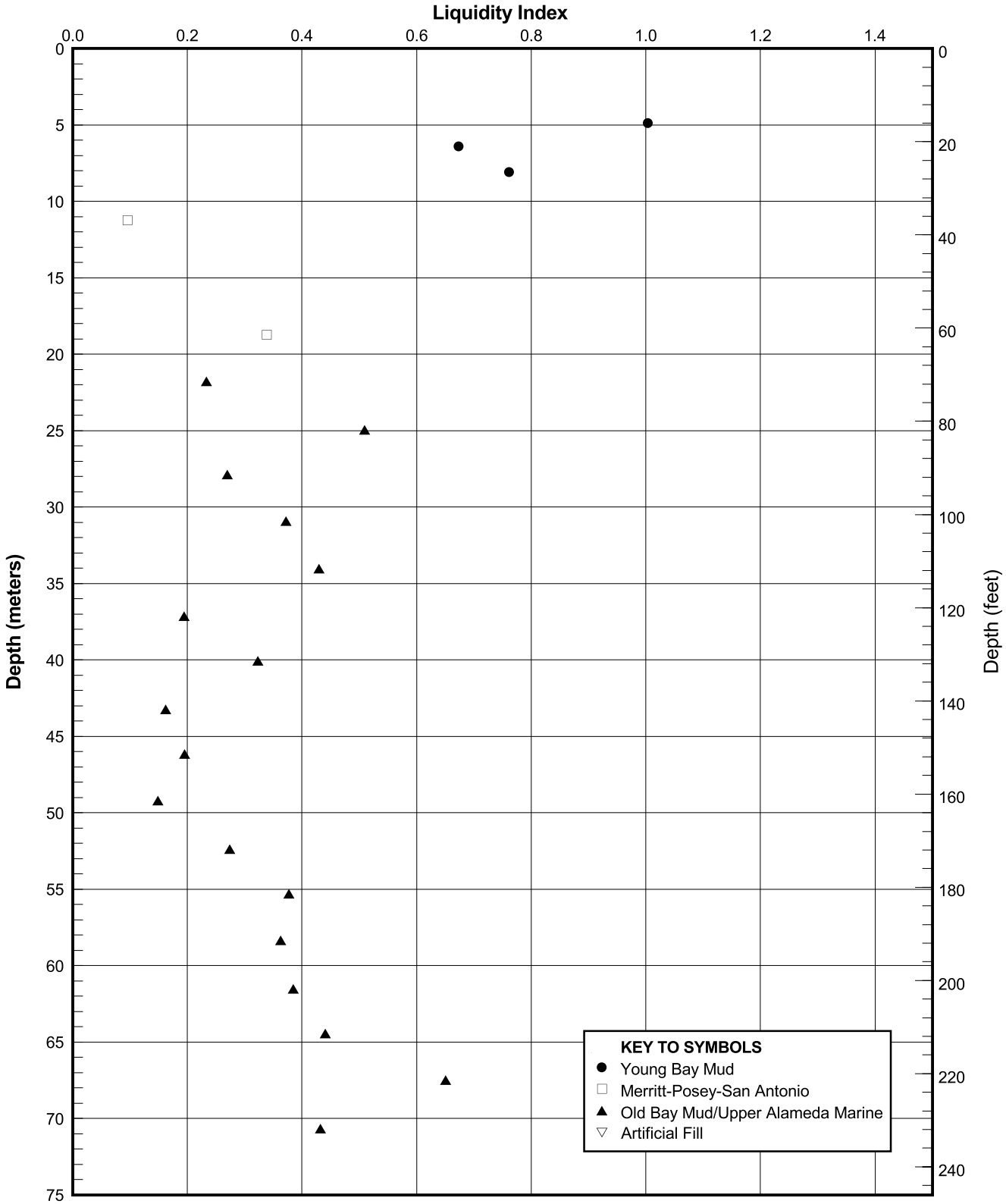
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



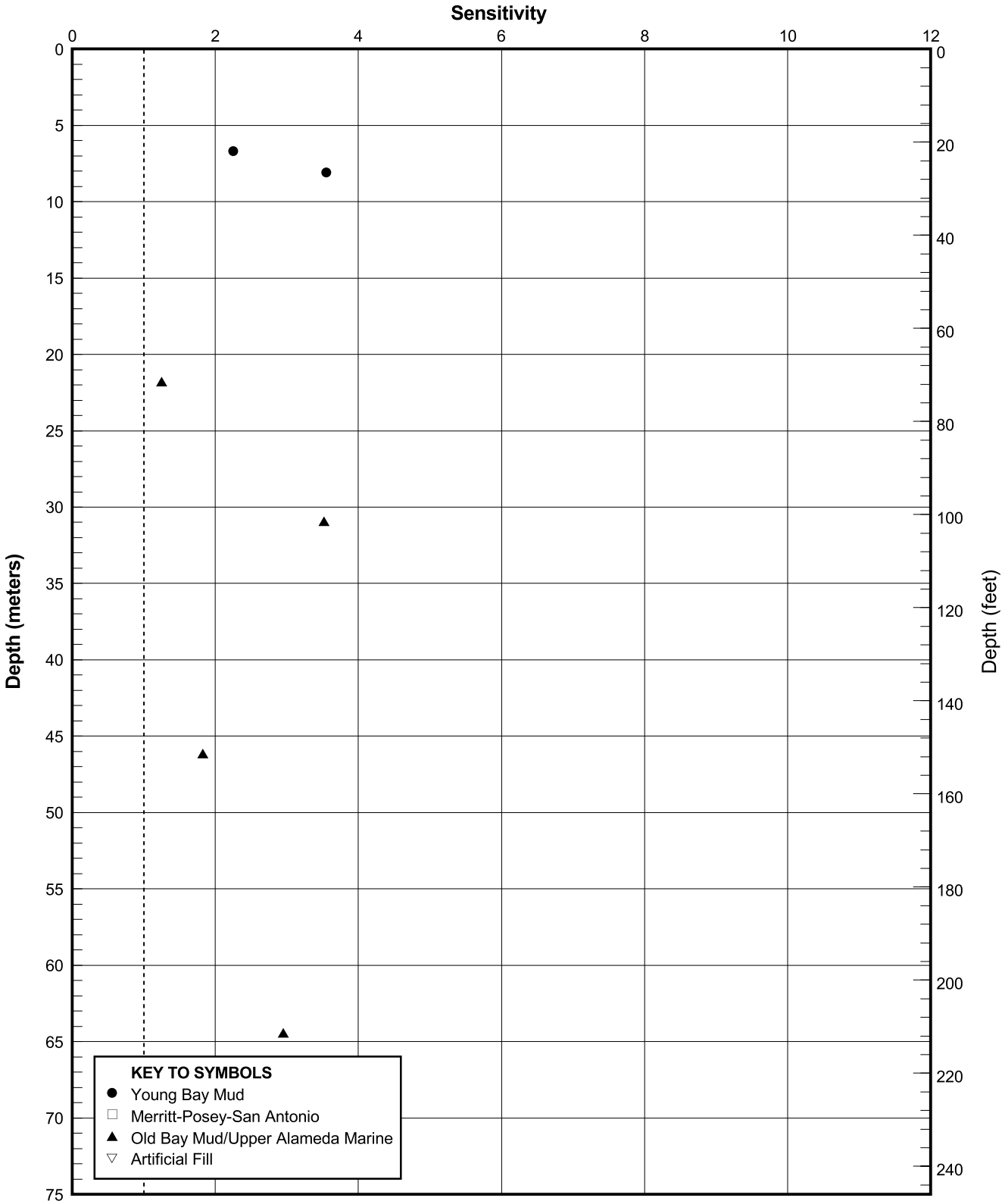
PLASTICITY INDEX PROFILE
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.12



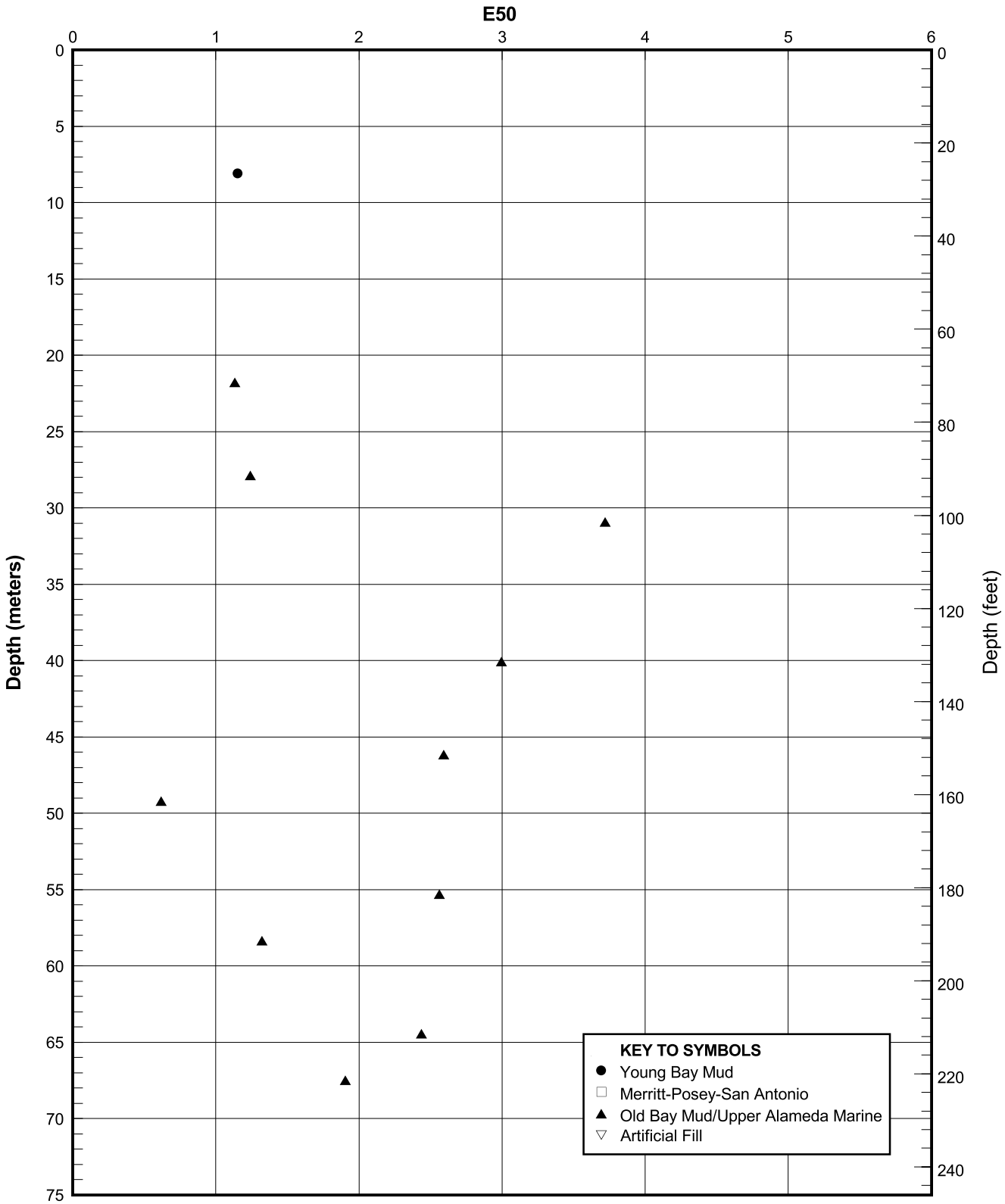
LIQUIDITY INDEX PROFILE
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.13



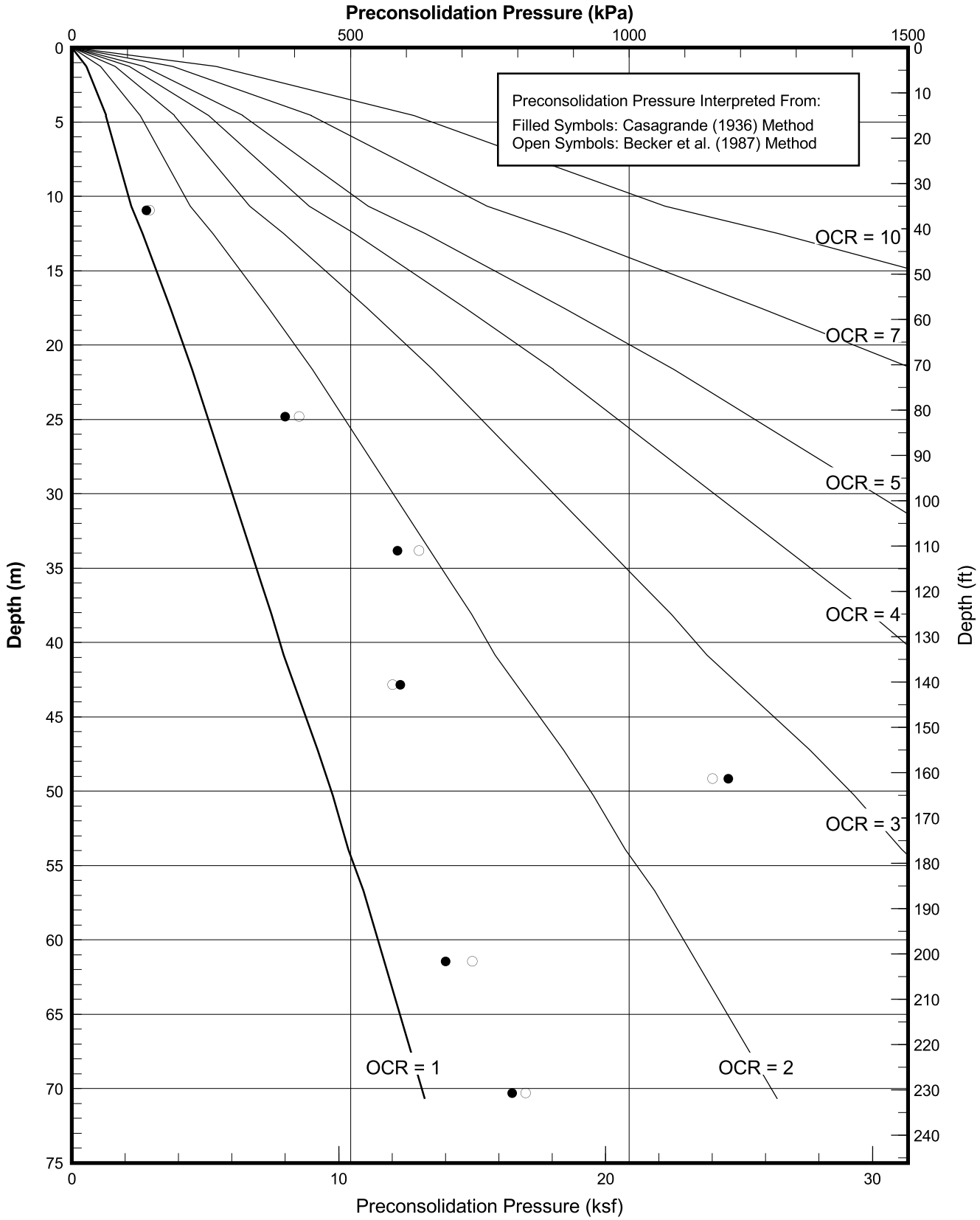
SENSITIVITY PROFILE
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.14



E50 PROFILE
Boring 98-51
SFOBB East Span Seismic Safety Project

PLATE 98-51.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-51

SFOBB East Span Seismic Safety Project

PLATE 98-51.16

LAND BORING 98-52

PROJECT NO:	98-42-0058	**START DATE:**	10/12/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-52 (Centerline E. Sta. 84+69)	**COMPLETION DATE:**	10/12/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838962 N648256
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 1.7m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
1	1				PAVEMENT, 0.1m Asphalt Concrete over 0.2m of Aggregate Base (0.3m)	I
					GRAVEL with sand (GW), loose to medium dense, brown	
0	2			16	-medium to coarse sand with gravel, at 1.7m ▽ (1.7m)	
-1	3			12		II
-2	4				-gray, silty fine sand with fine to coarse gravel and clay pockets, below 4.6m	
-3	5			12		
-4	6				(6.1m)	
-5	7			3	Fat CLAY (CH), firm to stiff, olive gray -with shells and shell fragments -lean clay to 10.1m	
-6	8			PUSH		
-7	9				-with a few silt pockets, a few silty fine sand pockets, and an H2S odor, at 9.4m	III
-8	10			PUSH		
-9	11			SAVE	-with a few silt pockets at 11.0m	
-10	12				(12.2m)	
-11	13			PUSH	-Clayey SAND (SC), dense, greenish gray -with fat clay seams at 12.2m	IV
-12	14			37	(13.4m) Silty Fine SAND (SM), dense, yellowish brown -with clay pockets at 12.2m	
-13	15					V
-14	16			35	-with black organic pockets and clay partings, at 15.2m (16.3m)	
-15	17			46	Fat CLAY (CH), stiff to very stiff, greenish gray -lean clay with many sand pockets, to 17.7m	
-16	18					VI
-17	19			16	(19.2m)	
-18	20				Fat CLAY (CH), stiff to very stiff, greenish gray	
-19	21					VII
-20	22			PUSH	-with organic pockets, silt partings, silty fine sand pockets and desiccated pockets, at 21.6m (22.6m)	
-21	23				Fat CLAY (CH), very stiff, greenish gray	
-22	24				-with sand pockets at 23.8m	
-23	25			29	-with gas blisters and black organic pockets, at 24.7m	
-24	26					
-25	27					
-26	28			PUSH	-with organic pockets and sand pockets, at 27.7m -dense, greenish gray, fine sand with silt, 27.9m to 28.5m	
-27	29			18	-with organic pockets and shell fragments, at 29.3m	VIII
-28	30					
-29	31					
-30	32			PUSH	-with silt partings at 32.3m	
-31	33					
-32	34					
-33	35				-gray below, 35.1m	
-34	36			SAVE	TOTAL DEPTH: 35.7m BACKFILLED WITH: Cement Grout	
-35	37					
-36	38					
-37	39					
-38						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-52.1

LOG OF BORING AND TEST RESULTS

BORING 98-52

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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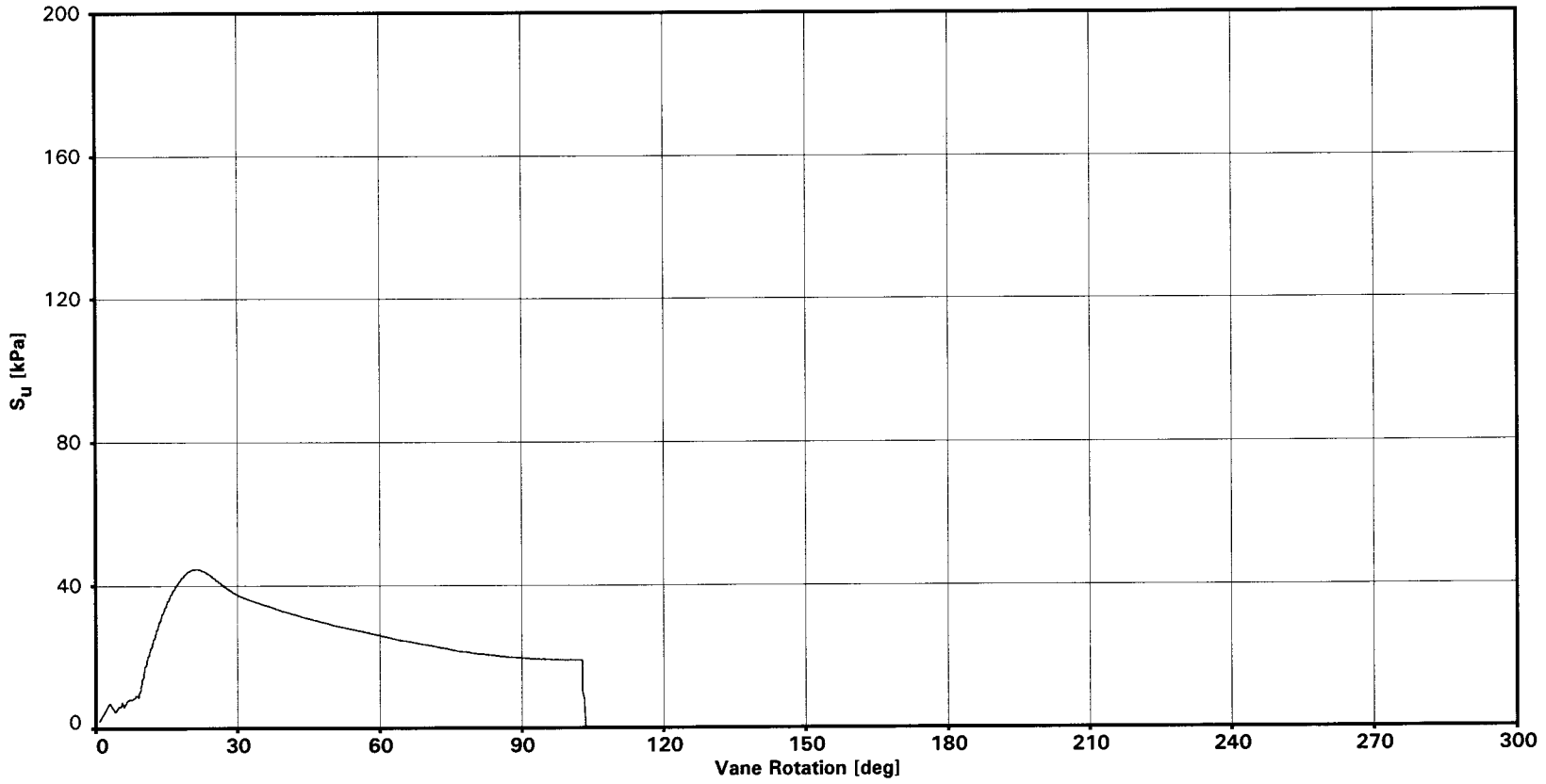
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strength)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 9.1m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

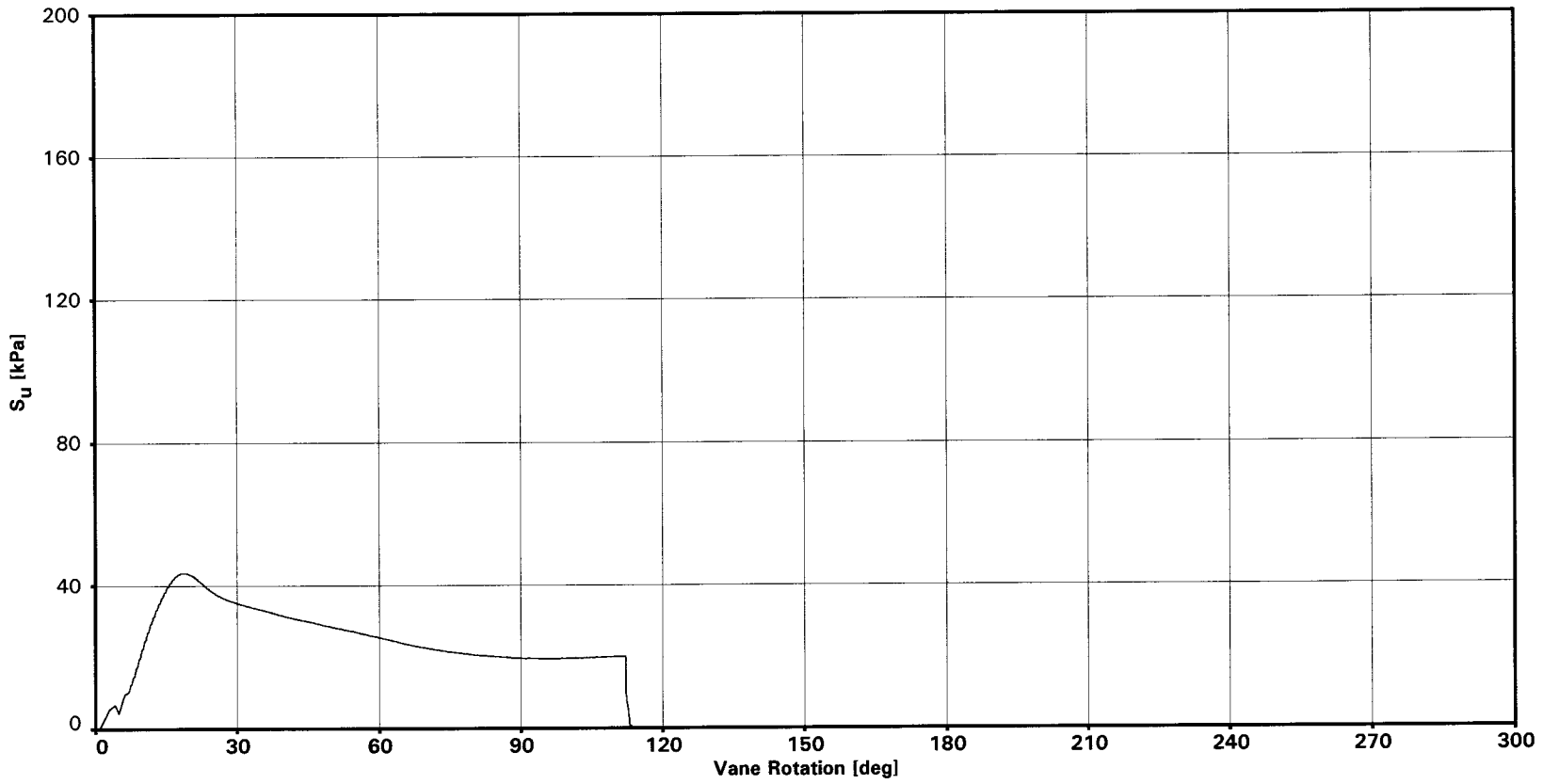
FUGRO

PLATE 98-52.2a

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 10.7m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

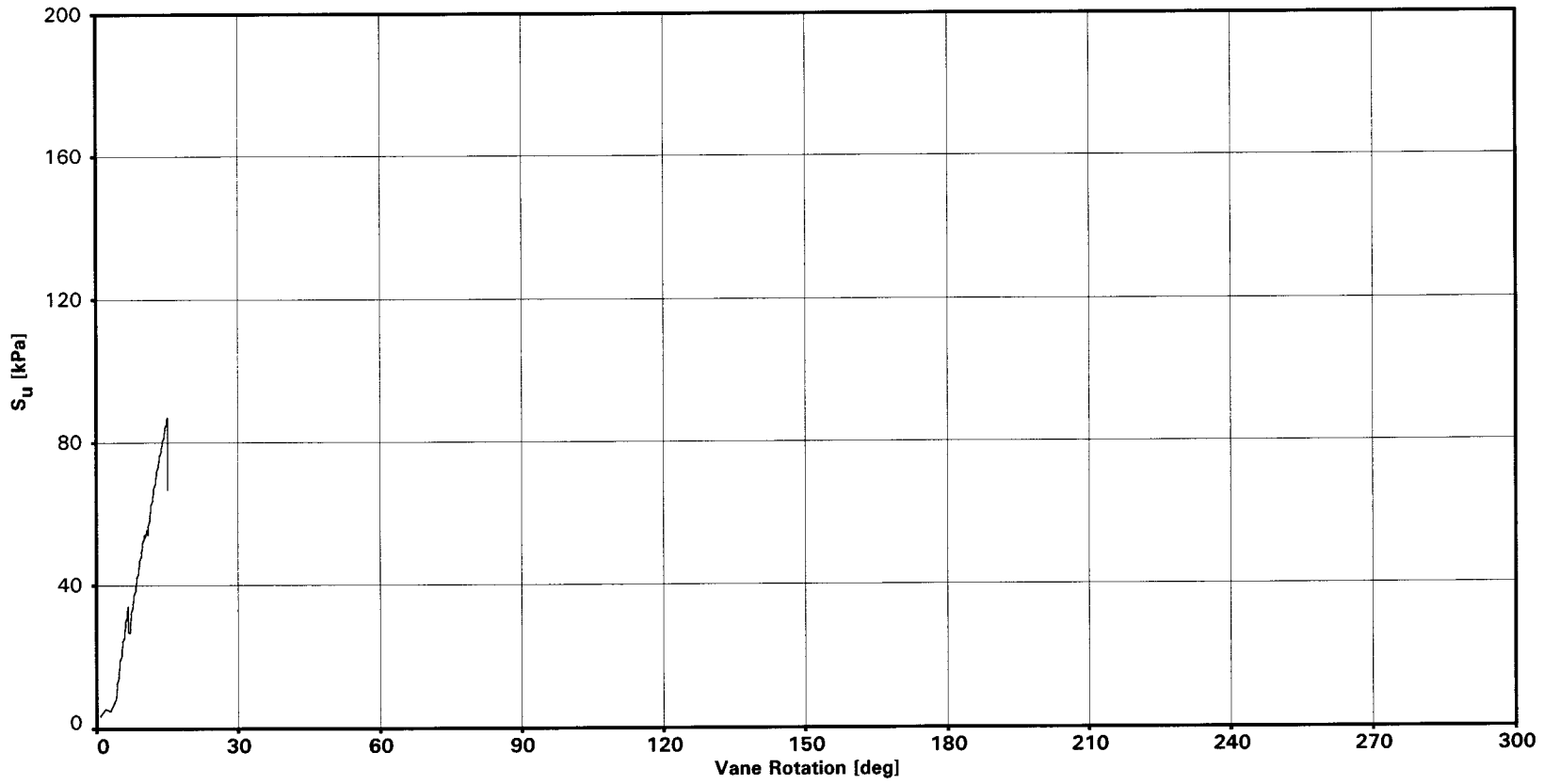
FUGRO

PLATE 98-52.2b

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

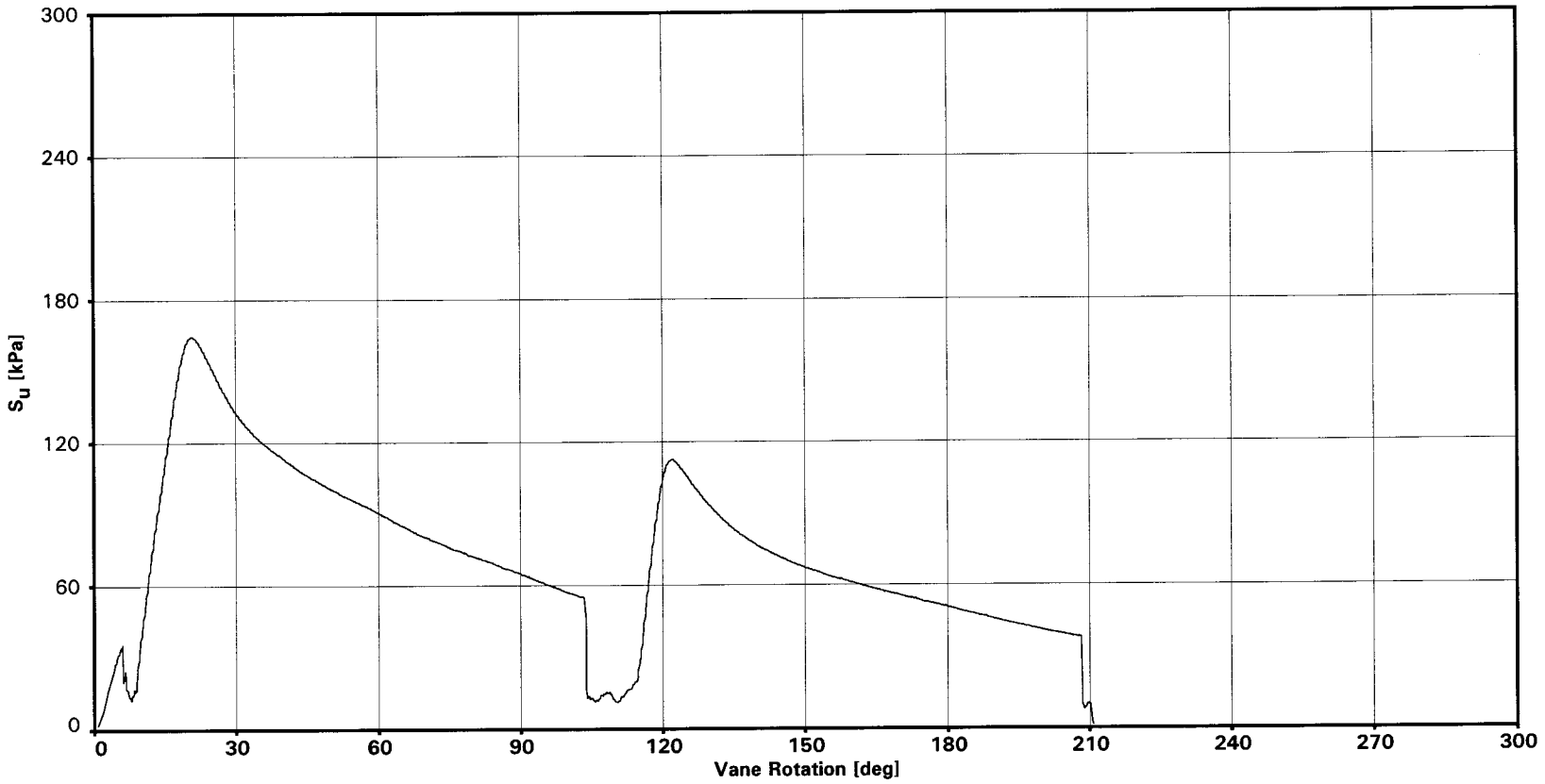
FUGRO

PLATE 98-52.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 19.8m and 20.4m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

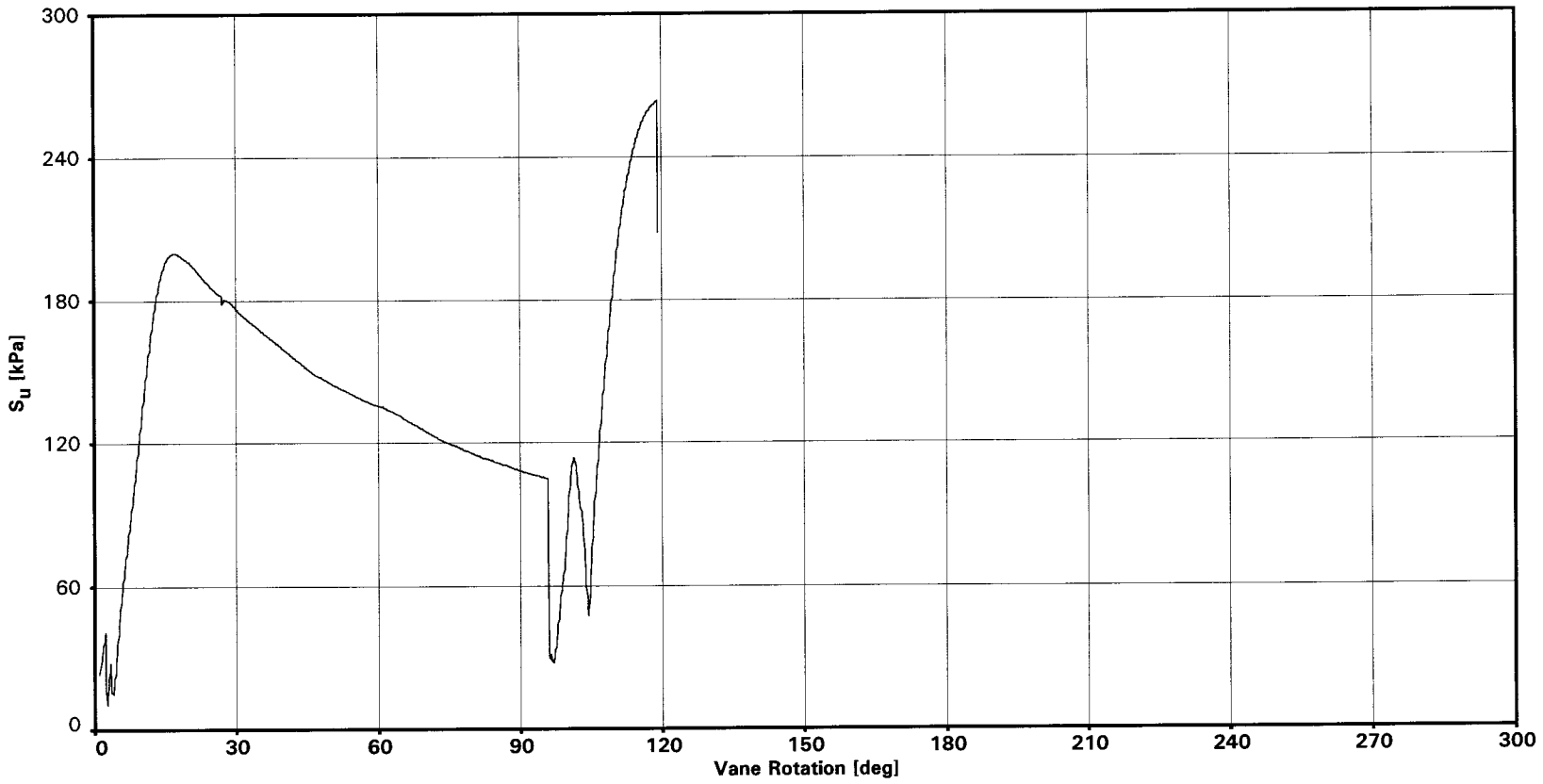
FUGRO

PLATE 98-52.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 22.9m and 23.5m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

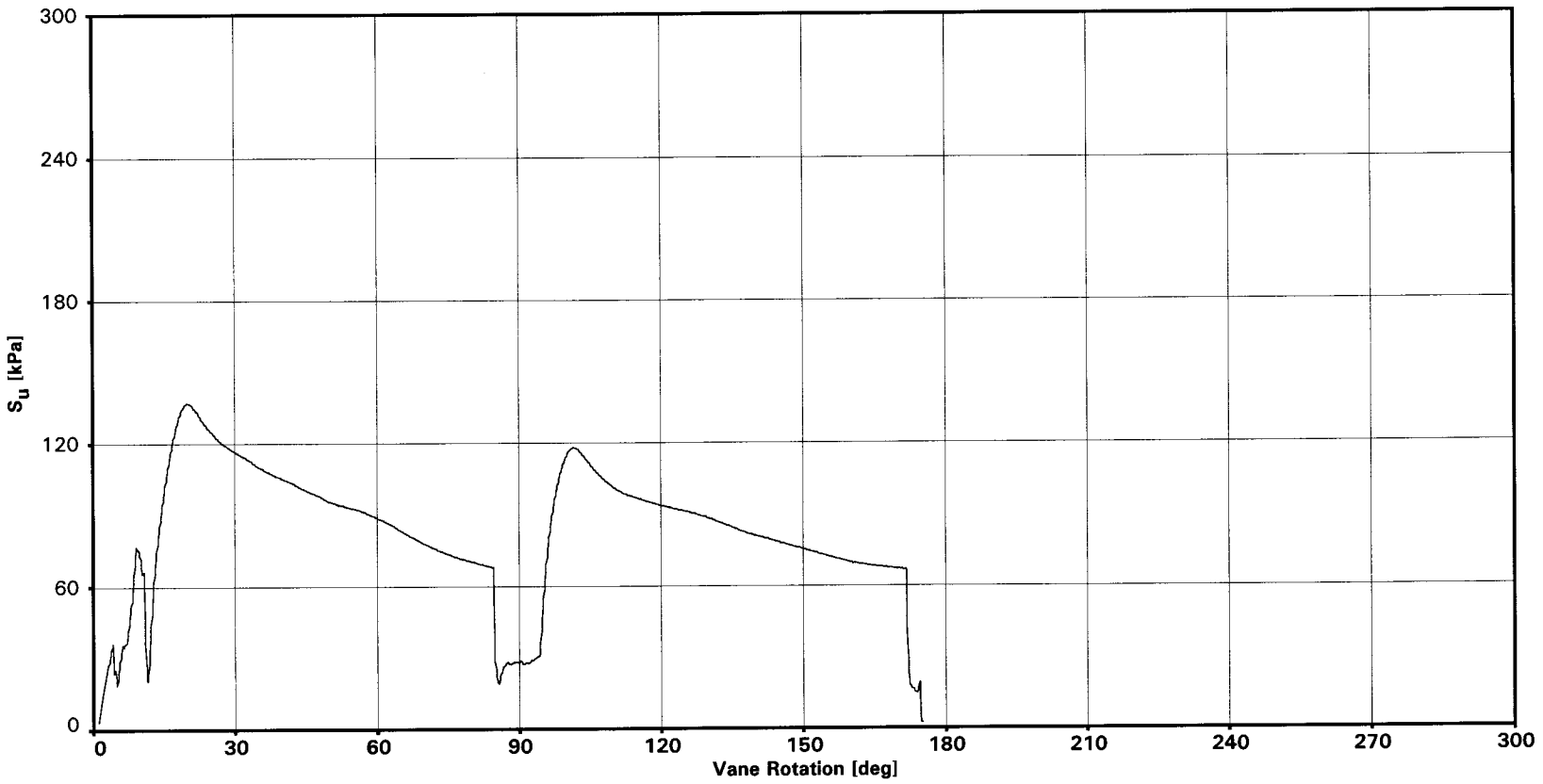
FUGRO

PLATE 98-52.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 25.9m and 26.5m
Boring 98-52
SFOBB East Span Seismic Safety Project

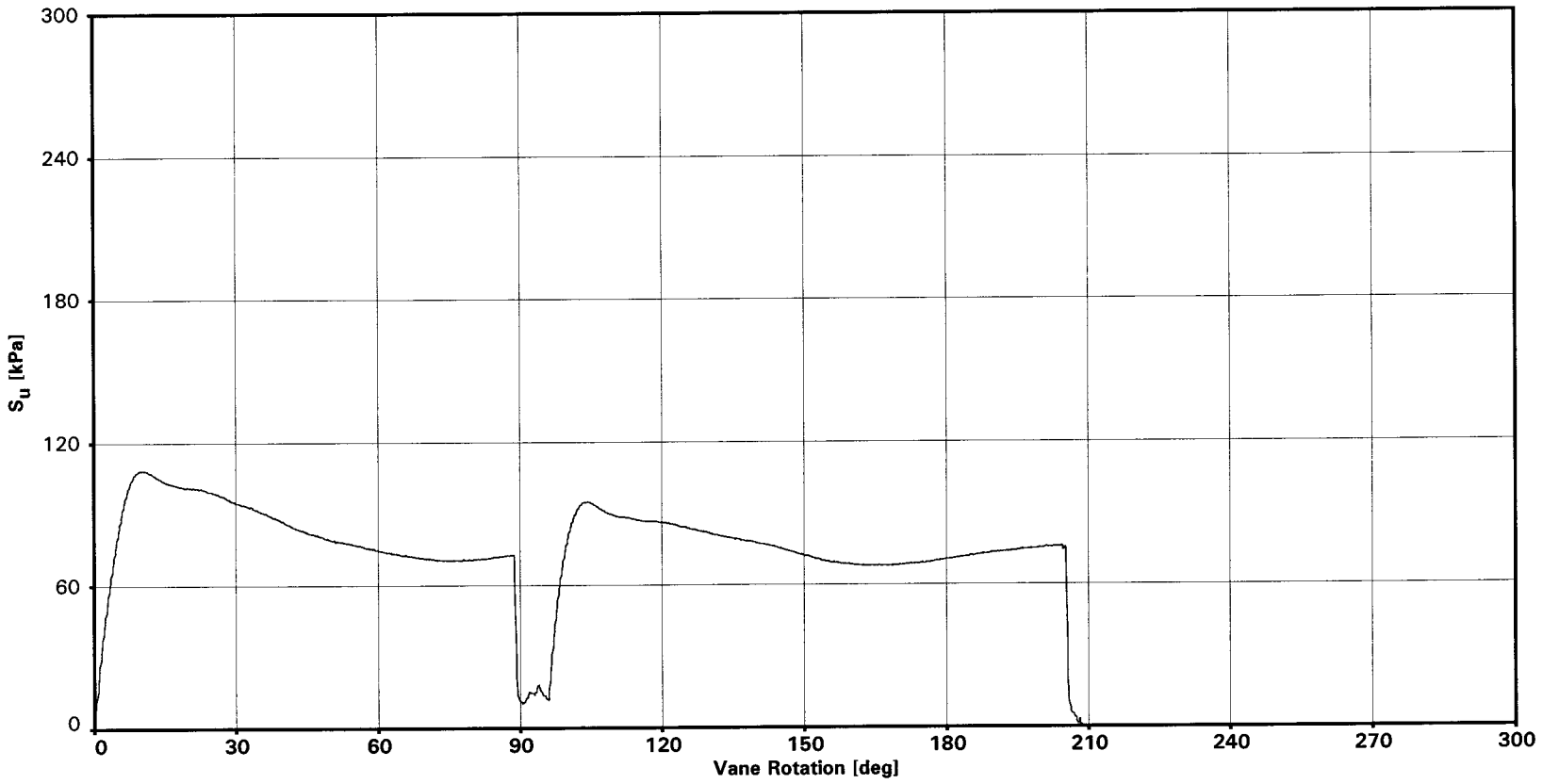
Earth Mechanics

FUGRO

PLATE 98-52.2f

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 30.5m and 31.1m
Boring 98-52
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

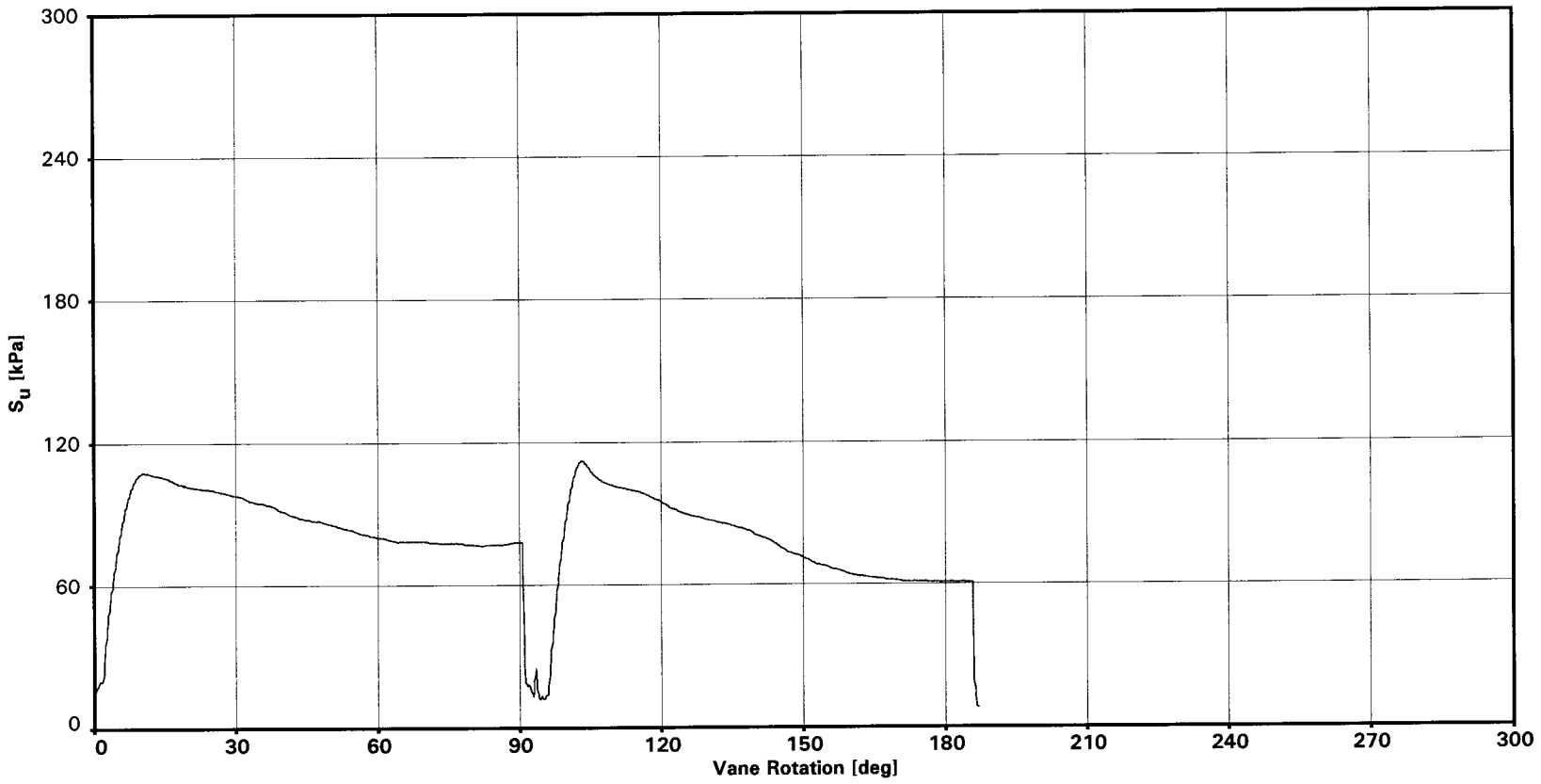
FUGRO

PLATE 98-52.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 33.5m and 34.1m
Boring 98-52
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-52.2h

98-52		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.7	1	16																									
3.3	2						4																				2.68
4.7	3	31					29																				
6.4	4	40	48	21	0.70																						
7.9	5	42	48	25	0.76																						2.72
8.1	6	42	46	24	0.84			33.5																			
9.1	400													45.0													
9.4	7	43	45	21	0.95	17.6																					
9.6	8							59.9			44.6	19.6															
9.8	9							33.5																			
10.7	401													43.6													
11.2	10							35.9																			
11.3	11	53	61	28	0.77						48.3																
11.9	402													87.1													
12.5	13	15					36																				

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.3a

Earth Mechanics

FUGRO

98-52		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
14.2	14	23					13																				2.73
15.7	15	23					14																				
17.1	17	21	43	18	0.11	20.7		119.7	186.9		168.3																
18.4	19	33	66	28	0.14																						
18.6	20	32				18.8		71.8			78.0																
19.8	403													161.8													
20.4	404													108.2													
21.8	22	44	48	24	0.82	18.3									68.1	17.4	3.9										
21.9	23							93.4																			
22.9	405													200.1													
23.5	406													263.3+													
24.5	24	24	65	25																							
24.7	25					20.1		141.2			142.3																
25.9	407													135.5													
26.4	27	49	71	32	0.45	16.9									92.6		2.6										

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-52		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
26.5	408													130.7													
27.7	27															32.9											
27.9	28							83.8																			
28.0	29	23					9																				
29.3	31	54	81	27	0.51	16.7		76.6			108.9					26.7											
30.5	409													106.3													
31.1	410													97.7													
32.5	34	44	70	31	0.34	17.4		91.0							97.6	31.4	1.9										
33.5	411													106.3													
34.1	412													110.6													
35.6	36	45	65	24	0.52																					C	
35.7	37	43	67	27	0.39						125.0																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

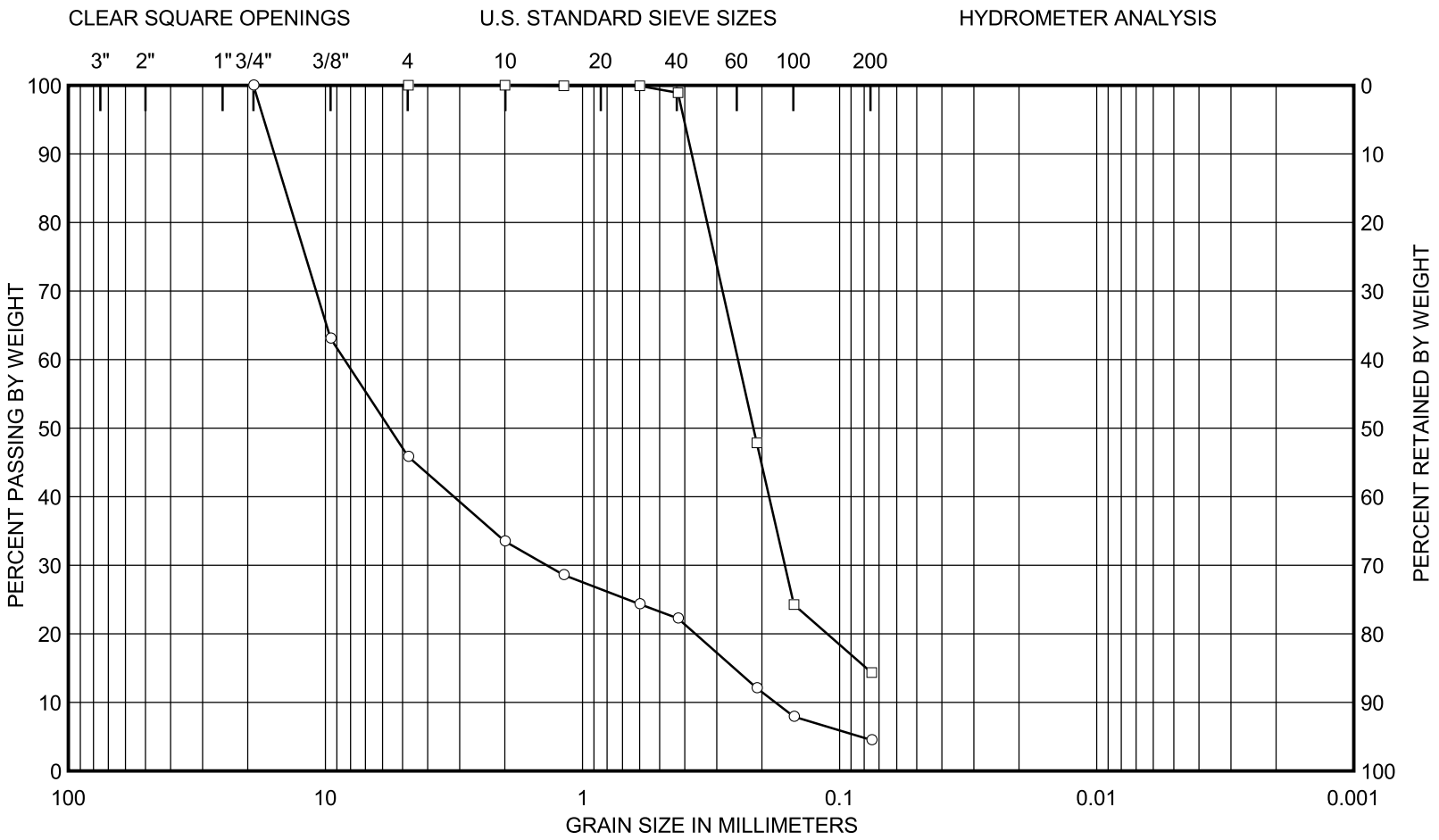
\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.3c

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.3	○——○	FINE GRAVEL (GW) with fine to coarse sand	1.3	47.4	5.6
15	15.7	□——□	SILTY FINE SAND (SM) with clay partings			0.22

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-52
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-52.4

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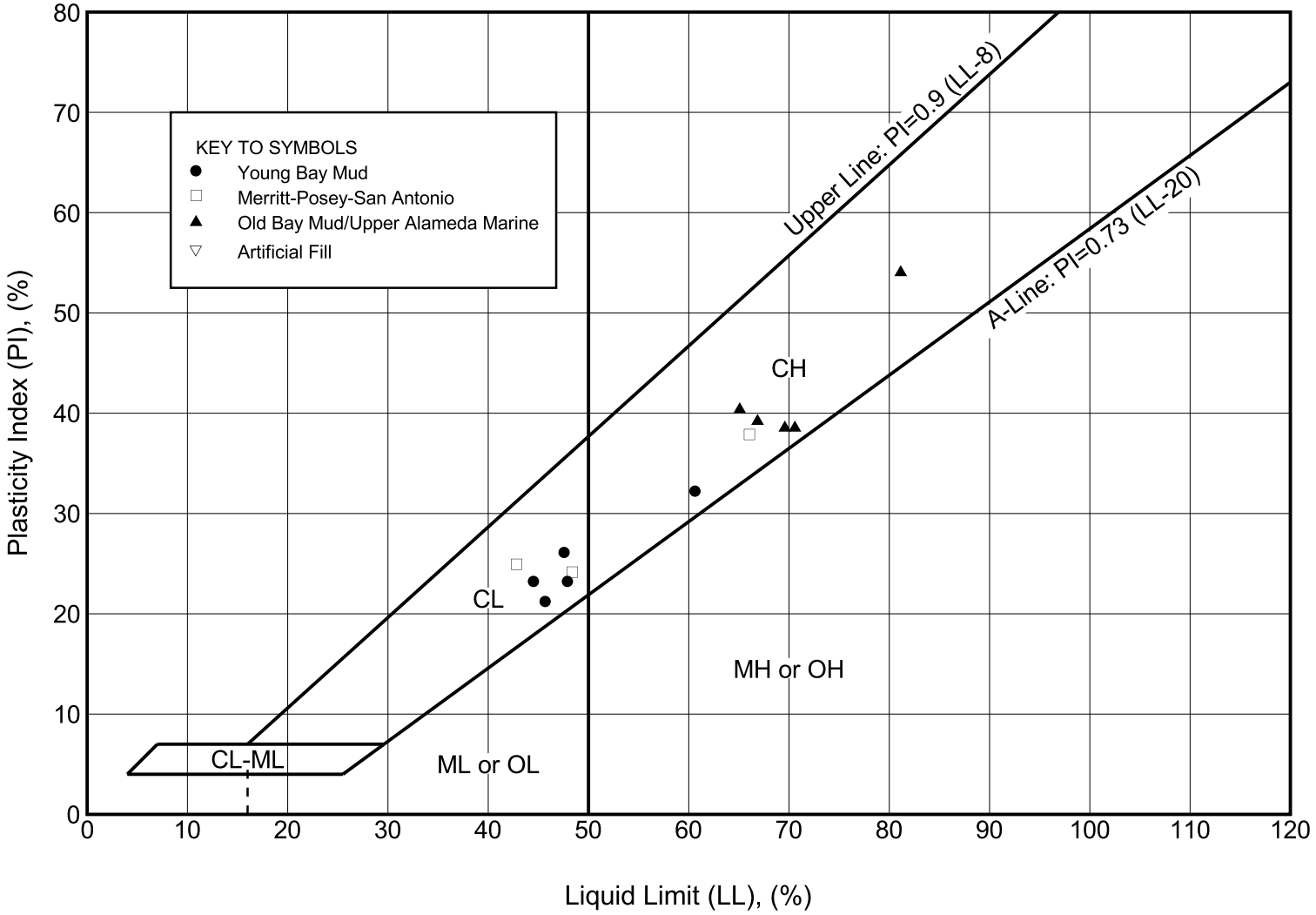

PLASTICITY CHART
Boring 98-52
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-52.5

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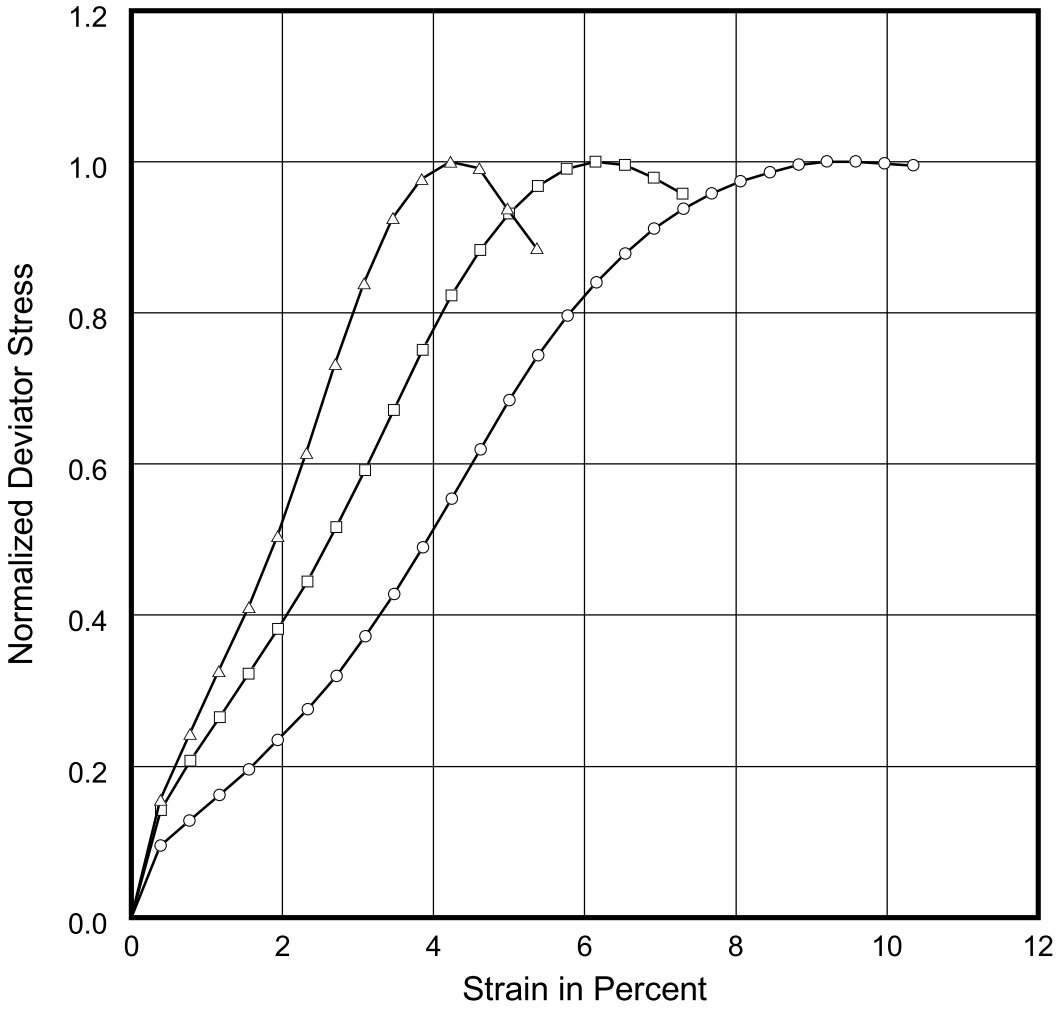


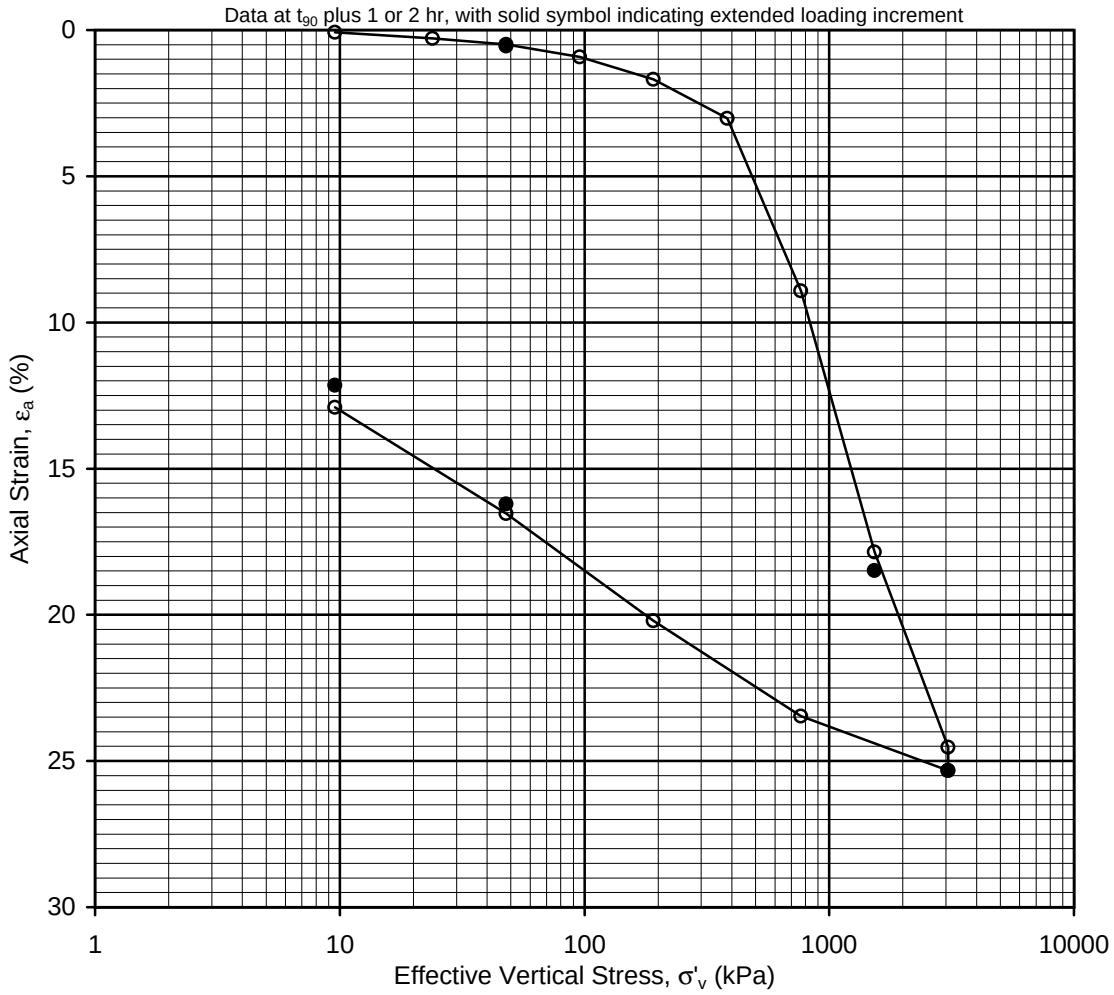
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	22	21.8	UU	758	136	3.9
□—□	27	27.7	UU	862	185	2.6
△—△	34	32.5	UU	896	195	1.9

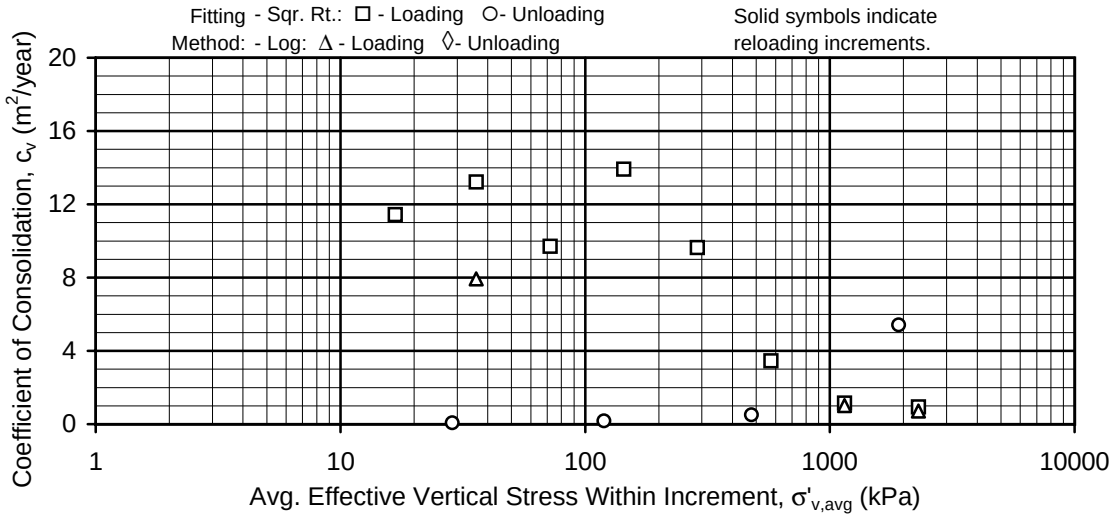
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.6





INCREMENTAL CONSOLIDATION TEST RESULTS

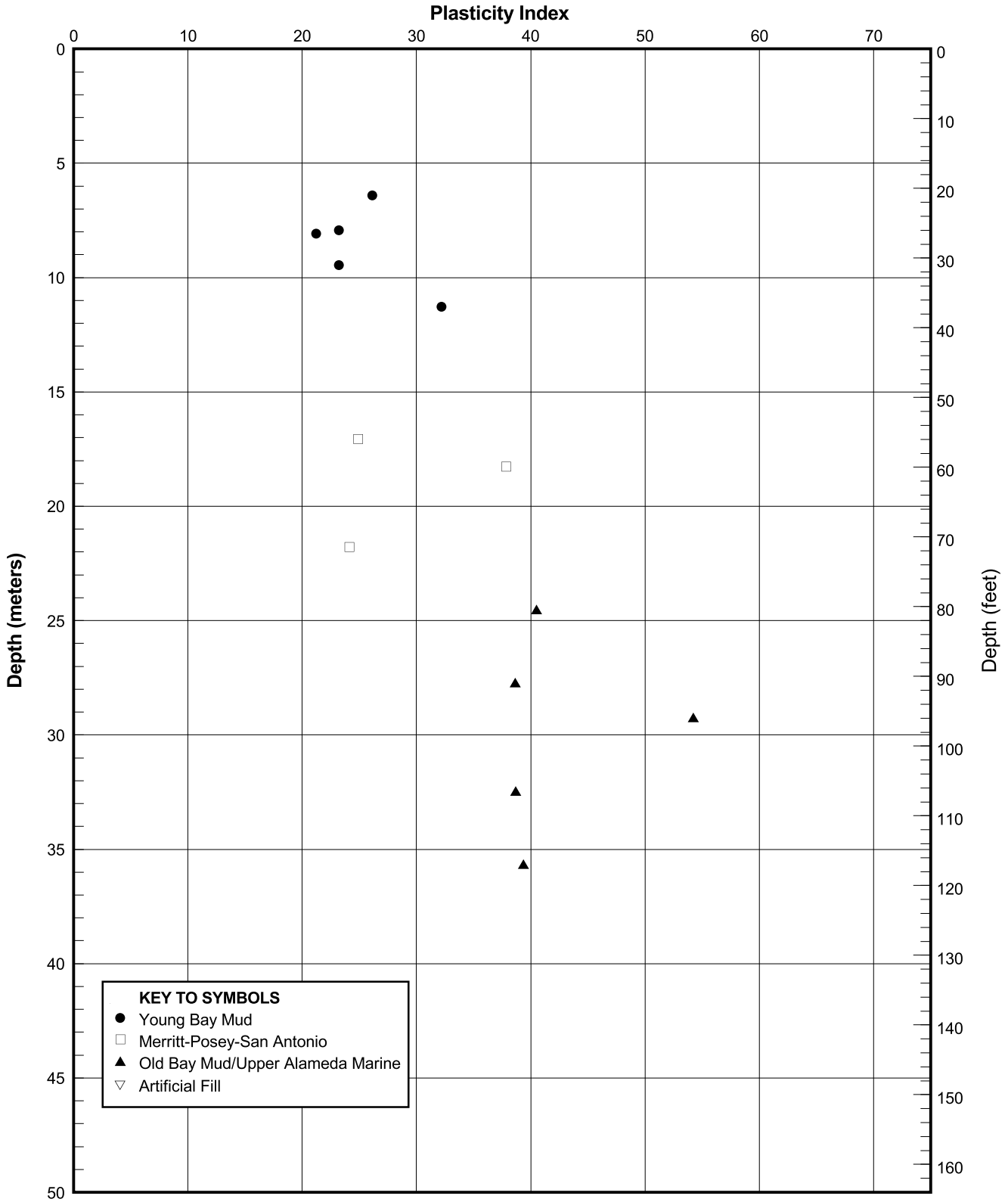
Sample No. 36 - Depth: 35.5m
Boring 98-52
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

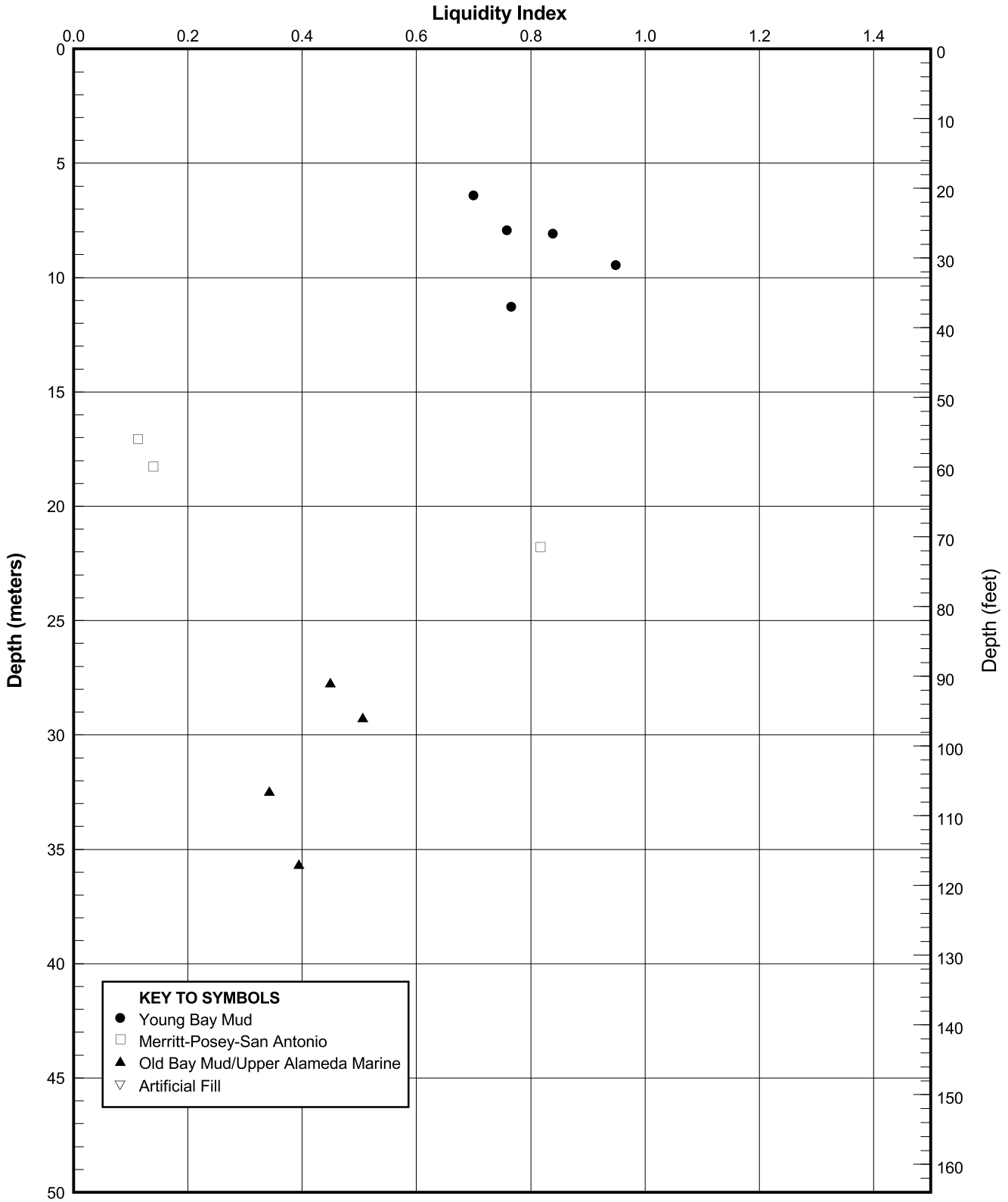
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



PLASTICITY INDEX PROFILE
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.12

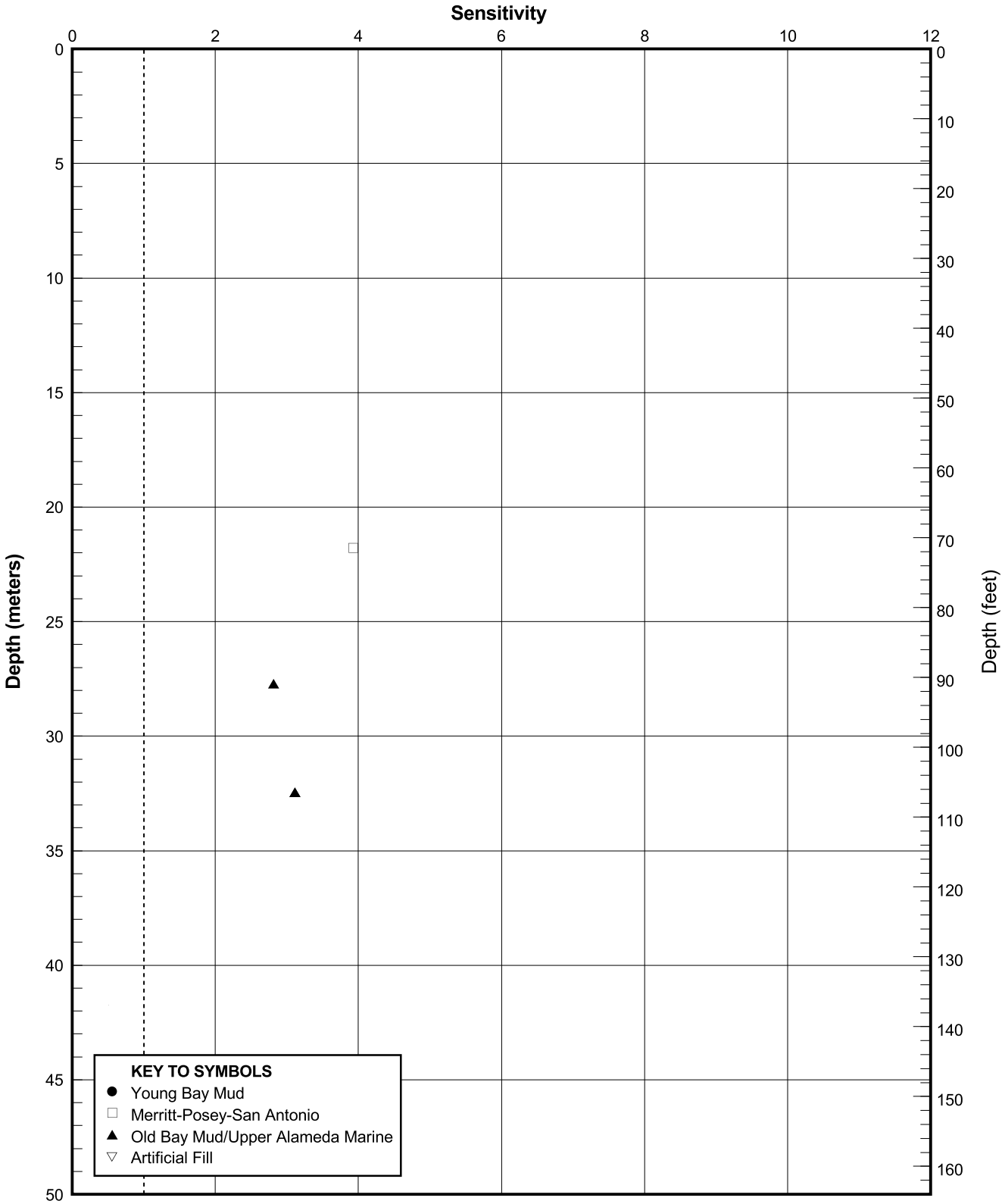


LIQUIDITY INDEX PROFILE
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.13

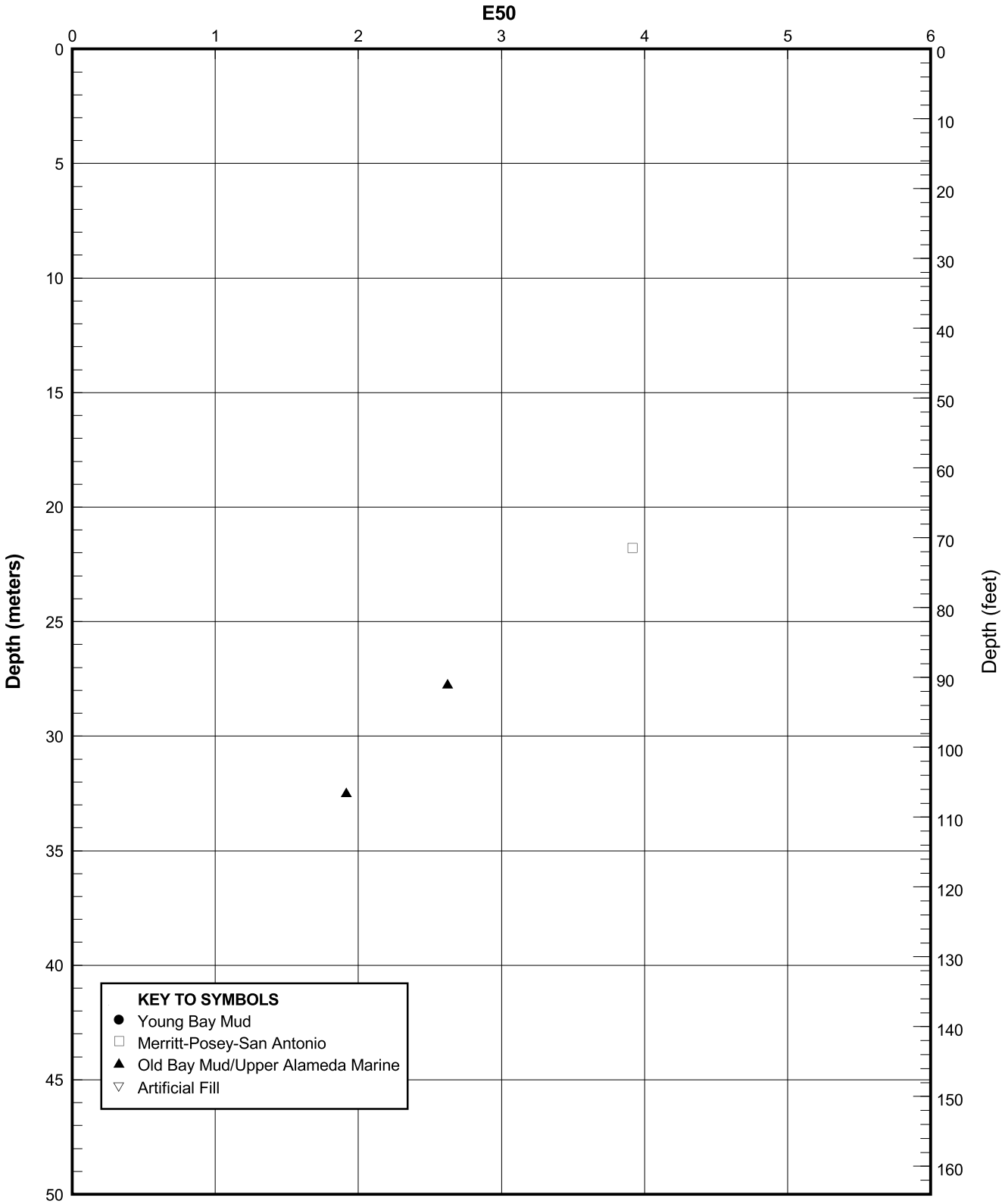
Earth Mechanics

FUGRO



SENSITIVITY PROFILE
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.14

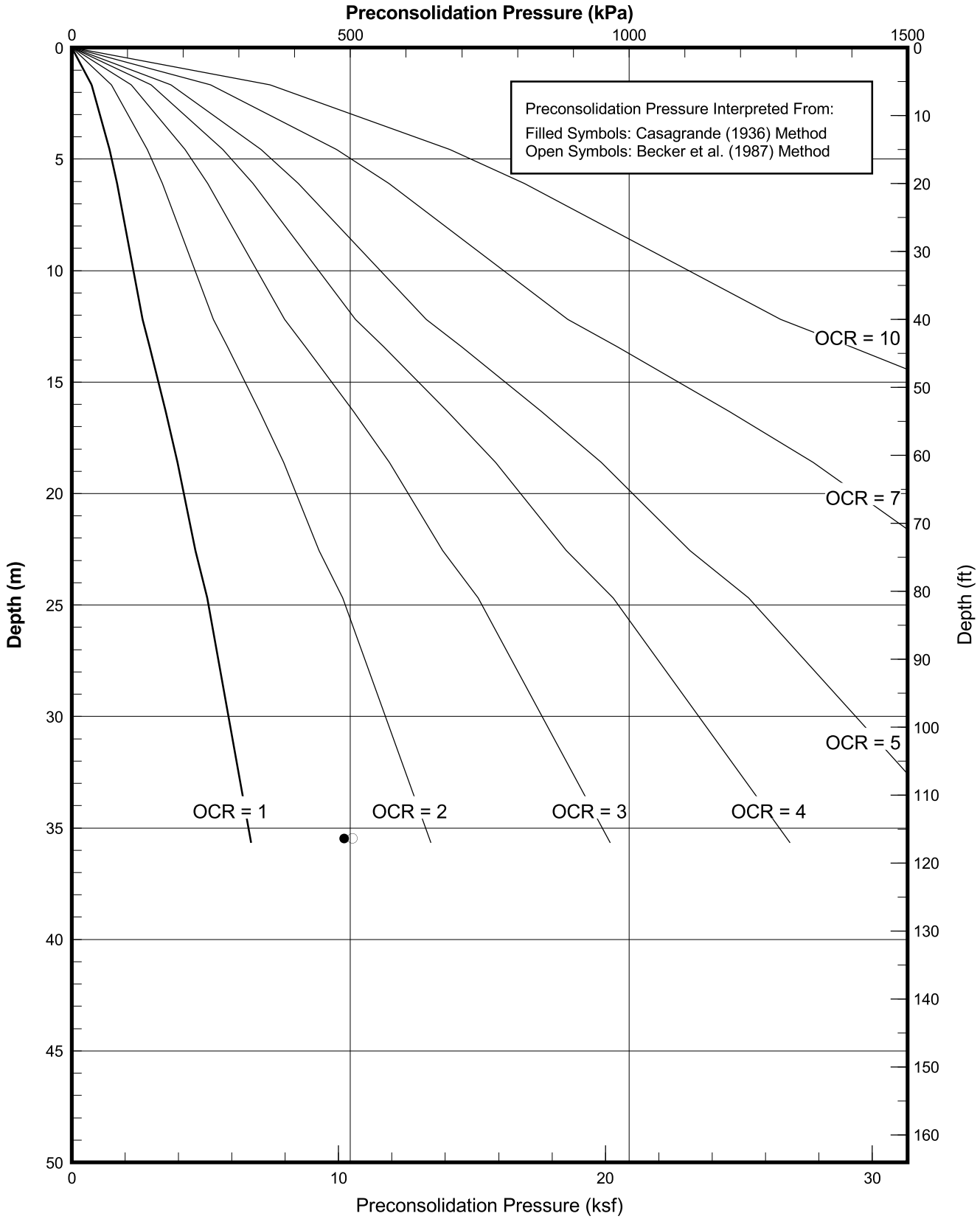


E50 PROFILE
Boring 98-52
SFOBB East Span Seismic Safety Project

PLATE 98-52.15

Earth Mechanics

FUGRO



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-52

SFOBB East Span Seismic Safety Project

PLATE 98-52.16

LAND BORING 98-53

PROJECT NO:	98-42-0058	**START DATE:**	10/2/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-53 (3m left of E. Sta. 85+60)	**COMPLETION DATE:**	10/3/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839052 N648267
CA State Plane Zone 3, NAD83, Meters

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					GROUND ELEVATION: 3.6m (MSL)	
3	1				Pavement, Asphalt Concrete over Aggregate Base (0.2m)	I
					Silty Fine SAND (SM), medium dense, brown, dry to moist	
2	2		☒	24	-silty fine gravel with sand and concrete fragments, at 1.7m	II
1	3				(3.1m)	
			▦	10	Fine SAND with silt (SP-SM) medium dense, olive gray ▽ (3.6m)	
0	4				-moist at 3.2m	
					-with angular gravel, to 5.0m	
-1	5		☒	14	-olive gray to brown at 4.9m	III
-2	6					
			▥	36	-with silty sand seams, at 6.4m	
-3	7				-with a sandy clay layer at 6.7m	
-4	8		☒	21	-with shell fragments at 7.8m	
					(8.4m)	
-5	9				Fat CLAY (CH), firm to stiff, gray	
					-with shell fragments	
-6	10		■	PUSH	-lean clay to 10.1m	
					-with silt pockets at 9.4m	
-7	11		■	SAVE	-with silty fine sand pockets, at 11.0m	IV
-8	12					
-9	13					
					(13.7m)	
-10	14		■	PUSH	Sandy Lean Clay (CL), very stiff, greenish gray	
					-with silt pockets and fine sand, at 14.0m	V
-11	15					
-12	16				(15.8m)	
					Silty Fine SAND (SM), very dense, greenish gray	
-13	17		☒	50/15cm	-with clay pockets, 16.8m to 18.9m	
					-with silt pockets at 16.8m	
-14	18					VI
-15	19		☒	82	-sand with silt, at 18.5m	
					-with sandy clay below, 19.2m	
-16	20				-silty fine sand with clay pockets at 19.8m (20.0m)	
			▥	52	Fat CLAY (CH),stiff to very stiff, greenish gray to gray	
-17	21				-with a fine sand seam and sand pockets, at 20.1m	
-18	22					VII
-19	23		■	PUSH	-with gas blisters, organic pockets, and black staining, at 23.2m	
-20	24					
					(24.7m)	
-21	25				Fat CLAY (CH), very stiff to hard, greenish gray	
-22	26		▥	65	-sandy clay with sand partings and pockets, at 26.2m	
-23	27					
-24	28					
-25	29		■	SAVE	-with sand pockets and a few organic pockets, at 29.3m	VIII
-26	30					
-27	31					
-28	32		▥	22	-with organic pockets and a few silt pockets, at 32.3m	
-29	33					
-30	34					
-31	35		■	PUSH	-with silty fine sand pockets and organic pockets, at 35.4m	
-32	36				TOTAL DEPTH: 35.7m BACKFILLED WITH: Cement Grout	
-33	37					
-34	38					
-35	39					
-36						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

120 →

PLATE 98-53.1

LOG OF BORING AND TEST RESULTS

BORING 98-53

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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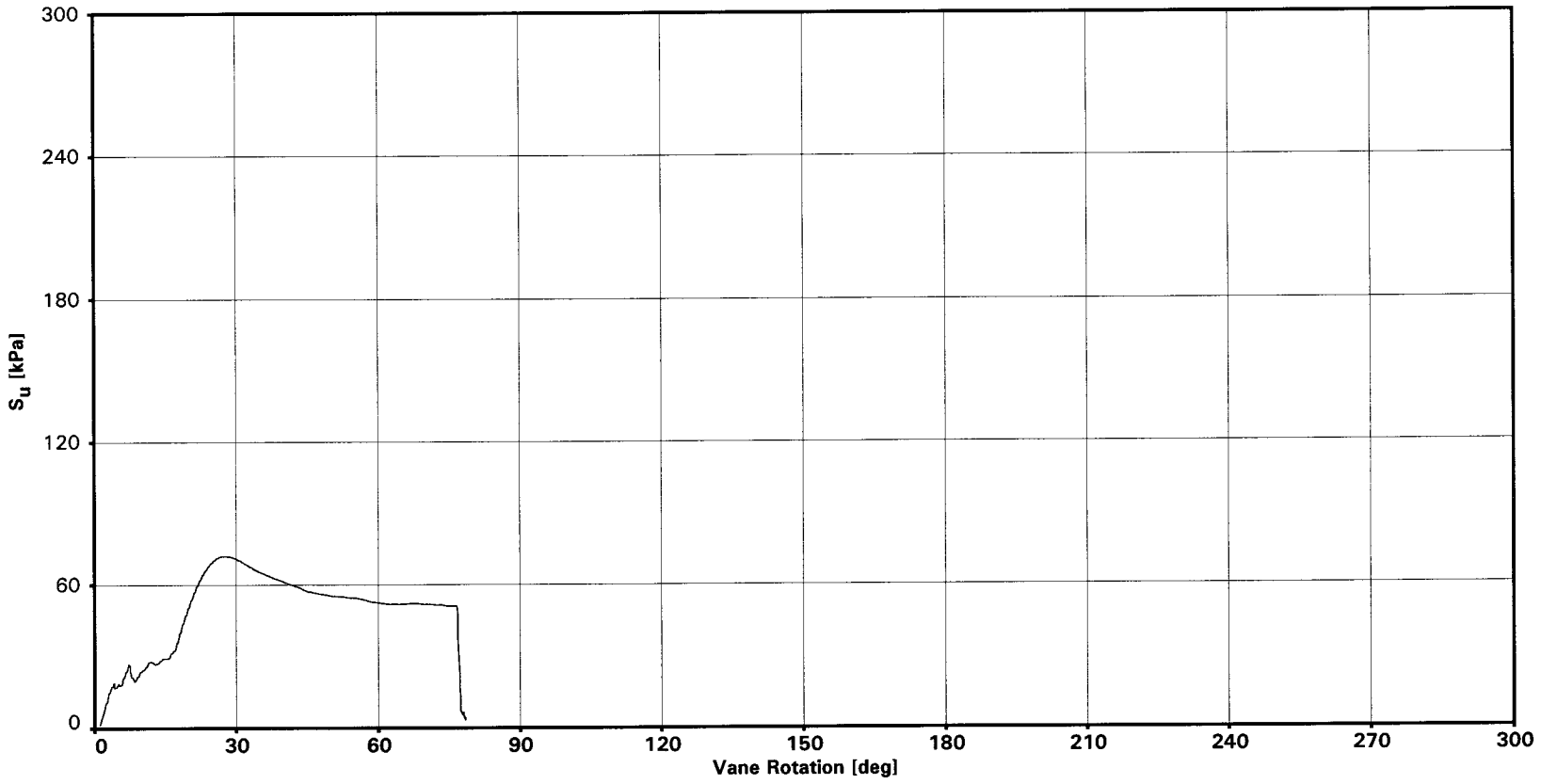
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-53
SFOBB East Span Seismic Safety Project

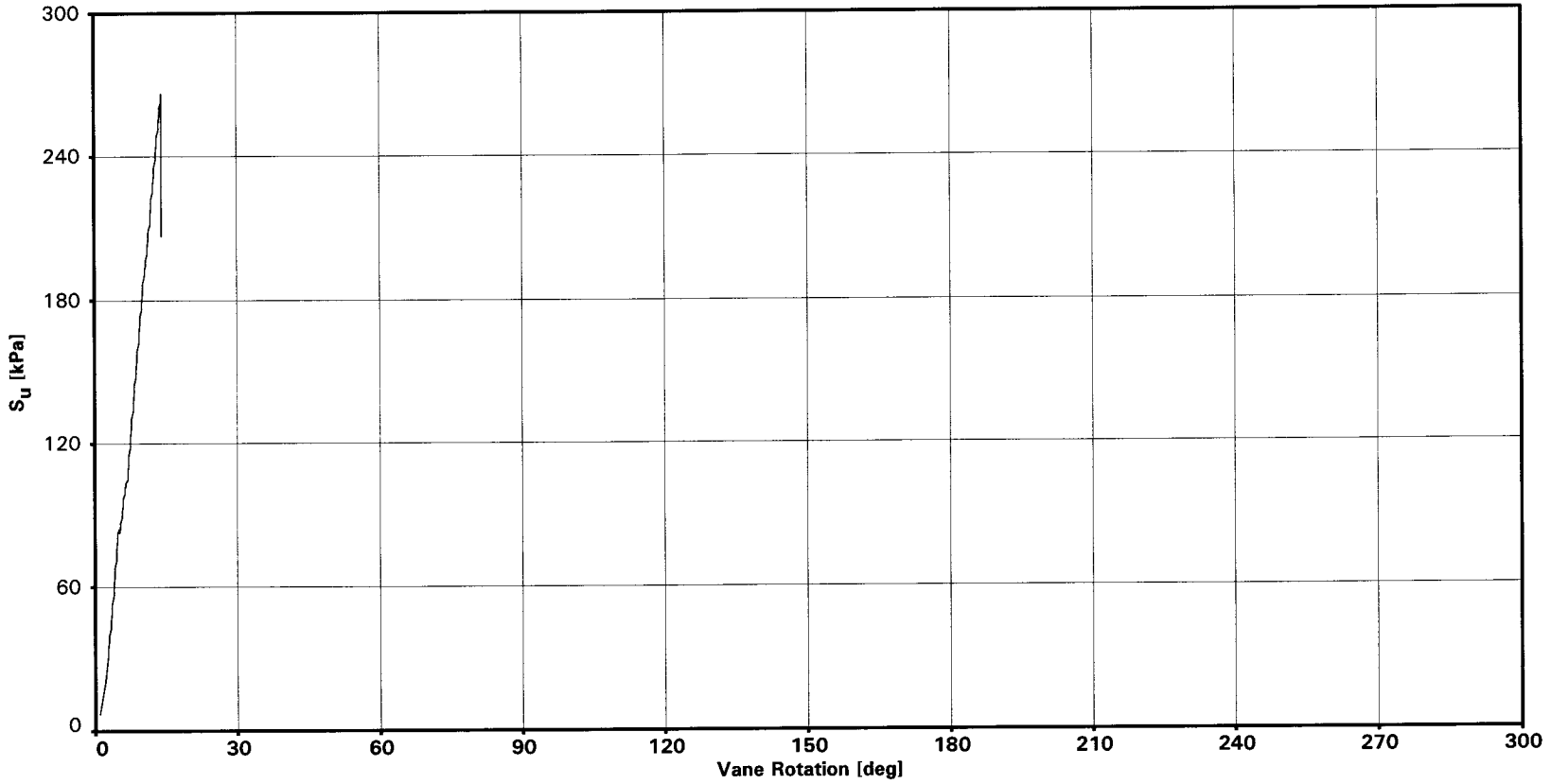
Earth Mechanics

FUGRO

PLATE 98-53.2a

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 15.2m
Boring 98-53
SFOBB East Span Seismic Safety Project

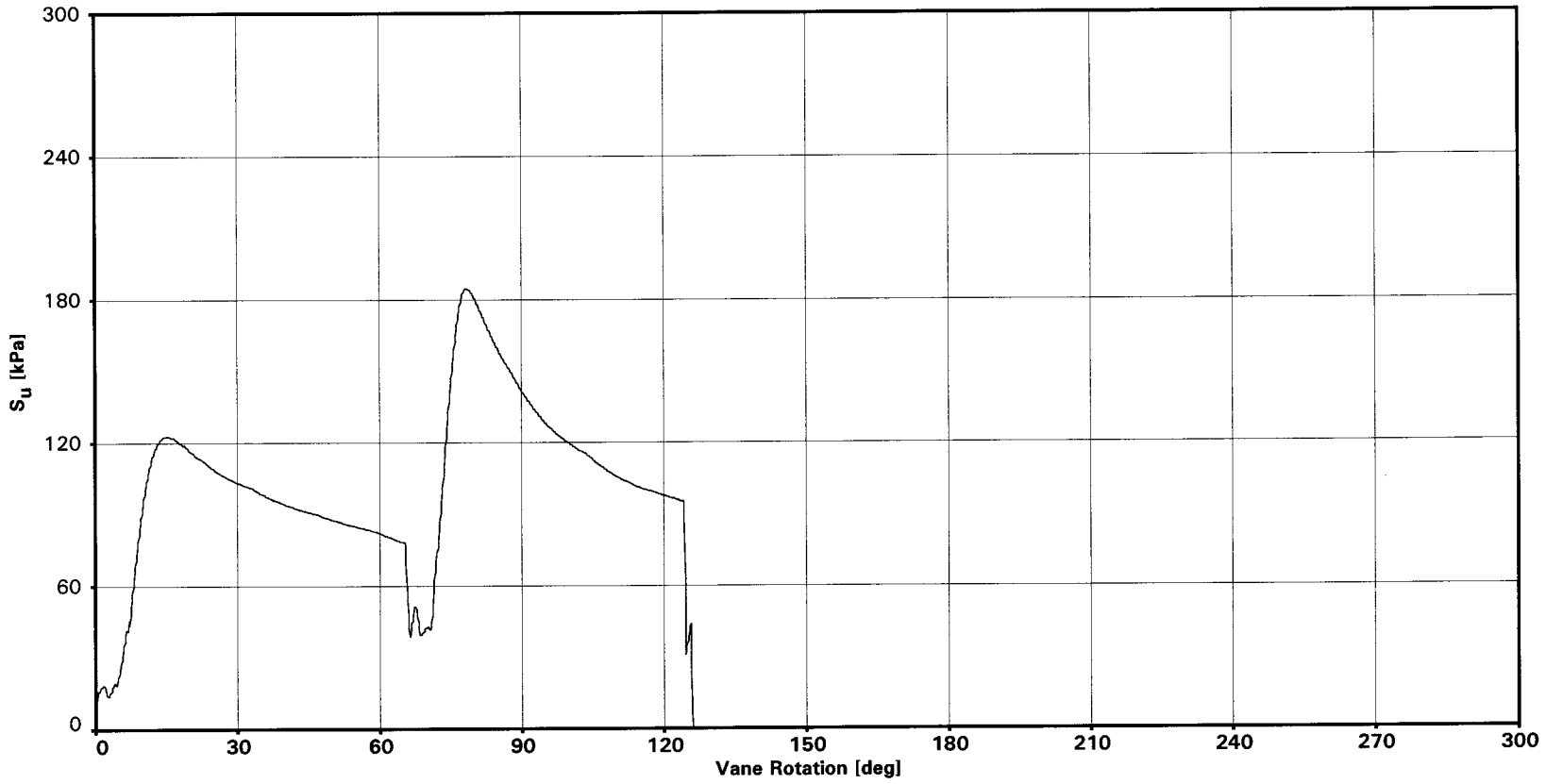
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 21.3m and 21.9m
Boring 98-53
SFOBB East Span Seismic Safety Project

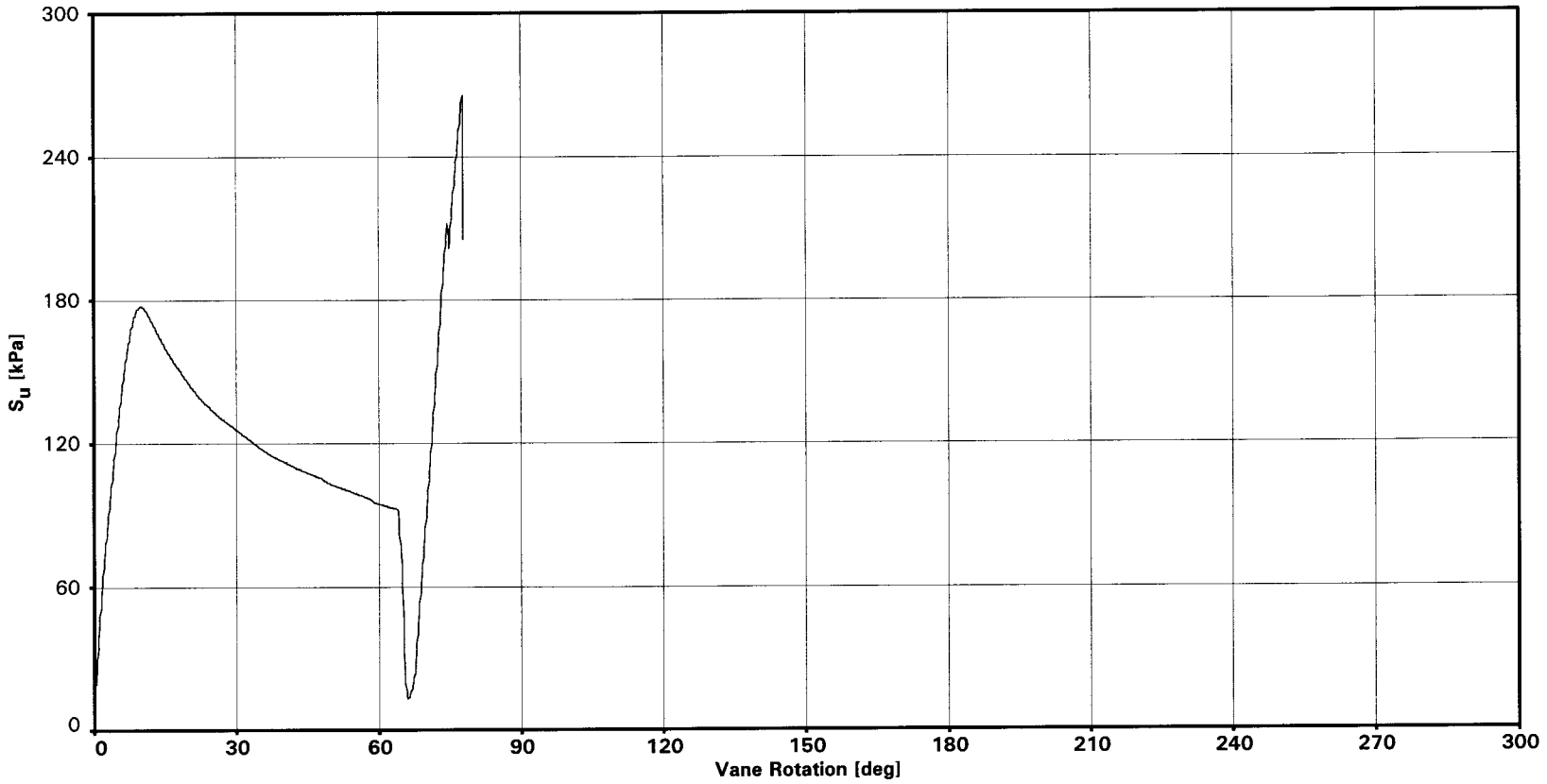
Earth Mechanics

FUGRO

PLATE 98-53.2c

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 27.4m and 28.0m
Boring 98-53
SFOBB East Span Seismic Safety Project

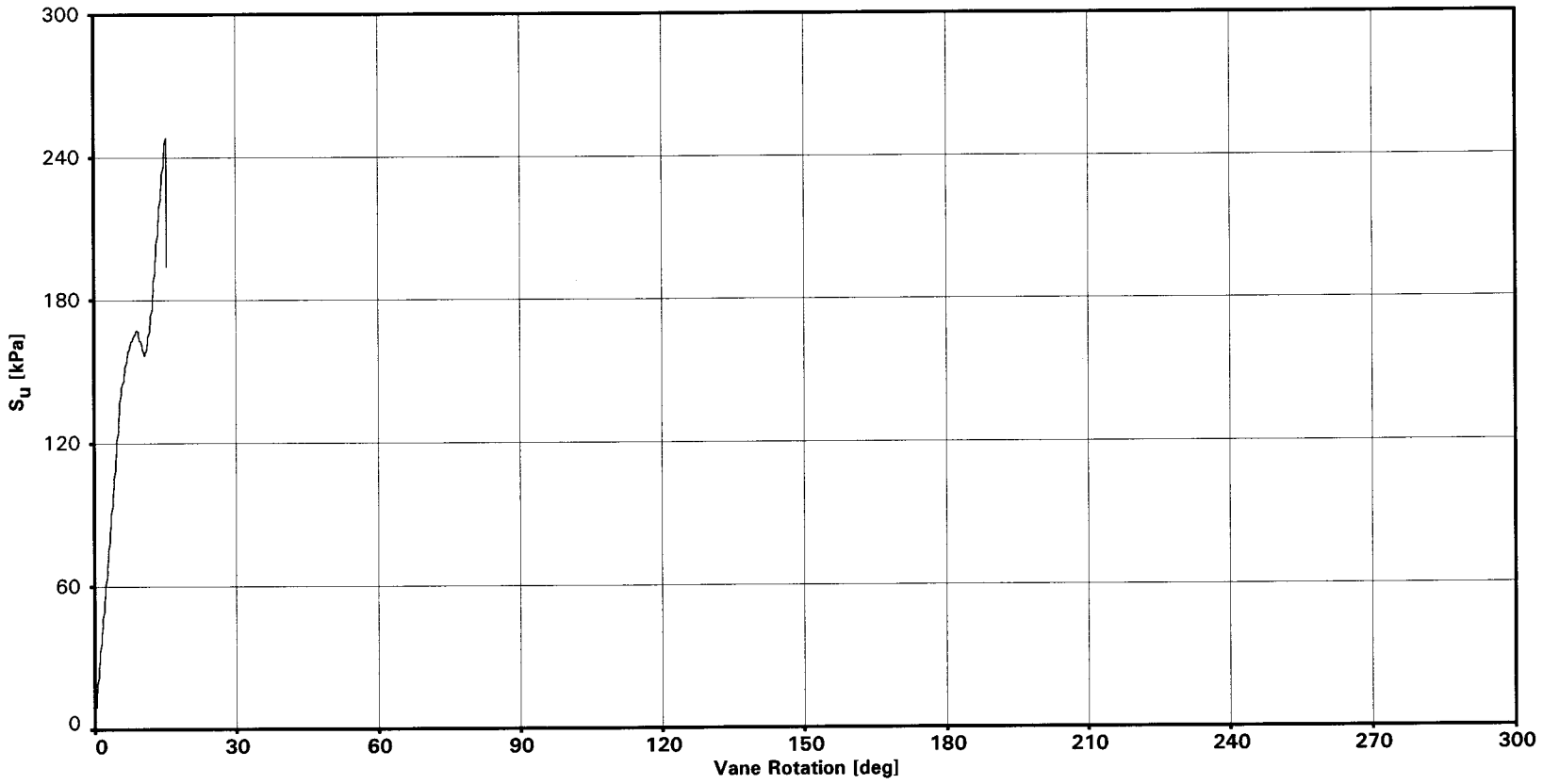
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 33.5m
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.2e

Earth Mechanics

FUGRO

98-53		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.5	300																										
1.7	1	5					12																				
3.3	3	17					9																				
4.9	4	16					10																				2.73
6.4	5	38					25																				
6.6	6	20				21.1																					
7.9	7	23					9																				
9.4	9										36.8		14.4														
9.6	10	36	45	24	0.55	17.7		44.0							28.2		1.1										
11.2	12	43	48	20	0.85						52.0															C	2.75
11.3	13	45	54	22	0.70			52.7																			
12.2	400													71.3													
14.2	15					21.3									100.5	84.4	1.1										
14.3	16	19	24	14	0.50			124.5																			
15.2	401													265.7+													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.3a

Earth Mechanics

FUGRO

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98-53		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
16.9	17	23					16																				
18.8	18	22					7																				2.74
20.0	19						31																				
20.3	21	28	50	20	0.27											65.6											
21.3	402													122.6													
21.9	403													183.4													
23.2	22	38						79.0			78.0																
23.3	23	41	74	26	0.31	17.3		83.8	143.6							46.9											
23.5	24							83.8																			
26.2	26								215.5																		
26.4	27	24	40	18	0.26	20.1					131.2					80.6											
27.4	404													177.2													
28.0	405													265.7+													
29.5	28	51	77	24	0.52																					C	
29.6	29	47	67	24	0.53			95.8			117.6																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-53
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-53.3b

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98-53		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
32.2	30	50				16.4					175.8																
32.3	31	49	75	25	0.49	16.5					86.6																
32.5	32							83.8																			
33.5	406													265.7+													
35.4	34	51	81	25	0.47	17.0					127.5																
35.5	35	38									127.5				83.9	27.3	0.7										
35.7	36							105.3																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.3c

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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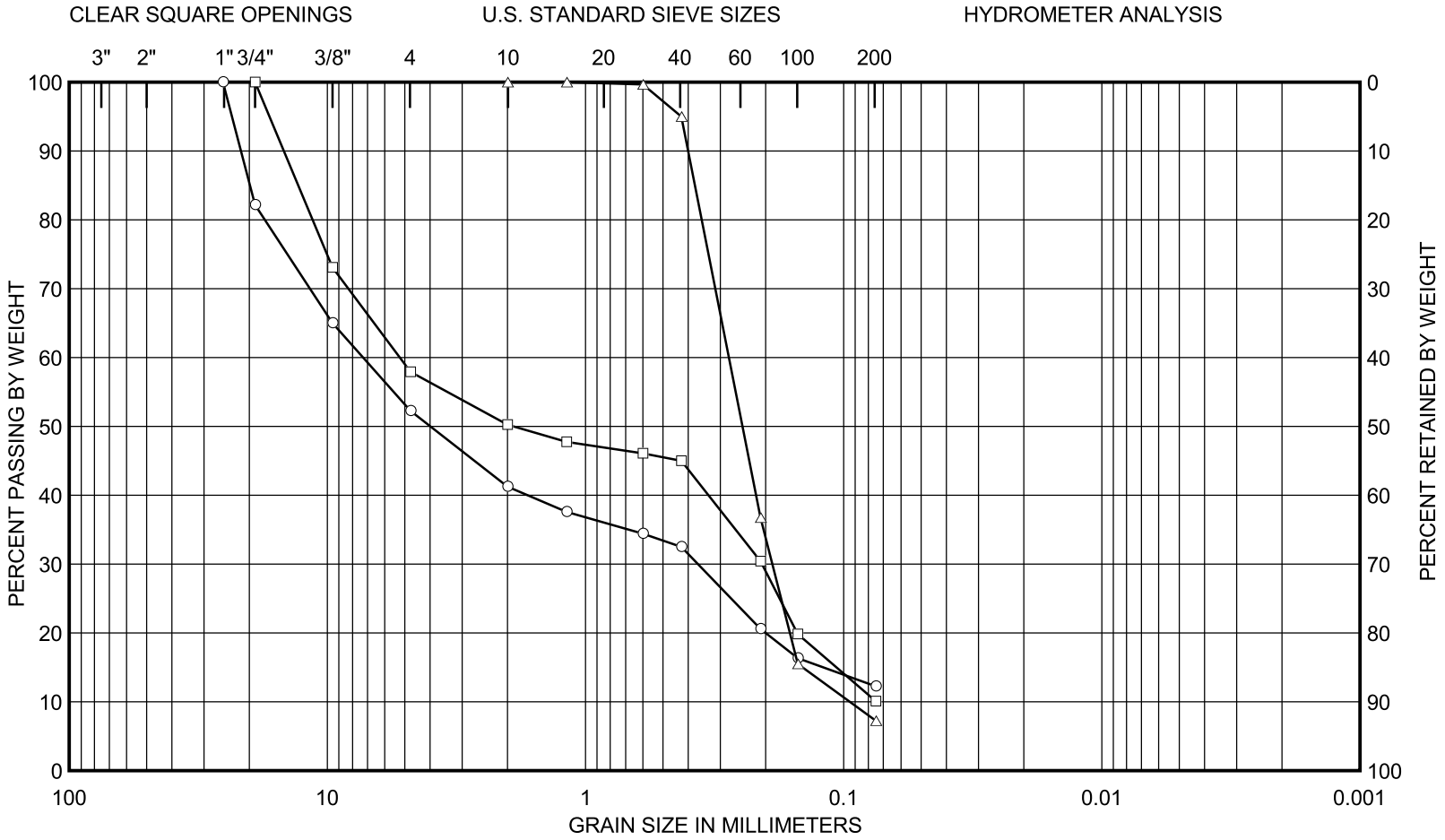


GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.7	○—○	SILTY FINE GRAVEL (GM) with fine to coarse sand and coarse gravel			4.0
4	4.9	□—□	FINE SAND (SP-SM) with silt, fine gravel and a trace of medium to coarse sand			1.9
18	18.8	△—△	FINE SAND (SP-SM) with silt	1.4	2.9	0.25

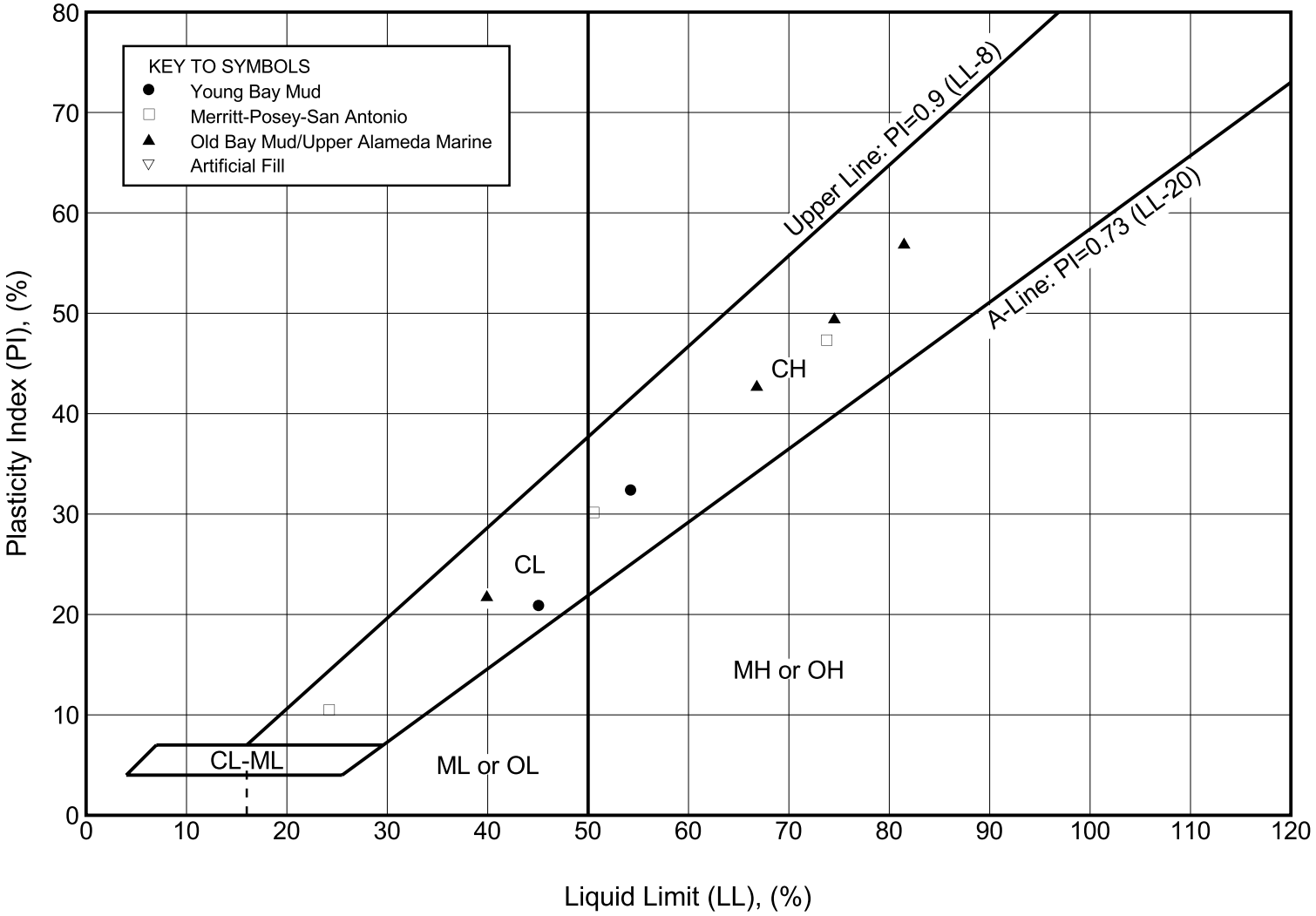
GRAIN SIZE DISTRIBUTION CURVES
Boring 98-53
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

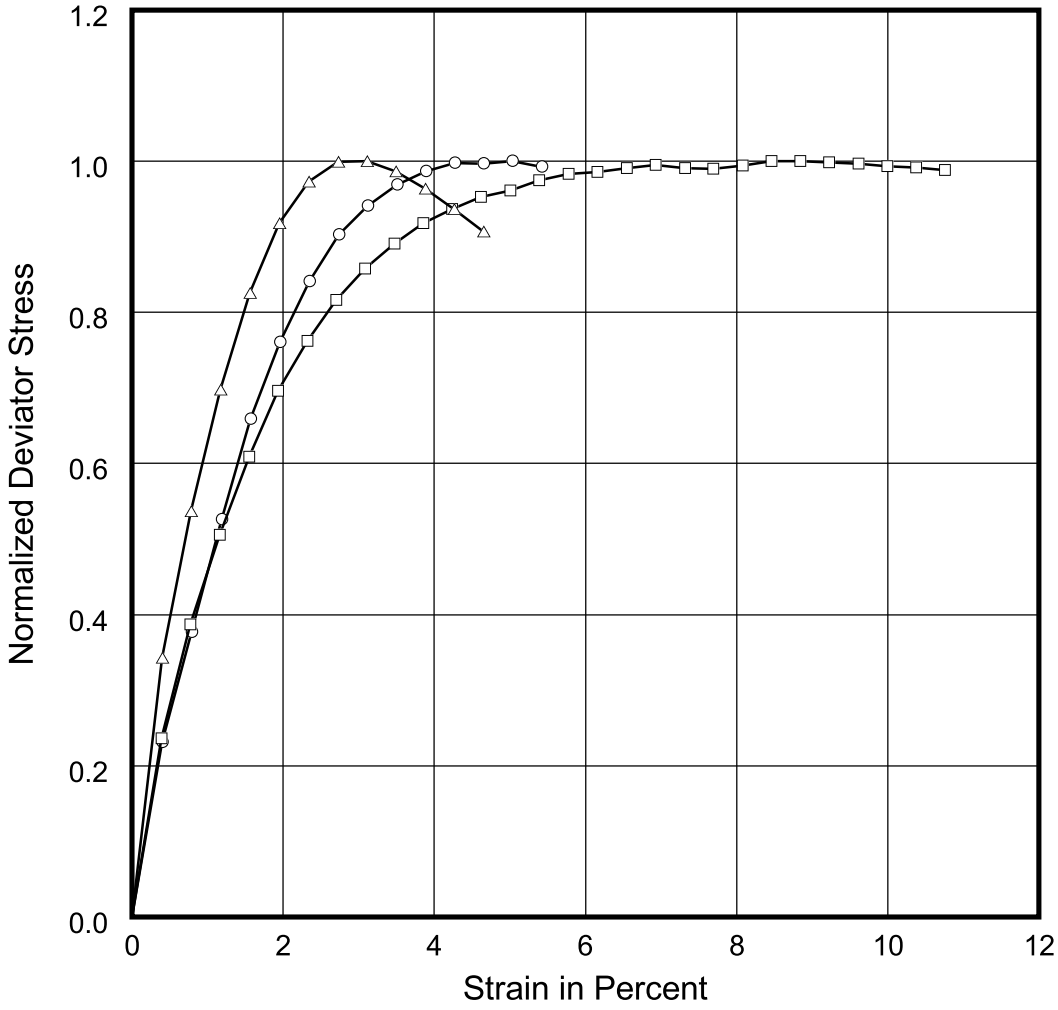
FUGRO

PLATE 98-53.4



PLASTICITY CHART
Boring 98-53
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO



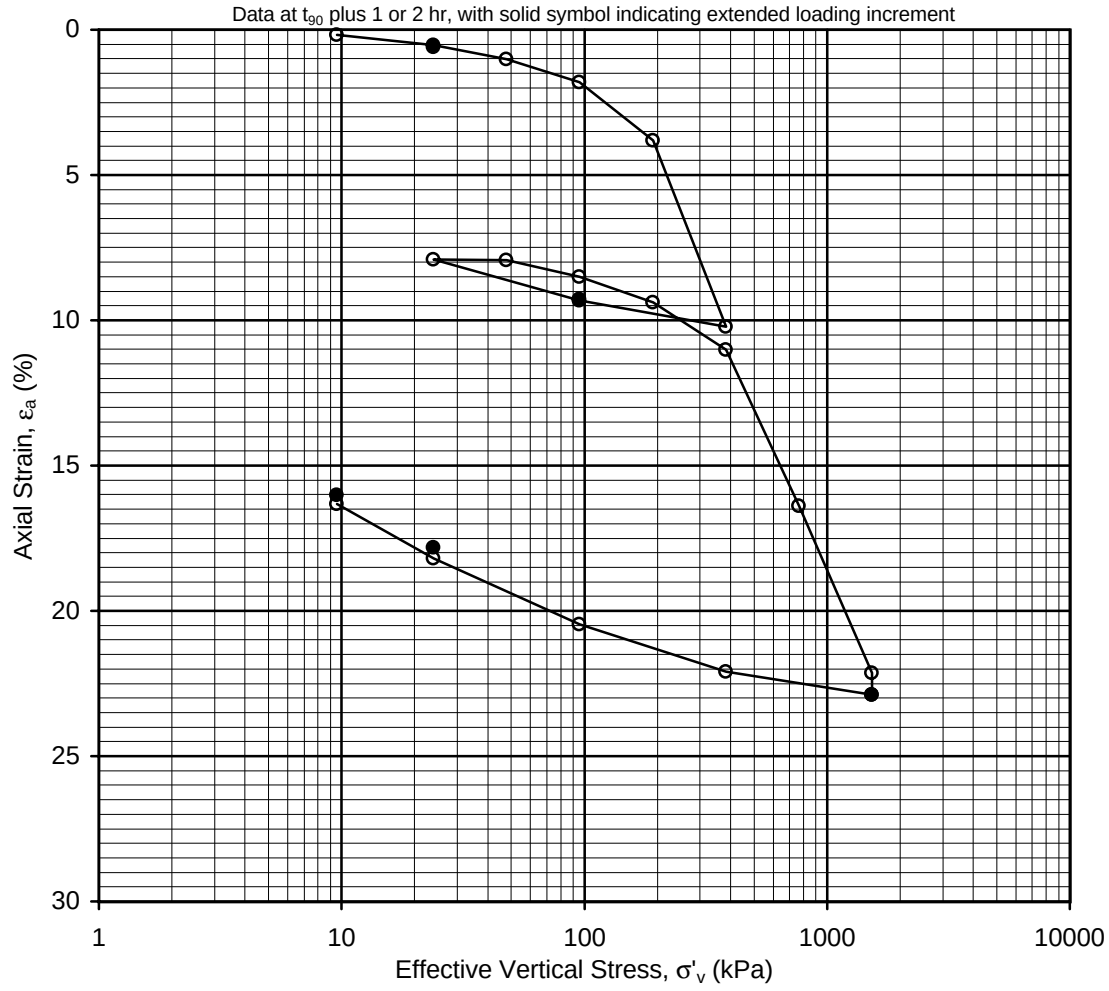
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	10	9.6	UU	207	56	1.1
□—□	15	14.2	UU	689	201	1.1
△—△	35	35.5	UU	1103	168	0.7

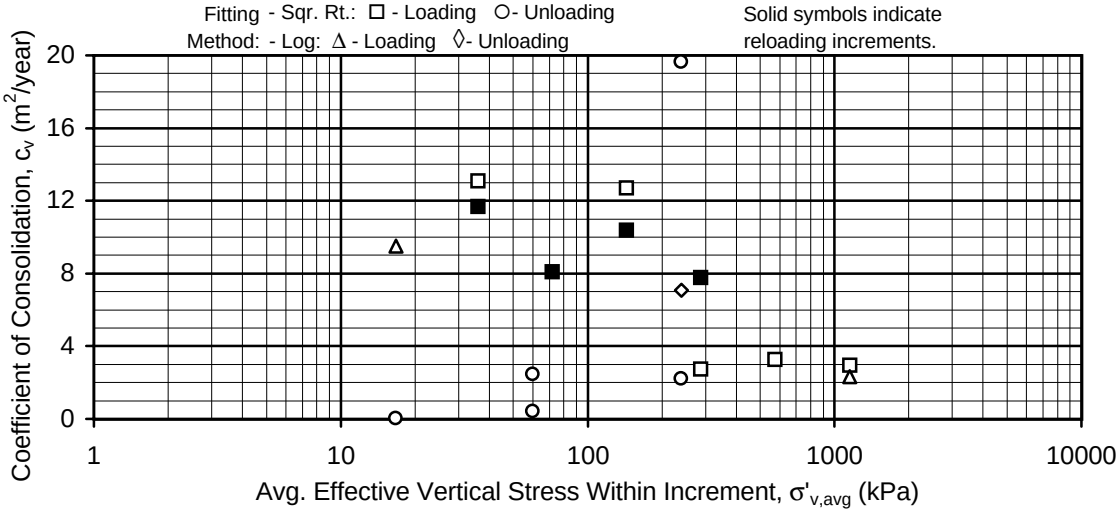
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-53
SFOBB East Span Seismic Safety Project

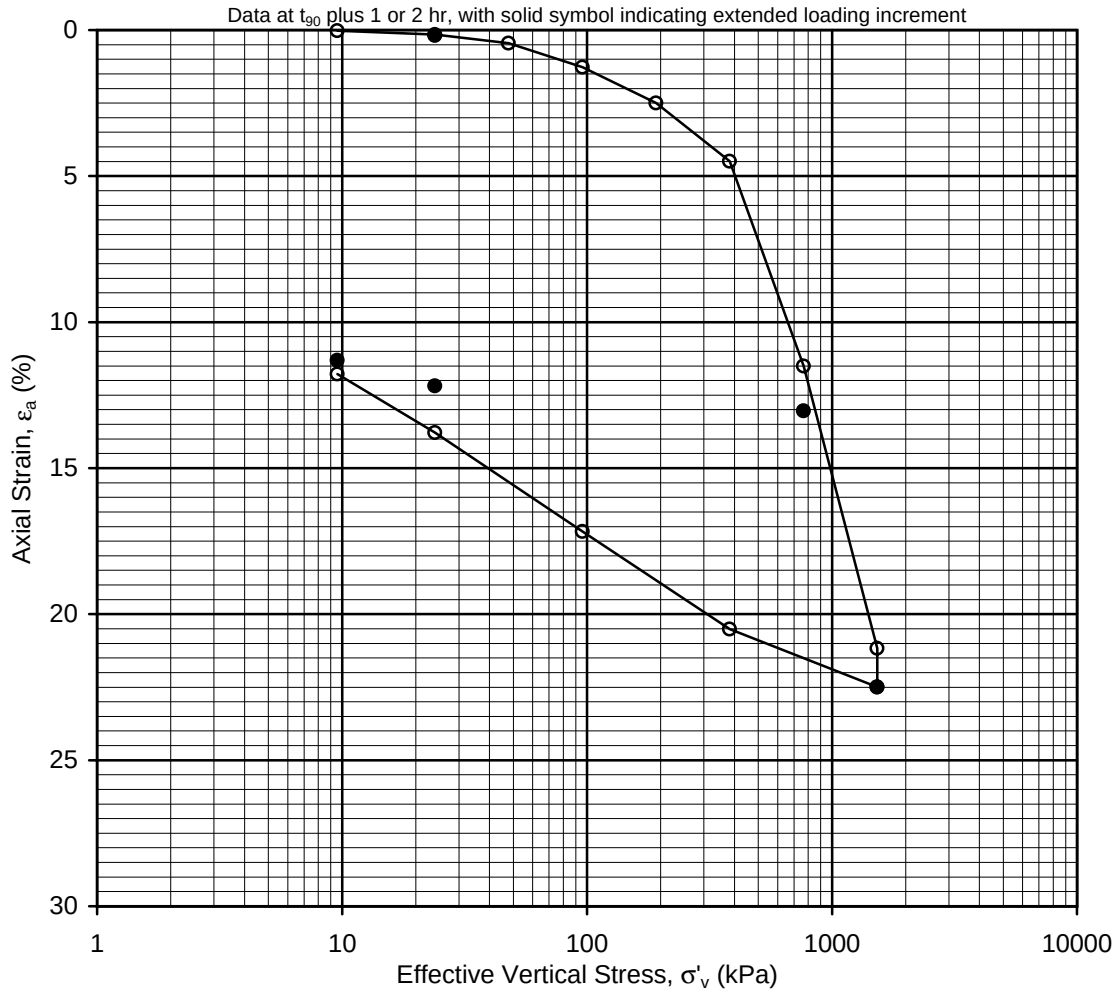
PLATE 98-53.6

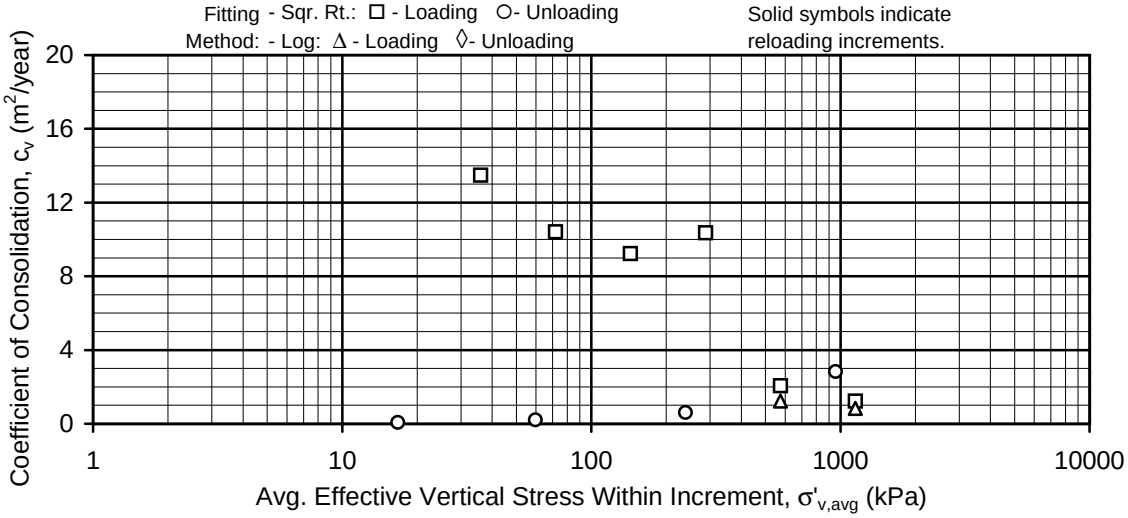




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 12 - Depth: 11.2m
Boring 98-53
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

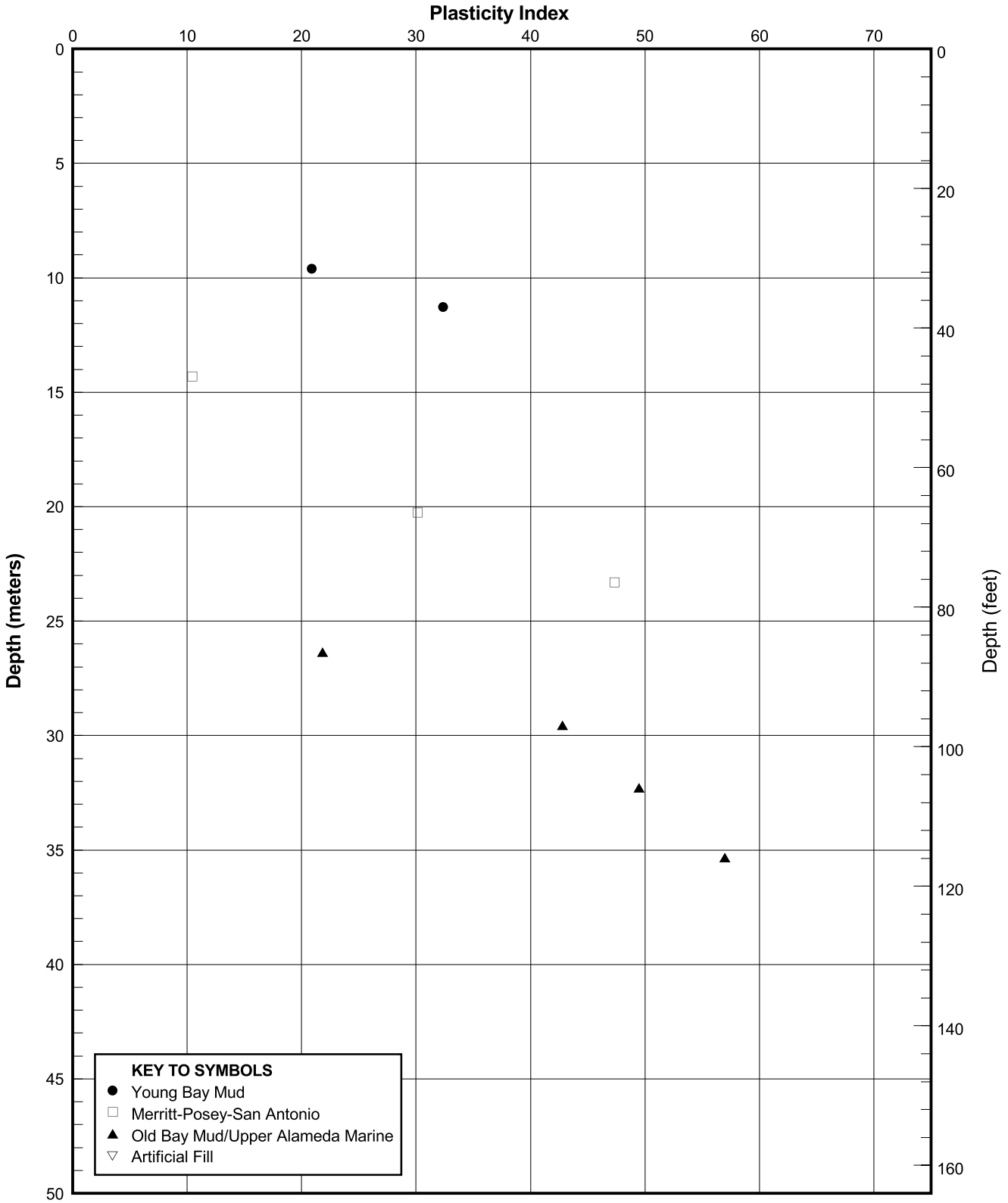
Sample No. 28 - Depth: 29.5m
Boring 98-53
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

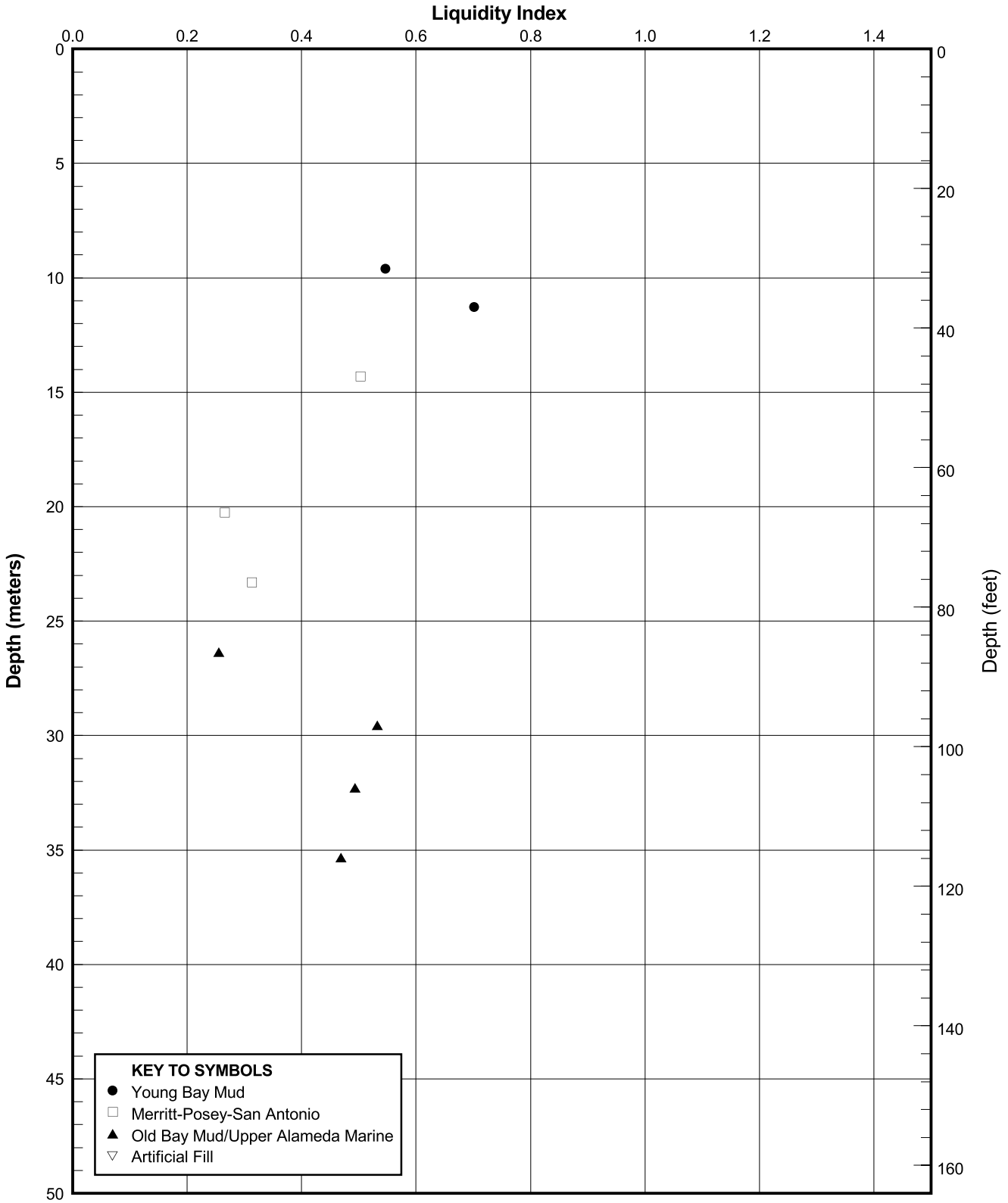
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



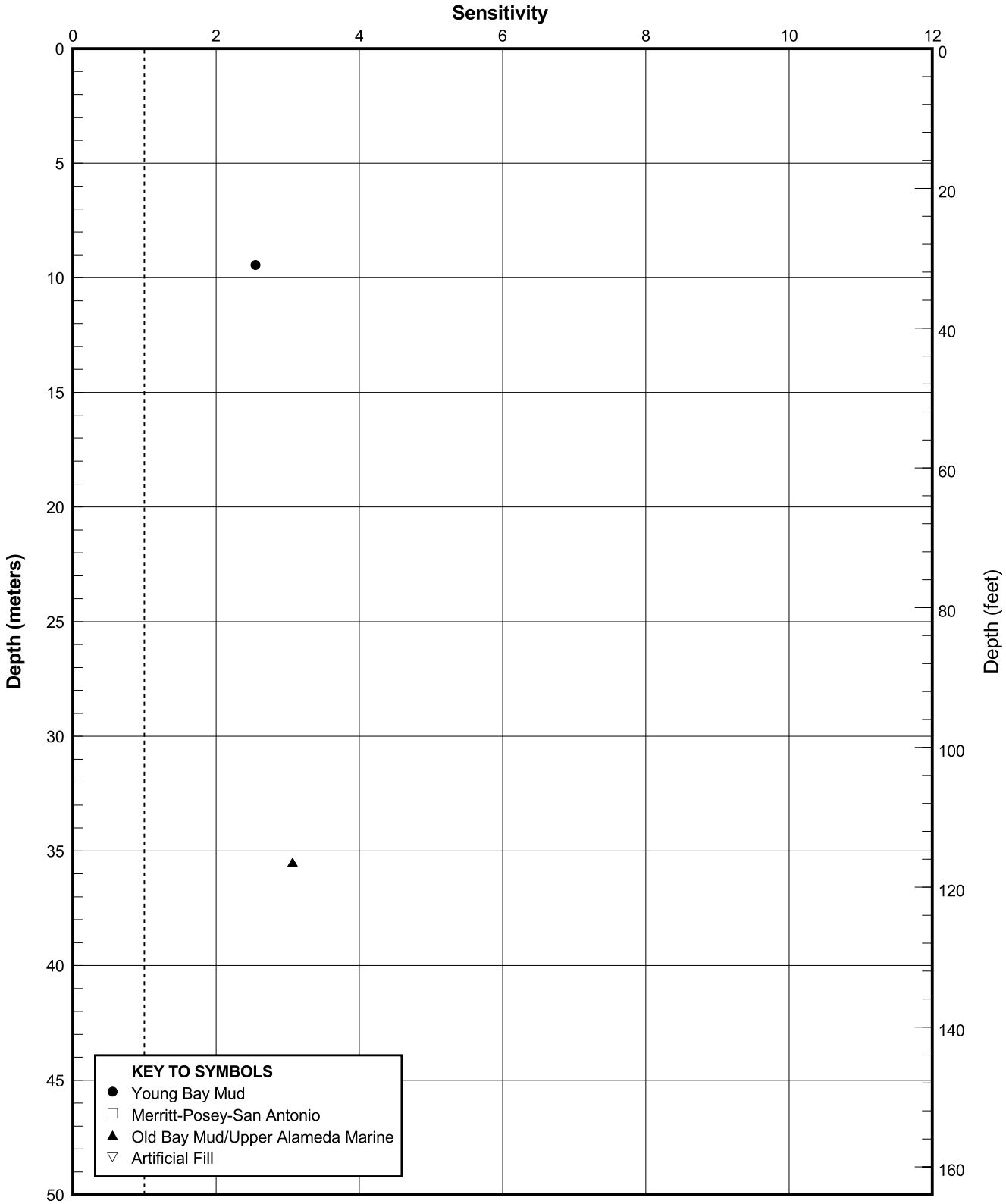
PLASTICITY INDEX PROFILE
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.12



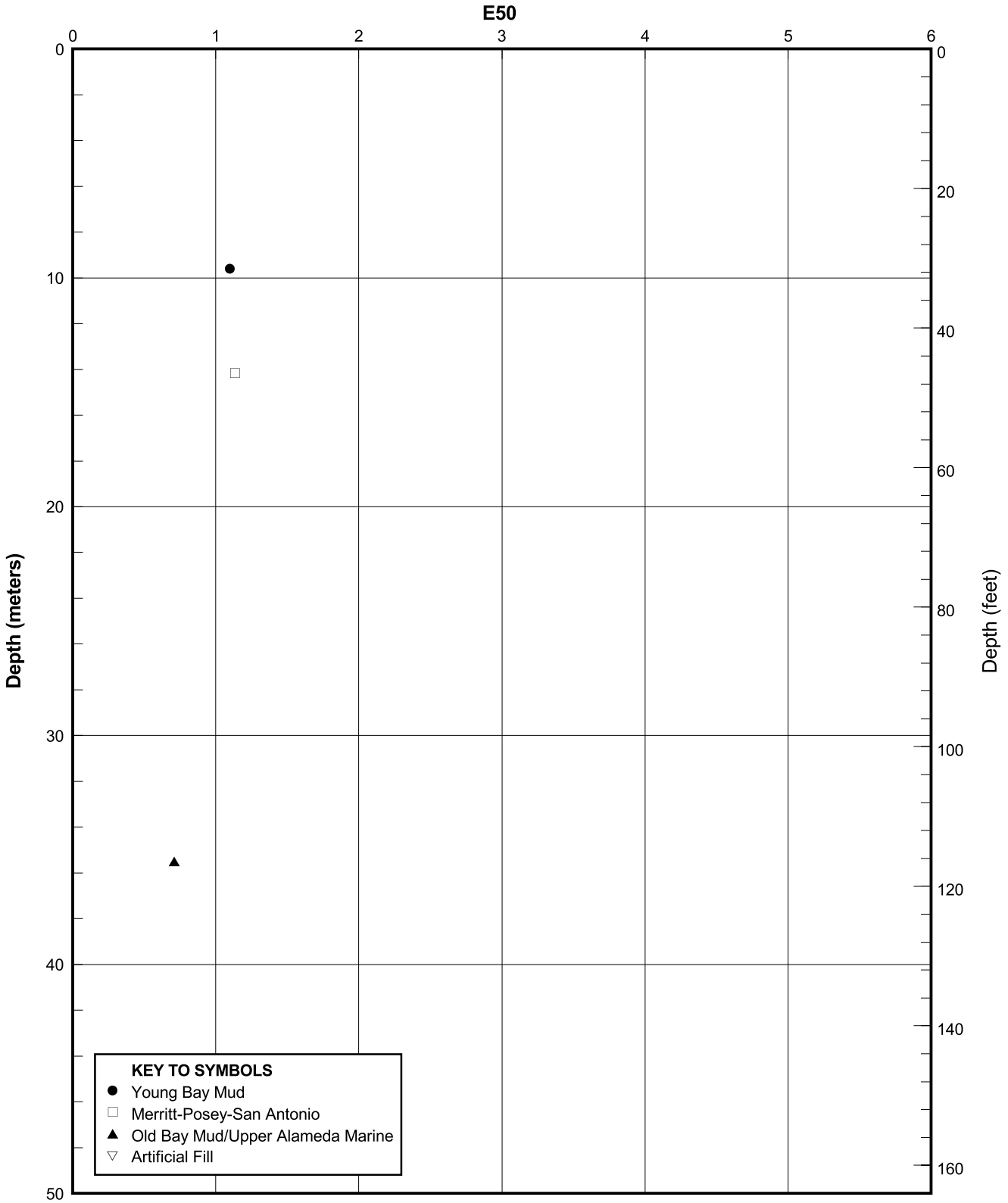
LIQUIDITY INDEX PROFILE
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.13



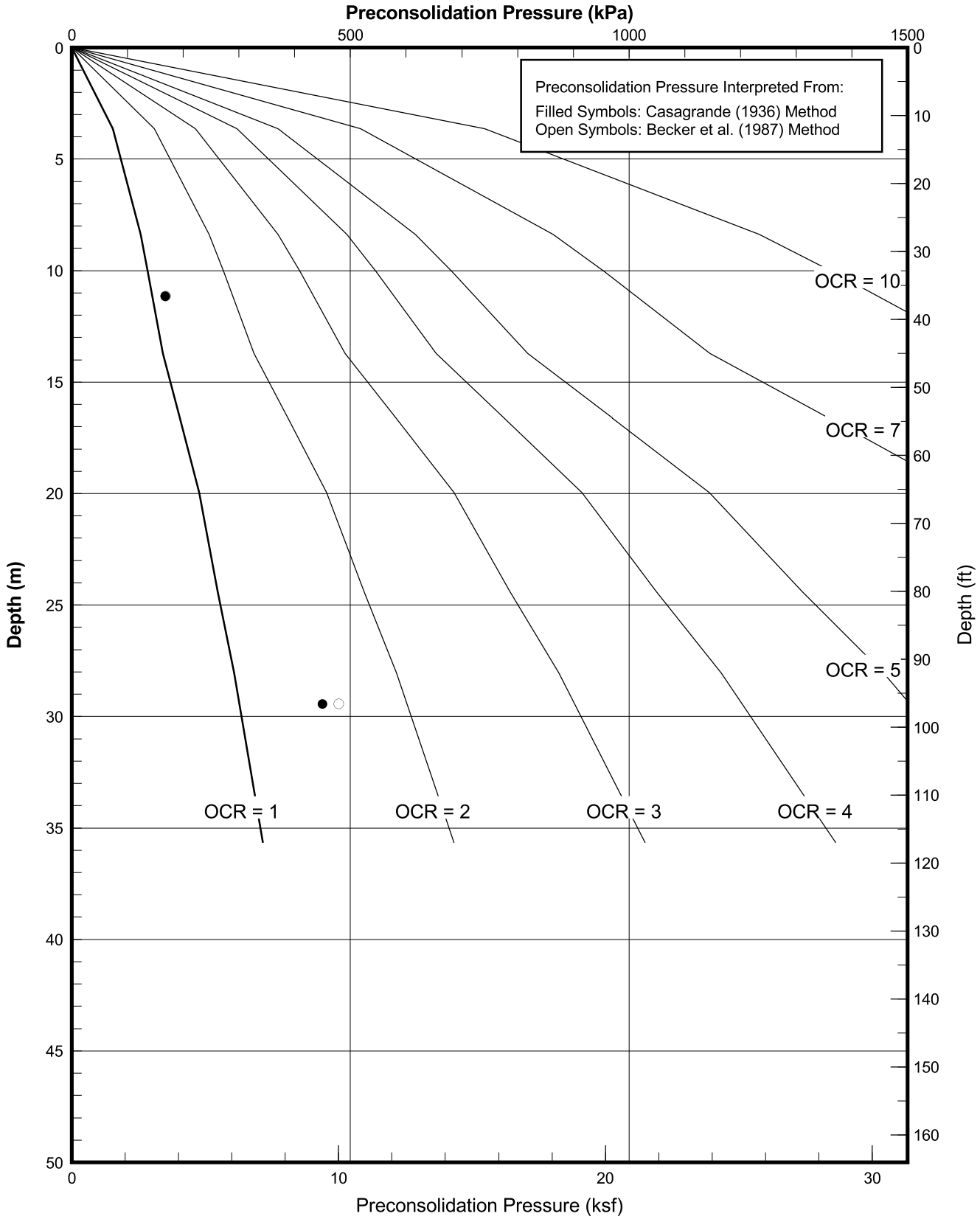
SENSITIVITY PROFILE
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.14



E50 PROFILE
Boring 98-53
SFOBB East Span Seismic Safety Project

PLATE 98-53.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-53

SFOBB East Span Seismic Safety Project

PLATE 98-53.16

LAND BORING 98-54

PROJECT NO: 98-42-0058
BORING: 98-54 (3m left of E. Sta. 85+88)
START DATE: 10/16/98
COMPLETION DATE: 10/17/98
DRILLER: Pitcher Drilling Company
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1839080 N648270
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.4m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	1				PAVEMENT, 0.1m Asphalt Concrete over Aggregate Base (0.2m)	I
				BAG	Silty Fine SAND (SM), medium dense to dense, light brown, moist -with fine gravel	II
2	2			41	-dense to very dense cemented fine sand with silt (lime treated base), below 1.2m (1.5m)	
1	3				Fine SAND with silt (SP-SM), medium dense, light brown -dense and moist, at 1.8m	
0	4			3	-gray, and with shell fragments, below 3.0m -very loose at 3.0m (3.4m)	
-1	5			18	-with a trace of gravel, at 4.6m	III
-2	6					
-3	7			14		
-4	8			23	(8.7m)	
-5	9				Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -lean clay to 10.1m -with silt pockets at 9.4m	
-6	10			PUSH		
-7	11			PUSH	-with silt pockets, sand partings, gas blisters, and an H2S odor, at 11.0m	IV
-8	12				-with shells at 12.2m	
-9	13			SAVE		
-10	14			PUSH	-with organic pockets and sand pockets, at 13.7m (13.9m)	
-11	15				Fine SAND with silt (SP-SM), dense to very dense, greenish gray -clayey sand, to 14.9m	
-12	16			PUSH		
-13	17				-silty fine sand, below 16.5m	V
-14	18			54	-brown, with clay pockets, 17.1m to 17.7m	
-15	19			20	-with clay seams and pockets, below 18.3m (19.2m)	
-16	20				Fat CLAY (CH), stiff to very stiff, greenish gray -sandy clay to 19.8m	
-17	21			PUSH	-with gas blisters at 20.1m	
-18	22					VI
-19	23			PUSH	-with gas blisters, a few organic pockets, and slickensides, at 23.2m	
-20	24				(24.4m)	
-21	25				Fat CLAY (CH), very stiff to hard, greenish gray	
-22	26			SAVE	-with a few sand pockets and partings, a few shell fragments and calcareous nodules, at 26.2m	VII
-23	27					
-24	28					
-25	29			PUSH	-with organic pockets, 29.0m to 32.6m -with sand seams, and silt seams and partings, at 29.3m (29.9m)	
-26	30				Fat CLAY (CH), very stiff, greenish gray	
-27	31					
-28	32			PUSH	-with silt pockets, sand pockets, and a few organic pockets, below 32.3m	VIII
-29	33					
-30	34					
-31	35					
-32	36			SAVE	-with shell fragments and many silty fine sand pockets, at 35.4m	
-33	37				TOTAL DEPTH: 35.7m BACKFILLED WITH: Cement Grout	
-34	38					
-35	39					
-36						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-54.1

LOG OF BORING AND TEST RESULTS
BORING 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

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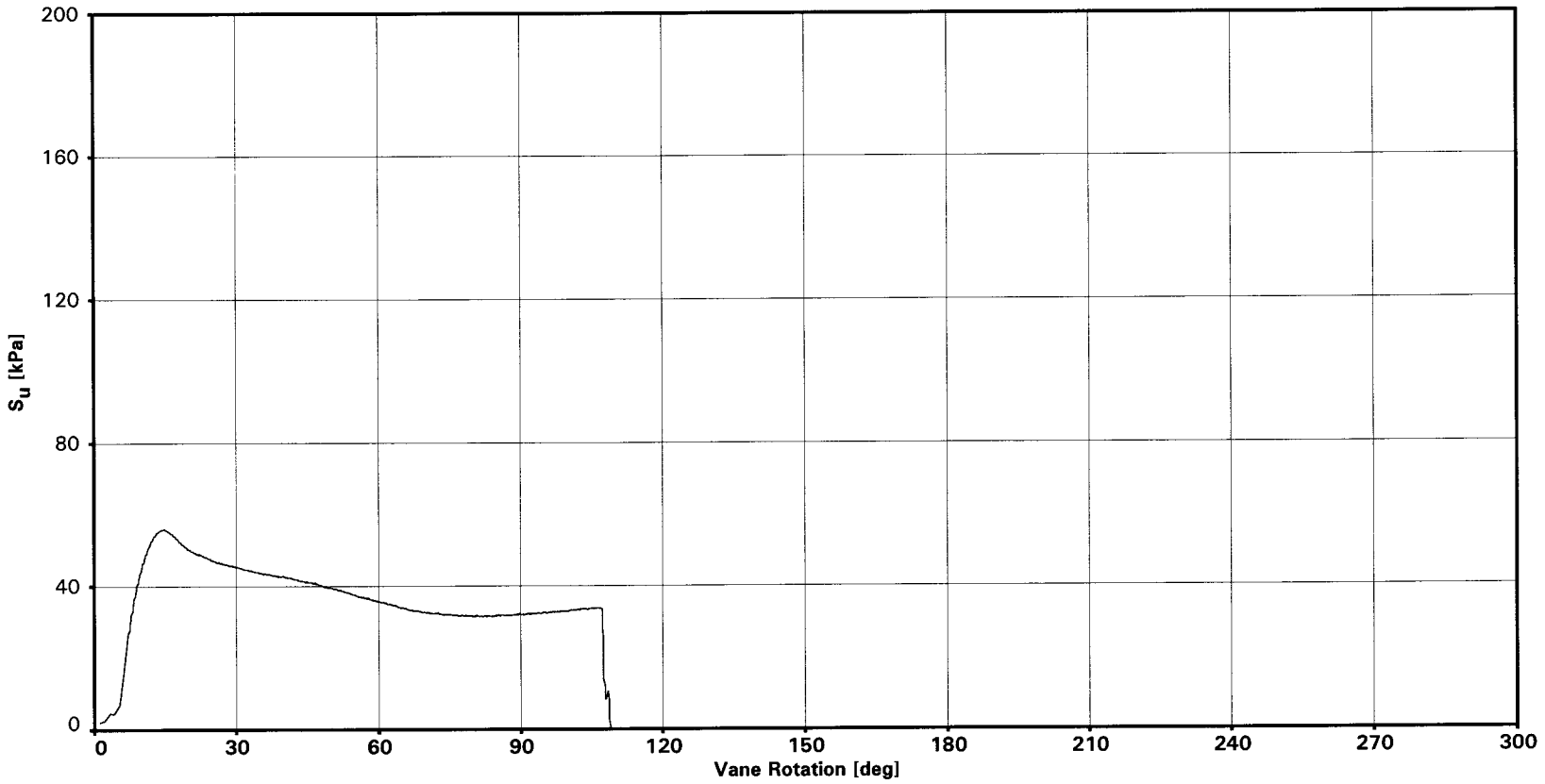
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 10.7m
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.2a

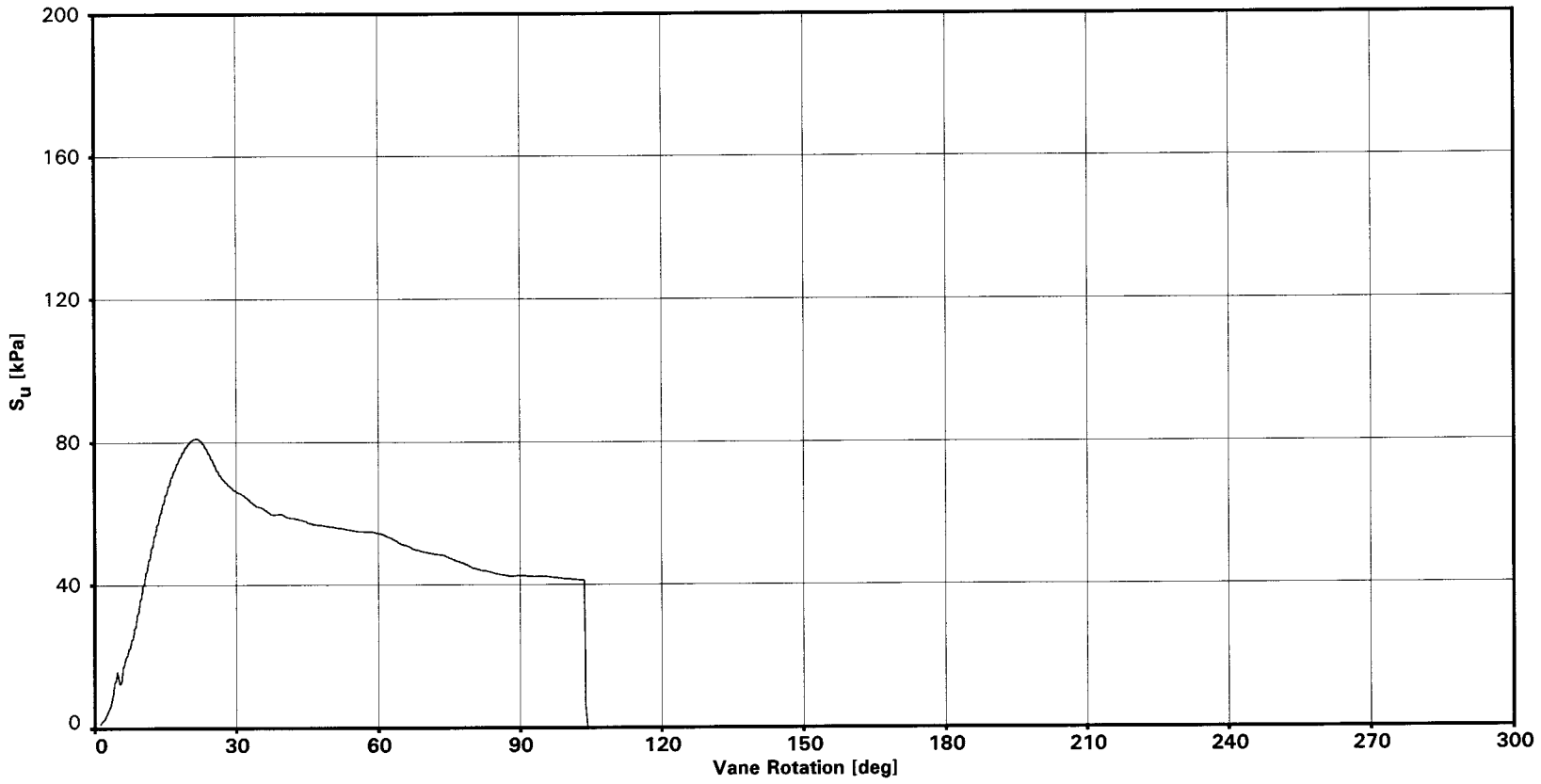
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.2b

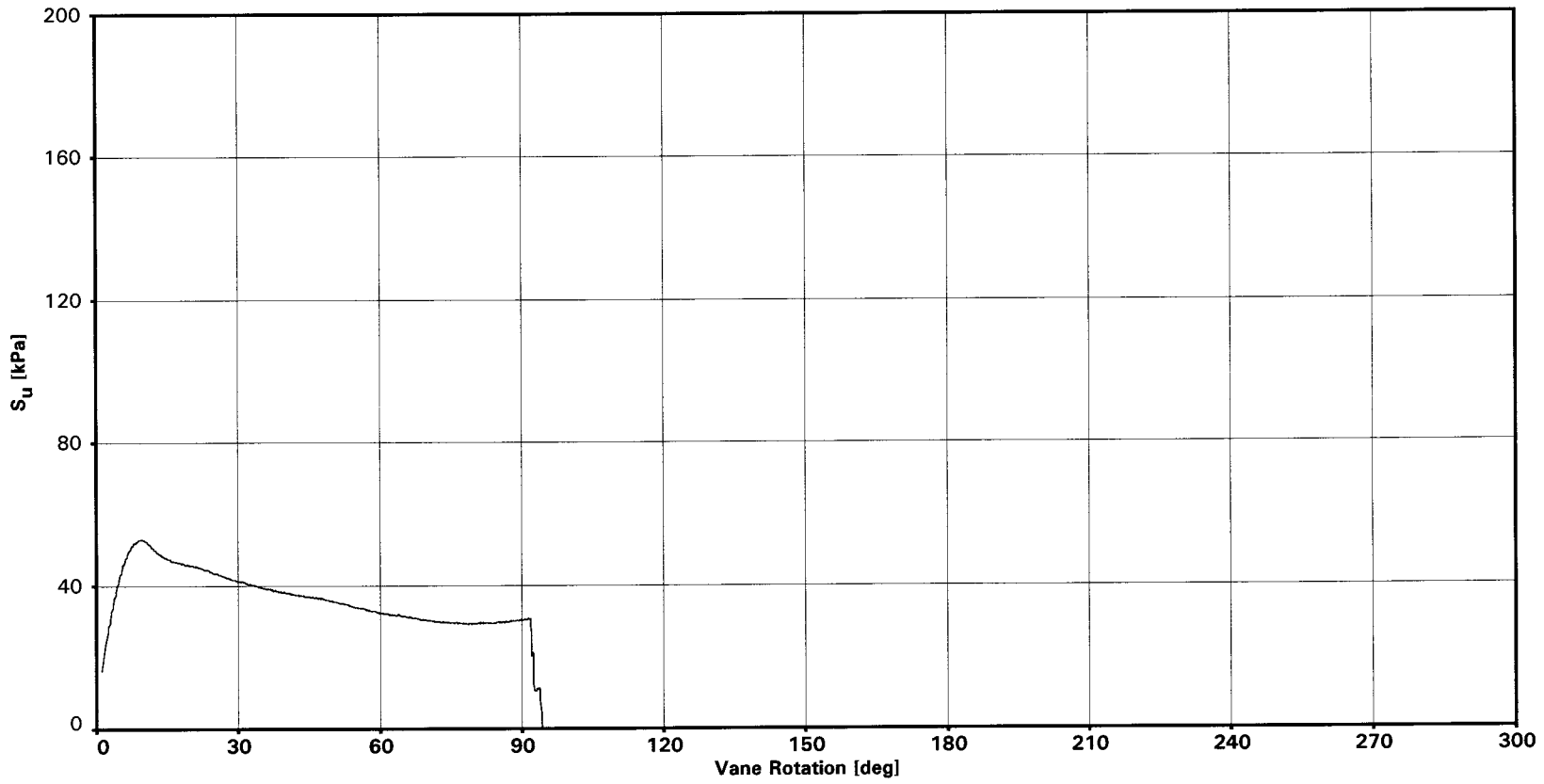
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 13.7m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

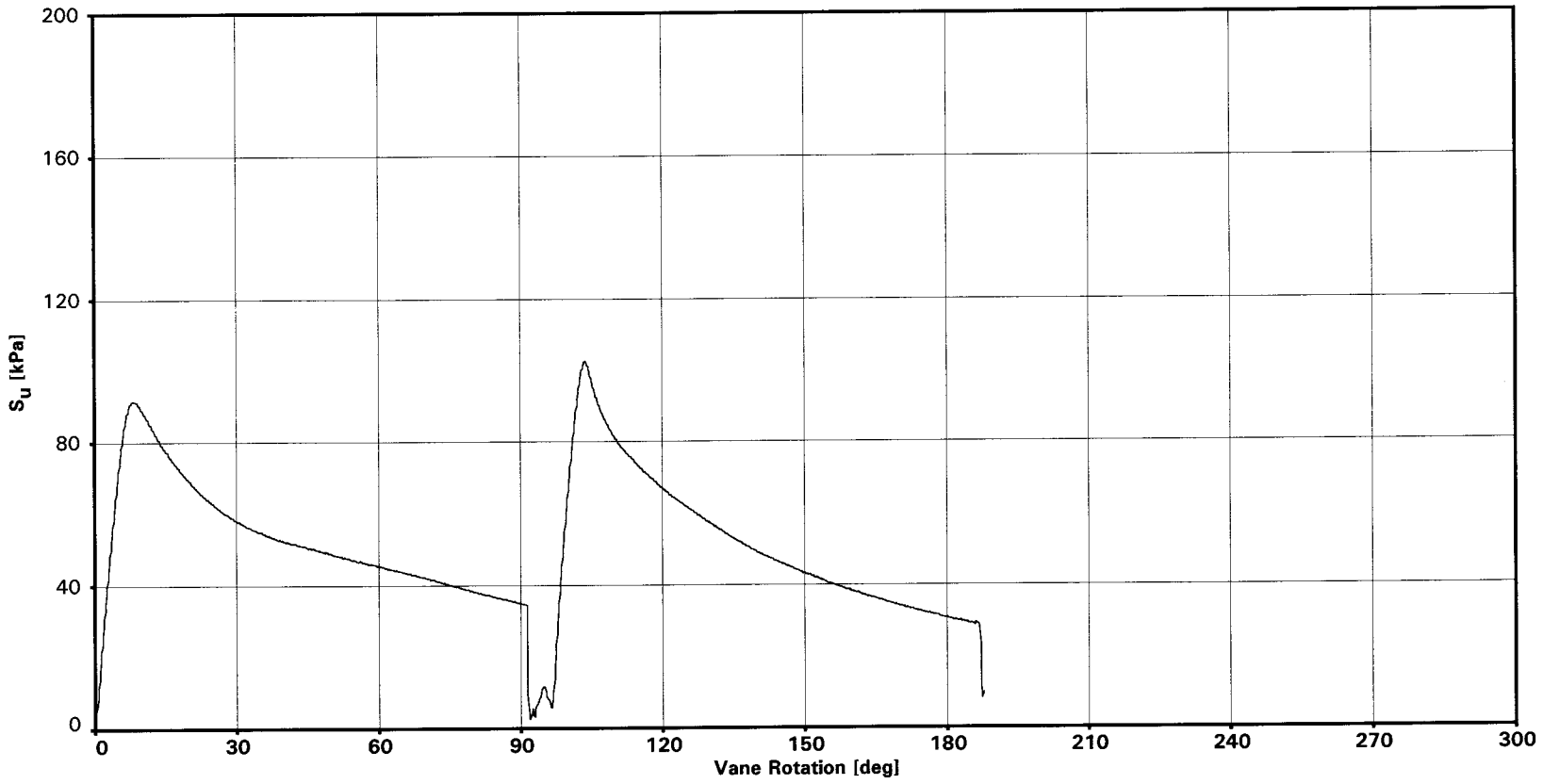
FUGRO

PLATE 98-54.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 21.3m and 21.9m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

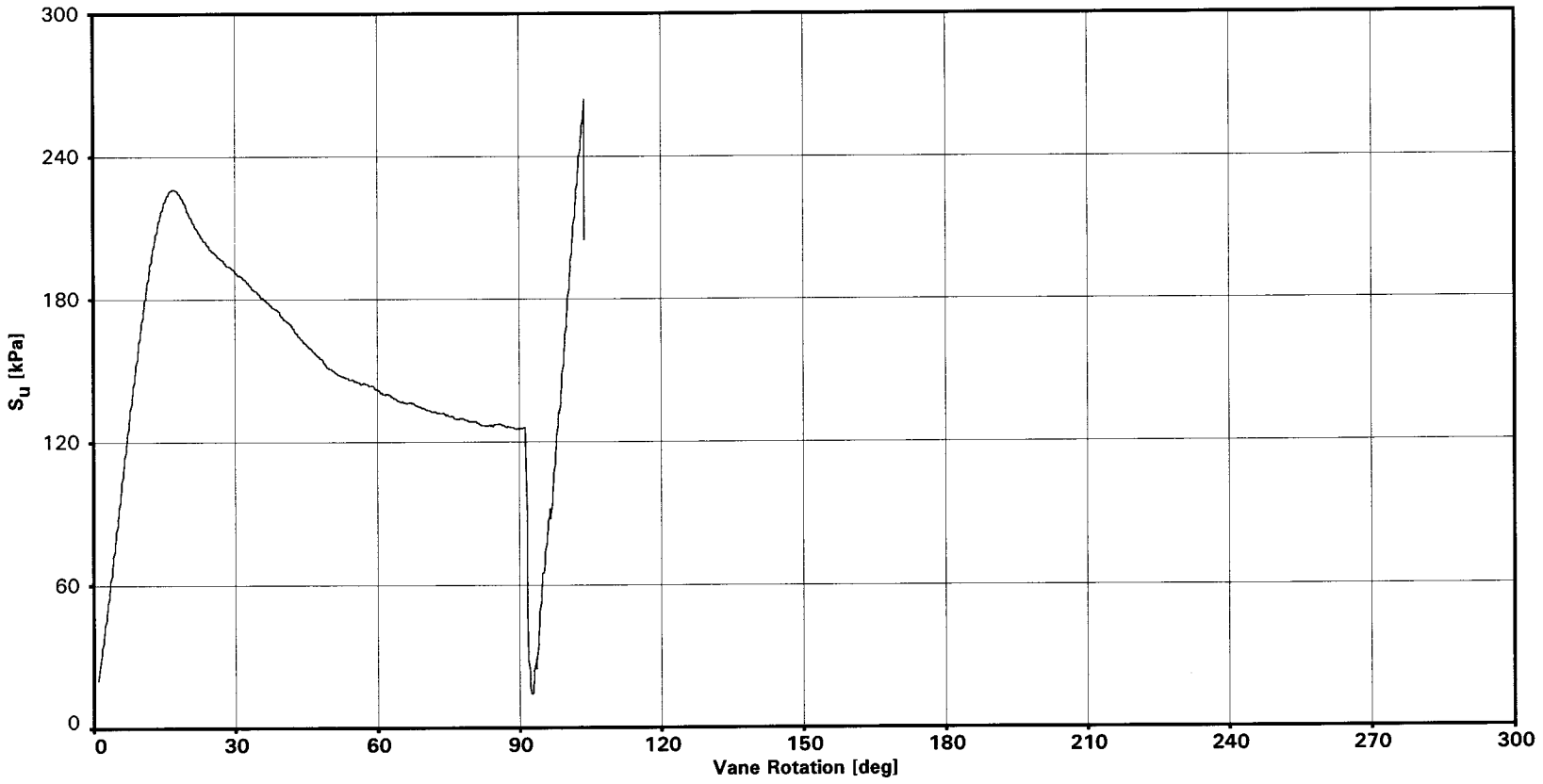
FUGRO

PLATE 98-54.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 24.4m and 25.0m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

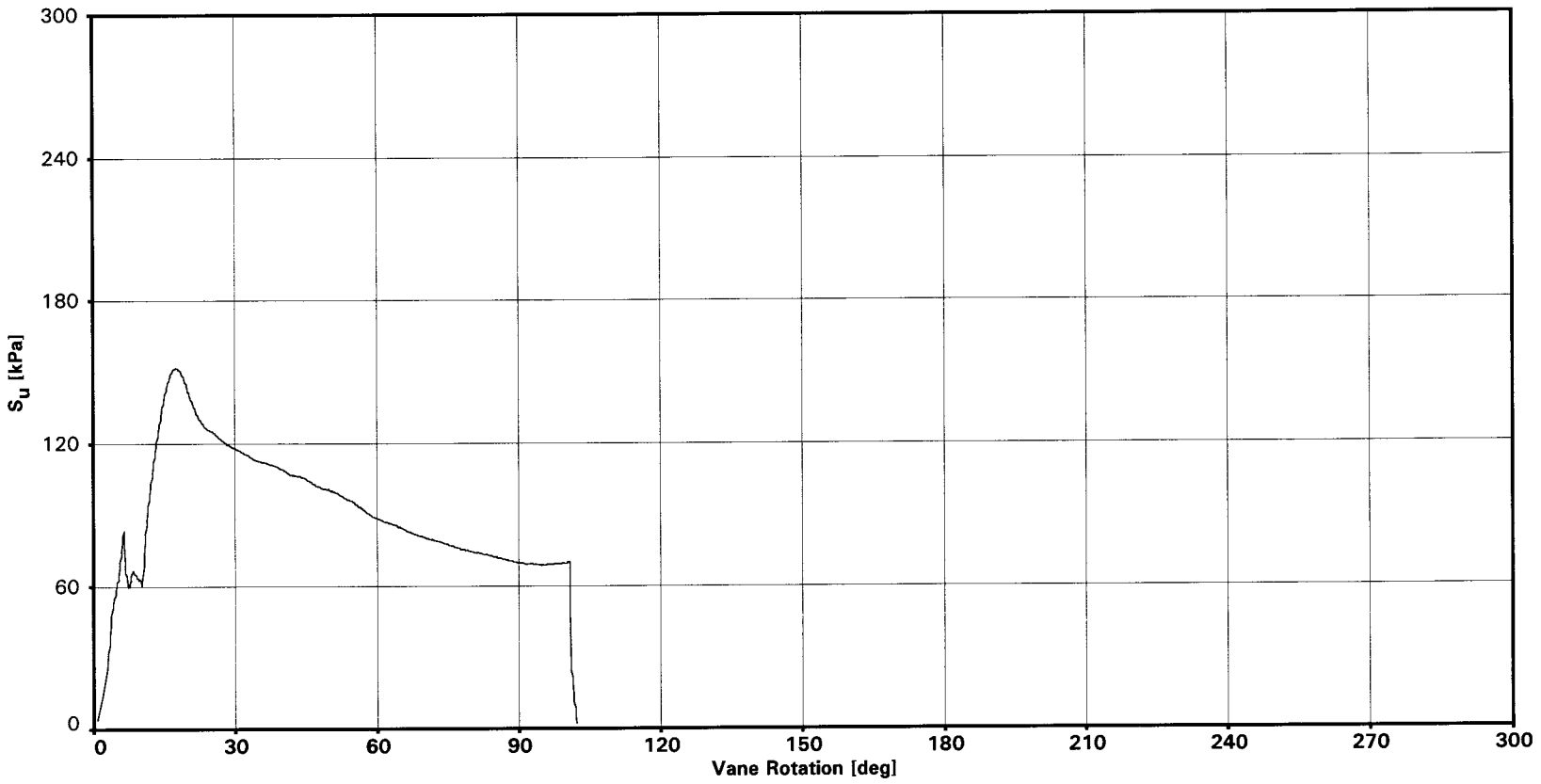
FUGRO

PLATE 98-54.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 27.4m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

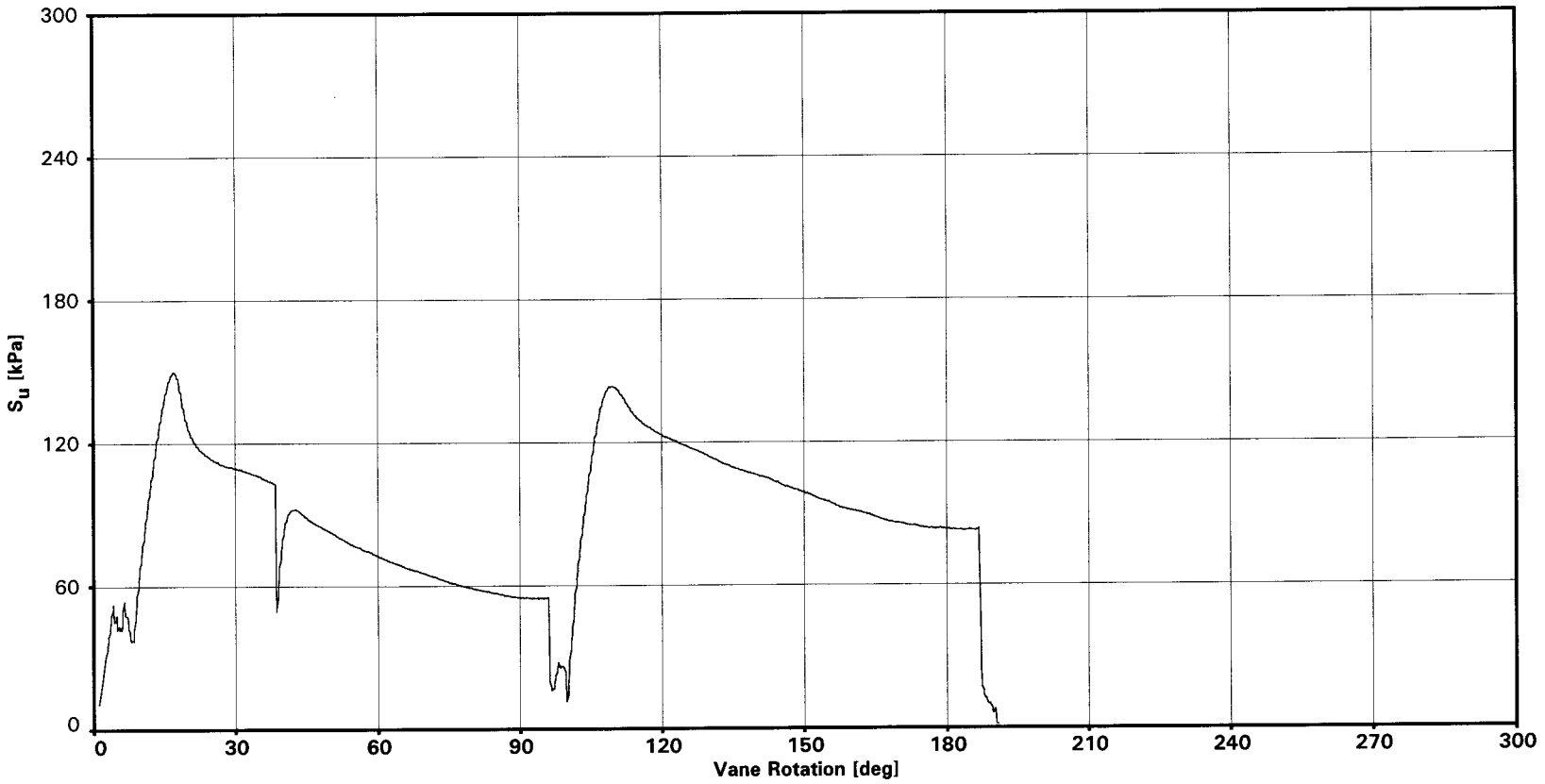
FUGRO

PLATE 98-54.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 30.5m and 31.1m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

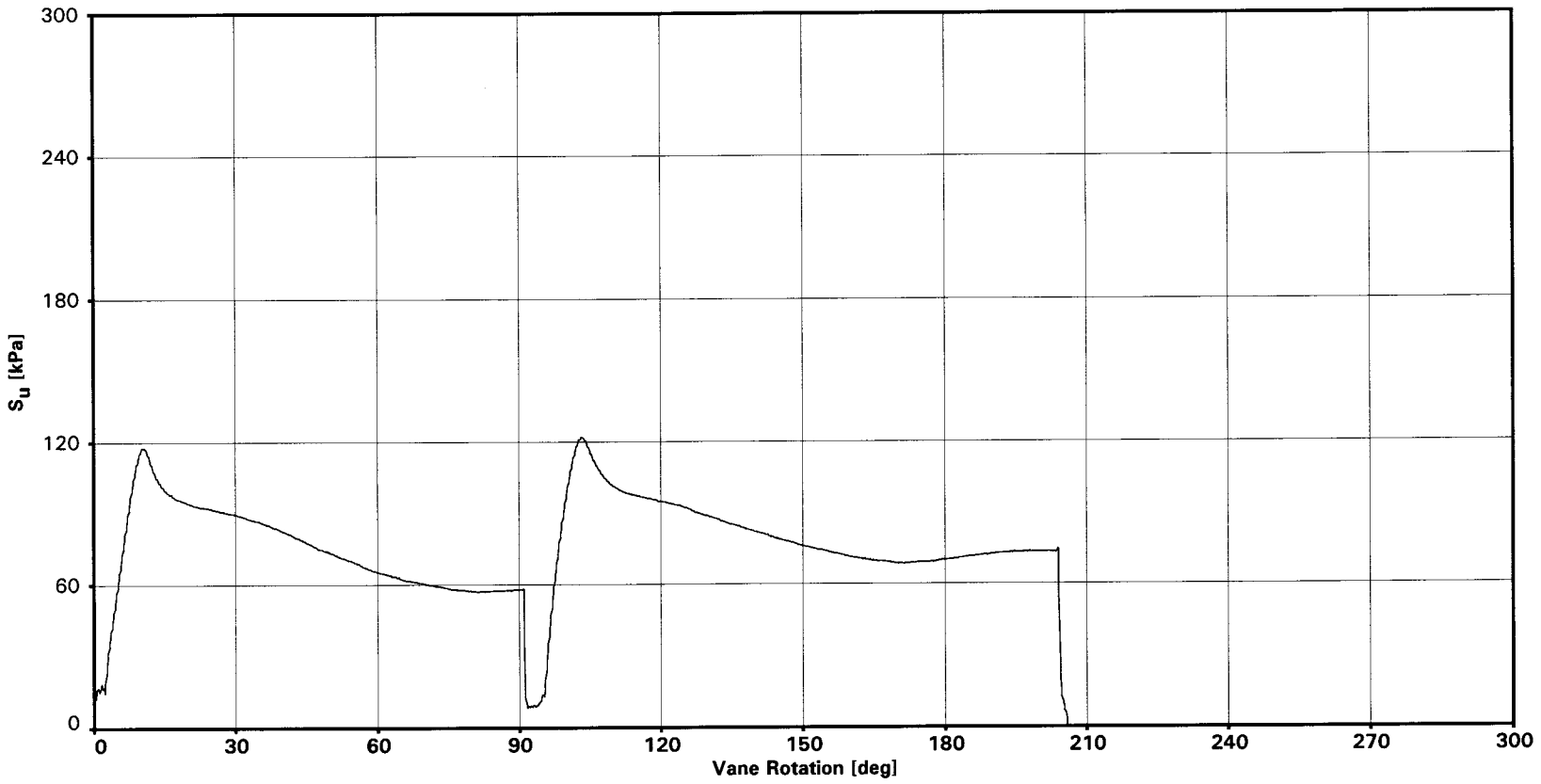
FUGRO

PLATE 98-54.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 33.5m and 34.1m
Boring 98-54
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-54.2h

98-54		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.9	1	3																									
3.1	2	24					5																			H	
4.8	3	25																									2.69
6.4	4	24					6																			H	
7.9	5	23					3																				
9.4	7	40	42	20	0.88	17.7																					
9.8	8							43.1			49.1																
10.7	400													55.1													
10.8	9																										2.73
11.1	11	46	53	21	0.79	17.5						20.7			54.1		0.8										
11.3	12							47.9			54.5																
12.2	401													80.9													
12.7	13	53	59	22	0.86			44.0																		C	
12.8	14	55	59	21	0.90						59.2																
13.7	402													51.7													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.3a

Earth Mechanics

FUGRO

98-54		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
13.9	15	57					94	47.9			51.4	13.5															2.72
15.4	16	20					8																				
16.9	17	22					13																				
17.1	18	21					23																				
18.7	19	23					14																				
20.1	20							107.7																			
20.3	21	34	65	20	0.32	18.4		95.8								44.3											
20.4	22							83.8			87.9																
21.3	403													90.0													
21.9	404													101.0													
23.2	23							83.8																			
23.3	24	50	60	22	0.74	17.0									83.3		0.9										
23.5	25							83.8			94.1																
24.4	405													227.0+													
25.0	406													263.3+													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-54		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
26.4	26	23	37	13	0.43				191.5		179.5															C	
26.5	27	31	63	19	0.28				191.5		179.5																
27.4	407													150.8													
29.3	28							88.6			107.7																
29.4	29	50	82	25	0.43	16.5									85.8	31.7	1.4										
29.6	30							83.8																			
30.5	408													149.9													
31.1	409													140.8													
32.2	31							95.8																			
32.5	33	46	71	27	0.44	16.8		95.8							93.9		1.4										
32.6	34							100.5			118.8																
33.5	410													114.9													
34.1	411													119.7													
35.4	35		48	18																						C	
35.5	36	34	49	18	0.54			83.8	95.8		103.9																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.3c

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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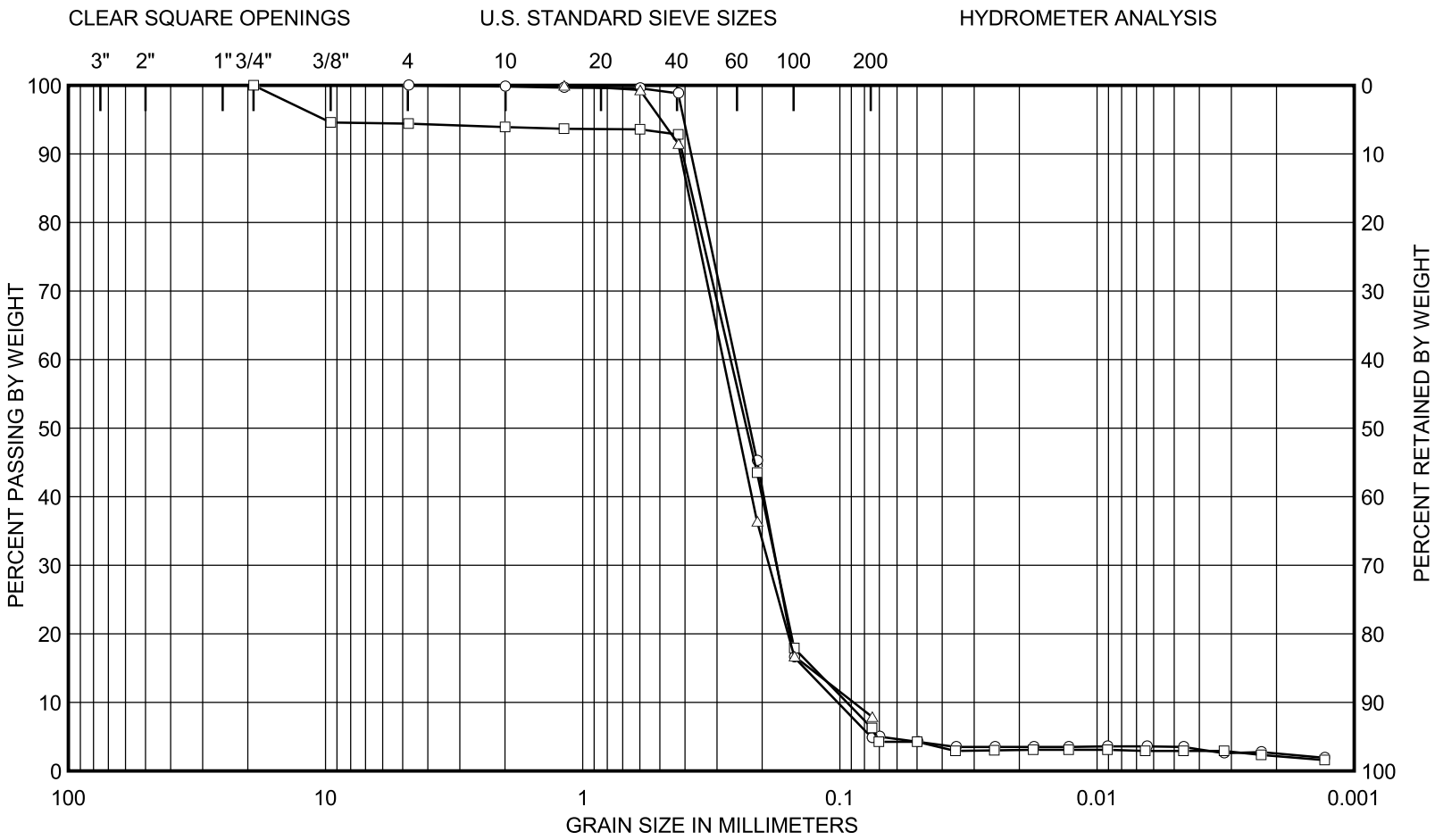

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.1	○—○	FINE SAND (SP-SM) with silt	1.2	2.5	0.22
4	6.4	□—□	FINE SAND (SP-SM) with silt	1.2	2.8	0.23
16	15.4	△—△	FINE SAND (SP-SM) with silt	1.4	3.2	0.25

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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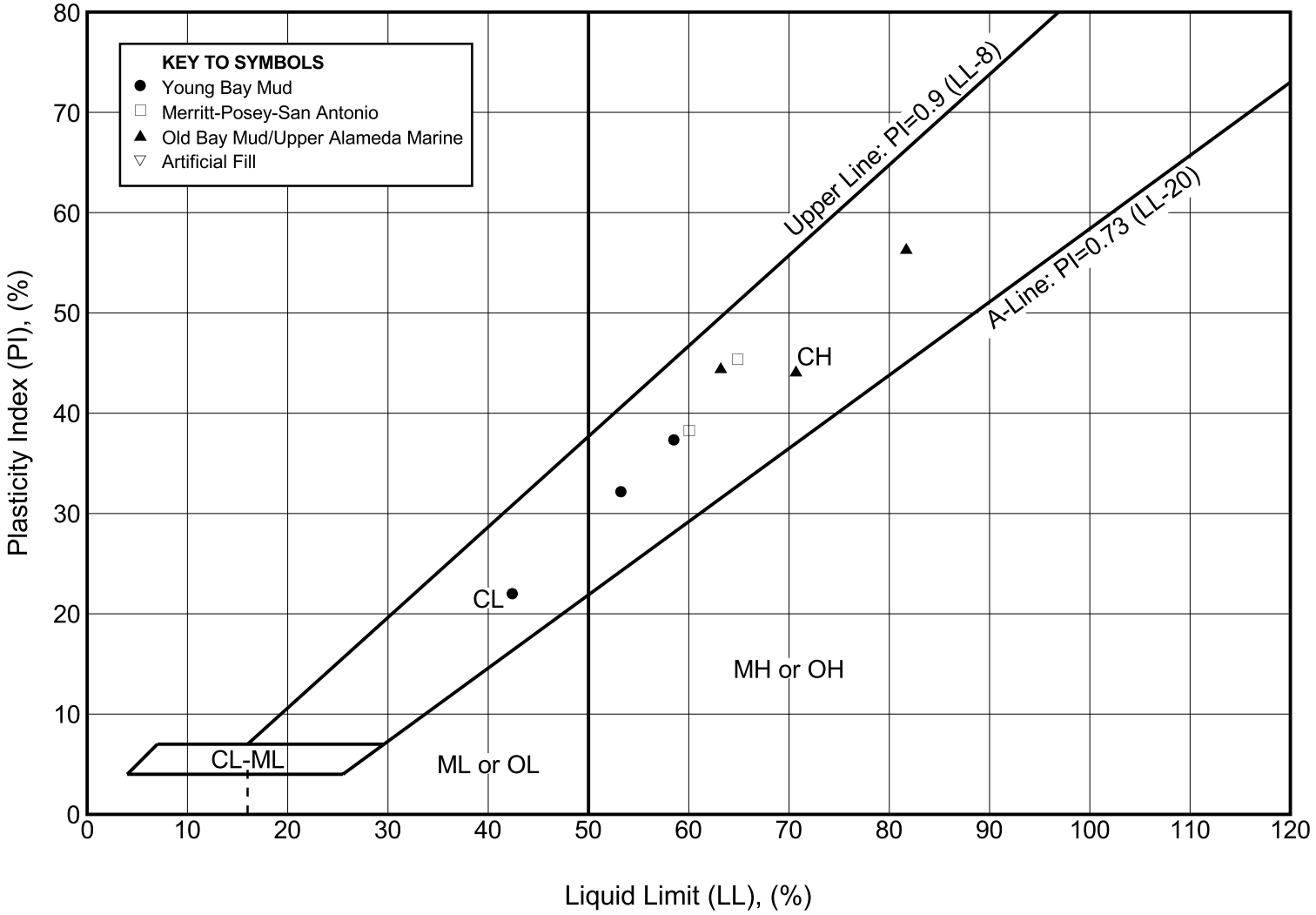
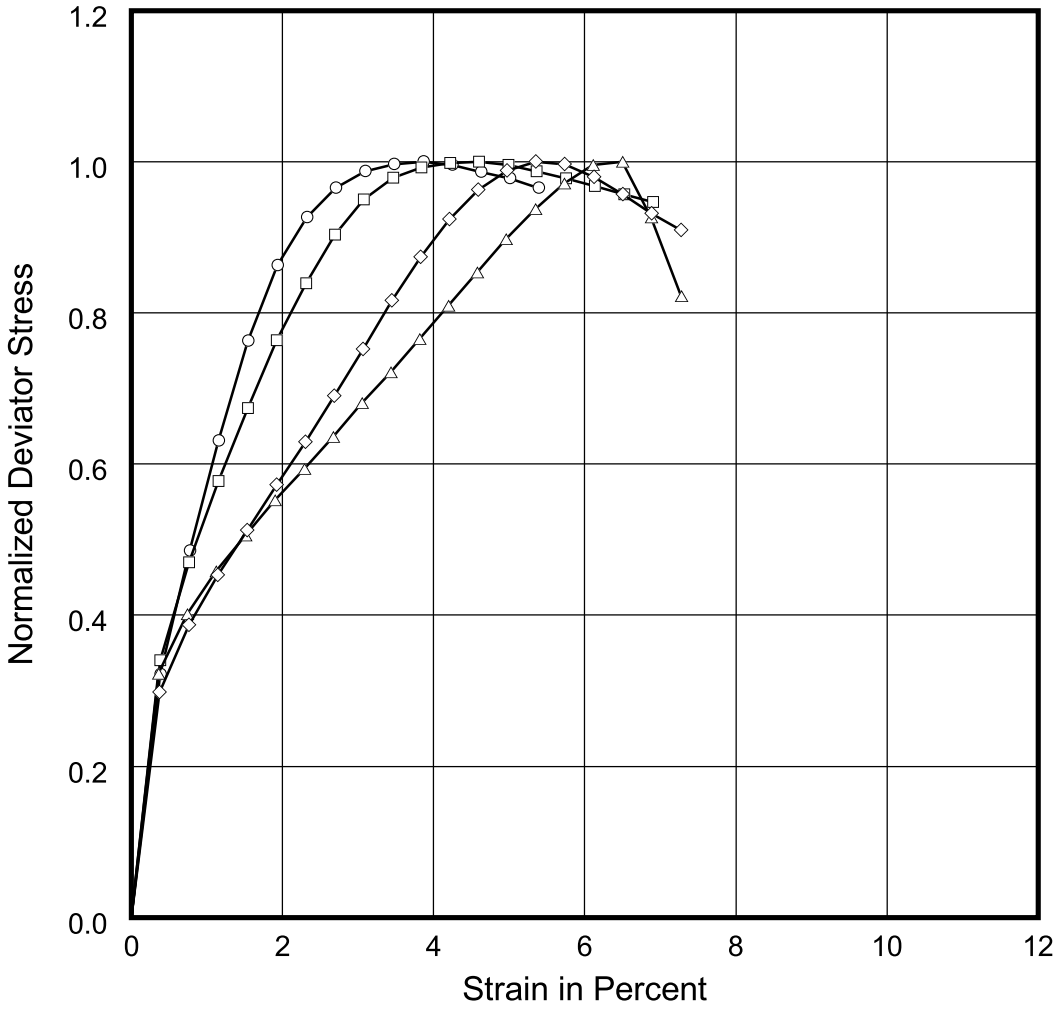


PLASTICITY CHART
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.5

Earth Mechanics

FUGRO



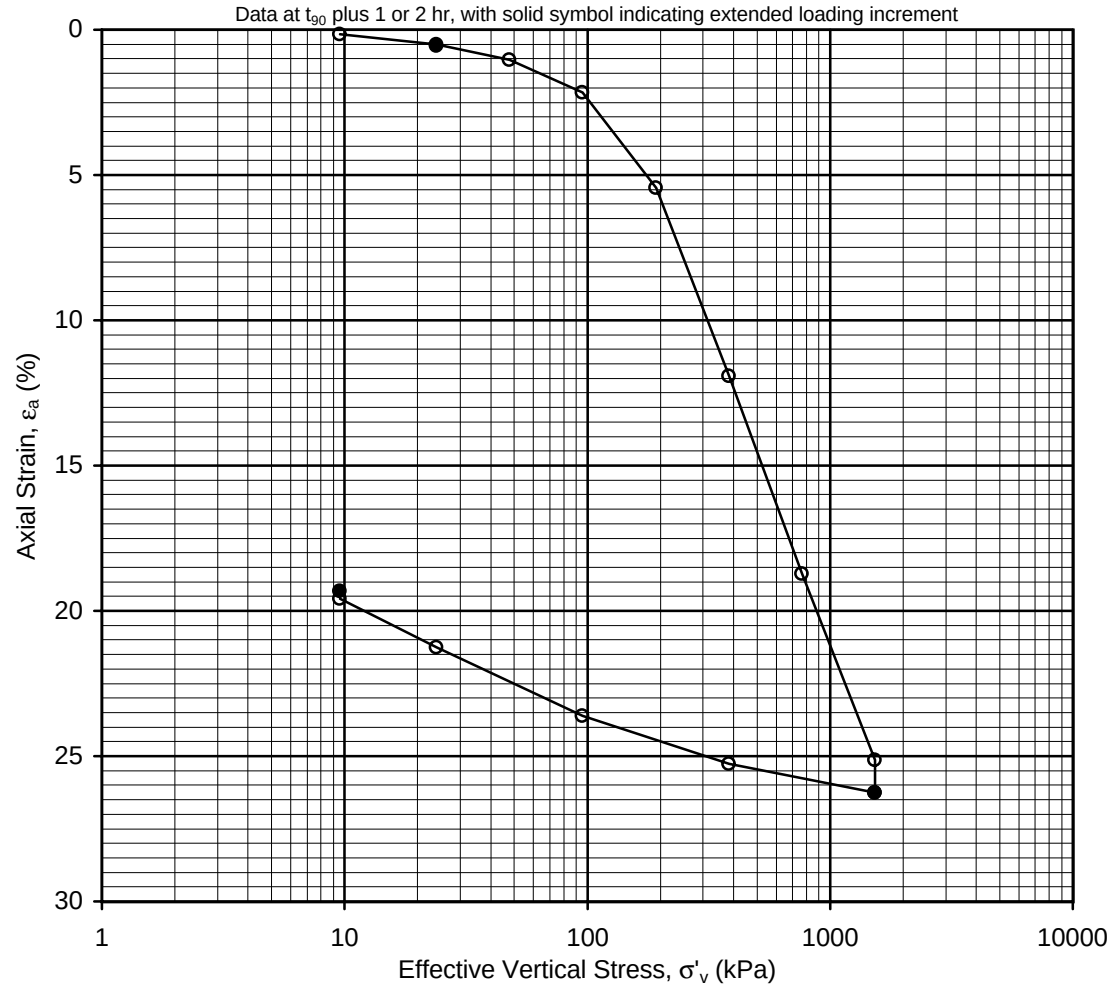
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	11	11.1	UU	207	108	0.8
□—□	24	23.3	UU	793	167	0.9
△—△	29	29.4	UU	827	171	1.4
◇—◇	33	32.5	UU	896	188	1.4

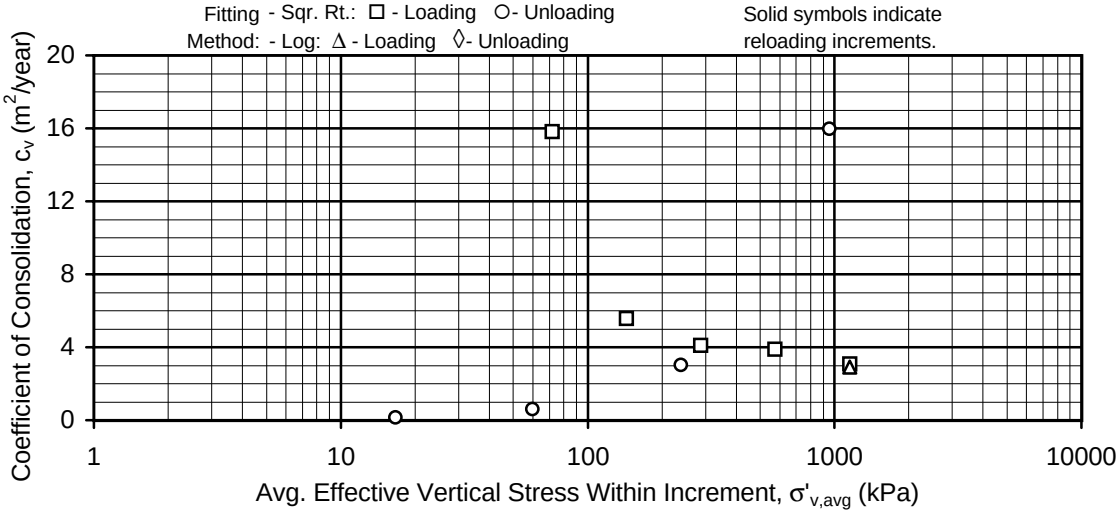
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-54
SFOBB East Span Seismic Safety Project

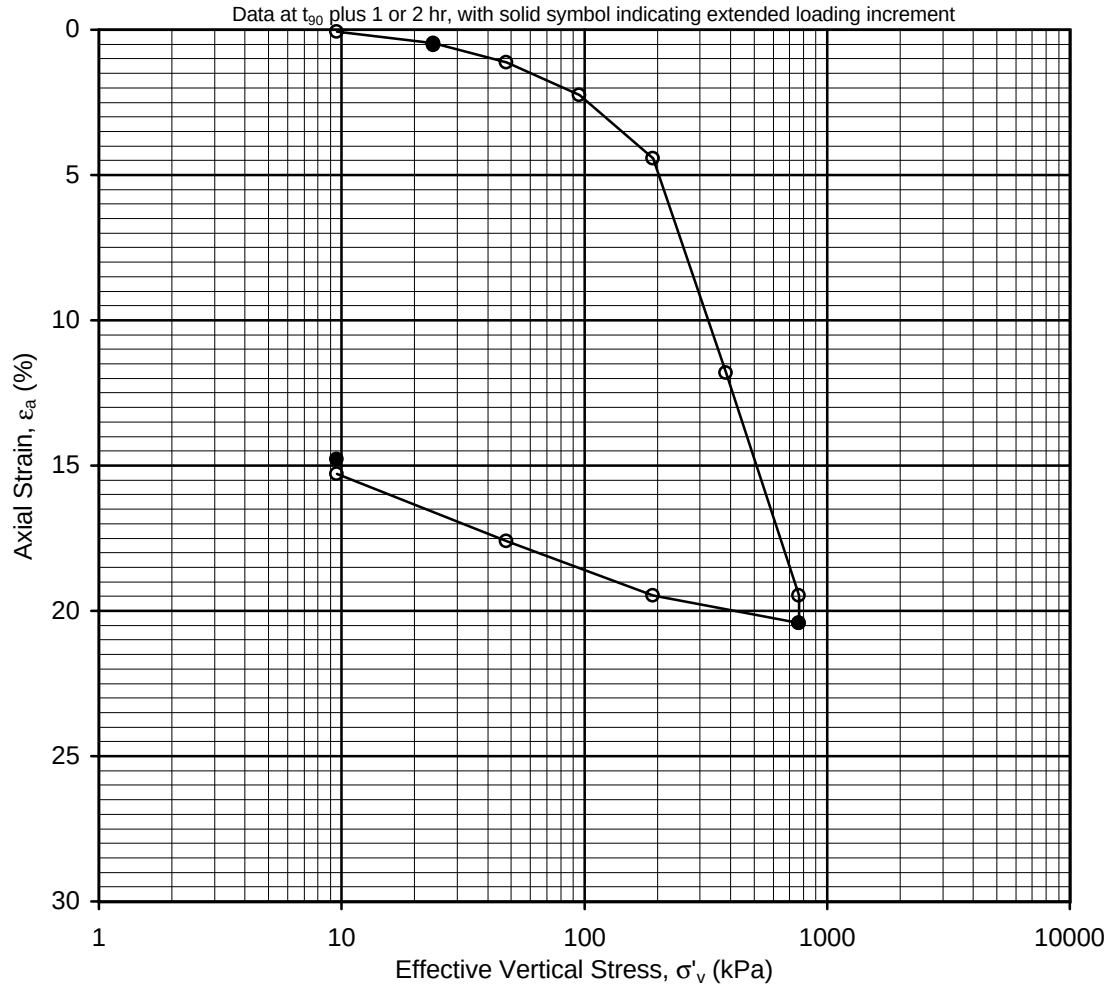
PLATE 98-54.6

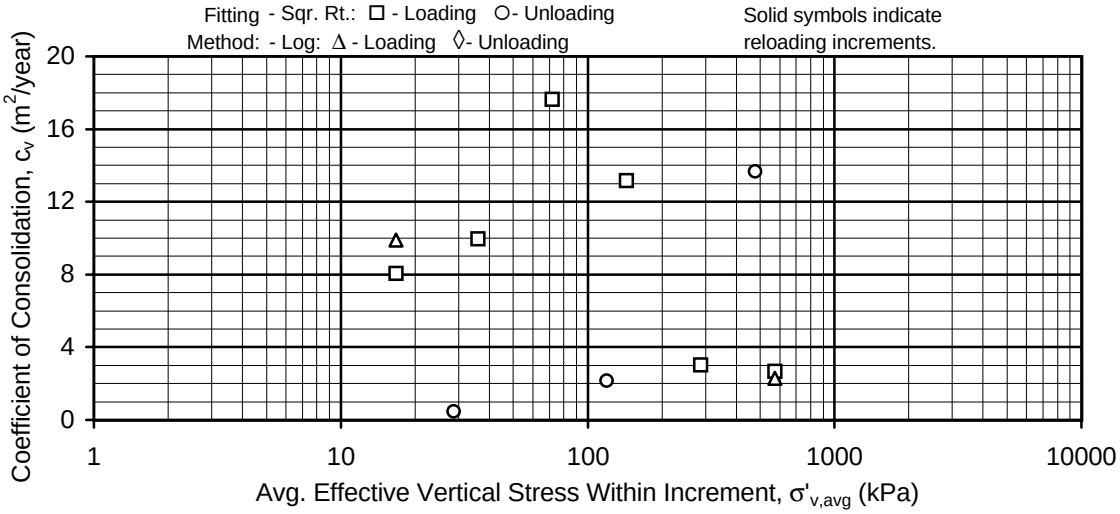




INCREMENTAL CONSOLIDATION TEST RESULTS

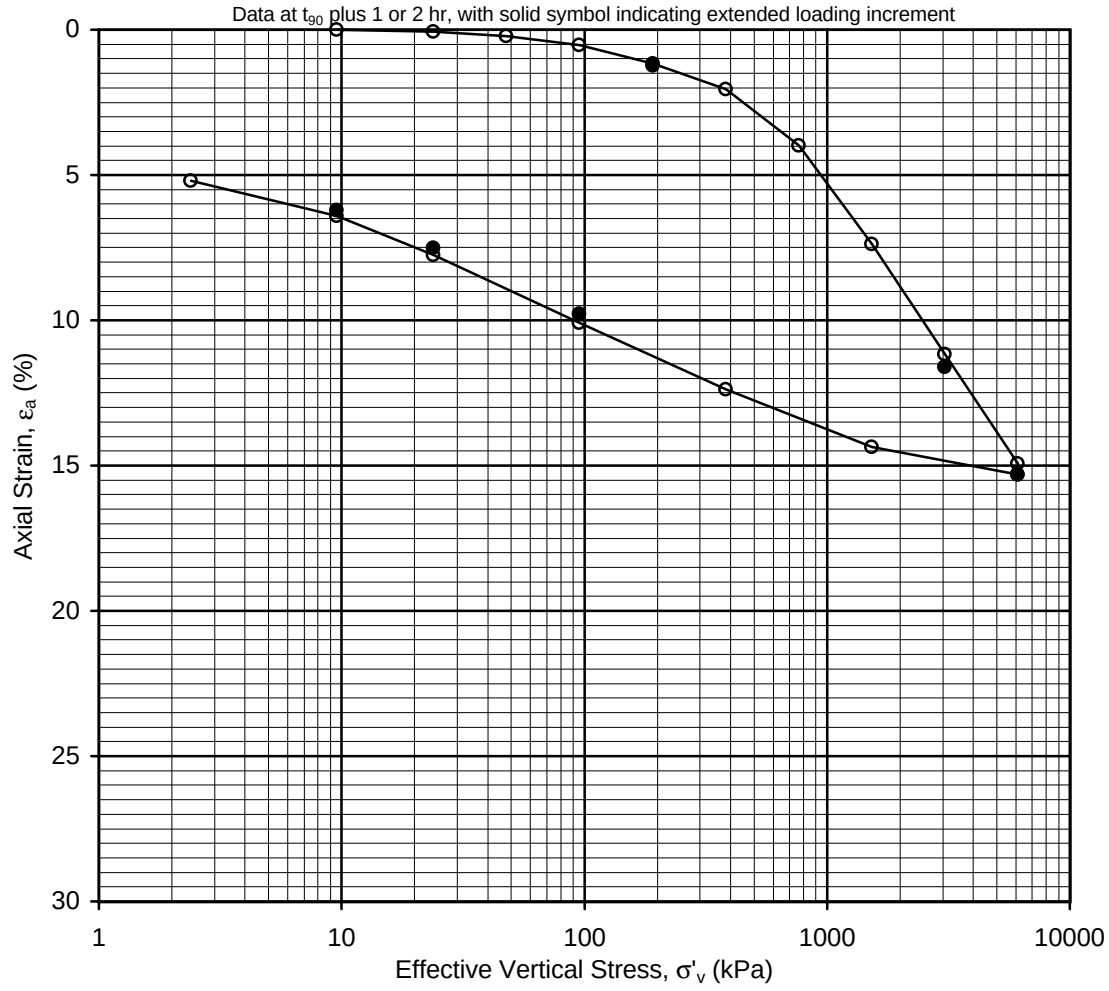
Sample No. 13A (Horizontal Loading) - Depth: 12.9m
Boring 98-54
SFOBB East Span Seismic Safety Project

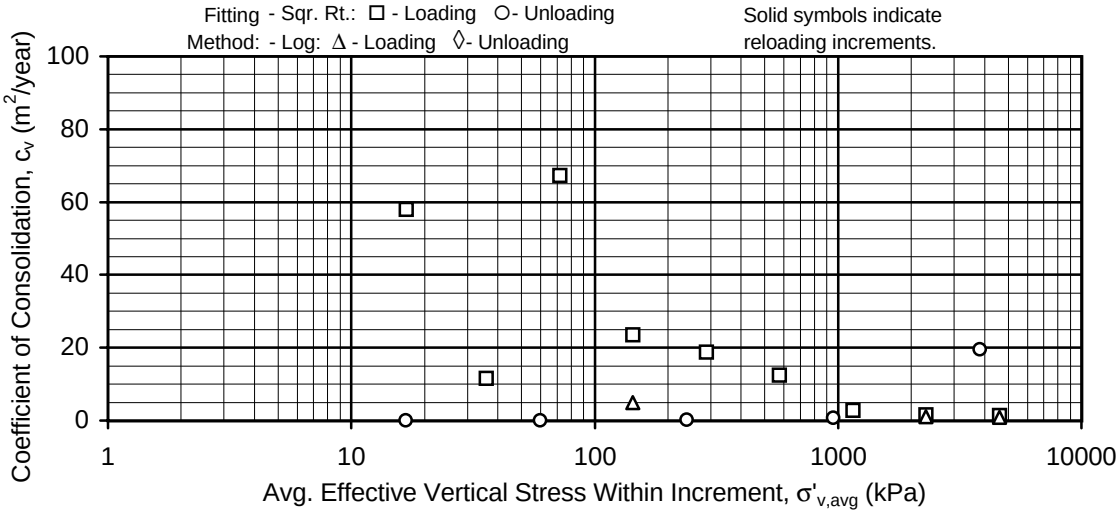




INCREMENTAL CONSOLIDATION TEST RESULTS

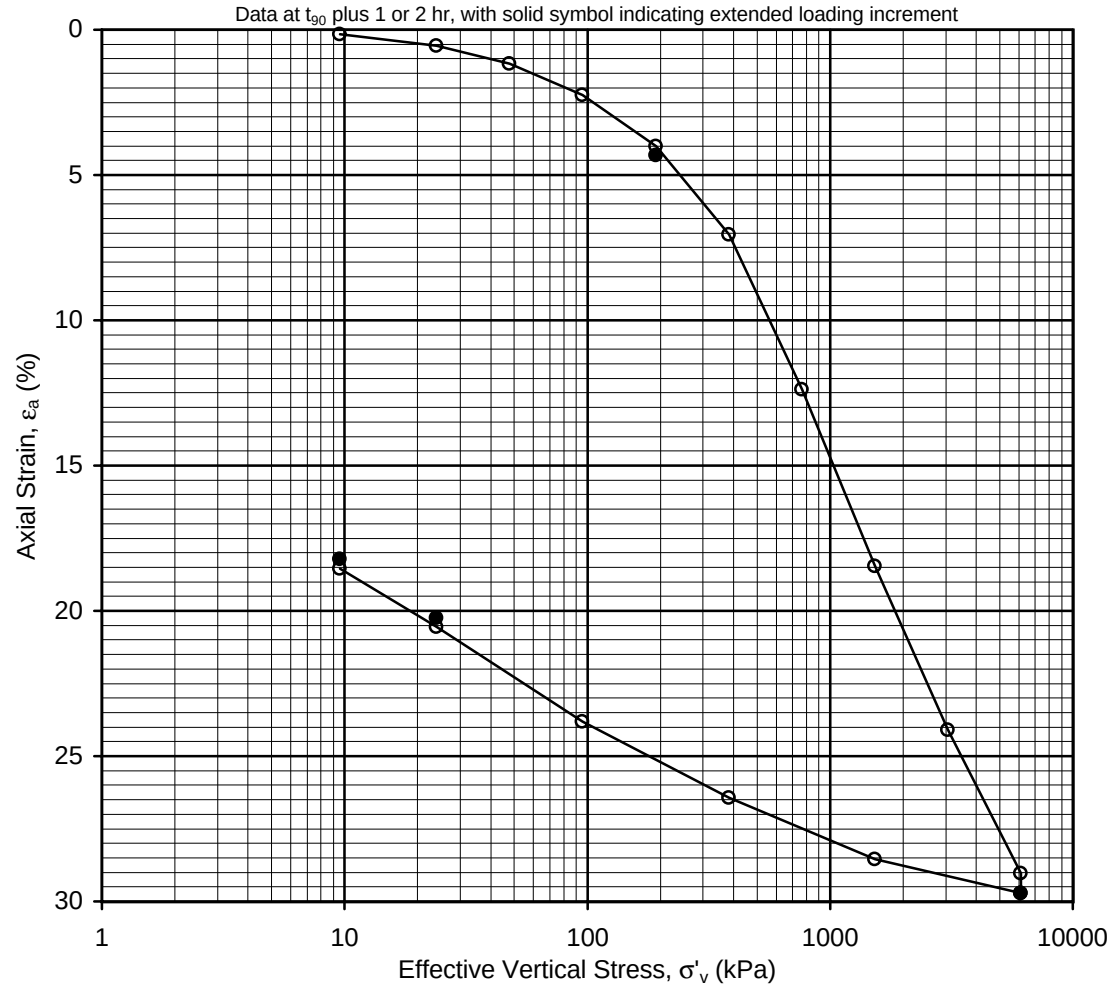
Sample No. 13B - Depth: 12.9m
Boring 98-54
SFOBB East Span Seismic Safety Project

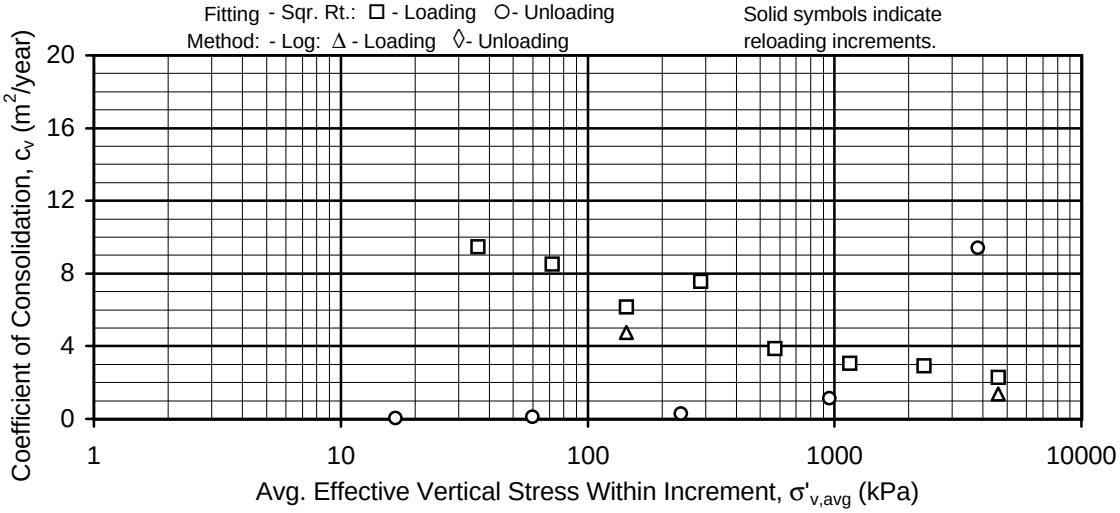




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 26 - Depth: 26.3m
Boring 98-54
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

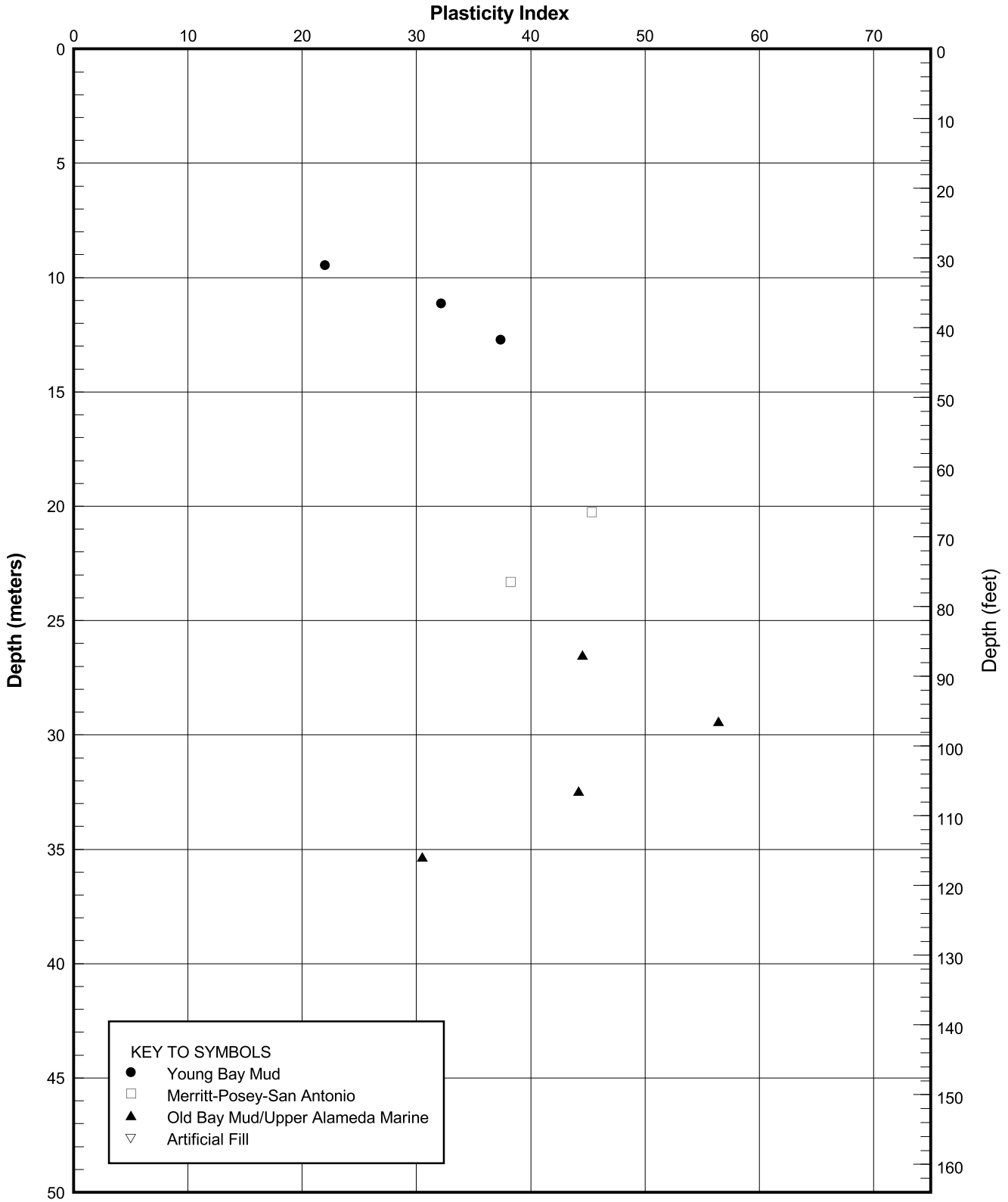
Sample No. 35 - Depth: 35.4m
Boring 98-54
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

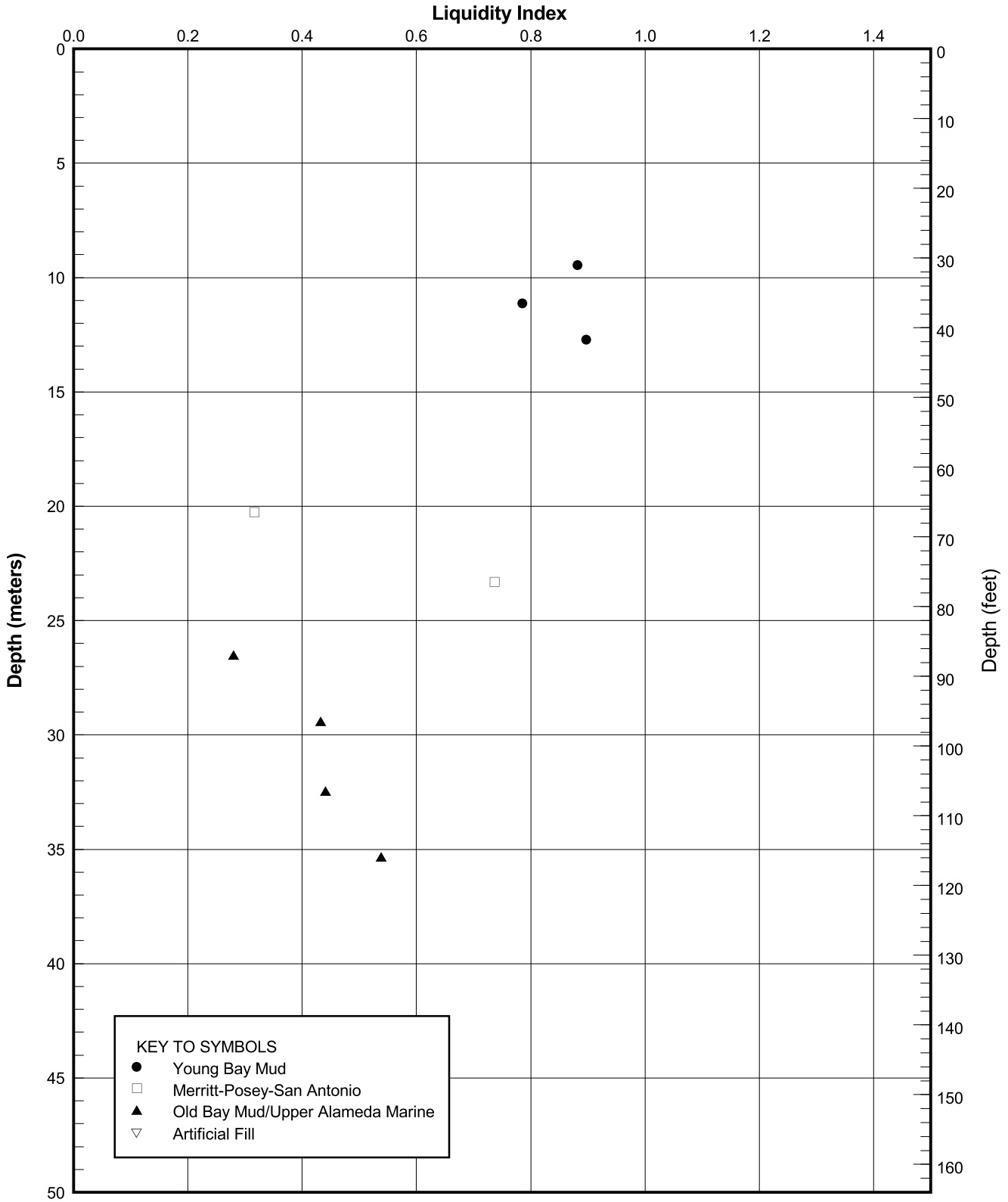
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



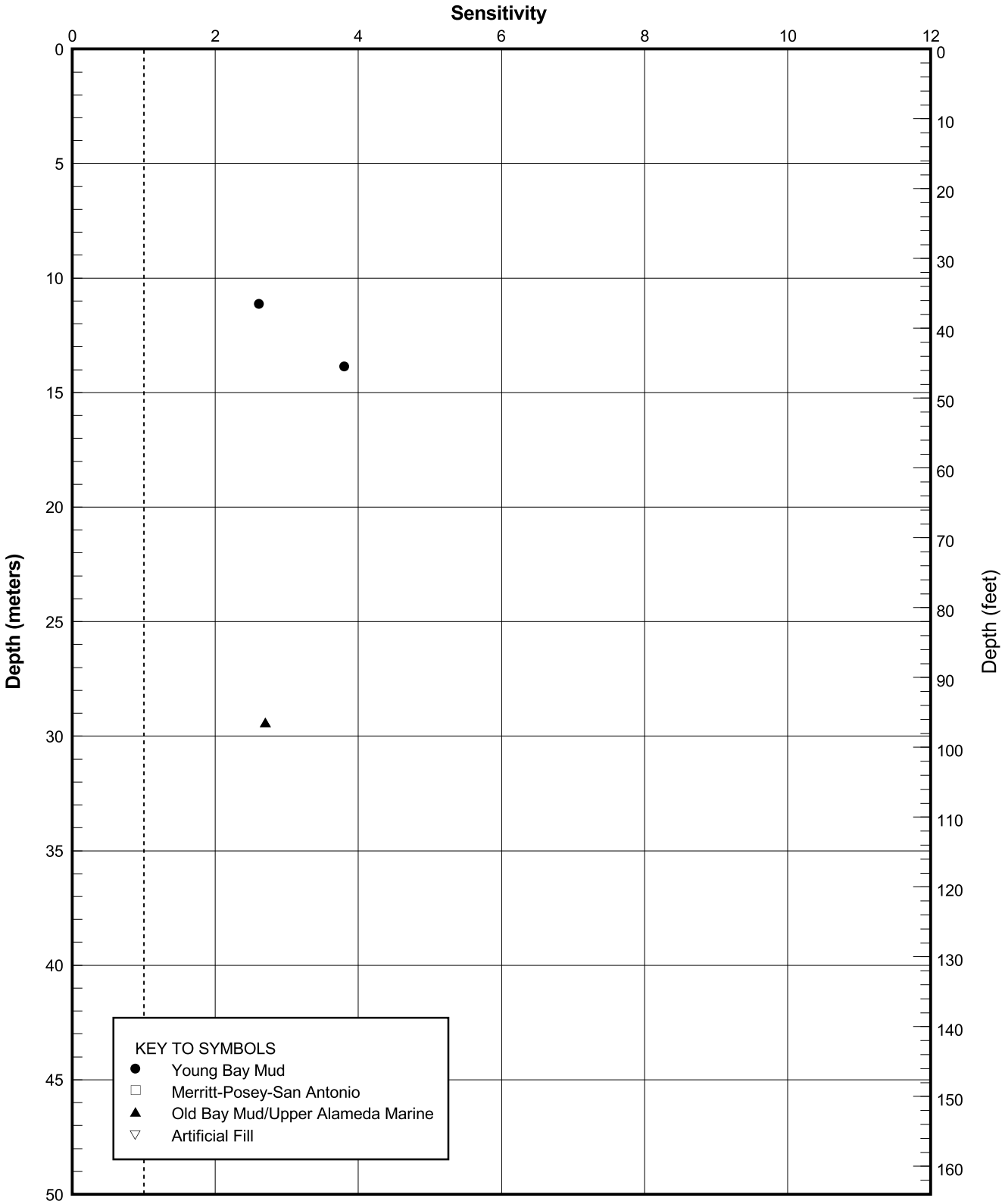
PLASTICITY INDEX PROFILE
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.12



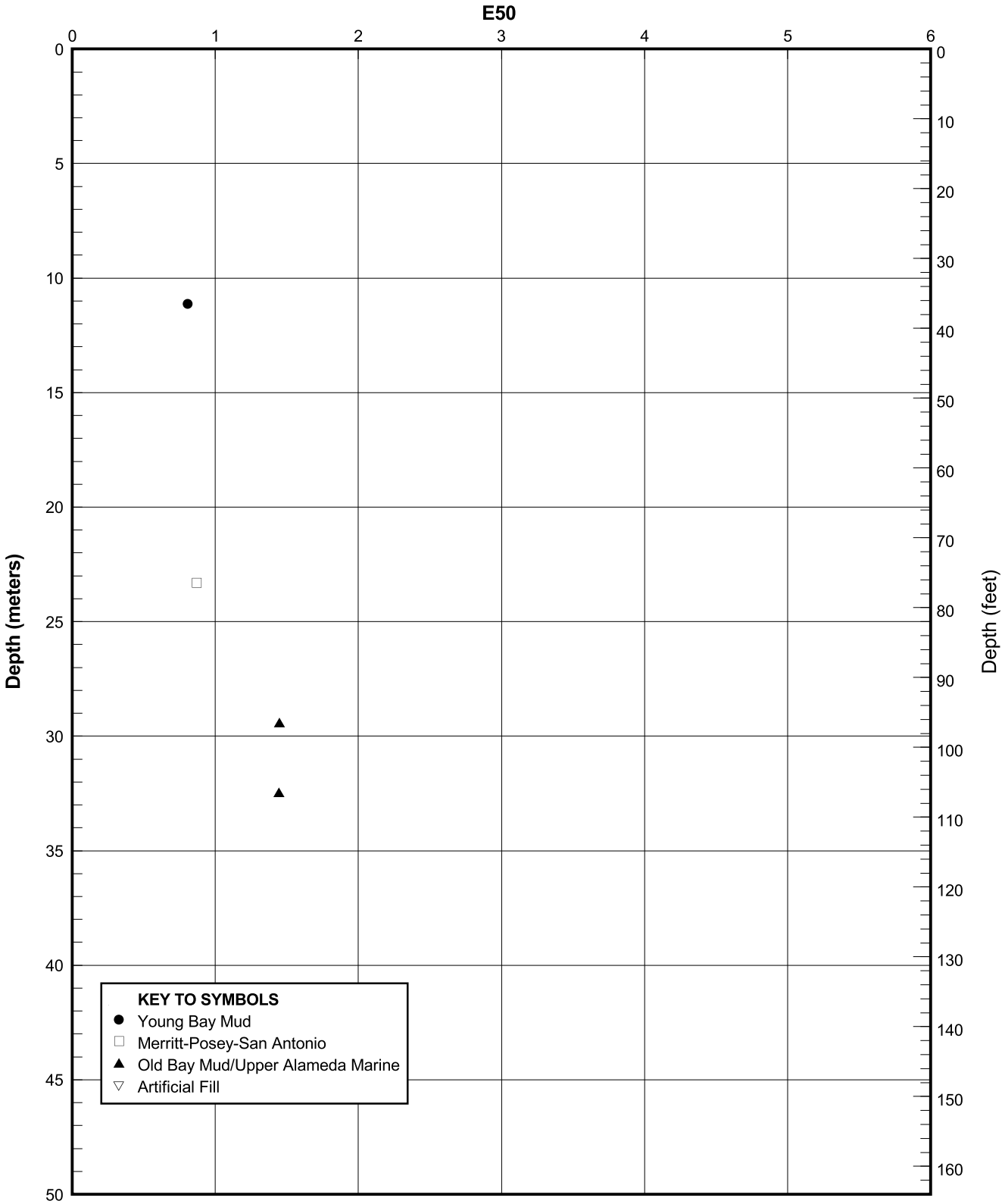
LIQUIDITY INDEX PROFILE
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.13



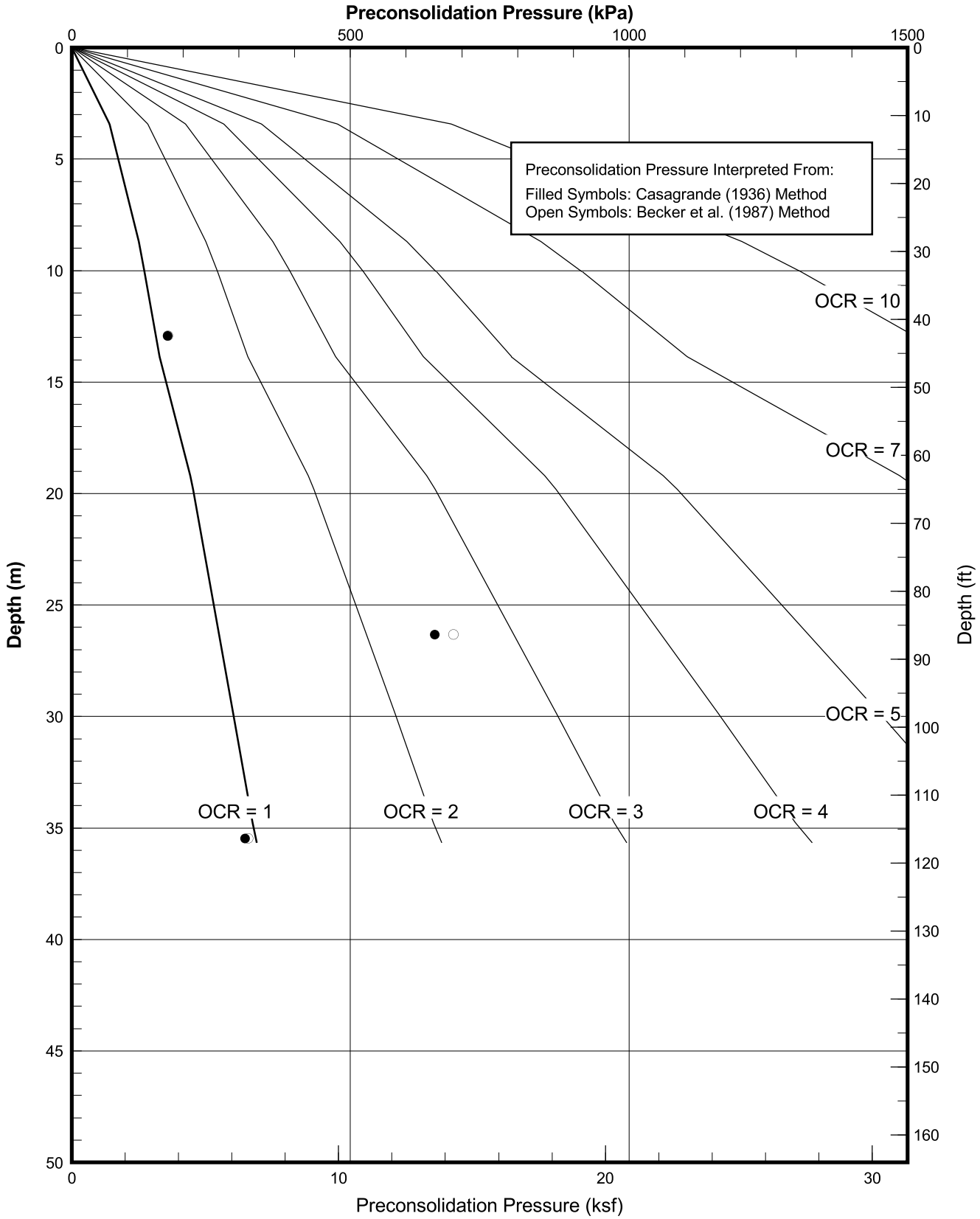
SENSITIVITY PROFILE
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.14



E50 PROFILE
Boring 98-54
SFOBB East Span Seismic Safety Project

PLATE 98-54.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-54

SFOBB East Span Seismic Safety Project

PLATE 98-54.16

LAND BORING 98-55

PROJECT NO:	98-42-0058	**START DATE:**	10/13/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-55 (5m right of W. Sta. 88+14)	**COMPLETION DATE:**	10/15/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839073 N648301
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.6m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
2	2			3	Silty Fine SAND (SM), loose, brown -with fine gravel and clay pockets, at 1.5m (2.6m)	I
0	4			63	GRAVEL with sand (GW), very dense, gray to white ▽ (3.6m) -with cobbles and boulders, 2.6m to 3.0m	II
-2	6			9	-stiff to very stiff, gray, lean clay with shell fragments, a trace of gravel, and fat clay pockets, below 5.5m (6.6m)	
-4	8			PUSH	Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -lean clay to 8.5m -with many silt pockets, silt seams, and organic pockets, at 7.9m	III
-6	10			PUSH	-with organic pockets and a few silt pockets, at 9.4m	
-8	12			SAVE PUSH	-dark greenish gray below 12.2m	
-10	14			PUSH	-with a few silty fine sand pockets, at 14.0m (15.5m)	
-12	16			SAVE 51	Fine SAND with silt (SP-SM), very dense, greenish gray (17.4m)	IV
-14	18			16	Fat CLAY (CH), stiff, greenish gray -with organic pockets -with gas blisters at 18.6m	V
-16	20					
-18	22			PUSH	-with silt pockets and a few silty fine sand pockets, at 21.6m (24.4m)	
-20	24			31	Fat CLAY (CH), very stiff, greenish gray -lean clay to 26.8m -with desiccated pockets and calcareous nodules, at 24.4m -with sand seams and layers, 25.3m to 26.2m	VI
-22	26					
-24	28			PUSH	-with sand seams and pockets, and organic partings, at 27.7m	
-26	30			16	-with silt partings and organic partings, at 30.5m	
-28	32					
-30	34			SAVE	-with silt pockets and a few shell fragments, at 33.8m (35.4m)	
-32	36				Fat CLAY (CH), very stiff to hard, greenish gray	VII
				PUSH	-with many silt pockets, and many silty fine sand pockets, at 36.9m	
-34	38					
-36	40			PUSH	-with silt partings, organic pockets and olive gray mottling, at 39.9m (40.8m)	
-38	42				Fat CLAY (CH), hard, greenish gray -lean clay to 47.2m -with slickensides to 49.4m	VIII
				SAVE	-with silt partings at 43.0m -sandy lean clay at 43.3m	
-40	44					
-42	46			PUSH	-with many silt seams and layers, at 45.7m	
-44	48			PUSH	-with yellow brown mottling, at 49.1m	
-46	50					
-48	52			SAVE	-sandy lean clay, 51.5m to 52.7m	
-50	54					
-52	56			PUSH	-with sand pockets, a few silt partings and organic pockets, at 55.2m	
-54	58			PUSH	-with shell fragments and slickensides, at 58.2m	
-56	60					
-58	62			SAVE	-with a few sand partings at 61.3m	
-60	64					
-62	66					

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TOTAL DEPTH: 61.6m BACKFILLED WITH: Cement Grout

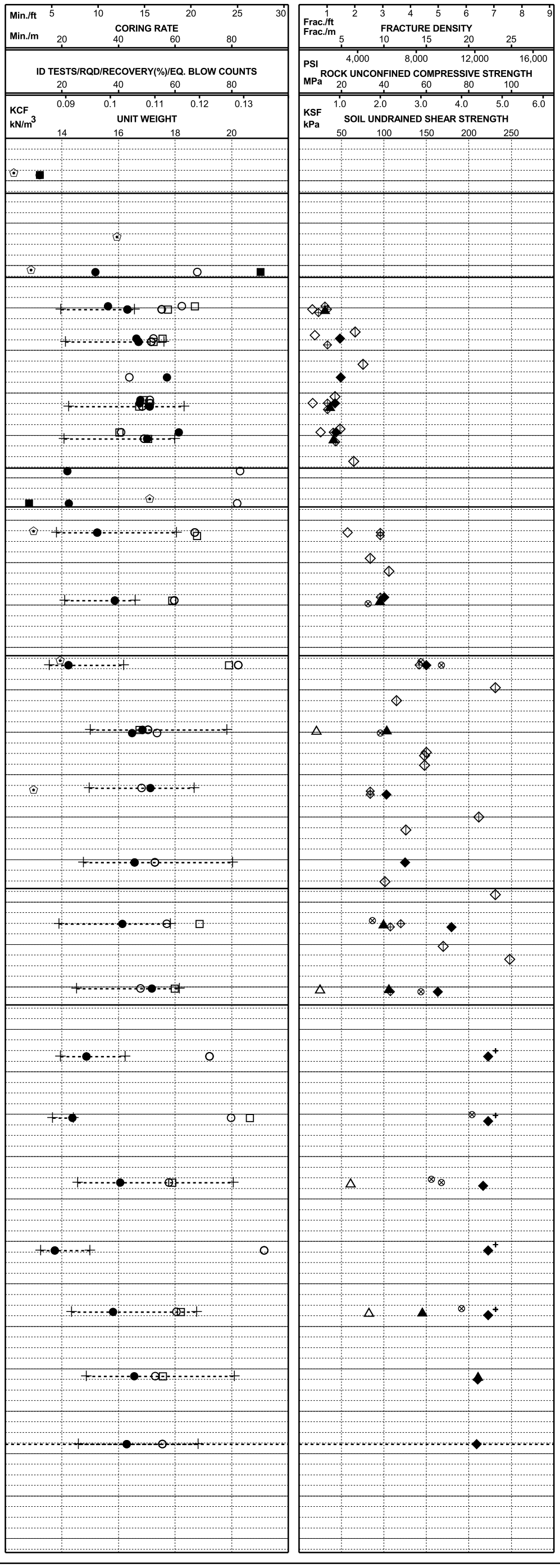


PLATE 98-55.1

LOG OF BORING AND TEST RESULTS

BORING 98-55

SFOBB East Span Seismic Safety Project

Report Date: 03/10/99

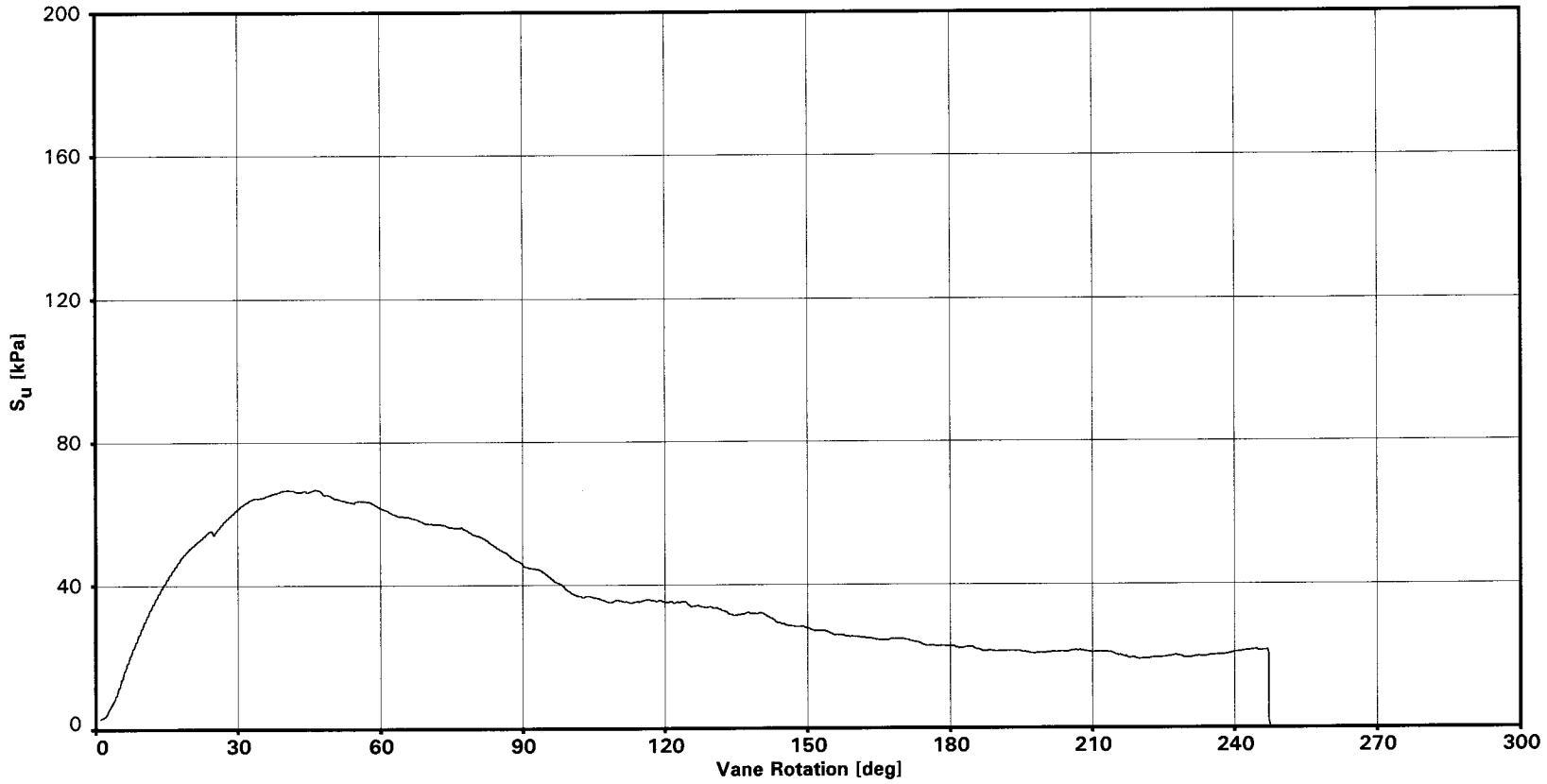
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 9.1m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

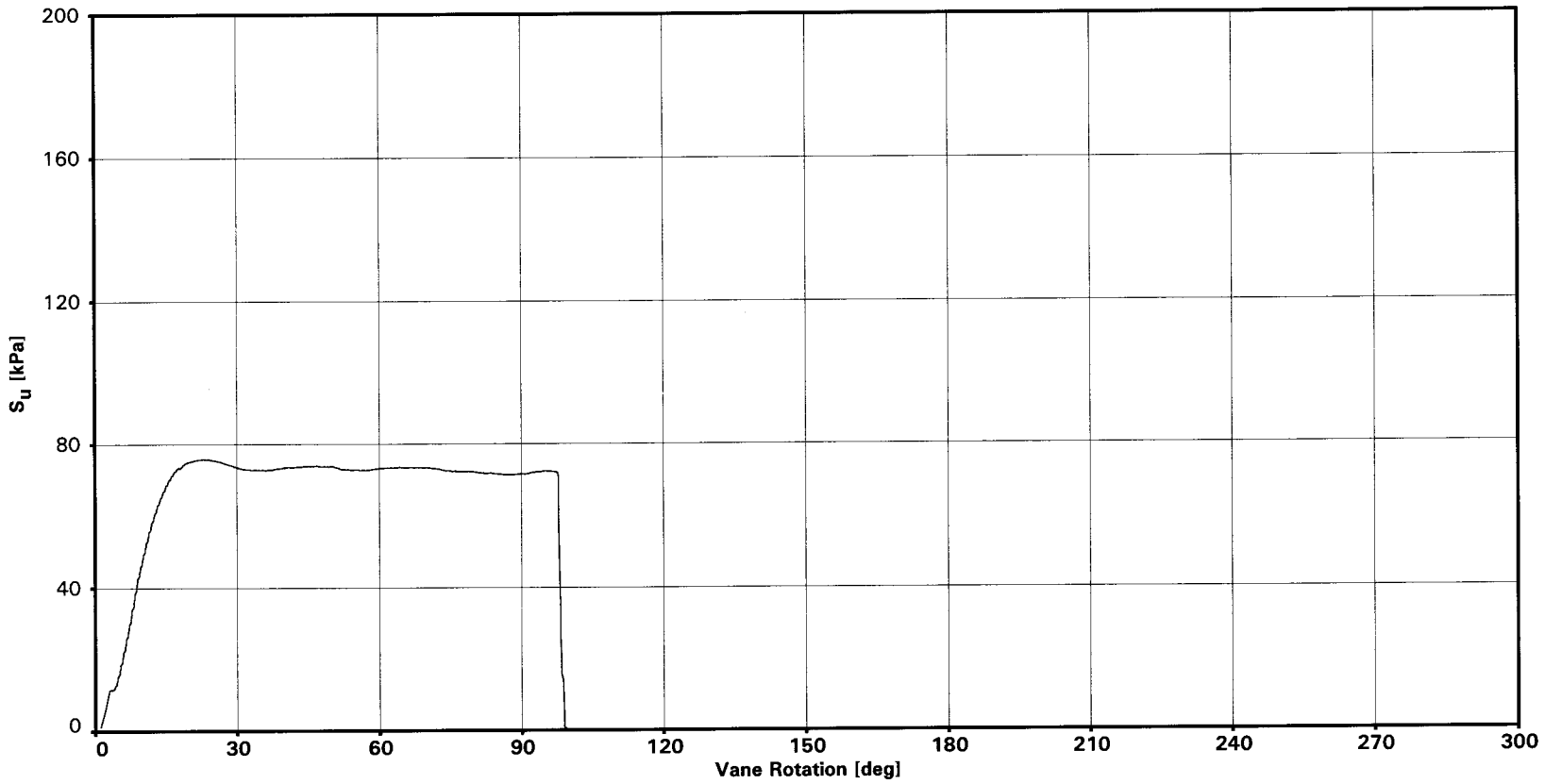
FUGRO

PLATE 98-55.2a

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 10.7m
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.2b

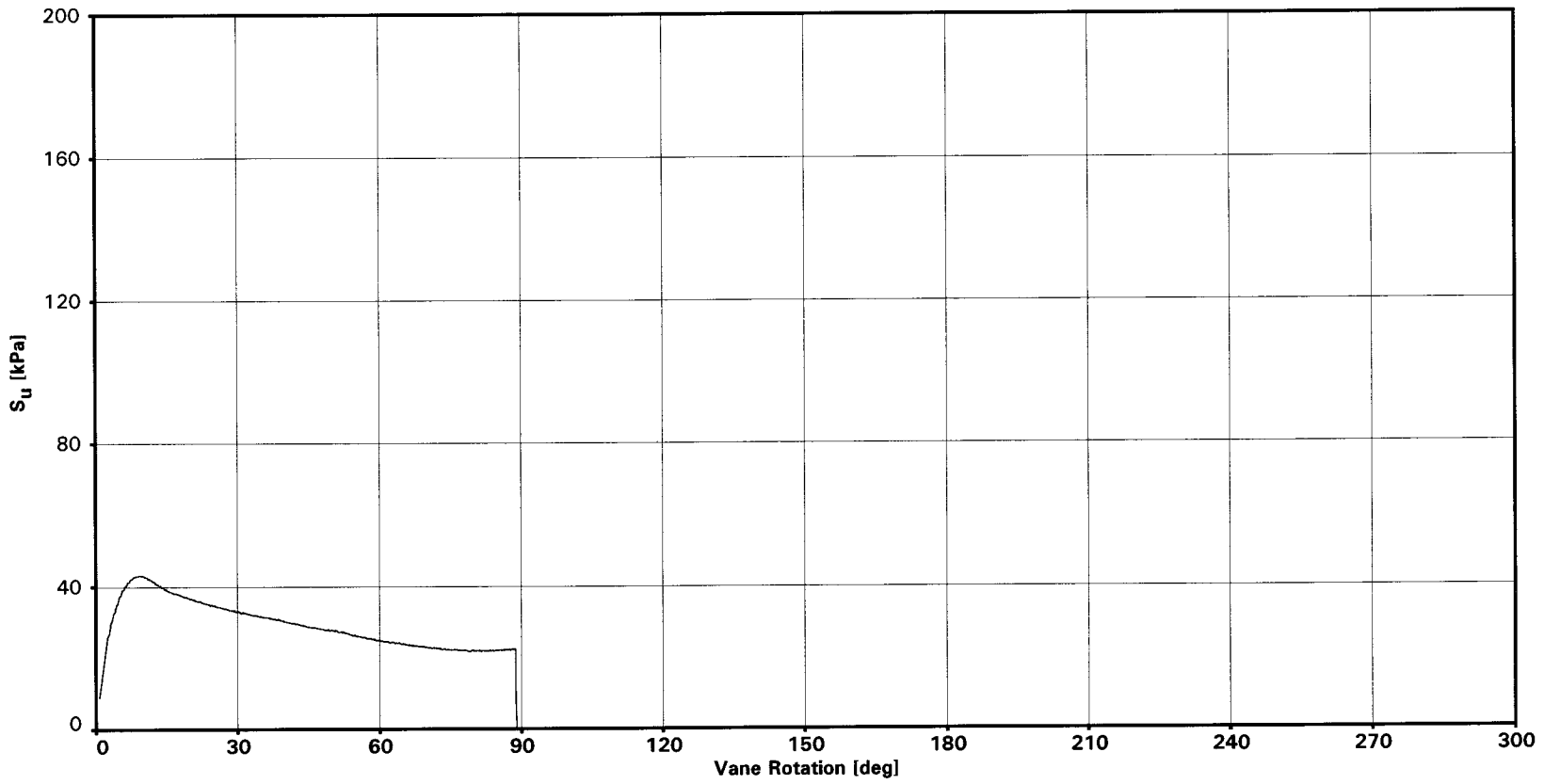
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

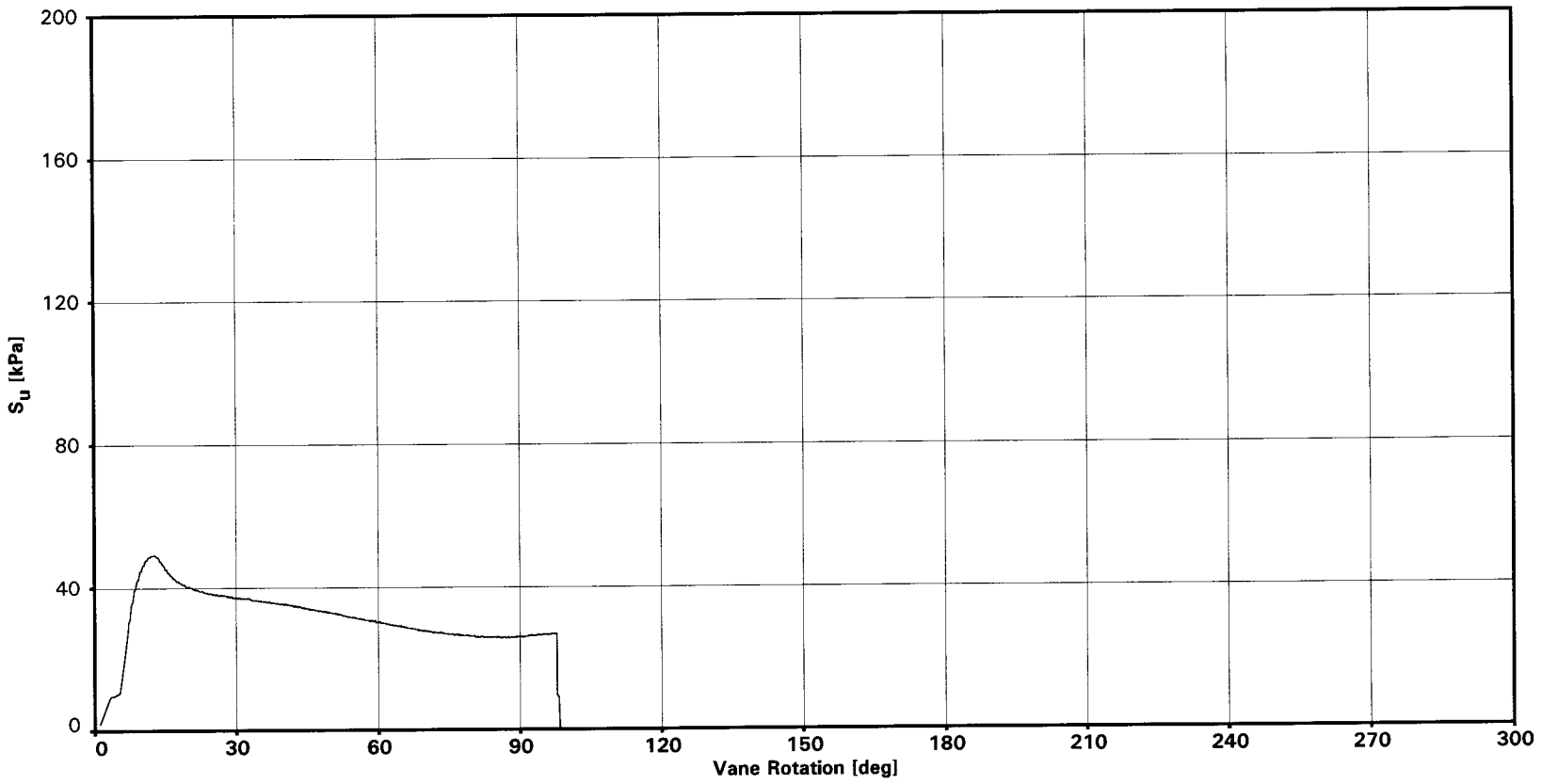
FUGRO

PLATE 98-55.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 13.7m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

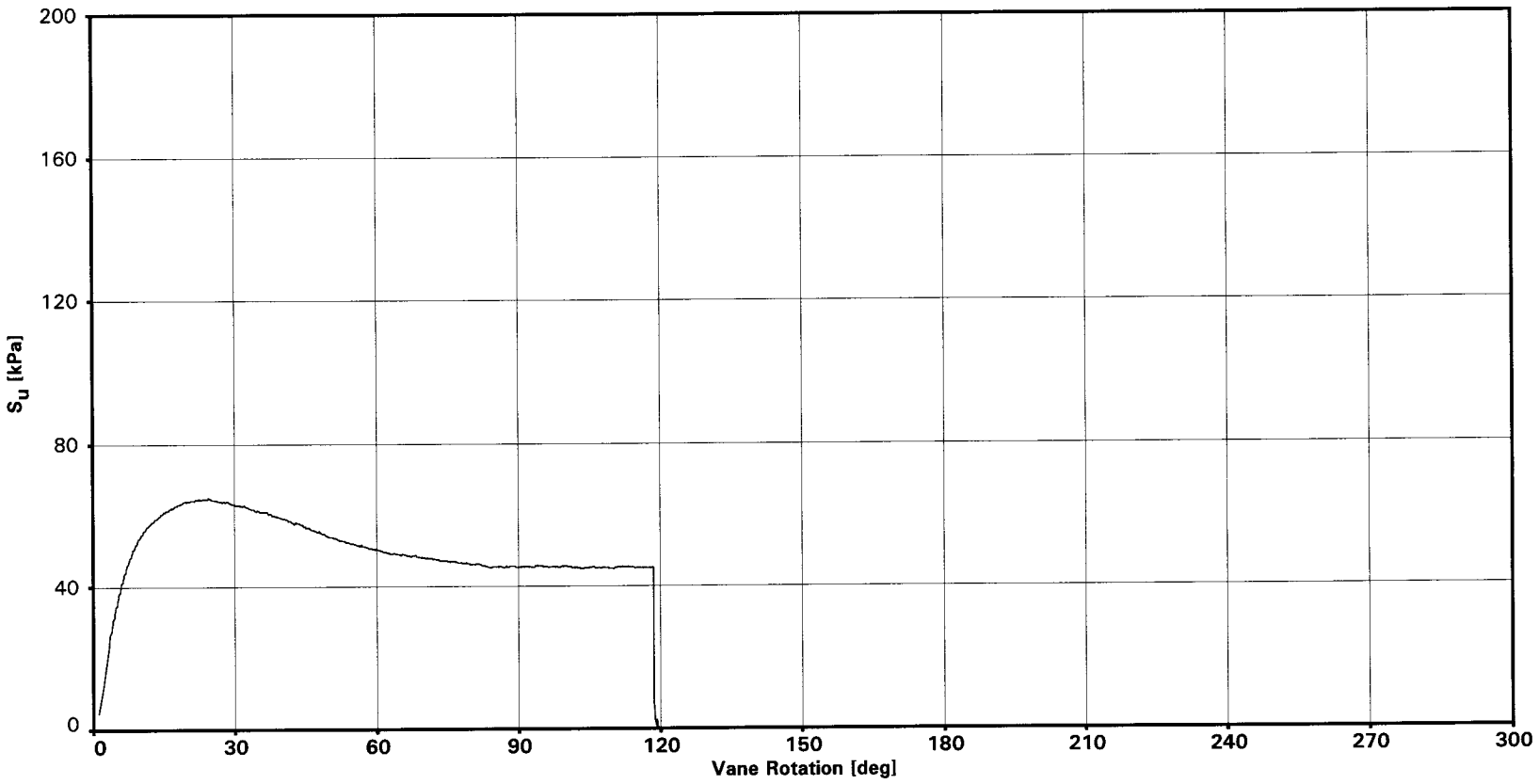
FUGRO

PLATE 98-55.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 15.2m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

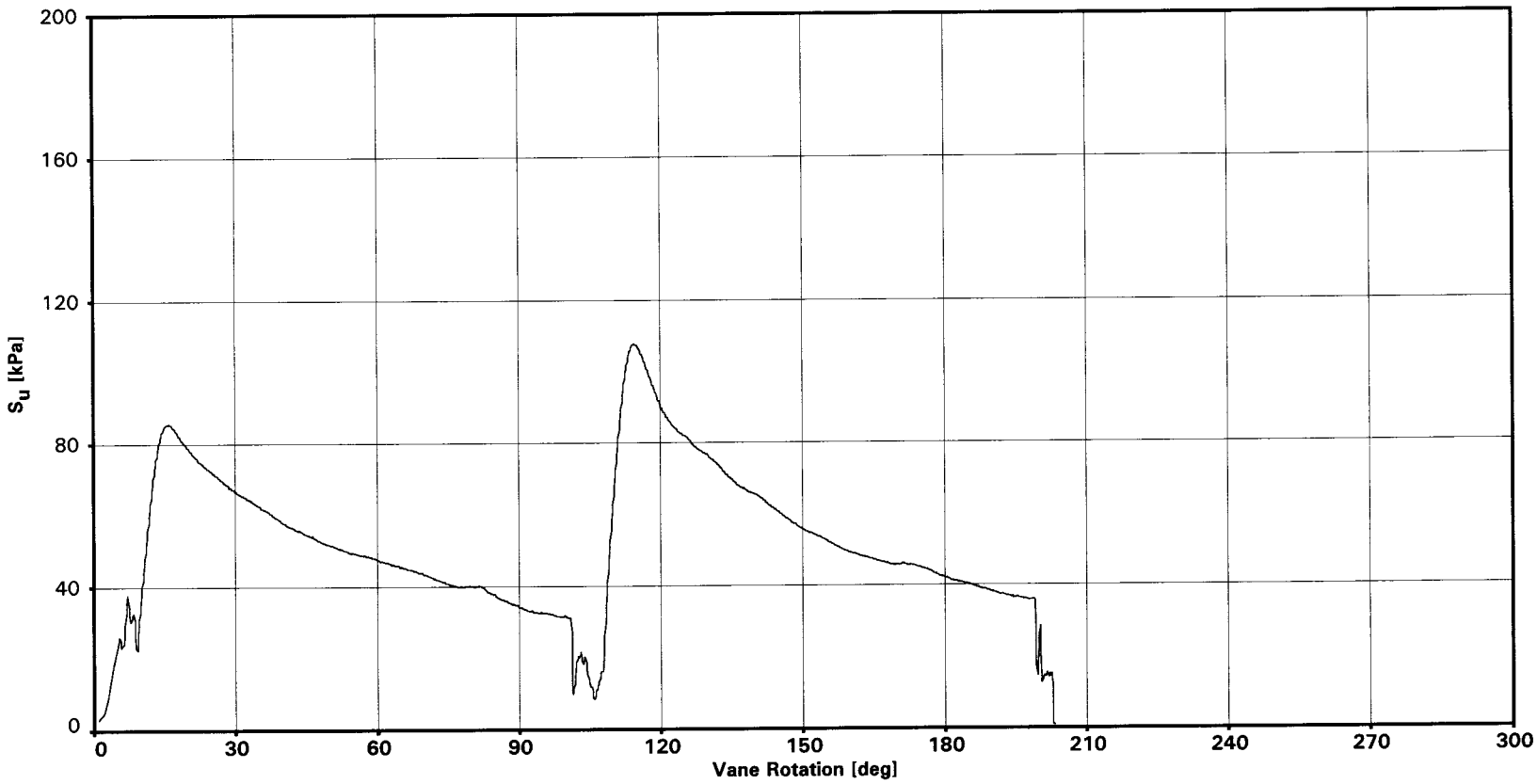
FUGRO

PLATE 98-55.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 19.8m and 20.4m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

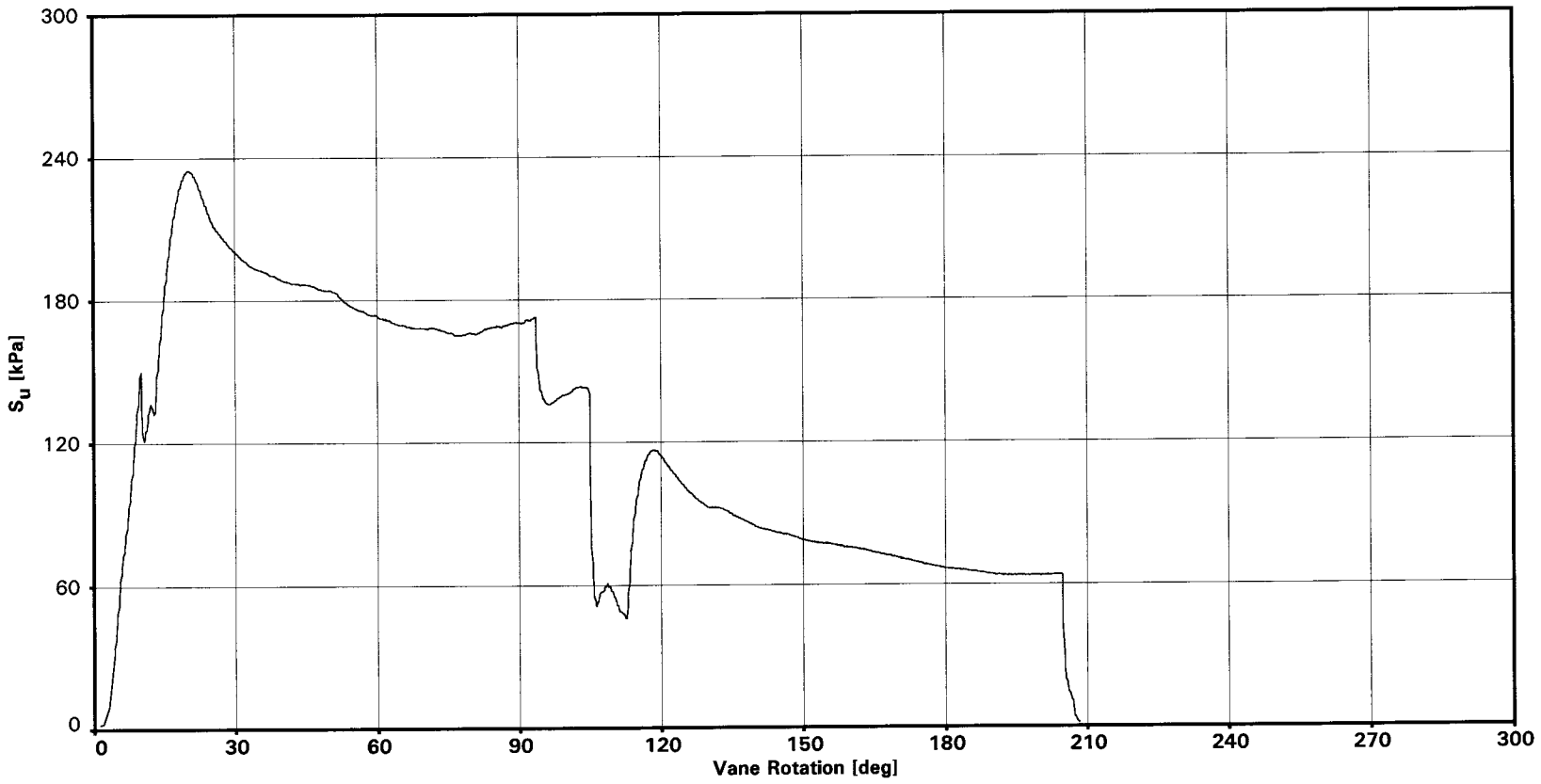
FUGRO

PLATE 98-55.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 25.9m and 26.5m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

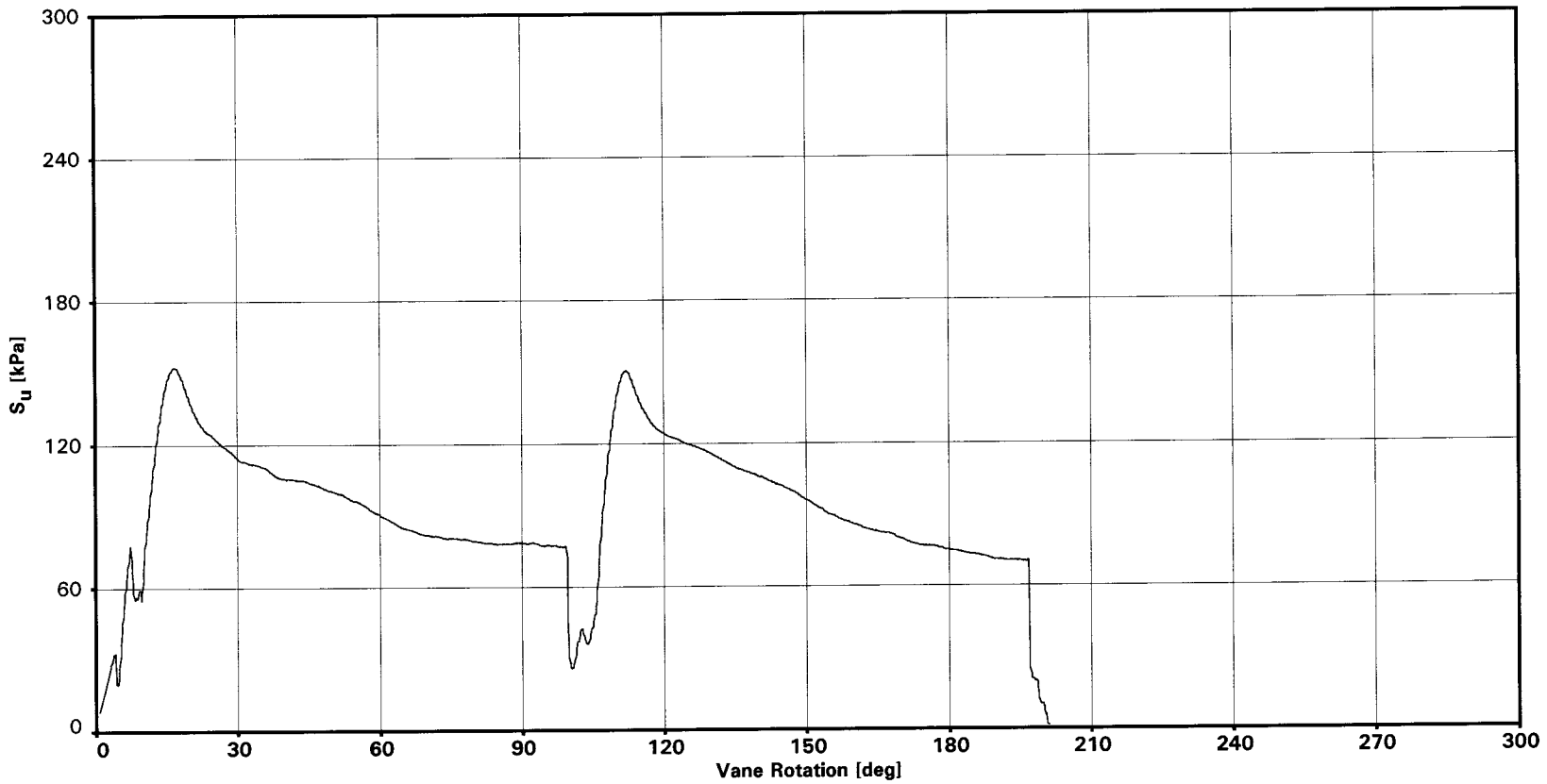
FUGRO

PLATE 98-55.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 29.0m and 29.6m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

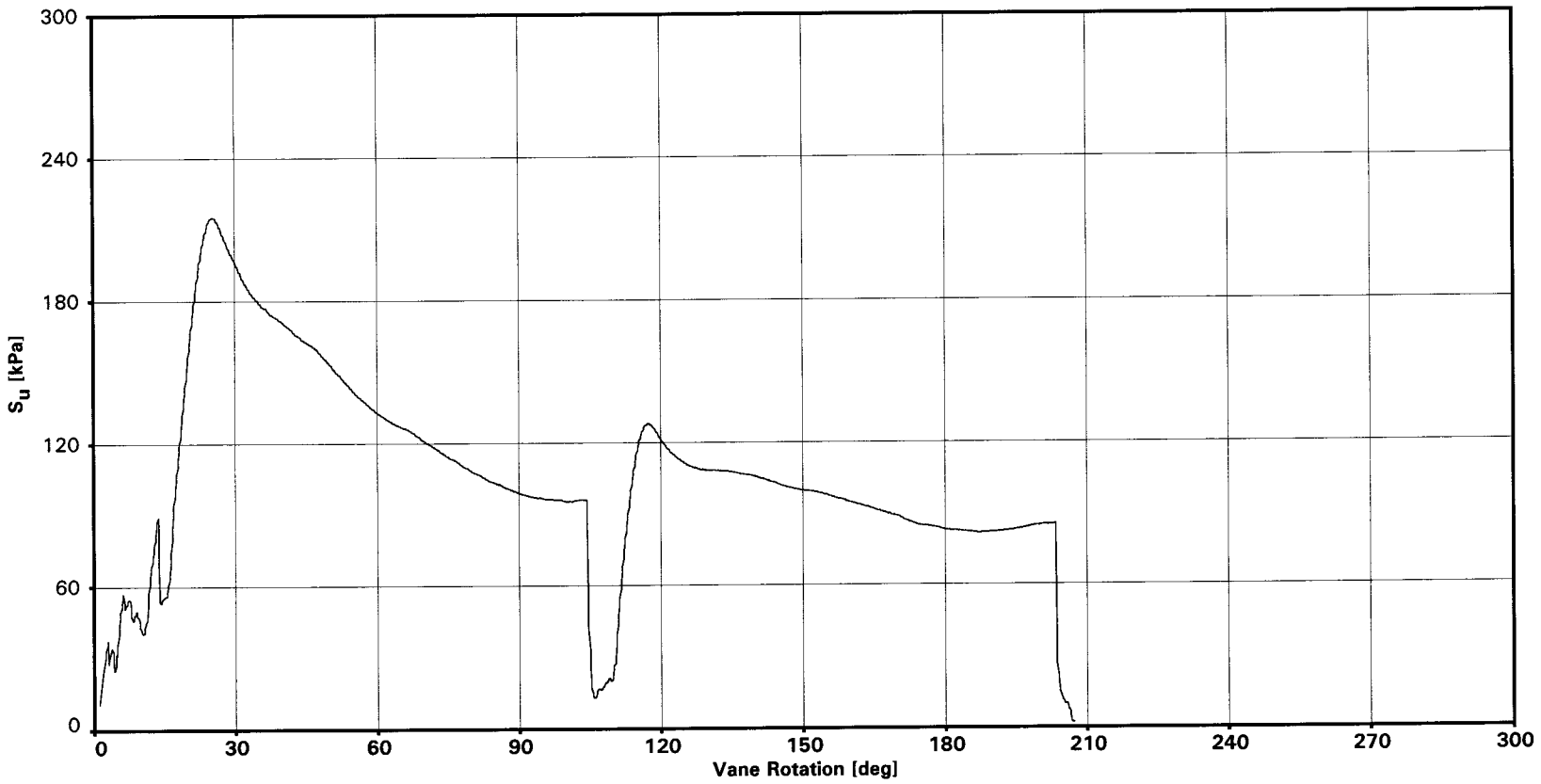
FUGRO

PLATE 98-55.2h

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 32.0m and 32.6m
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.2i

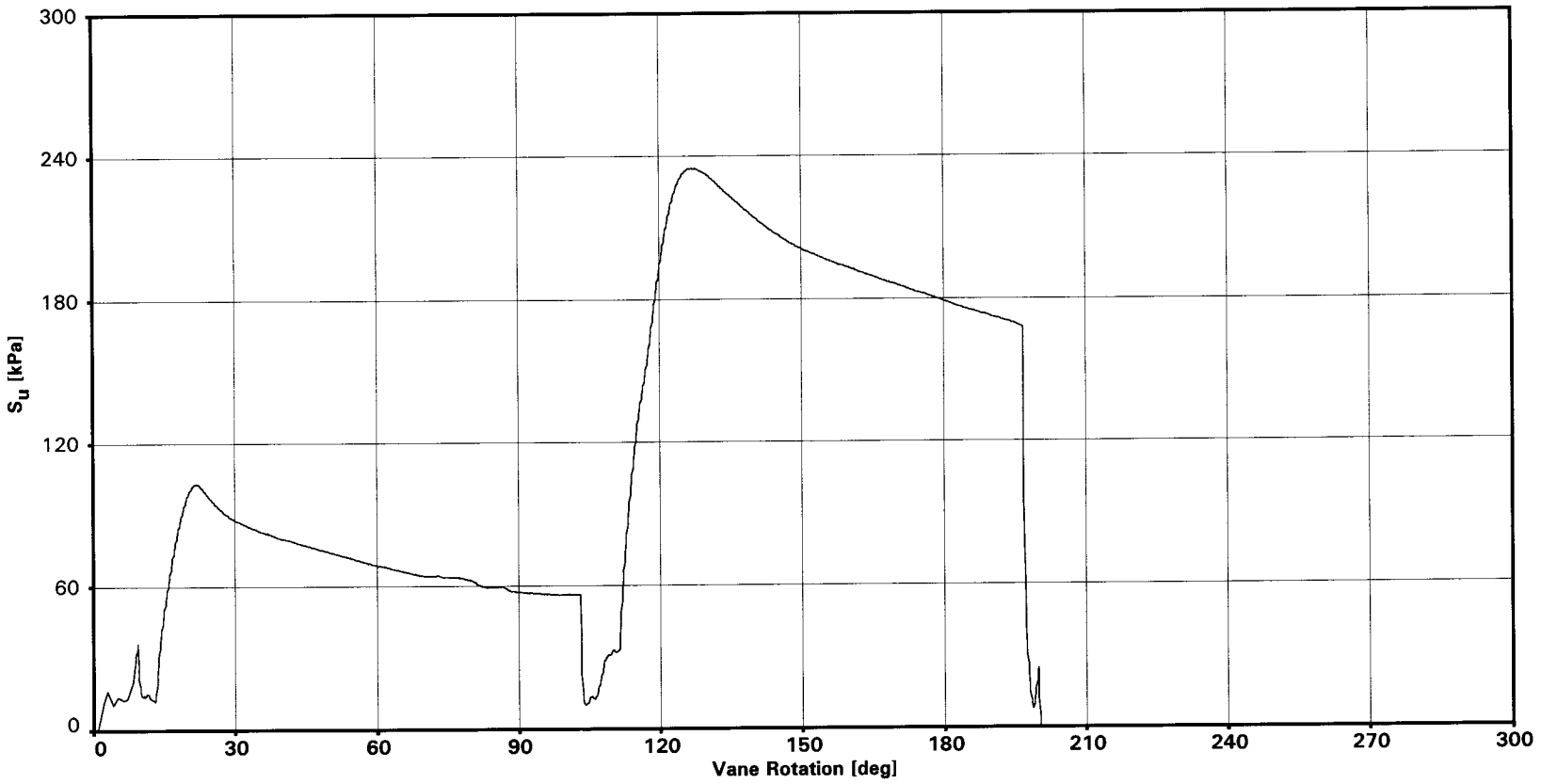
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 35.1m and 35.7m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

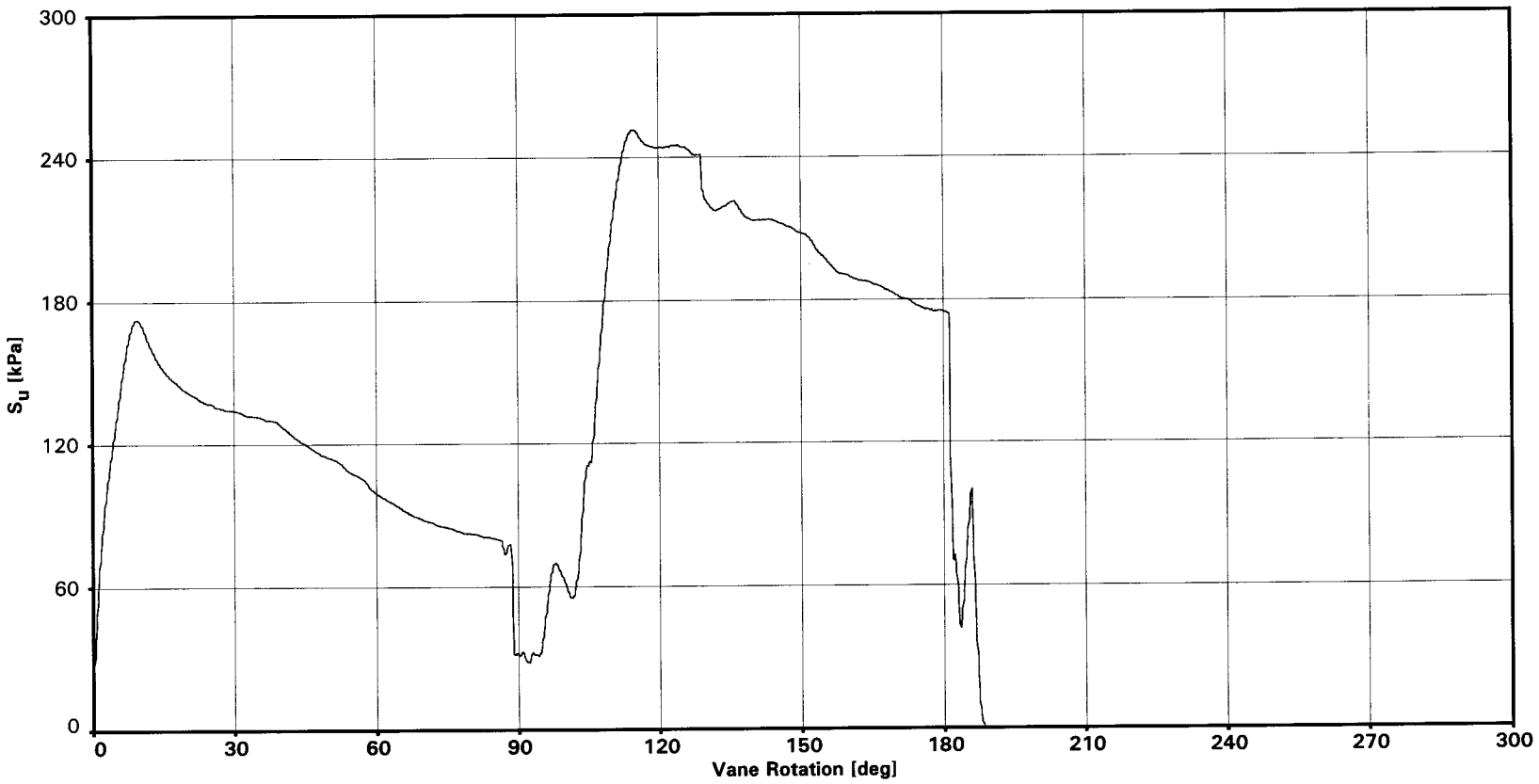
FUGRO

PLATE 98-55.2j

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 38.1m and 38.7m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

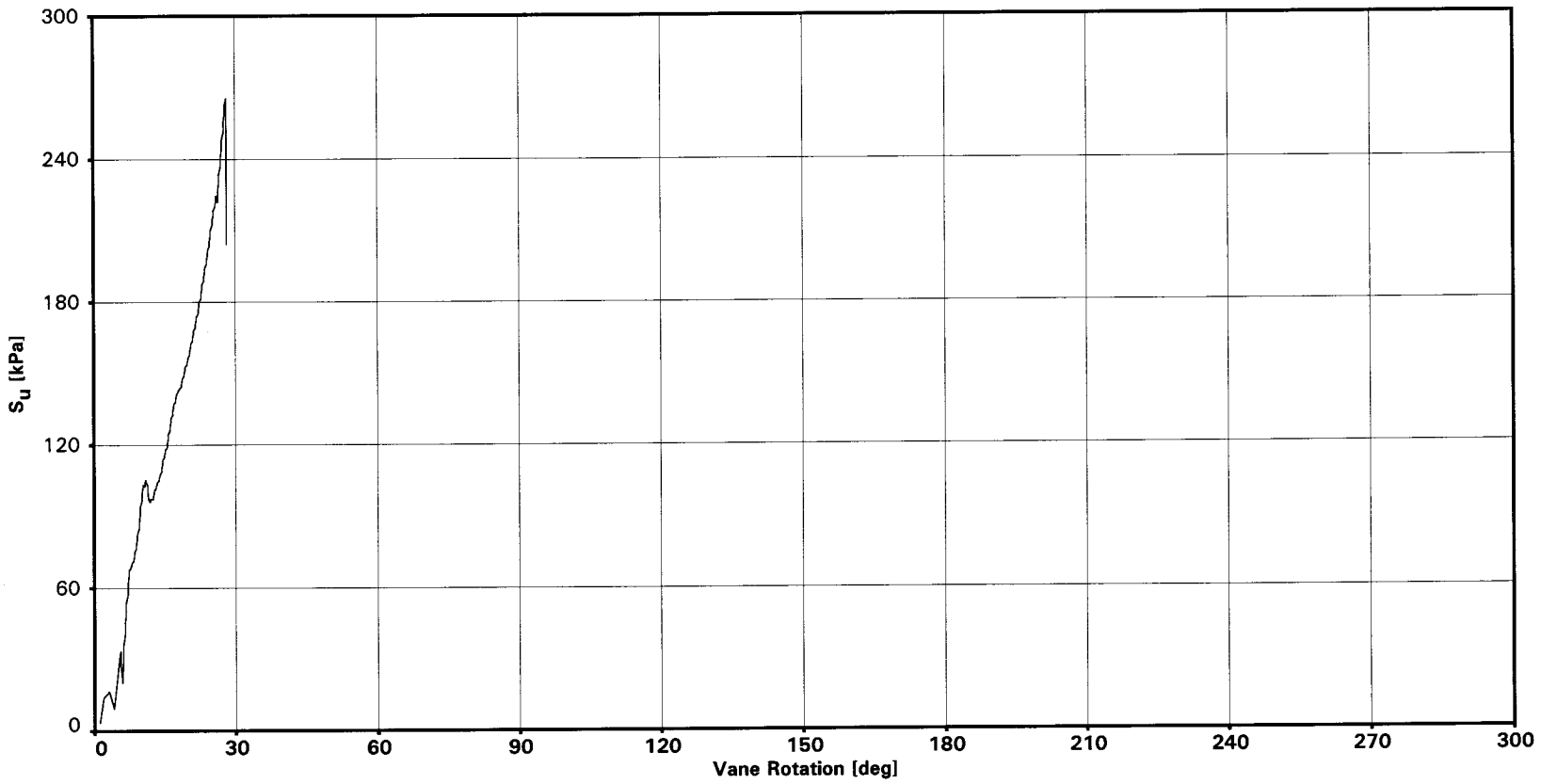
FUGRO

PLATE 98-55.2k

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 41.1m
Boring 98-55
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-55.2I

98-55		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.7	1	12					12																				
6.3	3	32					90																			H	
7.9	4	36	36	24	1.03	18.7		30.6																			
8.1	5	43	46	20	0.90	17.7		33.5				15.7			30.4		1.2										
8.2	6							23.0																			
9.1	400													66.1													
9.4	7	46				17.5		47.9			48.3	18.5															
9.6	8	47	56	21	0.74	17.2																					
9.8	9							33.5																			
10.7	401													75.2													
11.3	11	57									49.0																
12.2	402													42.1													
12.3	12	48				16.9																					2.72
12.5	13	47				17.1		33.5			42.4	16.2															
12.6	14	51	63	23	0.70	16.7									36.4		2.5										

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-55		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
12.8	15							33.5																			
13.7	403													48.4													
13.9	16	61				16.0		40.2			43.7	25.2															
14.0	17	36	71	29	0.17																						
14.2	18	50	60	21	0.75	17.0									40.5		1.6										
14.3	19							43.1																			
15.2	404													64.2													
15.7	21	22																									
17.2	22	22					8																				
18.6	24	32	61	18	0.34			95.8				56.9															
18.7	25					18.8		95.8																			
19.8	405													83.8													
20.4	406													105.8													
21.5	26	40	50	22	0.67																					C	2.73
21.6	27							95.8			100.5																

Identification Tests
MC = Moisture Content
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PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
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Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
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phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.3b

Earth Mechanics

FUGRO

98-55		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
21.8	28	39	46	21	0.70	17.9									95.1		0.9										
21.9	29								81.4																		
24.7	31								143.6																		
24.8	32	22	42	16	0.25	19.9		141.2	167.6		149.8																
25.9	407													231.3+													
26.5	408													114.9													
27.9	34	48	78	30	0.38	16.7									103.3	20.3	0.7										
28.0	35	45							95.8																		
29.0	409													149.9													
29.1	410													147.9													
29.6	411													147.9													
30.6	36	51	67	30	0.58																						2.71
30.8	37							83.8																			
30.9	38							83.8			102.8																
32.0	412													211.6													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.3c

Earth Mechanics

FUGRO

98-55		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
32.6	413													125.9													
34.0	39	45	63	25	0.54																					C	
34.1	40	46	80	28	0.34						125.0																
35.1	414													101.0													
35.7	415													231.3+													
36.9	41								86.2																		
37.0	42	41	58	19	0.56	18.9		119.7							99.3		0.9										
37.2	43							107.7			179.5																
38.1	416													170.0													
38.7	417													248.0+													
40.1	45	52	62	25	0.73	18.0									105.7	24.5	3.2										
40.2	46							107.7	143.6		163.4																
43.2	47	32	51	21	0.40																					C	
43.3	48	29	42	20	0.40						222.8+																
46.0	49								203.5																		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-55
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-55.3d

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98-55		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
46.2	50	24	24	17	0.93	20.6																					
46.3	51										222.8+																
49.1	52								155.6																		
49.2	53	41	81	26	0.27	17.9			167.6							60.4											
49.4	54										216.6																
52.3	55	16	31	12	0.21																					C	
52.4	56	17	30	13	0.28						222.8+																
55.2	57								191.5																		
55.3	58	38	68	23	0.33	18.2									145.3	82.0	0.7										
55.5	59										222.8+																
58.4	61	45	81	29	0.32	17.6									210.9		1.3										
58.5	62										210.4																
61.5	63	42	68	25	0.40																					C	
61.6	64	43	68	26	0.40						209.2																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-55
SFOBB East Span Seismic Safety Project

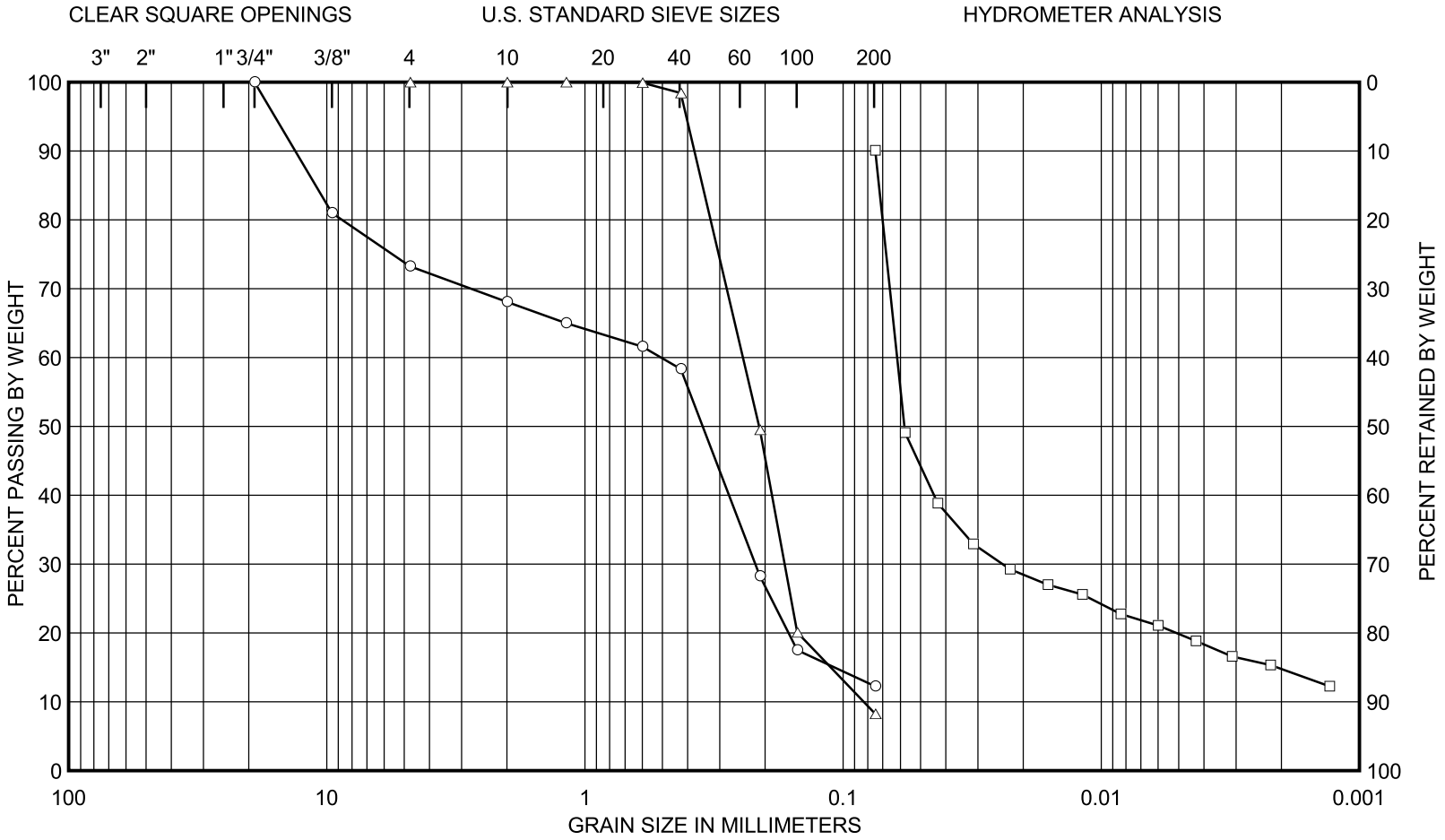
SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-55.3e

c:\snfco-oak\current\odb\98-55sume.odb



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.7	○—○	SILTY FINE SAND (SM) with fine gravel and a trace of medium sand			0.35
3	6.3	□—□	LEAN CLAY (CL)			0.058
22	17.2	△—△	FINE SAND (SP-SM) with silt	1.4	2.9	0.21

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-55
SFOBB East Span Seismic Safety Project

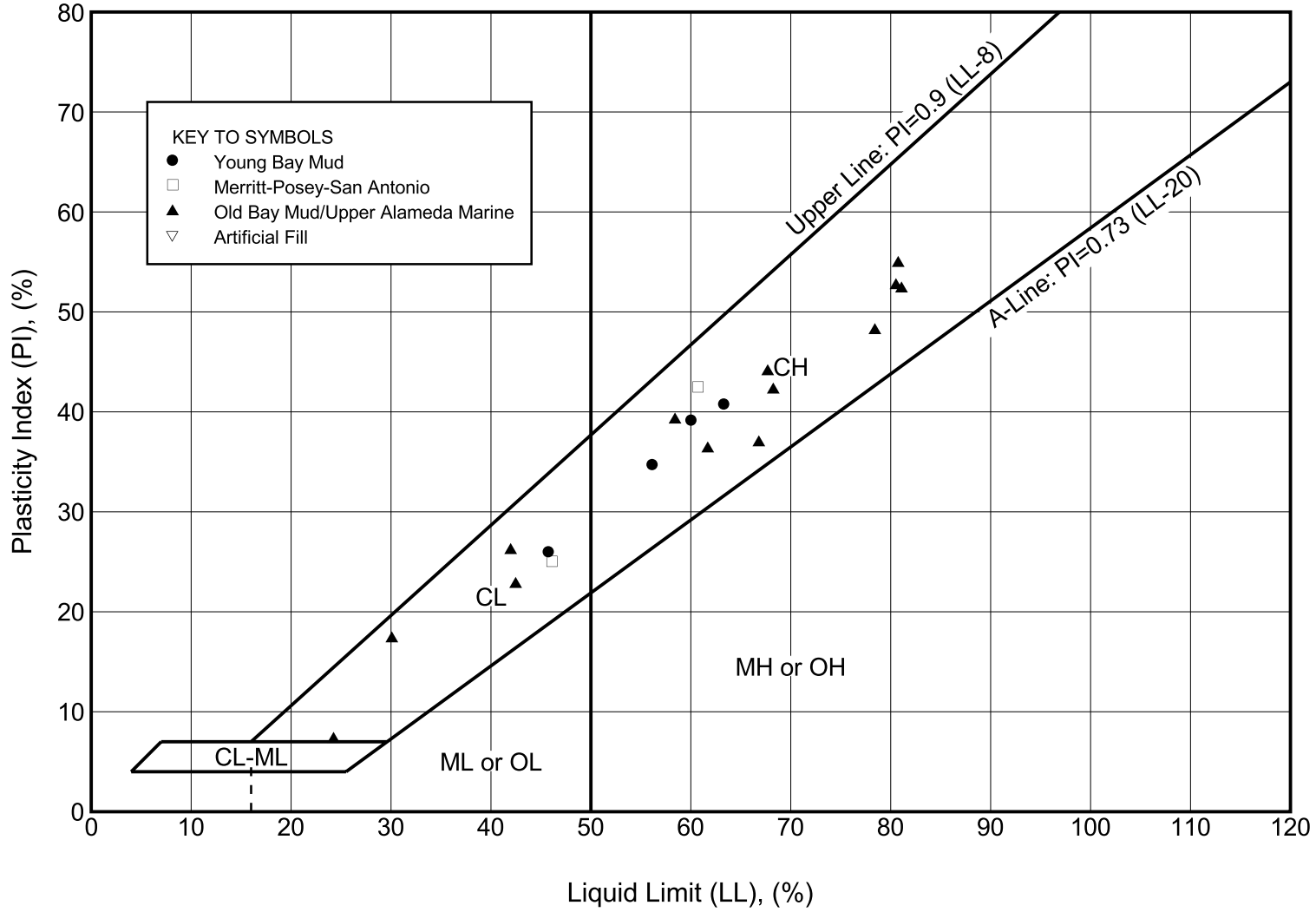
SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-55.4

c:\snfco-oak\current\odb\98-55grn.odb



PLASTICITY CHART
Boring 98-55
SFOBB East Span Seismic Safety Project

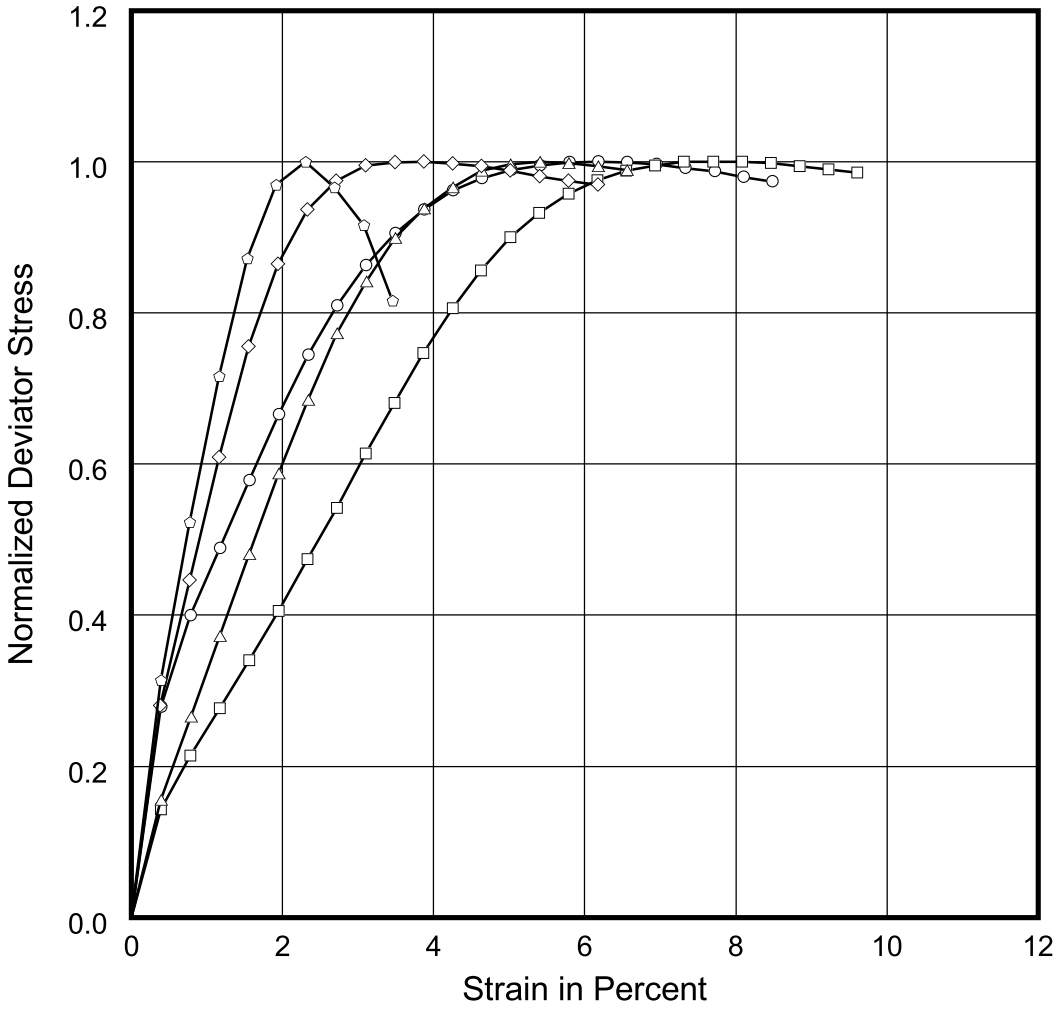
PLATE 98-55.5

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

c:\snfco-oak\current\odb\98-55pla.odb



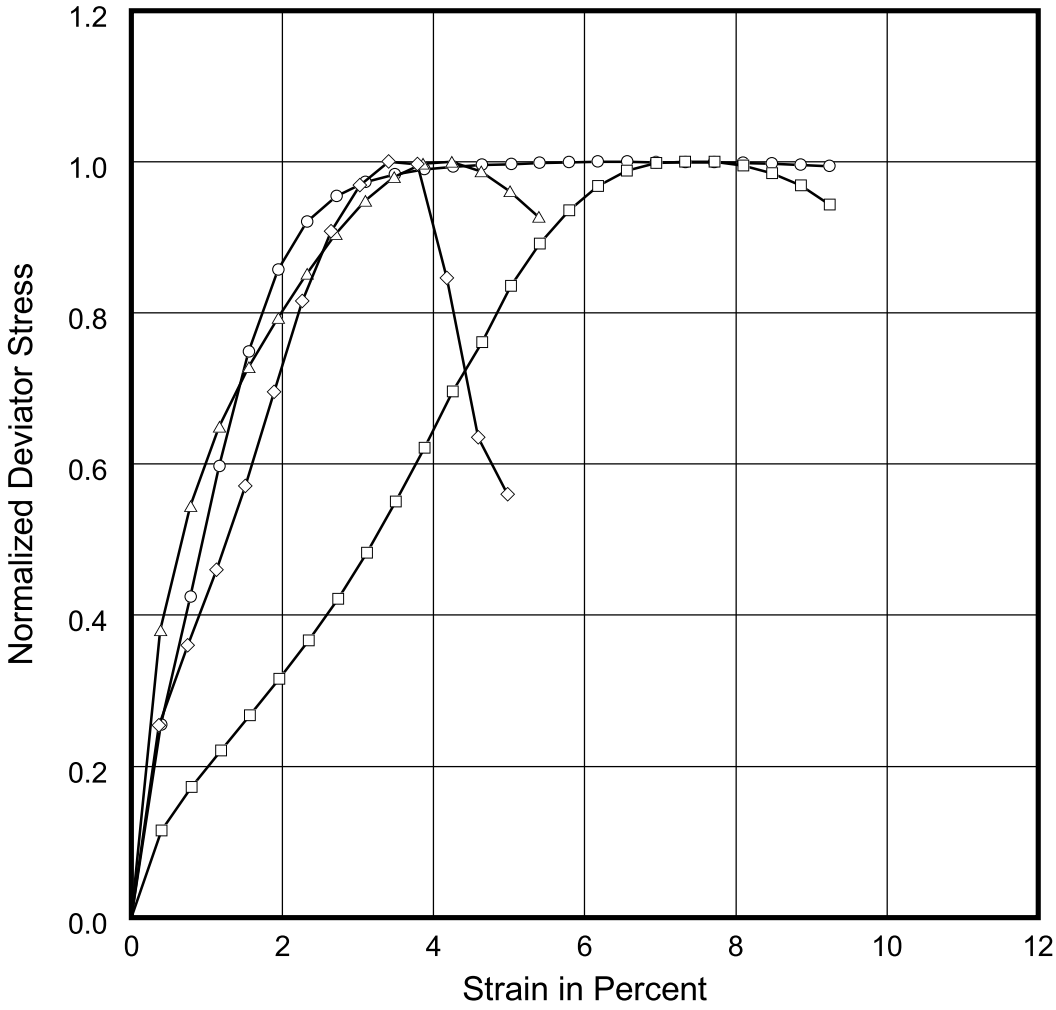
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	5	8.1	UU	152	61	1.2
□	14	12.6	UU	241	73	2.5
△	18	14.2	UU	276	81	1.6
◇	28	21.8	UU	758	190	0.9
⬠	34	27.9	UU	862	207	0.7

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.6a



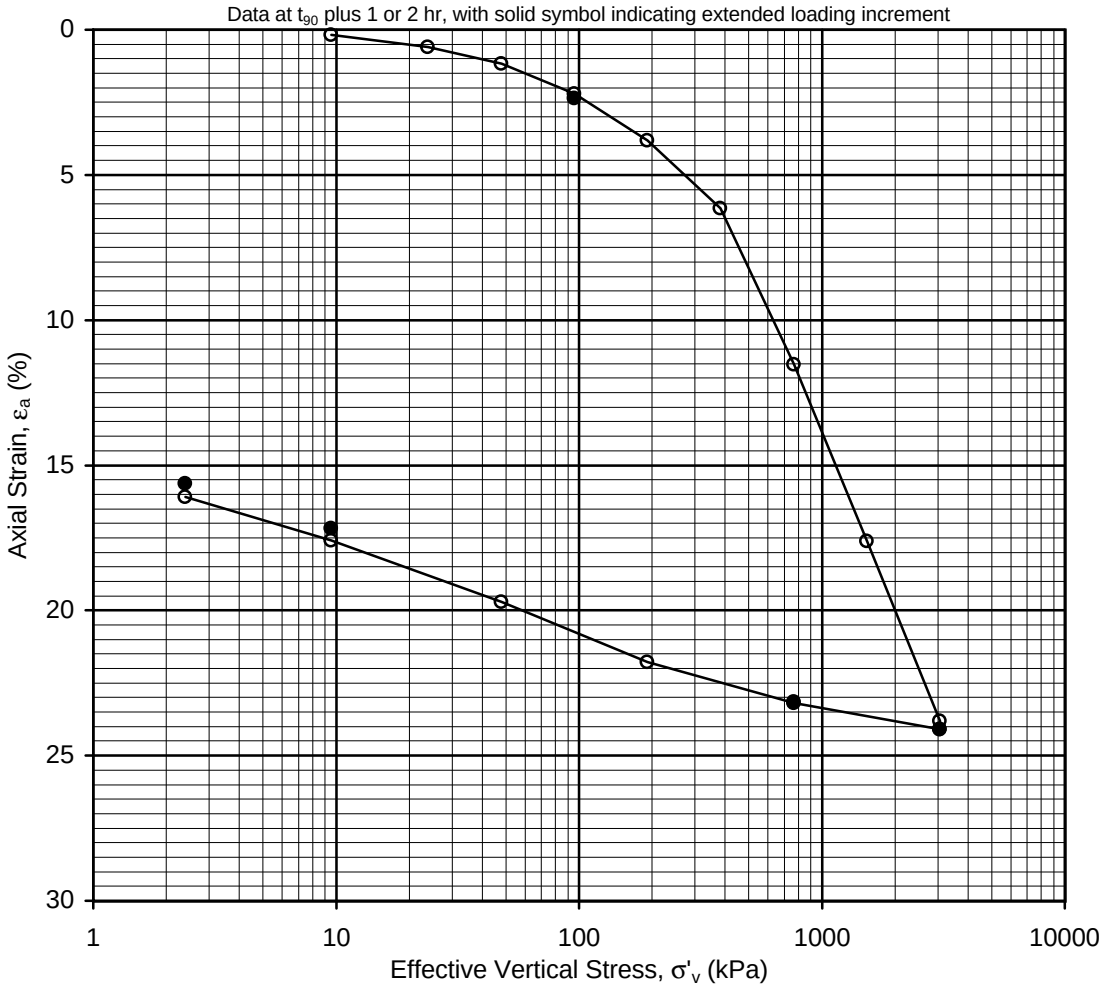
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	42	37.0	UU	1034	199	0.9
□	45	40.1	UU	1103	211	3.2
△	58	55.3	UU	1379	291	0.7
◇	61	58.4	UU	1448	422	1.3

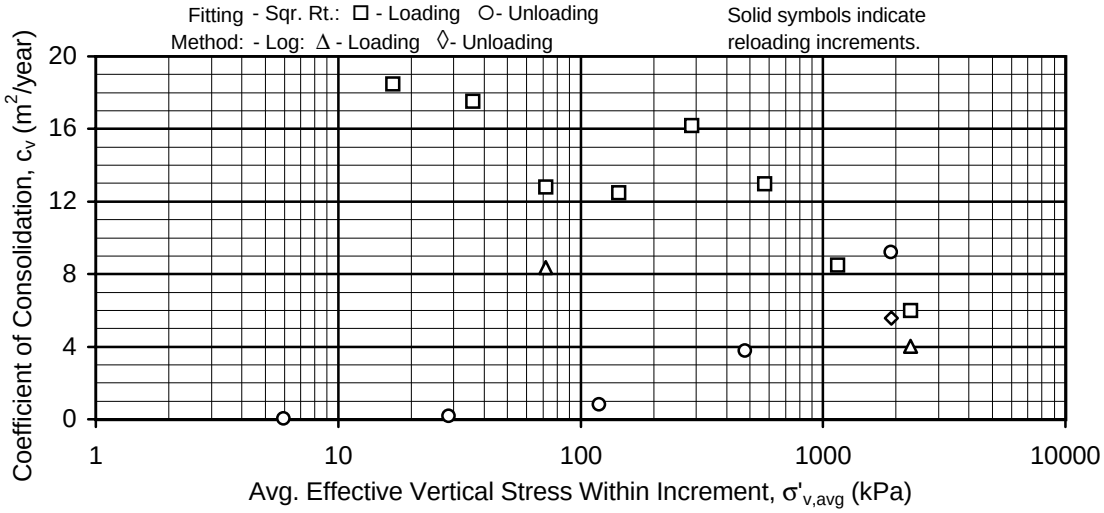
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-55
SFOBB East Span Seismic Safety Project

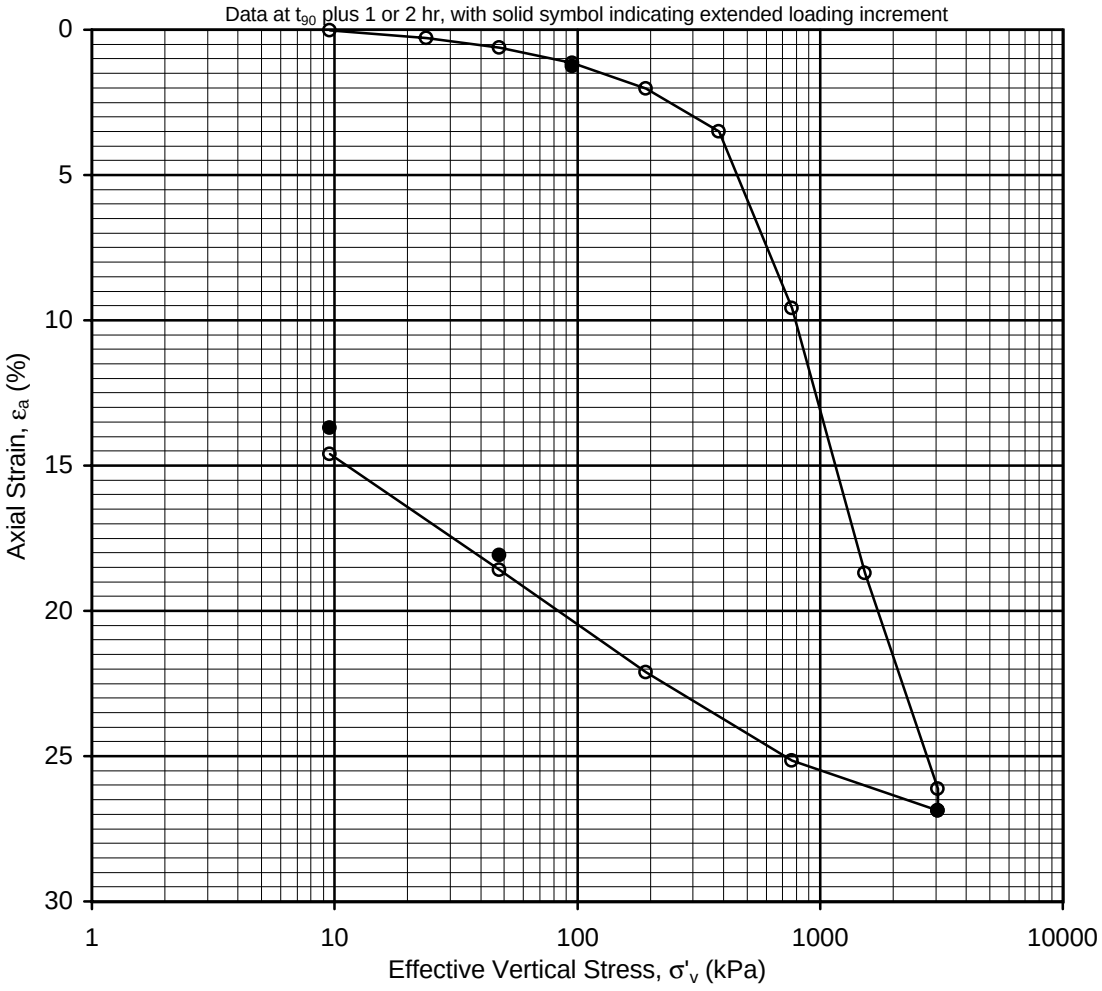
PLATE 98-55.6b

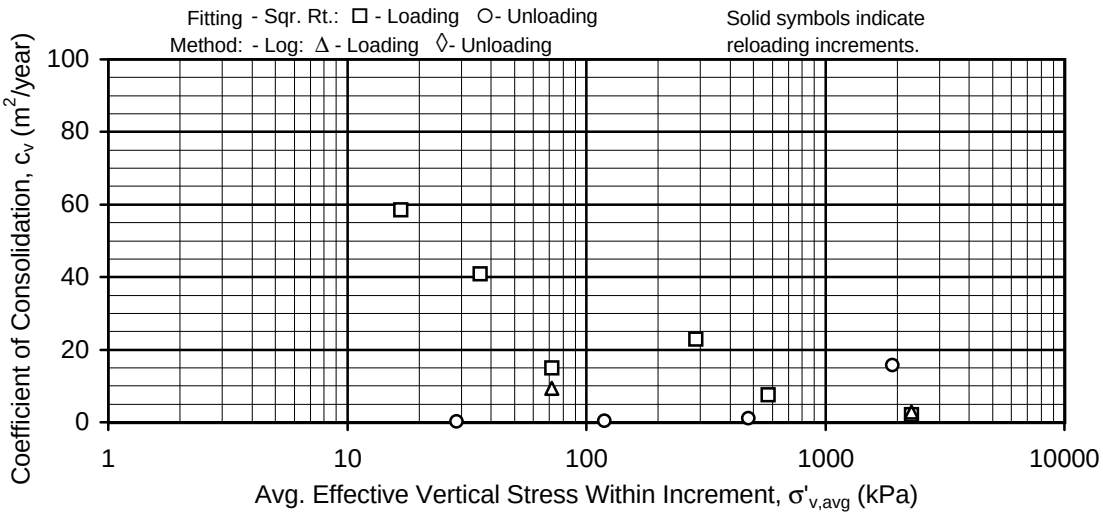




INCREMENTAL CONSOLIDATION TEST RESULTS

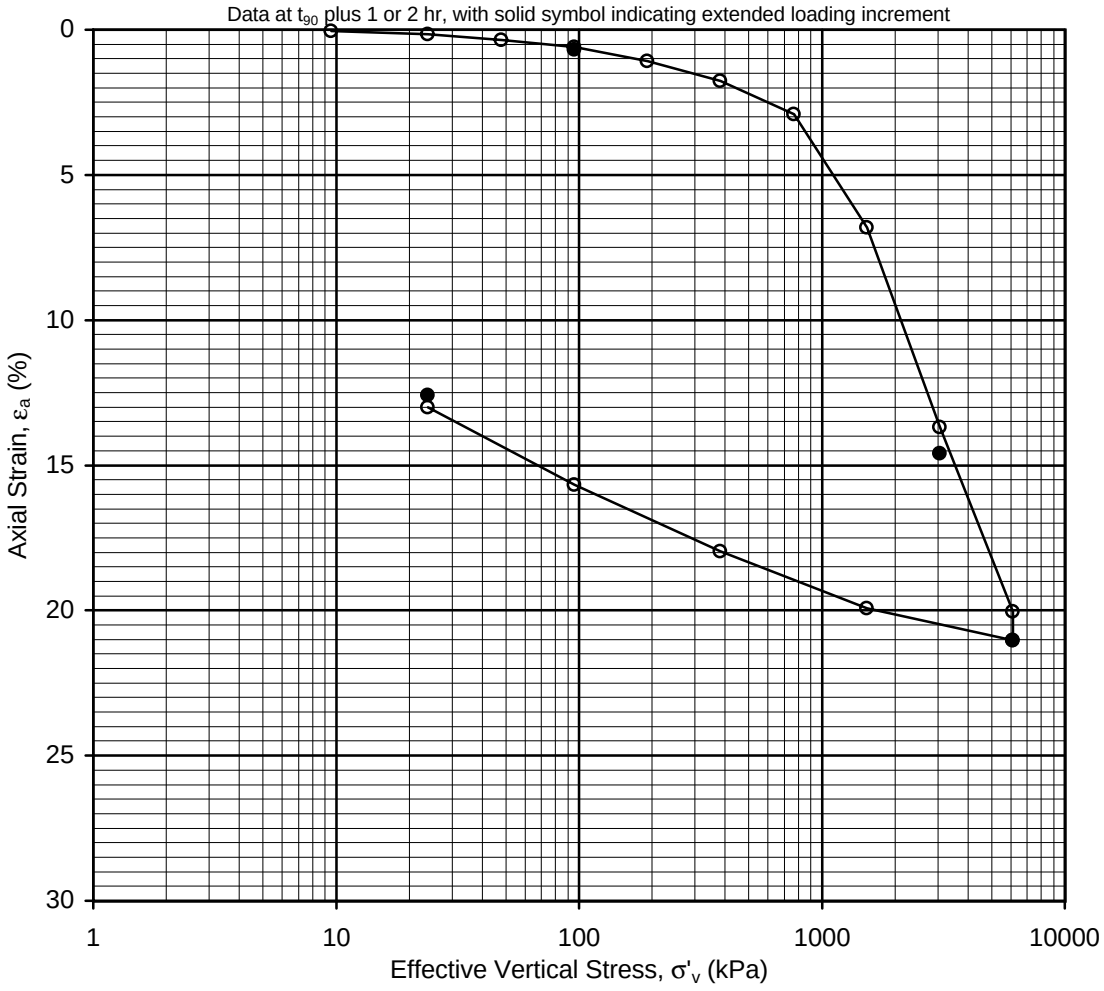
Sample No. 26 - Depth: 21.5m
Boring 98-55
SFOBB East Span Seismic Safety Project

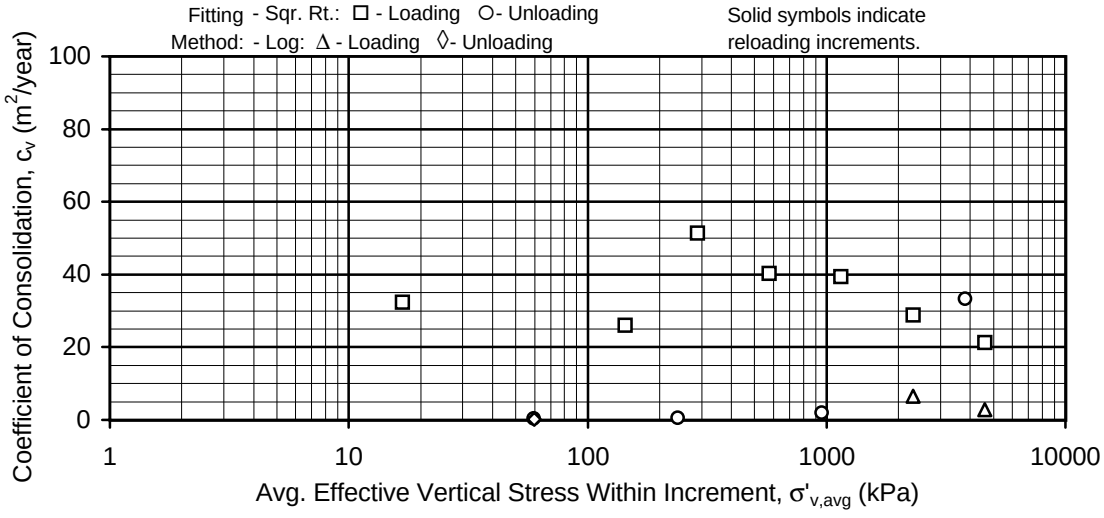




INCREMENTAL CONSOLIDATION TEST RESULTS

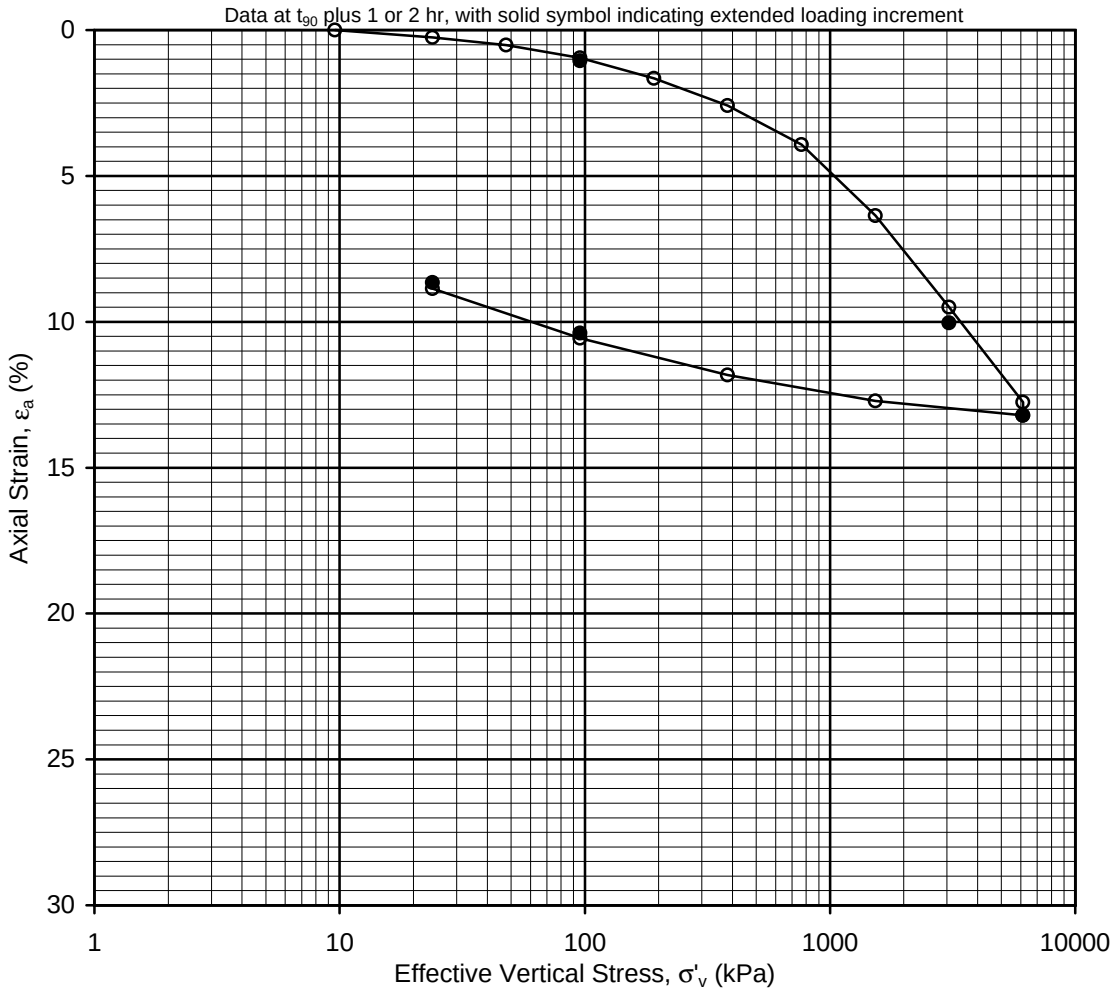
Sample No. 39 - Depth: 34.0m
Boring 98-55
SFOBB East Span Seismic Safety Project

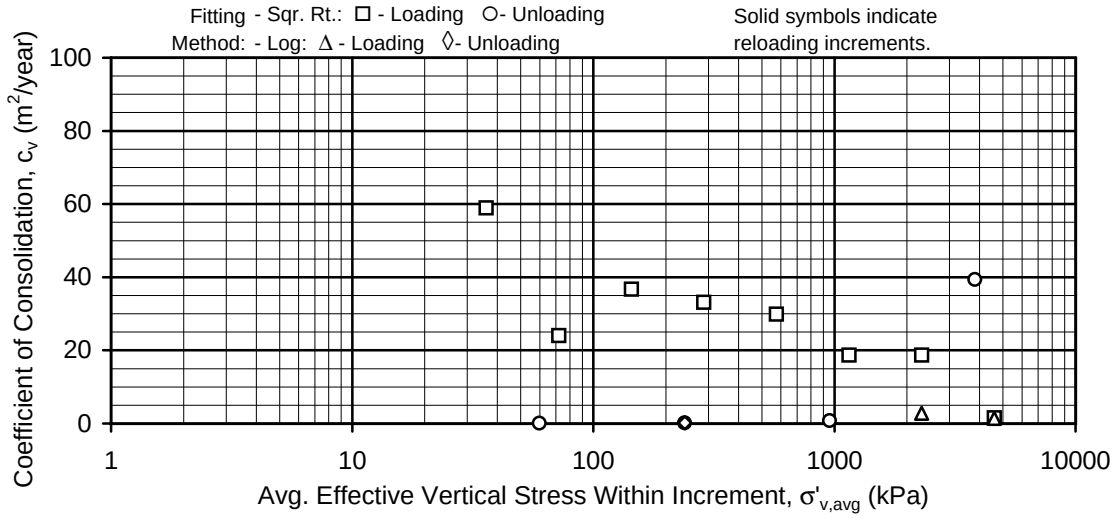




INCREMENTAL CONSOLIDATION TEST RESULTS

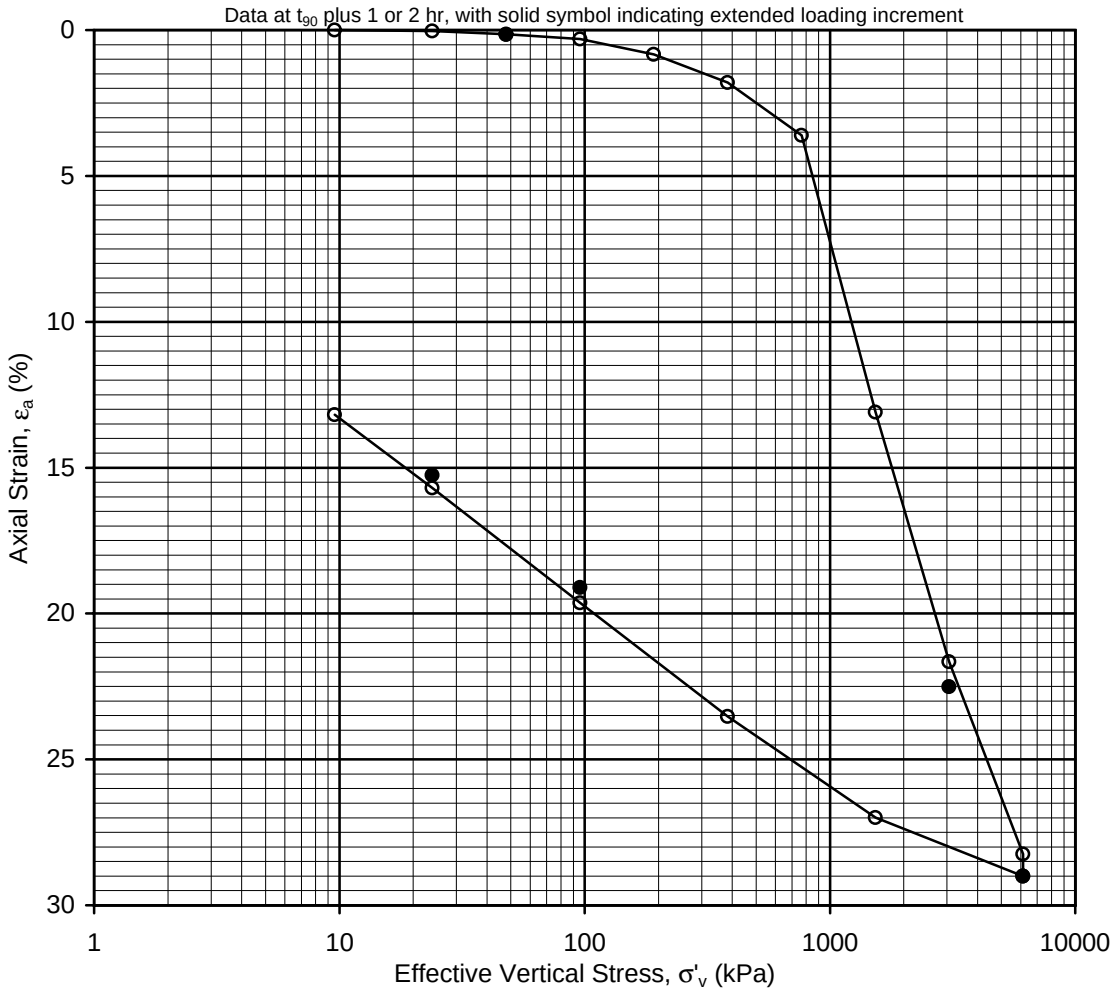
Sample No. 47 - Depth: 43.1m
Boring 98-55
SFOBB East Span Seismic Safety Project

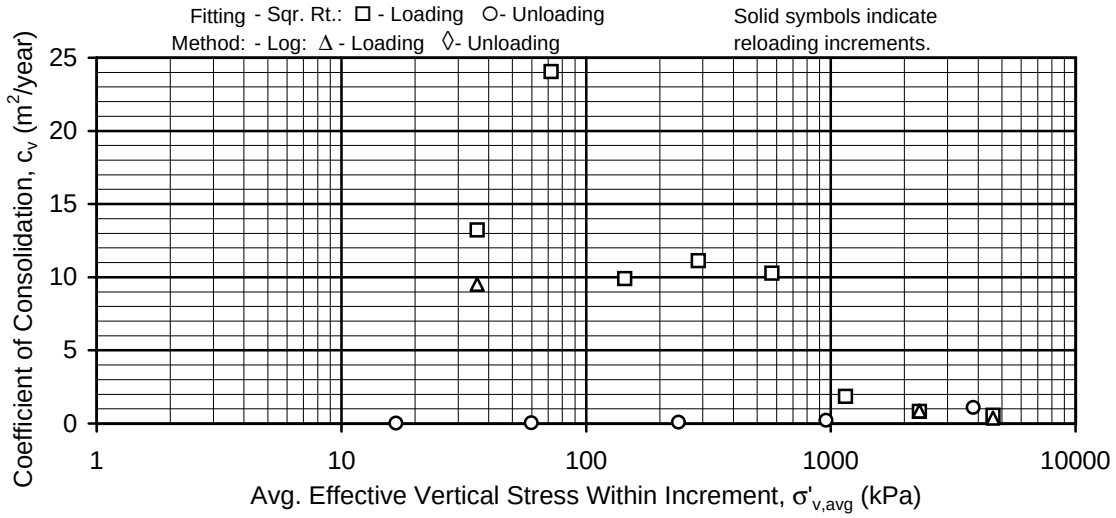




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 55 - Depth: 52.3m
Boring 98-55
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

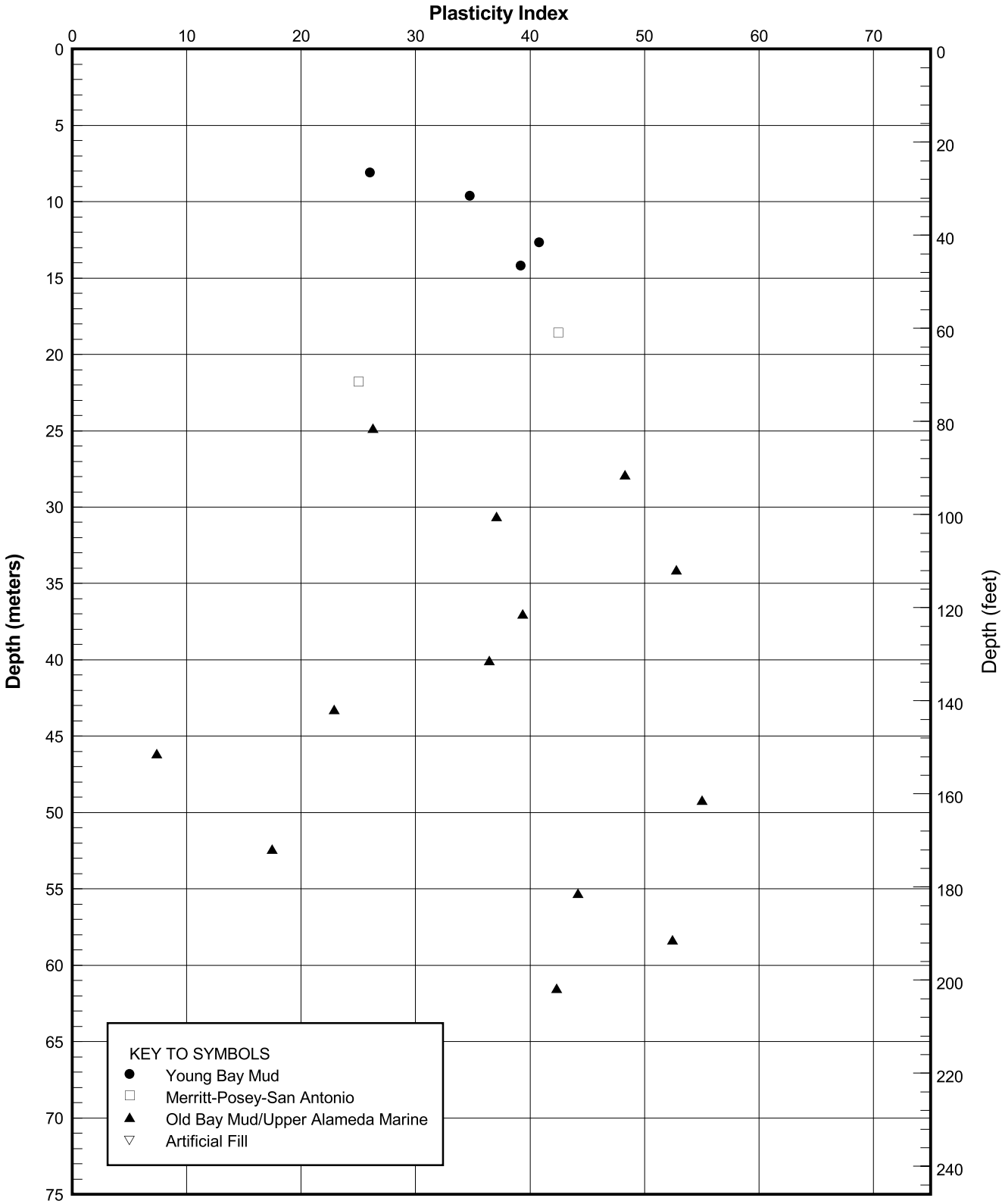
Sample No. 63 - Depth: 61.4m
Boring 98-55
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

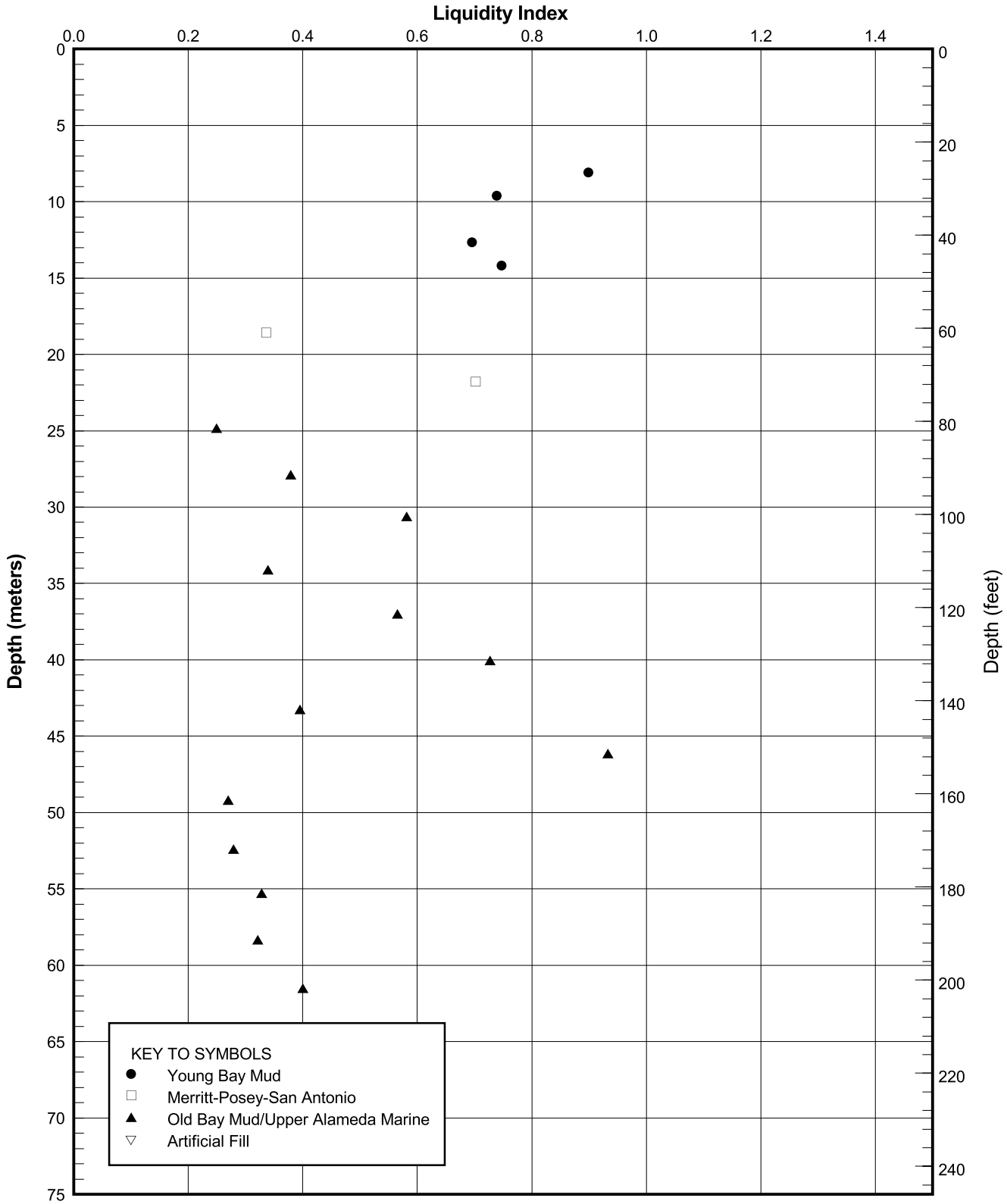
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



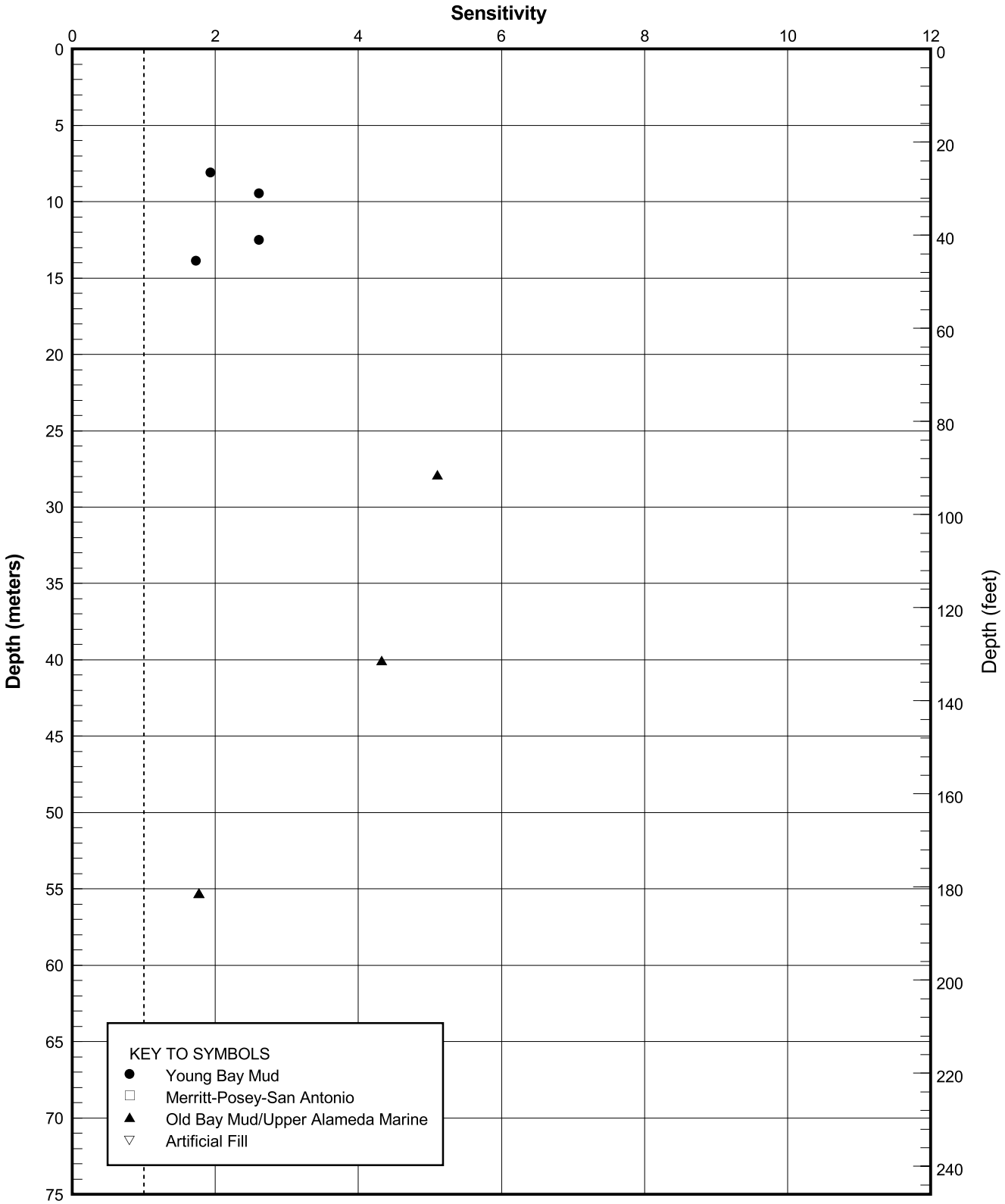
PLASTICITY INDEX PROFILE
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.12



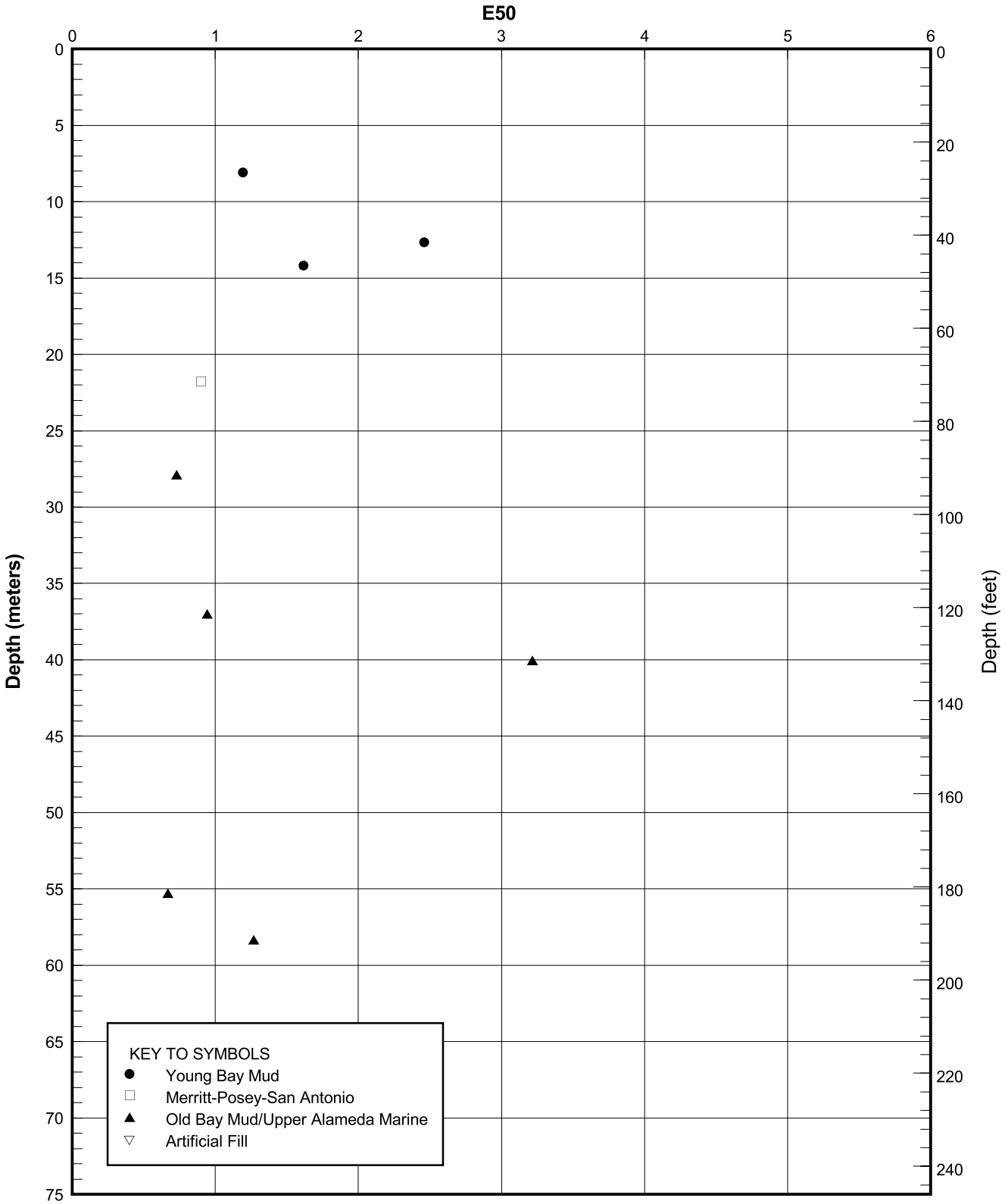
LIQUIDITY INDEX PROFILE
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.13



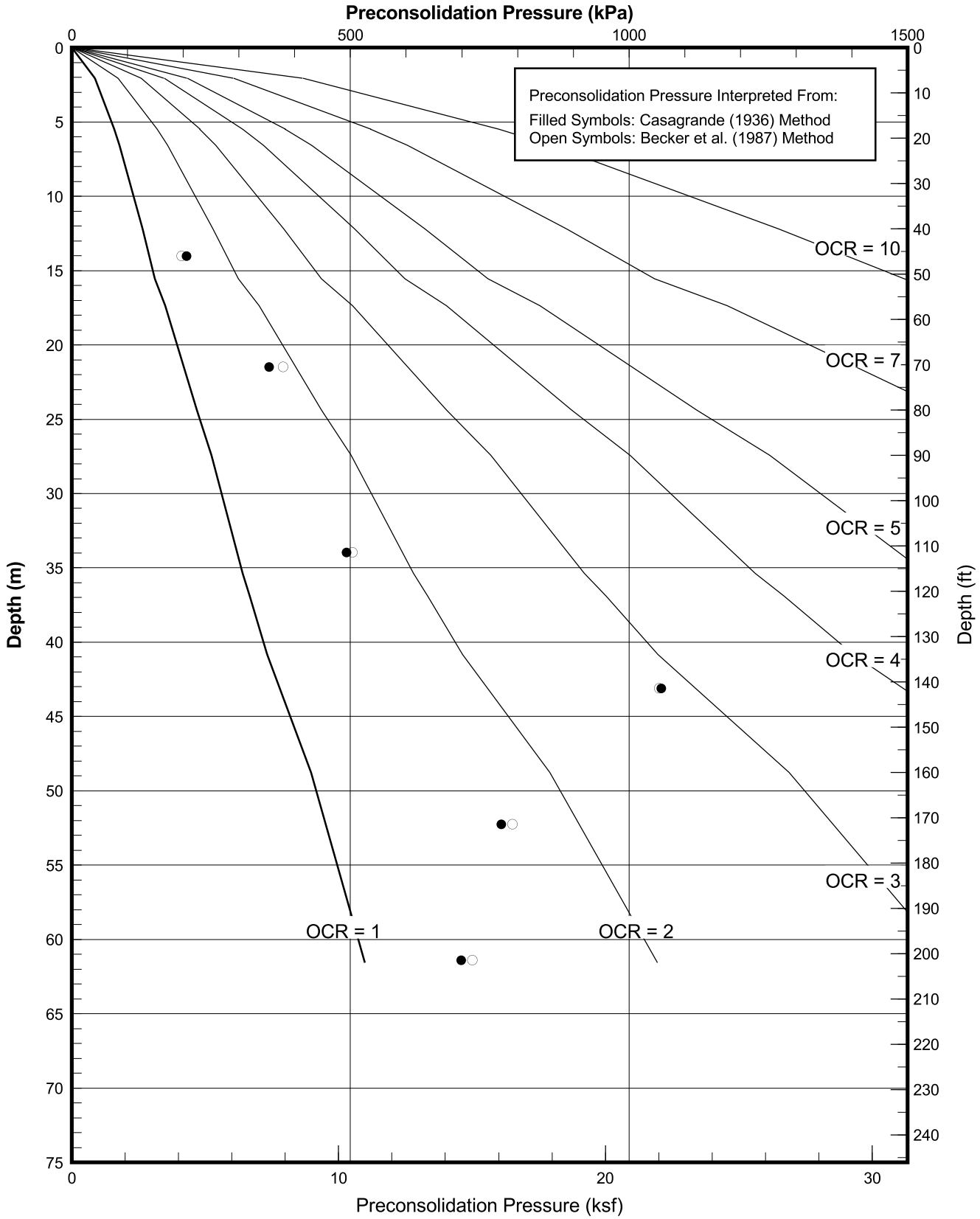
SENSITIVITY PROFILE
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.14



E50 PROFILE
Boring 98-55
SFOBB East Span Seismic Safety Project

PLATE 98-55.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-55

SFOBB East Span Seismic Safety Project

PLATE 98-55.16

LAND BORING 98-56

PROJECT NO: 98-42-0058
BORING: 98-56 (17m left of E. Sta. 87+21)
START DATE: 9/30/98
COMPLETION DATE: 10/1/98
DRILLER: Pitcher Drilling Company
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1839212 N648294
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.1m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
2	0				Fine SAND with silt (SP-SM), medium dense, brown -moist to 2.5m	I
	2			16	-with a silt pocket at 2.0m	
0	4			16	-wet below 3.0m (▽ 3.1m) -with shell fragments, below 3.0m -gray to dark gray, 3.7m to 7.8m	
-2	6			33	-silty fine sand with clay pockets at 4.7m -with a clay seam at 4.9m -fat clay, 5.0m to 5.3m	
				51		
-4	8			17	-olive gray to gray, below 7.8m	
-6					(9.1m)	
	10			7	Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -dark gray to black at 9.1m -lean clay to 11.5m	II
-8				PUSH	-with silt pockets at 11.0m	
	12			PUSH	-with fine sand at 12.5m	
-10						
	14			SAVE	-gray fine sand with silt, 14.0m to 14.8m	
-12				PUSH	-with organic pockets and a few silt pockets, at 15.5m	
	16					
-14				PUSH	-with gas blisters at 17.1m	
	18					
-16				SAVE	-with shell fragments at 18.6m (18.7m)	
	20			PUSH	Clayey Fine SAND (SC), dense, greenish gray -sandy lean clay, 19.1m to 19.8m -fat clay layer at 19.8m	III
-18						
	22			47	-with clay pockets at 21.6m	
-20				73/30cm	-with a sandy clay seam at 23.2m	
	24				(24.5m)	
				39	Fat CLAY (CH), very stiff, greenish gray -with many sand pockets at 24.5m -with a sand layer at 25.6m	IV
-22						
	26			14	-mottled reddish-brown with black staining, at 26.1m	
-24					(27.3m)	
				PUSH	Fat CLAY (CH), very stiff, greenish gray -sandy lean clay at 27.4m -dense, greenish gray, fine sand, 27.6m to 27.9m	V
	28					
-26				37	-with brown organic pockets, and fine sand pockets and partings, at 29.3m	
	30					
-28						
	32			PUSH	-with sand pockets, organic pockets, and silt pockets and partings, at 32.3m	
-30						
	34					
-32				24	-with silt pockets and sand pockets, below 35.1m	
	36					
-34						
	38				(38.1m)	
				SAVE	Lean CLAY (CL), very stiff to hard, greenish gray -with silt pockets and sand pockets, at 38.4m	VI
-36						
	40					
-38				87/30cm	-with organic pockets and silt pockets, at 41.5m	
	42					
-40						
	44				-fat clay with silt pockets, below 43.9m	
				PUSH		
-42					TOTAL DEPTH: 44.8m BACKFILLED WITH: Cement Grout	
	46					
-44						
	48					
-46						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-56.1

LOG OF BORING AND TEST RESULTS
BORING 98-56
SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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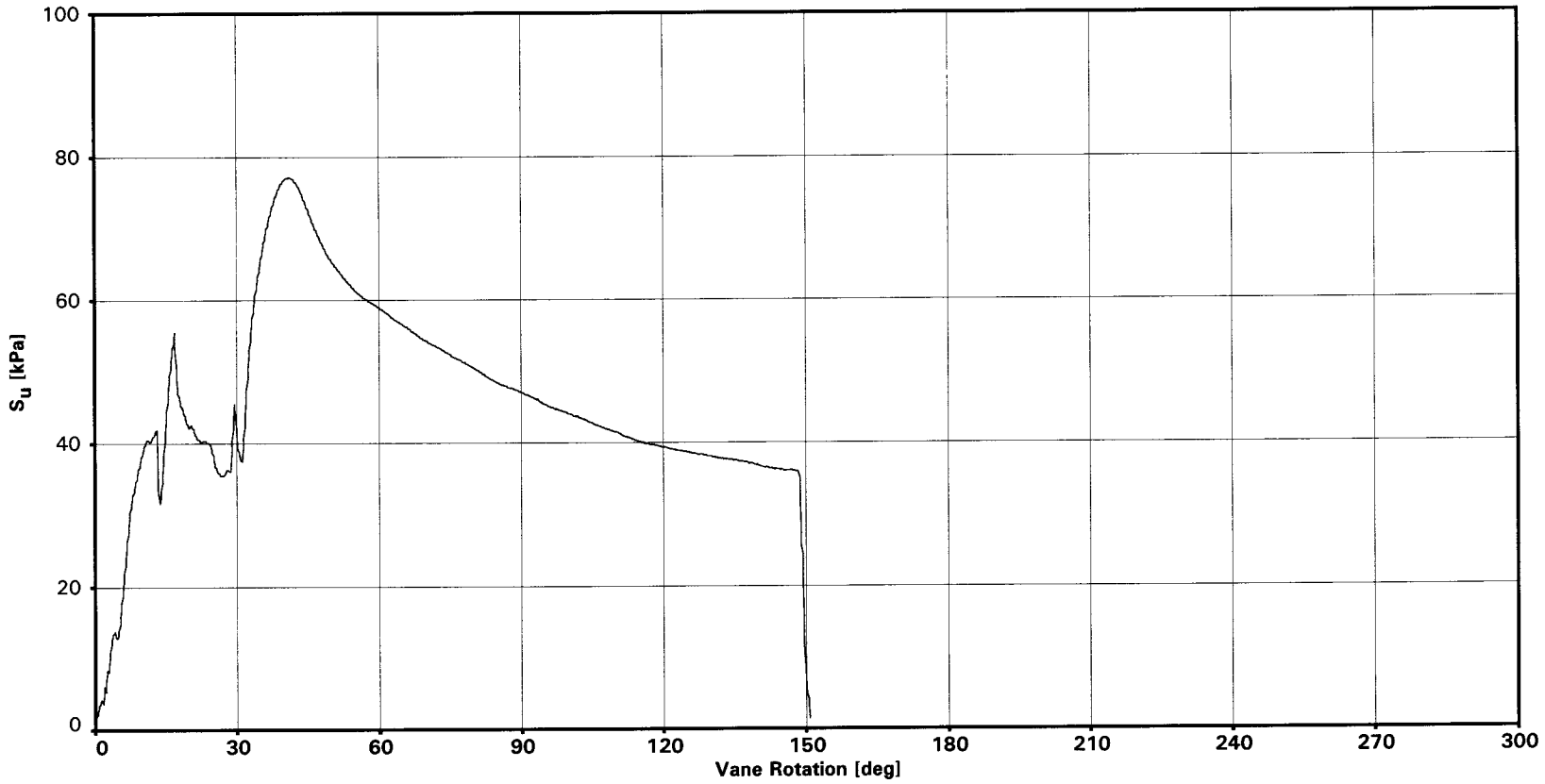
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 13.7m
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.2a

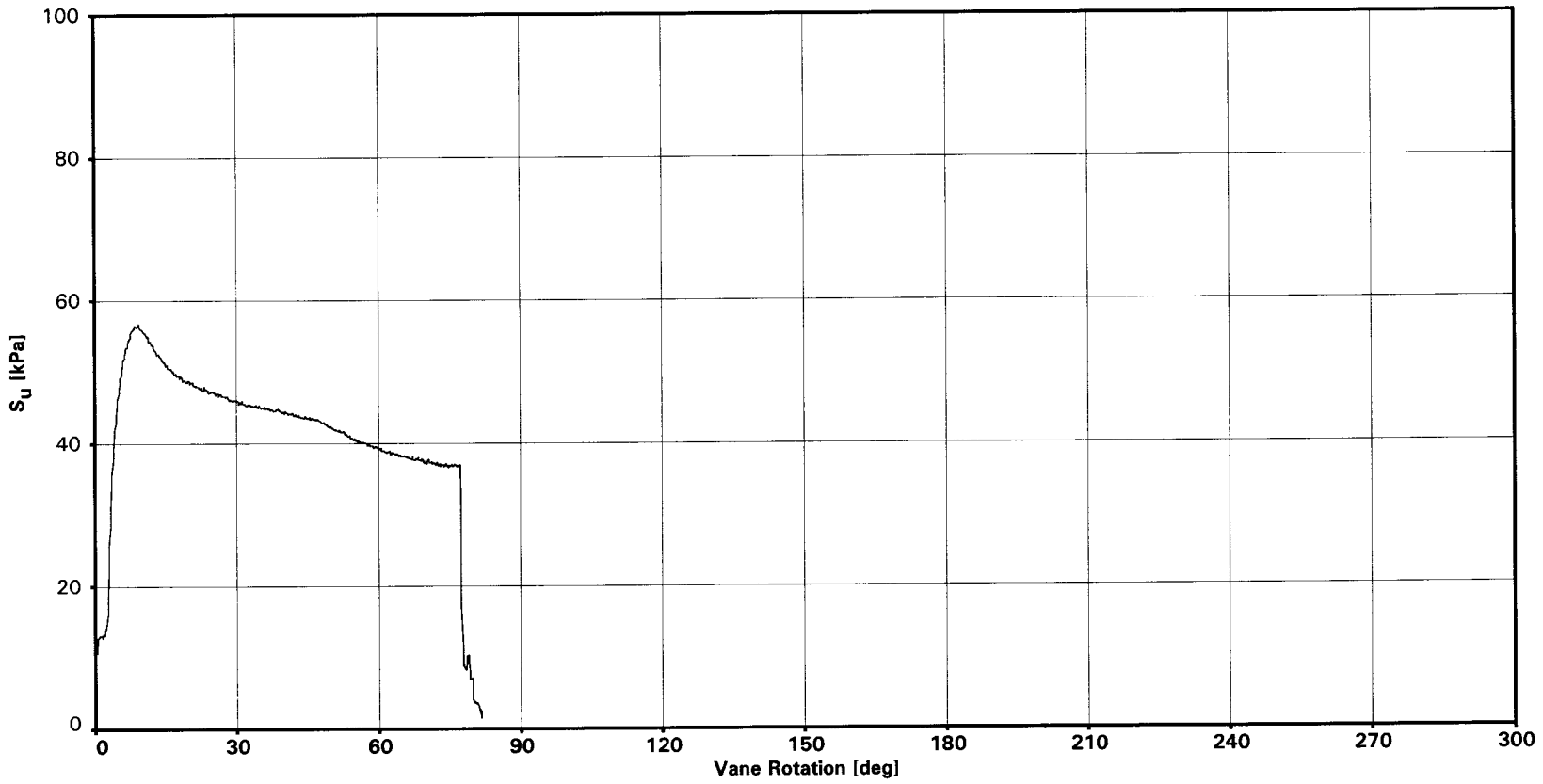
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 16.8m
Boring 98-56
SFOBB East Span Seismic Safety Project

Earth Mechanics

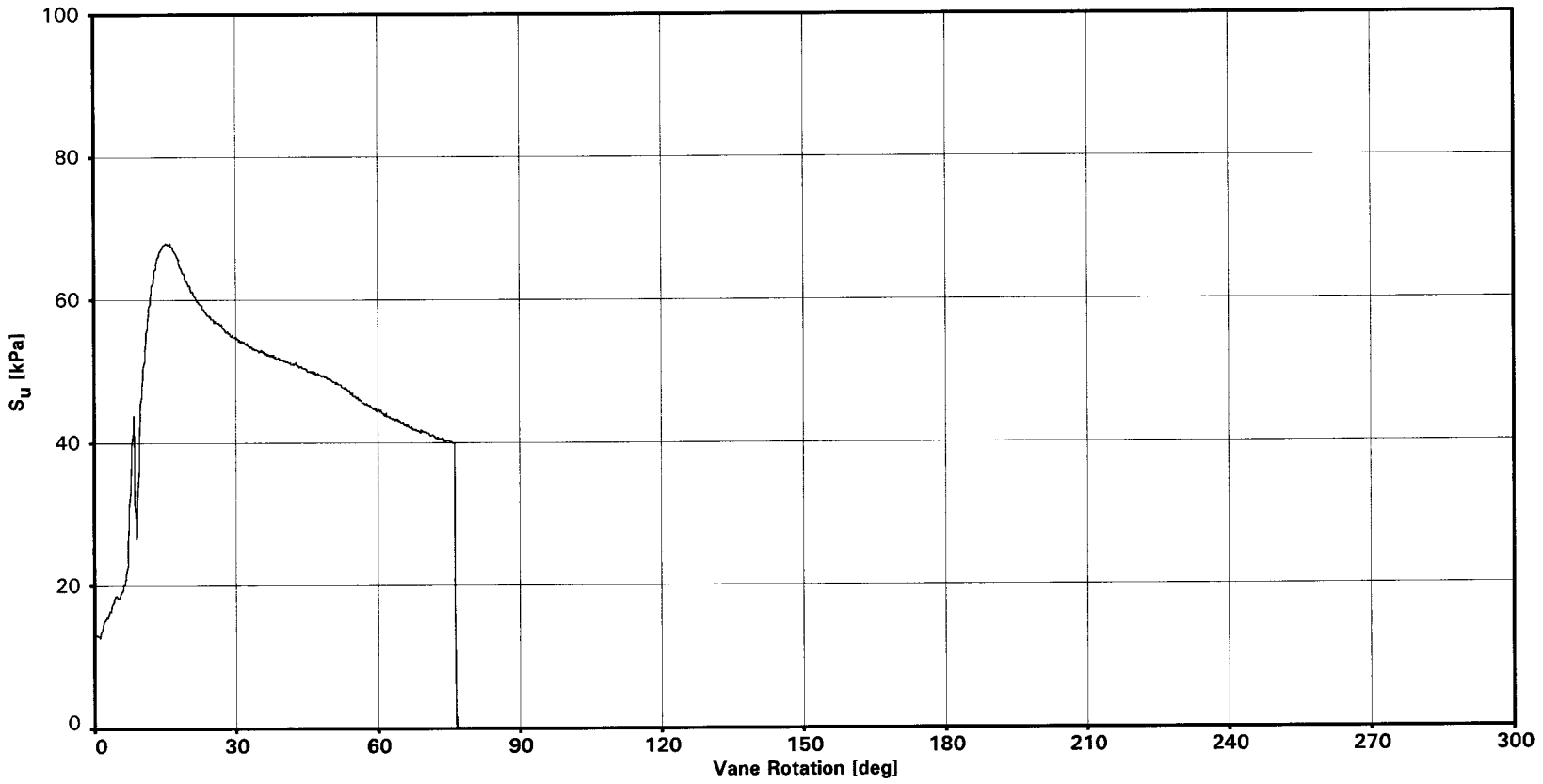
FUGRO

PLATE 98-56.2b

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 18.3m
Boring 98-56
SFOBB East Span Seismic Safety Project

Earth Mechanics

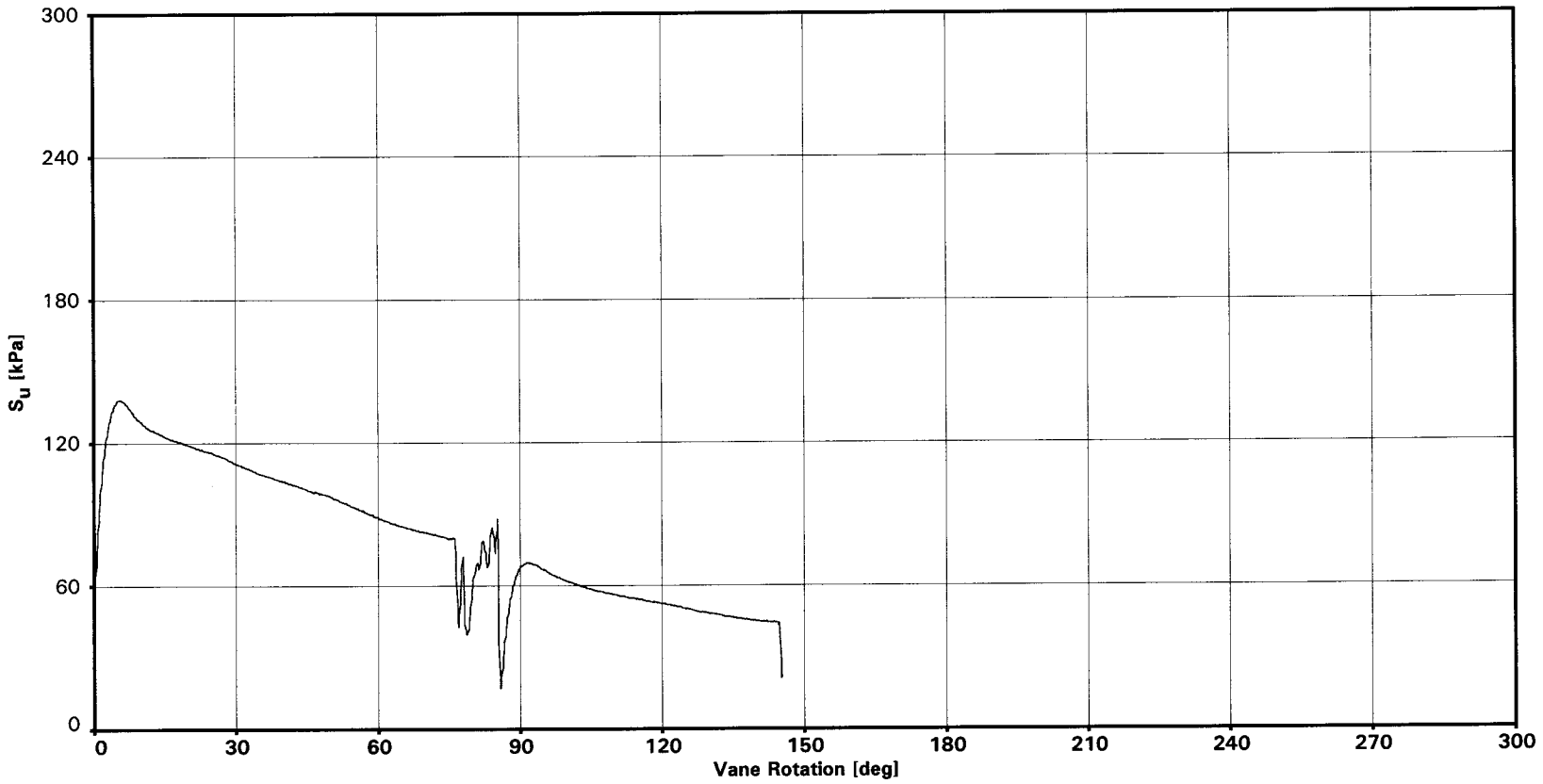
FUGRO

PLATE 98-56.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 30.5m
Boring 98-56
SFOBB East Span Seismic Safety Project

Earth Mechanics

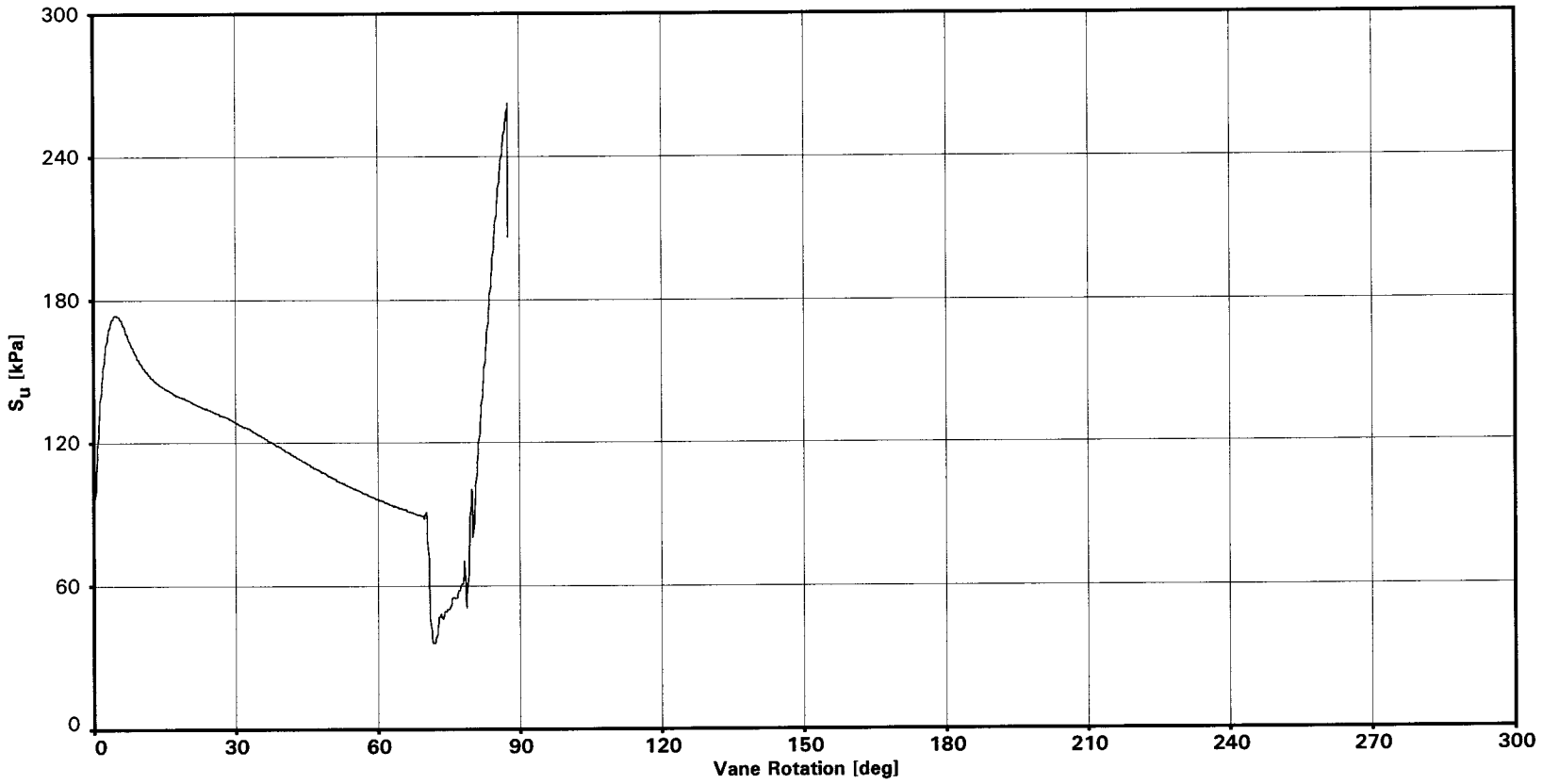
FUGRO

PLATE 98-56.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 33.5m and 34.1m
Boring 98-56
SFOBB East Span Seismic Safety Project

Earth Mechanics

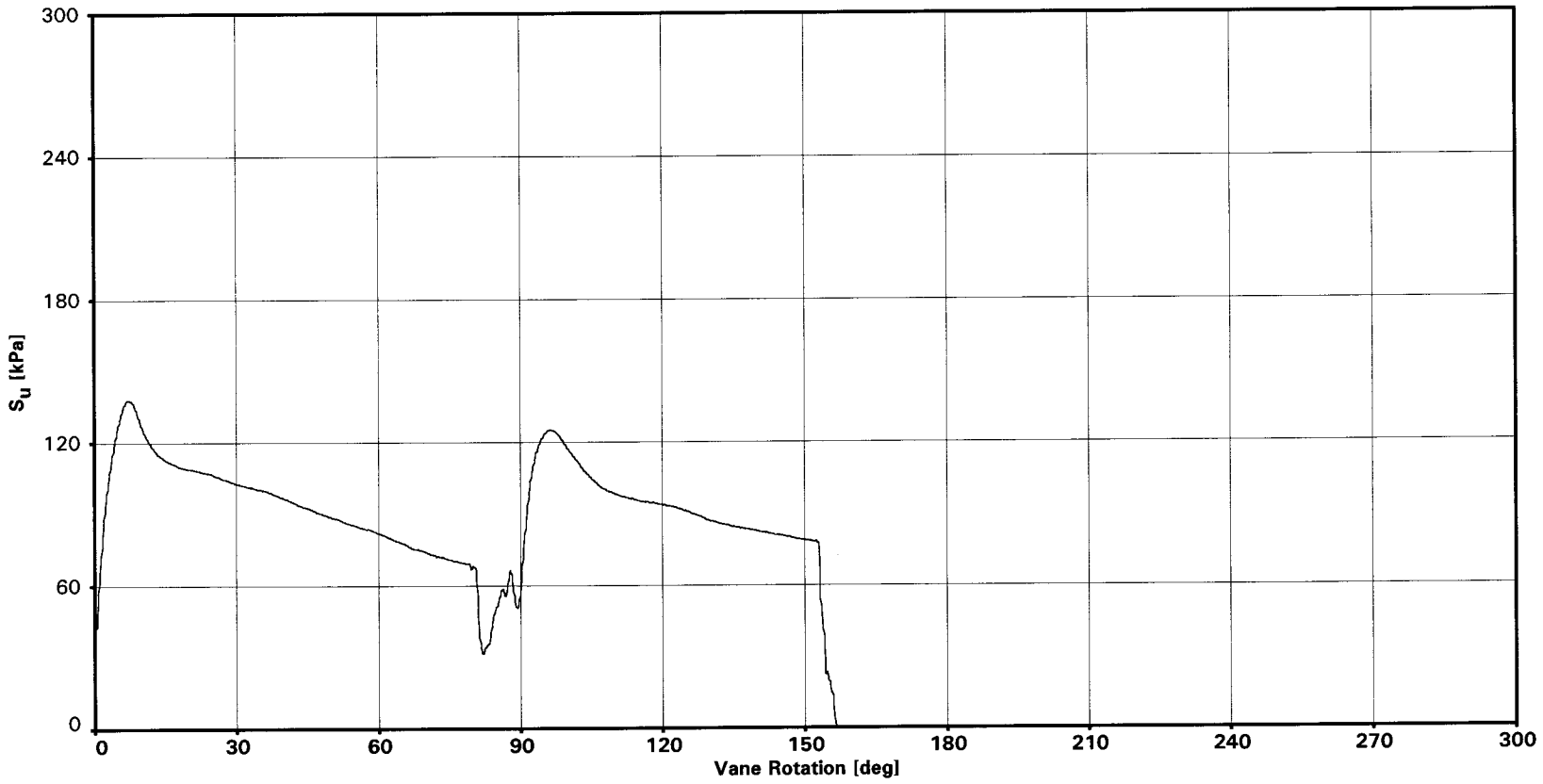
FUGRO

PLATE 98-56.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 36.6m and 37.2m
Boring 98-56
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-56.2f

98-56		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
2.0	1	9																									
3.4	2	24					4																				
4.8	3	23					30																			H	2.68
6.4	4	23					5																				
6.6	5					20.3	4																				
7.9	6	21					8																				
9.3	7							42.1			40.5																
9.6	9	32	47	25	0.34																						
10.8	10							43.1	35.9																		
11.0	11	42	44	23	0.89	18.1		52.7							38.0		2.1										
11.1	12							38.3			56.5	8.3															
12.3	13							38.3	35.9																		
12.6	15	47	58	24	0.67	17.4		39.3							50.9		1.9										
12.8	16							52.7			54.5	8.7															
13.7	400													77.1													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-56		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
14.3	17	50	55	24	0.83																					C	2.74
14.3	18	22																									
15.4	19							38.3	38.3																		
15.5	20	56	56	22	0.99	17.0		46.0							58.2		0.7										
15.7	21							52.7			58.4																
16.8	401													56.0													
17.1	23										40.5	9.2															
17.2	24	54	65	27	0.71	16.4		38.3																			
17.4	25							38.3	35.9																		
18.3	402													67.5													
19.1	27		25	14																							
19.9	29	54	58	24	0.87																						
20.0	30						22																				
21.8	31	31					46																				
23.3	32	21					31																			H	2.74

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.3b

Earth Mechanics

FUGRO

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98-56		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
24.8	33	29	52	20	0.29																						
26.4	34	44	73	24	0.41																						
27.5	35	42	42	17	1.00		65																				
27.6	36	23					3																				
29.1	37					19.3					97.8																
29.3	38	42	61	23	0.50																						
29.4	39							91.0																			
30.5	403													137.9													
32.2	40	44									134.9																
32.3	41							95.8	83.8																		
32.5	42	45	71	25	0.44	17.2									83.8	21.4	0.5										
32.6	43							83.8	95.8																		
33.5	404													172.8													
34.1	405													260.9+													
35.4	45	48	68	26	0.53						105.2					31.3											

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-56
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-56.3c

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98-56		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
35.5	46							83.8																			
36.6	406													137.9													
37.2	407													123.5													
38.8	47	27	50	19	0.25																					C	
38.9	48	28	46	17	0.38						194.3																
41.5	50	17	28	13	0.25																						
41.6	51	18							167.6		189.4					107.3											
44.5	52	34							119.7		141.1																
44.7	53	42	67	26	0.39	17.6									105.9	54.6	3.3										
44.8	54							119.7	119.7																		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.3d

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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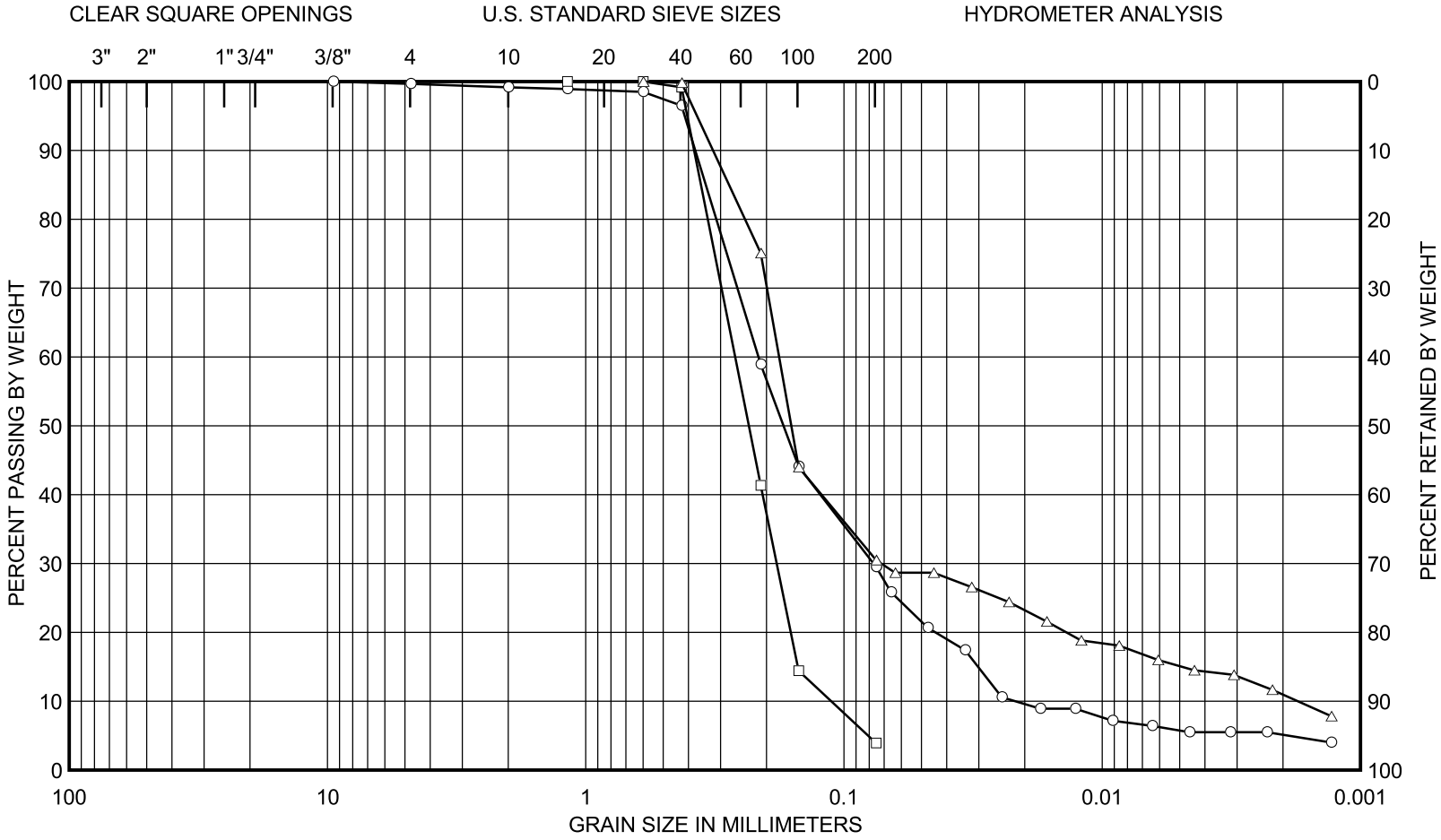

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
3	4.8	○—○	SILTY FINE SAND (SM)			0.17
5	6.6	□—□	FINE SAND (SP)	1.1	2.4	0.23
32	23.3	△—△	SILTY FINE SAND (SM)			0.16

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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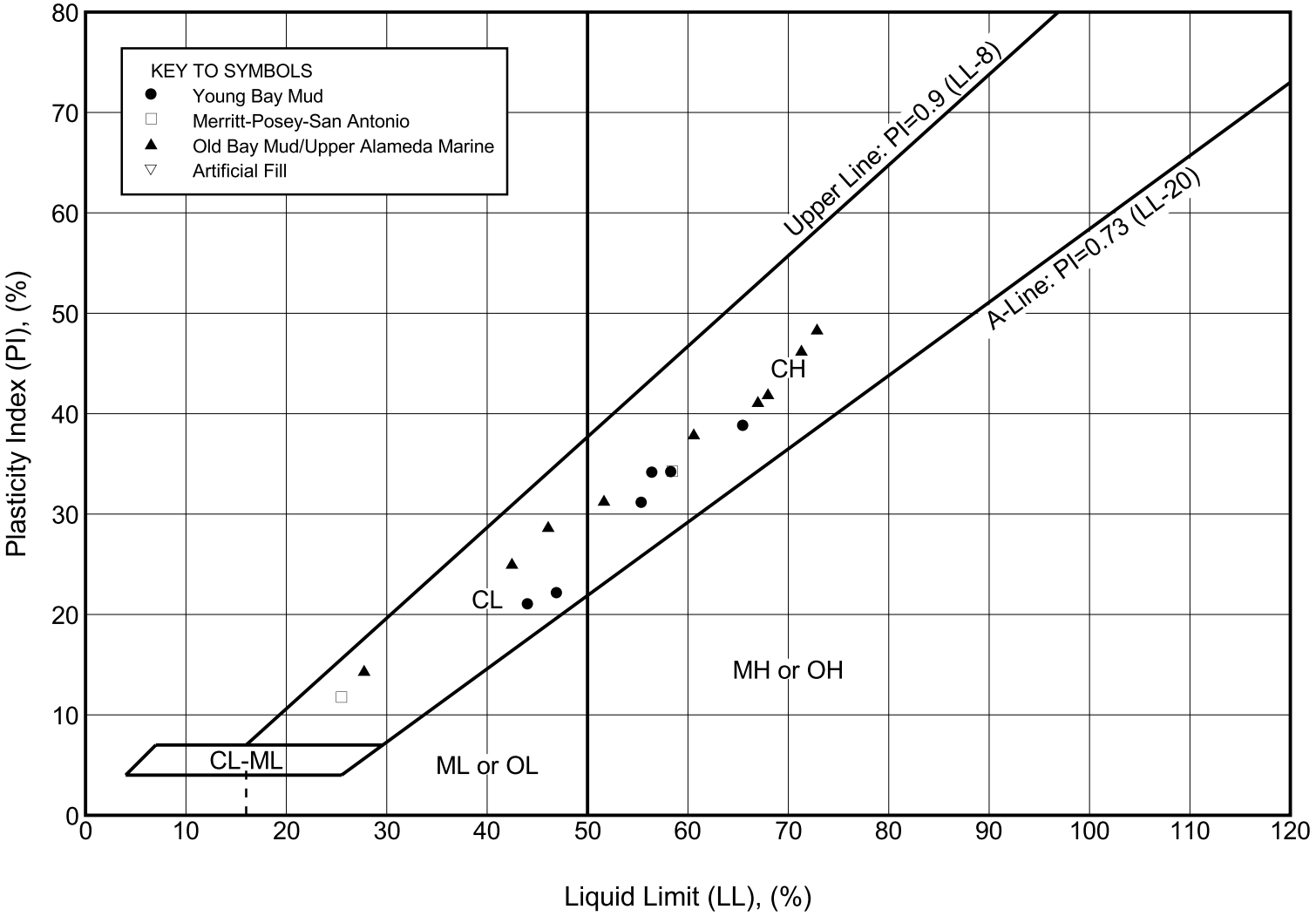
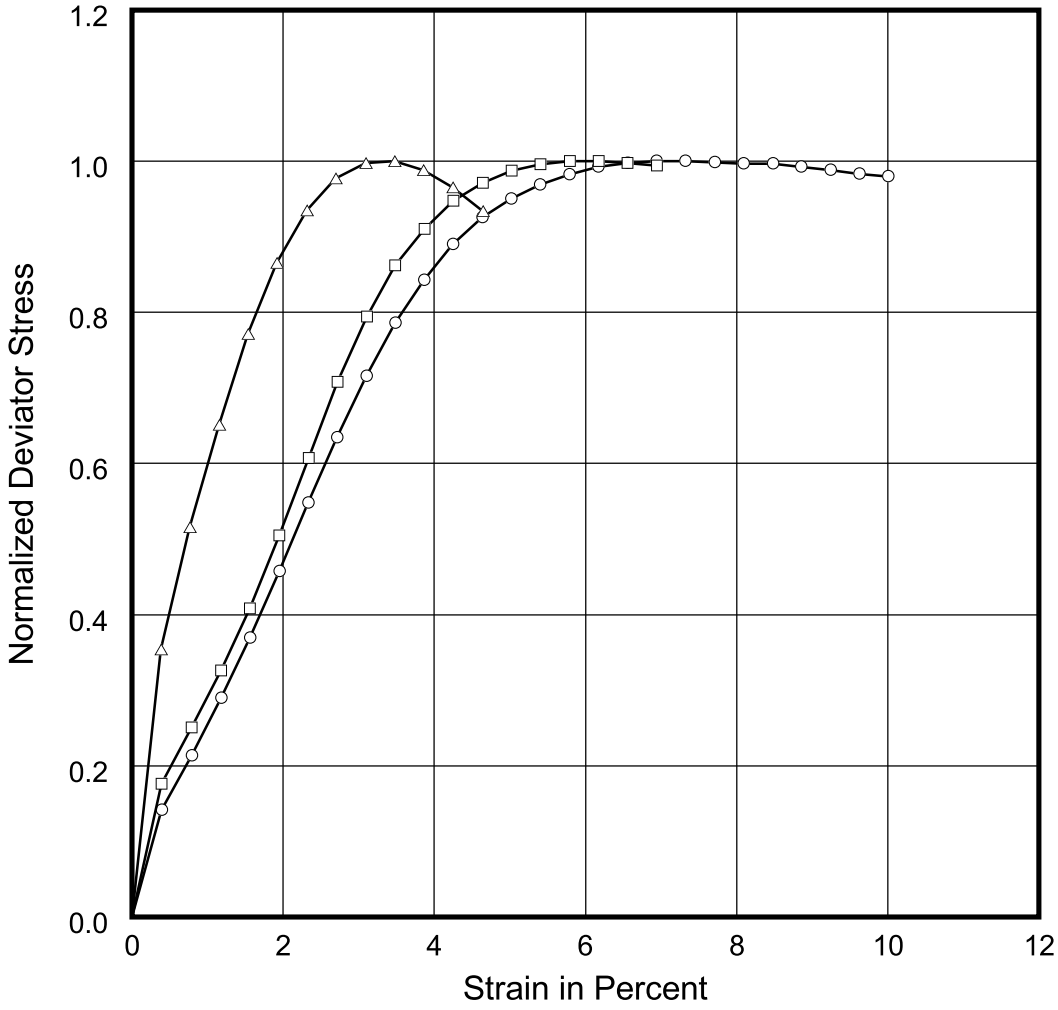


PLASTICITY CHART
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.5

Earth Mechanics

FUGRO



Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	11	11.0	UU	276	76	2.1
□—□	15	12.6	UU	276	102	1.9
△—△	20	15.7	UU	276	116	0.7

Deviator stress normalized with respect to maximum deviator stress.

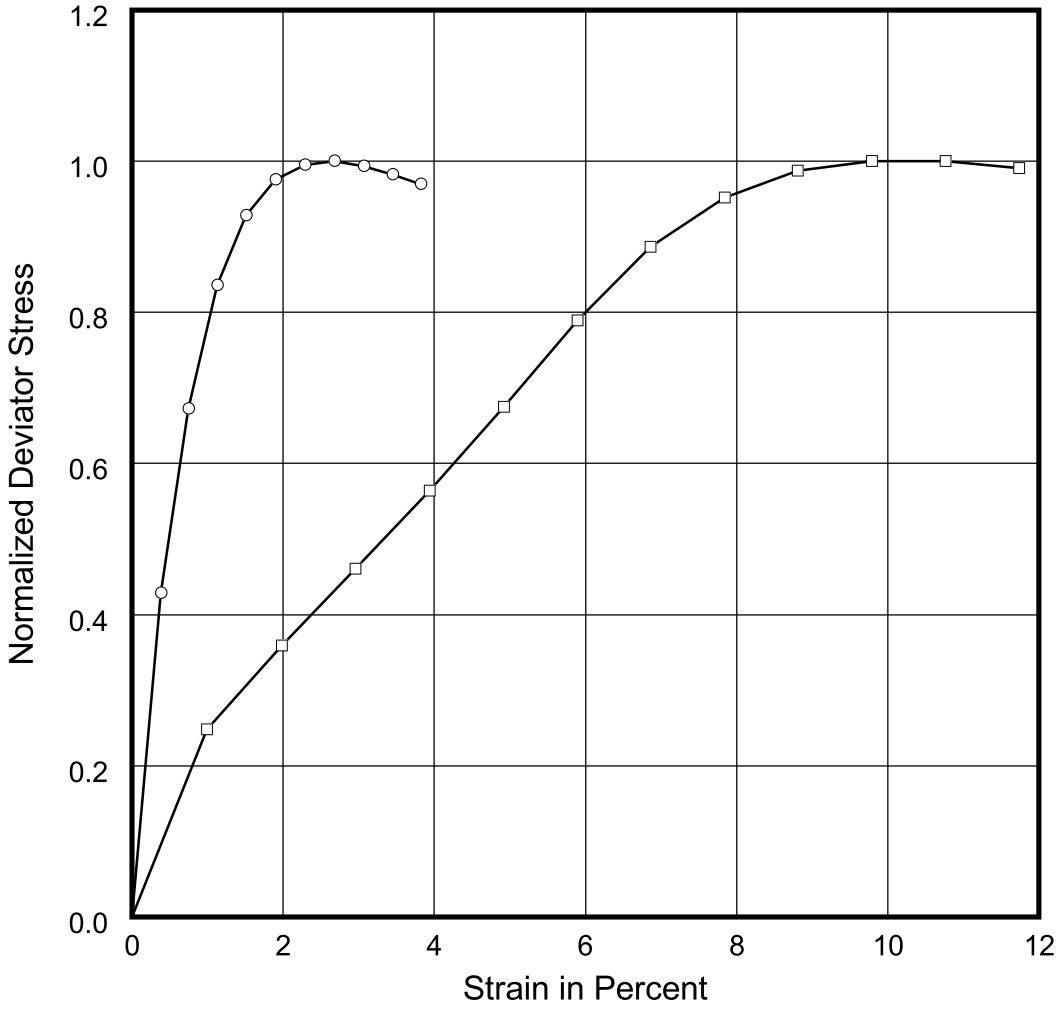
STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.6a

Earth Mechanics

FUGRO



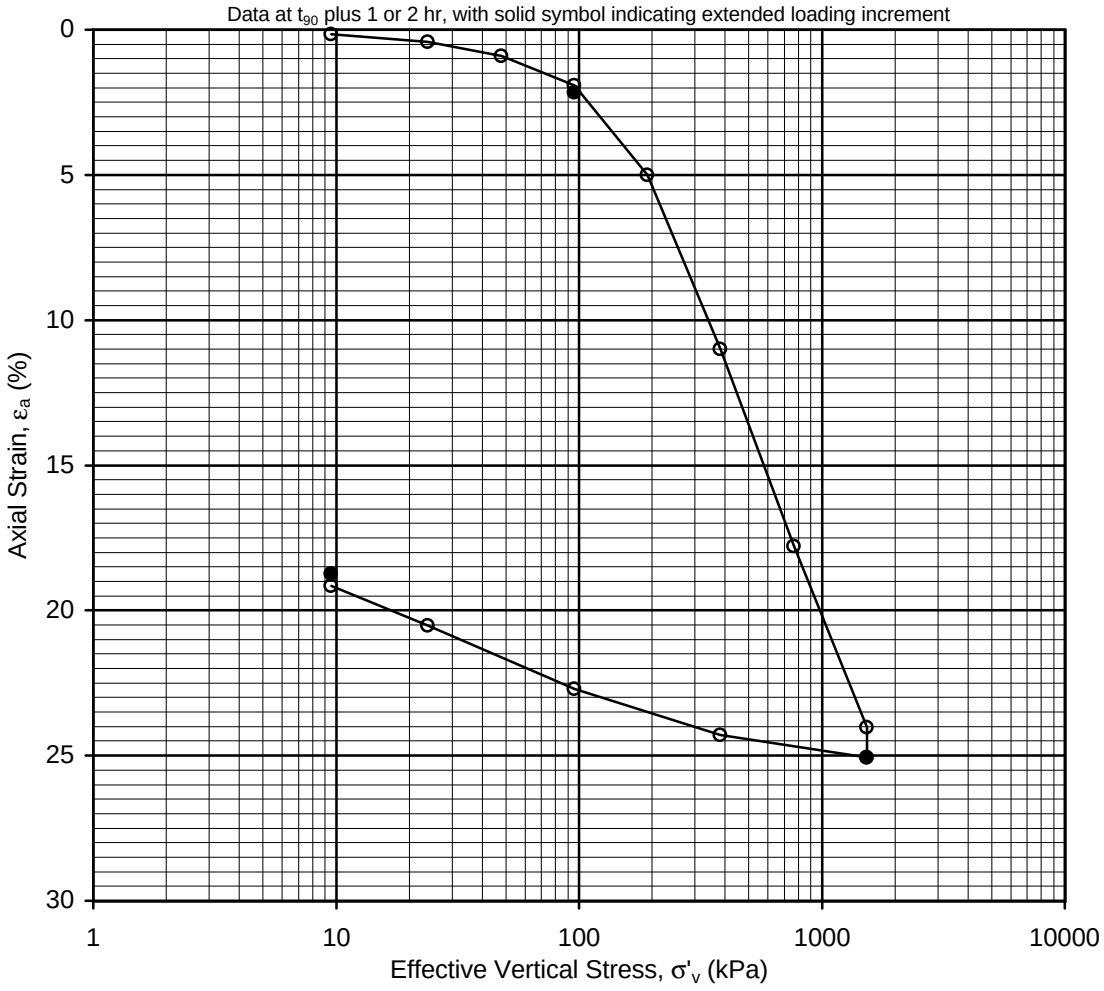
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	42	32.5	UU	1000	168	0.5
□—□	53	44.7	UU	1345	212	3.3

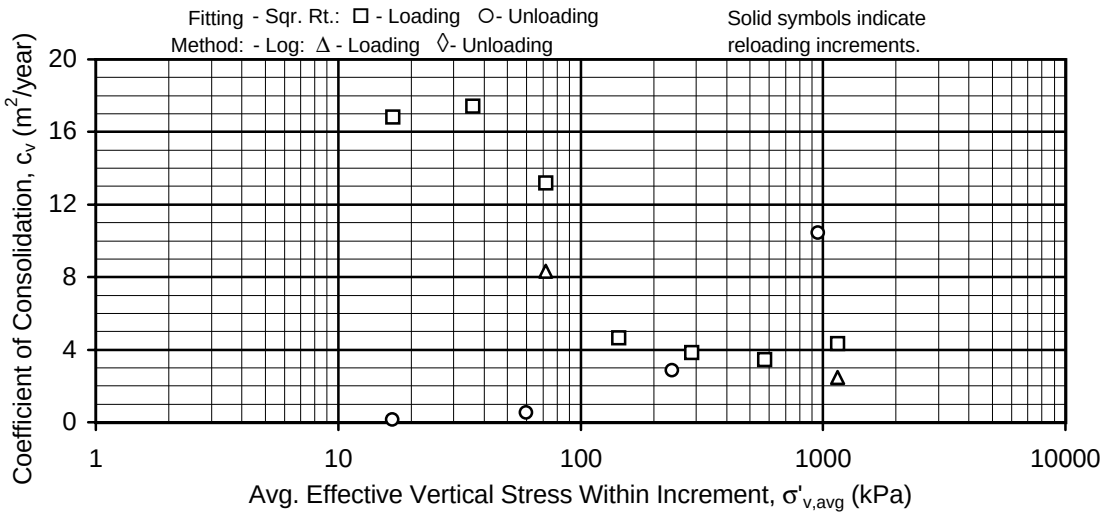
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-56
SFOBB East Span Seismic Safety Project

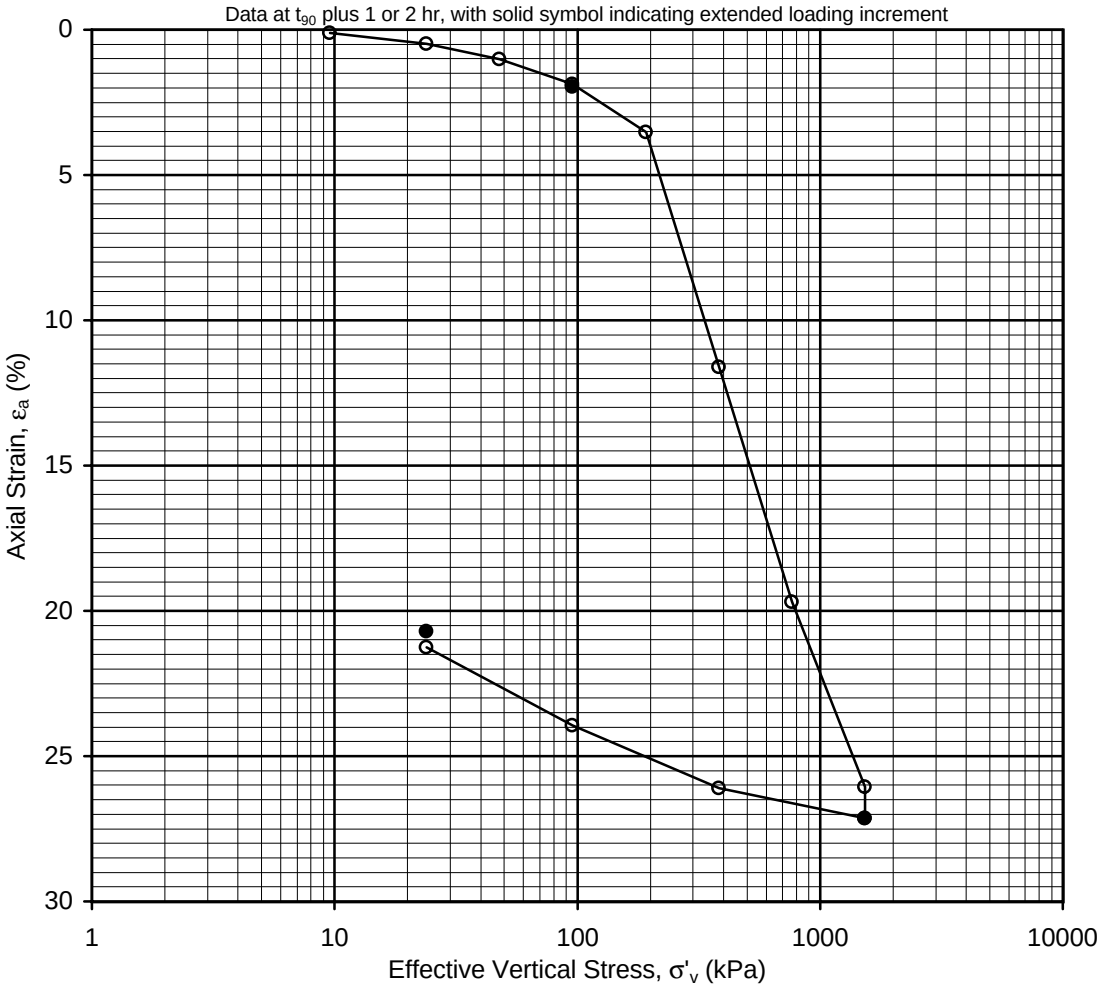
PLATE 98-56.6b

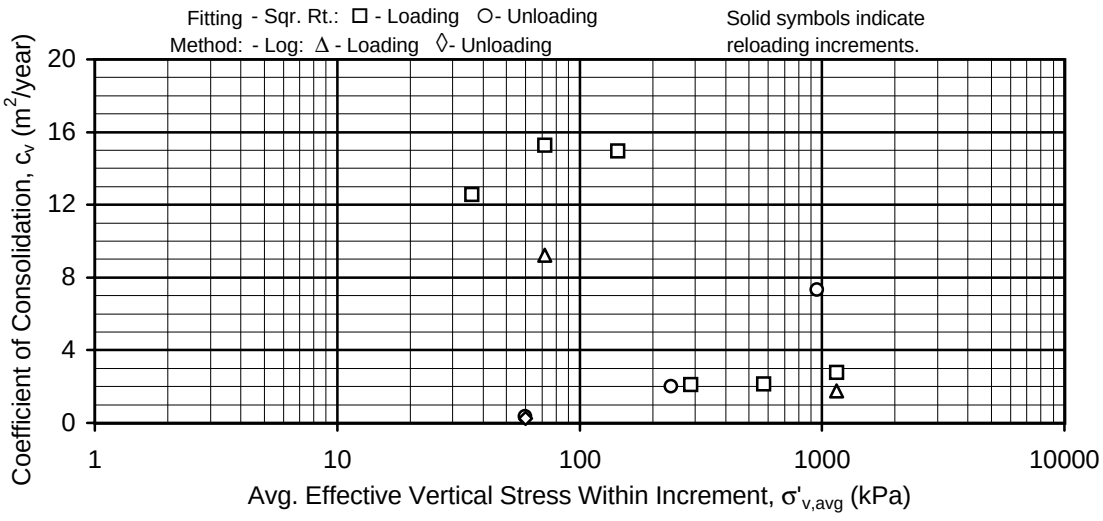




INCREMENTAL CONSOLIDATION TEST RESULTS

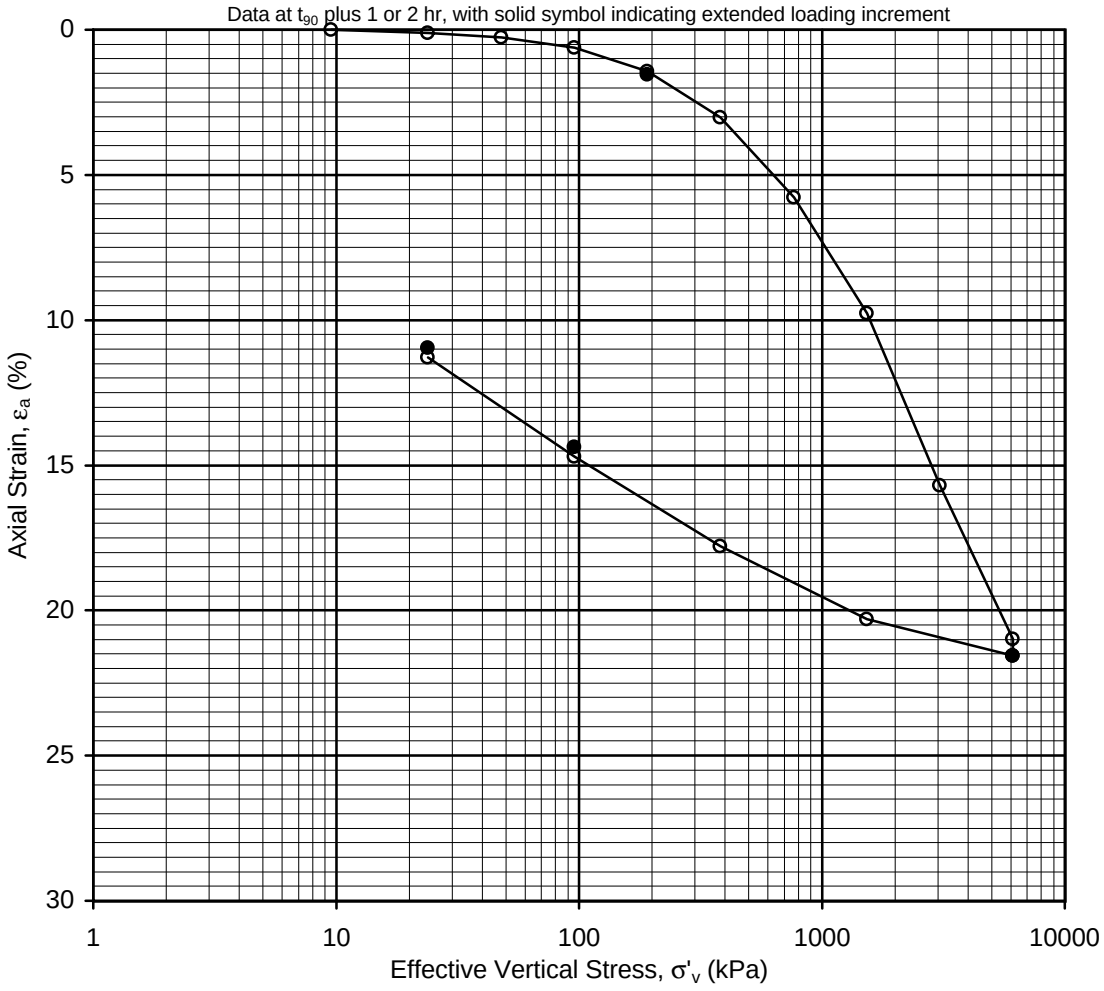
Sample No. 17A - Depth: 13.9m
Boring 98-56
SFOBB East Span Seismic Safety Project

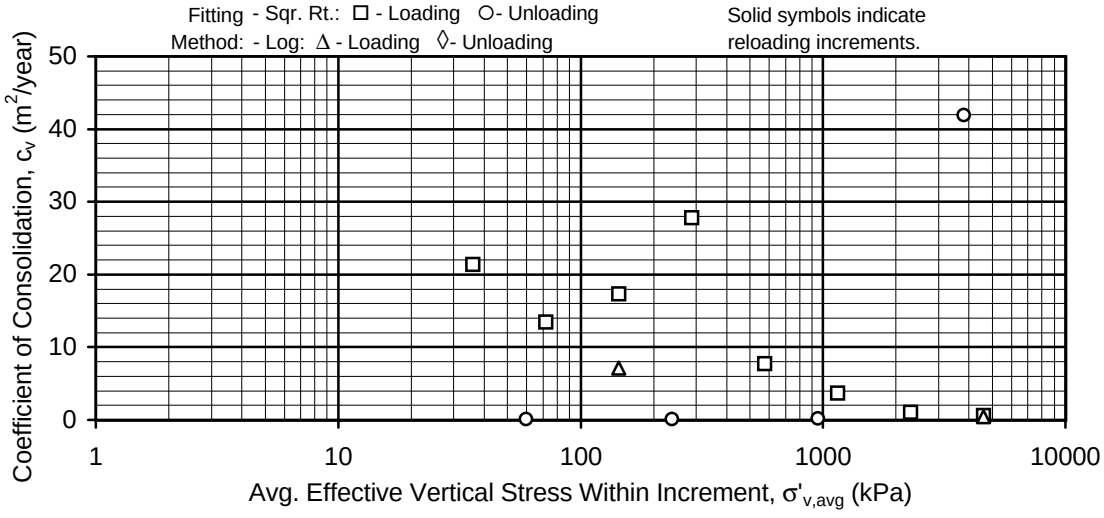




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 17B (Horizontal Loading) - Depth: 13.8m
Boring 98-56
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

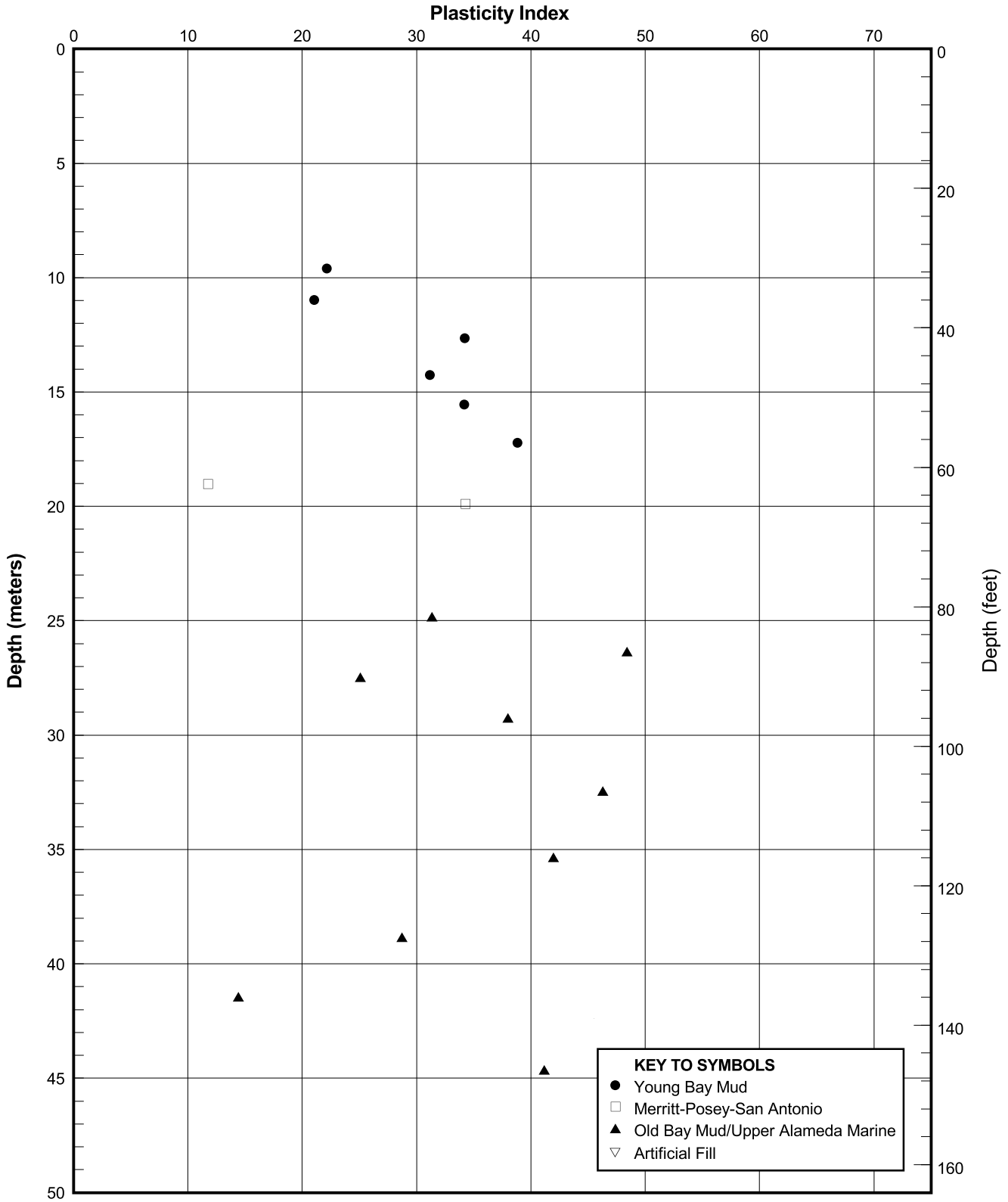
Sample No. 47 - Depth: 38.6m
Boring 98-56
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

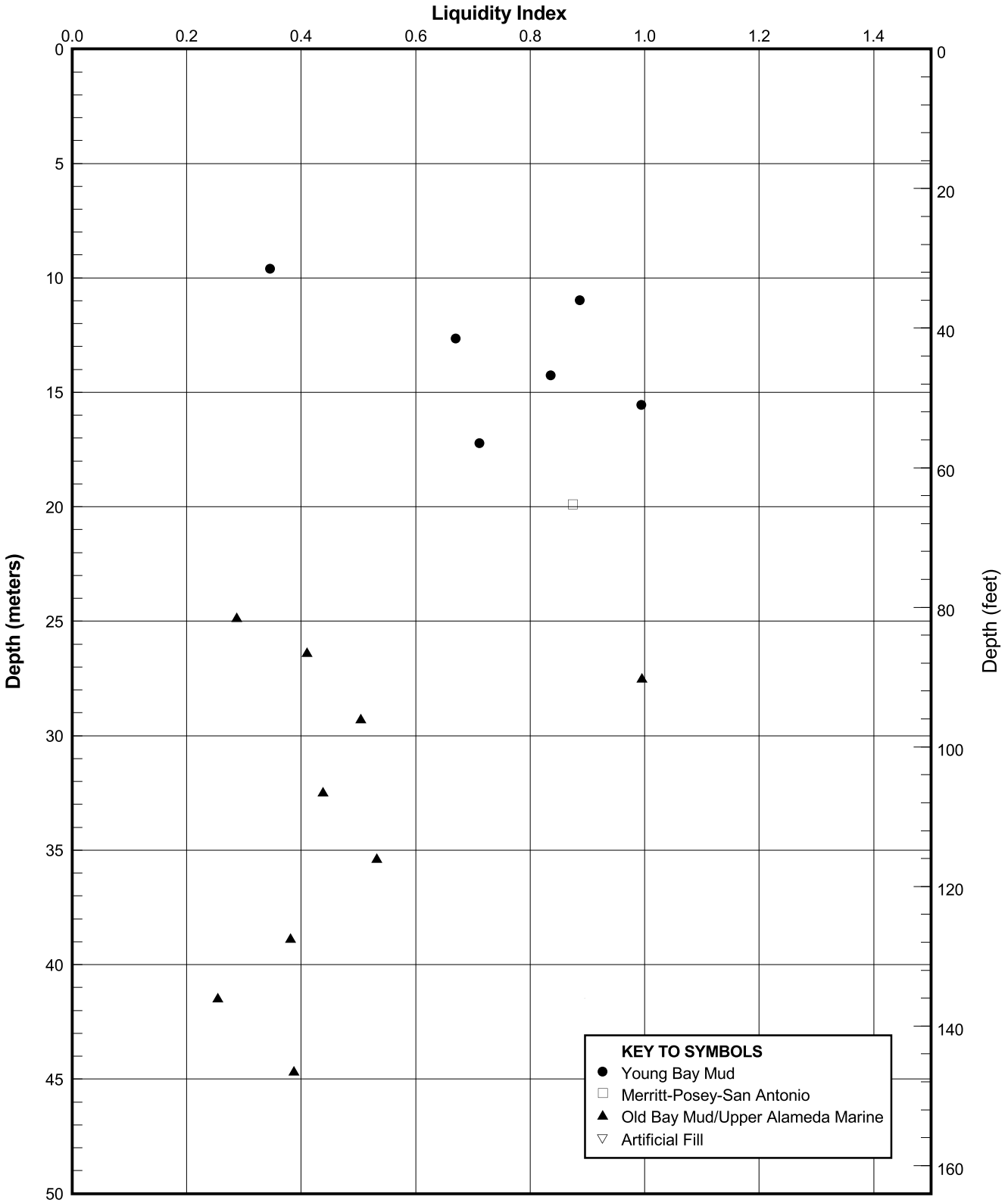
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



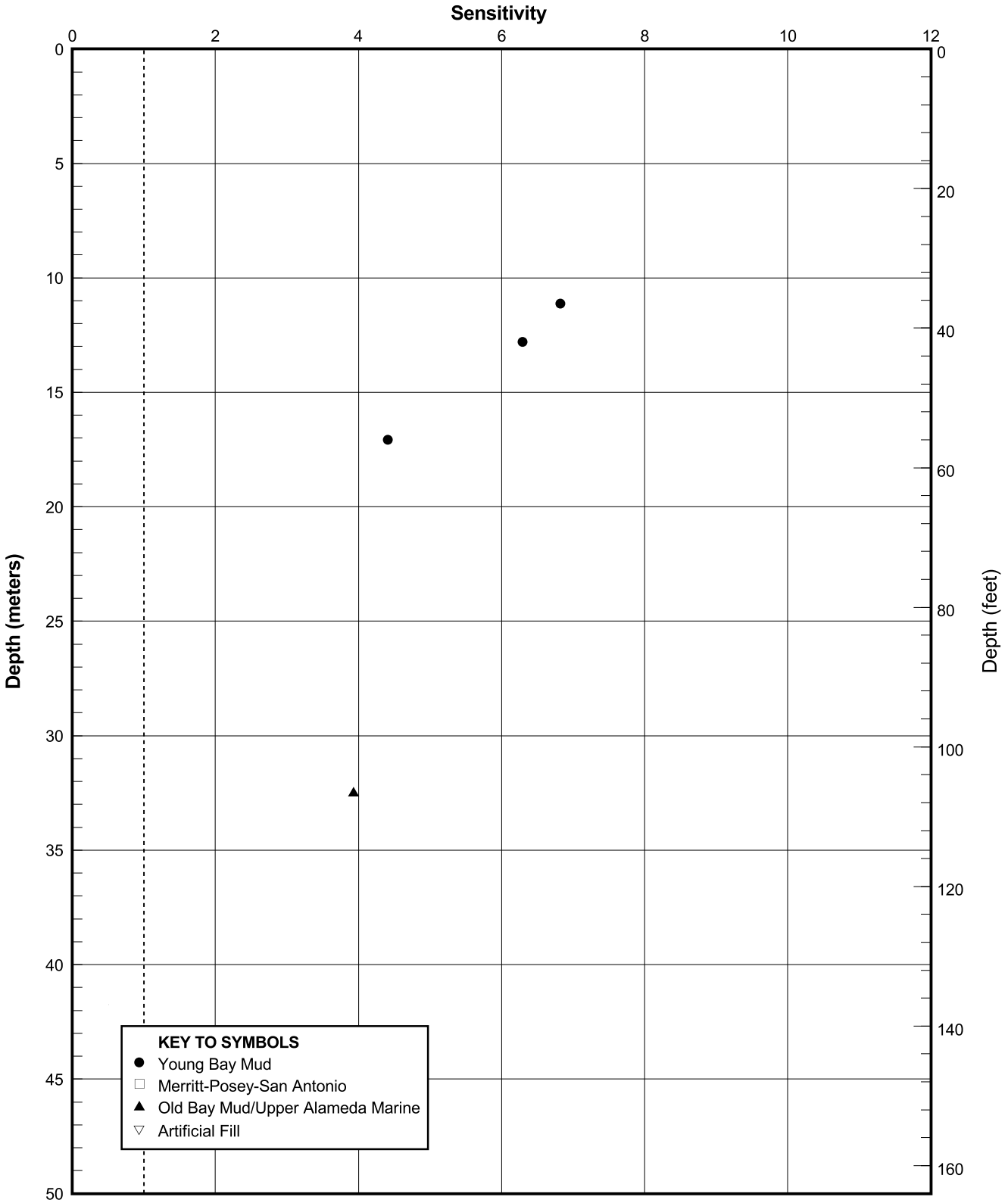
PLASTICITY INDEX PROFILE
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.12



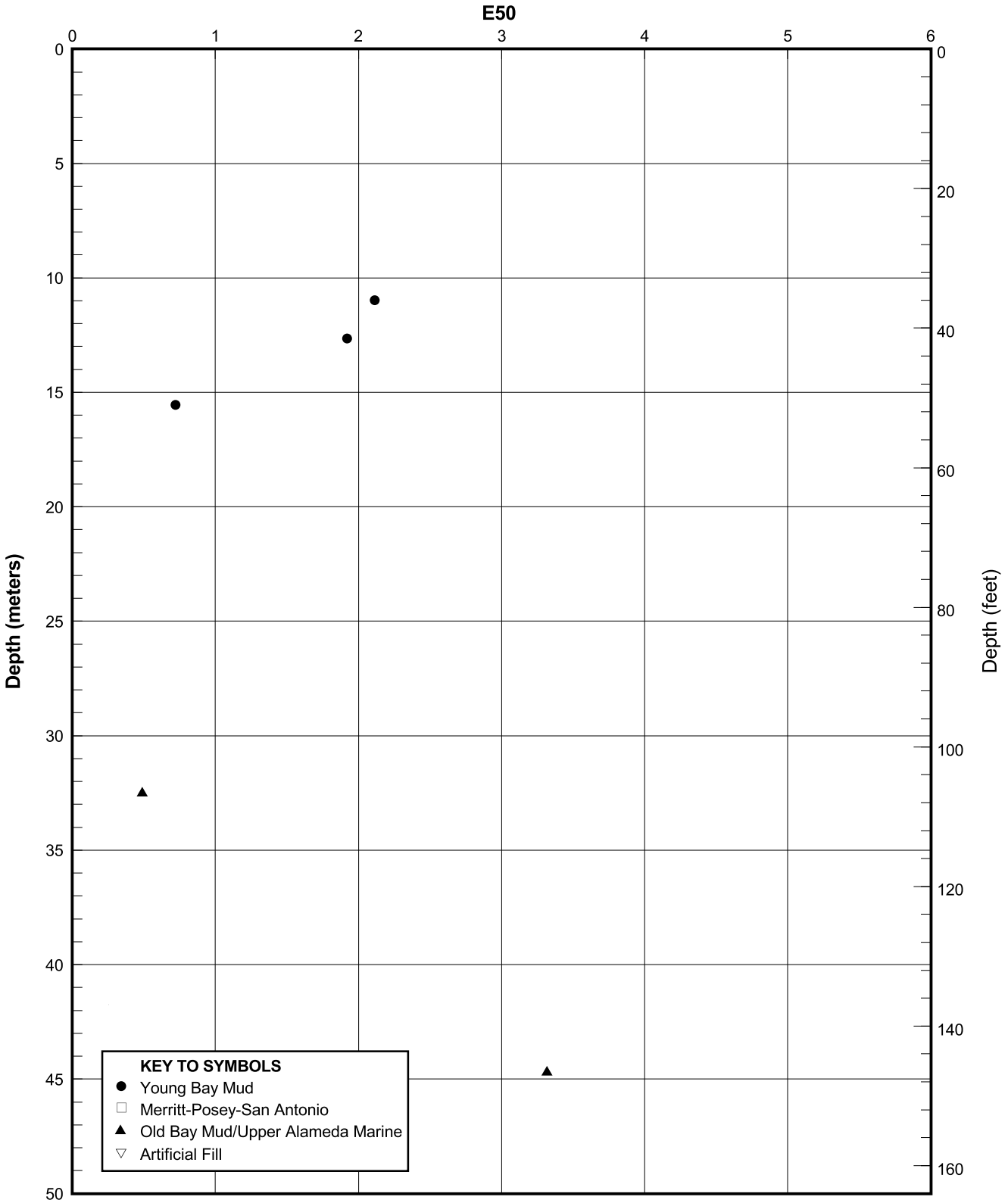
LIQUIDITY INDEX PROFILE
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.13



SENSITIVITY PROFILE
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.14



E50 PROFILE
Boring 98-56
SFOBB East Span Seismic Safety Project

PLATE 98-56.15

Earth Mechanics

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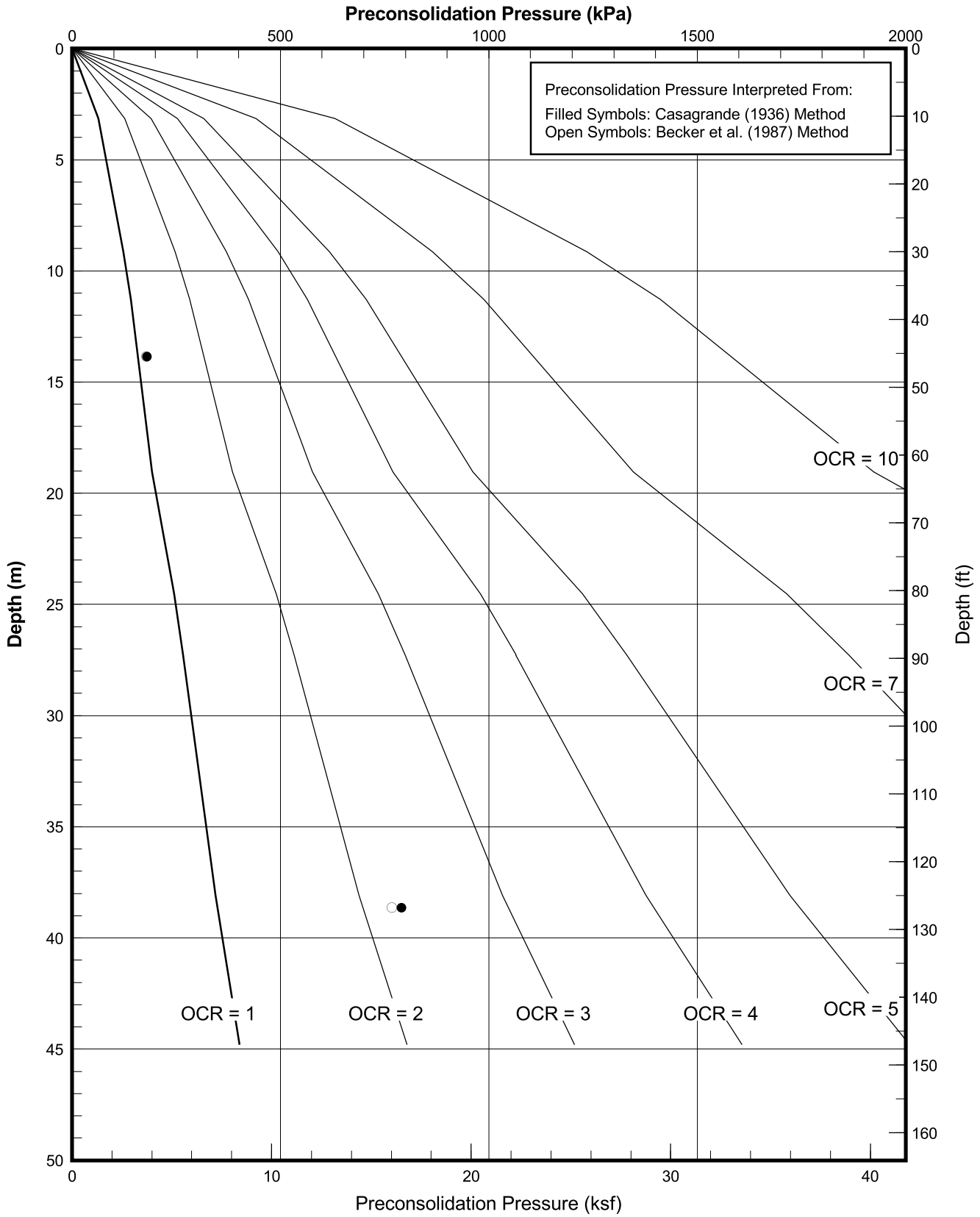

PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-56

SFOBB East Span Seismic Safety Project

PLATE 98-56.16

LAND BORING 98-57

PROJECT NO:	98-42-0058	**START DATE:**	10/17/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-57 (14m right of W. Sta. 88+07)	**COMPLETION DATE:**	10/20/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839266.37 N648307.37
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.5m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
				BAG	PAVEMENT, 3 Asphalt Concrete over 8 of Aggregate Base (0.3m)	II
					Silty Fine SAND with gravel (SM), medium dense to dense, brown (0.9m)	III
2	2			12	Lean CLAY with sand (CL), stiff, brown (1.4m) -with concrete and brick fragments	IV
					Silty Fine SAND with gravel (SM), medium dense, light brown -with a few clay pockets and a few shell fragments, at 1.5m (3.0m)	
0	4			10	Silty Fine GRAVEL with sand (GM), loose to medium dense, brown (3.5m) ▽ -gravel is angular, fractured sandstone	V
				17	-coarse gravel with silt and clay pockets, at 4.6m	
-2	6				(6.1m)	
				21	Fine SAND with silt (SP-SM), medium dense, greenish gray -with shell fragments	VI
-4	8			10	-silty fine sand below 7.6m	
					(8.8m)	
-6	10			PUSH	Fat CLAY (CH), firm to stiff, olive gray -with shells and shell fragments, to 12.8m -lean clay to 11.3m -with silt pockets at 9.1m	VII
				PUSH	-with a few silt pockets at 11.0m	
-8	12			SAVE		
-10	14			PUSH	-silty fine sand with clay pockets, 13.9m to 14.0m -with organic pockets and an H2S odor, at 14.2m	
-12	16			PUSH	-with gas blisters at 15.5m	
				SAVE	-with sand partings and a few shell fragments, at 17.1m	
-14	18				(18.3m)	
-16	20			PUSH	Fat CLAY (CH), very stiff, greenish gray -with sand partings, sand pockets and gas blisters, at 18.6m	VIII
					(20.6m)	
-18	22			50/15cm	Fine SAND with silt (SP-SM), very dense, gray to greenish gray -mottled with brownish yellow at 21.3m	IX
				50/15cm	-silty fine sand below 22.9m -with a clay seam and an H2S odor, at 22.9m	
-20	24				(24.2m)	
				PUSH	Fat CLAY (CH), very stiff, greenish gray -very stiff to hard lean clay, to 27.1m -with silt pockets, silt seams, sand pockets, and sand seams, at 24.7m	X
-22	26					
-24	28			SAVE	-with shell fragments at 27.7m	
-26	30			PUSH	-with silt and sand pockets, at 30.8m	
-28	32					
-30	34			PUSH	-with brown oxidation staining, sand pockets, and slickensides, at 33.8m	
-32	36				(36.6m)	
				SAVE	Fat CLAY (CH), very stiff, greenish gray -very stiff to hard lean clay, to 39.0m -with sand pockets at 36.9m	XI
-34	38					
-36	40			PUSH	-with brown streaks, and gas blisters, at 39.9m	
-38	42				(42.2m)	
				PUSH	Fat CLAY (CH), very stiff, olive gray -lean clay to 44.2m -greenish gray and with silt seams and layers, at 43.0m	XII
-40	44					
-42	46			SAVE	-with silt pockets at 46.0m	
-44	48				TOTAL DEPTH: 46.3m BACKFILLED WITH: Cement Grout	
-46						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-57.1

LOG OF BORING AND TEST RESULTS

BORING 98-57

SFOBB East Span Seismic Safety Project

Report Date: 03/10/99

Earth Mechanics

FUGRO

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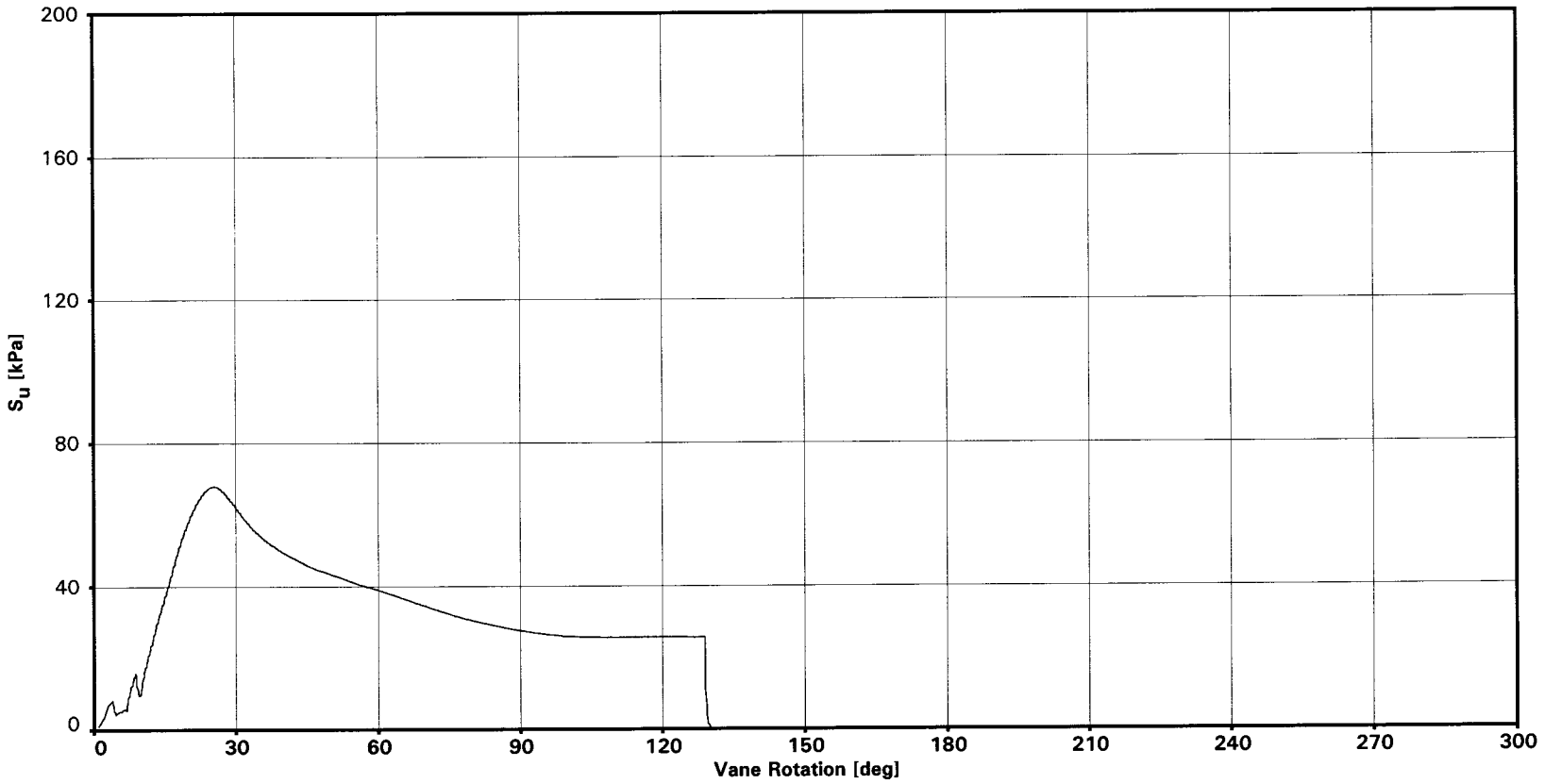
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.2a

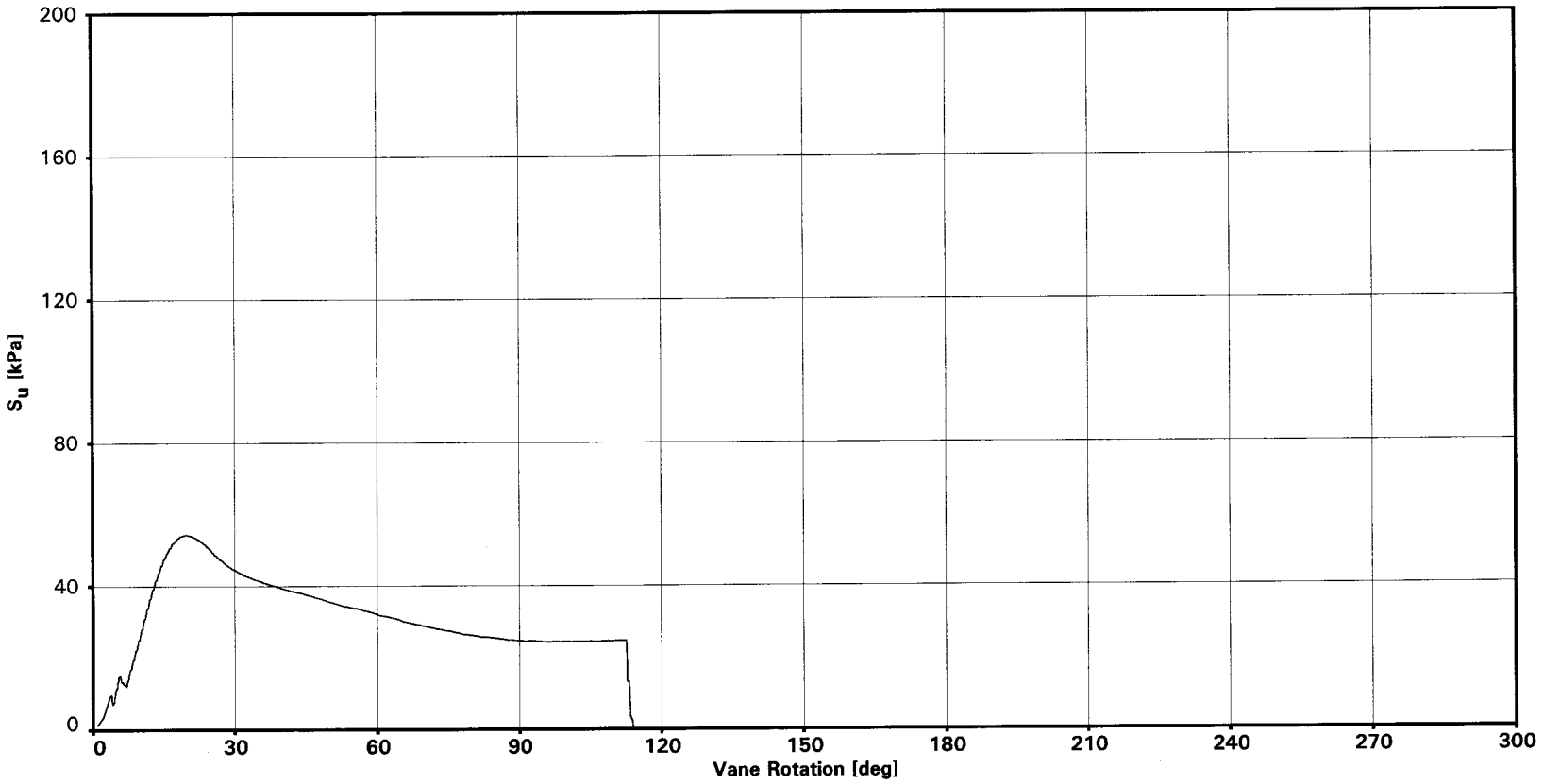
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 13.7m
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.2b

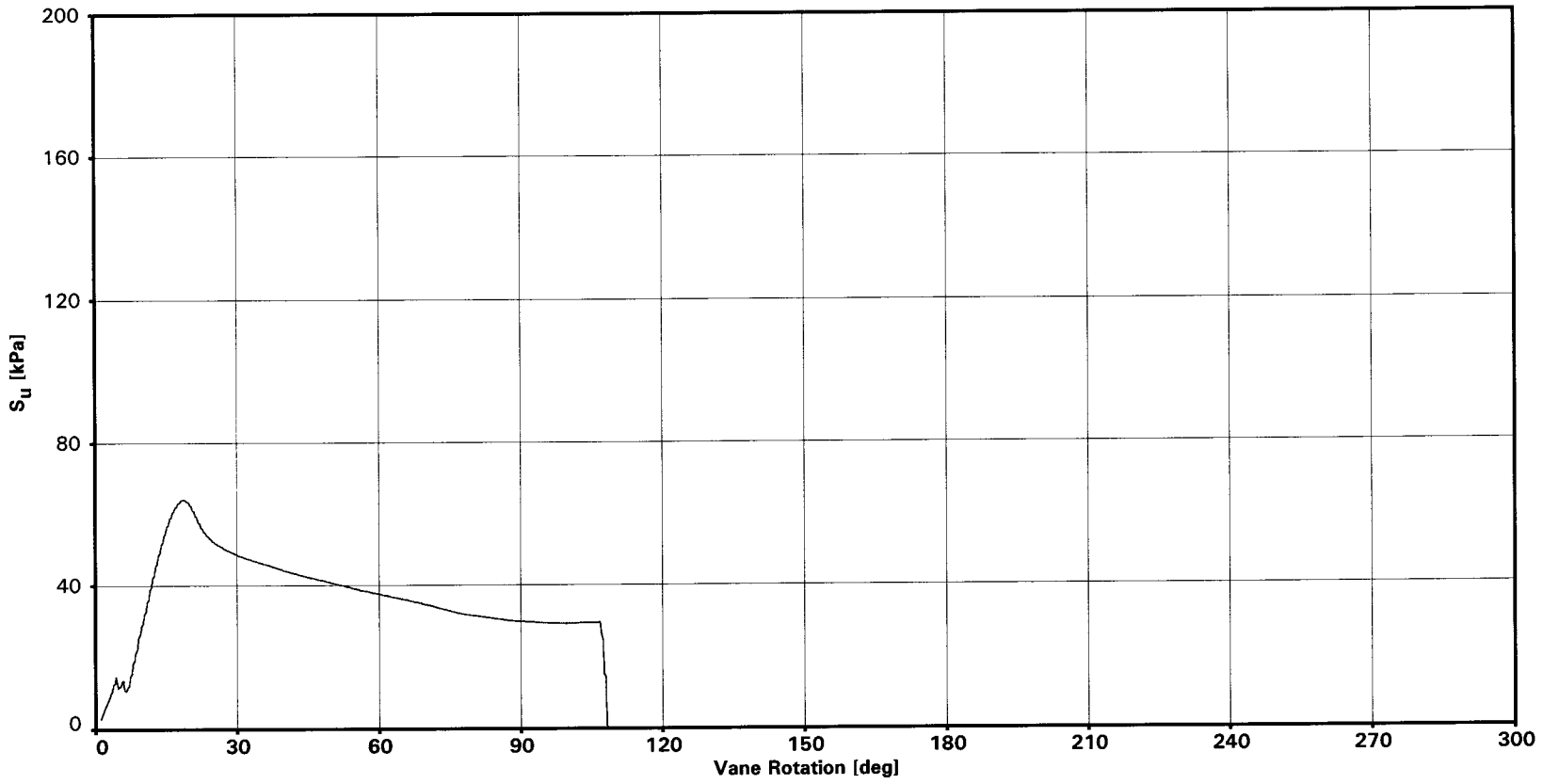
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 15.2m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

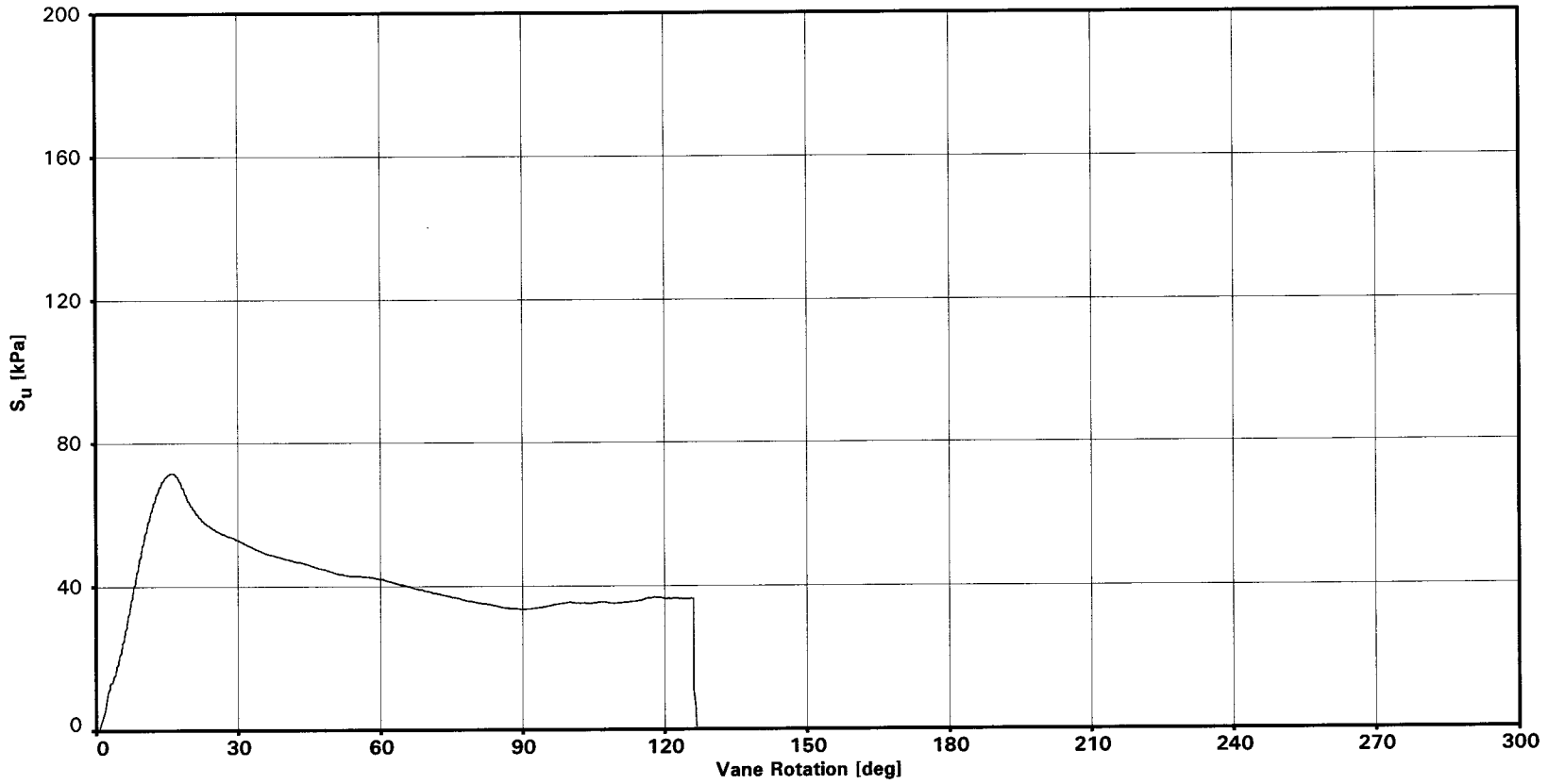
FUGRO

PLATE 98-57.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 16.8m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

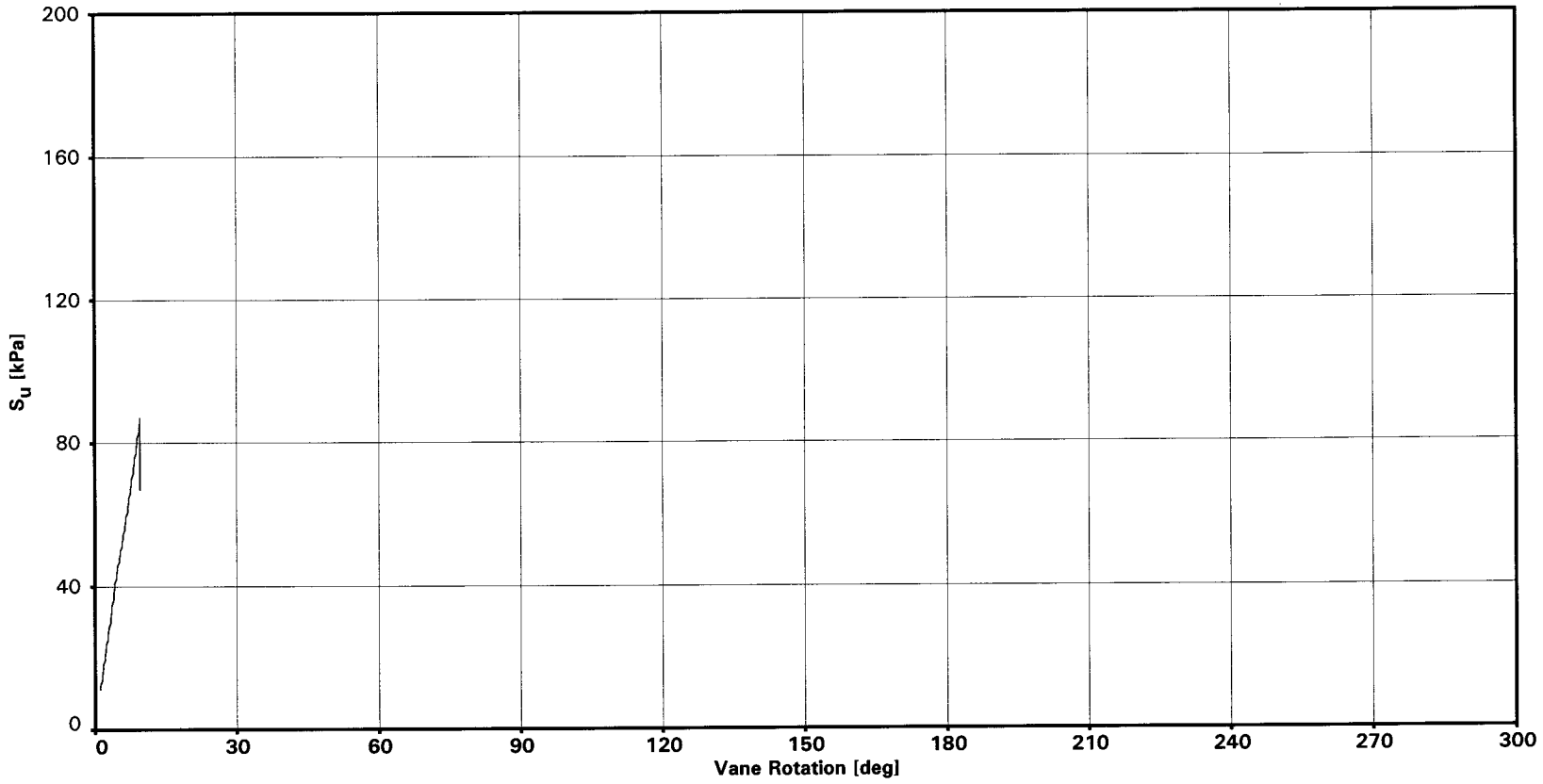
FUGRO

PLATE 98-57.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 18.3m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

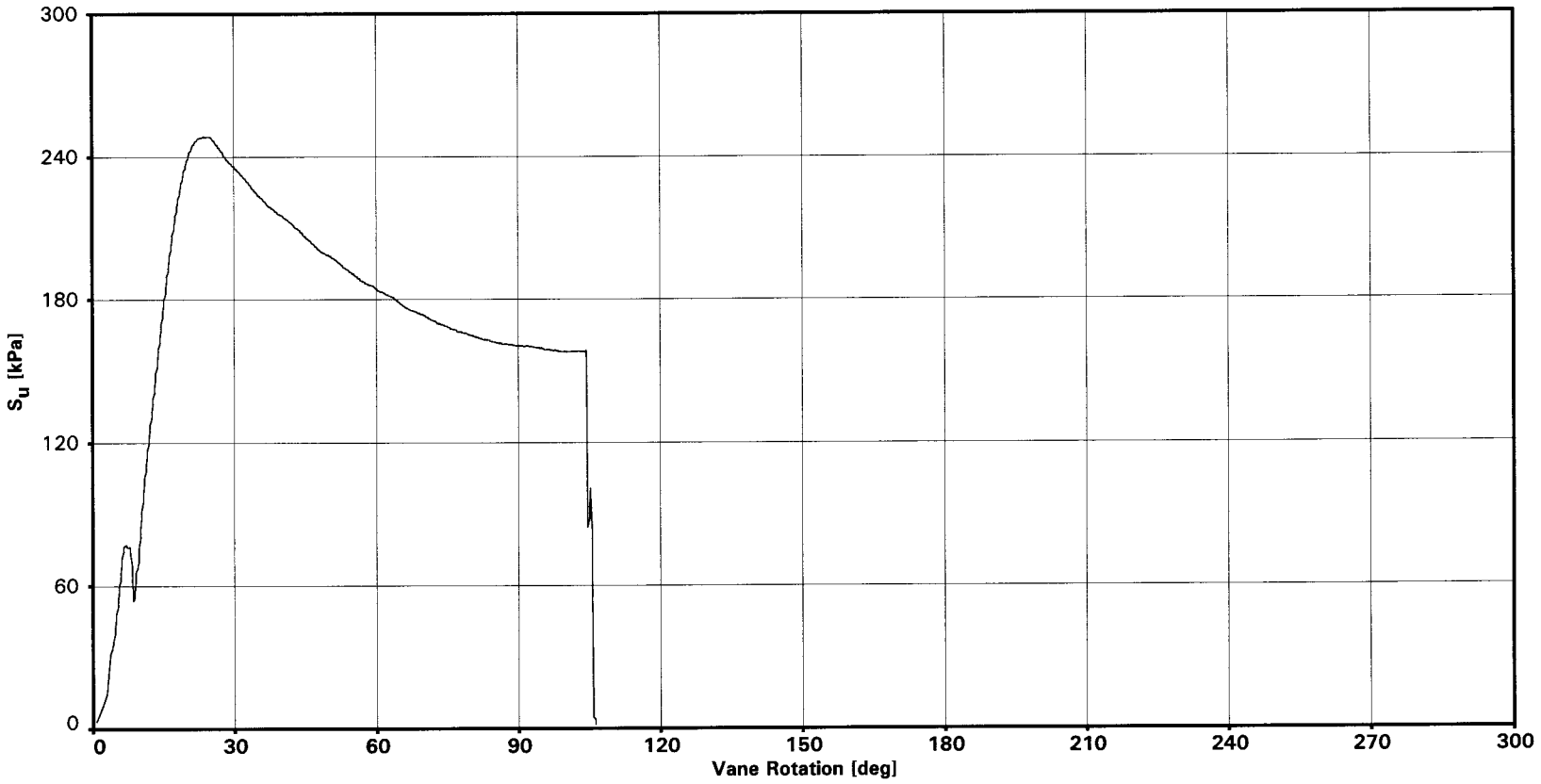
FUGRO

PLATE 98-57.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 25.6m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

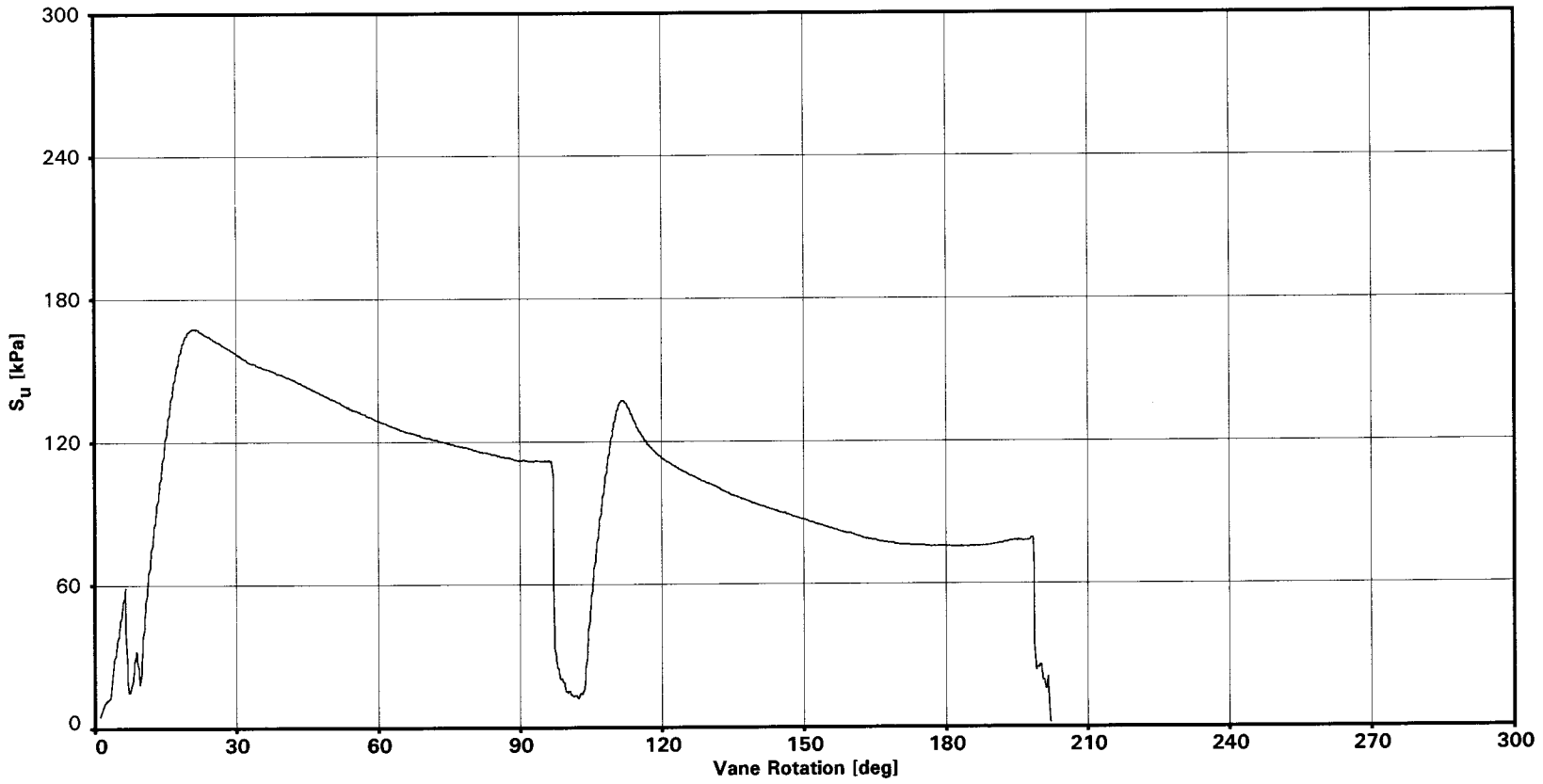
FUGRO

PLATE 98-57.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 29.0m and 29.6m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

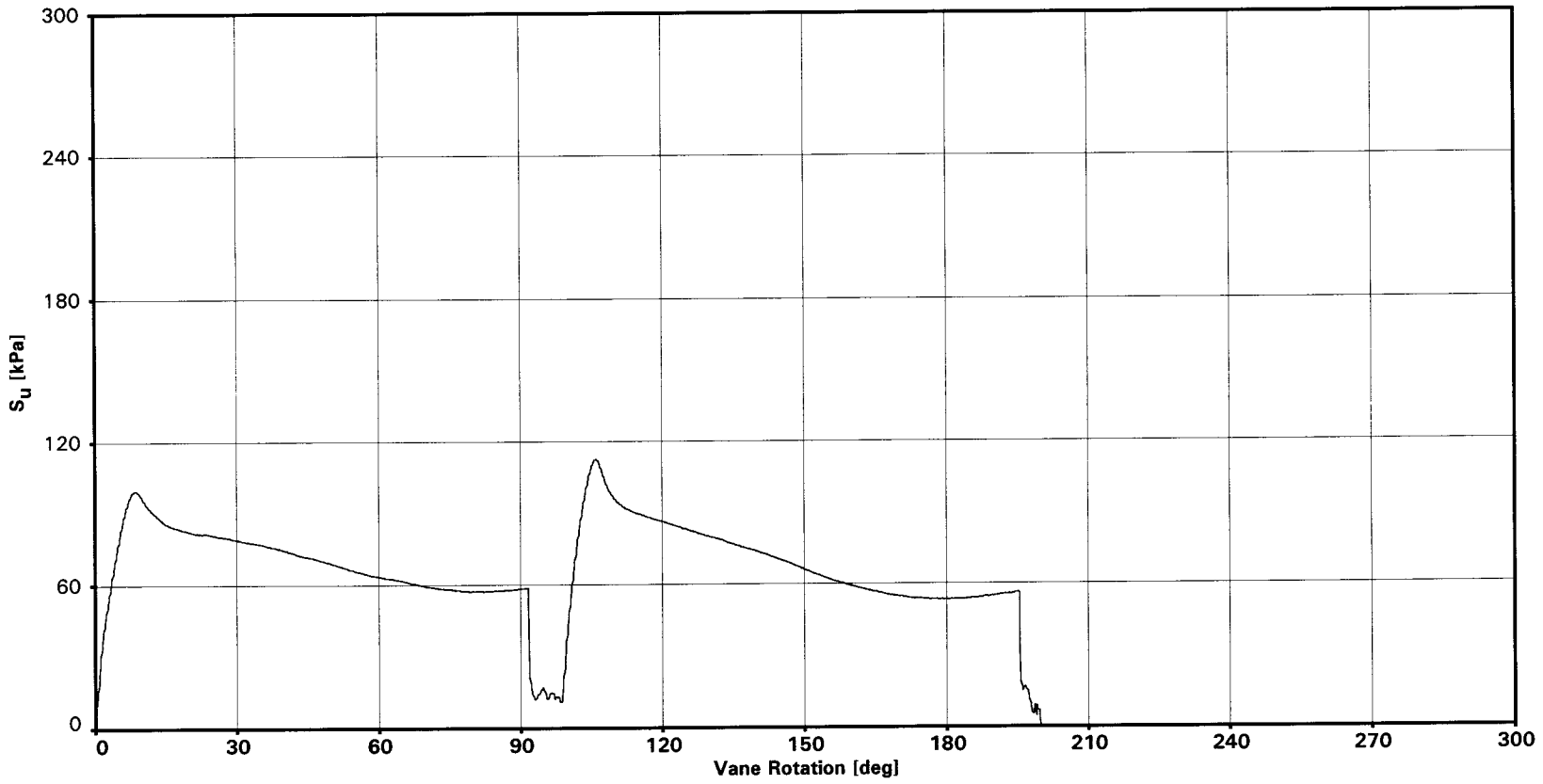
FUGRO

PLATE 98-57.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 32.0m and 32.6m
Boring 98-57
SFOBB East Span Seismic Safety Project

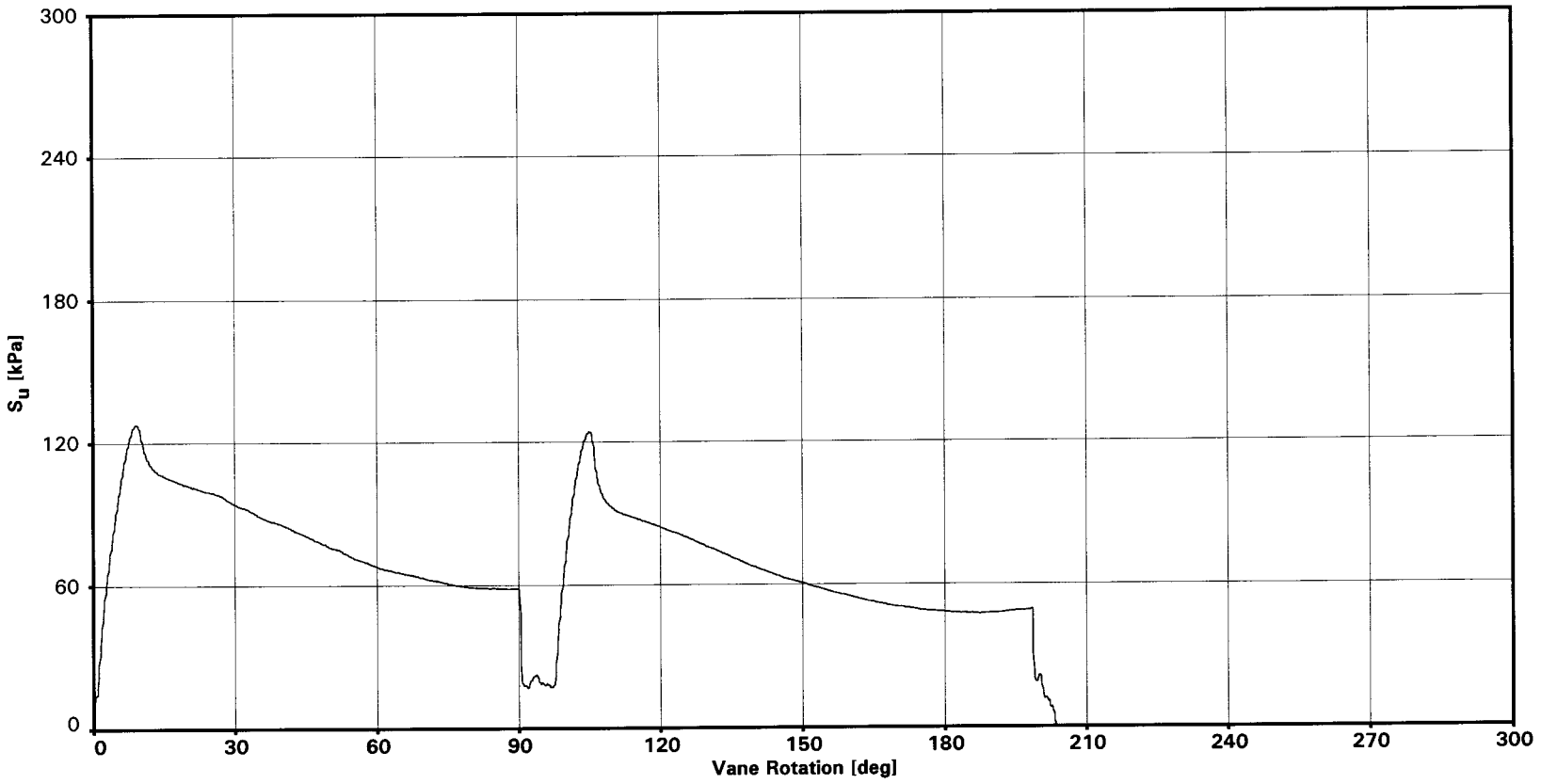
Earth Mechanics

FUGRO

PLATE 98-57.2h

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 35.1m and 35.7m
Boring 98-57
SFOBB East Span Seismic Safety Project

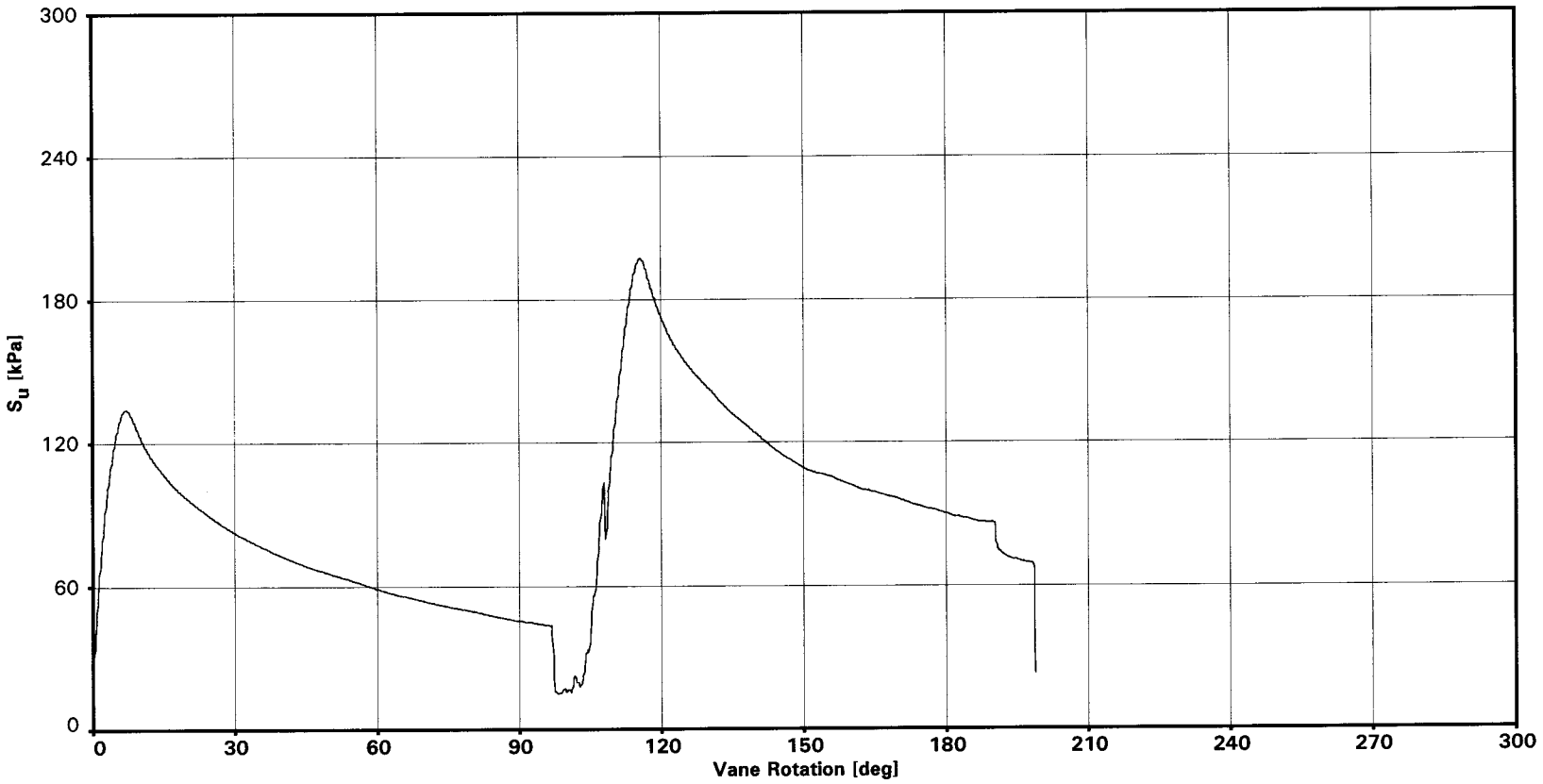
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 38.1m and 38.7m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

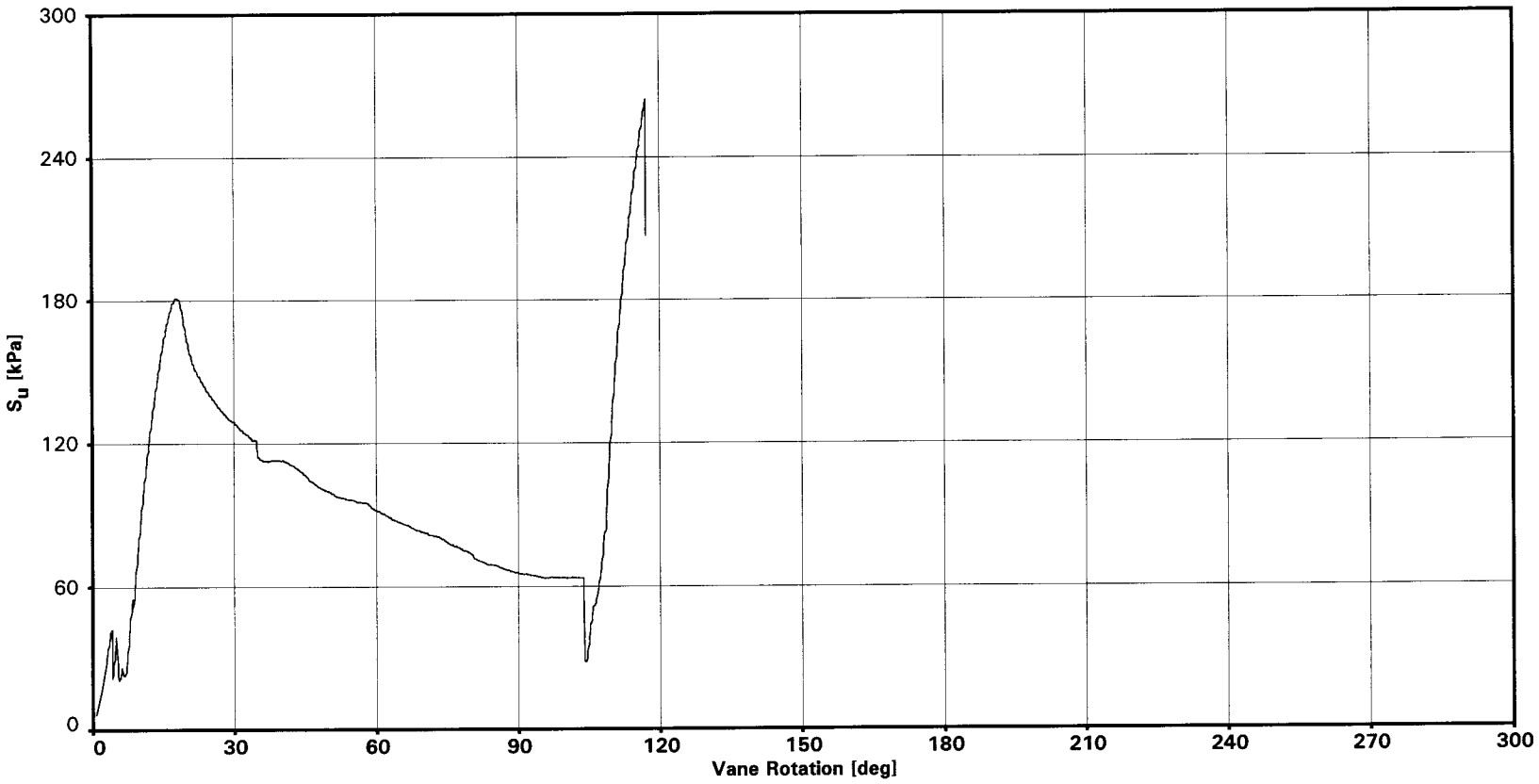
FUGRO

PLATE 98-57.2j

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 41.1m and 41.8m
Boring 98-57
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-57.2k

98-57		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.1	300																										
2.0	1	6					14																				
3.2	2	13					14																				
4.8	3	17					6																				
6.4	4	22					7																				
7.9	5	29					12																				2.69
9.6	7	35	45	21	0.57	18.5									29.4		1.3										
9.8	8										56.8																
11.1	10	38	47	23	0.62	17.6		43.1							35.3		1.1										2.73
11.3	11										45.2	16.7															
12.2	400													68.0													
13.0	13	57	69	28	0.70			46.9			49.8																
13.7	401													54.1													
14.0	14	36																									2.69
14.2	15	60	75	27	0.69	15.8									46.9	17.9	2.4										

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-57		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
14.3	16										59.9																
15.2	402													63.7													
15.7	18	57	63	26	0.83	16.5									49.8		1.8										
15.8	19							47.9			53.7																
16.8	403													69.9													
17.3	20	52	57	22	0.87																					C, K	
17.4	21	48	60	25	0.65						42.1																
18.3	404													87.1													
18.7	23	29	37	14	0.63	19.5		107.7	95.8						113.8	72.8	2.2										
18.9	24							119.7			92.6																
19.8	405													263.3+													
21.5	25	23					5																				
23.2	26	22					20																				2.70
24.8	28	24	35	14	0.46	20.4			191.5																		
25.0	29										222.8+																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.3b

Earth Mechanics

FUGRO

98-57		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
25.6	406													248.0+													
28.1	30	49	66	25	0.59																					C	2.74
28.2	31	53	77	29	0.50						117.6																
29.0	407													164.2													
29.6	408													134.5													
30.9	33	41	60	20	0.53	18.1									108.7	40.8	2.0										
31.1	34										148.5																
32.0	409													97.7													
32.6	410													110.1													
33.7	35								107.7																		
33.8	36							83.8			147.3																
34.0	37	47	87	26	0.35	17.3									92.5	67.2	0.4										
35.1	411													125.4													
35.7	412													122.1													
37.1	38	20	44	15	0.16																					C	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-57
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-57.3c

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98-57		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
37.2	39	23	42	15	0.30						222.8+																
38.1	413													134.1													
38.7	414													196.8													
39.9	40								131.7																		
40.1	41	48	70	26	0.50	16.9									79.9		0.5										
40.2	42							119.7			172.0																
41.1	415													181.0													
41.8	416													263.3+													
43.0	43								153.2																		
43.1	44	23	37	15	0.35	20.2									162.0	93.7	1.1										
43.3	45								153.2		162.1																
46.2	46	50	82	24	0.44																					C	
46.3	47	51	77	24	0.52						157.2																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-57
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-57.3d

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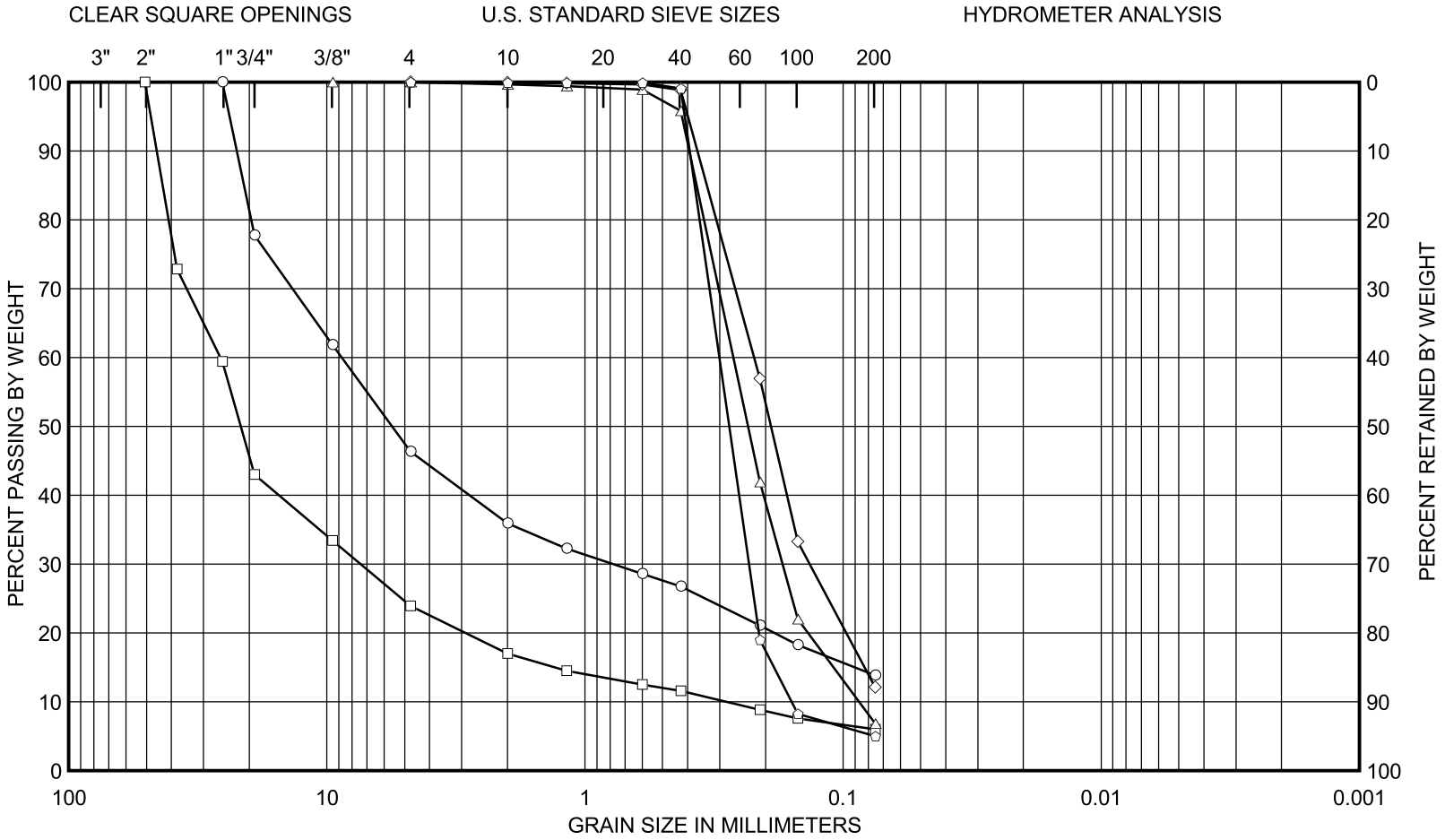

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.2	○—○	SILTY FINE GRAVEL (GM) with coarse gravel and fine to coarse sand			5.6
3	4.8	□—□	COARSE GRAVEL (GP-GM) with silt, fine gravel and fine to coarse sand	7.5	91.1	21.5
4	6.4	△—△	FINE SAND (SP-SM) with silt	1.3	3.1	0.23
5	7.9	◇—◇	FINE SAND (SP-SM) with silt			0.19
25	21.5	⬠—⬠	FINE SAND (SP-SM) with silt	1.1	1.9	0.28

GRAIN SIZE DISTRIBUTION CURVES

Boring 98-57

SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-57.4

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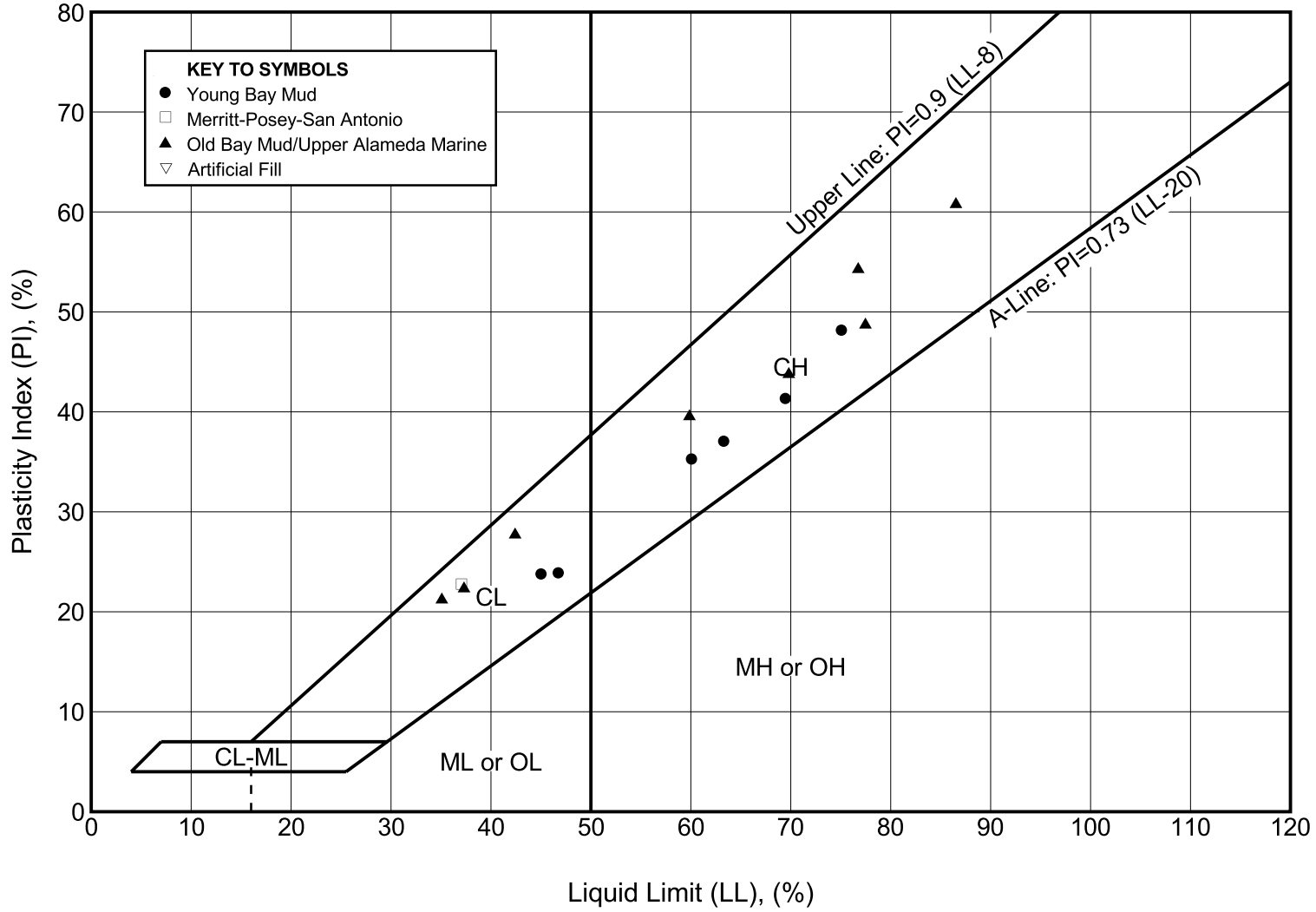

PLASTICITY CHART
Boring 98-57
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-57.5

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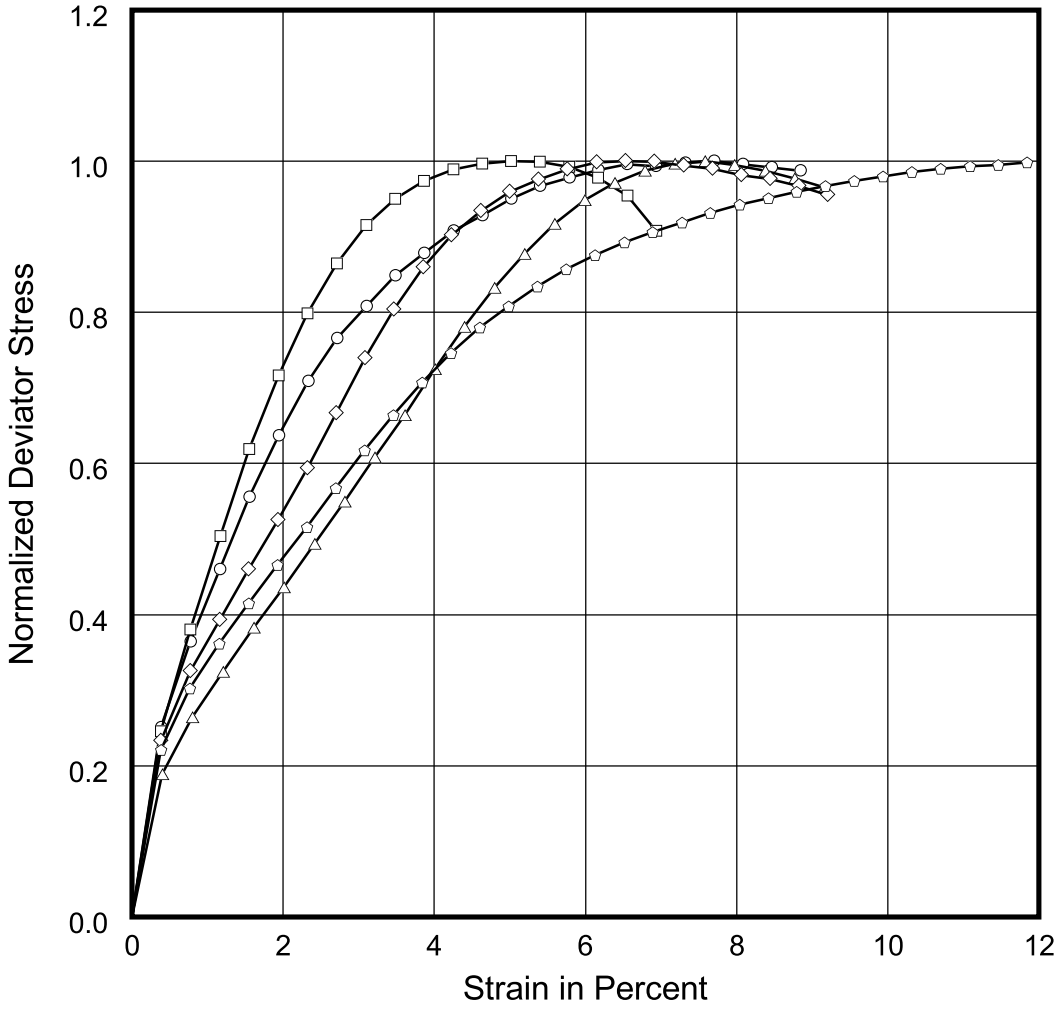
Earth Mechanics

FUGRO



Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
	7	9.6	UU	172	59	1.3
	10	11.1	UU	207	71	1.1
	15	14.2	UU	276	94	2.4
	18	15.7	UU	310	100	1.8
	23	18.7	UU	345	228	2.2

Deviator stress normalized with respect to maximum deviator stress.

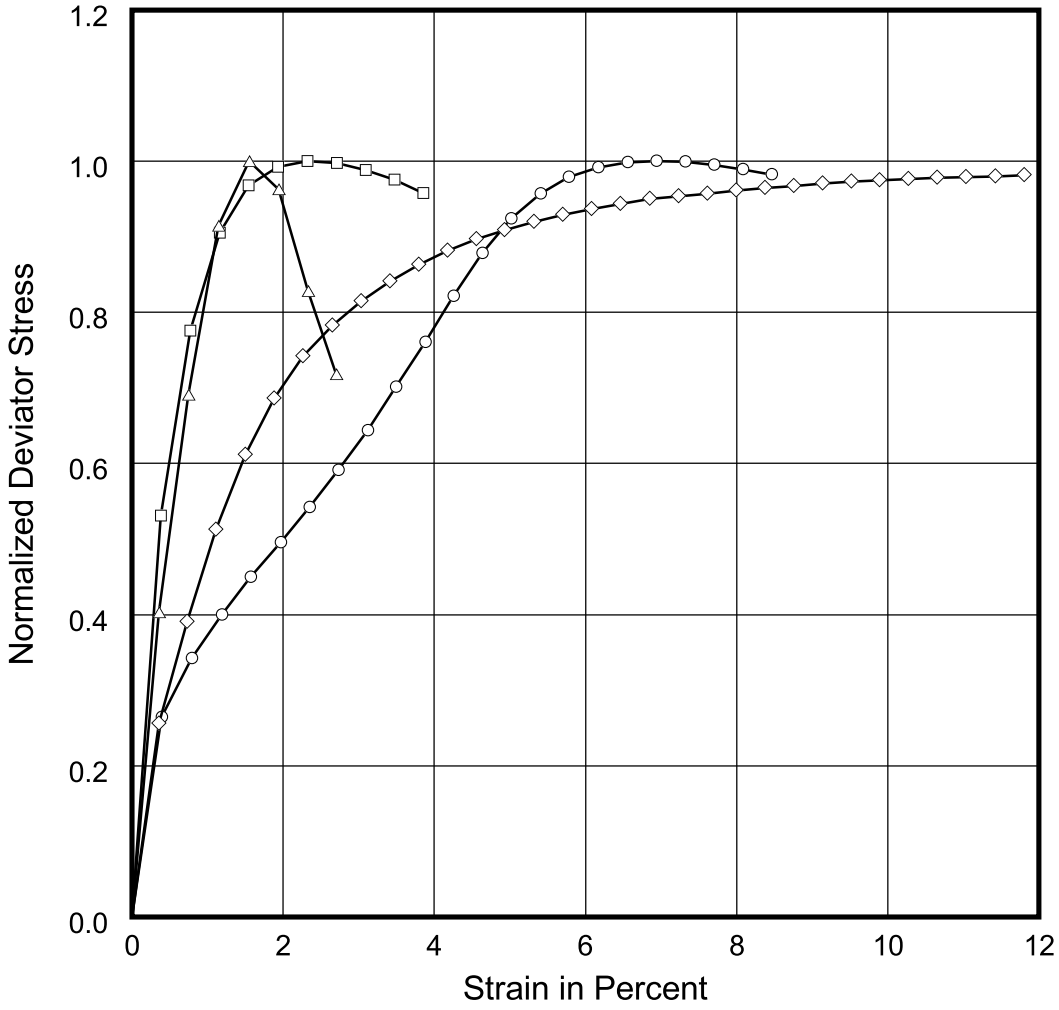
STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.6a

Earth Mechanics

FUGRO



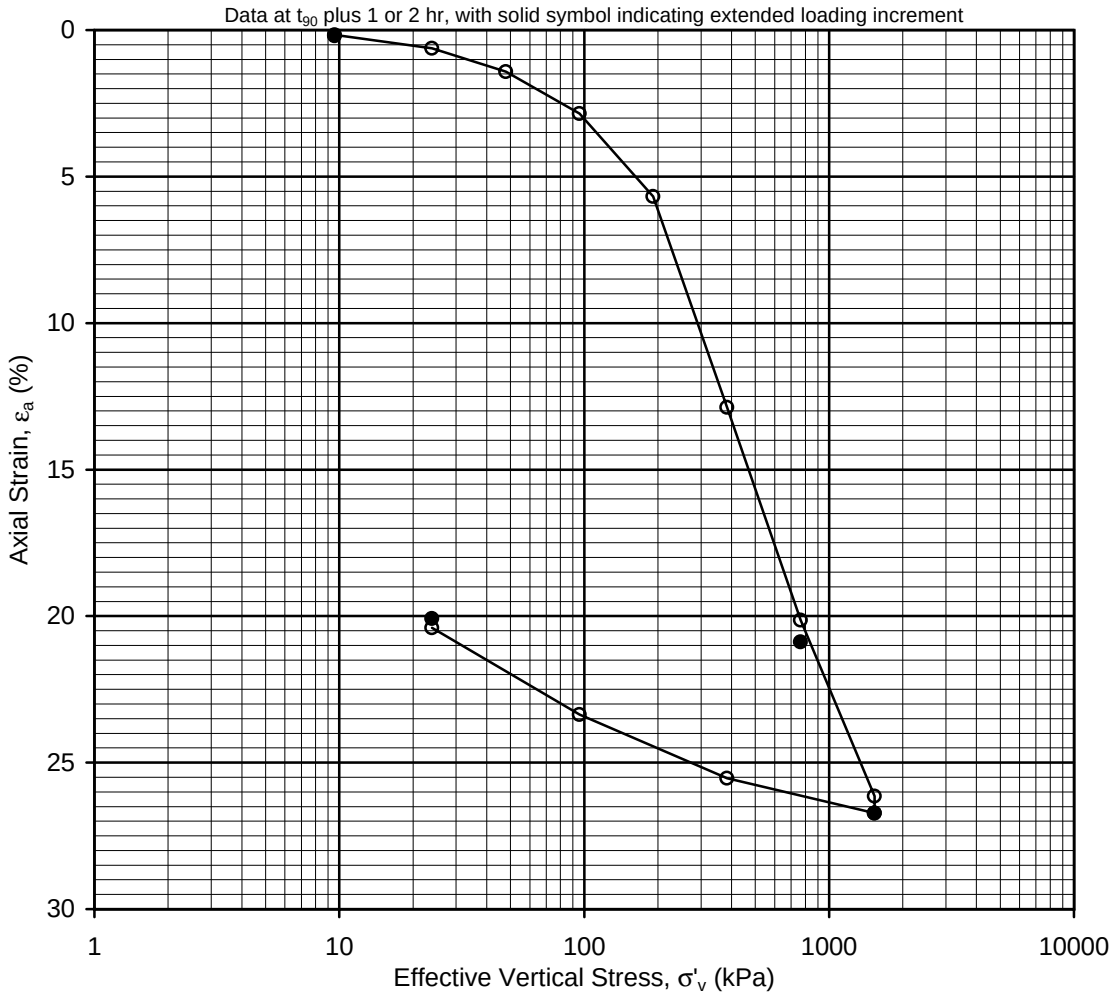
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	33	30.9	UU	931	218	2.0
□	37	34.0	UU	965	185	0.4
△	41	40.1	UU	1103	160	0.5
◇	44	43.1	UU	1172	324	1.1

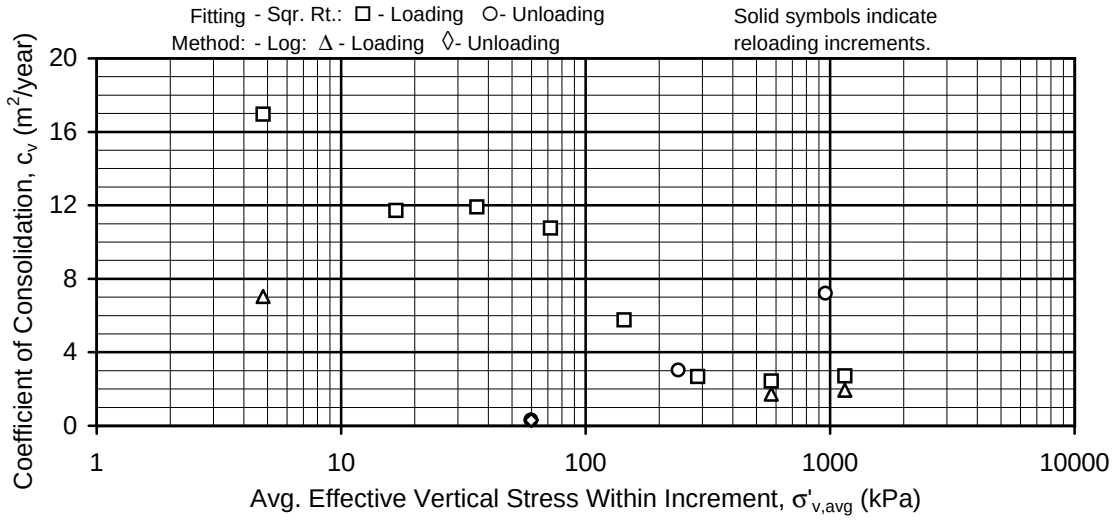
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-57
SFOBB East Span Seismic Safety Project

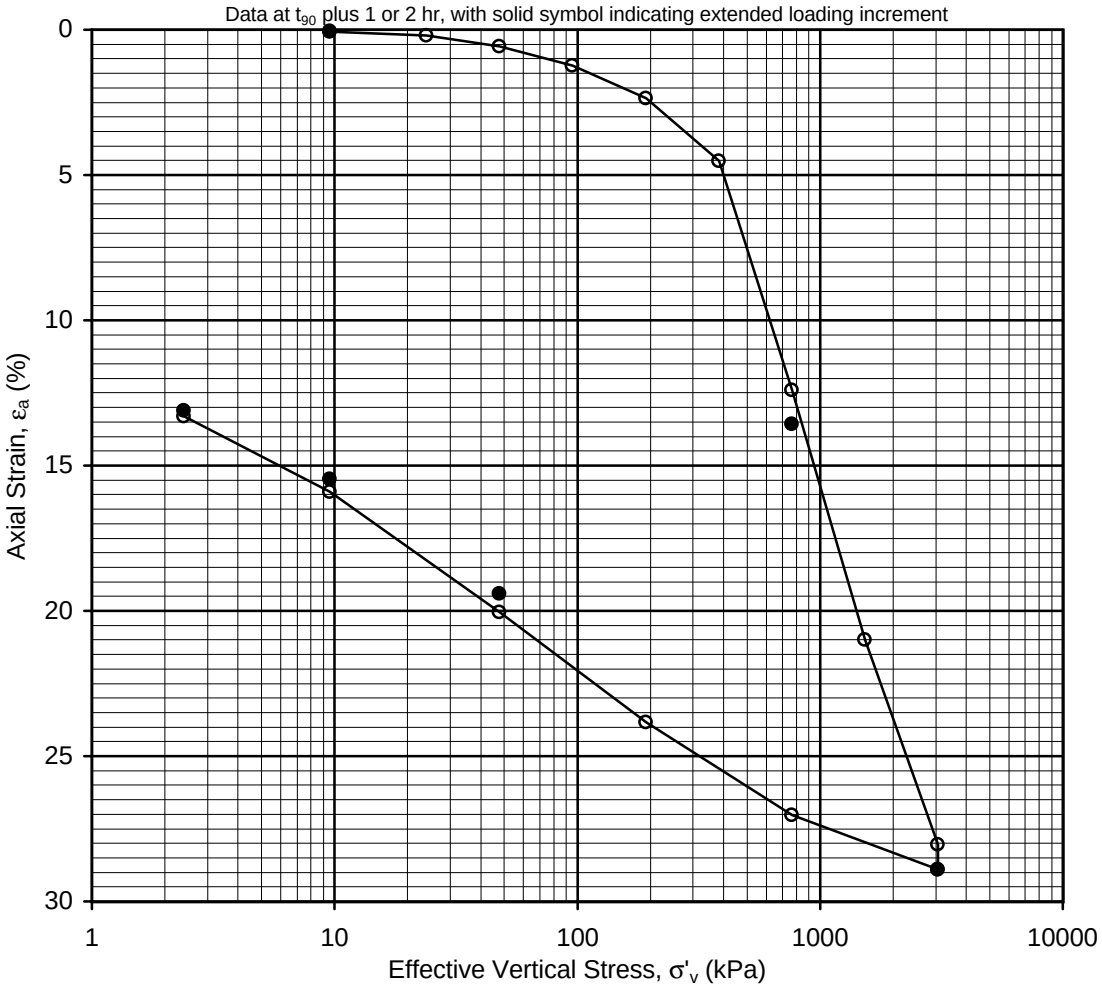
PLATE 98-57.6b

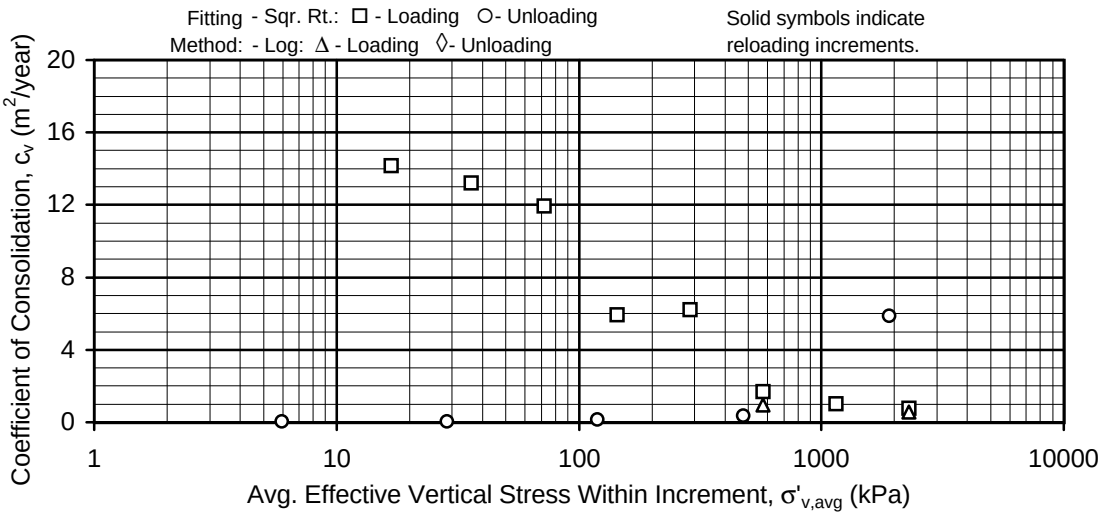




INCREMENTAL CONSOLIDATION TEST RESULTS

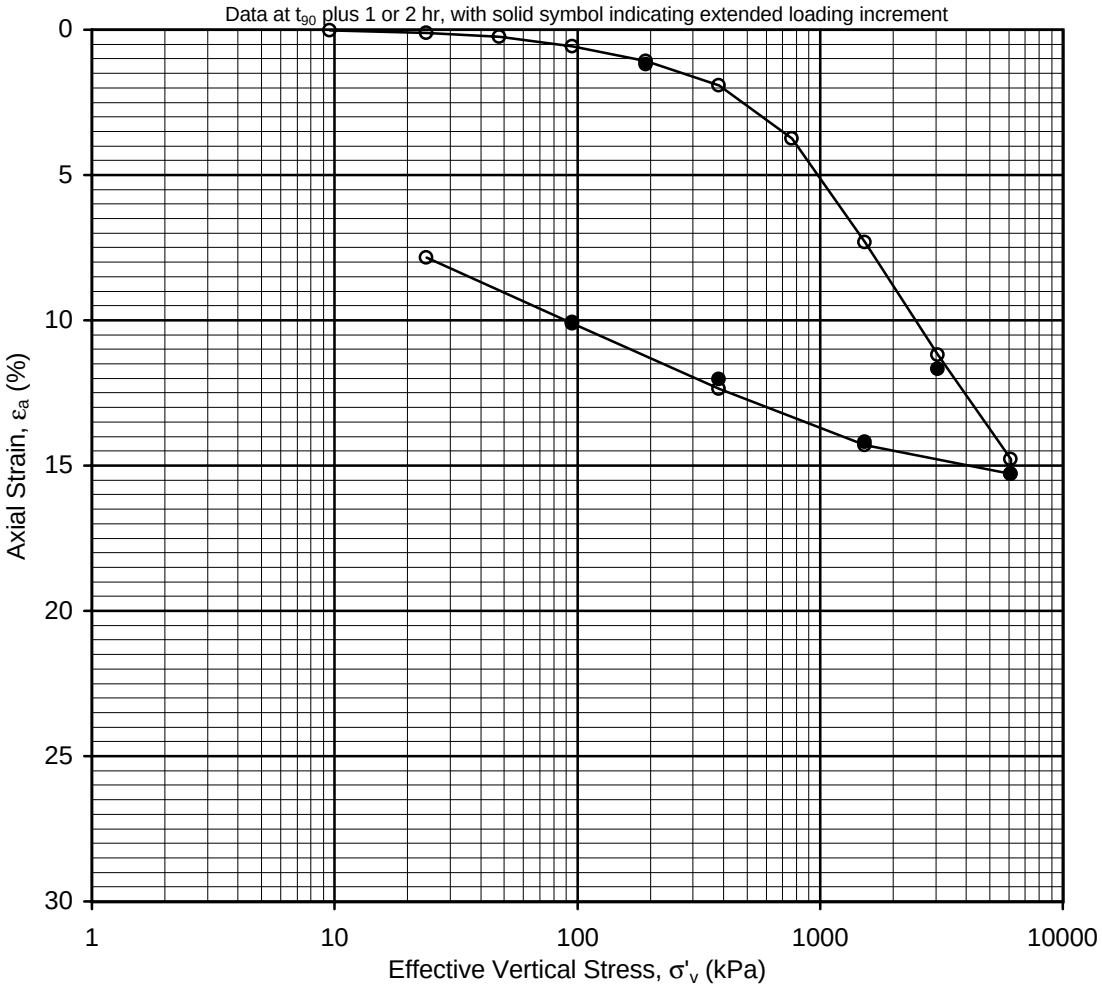
Sample No. 20 - Depth: 17.2m
Boring 98-57
SFOBB East Span Seismic Safety Project

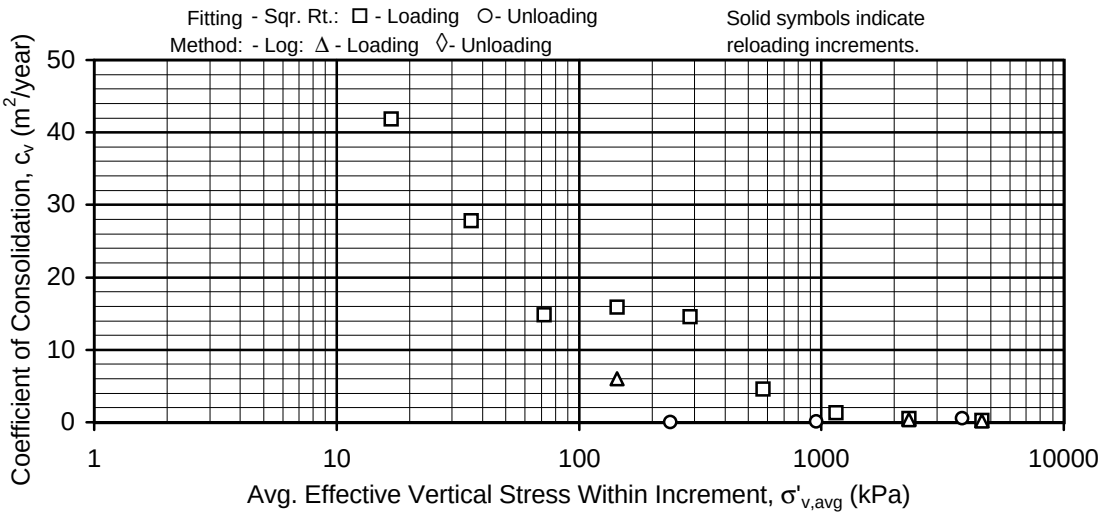




INCREMENTAL CONSOLIDATION TEST RESULTS

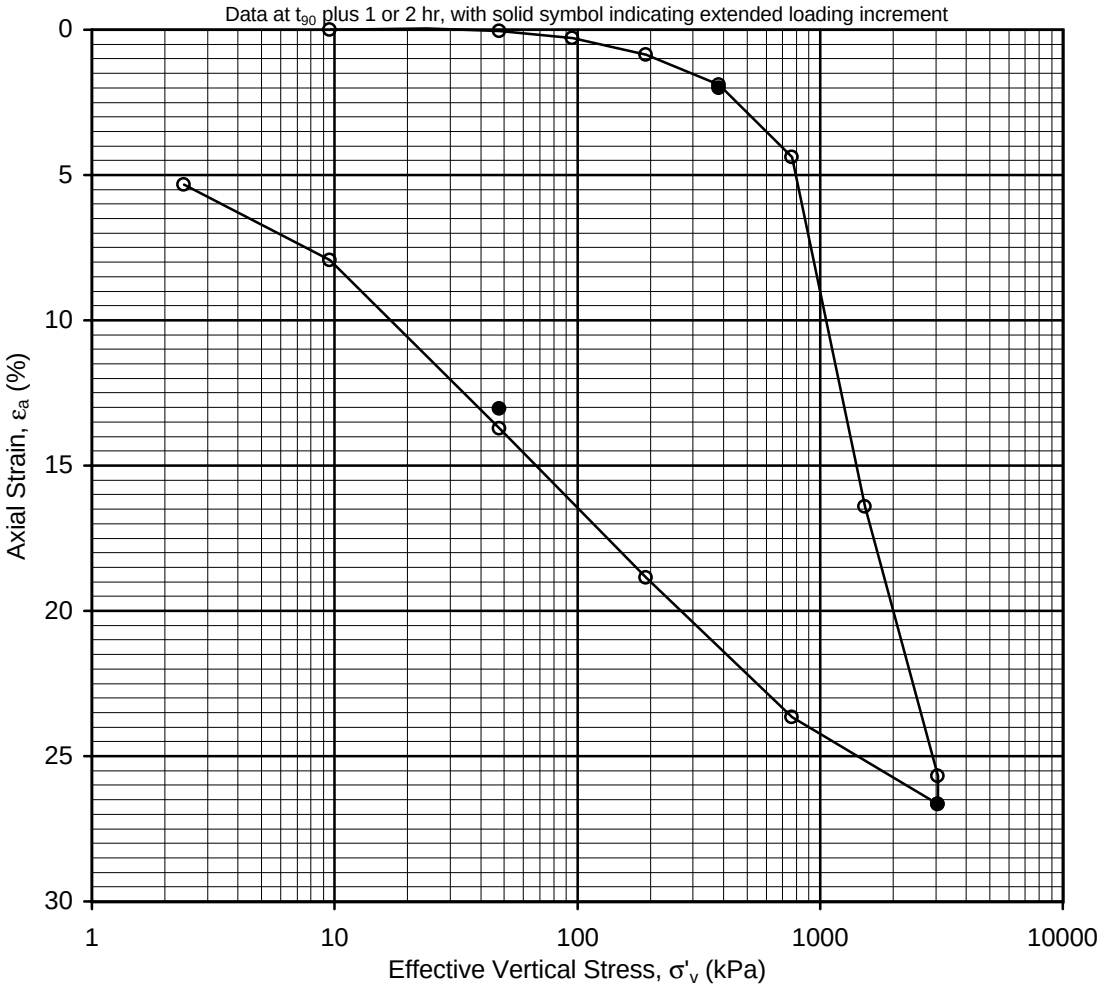
Sample No. 30 - Depth: 28.1m
Boring 98-57
SFOBB East Span Seismic Safety Project

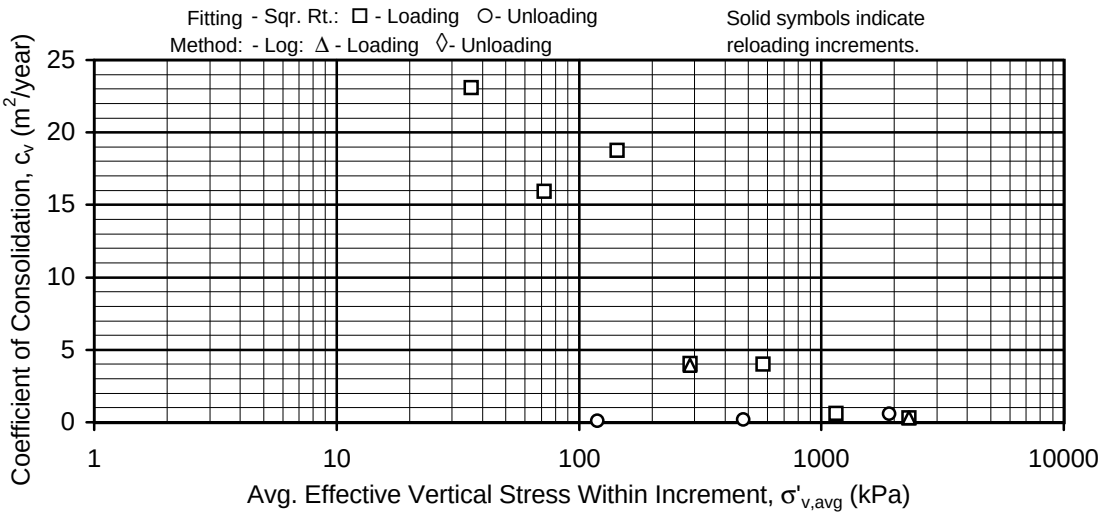




INCREMENTAL CONSOLIDATION TEST RESULTS

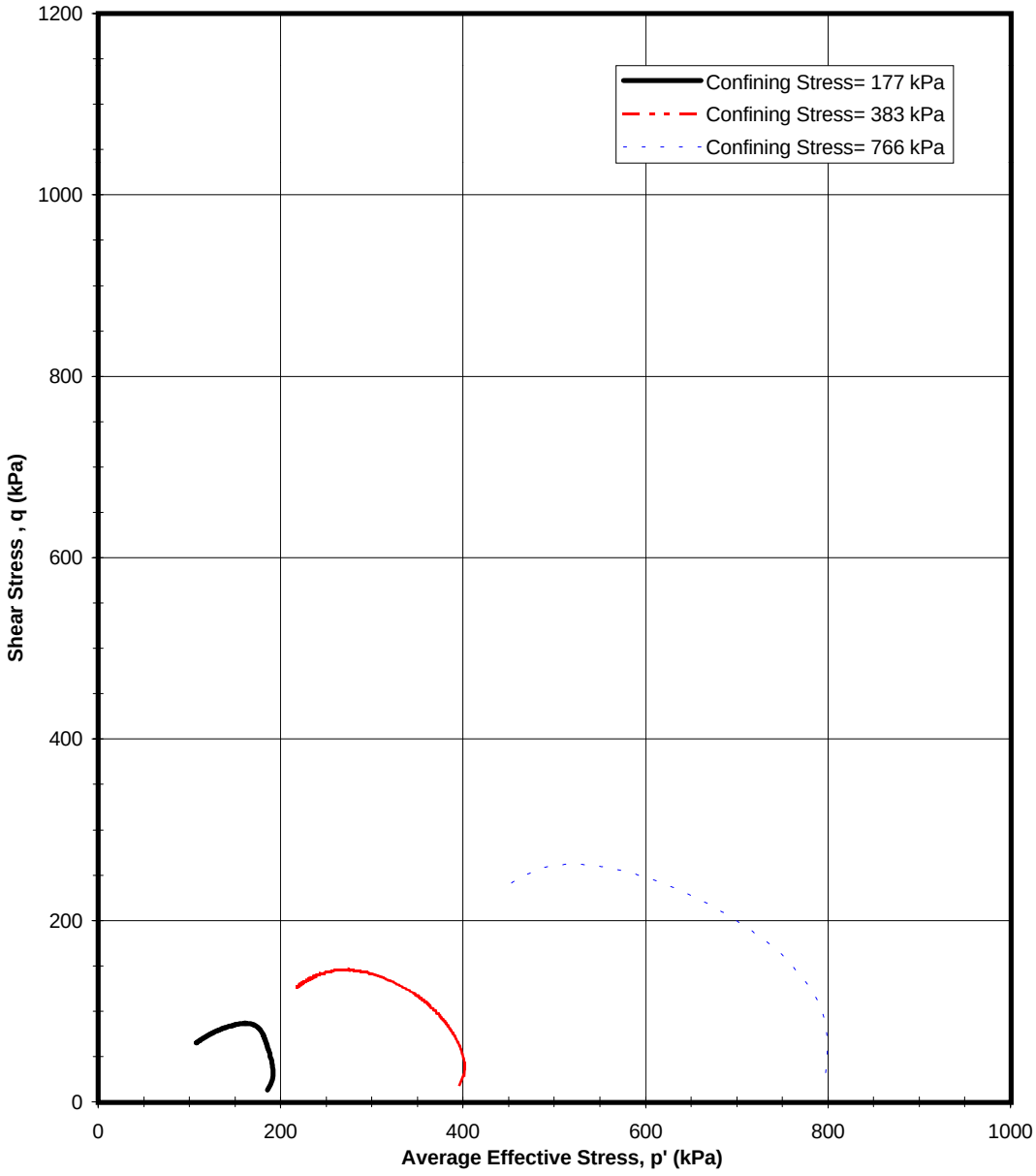
Sample No. 38 - Depth: 37.0m
Boring 98-57
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 46 - Depth: 46.0m
Boring 98-57
SFOBB East Span Seismic Safety Project



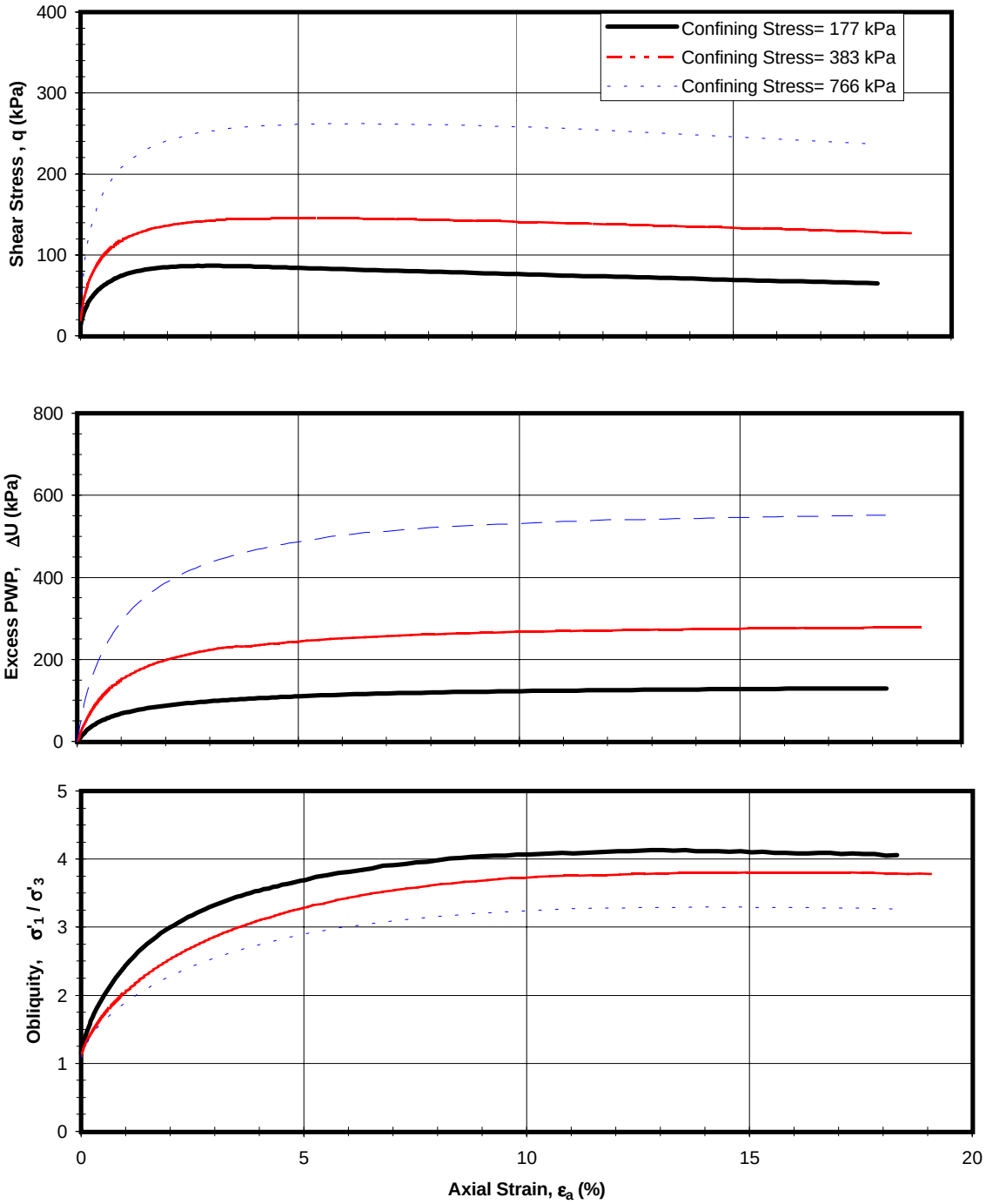
CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 20 - Depth: 16.9m

Boring 98-57

SFOBB East Span Seismic Safety Project

PLATE 98-57.8a



CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 20 - Depth: 16.9m

Boring 98-57

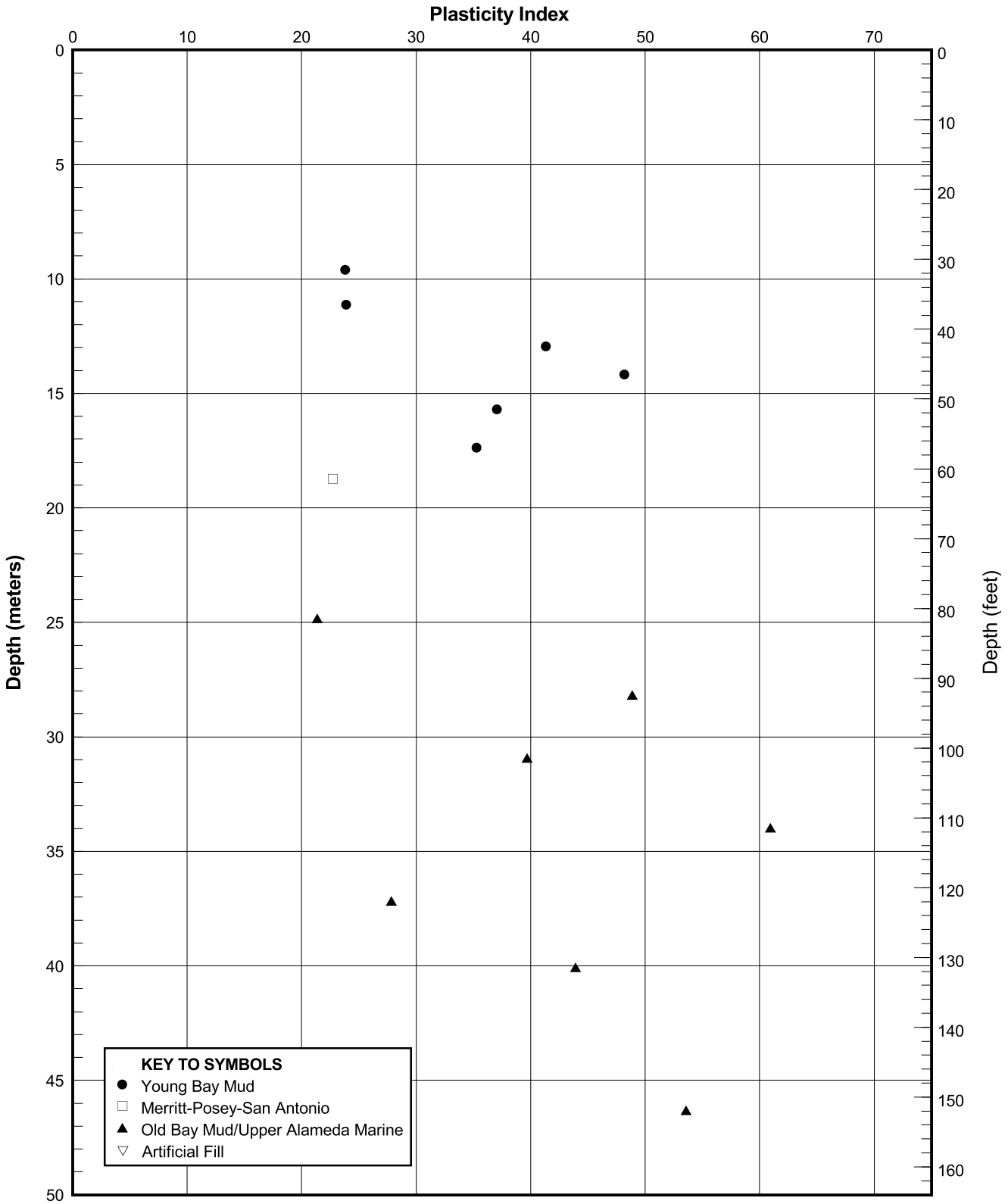
SFOBB East Span Seismic Safety Project

PLATE 98-57.8b

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring

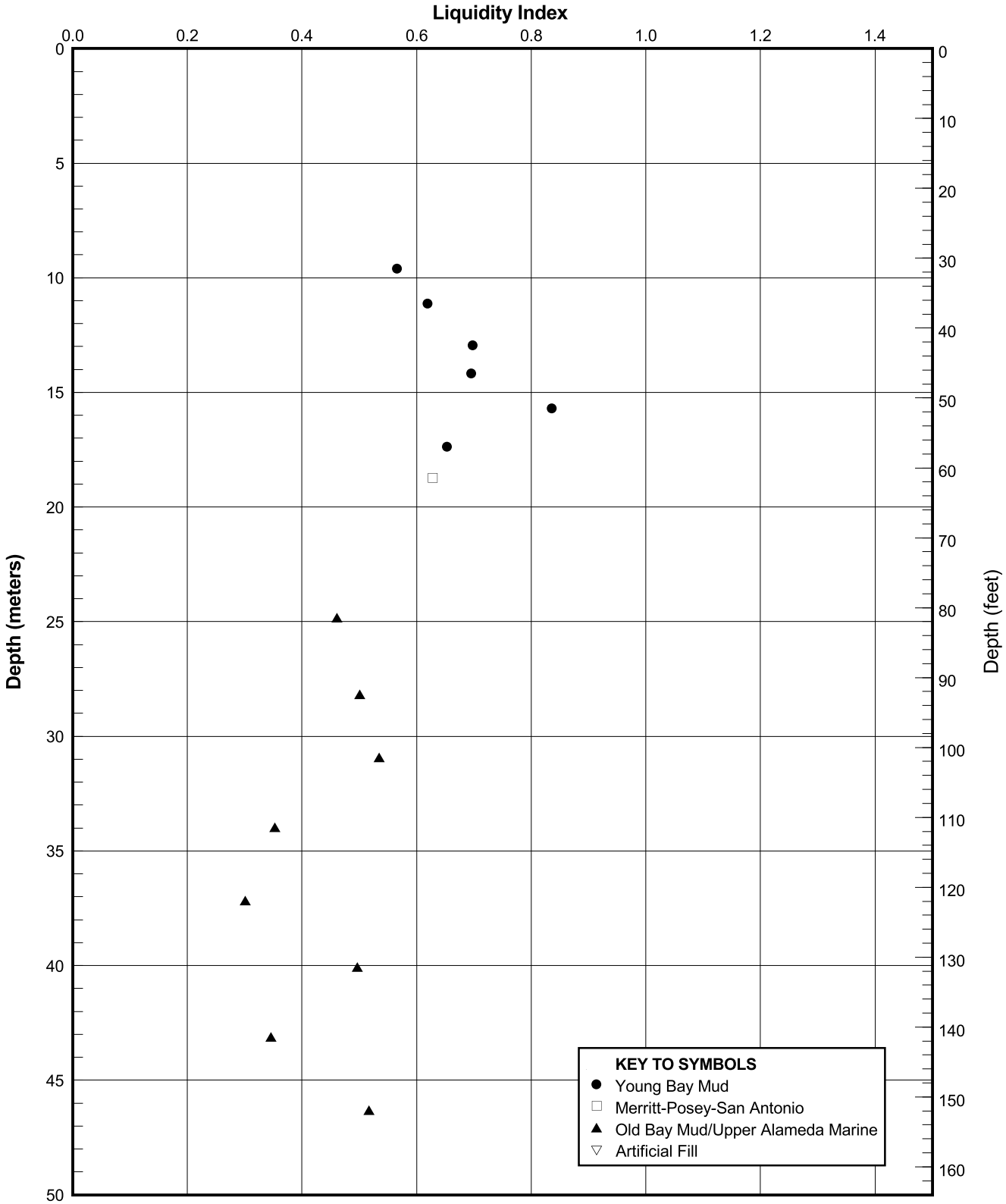


PLASTICITY INDEX PROFILE
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.12

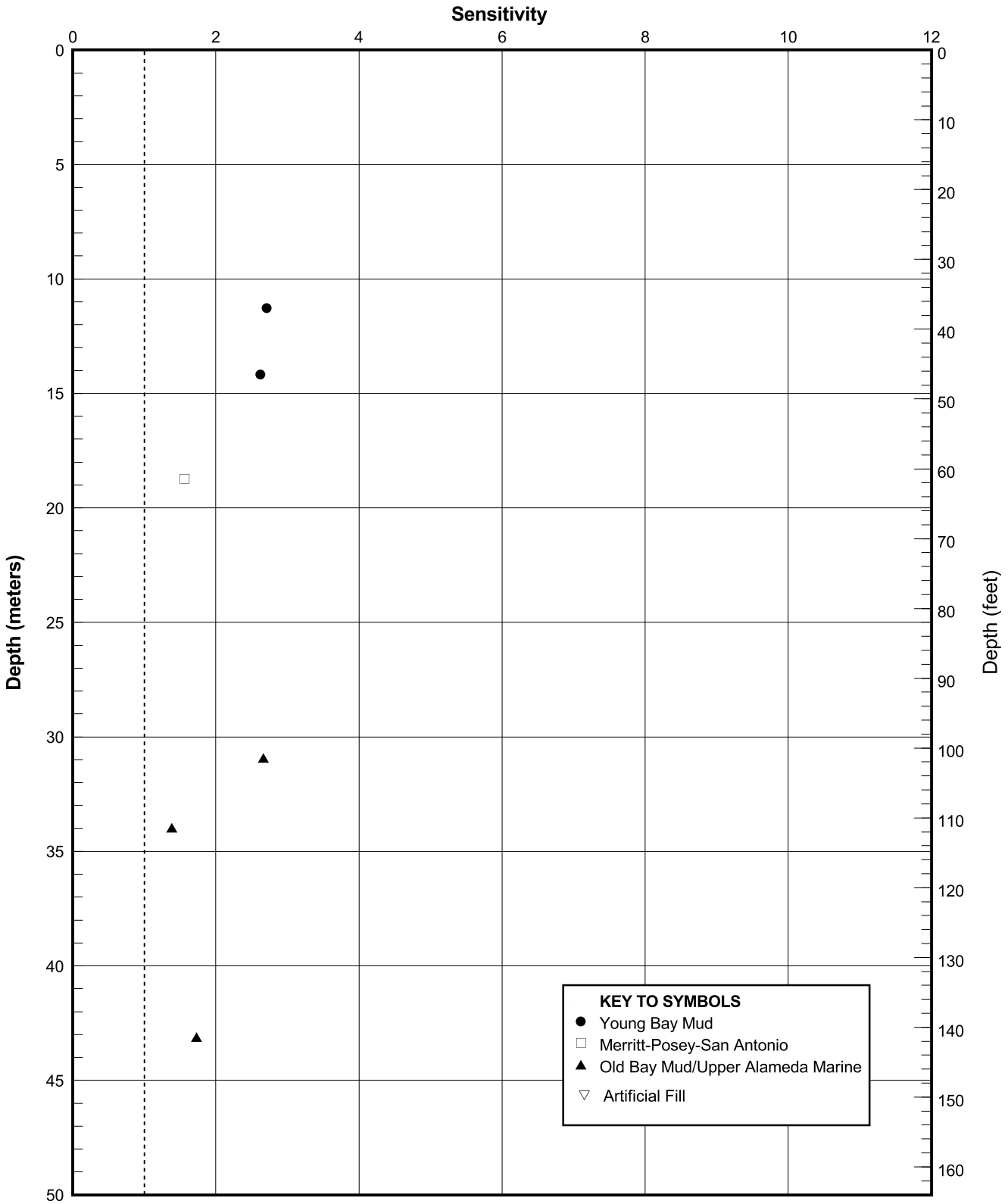
Earth Mechanics

FUGRO



LIQUIDITY INDEX PROFILE
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.13

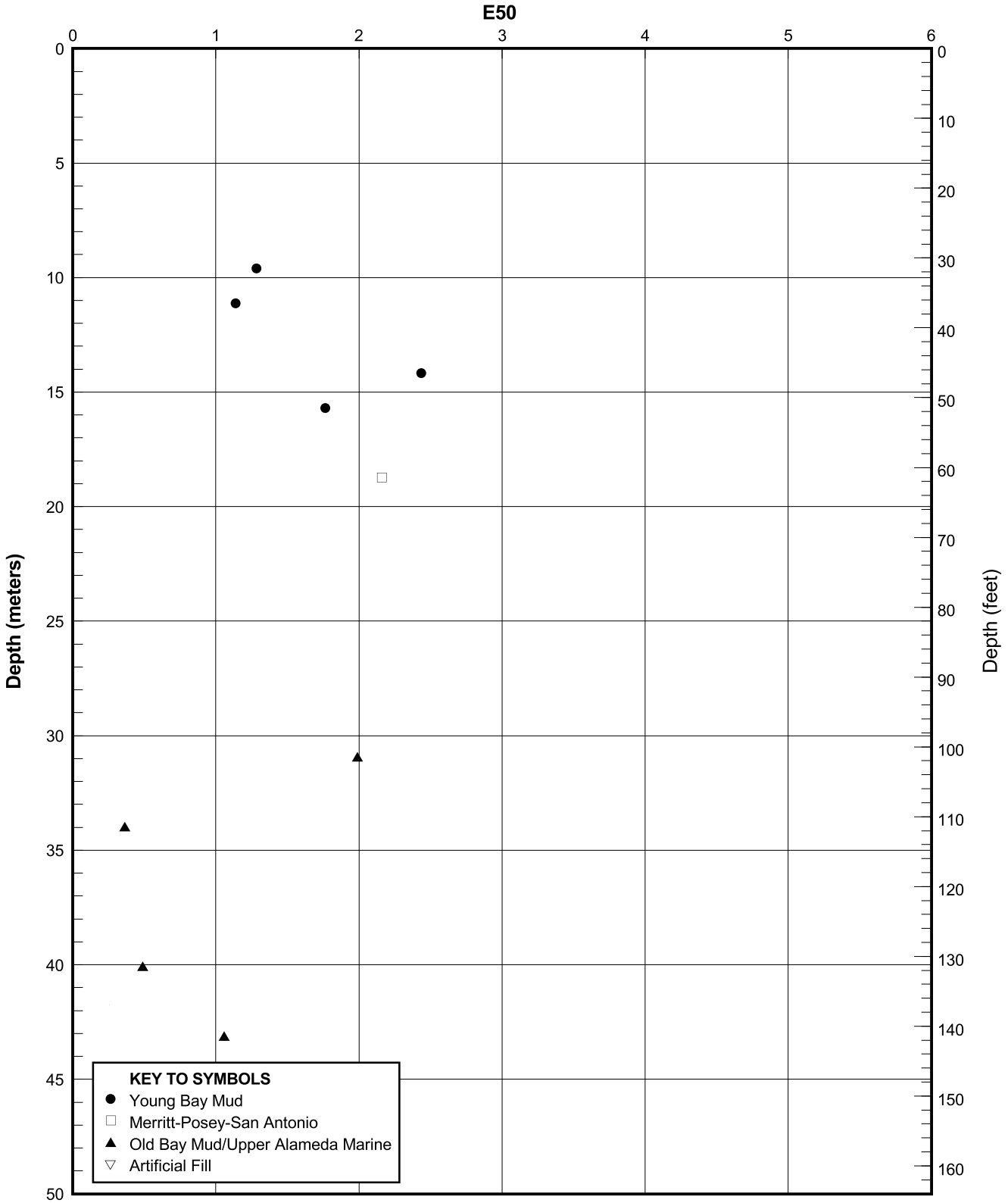


SENSITIVITY PROFILE
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.14

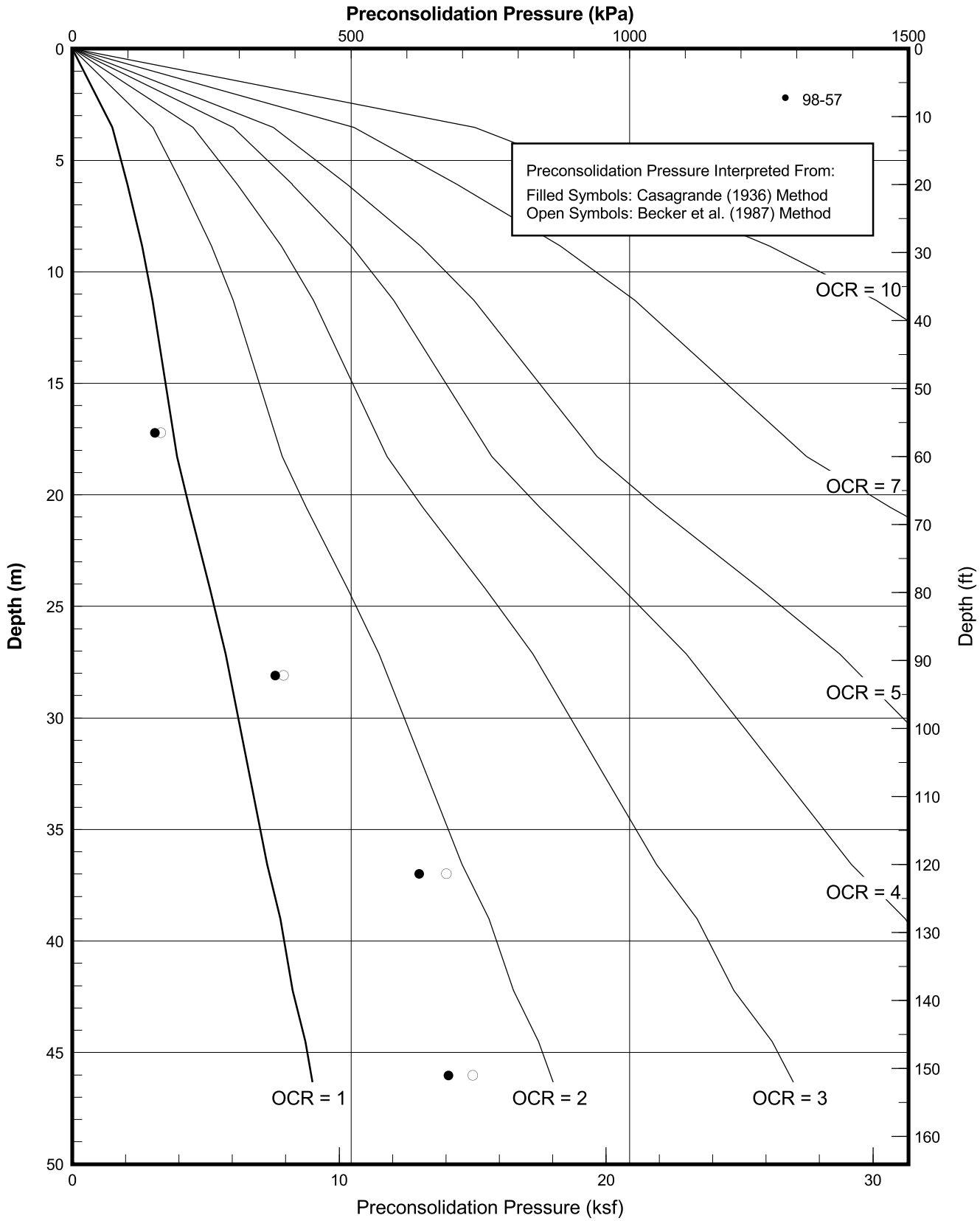
Earth Mechanics

FUGRO



E50 PROFILE
Boring 98-57
SFOBB East Span Seismic Safety Project

PLATE 98-57.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-57

SFOBB East Span Seismic Safety Project

PLATE 98-57.16

LAND BORING 98-58

PROJECT NO: 98-42-0058
BORING: 98-58 (5m left of W. Sta. 88+29)

START DATE: 10/23/98
COMPLETION DATE: 10/30/98

DRILLER: Pitcher Drilling Company
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1839287 N648327
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					PAVEMENT, 0.15m Asphalt Concrete over 0.15m of Aggregate Base (0.3m)	
2	2			16	Fat CLAY with gravel (CH), stiff to very stiff, brown -with sand pockets	II
				6	-with shell fragments at 3.0m (4.0m) ▽ (3.9m)	
0	4			15	Fine GRAVEL with sand (GW), medium dense, dark gray -with coarse gravel at 5.0m -with a black sand layer at 5.2m	III
-2	6			34	-coarse gravel and silt at 6.2m (7.6m)	
-4	8			23	Silty Fine SAND (SM), medium dense, greenish gray -with coarse gravel at 8.1m	IV
				18	-with clay pockets and shell fragments, at 9.1m	
-6	10			10	-with clay pockets at 10.7m (11.0m)	
-8	12			PUSH	Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -dark gray at 11.0m -with silt pockets at 12.5m	V
-10	14			SAVE	-silty fine sand, 14.2m to 14.5m -clayey sand, 14.5m to 15.8m	
-12	16			3		
				PUSH	-with gas blisters at 17.1m (18.4m)	
-14	18			PUSH	Fat CLAY (CH), very stiff, greenish gray -with many sand pockets to 18.9m	VI
-16	20			PUSH	-with organic pockets, sand pockets, calcareous nodules and slickensides, at 20.1m (20.6m)	
-18	22			50/15cm	Fine SAND with silt (SP-SM), very dense, greenish gray	VII
				50/15cm		
-20	24			12	-clayey sand below 24.4m (25.6m)	
-22	26			PUSH	Fat CLAY (CH), very stiff, greenish gray -with gas blisters and slickensides, at 26.2m	VIII
-24	28				-with sand pockets, silt pockets and calcareous nodules, at 29.3m	
-26	30			PUSH	(29.6m) Fat CLAY (CH), very stiff, greenish gray	IX
-28	32			SAVE	-with a few sand pockets at 32.3m	
-30	34					
-32	36			PUSH	-with silt pockets and partings, at 35.4m (36.6m)	
-34	38			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -with reddish brown oxidation staining, at 38.4m	X
-36	40					
-38	42			SAVE	-with many organic pockets and a few sand pockets, at 41.5m (42.1m)	
-40	44			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -with sand pockets, calcareous nodules and gas blisters, at 44.5m	XI
-42	46					
-44	48			PUSH	-with organic pockets and partings and reddish brown oxidation staining, at 47.5m	
-46	50				(50.3m)	
-48	52			SAVE	Fat CLAY (CH), very stiff to hard, greenish gray -lean clay to 52.7m	XII
-50	54			PUSH	-with sand pockets, a few silt pockets, and slickensides, at 53.6m	
-52	56					
-54	58			PUSH	-with a few silt partings and a few shell fragments, at 56.7m	
-56	60			SAVE	-with a few shell fragments at 59.7m	
-58	62				TOTAL DEPTH: 60.0m BACKFILLED WITH: Cement Grout	
-60	64					

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

120 →
101 →

PLATE 98-58.1

LOG OF BORING AND TEST RESULTS
BORING 98-58
SFOBB East Span Seismic Safety Project

Report Date: 03/11/99

Earth Mechanics

FUGRO

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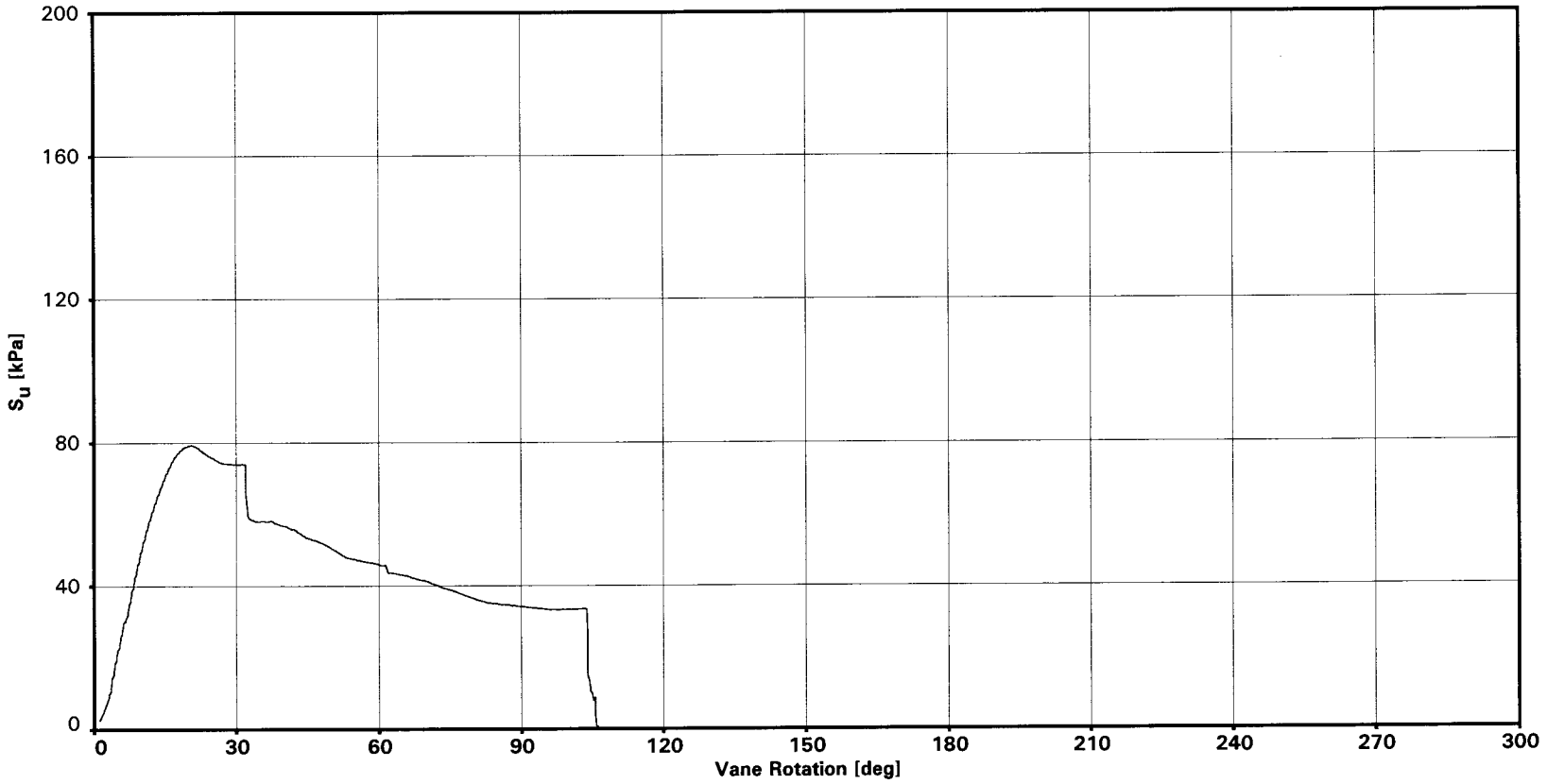
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 13.7m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

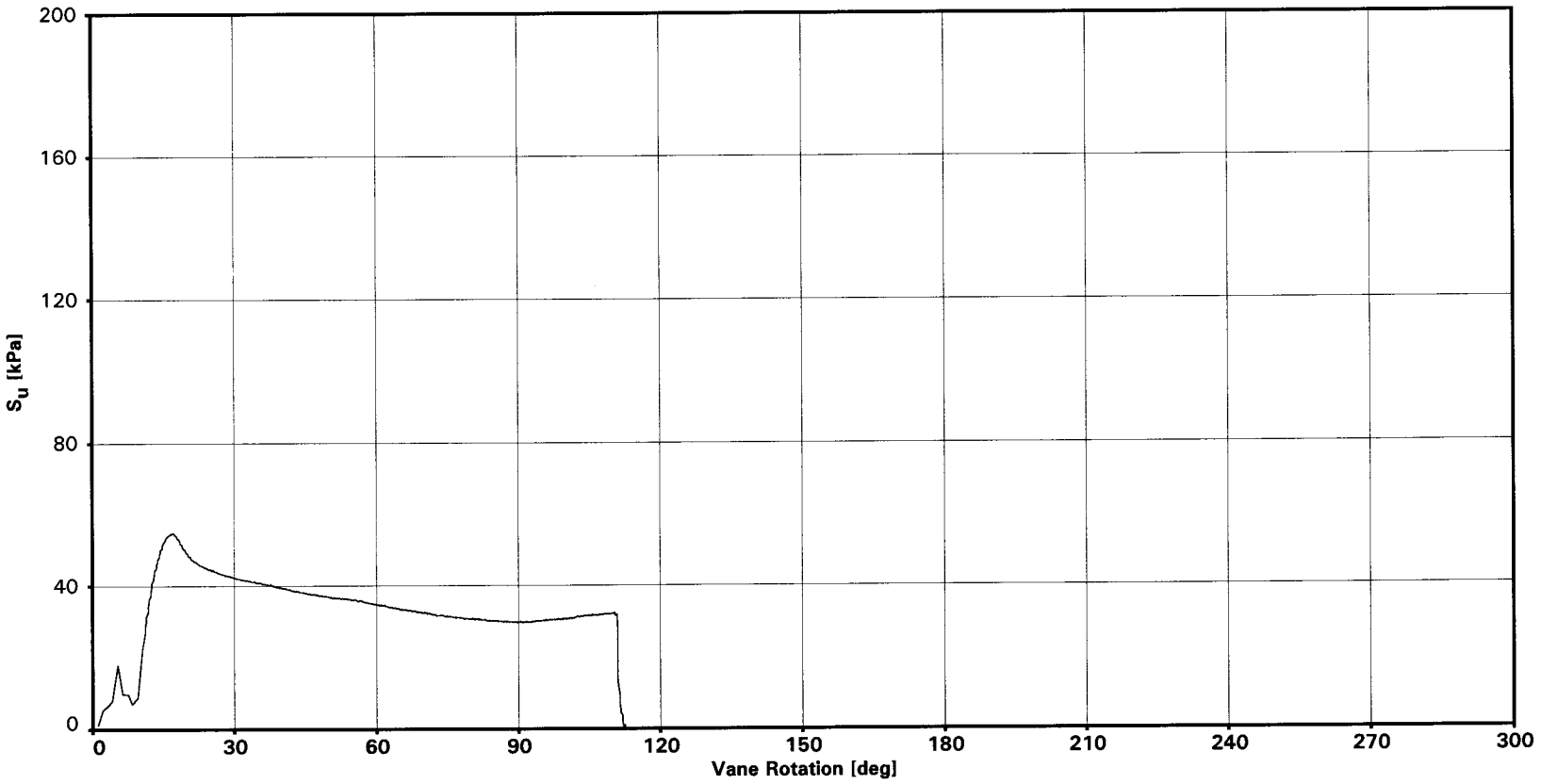
FUGRO

PLATE 98-58.2a

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 16.8m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

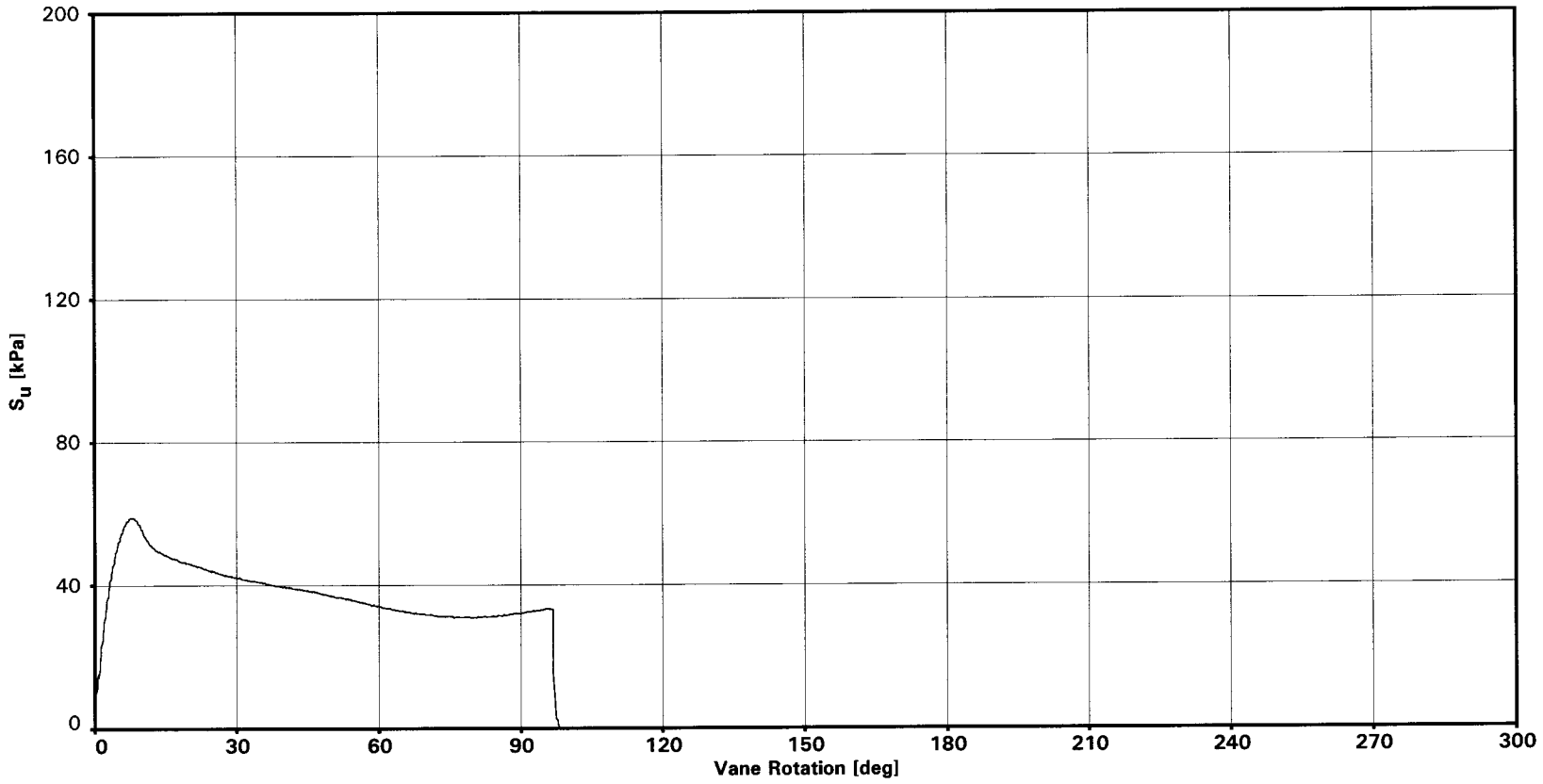
FUGRO

PLATE 98-58.2b

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 18.3m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

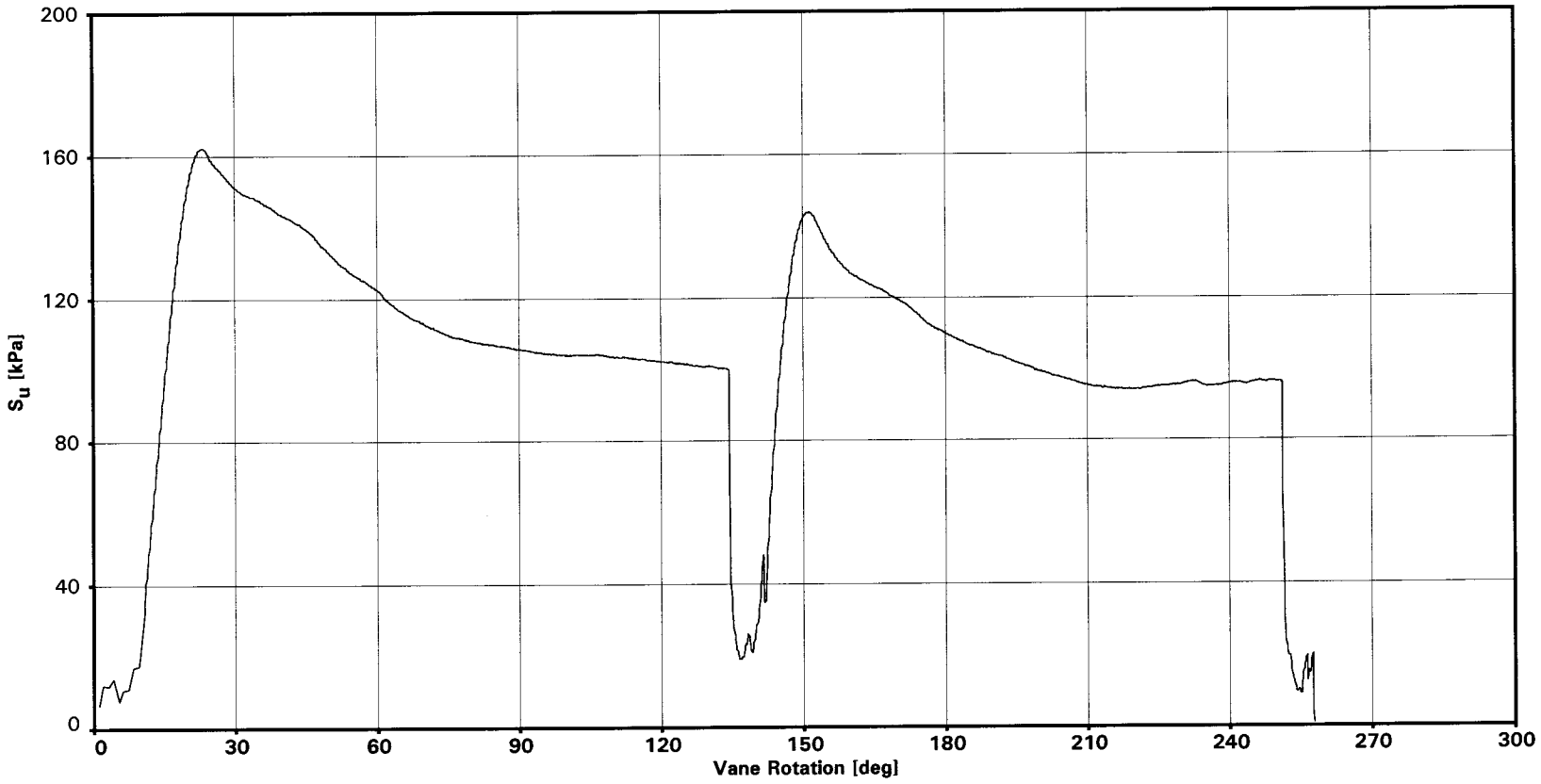
FUGRO

PLATE 98-58.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 27.4m and 28.0m
Boring 98-58
SFOBB East Span Seismic Safety Project

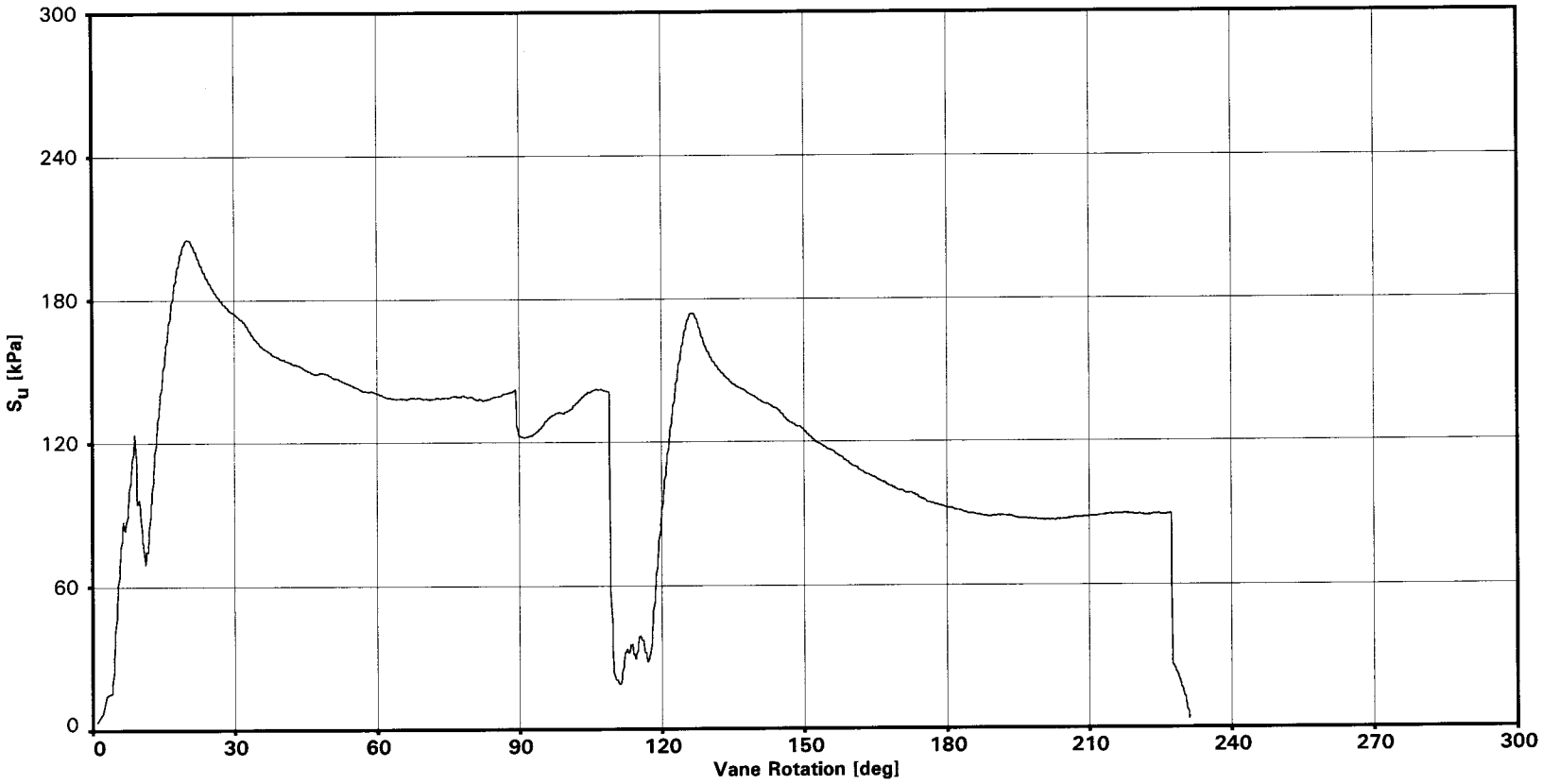
Earth Mechanics

FUGRO

PLATE 98-58.2d

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 30.5m and 31.1m
Boring 98-58
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

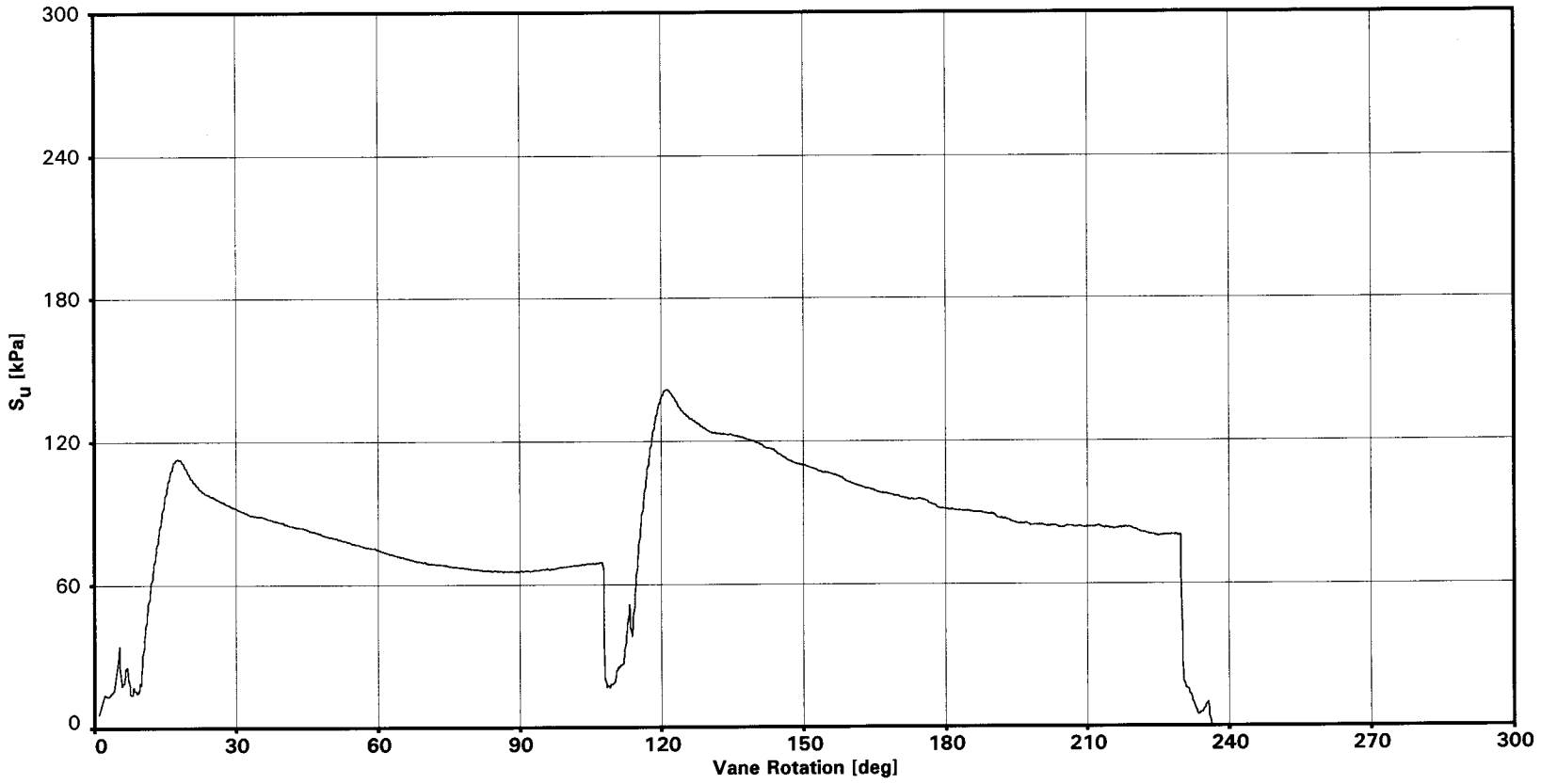
FUGRO

PLATE 98-58.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 33.5m and 34.1m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

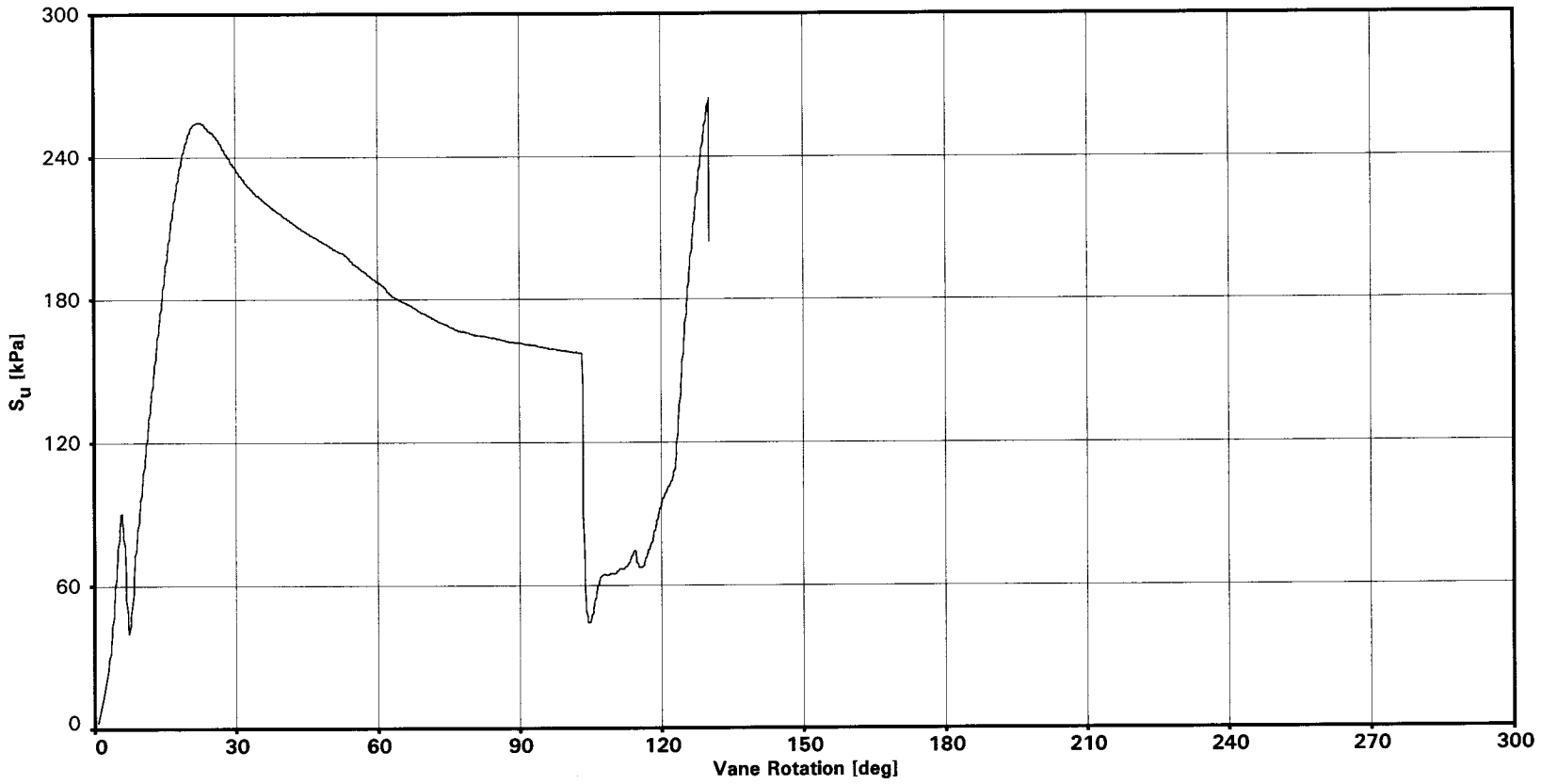
FUGRO

PLATE 98-58.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 36.6m and 37.2m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

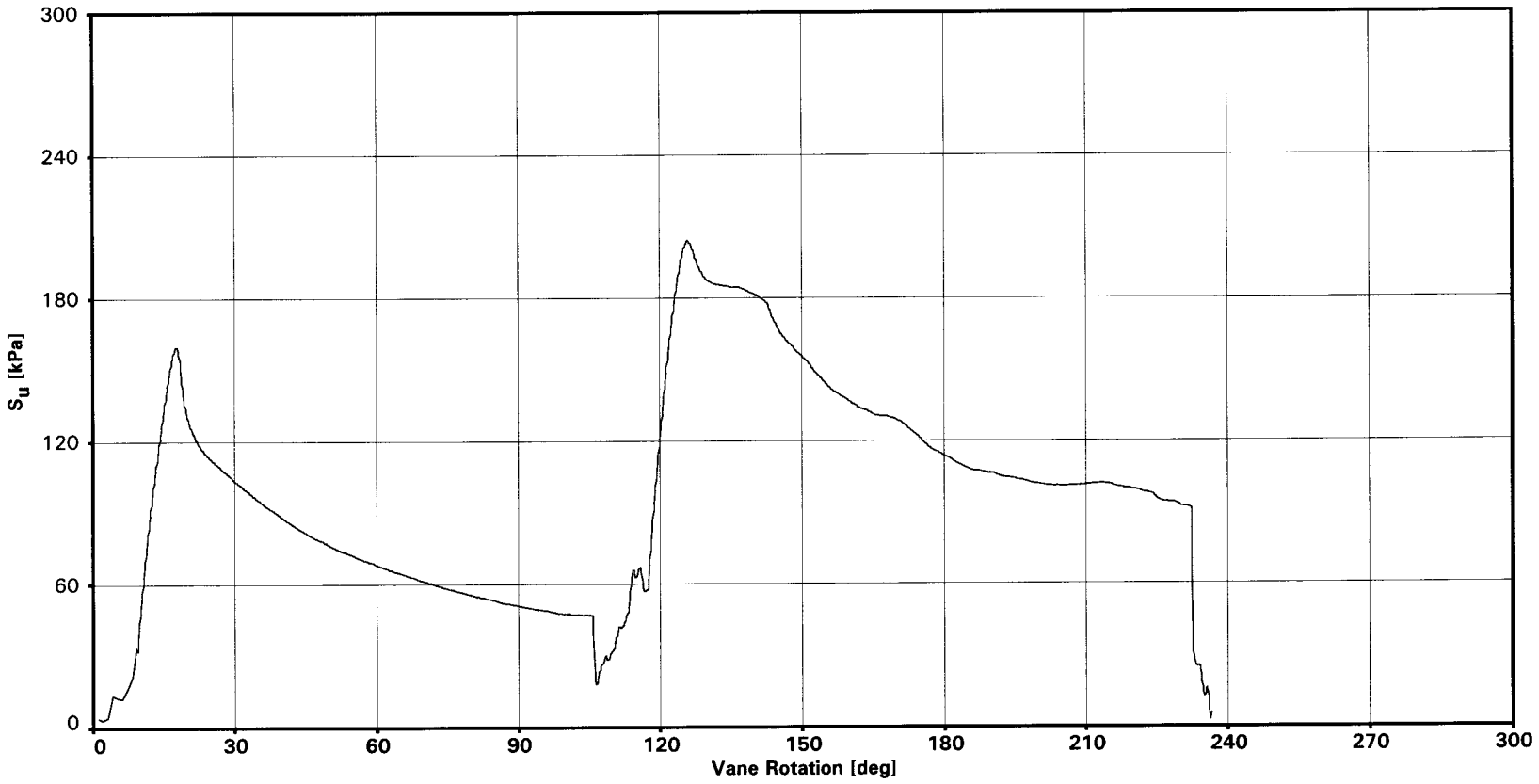
FUGRO

PLATE 98-58.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 39.6m and 40.2m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

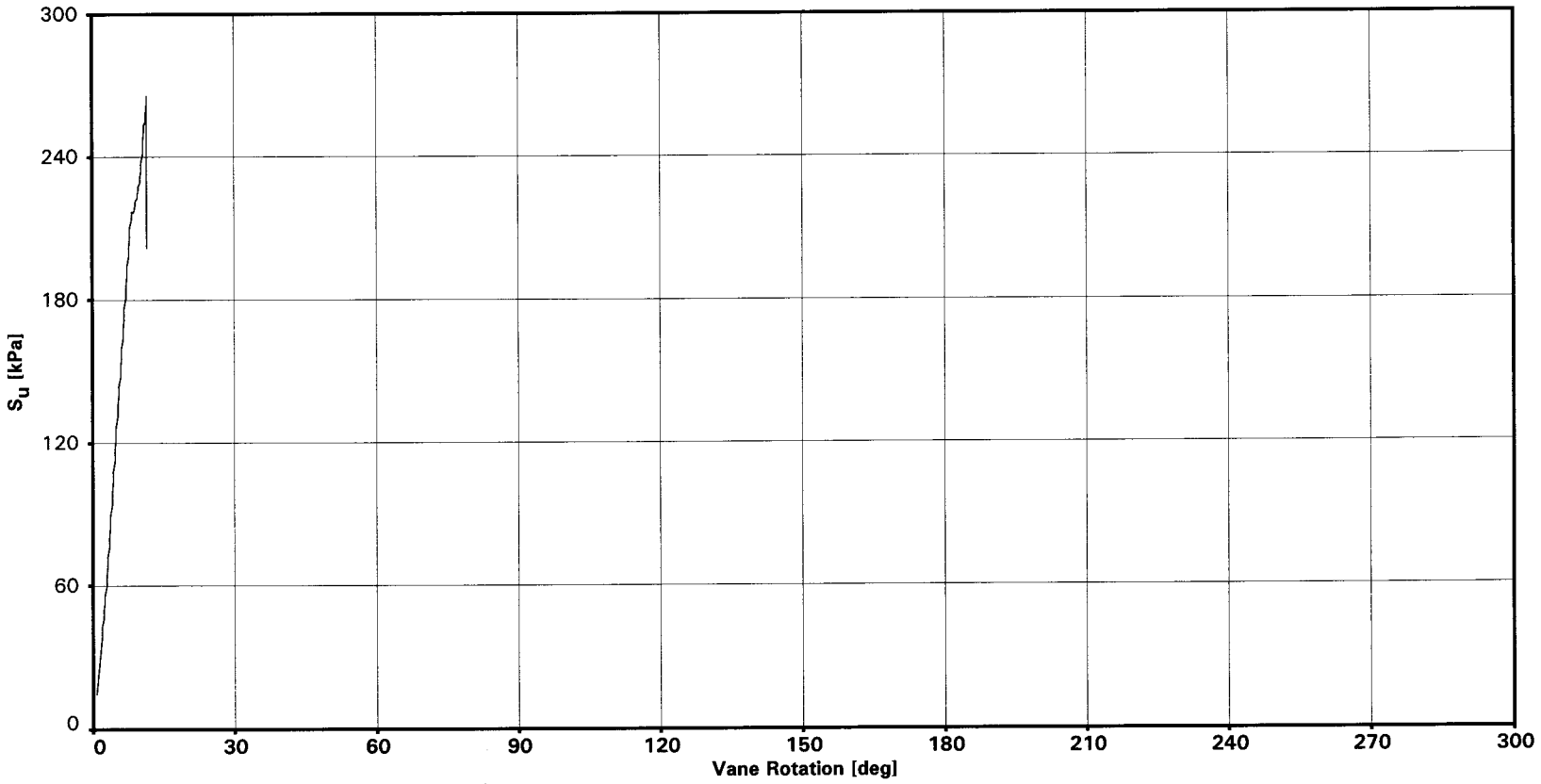
FUGRO

PLATE 98-58.2h

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 42.7m and 43.3m
Boring 98-58
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-58.2i

98-58		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
2.0	1	25	56	26																							2.67
3.5	2	31	67	28	0.07																						
5.0	3						0																				
6.2	4						5																				
8.1	5	26					28																				
9.6	6	27					6																				2.65
11.0	8	25					52																				
11.1	9	50	58	24	0.76																						
12.6	12	48	58	26	0.70	16.8		49.8							39.7		3.3										
12.8	13							53.6		53.6	54.3	9.5															
13.7	400													79.5													
14.5	15	21					21																				
15.7	16	34					36																				2.69
16.8	401													54.1													
17.1	18							50.8		56.5	58.3	10.3															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-58
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-58.3a

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98-58		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
17.2	19	52	70	27	0.58	16.5		45.0							58.5		0.9										
18.3	402													57.9													
18.7	22	27	51	18	0.29	18.9		95.8			91.6				85.4		0.7										
18.9	23							114.9																			
20.1	25	27	37	22	0.31	20.8									109.8	75.4	2.4										
20.3	26							179.6																			
21.6	27	21					5																				
23.0	28	25					9																				2.69
24.8	29	25					37																				
26.2	31	36	69	13	0.41	17.8										100.4											
26.4	32							112.5	114.9		136.1																
27.4	403													159.0													
28.0	404													141.2													
29.4	34	33	55	17	0.43	18.4																					
29.6	35							126.9	134.1		134.9																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.3b

Earth Mechanics

FUGRO

98-58		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
30.5	405													201.6													
31.1	406													170.9													
32.5	36	49	72	23	0.53																					C	
32.6	37	45	73	22	0.45			105.3			167.1																
33.5	407													110.6													
34.1	408													139.3													
35.4	39	50	69	29	0.52				95.8						100.3	34.2	2.1										
35.5	40					16.9		102.9			138.6																
35.7	41							112.5																			
36.6	409													254.7+													
37.2	410													263.3+													
38.4	43	52	94	34	0.29	16.9			134.1						122.0		0.6										
38.6	44							138.9			185.6																
39.6	411													157.0													
40.2	412													200.1													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-58
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-58.3c

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98-58		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
41.8	46	43	74	24	0.37			95.8	95.8		122.5															C	
42.7	413													263.3+													
44.5	48	34	40	18	0.70	18.7			177.2																		
44.7	49							155.6			222.8+																
44.8	50								167.6																		
47.5	52	52	101	38	0.22	16.7									186.2		1.4										
47.7	53										210.4																
50.7	55	17	44	17					215.5		222.8+															C	
53.6	57	28	54	23	0.17	18.9		124.5	140.2						125.9	60.3	1.3										
53.8	58							167.6	143.6																		
56.7	60	43	80	28	0.29										122.3		3.0										
56.8	61					17.6		136.5			183.2																
60.0	63	42	75	27	0.31			95.8	119.7		222.8+															C	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

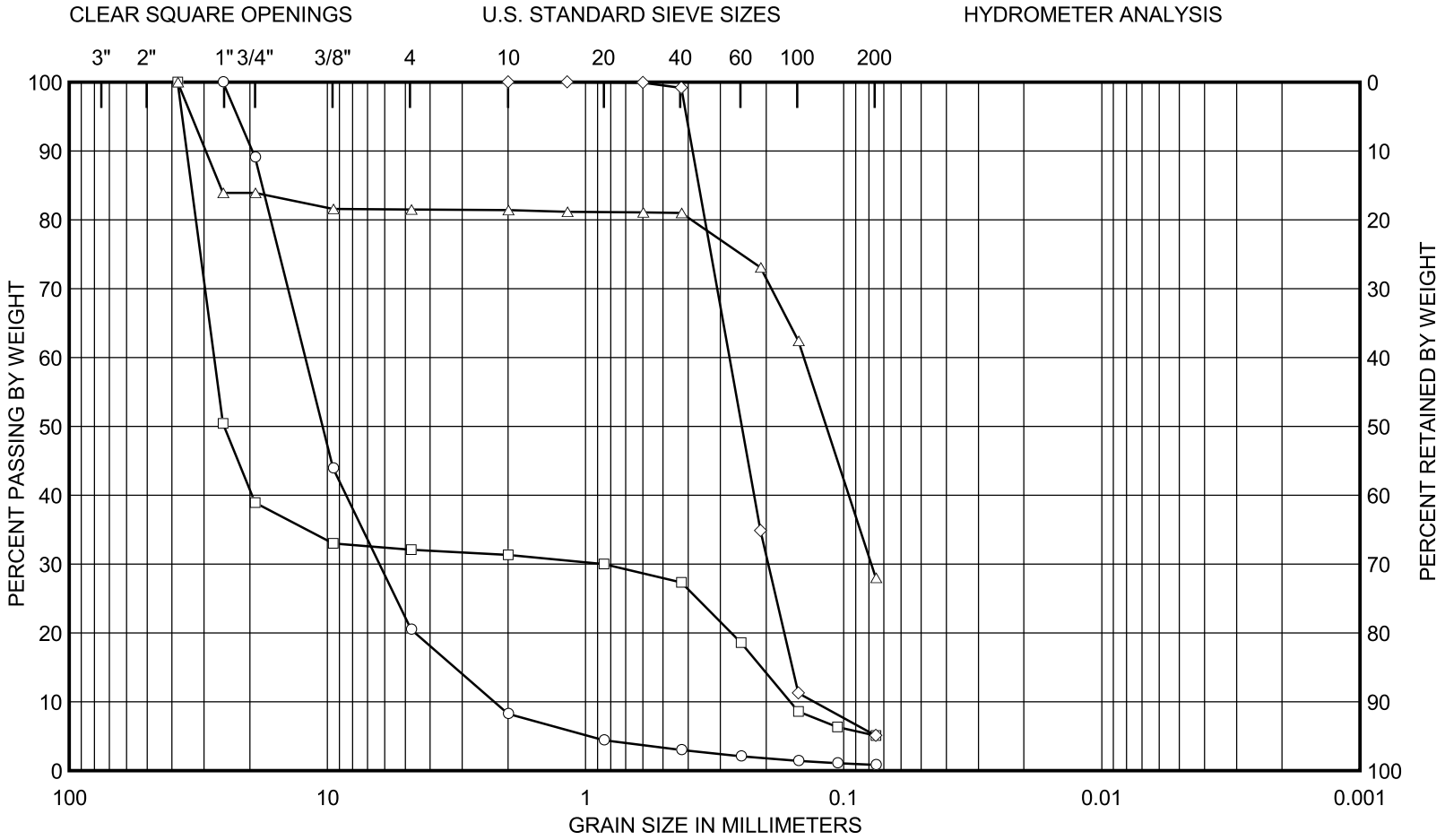
\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.3d

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
3	5.0	○—○	Fine GRAVEL (GW) with sand and a trace of coarse gravel	1.4	5.4	10.5
4	6.2	□—□	Coarse GRAVEL (GP-GM) with silt, fine sand, and a trace of fine gravel	0.2	170.5	25.1
5	8.1	△—△	Silty Fine SAND (SM) with coarse gravel			0.12
27	21.6	◇—◇	Fine SAND (SP-SM) with silt	1.1	2.1	0.25

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-58
SFOBB East Span Seismic Safety Project

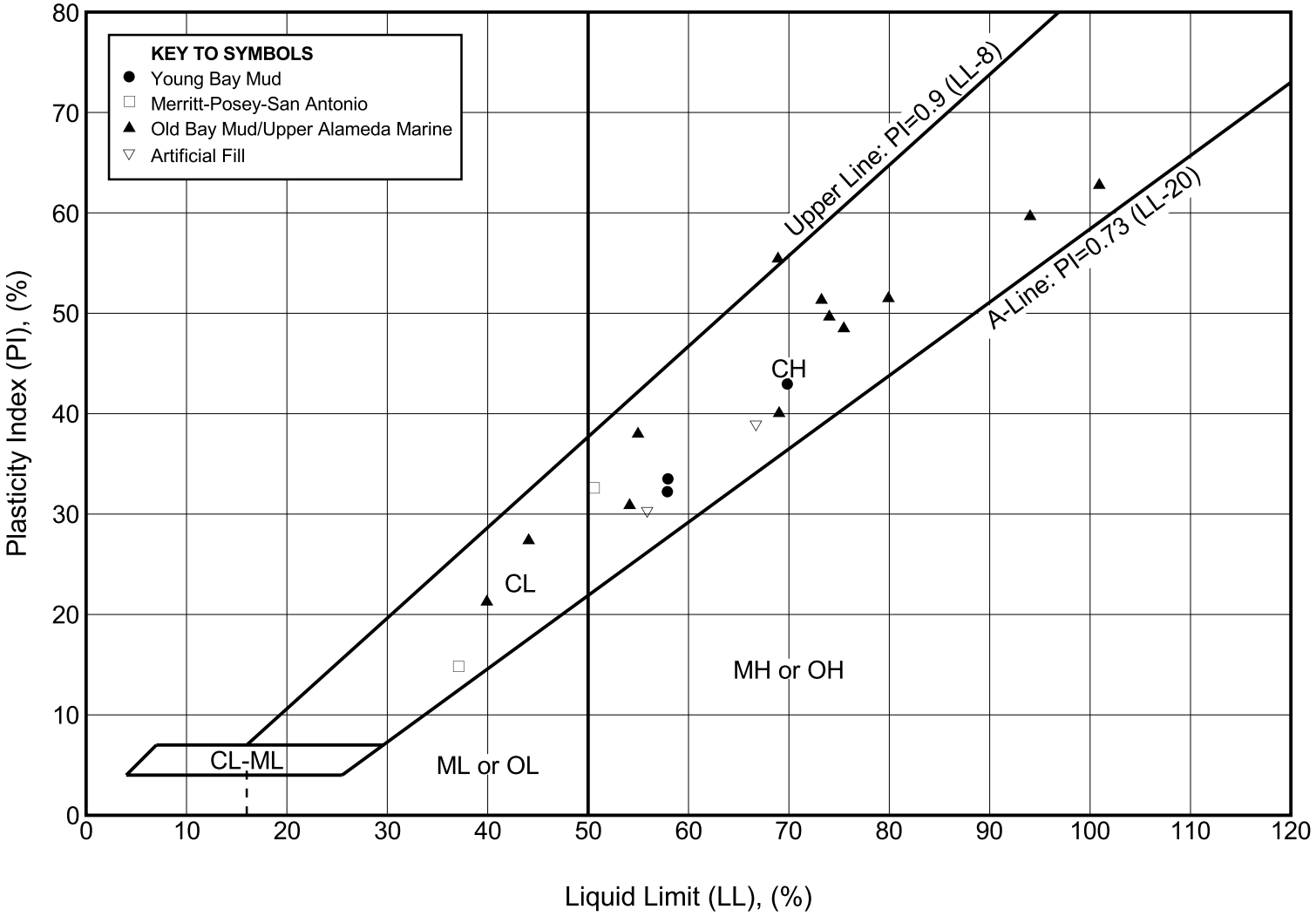
PLATE 98-58.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

c:\snfco-oak\current\odb\9858grn.odb



PLASTICITY CHART
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.5

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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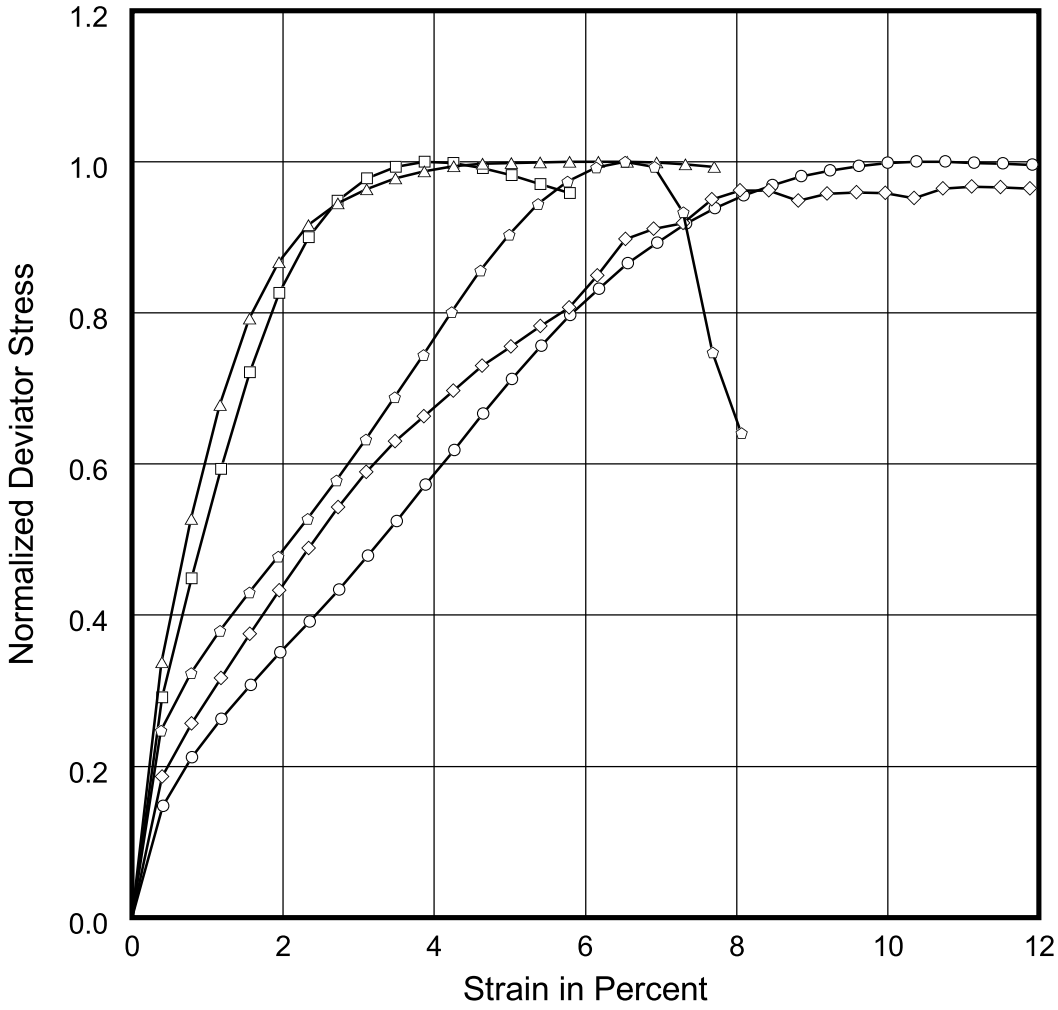


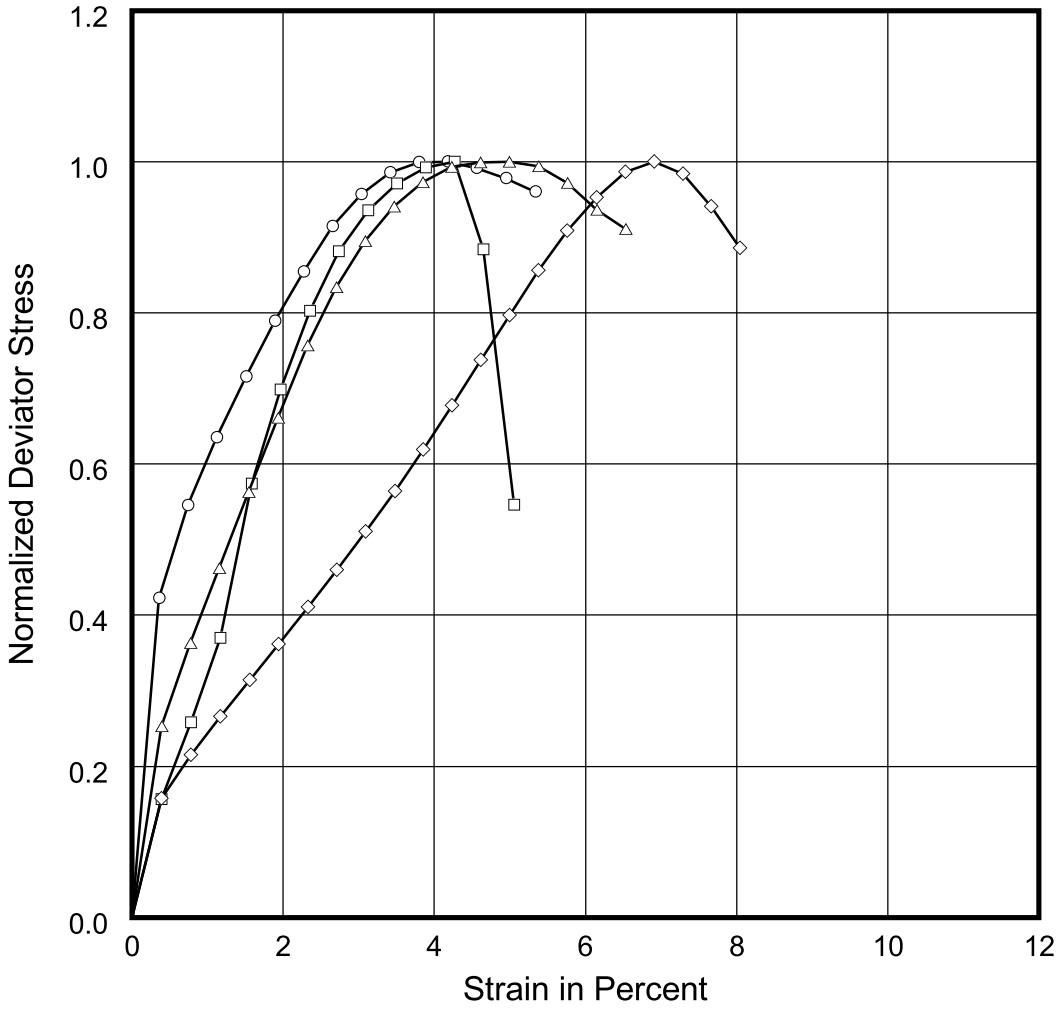
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	12	12.6	UU	241	80	3.2
□	19	17.2	UU	345	117	0.9
△	22	18.7	UU	689	171	0.7
◇	25	20.1	UU	689	220	2.4
⬠	39	35.4	UU	1000	201	2.1

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.6a



Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	43	38.4	UU	1069	244	0.6
□—□	52	47.5	UU	1241	372	1.4
△—△	57	53.6	UU	1344	252	1.3
◇—◇	60	56.7	UU	1413	245	3.0

Deviator stress normalized with respect to maximum deviator stress.

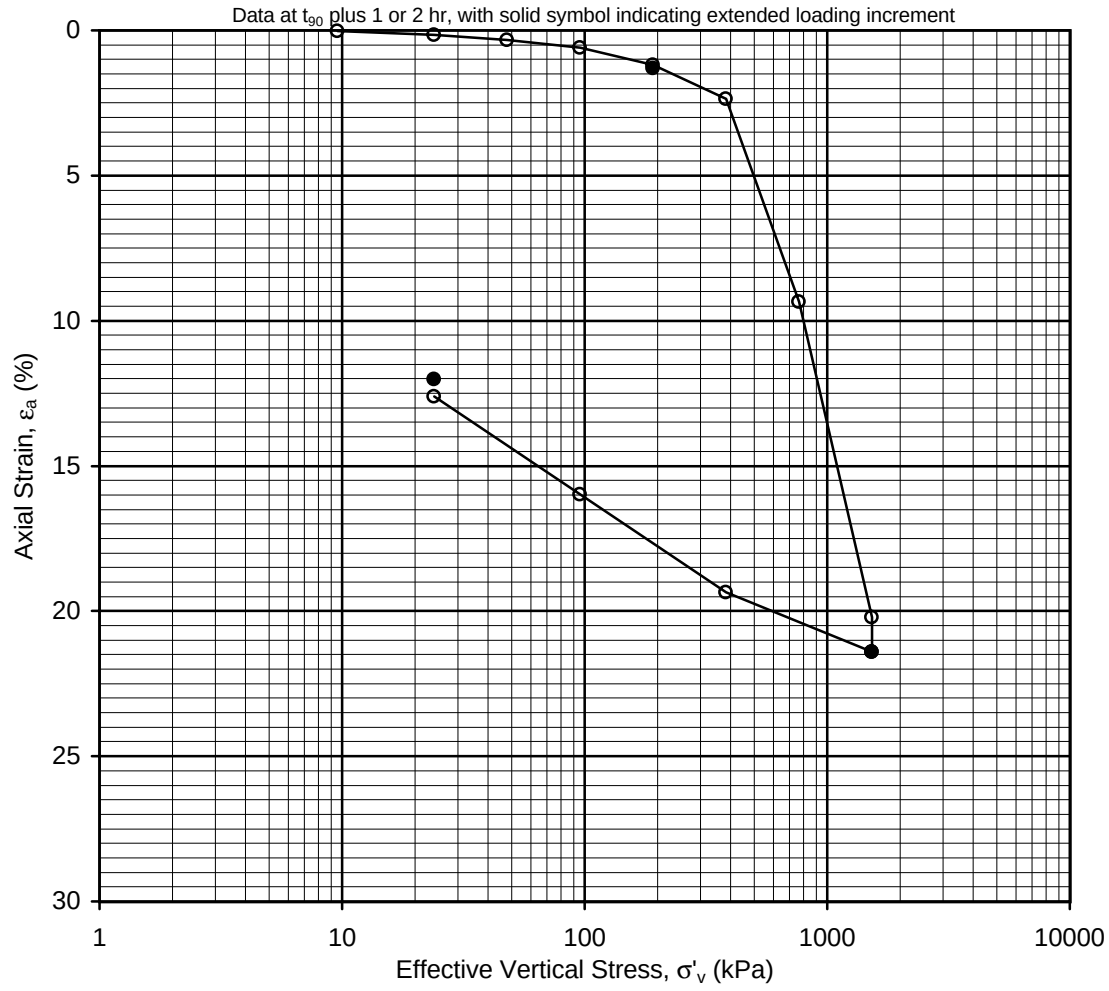
STRESS-STRAIN CURVES

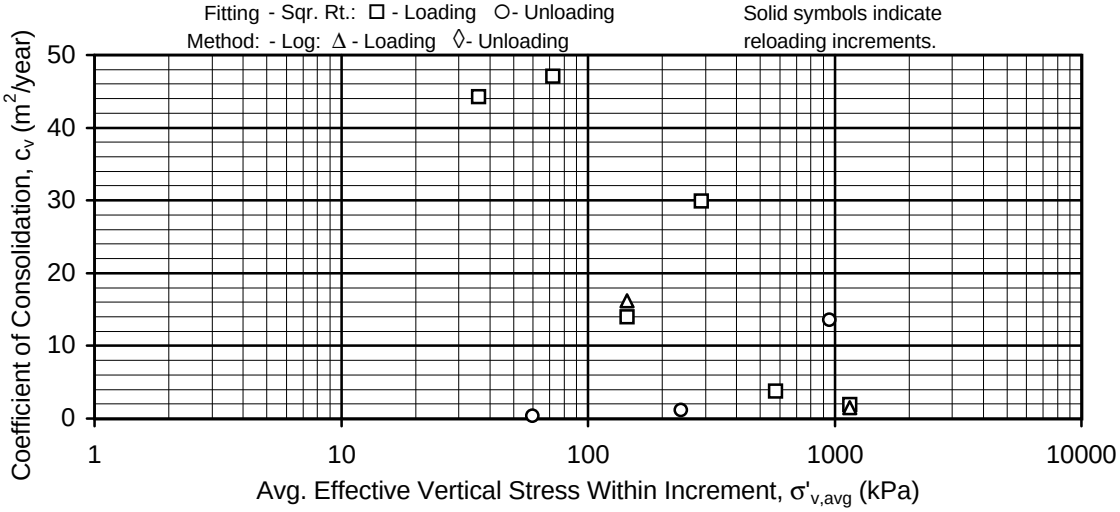
Unconsolidated-Undrained Triaxial Compression Test
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.6b

Earth Mechanics

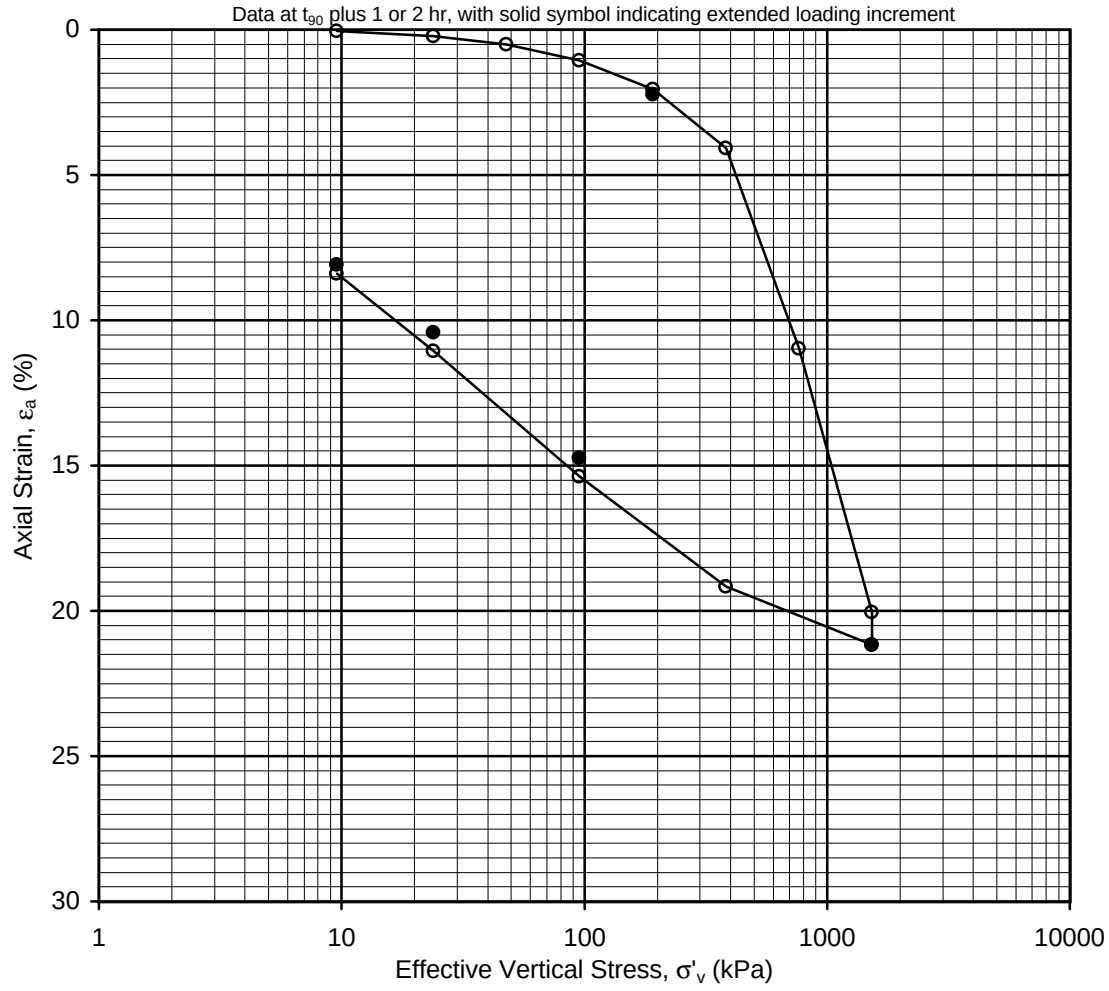
FUGRO

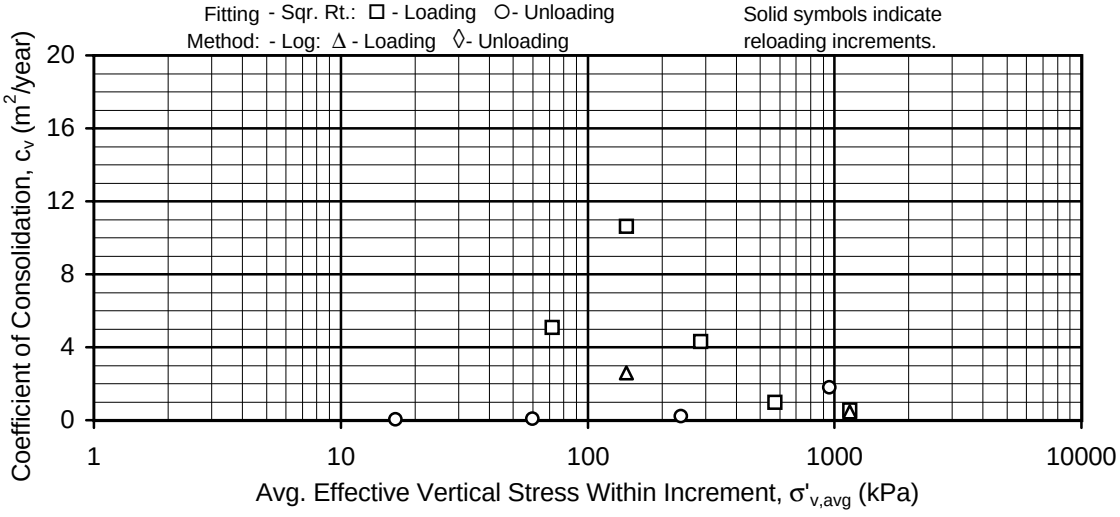




INCREMENTAL CONSOLIDATION TEST RESULTS

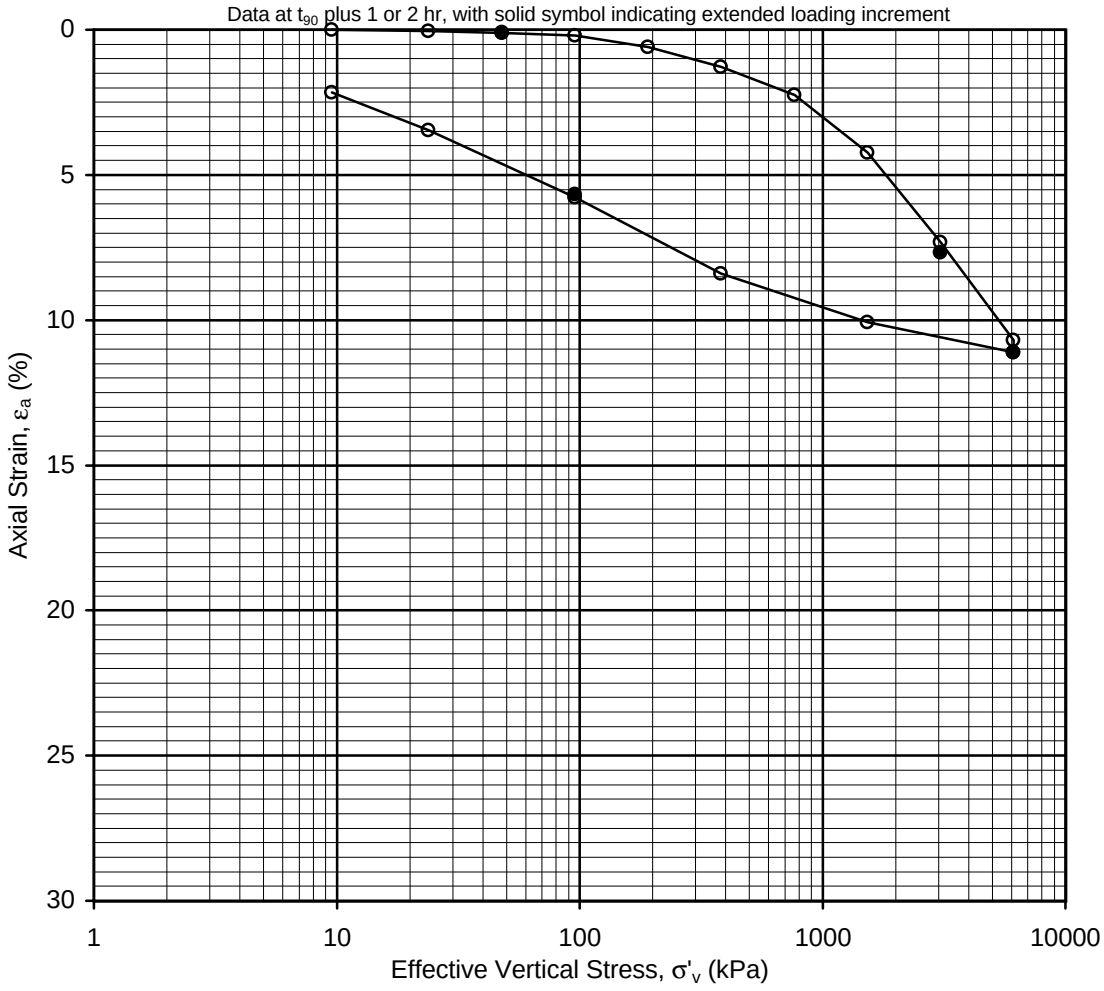
Sample No. 36 - Depth: 32.5m
Boring 98-57
SFOBB East Span Seismic Safety Project

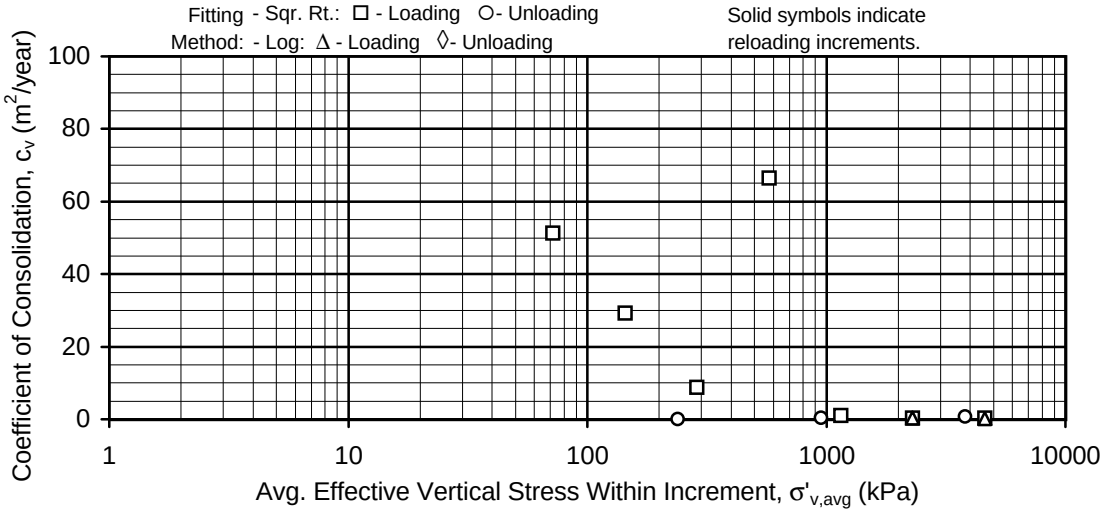




INCREMENTAL CONSOLIDATION TEST RESULTS

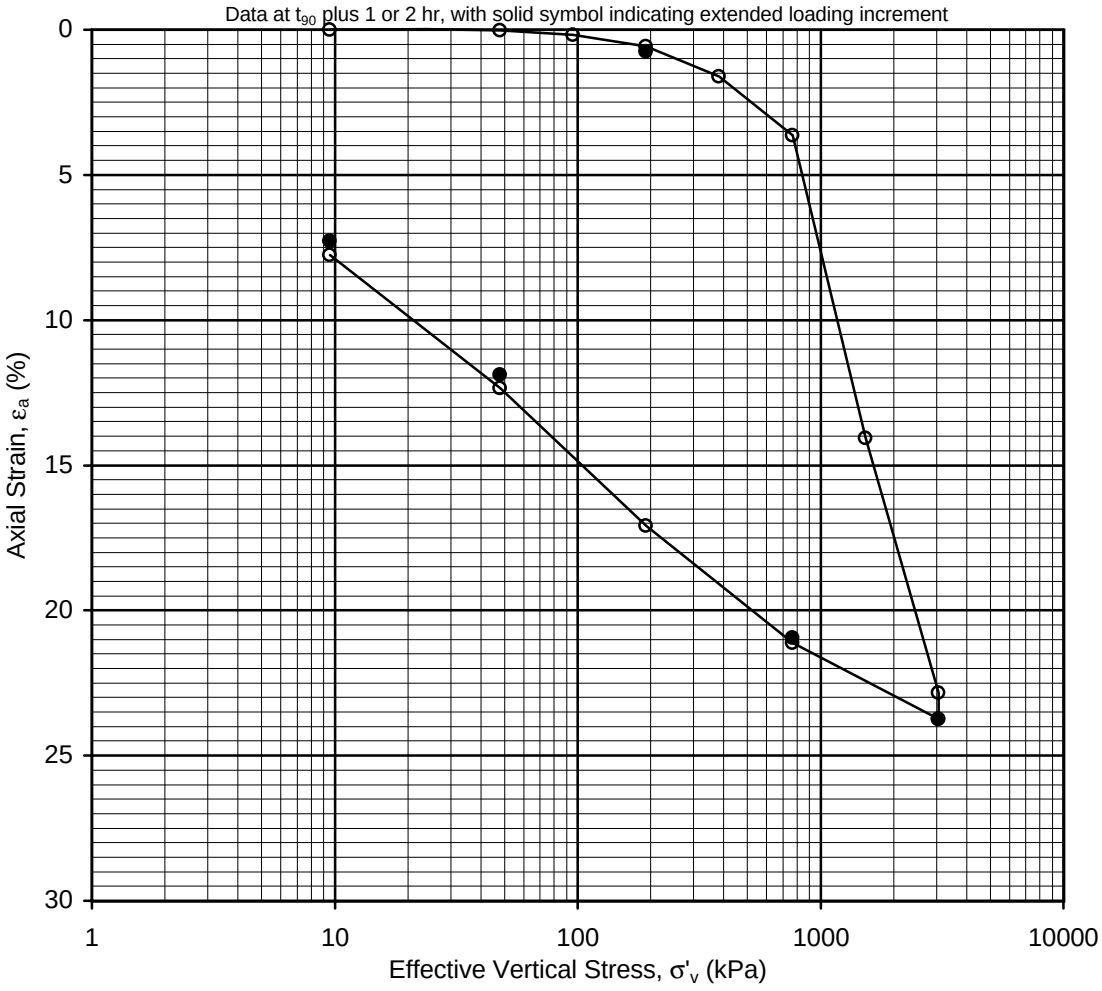
Sample No. 46 - Depth: 41.7m
Boring 98-58
SFOBB East Span Seismic Safety Project

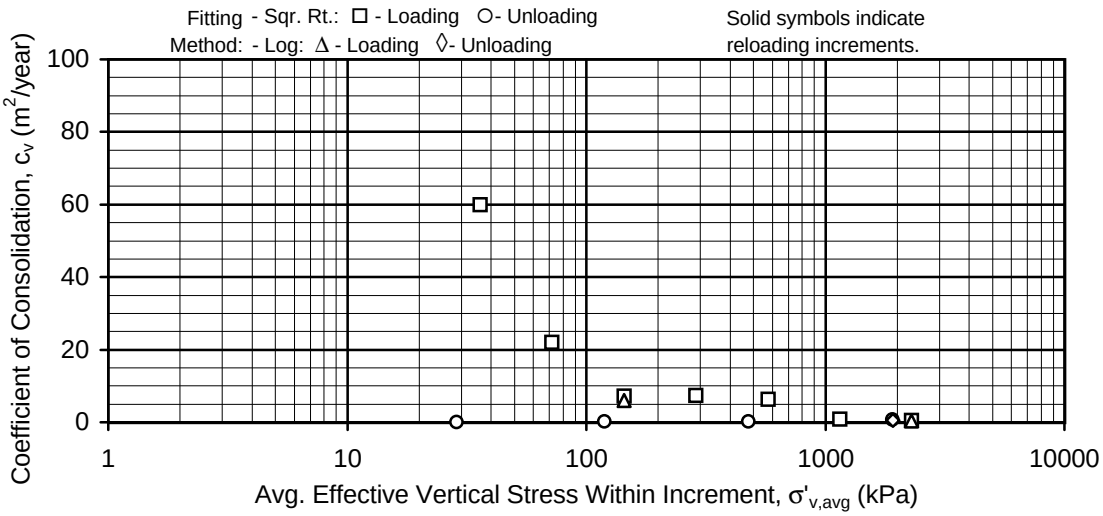




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 55 - Depth: 50.7m
Boring 98-58
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

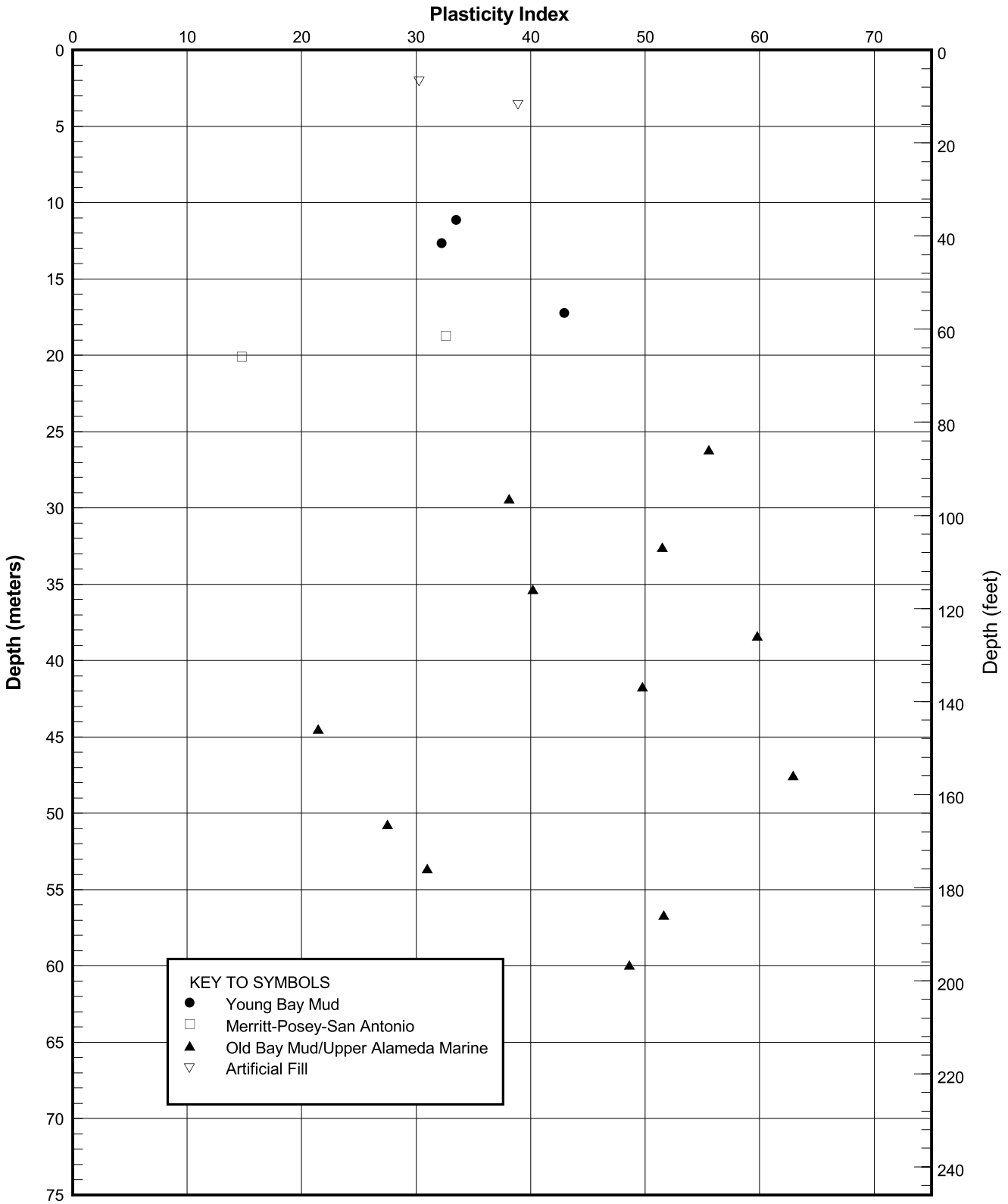
Sample No. 63 - Depth: 59.9m
Boring 98-58
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

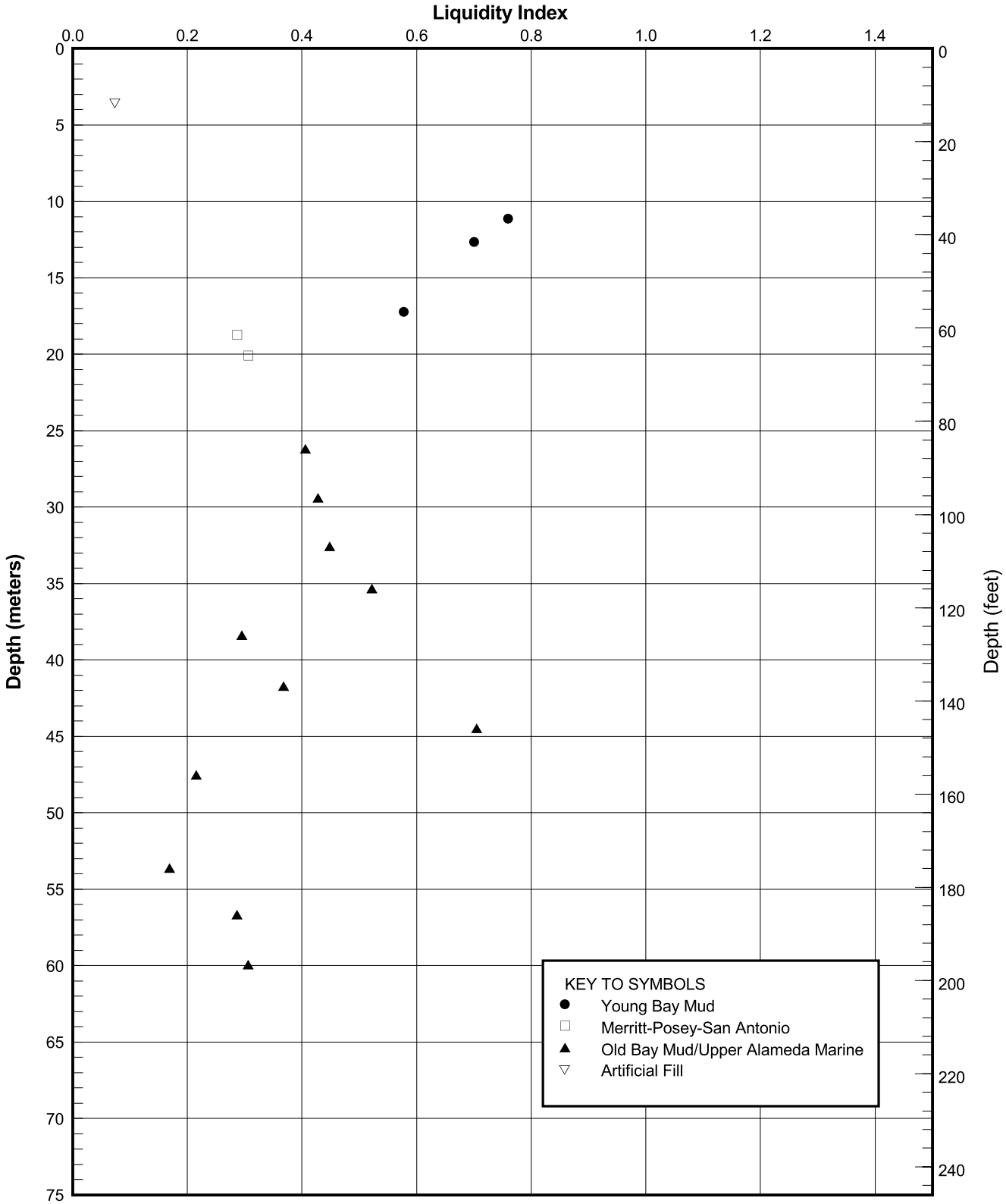
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



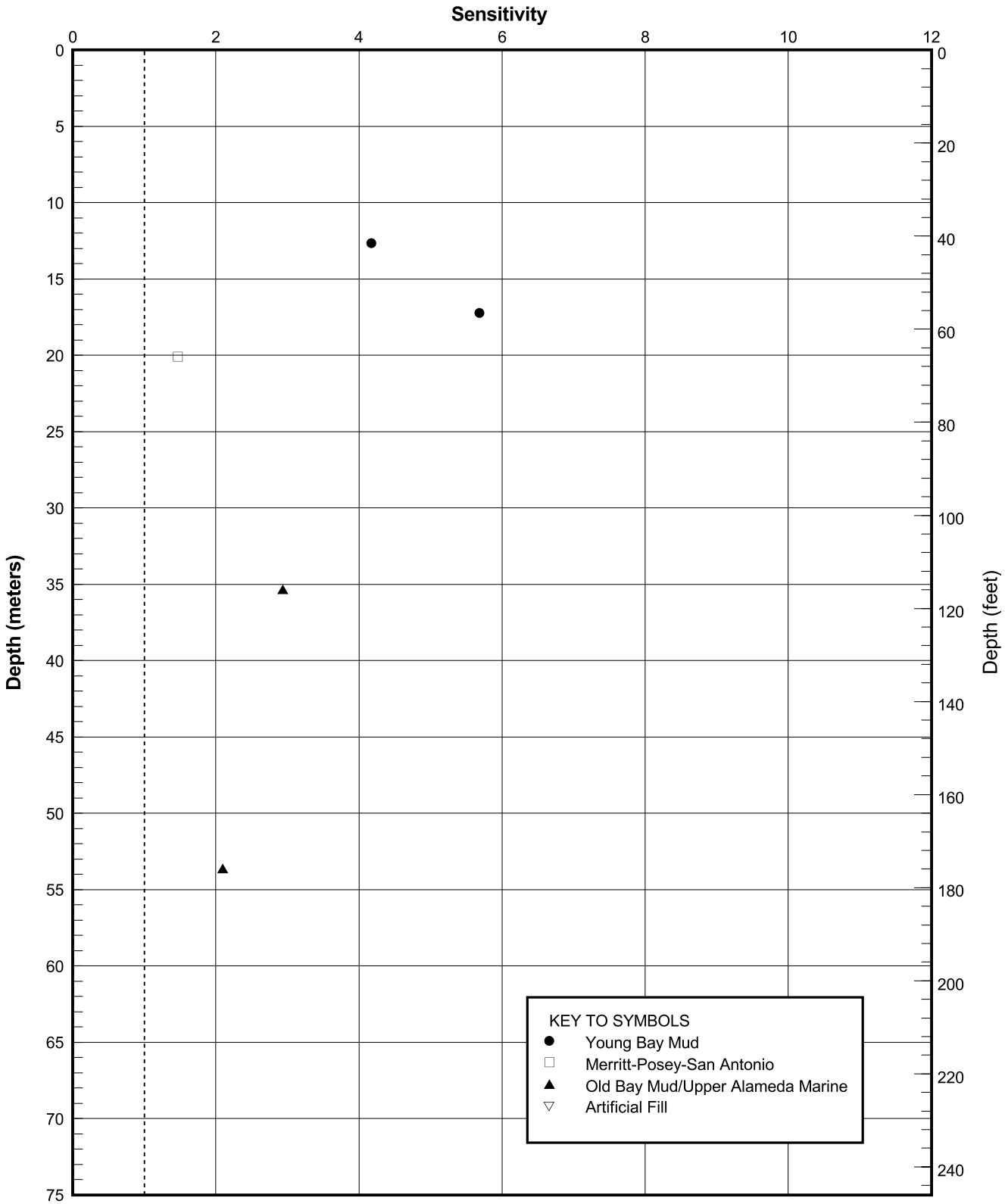
PLASTICITY INDEX PROFILE
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.12



LIQUIDITY INDEX PROFILE
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.13

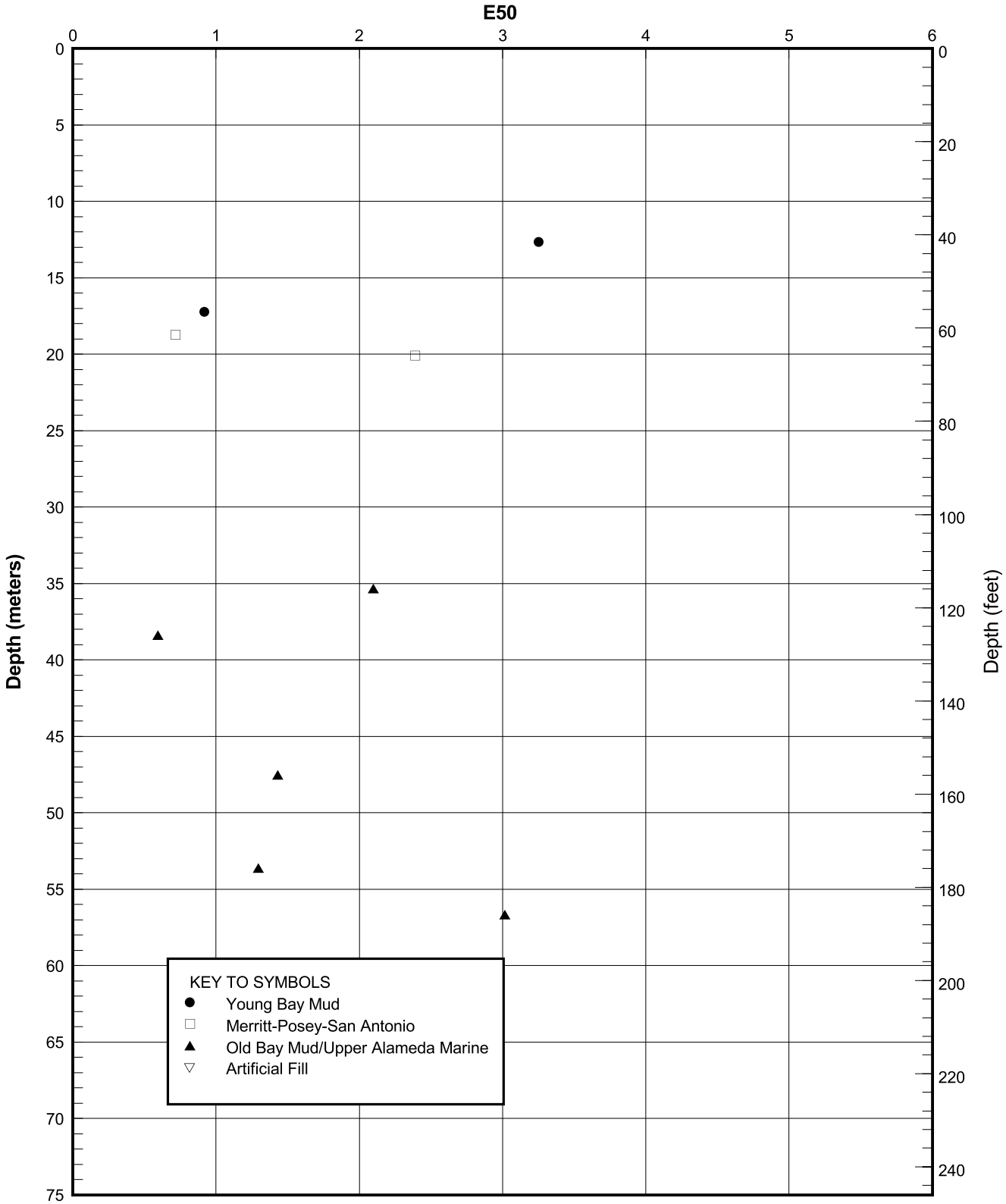


SENSITIVITY PROFILE
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.14

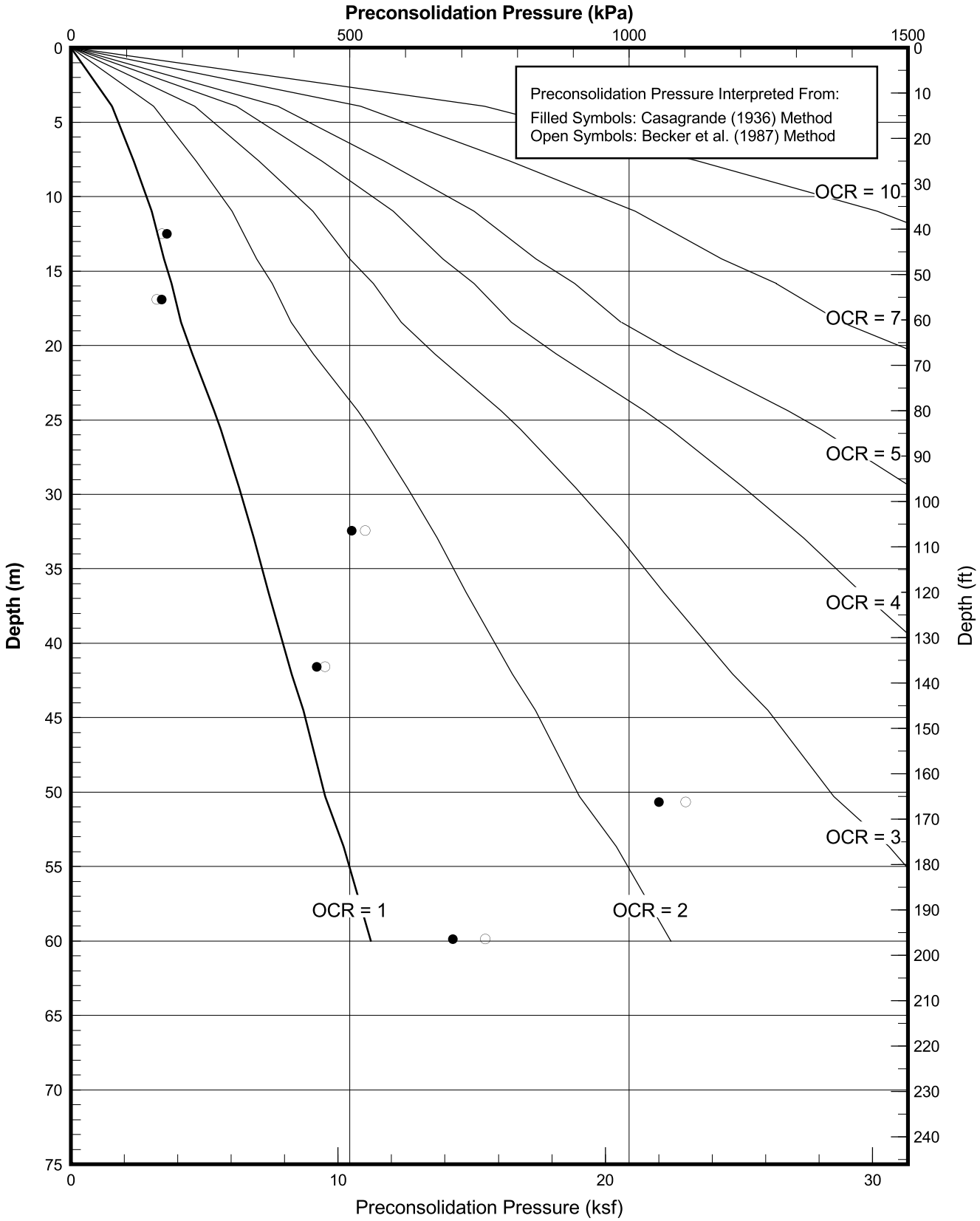
Earth Mechanics

FUGRO



E50 PROFILE
Boring 98-58
SFOBB East Span Seismic Safety Project

PLATE 98-58.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA

Boring 98-58

SFOBB East Span Seismic Safety Project

PLATE 98-58.16

LAND BORING 98-59

PROJECT NO:	98-42-0058	**START DATE:**	10/7/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-59 (9m right of W. Sta. 89+77)	**COMPLETION DATE:**	10/9/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839435 N648325
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.5m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	1				PAVEMENT, Asphalt Concrete over Aggregate Base (0.2m)	I
					Fine SAND with silt (SP-SM), medium dense, brown	
2	2			28	-moist at 1.8m	
1	3			23	▽ (3.5m)	II
0	4					
-1	5			15	-greenish gray below 4.6m -with shell fragments at 4.6m	
-2	6					
-3	7			24	(7.3m)	
-4	8			PUSH	Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -lean clay to 10.4m -with fine sand seams, 7.9m to 9.8m	
-5	9					
-6	10			SAVE		
-7	11			PUSH	-with an H2S odor, 10.7m to 12.8m -with silt pockets, mica, and gas blisters, at 11.0m	III
-8	12					
-9	13			PUSH	-with sand pockets and partings, below 12.5m	
-10	14			3		
-11	15				(15.5m)	
-12	16			PUSH	Silty Fine SAND (SM), dense, gray -with clay pockets and seams, and shell fragments, at 15.5m	IV
-13	17			41	-with clay pockets at 17.1m	
-14	18				(18.3m)	
-15	19			19	Fat Clay (CH), stiff to very stiff, greenish gray	V
-16	20			PUSH	-with sandy silt pockets, a few sand pockets, and gas blisters, at 20.1m	
-17	21					
-18	22				(22.6m)	
-19	23			28	Fat CLAY (CH), very stiff, greenish gray -with shell fragments, brown mottling, and a few calcareous nodules, at 23.2m	VI
-20	24					
-21	25					
-22	26			SAVE	-with sand pockets and a few shell fragments, at 26.2m	
-23	27				(27.4m)	
-24	28				Fat CLAY (CH), very stiff, greenish gray	VII
-25	29			19	-with silty sand pockets and calcareous nodules, at 29.3m	
-26	30					
-27	31					
-28	32			PUSH	-with a few silty sand pockets at 32.3m	
-29	33					
-30	34				(34.4m)	
-31	35			30	Fat CLAY (CH), very stiff to hard, greenish gray -with a few organic pockets and a few silt pockets, at 35.1m	VIII
-32	36					
-33	37					
-34	38					
-35	39			SAVE	-with fine sand partings at 38.4m	
-36					TOTAL DEPTH: 38.7m BACKFILLED WITH: Cement Grout	

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-59.1

LOG OF BORING AND TEST RESULTS

BORING 98-59

SFOBB East Span Seismic Safety Project

Report Date: 03/11/99

Earth Mechanics

FUGRO

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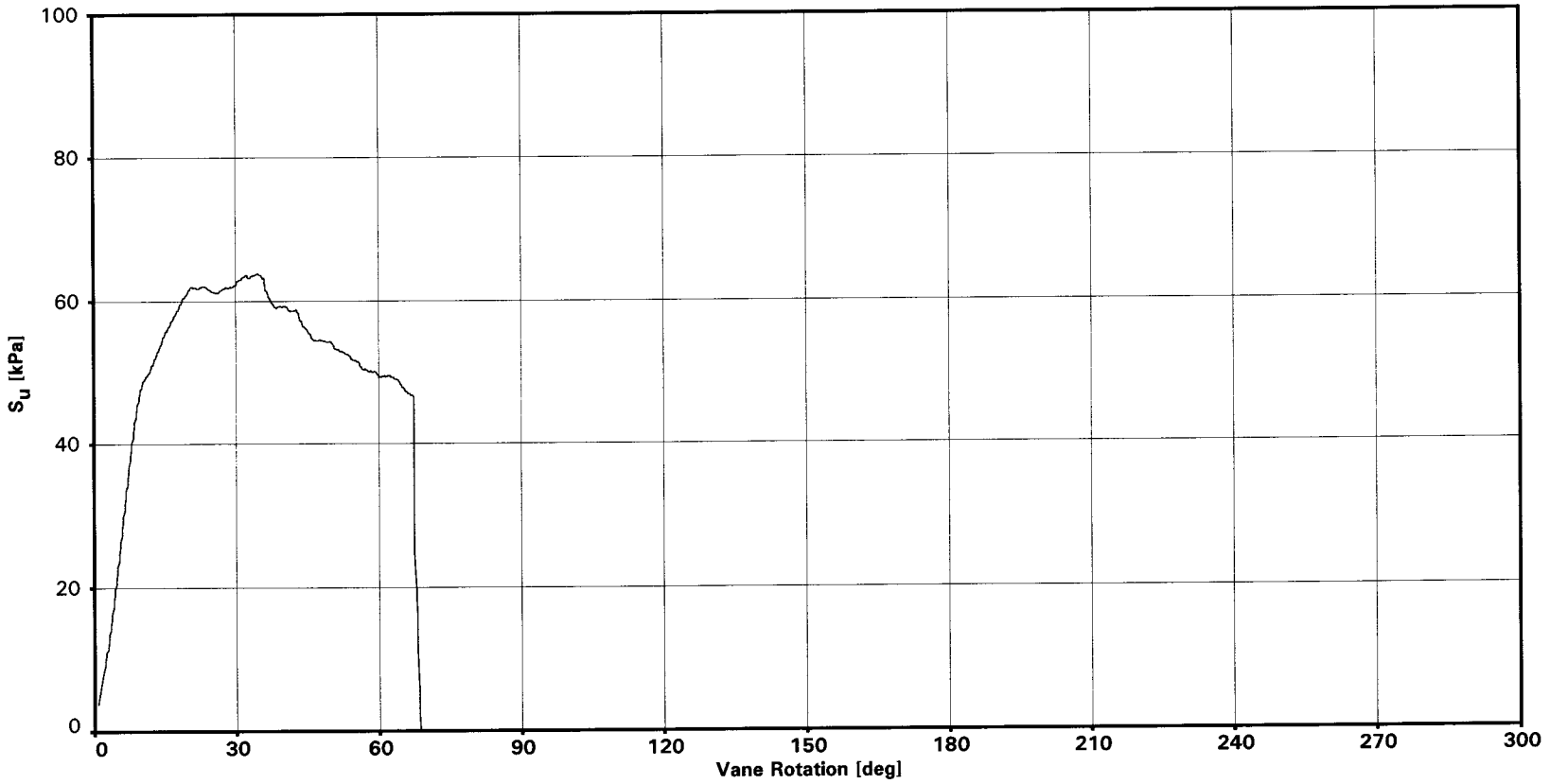
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 9.1m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

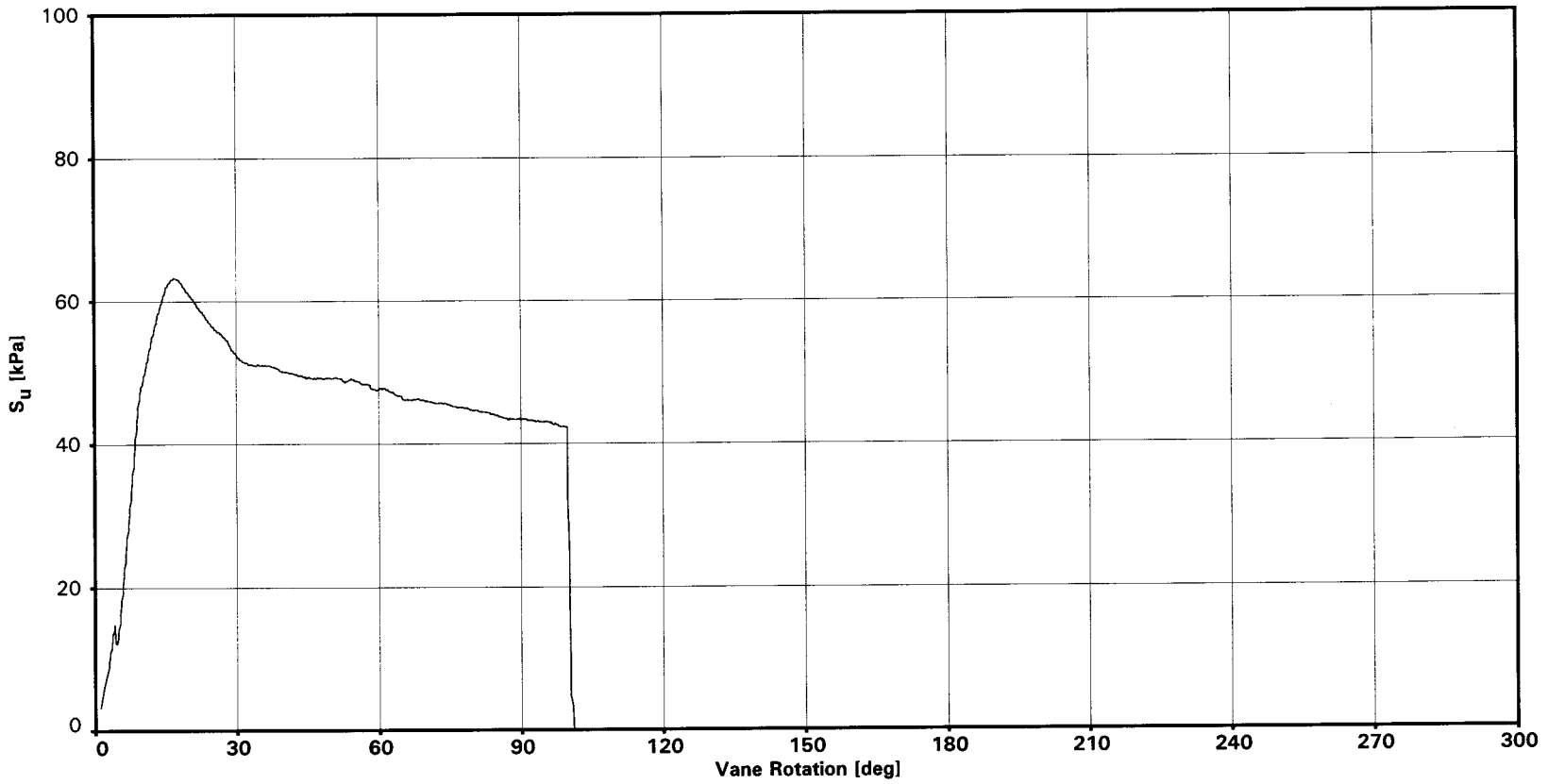
FUGRO

PLATE 98-59.2a

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Medium

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 10.7m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

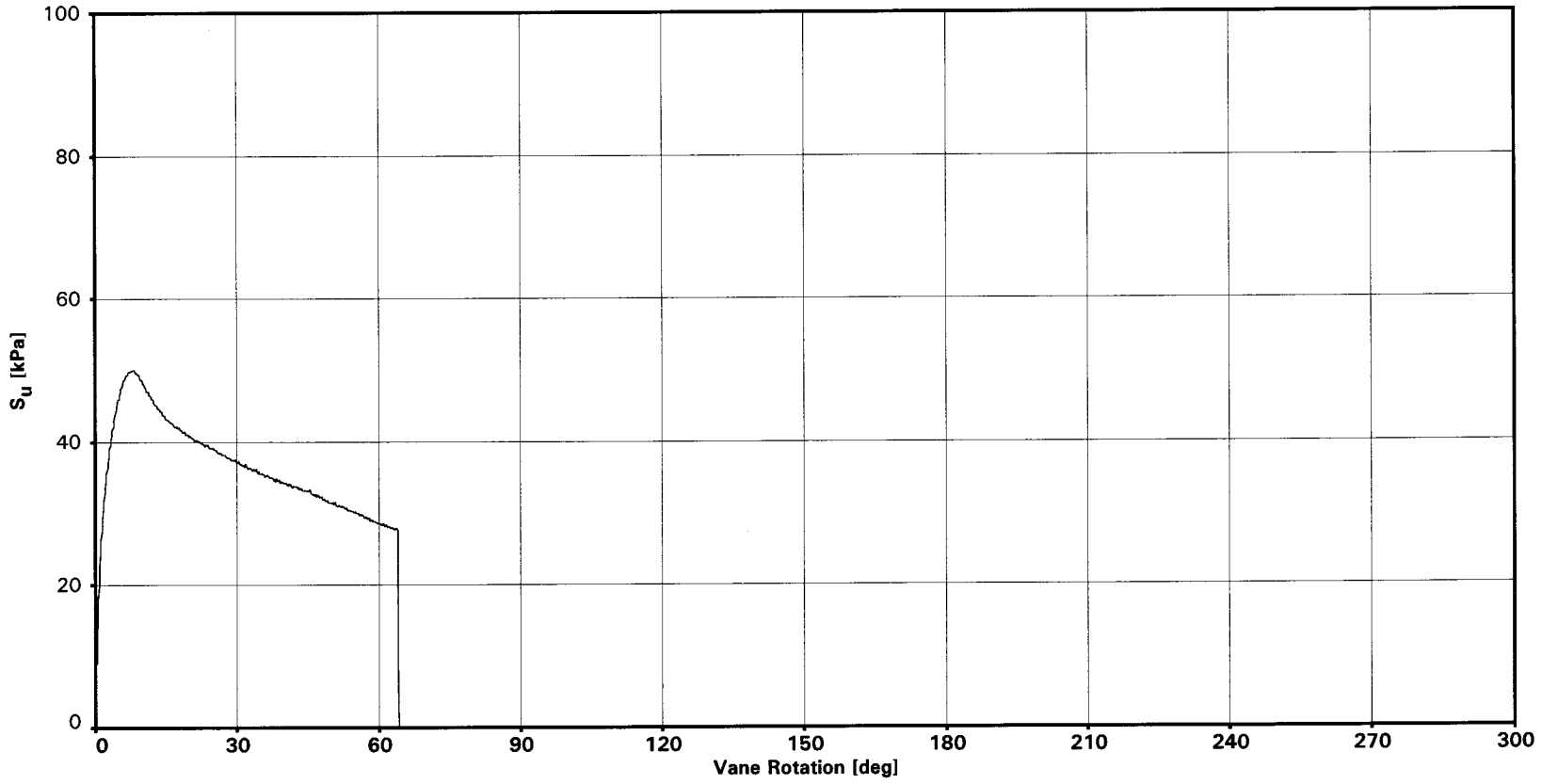
FUGRO

PLATE 98-59.2b

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 12.2m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

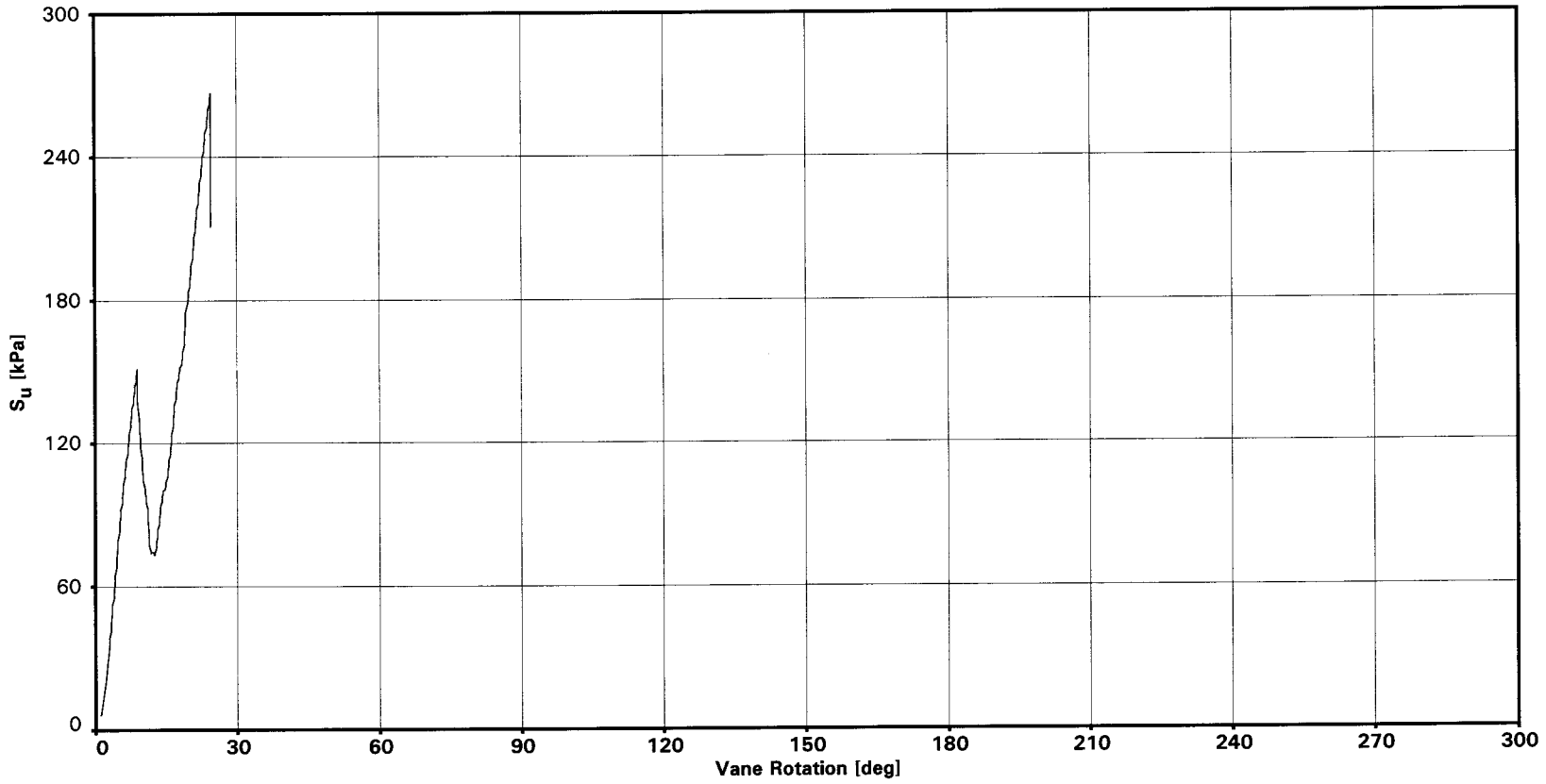
FUGRO

PLATE 98-59.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 24.4m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

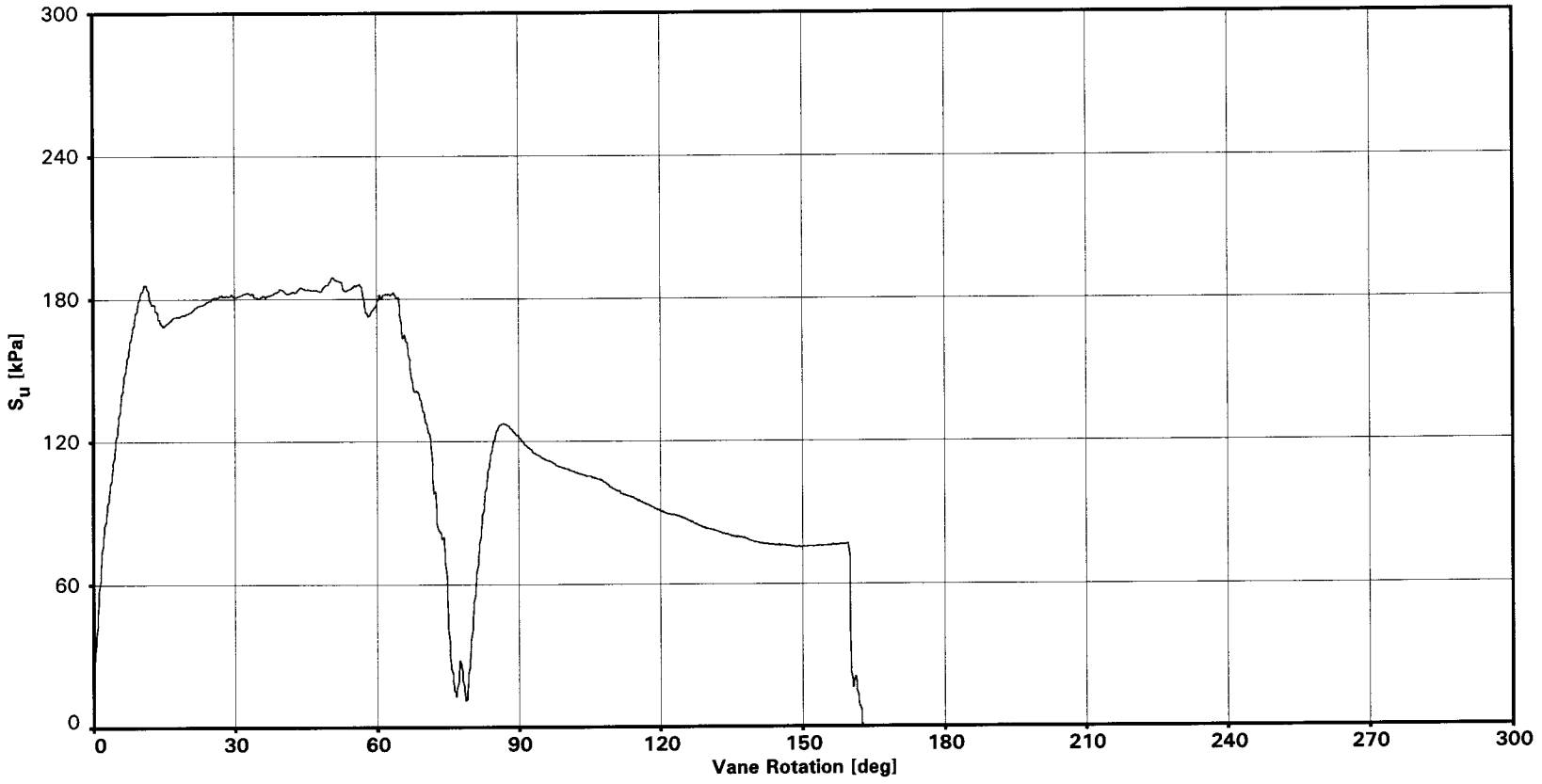
FUGRO

PLATE 98-59.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 27.4m and 28.0m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

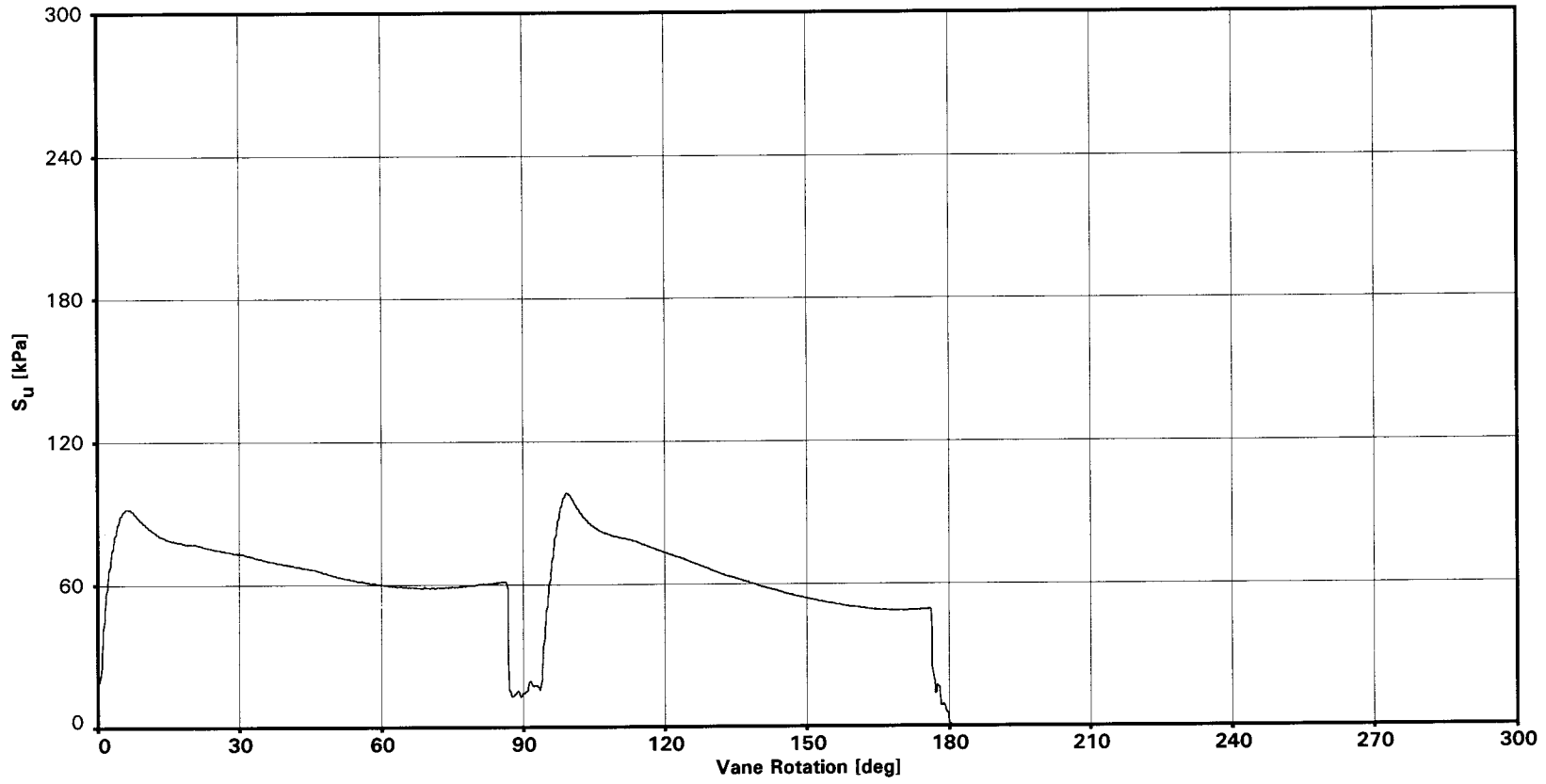
FUGRO

PLATE 98-59.2e

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 30.5m and 31.1m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

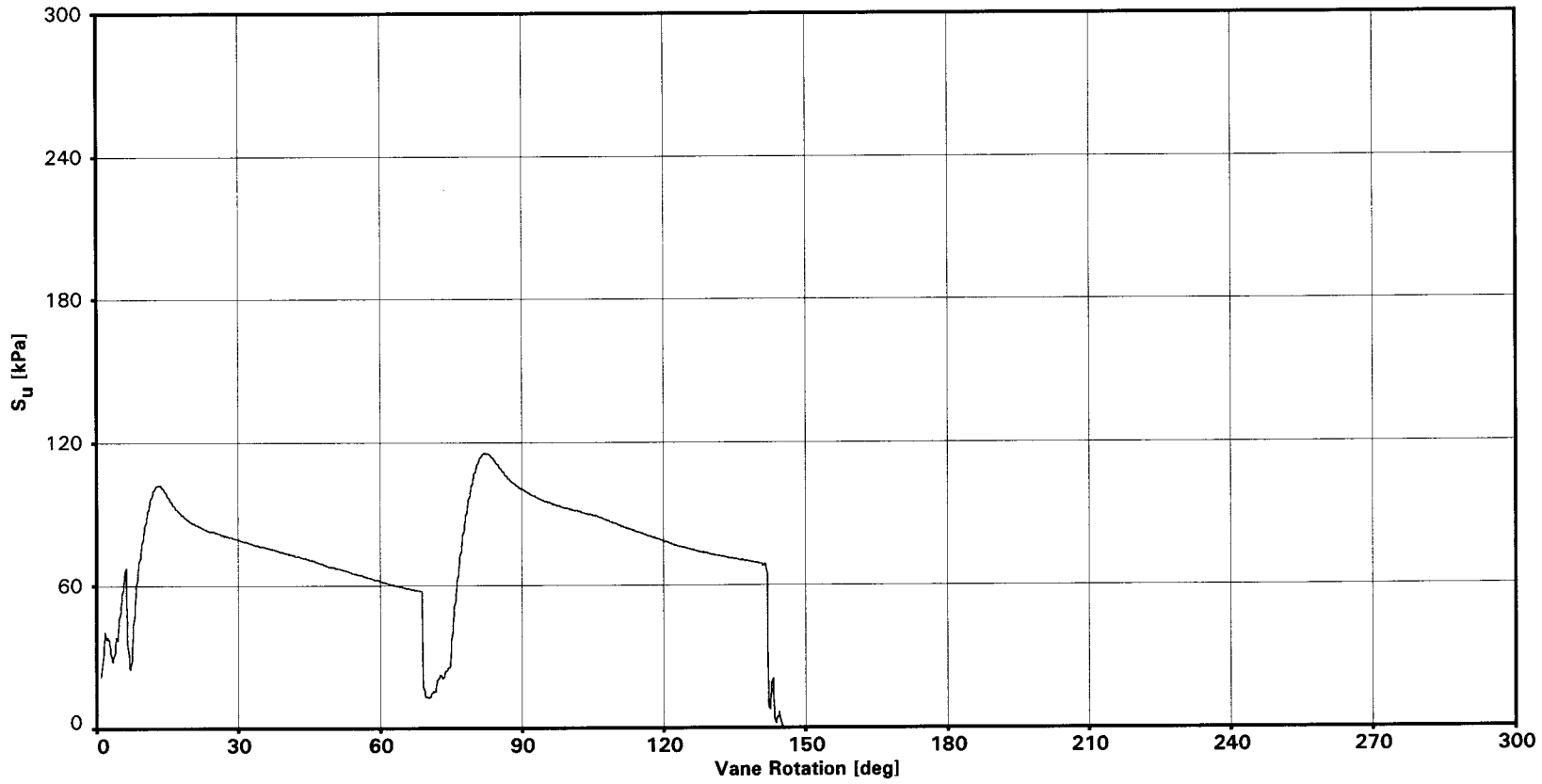
FUGRO

PLATE 98-59.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 33.5m and 34.1m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

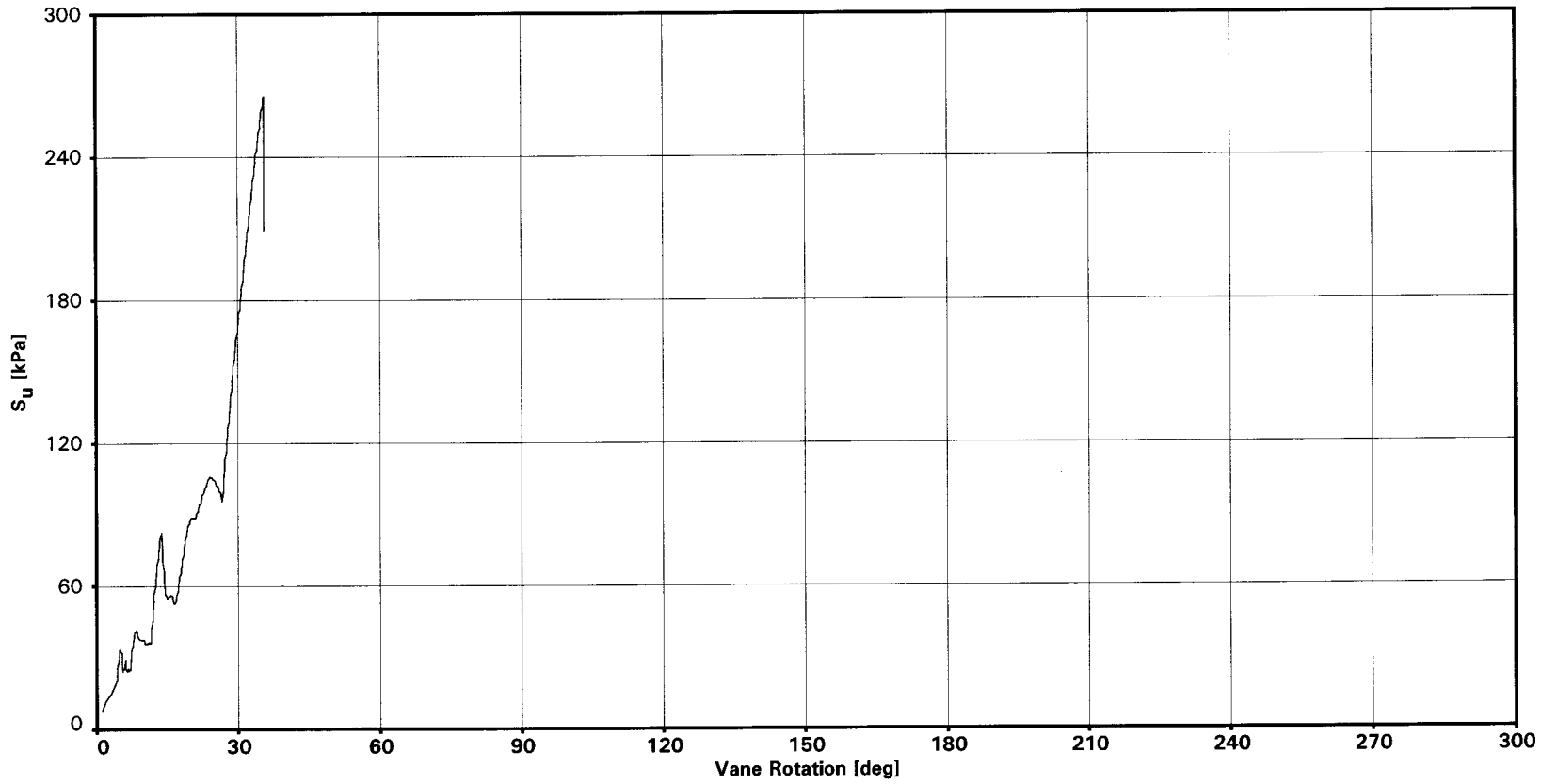
FUGRO

PLATE 98-59.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 36.6m
Boring 98-59
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-59.2h

98-59		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
2.0	1	5					11																				
3.5	2	22					8																				2.69
5.0	3	26					8																				
6.4	4					19.8												10.1	47								
6.6	5	25					8																				
8.2	7	40	44	20	0.82			38.3																			
9.1	400													63.2													
9.9	9	41	45	21	0.86						77.9																2.74
10.7	401													62.7													
11.0	11							57.5			80.2	23.9															
11.1	12	45	54	24	0.69	17.4		57.5																			
12.2	402													48.8													
12.6	15	34	41	18	0.68	18.9		43.1							36.0		1.1										
12.8	16	34	21	15	3.54																						
13.9	17	32																									

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.3a

Earth Mechanics

FUGRO

98-59		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
15.5	18	36	52	20	0.51	19.3		47.9							40.9	18.8	1.1										
15.7	19	21					12																				
17.2	20	26					15																			H	2.76
18.6	21	32	54	22	0.30			112.5																			
18.7	22					18.8					97.8	35.1															
20.3	24	29	50	24	0.19	19.4		119.7								91.5											
20.4	25							119.7																			
21.3	403													68.5													
21.9	404													70.9													
23.2	26	28	67	23	0.10	18.9		131.7				58.7	26.9														2.73
24.4	405													263.3+													
26.5	28	50	71	28	0.51																					C	
26.5	29										117.6		53.2														
27.4	407													182.9													
28.0	408													125.4													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-59
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-59.3b

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98-59		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
29.1	30							86.2																			
29.3	31	38	50	19	0.60	18.3					108.9	60.7															
30.5	409													91.0													
31.1	410													97.2													
32.3	33							79.0																			
32.5	34	54	77	25	0.56	16.5					113.9				77.0	36.4	0.8										
33.5	411													100.5													
34.1	412													114.0													
35.4	36	21	53	17	0.10	20.3		179.6			170.8																
36.6	413													263.3+													
38.6	38	34	55	21	0.39																					C	
38.7	39	38	59	23	0.43						186.9																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.3c

Earth Mechanics

FUGRO

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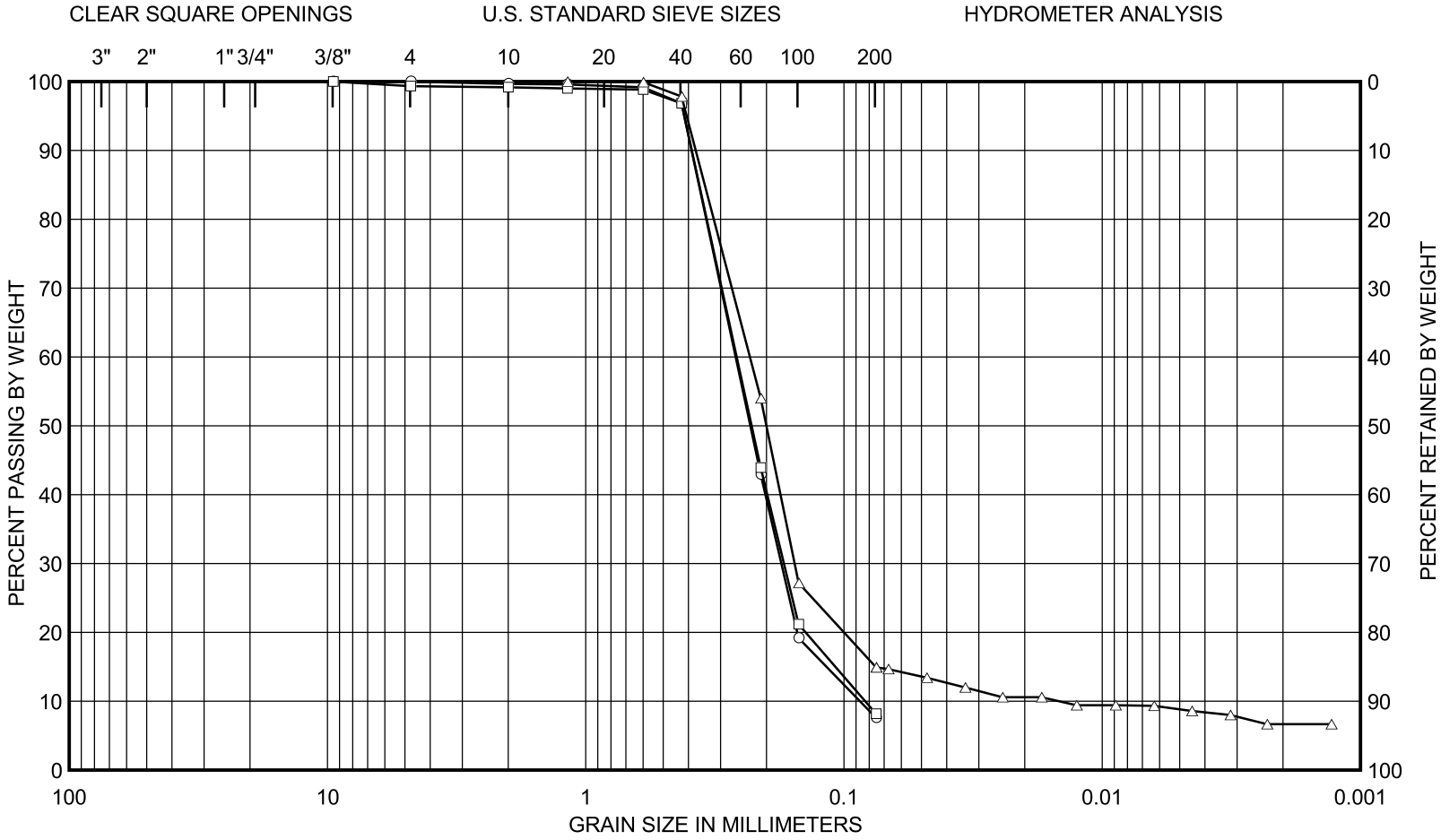

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.5	○—○	FINE SAND (SP-SM) with silt	1.3	3.0	0.23
3	5.0	□—□	FINE SAND (SP-SM) with silt	1.4	3.2	0.23
20	17.2	△—△	SILTY FINE SAND (SM)			0.20

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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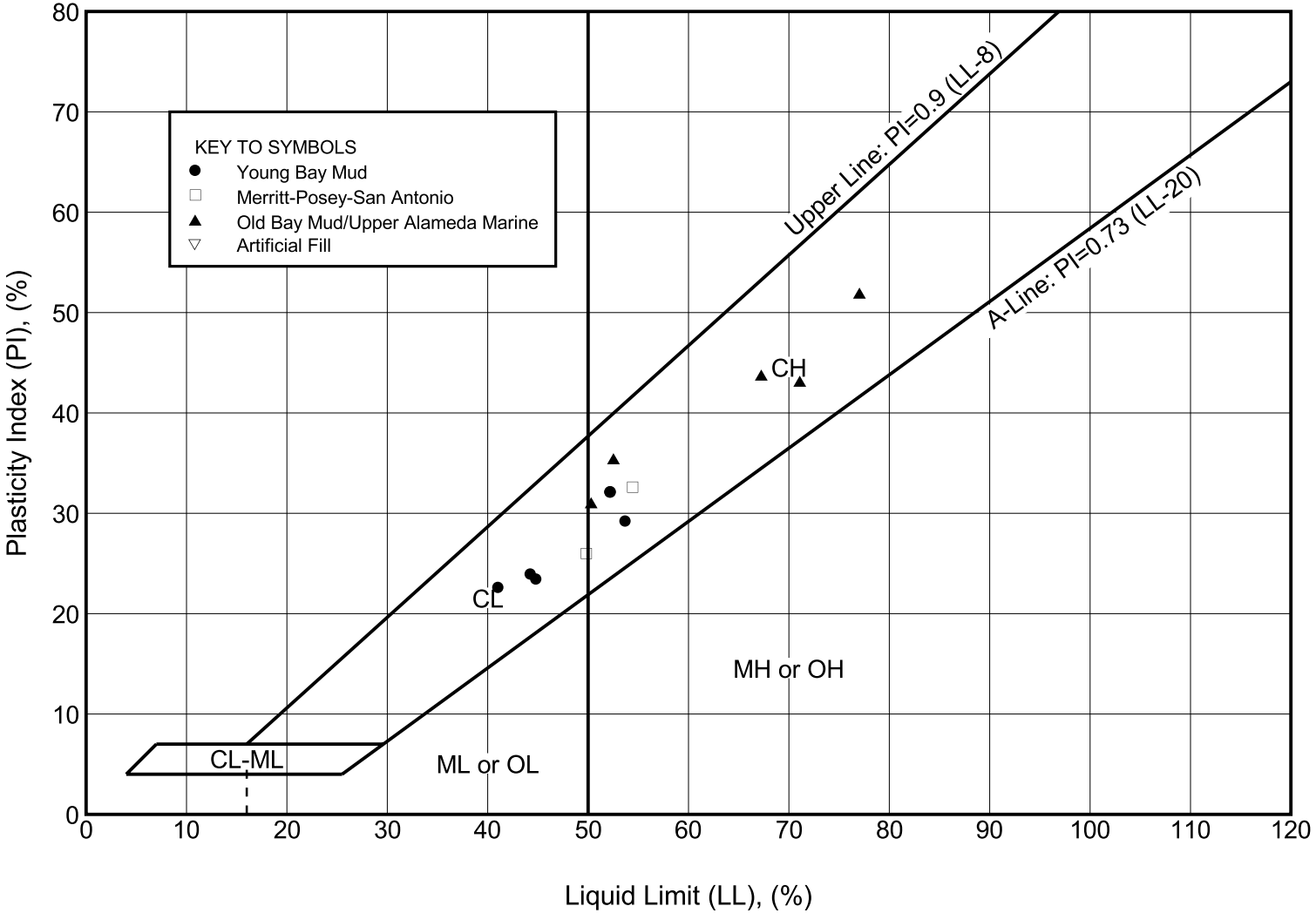
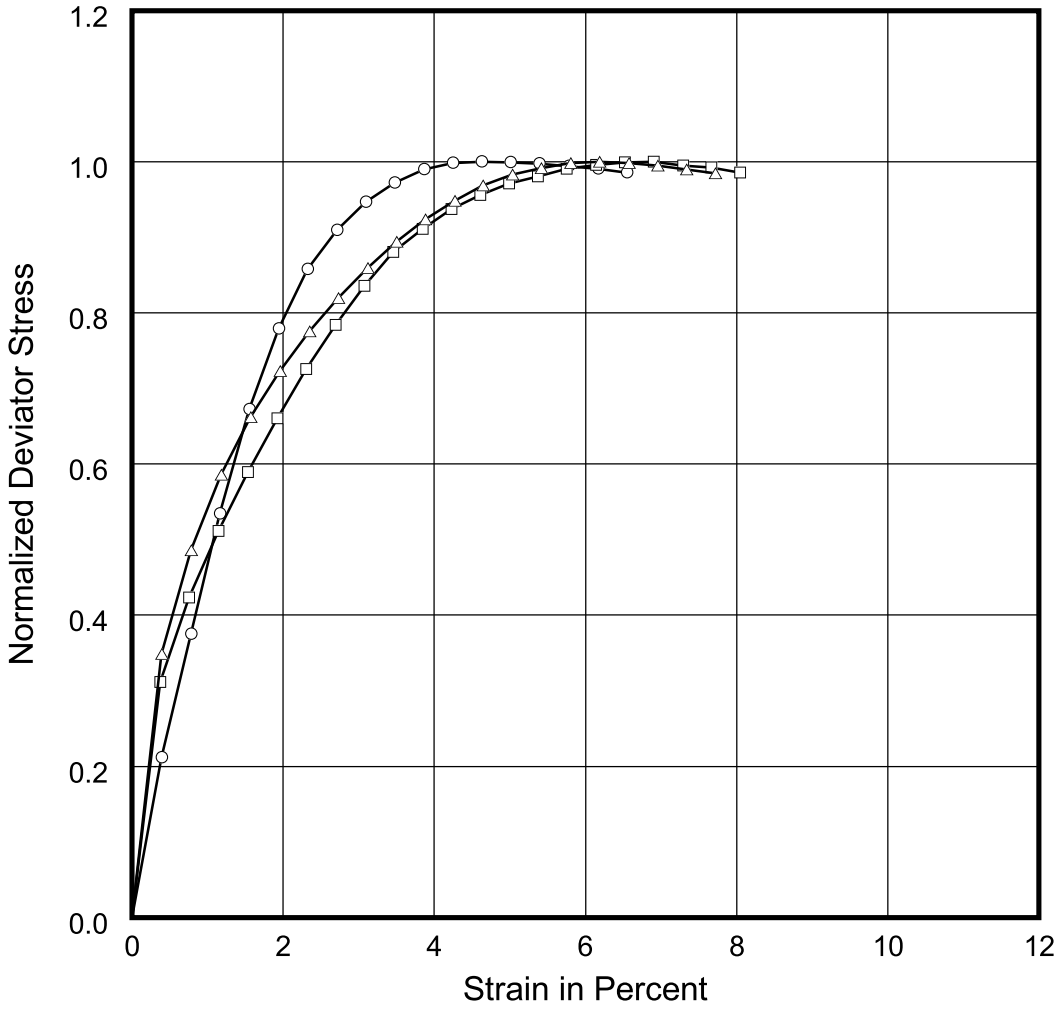


PLASTICITY CHART
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.5



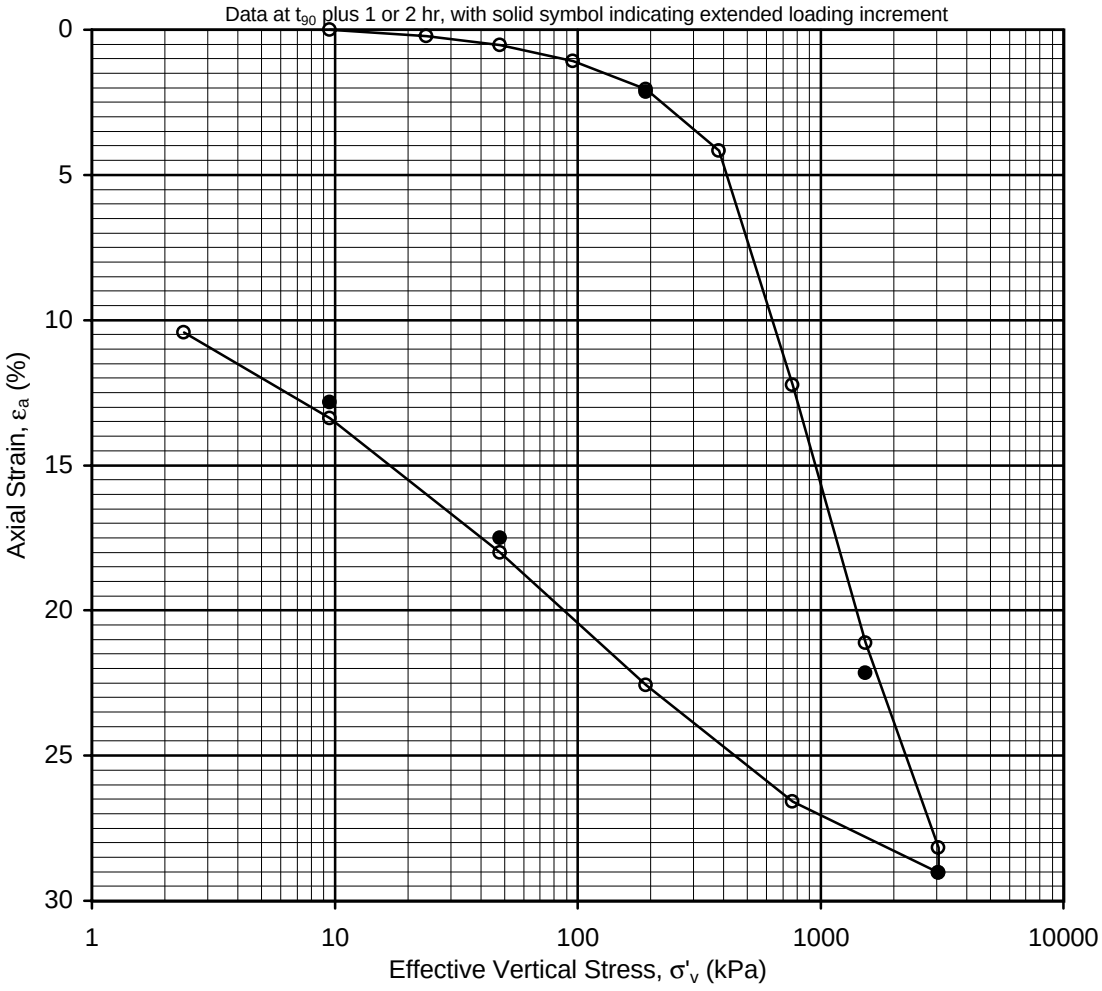
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	15	12.6	UU	241	72	1.1
□—□	18	15.5	UU	345	82	1.1
△—△	34	32.5	UU	931	154	0.8

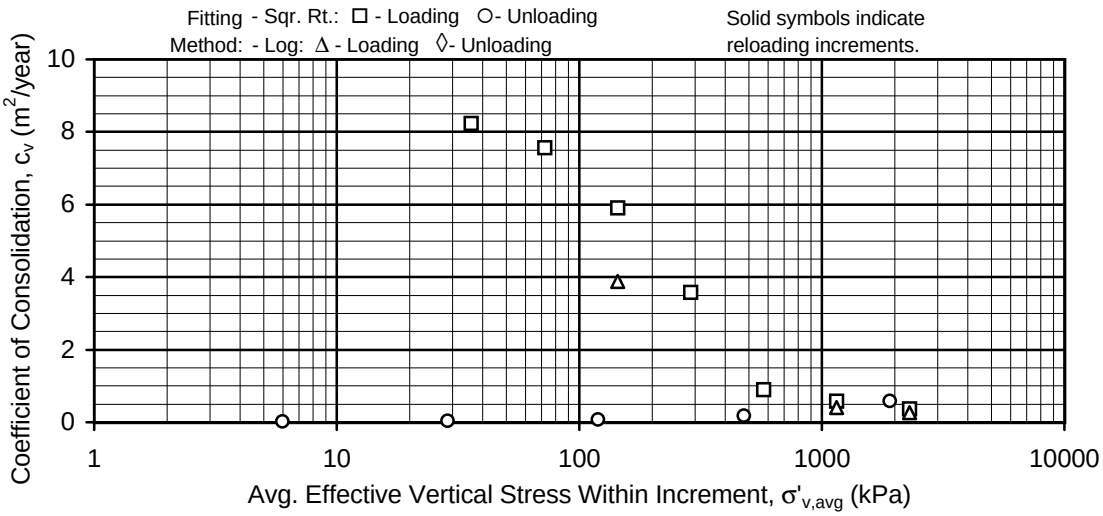
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-59
SFOBB East Span Seismic Safety Project

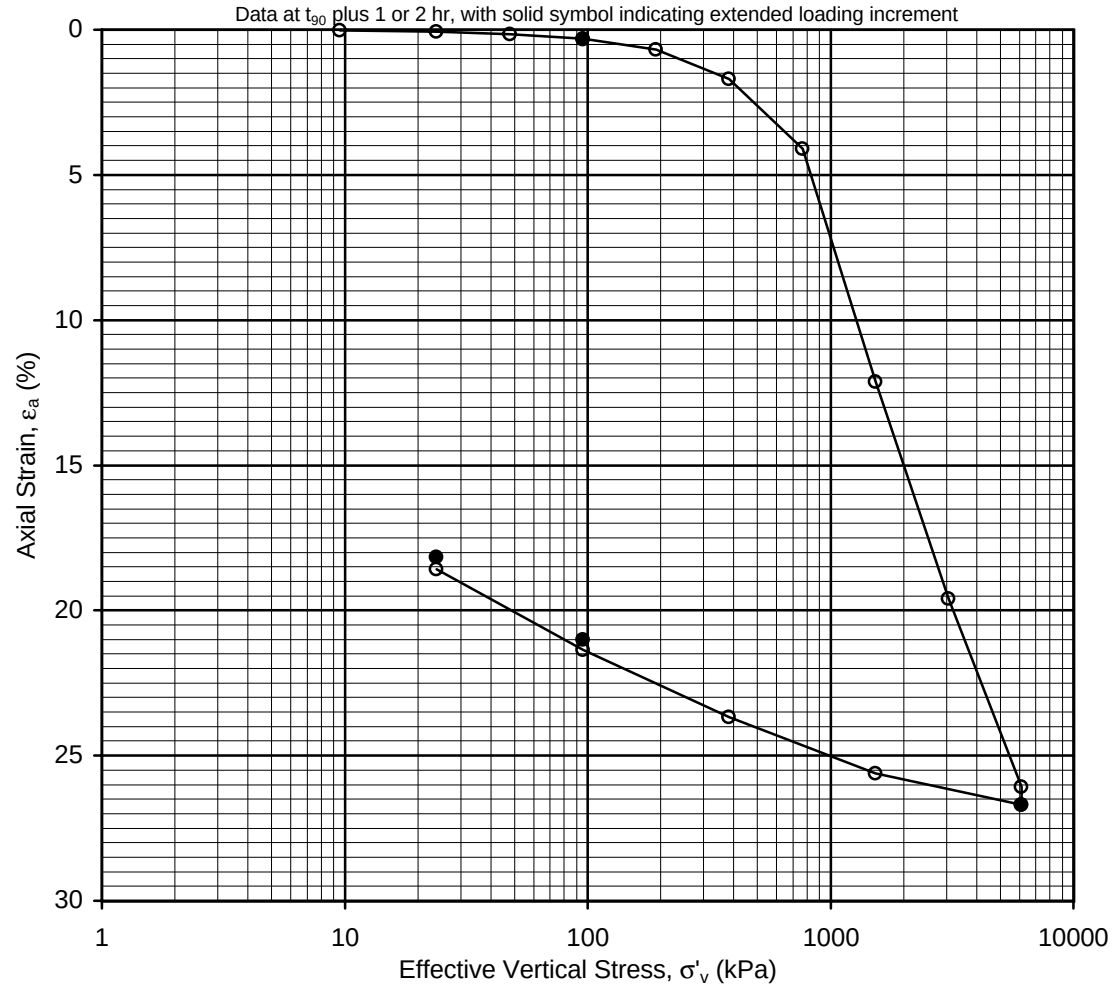
PLATE 98-59.6

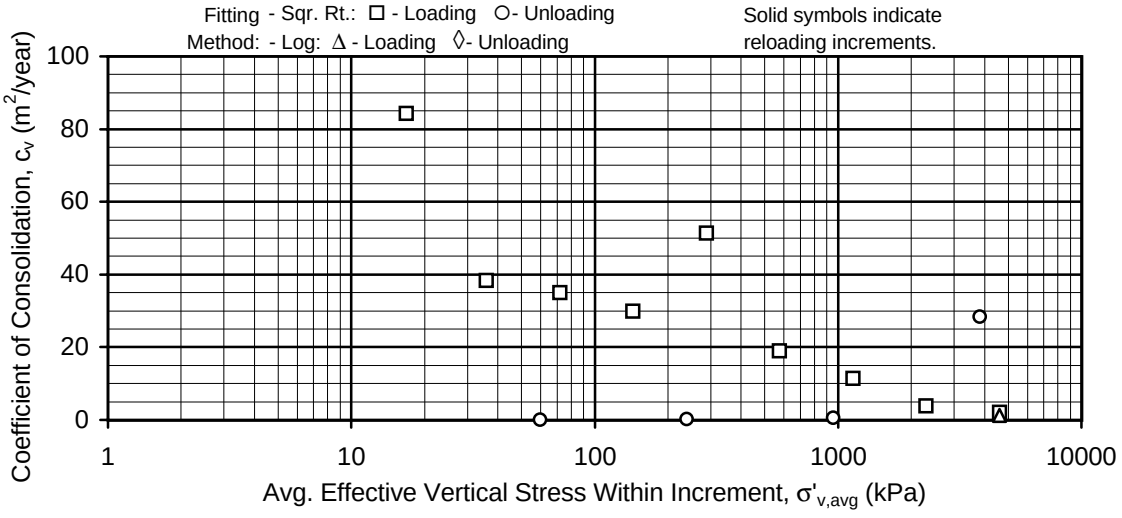




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 28 - Depth: 26.4m
Boring 98-59
SFOBB East Span Seismic Safety Project

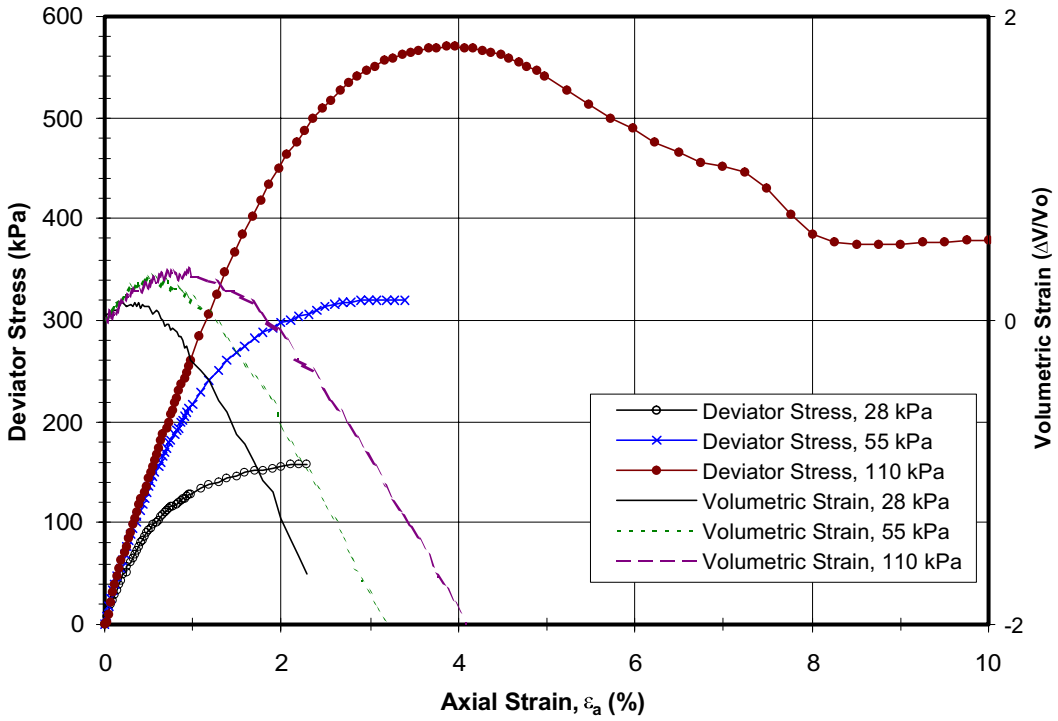


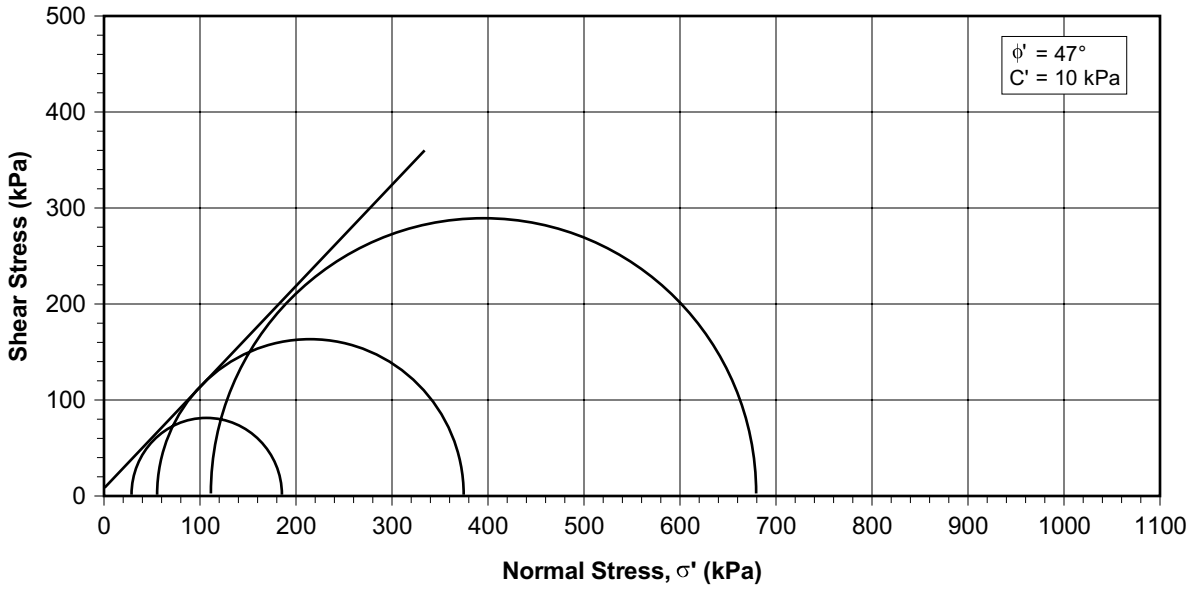


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 38 - Depth: 38.5m
Boring 98-59
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring





ISOTROPICALLY CONSOLIDATED-DRAINED TRIAXIAL COMPRESSION TEST

Sample 4 - Depth: 6.4m

Boring 98-59

SFOBB East Span Seismic Safety Project

PLATE 98-59.9

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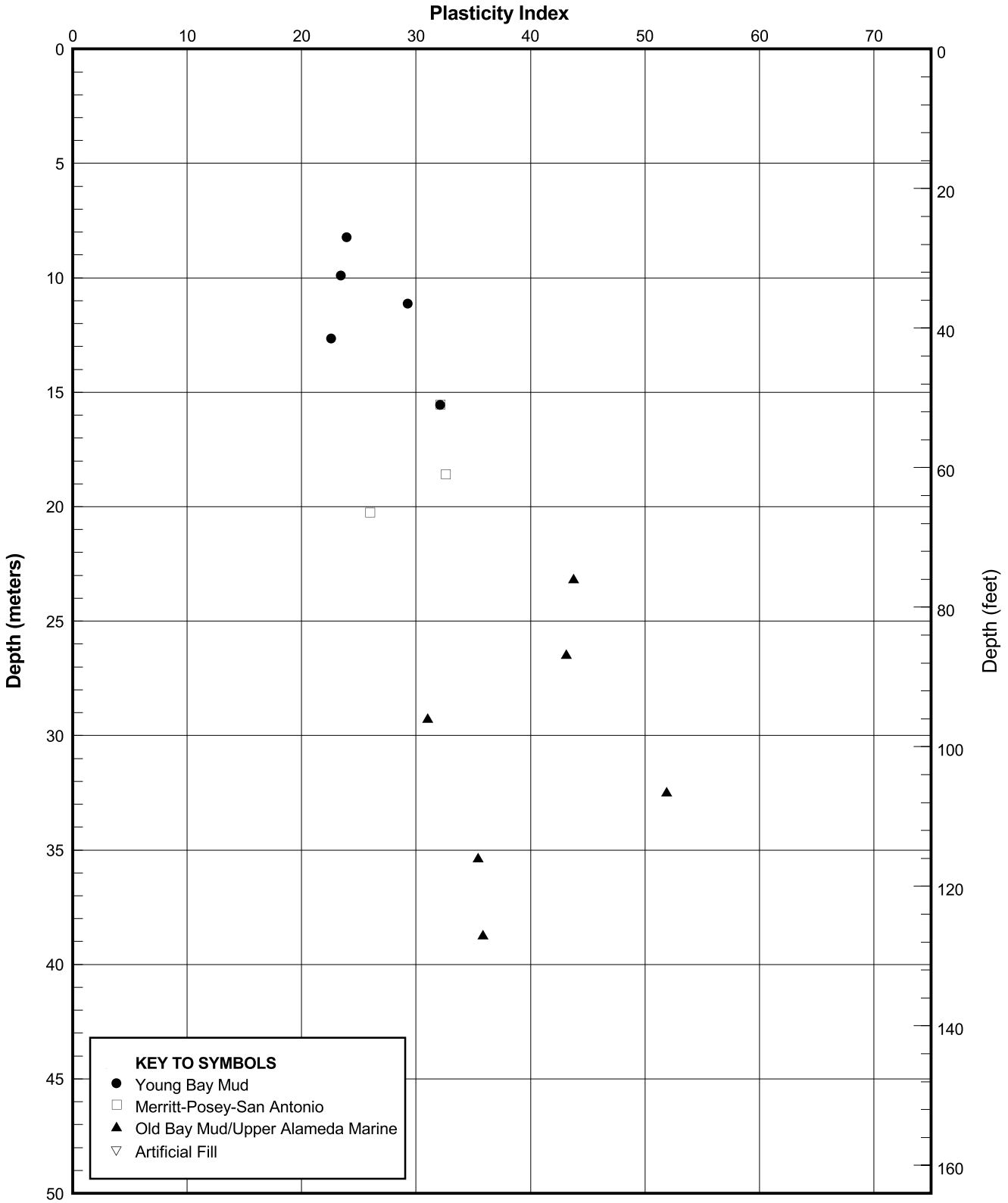
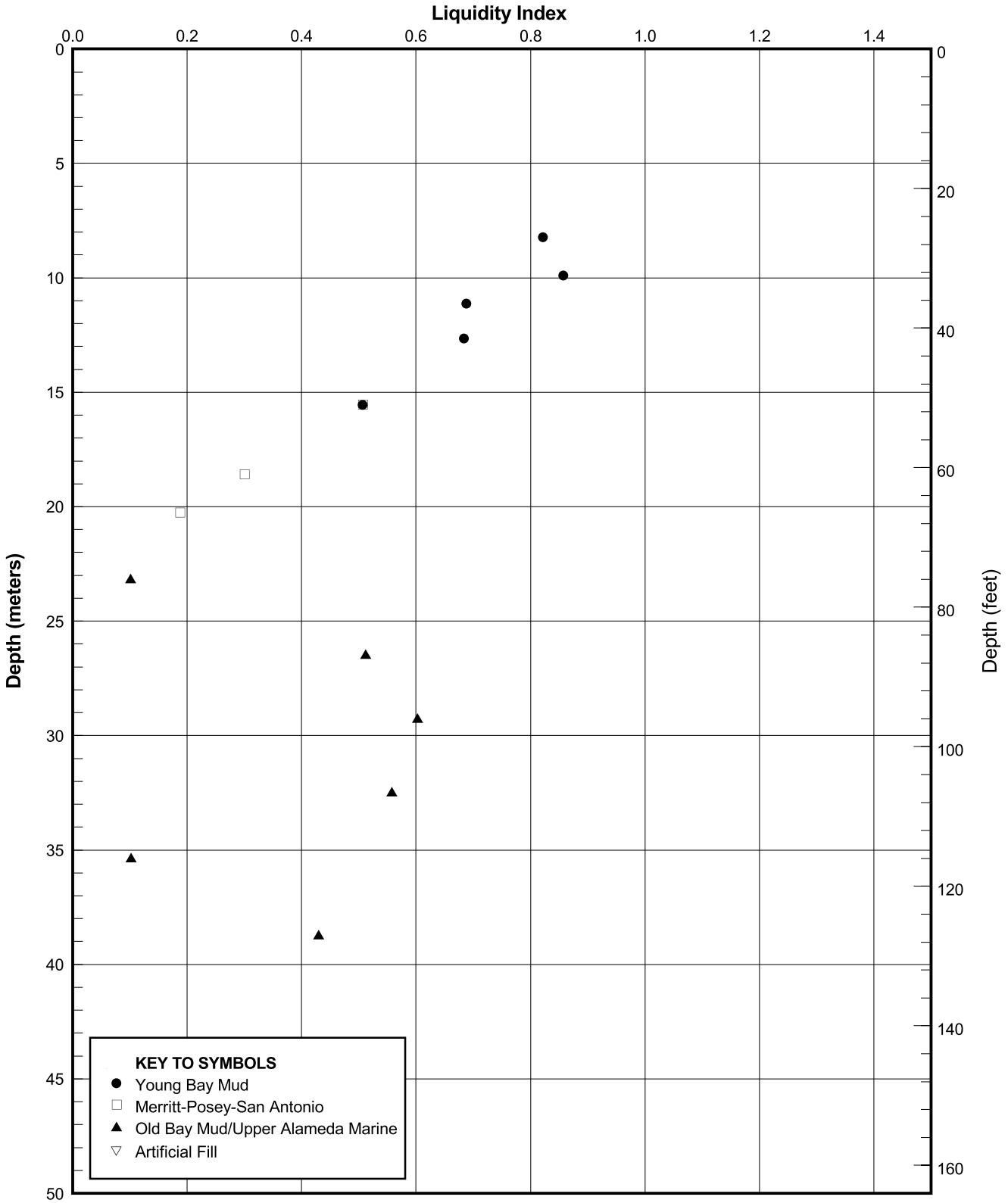
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



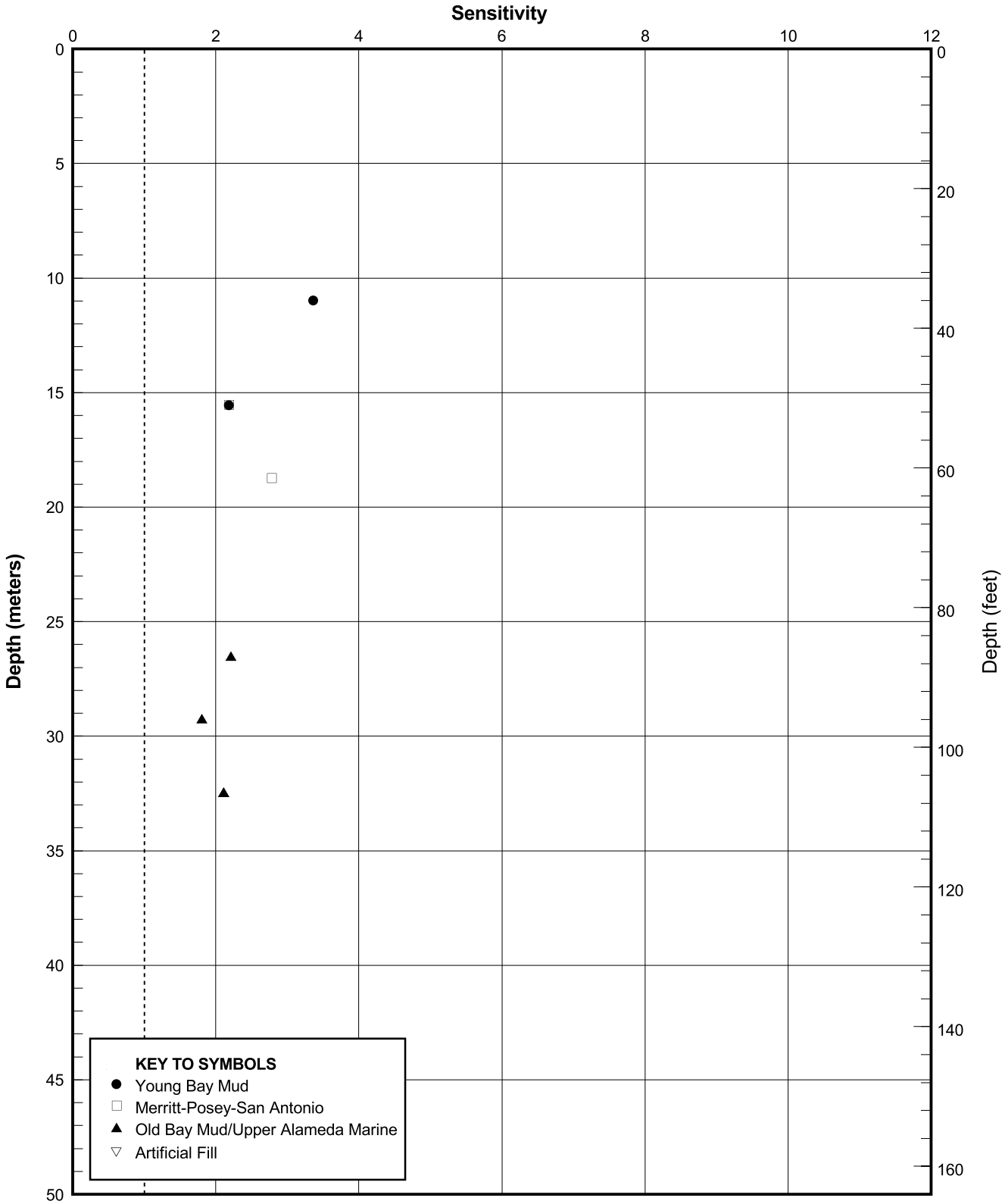
PLASTICITY INDEX PROFILE
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.12



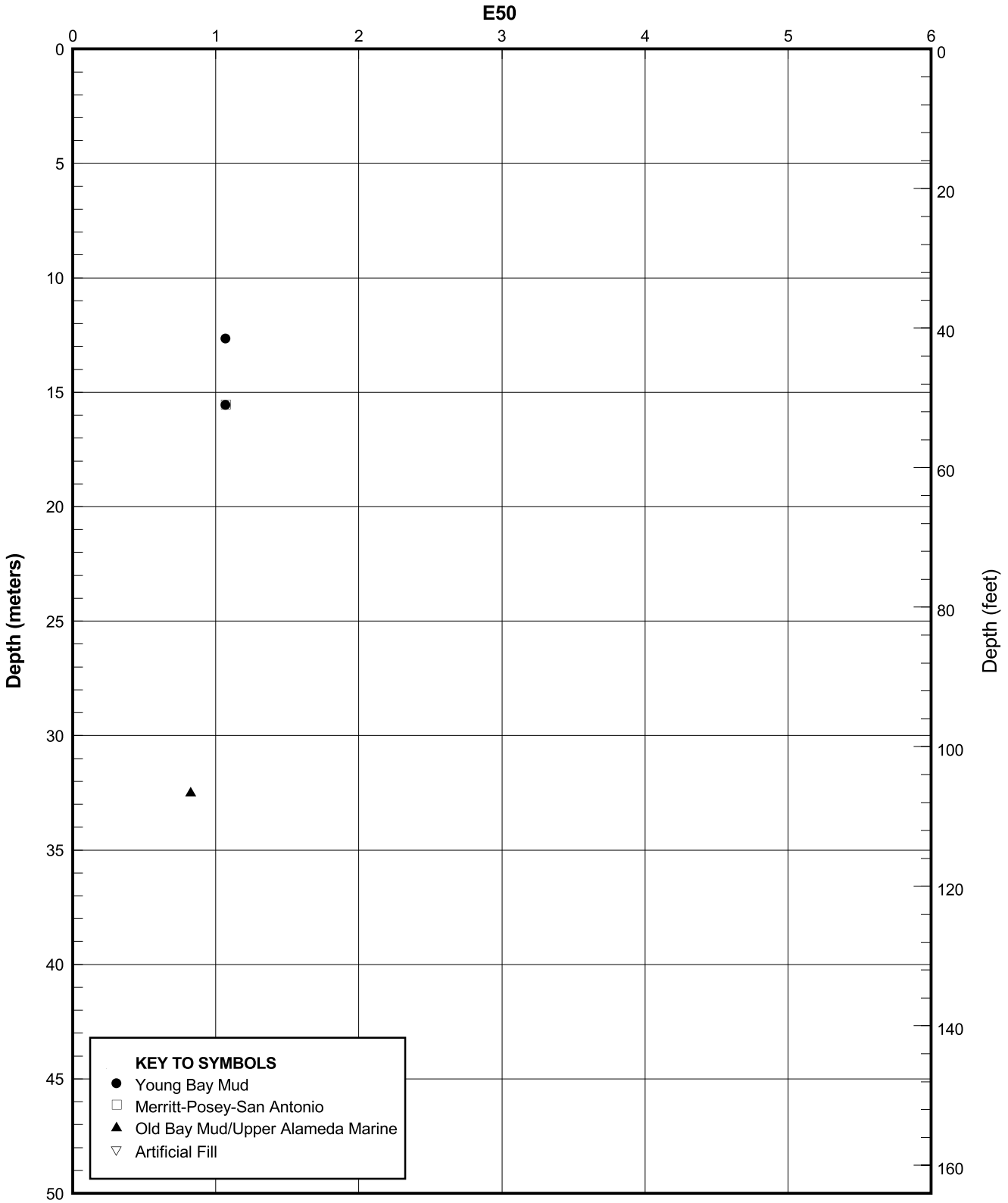
LIQUIDITY INDEX PROFILE
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.13



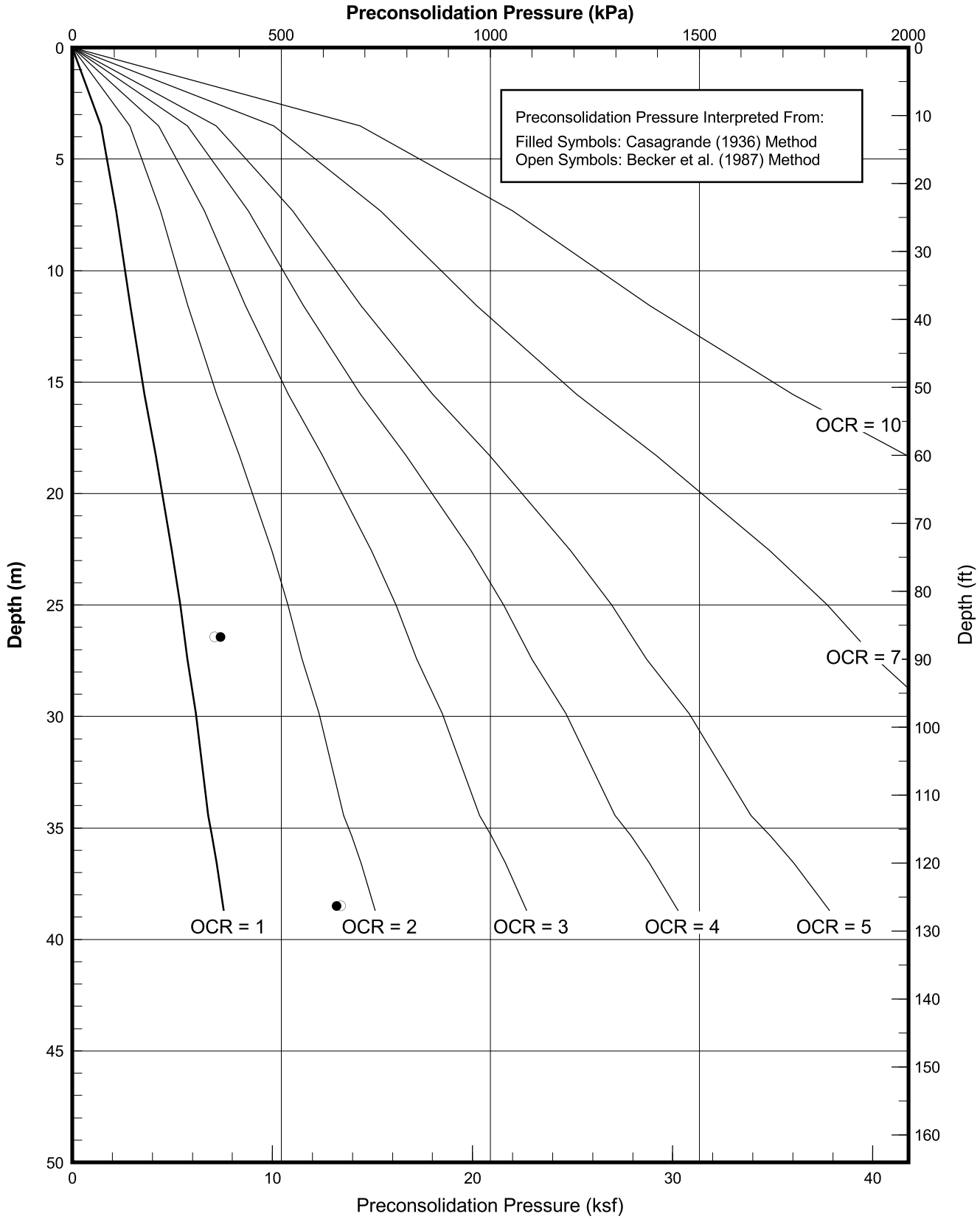
SENSITIVITY PROFILE
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.14



E50 PROFILE
Boring 98-59
SFOBB East Span Seismic Safety Project

PLATE 98-59.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-59

SFOBB East Span Seismic Safety Project

PLATE 98-59.16

LAND BORING 98-60

PROJECT NO:	98-42-0058	**START DATE:**	11/3/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-60 (Centerline W. Sta. 90+89)	**COMPLETION DATE:**	11/6/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839546 N648349
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.4m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					PAVEMENT, 0.2m Asphalt Concrete over 0.3m Concrete (0.5m)	I
2	2			BAG	Fine SAND with silt (SP-SM), medium dense, brown -moist to 3.0m	
				12	-with clayey sand pockets at 1.5m	
0	4			29	-with shell fragments at 3.2m ▽ (3.4m)	II
				14	-gray below 4.6m	
-2	6			9	-with shell fragments, at 6.1m	
					(7.6m)	
-4	8			3	Fat CLAY (CH), firm to stiff, olive gray -dark gray and with sand, at 7.9m	
-6				PUSH	-with shells, sand pockets and silt pockets, at 9.4m	
	10				-lean clay below 10.1m	
-8				SAVE	-sandy lean clay with an H2S odor, at 11.0m	III
	12			PUSH	-with many sand pockets, at 12.2m -clayey sand, 12.5m to 12.8m	
-10	14			PUSH	-with many sand pockets, partings and a few shell fragments, at 14.0m	
					(15.2m)	
-12	16			64	Fine SAND with silt (SP-SM), very dense, olive gray	IV
					(16.6m)	
-14	18			PUSH	Fat CLAY (CH), very stiff, greenish gray to gray -with many sand pockets at 17.1m	
				PUSH	-with gas blisters and a few black stains, at 18.6m	V
-16	20					
-18	22			PUSH	-with organic pockets, at 21.6m	
					(23.2m)	
-20	24				Fat CLAY (CH), very stiff, greenish gray	VI
				SAVE		
-22	26					
					(27.4m)	
-24	28			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -lean clay to 29.0m	
-26	30					
				PUSH	-with sand pockets, below 30.5m	VII
-28	32					
-30				SAVE		
	34				(34.4m)	
-32	36				Fat CLAY (CH), very stiff to hard, greenish gray	
				PUSH	-greenish gray and with organic stains and gas blisters, at 36.9m	
-34	38					
-36	40			PUSH	-with silt partings at 39.9m	VIII
-38	42					
				SAVE	-with organic stains at 43.0m	
-40	44					
-42	46			PUSH	-with silt pockets at 46.0m	
					TOTAL DEPTH: 46.3m BACKFILLED WITH: Cement Grout	
-44	48					
-46						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-60.1

LOG OF BORING AND TEST RESULTS

BORING 98-60

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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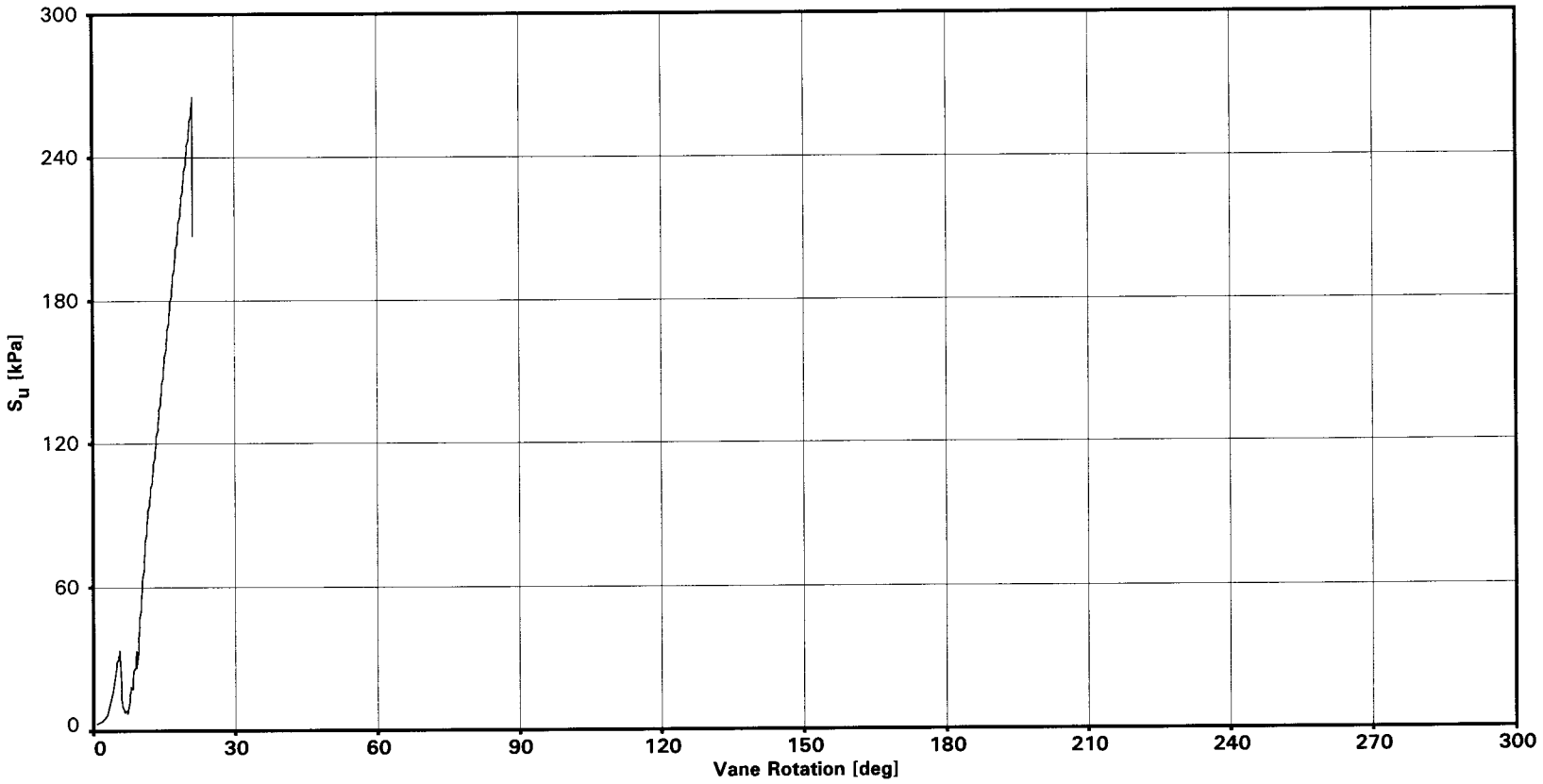
SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 15.2m
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.2a

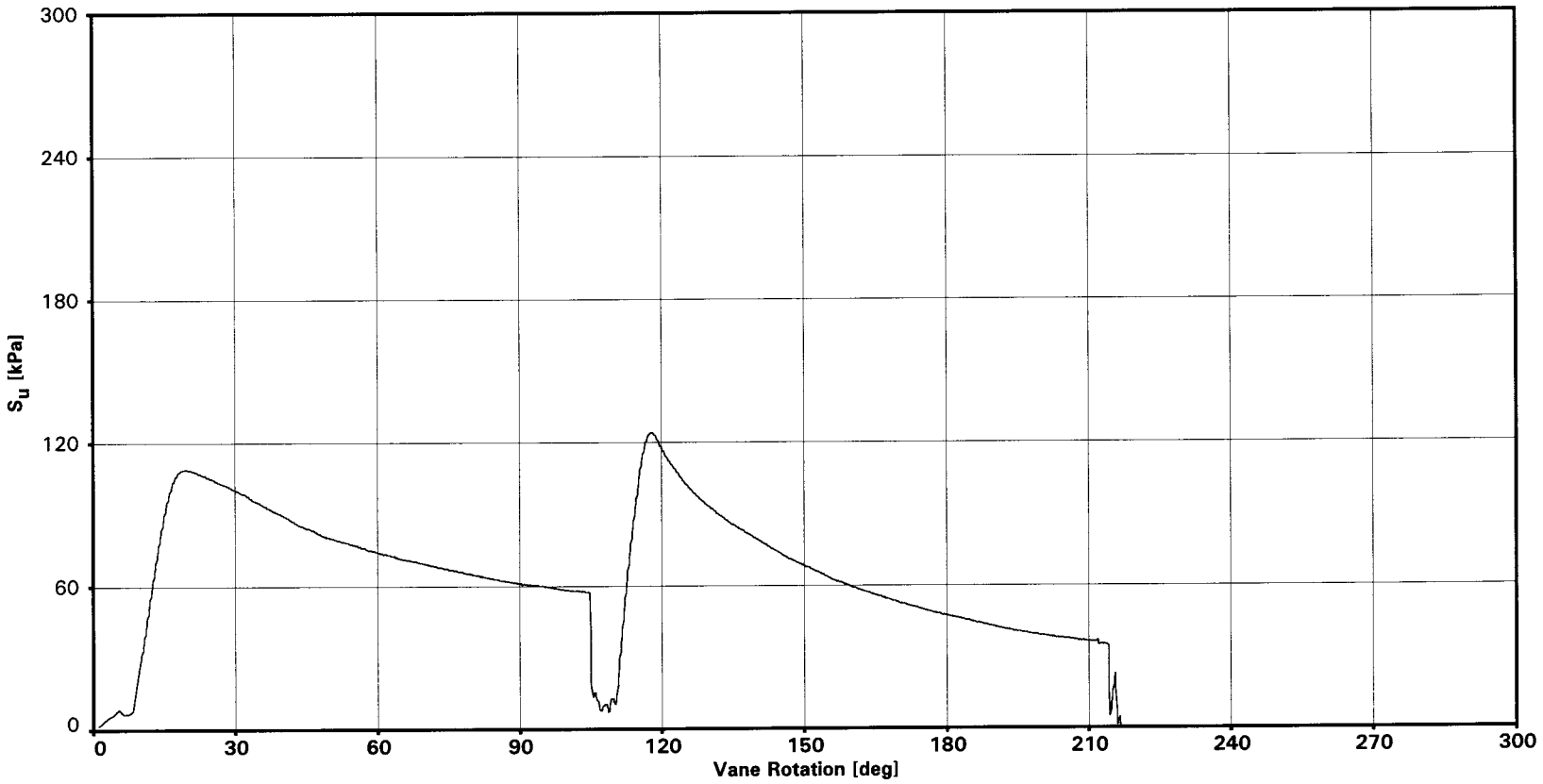
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 19.8m and 20.4m
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.2b

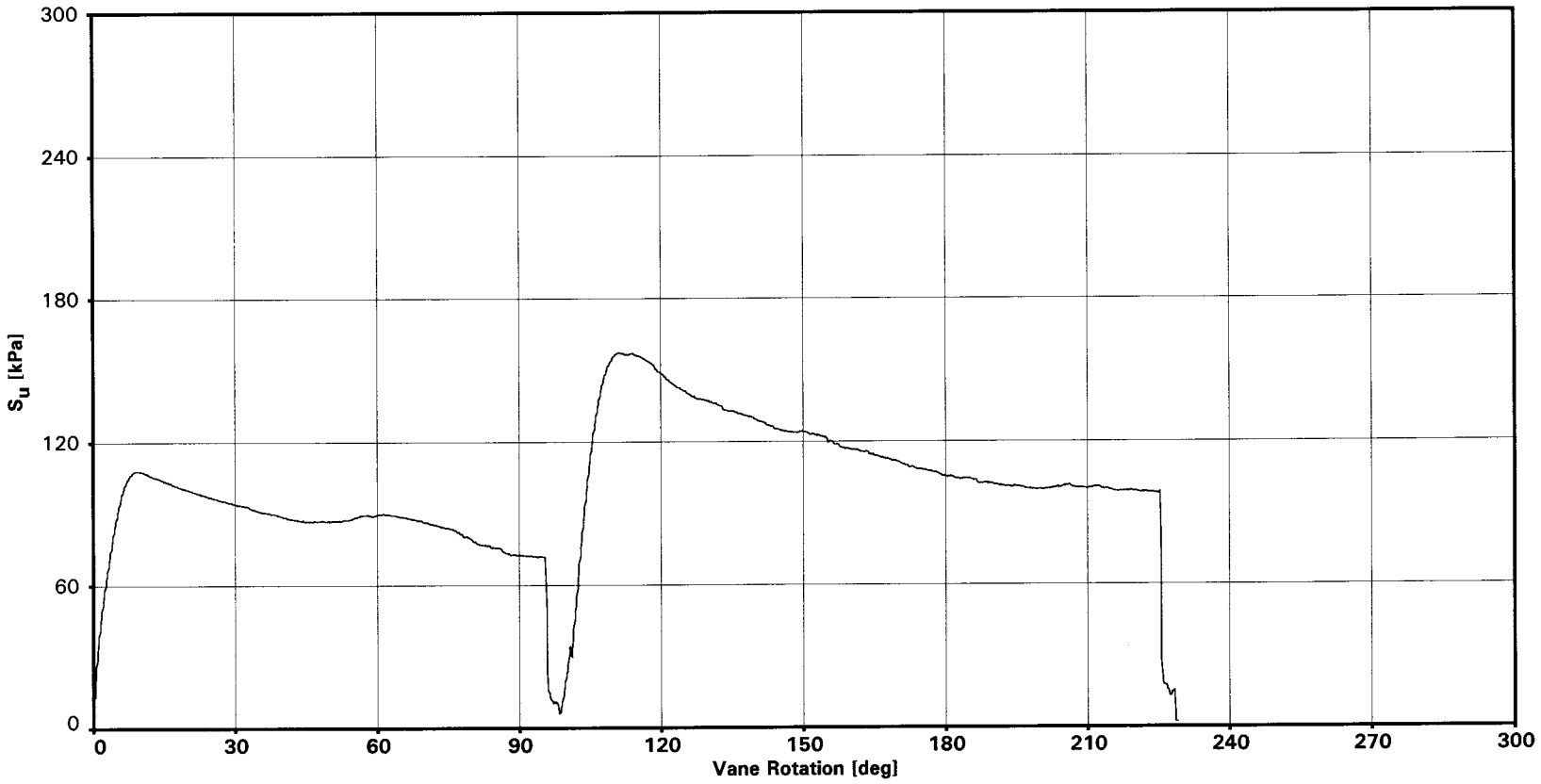
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 22.9m and 23.5m
Boring 98-60
SFOBB East Span Seismic Safety Project

Earth Mechanics

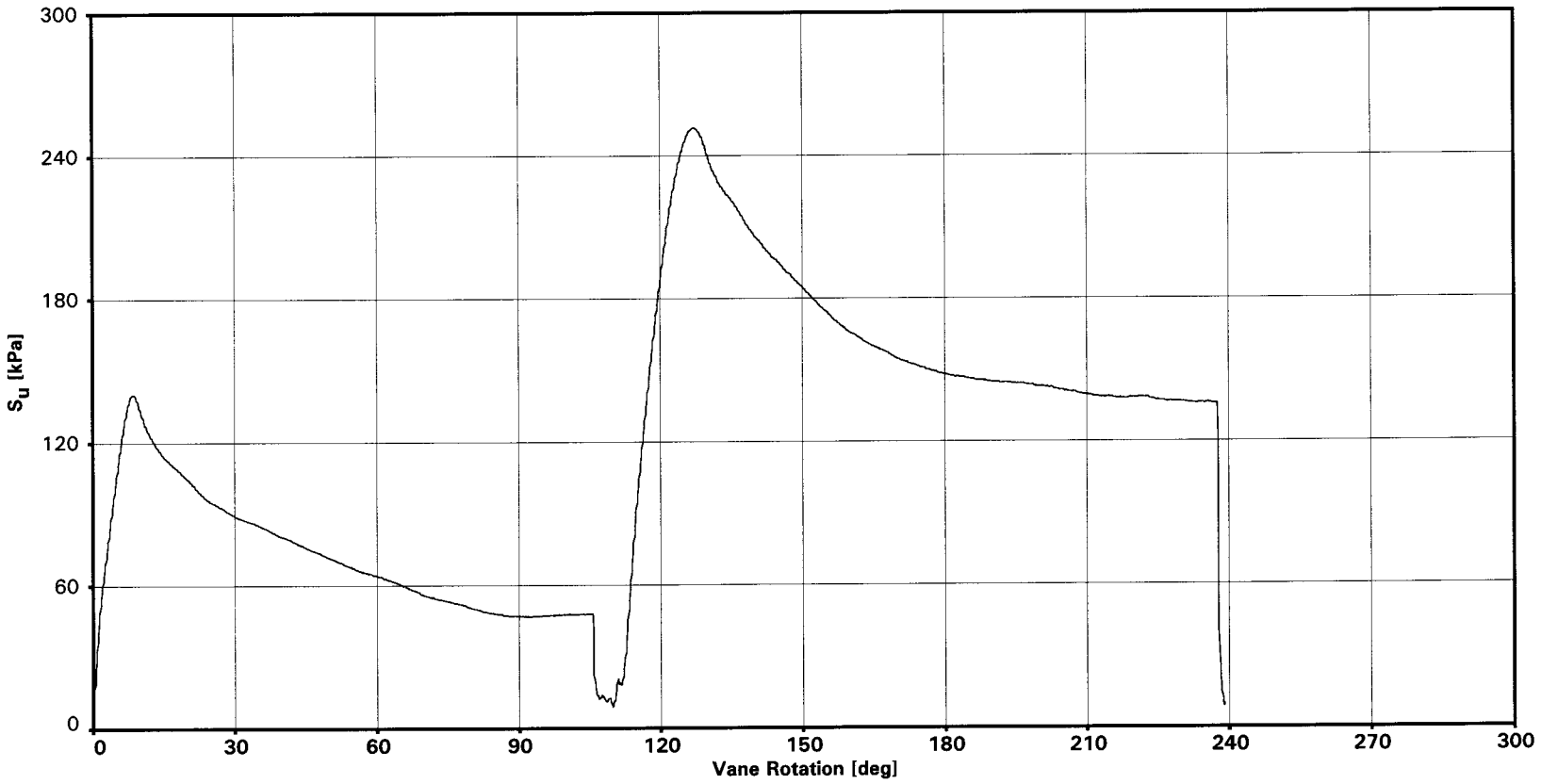
FUGRO

PLATE 98-60.2c

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 25.9m and 26.5m
Boring 98-60
SFOBB East Span Seismic Safety Project

Earth Mechanics

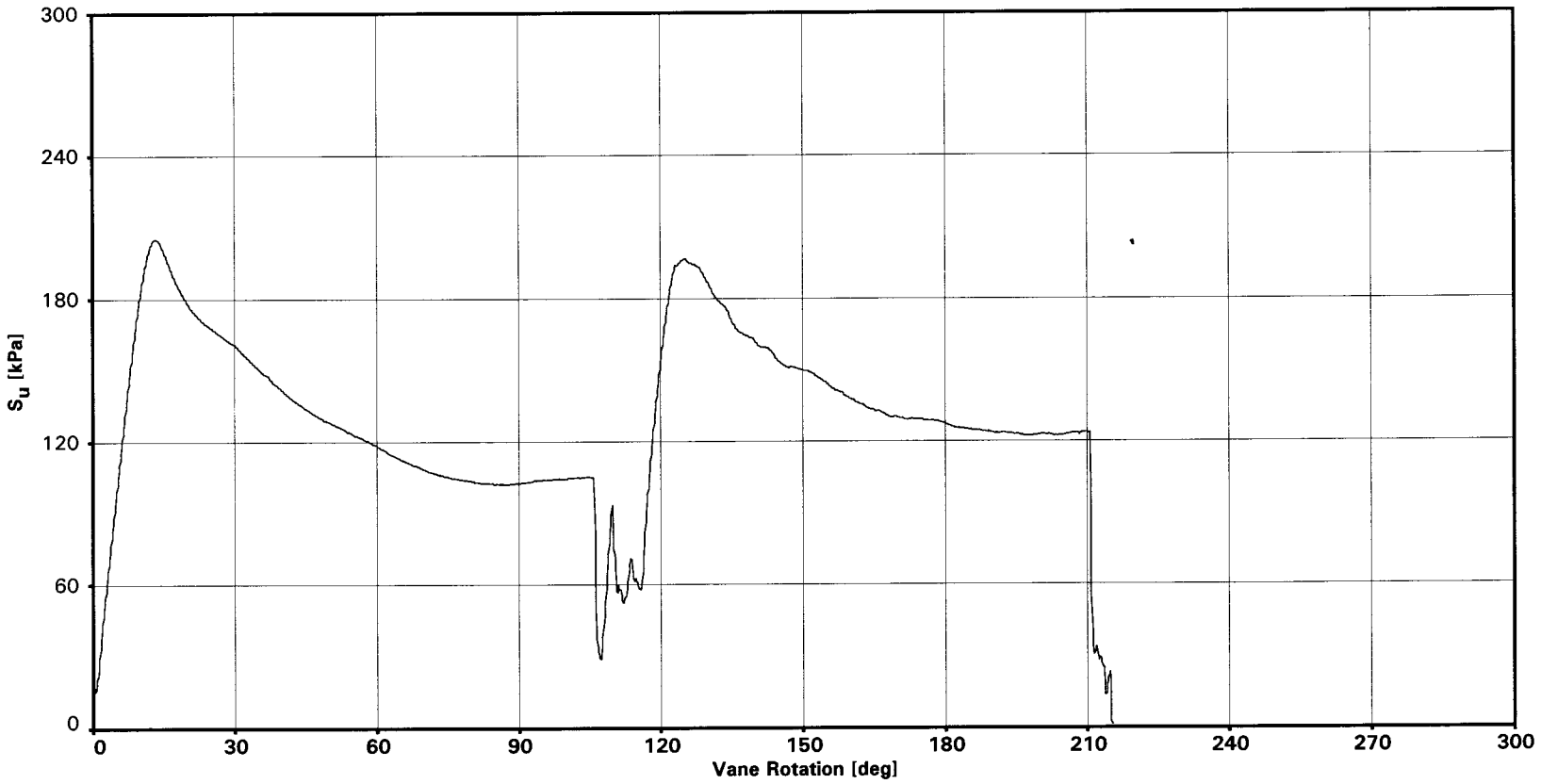
FUGRO

PLATE 98-60.2d

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 29.0m and 29.6m
Boring 98-60
SFOBB East Span Seismic Safety Project

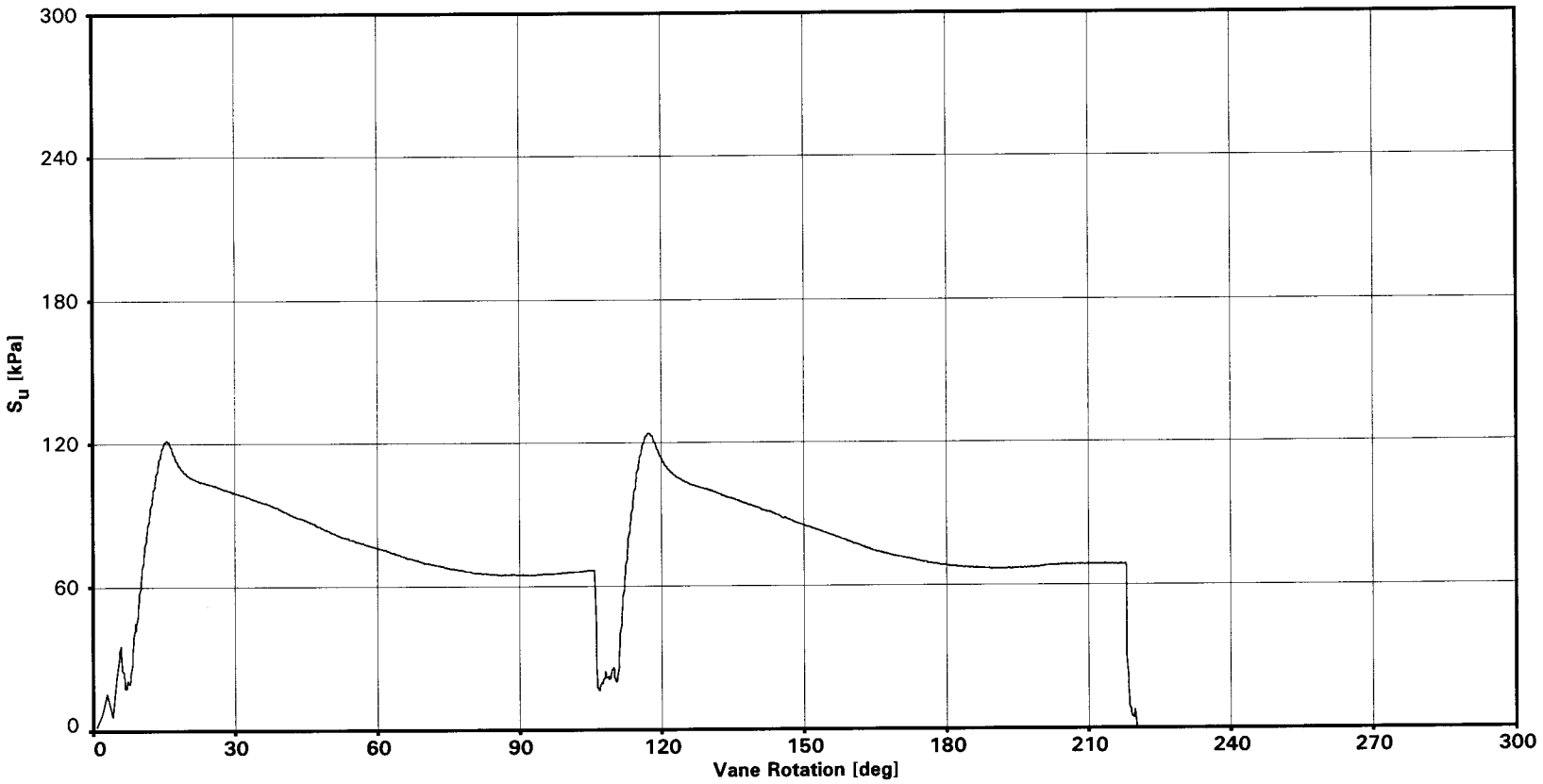
Earth Mechanics

FUGRO

PLATE 98-60.2e

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 32.0m and 32.6m
Boring 98-60
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

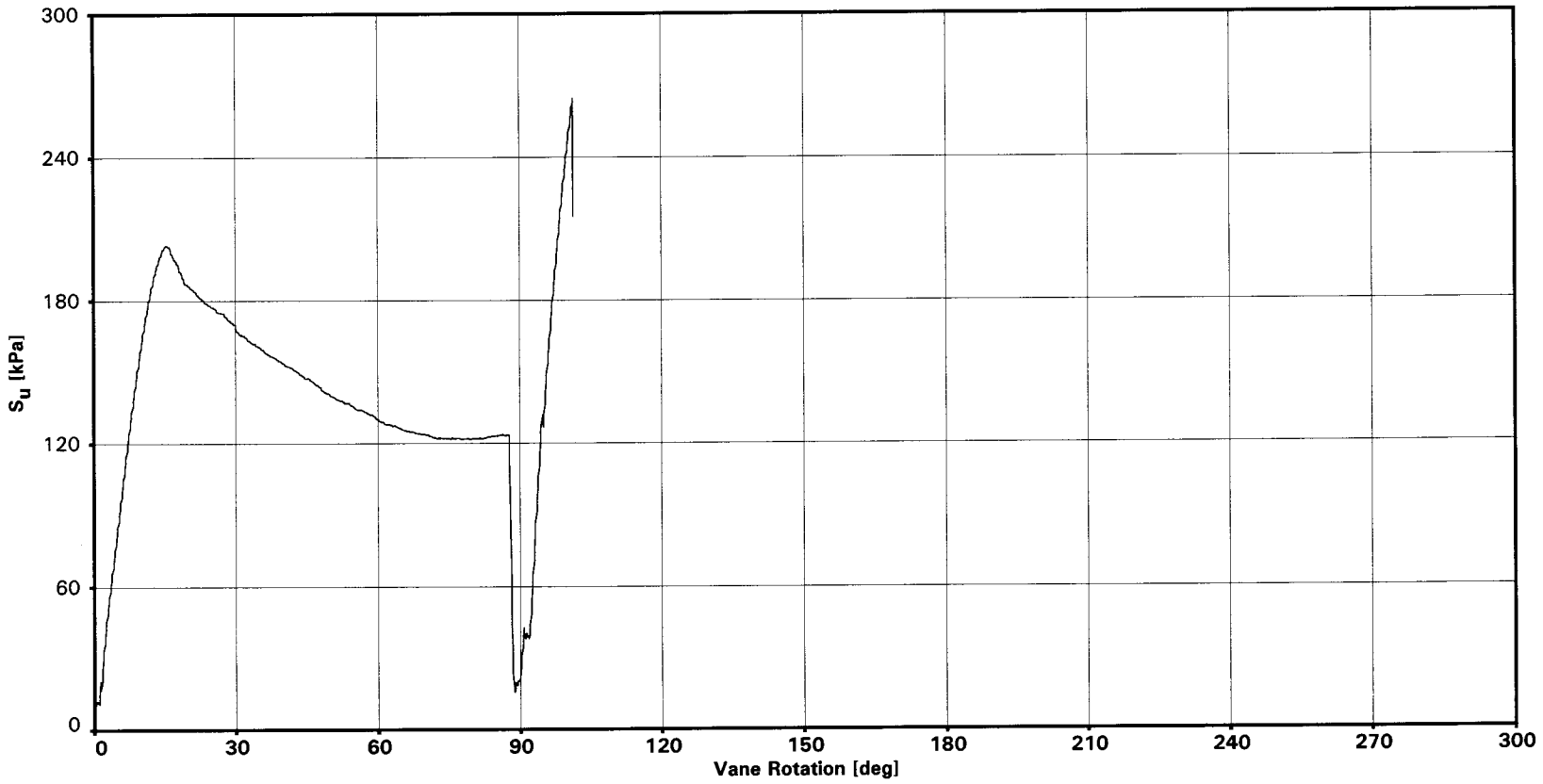
FUGRO

PLATE 98-60.2f

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 35.1m and 35.7m
Boring 98-60
SFOBB East Span Seismic Safety Project

Earth Mechanics

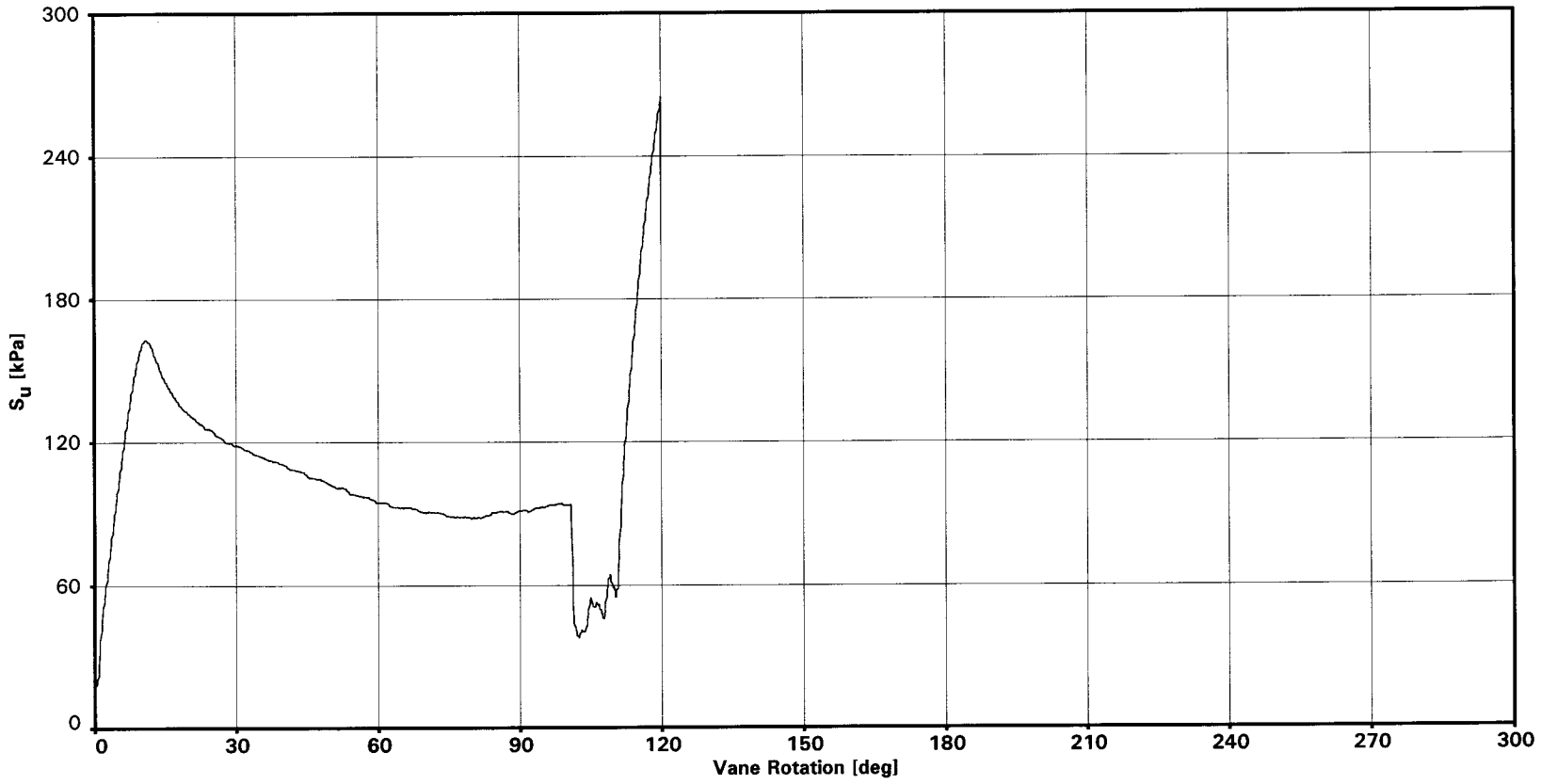
FUGRO

PLATE 98-60.2g

SFOBB Task Order No. 5
Project No. 98-42-0058

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 38.1m and 38.7m
Boring 98-60
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-60.2h

98-60		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.5	300																										
2.0	1	8																									
3.4	2	19					8																				
4.9	3	25					12																				2.70
6.1	4	25					7																				
8.1	5	41	57	29	0.42																						
9.3	6							30.6			36.5		11.6														
9.6	8	39	50	25	0.55	17.3									29.0		1.5										
9.8	9	39	46	24	0.70			53.6																			
11.4	10	31									52.0																
12.3	11	29	33	15	0.81	17.9																					
12.5	12														39.3		1.6										
12.8	13		26	18			23																				
14.2	16					17.9					46.3	9.3			34.5		1.1										
14.3	17	34	30	15	1.21																						

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.3a

Earth Mechanics

FUGRO

98-60		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
15.2	400													263.3+													
15.7	18	22					6																				
17.4	20	38																									
18.6	21	31	54	20	0.34										67.8		0.6										
18.7	22					18.7																					
18.9	23								71.8		108.9																
19.8	401													107.3													
20.4	402													121.1													
21.6	24	82	76	27	1.11			114.9																			
21.8	25					16.1										18.3											2.69
21.9	26							107.7			105.2																
22.9	403													106.3													
23.5	404													154.7													
25.0	27	24									80.1																
25.9	405													137.4													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

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98-60		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
26.5	406													251.8+													
27.9	29	23	43	19	0.18			148.4							113.2		1.5										
28.0	30					20.1			225.0		189.4																
29.0	407													204.9													
29.6	408													196.3													
30.6	31	44	57	22	0.64	17.8																					
30.8	32							100.5			89.1																
32.0	409													119.2													
32.6	410													121.6													
34.1	33	41	63	22	0.47			107.7			126.3															C	
35.1	411													204.0													
35.7	412													263.3+													
37.0	35	45	91	30	0.25	17.3										32.4											
37.2	36							143.6	179.6		211.6																
38.1	413													161.8													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-60
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-60.3c

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98-60		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
38.7	414													263.3+													
40.1	38	29	52	22	0.25	18.6		117.3	179.6						94.9		4.3										
40.2	39							131.7			95.3																
43.3	40	20	43	16	0.13			126.9			216.6															C	
46.0	41							119.7																			
46.2	42	26	57	17	0.22	19.9										109.8											
46.3	43							124.5	143.6		173.3																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-60
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-60.3d

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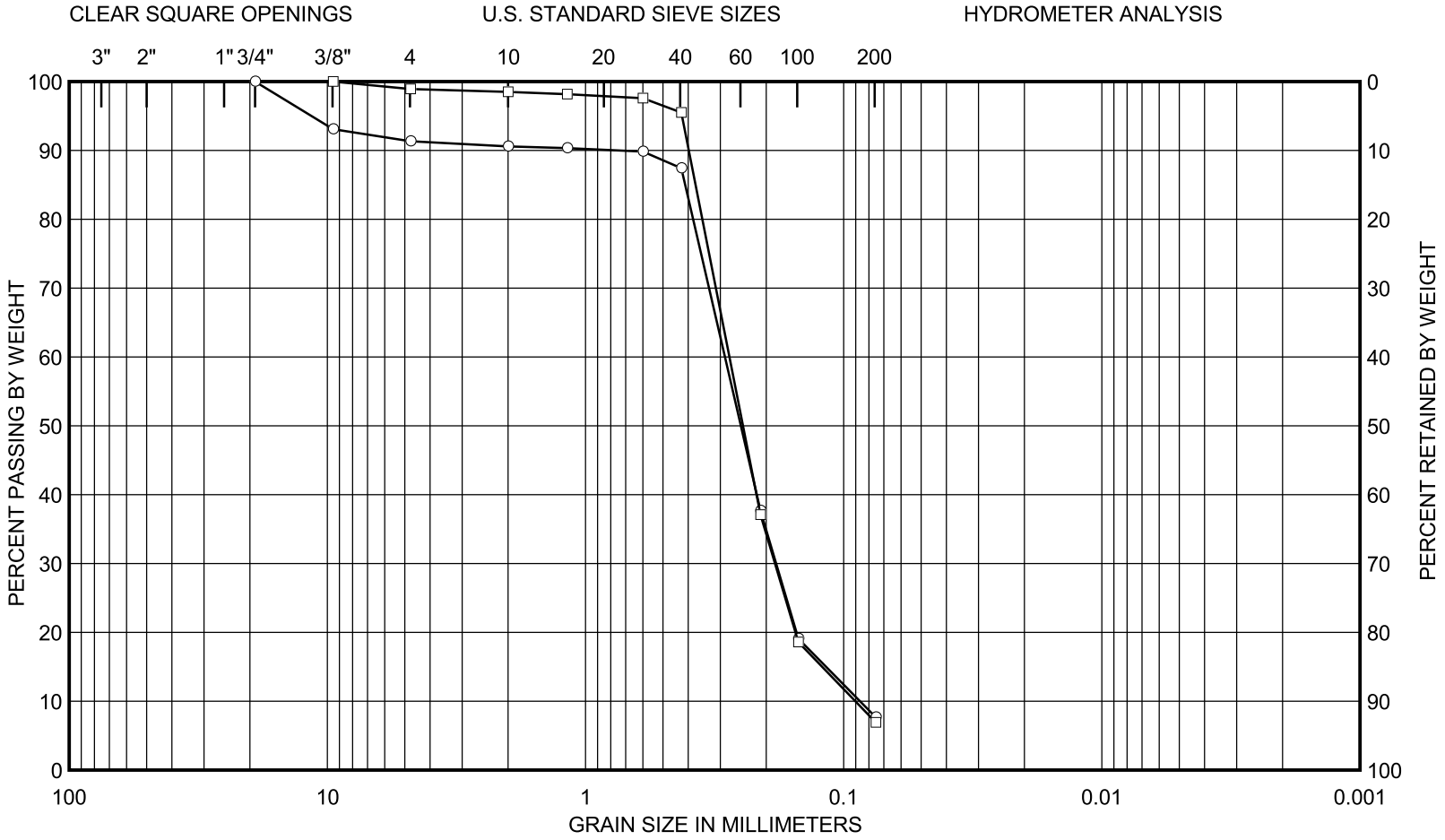

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	3.4	○—○	FINE SAND (SP-SM) with silt	1.3	3.3	0.25
4	6.1	□—□	FINE SAND (SP-SM) with silt	1.4	3.1	0.25

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

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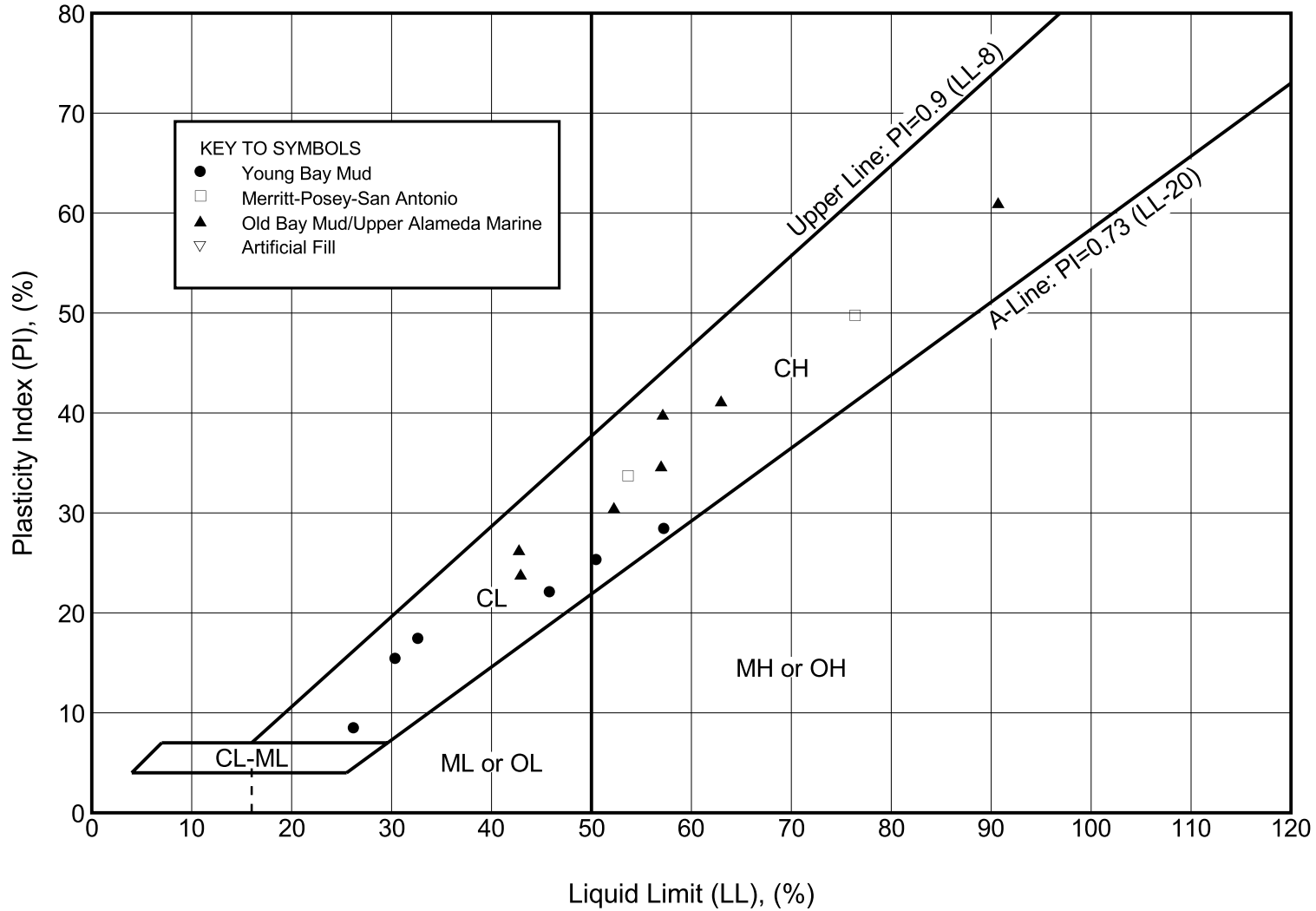

PLASTICITY CHART
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.5

Earth Mechanics

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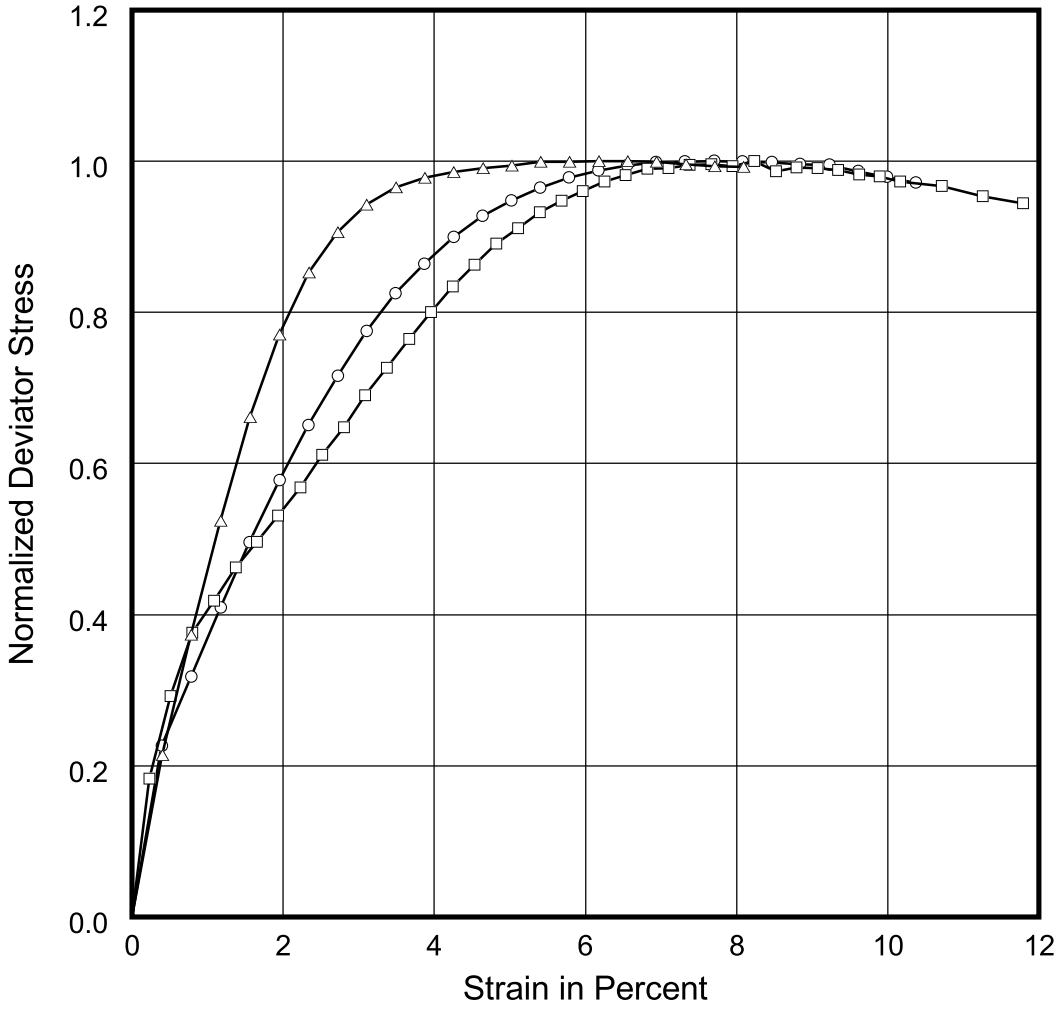


Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	8	9.6	UU	172	58	1.5
□—□	12	12.5	UU	241	79	1.6
△—△	16	14.2	UU	276	69	1.1

Deviator stress normalized with respect to maximum deviator stress.

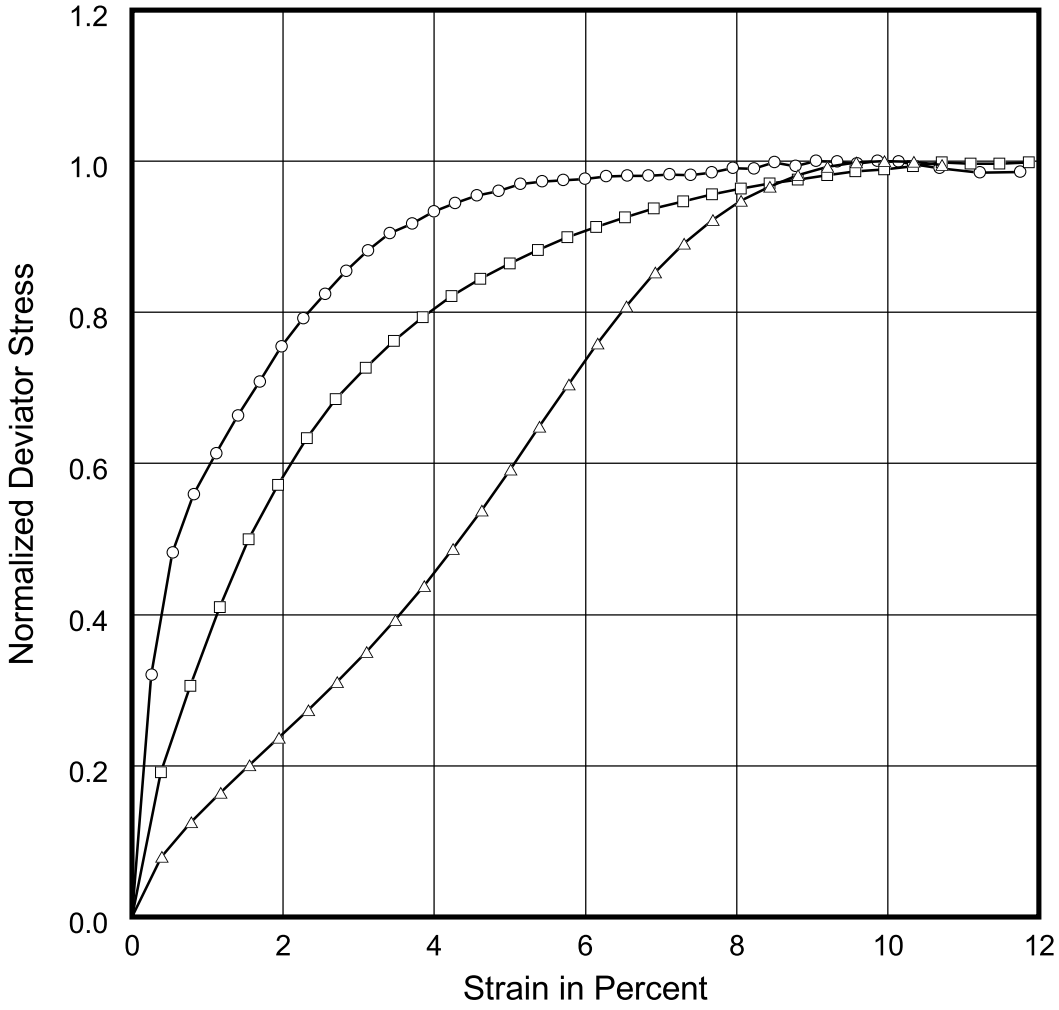
STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.6a

Earth Mechanics

FUGRO



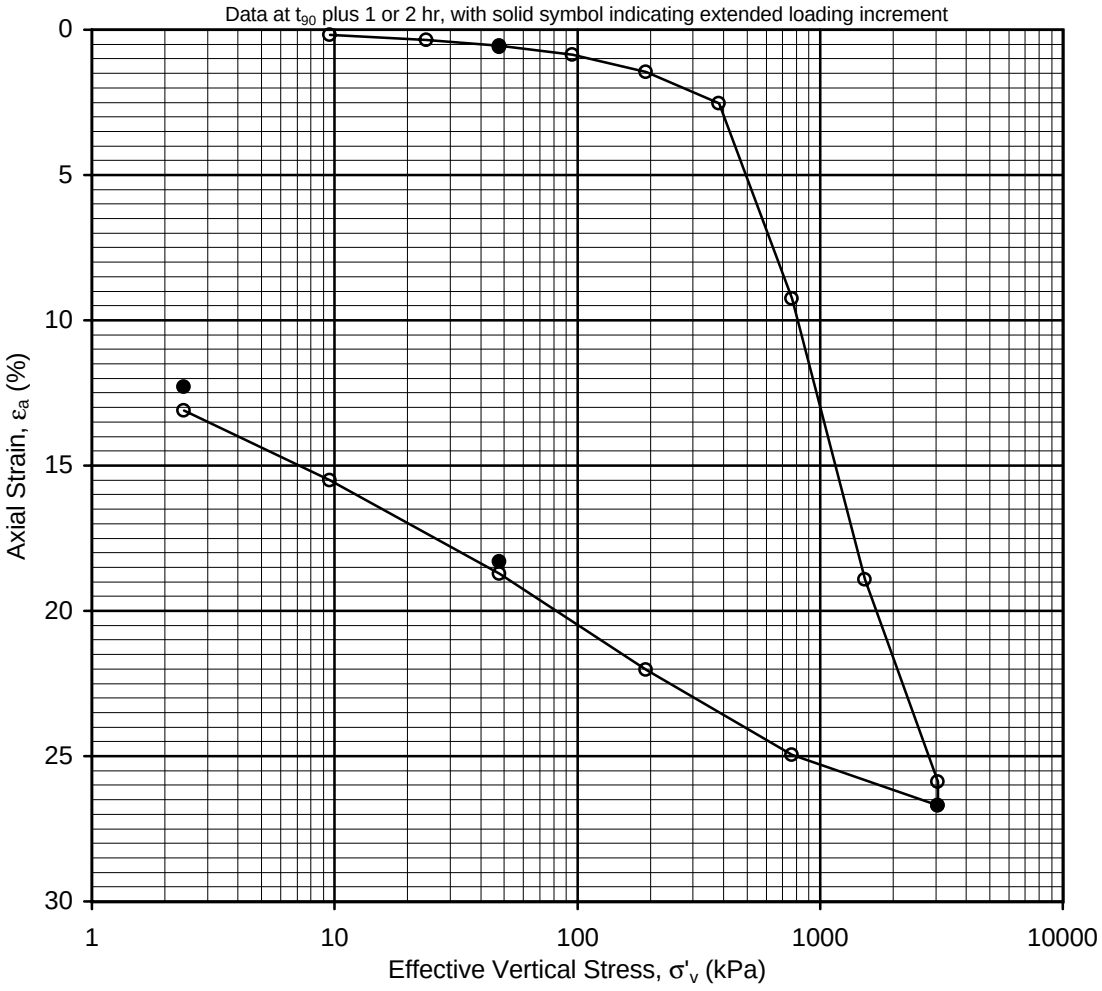
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	21	18.6	UU	689	136	0.6
□	29	27.9	UU	862	226	1.5
△	38	40.1	UU	1103	190	4.3

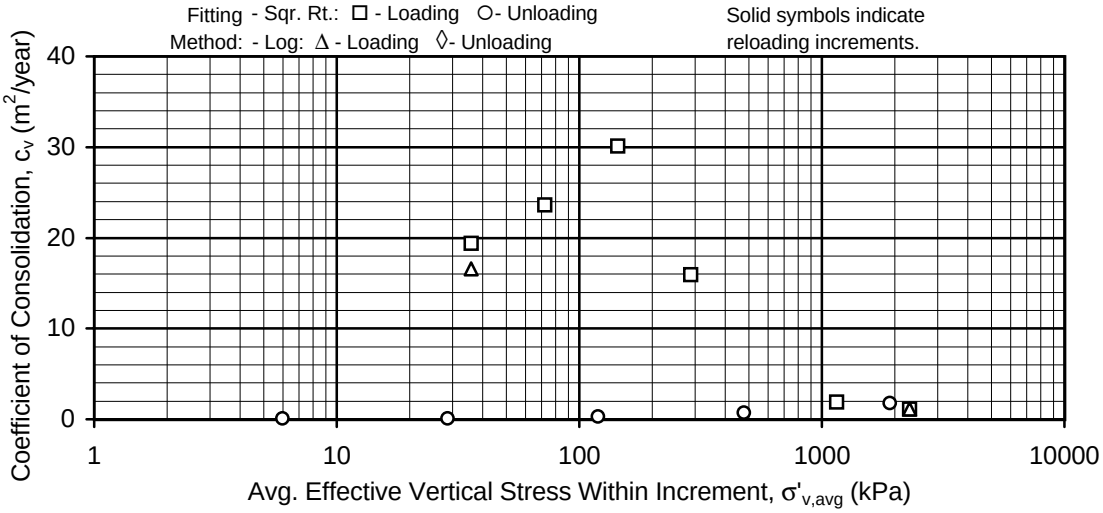
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-60
SFOBB East Span Seismic Safety Project

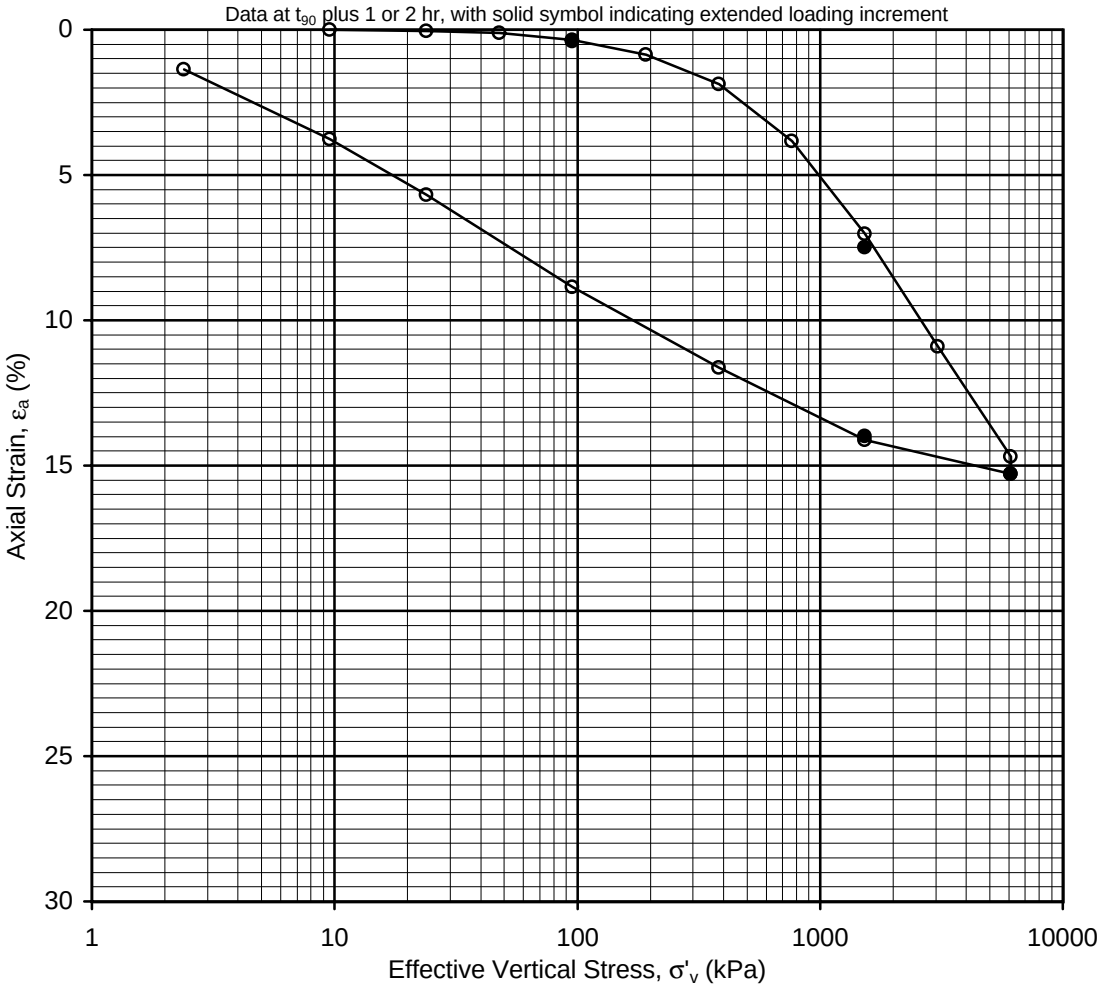
PLATE 98-60.6b

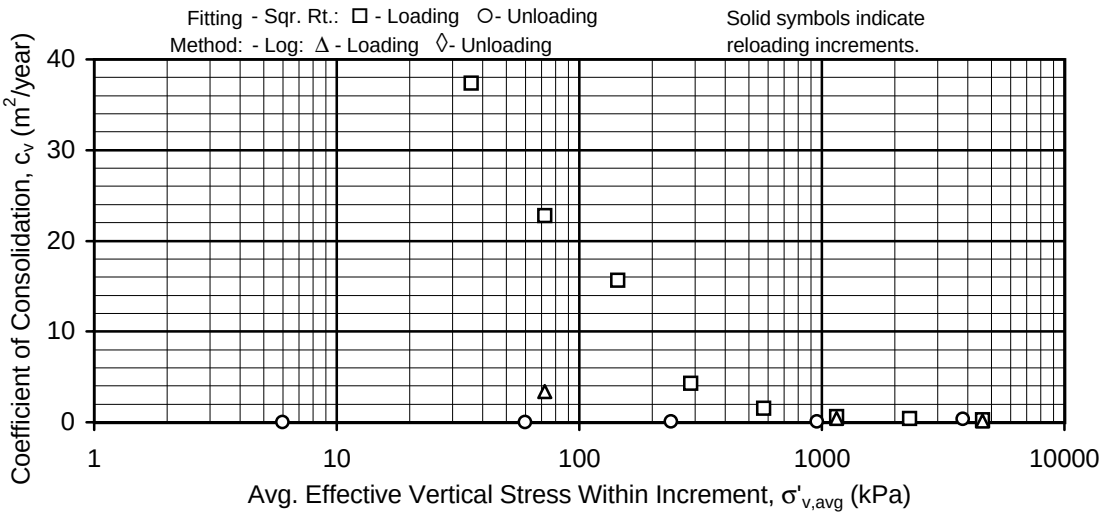




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 33 - Depth: 34.1m
Boring 98-60
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

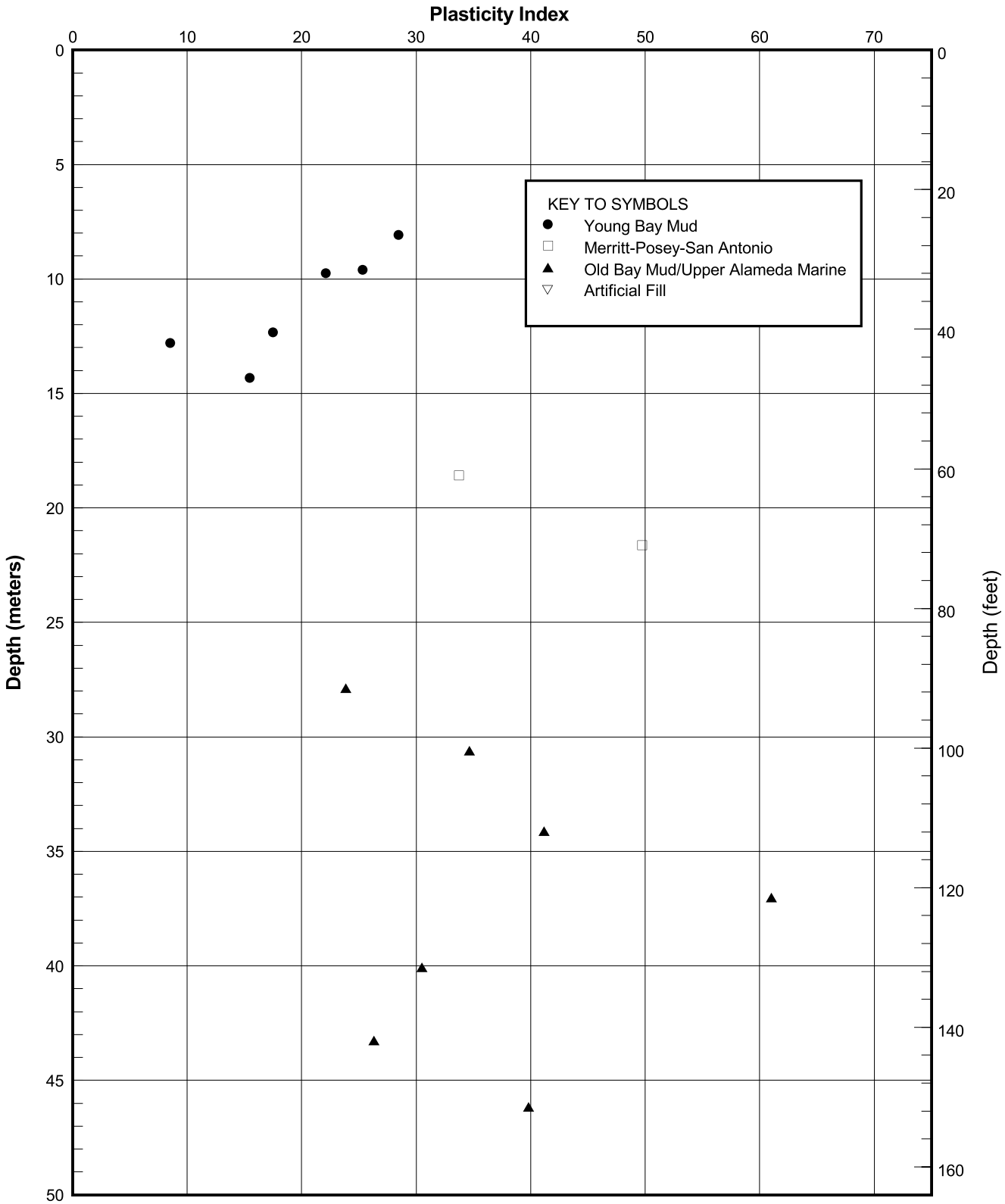
Sample No. 40 - Depth: 43.3m
Boring 98-60
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

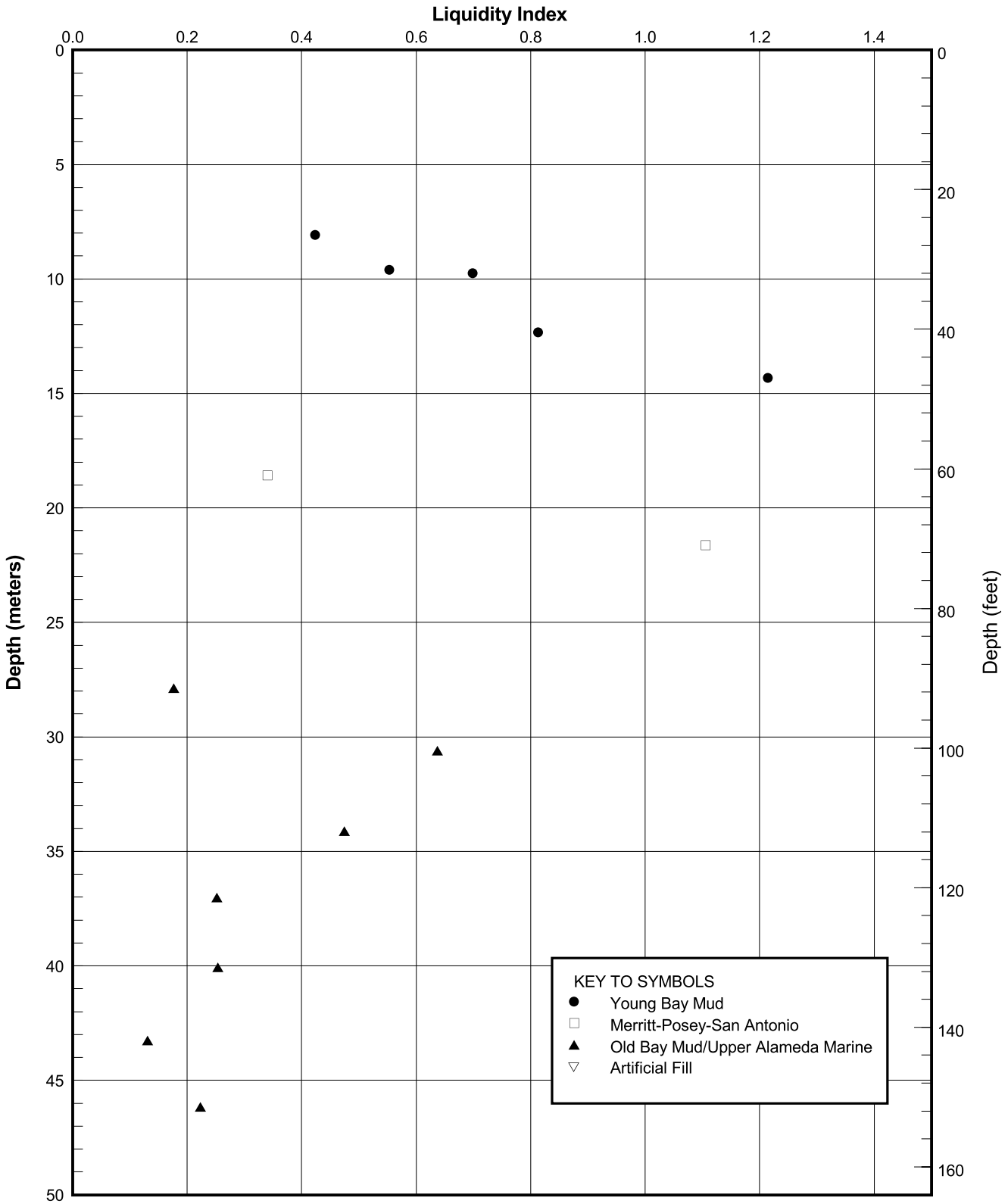
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



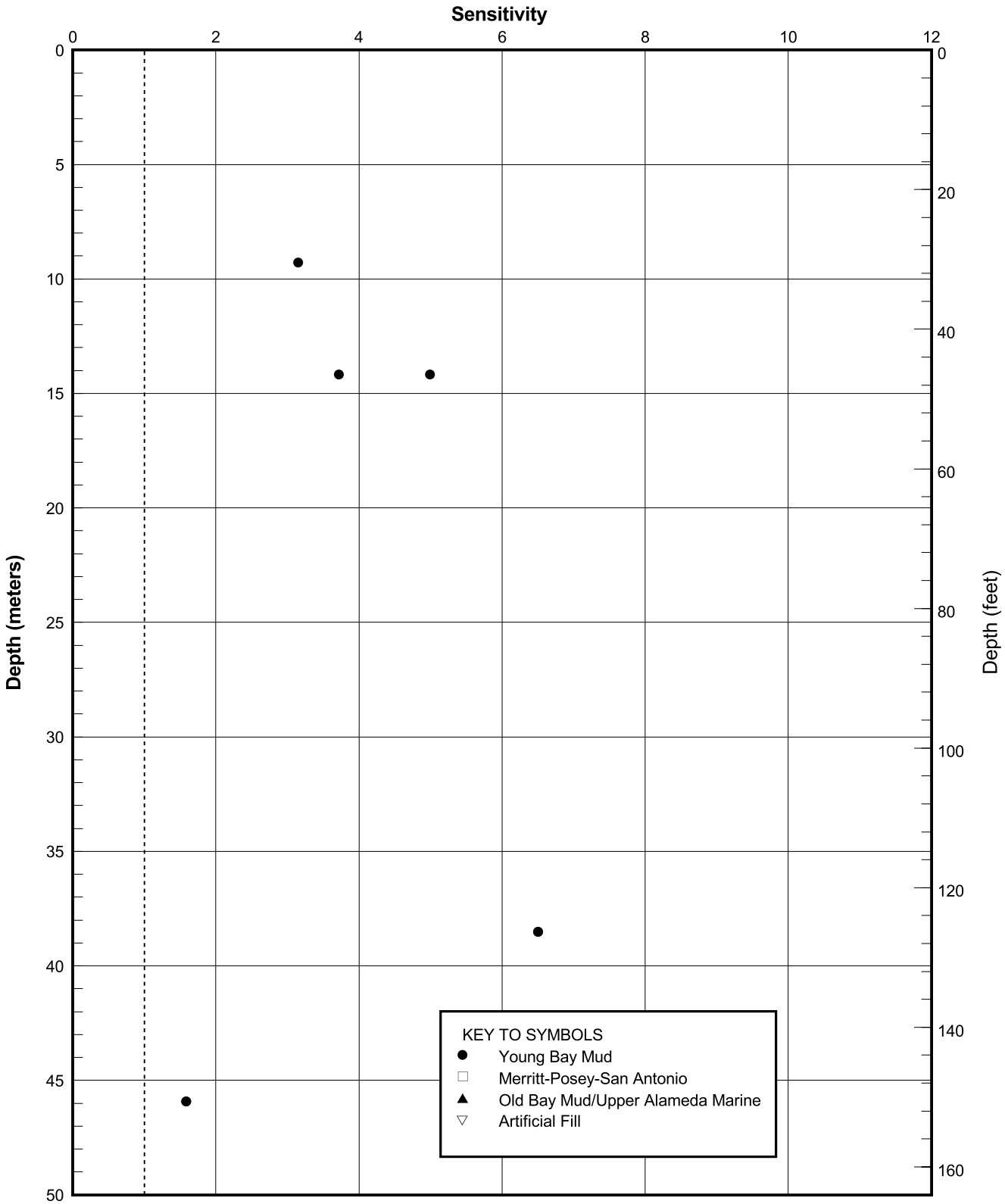
PLASTICITY INDEX PROFILE
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.12



LIQUIDITY INDEX PROFILE
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.13



SENSITIVITY PROFILE
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.14

Earth Mechanics

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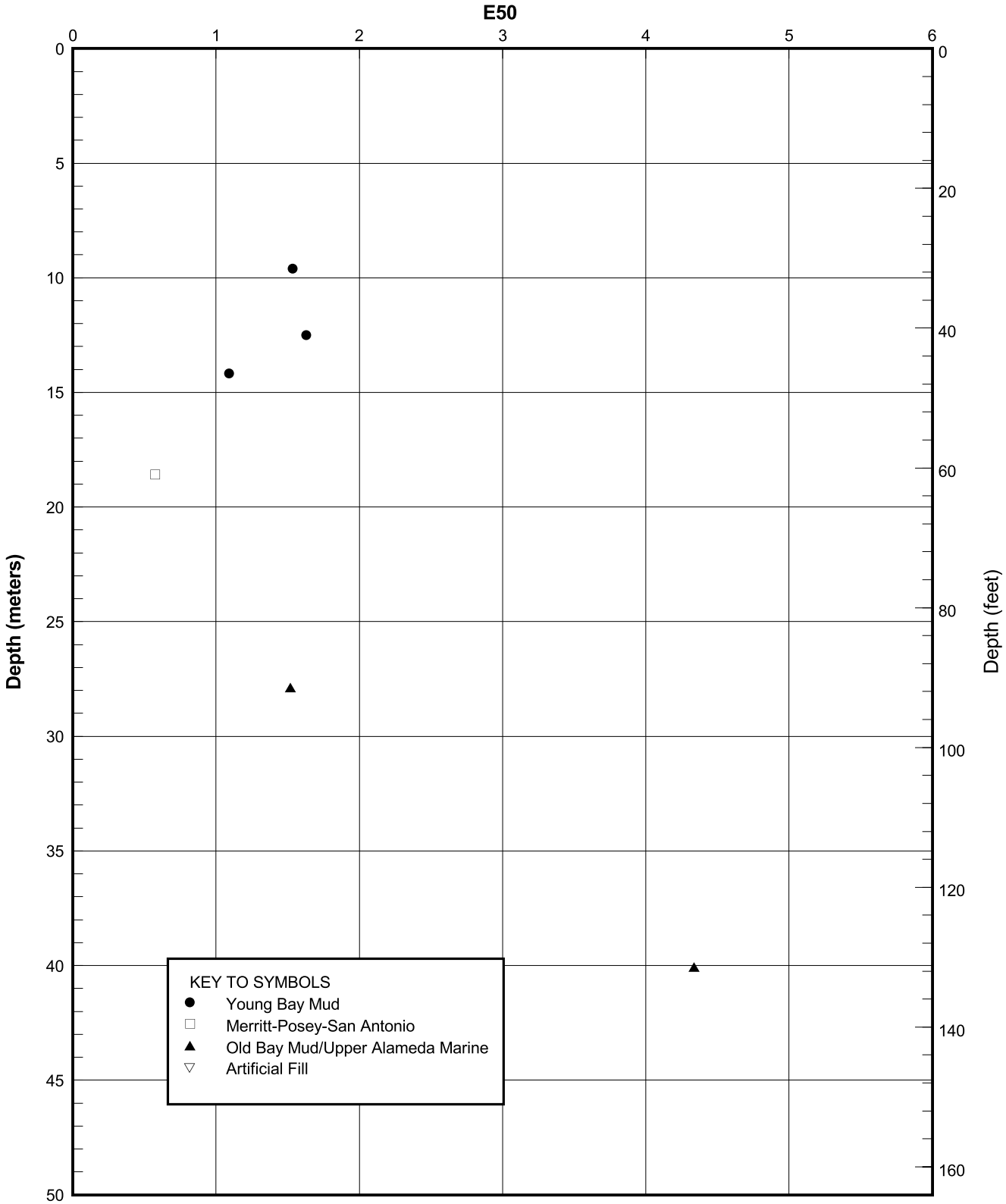
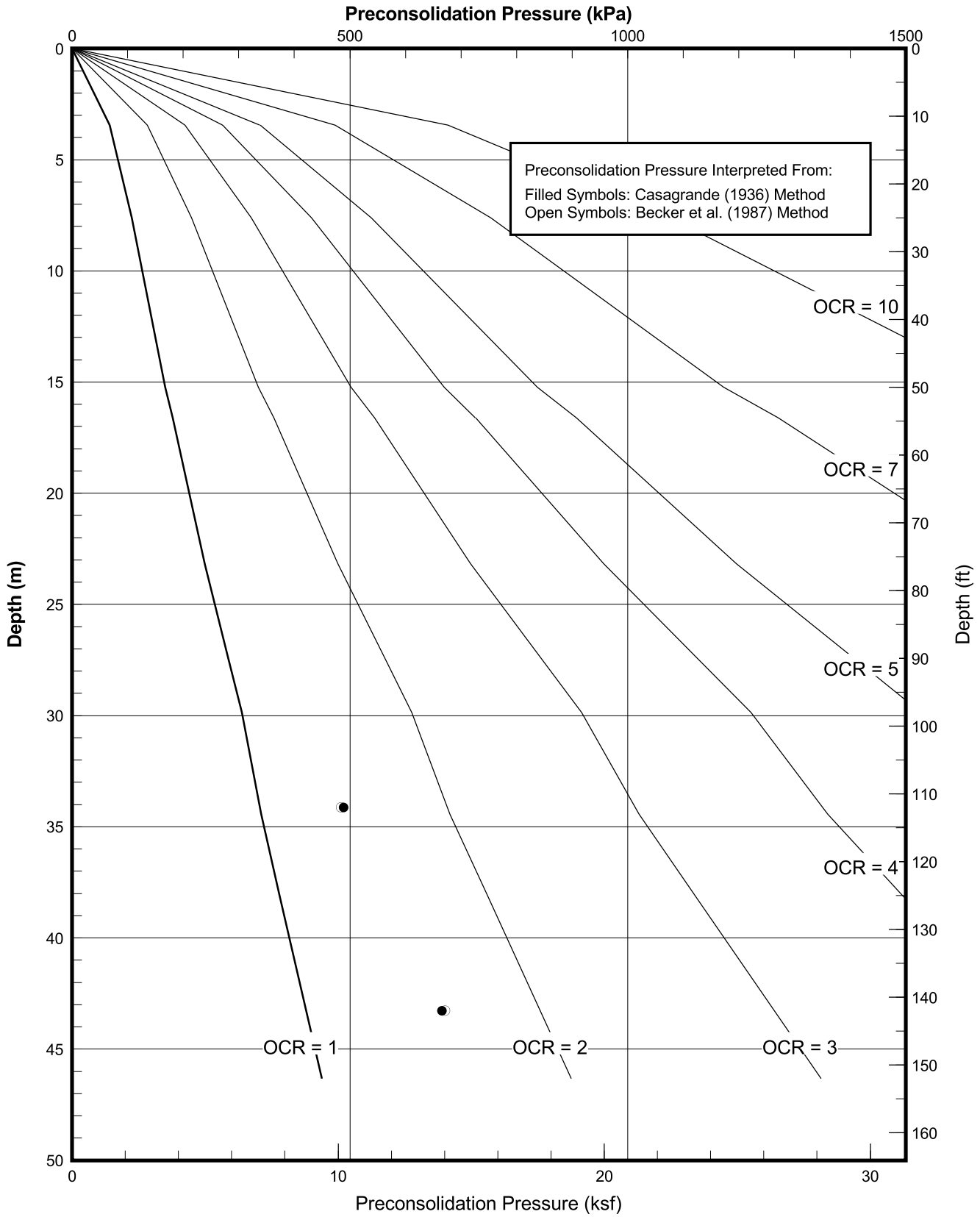


E50 PROFILE
Boring 98-60
SFOBB East Span Seismic Safety Project

PLATE 98-60.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA

Boring 98-60

SFOBB East Span Seismic Safety Project

PLATE 98-60.16

Earth Mechanics

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A JOINT VENTURE

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

VOLUME 2B - APPENDICES
(Land Borings 98-61 through 98-75 and
Marine Borings 98-39 and 98-44)

Prepared for

CALIFORNIA DEPARTMENT OF TRANSPORTATION

March 2001

Earth Mechanics

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A JOINT VENTURE

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March 5, 2001
Project No. 98-42-0058/EMI Project No. 98-145

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian
Contract Manager

Final Oakland Shore Approach Geotechnical Site Characterization
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. The majority of the Oakland Mole exploration was conducted as part of the Phase 2, Task 5 (final site characterization phase) studies of the referenced contract, although three cone penetration test (CPT) soundings were conducted as part of the earlier Phase 1, Task 3 work scope (preliminary site characterization) of the referenced contract.

The field exploration conducted on the Oakland Mole in the Spring and Fall of 1998 as part of the referenced contract included 25 soil borings (designated in the subsurface database created for the project as 98-51 through 98-75) and 9 CPT soundings (designated as 98-16 through 98-18 and 98-101 through 98-110 [several planned locations were abandoned due to electrical interference]). A total of 53 offshore tethered Seascout CPT soundings were conducted in December 1998 during seasonal high tides on the tidal flat to the north of the Oakland Mole. Fifteen all-terrain CPT soundings were conducted on the Tidal Flat to the north of the Mole in March 1999 during low tide conditions. Two trench and two pit excavations were conducted in April 1999. In Fall 2000, 11 marine Seacalf CPT soundings were performed in the vicinity of the Oakland Shore Approach to the west and northwest of the western tip of the Mole. The Seacalf CPTs were conducted as part of the Phase 3 field investigation program.

This Oakland Shore Approach Geotechnical Site Characterization report summarizes the field exploration for the Oakland Shore Approach and describes our interpretation of the geotechnical conditions based on the information collected from the exploration. Our present interpretations are based on the field data from the borings, the results of laboratory tests completed in the onshore laboratories, and the CPT soundings.

This report is provided in four volumes. Volume 1 provides the interpretational text and illustrations. Volume 2 contains 27 appendices that provide boring logs and test data from 25 land borings on the Oakland Mole and 2 marine borings offshore from the northwest tip of the Oakland Mole. Volume 3 contains the

results of the CPT soundings conducted on land, on the northern shore of the tidal flat, and offshore to the north and west of the Oakland Mole. Volume 4 contains four documents that include a preliminary study of approach fills at the Oakland Mole, studies on lateral spreading of fills at the Oakland Mole, findings from trench and pit excavations, and the advanced geotechnical laboratory studies conducted at the University of California at Berkeley.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO-EARTH MECHANICS, A Joint Venture

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Thomas W. McNeilan, C.E., G.E.
Vice President, Fugro West, Inc.

Attachment

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Mr. Saba Mohan, Caltrans
Mr. Robert Price, Caltrans
Dr. Brian Maroney, Caltrans
Ms. Sharon Naramore, Caltrans
Mr. Gerry Houlahan, TY Lin/M&N
Mr. Sajid Abbas, TY Lin/M&N
Mr. Al Ely, TY Lin/M&N

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CALTRANS CONTRACT 59A0053

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

VOLUME 2B - APPENDICES
(Land Borings 98-61 through 98-75 and Marine Borings 98-39 and 98-44)

MARCH 2001

Prepared For:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
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Prepared By:

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- Land Boring Logs 2
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PLATES

Plate

Key to Terms and Symbols Used on Logs ..... A1a through c
Exploration Location Map ..... 2.1a and b

APPENDICES

VOLUME 2A - Land Borings 98-51 Through 98-60

VOLUME 2B - Land Borings 98-61 Through 98-75, and Marine Borings 98-39 and 98-44

For boring-specific appendix plate numbers, please refer to the chart on the next page.

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Consolidated-undrained triaxial compression	8	8	8	8	8	8	8a-b	8	8	8	8	8	8	8a-b	8	8	8a-b	8	8	8	8	8	8	8	8	15a.1-a.2 15b.1-b.2	15
Consolidated-drained triaxial compression	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	16	16
R-value laboratory testing	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10		
Corrosion testing	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11		
Soil Property Profiles:																											
Plasticity index	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	17	17
Liquidity index	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	18	18
Soil sensitivity	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	19	19
ε_{50}	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	20	20
Preconsolidation stress	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	21	21
Direct shear test													17														
Relative density																										22	22

Testing performed

No testing performed

Earth Mechanics

FUGRO

VOLUME 2
INDIVIDUAL BORING DATA AND ANALYSES APPENDICES

The exploration program for the site characterization of the Oakland Shore Approach of the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project included 25 onshore borings (10 with in situ testing), approximately 24 land-based cone penetration test (CPT) soundings, 53 marine tethered Seascout CPT soundings, and 11 marine Seacalf CPT soundings. In addition, 2 marine borings, which were performed in the shallow water tidal flat to the north and northwest of the Mole, are relevant to the characterization of the Oakland Shore Approach of the bridge. A description of the marine exploration program is provided under separate cover in the Final Marine Geotechnical Site Characterization report[1].

GEOTECHNICAL SITE CHARACTERIZATION SYNOPSIS - VOLUME 1

A general description of the Task Order No. 5, Final Oakland Shore Approach Geotechnical Site Characterization work scope is provided in Section 1.0 of Volume 1. A description of the land exploration program (drilling and CPT testing), tethered Seascout CPT program (including equipment used and field procedures), and marine Seacalf CPT program is presented in Section 2.0. Section 3.0 includes a description of the laboratory testing equipment and procedures. The locations of the borings and CPT soundings are provided on Plate 2.1 (included in this volume for reference), and a summary of the details of the individual exploration locations and depths is provided in Table 2.1 of Volume 1.

INDIVIDUAL BORING APPENDICES - VOLUMES 2A & 2B

Individual boring appendices are provided for each of the 27 borings (25 land borings and 2 marine borings). Each boring appendix includes boring logs and various in situ, downhole, and laboratory data.

Boring Appendices Collation and Plate Number Guide

A table is provided at the end of the Volume 2 Table of Contents that shows the plate titles and numbers included in each boring-specific appendix. The individual appendix plates are numbered with the boring number and a sequential number (e.g., 98-51.4, 98-51.5a, etc.).

[1] Fugro-Earth Mechanics (2001), *Final Marine Geotechnical Site Characterization, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Volume 1*, FWI Job No. 98-42-0054, prepared for California Department of Transportation, March 5.

Key to Terms and Symbols Used on the Boring Logs

A description of the terms and symbols used on the logs is provided on Plates A1a through A1c that follow this introductory text.

Land Boring Logs

The boring logs for each boring provide: lithology descriptions, sampling depths, descriptions of the soil characteristics, and plotted in situ, remote vane, and laboratory test data.

Sampler types are shown on the Key to Terms and Symbols Used on Logs (Plates A1a through A1c). The following nomenclature applies to the information in the blow count column of the log: a) "PUSH" denotes thin-wall tube pushed samples; b) "WOH" denotes samplers advanced by the weight of the drill string; and c) numerical values indicate either standard penetration test (SPT) N-values or California modified sampler blow counts. Additional description of the blow count and sampler nomenclature is provided on Plates A1a through A1c.

The center column of the log provides water content, plastic limit, liquid limit, percent passing the number 200 sieve, and density measurements (presented as total unit weights). In addition to the direct measurements of density, below El. 0 (mean sea level [MSL]) the logs show the theoretical unit weight based on the measured water content, an assumed specific gravity of 2.7, and an assumed 100-percent saturation.

The right-hand column presents the results of the undrained shear strength measurements conducted on samples recovered from the borings as well as in situ, remote vane measurements. Undrained shear strengths measured on remolded samples are also included in the plotted data.

Marine Boring Logs

The boring logs for each marine boring provide lithology descriptions, show sampling depths, contain descriptions of the soil and provide plotted remote vane, laboratory, and downhole geophysical test data. The appendices include three single-page boring logs (the data for the entire depth of the borings are shown on one page) that show geotechnical test data, downhole geophysical data, and CPT data, respectively. In addition to the single-page logs, multiple-page logs that show geotechnical test data and CPT data are provided at an expanded depth scale. Also included in the marine boring appendices is a geotechnical test data log of the near-surface sediments with an expanded undrained shear strength scale.

Geotechnical Test Data Logs. Sampler types are shown on the Key to Terms and Symbols Used on Logs (Plates A1b and A1c). The following nomenclature applies to the information in the blow count column of the log: a) "PUSH" denotes thin-wall tube samples pushed with the weight of the drill pipe; b) "WOH" denotes liner samplers advanced by the

weight of the down-hole hammer; c) values such as 18 designate either SPT N-values or California modified sampler; d) 50/7.5 centimeters (cm) is an SPT N-value; and e) 30/60 cm is a downhole, wireline hammer blow count. Additional description of the blow count and sampler nomenclature is provided on Plates A1b and A1c.

The center column of the log provides water content, plastic limit, liquid limit, percent passing the number 200 sieve, and density measurements (presented as submerged unit weights). In addition to the direct measurements of density, the logs also show the theoretical submerged unit weight based on the measured water content, an assumed specific gravity of 2.7, and an assumed 100-percent saturation.

The right-hand column presents the results of the undrained shear strength measurements conducted on samples recovered from the borings as well as the strengths measured in situ using the Halibut and Dolphin remote vane tools. The range of undrained shear strengths that are calculated from CPT cone tip resistances (corrected for unequal end area effects) also are shown based on cone bearing capacity (N_k values) of 12 and 15. Undrained shear strengths measured on remolded samples also are included in the plotted data.

CPT Logs. The in situ CPTs were conducted downhole using the Dolphin system. This downhole in situ tool has a maximum stroke (or test length) of 3 meters. Data are acquired in 3-meter-long increments or until the CPT meets refusal. The CPT intervals were interspersed with soil sampling. The CPT intervals are shown on the right of the logs for those borings.

The CPT logs for each boring with CPT data provide graphical plots of the data versus depth below mudline (or bay bottom). Data that are shown include: a) tip resistance in megapascals (MPa), b) sleeve friction in MPa, c) excess pore pressure readings in MPa, and d) friction ratio in percent.

Downhole Geophysical Logs. The geophysical tests for Borings 98-39 and 98-44 included compression and shear wave velocity (Vp and Vs, respectively) measurements. The data from those downhole measurements are provided on a separate downhole geophysical log that presents the measured downhole geophysical data.

Laboratory Test Results

The offshore and onshore laboratory test results are incorporated in the individual boring appendices. In addition to the test data plotted on the geotechnical test data logs, the appendices include the following information (where relevant):

- Remote vane test data
- Tabulated summary of test results

- Grain size distribution curves
- Plasticity chart showing the Atterberg limit data
- Plotted stress-strain curves from unconsolidated-undrained (UU) triaxial compression tests
- Plotted consolidation test results including axial strain and coefficient of consolidation versus effective vertical stress
- Plotted consolidated-undrained triaxial compression test results including consolidation curves, stress path, stress-strain curves, pore water pressure-strain curves, and obliquity-strain curves
- Plotted consolidated-drained triaxial compression test results including stress-strain curves and Mohr circles
- R-value test data (land borings)
- Corrosion testing results (land borings)

In addition to the static test results presented herein, the results of cyclic tests conducted on samples of Young Bay Mud recovered from the land borings are provided under separate cover in Volume 4.

Soil Property Profiles

Where data are available, the following soil properties are plotted versus depth:

- Plasticity Index (Liquid Limit minus Plastic Limit)
- Liquidity Index ([water content minus Plastic Limit] divided by Plasticity Index)
- Soil Sensitivity (undisturbed shear strength divided by remolded shear strength)
- ε_{50} (strain at 50 percent of the failure stress in UU triaxial tests)
- Preconsolidation Pressure - The interpreted preconsolidation pressure profiles show interpreted preconsolidation pressures from consolidation tests and estimated preconsolidation pressures from the in situ CPT data. Also shown on those plots are the calculated effective overburden pressure and isochrones of calculated overconsolidation ratios (OCR).
- Relative Density from CPT test data (marine borings)

CONE PENETRATION DATA SYNOPSIS – VOLUME 3

CPT soundings were performed on land using full-sized cones deployed from truck-mounted and all-terrain-vehicle- (ATV-) mounted cone penetration test (CPT) rigs. Tethered Seascout CPT soundings were performed over water using a miniature cone deployed from a workboat to the north of the Mole. Marine Seacalf soundings were performed using Fugro's wheel drive CPT system deployed from a barge.

Logs of the CPT soundings including graphical plots of tip resistance, sleeve friction, pore pressure, and seismic velocity measurements (where relevant) are presented in Volume 3 of this report. In addition to the CPT data, correlations with undrained shear strength, preconsolidation stress, and relative density are included for the track-mounted and ATV-mounted CPT soundings. Laboratory test results have been included for two ATV-mounted CPT locations (99C-17 and 99C-14) where sampling was performed. The Seacalf CPT sounding logs include estimates of undrained shear strength interpreted from CPT tip resistance for fine-grained layers.

Earth Mechanics

FUGRO

SOIL TYPES

- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- GRAVEL with sand (GP or GW)
- GRAVEL with clay (GP or GW)
- Clayey GRAVEL (GC)
- GRAVEL with silt (GP or GW)
- Silty GRAVEL (GM)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- SAND with gravel (SP or SW)
- SAND with clay (SP-SC)
- Clayey SAND (SC)
- Silty SAND (SM)
- SAND with silt (SP-SM)
- Fat CLAY(CH)
- Sandy fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Silty CLAY (CL-ML)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)
- Low plasticity ORGANICS (OL)
- SANDSTONE (Rx)
- SILTSTONE (Rx)
- CLAYSTONE (Rx)
- Interbedded Rock Strata (Rx)
- CONGLOMERATE (Rx)
- PAVEMENT

SAMPLERS

- Thin Walled 7.5 cm Tube
- Offshore Liner
- SPT
- Bulk Bag
- 5.7 cm Driven Tube
- Modified California Liner
- Rock Core (Interior symbol represents percent recovery)

CLASSIFICATION TESTS AND BLOW COUNTS

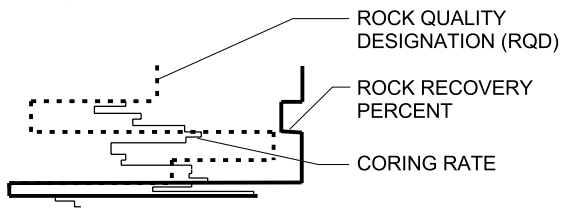
- ■ PERCENT PASSING 0.075 mm SIEVE
- ● WATER CONTENT (%)
- □ TOTAL UNIT WEIGHT (kN/m^3)
- ○ THEORETICAL TOTAL UNIT WEIGHT (kN/m^3)

PLASTIC LIMIT LIQUID LIMIT

+----------+

- ⬟ EQUIVALENT SPT BLOW COUNT

ROCK QUALITY AND CORING RATE



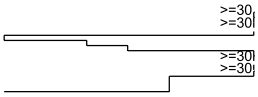
STRENGTH TESTS

- ⊗ POCKET PENETROMETER
- ⊕ TORVANE
- ◇ REMOTE VANE
- ◆ MINIATURE VANE (◈ RESIDUAL VANE)
- ▲ UNCONSOLIDATED UNDRAINED TRIAXIAL
- ▽ SWEDISH FALL CONE
- ▣ UNCONFINED COMPRESSION (SOIL)
- ◎ POINT LOAD TEST (INTACT SPECIMEN)
- ◍ POINT LOAD TEST (ALONG WEAK PLANE)
- ■ UNCONFINED COMPRESSION (ROCK)

△◇ (Open symbols indicate remolded tests)
+ Strength Exceeds Capacity of Measuring Device

PCPT (Nk = 12 to 15)

FRACTURE DENSITY



KEY TO TERMS AND SYMBOLS USED ON LAND BORING LOGS

SFOBB East Span Seismic Safety Project

PLATE A1a

Earth Mechanics

FUGRO

SOIL TYPES

- Well graded GRAVEL (GW)
- Poorly graded GRAVEL (GP)
- GRAVEL with sand (GP or GW)
- GRAVEL with clay (GP or GW)
- Clayey GRAVEL (GC)
- GRAVEL with silt (GP or GW)
- Silty GRAVEL (GM)
- Well graded SAND (SW)
- Poorly graded SAND (SP)
- SAND with gravel (SP or SW)
- SAND with clay (SP-SC)
- Clayey SAND (SC)
- Silty SAND (SM)
- SAND with silt (SP-SM)
- Fat CLAY(CH)
- Sandy fat CLAY (CH)
- Lean CLAY (CL)
- Sandy lean CLAY (CL)
- Silty CLAY (CL-ML)
- Elastic SILT (MH)
- SILT (ML)
- Sandy SILT (ML)
- Highly plastic ORGANICS (OH)
- Low plasticity ORGANICS (OL)
- SANDSTONE (Rx)
- SILTSTONE (Rx)
- CLAYSTONE (Rx)
- Interbedded Rock Strata (Rx)
- CONGLOMERATE (Rx)
- PAVEMENT

SAMPLERS

- Thin Walled 7.5 cm Tube
- Offshore Liner
- SPT
- Bulk Bag
- 5.7 cm Driven Tube
- Modified California Liner
- Rock Core (Interior symbol represents percent recovery)

CLASSIFICATION TESTS AND BLOW COUNTS

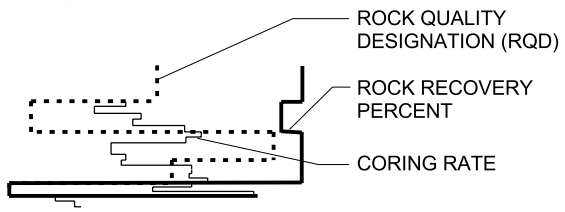
- ■ PERCENT PASSING 0.075 mm SIEVE
- ● WATER CONTENT (%)
- □ SUBMERGED UNIT WEIGHT (kN/m^3)
- ○ THEORETICAL SUBMERGED UNIT WEIGHT (kNm^3)

PLASTIC LIMIT LIQUID LIMIT

+----------+

⬠ EQUIVALENT SPT BLOW COUNT

ROCK QUALITY AND CORING RATE



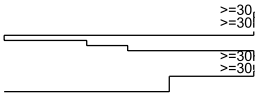
STRENGTH TESTS

- ⊗ POCKET PENETROMETER
- ⊕ TORVANE
- ◇ REMOTE VANE
- ◆ MINIATURE VANE (◈ RESIDUAL VANE)
- ▲ UNCONSOLIDATED UNDRAINED TRIAXIAL
- ▽ SWEDISH FALL CONE
- ▣ UNCONFINED COMPRESSION (SOIL)
- ◎ POINT LOAD TEST (INTACT SPECIMEN)
- ◍ POINT LOAD TEST (ALONG WEAK PLANE)
- ■ UNCONFINED COMPRESSION (ROCK)

△◇ (Open symbols indicate remolded tests)
+ Strength Exceeds Capacity of Measuring Device

PCPT (Nk = 12 to 15)

FRACTURE DENSITY



KEY TO TERMS AND SYMBOLS USED ON MARINE BORING LOGS

SFOBB East Span Seismic Safety Project

PLATE A1b

TUBE AND LINER SAMPLERS

WOH	Liner sample advanced with the weight of an 80 kg hammer.
PUSH or SAVE	Pushed thin-walled 7.5cm-tube.
15/60cm	Number of blows required to produce the indicated penetration using a 5.7 cm tube sampler. The sampler was driven with an 80 kg downhole hammer dropped approximately 1.5 m.

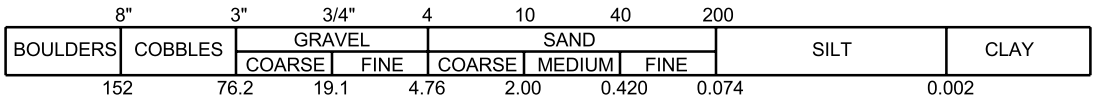
SPT AND MODIFIED CALIFORNIA LINER SAMPLERS

Samplers were driven with a 63.5 kg hammer dropped approximately 760 mm.

20	Number of blows to produce 30 cm of penetration after the initial 15 cm of seating.
86/28cm	Number of blows required to produce the indicated penetration after an initial 15 cm seating.
Ref/8cm	50 blows produced the indicated penetration during the initial 15 cm interval.

SOIL GRAIN SIZE

U.S. STANDARD SIEVE



SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, kPa
Very Soft	less than 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very Stiff	100 to 200
Hard	greater than 200

DENSITY OF GRANULAR SOILS

Descriptive Term	Relative Density (%)*
Very Loose	less than 15
Loose	15 to 35
Medium Dense	35 to 65
Dense	65 to 85
Very Dense	greater than 85

*Estimated from sampler driving record and PCPT tip resistance.

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the ease of breaking along these planes.
Fissured	Containing shrinkage or relief crack, often filled with fine sand or silt, usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 3 mm thick extending through the sample.
Seam	Inclusion 3 mm to 75 mm thick extending through the sample.
Layer	Inclusion greater than 75 mm thick extending through the sample.
Laminated	Soil sample composed of alternating partings or seams of different soil types.
Interlayered	Soil sample composed of alternating layers of different soil types.
Intermixed	Soil sample composed of pockets of different soil types and layered or laminated structure is not evident.
Calcareous	Having appreciable quantities of carbonate.

KEY TO TERMS AND SYMBOLS USED ON LOGS

SFOBB East Span Seismic Safety Project

Field6.apr,Fld.MetricKey2, CBD, 10/33/YY
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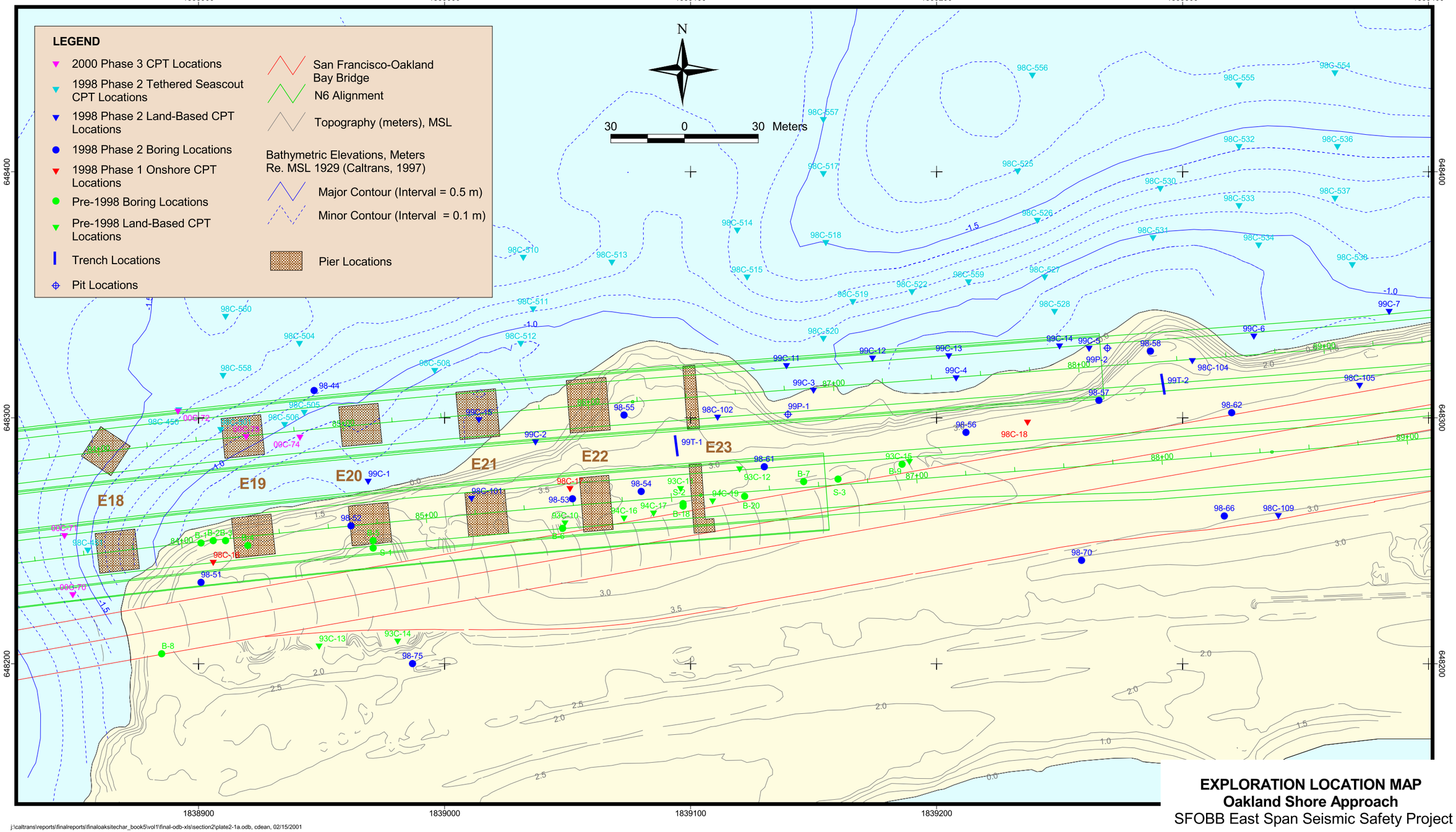
Earth Mechanics

FUGRO



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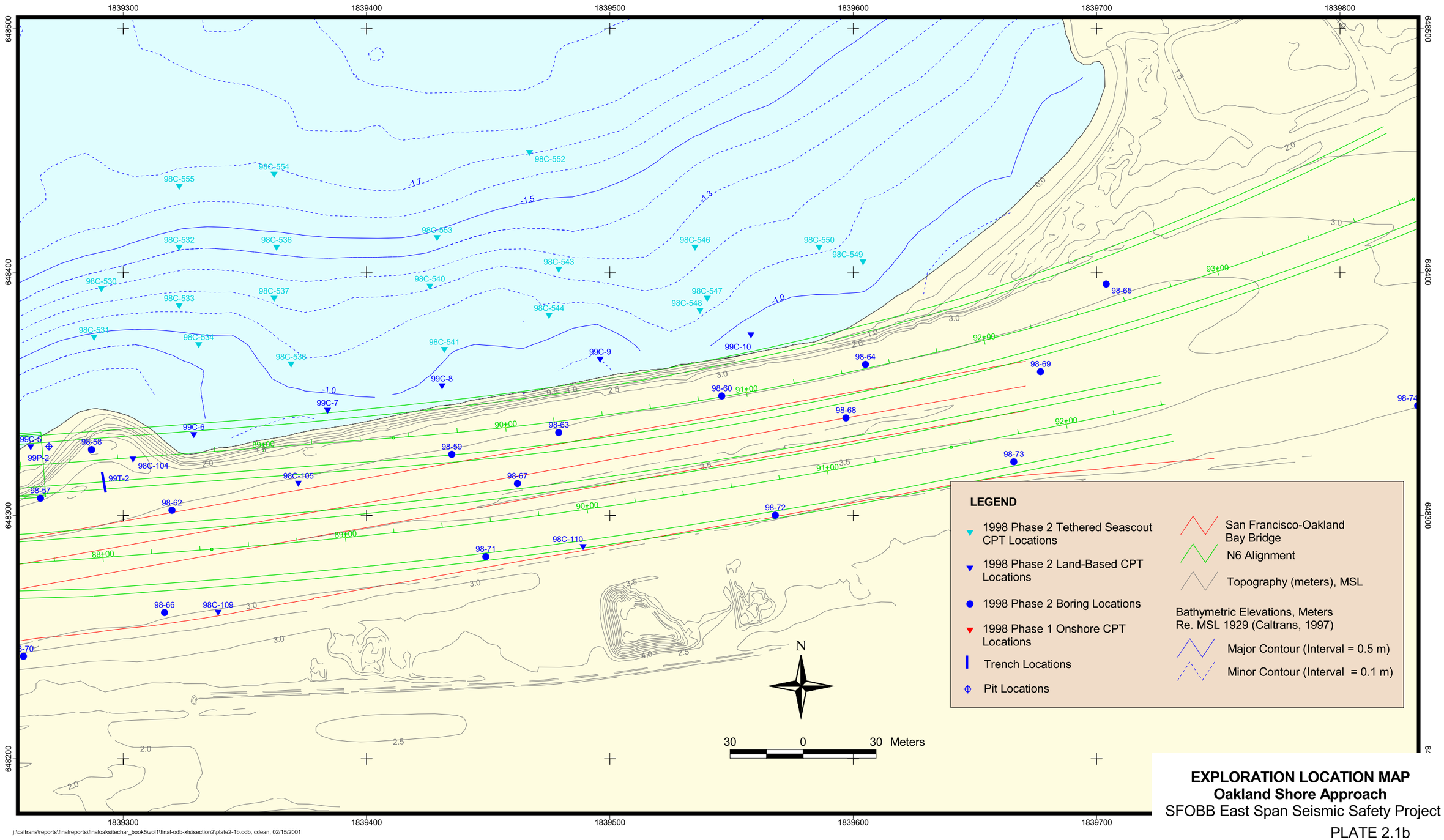
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1a

Earth Mechanics

FUGRO



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EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1b

LAND BORING 98-61

PROJECT NO:	98-42-0058	**START DATE:**	9/29/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-61 (10m left of E. Sta. 86+39)	**COMPLETION DATE:**	9/30/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839130 N648280
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 2.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
2	1			BAG	Fine SAND with silt (SP-SM), dense, brown -clayey gravel with silt and sand, to 0.6m -sandy silt, 0.6m to 1.5m	I
1	2			29	-with a few organic pockets, gravel pockets, and orange oxidation staining, at 1.5m	I
0	3			80	-very dense, brown, fine to coarse gravel with silt and sand, below 3.0m (2.9m)	I
					(4.6m)	
-1	4			12	Fine SAND (SP), loose to medium dense, greenish gray to gray -with a few shell fragments	II
-2	5					II
-3	6			20		II
-4	7					II
-5	8			13	-silty fine sand at 7.6m	II
-6	9				(9.1m)	
-7	10			WOH	Fat CLAY (CH), firm to stiff, olive gray to gray -sandy clay to 9.4m -with shell fragments and silt pockets, at 9.4m -lean clay to 12.2m	III
-8	11			PUSH	-with silt pockets, shell fragments and a trace of gravel, at 11.0m	III
-9	12					III
-10	13			PUSH	-with a few shell fragments and silt pockets, at 12.5m	III
-11	14			SAVE	-sandy clay with gravel, at 14.0m	III
-12	15					III
-13	16			PUSH	-with shell fragments at 15.5m	III
-14	17			PUSH	-with gas blisters, sand pockets, and silt pockets, at 17.1m	III
-15	18					III
-16	19			PUSH	-with shell fragments at 18.3m -greenish gray to gray silty fine to medium sand with shell fragments, below 18.4m	III
					(19.4m)	
-17	20			SAVE	Fat CLAY (CH), stiff to very stiff, greenish gray to gray -clay with sand at 20.1m	IV
-18	21					IV
-19	22			PUSH	-with silt partings, organic pockets, and silty sand pockets and seams, at 21.6m	IV
-20	23			PUSH	-with gas blisters, fissures, organic pockets, and calcareous nodules, at 23.2m -with a sand layer at 23.5m	IV
-21	24				TOTAL DEPTH: 23.5m BACKFILLED WITH: Cement Grout	
-22						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-61.1

LOG OF BORING AND TEST RESULTS

BORING 98-61

SFOBB East Span Seismic Safety Project

Report Date: 03/10/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-61		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS	R-VALUE	SAND EQUIVALENT
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)			
0.6	390		30	17			19																					
1.5	1																			762	9.17	720	630	23.4			18	12
2.0	2	6					6																			H		
3.1	3						7																					
4.7	4	24					4																			H		
6.3	5	21					4																					
7.8	6	24					12																			H		
9.3	7	42	41	22	1.06	18.3	59				28.9		14.7													H		
9.6	9	45																										
11.1	11	41	44	23	0.85	17.9	91								29.9		1.5									H		
11.3	12							52.7																				
12.5	13							46.9																				
12.6	14	39	50	23	0.60	17.3		41.2							44.4		1.0											
12.8	15							46.9																				
14.2	16	34	37	19	0.82		63																			H,C		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

c:\snfco-oak\current\odb\98-61suma.odb

98-61		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS	R-VALUE	SAND EQUIVALENT
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)			
15.8	302	65	79	30	0.70	16.2		43.1				8.4			47.8		1.2											
16.0	303										56.8																	
17.1	304	51	65	26	0.65																					C		
17.4	306	51	61	25	0.72	17.3		52.7			50.6	9.8			53.1		1.0											
17.5	307										56.1																	
18.4	22	50	64	24	0.65			49.8																				
18.6	23	23					17																					
20.1	24	40	81	31	0.17		85																			H,C		
20.2	25	46																										
21.6	26						67	91.0																				
21.8	27	29									89.1																	
21.9	28	30	63	21	0.21	18.6									63.8		0.7											
23.2	29							119.7	107.7																			
23.3	30	21	57	19	0.06	20.2										89.1												
23.5	31							138.9	148.4		128.7																	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

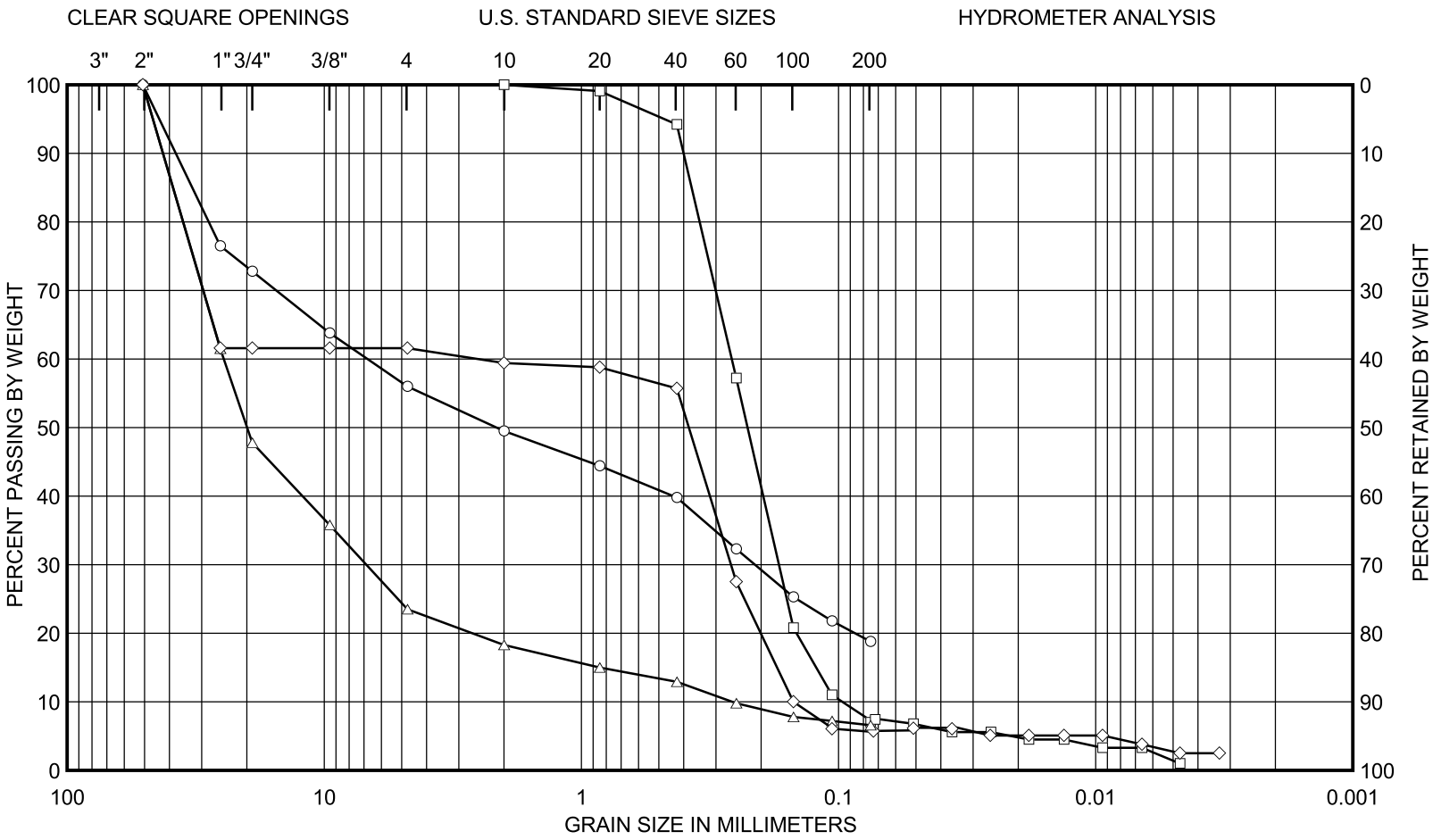
\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.3b

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.5	○—○	COARSE TO FINE GRAVEL (GW-GM) with silt and fine to coarse sand			2.1
2	2.0	□—□	FINE SAND (SP-SM) with silt and a trace of medium sand	1.2	2.7	0.23
3	3.1	△—△	COARSE TO FINE GRAVEL (GP-GM) with silt and sand	7.4	95.1	20.0
4	4.7	◇—◇	FINE SAND (SP) with coarse gravel	0.2	16.9	0.38

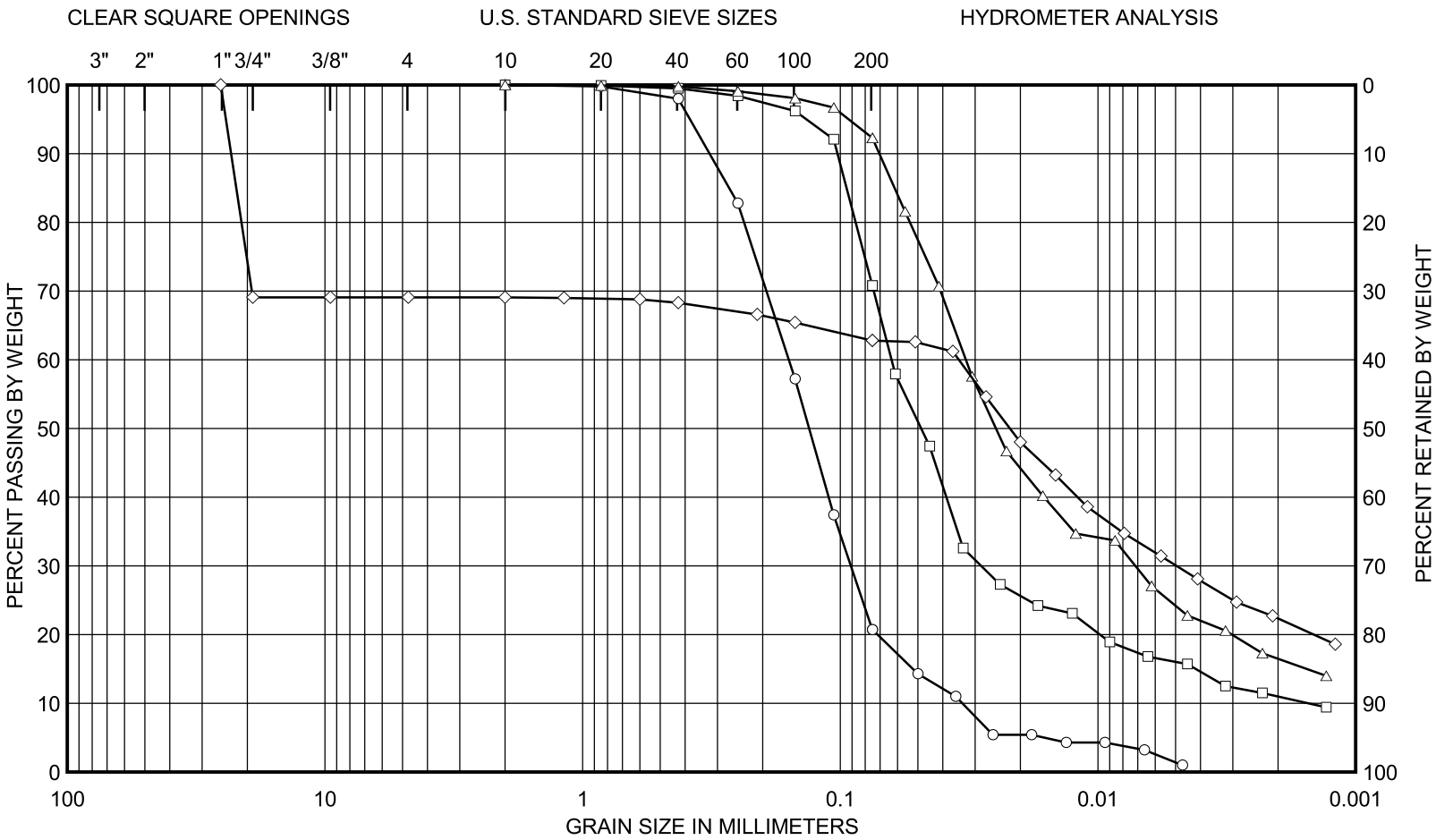
GRAIN SIZE DISTRIBUTION CURVES
Boring 98-61
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-61.4a



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
6	7.8	○—○	SILTY FINE SAND (SM)			0.13
7	9.3	□—□	LEAN CLAY (CL) with sand			0.049
11	11.1	△—△	FAT CLAY (CH)			0.025
16	14.2	◇—◇	LEAN CLAY (CL) with coarse gravel			0.022

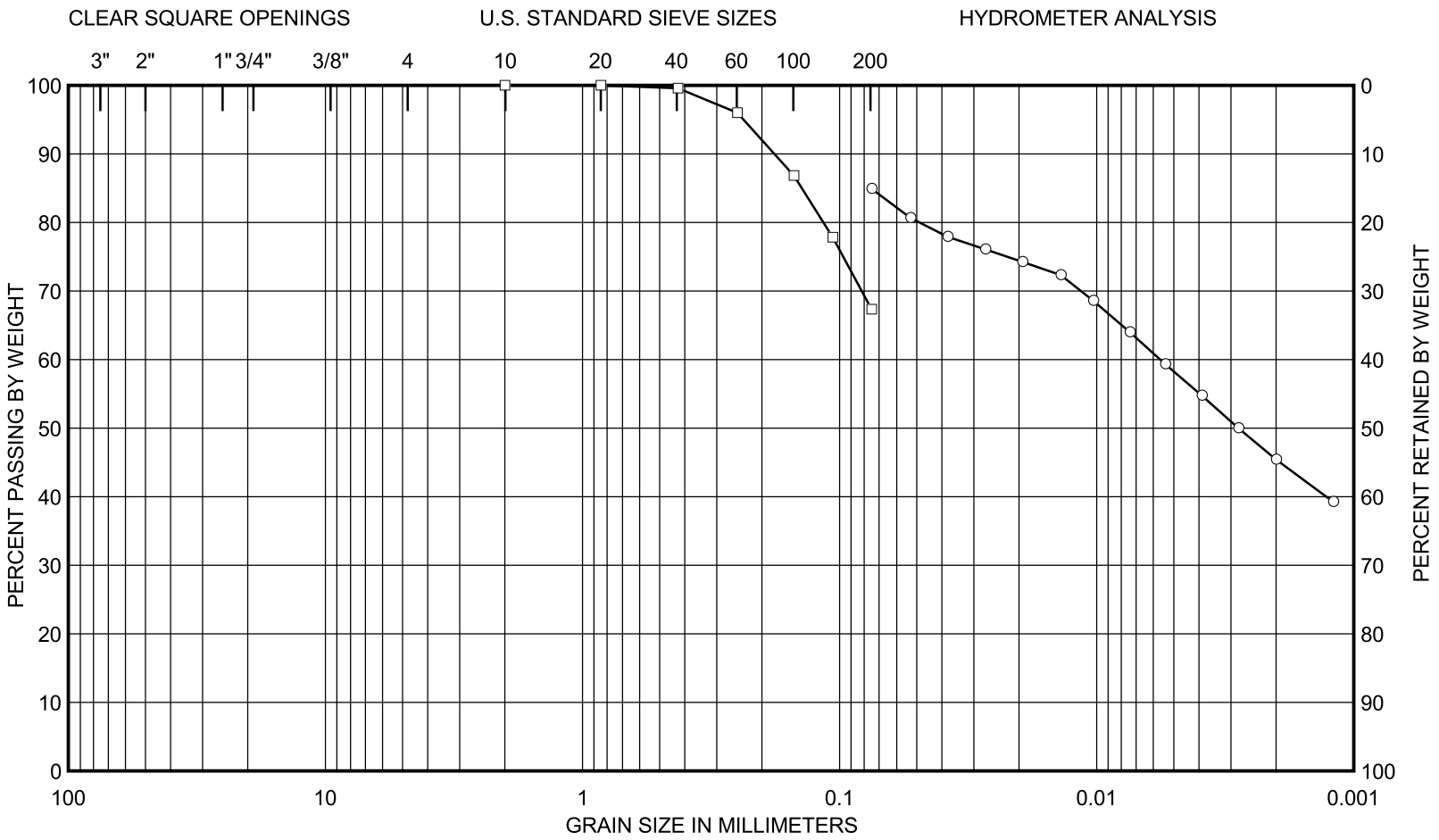
GRAIN SIZE DISTRIBUTION CURVES
Boring 98-61
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-61.4b



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
24	20.1	○——○	FAT CLAY (CH) with sand			0.0028
26	21.6	□——□	FAT CLAY (CH) with silty sand seams and pockets			

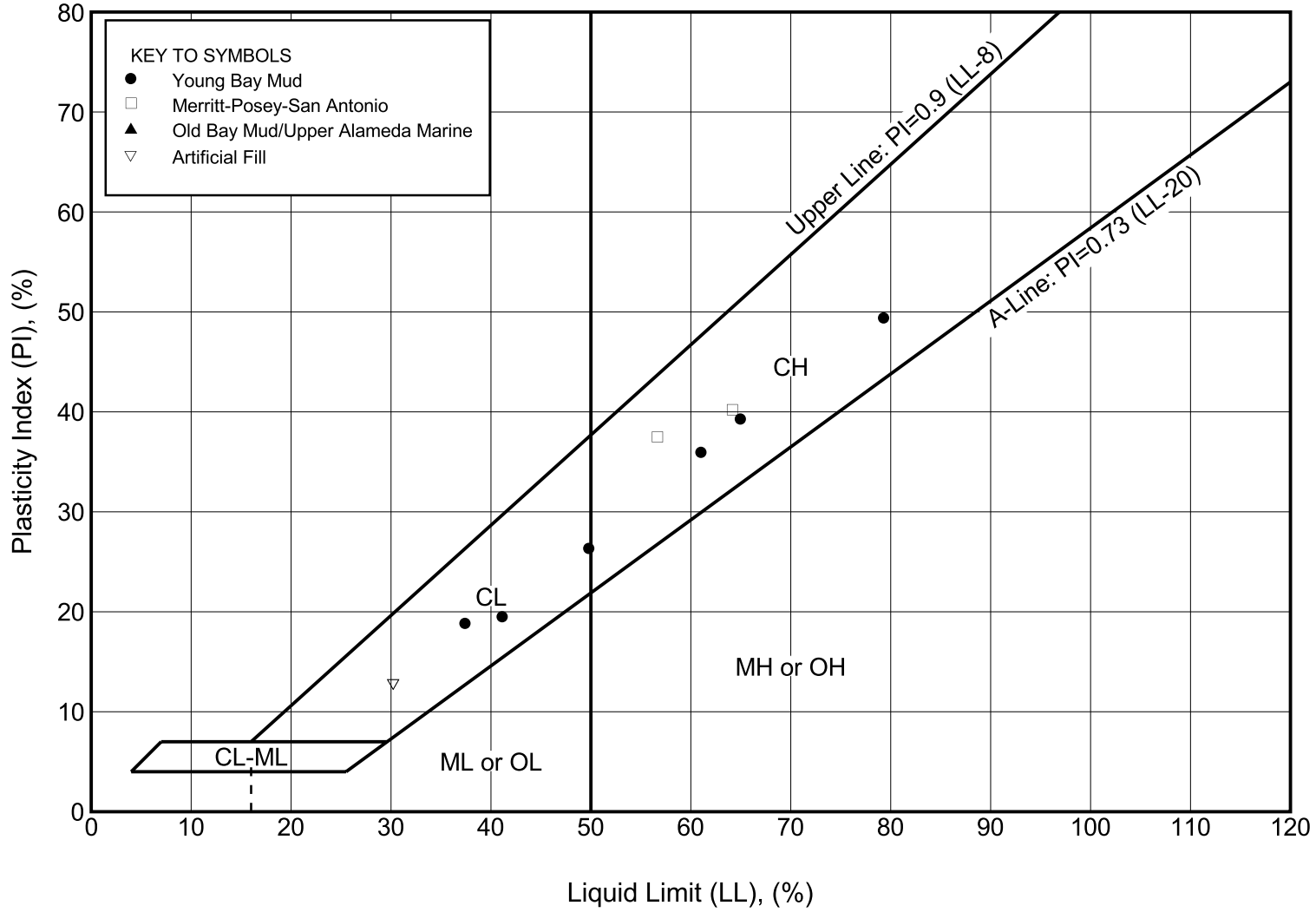
GRAIN SIZE DISTRIBUTION CURVES
Boring 98-61
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

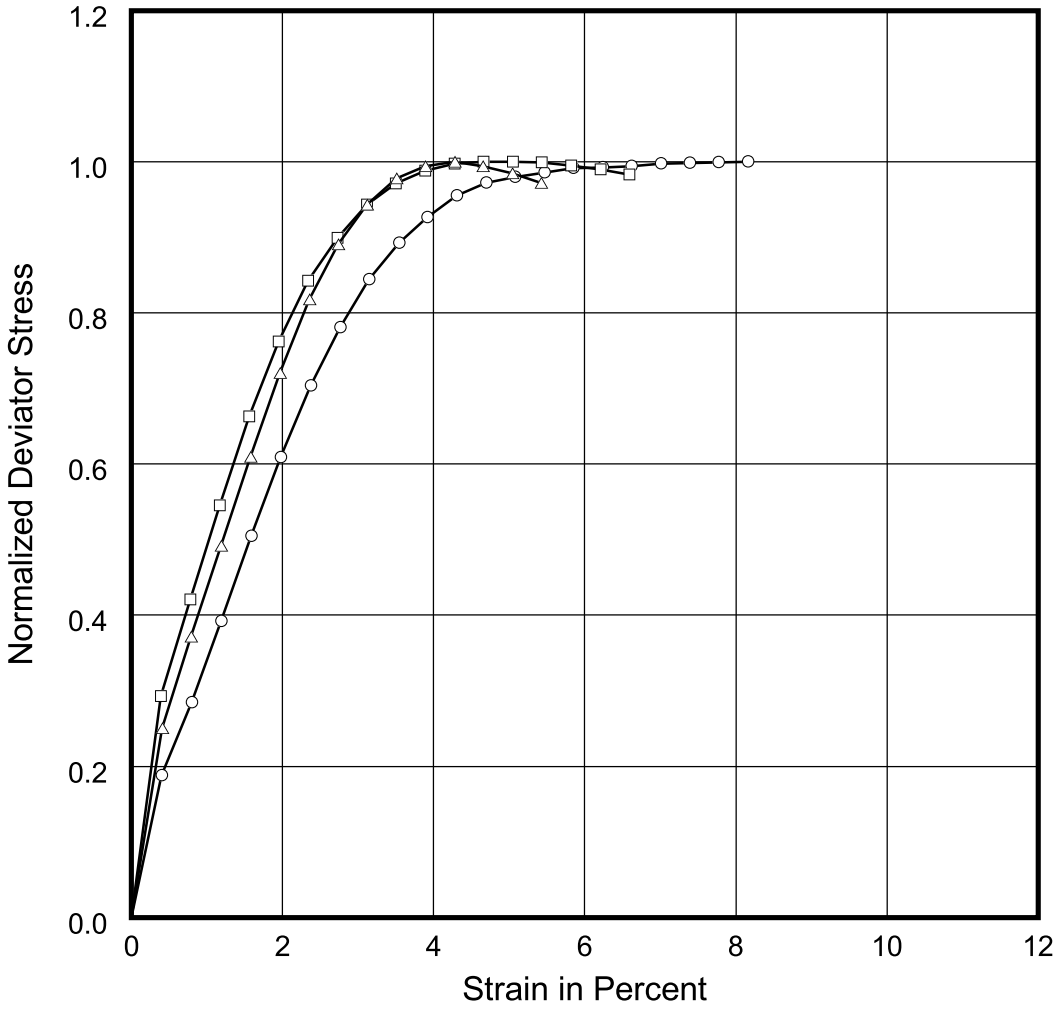
FUGRO

PLATE 98-61.4c



PLASTICITY CHART
Boring 98-61
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO



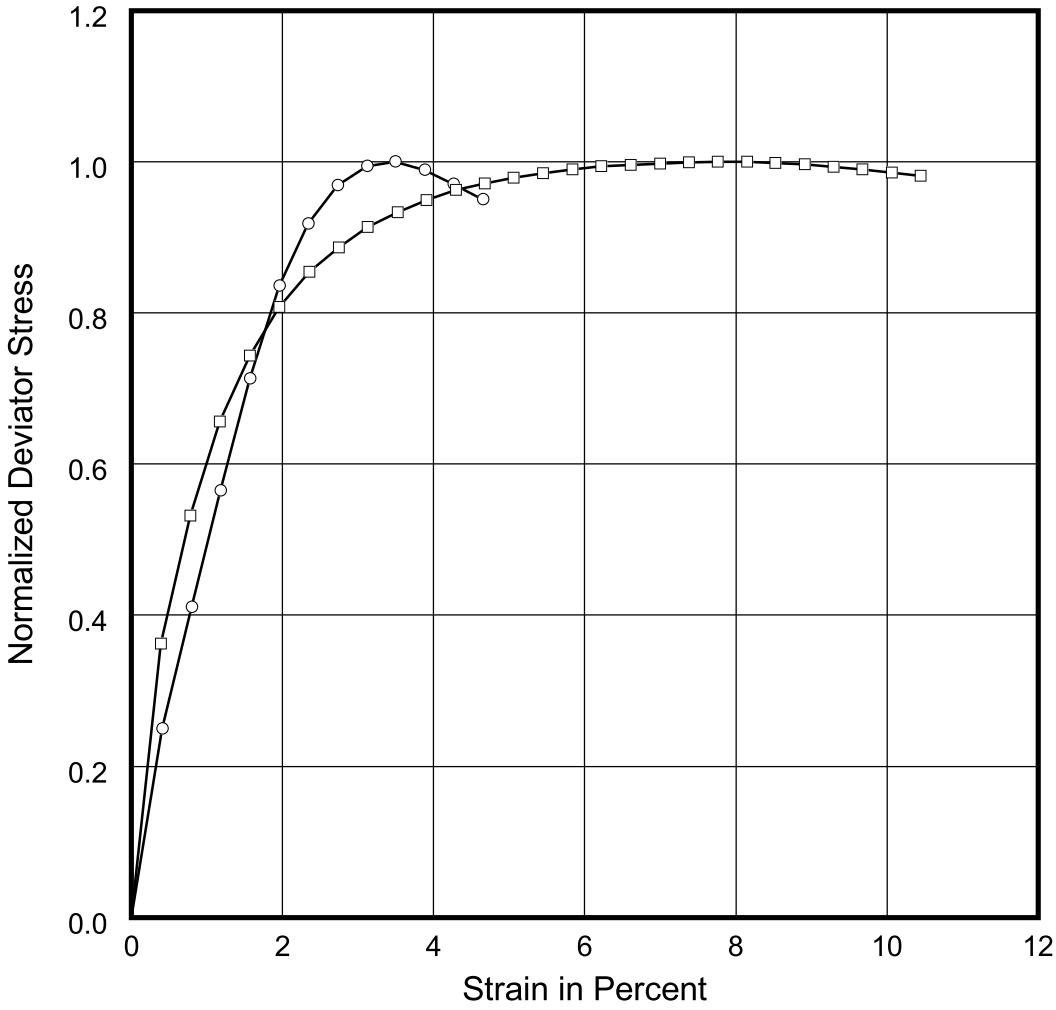
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	11	11.1	UU	276	60	1.5
□—□	14	12.6	UU	276	89	1.0
△—△	302	15.8	UU	345	96	1.2

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.6a



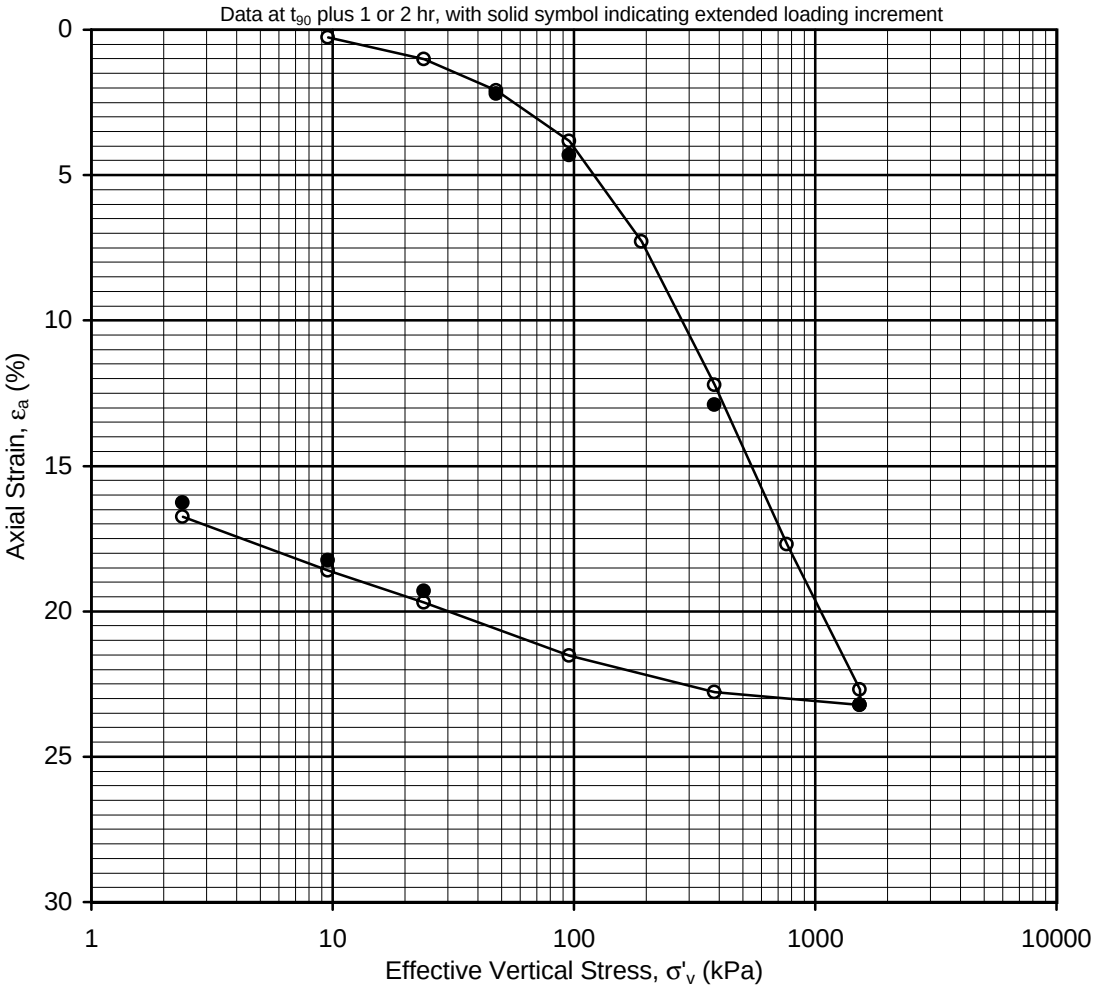
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○——○	306	17.4	UU	379	106	1.0
□——□	28	21.9	UU	827	128	0.7

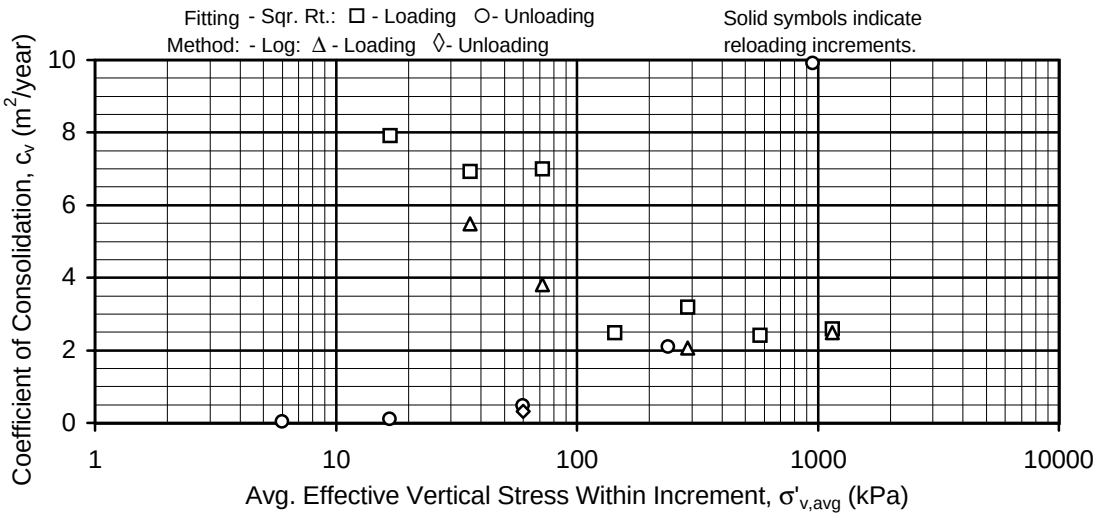
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-61
SFOBB East Span Seismic Safety Project

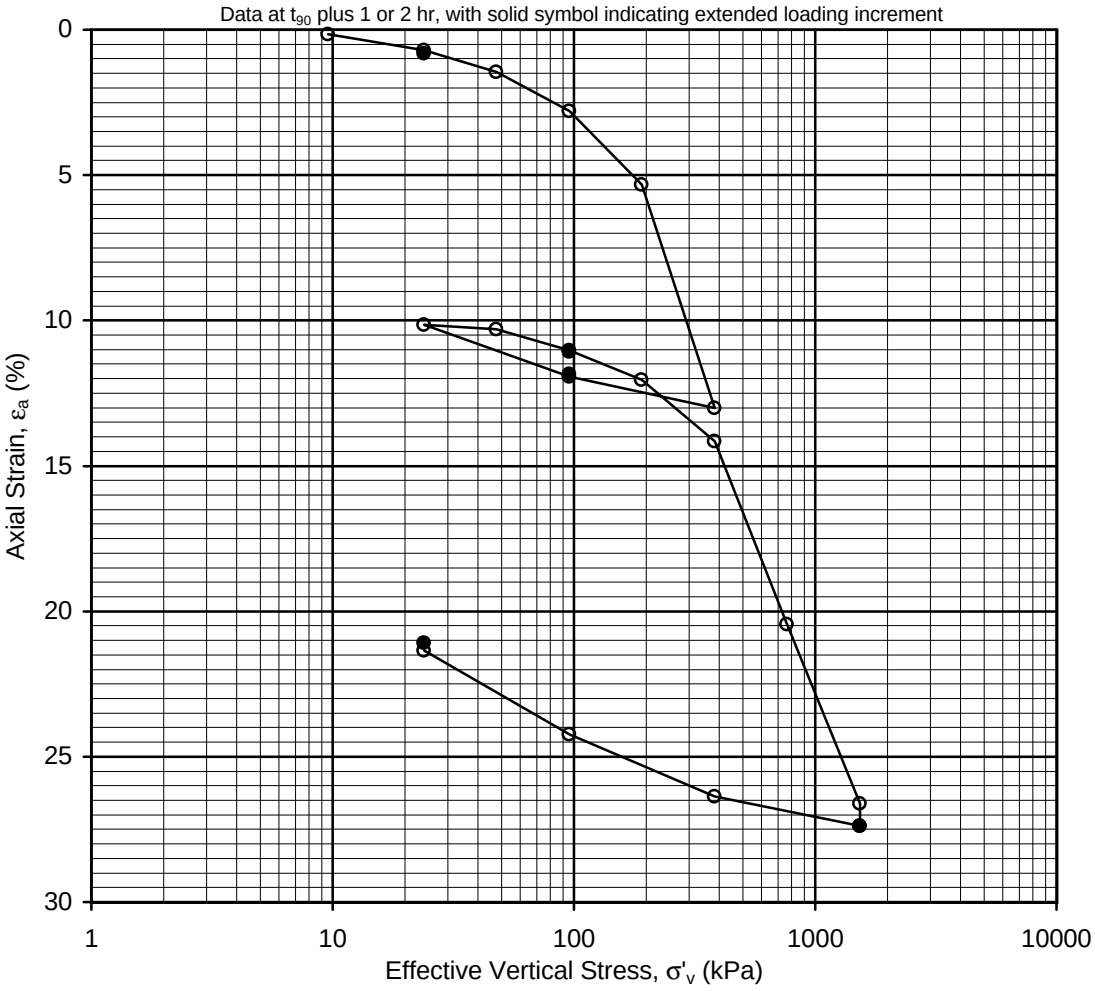
PLATE 98-61.6b

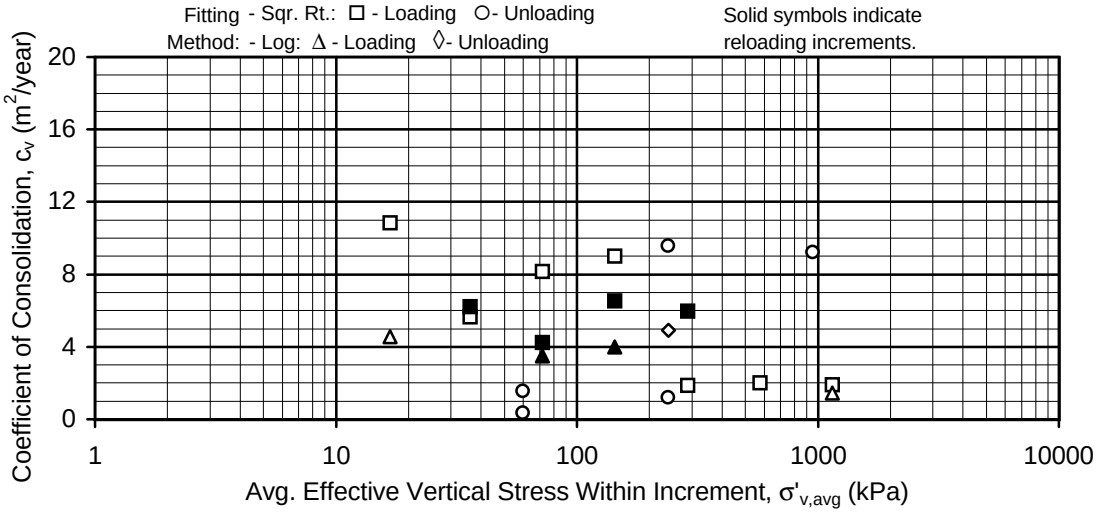




INCREMENTAL CONSOLIDATION TEST RESULTS

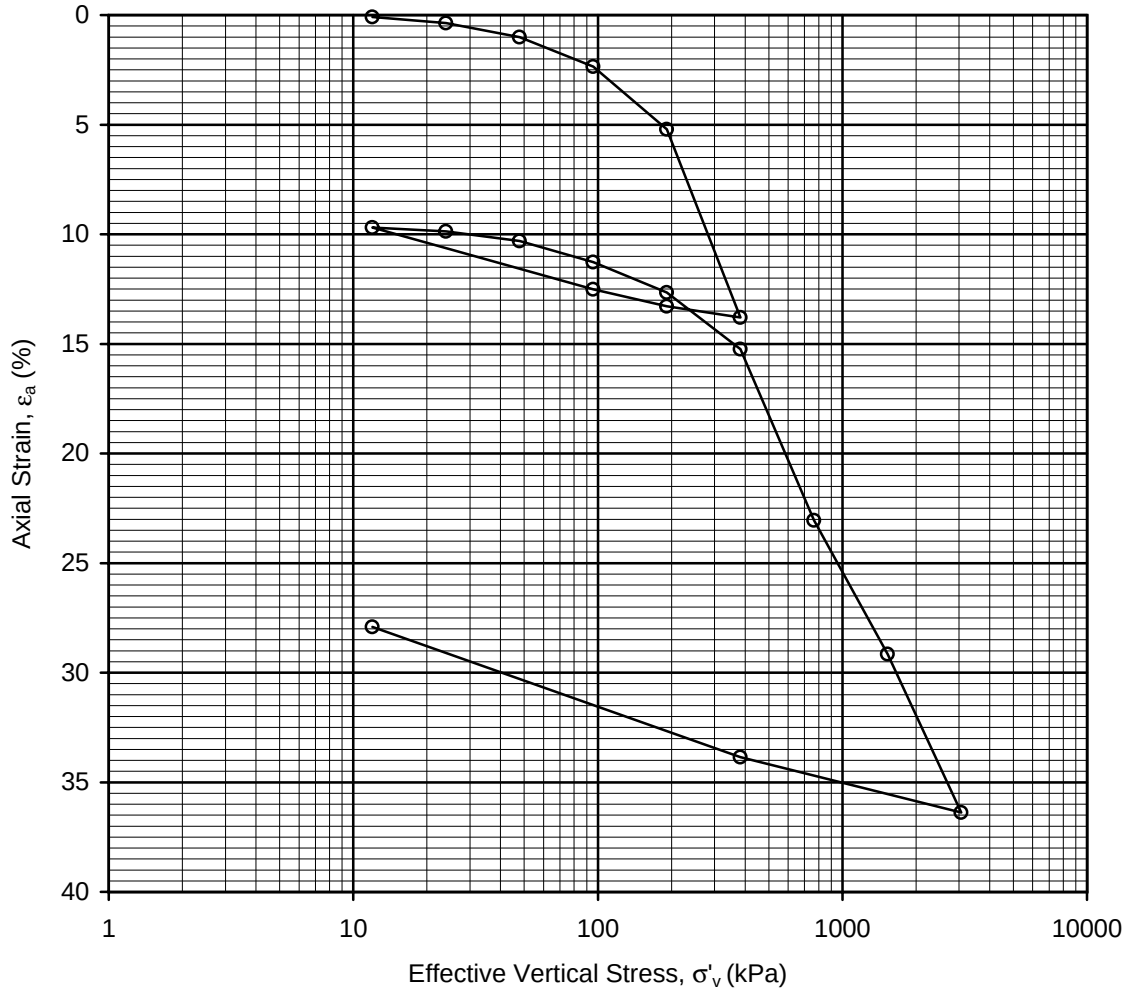
Sample No. 16 - Depth: 14.1m
Boring 98-61
SFOBB East Span Seismic Safety Project

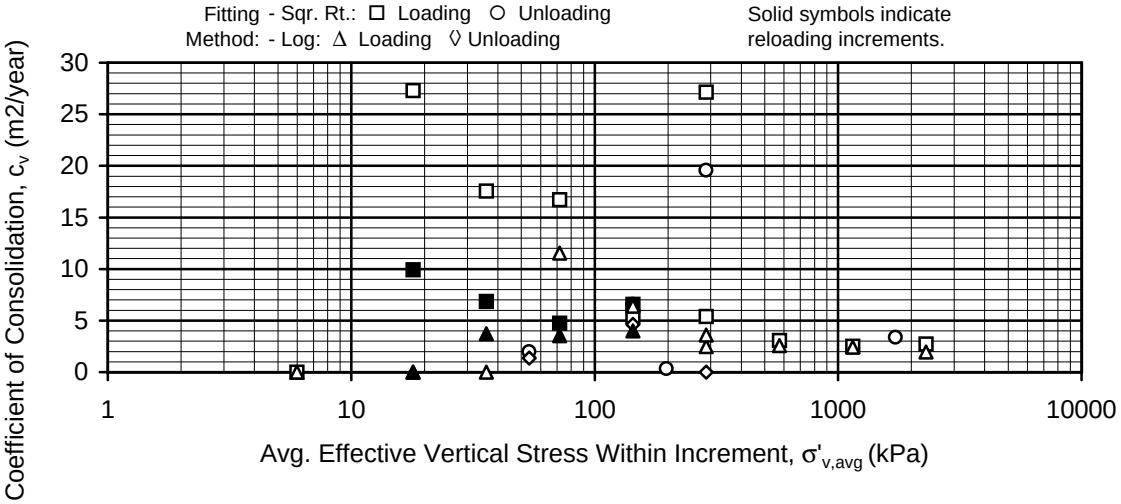




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 16 RT - Depth: 14.1m
Boring 98-61
SFOBB East Span Seismic Safety Project

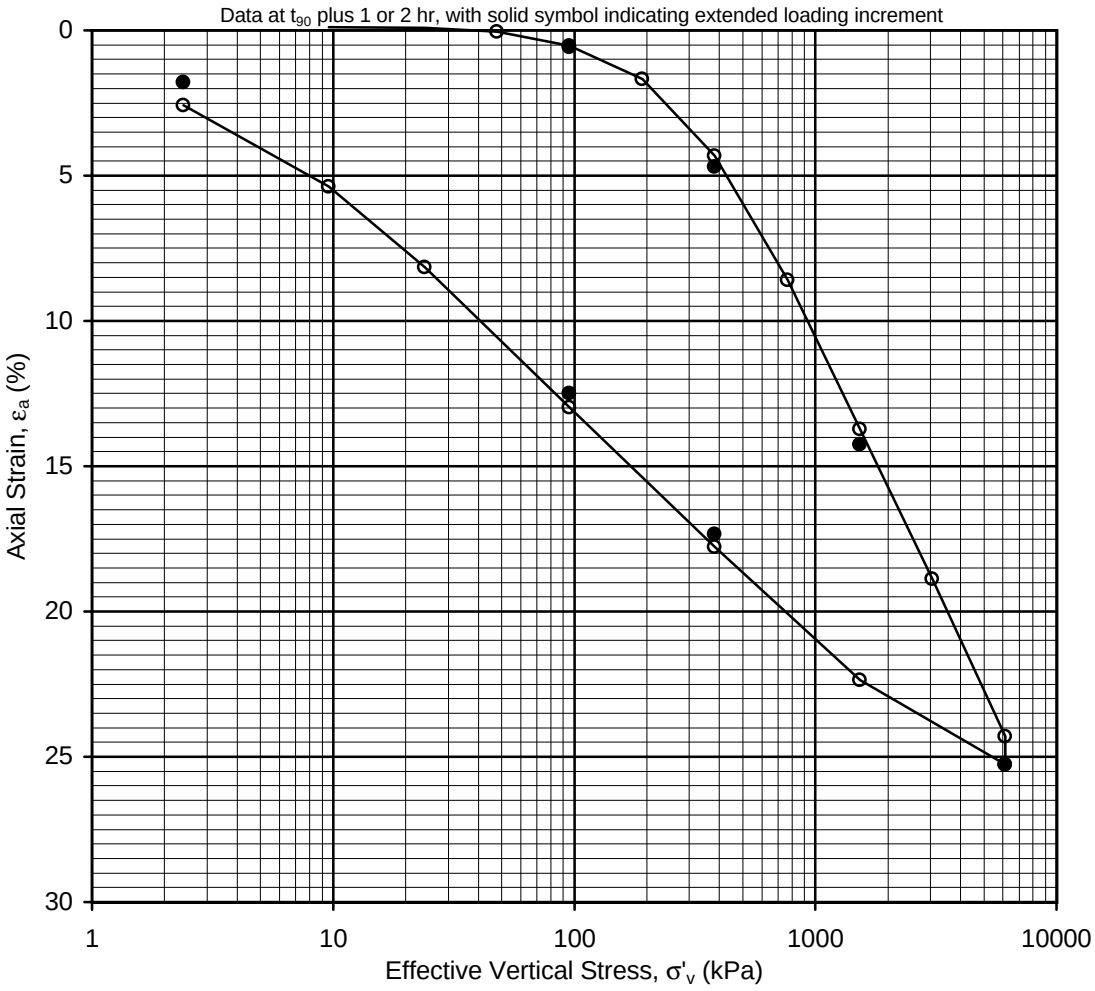


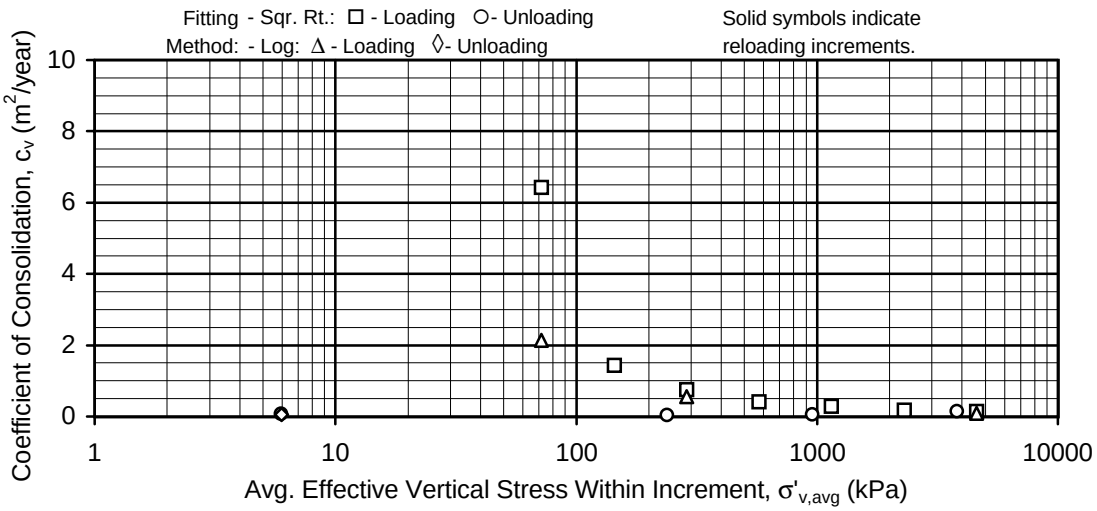


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 304 - Penetration: 17.1m
Boring 98-61
SFOBB East Span Seismic Safety Project

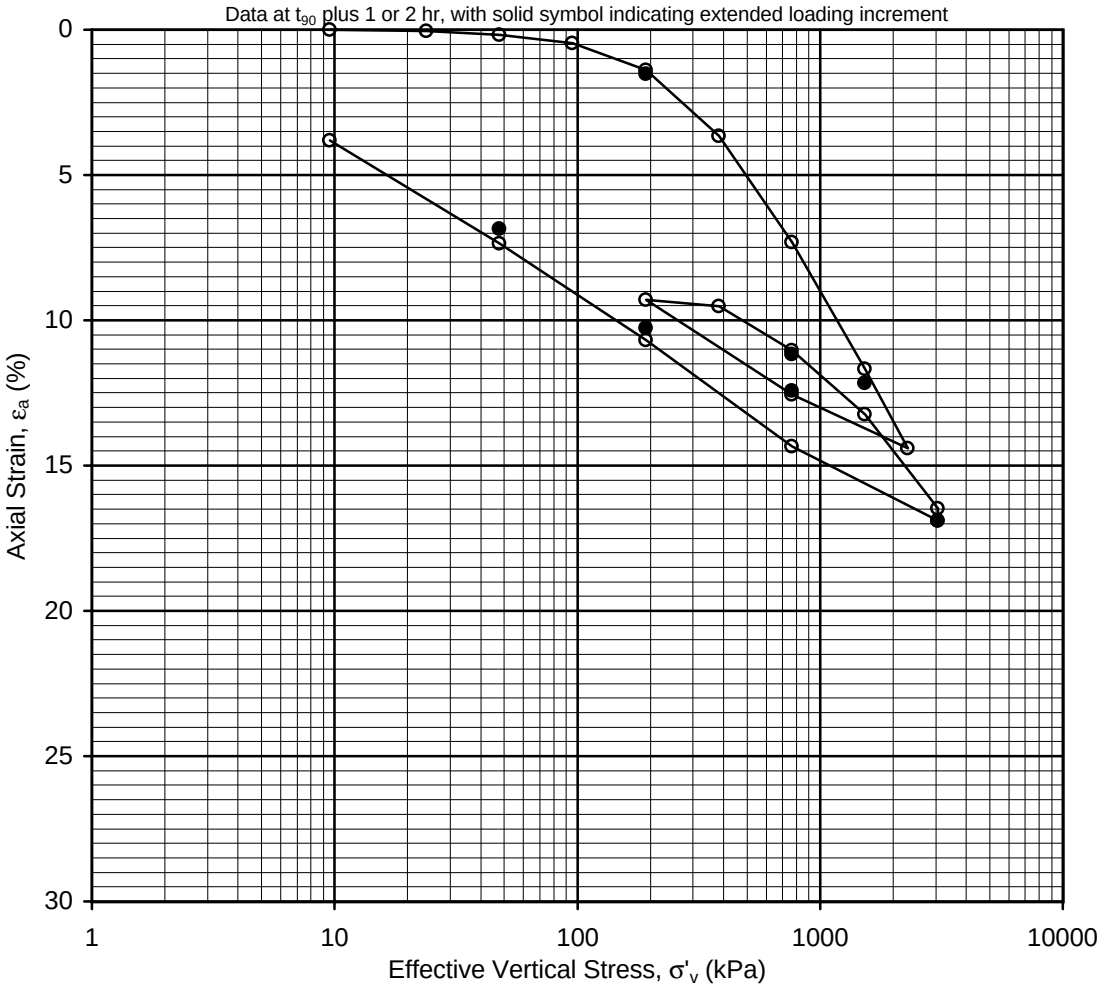
PLATE 98-61.7c

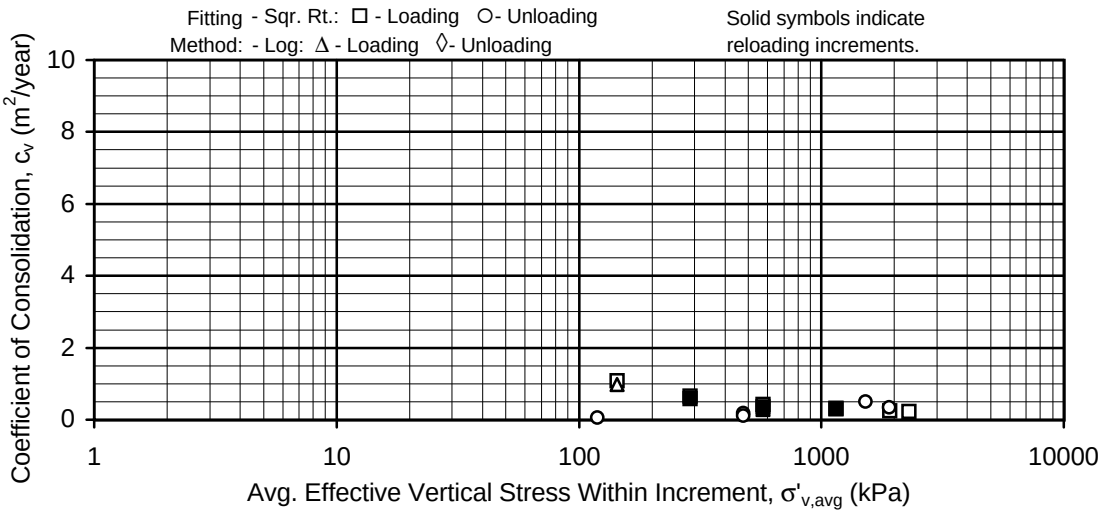




INCREMENTAL CONSOLIDATION TEST RESULTS

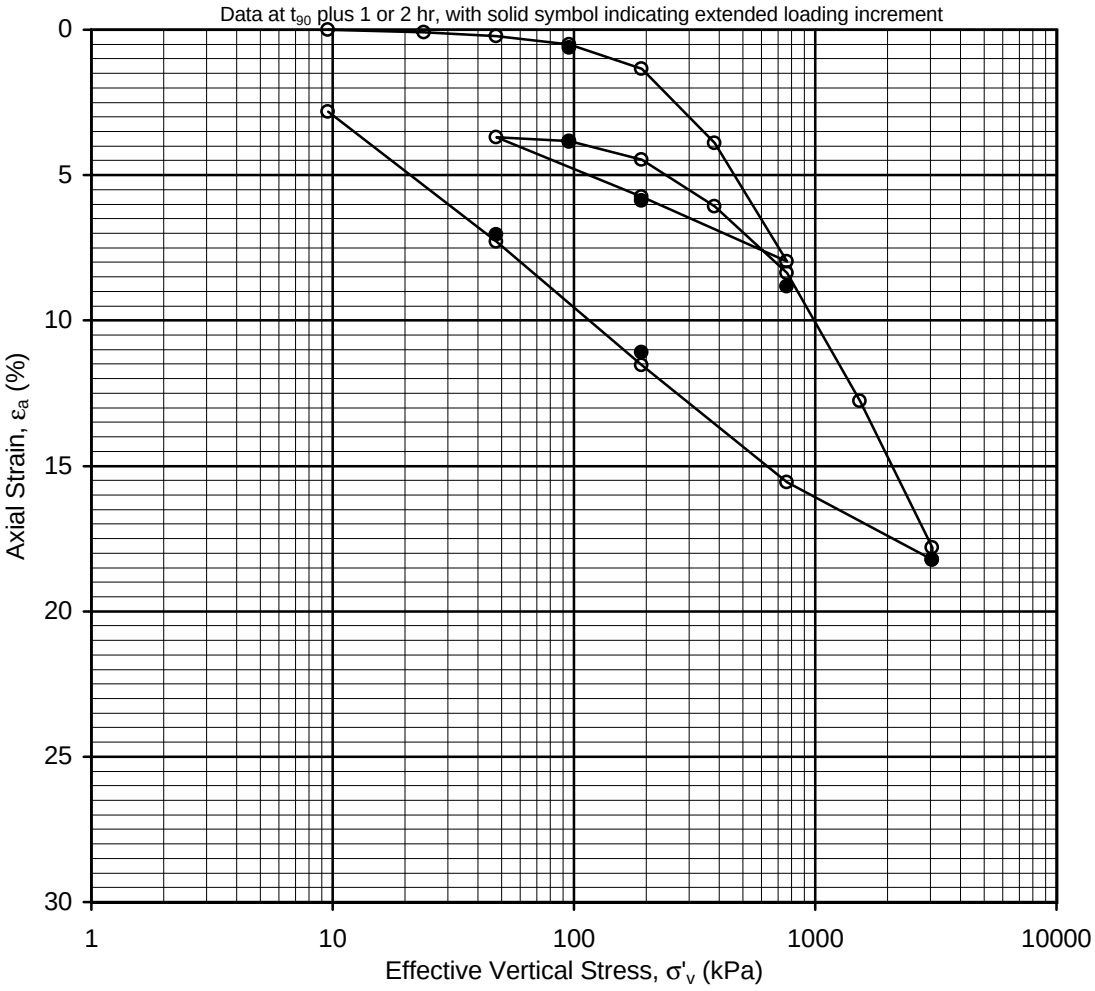
Sample No. 24 - Depth: 20.1m
Boring 98-61
SFOBB East Span Seismic Safety Project

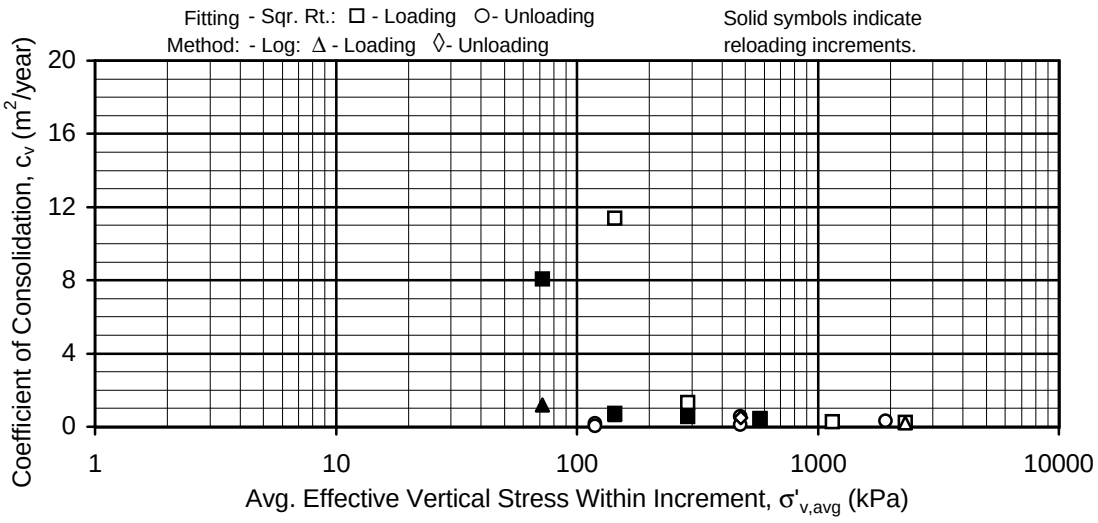




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 24B (Horizontal Loading) - Depth: 20.0m
Boring 98-61
SFOBB East Span Seismic Safety Project



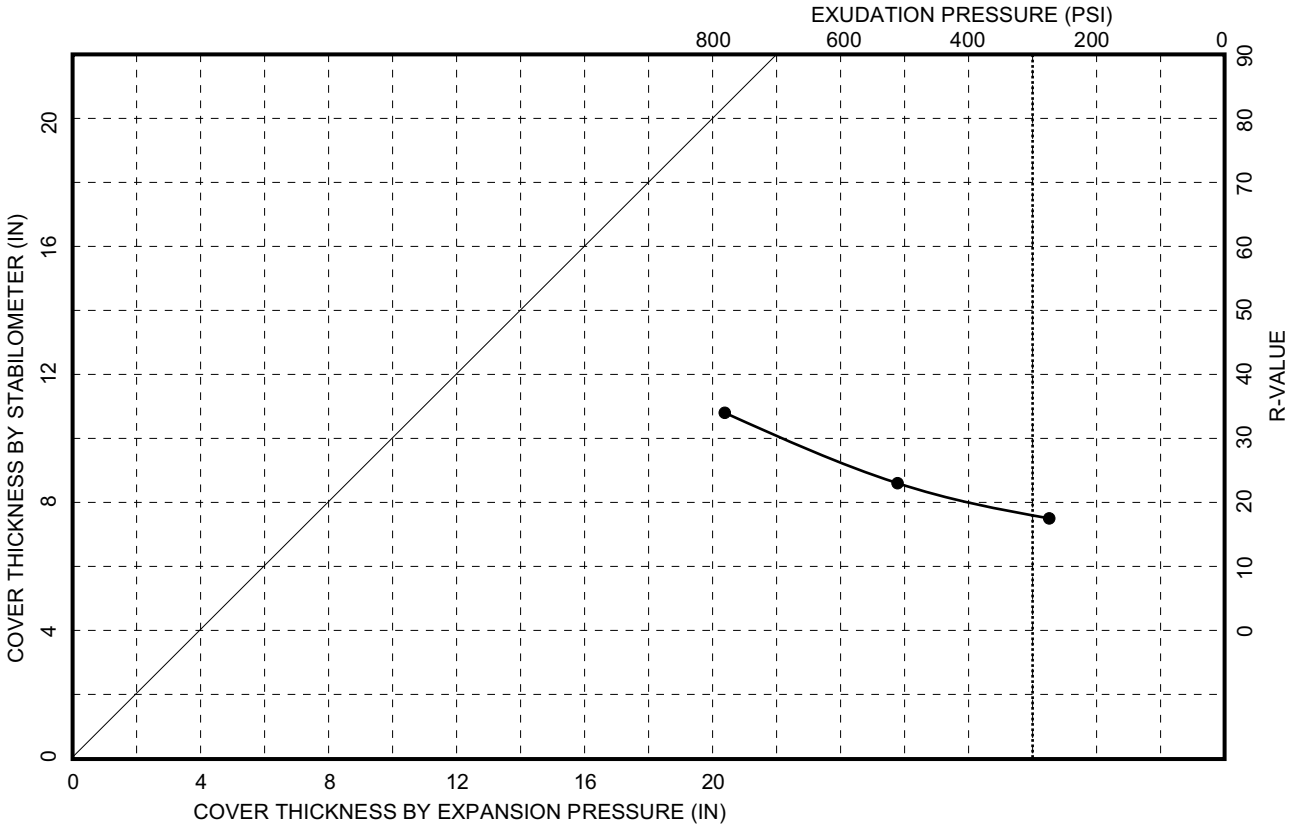


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 24C (Horizontal Loading) - Depth: 20.0m
Boring 98-61
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring



SAMPLE NO. 1
DESCRIPTION: Fine SAND with (SP-SM)

SPECIMEN	A	B	C
EXUDATION PRESSURE (PSI)	780	510	287
EXPANSION PRESSURE (PSF)	150	120	110
RESISTANCE VALUE, "R"	34	22	18
% MOISTURE AT TEST	9.0	9.5	10.0
DRY DENSITY AT TEST (PCF)	124.7	126.4	124.1
R-VALUE AT 300 PSI EXUDATION PRESSURE: 18			

R-VALUE TEST RESULTS
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61-10

Health Science Associates

LABORATORY REPORT

Report Number : 991057
Purchase Order :
Job No. : 98-42-0057

GREG DENLINGER
FUGRO WEST INC.
5855 OLIVAS PARK DR.
VENTURA, CA. 93003-7672

Date Received : 13-NOV-98
Date Completed : 19-NOV-98
Date Sent : 19-NOV-98
Page / 1 of 1

Sample Description : 4 - Bulk Soils
Project : Oakland

California Test Methods : 532,643

Auto No.	Submitter Sample Number	Resistivity ohms/cm	pH Units	Chloride ppm	Sulfate ppm
174124	98-63-14 @ 35.5'	653	9.13	4000	290
174125	98-72-300 @ 1.5'	399	12.11	<1.0	24.0
174126	98-66-300 @ 1.5'	327	12.17	<1.0	160
174127	98-61-1 @ 5'	762	9.17	720	630
Detection Limit :		10	NA	1.0	1.0

Milliliters Water Added	50	100	150	200	250	300	350
	Resistivity Ohm-cm						
Sample No.							
98-63-14	1525	1162	908	762	653	653	690
98-73-300	1343	762	472	399	581	1416	-
98-66-300	581	363	327	363	544	-	-
98-61-1	1198	908	762	1161	1089	-	-

Remarks : Sample(s) and sampling data as provided : by :

Analyst(s) : ED

Ref :

California ELAP No.: 1406
AIHA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AIHA ELLAP Accreditation No.: 10985
LACSD Lab No.: 10125

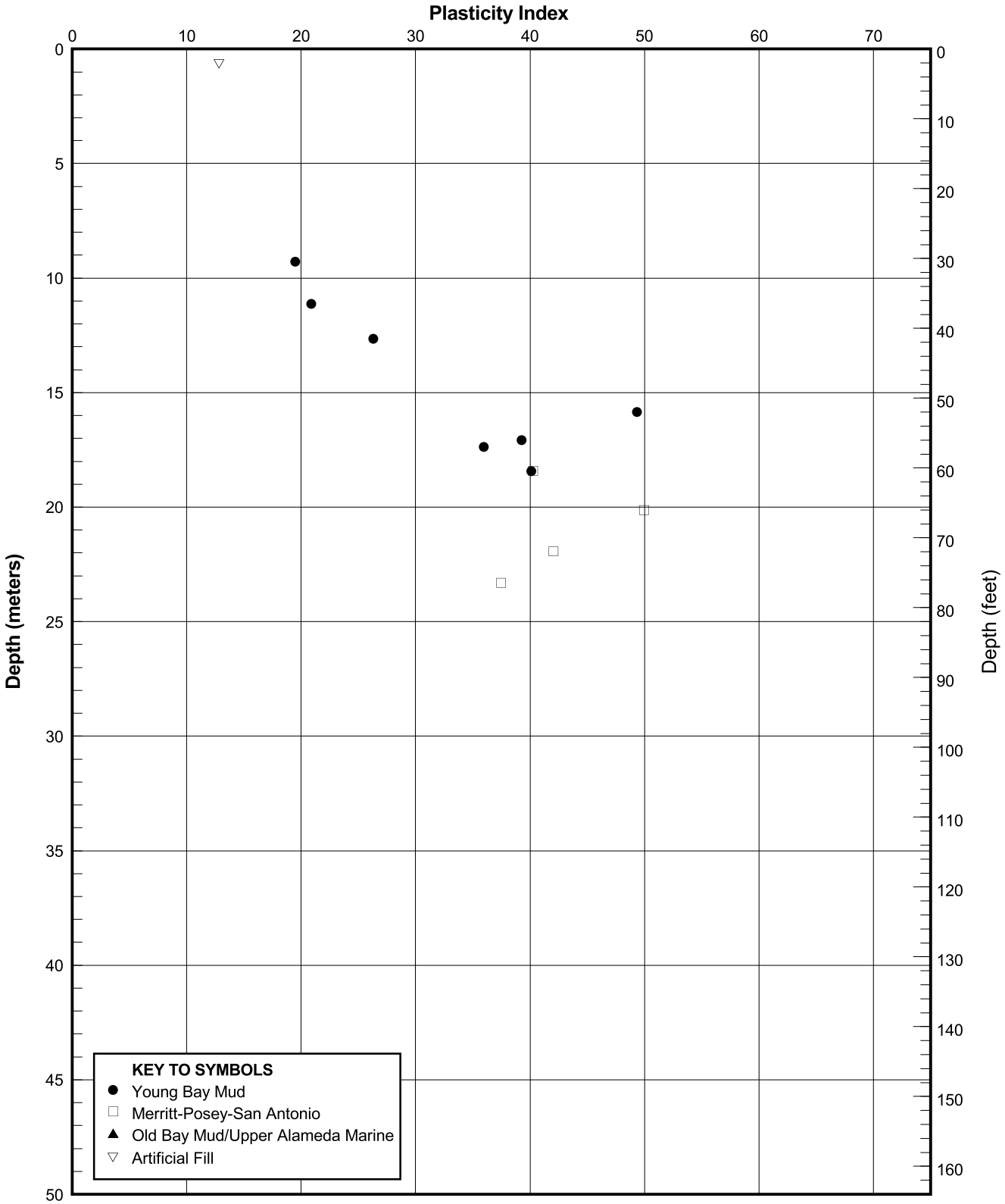
Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Susan Rosenberg
Laboratory Director, Susan B. Rosenberg, CIH

PLATE 98-61.11

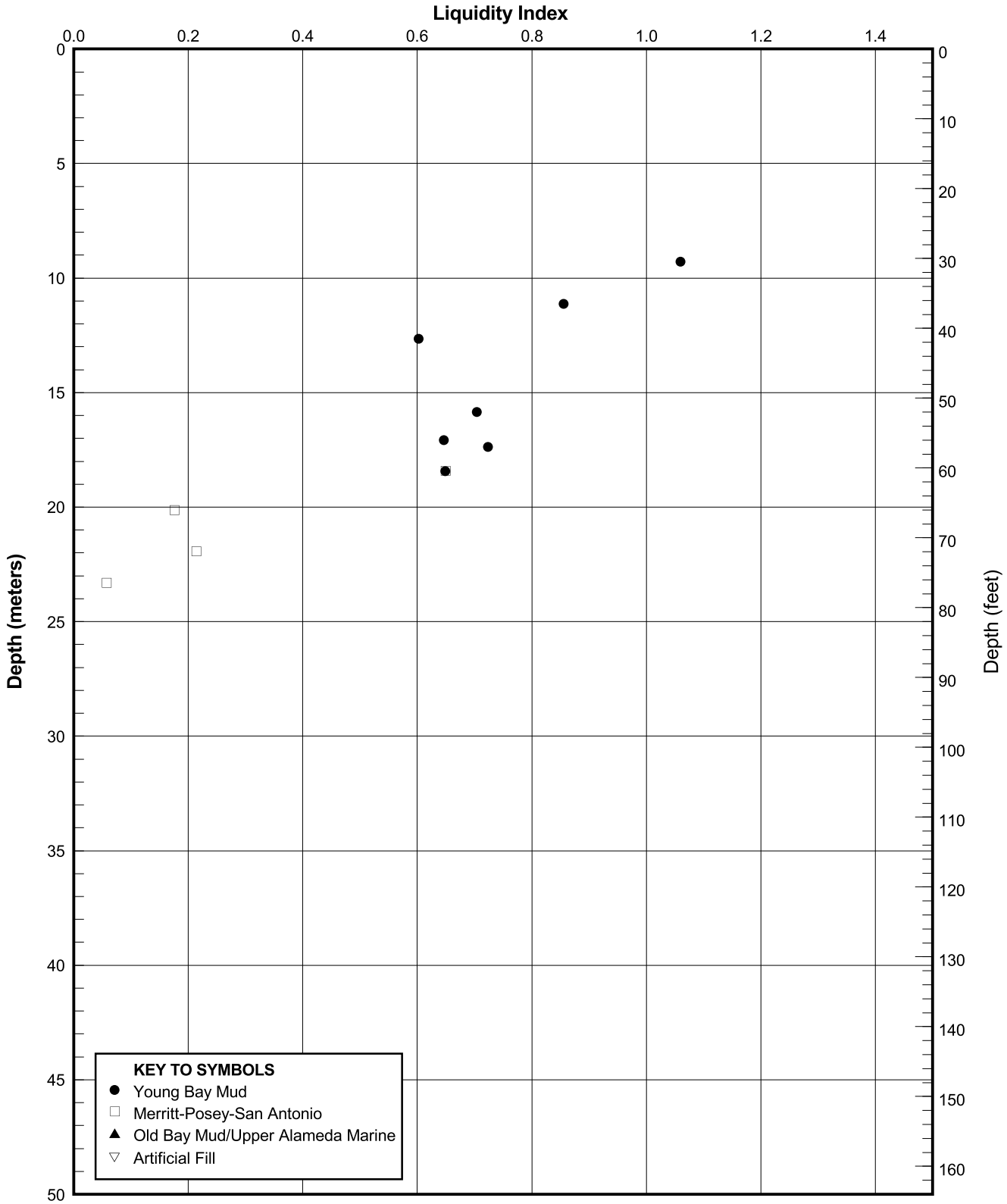
10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

This report pertains only to the samples investigated and does not necessarily apply to other apparently identical or similar materials. This report is submitted for the exclusive use of the client to whom it is addressed. Any reproduction of this report or use of this Laboratory's name for advertising or publicity purposes without written authorization is prohibited.



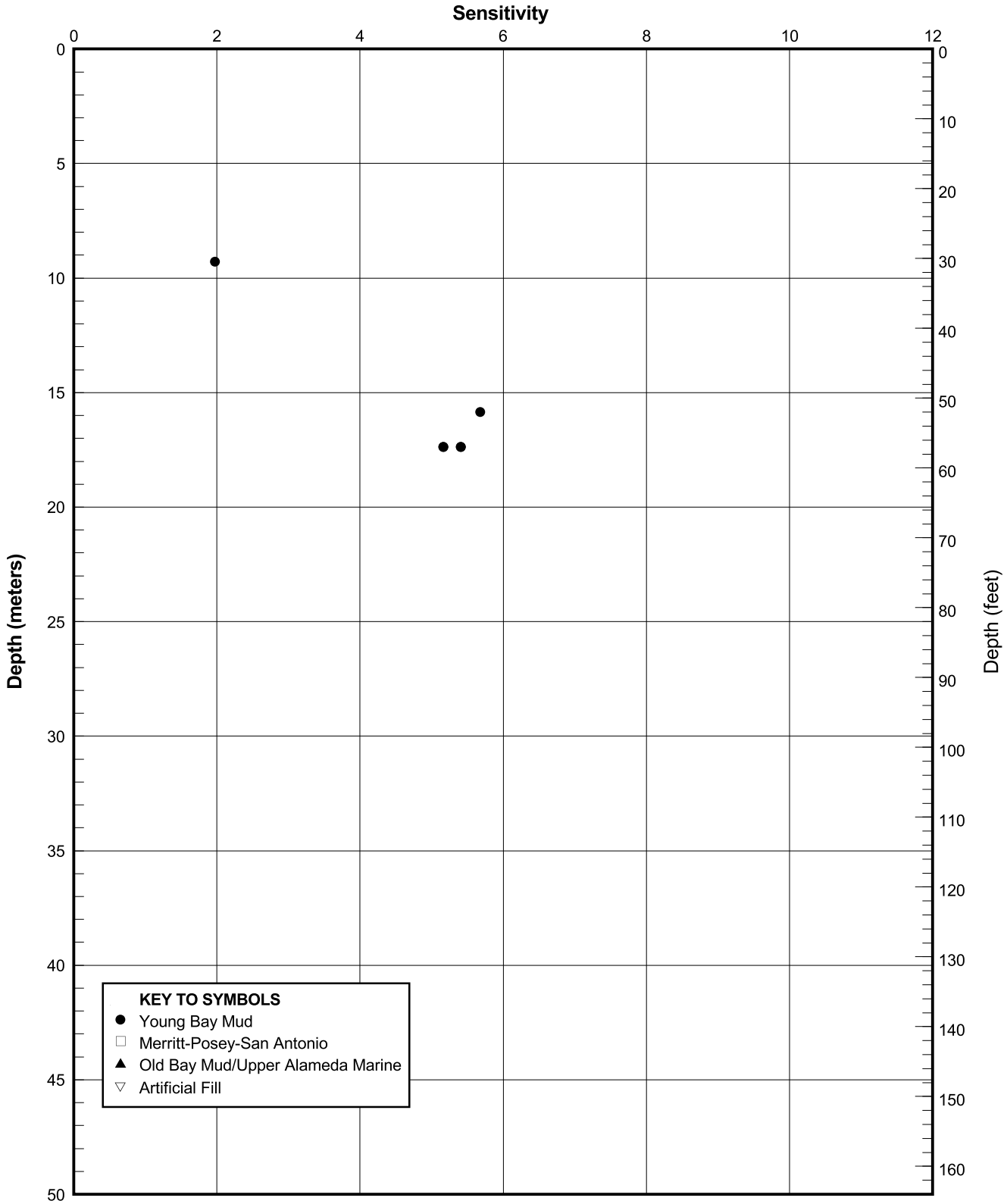
PLASTICITY INDEX PROFILE
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.12



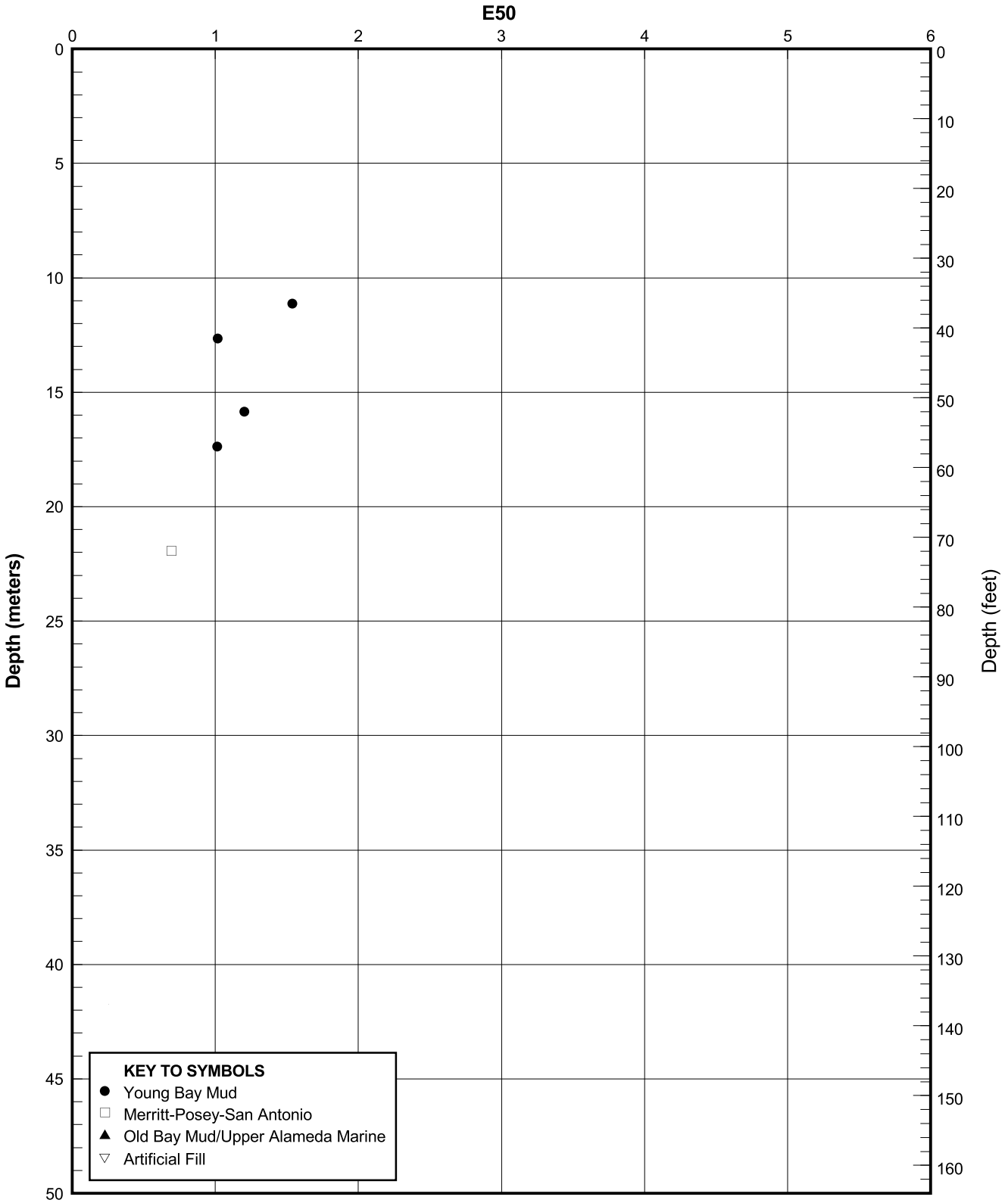
LIQUIDITY INDEX PROFILE
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.13



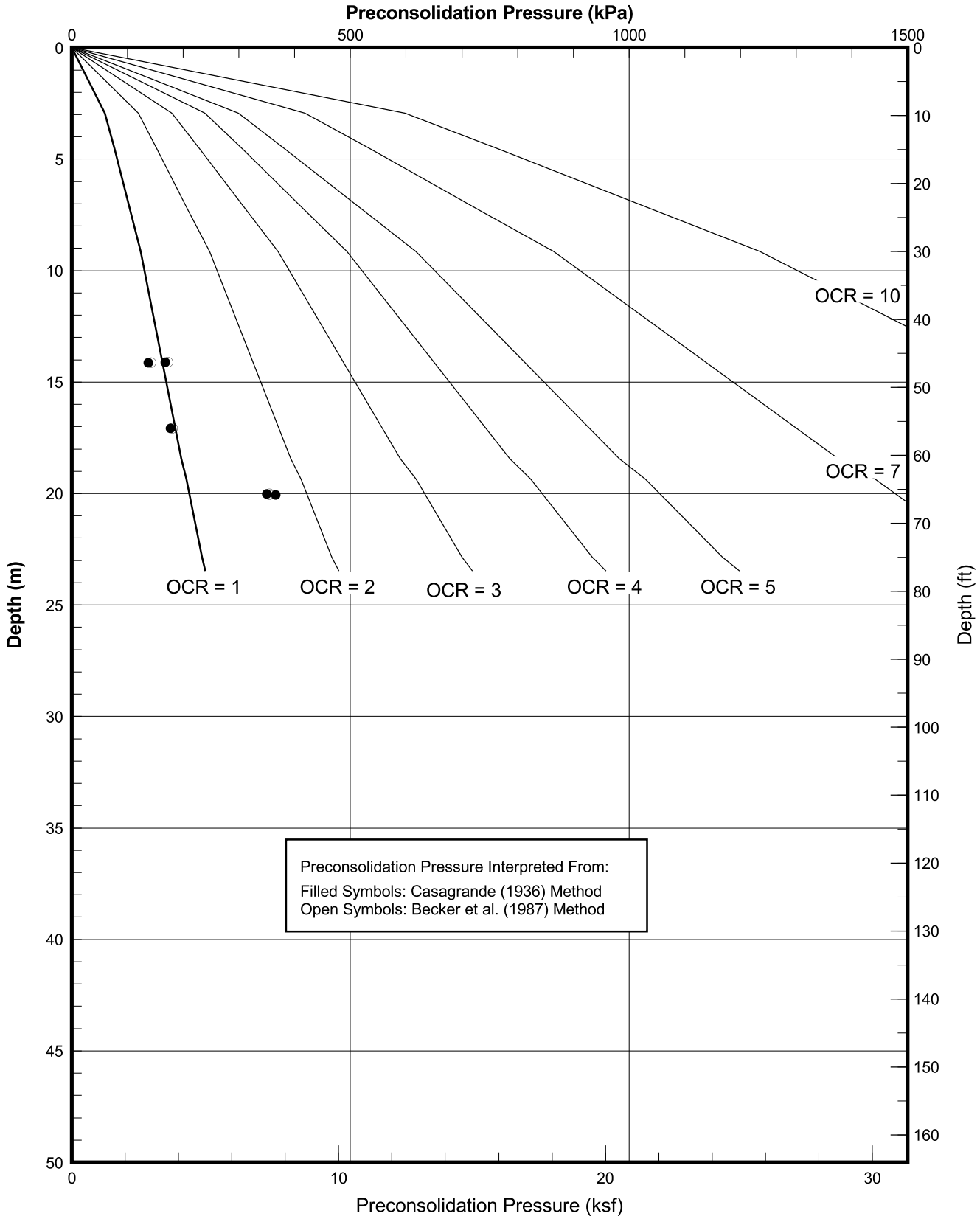
SENSITIVITY PROFILE
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.14



E50 PROFILE
Boring 98-61
SFOBB East Span Seismic Safety Project

PLATE 98-61.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-61

SFOBB East Span Seismic Safety Project

PLATE 98-61.16

LAND BORING 98-62

PROJECT NO:	98-42-0058	**START DATE:**	10/08/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-62 (17m left of E. Sta. 88+30)	**COMPLETION DATE:**	10/09/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839320 N648302
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.6m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	1			13	Pavement, 0.1m of Asphalt Concrete over 0.2m of Aggregate Base (0.3m)	I
2	2			9	Fine SAND with silt (SP-SM), loose to medium dense, brown	
1	3			36	-with shell fragments at 3.4m ▽ (3.6m)	
0	4					
-1	5			48	-gray, silty sand, 4.6m to 6.1m -dense to very dense sand with silt pockets and clay pockets, at 4.9m	II
-2	6			23		
-3	7					
-4	8			18	(8.7m)	
-5	9			6	Fat CLAY (CH), firm to stiff, gray -lean clay with shells to 11.6m -with shell fragments to 12.8m	
-6	10					
-7	11			PUSH	-with silt pockets, at 11.0m	
-8	12					
-9	13			SAVE		
-10	14			PUSH	-silty fine sand, 13.7m to 14.0m -with organic partings at 14.0m	III
-11	15					
-12	16			PUSH	-with organic pockets below 15.2m	
-13	17			5		
-14	18				(18.3m)	
-15	19			PUSH	Lean CLAY with sand (CL), very stiff, greenish gray	IV
-16	20			PUSH	-with desiccated clay pockets at 20.0m	
-17	21				(21.2m)	
-18	22			50/15cm	Fine SAND with silt (SP-SM), very dense, gray to greenish gray -with a few clay pockets	V
-19	23			50/15cm	-silty sand at 22.9m TOTAL DEPTH: 23.0m BACKFILLED WITH: Cement Grout	
-20	24					
-21						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

120 → (two occurrences)

LOG OF BORING AND TEST RESULTS

BORING 98-62

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

PLATE 98-62.1

c:\snfco-oak\shore_approach\mole\vol_2b\odb\11x17\plate98-62_1.odb

No Remote Vane Testing Performed For This Boring

98-62		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
1.4	1	6					5																			
2.0	2	8					6																			
3.2	3	26																								
3.4	4	20				19.9	4																			
4.9	6	21					20																			
6.4	7	24					12																			
7.9	8	24					5																			
9.3	9							35.9																		
9.4	10	36	46	21	0.59	18.2		38.3			29.7	19.8														
11.0	12	39	47	26	0.63			38.3			39.2	17.2														
11.1	13					17.5		43.1							42.2		1.1									
11.3	14							38.3																		
12.7	15	39	51	23	0.58																					C
12.8	16										81.1															
13.9	17						16																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.3a

Earth Mechanics

FUGRO

98-62		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
14.2	19					15.5					68.1				66.2	15.2	1.0									
14.3	20	69	91	34	0.61			59.9																		
15.4	21							47.9																		
15.7	23	46	56	23	0.69	17.4	91				44.2				49.0		2.2									H
15.8	24							47.9																		
16.9	25	54	58	22	0.91																					C
17.1	26					16.3		45.5			35.1	16.8														
17.2	27							55.1																		
18.4	28	25				20.5		143.6	107.7						224.0	183.8	0.7									
18.6	29						76																			
20.3	31					20.7		105.3	143.6						103.7		0.8									
20.4	32	21	26	15	0.55																					
21.5	33	28					7																			
23.0	34	27					18																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
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TUW = Total Unit Weight
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Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

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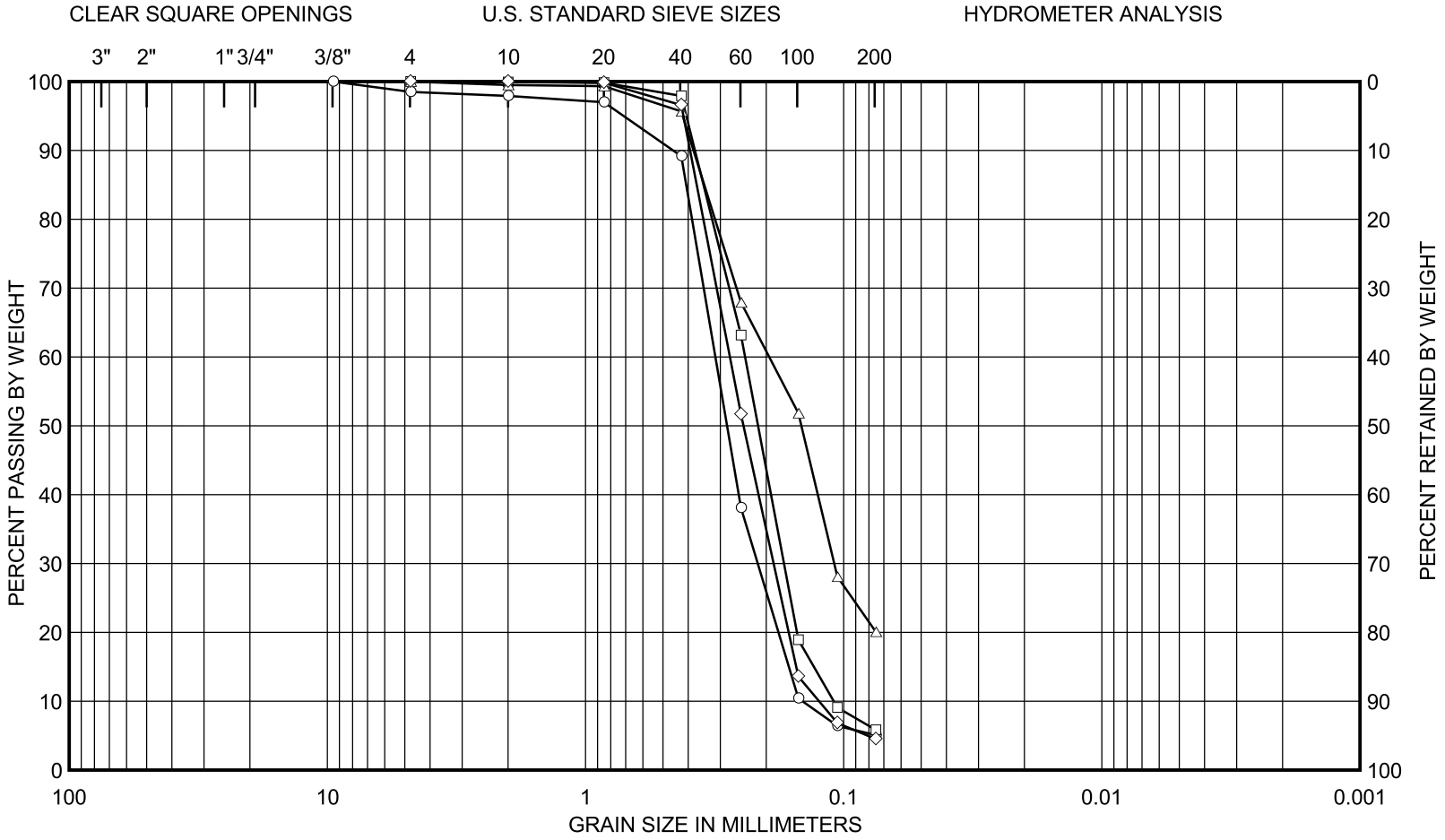

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.4	○—○	FINE SAND (SP-SM) with silt and a trace of medium sand	1.0	2.2	0.28
2	2.0	□—□	FINE SAND (SP-SM) with silt	1.1	2.2	0.21
6	4.9	△—△	SILTY FINE SAND (SM) with a trace of medium sand			0.15
8	7.9	◇—◇	FINE SAND (SP-SM) with silt	1.0	2.2	0.24

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.4a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

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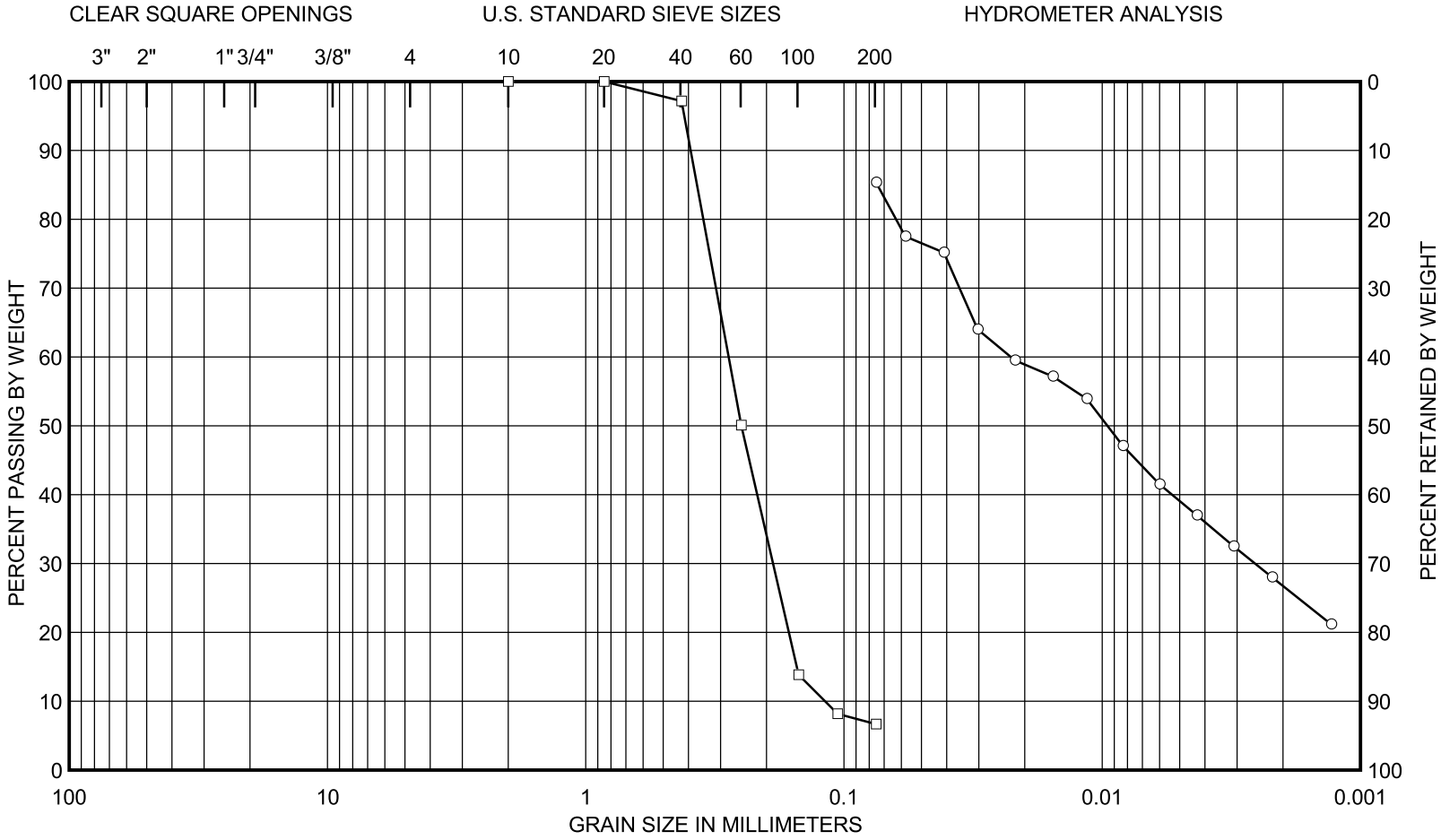

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
23	15.7	○——○	FAT CLAY (CH)			0.0095
33	21.5	□——□	FINE SAND (SP-SM) with silt	1.1	2.4	0.25

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.4b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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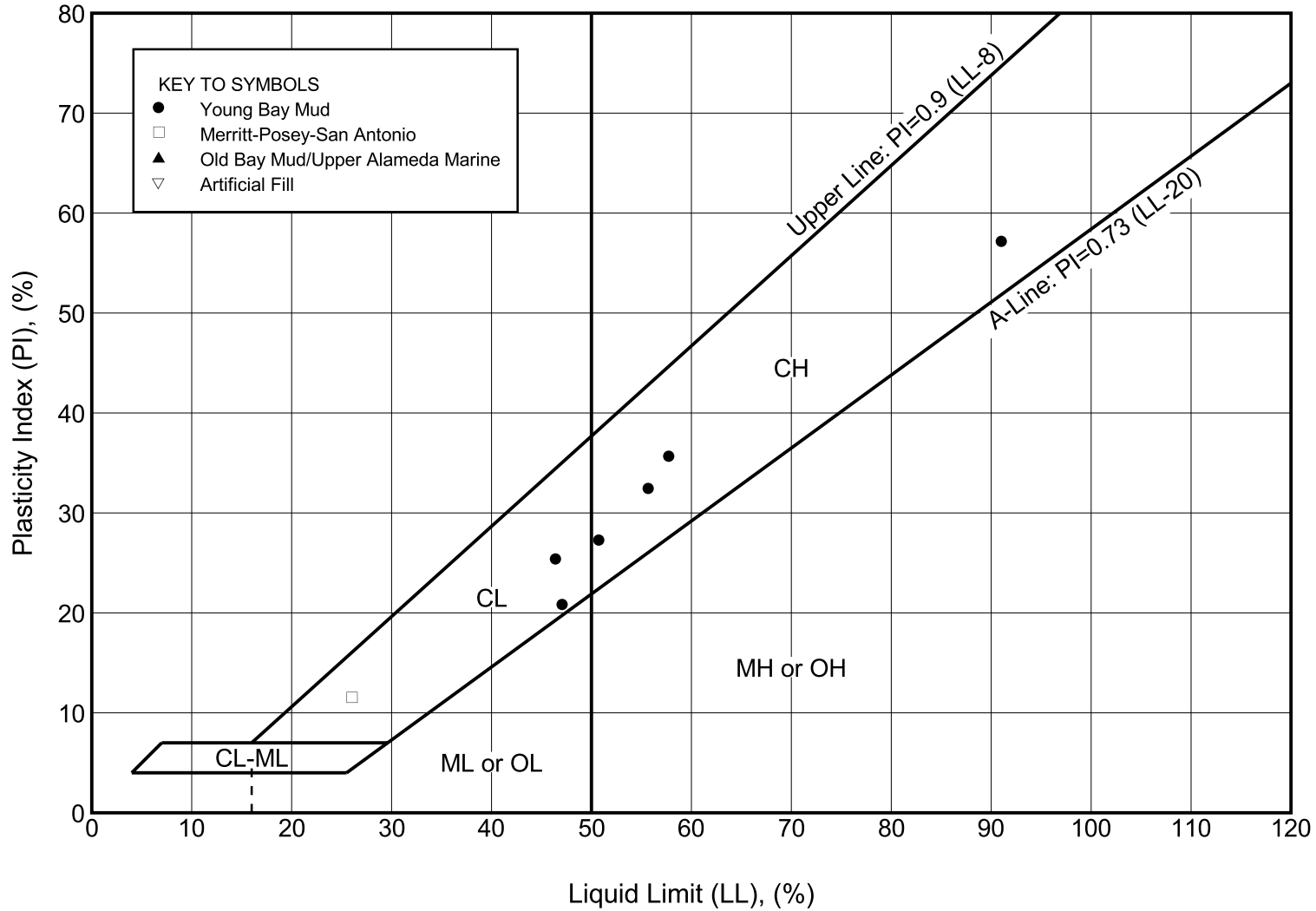
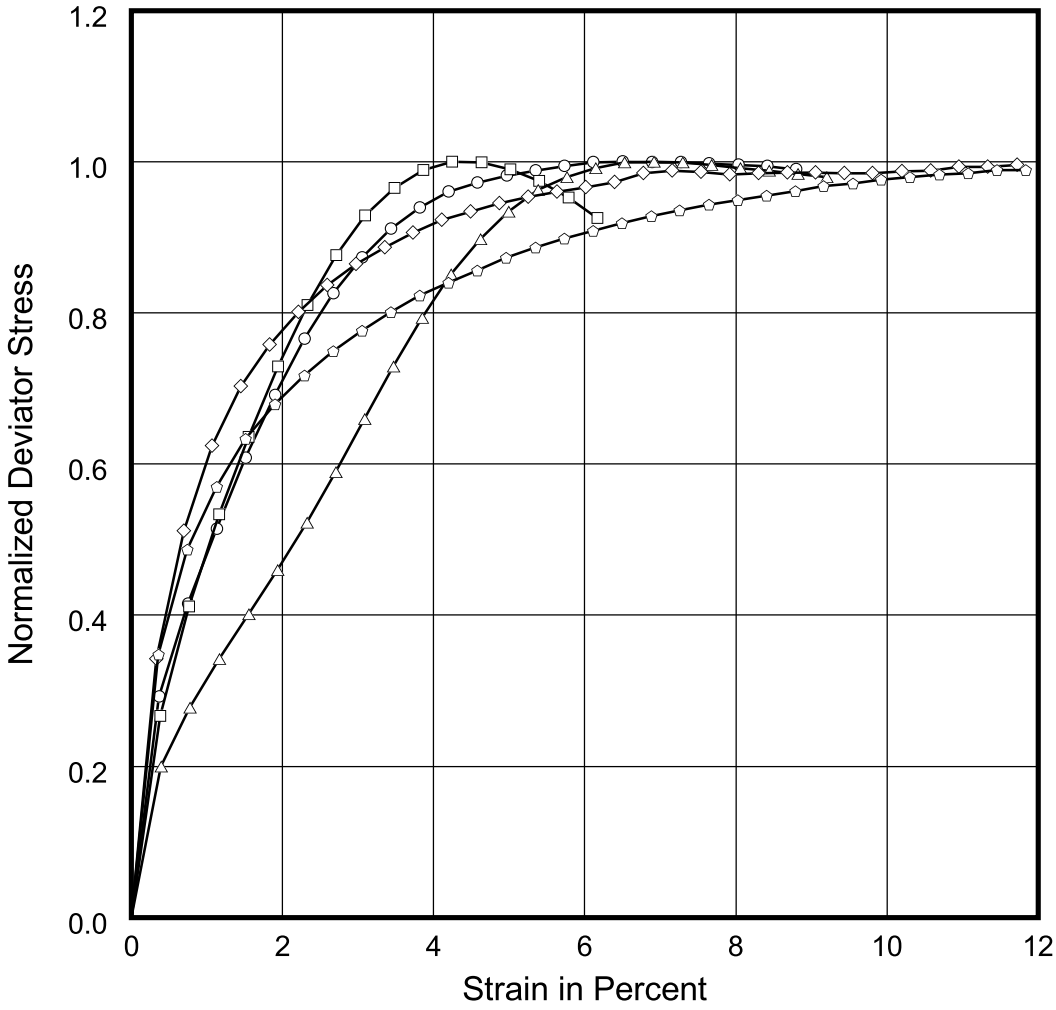


PLASTICITY CHART
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.5



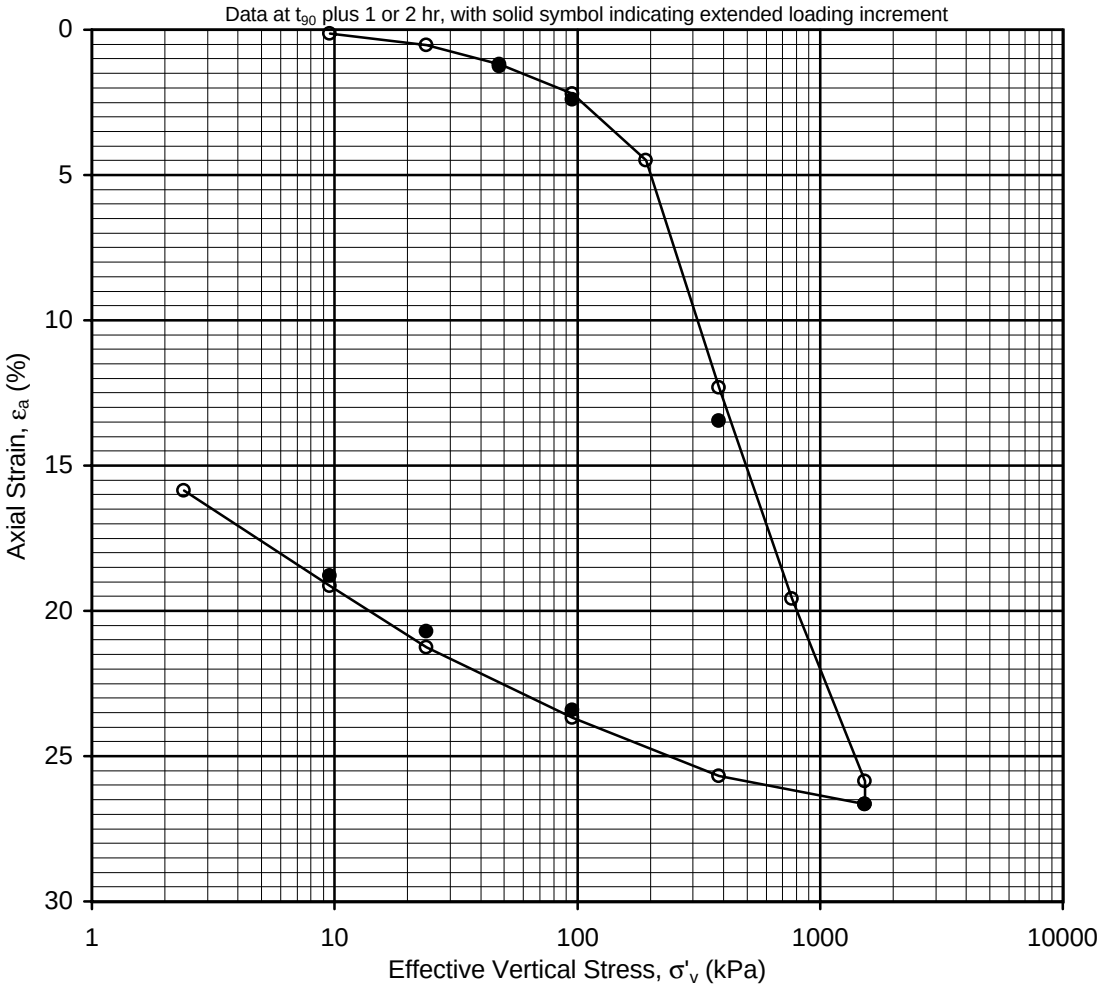
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	13	11.1	UU	207	84	1.1
□	19	14.2	UU	255	132	1.0
△	23	15.7	UU	283	98	2.2
◇	28	18.4	UU	689	448	0.7
⬠	31	20.3	UU	724	207	0.8

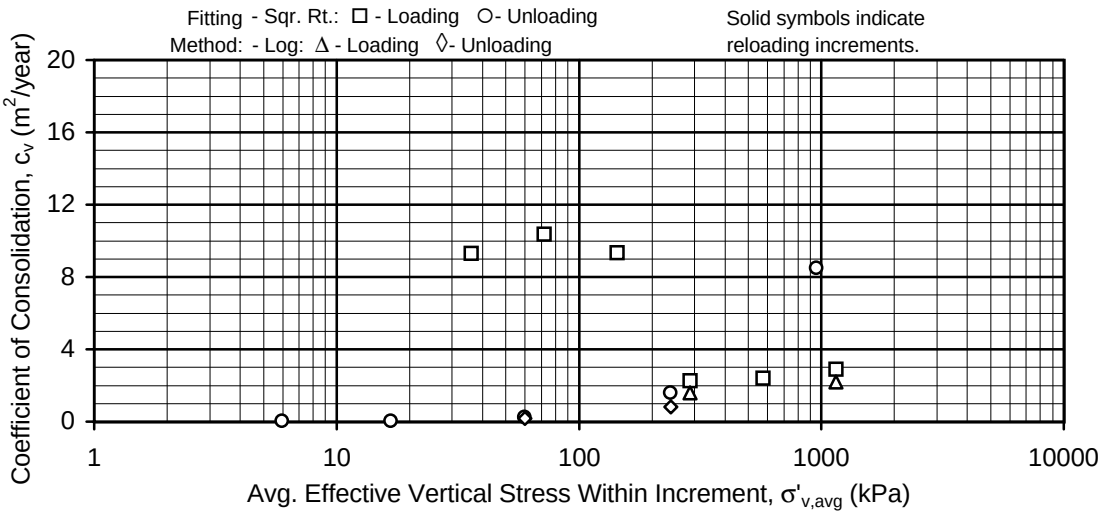
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-62
SFOBB East Span Seismic Safety Project

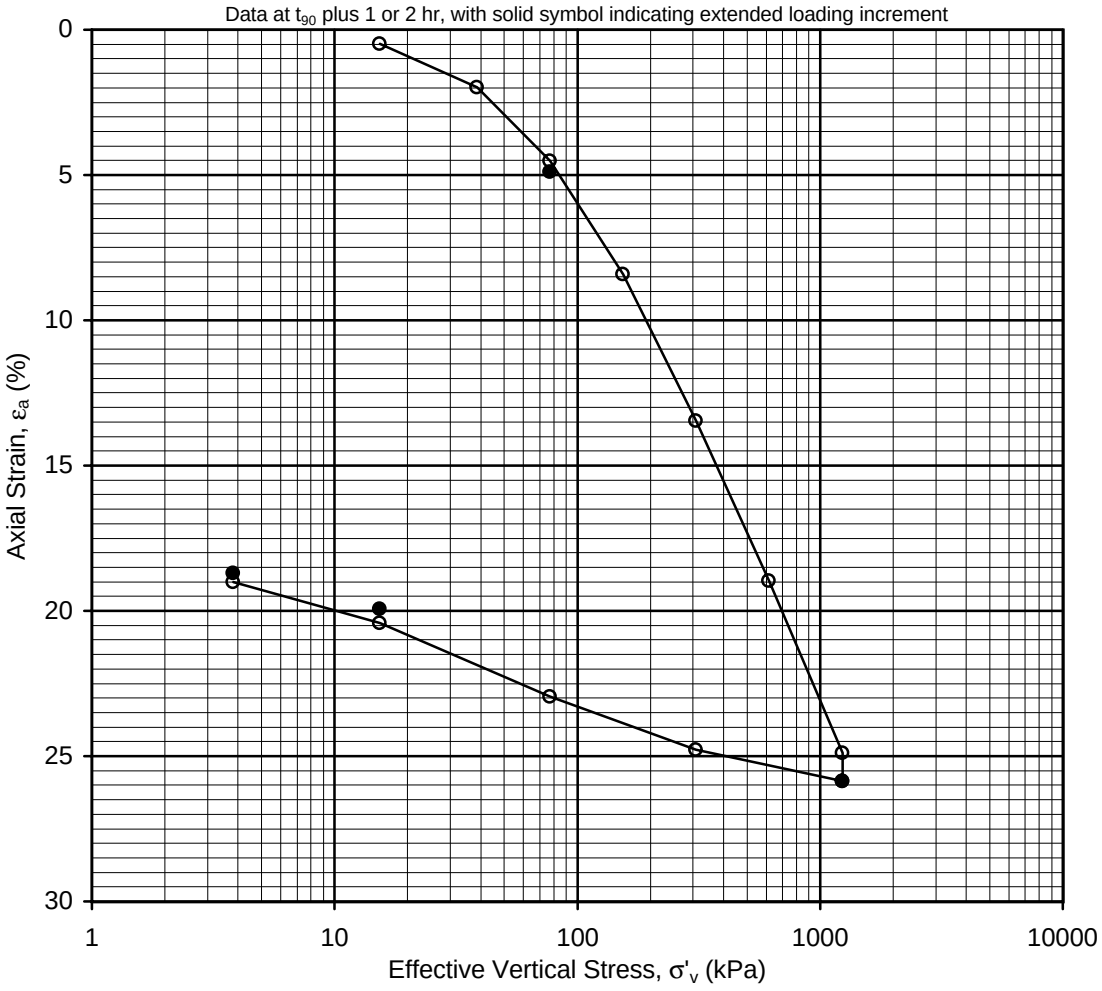
PLATE 98-62.6

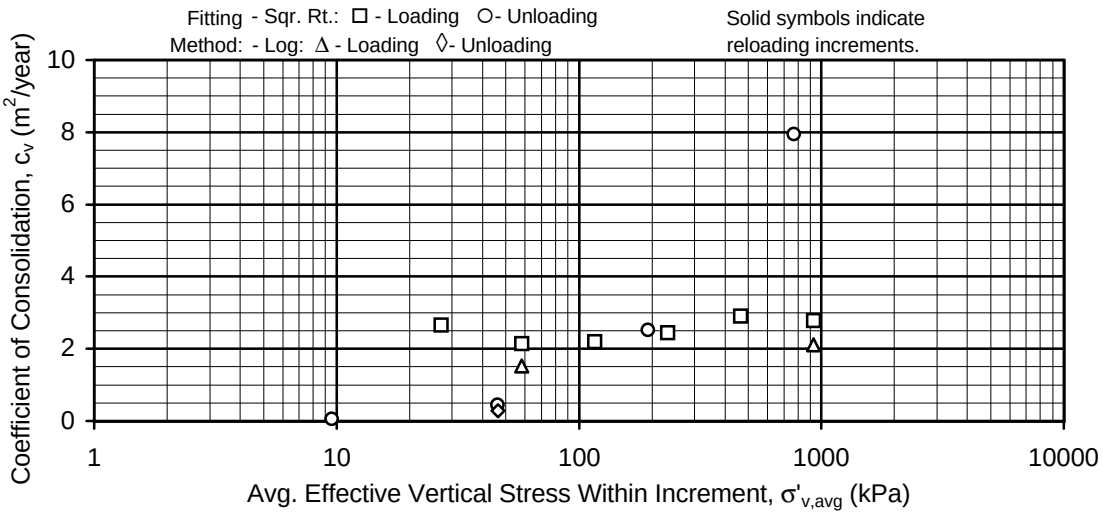




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 15 - Depth: 12.7m
Boring 98-62
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 25 - Depth: 16.9m
Boring 98-62
SFOBB East Span Seismic Safety Project

Earth Mechanics

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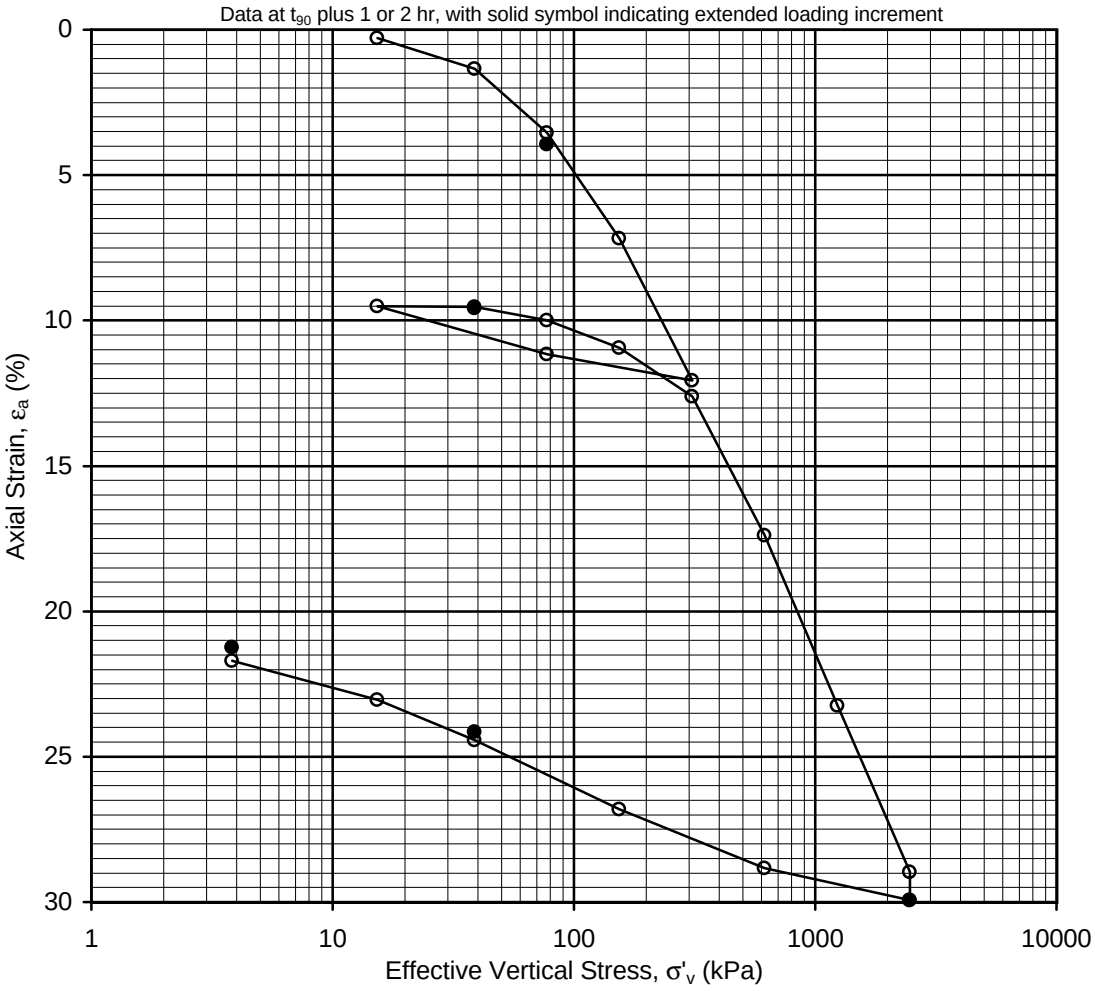
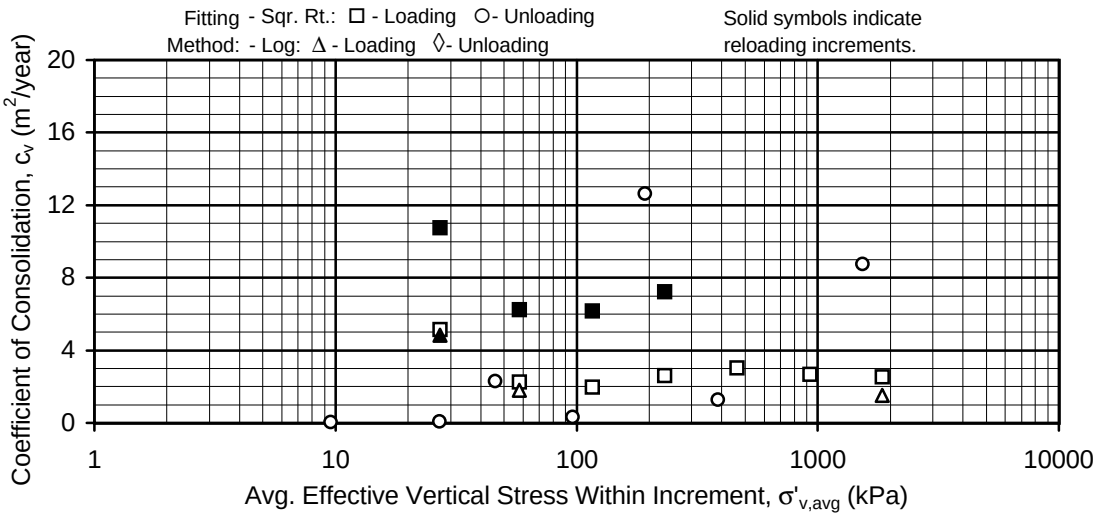




INCREMENTAL CONSOLIDATION TEST RESULTS

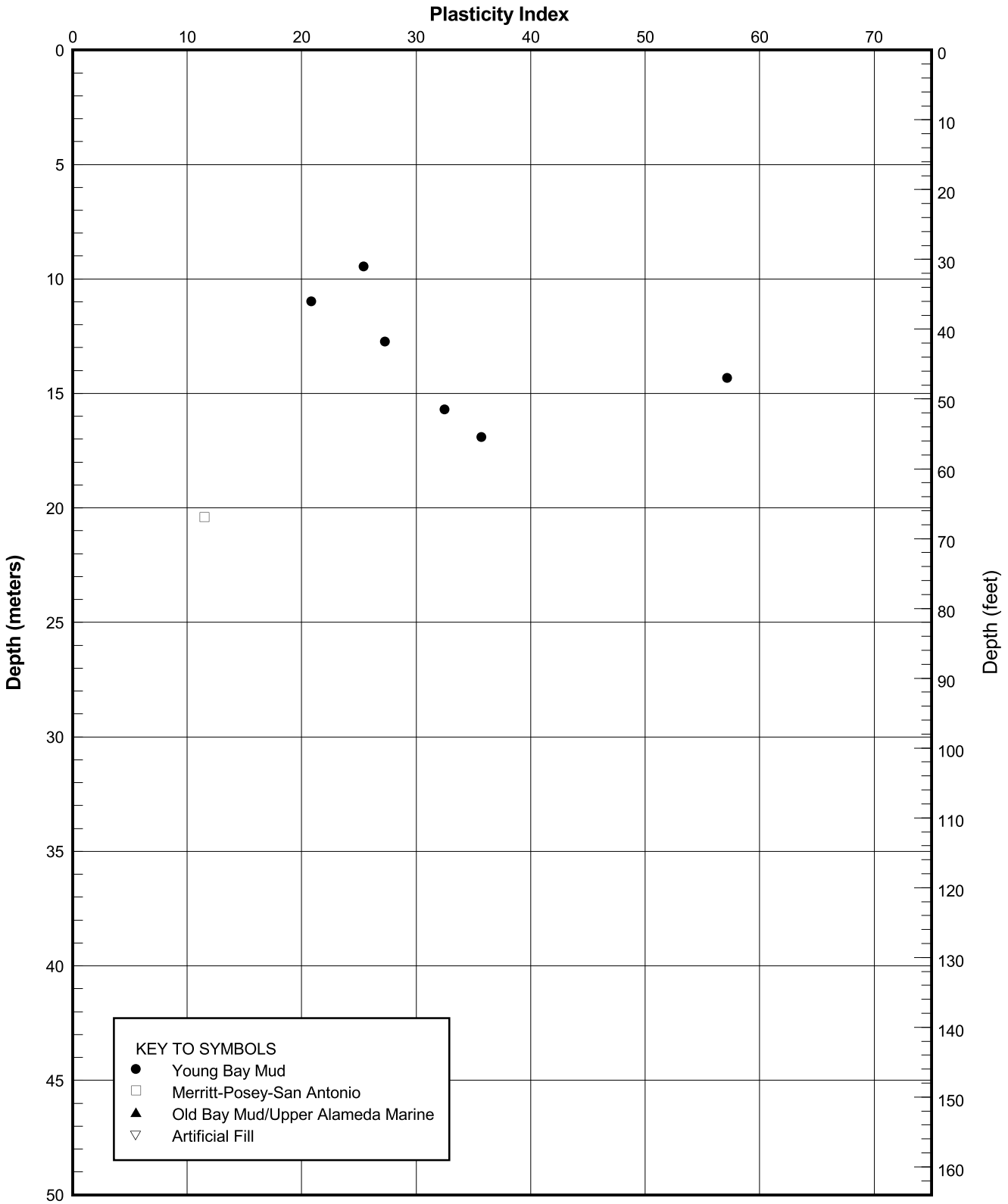
Sample No. 25 RT - Depth: 16.9m
Boring 98-62
SFOBB East Span Seismic Safety Projects

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

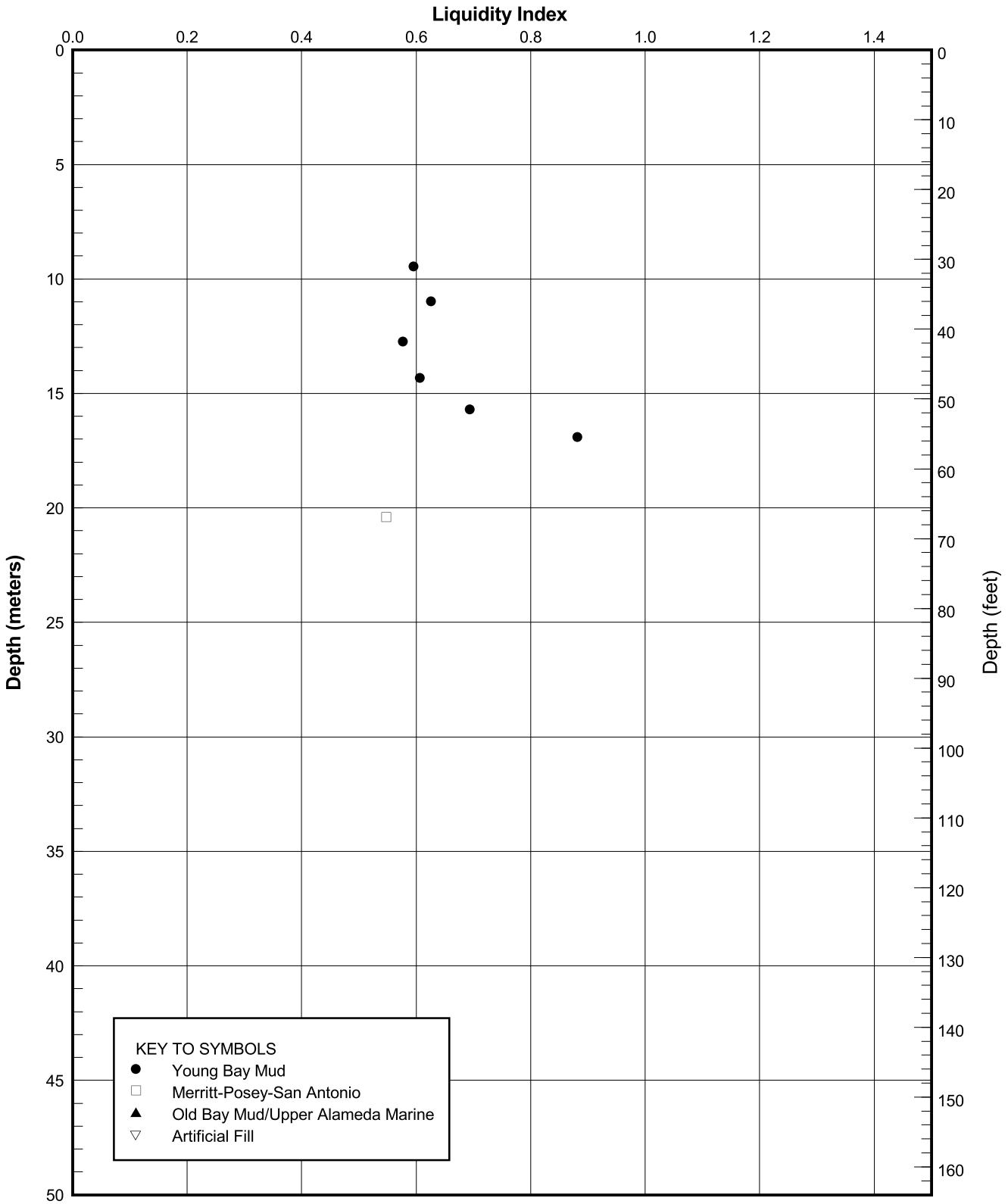
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



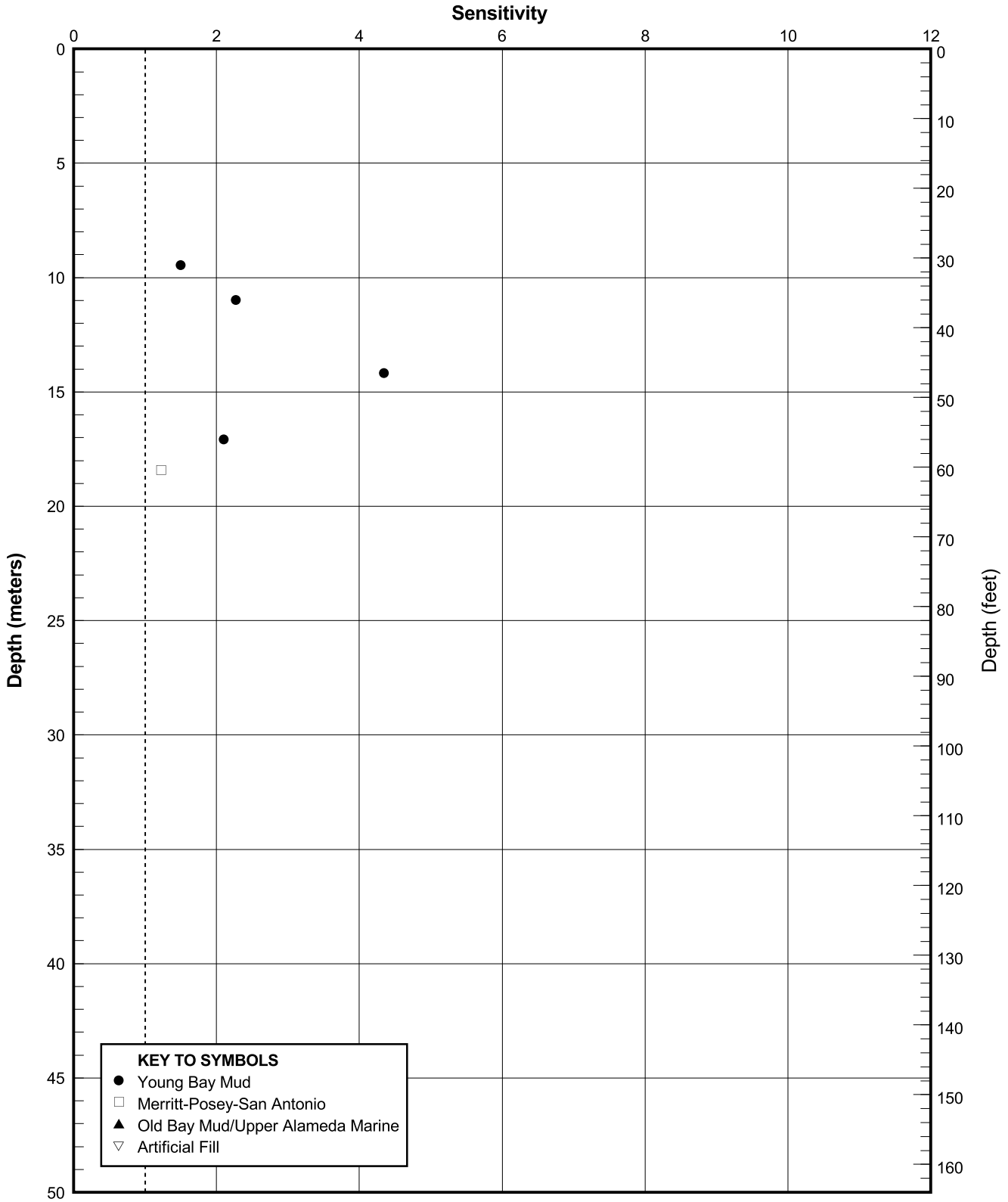
PLASTICITY INDEX PROFILE
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.12



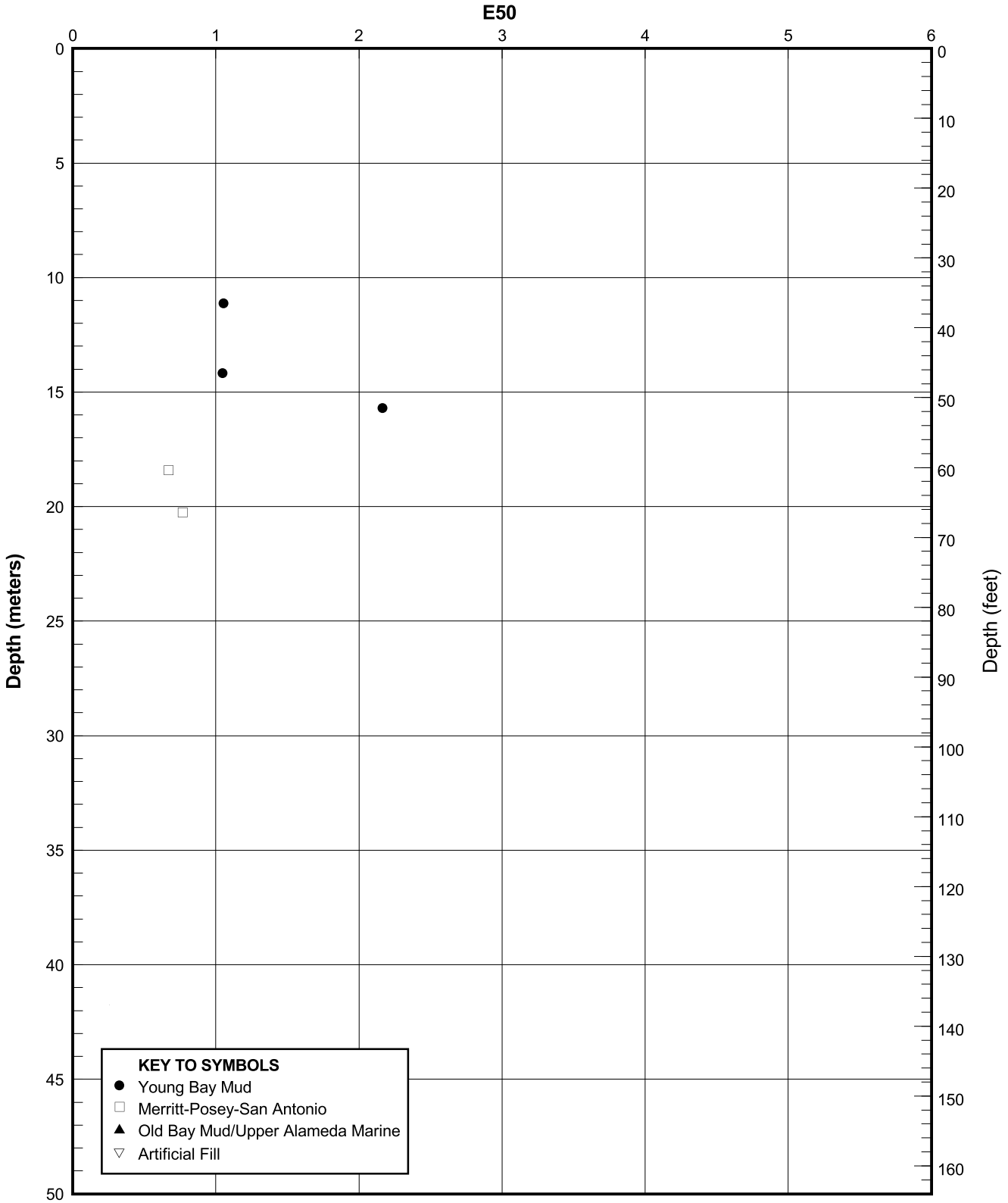
LIQUIDITY INDEX PROFILE
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.13



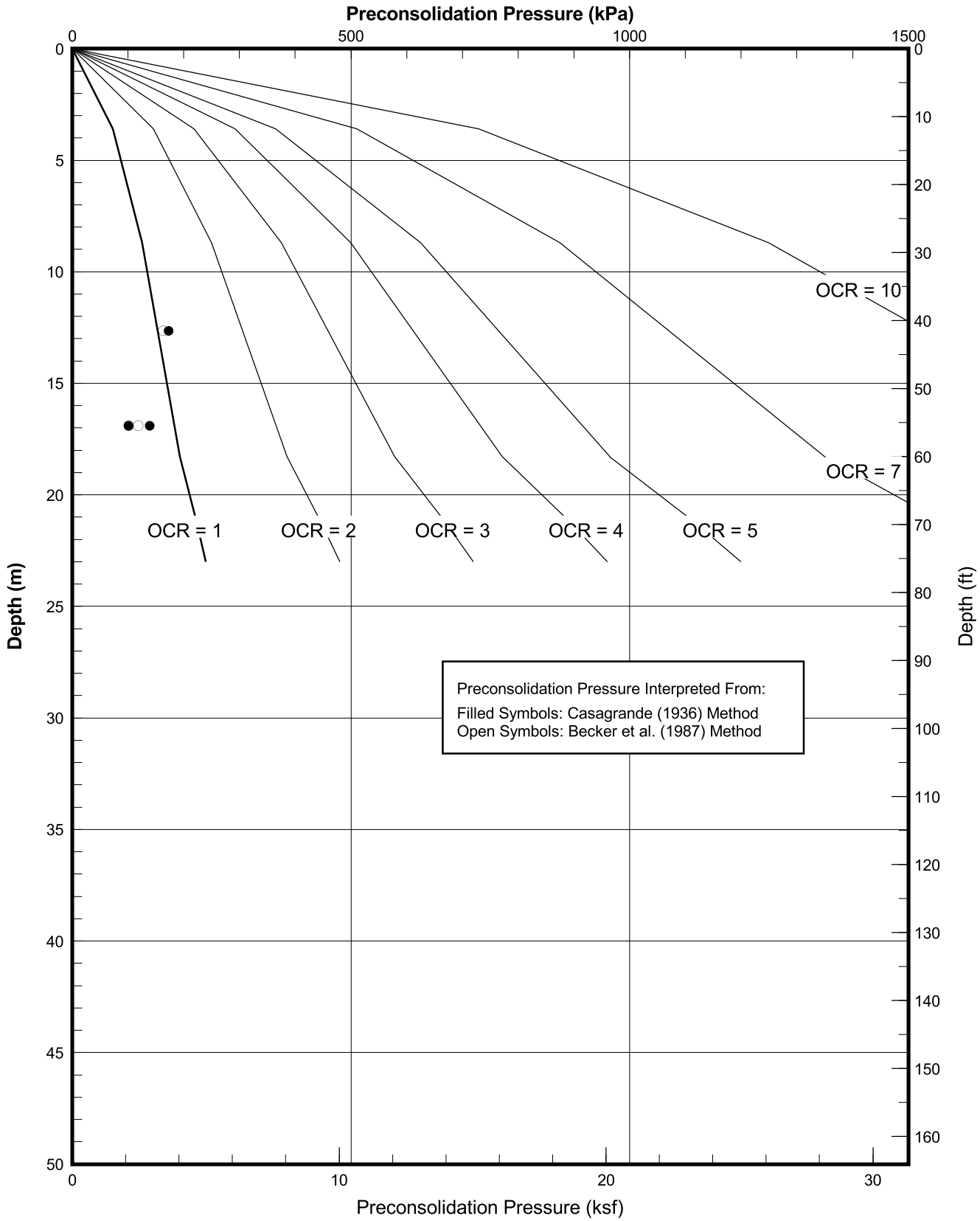
SENSITIVITY PROFILE
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.14



E50 PROFILE
Boring 98-62
SFOBB East Span Seismic Safety Project

PLATE 98-62.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-62

SFOBB East Span Seismic Safety Project

PLATE 98-62.16

LAND BORING 98-63

PROJECT NO:	98-42-0058	**START DATE:**	10/6/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-63 (5m right of W. Sta. 90+21)	**COMPLETION DATE:**	10/9/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839479 N648334
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.5m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	1				Pavement (0.5m)	I
					Fine SAND with silt (SP-SM), medium dense, yellow brown -fine sand to 1.8m -with shell fragments	
2	2			24		
				27	-with shells and clay seams, at 1.8m	
1	3					
				27	-olive gray below 3.0m ▽ (3.5m)	
0	4					II
-1	5			35		
-2	6			34	-with clay pockets and shell fragments, at 6.1m	
-3	7				(7.6m)	
-4	8			3	Fat CLAY (CH), firm, olive gray -lean clay to 9.8m -with shell fragments -with silt pockets to 11.3m	
-5	9					
-6	10			WOH		
-7	11			PUSH	-with an H2S odor, silt pockets and gas blisters, at 11.0m	III
-8	12					
-9	13			SAVE	-with many sand pockets at 12.8m	
-10	14			5	-sand pockets and seams, at 13.7m -clayey sand, 13.9m to 14.2m	
-11	15				(15.2m)	
-12	16			20	Fat CLAY (CH), stiff, greenish gray -greenish gray with organic pockets and silt pockets, at 15.5m	
-13	17			39	-dense, greenish gray, silty fine sand with many clay pockets and seams, below 16.8m	IV
-14	18				(18.3m)	
-15	19			PUSH	Fat CLAY (CH), stiff to very stiff, greenish gray to gray -with calcareous nodules, sand pockets and seams, at 18.3m	
-16	20			SAVE	-with a few silt pockets at 20.1m	V
-17	21					
-18	22			PUSH	-with black organic pockets, silt pockets and partings and sand pockets, at 21.6m	
-19	23			PUSH	-with desiccated pockets and calcareous nodules, at 23.2m	
-20	24				TOTAL DEPTH: 23.5m BACKFILLED WITH: Cement Grout	
-21						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-63.1

LOG OF BORING AND TEST RESULTS

BORING 98-63

SFOBB East Span Seismic Safety Project

Report Date: 03/09/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-63		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				CORROSIVITY TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	
1.7	1	8					6																					H
2.1	2	6																										
3.4	3	23					7																					H
4.9	4	21																										
6.2	5	25					11																					H
6.4	6					20.4														24.4	41							
7.9	9	50	42	22	1.35	17.8																						C
9.4	12					17.8																						
9.6	13	41	43	25	0.86			33.5				20.0																
10.8	14																							653	9.13	4000	290	
11.0	15											22.1																
11.1	16	44	56	26	0.61	17.1		43.1							35.7		1.2											
12.7	18	31	42	18	0.53																							C
12.8	19										51.4		23.4															
13.9	20	25	24	16	1.10		36																					

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-63		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				CORROSIVITY TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	
14.0	21					19.2																						
15.4	23	47	60	24	0.64																							
15.5	24	47	56	25	0.72	17.0					63.5	37.9	32.9															
17.2	26	21					15																					H
18.6	28	27	53	19	0.21	19.6		59.9	95.8		147.3					93.6												
18.7	29							105.3	83.8																			
20.4	30	22	42	17	0.18																							C
20.4	31							102.9	83.8		144.8																	
21.6	32	44									117.6																	
21.8	33	33	48	18	0.50	18.6					91.6				63.5		0.9											
21.9	34							64.6																				
23.2	35							126.9	167.6																			
23.3	36	25	55	17	0.20	19.9										58.0												

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

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Corrosivity Tests
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Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
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Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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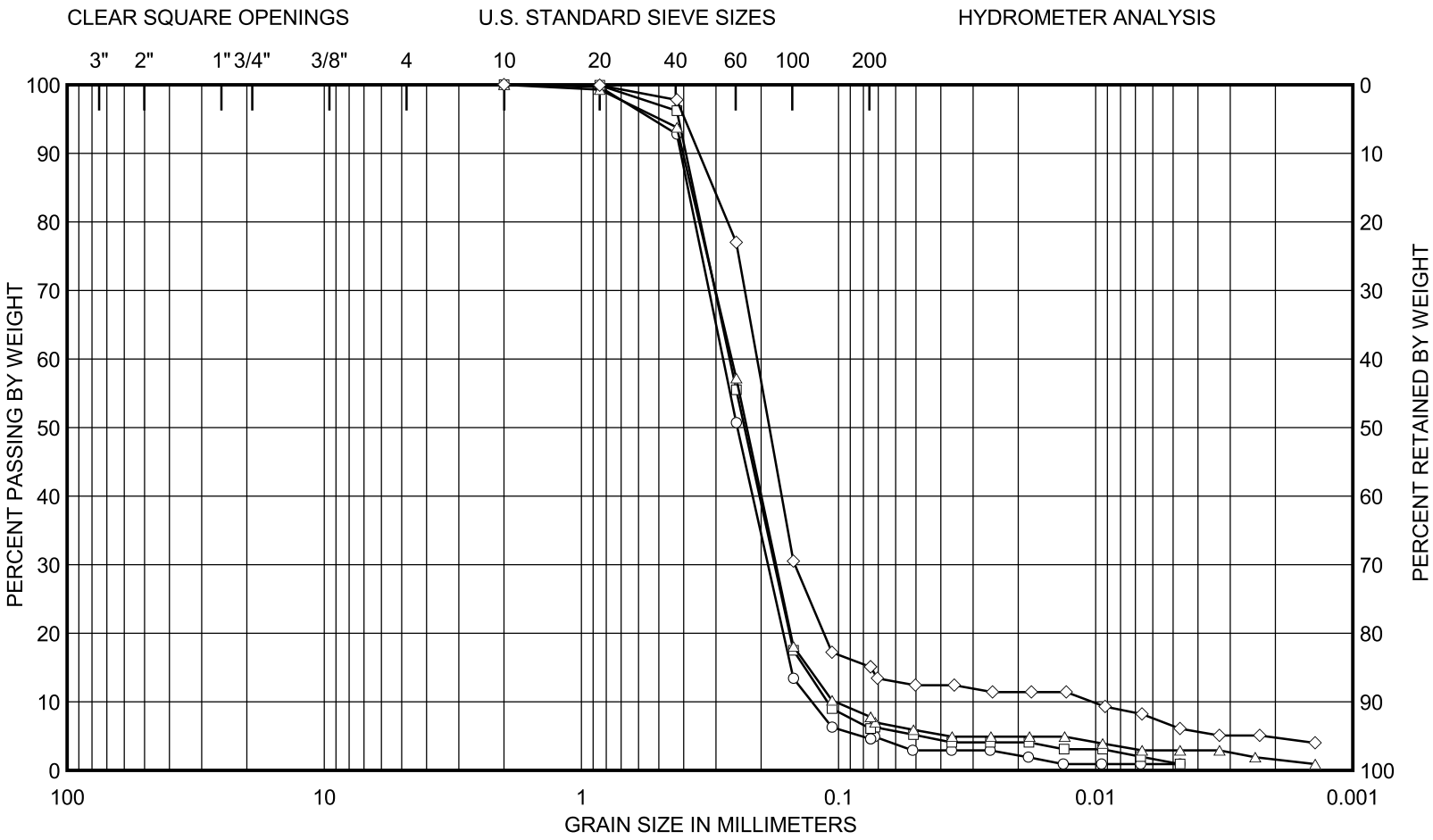

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.7	○—○	FINE SAND (SP)	1.0	2.2	0.25
3	3.4	□—□	FINE SAND (SP-SM) with silt	1.1	2.4	0.23
5	6.2	△—△	FINE SAND (SP-SM) with silt	1.1	2.5	0.23
26	17.2	◇—◇	SILTY FINE SAND (SM)			0.19

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-63
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-63.4

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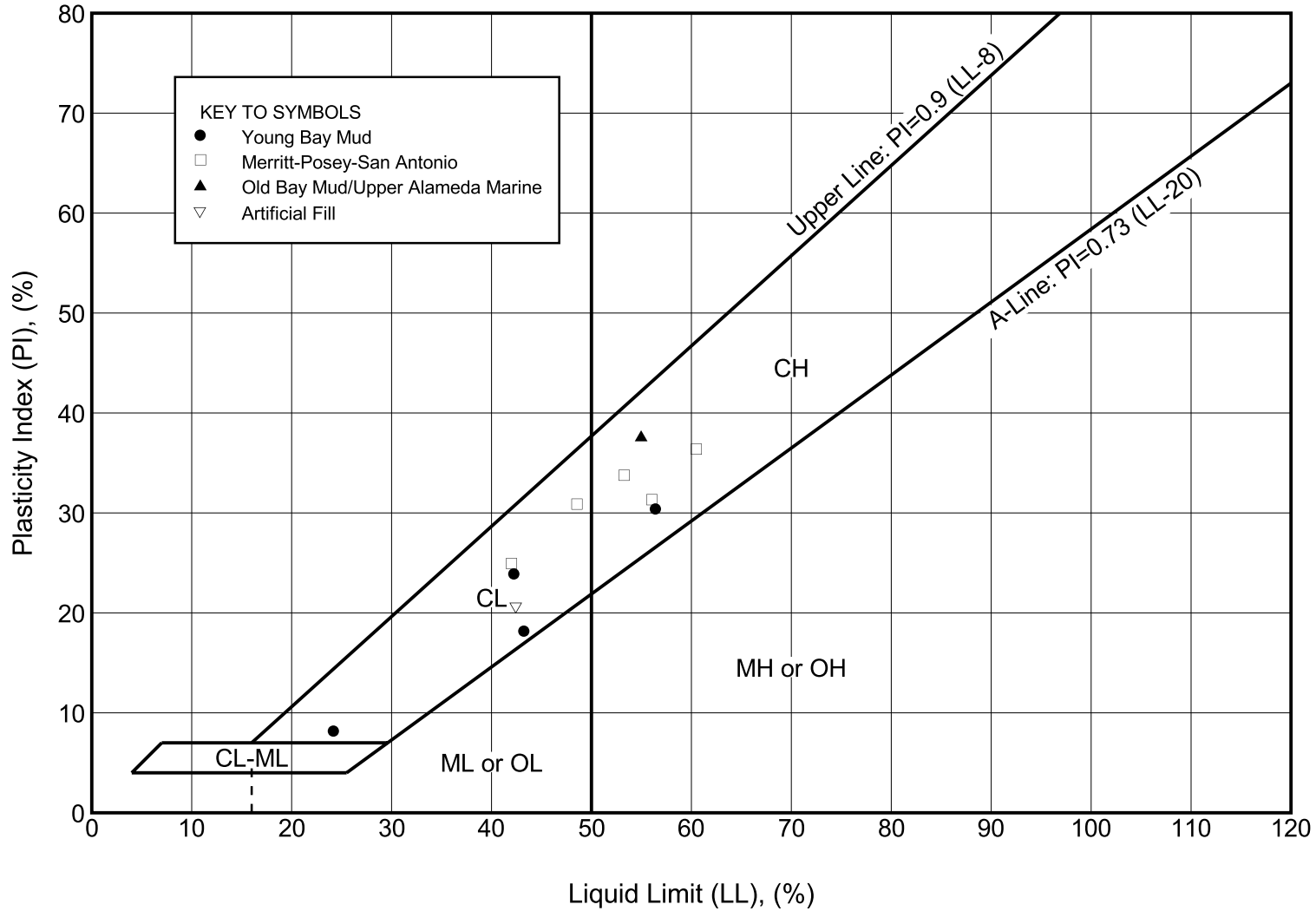

PLASTICITY CHART
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.5

Earth Mechanics

FUGRO

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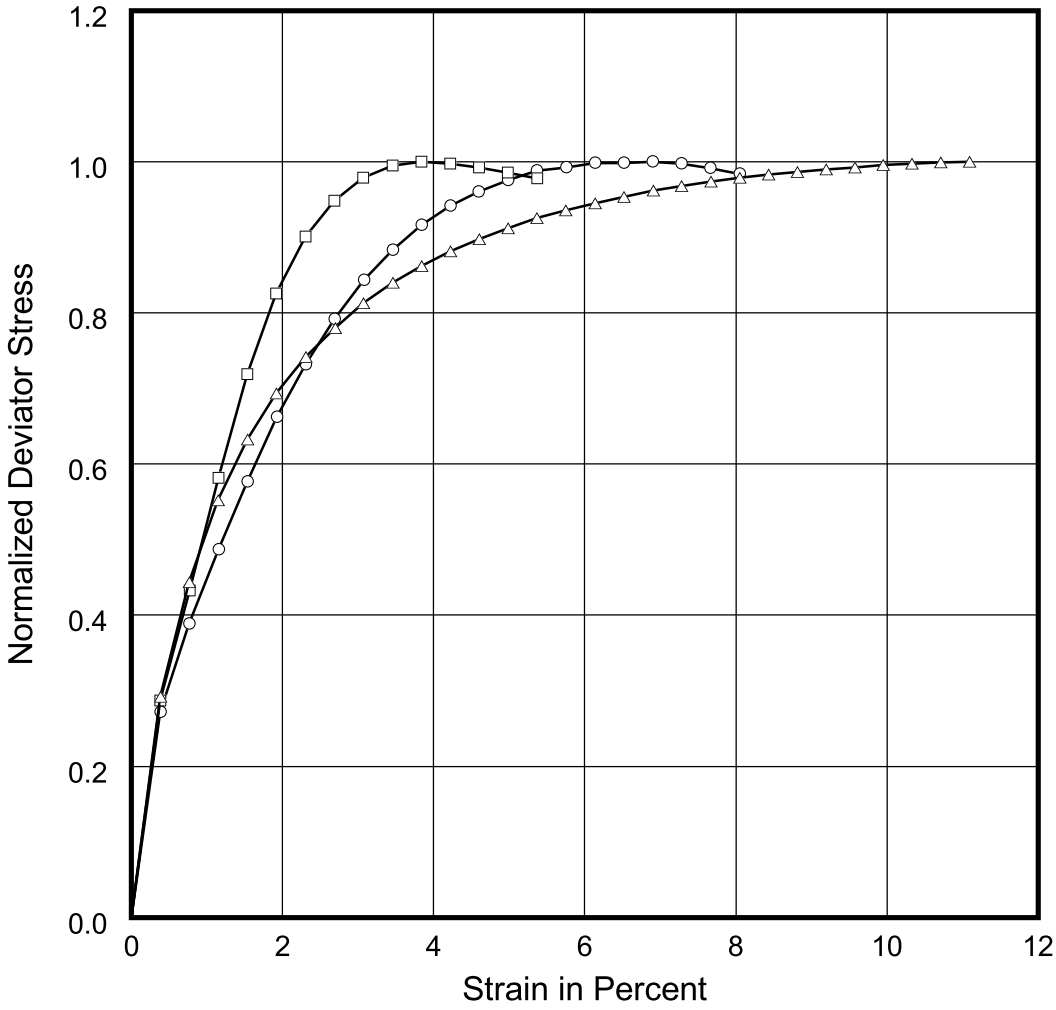


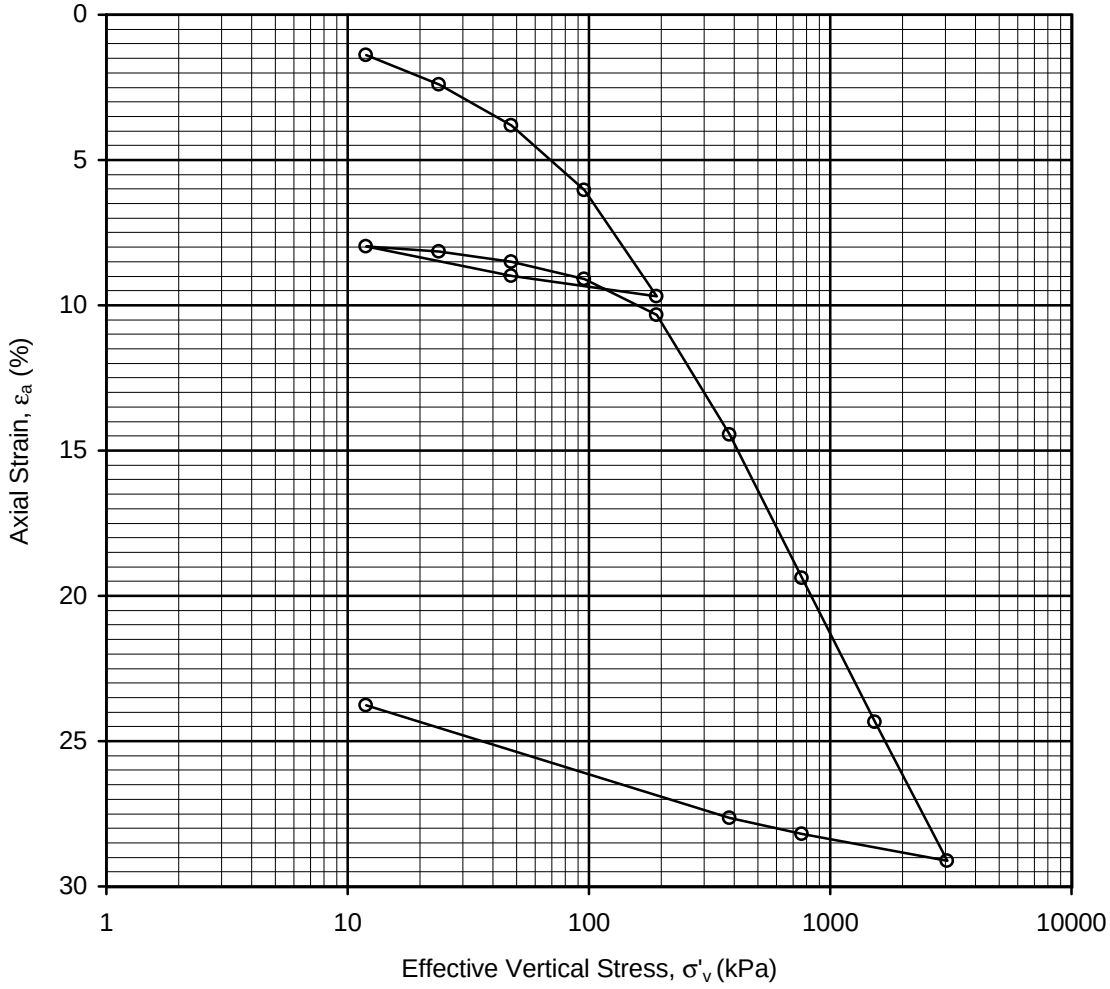
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	16	11.1	UU	207	71	1.2
□—□	33	21.8	UU	827	127	0.9
△—△	36	23.3	UU	862	150	0.9

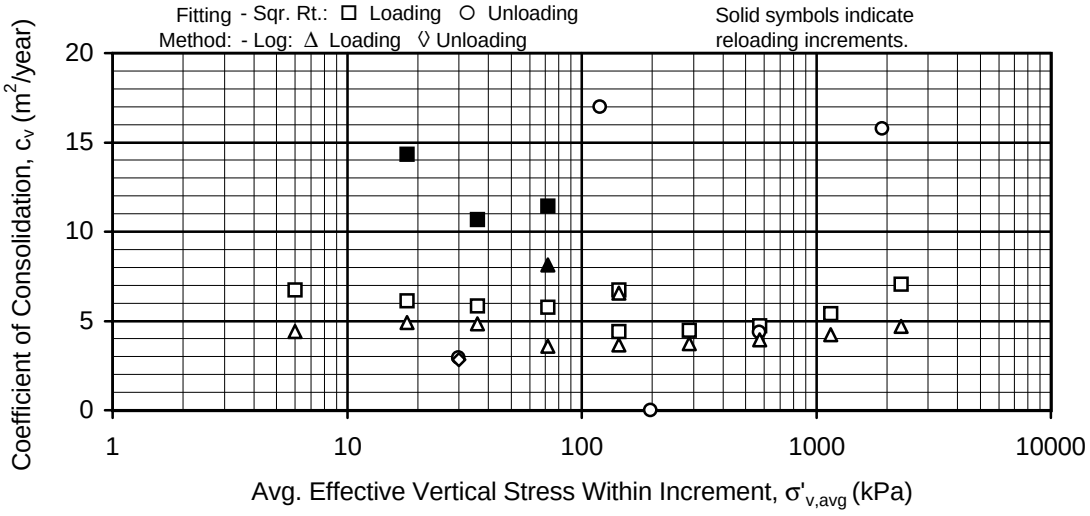
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.6

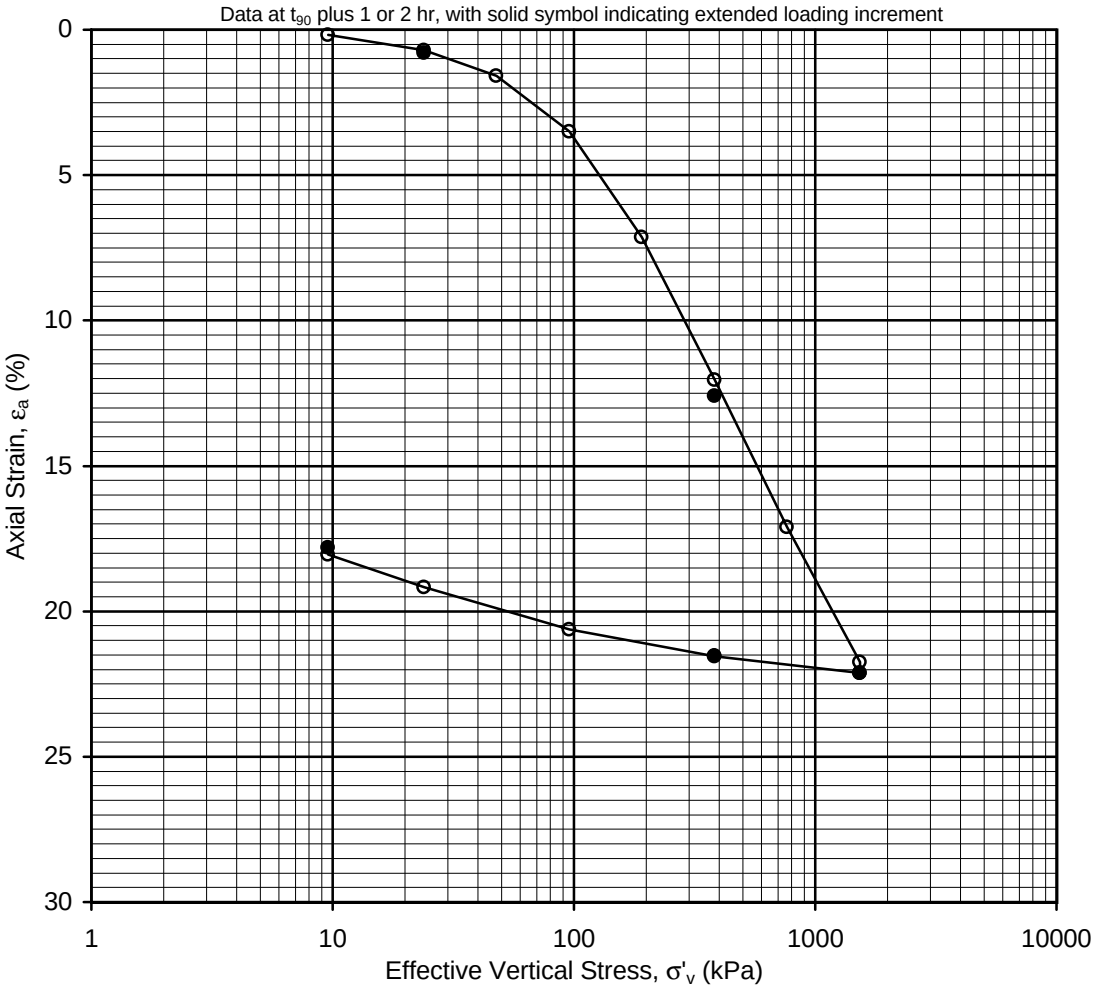


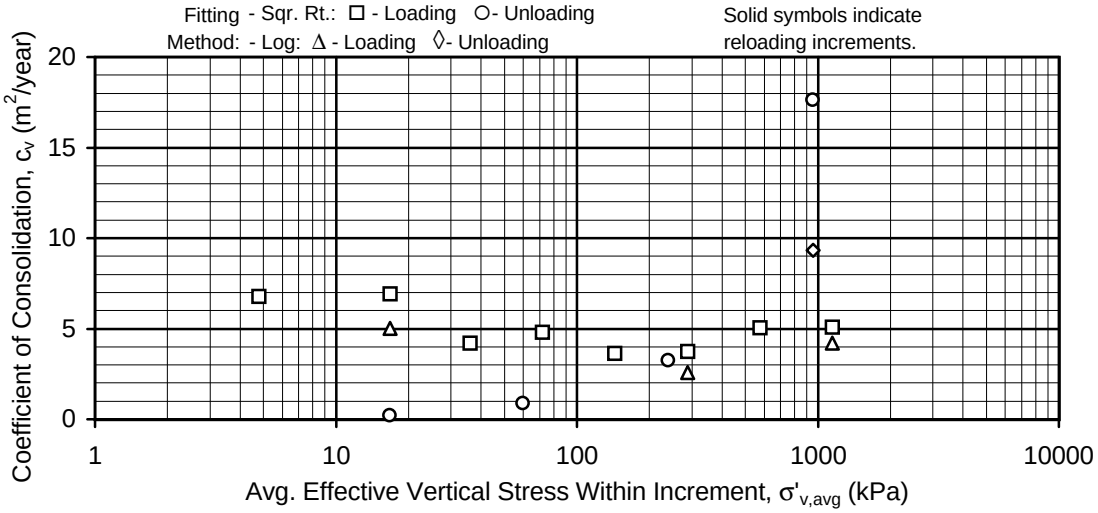


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 9 - Penetration: 7.9m
Boring 98-63
SFOBB East Span Seismic Safety Project

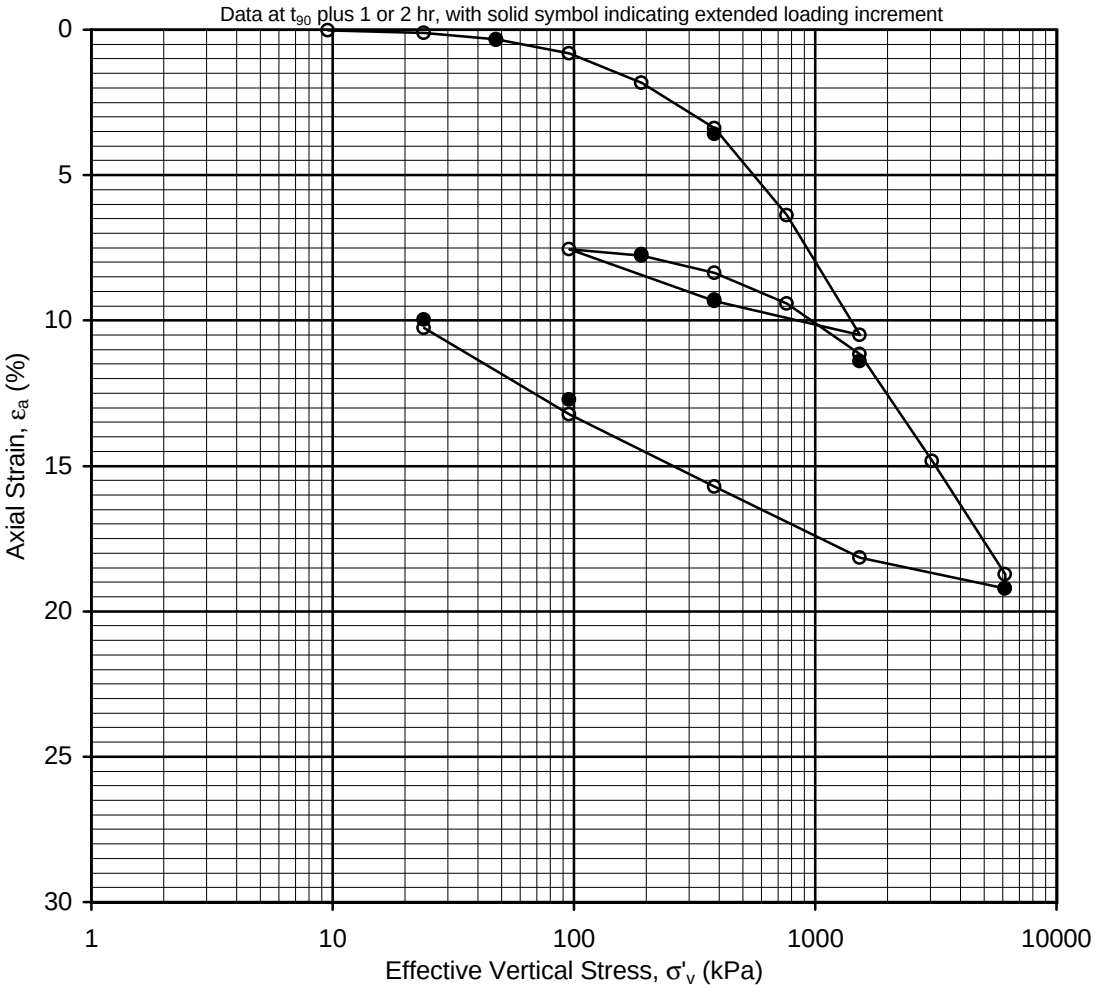
PLATE 98-63.7a

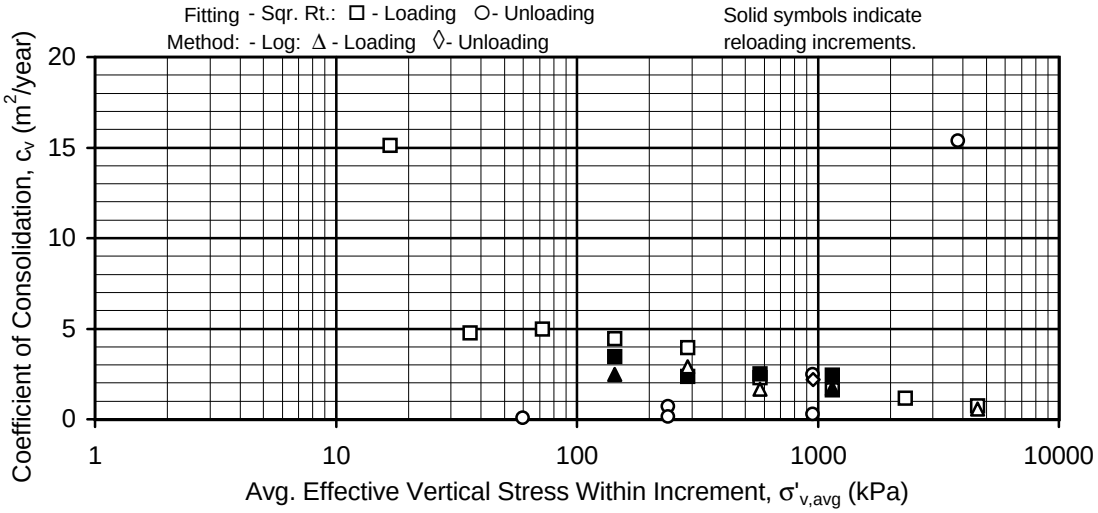




INCREMENTAL CONSOLIDATION TEST RESULTS

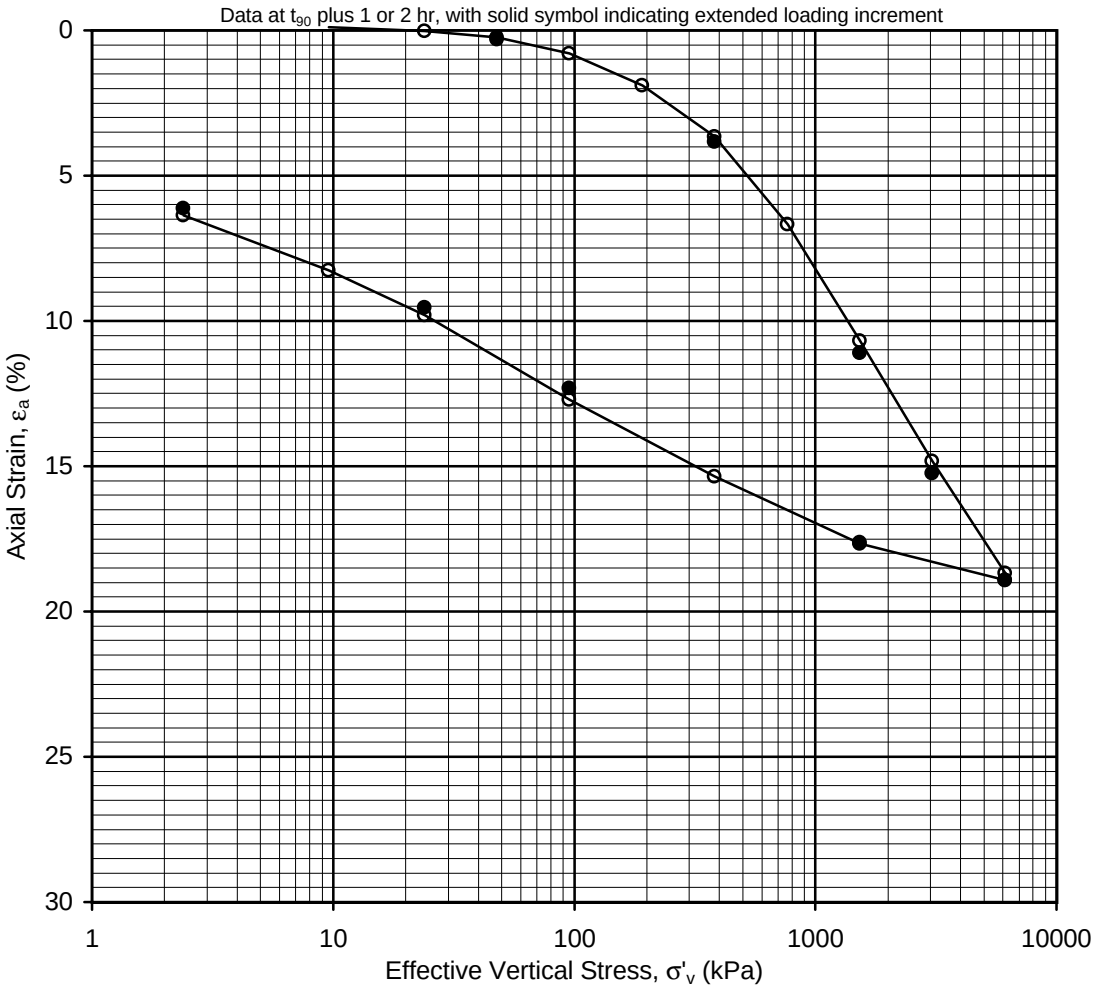
Sample No. 18 - Depth: 12.7m
Boring 98-63
SFOBB East Span Seismic Safety Project

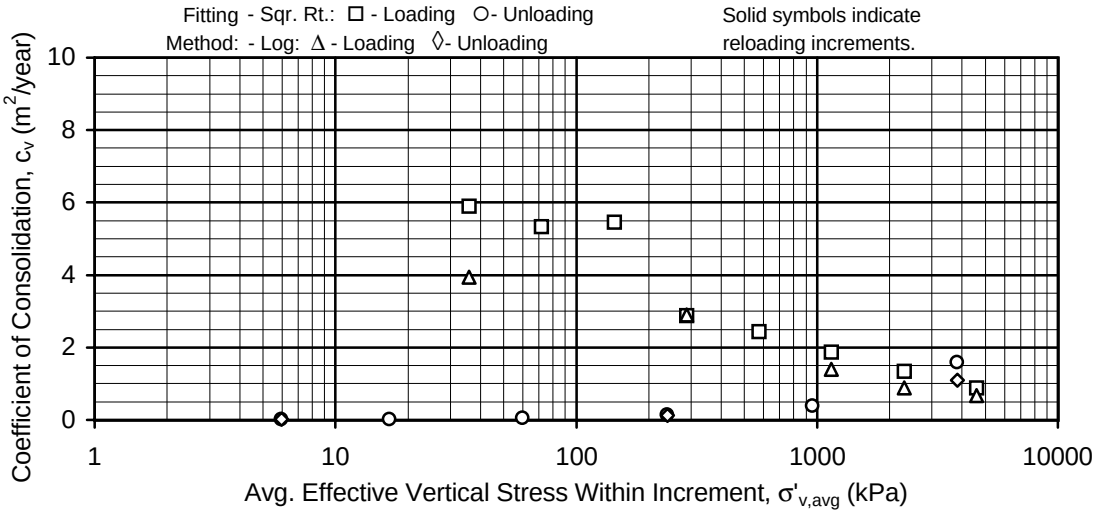




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 30 RT - Depth: 20.2m
Boring 98-63
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 30 - Depth: 20.3m
Boring 98-63
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

No R-Value Laboratory Testing Performed For This Boring

Health Science Associates

LABORATORY REPORT

Report Number : 991057
Purchase Order :
Job No. : 98-42-0057

GREG DENLINGER
FUGRO WEST INC.
5855 OLIVAS PARK DR.
VENTURA, CA. 93003-7672

Date Received : 13-NOV-98
Date Completed : 19-NOV-98
Date Sent : 19-NOV-98
Page / 1 of 1

Sample Description : 4 - Bulk Soils
Project : Oakland

California Test Methods : 532,643

Auto No.	Submitter Sample Number	Resistivity ohms/cm	pH Units	Chloride ppm	Sulfate ppm
174124	98-63-14 @ 35.5'	653	9.13	4000	290
174125	98-72-300 @ 1.5'	399	12.11	<1.0	24.0
174126	98-66-300 @ 1.5'	327	12.17	<1.0	160
174127	98-61-1 @ 5'	762	9.17	720	630
Detection Limit :		10	NA	1.0	1.0

Milliliters Water Added	50	100	150	200	250	300	350
	Resistivity Ohm-cm						
Sample No.							
98-63-14	1525	1162	908	762	653	653	690
98-73-300	1343	762	472	399	581	1416	-
98-66-300	581	363	327	363	544	-	-
98-61-1	1198	908	762	1161	1089	-	-

Remarks : Sample(s) and sampling data as provided : by :

Analyst(s) : ED

Ref :

California ELAP No.: 1406
AIHA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AIHA ELLAP Accreditation No.: 10985
LACSD Lab No.: 10125

Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Susan Rosenberg
Laboratory Director, Susan B. Rosenberg, CIH

PLATE 98-63.11

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

This report pertains only to the samples investigated and does not necessarily apply to other apparently identical or similar materials. This report is submitted for the exclusive use of the client to whom it is addressed. Any reproduction of this report or use of this Laboratory's name for advertising or publicity purposes without written authorization is prohibited.

Earth Mechanics

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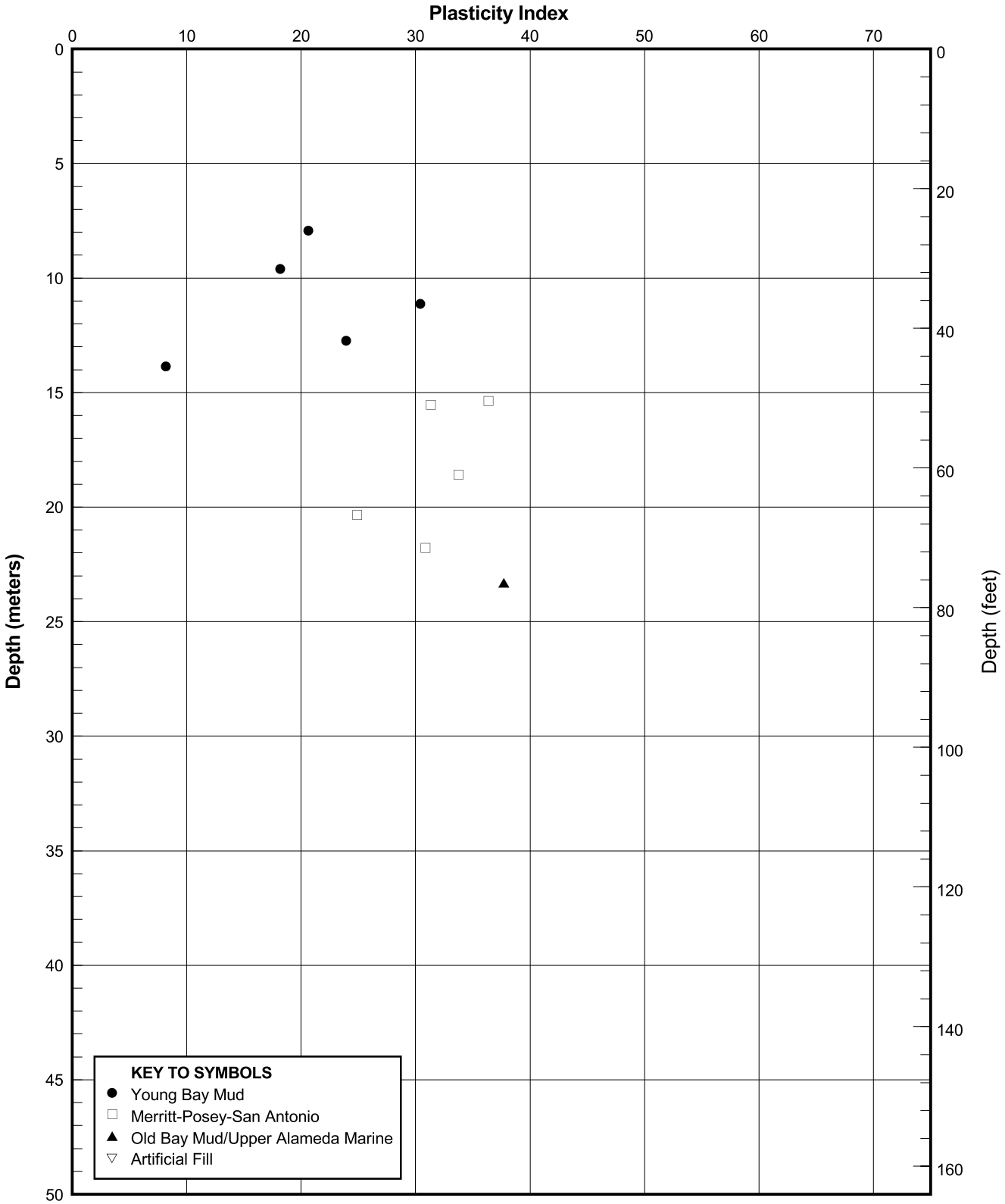
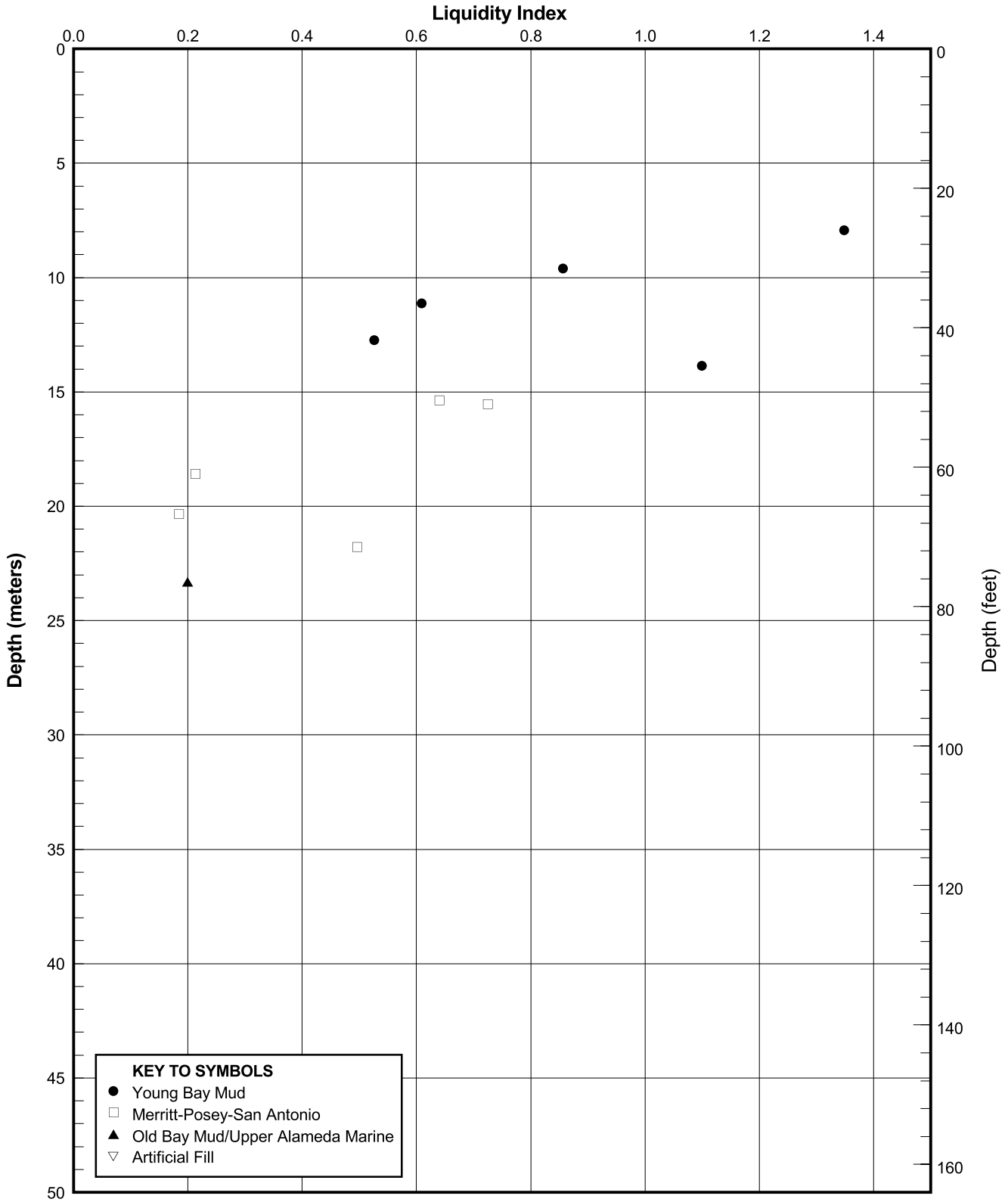


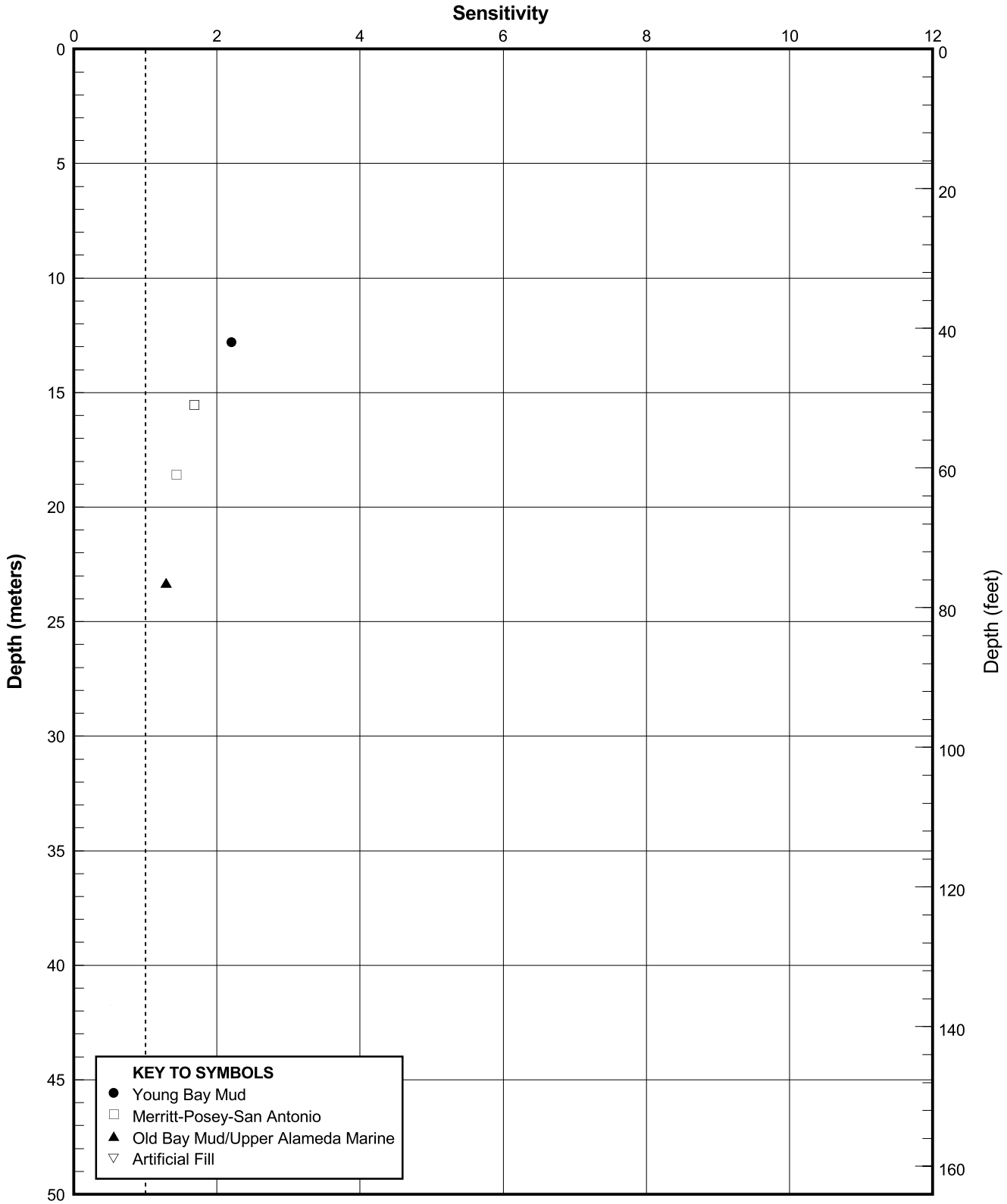
PLASTICITY INDEX PROFILE
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.12



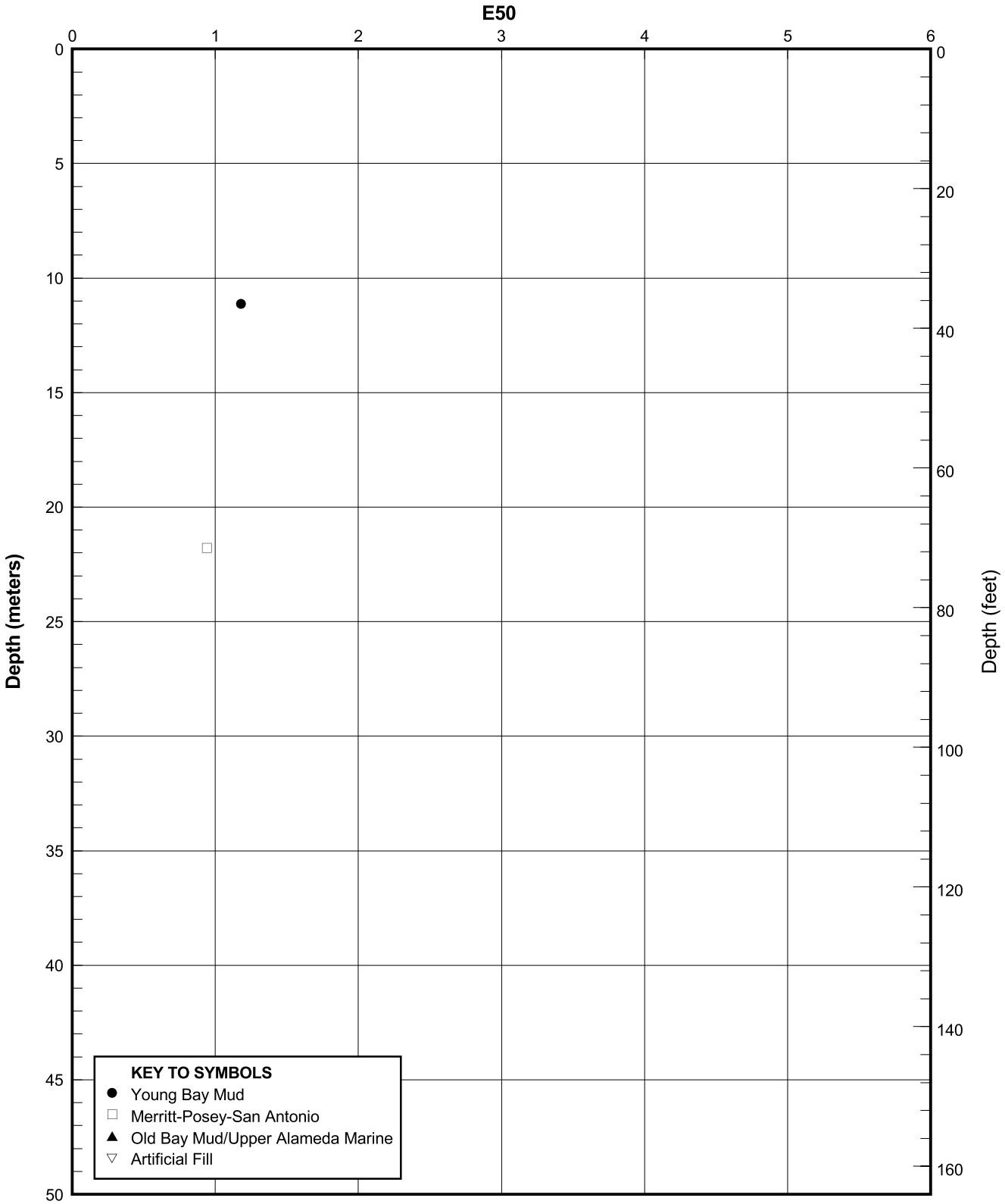
LIQUIDITY INDEX PROFILE
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.13



SENSITIVITY PROFILE
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.14

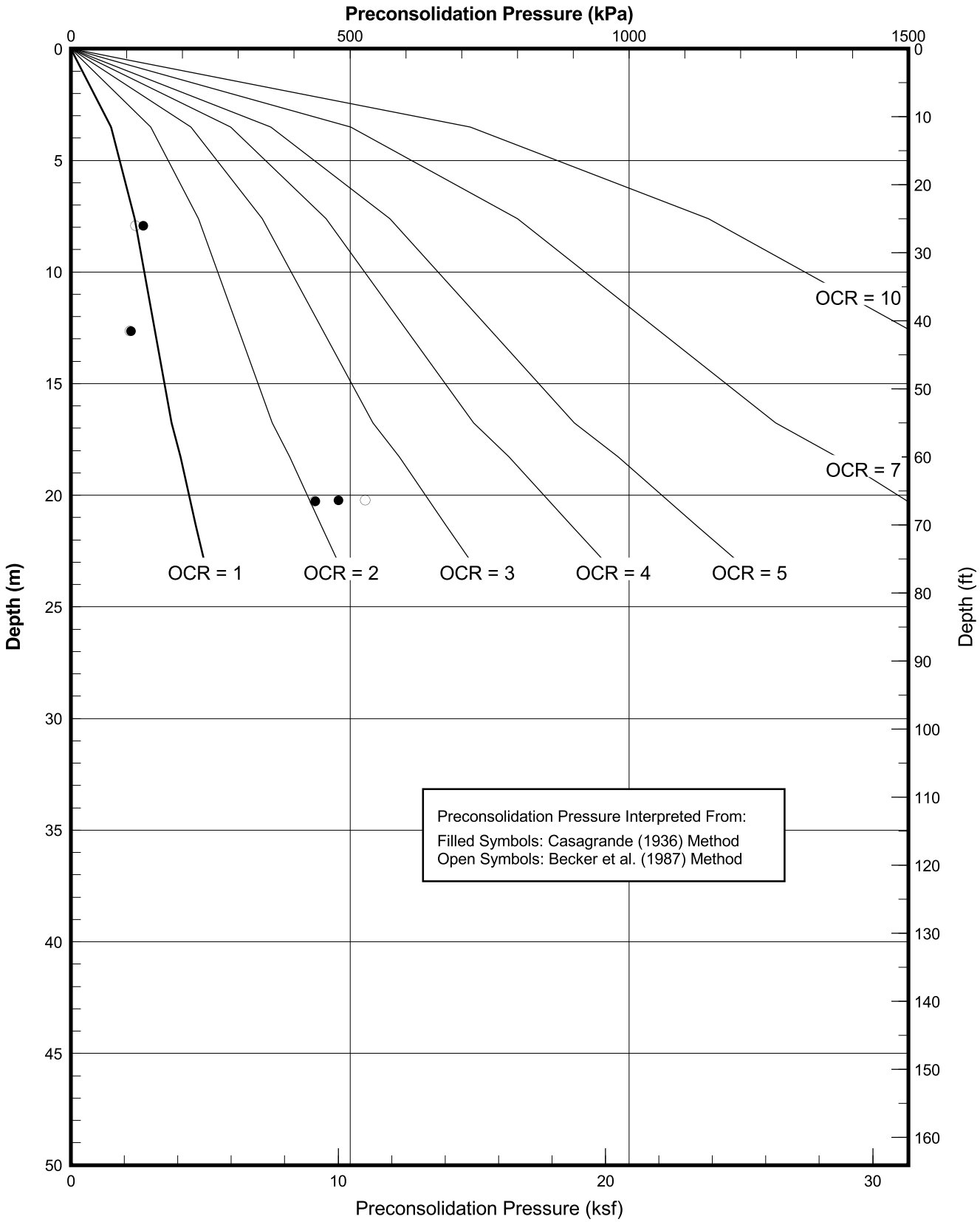


E50 PROFILE
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.15

Earth Mechanics

FUGRO

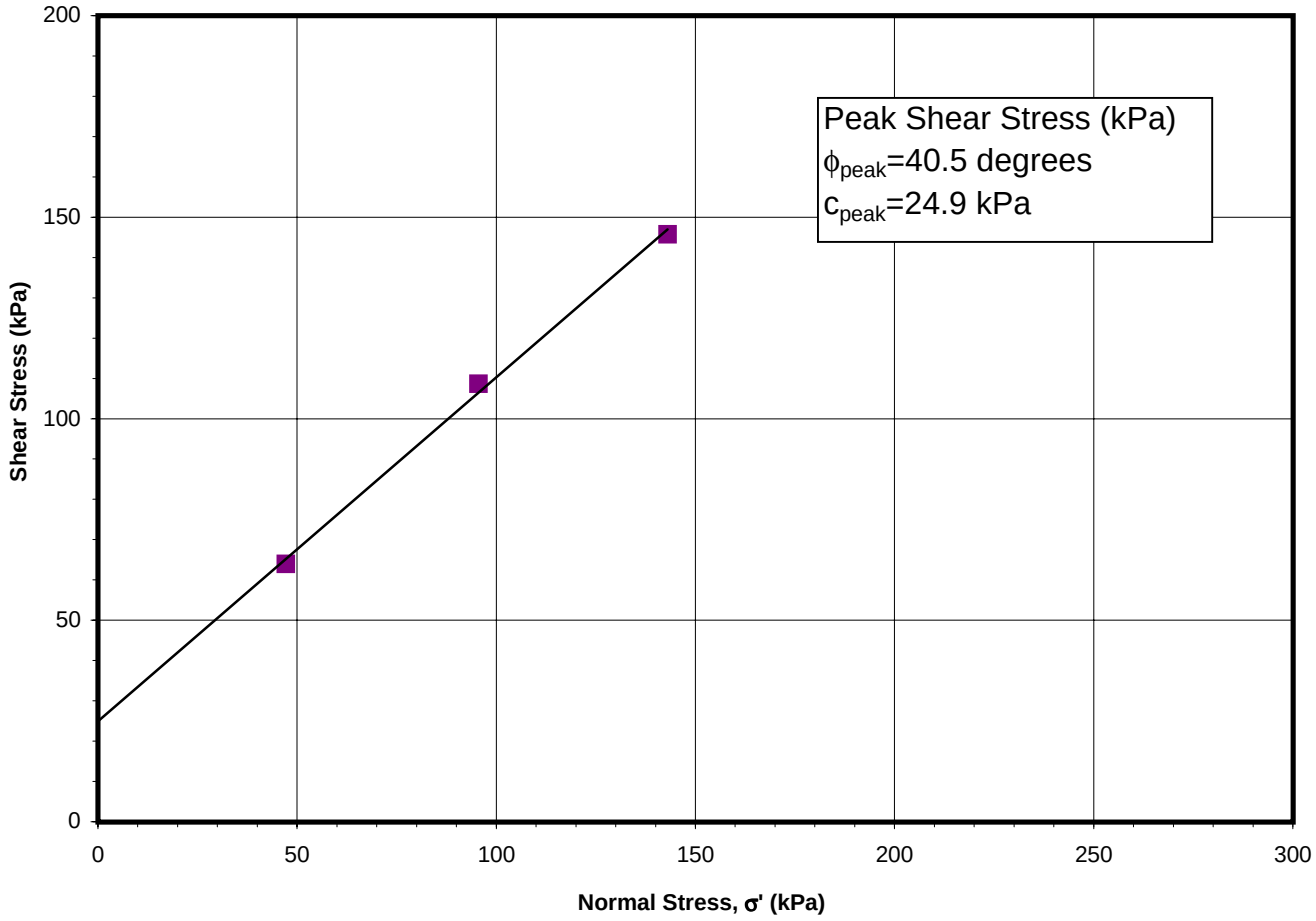


PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-63

SFOBB East Span Seismic Safety Project

PLATE 98-63.16



Direct Shear Test
Sample 6 - Depth: 6.4m
Boring 98-63
SFOBB East Span Seismic Safety Project

PLATE 98-63.17

LAND BORING 98-64

PROJECT NO:	98-42-0058	**START DATE:**	10/6/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-64 (2m left of W. Sta. 91+50)	**COMPLETION DATE:**	10/7/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839605 N648362
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.5m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	1				Pavement (0.5m)	I
				37	GRAVEL with silt (GW-GM), dense, brown (0.9m)	II
2	2			19	Fine SAND with silt (SP-SM), loose to medium dense, brown -with clayey sand pockets, to 2.0m	
1				10		
0	3			11	-with shell fragments at 3.0m -olive gray below 3.4m ▽ (3.5m)	III
-1	4			7	-with shell fragments, at 4.6m	
-2	5			16	(7.2m)	
-3	6				Fat CLAY (CH), firm to stiff, olive gray to gray -with shell fragments and silt pockets -lean clay to 11.6m	IV
-4	7			5		
-5	8					
-6	9			PUSH		
-7	10				-with an H2S odor, 10.7m to 12.8m	
-8	11			SAVE	-with sand pockets and seams, at 10.7m	
-9	12			PUSH		
-10	13					
-11	14			PUSH		
-12	15				(15.1m)	
-13	16			34	Fat CLAY (CH), stiff to very stiff, greenish gray -dense, greenish gray silty sand layer with clay pockets and seams and an H2S odor, to 15.5m	V
-14	17			12	-sand layer, 16.5m to 17.1m -with sandy lean clay at 17.2m	
-15	18			PUSH	-with gas blisters, sand pockets, and calcareous nodules, at 18.6m	
-16	19					
-17	20			SAVE	-with a few shell fragments at 20.1m	
-18	21			PUSH	-olive gray with slickensides, sand pockets, gas blisters and a few organic pockets, at 21.6m	
-19	22					
-20	23			PUSH	-lean clay below 22.9m -with calcareous nodules and organic pockets, at 23.2m	
-21	24				TOTAL DEPTH: 23.5m BACKFILLED WITH: Cement Grout	

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-64.1

LOG OF BORING AND TEST RESULTS

BORING 98-64

SFOBB East Span Seismic Safety Project

Report Date: 08/25/99

Earth Mechanics

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No Remote Vane Testing Performed For This Boring

98-64		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.9	1	7																								
1.4	2	6					10																			
2.0	3	5					6																			H
3.3	4	21					4																			
5.0	5	25					9																			H
6.4	6	21					10																			
7.9	8	42	46	22	0.81	17.4					37.3	14.2														
8.1	9							28.7																		
9.4	10							50.8			58.0	18.7														
9.6	11	42	44	23	0.89	18.0									35.8		1.0									
9.8	12							45.0																		
11.2	13	29	43	21	0.36																					C, K
11.3	14	33									58.2															
12.3	15							47.9			56.8															
12.6	17	55	70	27	0.64	16.5									52.6	9.6	0.8									

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-64
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-64.3a

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98-64		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
12.8	18							44.0																		
14.0	19							41.2																		
14.2	20	53	64	26	0.70	16.6																				
15.7	24	30				18.7					189.4	68.1	65.6													
18.6	26							105.3			121.3															
18.7	27	30	76	26	0.07	19.1					92.8					41.8										
18.9	28							93.4																		
20.4	29	38	60	17	0.48																					C
20.4	30								83.8		115.1															
21.6	31							107.7																		
21.8	32	47	90	27	0.31	17.6		95.8							43.7		0.4									
21.9	33							107.7																		
23.3	36	22	43	17	0.20	20.0		107.7							74.7	52.3	1.1									
23.5	37							119.7	119.7																	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.3b

Earth Mechanics

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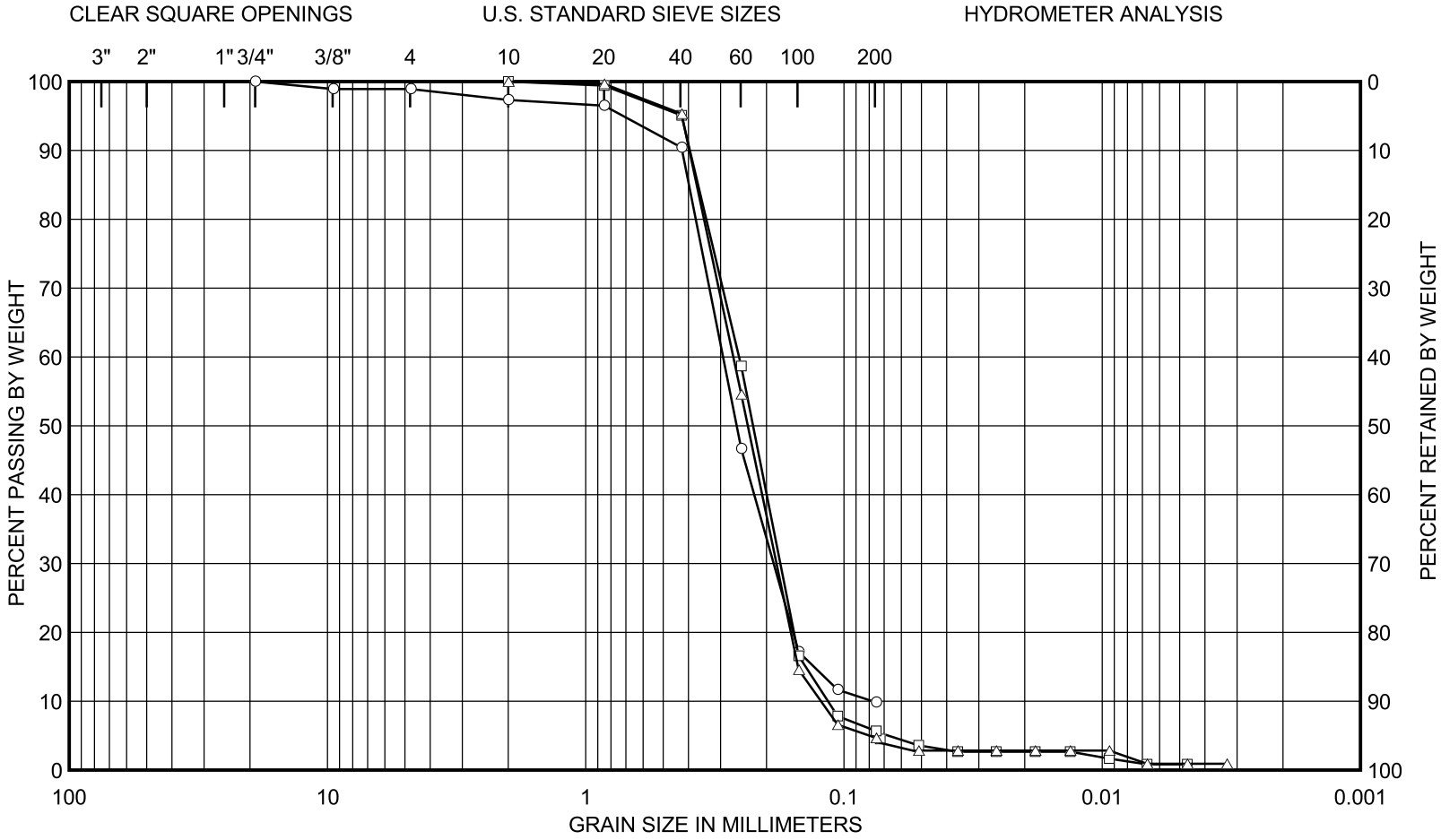

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	1.4	○—○	FINE SAND (SP-SM) with silt and a trace of medium sand	1.5	3.8	0.26
3	2.0	□—□	FINE SAND (SP-SM) with silt	1.1	2.2	0.23
5	5.0	△—△	FINE SAND (SP)	1.0	2.2	0.24

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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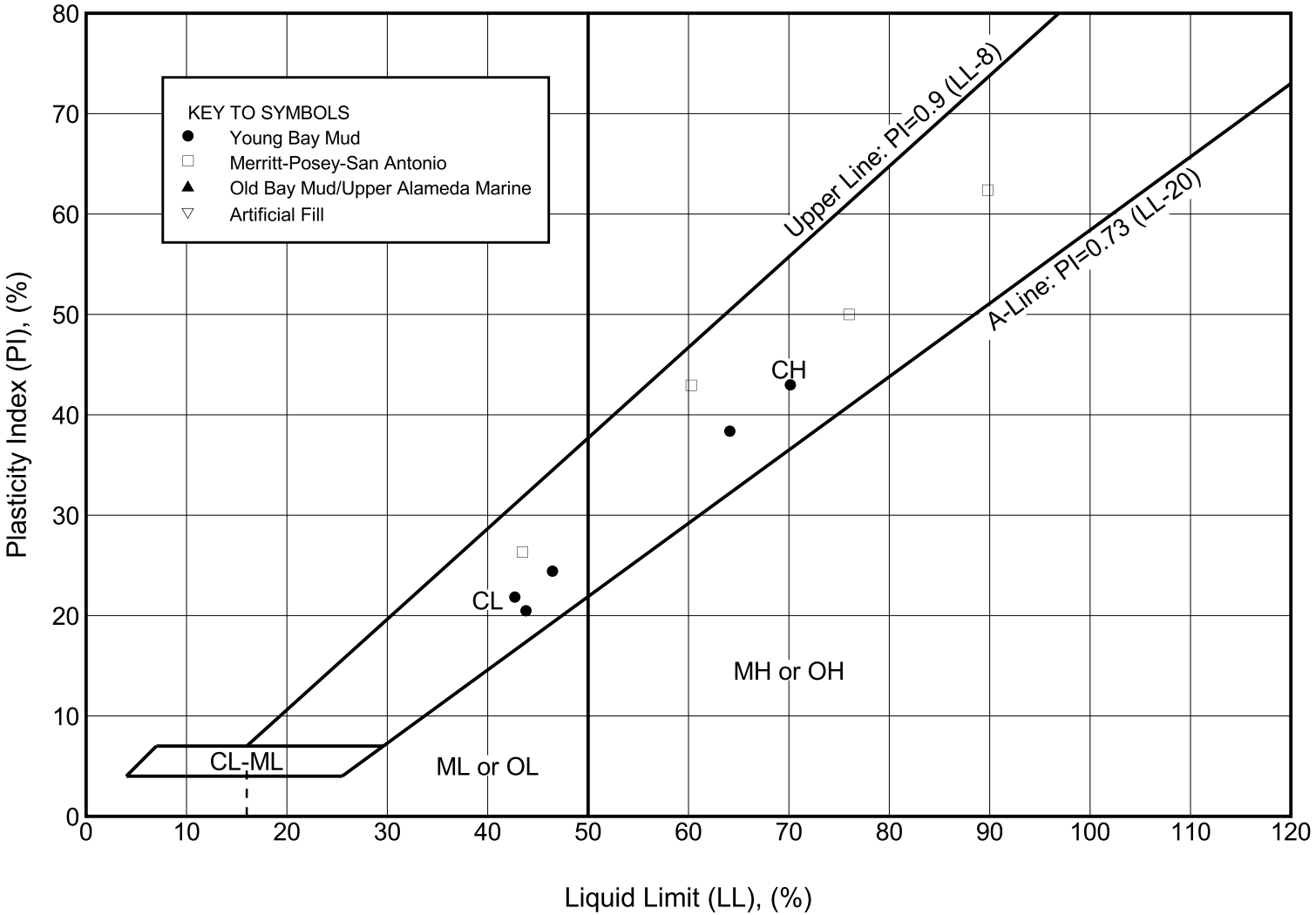
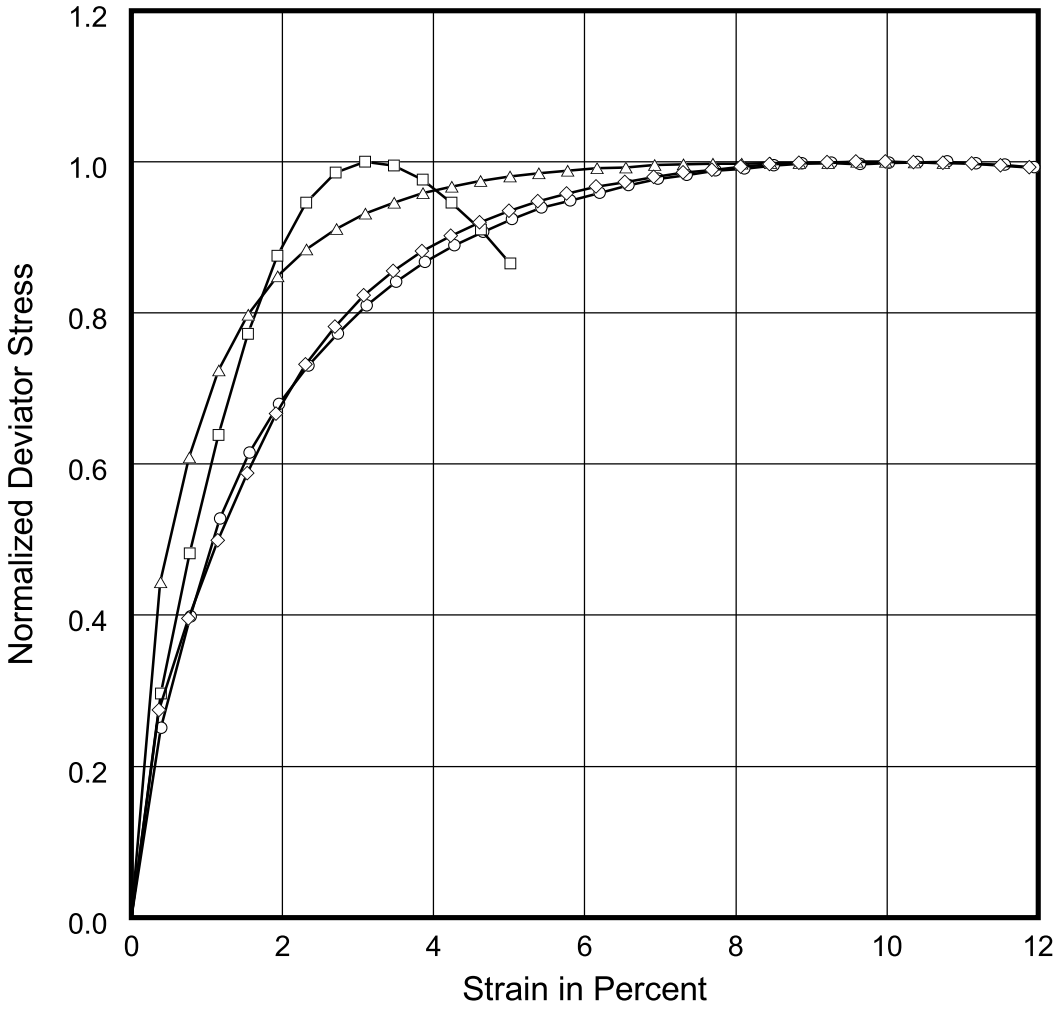


PLASTICITY CHART
Boring 98-64
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO



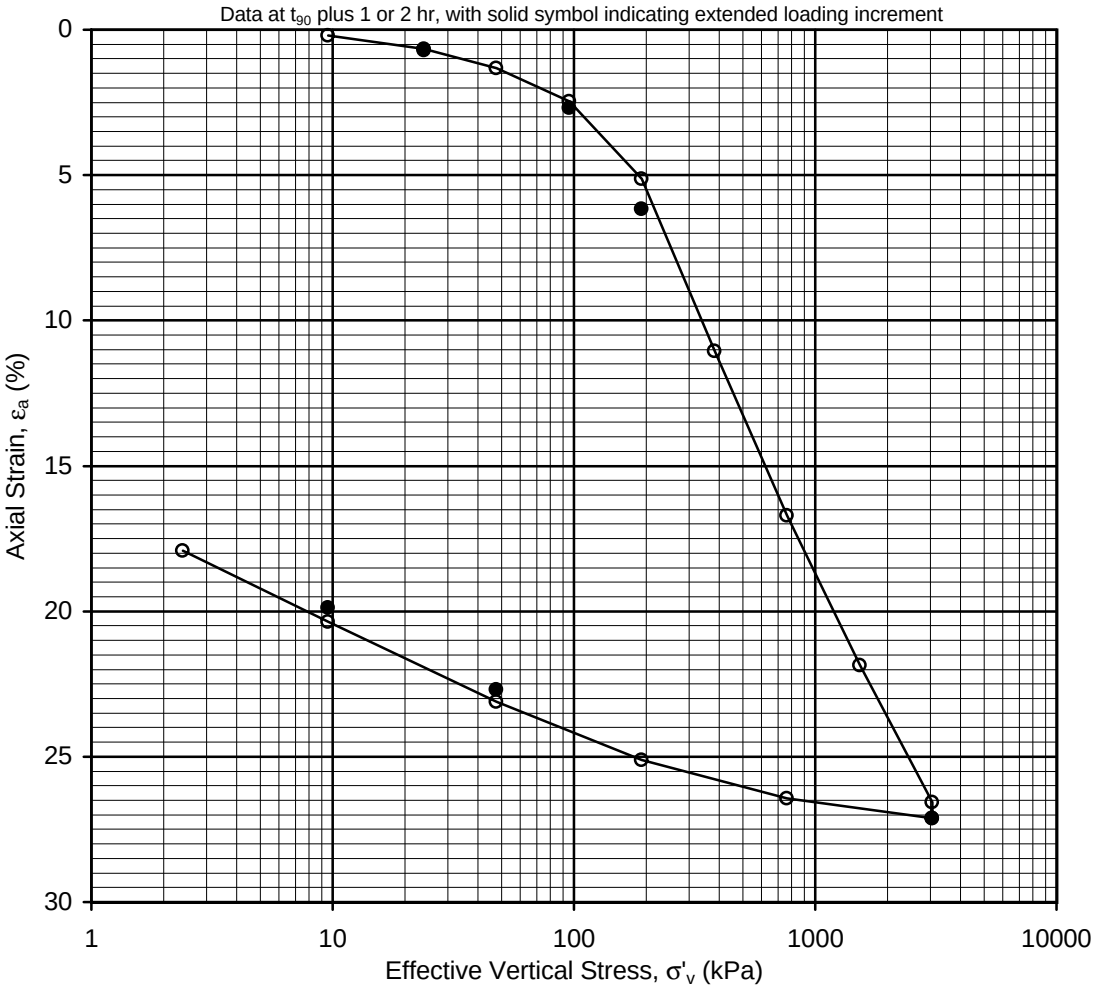
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	11	9.6	UU	207	72	1.0
□	17	12.5	UU	276	105	0.8
△	27	18.7	UU	758	129	0.5
◇	36	23.3	UU	862	149	1.1

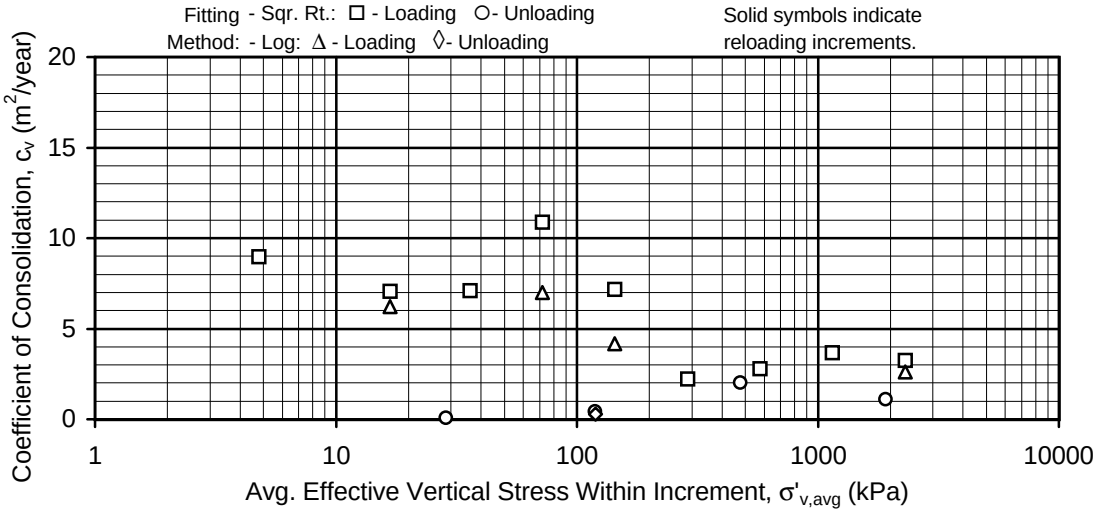
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-64
SFOBB East Span Seismic Safety Project

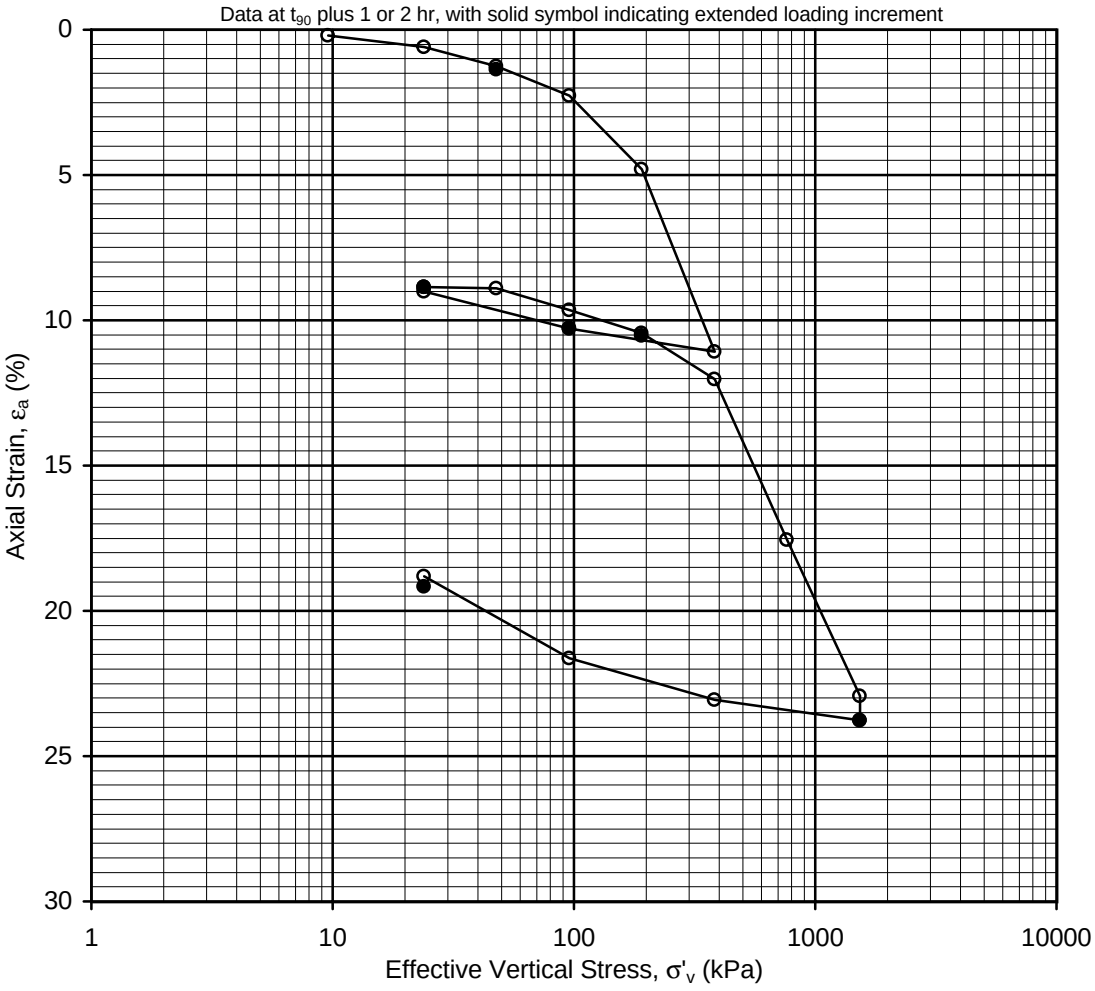
PLATE 98-64.6

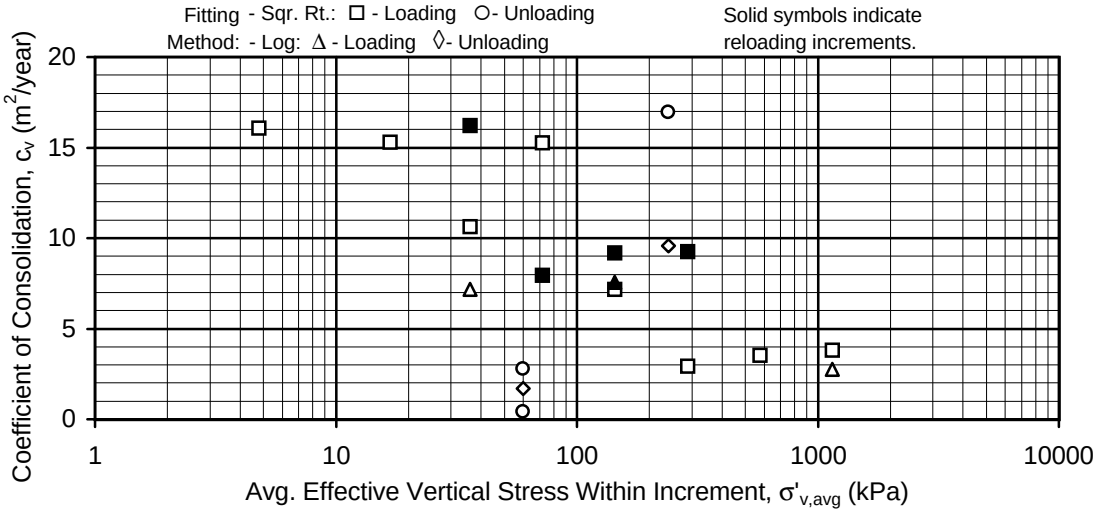




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 13 - Depth: 11.1m
Boring 98-64
SFOBB East Span Seismic Safety Project



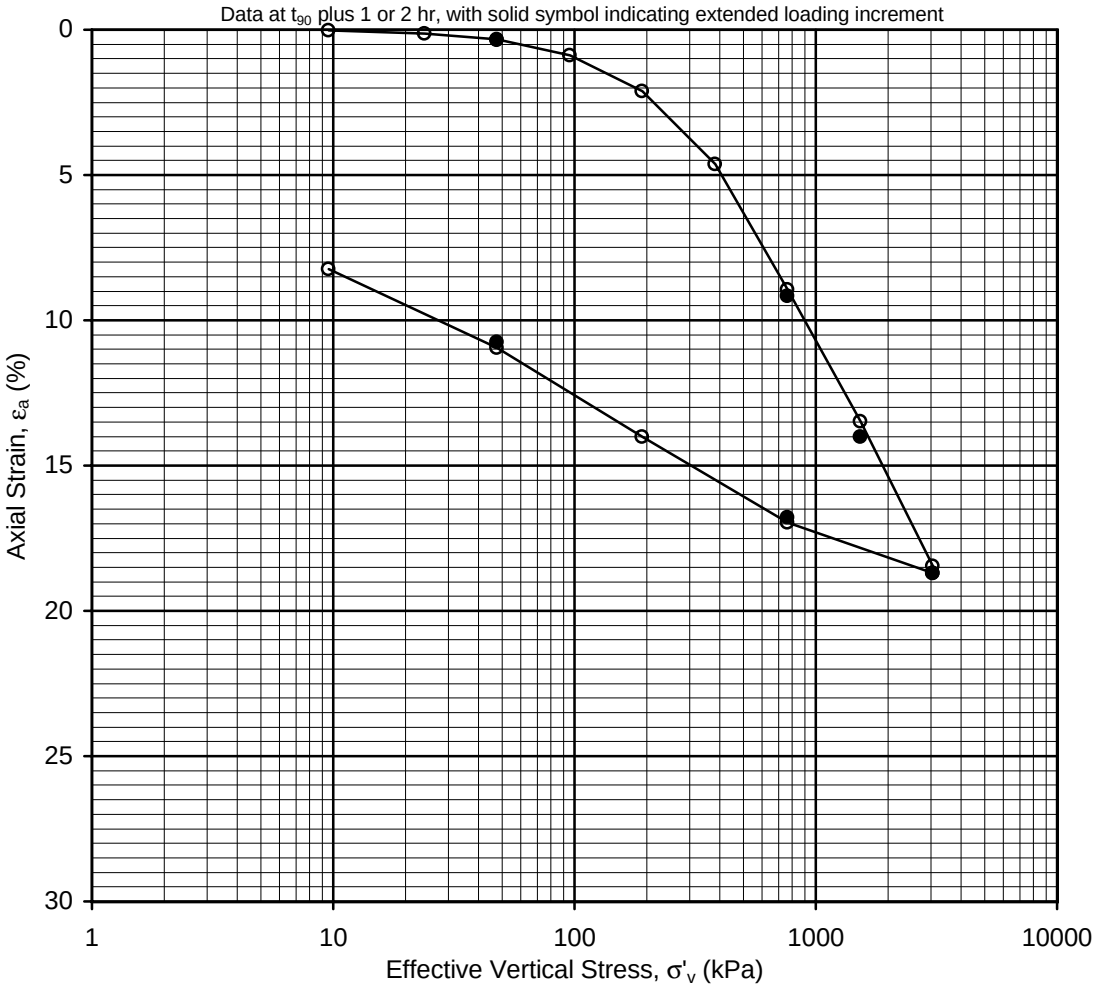


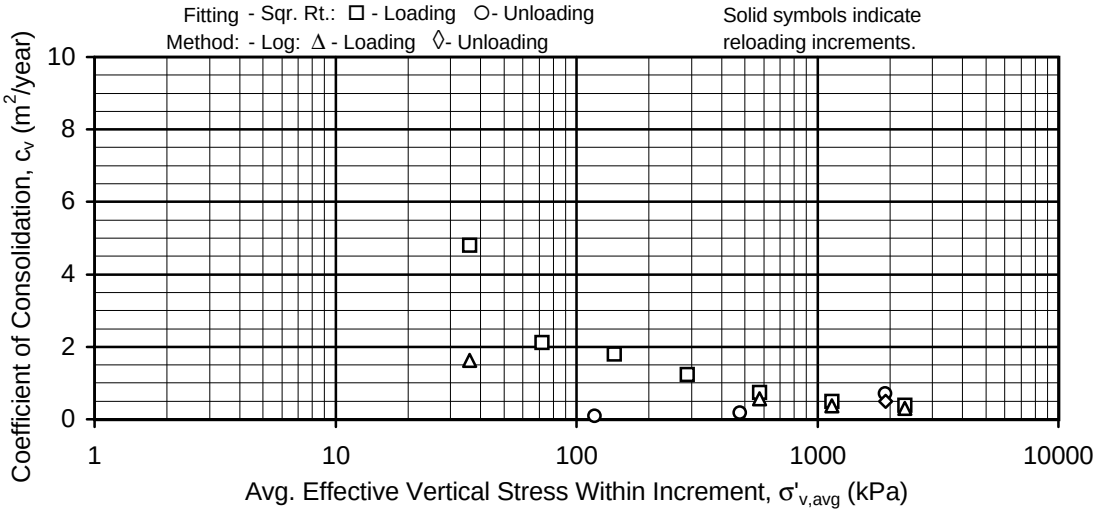
INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 13 RT - Depth: 11.1m
Boring 98-64
SFOBB East Span Seismic Safety Project

Earth Mechanics

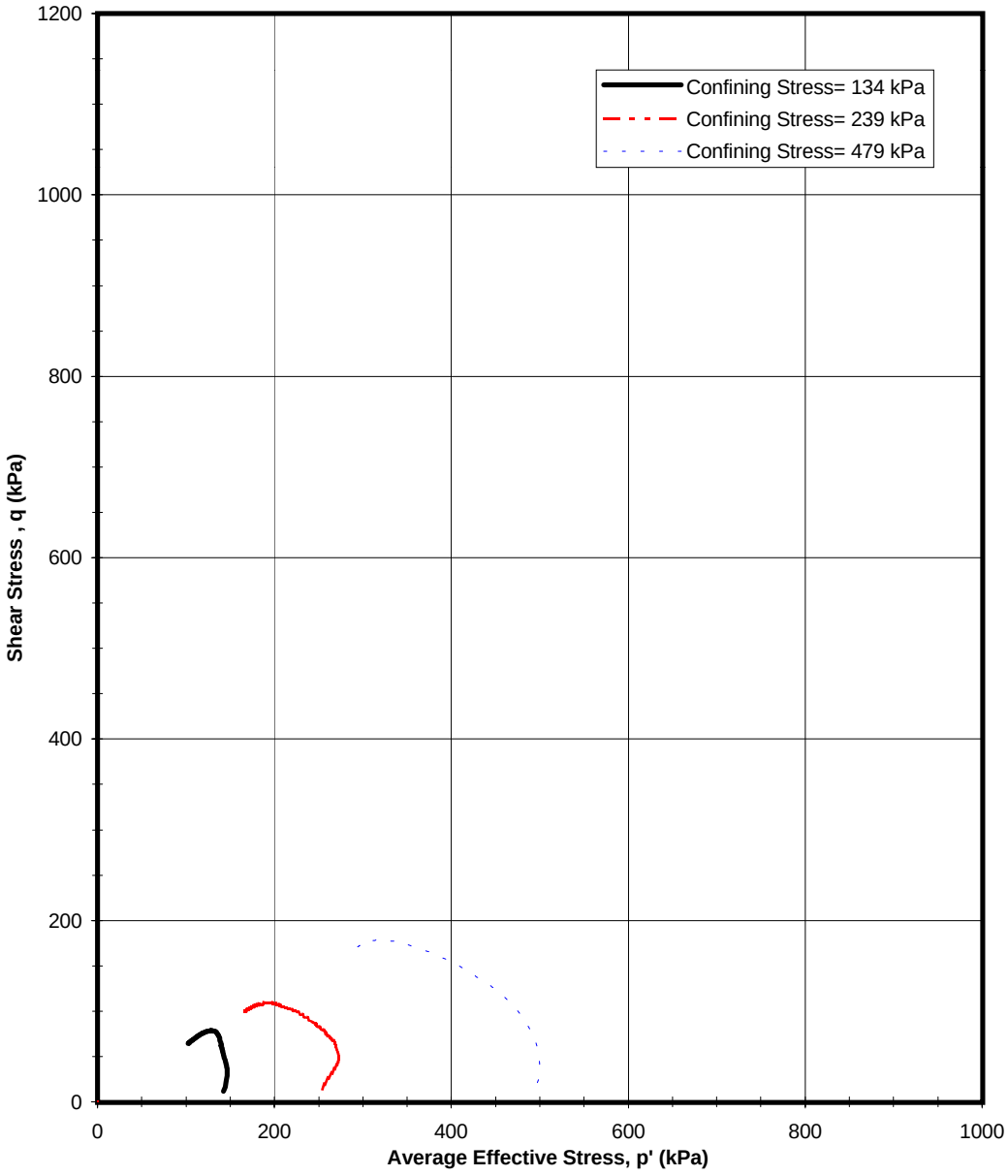
FUGRO





INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 29 - Depth: 20.3m
Boring 98-64
SFOBB East Span Seismic Safety Project



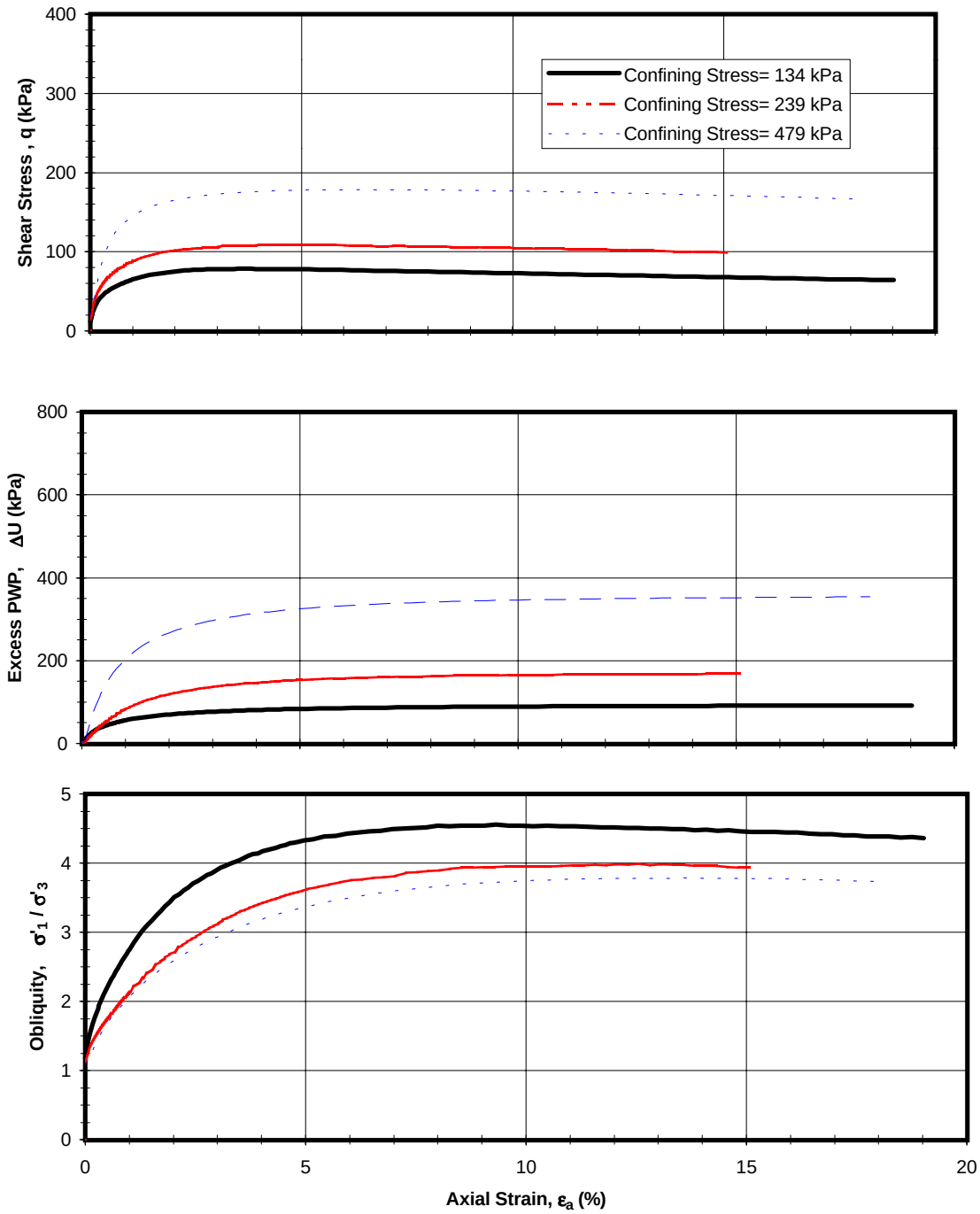
CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 13 - Depth: 10.8m

Boring 98-64

SFOBB East Span Seismic Safety Project

PLATE 98-64.8a



CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 13 - Depth: 10.8m

Boring 98-64

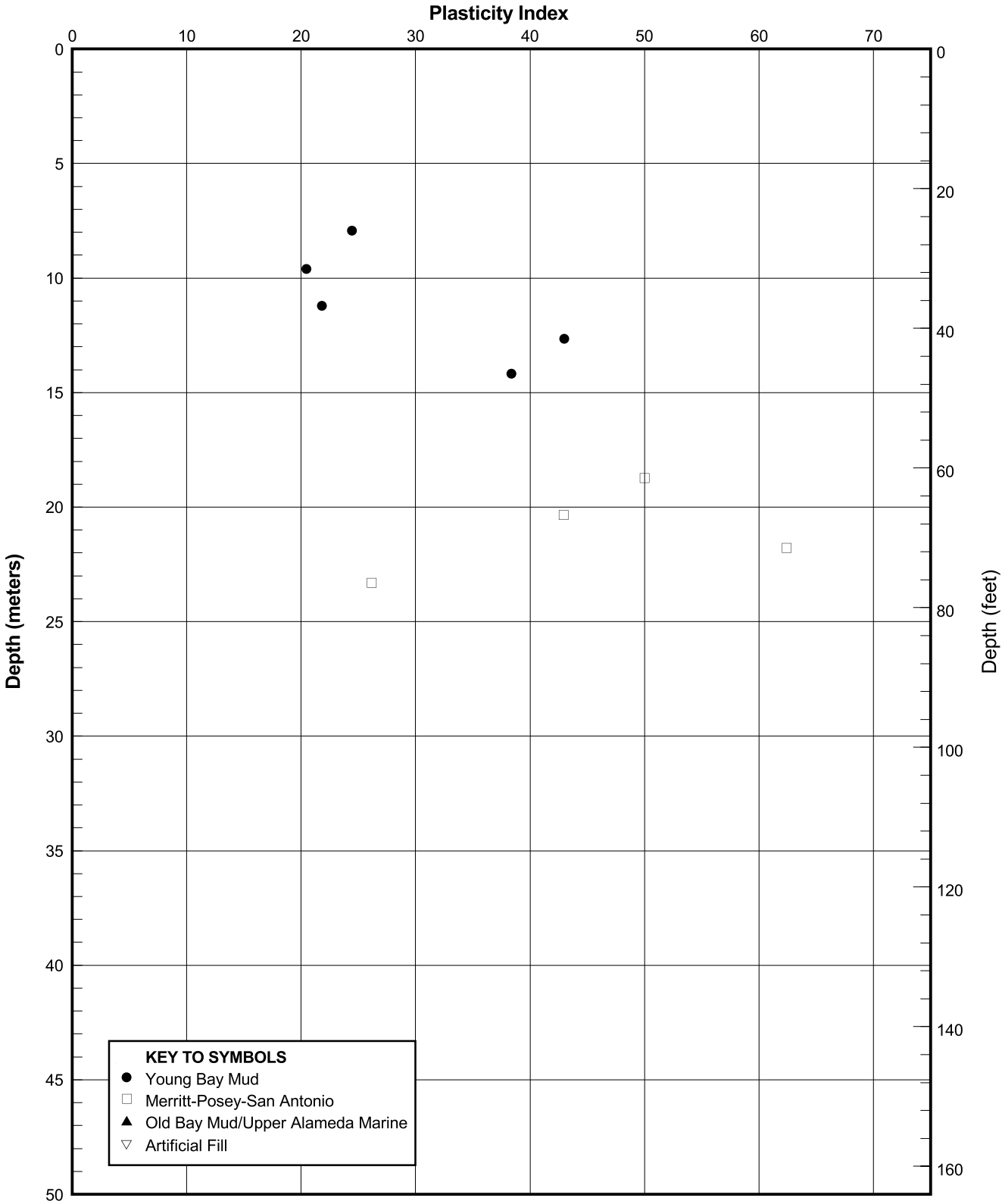
SFOBB East Span Seismic Safety Project

PLATE 98-64.8b

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

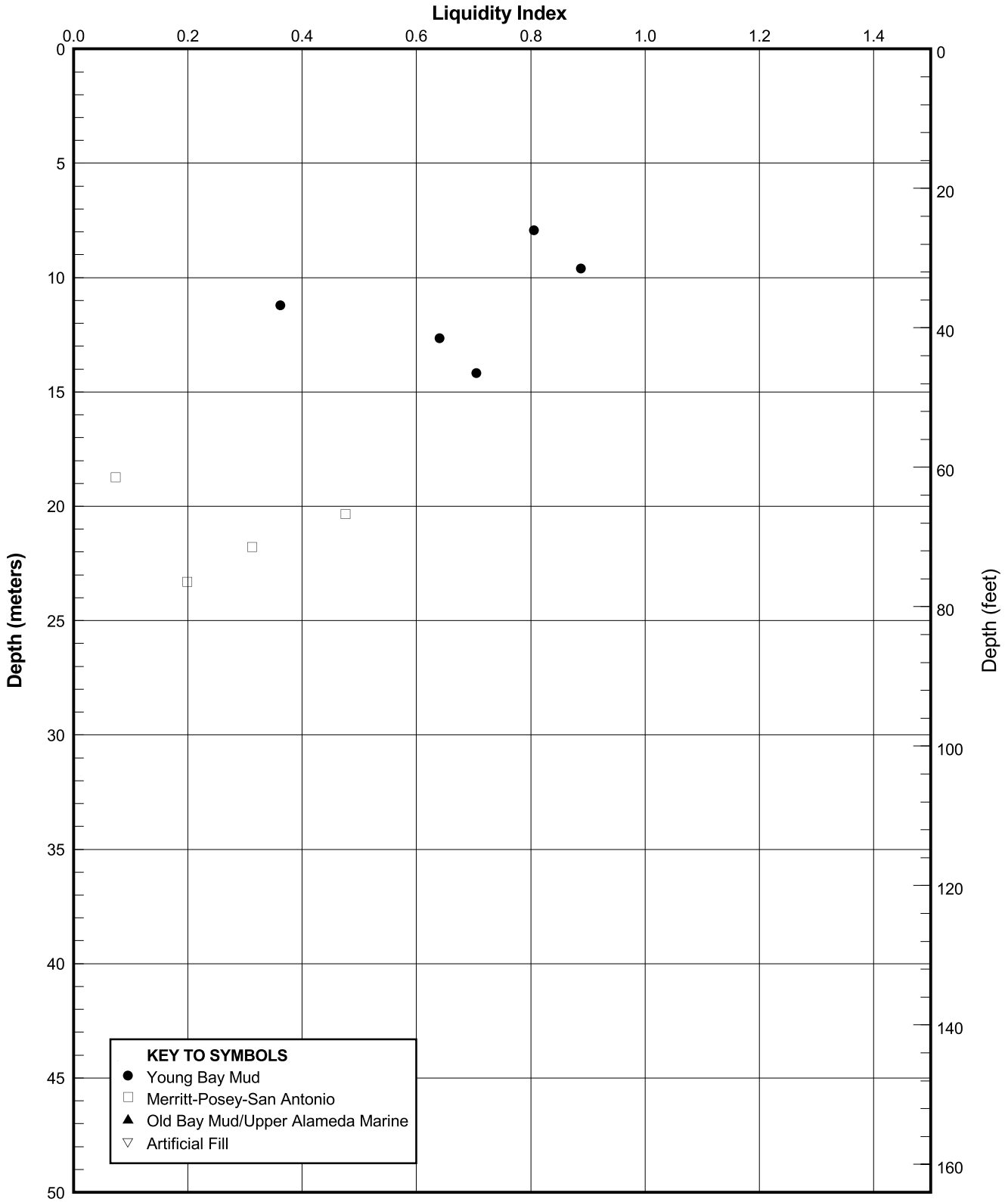
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



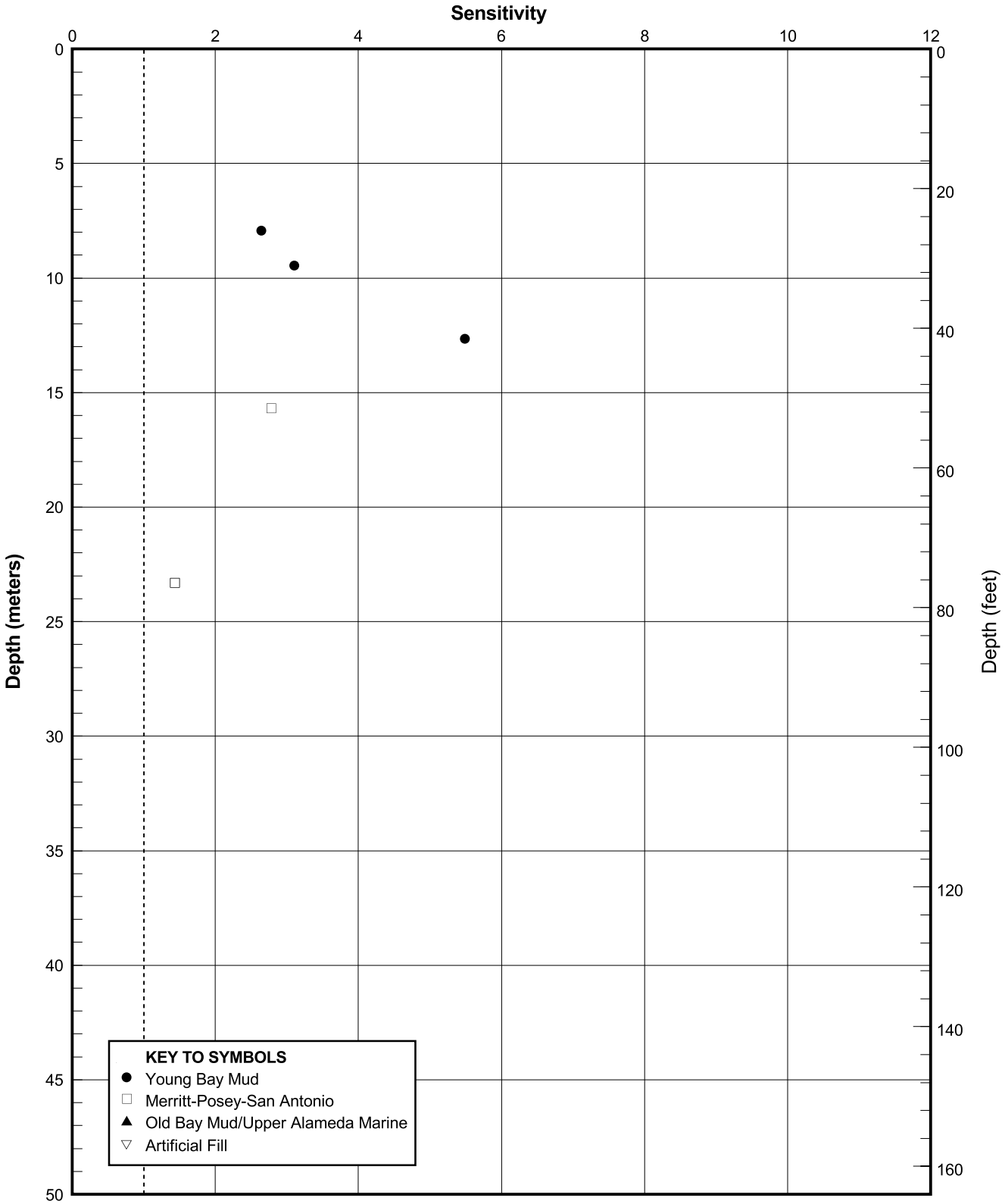
PLASTICITY INDEX PROFILE
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.12



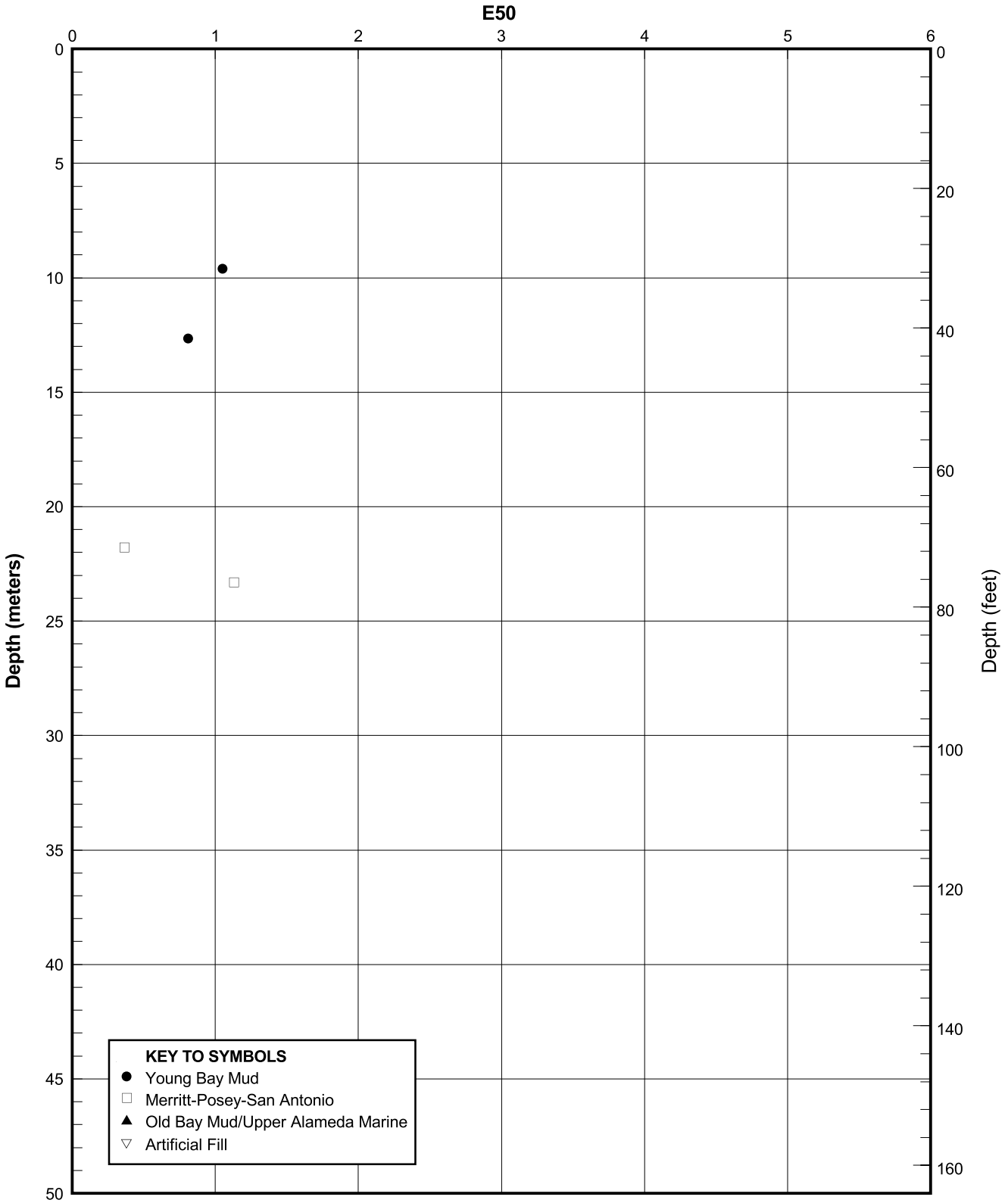
LIQUIDITY INDEX PROFILE
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.13



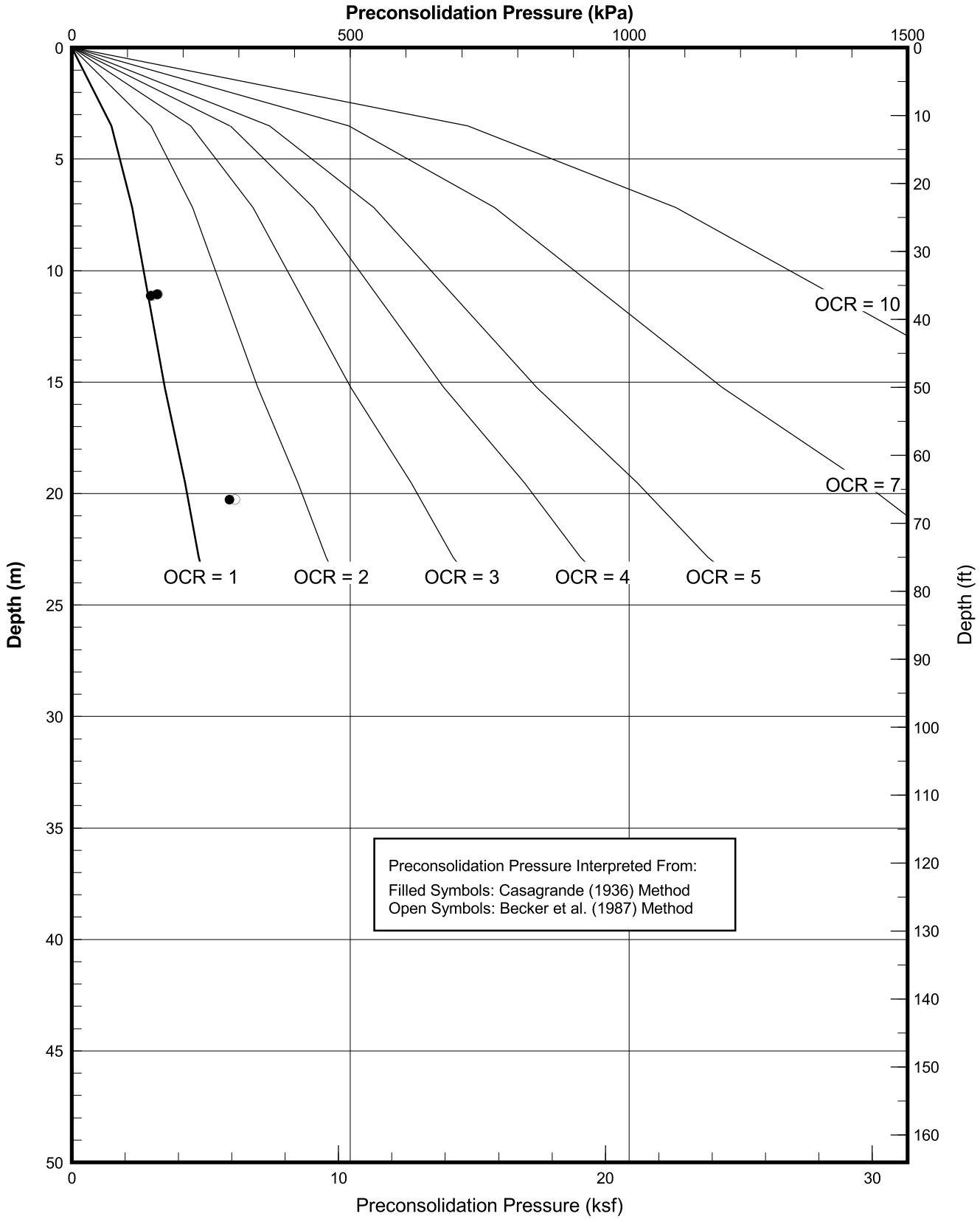
SENSITIVITY PROFILE
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.14



E50 PROFILE
Boring 98-64
SFOBB East Span Seismic Safety Project

PLATE 98-64.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-64

SFOBB East Span Seismic Safety Project

PLATE 98-64.16

LAND BORING 98-65

PROJECT NO: 98-42-0058
BORING: 98-65 (9m left of W. Sta 92+54)
START DATE: 10/15/98
COMPLETION DATE: 10/16/98
DRILLER: Pitcher Drilling Company
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1839704 N648395
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.4m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	0			BAG	Fine SAND (SP), dense, brown, moist	I
					-with brown gravel at 0.5m	
1	2			44		
				35		
2	1					
	3				-olive gray, sand with silt and shell fragments, below 3.0m	
0				49	▽ (3.4m)	
	4				(4.0m)	
-1				25	Fine SAND with silt (SP-SM), medium dense, olive gray, wet	II
	5				-with shell fragments	
-2					-with clay pockets to 4.6m	
	6			25	-silty sand below 6.4m	
-3						
	7				(7.6m)	
-4				1	Fat CLAY (CH), firm to stiff, olive gray	III
	8				-dark gray at 7.6m	
-5						
	9				-with dark gray seams at 9.4m	
-6				WOH		
	10					
-7					-with shell fragments below 10.7m	
	11			SAVE	-sandy clay with silt partings, at 11.0m	
-8						
	12					
-9				PUSH		
	13					
-10						
	14			PUSH		
-11						
	15				(15.2m)	
-12				PUSH	Clayey SAND (SC), dense, olive gray	IV
	16				-with many clay pockets	
-13						
	17			33		
-14						
	18				(18.3m)	
-15				40	Fat CLAY (CH), light olive gray, very stiff	V
	19				-with brown mottling and oxidation, to 20.4m	
-16						
	20			PUSH	-with silt pockets, at 20.1m	
-17						
	21				-dense, olive gray sand with silt, below 21.3m	
-18				SAVE		
	22				(21.9m)	
-19					Fat CLAY (CH), very stiff, greenish gray	VI
	23			PUSH	-with many sand pockets, at 23.2m	
-20					TOTAL DEPTH: 23.5m BACKFILLED WITH: Cement Grout	
	24					
-21						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-65.1

LOG OF BORING AND TEST RESULTS
BORING 98-65
SFOBB East Span Seismic Safety Project

Report Date: 03/07/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-65		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.3	300																									
0.8	1	9																								
0.9	2	6																								
1.4	3	5					0																			
3.4	4	21					5																			H
4.9	5	22					6																			
6.6	6	26					18																			
8.1	7	65	93	32	0.54																					
9.4	8	61	74	29	0.71	16.0		32.6			27.5	12.2														
9.6	9							33.5																		C
11.3	10	31	41	19	0.54																					C
12.5	12					16.3		55.1			47.3															
12.6	13	54	60	28	0.81	16.7									32.2		1.3									
12.8	14							49.8																		
13.9	15	35	56	24	0.33																					C

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.3a

Earth Mechanics

FUGRO

98-65		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
14.0	16							47.9	47.9		55.9	27.1														
14.2	17	61	70	29	0.78	16.3		49.8							37.6	13.9	1.0									
15.5	19	14																								
15.8	20						19																			
17.1	22	26				19.8	17																			
18.6	24	25	50	19	0.21	19.7		143.6			130.8															
20.1	26							126.9	148.4																	
20.3	27	26	50	22	0.16	20.1									92.5	90.5	1.1									
21.8	30	23					8																			
23.2	31							143.6	158.0																	
23.3	32	19	53	20		19.1																				
23.5	33										178.2															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-65
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-65.3b

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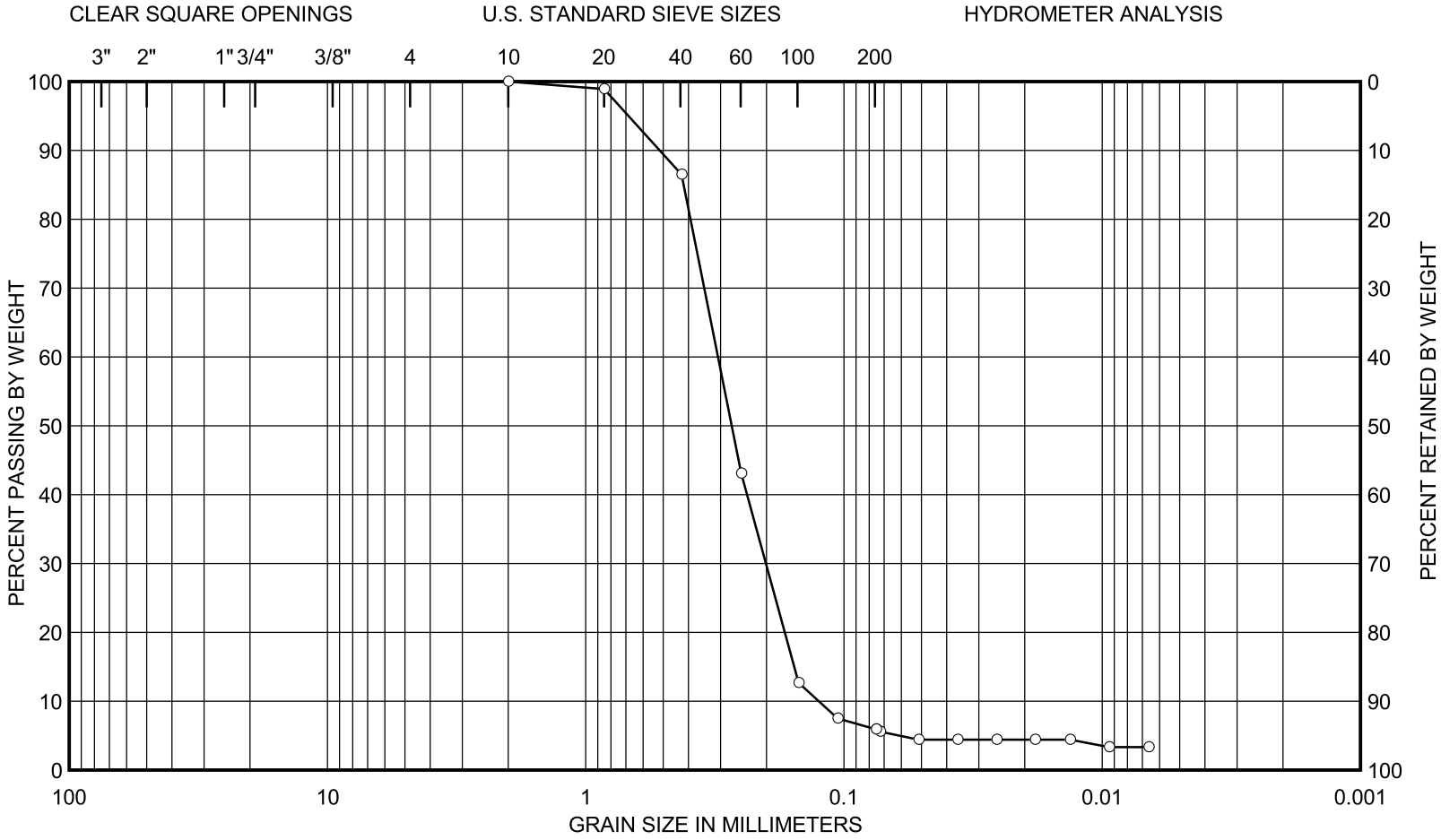

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
4	3.4	○——○	FINE SAND (SP-SM) with silt and a trace of medium sand	1.0	2.5	0.27

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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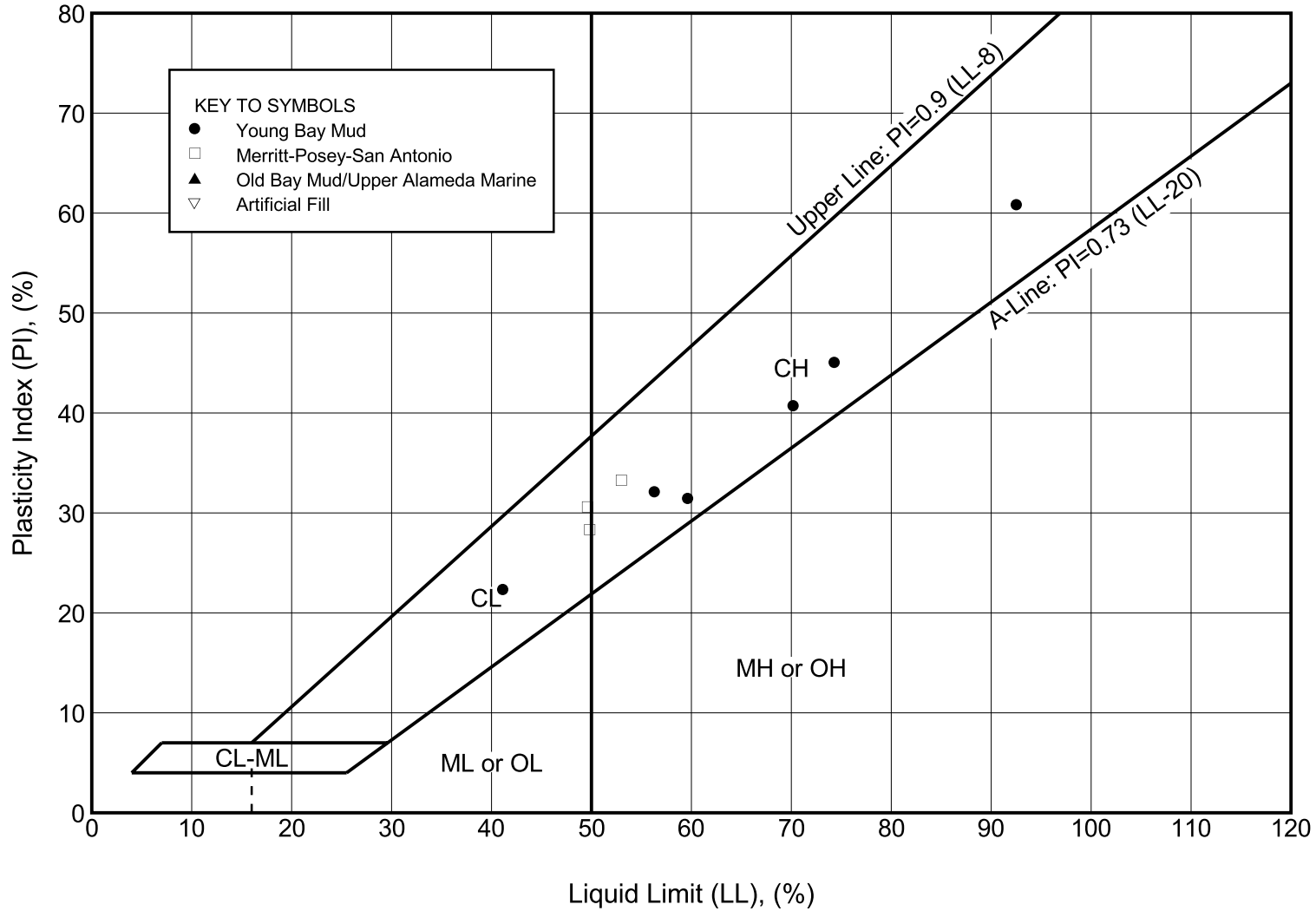
i:\caltrans\ 02/44/YY



PLASTICITY CHART
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.5

Earth Mechanics

FUGRO

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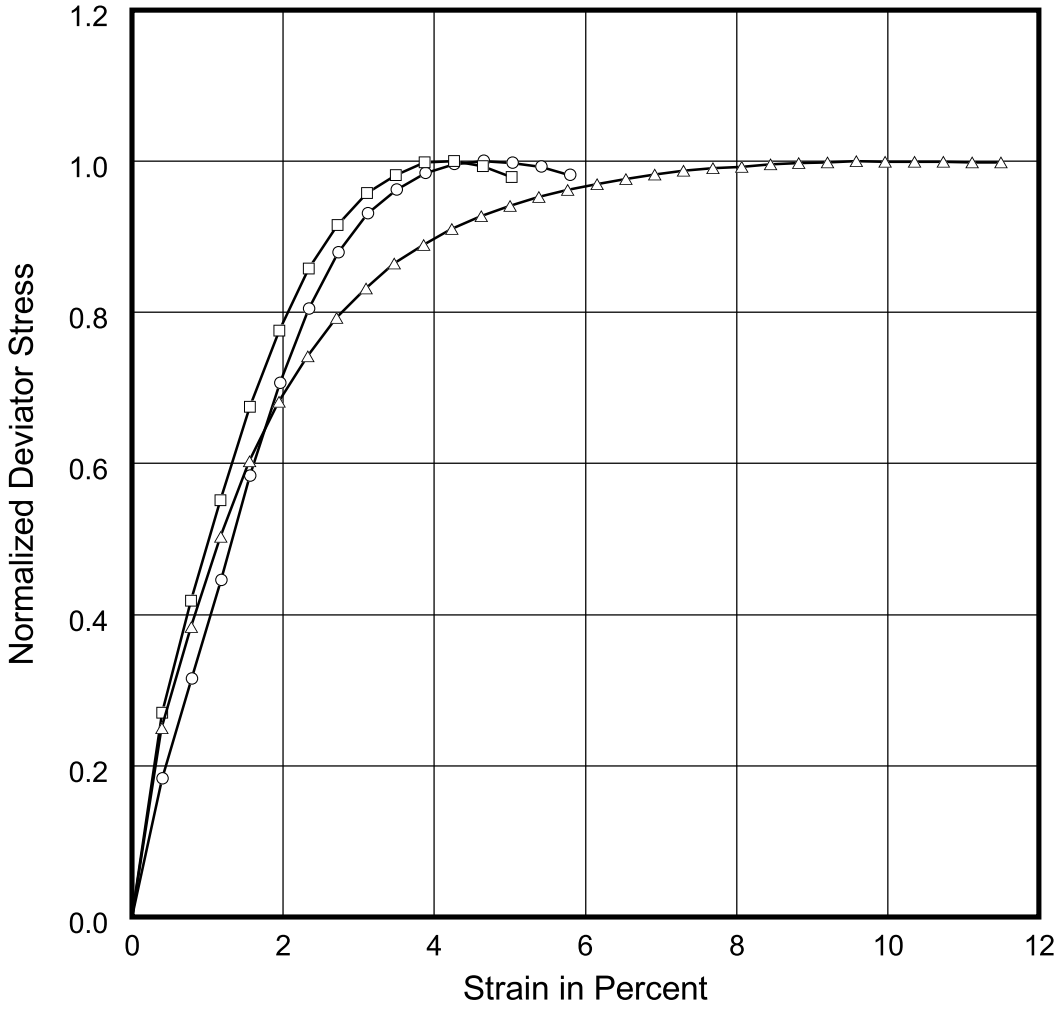


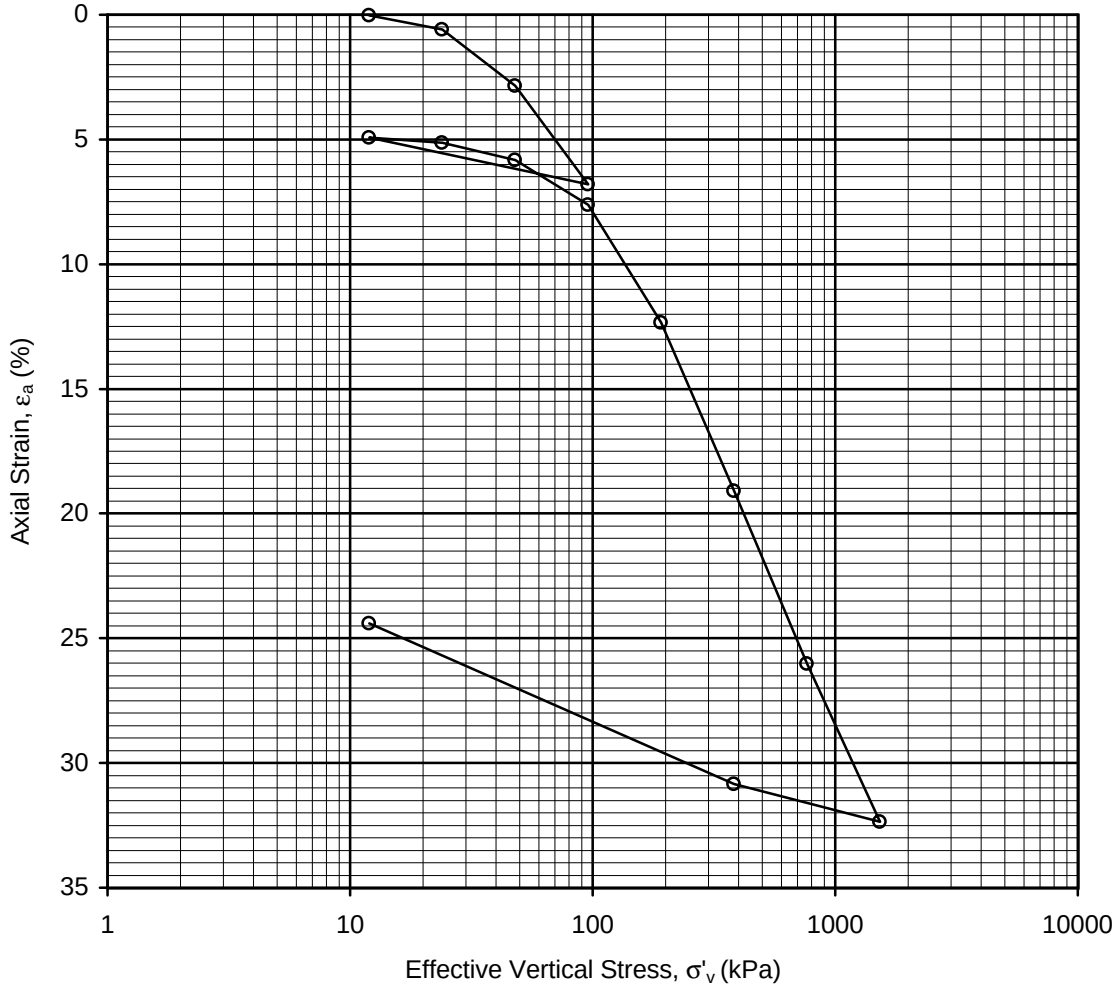
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	13	12.6	UU	241	64	1.3
□	17	14.2	UU	269	75	1.0
△	27	20.3	UU	724	185	1.1

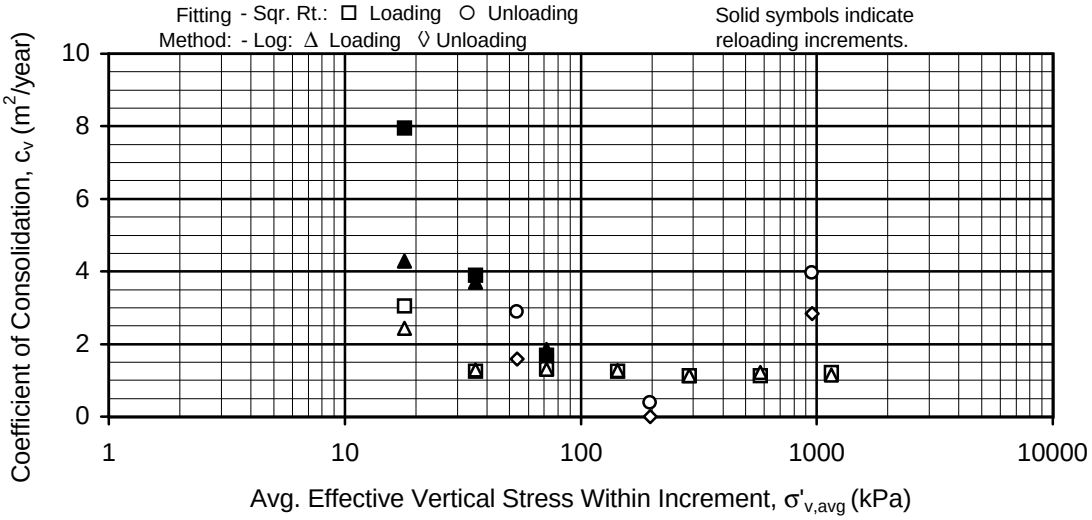
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.6

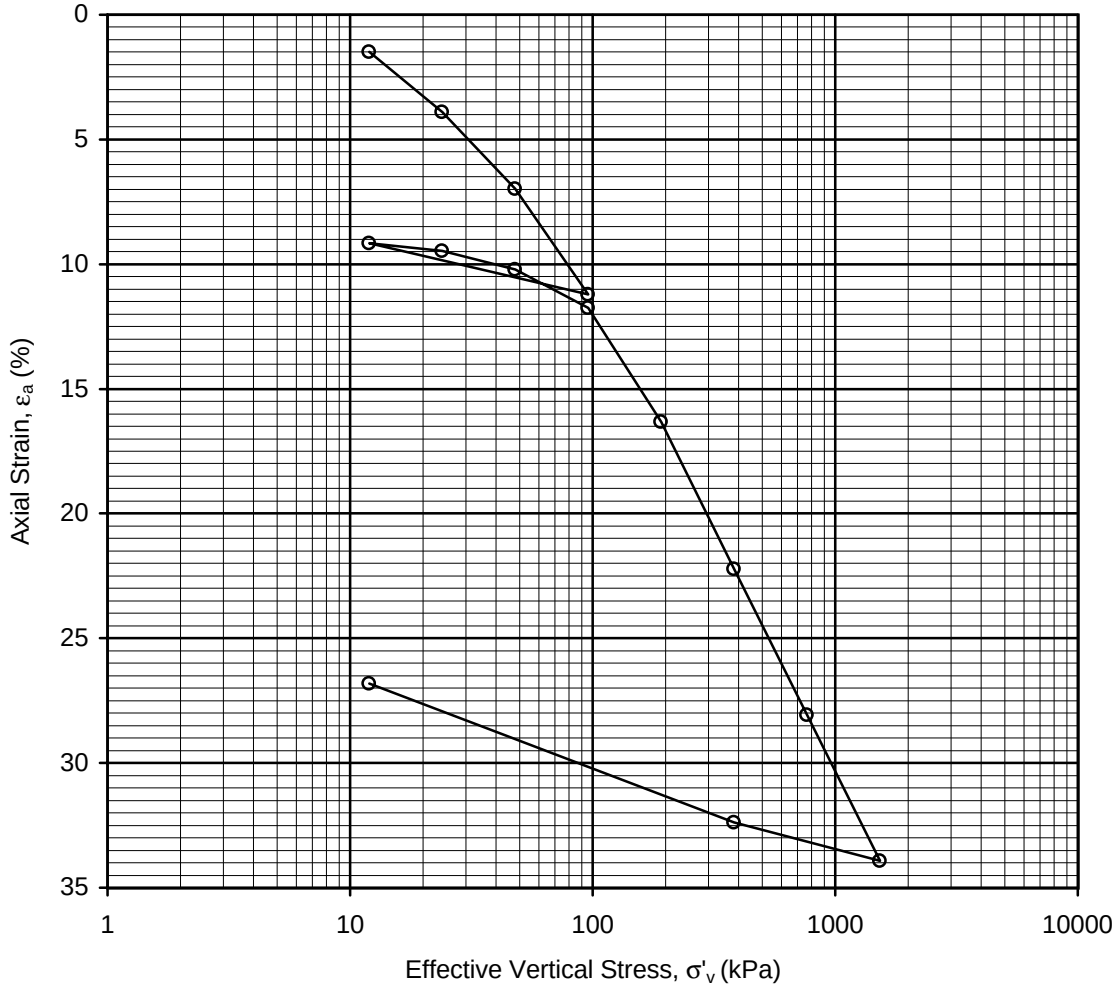


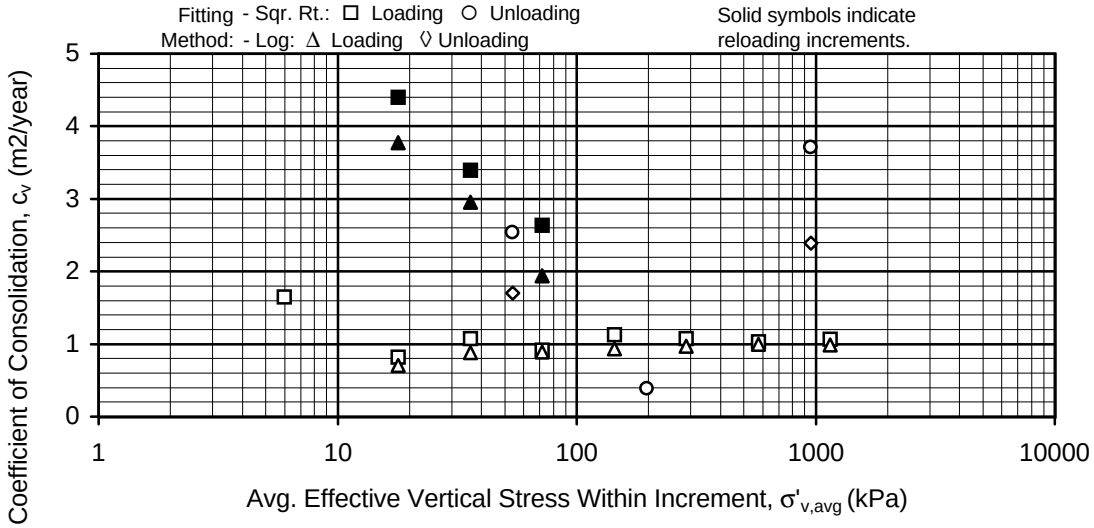


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 9A - Depth: 9.6m
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.7a

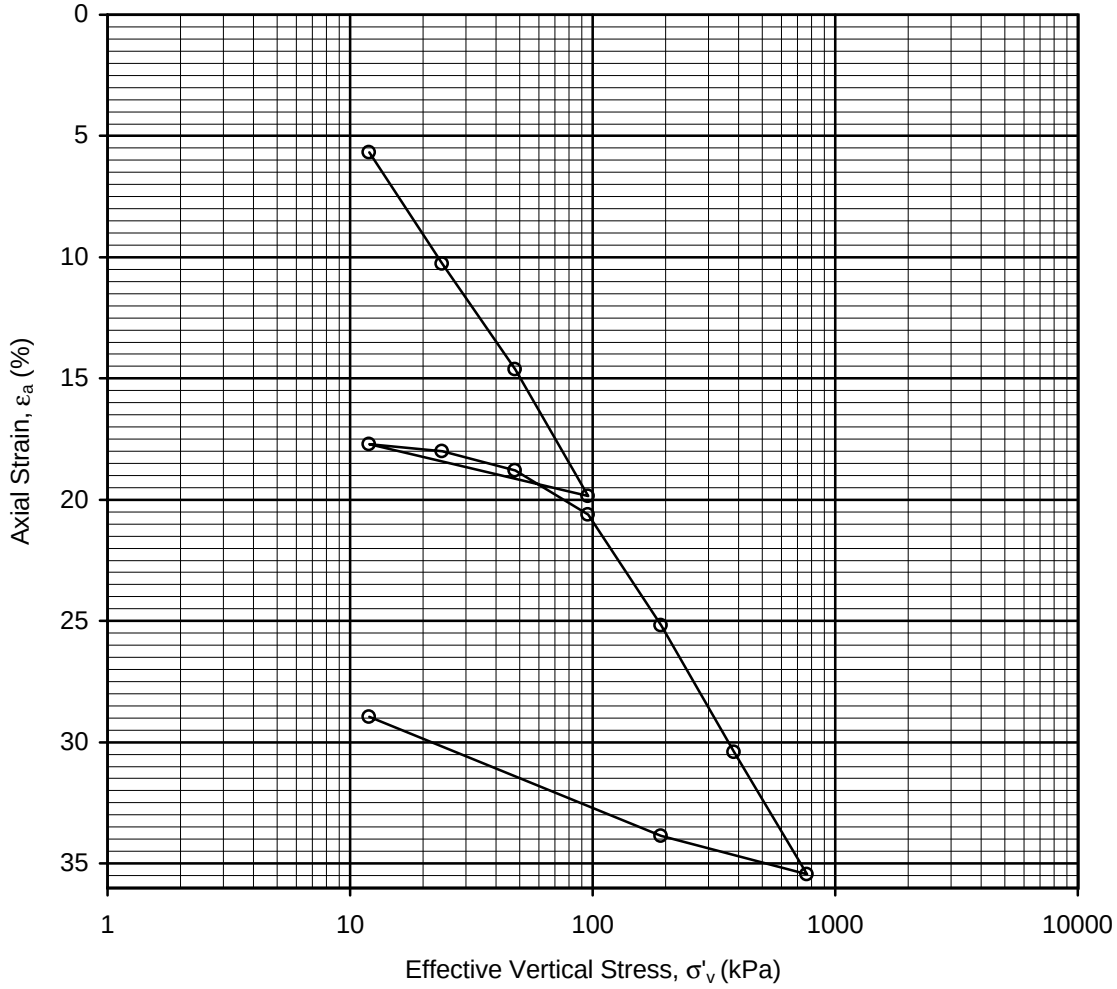


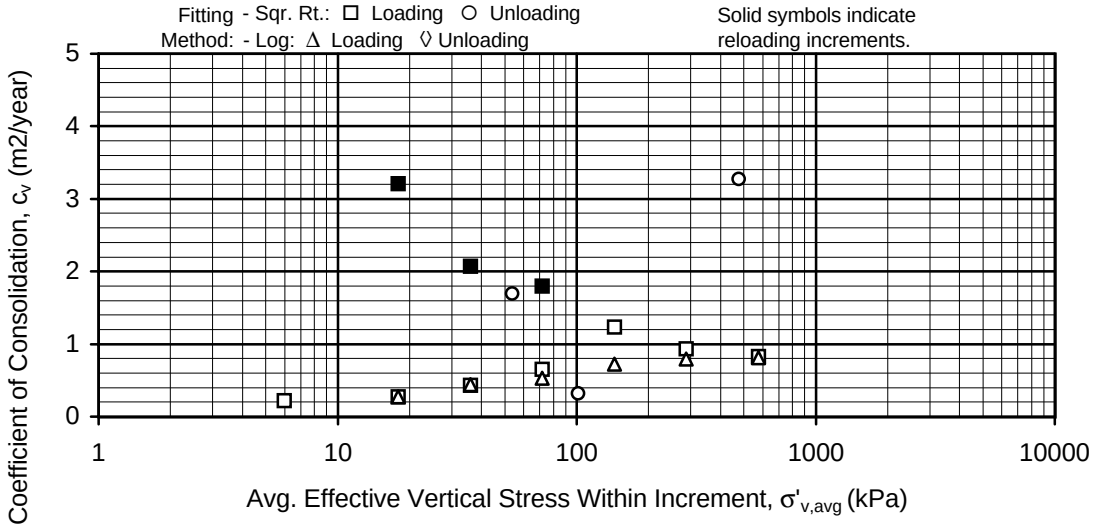


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 9B (Remolded at Natural Water Content) - Depth: 9.6m
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.7b

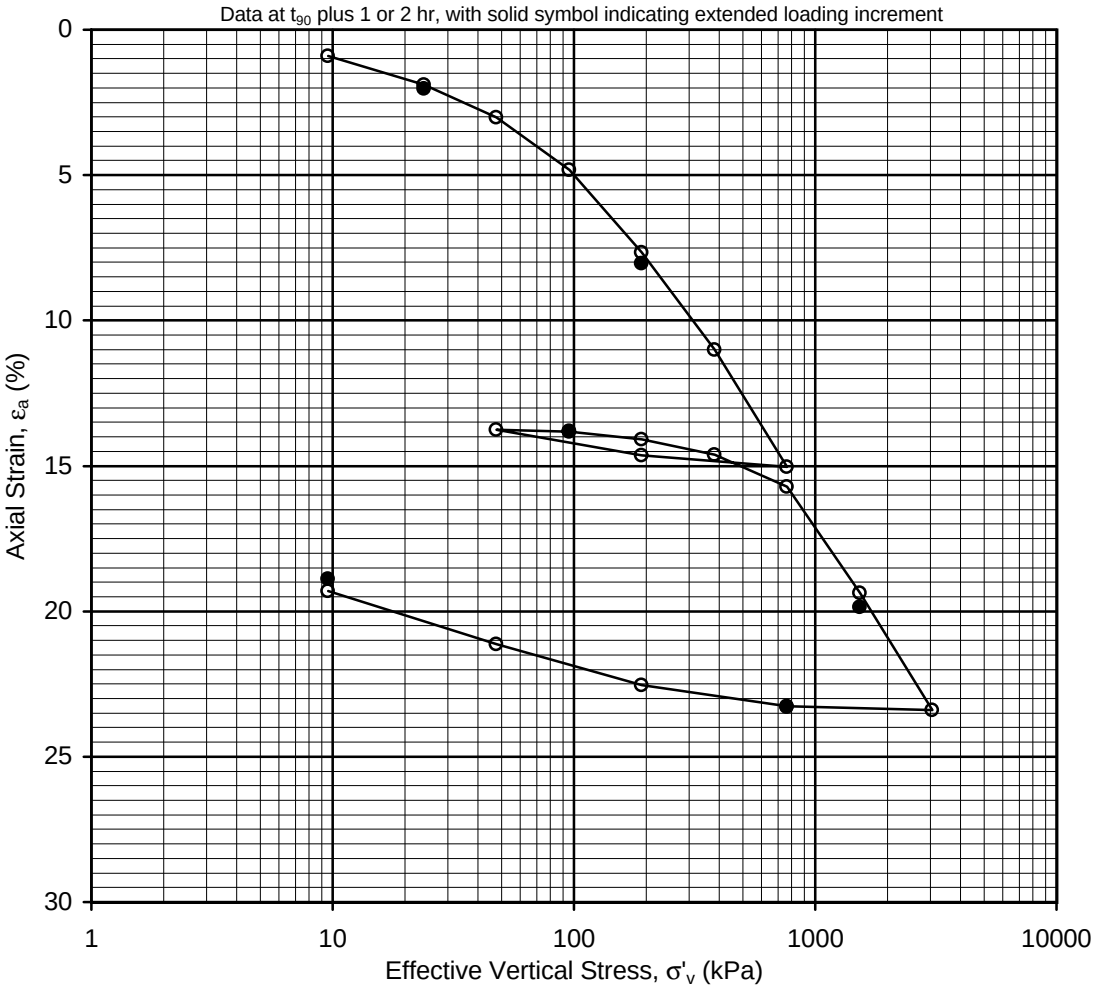


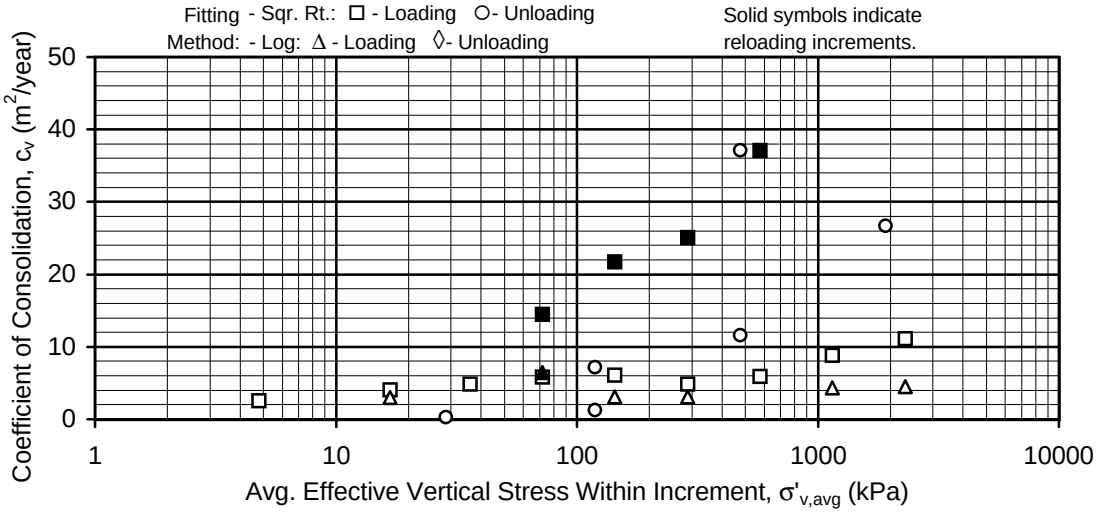


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 9C (Remold at Natural Water Content + 5%) - Depth: 9.6m
Boring 98-65
SFOBB East Span Seismic Safety Project

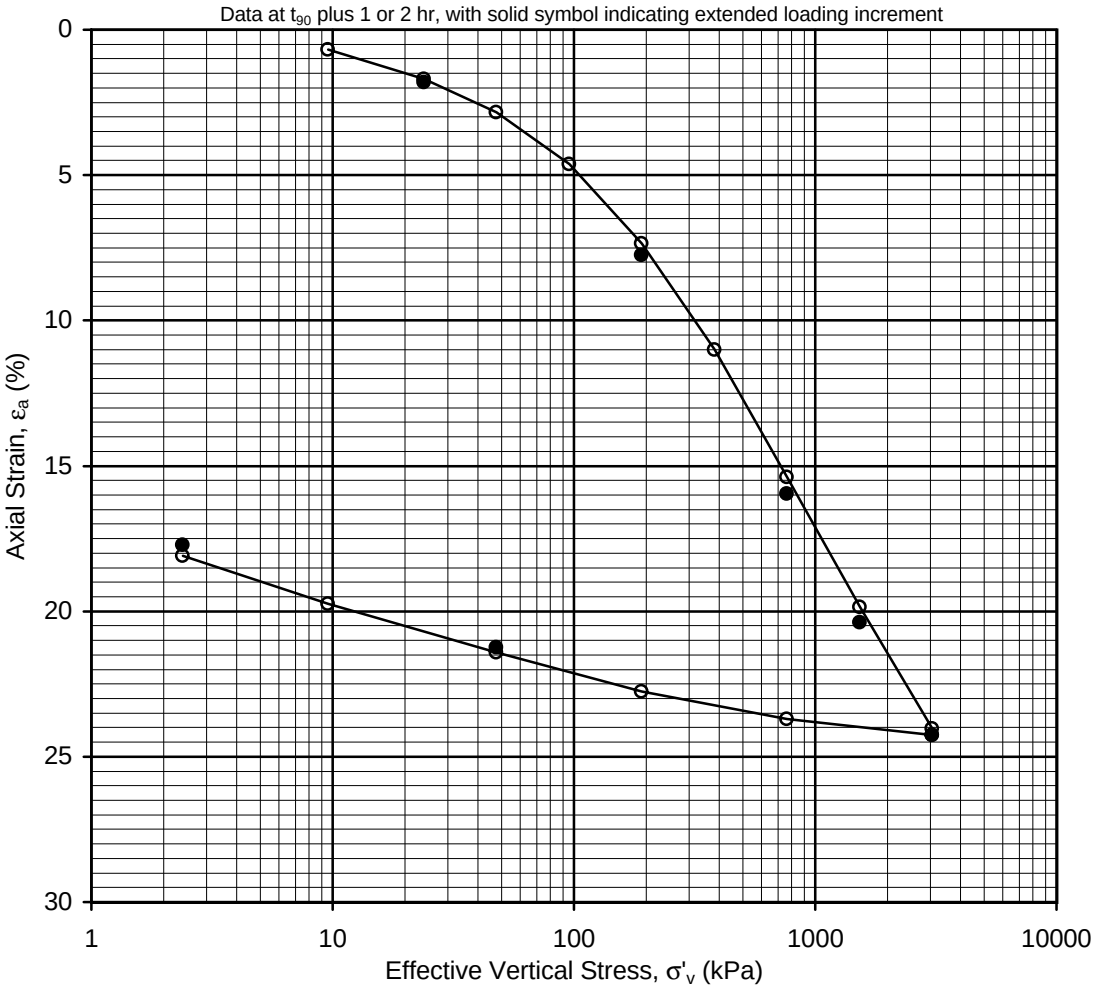
PLATE 98-65.7c

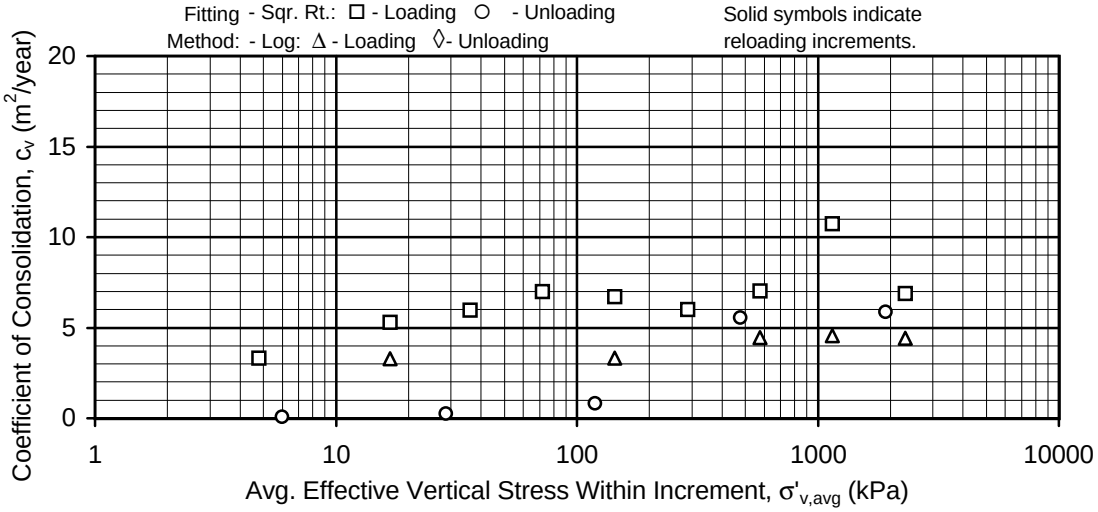




INCREMENTAL CONSOLIDATION TEST RESULTS

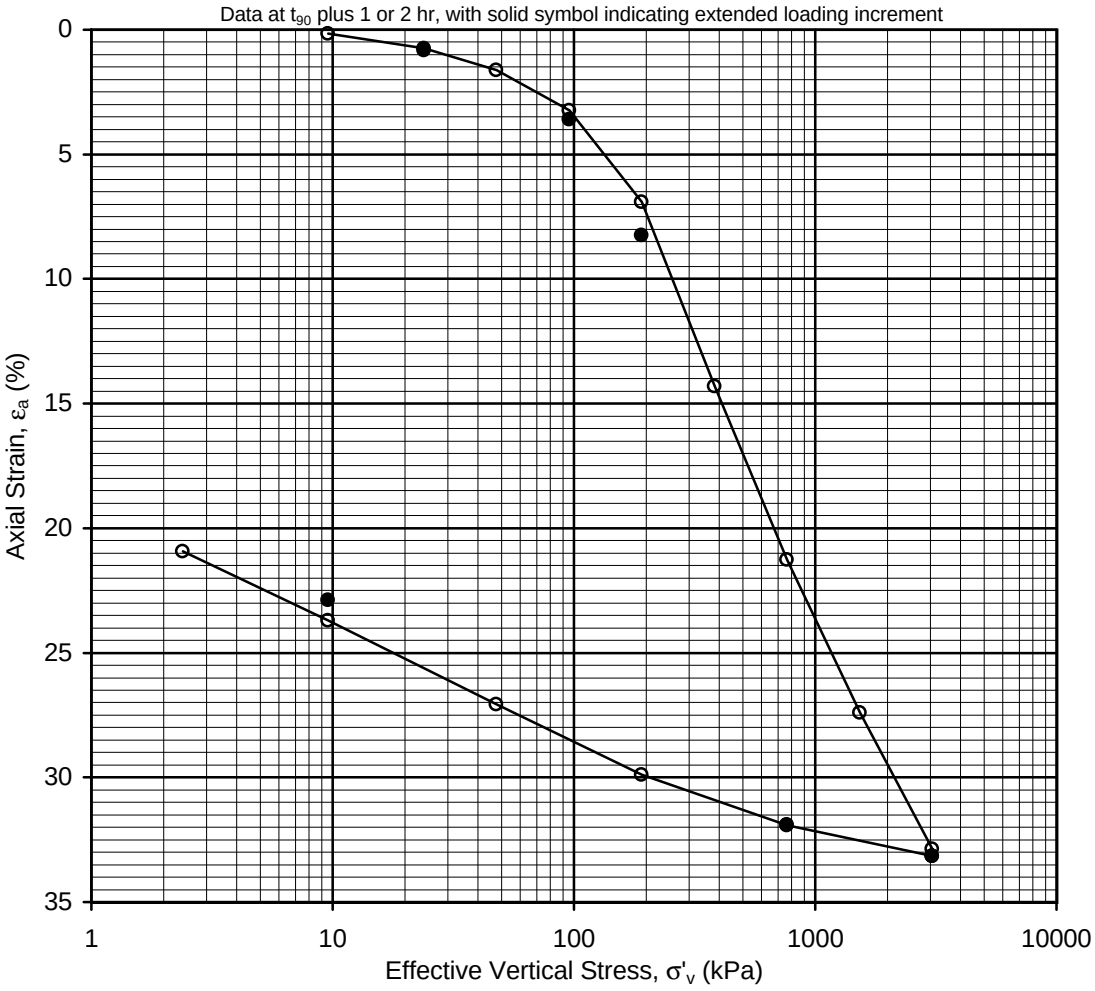
Sample No. 10 RT - Depth: 11.1m
Boring 98-65
SFOBB East Span Seismic Safety Project

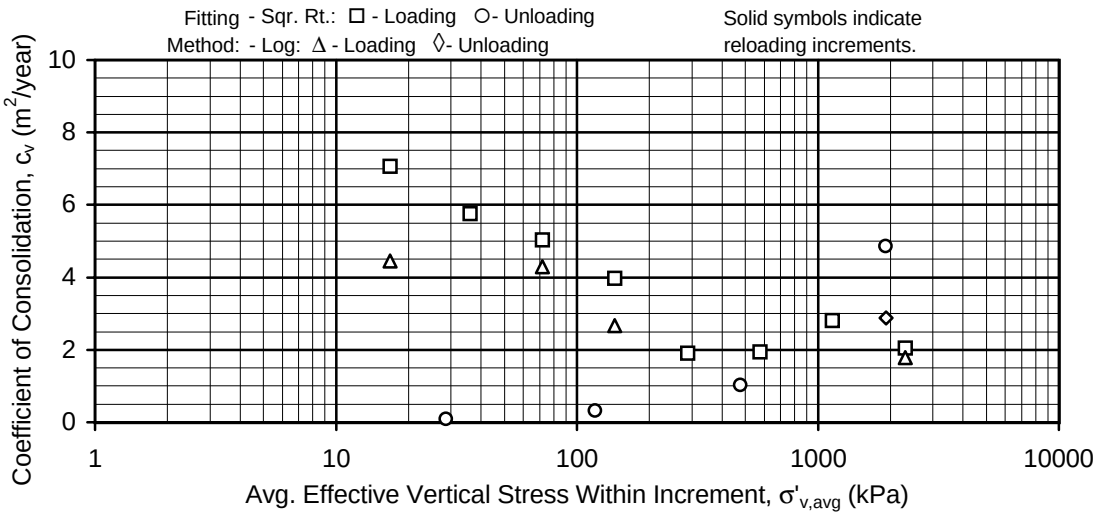




INCREMENTAL CONSOLIDATION TEST RESULTS

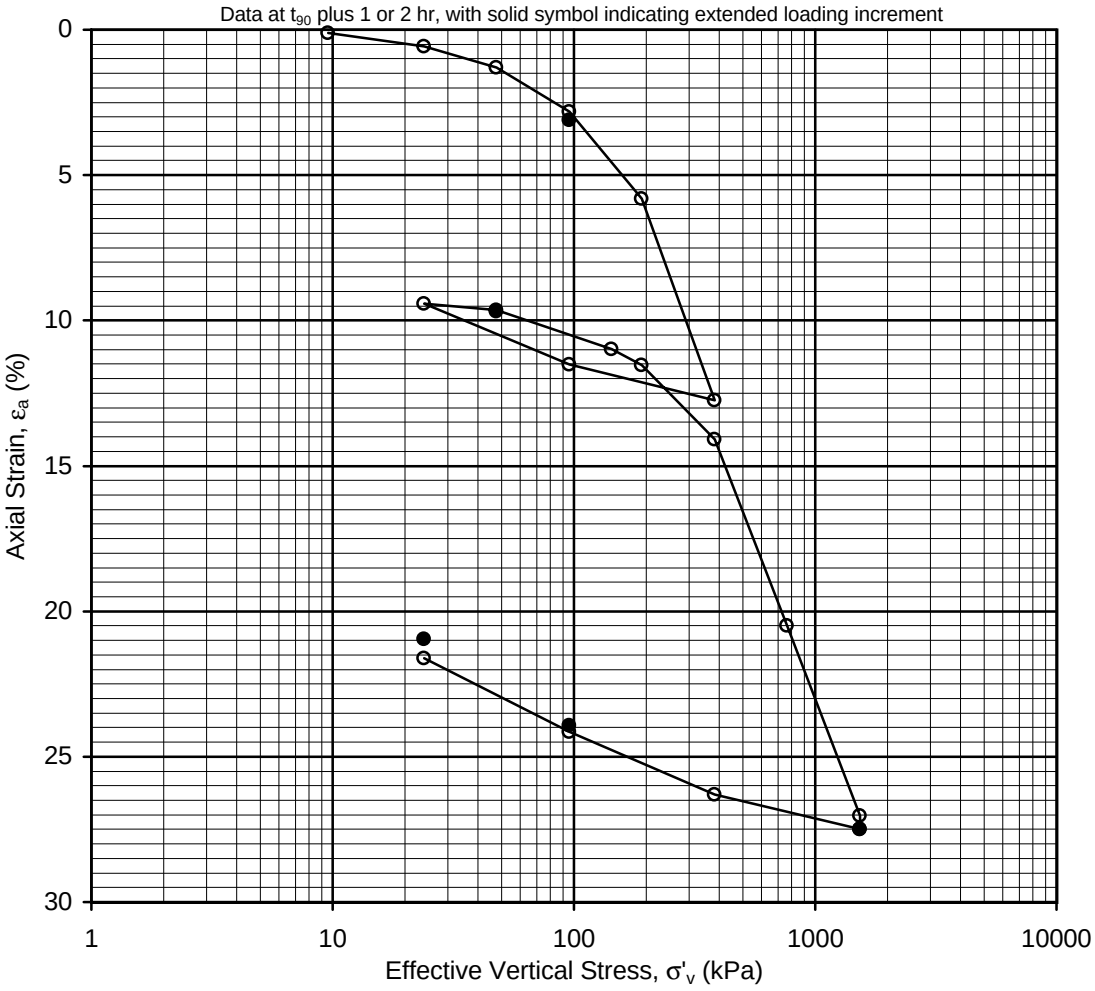
Sample No. 10 - Depth: 11.2m
Boring 98-65
SFOBB East Span Seismic Safety Project

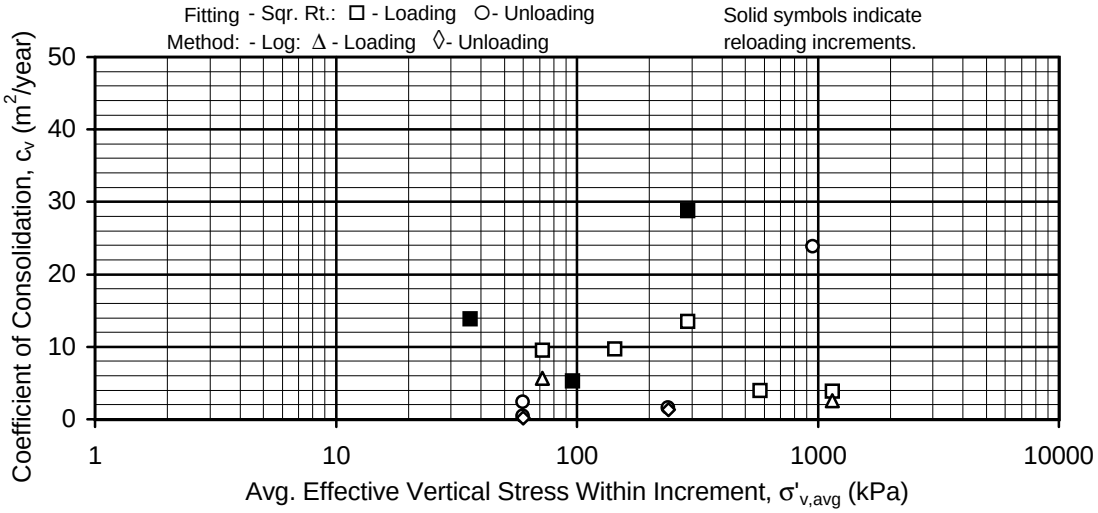




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 15 - Depth: 13.9m
Boring 98-65
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

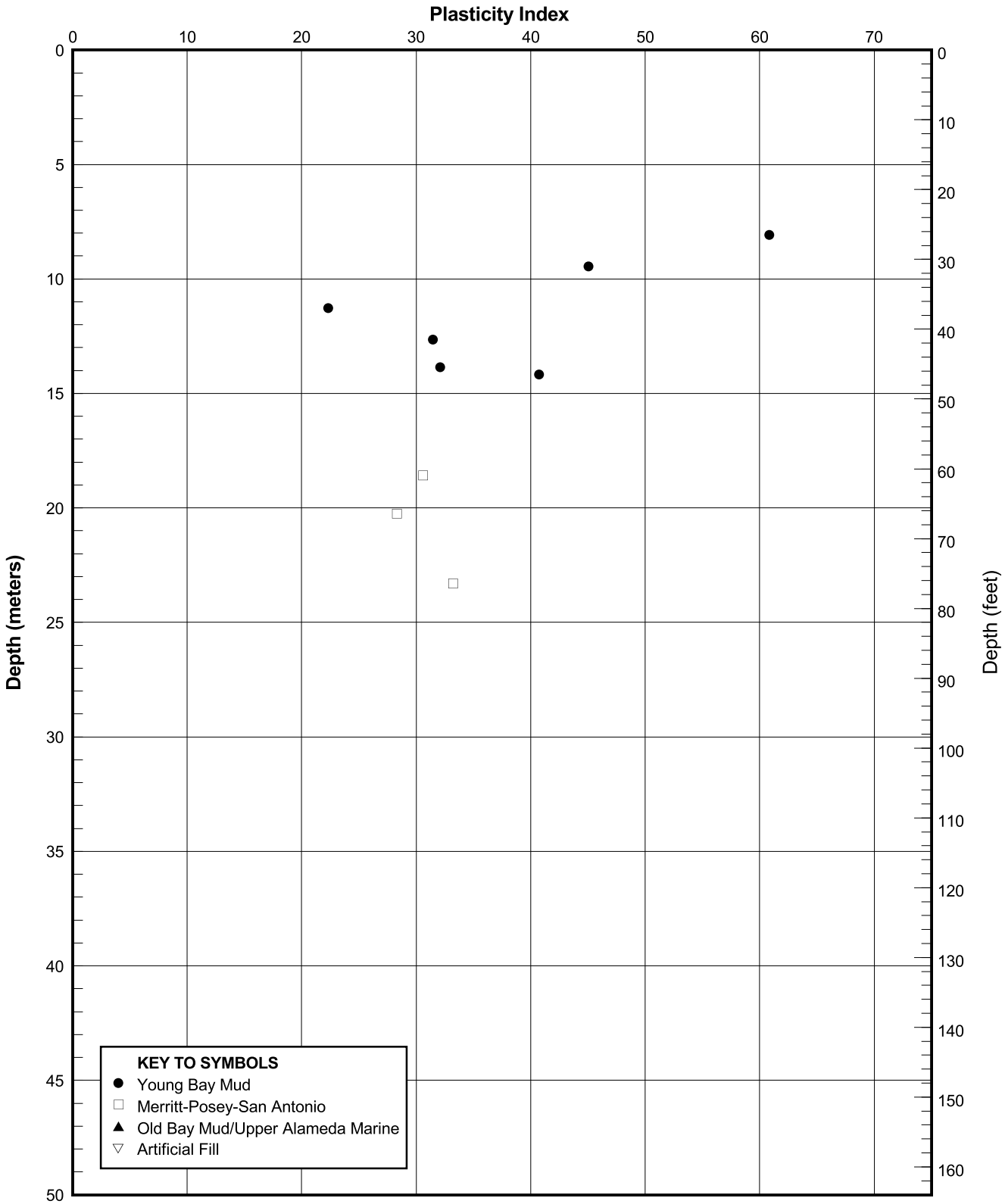
Sample No. 15 RT - Depth: 13.9m
Boring 98-65
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

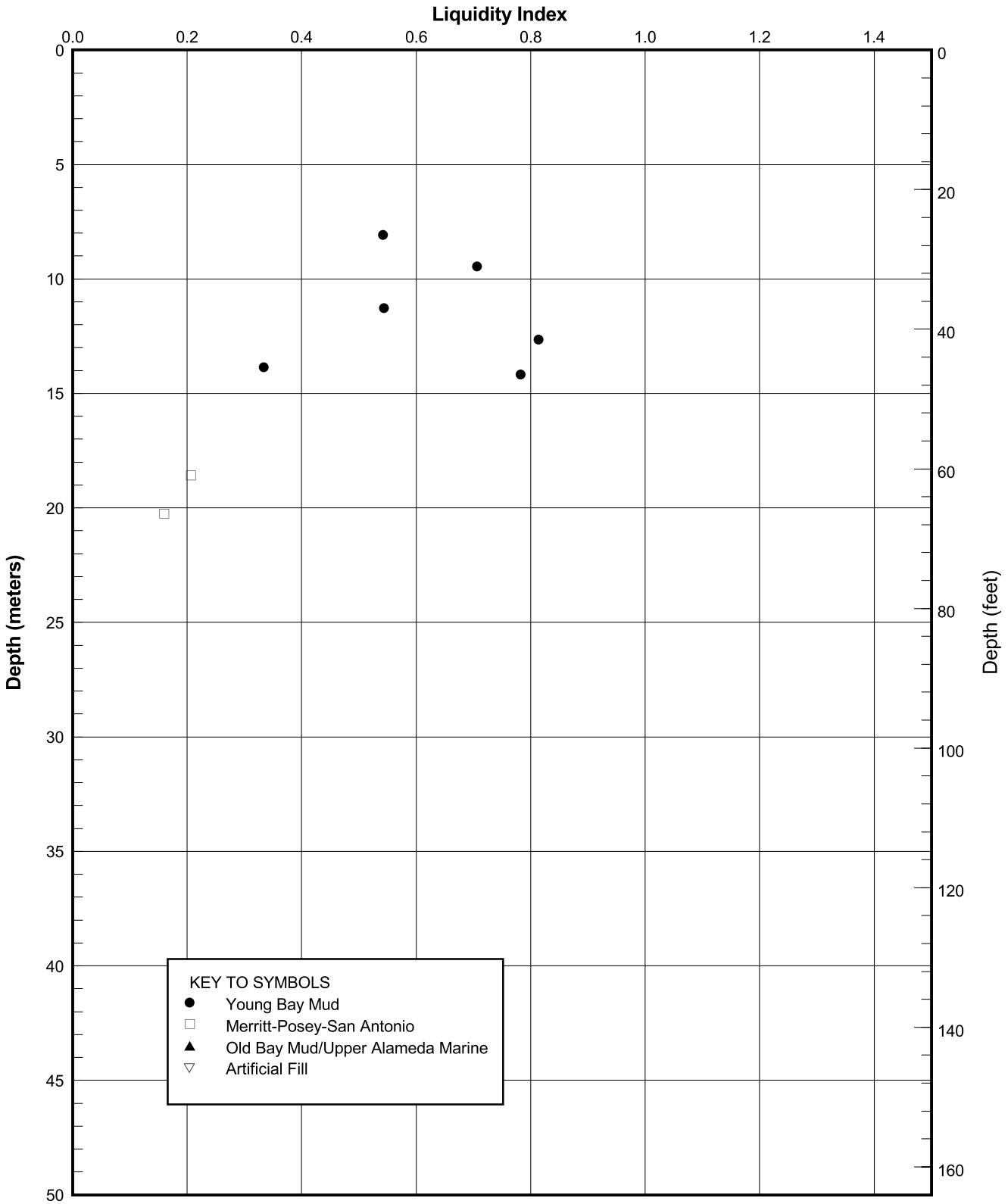
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



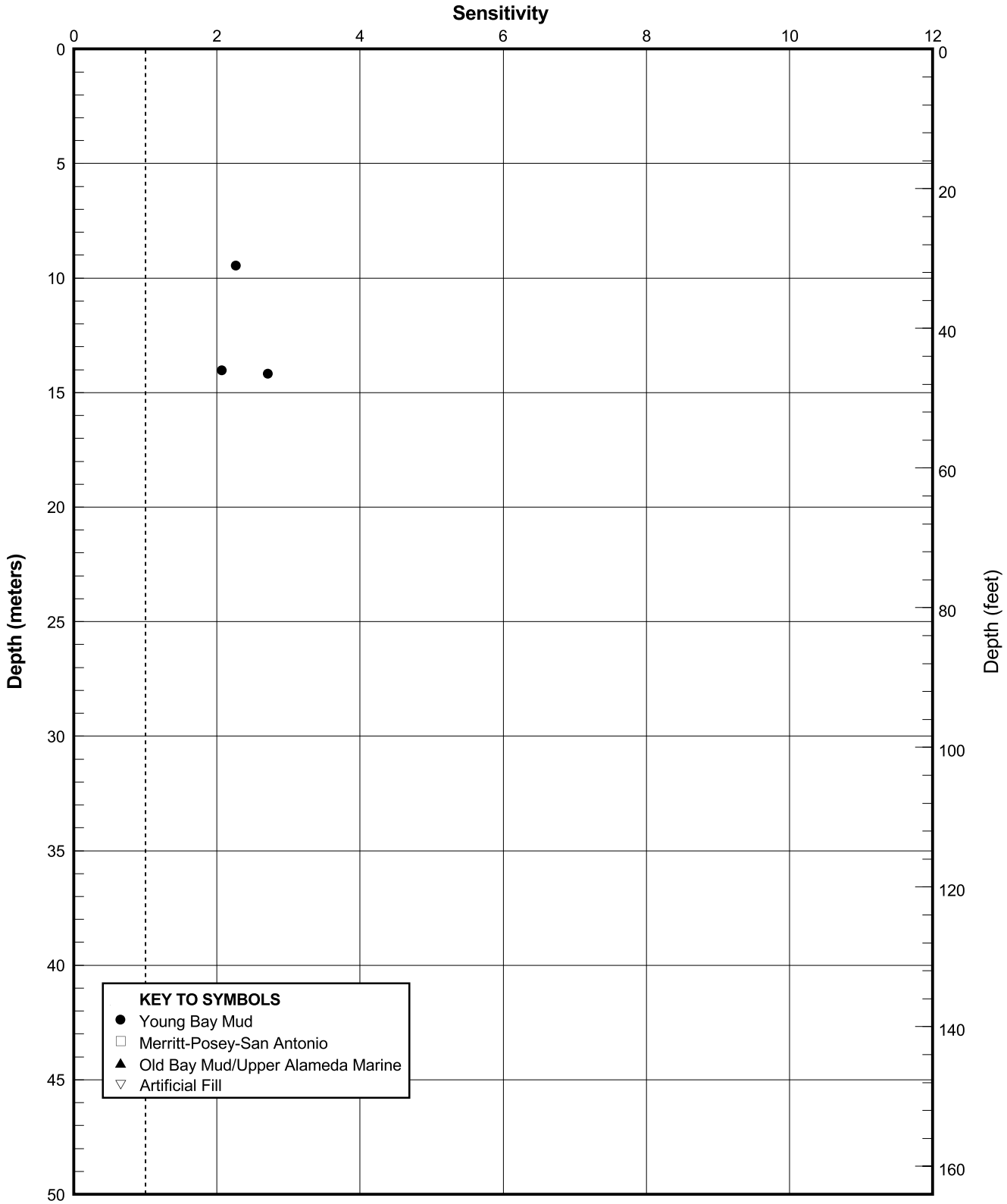
PLASTICITY INDEX PROFILE
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.12



LIQUIDITY INDEX PROFILE
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.13

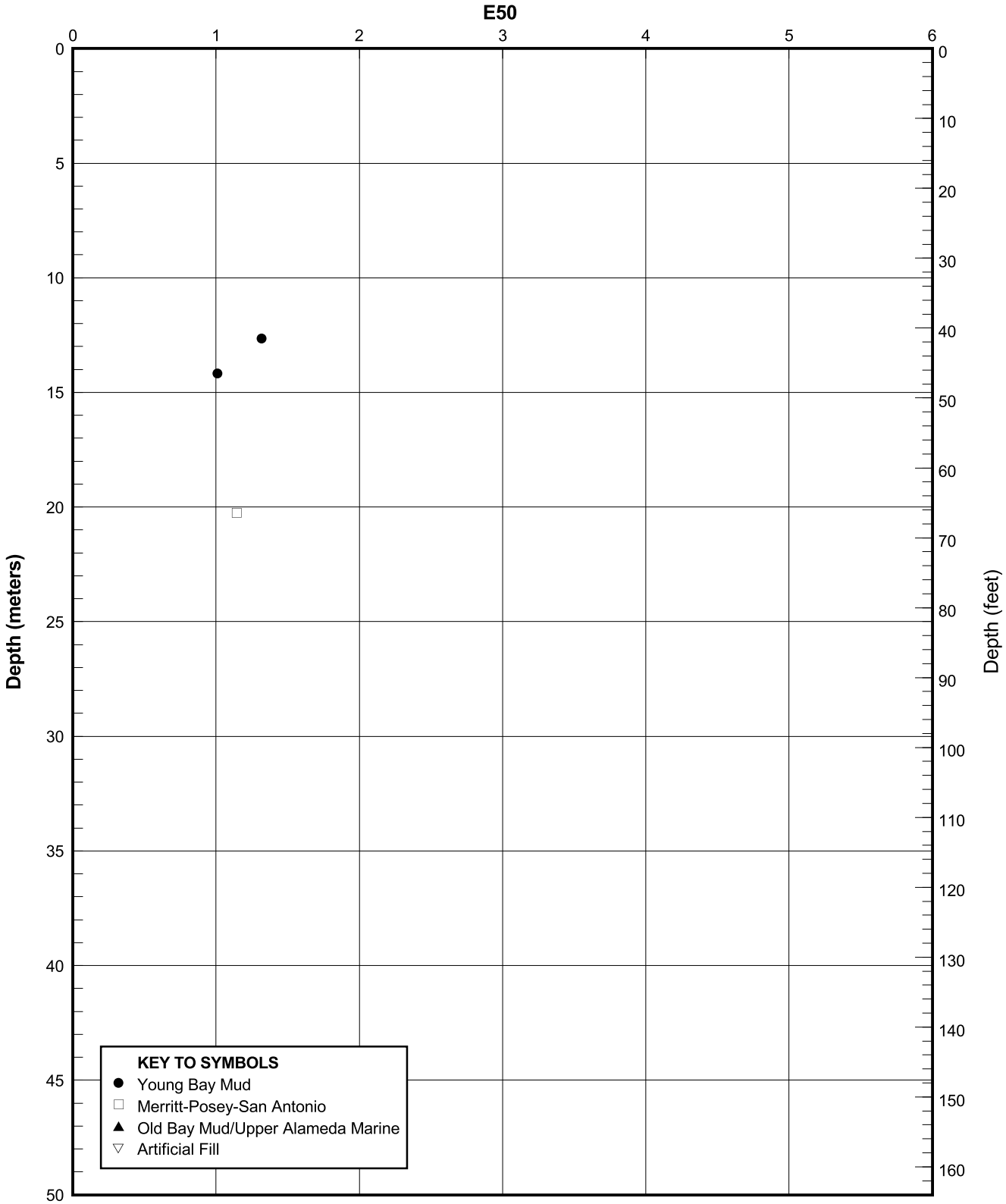


SENSITIVITY PROFILE
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.14

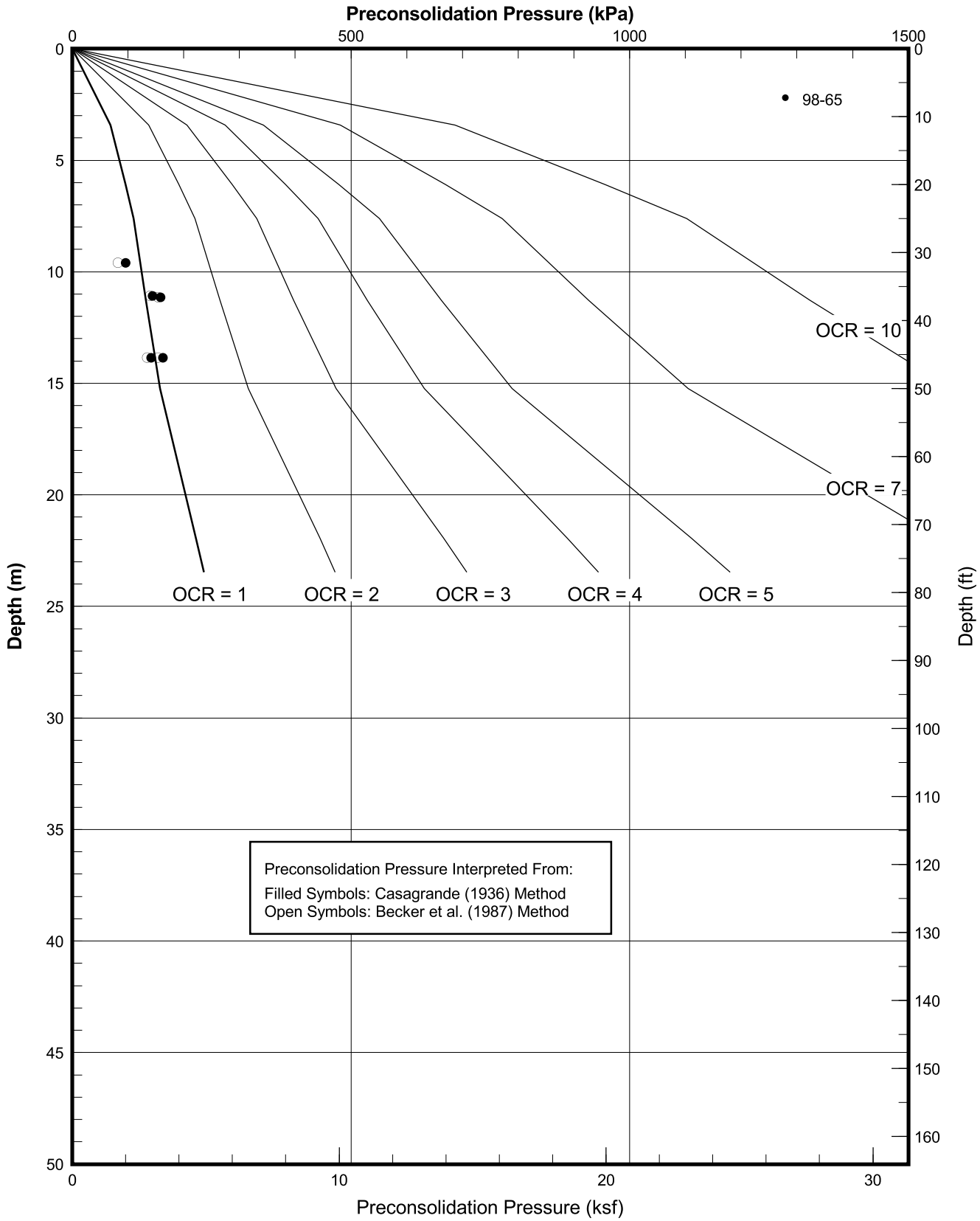
Earth Mechanics

FUGRO



E50 PROFILE
Boring 98-65
SFOBB East Span Seismic Safety Project

PLATE 98-65.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-65

SFOBB East Span Seismic Safety Project

PLATE 98-65.16

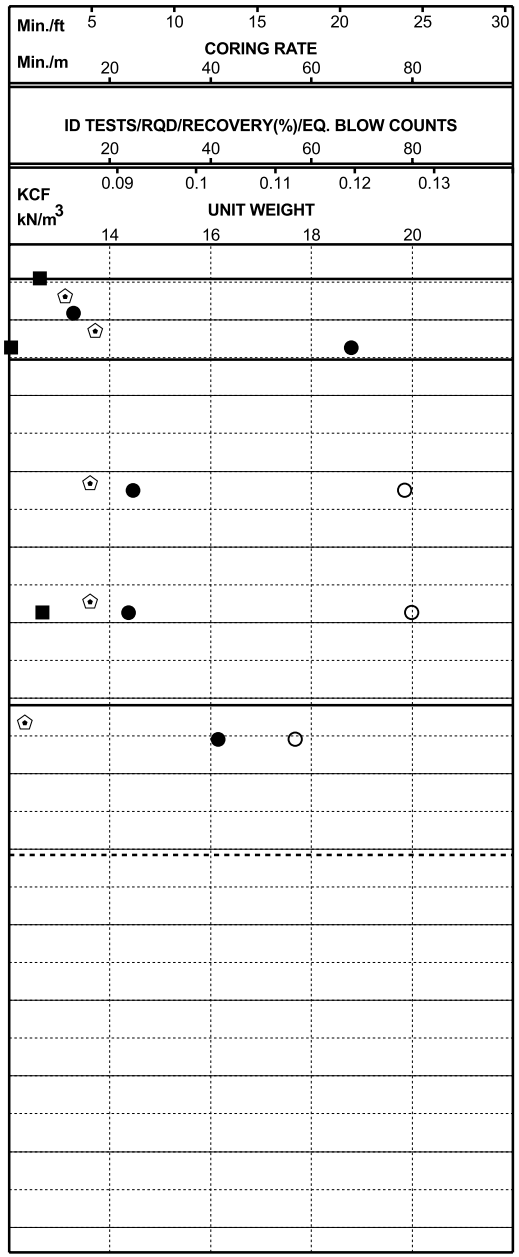
LAND BORING 98-66

PROJECT NO:	98-42-0058	**START DATE:**	10/13/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-66 (25m right of E. Sta. 88+24)	**COMPLETION DATE:**	10/13/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839317 N648260
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.1m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	0				PAVEMENT (0.5m)	I
				11 BAG	Fine GRAVEL (GP), with fine to coarse sand (lime treated base), medium dense, gray, moist	II
2	1			17	(1.5m)	
	2				Fine SAND (SP-SM), with silt, medium dense, brown	III
1						
	3				-with shell fragments at 3.0m ▽ (3.1m)	
0				16		
	4					
-1					-greenish gray and with shell fragments, at 4.6m	
	5			16		
-2					-with wood fragments and gravel, at 5.5m	
	6				(6.1m)	
-3				3	Fat CLAY (CH), firm, olive gray to gray	IV
	7				-with shell fragments	
-4					-with many silt pockets at 6.1m	
	8			NR		
-5					TOTAL DEPTH: 8.1m BACKFILLED WITH: Cement Grout	
	9					
-6						
	10					
-7						
	11					
-8						
	12					
-9						
	13					
-10						



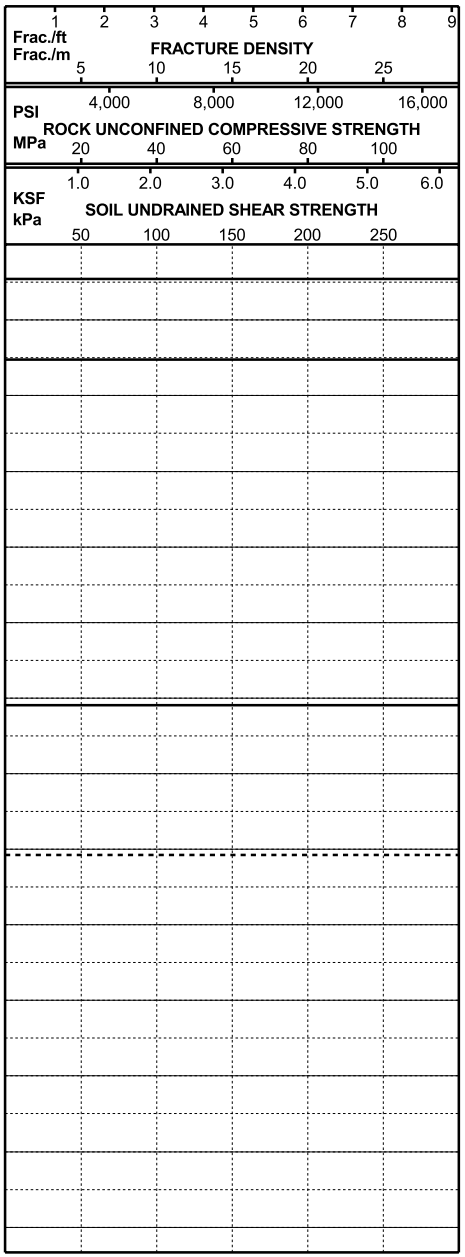


PLATE 98-66.1

LOG OF BORING AND TEST RESULTS

BORING 98-66

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

No Remote Vane Testing Performed For This Boring

98-66		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS	R-VALUE	
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max WD (kN/m3)	OMC (%)		SAND EQUIVALENT	
0.5	300						6													327	12.17	1	160	15.5			75	18
0.9	1	13																										
1.4	2	68					0																					
3.3	3	24																										
4.9	4	24					7																			H		
6.6	5	41																										

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-66
SFOBB East Span Seismic Safety Project

PLATE 98-66.3

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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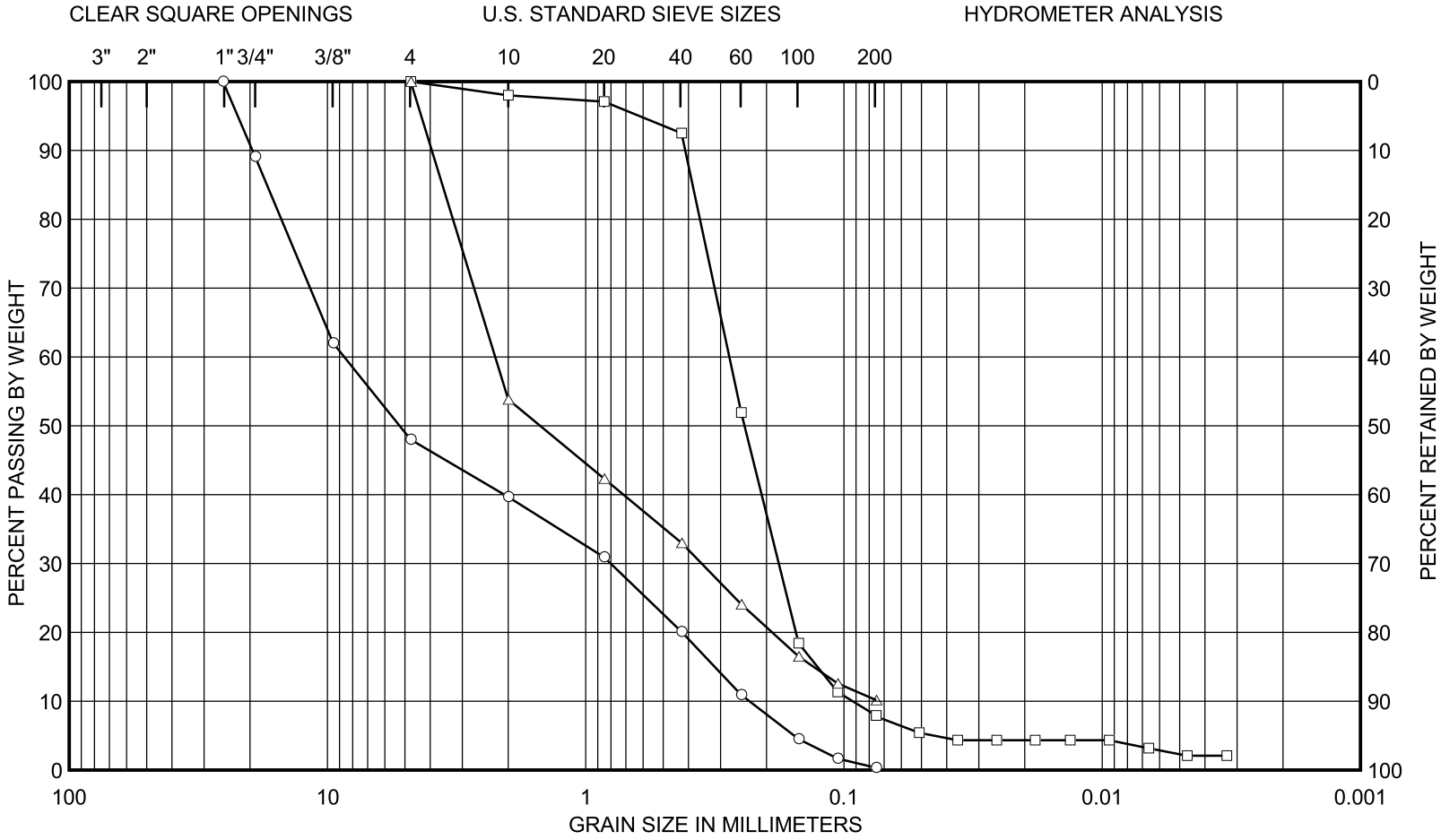

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
300	0.5	△—△	COARSE SAND (SP-SM) with silt, medium sand and fine sand			1.5
2	1.4	○—○	FINE GRAVEL (GP) with a trace of coarse gravel and fine to coarse sand	0.3	37.1	5.2
4	4.9	□—□	FINE SAND (SP-SM) with silt and a trace of medium sand	1.2	3.0	0.24

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-66
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-66.4

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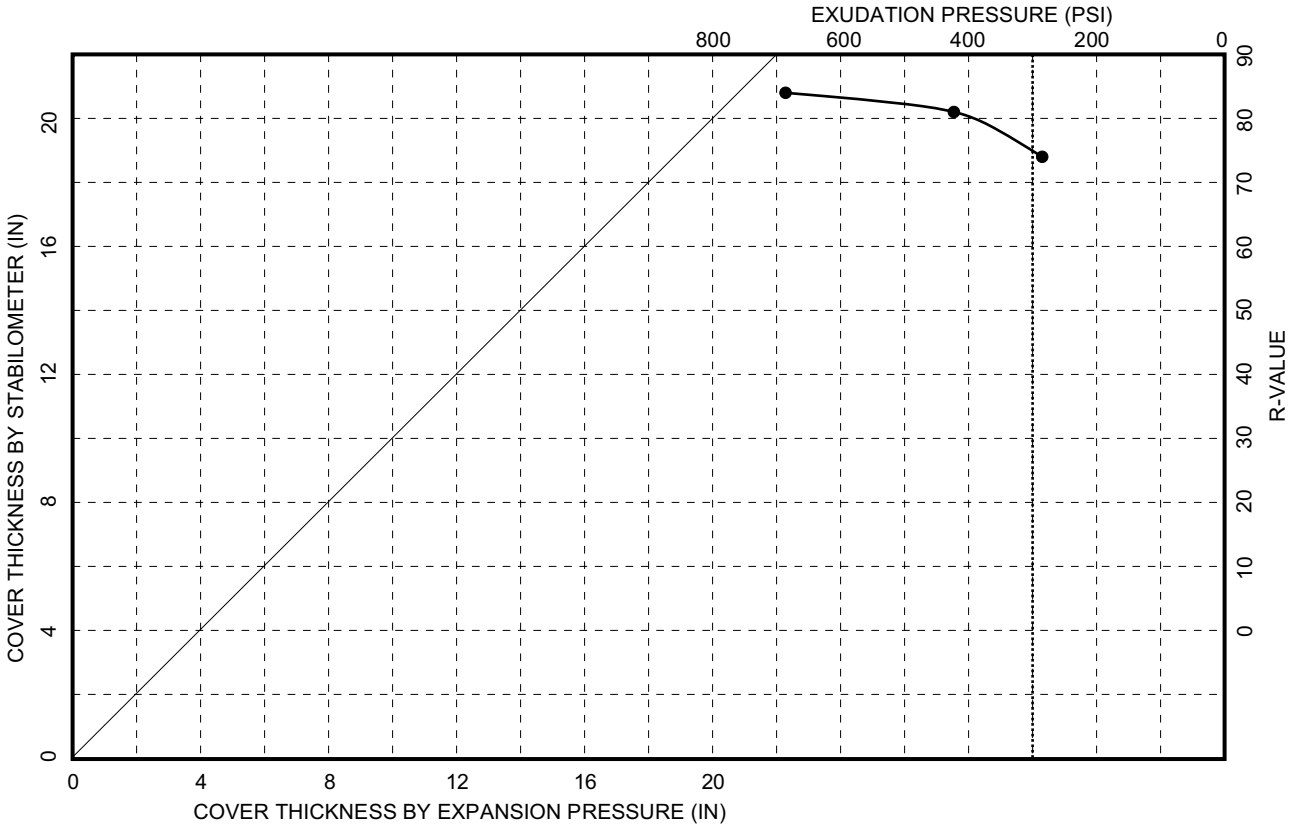
No Atterberg Limit Testing Performed For This Boring

No Unconsolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Incremental Consolidation Testing Performed For This Boring

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring



SAMPLE NO. 300
DESCRIPTION: Fine Gravel (GP) with silt and fine to coarse sand (lime treated base)

SPECIMEN	A	B	C
EXUDATION PRESSURE (PSI)	685	422	283
EXPANSION PRESSURE (PSF)	220	160	140
RESISTANCE VALUE, "R"	84	81	74
% MOISTURE AT TEST	25.0	26.0	28.0
DRY DENSITY AT TEST (PCF)	86.9	89.4	86.8
R-VALUE AT 300 PSI EXUDATION PRESSURE: 75			

R-VALUE TEST RESULTS
Boring 98-66
SFOBB East Span Seismic Safety Project

PLATE 98-66-10

Health Science Associates

LABORATORY REPORT

Report Number : 991057
Purchase Order :
Job No. : 98-42-0057

GREG DENLINGER
FUGRO WEST INC.
5855 OLIVAS PARK DR.
VENTURA, CA. 93003-7672

Date Received : 13-NOV-98
Date Completed : 19-NOV-98
Date Sent : 19-NOV-98
Page # 1 of 1

Sample Description : 4 - Bulk Soils
Project : Oakland

California Test Methods : 532,643

Auto No.	Submitter Sample Number	Resistivity ohms/cm	pH Units	Chloride ppm	Sulfate ppm
174124	98-63-14 @ 35.5'	653	9.13	4000	290
174125	98-72-300 @ 1.5'	399	12.11	<1.0	24.0
174126	98-66-300 @ 1.5'	327	12.17	<1.0	160
174127	98-61-1 @ 5'	762	9.17	720	630
Detection Limit :		10	NA	1.0	1.0

Millliliters Water Added	50	100	150	200	250	300	350
	Resistivity Ohm-cm						
Sample No.							
98-63-14	1525	1162	908	762	653	653	690
98-73-300	1343	762	472	399	581	1416	-
98-66-300	581	363	327	363	544	-	-
98-61-1	1198	908	762	1161	1089	-	-

Remarks : Sample(s) and sampling data as provided : by :

Analyst(s) : ED

Ref :

California ELAP No.: 1406
AIHA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AIHA ELLAP Accreditation No.: 10985
LACSD Lab No.: 10125

Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Susan Rosenberg
Laboratory Director, Susan B. Rosenberg, CIH

PLATE 98-66.11

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

This report pertains only to the samples investigated and does not necessarily apply to other apparently identical or similar materials. This report is submitted for the exclusive use of the client to whom it is addressed. Any reproduction of this report or use of this Laboratory's name for advertising or publicity purposes without written authorization is prohibited.

No Soil Property Profiles For This Boring

LAND BORING 98-67

PROJECT NO:	98-42-0058	**START DATE:**	10/28/1998	**DRILLER:**	Pitcher Drilling Company
BORING:	98-67 (14m left of E. Sta. 89+73)	**COMPLETION DATE:**	10/28/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

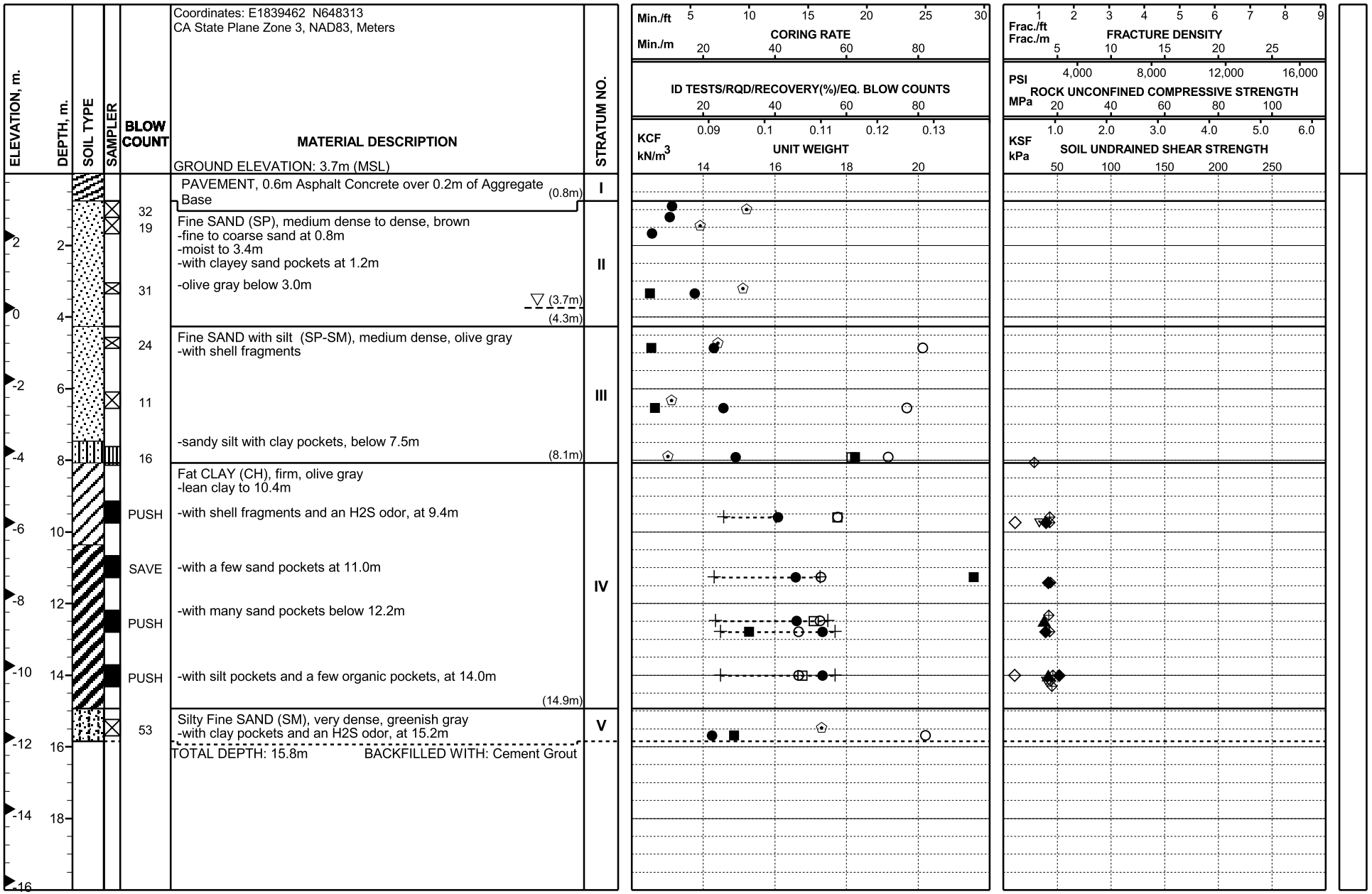


PLATE 98-67.1

LOG OF BORING AND TEST RESULTS

BORING 98-67

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-67		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.9	1	11																								
1.2	2	11																								
1.7	3	6																								
3.4	4	17					5																			
4.9	5	23					5																			
6.6	6	26					6																			
7.9	7	29				18.1	62																			
8.1	8							28.7																		
9.6	10	41	40	26	1.02	17.7		43.1																		
9.8	11							43.1		33.5	39.6	10.8														
11.3	12	46	53	23	0.76		95																			C,H,K
11.4	13							44.0			41.8															
12.3	14							42.1																		
12.5	15	46	55	23	0.71	17.1									37.9		1.8									
12.8	17	53	57	25	0.88		33	43.1			39.2															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-67
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-67.3a

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98-67		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
14.0	19	53	57	25	0.88	16.8		46.0			52.0	10.3			41.6		2.3									
14.2	20							44.0		40.2																
14.3	21							45.0																		
15.7	22	22					28																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.3b

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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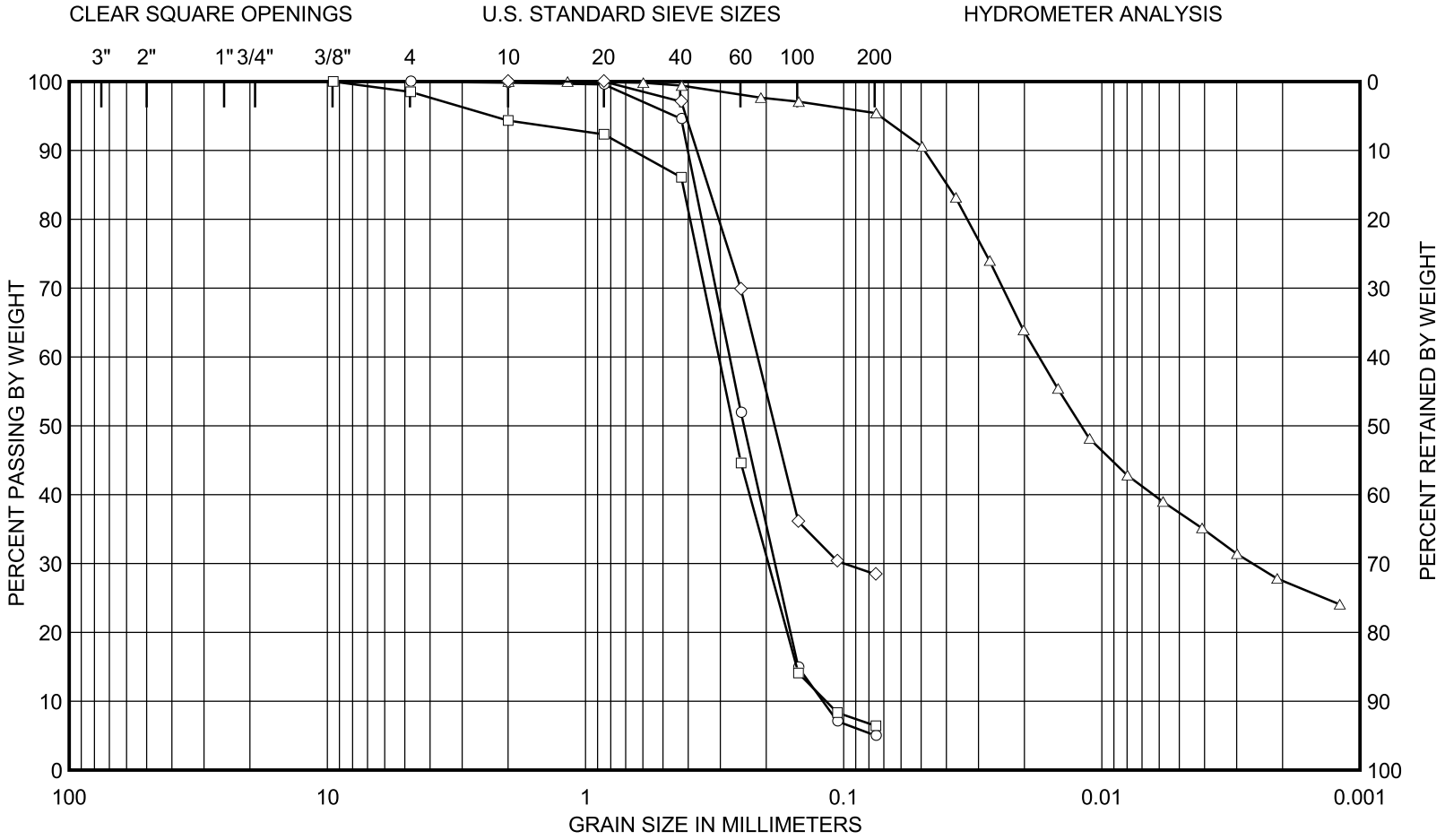

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
4	3.4	○—○	FINE SAND (SP)	1.0	2.3	0.24
6	6.6	□—□	FINE SAND (SP-SM) with silt and a trace of medium sand	1.1	2.6	0.27
12	11.3	△—△	FAT CLAY (CH)			0.012
22	15.7	◇—◇	SILTY FINE SAND (SM)			0.19

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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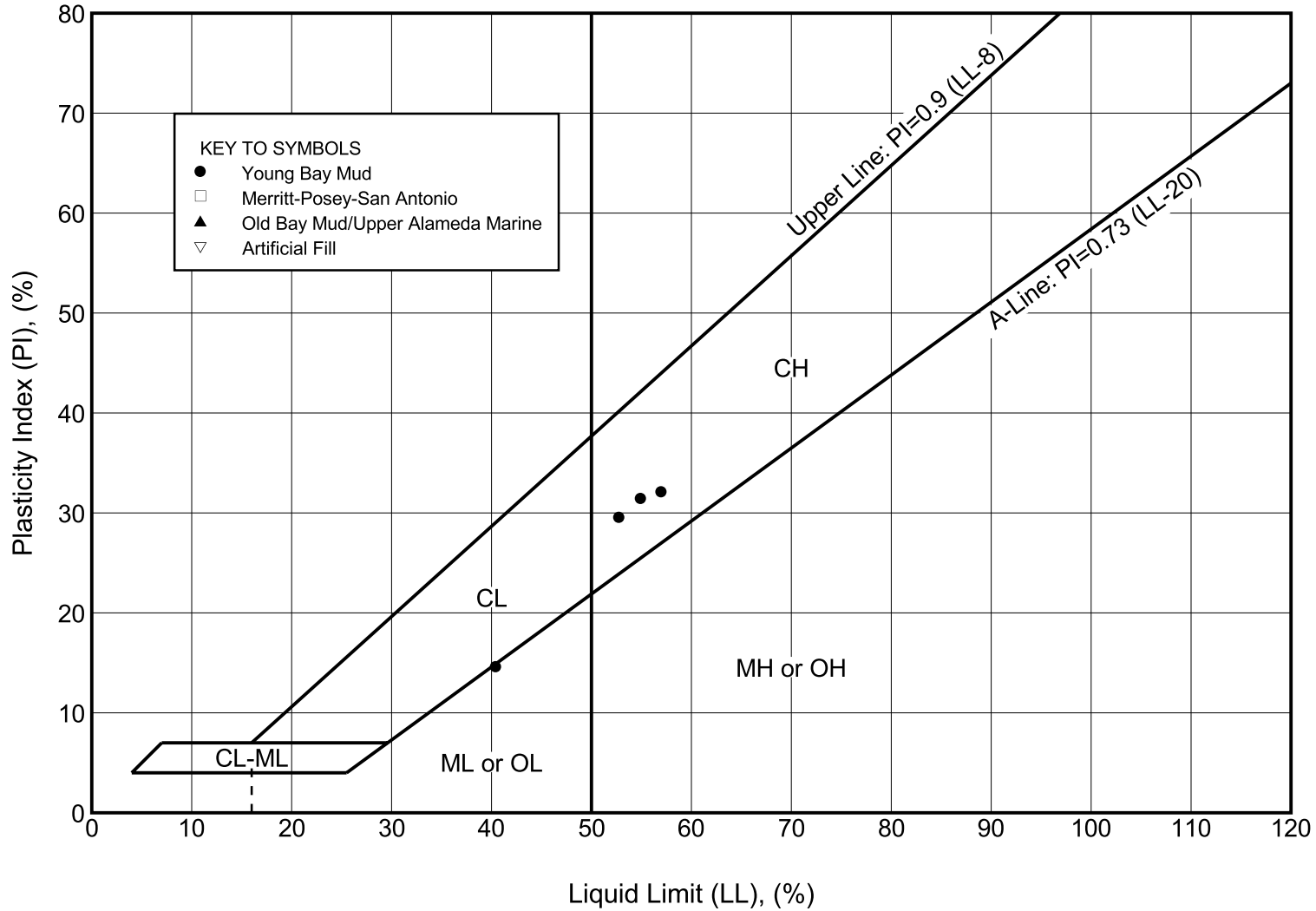
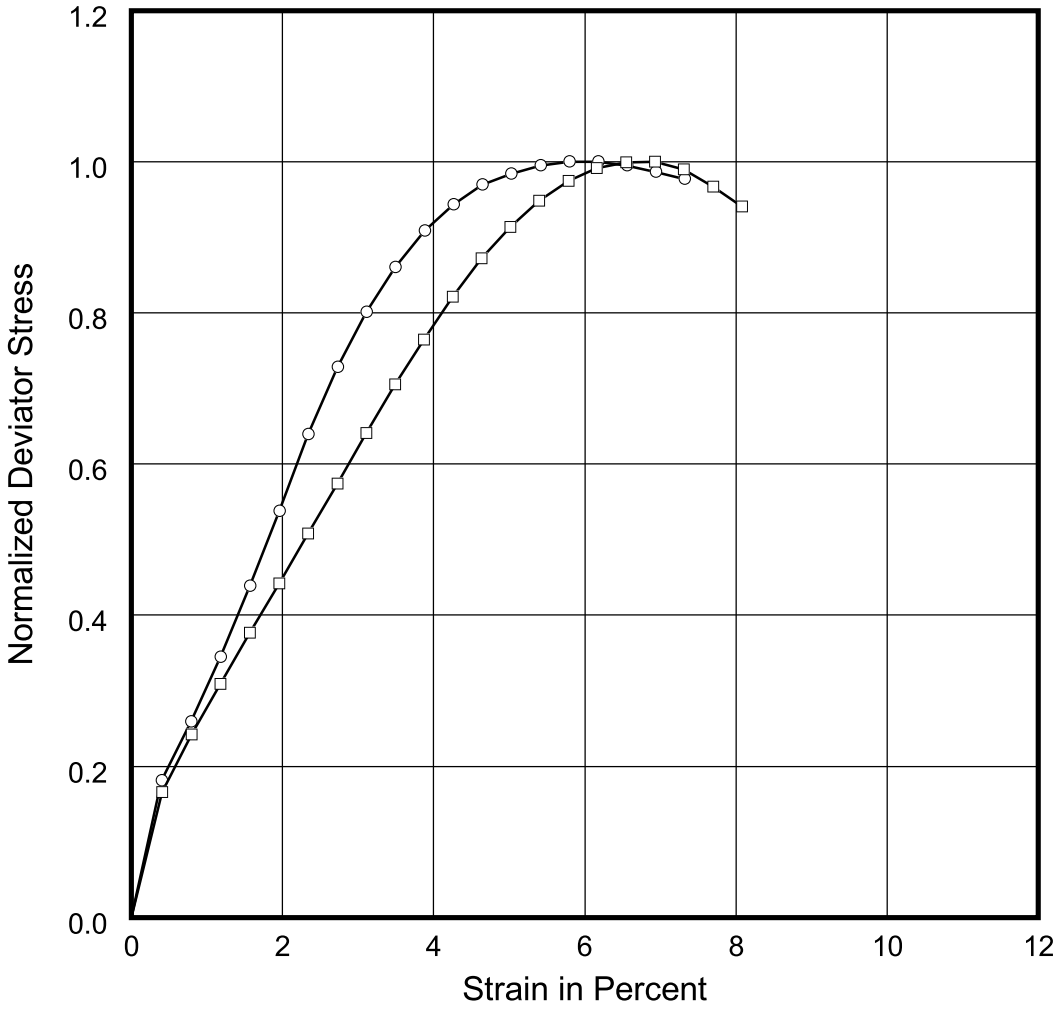


PLASTICITY CHART
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.5

Earth Mechanics

FUGRO



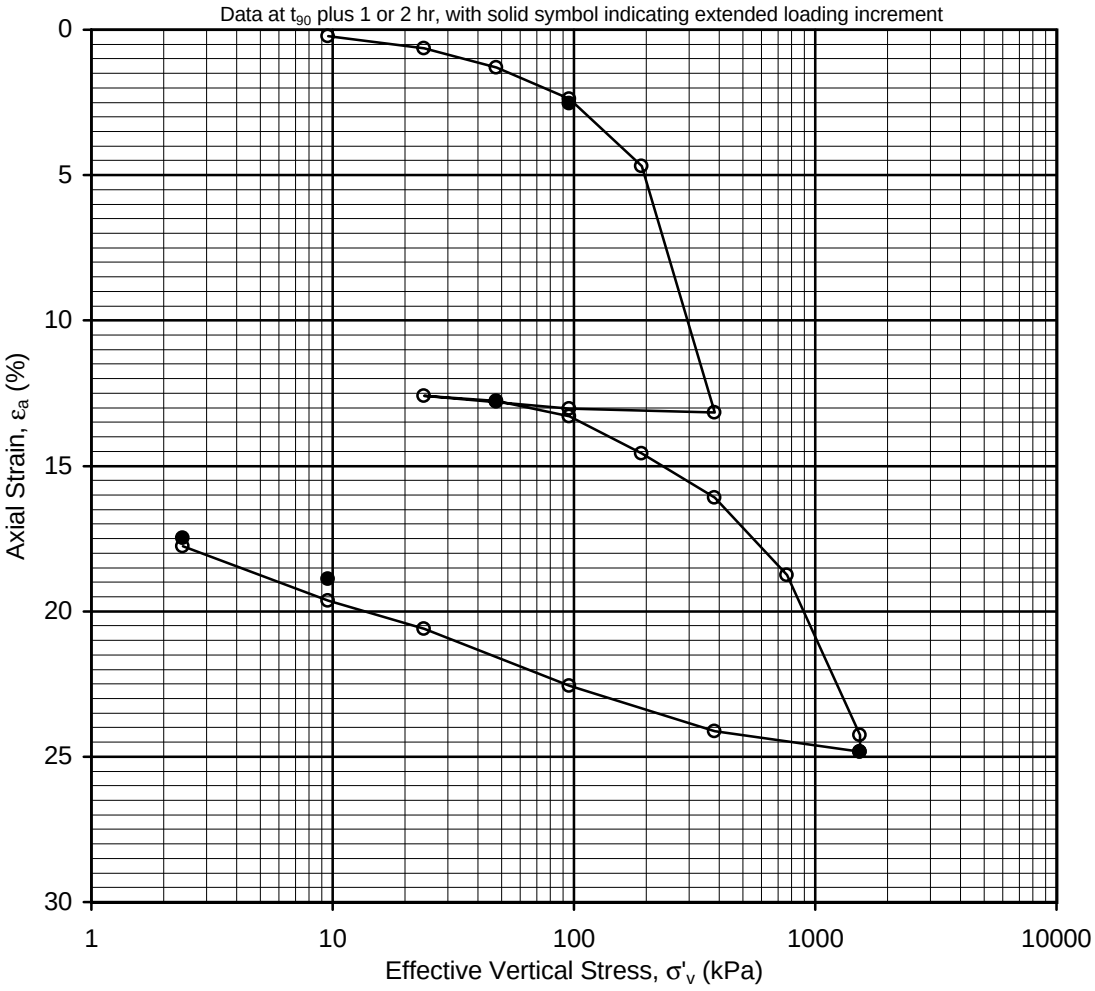
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	15	12.5	UU	241	76	1.8
□—□	19	14.0	UU	262	83	2.3

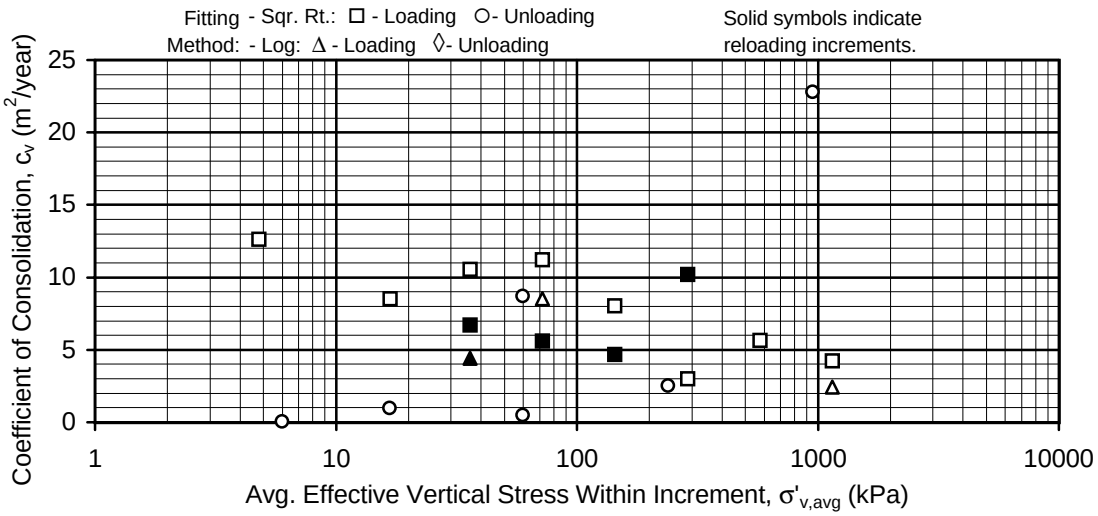
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-67
SFOBB East Span Seismic Safety Project

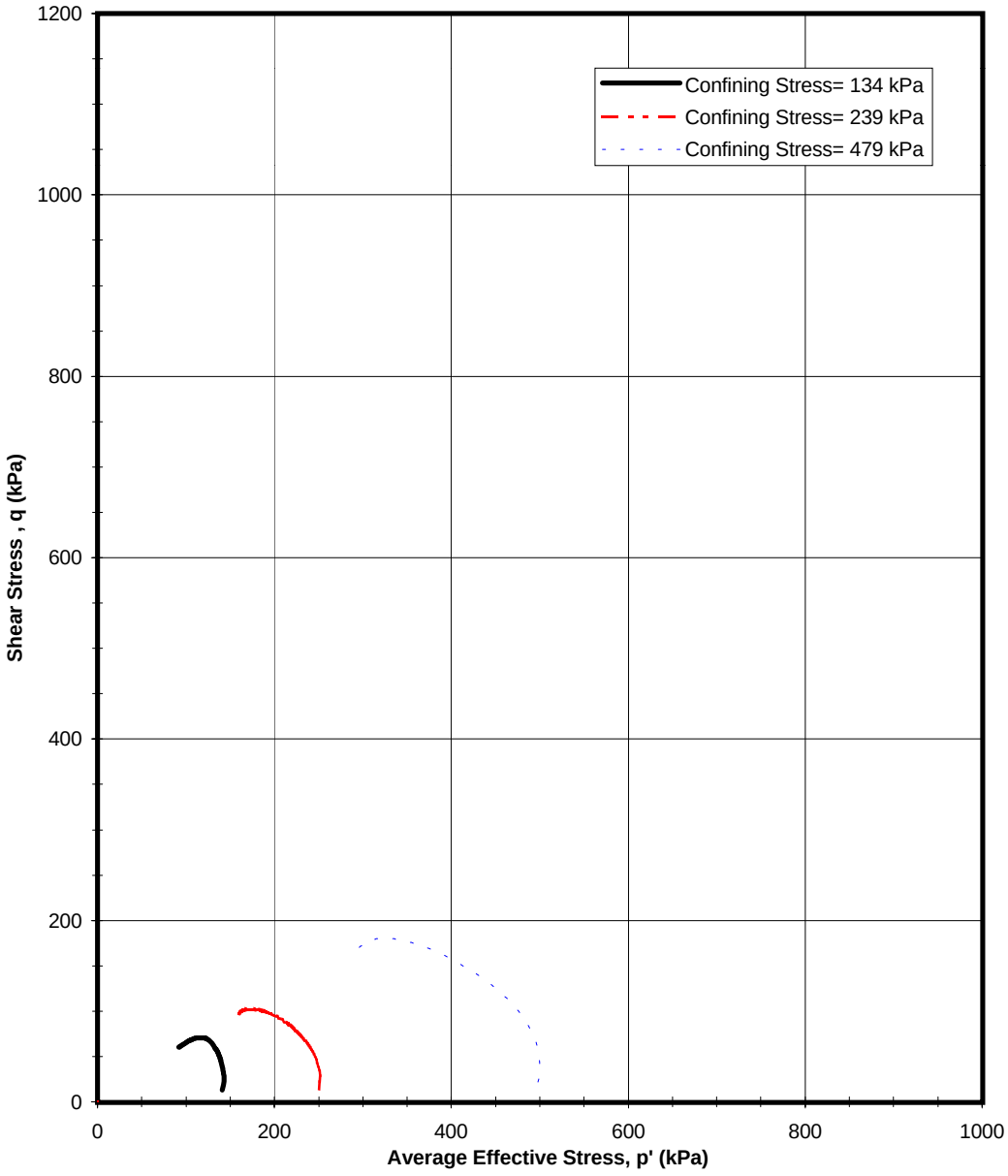
PLATE 98-67.6





INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 12 - Depth: 11.2m
Boring 98-67
SFOBB East Span Seismic Safety Project



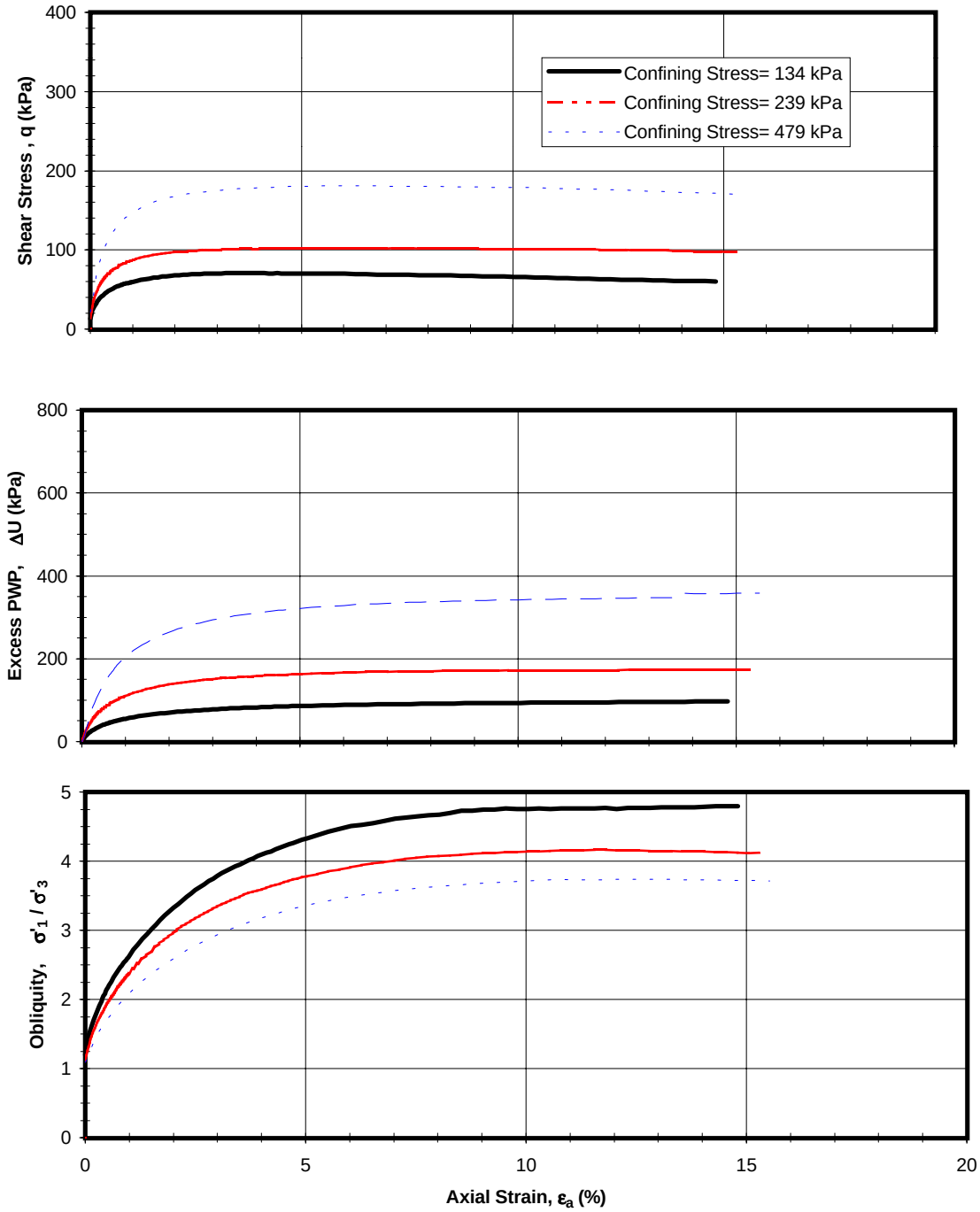
CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 12 - Depth: 11.0m

Boring 98-67

SFOBB East Span Seismic Safety Project

PLATE 98-67.8a



CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 12 - Depth: 11.0m

Boring 98-67

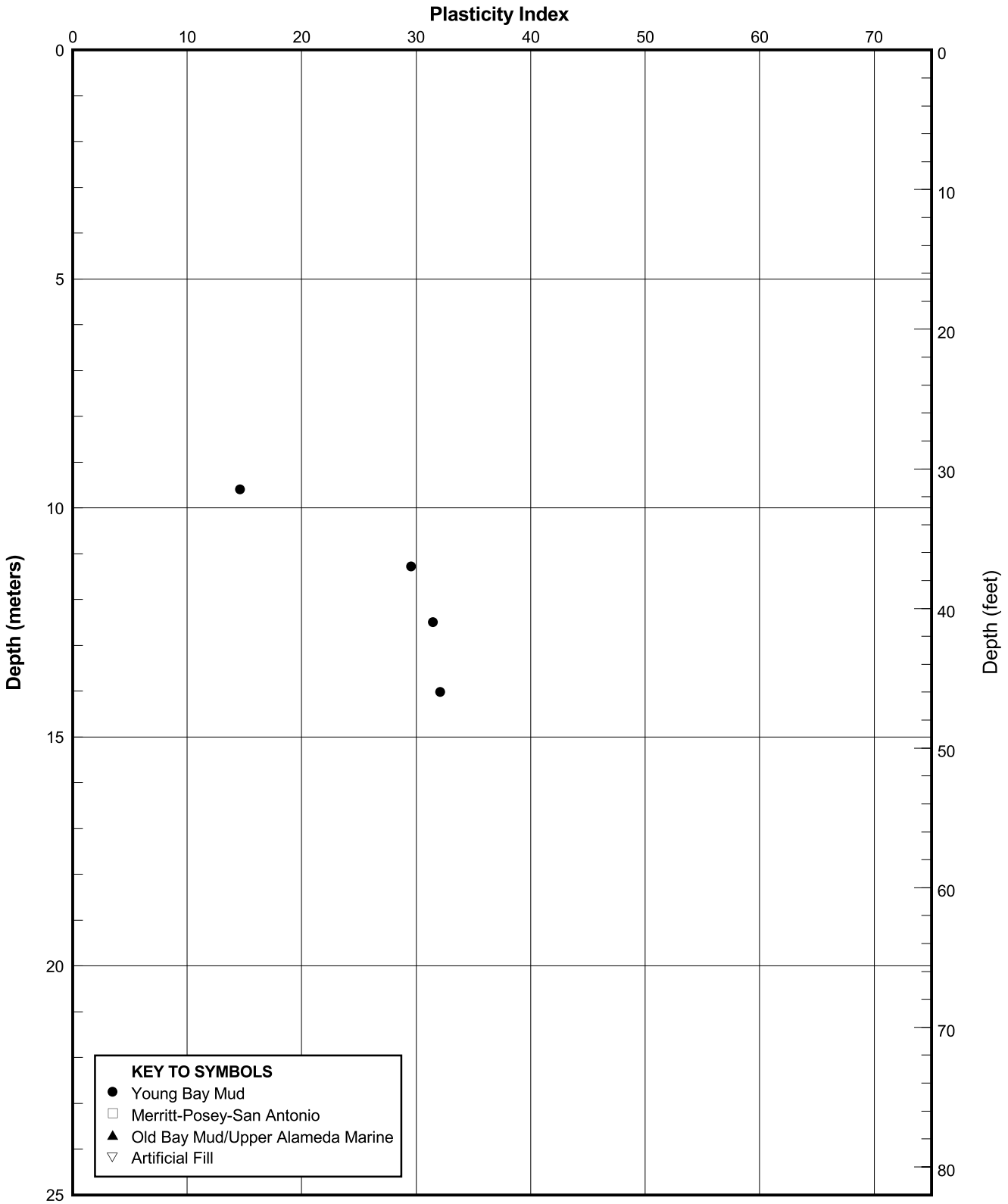
SFOBB East Span Seismic Safety Project

PLATE 98-67.8b

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring

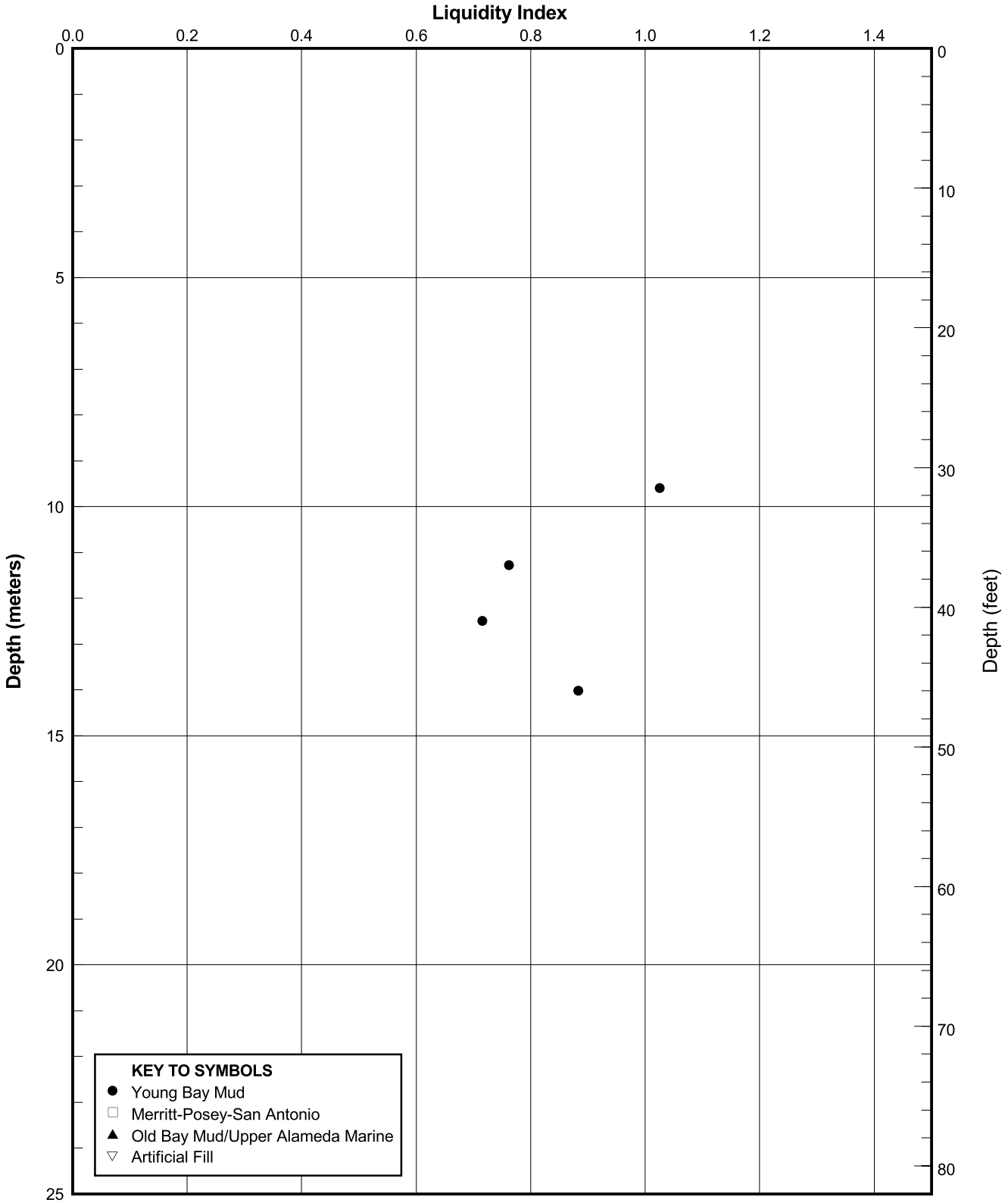


PLASTICITY INDEX PROFILE
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.12

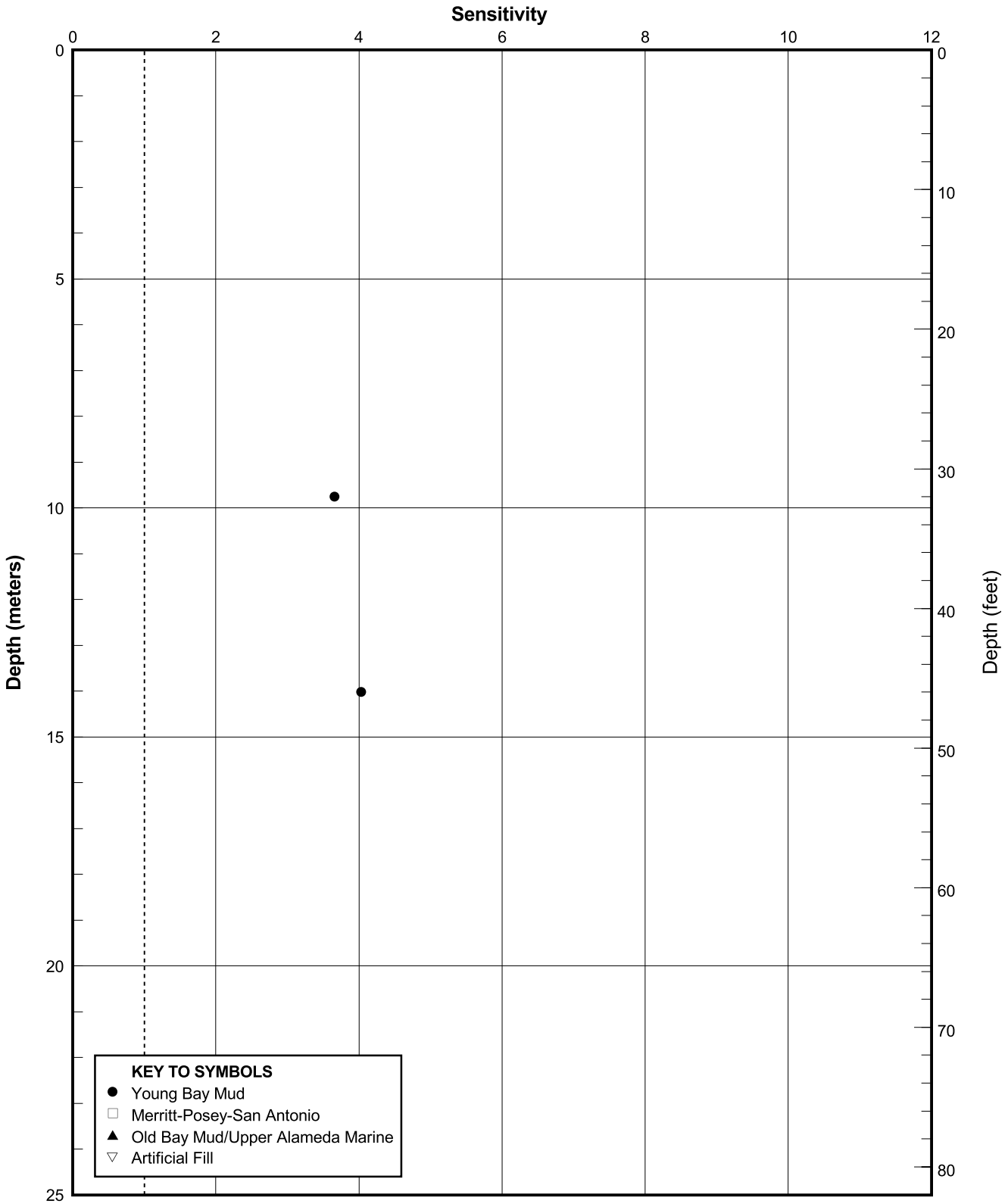
Earth Mechanics

FUGRO



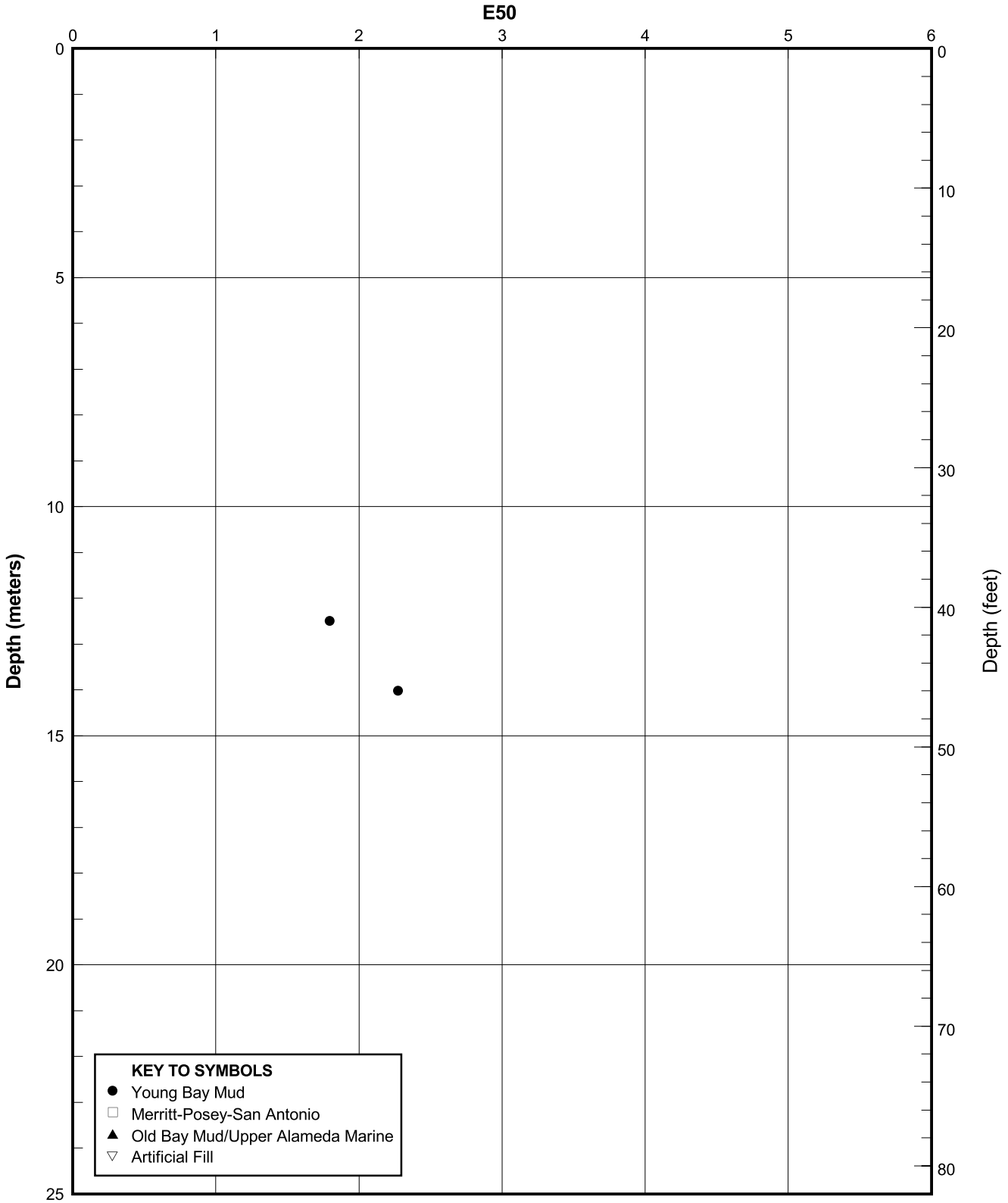
LIQUIDITY INDEX PROFILE
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.13



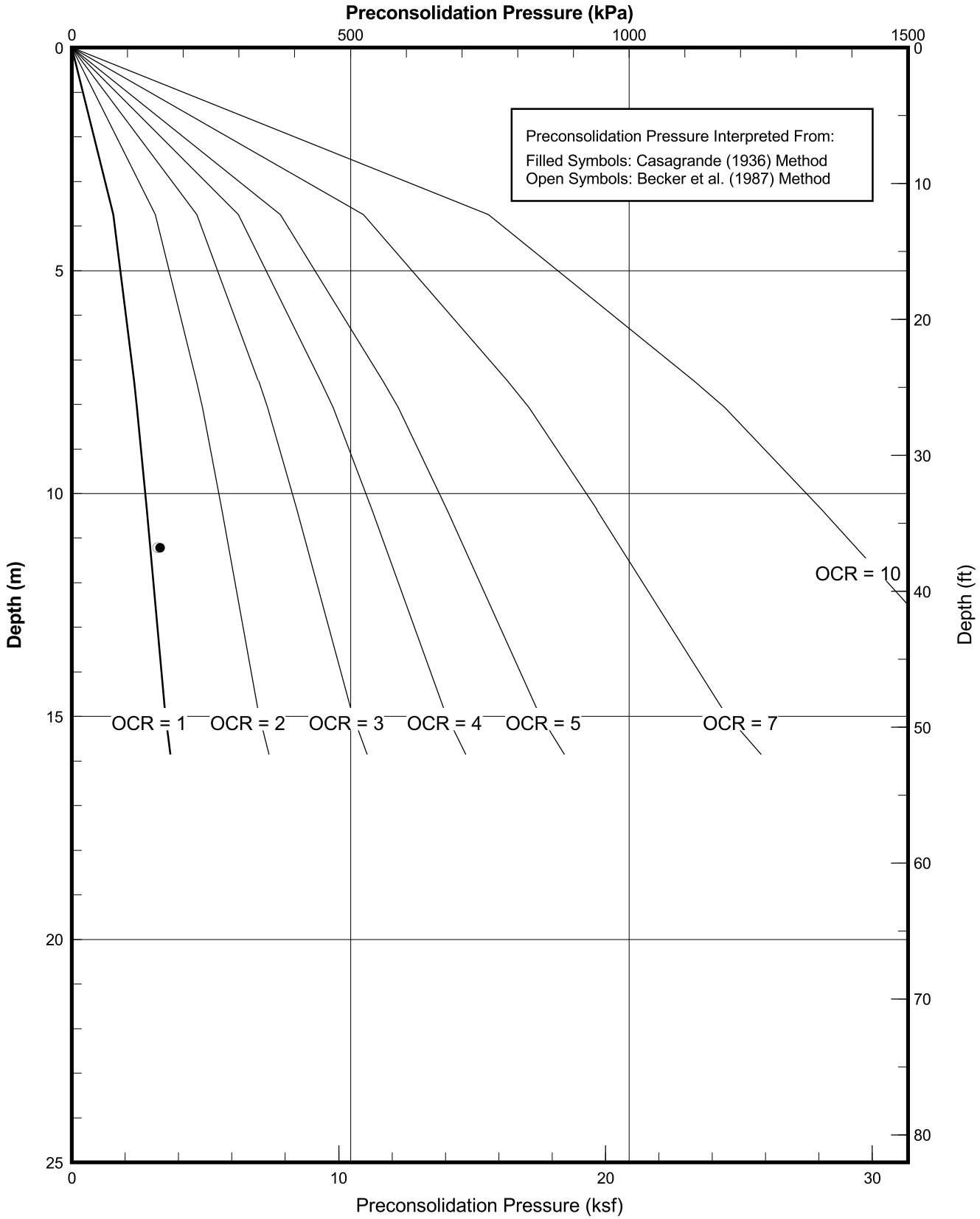
SENSITIVITY PROFILE
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.14



E50 PROFILE
Boring 98-67
SFOBB East Span Seismic Safety Project

PLATE 98-67.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-67

SFOBB East Span Seismic Safety Project

PLATE 98-67.16

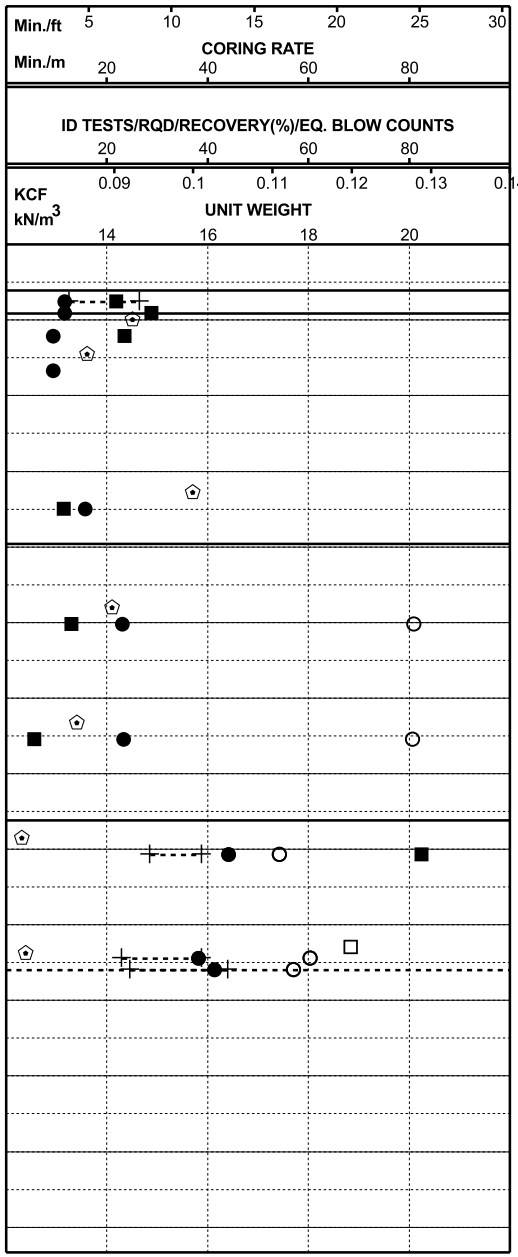
LAND BORING 98-68

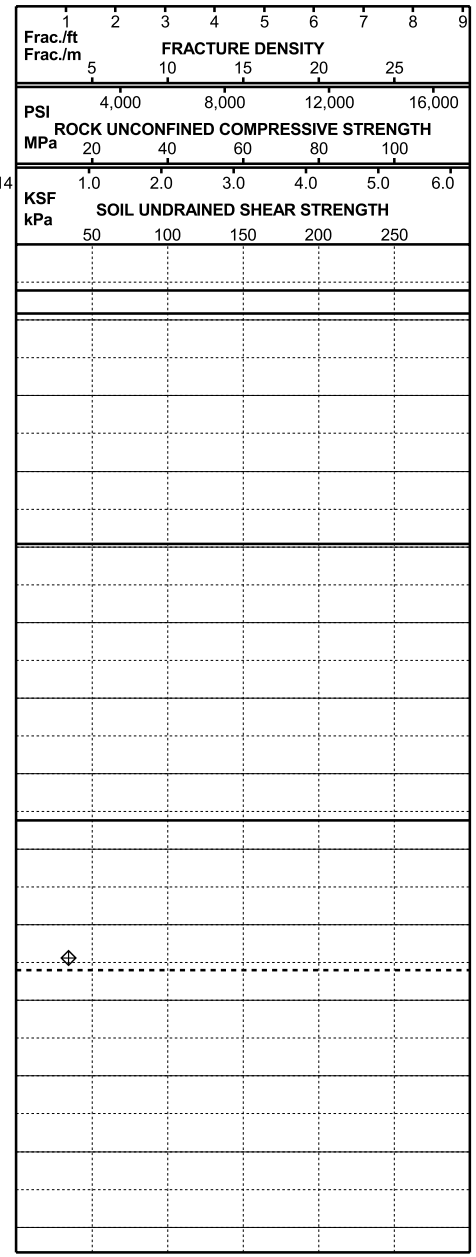
PROJECT NO:	98-42-0058	**START DATE:**	10/27/98	**DRILLER:**	Pitcher Drilling Company	Page 1 of 1
BORING:	98-68 (18m right of W. Sta. 91+38)	**COMPLETION DATE:**	10/27/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)	

Coordinates: E1839597 N648340
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.7m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
			PAVEMENT, 0.4m Asphalt Concrete over 0.2m of Aggregate Base (0.6m)	I
			(0.9m)	II
3	1	25	Silty Fine GRAVEL (GM), medium dense, reddish brown -with fine to coarse sand and coarse gravel -clayey fine sand at 0.8m	
		BAG		
2	2	16	Silty Fine SAND (SM), medium dense to dense, brown -with shell fragments -moist to 3.0m	III
1	3	37	▽ (3.7m)	
0	4		(4.0m)	
			Silty Fine SAND (SM), medium dense, olive gray -with shell fragments	
-1	5	21		
-2	6		-fine sand with silt below 5.8m	IV
		14		
-3	7		(7.6m)	
-4	8	3	Lean CLAY (CL), firm, olive gray -with many fine sand pockets and shell fragments, at 7.9m	V
-5	9		-with many shell fragments at 9.1m	
		6		
-6	10		TOTAL DEPTH: 9.6m BACKFILLED WITH: Cement Grout	
-7	11			
-8	12			
-9	13			





LOG OF BORING AND TEST RESULTS

BORING 98-68

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

PLATE 98-68.1

c:\snfco-oak\current\odb\9868m.odb

No Remote Vane Testing Performed For This Boring

98-68		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS	R-VALUE	SAND EQUIVALENT
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)			
0.8	300	12	27	13			22																	21.7			13	14
0.9	1						29																					
1.2	2	9					23																					
1.7	3	9																										
3.5	4	16					11																					
5.0	5	23					13																					
6.6	6	23					6																					
8.1	7	44	39	29	1.51		82																					
9.3	8					18.8																						
9.4	9	38	39	23	0.95			34.5																				
9.6	10	41	44	25	0.86																							

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

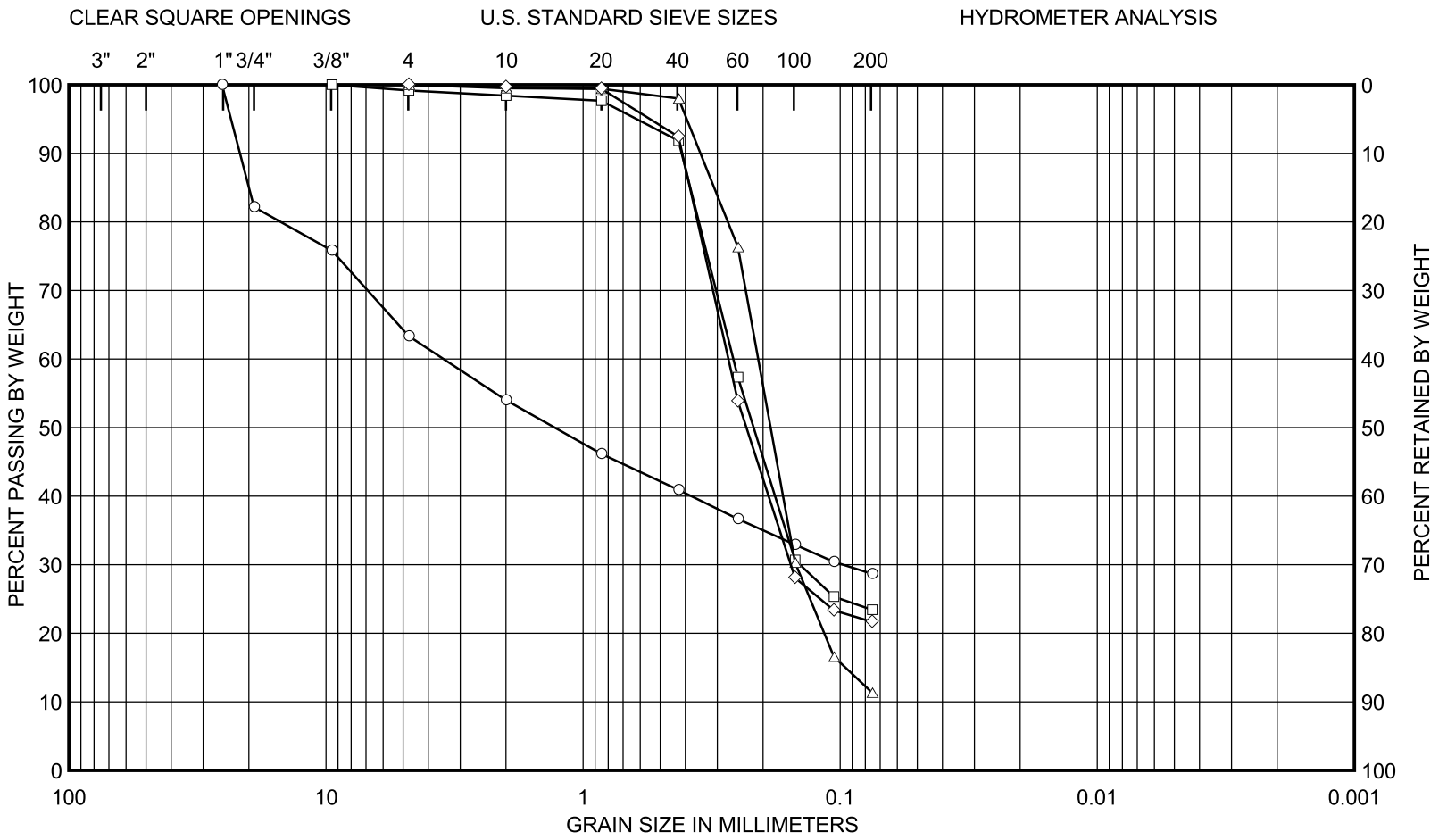
\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-68
SFOBB East Span Seismic Safety Project

PLATE 98-68.3

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	0.9	○—○	SILTY FINE GRAVEL (GM) with fine to coarse sand, and coarse gravel			1.3
2	1.2	□—□	SILTY FINE SAND (SM) with a trace of medium sand			0.22
4	3.5	△—△	FINE SAND (SP-SM) with silt			0.19
300	0.8	◇—◇	CLAYEY FINE SAND (SC) with a trace of medium sand			0.23

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-68
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-68.4

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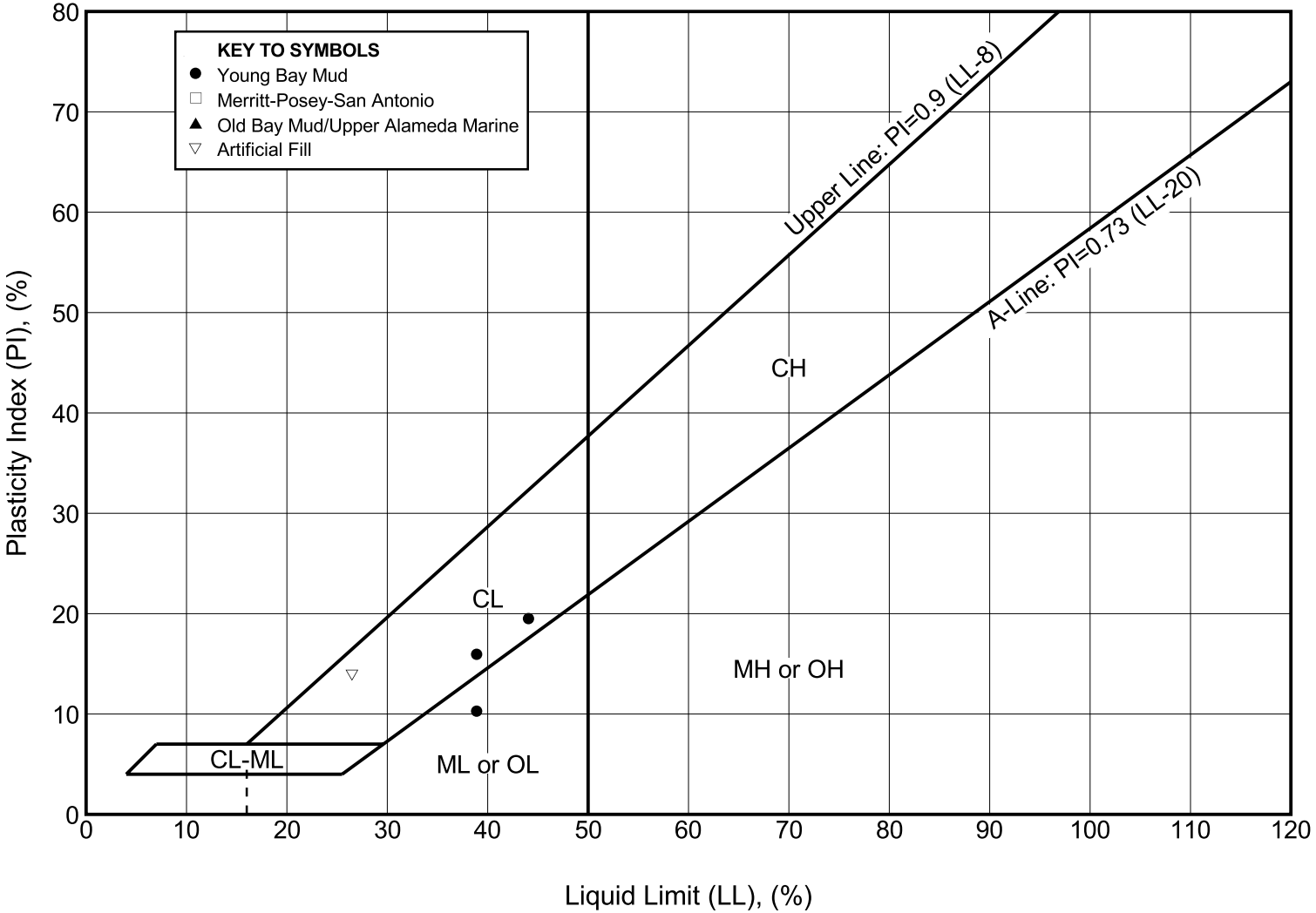


PLASTICITY CHART
Boring 98-68
SFOBB East Span Seismic Safety Project

PLATE 98-68.5

Earth Mechanics

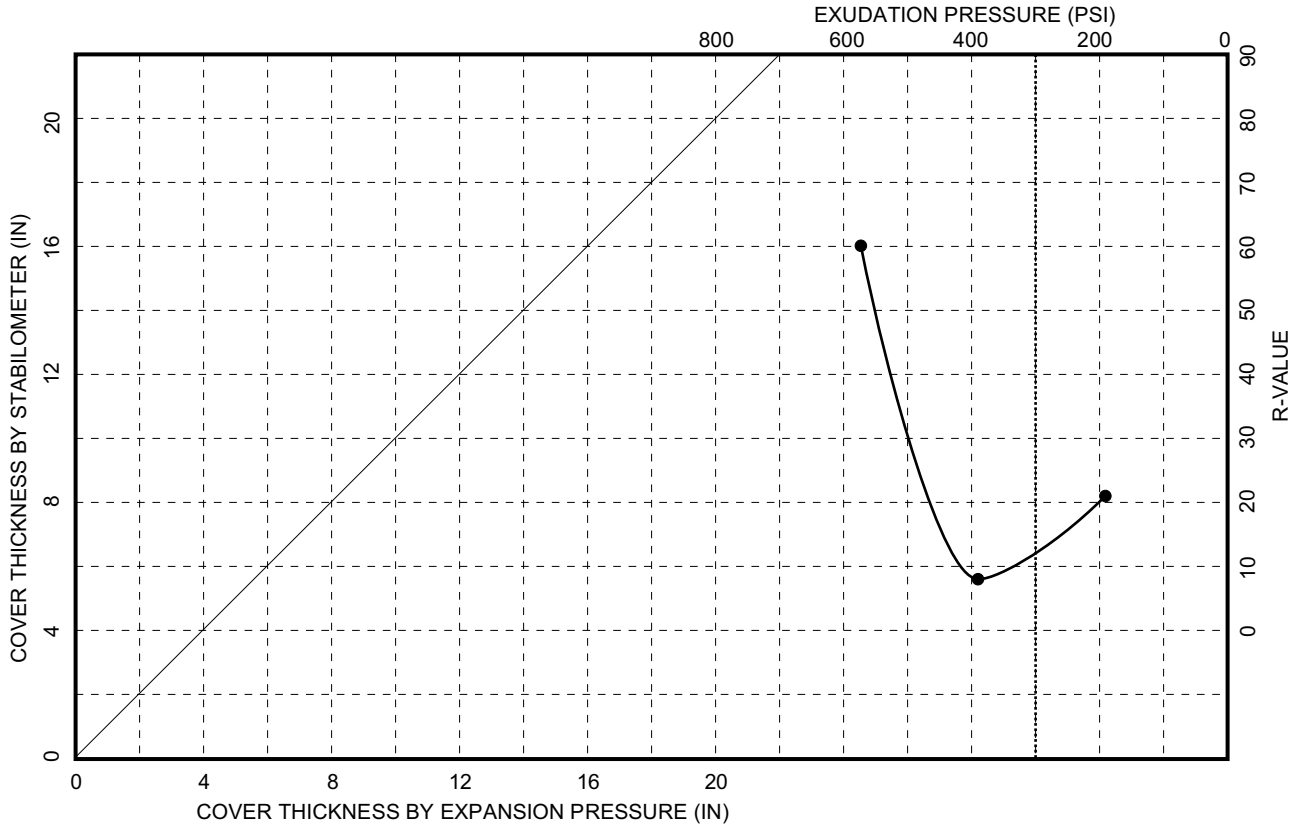
FUGRO

No Unconsolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Incremental Consolidation Testing Performed For This Boring

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring



SAMPLE NO. 300
DESCRIPTION: Silty Fine Gravel (GM) with fine to coarse sand

SPECIMEN	A	B	C
EXUDATION PRESSURE (PSI)	573	191	390
EXPANSION PRESSURE (PSF)	130	120	120
RESISTANCE VALUE, "R"	60	21	8
% MOISTURE AT TEST	10.1	11.1	11.6
DRY DENSITY AT TEST (PCF)	129.1	126.8	125.1
R-VALUE AT 300 PSI EXUDATION PRESSURE: 13			

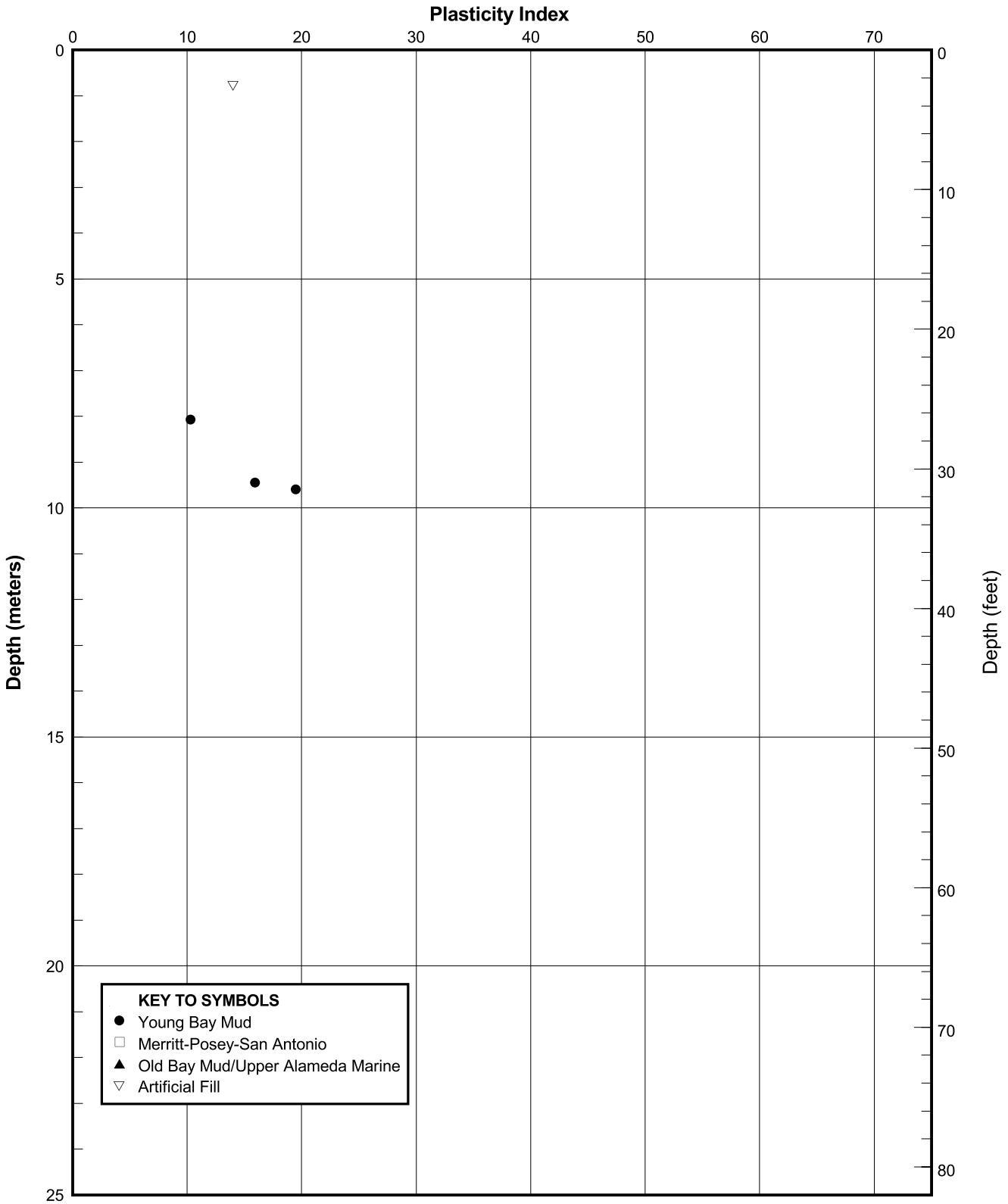
R-VALUE TEST RESULTS
Boring 98-68
SFOBB East Span Seismic Safety Project

PLATE 98-68-10

No Corrosion Testing Performed For This Boring

Earth Mechanics

FUGRO

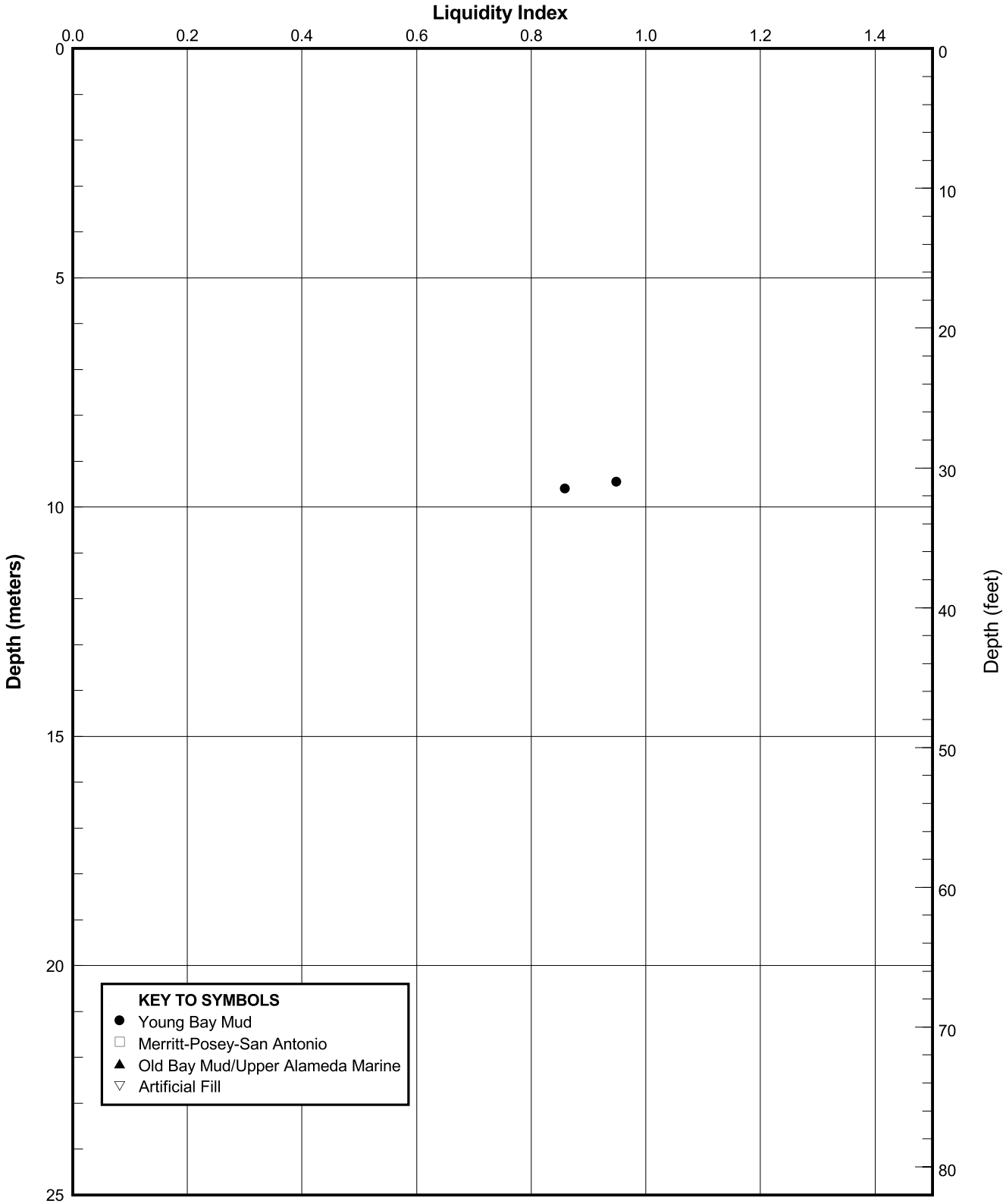


PLASTICITY INDEX PROFILE
Boring 98-68
SFOBB East Span Seismic Safety Project

PLATE 98-68.12

Earth Mechanics

FUGRO



LIQUIDITY INDEX PROFILE
Boring 98-68
SFOBB East Span Seismic Safety Project

PLATE 98-68.13

No Sensitivity Data Exists For This Boring

No Unconsolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Incremental Consolidation Testing Performed For This Boring

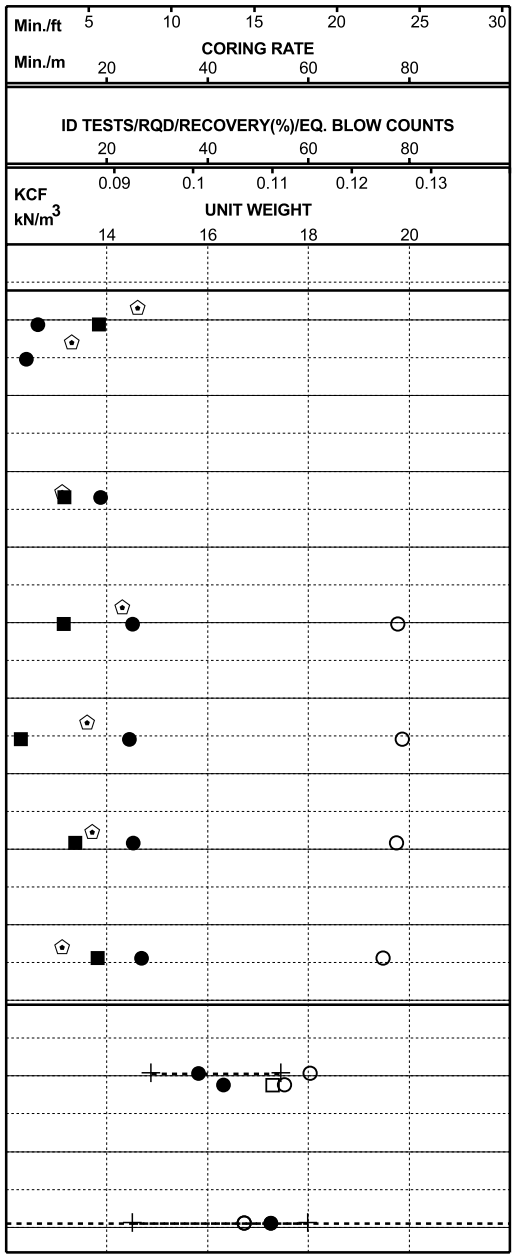
LAND BORING 98-69

PROJECT NO:	98-42-0058	**START DATE:**	10/27/98	**DRILLER:**	Pitcher Drilling Company	Page 1 of 1
BORING:	98-69 (18m right of W. Sta. 92+19)	**COMPLETION DATE:**	10/27/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)	

Coordinates: E1839677 N648359
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.8m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
			PAVEMENT, 0.4m Asphalt Concrete over 0.2m of Aggregate Base (0.6m)	I
3	1	26 BAG 13	Fine SAND with silt (SP-SM), medium dense, brown -moist to 3.0m -gravel with clay at 0.8m -silty fine sand at 0.9m -with a clayey sand seam at 1.5m	
2	2			
1	3	11	-with shell fragments below 3.0m ▽ (3.8m)	
0	4			
-1	5	23	-olive gray below 4.6m	II
-2	6	16	-fine sand at 6.1m	
-3	7		-silty fine sand below 7.3m	
-4	8	17		
-5	9	11		
-6	10		-with a clayey sand seam at 9.4m (10.1m)	
-7	11	PUSH	Fat CLAY (CH), firm to stiff, olive gray -with a few shell fragments -with an H2S odor at 10.7m	III
-8	12			
-9	13	SAVE	TOTAL DEPTH: 13.0m BACKFILLED WITH: Cement Grout	



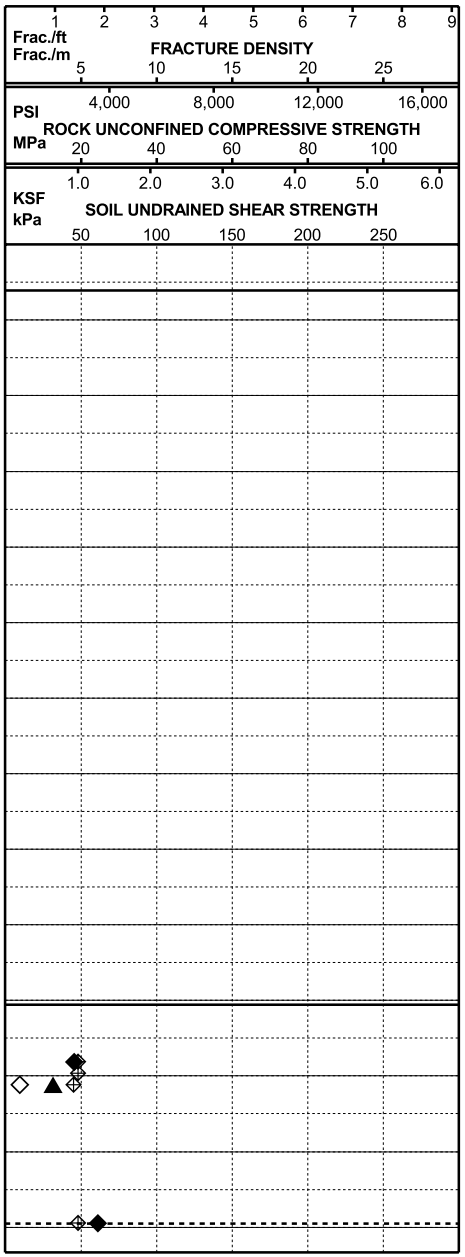


PLATE 98-69.1

LOG OF BORING AND TEST RESULTS

BORING 98-69

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

FUGRO

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No Remote Vane Testing Performed For This Boring

98-69		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS (CA-216)		ADDITIONAL TESTS	R-VALUE	SAND EQUIVALENT
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)			
0.6	300																			1271	8.68	223	122	19.9			35	28
1.1	1	6					18																					
1.5	2	4																										
3.4	3	19					11																					
5.0	4	25					11																					
6.6	5	24					3																					
7.9	6	25					14																					
9.4	7	27					18																					
10.8	8							47.9			45.4																	
11.0	9	38	55	29	0.36			47.9																		C		
11.1	10	43				17.3		45.0				9.7			31.6		1.0											
13.0	12	52	60	25	0.78			47.9			61.4																	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.3

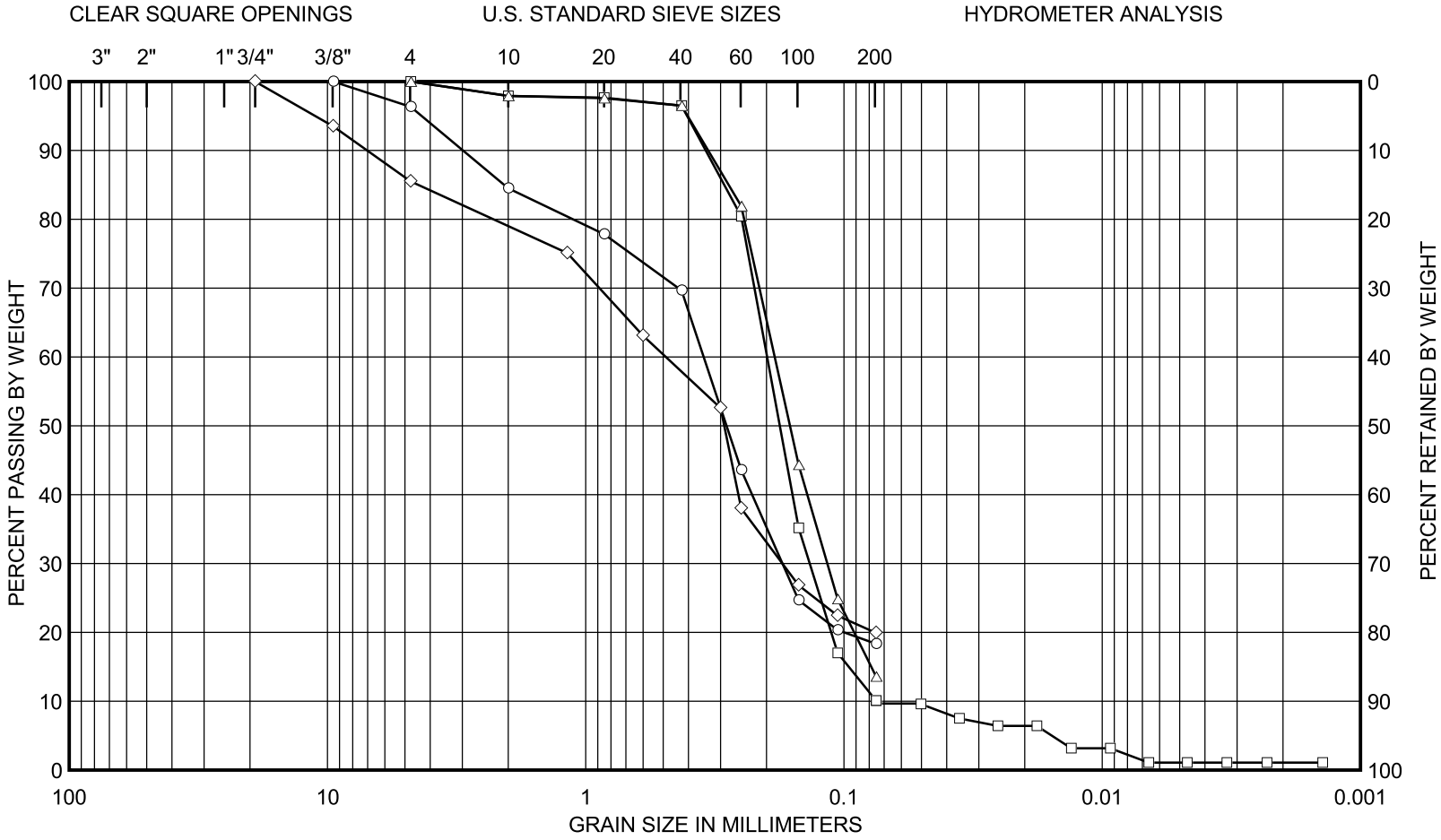
SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

c:\snfco-oak\current\odb\98-69sum.odb

i:\caltrans\98-69 02/55/YY



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.1	○—○	SILTY FINE SAND (SM) with a trace of medium and coarse sand			0.28
3	3.4	□—□	FINE SAND (SP-SM) with silt			0.18
6	7.9	△—△	SILTY FINE SAND (SM)			0.16
300	0.6	◇—◇	SILTY FINE SAND (SM) with medium sand and fine gravel			0.29

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-69
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-69.4

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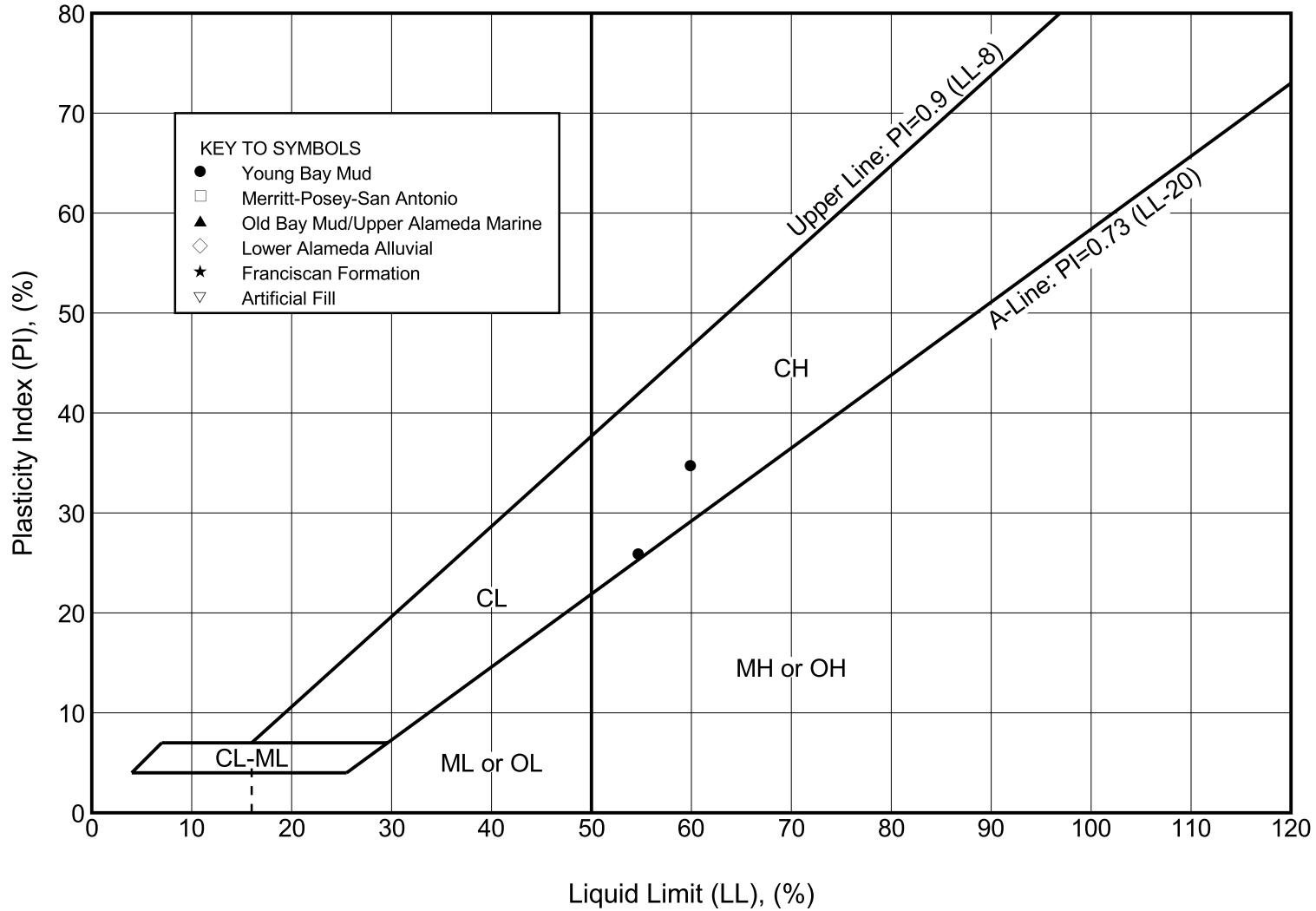
i:\caltrans\ 02/55/YY



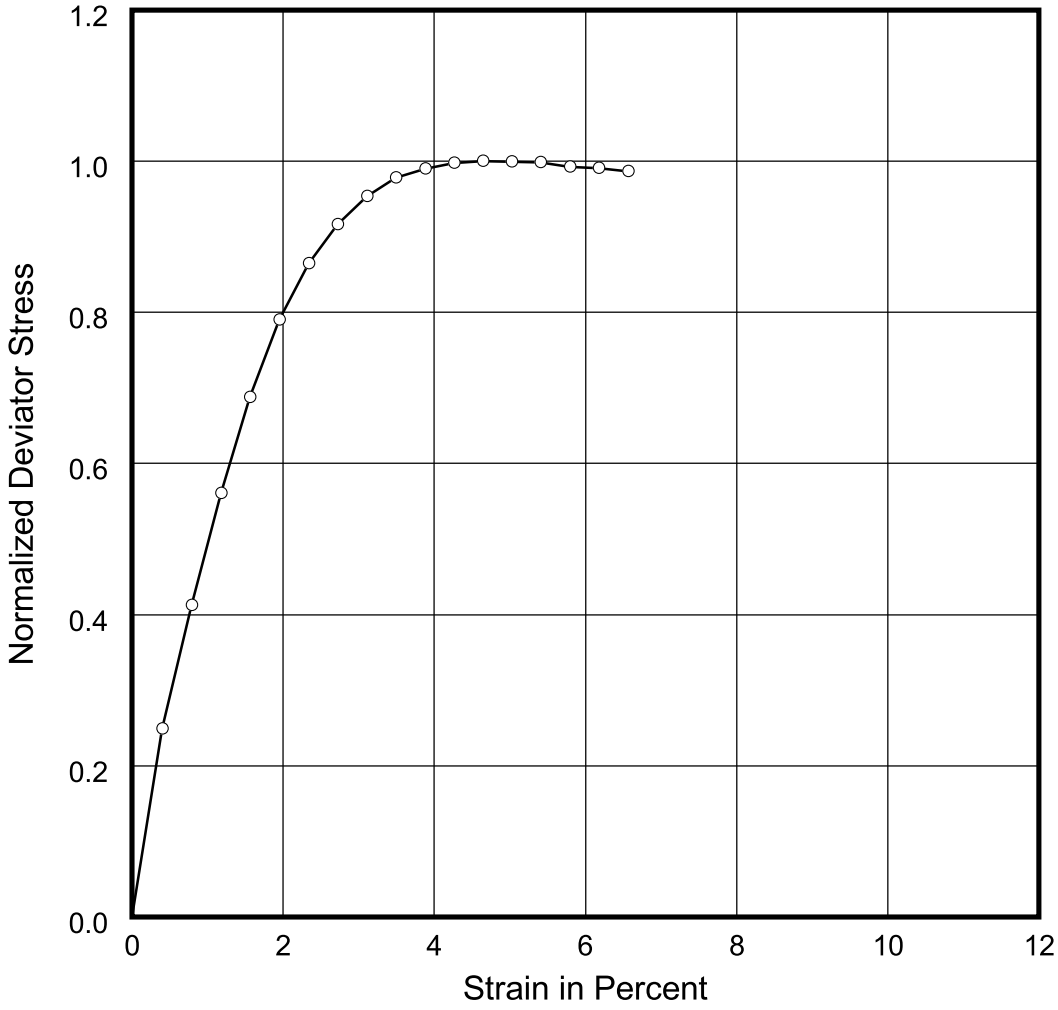
PLASTICITY CHART
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.5

Earth Mechanics

FUGRO

c:\snfco-oak\current\odb\plate98-69_5.odb



Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
⊙——⊙	10	11.1	UU	207	63	1.0

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-69
SFOBB East Span Seismic Safety Project

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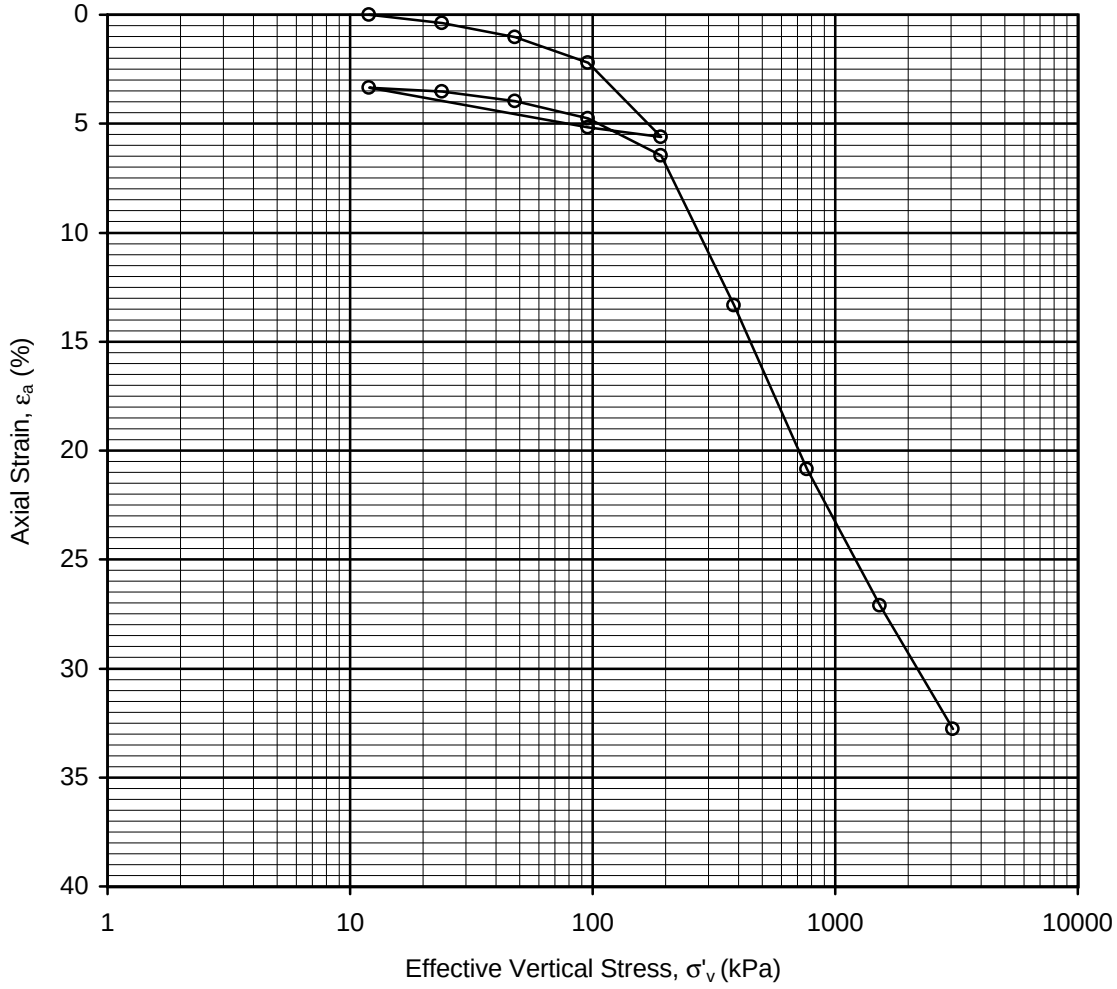
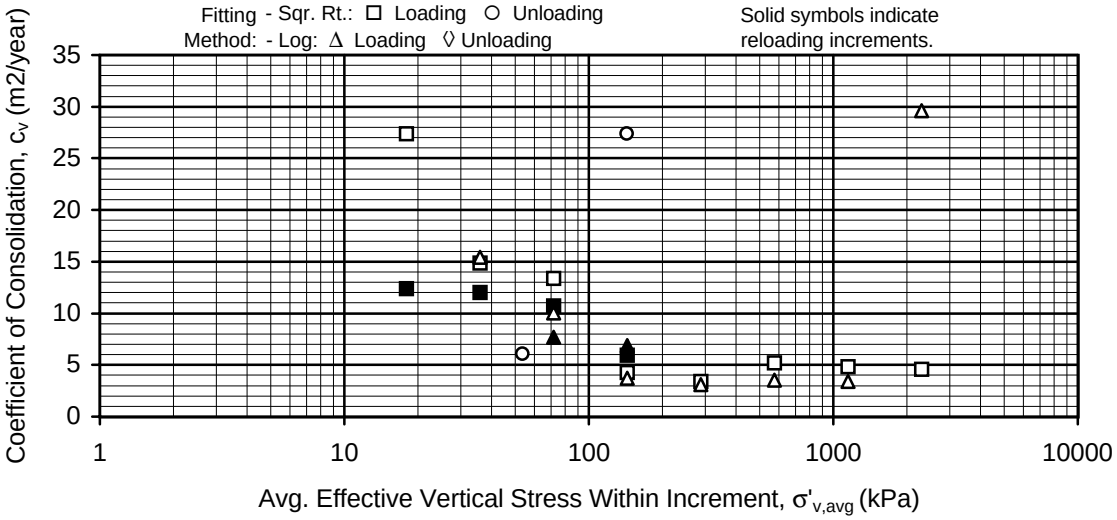




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 9 - Depth: 11.0m
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.7

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

SAMPLE NO. 300
DESCRIPTION: Fine Sand (SP-SM) with silt, gravel and clay

SPECIMEN	A	B	C
EXUDATION PRESSURE (PSI)	717	239	139
EXPANSION PRESSURE (PSF)	150	130	110
RESISTANCE VALUE, "R"	62	30	6
% MOISTURE AT TEST	10	11	12
DRY DENSITY AT TEST (PCF)	126.2	126.1	123.8
R-VALUE AT 300 PSI EXUDATION PRESSURE: 35			

R-VALUE TEST RESULTS
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69-10

Health Science Associates

LABORATORY REPORT

Report Number : 992011
Purchase Order :
Job No. 98-42-0057

JACOB CHACKO
FUGRO WEST INC.
5855 OLIVAS PARK DRIVE
VENTURA, CA. 93003-7672

Date Received : 04-FEB-99
Date Completed : 10-FEB-99
Date Sent : 10-FEB-99
Page # 1 of 1

Sample Description : 1 - Bulk Soil
Project : Oakland

California Test Methods : 532,643

Auto No.	Submitter Sample Number	Resistivity ohms/cm	pH Units	Chloride ppm	Sulfate ppm
180800	300 @ 2'	1,271	8.68	223	122
Detection Limit :		10	NA	1.0	1.0

Milliliters Water Added	50	100	150	200	250	300	350	400
	Resistivity Ohm-cm							
Sample No.								
300 @ 2'	2606	1779	1597	1452	1379	1307	1271	1307

Remarks : Sample(s) and sampling data as provided :
by : Jacob Chacko

Analyst(s) : ED

Ref :

California ELAP No.: 1406
AIHA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AIHA ELLAP Accreditation No.: 10985
LACSD Lab No.: 10125

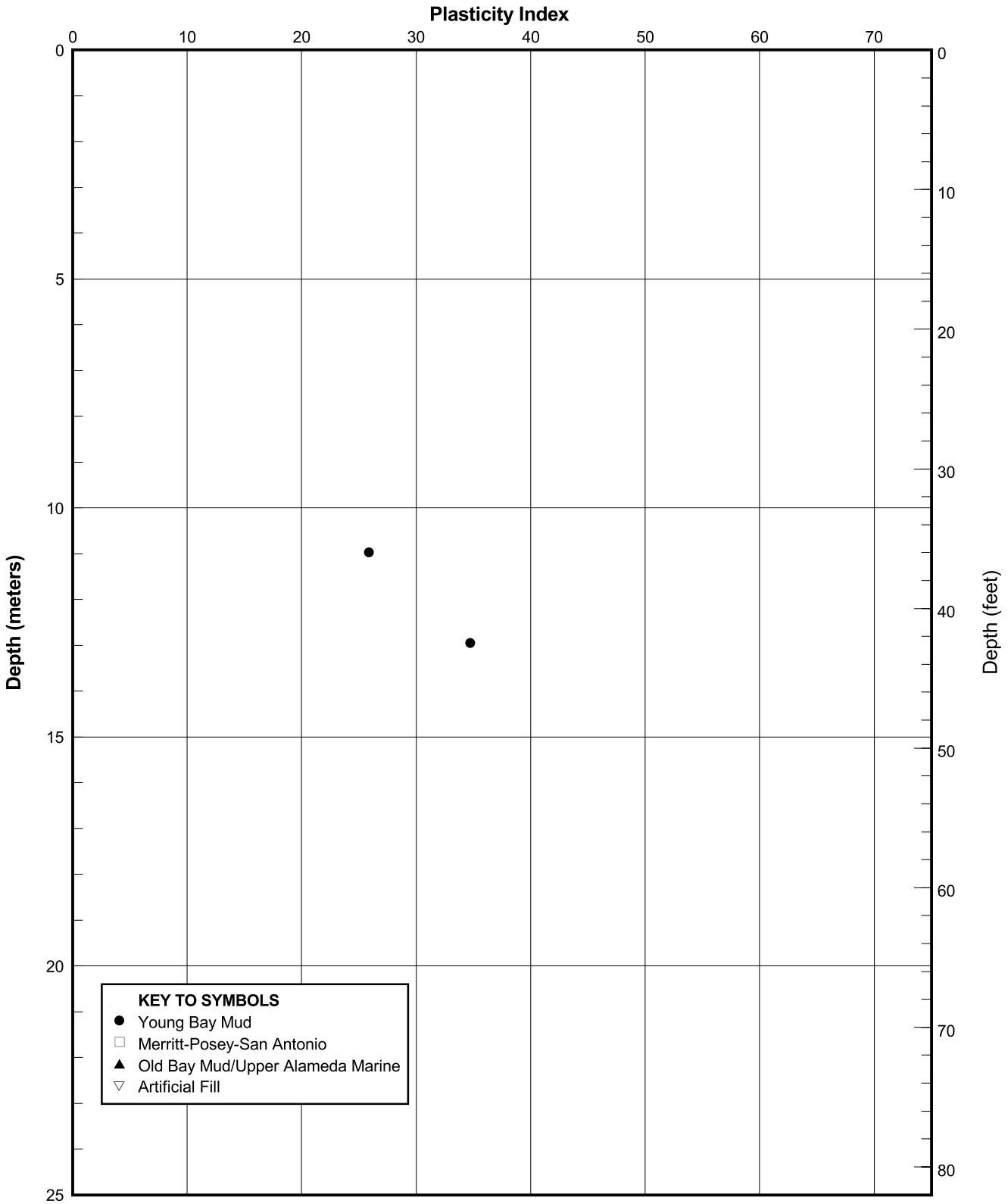
Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Jamie Steedman-Lyde
Laboratory Director, Jamie Steedman-Lyde

PLATE 98-69.11

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

This report pertains only to the samples investigated and does not necessarily apply to other apparently identical or similar materials. This report is submitted for the exclusive use of the client to whom it is addressed. Any reproduction of this report or use of this Laboratory's name for advertising or publicity purposes without written authorization is prohibited.

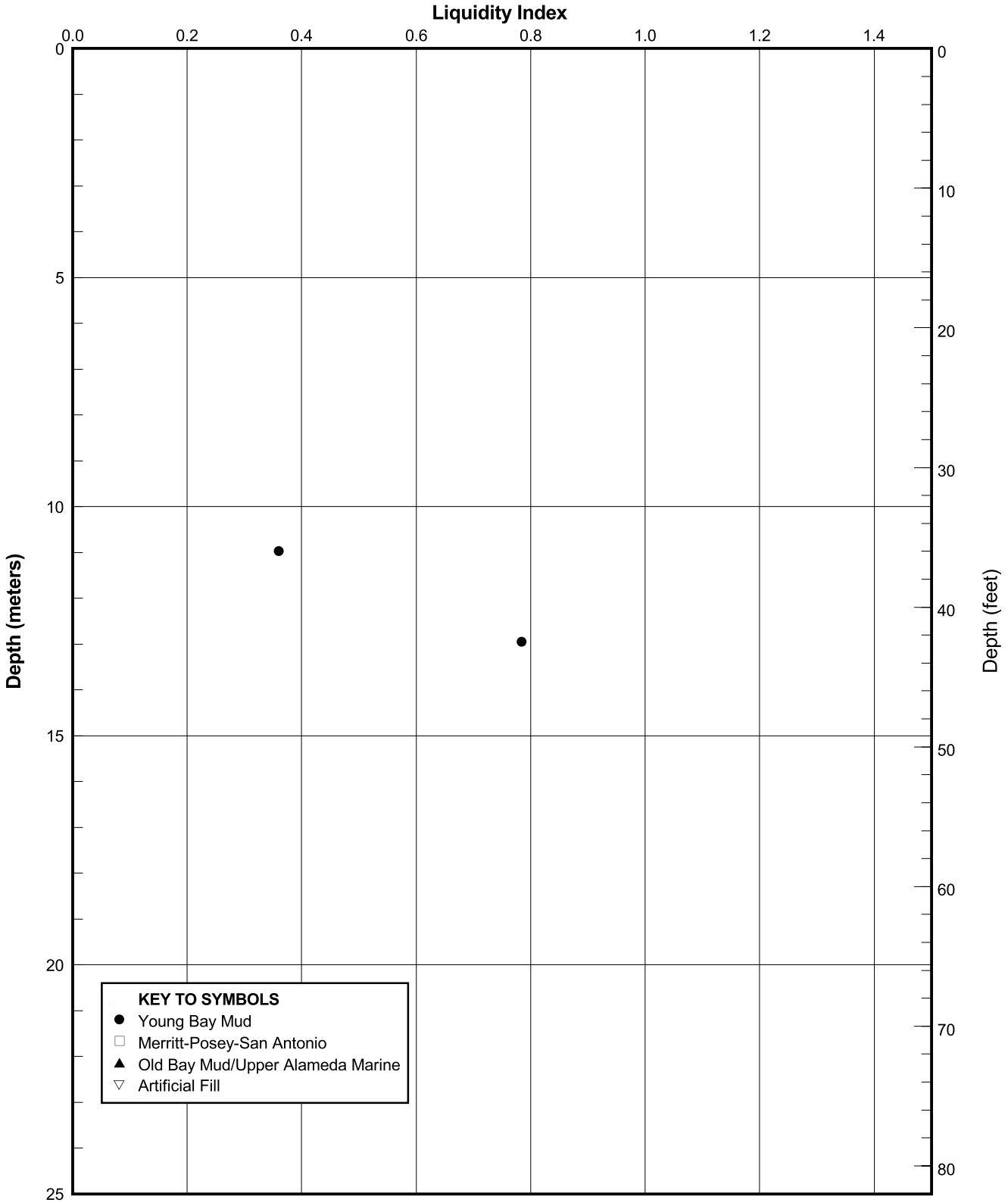


PLASTICITY INDEX PROFILE
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.12

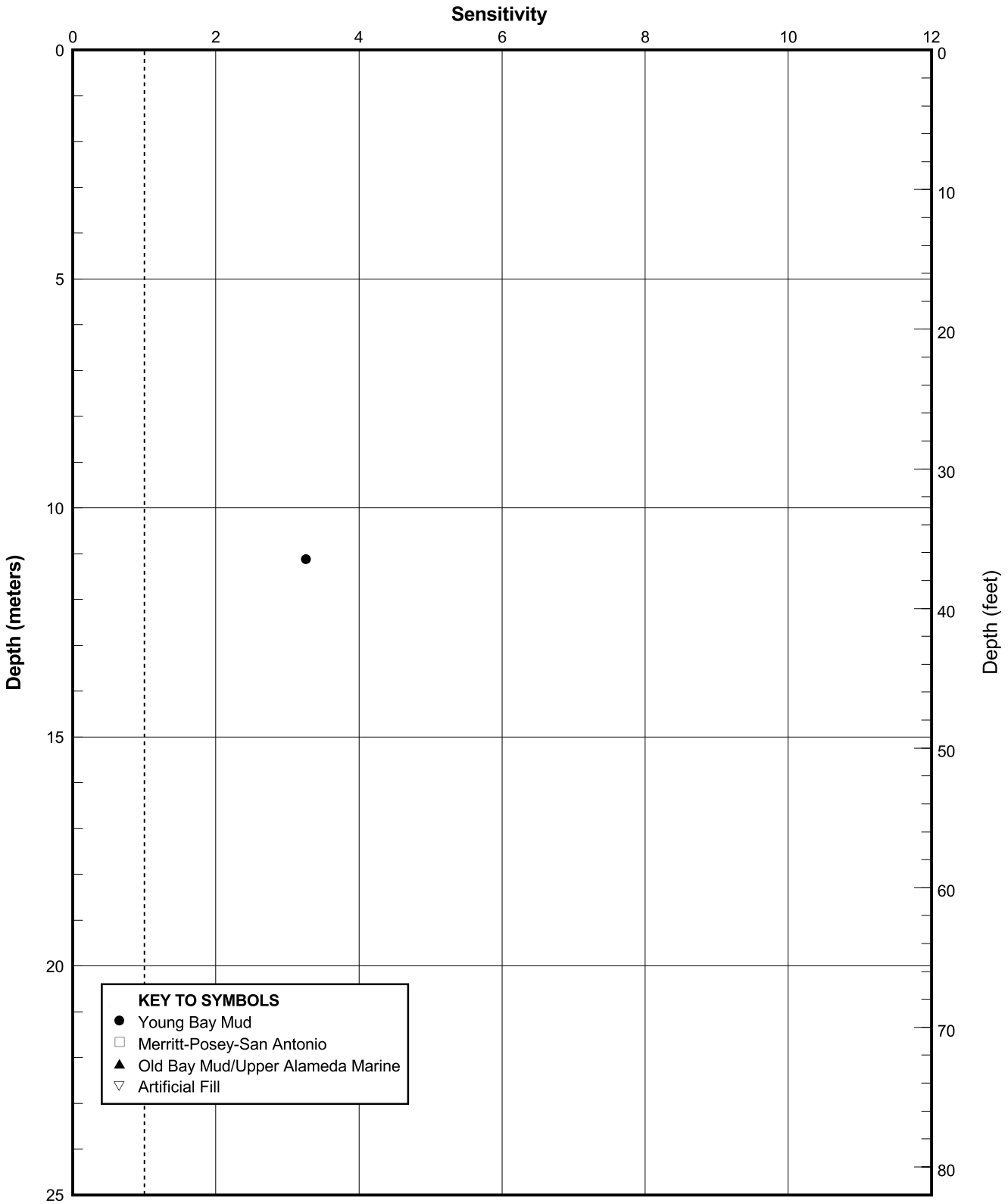
Earth Mechanics

FUGRO



LIQUIDITY INDEX PROFILE
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.13

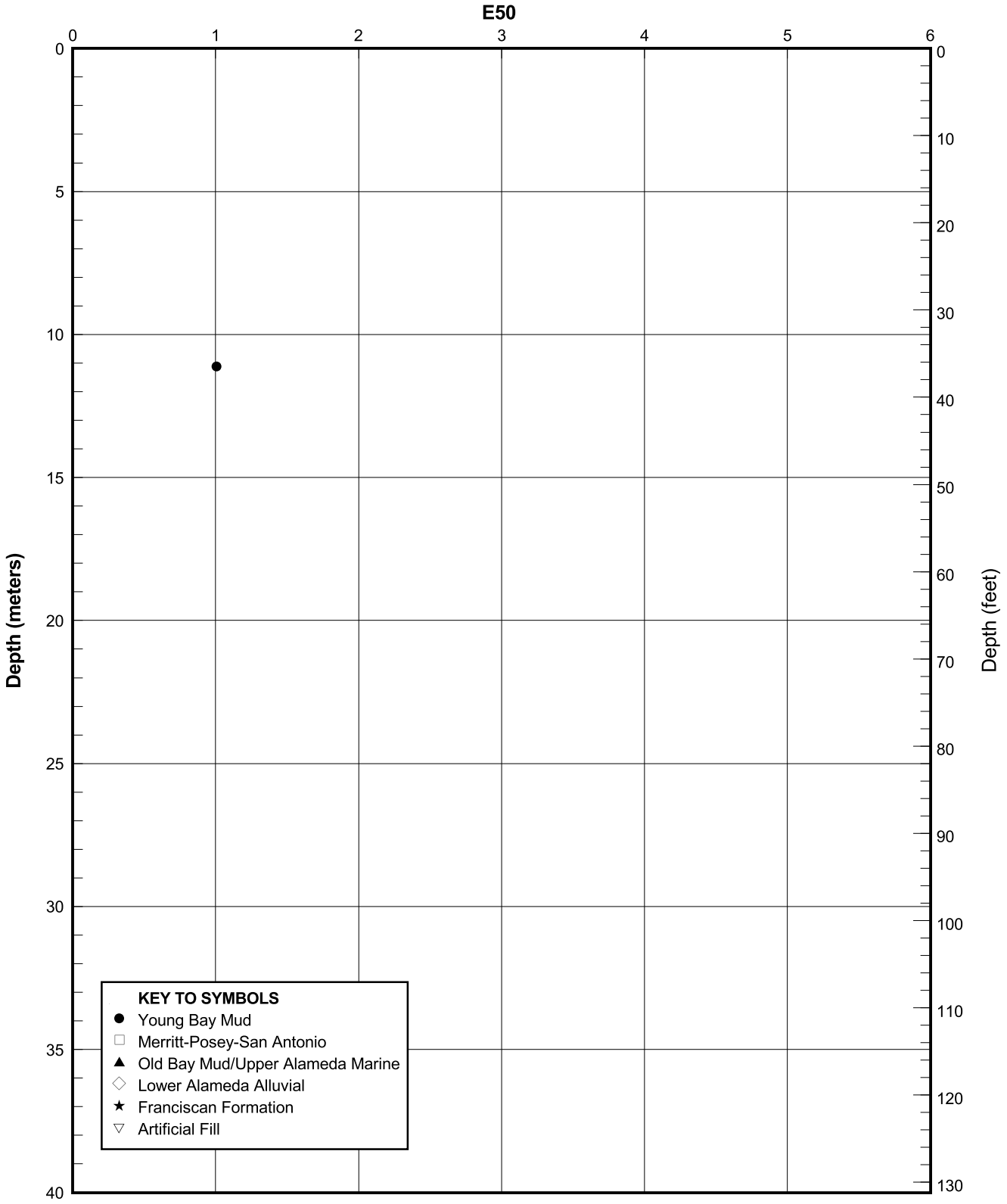


SENSITIVITY PROFILE
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.14

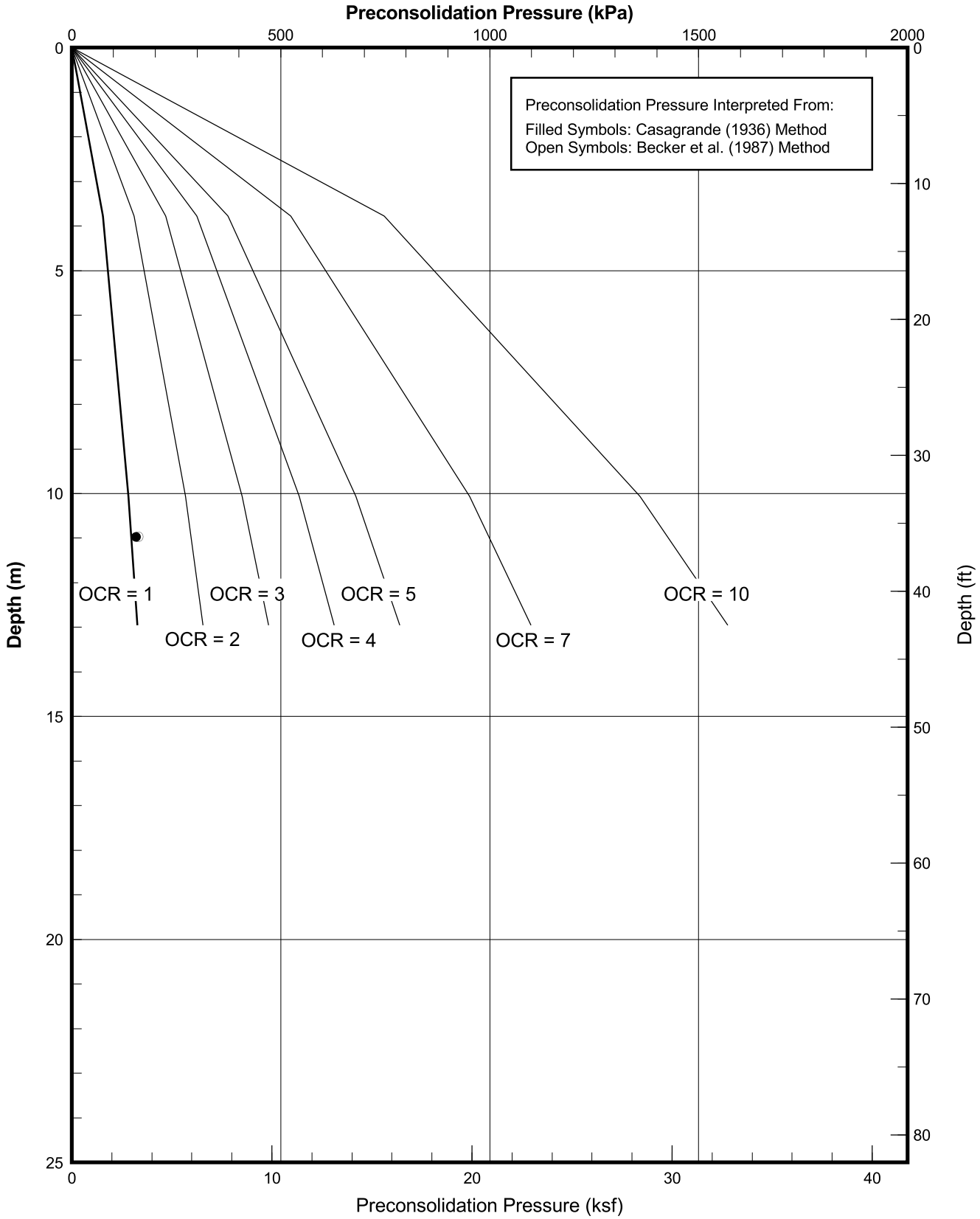
Earth Mechanics

FUGRO



E50 PROFILE
Boring 98-69
SFOBB East Span Seismic Safety Project

PLATE 98-69.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-69

SFOBB East Span Seismic Safety Project

PLATE 98-69.16

LAND BORING 98-70

PROJECT NO:	98-42-0058	**START DATE:**	10/14/73	**DRILLER:**	Pitcher Drilling Company
BORING:	98-70 (78m right of W. Sta. 87+95)	**COMPLETION DATE:**	11/12/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1839259 N648242
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.0m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					PAVEMENT, 0.3m Asphalt Concrete over 0.2m of Aggregate Base (0.5m)	I
2	1			42	Fine GRAVEL with silt and sand (GW-GM), dense, brown to gray -fine to coarse sand with clay, at 0.6m (1.2m)	II
1	2			21	Fine SAND (SP), medium dense, brown, moist (3.0m) ▽ (3.0m)	III
0	3			40	Fine SAND with silt (SP-SM), dense, brown, slightly cemented	IV
-1	4					
-2	5			48	-fine gravel with silt and sand, at 4.6m (6.1m)	
-3	6			63	Coarse GRAVEL (GP), very dense, gray -with clay pockets	V
-4	7					
-5	8			NR		
-6	9					
-7	10			34	-brown to gray, at 9.8m (10.1m)	
					Fat CLAY (CH), firm to stiff, olive gray	VI
-8	11			10	-with a few silt pockets and a few shell fragments, at 11.0m	
-9	12					
-10	13			PUSH	-with many sand pockets, sand seams, silt pockets, and shell fragments, at 12.5m -sandy clay, 12.6m to 13.0m	
-11	14			PUSH	-with brown organic pockets, at 14.0m	
-12	15				(15.5m)	
				SAVE	Fine SAND with silt (SP-SM), medium dense, gray to olive gray -clayey sand at 15.5m	VII
-13	16				(17.1m)	
-14	17			23	Lean CLAY (CL), stiff to very stiff, greenish gray -sandy lean clay, to 18.0m	VIII
-15	18					
-16	19			PUSH	-with reddish brown mottling, and a few silt pockets, at 18.6m (19.2m)	
					Fine SAND (SP), very dense, brown	IX
-17	20			50/15cm		
-18	21				-greenish gray, clayey sand, below 21.0m (21.5m)	
				8	Fat CLAY (CH), stiff to very stiff, greenish gray -with sand pockets, at 21.6m	X
-19	22					
-20	23			PUSH	-with sand seams and partings, at 23.2m	
-21	24				-lean clay with sand pockets below 24.4m	
-22	25			SAVE	TOTAL DEPTH: 25.0m BACKFILLED WITH: Cement Grout	
-23						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m^3 14 16 18 20
UNIT WEIGHT

22.8 → ○
22.5 → ○
120 →

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-70.1

LOG OF BORING AND TEST RESULTS

BORING 98-70

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-70		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.6	300	8	25	18			11																			
1.7	2	8																								
3.3	3	10					8																			
4.7	4	18					4																			
6.2	5	21																								
7.9	6	11																								
9.8	301						0																			
11.0	303							50.8																		C
11.1	304	46	59	23	0.64	18.2		52.7			58.2															
12.6	307	37				17.4		52.7							42.9		1.9									
12.8	308							47.9			45.8															
14.2	310					16.7		57.5				14.8														
14.3	311	54	70	27	0.64			57.5			66.8	14.8														
15.8	312																									C
15.8	313	27																								

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.3a

Earth Mechanics

FUGRO

98-70		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
17.1	314	28					10																			
17.2	315	33	32	13	1.03																					
18.6	316															54.2										
18.7	317					19.3		119.7								29.3										
18.9	318	28	43	17	0.42			131.7			84.2															
20.1	319	21					5																			
21.5	320	27					32																			
21.8	321	48	59	16	0.75																					
23.2	323	30	46	18	0.43	19.7		107.7	107.7						68.8	39.9	2.3									
23.3	324							83.8																		
24.9	325		72	23																						C
25.0	326	24	44	20	0.16						167.1															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.3b

Earth Mechanics

FUGRO

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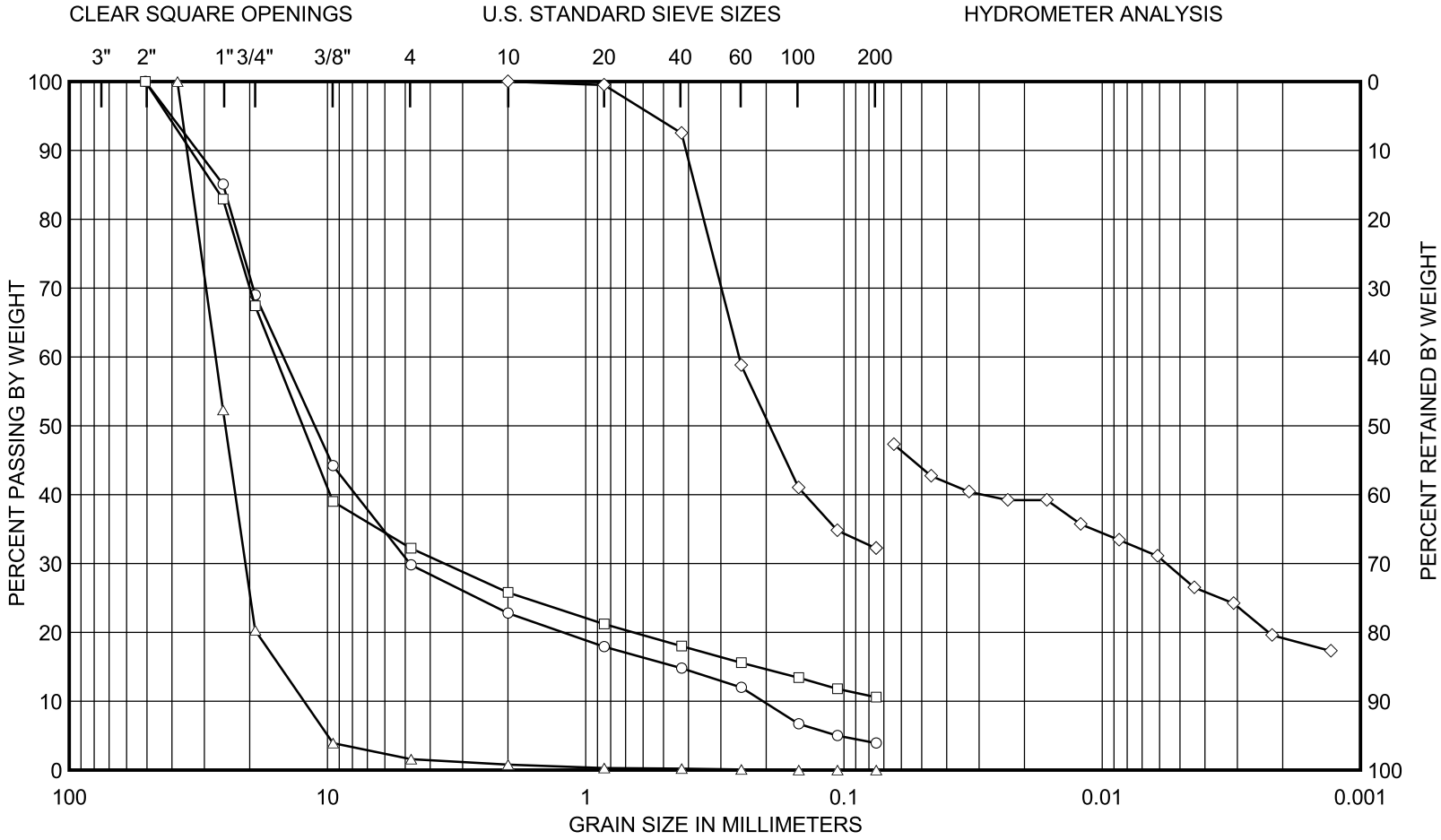

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
4	4.7	○—○	FINE TO COARSE GRAVEL (GP-GM) with silt and sand	7.5	71.8	11.2
300	0.6	□—□	FINE TO COARSE GRAVEL (GP) with sand			12.5
301	9.8	△—△	COARSE GRAVEL (GP) with fine gravel	1.3	2.2	24.9
320	21.5	◇—◇	SANDY FAT CLAY (CH)			0.19

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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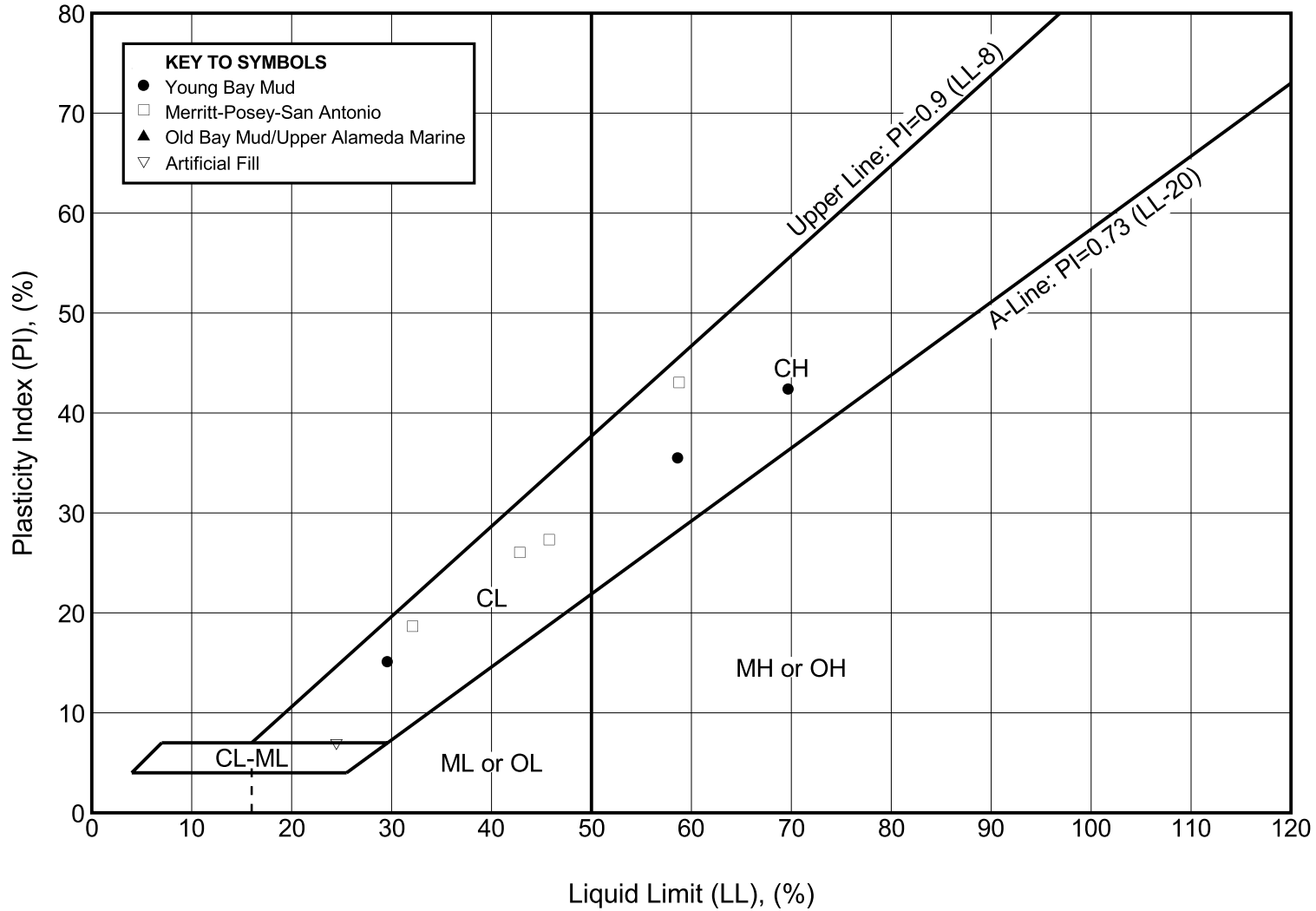

PLASTICITY CHART
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.5

Earth Mechanics

FUGRO

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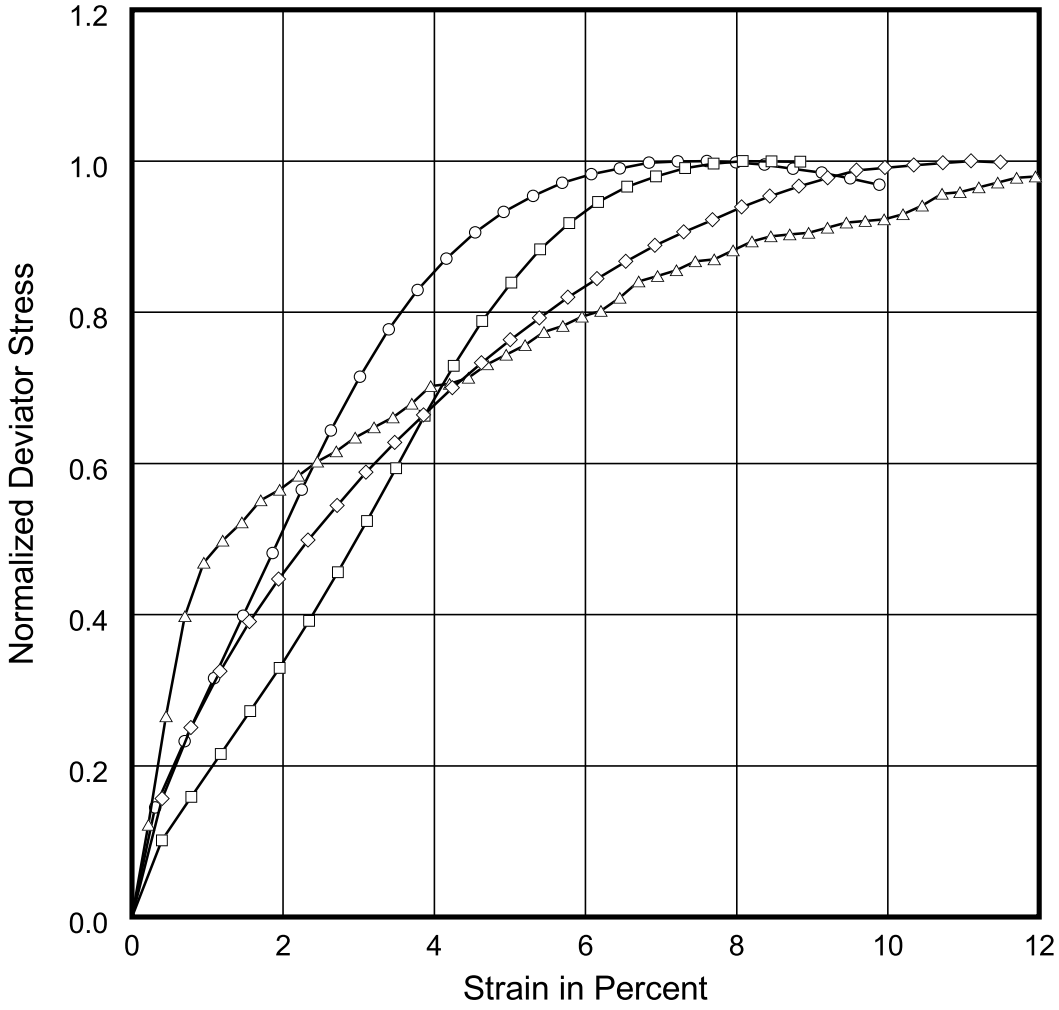
Earth Mechanics

FUGRO



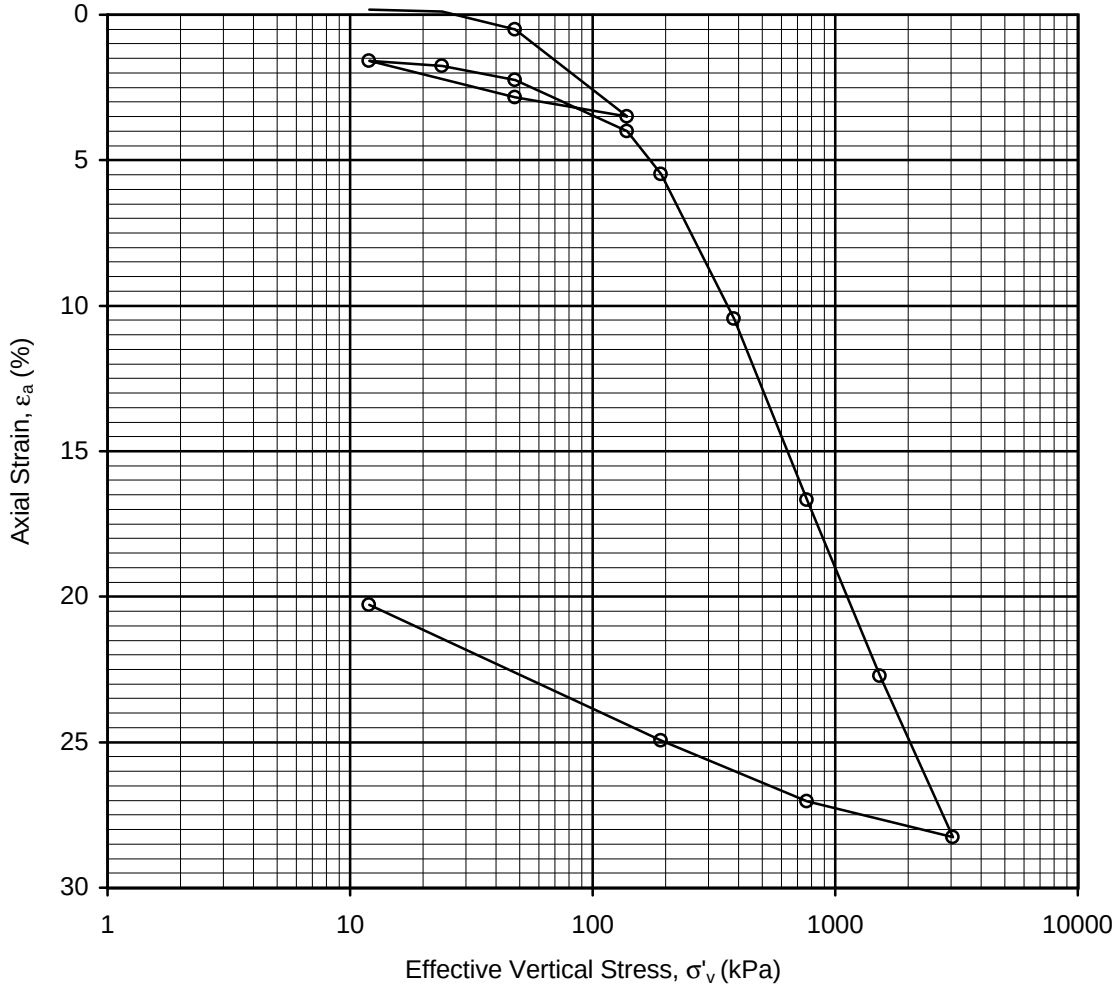
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	307	12.6	UU	241	86	1.9
□	310	14.2	UU	276	79	3.0
△	316	18.6	UU	345	123	1.1
◇	323	23.2	UU	793	138	2.3

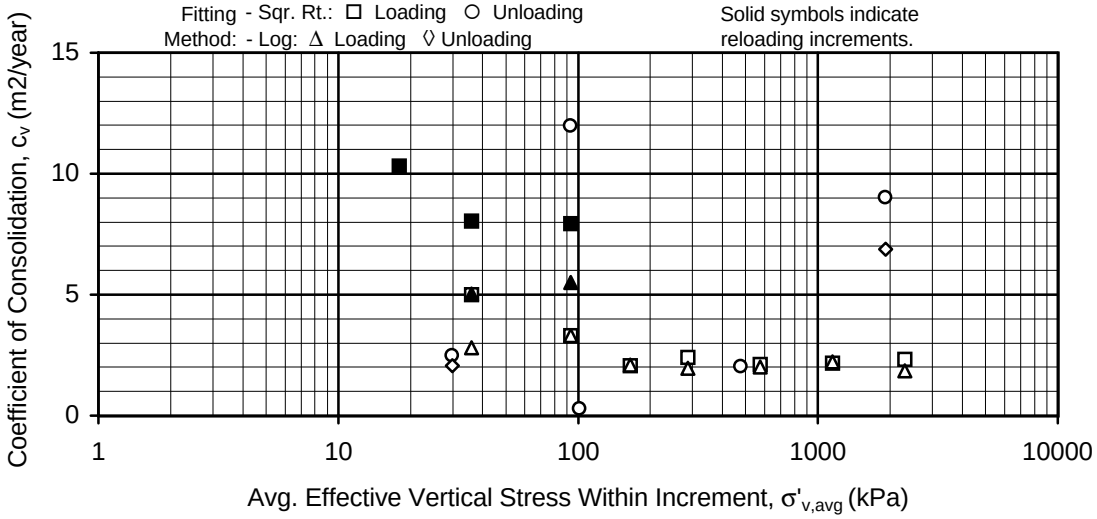
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.6

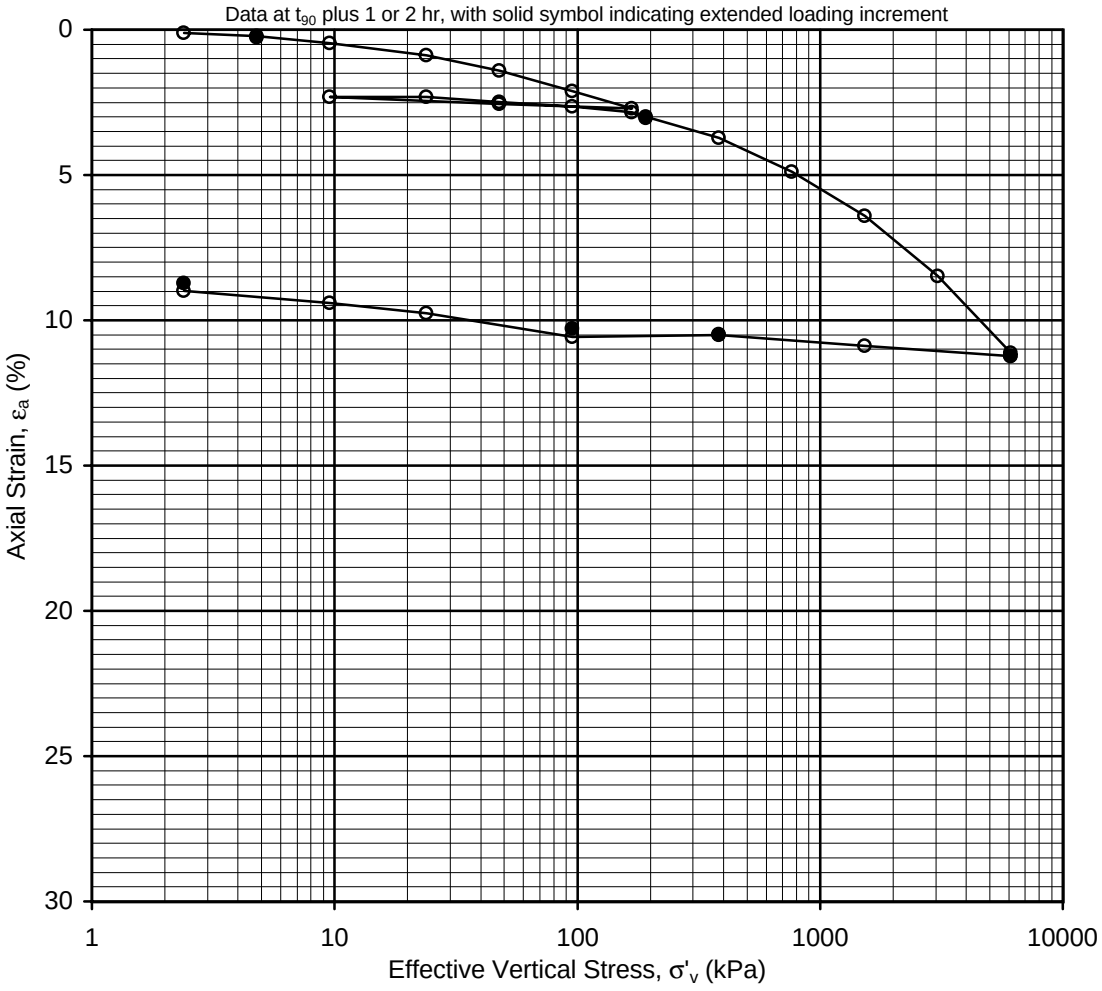


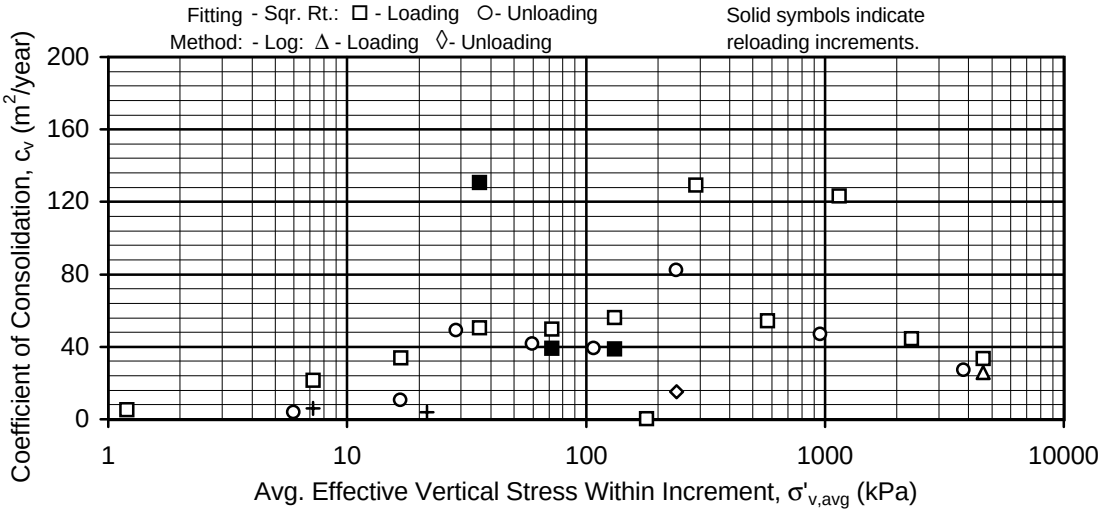


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 303 - Depth: 11.0m
Boring 98-70
SFOBB East Span Seismic Safety Project

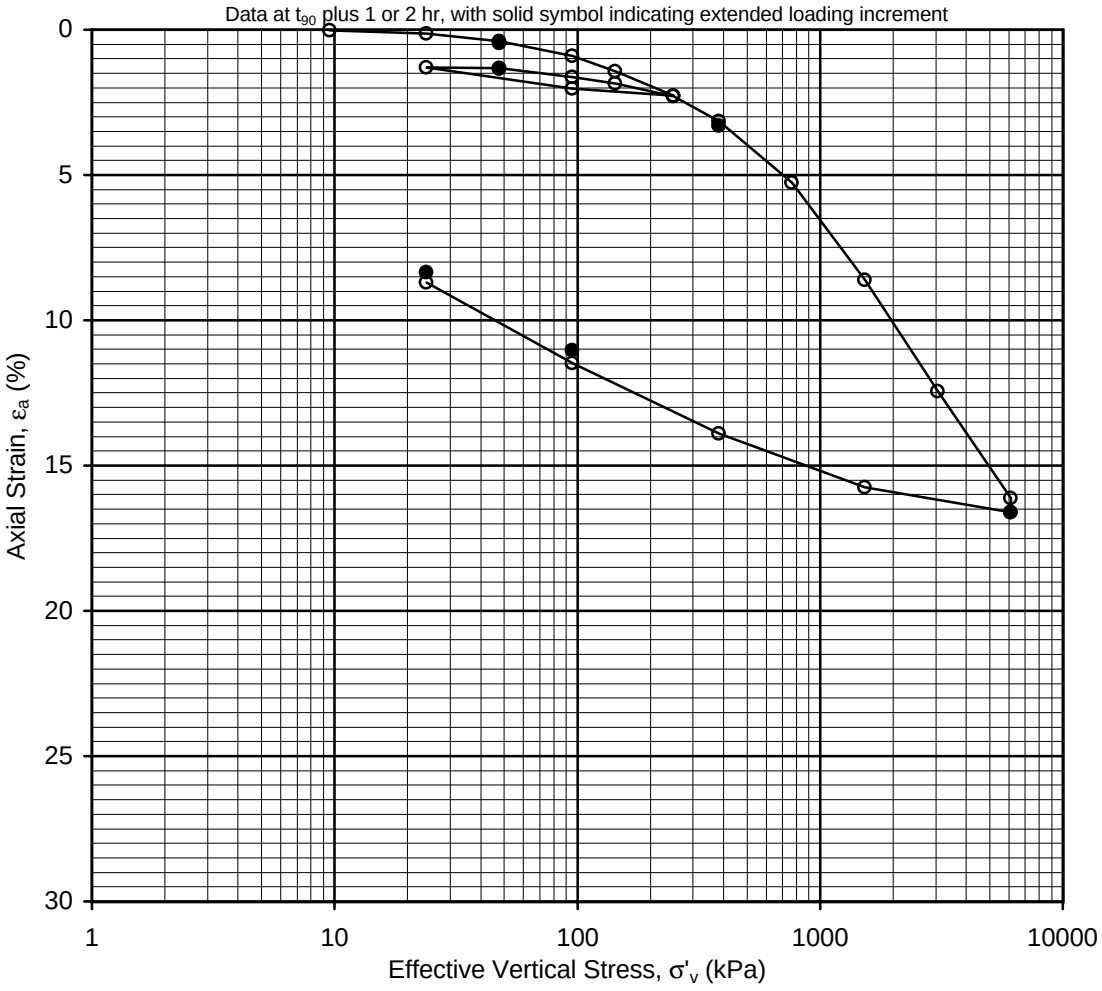
PLATE 98-70.7a

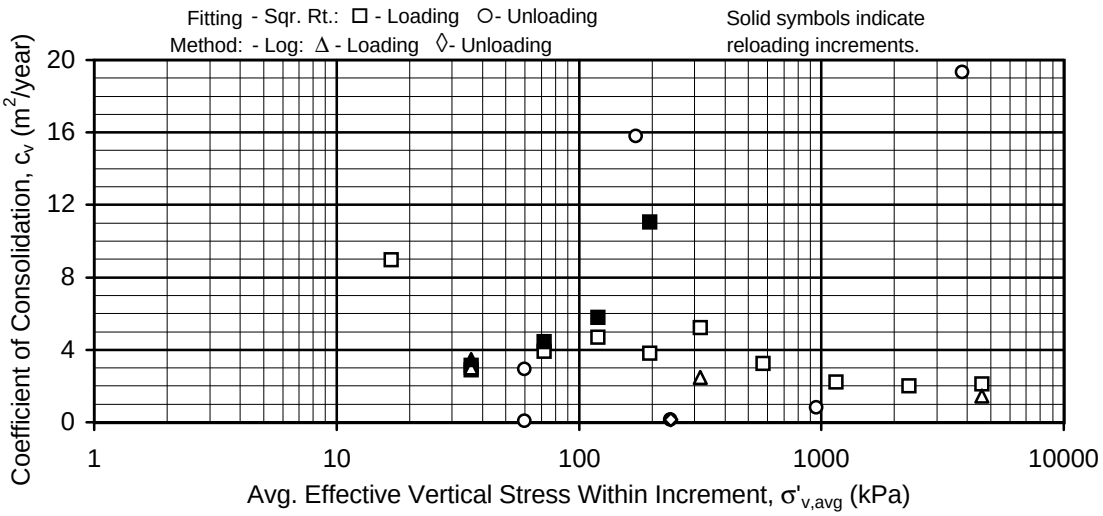




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 312 - Depth: 15.7m
Boring 98-70
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

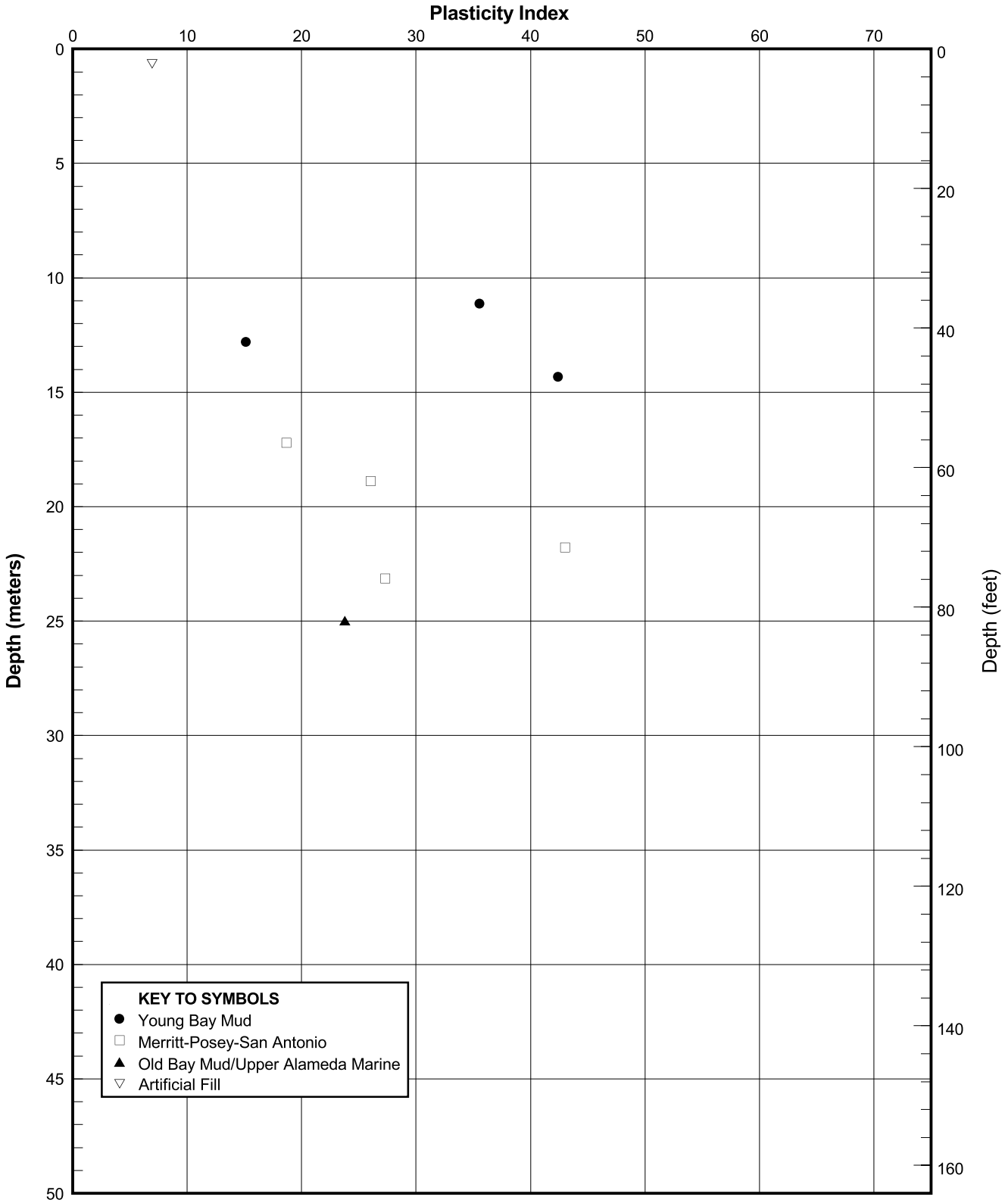
Sample No. 325 - Depth: 24.9m
Boring 98-70
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

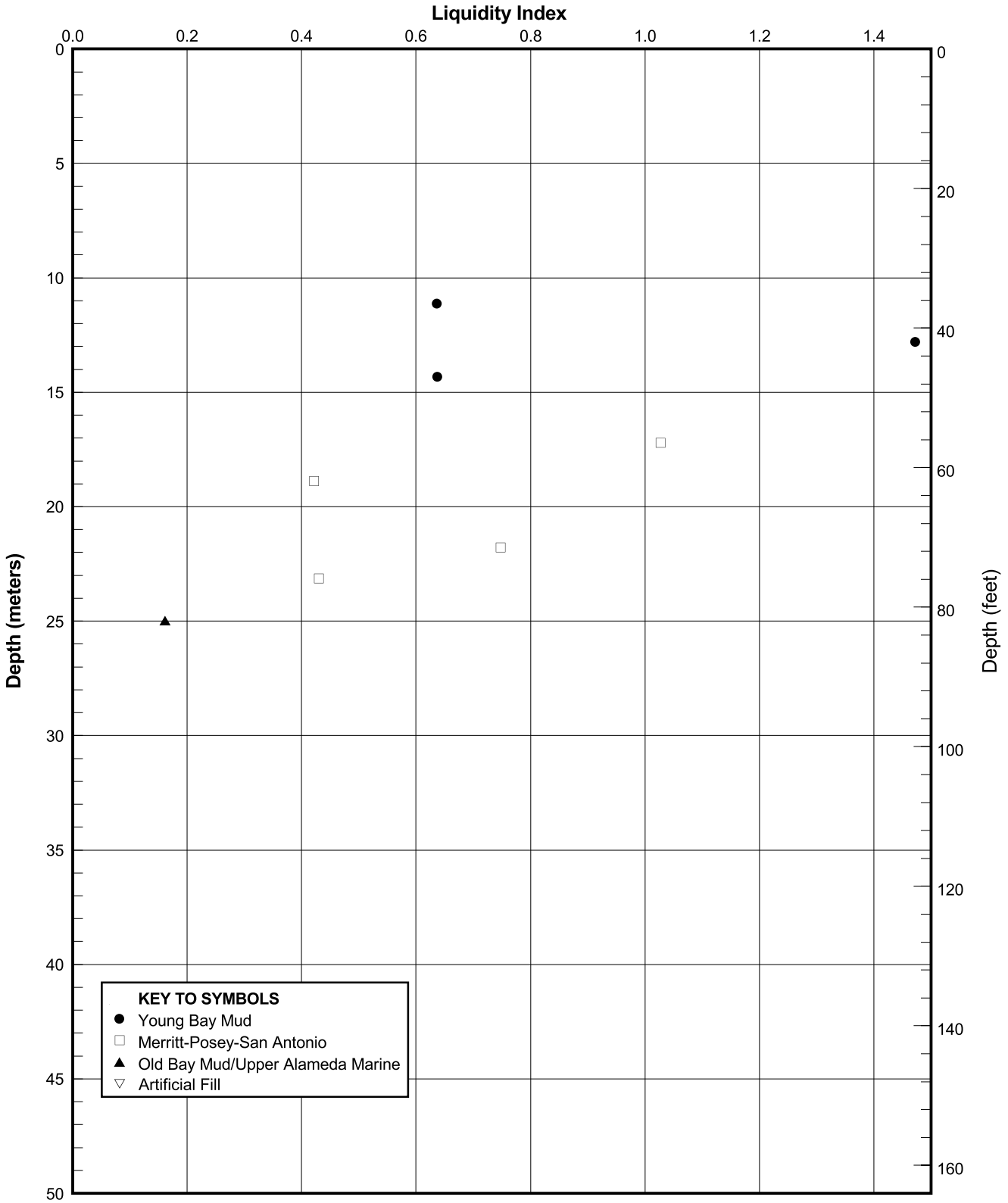
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



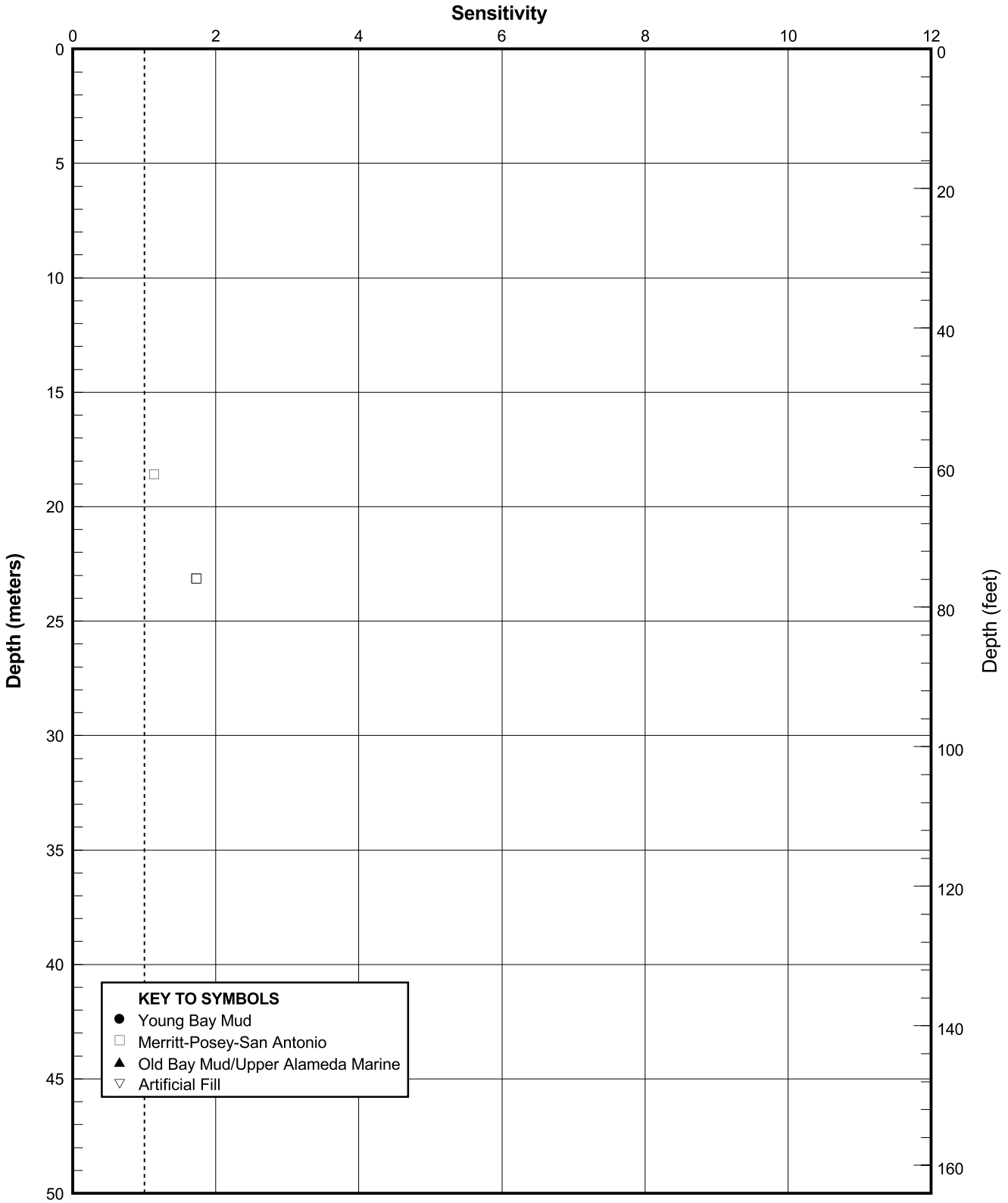
PLASTICITY INDEX PROFILE
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.12



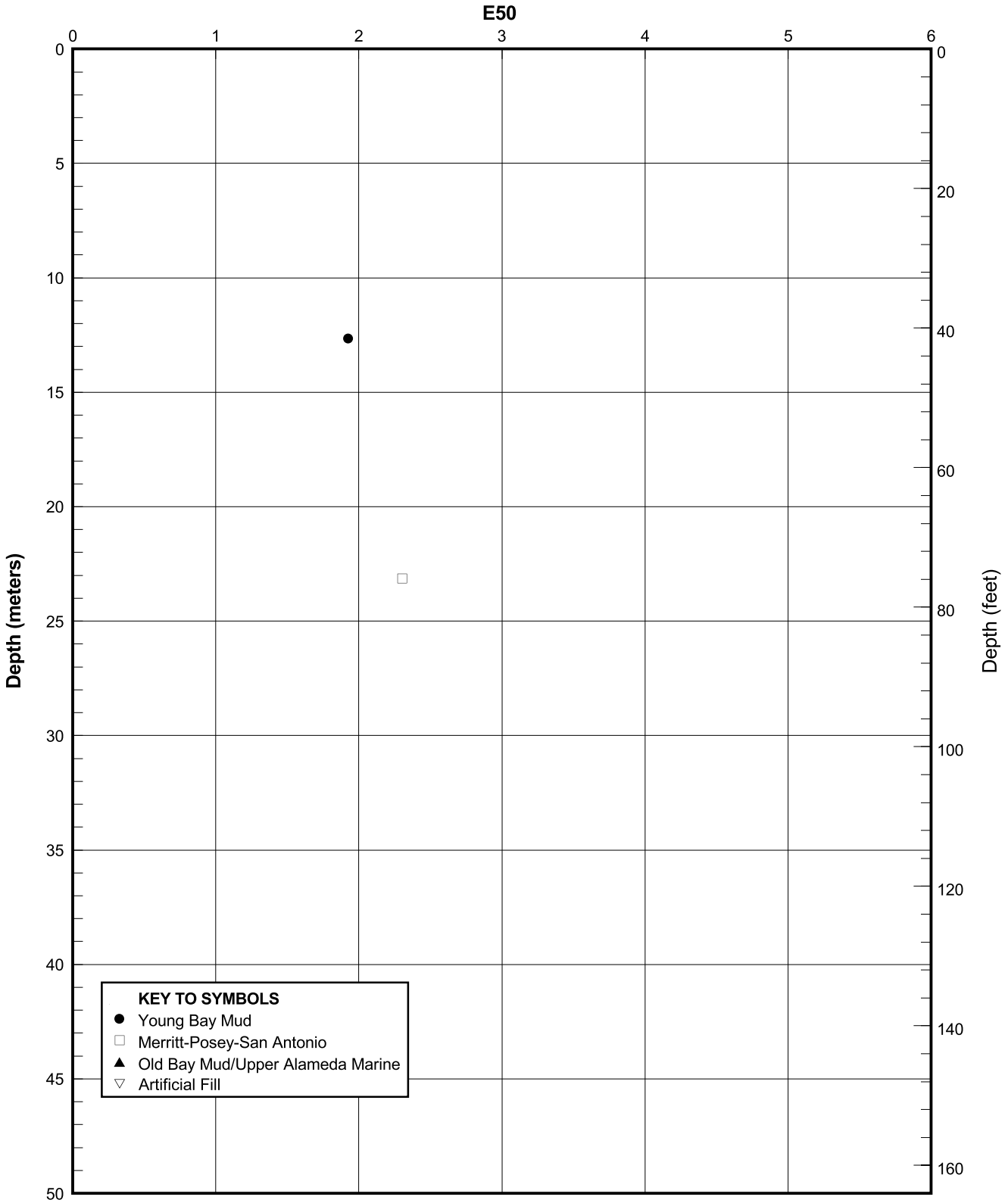
LIQUIDITY INDEX PROFILE
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.13



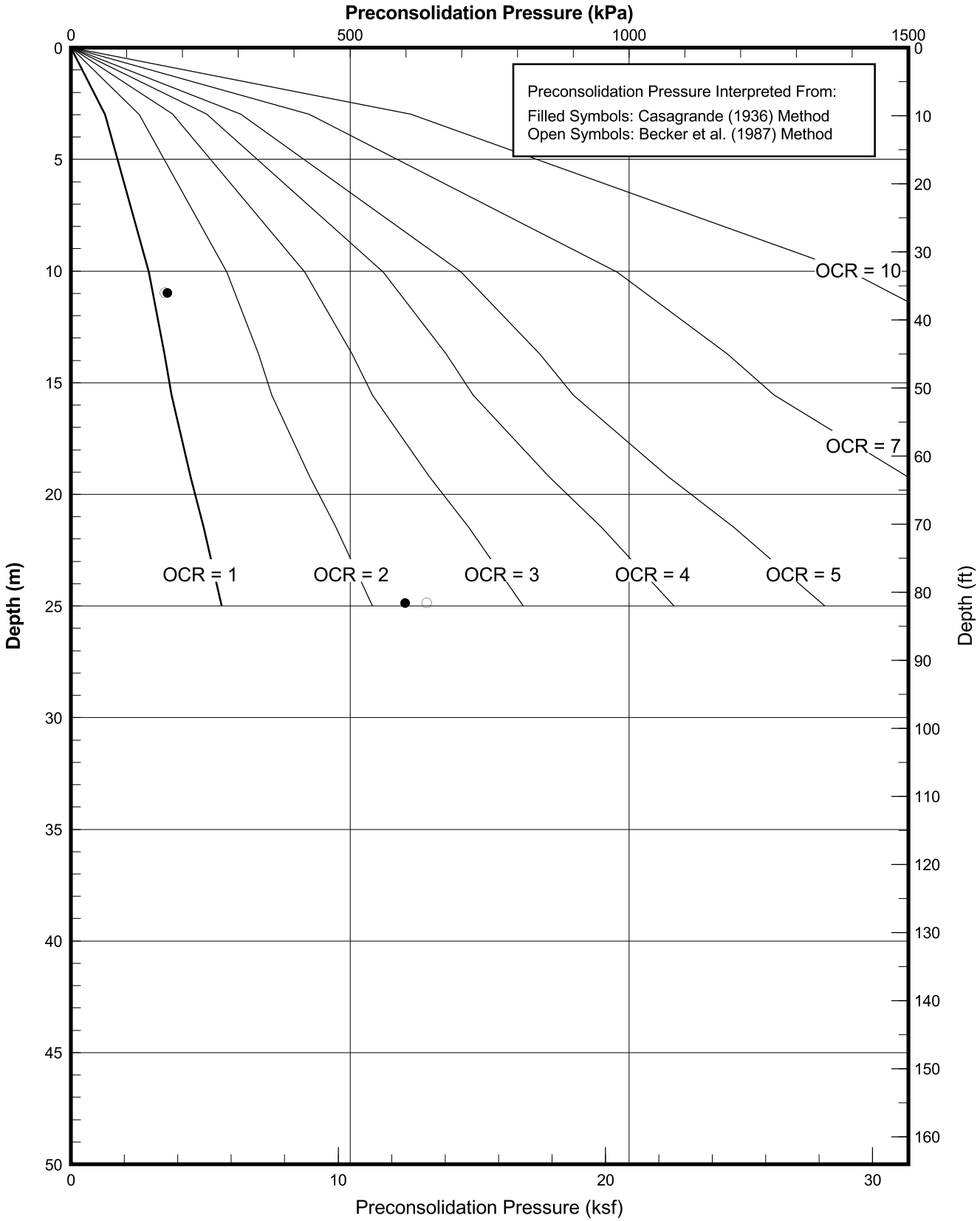
SENSITIVITY PROFILE
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.14



E50 PROFILE
Boring 98-70
SFOBB East Span Seismic Safety Project

PLATE 98-70.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-70

SFOBB East Span Seismic Safety Project

PLATE 98-70.16

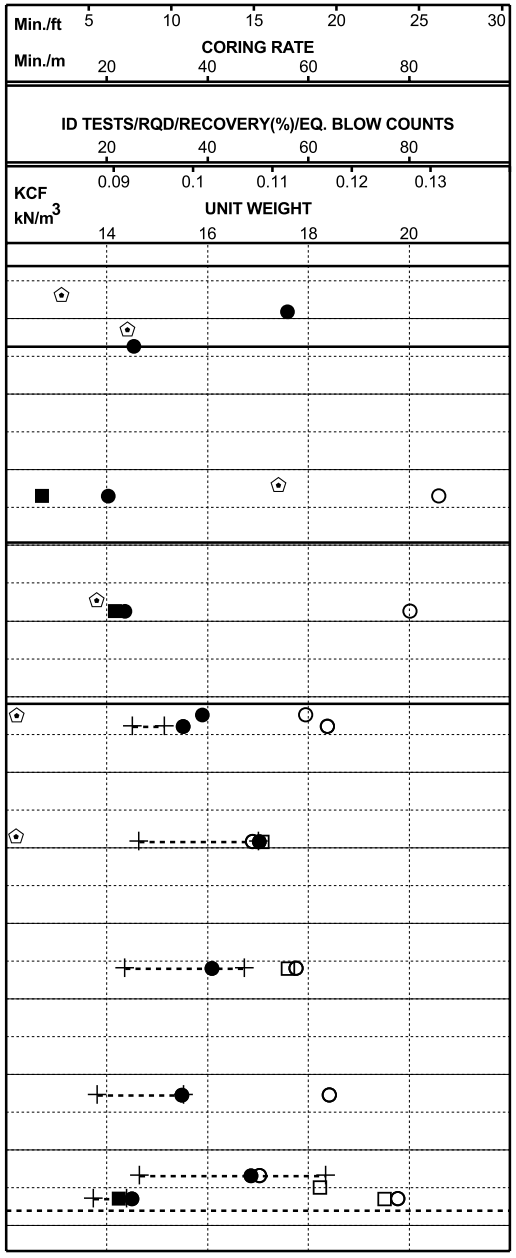
LAND BORING 98-71

PROJECT NO:	98-42-0058	**START DATE:**	10/13/98	**DRILLER:**	Pitcher Drilling Company	Page 1 of 1
BORING:	98-71 (38m right of E. Sta. 87+64)	**COMPLETION DATE:**	10/13/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)	

Coordinates: E1839449 N648283
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.2m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	0				PAVEMENT, Asphalt Concrete (0.3m)	I
1	2			11 BAG 24	Fine SAND with silt (SP-SM), medium dense, gray to light olive gray (cement treated base) (1.4m)	II
2	1				Fine SAND with silt (SP-SM), dense to very dense, brown -with shell fragments -moist to 3.0m	III
0	3			54	▽ (3.2m)	
	4				(4.0m)	
-1	5			18	Silty Fine SAND (SM), medium dense, olive gray -with sandy clay pockets and shell fragments, at 4.9m	IV
-2	6				(6.1m)	
-3	7			2	Fat CLAY (CH), firm to stiff, olive gray to gray -with shell fragments -lean clay to 7.0m -with many silt pockets at 6.1m	V
-4	8			3	-with dark gray silt partings and pockets, at 7.9m	
-5	9					
-6	10			PUSH	-with gas blisters, shells, and an H2S odor, below 9.4m	
-7	11			SAVE	-with many sand pockets at 11.0m	
-8	12					
-9	13			PUSH	-with silt pockets at 12.3m -olive gray, clayey sand, below 12.5m	
-10					TOTAL DEPTH: 12.8m BACKFILLED WITH: Cement Grout	



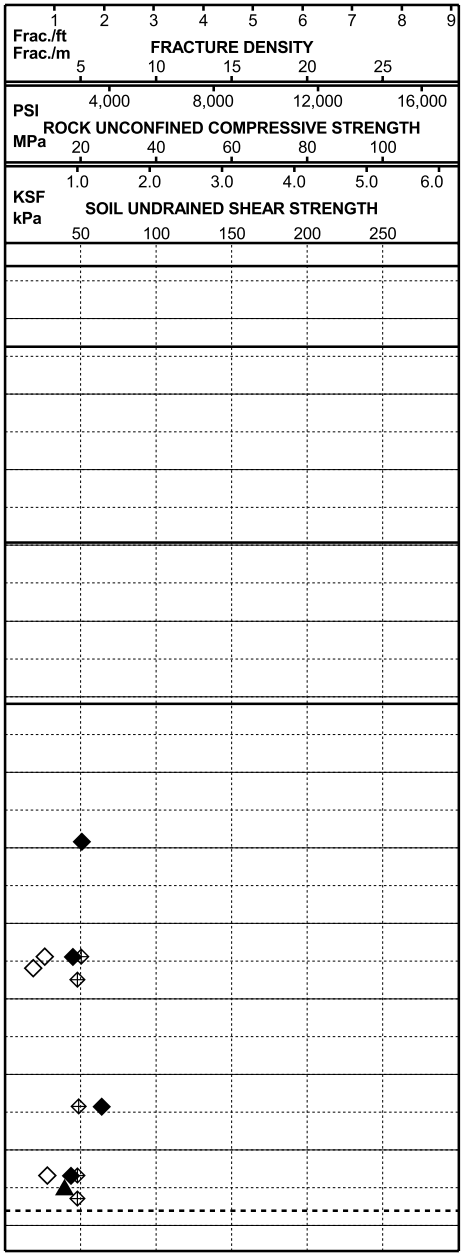


PLATE 98-71.1

LOG OF BORING AND TEST RESULTS

BORING 98-71

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-71		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.5	300																									
0.9	1	56																								
1.4	2	25																								
3.4	3	20					7																			
4.9	4	23					21																			
6.2	5	39																								
6.4	6	35	32	25	1.56																					
7.9	8	50	50	26	1.00	17.1					50.6															
9.4	11							50.3			44.9	26.2														
9.6	12	41	47	24	0.72	17.6						18.5														
9.8	13							47.9																		
11.3	14	35	35	18	0.96																					C
11.4	15							48.8			63.8															
12.3	16	49	64	27	0.59			47.9			43.6	28.0														
12.5	17					18.2									39.4		1.4									

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-71
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO

98-71		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
12.6	18	25	24	17	1.15	19.5	22	47.9																		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
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phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-71
SFOBB East Span Seismic Safety Project

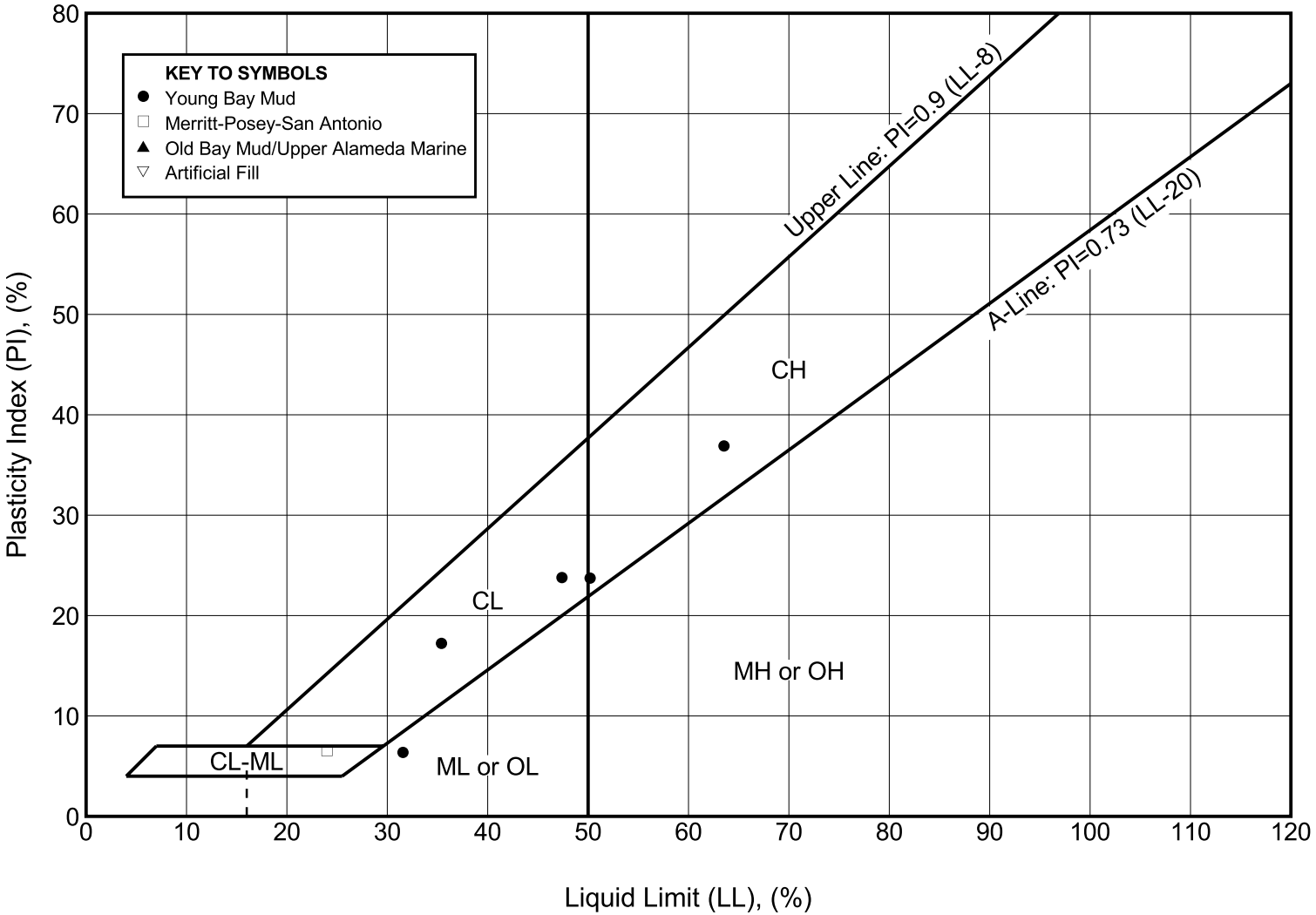
SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

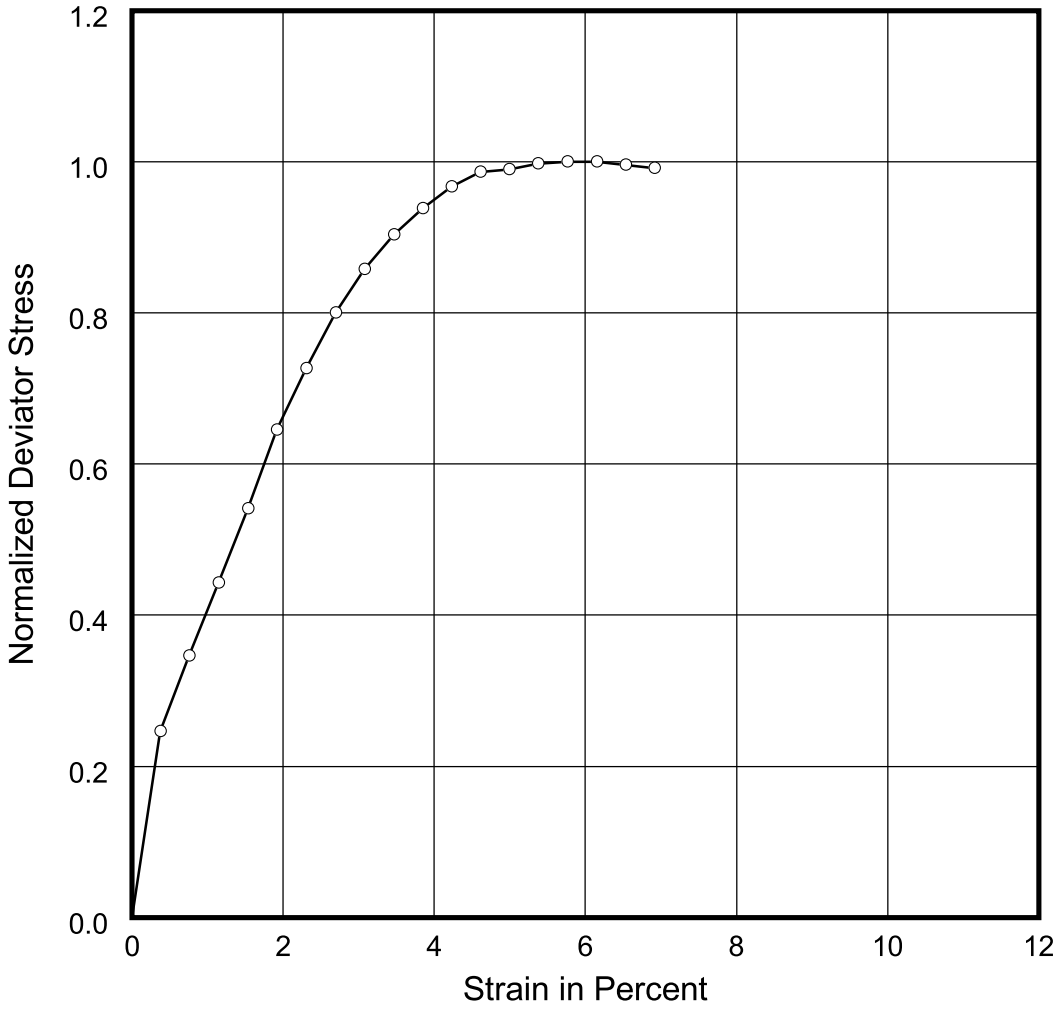
PLATE 98-71.3b

No Grain Size Testing Performed For This Boring



PLASTICITY CHART
Boring 98-71
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO



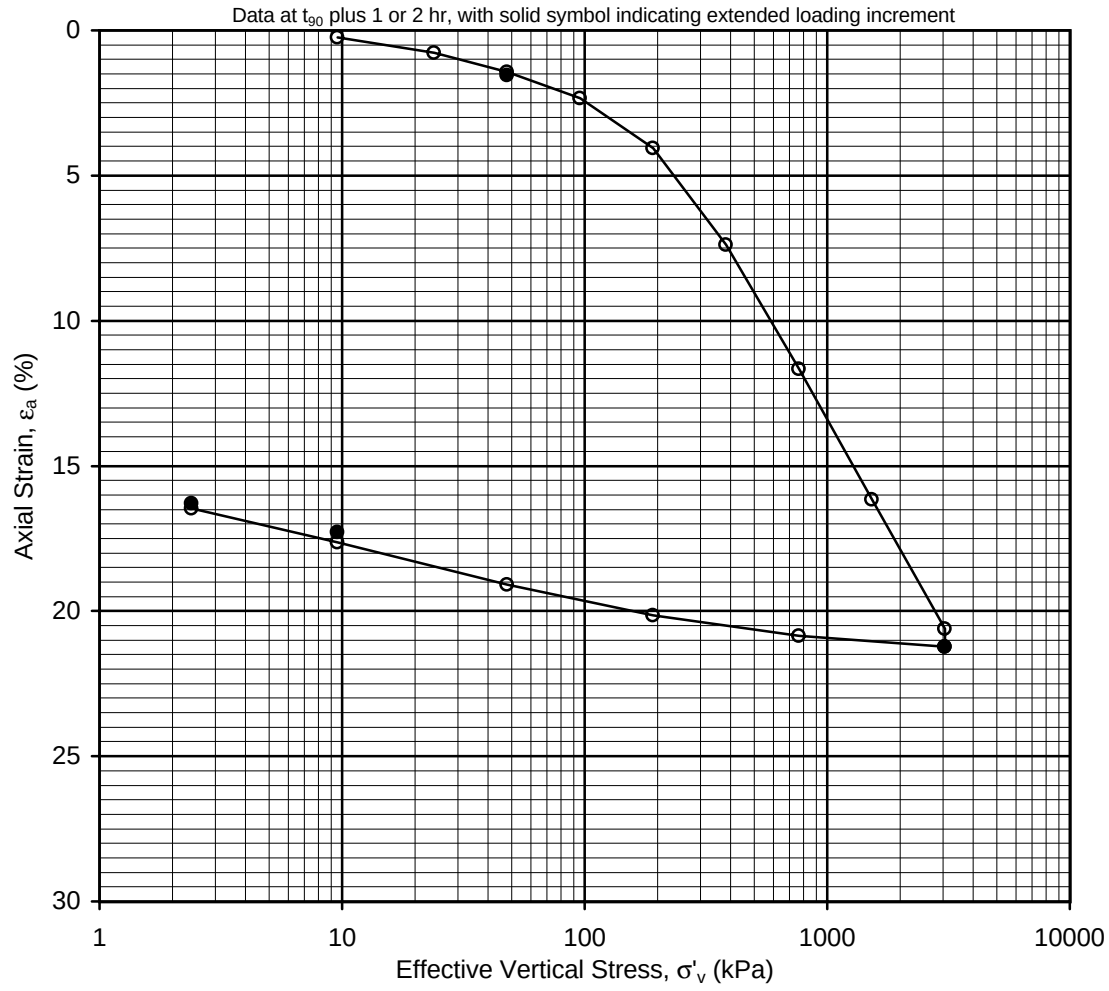
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
⊙——⊙	17	12.5	UU	241	79	1.4

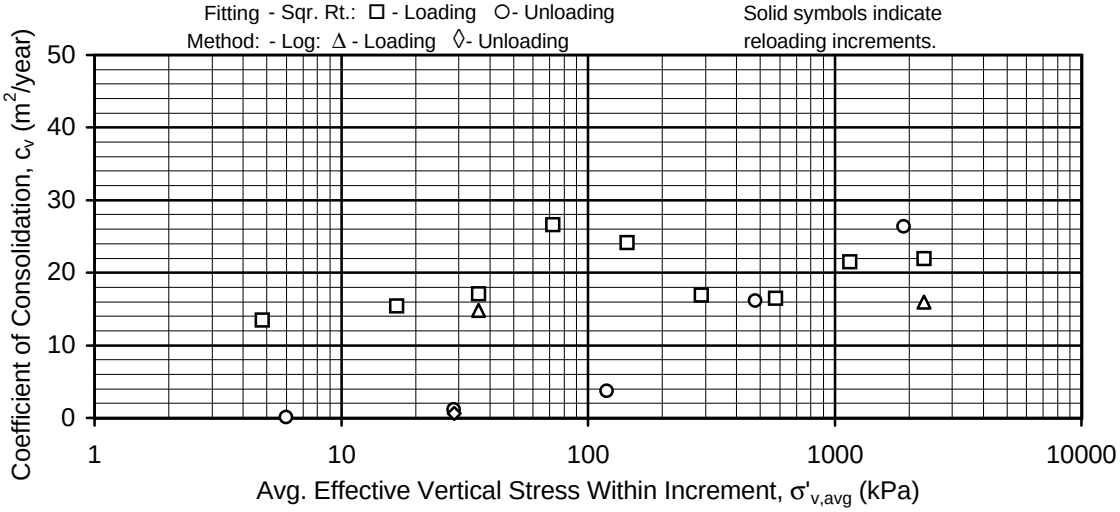
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-71
SFOBB East Span Seismic Safety Project

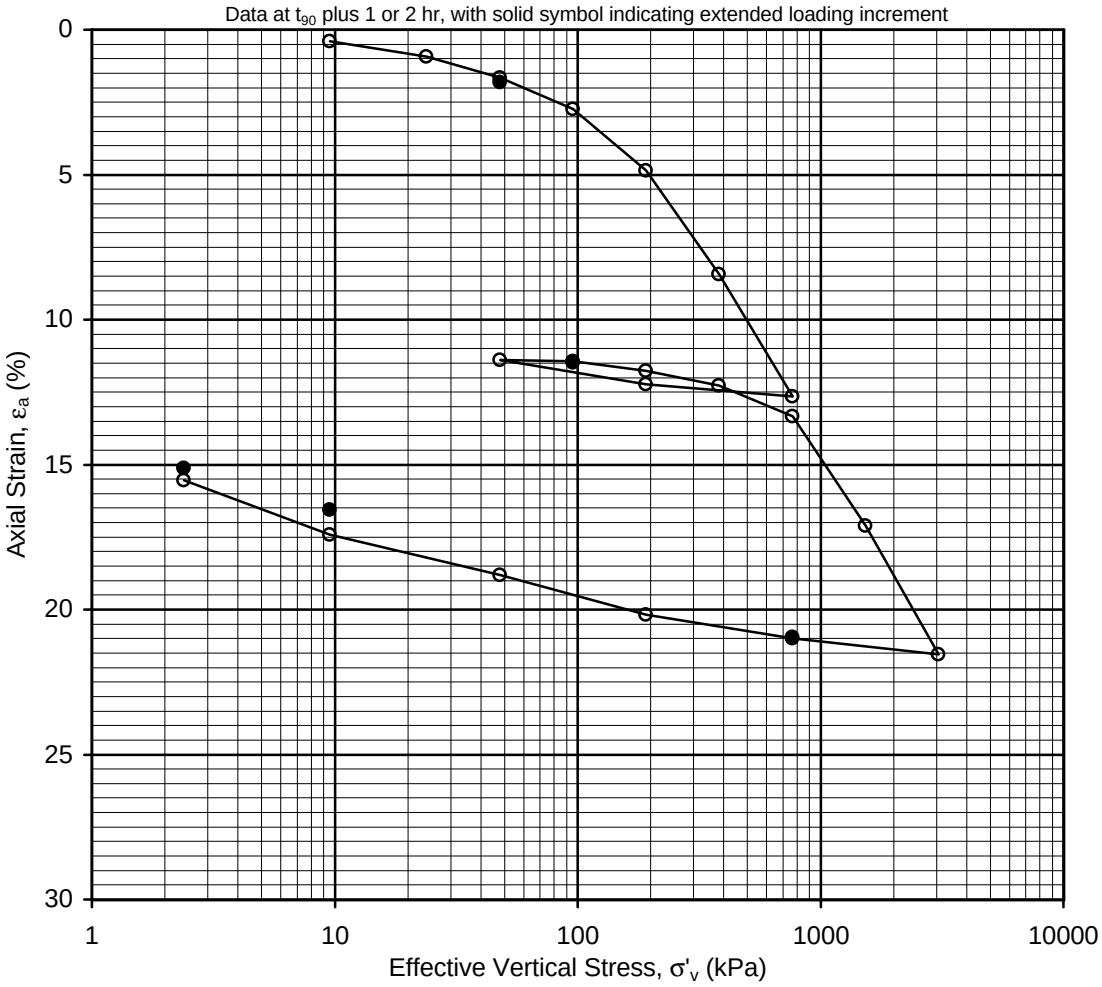
PLATE 98-71.6

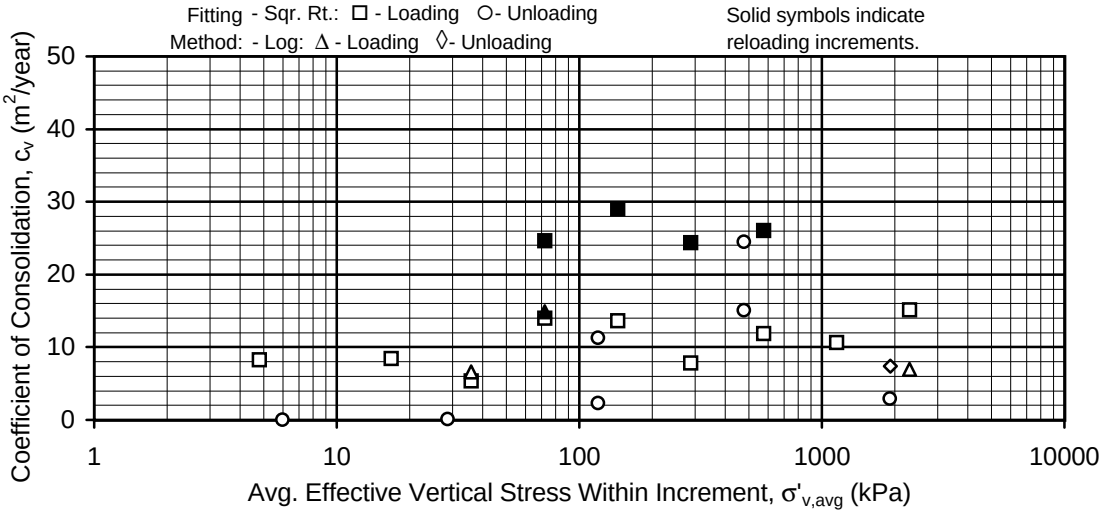




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 14 - Depth: 11.2m
Boring 98-71
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

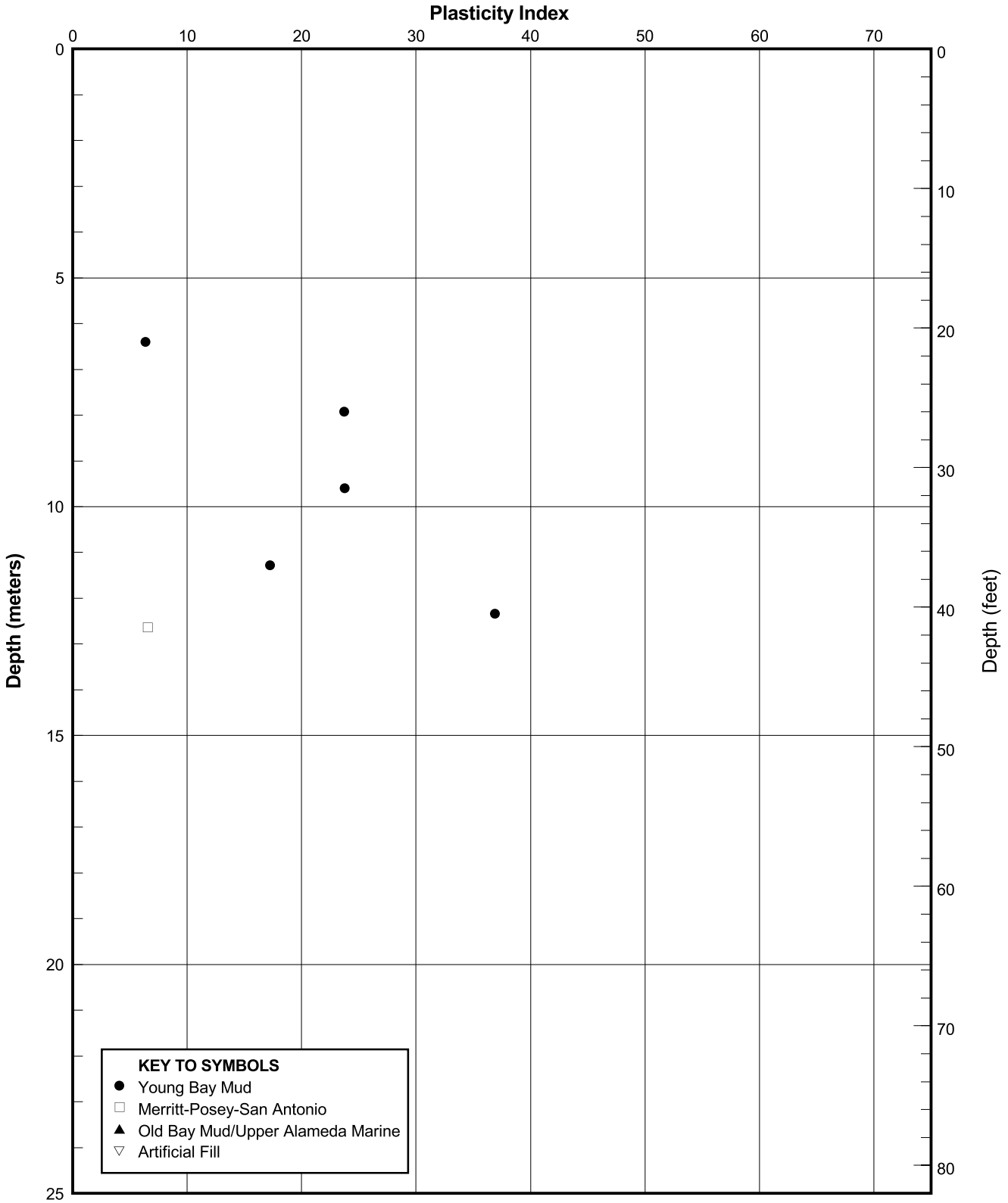
Sample No. 14rt - Depth: 11.2m
Boring 98-71
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

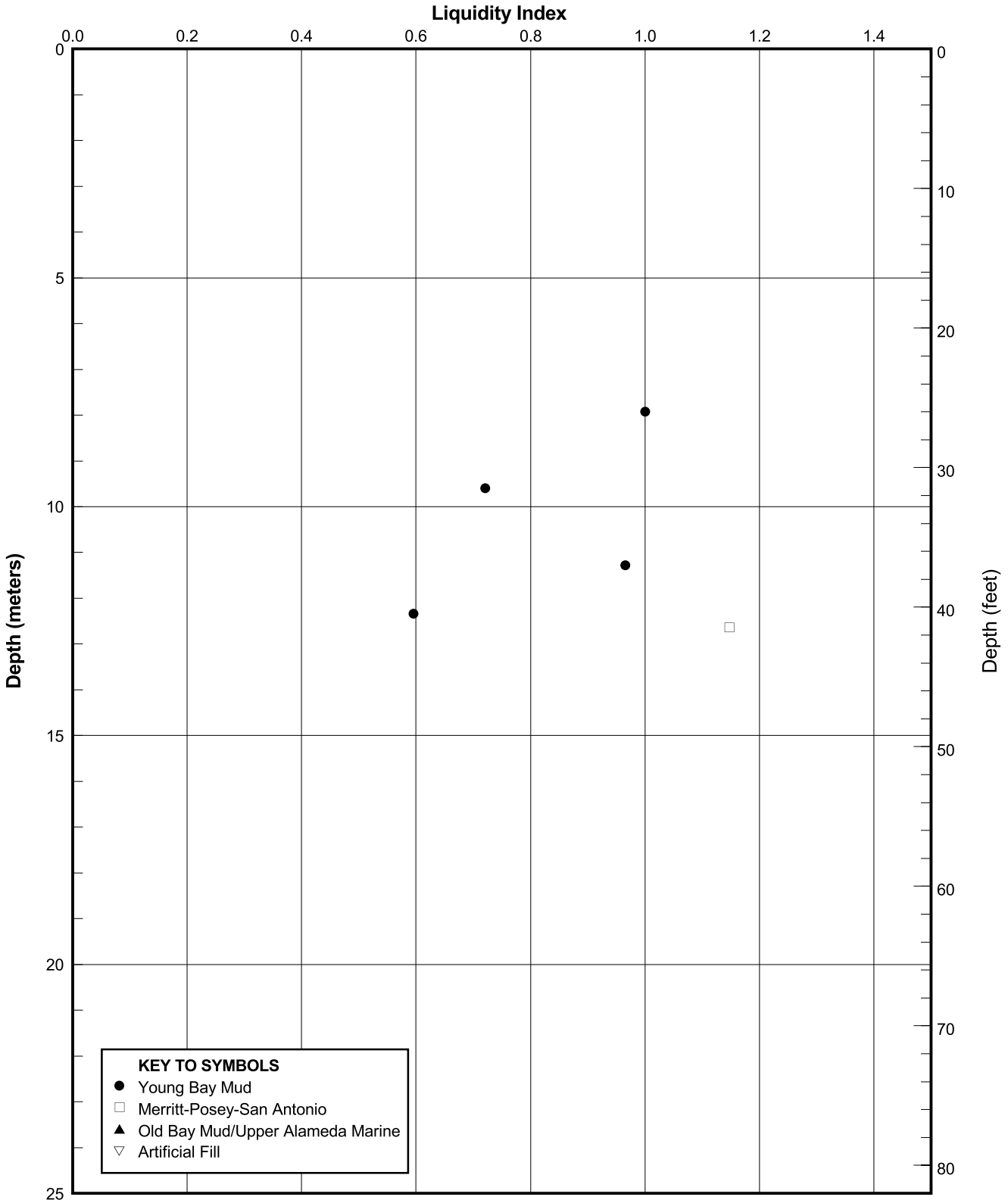
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



PLASTICITY INDEX PROFILE
Boring 98-71
SFOBB East Span Seismic Safety Project

PLATE 98-71.12

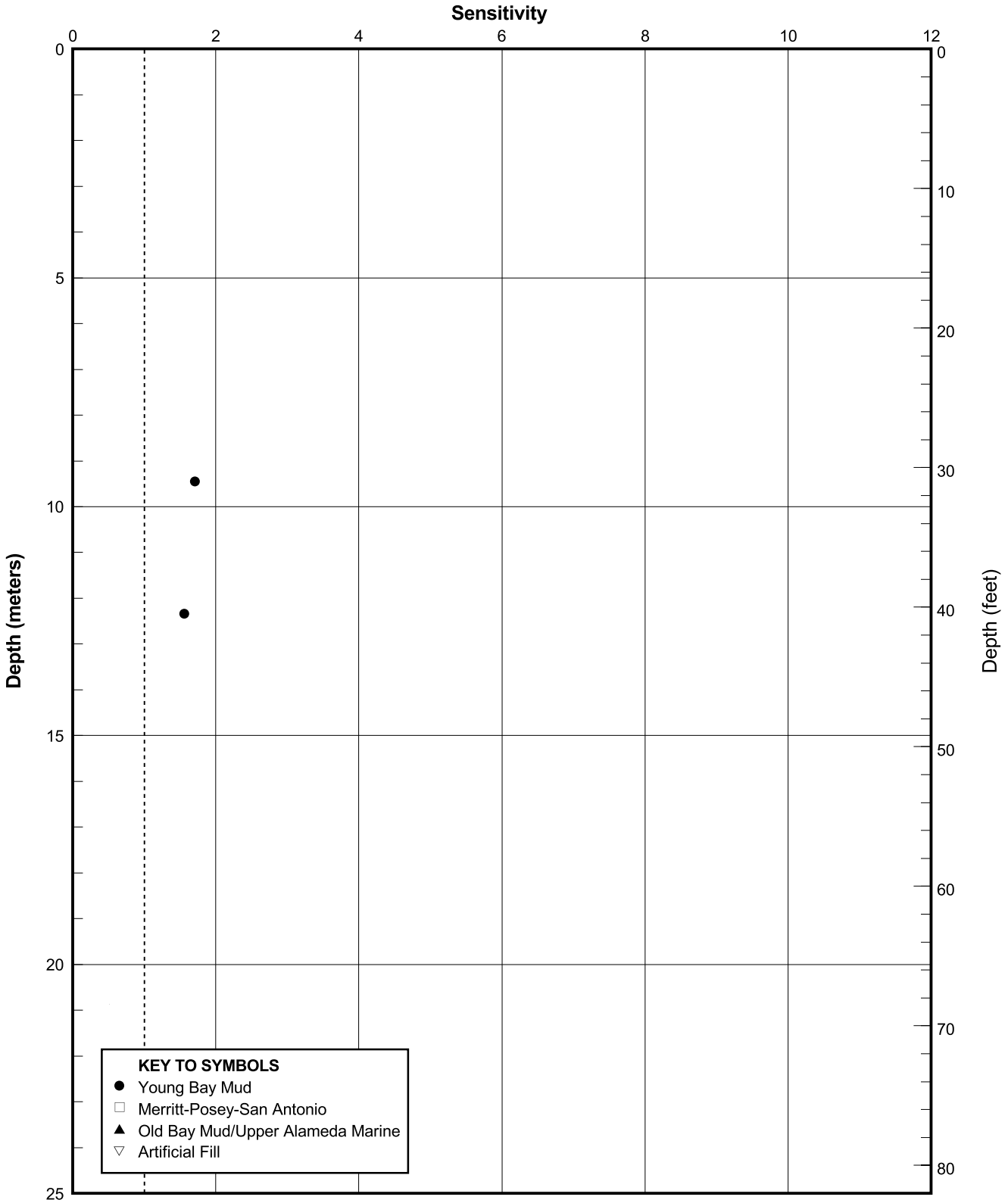


LIQUIDITY INDEX PROFILE
Boring 98-71
SFOBB East Span Seismic Safety Project

PLATE 98-71.13

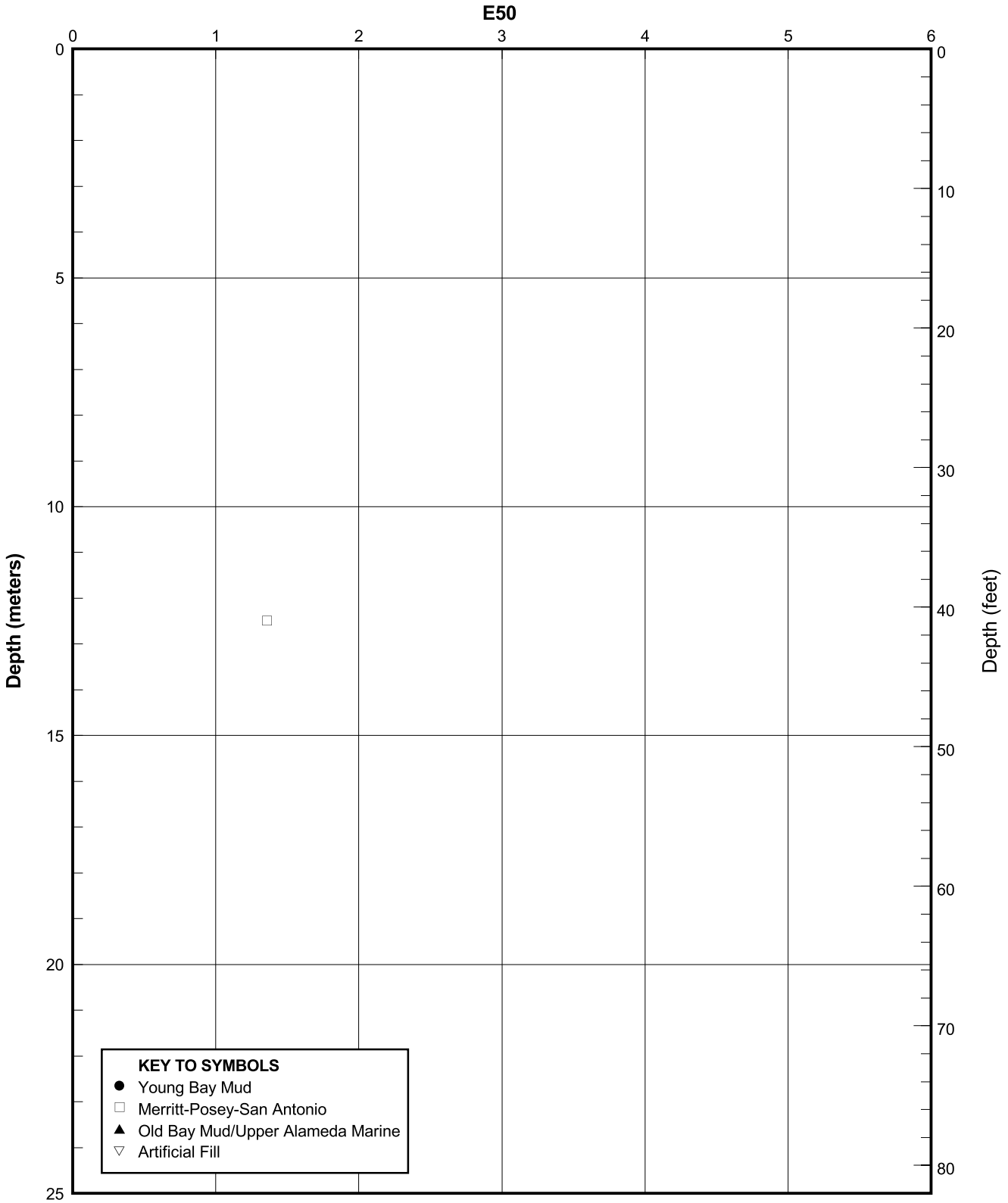
Earth Mechanics

FUGRO



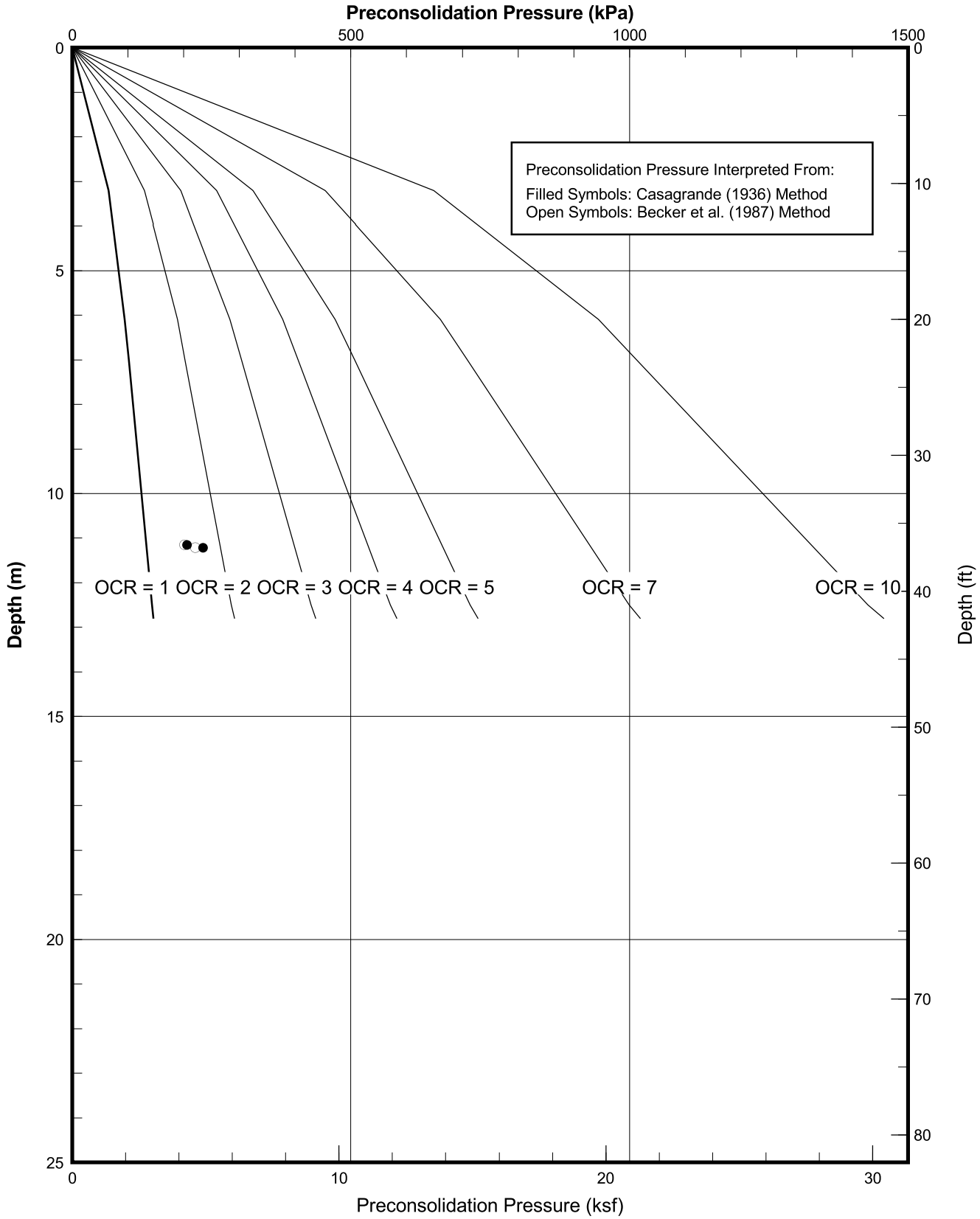
SENSITIVITY PROFILE
Boring 98-71
SFOBB East Span Seismic Safety Project

PLATE 98-71.14



E50 PROFILE
Boring 98-71
SFOBB East Span Seismic Safety Project

PLATE 98-71.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-71

SFOBB East Span Seismic Safety Project

PLATE 98-71.16

LAND BORING 98-72

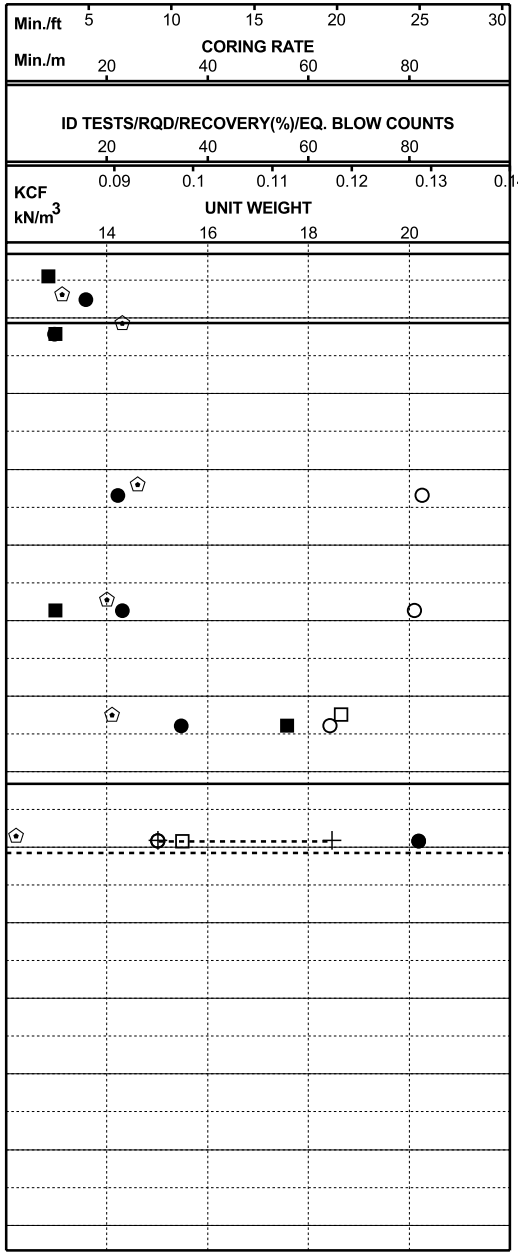
PROJECT NO:	98-42-0058	**START DATE:**	10/11/98	**DRILLER:**	Pitcher Drilling Company	Page 1 of 1
BORING:	98-72 (14m right of E. Sta. 90+76)	**COMPLETION DATE:**	10/12/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)	

Coordinates: E1839568 N648300
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 3.1m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
3	0				PAVEMENT, Asphalt Concrete (0.2m)	I
2	1			11 BAG 23	Coarse SAND with silt (SP-SM), medium dense, brown, (cement treated base) (1.1m) -with fine to medium sand	II
1	2				Fine SAND with silt (SP-SM), medium dense, yellow brown -with shell fragments -moist to 3.0m	
0	3			26	-with shell fragements ▽ (3.1m)	III
-1	4					
-2	5			20	-olive gray below 4.6m	
-3	6			21	-sandy silt below 5.8m	
-4	7				(7.2m)	
-5	8			3	Fat CLAY (CH), firm, olive gray -with shell fragments	IV
-6	9					
-7	10					
-8	11					
-9	12					
-10	13					

TOTAL DEPTH: 8.1m BACKFILLED WITH: Cement Grout



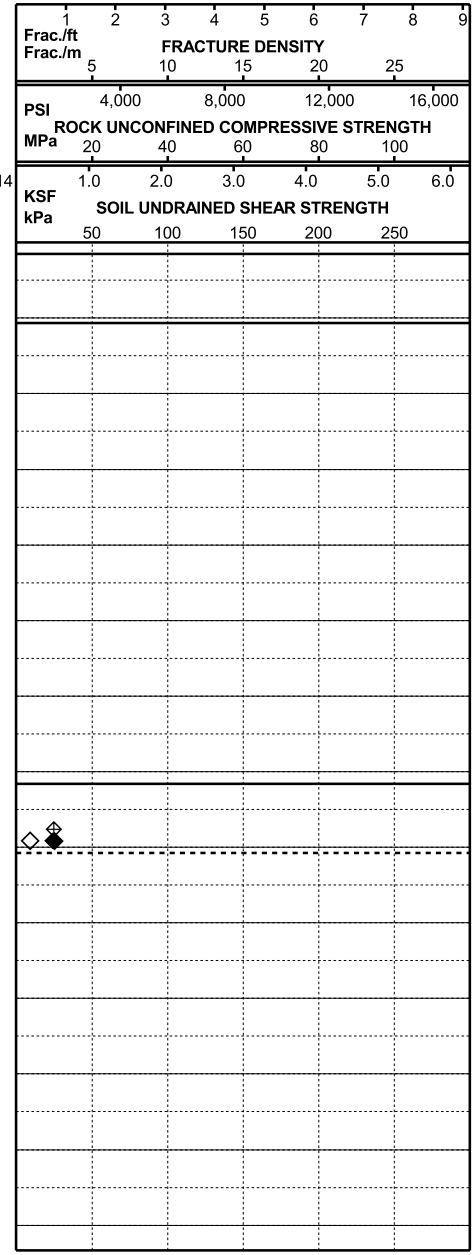


PLATE 98-72.1

LOG OF BORING AND TEST RESULTS

BORING 98-72

SFOBB East Span Seismic Safety Project

Report Date: 03/13/99

FUGRO

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No Remote Vane Testing Performed For This Boring

98-72		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	R-VALUE	
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)			SAND EQUIVALENT
0.5	300						8													399	12.11	1	24				75	23
0.8	1	16																										
1.2	3	10					10																			H		
3.4	4	22																										
4.9	5	23					10																			H		
6.2	6					18.6																						
6.4	7	35					56																					
7.8	8							24.9																				
7.9	9	82	65	30	1.49	15.5		23.9			25.4	9.3																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-72
SFOBB East Span Seismic Safety Project

PLATE 98-72.3

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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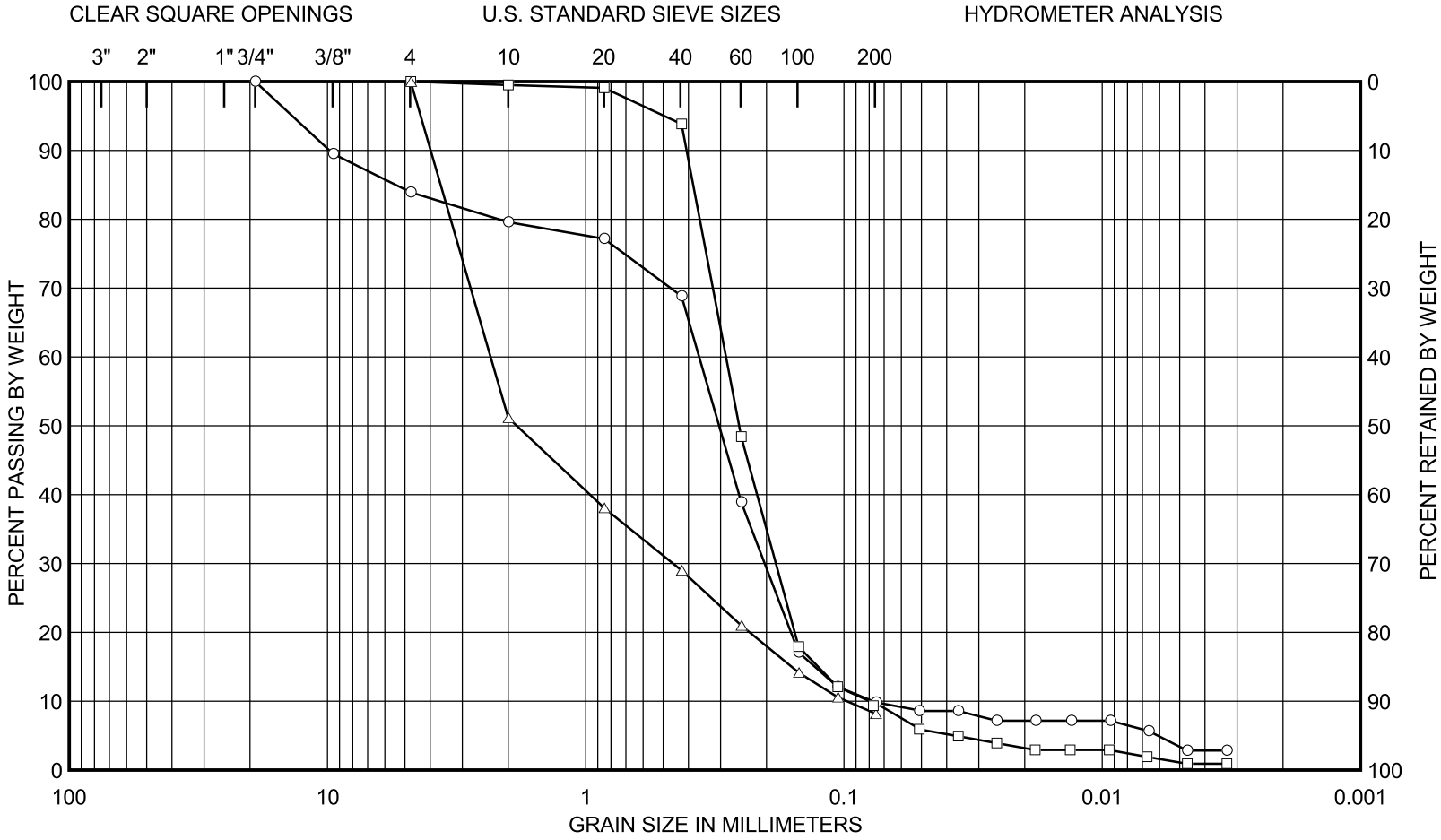

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
3	1.2	○—○	FINE SAND (SP-SM) with silt, a trace of medium sand and fine gravel	1.5	4.7	0.30
5	4.9	□—□	FINE SAND (SP-SM) with silt and a trace of medium sand	1.5	3.6	0.25
300	0.5	△—△	COARSE SAND (SP-SM) with silt and fine to medium sand	0.9	24.0	1.8

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-72
SFOBB East Span Seismic Safety Project

PLATE 98-72.4

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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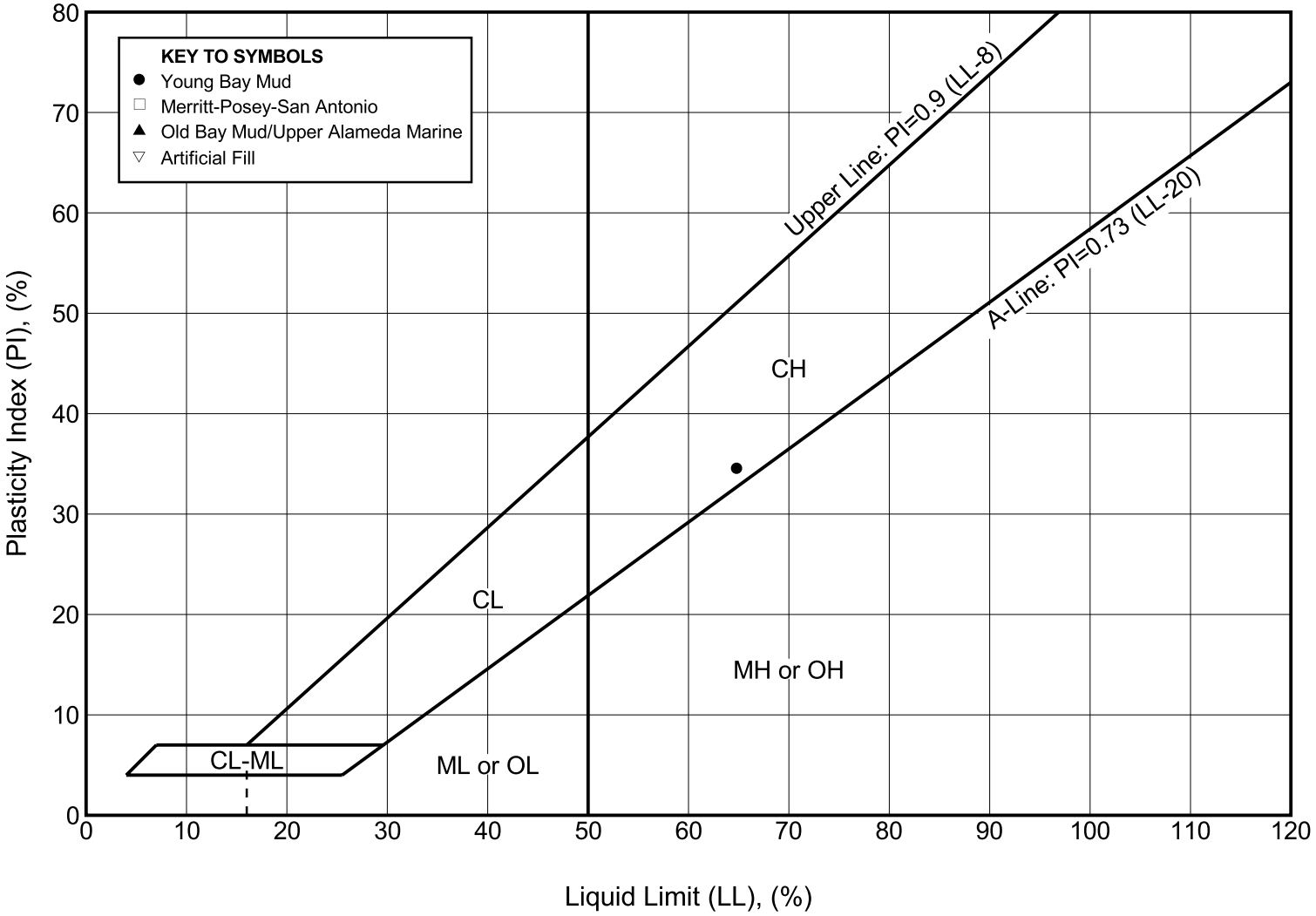


PLASTICITY CHART
Boring 98-72
SFOBB East Span Seismic Safety Project

PLATE 98-72.5

Earth Mechanics

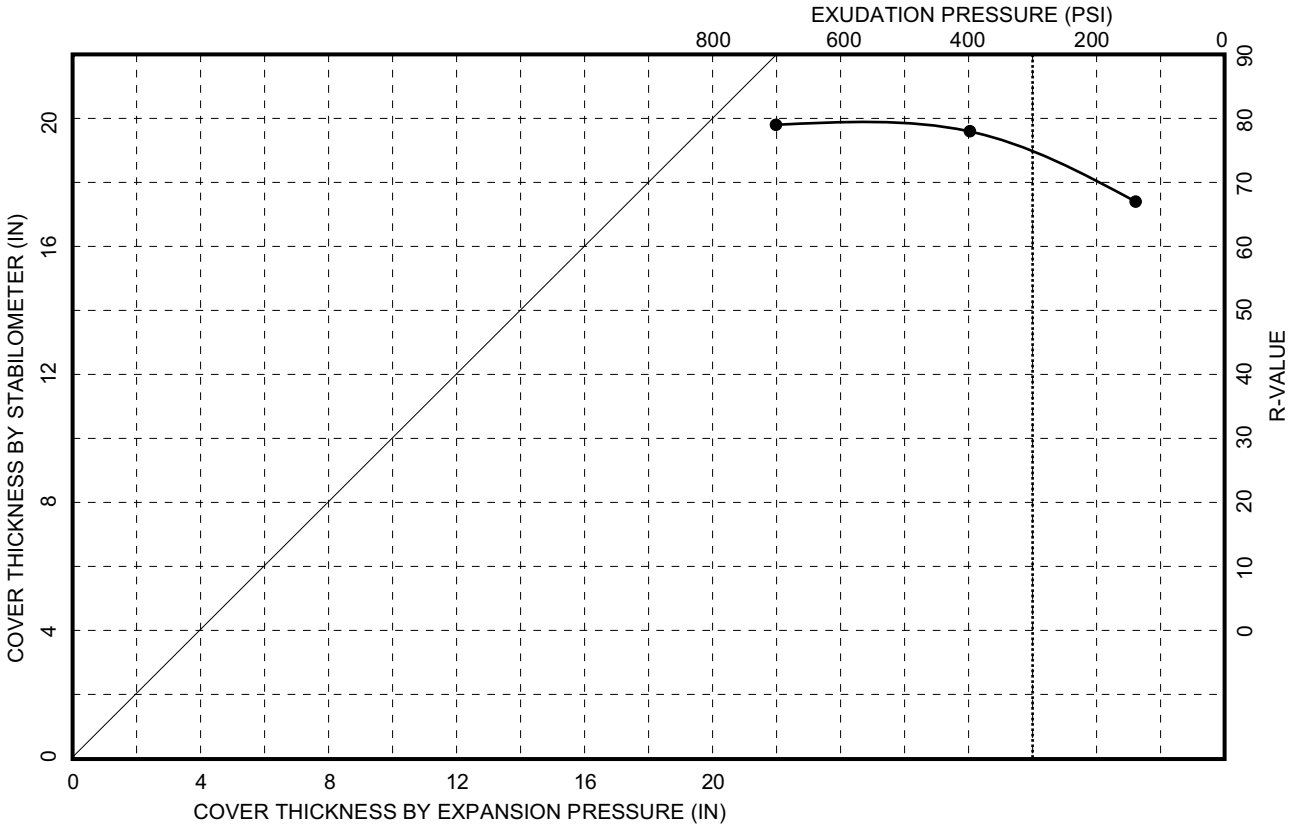
FUGRO

No Unconsolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Incremental Consolidation Testing Performed For This Boring

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring



SAMPLE NO. 300
DESCRIPTION: Coarse Sand (SP-SM) with silt (cement treated base)

SPECIMEN	A	B	C
EXUDATION PRESSURE (PSI)	701	398	139
EXPANSION PRESSURE (PSF)	200	190	160
RESISTANCE VALUE, "R"	79	78	67
% MOISTURE AT TEST	24.9	25.9	26.9
DRY DENSITY AT TEST (PCF)	88.1	91.1	89.6
R-VALUE AT 300 PSI EXUDATION PRESSURE: 75			

R-VALUE TEST RESULTS
Boring 98-72
SFOBB East Span Seismic Safety Project

PLATE 98-72-10

Health Science Associates

LABORATORY REPORT

Report Number : 991057
Purchase Order :
Job No. : 98-42-0057

GREG DENLINGER
FUGRO WEST INC.
5855 OLIVAS PARK DR.
VENTURA, CA. 93003-7672

Date Received : 13-NOV-98
Date Completed : 19-NOV-98
Date Sent : 19-NOV-98
Page 1 of 1

Sample Description : 4 - Bulk Soils
Project : Oakland

California Test Methods : 532,643

Lab No.	Submitter Sample Number	Resistivity ohms/cm	pH Units	Chloride ppm	Sulfate ppm
174124	98-63-14 @ 35.5'	653	9.13	4000	290
174125	98-72-300 @ 1.5'	399	12.11	<1.0	24.0
174126	98-66-300 @ 1.5'	327	12.17	<1.0	160
174127	98-61-1 @ 5'	762	9.17	720	630
Detection Limit :		10	NA	1.0	1.0

Milliliters Water Added	50	100	150	200	250	300	350
	Resistivity Ohm-cm						
Sample No.							
98-63-14	1525	1162	908	762	653	653	690
98-73-300	1343	762	472	399	581	1416	-
98-66-300	581	363	327	363	544	-	-
98-61-1	1198	908	762	1161	1089	-	-

Remarks : Sample(s) and sampling data as provided by : Analyst(s) : ED Ref :

California ELAP No.: 1406
AIHA Accreditation No.: 172
NVLAP Accreditation No.: 101384
AIHA ELLAP Accreditation No.: 10985
ACSD Lab No.: 10125

Reviewed by: Thomas Shultz
Thomas Shultz

Technical Approval: Susan Rosenberg
Laboratory Director, Susan B. Rosenberg, CIH

PLATE 98-72.11

10771 Noel St., Los Alamitos, CA 90720 714/220-3922 FAX 714/220-2081 e-mail hsa@earthlink.net

This report pertains only to the samples investigated and does not necessarily apply to other apparently identical or similar materials. This report is submitted for the exclusive use of the client to whom it is addressed. Any reproduction of this report or use of this Laboratory's name for advertising or publicity purposes without written authorization is prohibited.

No Soil Property Profiles For This Boring

LAND BORING 98-73

PROJECT NO:	98-42-0058	**START DATE:**	10/11/98	**DRILLER:**	Pitcher Drilling Company	Page 1 of 1
BORING:	98-73 (11m right of E. Sta. 91+76)	**COMPLETION DATE:**	10/12/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)	

Coordinates: E1839666 N648322
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 2.8m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
			PAVEMENT, 0.5m Asphalt Concrete (0.5m)	I
2	1	38 30/15cm BAG	Fine GRAVEL with silt and sand (GP-GM), dense to very dense, brown -moist to 2.7m -silty sand with gravel, at 0.8m -with coarse gravel at 1.1m	II
1	2		▽ (2.8m)	
0	3	4	Clayey Fine SAND (SC), loose, gray -with shell fragments at 3.0m	III
-1	4		-dense fine sand with silt, 4.3m to 5.5m	
-2	5	32		
-3	6	4	-with gravel at 6.4m	
-4	7		(7.6m)	
-5	8	WOH	Fat CLAY (CH), firm to stiff, olive gray -with shell fragments -dark gray with silt pockets, at 7.9m	IV
-6	9			
-7	10	PUSH		
-8	11	PUSH	-with gas blisters at 10.8m	
-9	12			
-10	13	PUSH	-with sand pockets and an H2S odor, at 12.5m	
			TOTAL DEPTH: 12.8m BACKFILLED WITH: Cement Grout	

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13 0.14
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

PLATE 98-73.1

LOG OF BORING AND TEST RESULTS

BORING 98-73

SFOBB East Span Seismic Safety Project

Report Date: 03/14/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-73		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.8	1	10					18																			
1.1	2	8					10																			
3.2	3	24					32																			
5.0	4	23					6																			
6.6	6	35					40																			
7.9	7		51	26		16.6		28.7			30.2	9.8	9.5													C
8.1	8	51	44	24	1.37																					C
9.4	9							44.0																		C
9.6	10					17.7		52.7				19.6														
9.8	11	40	48	23	0.66			52.7																		
10.9	12							44.0			59.2				35.0		1.8									
11.0	13	46	49	23	0.86			40.2																		
12.3	14														54.0		0.7									
12.5	15							47.9			53.7	17.6														
12.6	16					16.5						19.6														

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.3a

Earth Mechanics

FUGRO

98-73		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
12.8	17	48	50	23	0.93			52.7																		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

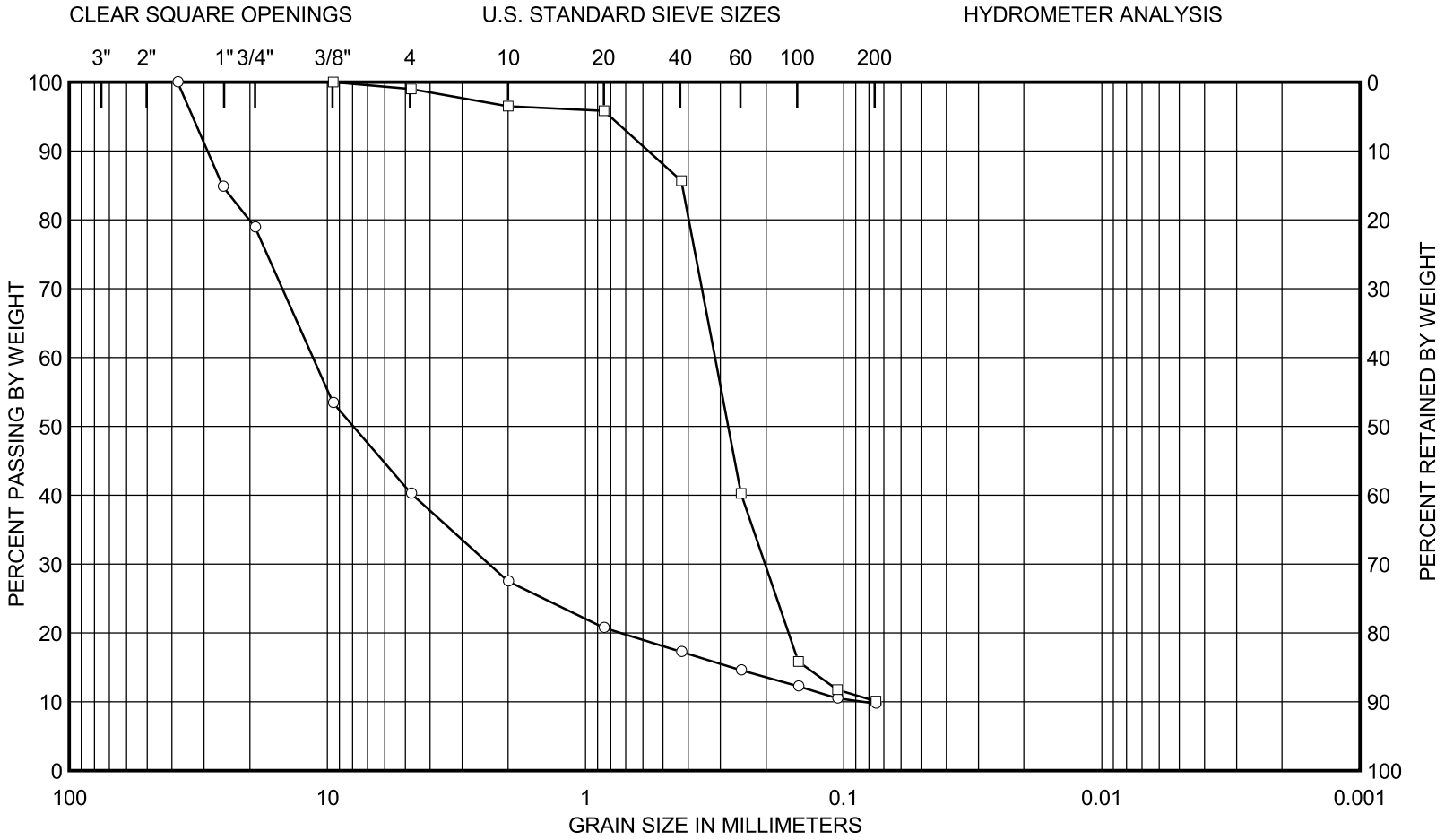
\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.3b

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	1.1	○——○	FINE GRAVEL (GP-GM) with silt, coarse gravel and fine to coarse sand	5.0	133.5	8.0
4	5.0	□——□	FINE SAND (SP-SM) with silt and a trace of medium sand			0.28

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-73
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-73.4

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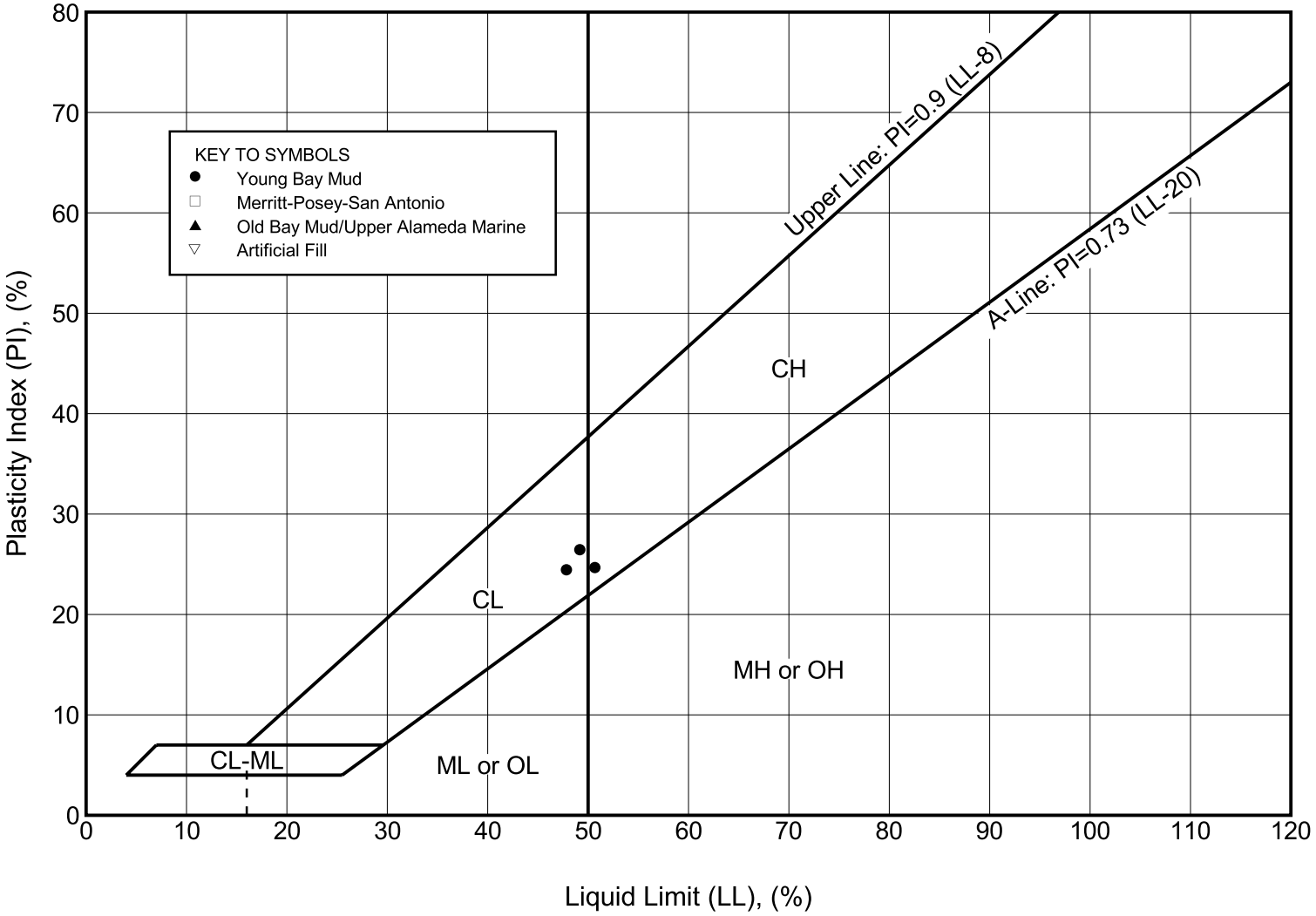

PLASTICITY CHART
Boring 98-73
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-73.5

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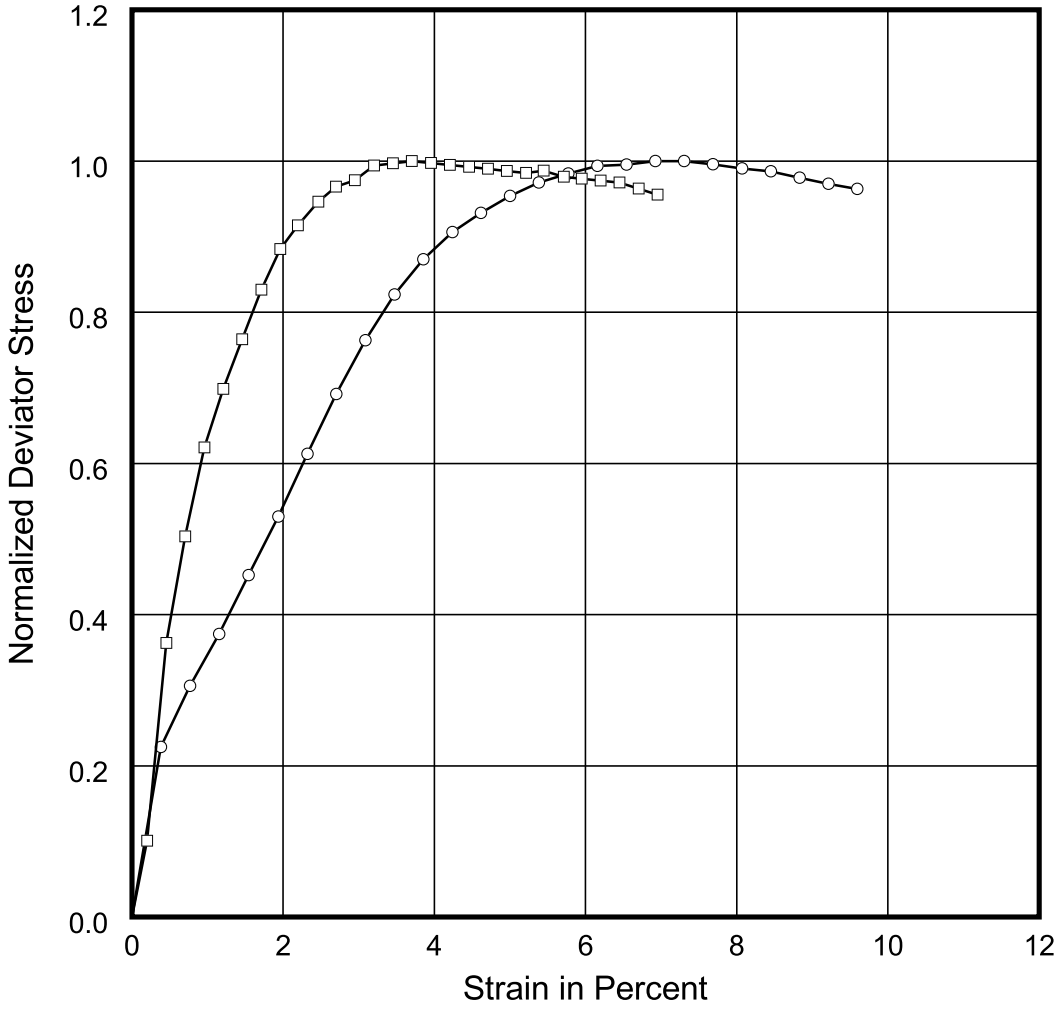


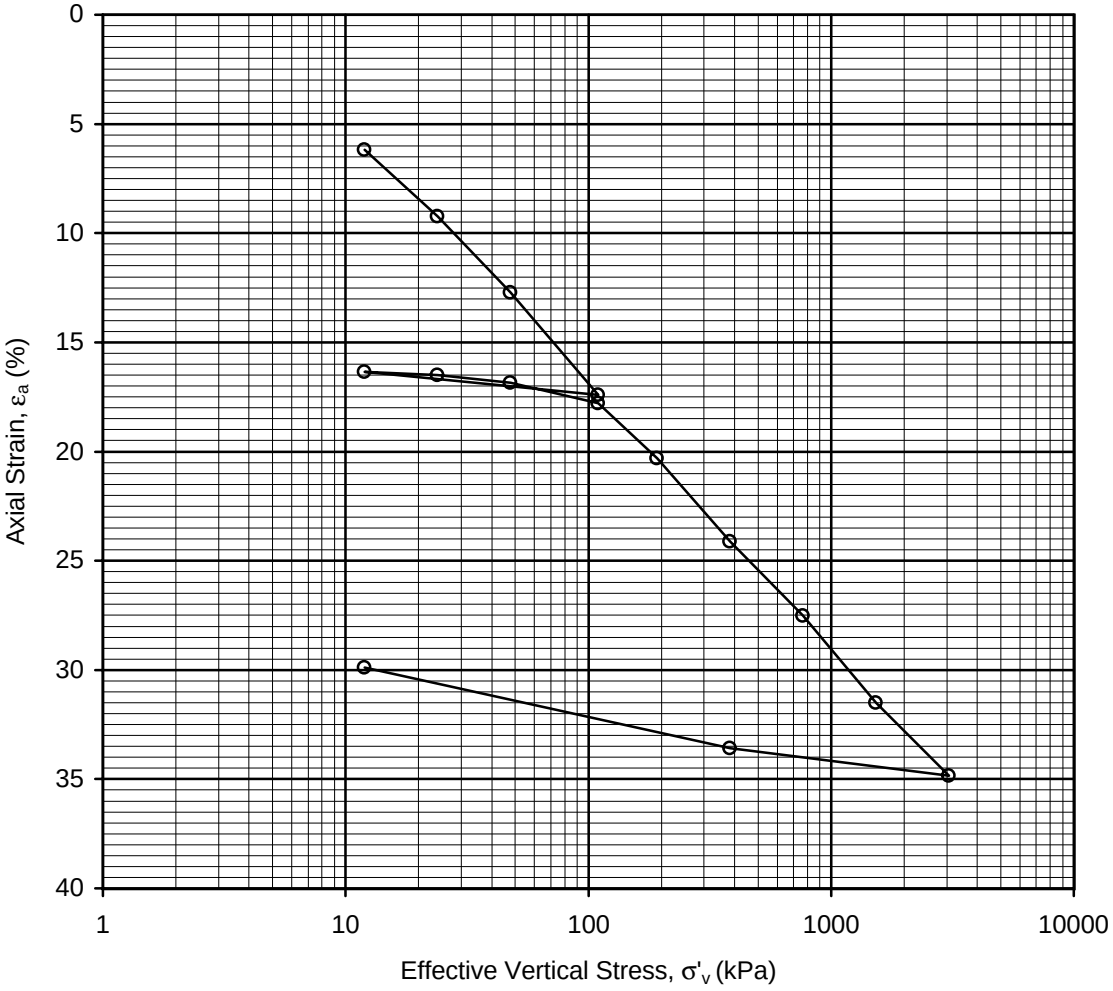
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	12	10.9	UU	207	70	1.8
□—□	14	12.3	UU	234	108	0.7

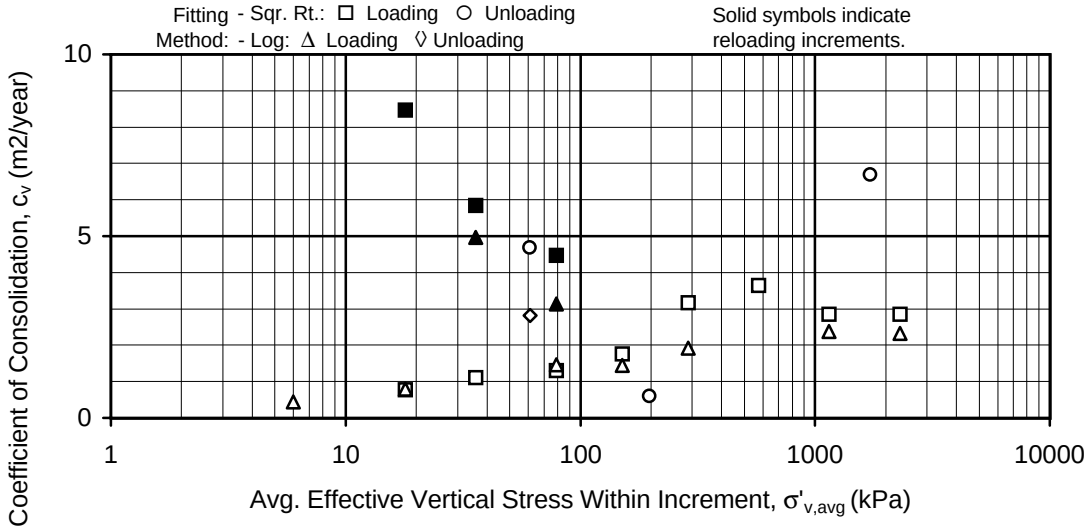
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-73
SFOBB East Span Seismic Safety Project

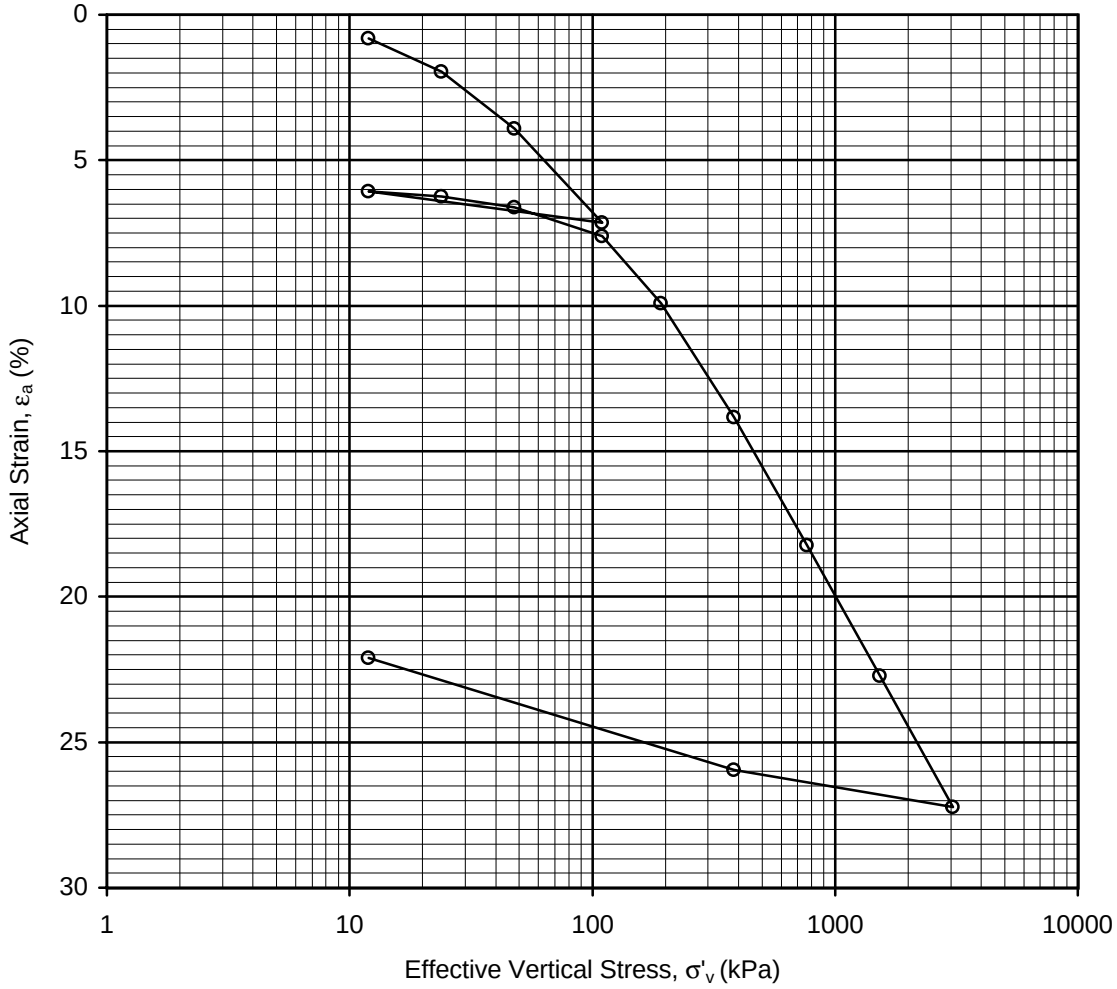
PLATE 98-73.6

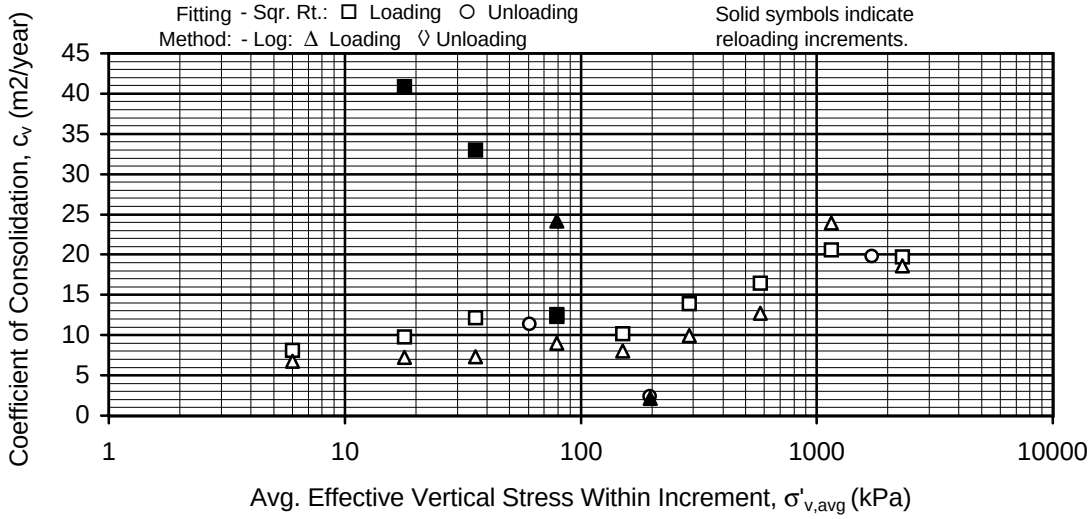




INCREMENTAL CONSOLIDATION TEST RESULTS

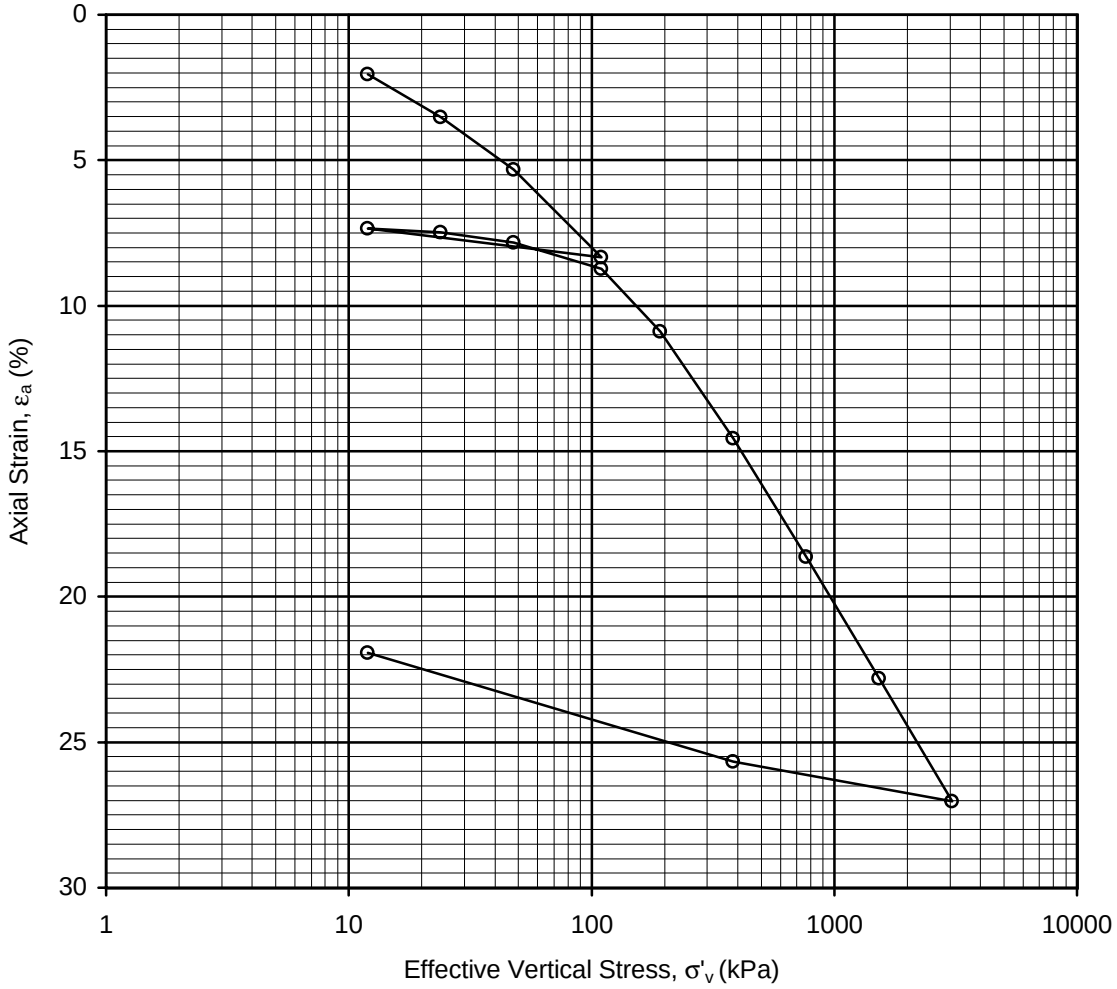
Sample No. 7A (Remold at Natural Water Content + 5%) - Depth: 7.9m
Boring 98-73
SFOBB East Span Seismic Safety Project

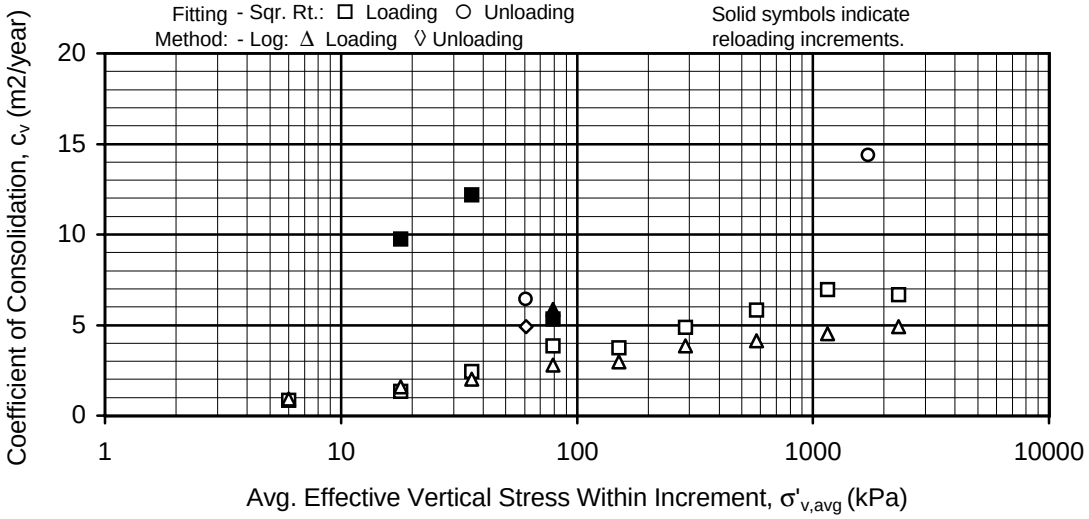




INCREMENTAL CONSOLIDATION TEST RESULTS

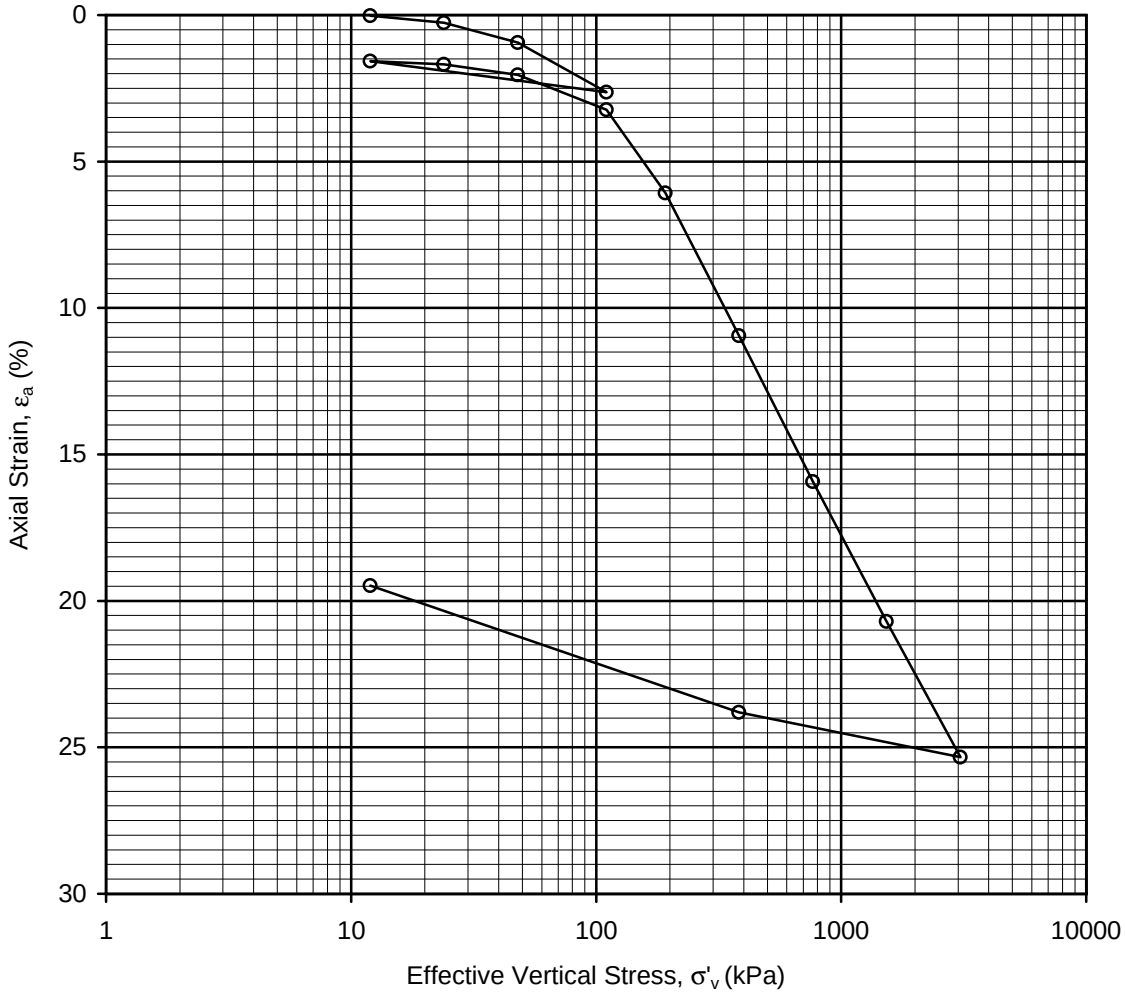
Sample No. 8A - Depth: 8.1m
Boring 98-73
SFOBB East Span Seismic Safety Project

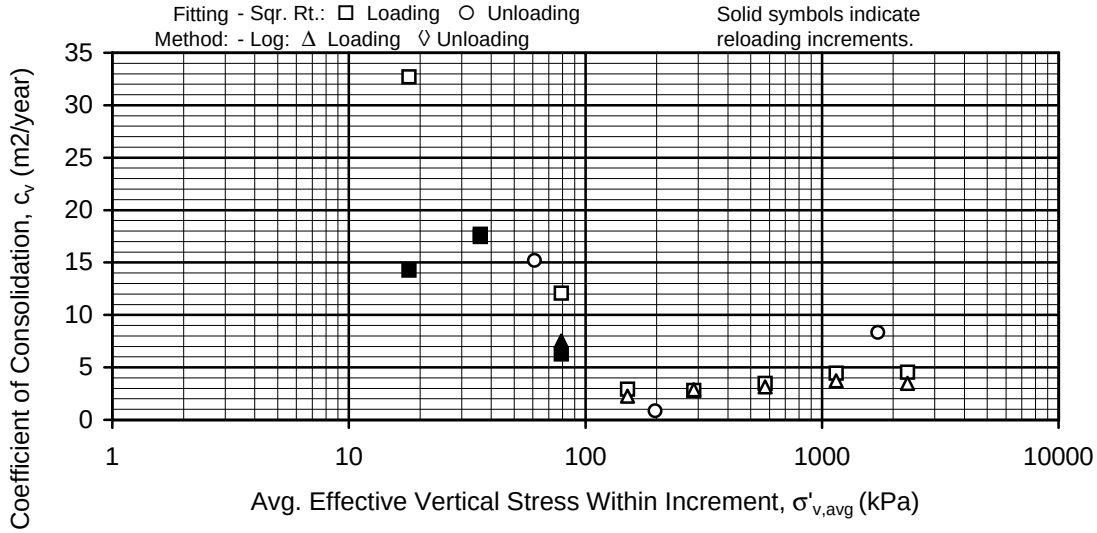




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 8B (Remolded at Natural Water Content) - Depth: 8.1m
Boring 98-73
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

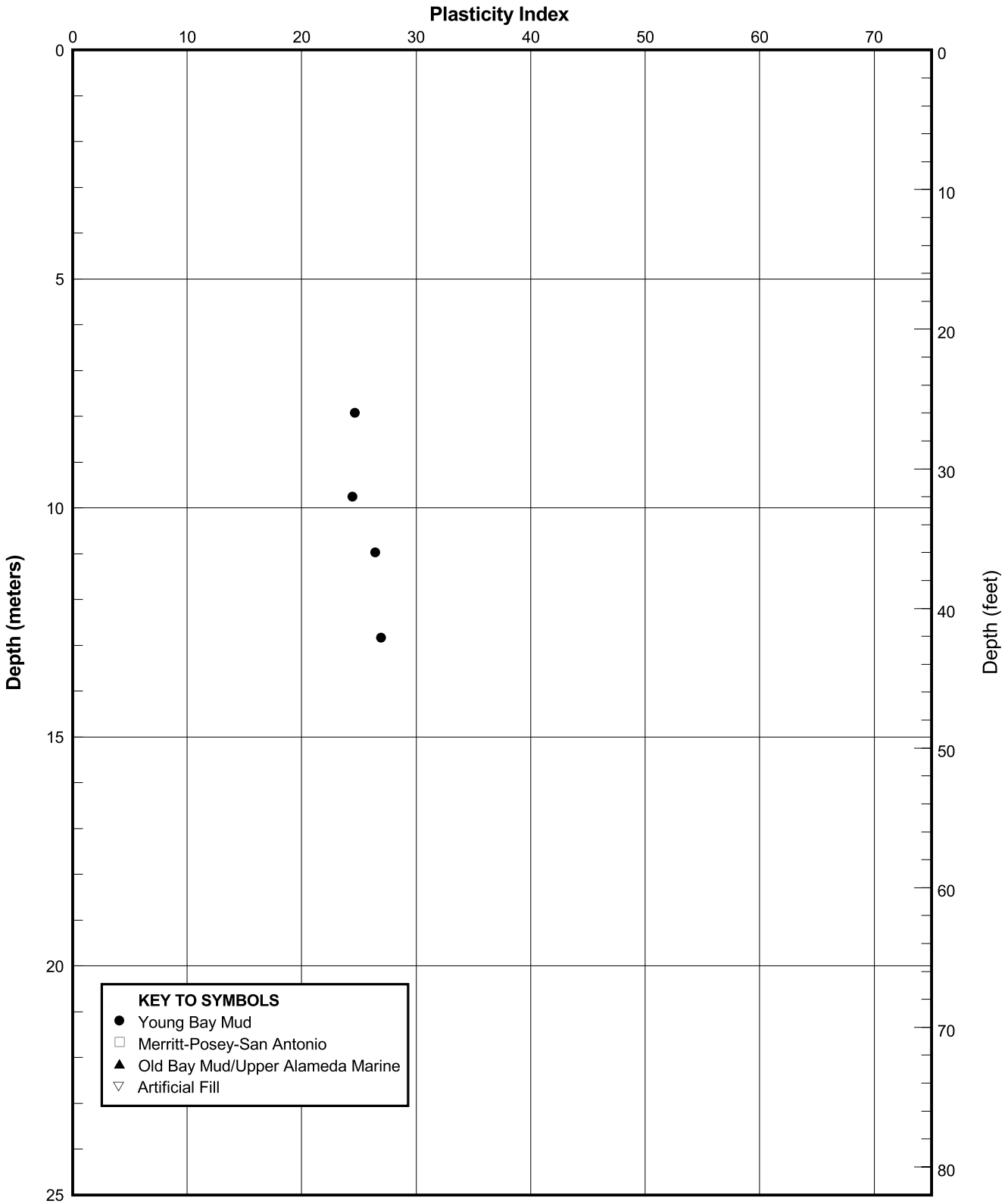
Sample No. 9 - Depth: 9.5m
Boring 98-73
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring

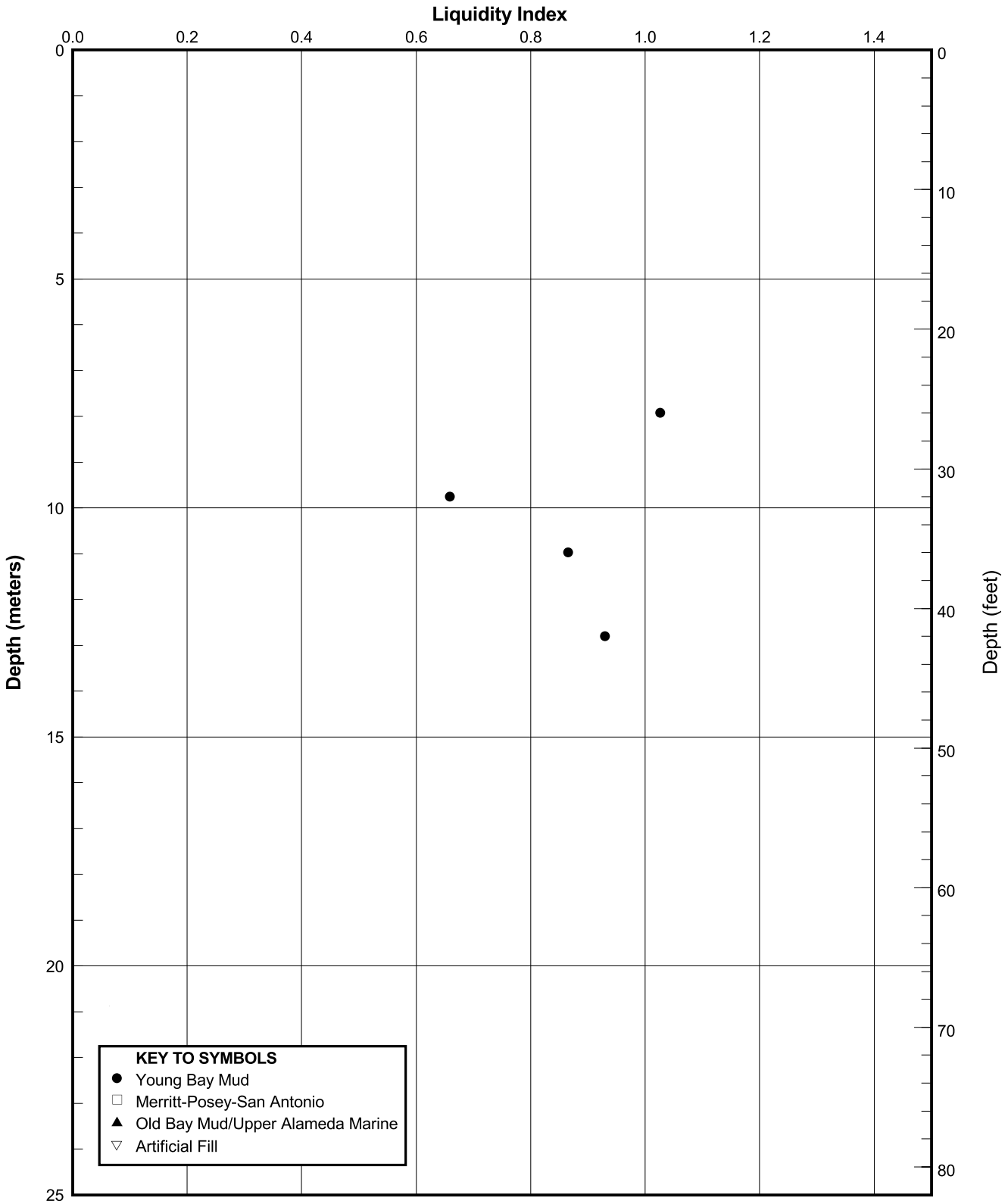


PLASTICITY INDEX PROFILE
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.12

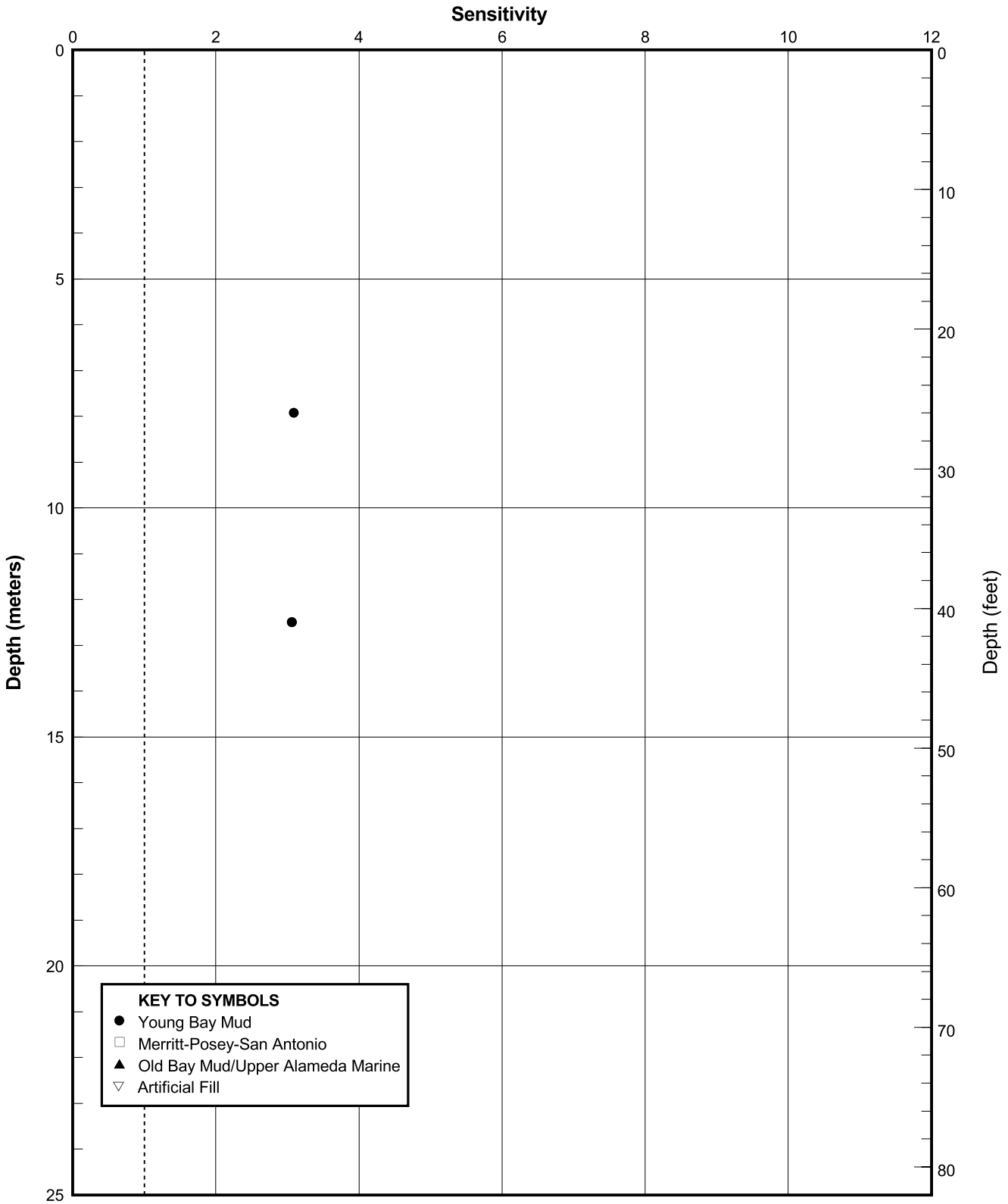
Earth Mechanics

FUGRO



LIQUIDITY INDEX PROFILE
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.13

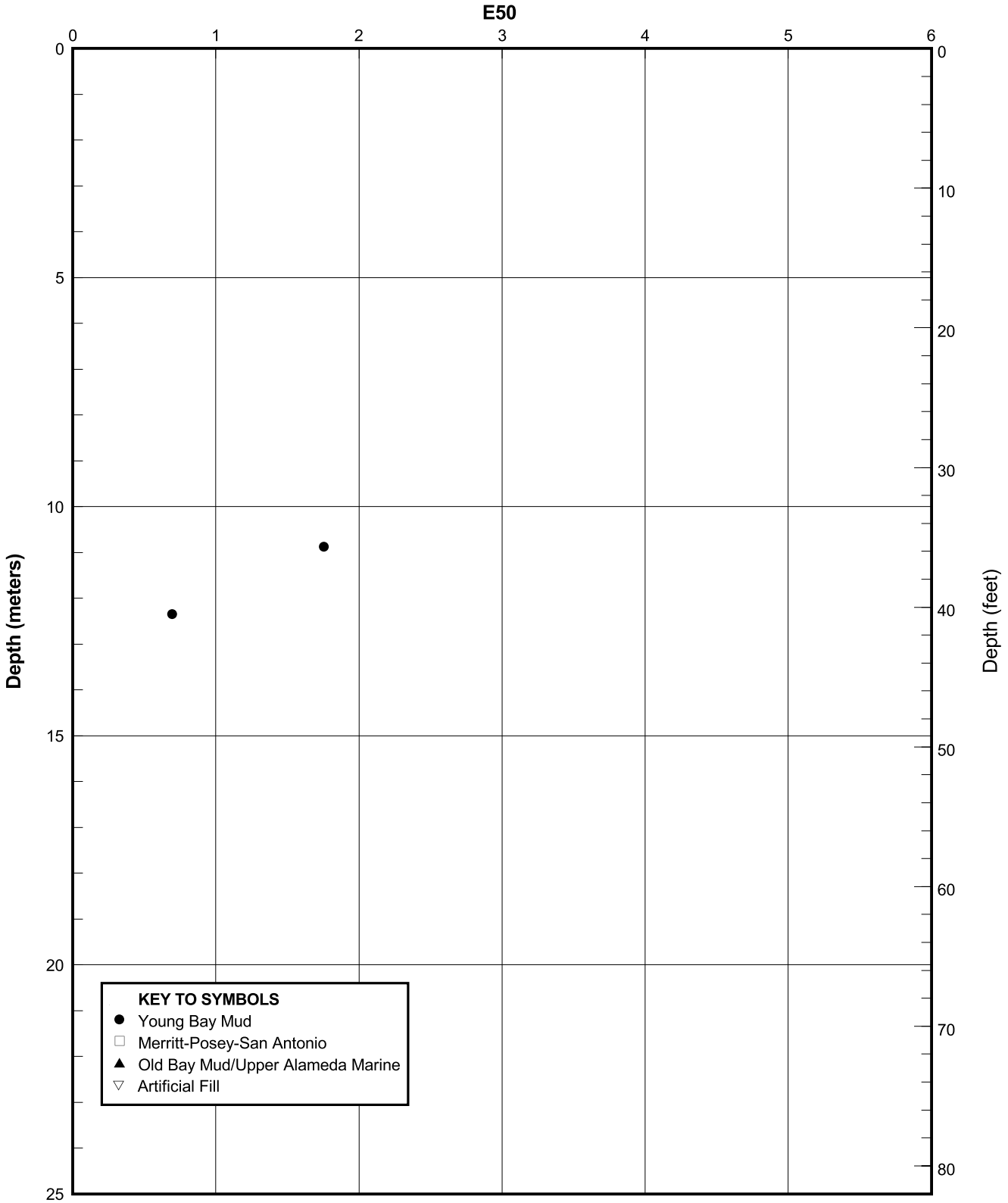


SENSITIVITY PROFILE
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.14

Earth Mechanics

FUGRO

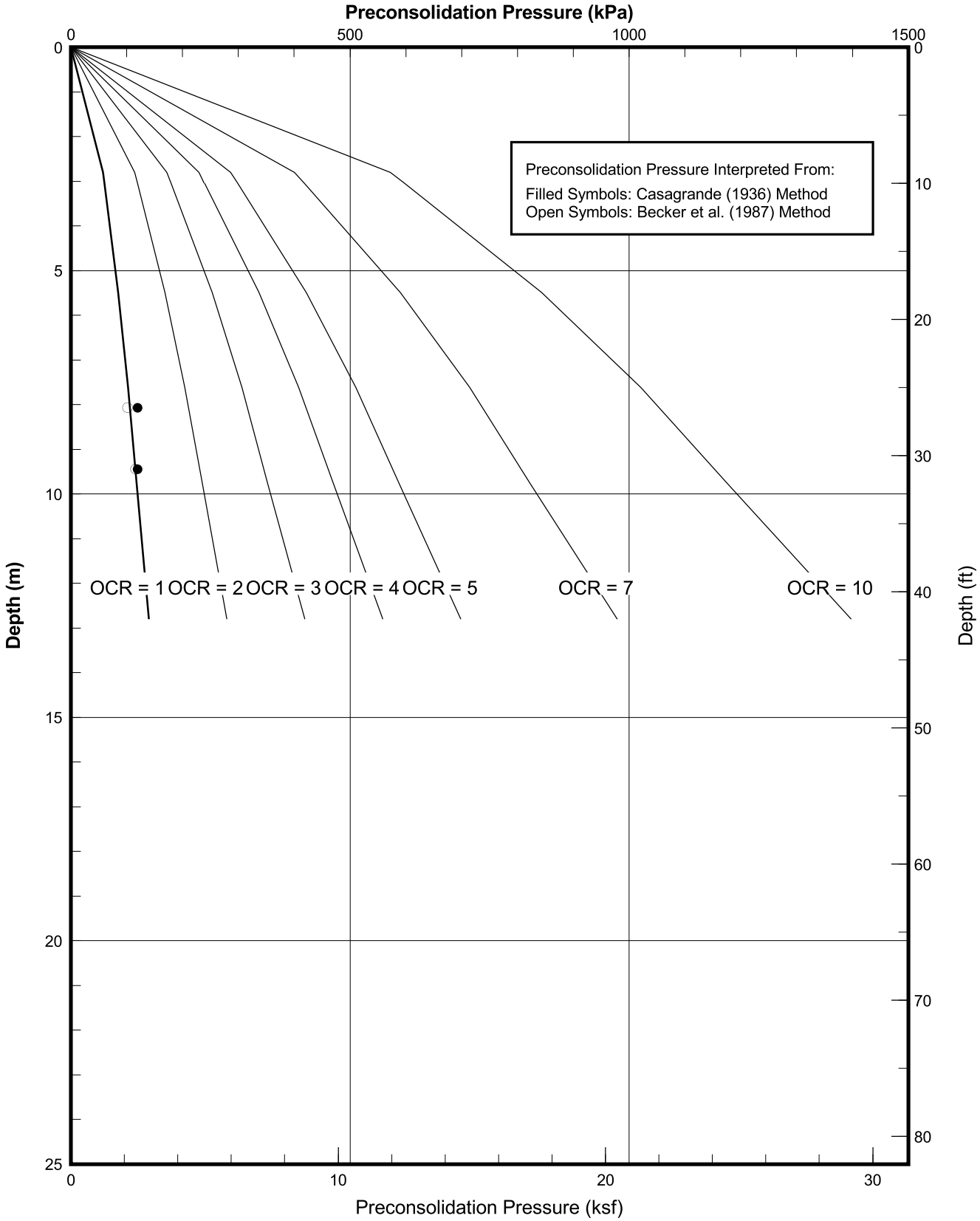


E50 PROFILE
Boring 98-73
SFOBB East Span Seismic Safety Project

PLATE 98-73.15

Earth Mechanics

FUGRO



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

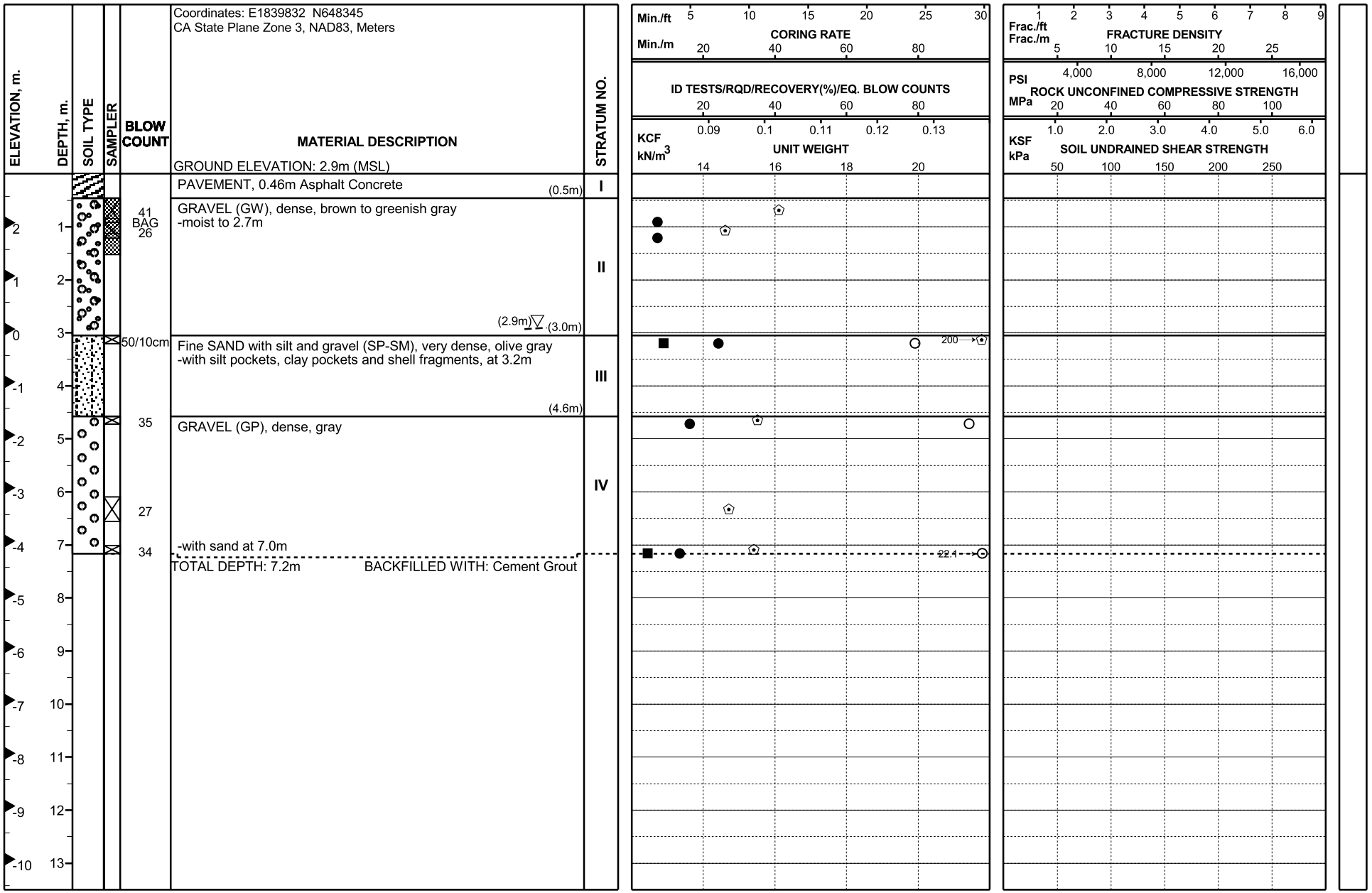
Boring 98-73

SFOBB East Span Seismic Safety Project

PLATE 98-73.16

LAND BORING 98-74

PROJECT NO:	98-42-0058	**START DATE:**	10/14/98	**DRILLER:**	Pitcher Drilling Company
BORING:	98-74 (80m right of W. Sta. 93+57)	**COMPLETION DATE:**	10/14/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)



LOG OF BORING AND TEST RESULTS

BORING 98-74

SFOBB East Span Seismic Safety Project

Report Date: 08/31/99

Earth Mechanics

FUGRO

PLATE 98-74.1

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No Remote Vane Testing Performed For This Boring

98-74		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	
0.9	1	7																								
1.2	2	7																								
3.2	3	24					9																			
4.7	4	16																								
7.2	5	13					4																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-74
SFOBB East Span Seismic Safety Project

PLATE 98-74.3

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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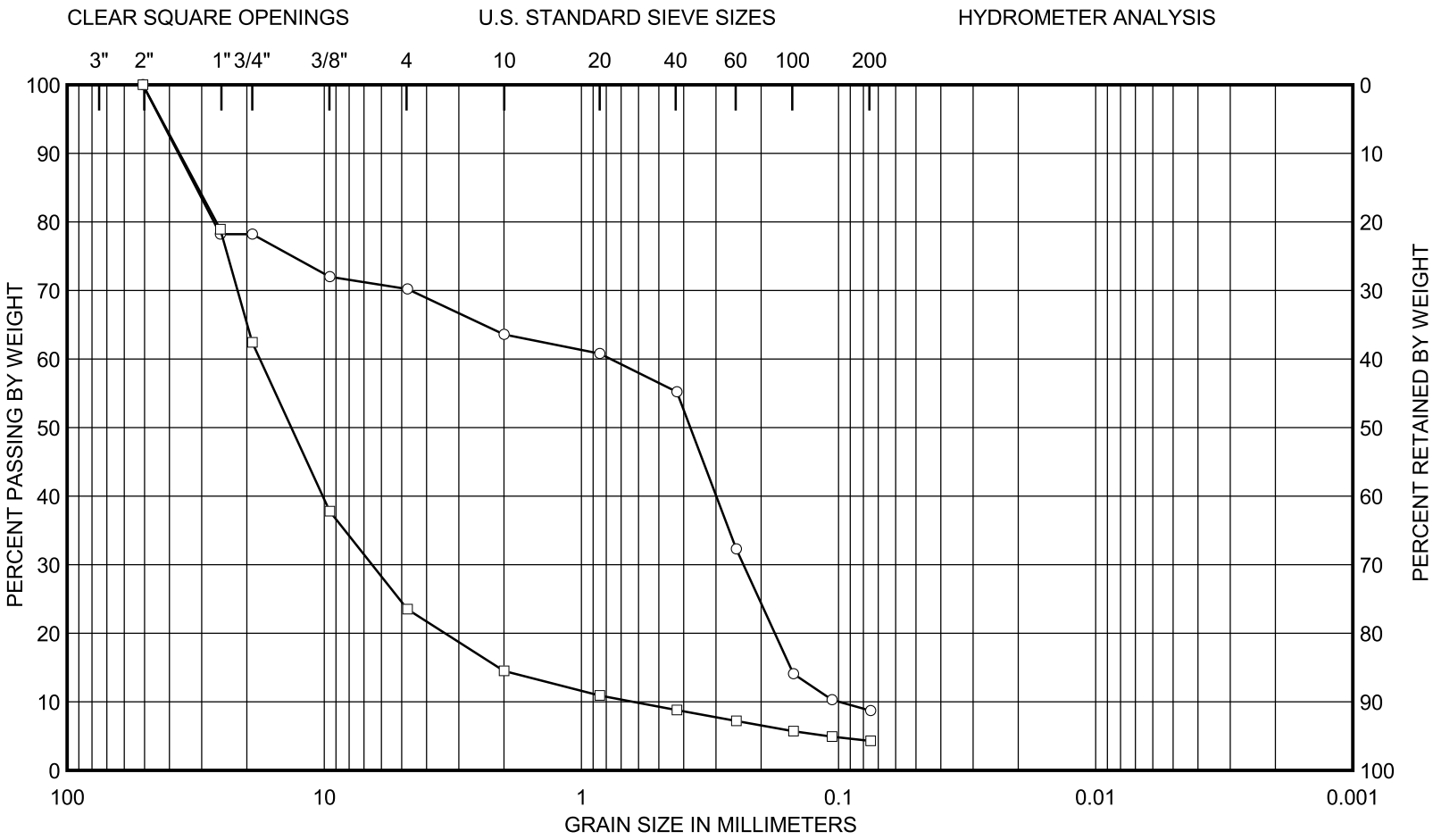

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
3	3.2	○——○	FINE SAND (SP-SM) with silt, a trace of medium to coarse sand and fine to coarse gravel	0.7	7.7	0.38
5	7.2	□——□	FINE TO COARSE GRAVEL (GP) with sand	3.8	28.2	13.4

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-74
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-74.4

No Atterberg Limit Testing Performed For This Boring

No Unconsolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Incremental Consolidation Testing Performed For This Boring

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring

No Soil Property Profiles For This Boring

LAND BORING 98-75

PROJECT NO:	98-42-0058	**START DATE:**	11/09/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-75 (58m right of E. Sta. 84+89)	**COMPLETION DATE:**	11/10/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838987 N648200
CA State Plane Zone 3, NAD83, Meters

GROUND ELEVATION: 2.4m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
2	1	36	PAVEMENT, 3 Asphalt Concrete over 3 of Concrete (0.2m)	I
		7	Silty Fine GRAVEL with sand (GM), medium dense, brown -moist to 2.1m -loose at 1.1m	
1	2	14		
			▽ (2.4m)	II
0	3	20	-with coarse gravel at 3.2m	
-1	4		(4.6m)	
-2	5	13	Fine to Coarse GRAVEL (GW), medium dense to dense, gray to greenish gray	III
-3	6			
-4	7	49		
-5	8	34	-sand with gravel, below 7.6m	
-6	9		(9.1m)	
-7	10	7	Fat CLAY (CH), firm to stiff, olive gray -lean clay to 10.1m -dark gray with many shell fragments at 9.1m	IV
-8	11	PUSH	-with silt pockets and partings, at 11.0m	
-9	12		(11.9m)	
-10	13	PUSH	Lean CLAY with sand (CL), hard, greenish gray	V
-11	14		(13.7m)	
-12	15	90/30cm	Silty Fine SAND (SM), very dense, brown -fine sand with silt, to 14.6m	VI
-13	16	90/30cm		
-14	17	81	-gray, and with clay pockets, below 17.1m	
-15	18		(18.6m)	
-16	19	40	Fat CLAY (CH), very stiff, greenish gray -sandy lean clay to 19.2m	VII
-17	20	PUSH	-with black organic partings, silt partings, and a few desiccated pockets, at 20.1m	
-18	21			
-19	22	SAVE	-with many sand pockets and calcareous nodules, at 21.6m	
-20	23		(22.9m)	
-21	24	PUSH	Fat CLAY (CH), very stiff, greenish gray -with sand seams and calcareous nodules, at 23.2m	VIII
-22	25	PUSH	-clayey sand, 24.4m to 25.0m	
-23	26			
-24	27	SAVE	-with silt partings at 26.2m	
-25	28	PUSH	-with silt partings, sand seams and pockets, and organic pockets, 27.4m to 29.6m	
-26	29			
-27	30	PUSH	-mottled with olive gray, at 29.3m	
-28	31	SAVE	-with a few sand pockets at 30.8m	
-29	32		TOTAL DEPTH: 31.1m BACKFILLED WITH: Cement Grout	
-30	33			

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.09 0.1 0.11 0.12 0.13
kN/m3 14 16 18 20
UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9
Frac./m 5 10 15 20 25
FRACTURE DENSITY

PSI 4,000 8,000 12,000 16,000
MPa 20 40 60 80 100
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0
kPa 50 100 150 200 250
SOIL UNDRAINED SHEAR STRENGTH

22.3

PLATE 98-75.1

LOG OF BORING AND TEST RESULTS

BORING 98-75

SFOBB East Span Seismic Safety Project

Report Date: 03/14/99

Earth Mechanics

FUGRO

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No Remote Vane Testing Performed For This Boring

98-75		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ROCK TESTS	ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	Unconf. Comp. (MPa)	
0.7	1	9																									
1.0	2	12					18																				
1.6	3	12					12																				
3.3	4	14					11																				
4.7	5						3																				
6.5	6						1																				
9.3	7	35	44	19	0.62																						
11.0	8	31	32	16	0.95																						C
11.1	9					18.9		45.0							41.8	12.7	2.0										
11.3	10	32	53	23	0.31			51.7		59.4	52.3																
12.4	11	16				21.8	81								218.9		2.2										H
14.2	13	20				22.2	10																				
15.7	14	21					12																				
17.2	15	21					13																				
18.6	16	25					20																				

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.3a

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

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98-75		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		CORROSIVITY TESTS				COMPACTION TESTS		ROCK TESTS	ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)	Unconf. Comp. (MPa)	
18.7	17	28					61																				H
20.0	18	25	49	17	0.27	20.6										88.8											
20.2	19							155.6	191.5		167.1																
21.9	20	59	38	14	1.89						122.5																C
23.2	22						88		155.6							22.8											
23.3	23					18.0		177.2	203.5																		
23.5	24	42	61	20	0.54			134.1			167.1																
24.8	26	20	30	12	0.41		30																				H
26.5	27	34	61	20	0.34																						C
26.5	28										188.1																
27.9	30					17.4									99.4	41.8	1.0										
28.0	31	45	76	27	0.37				119.7		136.1																
29.3	32	49	59	24	0.72			79.0	81.4						93.9		1.5										
31.0	34	56	70	22	0.70																						C
31.1	35										162.1																

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-75
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-75.3b

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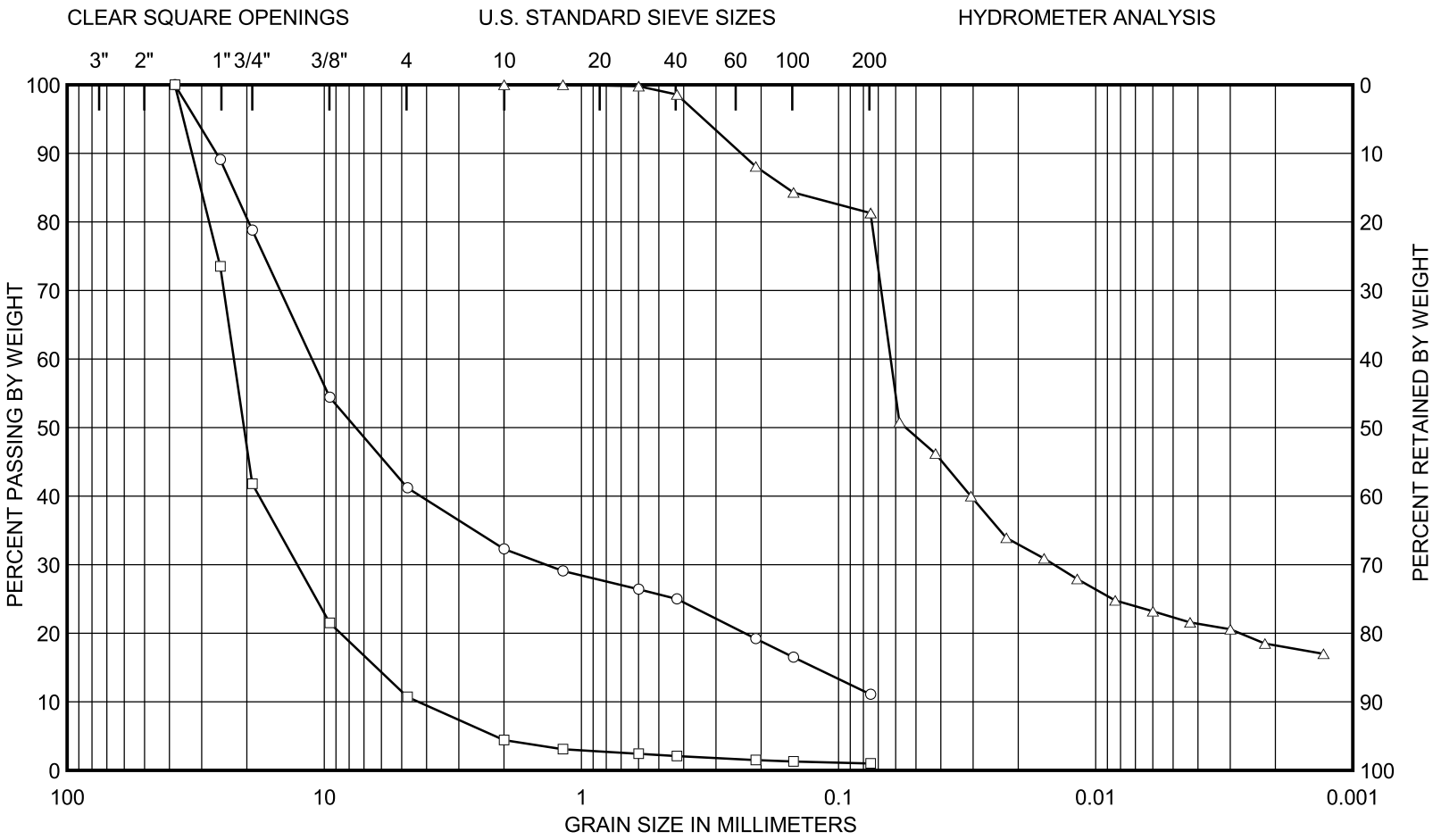


GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
4	3.3	○—○	FINE GRAVEL (GW-GM) with silt, fine to coarse sand and coarse gravel			7.6
6	6.5	□—□	COARSE TO FINE GRAVEL (GW) with a trace of coarse sand	1.7	5.2	20.5
11	12.4	△—△	LEAN CLAY (CL) with fine sand			0.055

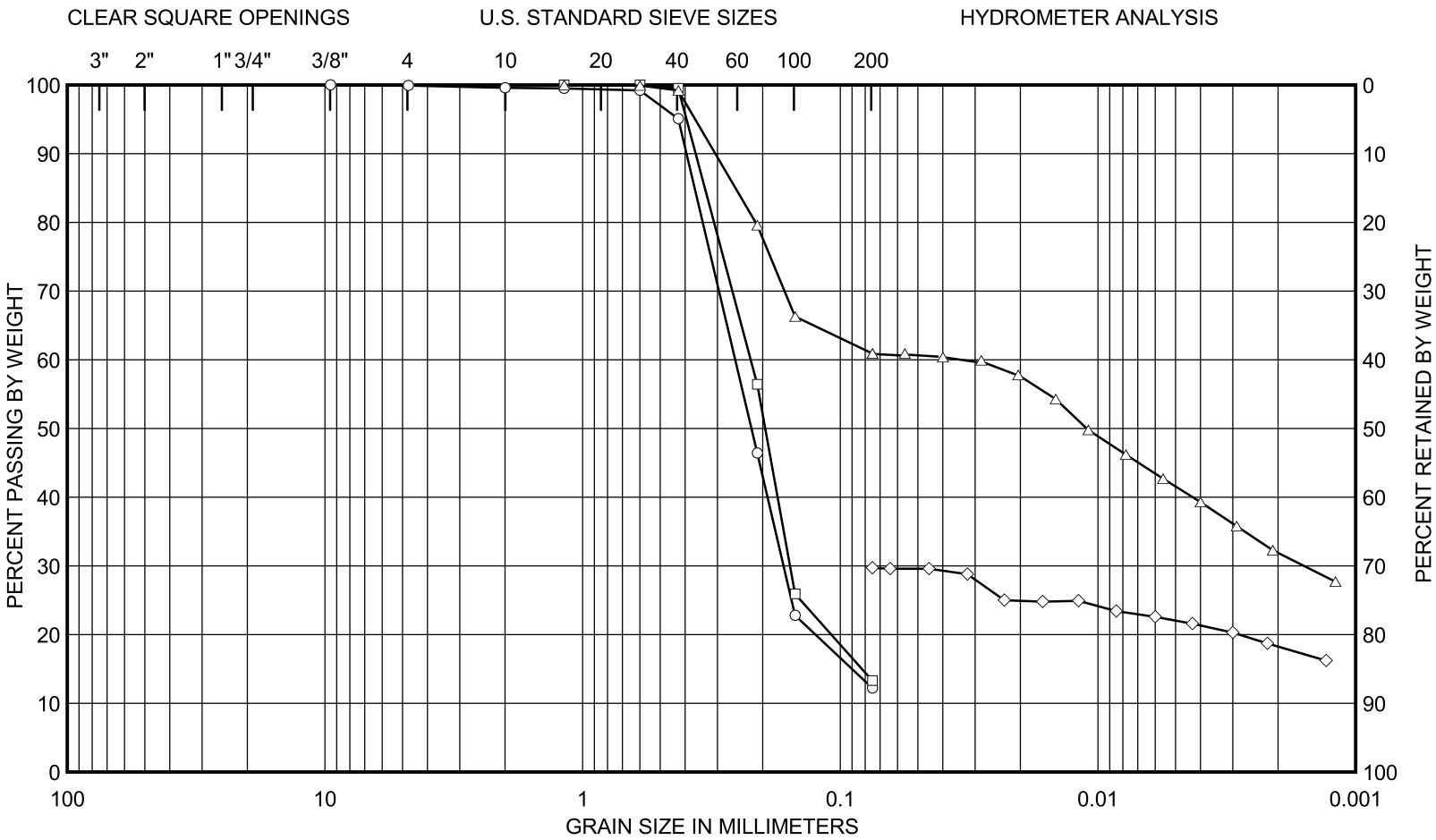
GRAIN SIZE DISTRIBUTION CURVES
Boring 98-75
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-75.4a



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
14	15.7	○—○	SILTY FINE SAND (SM)			0.22
15	17.2	□—□	SILTY FINE SAND (SM)			0.20
17	18.7	△—△	SANDY LEAN CLAY (CL)			0.011
26	24.8	◇—◇	CLAYEY FINE SAND (SC)			

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-75
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

PLATE 98-75.4b

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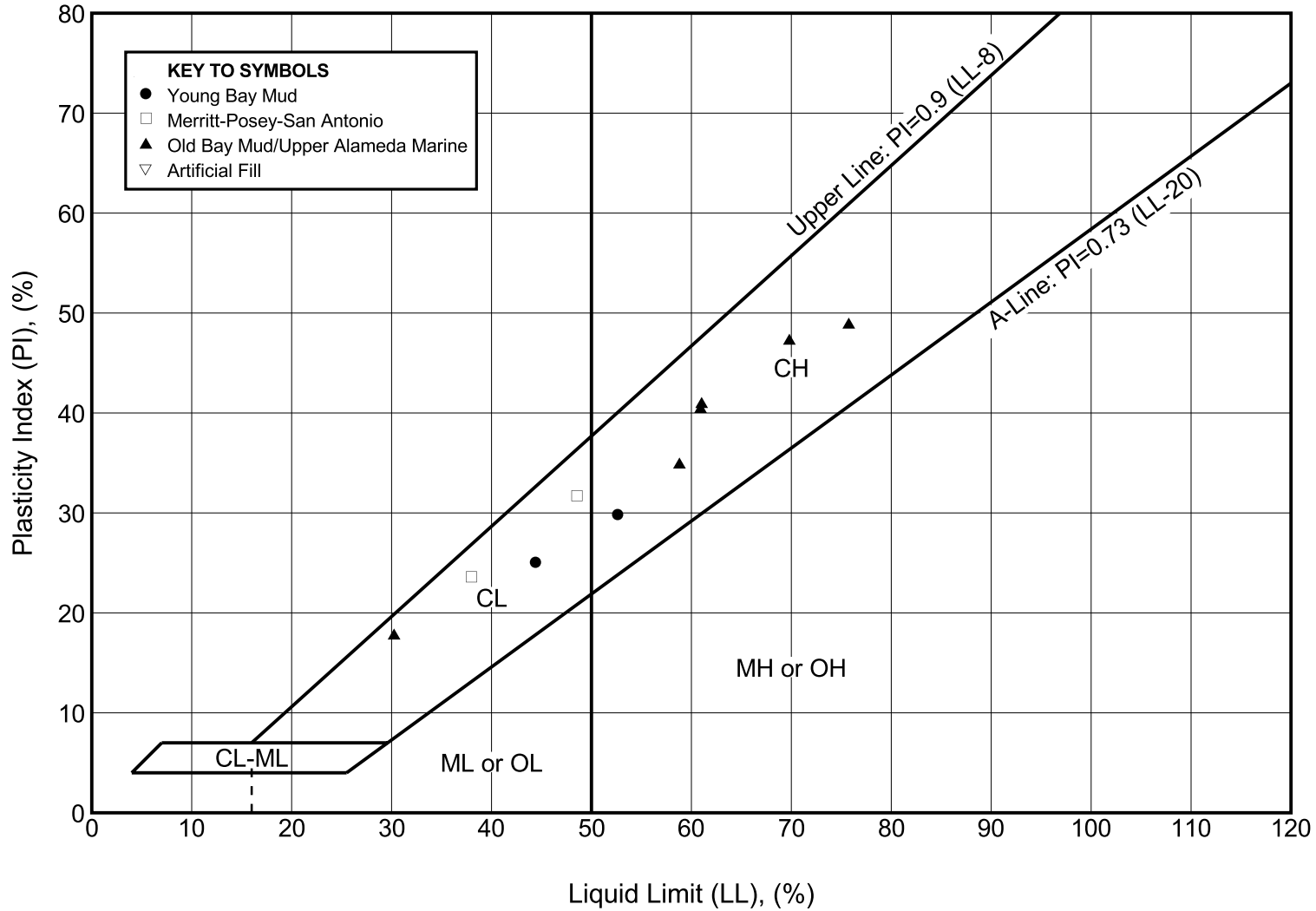

PLASTICITY CHART
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.5

Earth Mechanics

FUGRO

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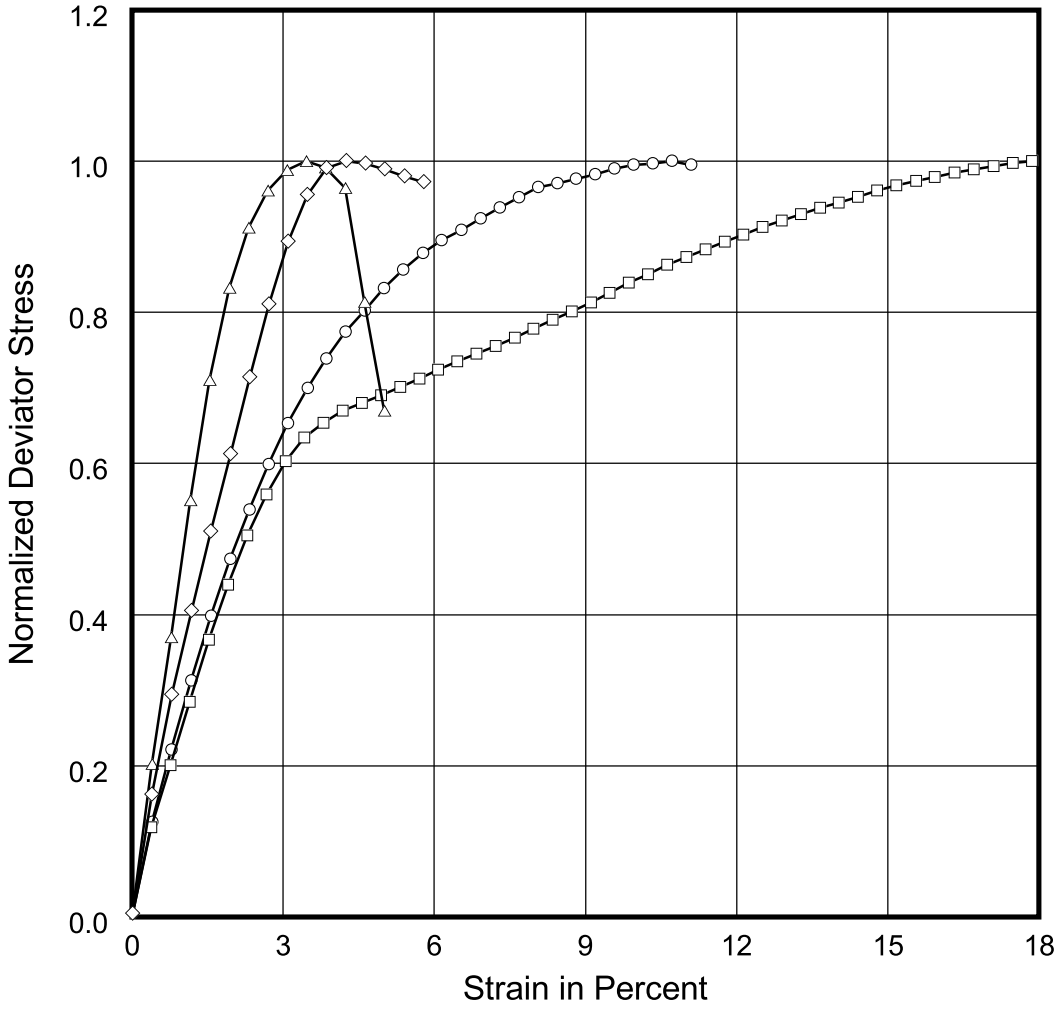


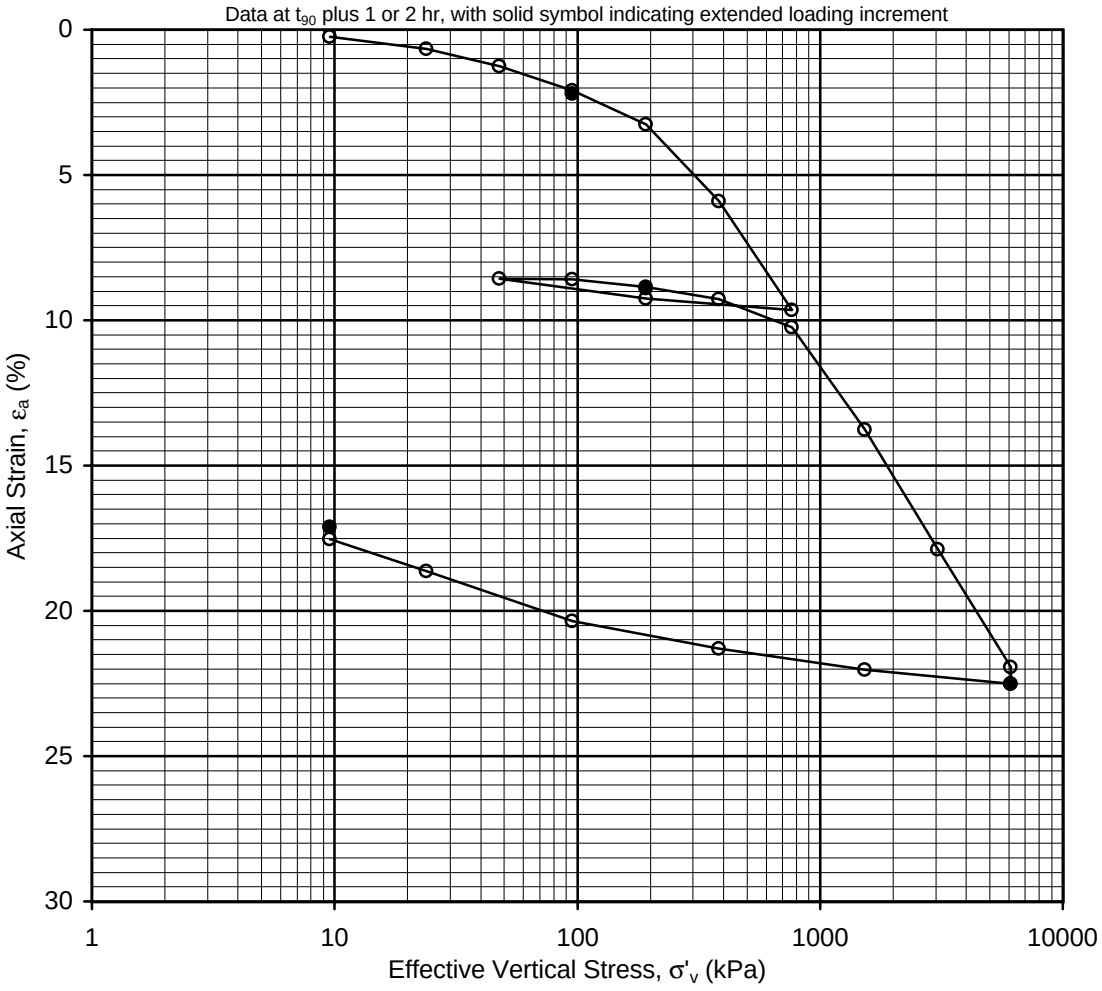
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	9	11.1	UU	207	84	2.0
□—□	11	12.4	UU	586	438	2.2
△—△	30	27.9	UU	827	199	1.0
◇—◇	32	29.3	UU	1000	188	1.5

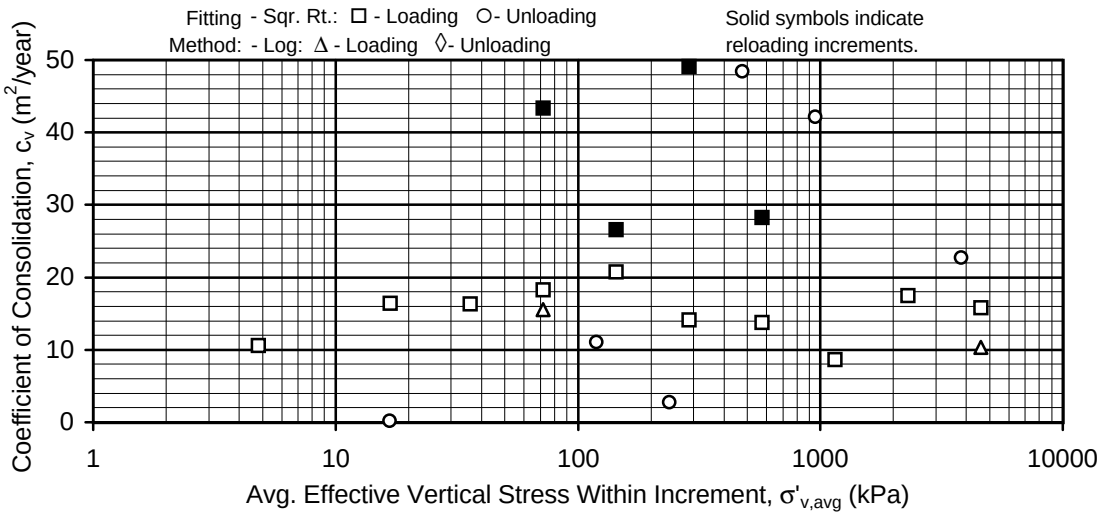
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-75
SFOBB East Span Seismic Safety Project

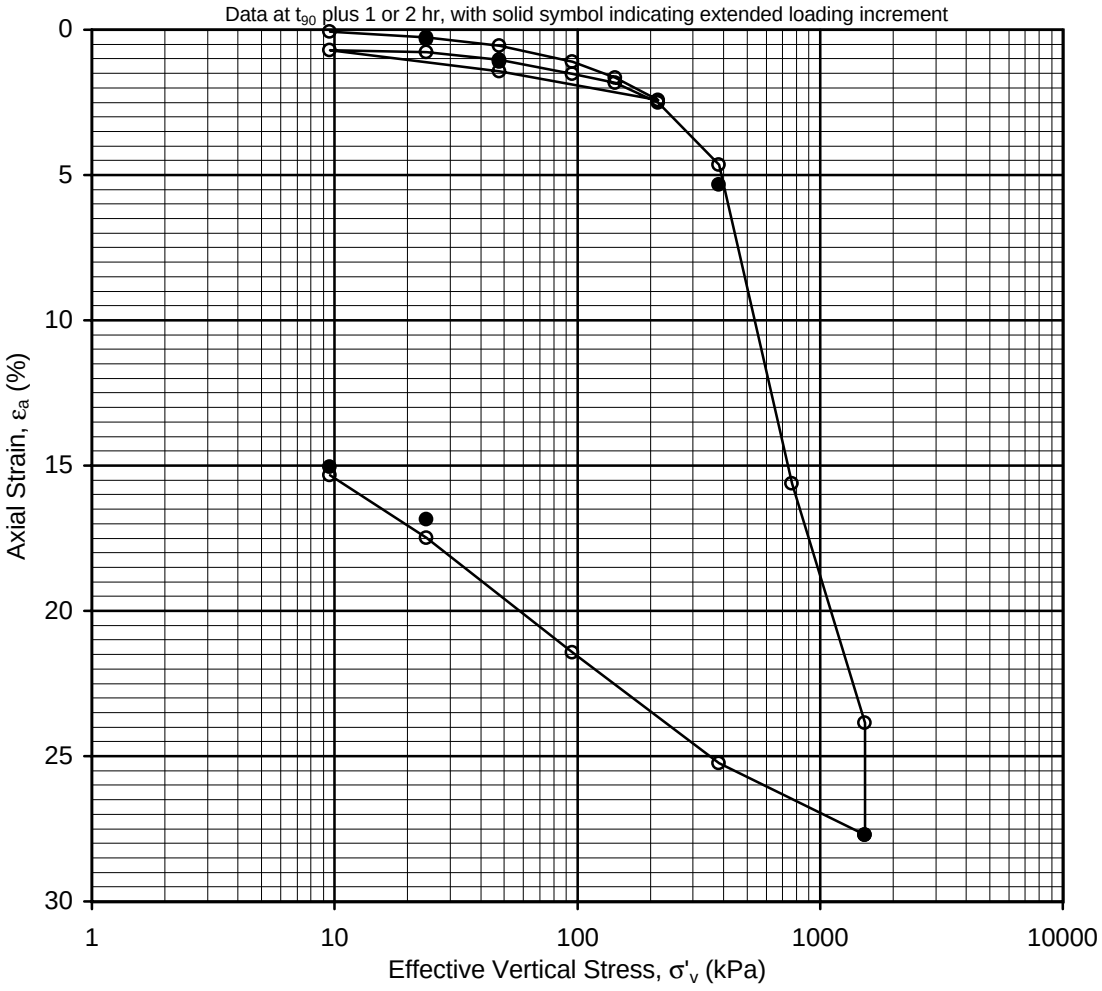
PLATE 98-75.6

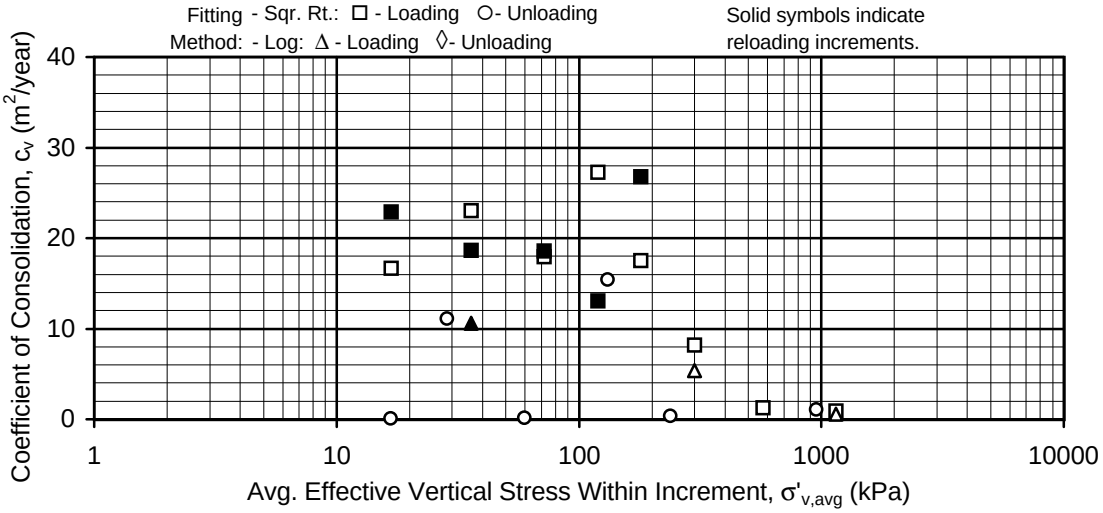




INCREMENTAL CONSOLIDATION TEST RESULTS

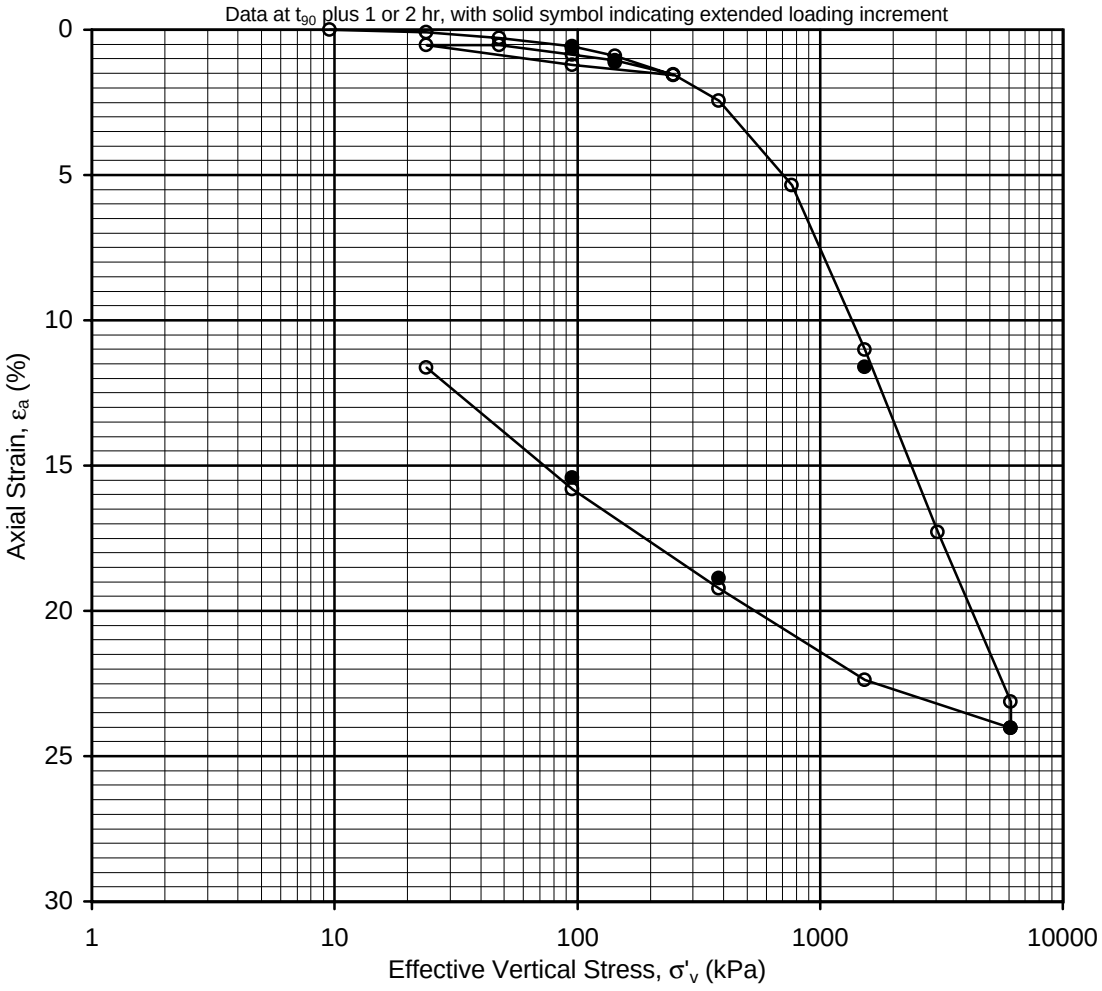
Sample No. 8 - Depth: 11.0m
Boring 98-75
SFOBB East Span Seismic Safety Project

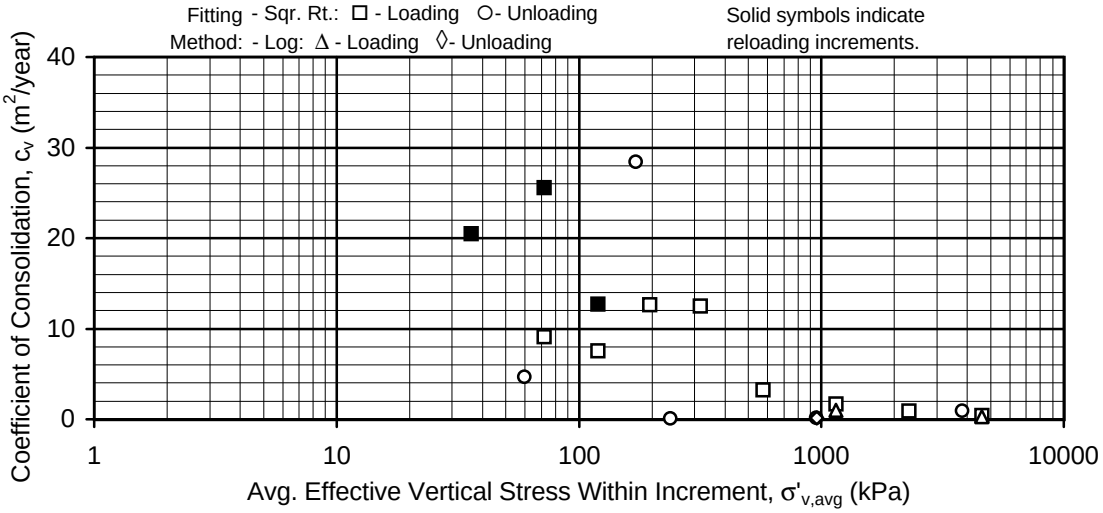




INCREMENTAL CONSOLIDATION TEST RESULTS

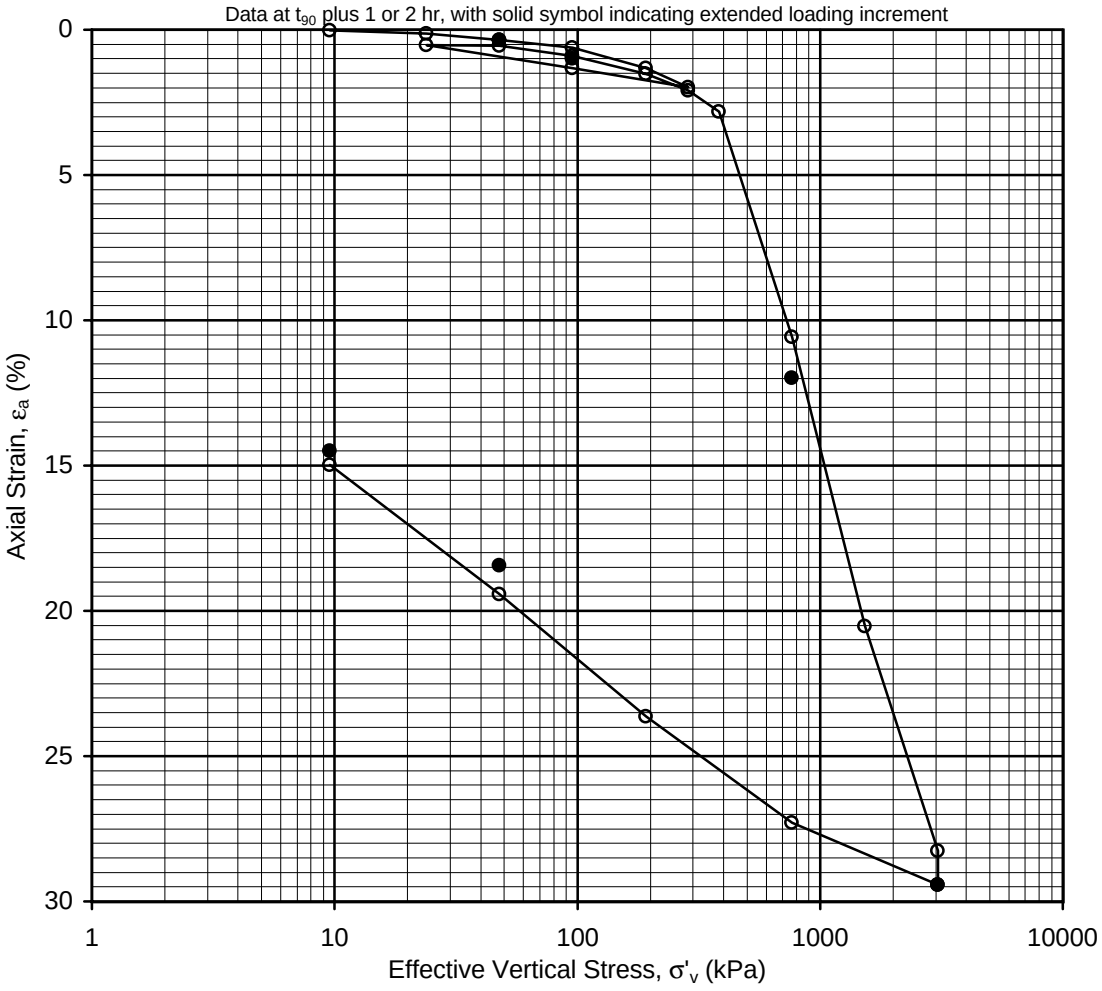
Sample No. 20 - Depth: 21.8m
Boring 98-75
SFOBB East Span Seismic Safety Project

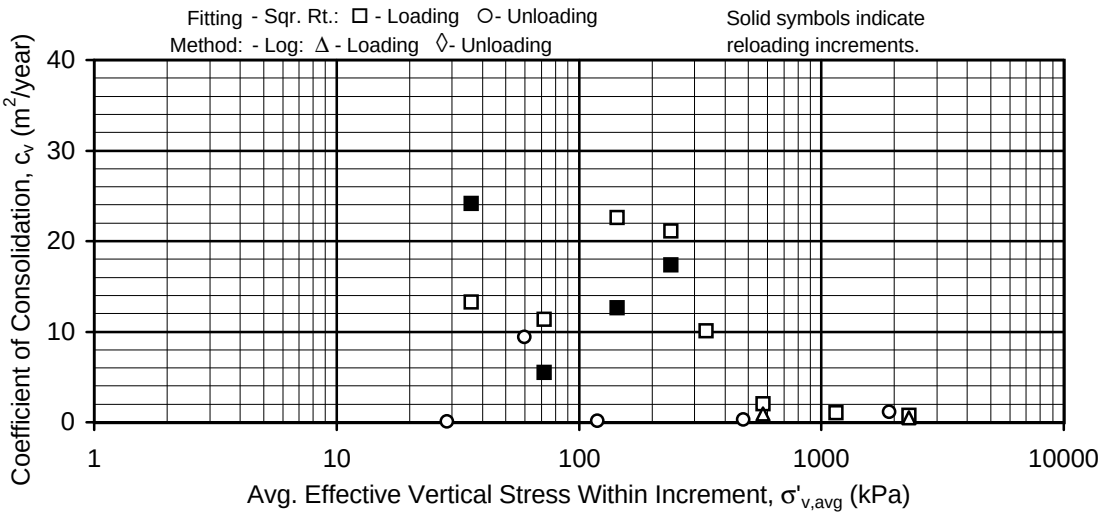




INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 27 - Depth: 26.4m
Boring 98-75
SFOBB East Span Seismic Safety Project





INCREMENTAL CONSOLIDATION TEST RESULTS

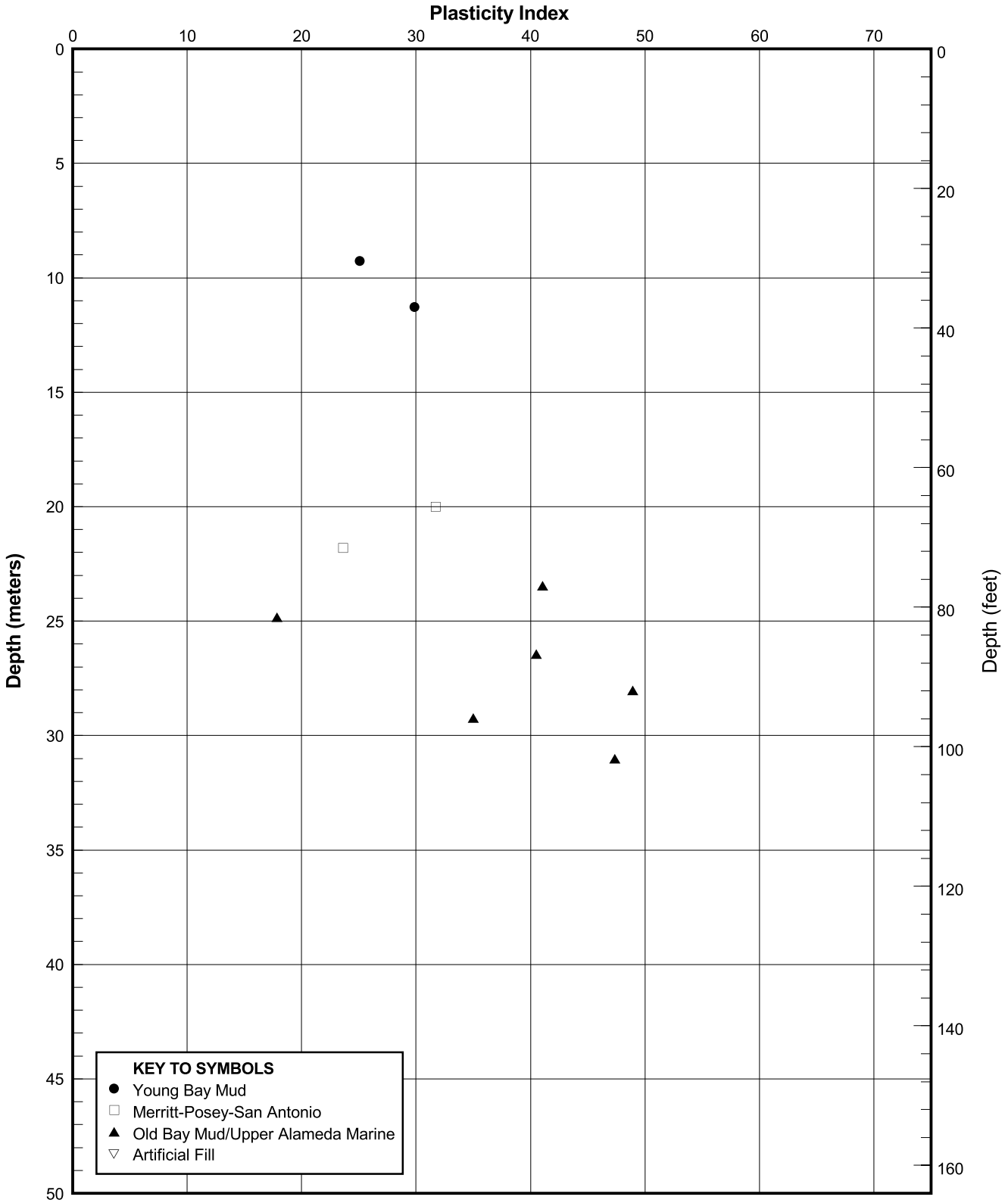
Sample No. 34 - Depth: 30.9m
Boring 98-75
SFOBB East Span Seismic Safety Project

No Consolidated-Undrained Triaxial Compression Testing Performed For This Boring

No Consolidated-Drained Triaxial Compression Testing Performed For This Boring

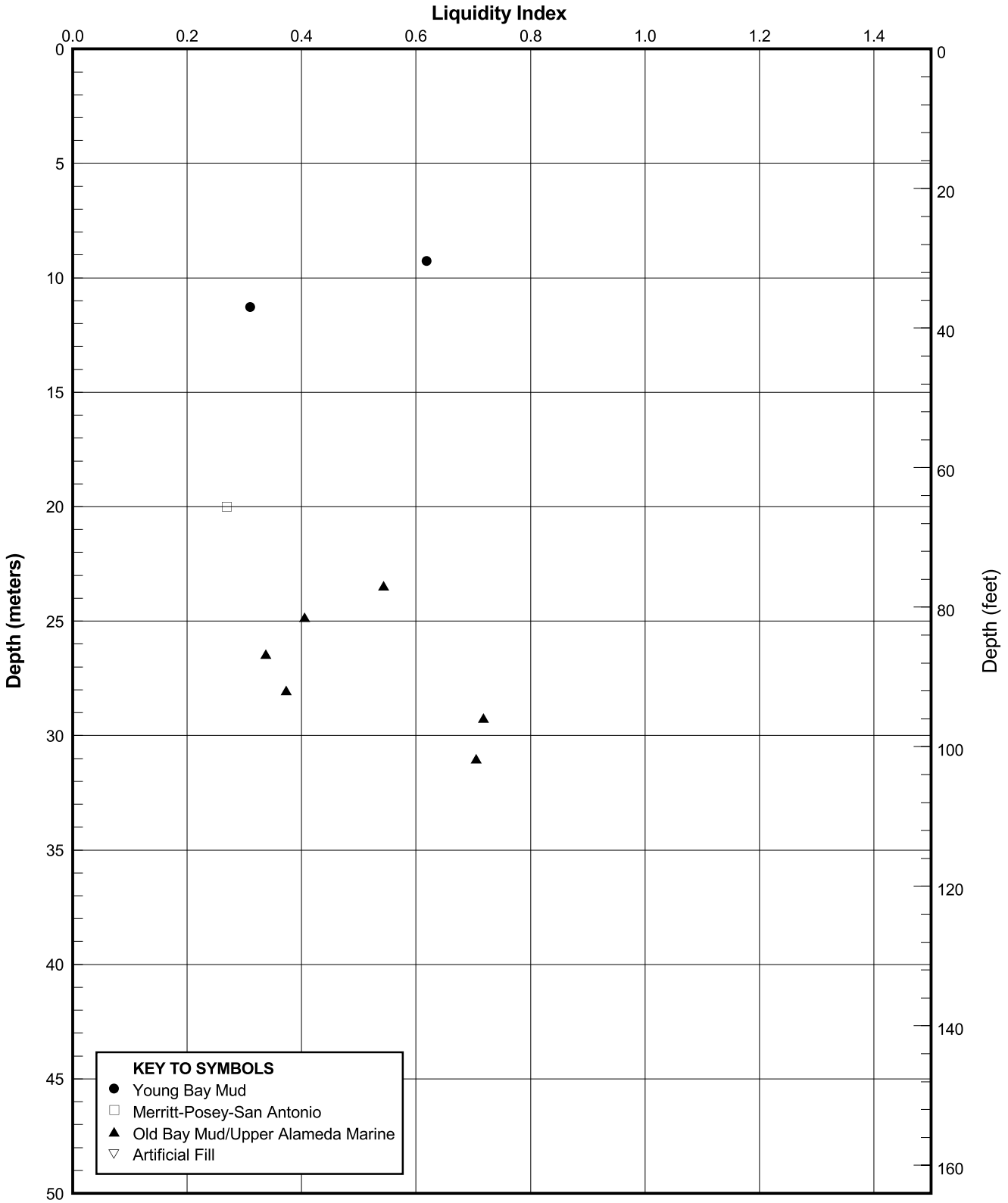
No R-Value Laboratory Testing Performed For This Boring

No Corrosion Testing Performed For This Boring



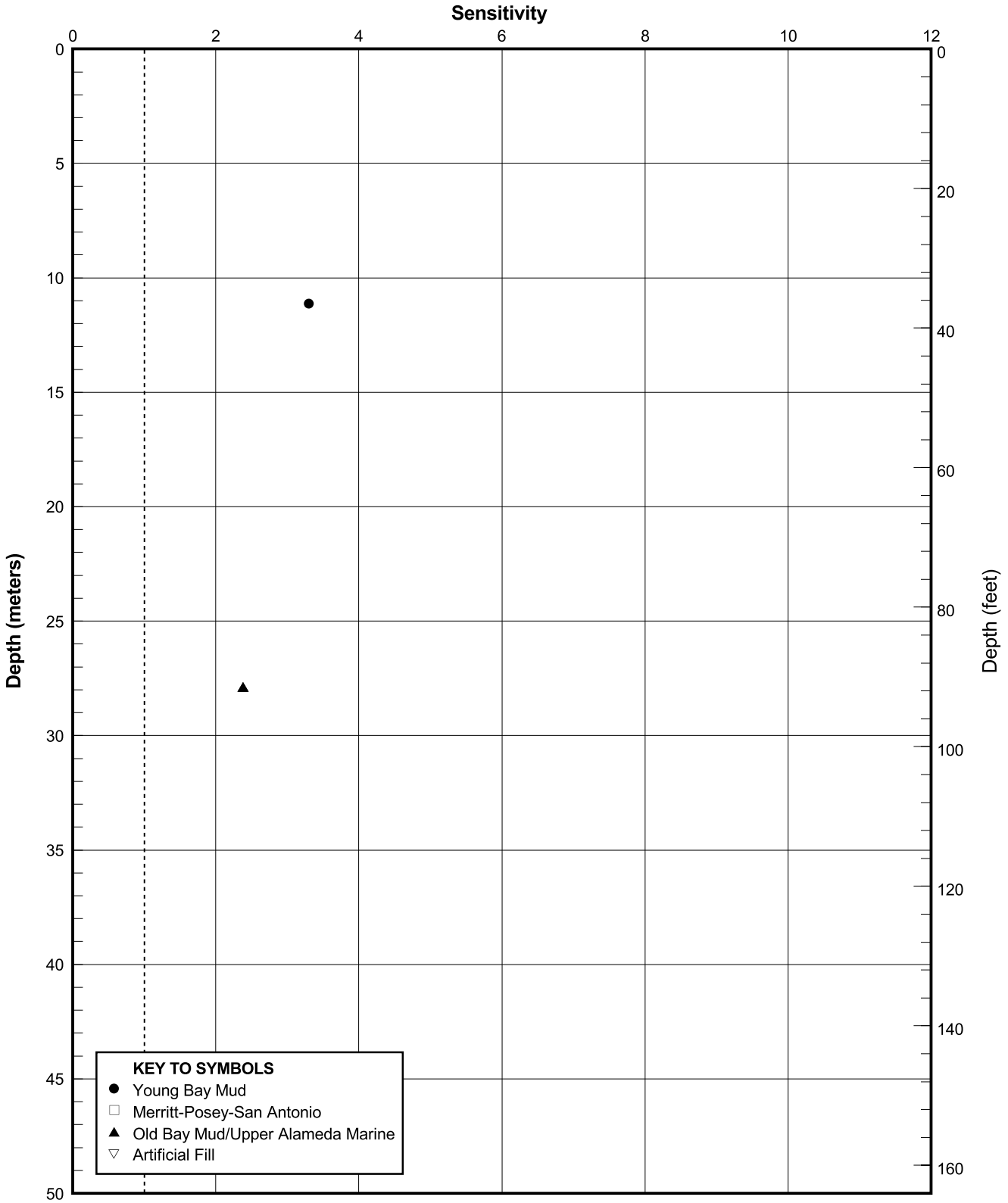
PLASTICITY INDEX PROFILE
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.12



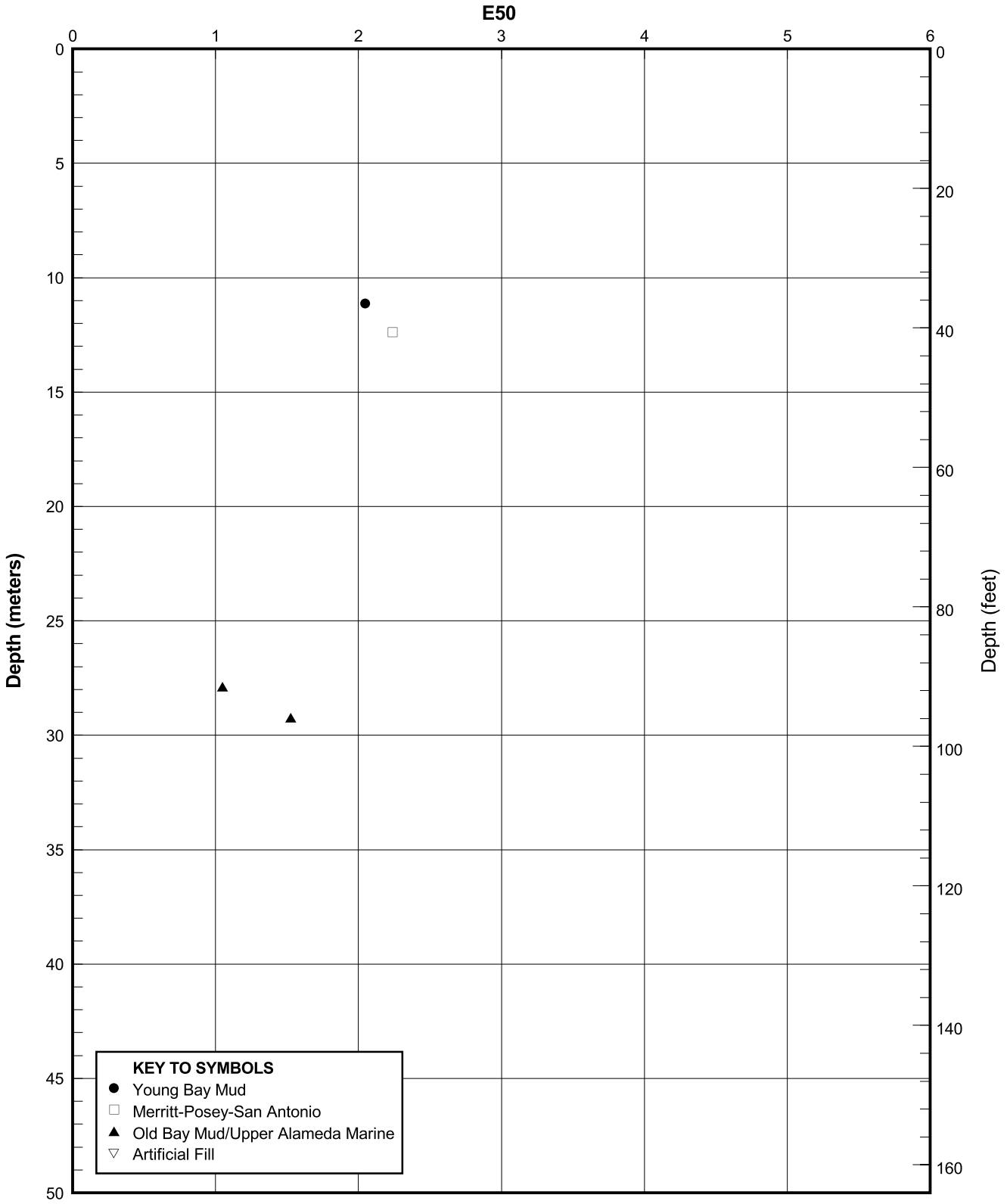
LIQUIDITY INDEX PROFILE
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.13



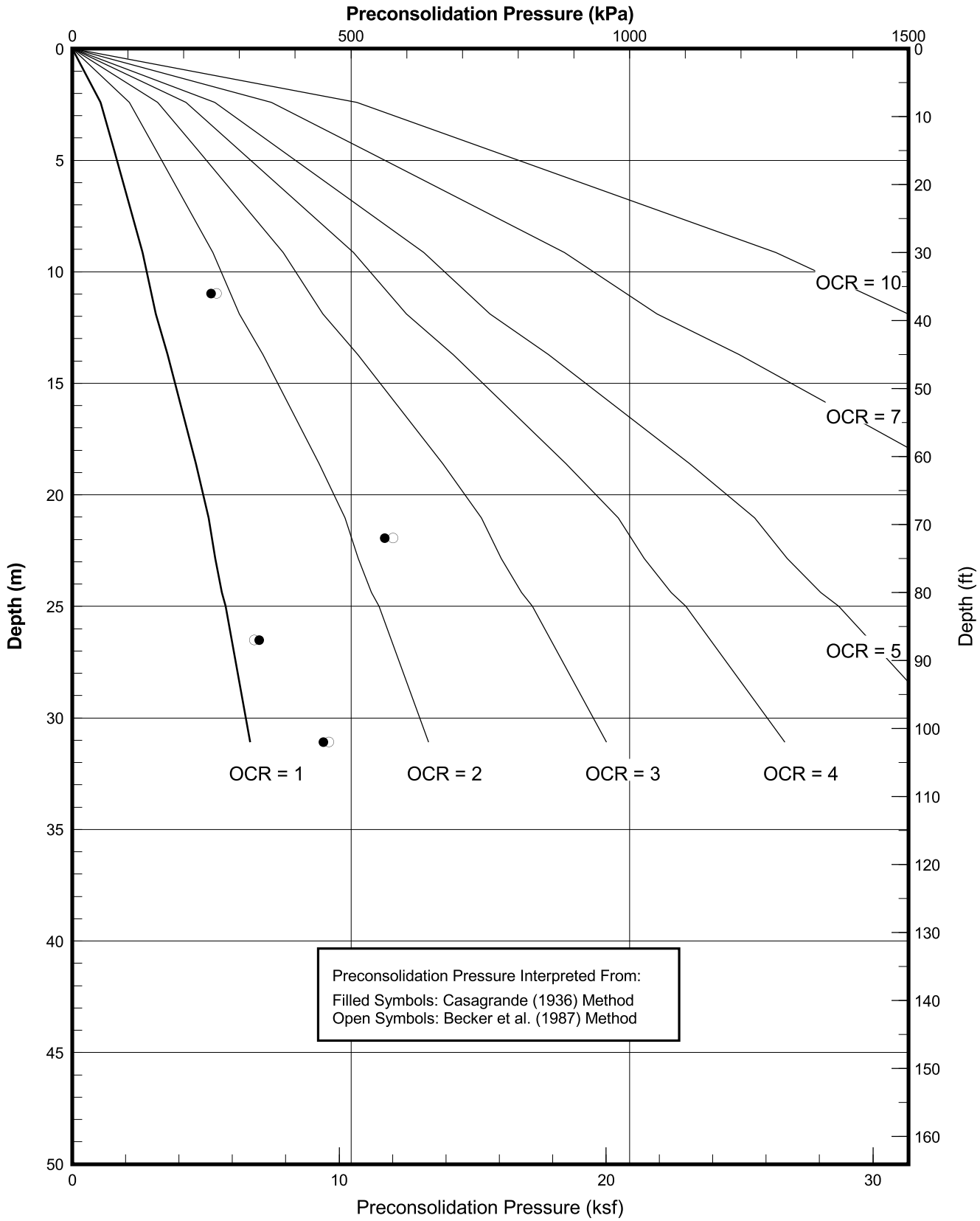
SENSITIVITY PROFILE
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.14



E50 PROFILE
Boring 98-75
SFOBB East Span Seismic Safety Project

PLATE 98-75.15



PRECONSOLIDATION PRESSURE INTERPRETED FROM LABORATORY DATA

Boring 98-75

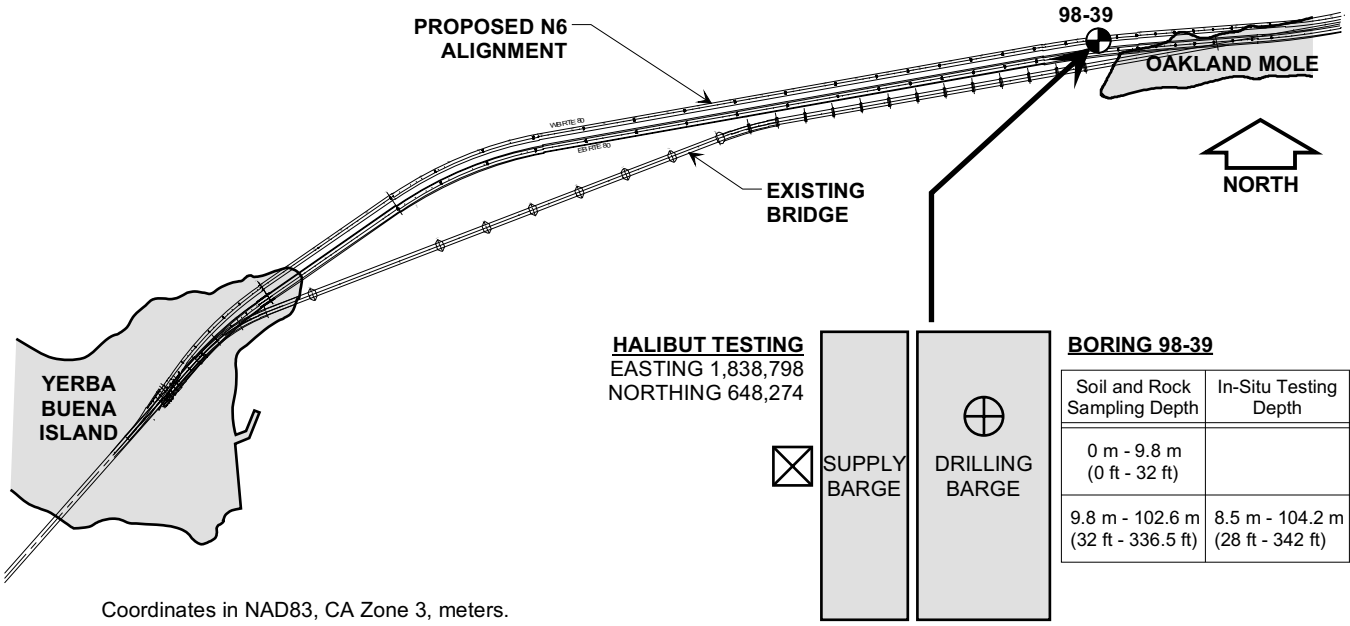
SFOBB East Span Seismic Safety Project

PLATE 98-75.16

MARINE BORING 98-39

Date	Time From	Time To	Description of Activity
September 30, 1998	2100	2200	Move barge to location 98-39. Set 4 anchors and 2 spuds.
	2200	2330	Rig up for drilling. Lower drill pipe to mudline.
	2330	2345	Measure water depth of 2.1m (6.8 ft) using bottom sensor. Current tide level is approximately -0.1m (-0.2 ft) MSL. Calculate mudline elevation of –2.0m (-6.6 ft) MSL.
	2345	2400	Drill and sample from mudline to 2.4m (8 ft).
October 1, 1998	0000	0315	Drill and sample from 2.4m (8 ft) to 9.8m (32 ft). Halibut testing from 0.6m (2 ft) to 1.8m (6 ft)
	0315	0330	Pull drill pipe to deck.
	0330	0600	Rig maintenance. Wait on tide to facilitate barge relocation.
	0600	0615	Reposition barge.
	0615	1100	Set casing. Drive stinger to 8.8m (29 ft).
	1100	1215	Lower drill pipe to mudline. Drill, sample, and CPT testing from mudline to 8.5m (28 ft).
	1215	1330	Change latch sub on CPT unit. Perform CPT pipe test.
	1330	2400	Drill, sample, and CPT testing from 8.5m (28 ft) to 35.7m (117 ft).
October 2, 1998	0000	1200	Drill, sample, and CPT testing from 35.7m (117 ft) to 92.4m (303 ft).
	1200	1330	Unable to retrieve Shelby tube. Pull drill pipe to deck.
	1330	1615	Repair damaged overshot. Run CPT pipe test.
	1615	2030	Drill, sample, and CPT testing from 92.4m (303 ft) to 104.2m (342 ft).
	2030	2115	Pull drill pipe to deck.
	2115	2400	Perform P- and S-wave velocity logging from 91.0m (298.6 ft) to 9.1m (30 ft).
October 3, 1998	0000	0200	Complete P- and S-wave logging.
	0200	0300	Pull casing to 1.5m (5 ft).
	0300	0415	P- and S-wave velocity logging from 9.1m (30 ft) to 2.0m (6.6 ft).
	0415	0730	Lower N-rod. Mix and circulate cement. Grout hole 98-39. Pull N-rod to deck.
	0730	1200	Pull 2 spuds, 4 anchors, and move barge to location 98-27.

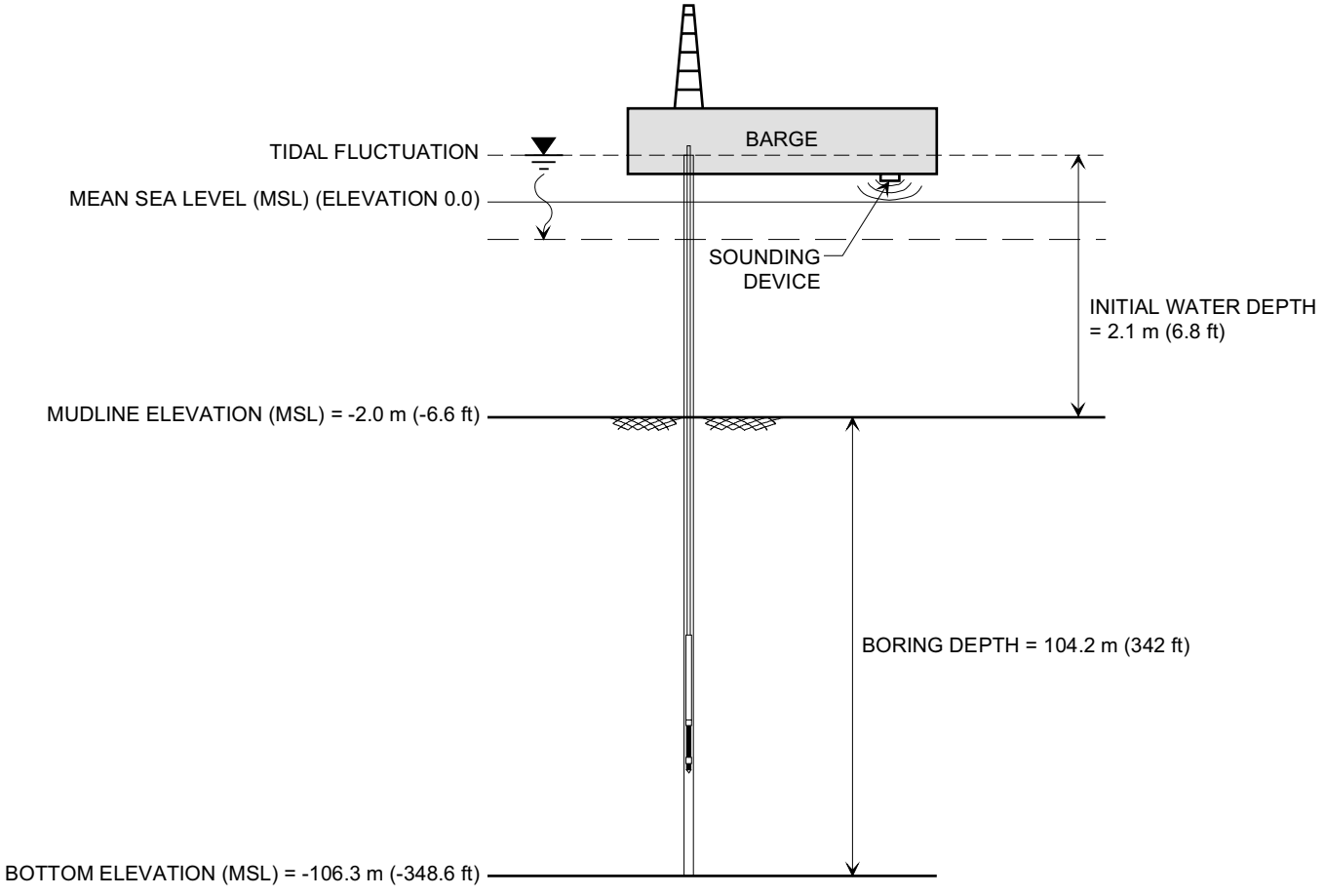
SUMMARY OF FIELD OPERATIONS
Boring 98-39
SFOBB East Span Seismic Safety Project



BORING 98-39

Soil and Rock Sampling Depth	In-Situ Testing Depth	Coordinates
0 m - 9.8 m (0 ft - 32 ft)		E = 1,838,813 N = 648,273
9.8 m - 102.6 m (32 ft - 336.5 ft)	8.5 m - 104.2 m (28 ft - 342 ft)	E = 1,838,812 N = 648,275

Coordinates in NAD83, CA Zone 3, meters.



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DEPTH AND LOCATION REFERENCE MAP
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.2

PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
		WOH	Fat CLAY (CH), very soft, dark gray	I
-4		WOH		
		WOH		
		WOH		
	4	PUSH	(3.7m)	
		PUSH	Fat CLAY (CH), soft to firm, olive gray	II
-8		PUSH		
		PUSH		
	8	PUSH	- with shell fragments at 7.6m	
		PUSH	(8.8m)	
		30/20cm	Silty Fine SAND (SM), very dense, greenish gray	III
-12		77	-silty fine with medium sand at 9.3m	
	12	30/20cm	-yellowish brown sand with silt, 10.7m to 11.3m	
		30/25cm	(13.3m)	
-16			Fat CLAY (CH), very stiff, greenish gray	IV
	16	PUSH	-with sand layers, at 13.4m and 13.6m	
-20			(17.7m)	
			Fat CLAY (CH), very stiff to hard, greenish gray	V
	20	PUSH SAVE	-sand with clay seams and layers, 17.7m to 18.9m	
-24			(21.9m)	
	24	PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	VI
-28			-micaceous	
			-blocky, dessicated, and with organic matter pockets, at 23.8m	
			See Plate 98-39.6 for detailed stratigraphy	
	28	PUSH	-dark gray with sand pockets and seams, below 28.3m	
-32			(31.1m)	
	32	PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	VII
-36			-silt with clay seams, 32.6m to 33.2m	
			-silt layer, 34.3m to 34.6m	
	36	PUSH SAVE	(36.3m)	
			Fat CLAY (CH), very stiff to hard, olive gray	VIII
-40		PUSH	-greenish gray lean clay to 38.4m	
	40		(41.1m)	
-44				IX
	44	PUSH	Fat CLAY (CH), very stiff to hard, olive gray	
-48			-with organic matter pockets at 44.2m	
			-sand layer, 46.3m to 46.5m	
	48		-with a silt layer at 47.5m	
		PUSH	-with organic matter pockets at 49.1m	
-52			-silt layer, 50.1m to 50.4m (50.9m)	
	52		Fat CLAY (CH), very stiff to hard, gray	X
-56		PUSH SAVE	-with a few silt pockets and partings, at 53.9m	
	56			
-60				
	60	PUSH	-with organic matter pockets at 59.4m	
-64				
	64	PUSH SAVE	-with organic matter pockets below 64.9m	
-68				
	68			
-72		PUSH	-with a few silt pockets at 69.8m (70.7m)	
	72		Fat CLAY (CH), hard, greenish gray	XI
-76		PUSH SAVE	-friable at 74.7m	
	76		(77.7m)	
-80			Silty fine SAND (SM), dense to very dense, greenish gray	XII
	80	PUSH	-clay layer, 77.9m to 78.0m (80.6m)	
-84			Lean CLAY (CL), hard, olive gray	XIII
	84	PUSH	-with silt seams and layers	
			-with a few fat clay partings at 84.4m	
-88				
	88	30/10cm	-with a sand layer at 87.2m	
			(89.0m)	
-92			Fine to medium SAND with silt (SP-SM), dense to very dense, gray	XIV
	92	30/15cm	-with clay pockets and coarse sand, at 91.7m	
-96		30/20cm	-desiccated, greenish gray lean clay, with gravel and sand	
		PUSH	pockets, 94.6m to 95.7m (96.0m)	
	96		Fat CLAY with sand (CH), hard, yellowish brown	XV
-100		PUSH SAVE	-mottled with gray, and with ferrous stains and organic matter pockets	
	100		(102.1m)	
-104		PUSH	Silty Fine SAND (SM), dense to very dense, yellowish red	XVI
	104		-mottled with gray	
			-clay layer, 103.2m to 103.9m	
-108			-silt layer, 104.1m to 104.2m	
	108		TOTAL DEPTH: 104.2m BACKFILLED WITH: Cement Grout	
-112				
	112			
-116				
	116			
-120				

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

101 → 13.1 →

CPT INTERVAL

PLATE 98-39.3

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 05/03/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
		WOH	Fat CLAY (CH), very soft, dark gray	I
-4		WOH		
		WOH		
	4	PUSH		
		WOH		
		PUSH	Fat CLAY (CH), soft to firm, olive gray	II
-8		PUSH	See Plate 98-39.6 for detailed stratigraphy	
		PUSH		
	8	PUSH		
		30/20cm	Silty Fine SAND (SM), very dense, greenish gray	III
-12		77	-yellowish brown sand with silt, 10.7m to 11.3m	
		30/20cm		
	12	30/25cm		
-16			Fat CLAY (CH), very stiff, greenish gray	IV
	16	PUSH		
-20			Fat CLAY (CH), very stiff to hard, greenish gray	V
	20	PUSH SAVE		
-24			Fat CLAY (CH), very stiff to hard, greenish gray	VI
	24	PUSH	-micaceous	
-28			-blocky, dessicated, and with organic matter pockets, at 23.8m	
	28	PUSH	-dark gray with sand pockets and seams, below 28.3m	
-32				
	32	PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	VII
-36			-silt with clay seams, 32.6m to 33.2m	
	36	PUSH SAVE	-silt layer, 34.3m to 34.6m	
-40			Fat CLAY (CH), very stiff to hard, olive gray	VIII
	40	PUSH	-greenish gray lean clay to 38.4m	
-44			Fat CLAY (CH), very stiff to hard, olive gray	IX
	44	PUSH	-with organic matter pockets at 44.2m	
-48			-sand layer, 46.3m to 46.5m	
	48	PUSH	-with a silt layer at 47.5m	
-52			-with organic matter pockets at 49.1m	
			-silt layer, 50.1m to 50.4m	
	52		Fat CLAY (CH), very stiff to hard, gray	X
-56		PUSH SAVE	-with a few silt pockets and partings, at 53.9m	
	56			
-60				
	60	PUSH	-with organic matter pockets at 59.4m	
-64				
	64	PUSH SAVE	-with organic matter pockets below 64.9m	
-68				
	68			
-72		PUSH	-with a few silt pockets at 69.8m	
	72		Fat CLAY (CH), hard, greenish gray	XI
-76		PUSH SAVE	-friable at 74.7m	
	76			
-80			Silty fine SAND (SM), dense to very dense, greenish gray	XII
	80	PUSH	-clay layer, 77.9m to 78.0m	
-84			Lean CLAY (CL), hard, olive gray	XIII
	84	PUSH	-with silt seams and layers	
-88			-with a few fat clay partings at 84.4m	
	88	30/10cm	-with a sand layer at 87.2m	
-92			Fine to medium SAND with silt (SP-SM), dense to very dense, gray	XIV
	92	30/15cm		
-96		30/20cm	-desiccated, greenish gray lean clay, with gravel and sand pockets, 94.6m to 95.7m	
	96	PUSH		
-100		PUSH SAVE	Fat CLAY with sand (CH), hard, yellowish brown	XV
	100		-mottled with gray, and with ferrous stains and organic matter pockets	
-104		PUSH	Silty Fine SAND (SM), dense to very dense, yellowish red	XVI
	104		-clay layer, 103.2m to 103.9m	
-108			-silt layer, 104.1m to 104.2m	
	108		TOTAL DEPTH: 104.2m	
-112			BACKFILLED WITH: Cement Grout	
	112			
-116				
	116			
-120				

SLEEVE FRICTION: TSF 1 2 3 4 5 6 7 8 9 10; MPa 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

TIP RESISTANCE: TSF 50 100 150 200 250 300 350 400 450 500; MPa 5 10 15 20 25 30 35 40 45

FRICTION RATIO (%): 1 2 3 4 5 6 7 8 9

EXCESS PORE PRESSURE: TSF 0 10 20 30 40; MPa 0 1 2 3

64 1.0 1.1 12.6 1.2

CPT INTERVAL

PLATE 98-39.4

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 05/07/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-4	4			WOH WOH WOH WOH PUSH PUSH	Fat CLAY (CH), very soft, dark gray (3.7m)	I
-8	8			PUSH PUSH PUSH PUSH PUSH	Fat CLAY (CH), soft to firm, olive gray See Plate 98-39.6 for detailed stratigraphy (8.8m)	II
-12	12			30/20cm 77 30/20cm 30/25cm	Silty Fine SAND (SM), very dense, greenish gray -yellowish brown sand with silt, 10.7m to 11.3m (13.3m)	III
-16	16			PUSH	Fat CLAY (CH), very stiff, greenish gray (17.7m)	IV
-20	20			PUSH SAVE	Fat CLAY (CH), very stiff to hard, greenish gray (21.9m)	V
-24	24			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray (31.1m)	VI
-28	28			PUSH		
-32	32			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -silt with clay seams, 32.6m to 33.2m -silt layer, 34.3m to 34.6m (36.3m)	VII
-36	36			PUSH SAVE	Fat CLAY (CH), very stiff to hard, olive gray (41.1m)	VIII
-40	40			PUSH		
-44	44			PUSH	Fat CLAY (CH), very stiff to hard, olive gray -with organic matter pockets at 44.2m -sand layer, 46.3m to 46.5m -with a silt layer at 47.5m -with organic matter pockets at 49.1m -silt layer, 50.1m to 50.4m (50.9m)	IX
-48	48					
-52	52			PUSH	Fat CLAY (CH), very stiff to hard, gray -with a few silt pockets and partings, at 53.9m	X
-56	56			PUSH SAVE		
-60	60			PUSH	-with organic matter pockets at 59.4m	
-64	64			PUSH SAVE	-with organic matter pockets below 64.9m	
-68	68					
-72	72			PUSH	-with a few silt pockets at 69.8m (70.7m)	
-76	76			PUSH SAVE	Fat CLAY (CH), hard, greenish gray -friable at 74.7m (77.7m)	XI
-80	80			PUSH	Silty fine SAND (SM), dense to very dense, greenish gray -with clay seams -clay layer, 77.9m to 78.0m (80.6m)	XII
-84	84			PUSH	Lean CLAY (CL), hard, olive gray -with silt seams and layers -with a few fat clay partings at 84.4m	XIII
-88	88			30/10cm	-with a sand layer at 87.2m (89.0m)	
-92	92			30/15cm	Fine to medium SAND with silt (SP-SM), dense to very dense, gray -with clay pockets and coarse sand, at 91.7m -fine to coarse gravel, with silt and sand, at 94.2m	XIV
-96	96			30/20cm PUSH	-desiccated, greenish gray lean clay, with gravel and sand pockets, 94.6m to 95.7m (96.0m)	
-100	100			PUSH SAVE	Fat CLAY with sand (CH), hard, yellowish brown -mottled with gray, and with ferrous stains and organic matter pockets (102.1m)	XV
-104	104			PUSH	Silty Fine SAND (SM), dense to very dense, yellowish red -mottled with gray -clay layer, 103.2m to 103.9m -silt layer, 104.1m to 104.2m	XVI
-108	108				TOTAL DEPTH: 104.2m BACKFILLED WITH: Cement Grout	
-112	112					
-116	116					
-120						

SHEAR WAVE VELOCITY: ft/s 2,500 5,000; m/s 0,500 1,000 1,500 2,000

COMPRESSION WAVE VELOCITY: ft/s 2,500 5,000; m/s 500 1,000 1,500 2,000

RESISTIVITY: ohm-ft 50 100 150 200 250; ohm-m 20 40 60

NATURAL GAMMA (API UNITS): 40 80 120

CALIPER: in 2 4 6 8 10 12 14; cm 5 10 15 20 25 30 35

PLATE 98-39.5

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 05/05/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
		WOH	Fat CLAY (CH), very soft, dark gray	I
			-with shells and shell fragments	
			-with sand pockets and organic matter pockets, at 0.2m	
-3	1	WOH	-with sand seams at 1.2m	
-4	2	WOH		
-5	3	WOH		
			(3.7m)	
-6	4	PUSH	Fat CLAY (CH), soft to firm, olive gray	II
			-with shell and shell fragments at 3.7m	
-7	5	PUSH	-with many sand pockets at 4.9m	
-8	6	PUSH	-with many silt pockets at 5.8m	
-9	7	PUSH		
-10	8	PUSH	- with shell fragments at 7.6m	
		PUSH	-with a few sand pockets at 8.5m	
			(8.8m)	
-11	9	30/20cm	Silty Fine SAND (SM), very dense, greenish gray	III
			-with many shell fragments, 8.8m to 9.1m	
-12	10		-silty fine with medium sand at 9.3m	
		77		
-13	11	30/20cm	-yellowish brown sand with silt, 10.7m to 11.3m	
-14	12			
		30/25cm		
-15	13		-with clay seams at 12.8m	
			(13.3m)	
-16	14		Fat CLAY (CH), very stiff, greenish gray	IV
			-with sand layers, at 13.4m and 13.6m	
-17	15		-with a silt layer at 14.6m	
-18	16	PUSH	-blocky, slightly micaceous, mottled with gray, with gas blisters, organic matter pockets and veins, and voids, below 16.2m	
-19	17			
			(17.7m)	
-20	18		Fat CLAY (CH), very stiff to hard, greenish gray	V
			-with sand pockets	
-21	19		-sand with clay seams and layers, 17.7m to 18.9m	
-22	20	PUSH	-micaceous and with gas blisters, voids and organic matter pockets, at 20.1m	
-23	21	SAVE	-dark gray below 20.7m	
			(21.9m)	
-24	22		Fat CLAY (CH), very stiff to hard, greenish gray	VI
			-micaceous	
-25	23			
-26	24	PUSH	-blocky, dessicated, and with organic matter pockets, at 23.8m	
-27	25			
-28	26			
-29	27			
-30	28	PUSH	-dark gray with sand pockets and seams, below 28.3m	
-31	29			
-32	30			
-33	31			
			(31.1m)	
-34	32	PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	VII
			-with silt pockets	
-35	33		-micaceous and with silt seams, at 31.7m	
			-silt with clay seams, 32.6m to 33.2m	
-36	34		-silt layer, 34.3m to 34.6m	
-37	35		-with silt layers, at 34.9m and 35.4m	
-38	36		-with organic matter pockets at 36.6m	
			(36.3m)	
-39	37	PUSH	Fat CLAY (CH), very stiff to hard, olive gray	VIII
		SAVE	-with silt pockets	
-40	38		-greenish gray lean clay to 38.4m	
-41	39	PUSH	-friable and with large gas blisters at 39.0m	

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

CPT INTERVAL

PLATE 98-39.6a

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					MUDLINE ELEVATION: -2.0m (MSL)	
-43	41				Fat CLAY (CH), very stiff to hard, olive gray (41.1m)	VIII
-44	42				Fat CLAY (CH), very stiff to hard, olive gray	IX
-45	43					
-46	44			PUSH	-with organic matter pockets at 44.2m	
-47	45					
-48	46				-sand layer, 46.3m to 46.5m	
-49	47				-with a silt layer at 47.5m	
-50	48					
-51	49			PUSH	-with organic matter pockets at 49.1m	
-52	50				-silt layer, 50.1m to 50.4m (50.9m)	
-53	51				Fat CLAY (CH), very stiff to hard, gray	X
-54	52					
-55	53					
-56	54			PUSH SAVE	-with a few silt pockets and partings, at 53.9m	
-57	55					
-58	56					
-59	57					
-60	58					
-61	59			PUSH	-with organic matter pockets at 59.4m	
-62	60					
-63	61					
-64	62					
-65	63					
-66	64			PUSH		
-67	65			SAVE	-with organic matter pockets below 64.9m	
-68	66					
-69	67					
-70	68					
-71	69					
-72	70			PUSH	-with a few silt pockets at 69.8m (70.7m)	
-73	71				Fat CLAY (CH), hard, greenish gray	XI
-74	72					
-75	73					
-76	74			PUSH	-friable at 74.7m	
-77	75			SAVE		
-78	76					
-79	77				(77.7m)	
-80	78				Silty fine SAND (SM), dense to very dense, greenish gray -with clay seams -clay layer, 77.9m to 78.0m	XII
-81	79			PUSH		

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

CPT INTERVAL

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

PLATE 98-39.6b

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					Silty fine SAND (SM), dense to very dense, greenish gray (80.6m)	XII
-83	81				Lean CLAY (CL), hard, olive gray -with silt seams and layers	XIII
-84	82					
-85	83					
-86	84			PUSH	-with a few fat clay partings at 84.4m	
-87	85					
-88	86					
-89	87				-with a sand layer at 87.2m	
-90	88			30/10cm	(89.0m)	
-91	89				Fine to medium SAND with silt (SP-SM), dense to very dense, gray	XIV
-92	90					
-93	91					
-94	92			30/15cm	-with clay pockets and coarse sand, at 91.7m	
-95	93					
-96	94			30/20cm	-fine to coarse gravel, with silt and sand, at 94.2m	
-97	95			PUSH	-desiccated, greenish gray lean clay, with gravel and sand pockets, 94.6m to 95.7m	
-98	96				(96.0m)	
-99	97				Fat CLAY with sand (CH), hard, yellowish brown -mottled with gray, and with ferrous stains and organic matter pockets	XV
-100	98			PUSH		
-101	99			SAVE		
-102	100					
-103	101					
-104	102			PUSH	(102.1m)	
-105	103				Silty Fine SAND (SM), dense to very dense, yellowish red -mottled with gray	XVI
-106	104				-clay layer, 103.2m to 103.9m -silt layer, 104.1m to 104.2m	
-107	105				TOTAL DEPTH: 104.2m BACKFILLED WITH: Cement Grout	
-108	106					
-109	107					
-110	108					
-111	109					
-112	110					
-113	111					
-114	112					
-115	113					
-116	114					
-117	115					
-118	116					
-119	117					
-120	118					
-121	119					

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

13.1 → 13.1

CPT INTERVAL

PLATE 98-39.6c

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO: 98-42-0054
BORING: 98-39 (Skyway - Frame 5)

START DATE: 09/30/98
COMPLETION DATE: 10/03/98

DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-3	1			WOH	Fat CLAY (CH), very soft, dark gray -with shells and shell fragments -with sand pockets and organic matter pockets, at 0.2m -with sand seams at 1.2m	I
-4	2			WOH		
-5	3			WOH	(3.7m)	
-6	4			PUSH	Fat CLAY (CH), soft to firm, olive gray -with shell and shell fragments at 3.7m	II
-7	5			PUSH	-with many sand pockets at 4.9m	
-8	6			PUSH	-with many silt pockets at 5.8m	
-9	7			PUSH		
-10	8			PUSH	- with shell fragments at 7.6m	
-11	9			PUSH	-with a few sand pockets at 8.5m (8.8m)	
-12	10			30/20cm	Silty Fine SAND (SM), very dense, greenish gray -with many shell fragments, 8.8m to 9.1m -silty fine with medium sand at 9.3m	III
-13	11			77	-yellowish brown sand with silt, 10.7m to 11.3m	
-14	12			30/20cm		
-15	13			30/25cm	-with clay seams at 12.8m (13.3m)	
-16	14				Fat CLAY (CH), very stiff, greenish gray -with sand layers, at 13.4m and 13.6m	IV
-17	15				-with a silt layer at 14.6m	
-18	16			PUSH	-blocky, slightly micaceous, mottled with gray, with gas blisters, organic matter pockets and veins, and voids, below 16.2m	
-19	17				(17.7m)	
-20	18				Fat CLAY (CH), very stiff to hard, greenish gray -with sand pockets -sand with clay seams and layers, 17.7m to 18.9m	V
-21	19					
-22	20			PUSH	-micaceous and with gas blisters, voids and organic matter pockets, at 20.1m	
-23	21			SAVE	-dark gray below 20.7m	
-24	22				(21.9m)	
-25	23				Fat CLAY (CH), very stiff to hard, greenish gray -micaceous	VI
-26	24			PUSH	-blocky, dessicated, and with organic matter pockets, at 23.8m	
-27	25					
-28	26					
-29	27					
-30	28			PUSH	-dark gray with sand pockets and seams, below 28.3m	
-31	29					
-32	30					
-33	31				(31.1m)	
-34	32			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -with silt pockets -micaceous and with silt seams, at 31.7m -silt with clay seams, 32.6m to 33.2m	VII
-35	33					
-36	34				-silt layer, 34.3m to 34.6m	
-37	35				-with silt layers, at 34.9m and 35.4m	
-38	36				-with organic matter pockets at 36.6m (36.3m)	
-39	37			PUSH SAVE	Fat CLAY (CH), very stiff to hard, olive gray -with silt pockets -greenish gray lean clay to 38.4m	VIII
-40	38					
-41	39			PUSH	-friable and with large gas blisters at 39.0m	

TSF 1 2 3 4 5 6 7 8 9 10
MPa 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
SLEEVE FRICTION

TSF 50 100 150 200 250 300 350 400 450 500
MPa 5 10 15 20 25 30 35 40 45
TIP RESISTANCE

FRICTION RATIO (%)
1 2 3 4 5 6 7 8 9

TSF 0 10 20 30 40
MPa 0 1 2 3
EXCESS PORE PRESSURE

CPT INTERVAL

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

PLATE 98-39.7a

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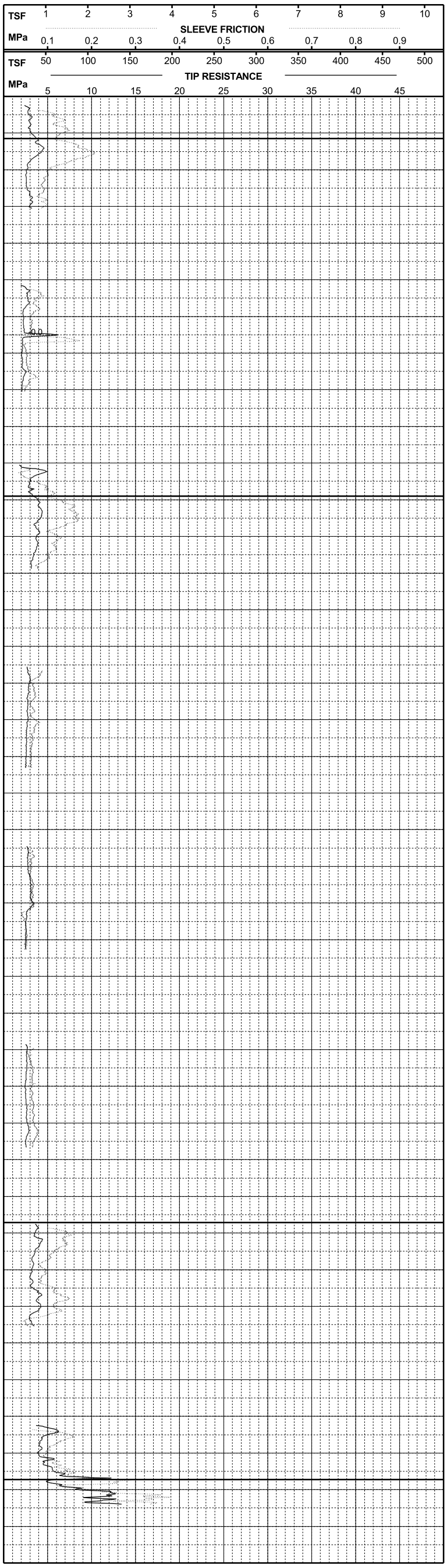
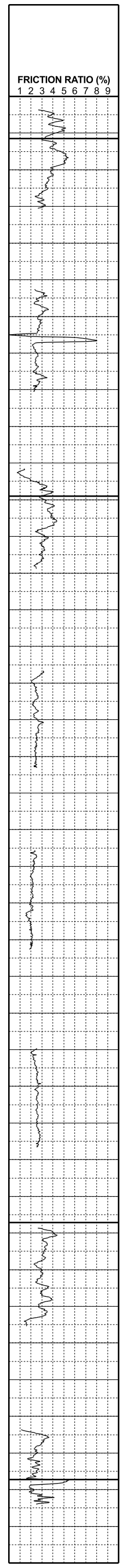
PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-43	41			Fat CLAY (CH), very stiff to hard, olive gray	VIII
				(41.1m)	
-44	42			Fat CLAY (CH), very stiff to hard, olive gray	IX
-45	43				
-46	44		PUSH	-with organic matter pockets at 44.2m	
-47	45				
-48	46			-sand layer, 46.3m to 46.5m	
-49	47			-with a silt layer at 47.5m	
-50	48				
-51	49		PUSH	-with organic matter pockets at 49.1m	
-52	50			-silt layer, 50.1m to 50.4m	
				(50.9m)	
-53	51			Fat CLAY (CH), very stiff to hard, gray	X
-54	52				
-55	53				
-56	54		PUSH	-with a few silt pockets and partings, at 53.9m	
			SAVE		
-57	55				
-58	56				
-59	57				
-60	58				
-61	59		PUSH	-with organic matter pockets at 59.4m	
-62	60				
-63	61				
-64	62				
-65	63				
-66	64		PUSH		
-67	65		SAVE	-with organic matter pockets below 64.9m	
-68	66				
-69	67				
-70	68				
-71	69				
-72	70		PUSH	-with a few silt pockets at 69.8m	
				(70.7m)	
-73	71			Fat CLAY (CH), hard, greenish gray	XI
-74	72				
-75	73				
-76	74		PUSH	-friable at 74.7m	
-77	75		SAVE		
-78	76				
-79	77				
				(77.7m)	
-80	78			Silty fine SAND (SM), dense to very dense, greenish gray -with clay seams -clay layer, 77.9m to 78.0m	XII
-81	79		PUSH		





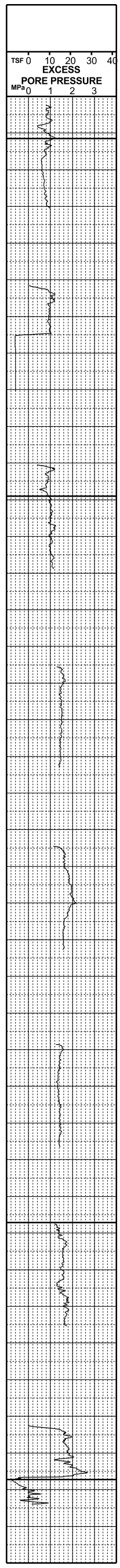


PLATE 98-39.7b

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO: 98-42-0054
BORING: 98-39 (Skyway - Frame 5)

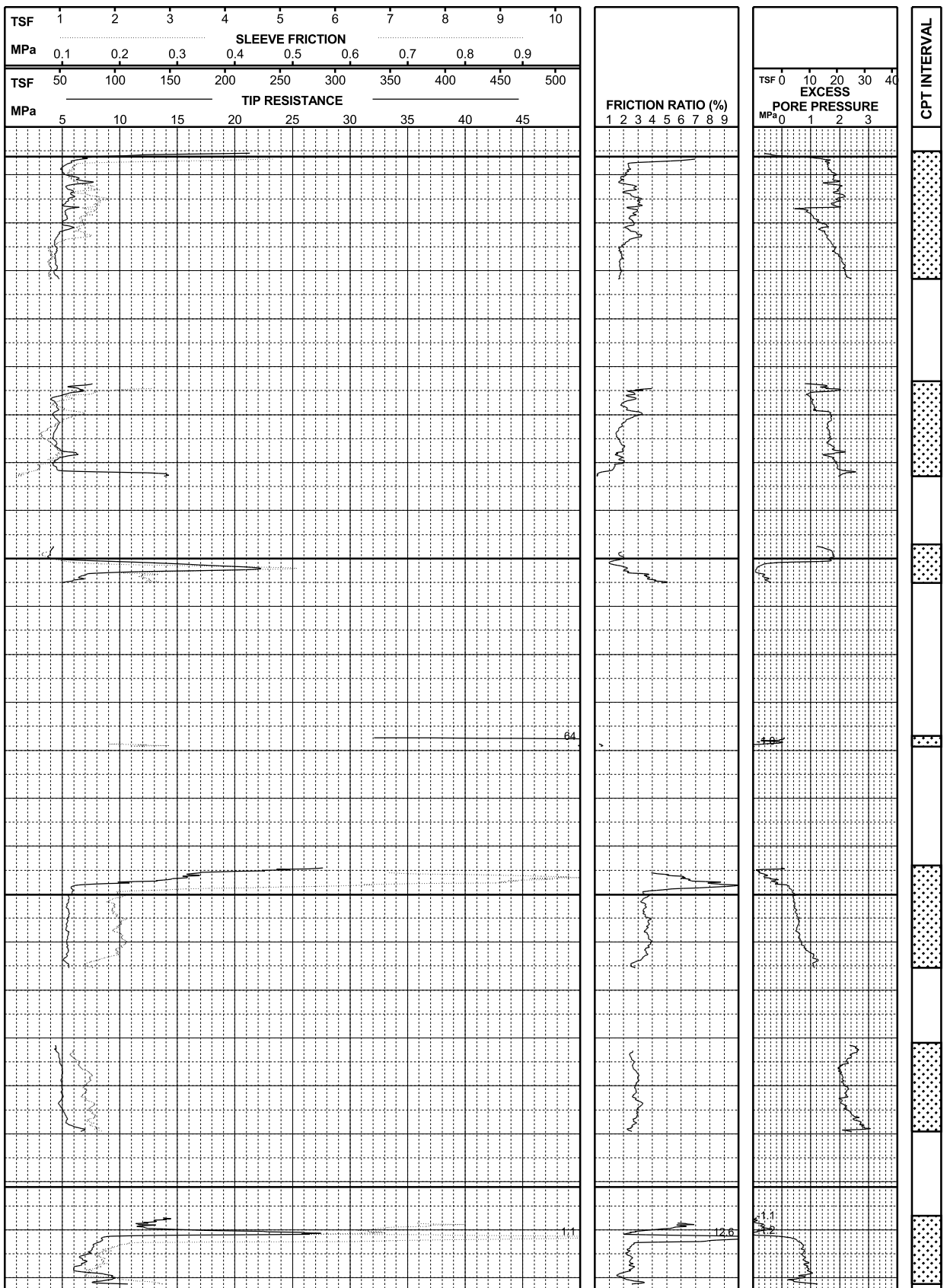
START DATE: 09/30/98
COMPLETION DATE: 10/03/98

DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838812 N648275
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -2.0m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
					Silty fine SAND (SM), dense to very dense, greenish gray (80.6m)	XII
-83	81				Lean CLAY (CL), hard, olive gray -with silt seams and layers	
-84	82					
-85	83					
-86	84			PUSH	-with a few fat clay partings at 84.4m	XIII
-87	85					
-88	86					
-89	87				-with a sand layer at 87.2m	
-90	88			30/10cm		
-91	89				(89.0m) Fine to medium SAND with silt (SP-SM), dense to very dense, gray	
-92	90					
-93	91					
-94	92			30/15cm	-with clay pockets and coarse sand, at 91.7m	XIV
-95	93					
-96	94			30/20cm	-fine to coarse gravel, with silt and sand, at 94.2m	
-97	95			PUSH	-desiccated, greenish gray lean clay, with gravel and sand pockets, 94.6m to 95.7m	
-98	96				(96.0m) Fat CLAY with sand (CH), hard, yellowish brown	
-99	97				-mottled with gray, and with ferrous stains and organic matter pockets	
-100	98			PUSH		XV
-101	99			SAVE		
-102	100					
-103	101					
-104	102			PUSH	(102.1m) Silty Fine SAND (SM), dense to very dense, yellowish red	
-105	103				-mottled with gray -clay layer, 103.2m to 103.9m	XVI
-106	104				-silt layer, 104.1m to 104.2m	
					TOTAL DEPTH: 104.2m	
-107	105				BACKFILLED WITH: Cement Grout	
-108	106					
-109	107					
-110	108					
-111	109					
-112	110					
-113	111					
-114	112					
-115	113					
-116	114					
-117	115					
-118	116					
-119	117					
-120	118					
-121	119					



CPT INTERVAL

PLATE 98-39.7c

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	09/30/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-39 (Skyway - Frame 5)	**COMPLETION DATE:**	10/03/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

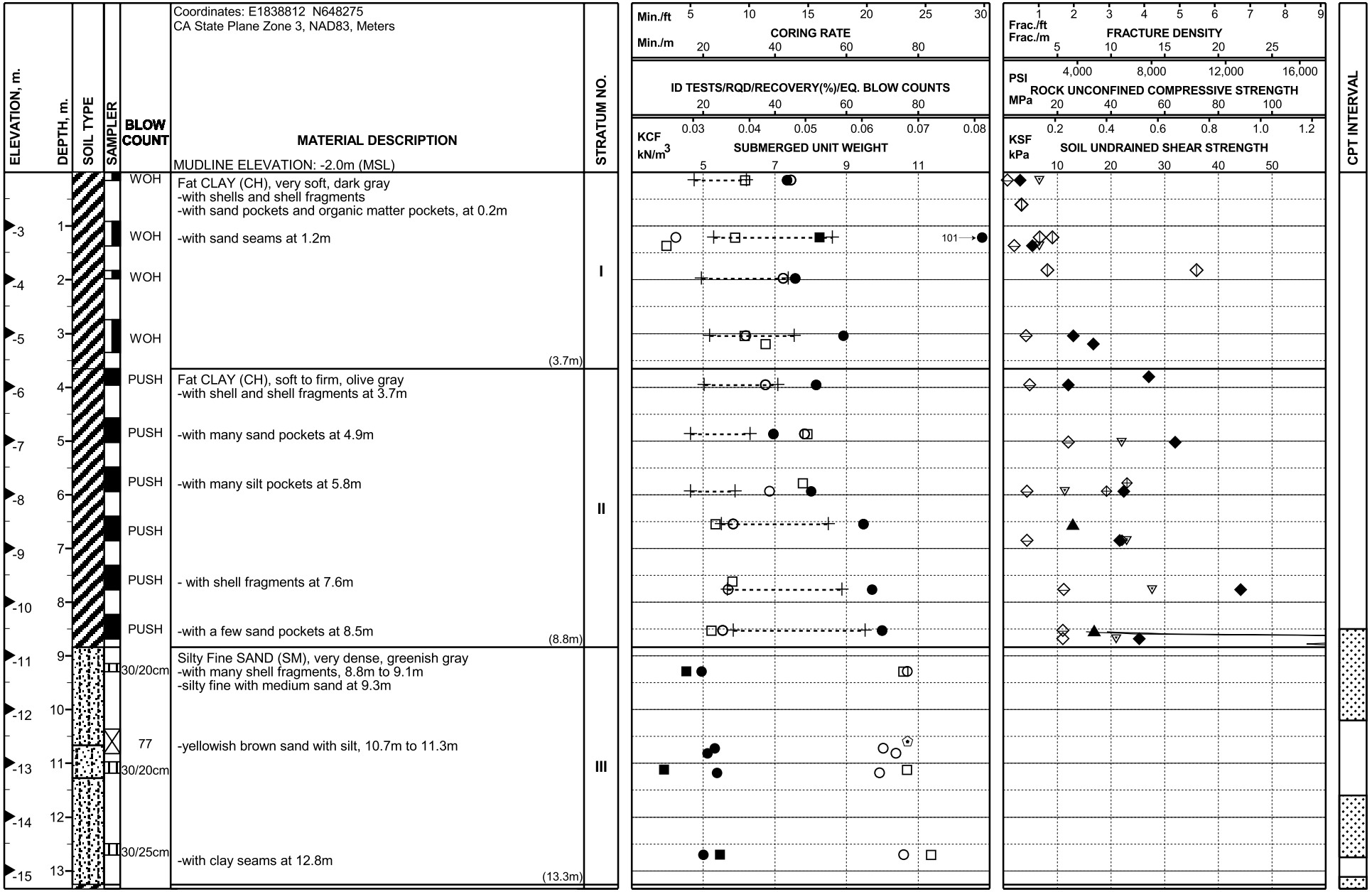

PLATE 98-39.8

LOG OF BORING AND TEST RESULTS

BORING 98-39

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

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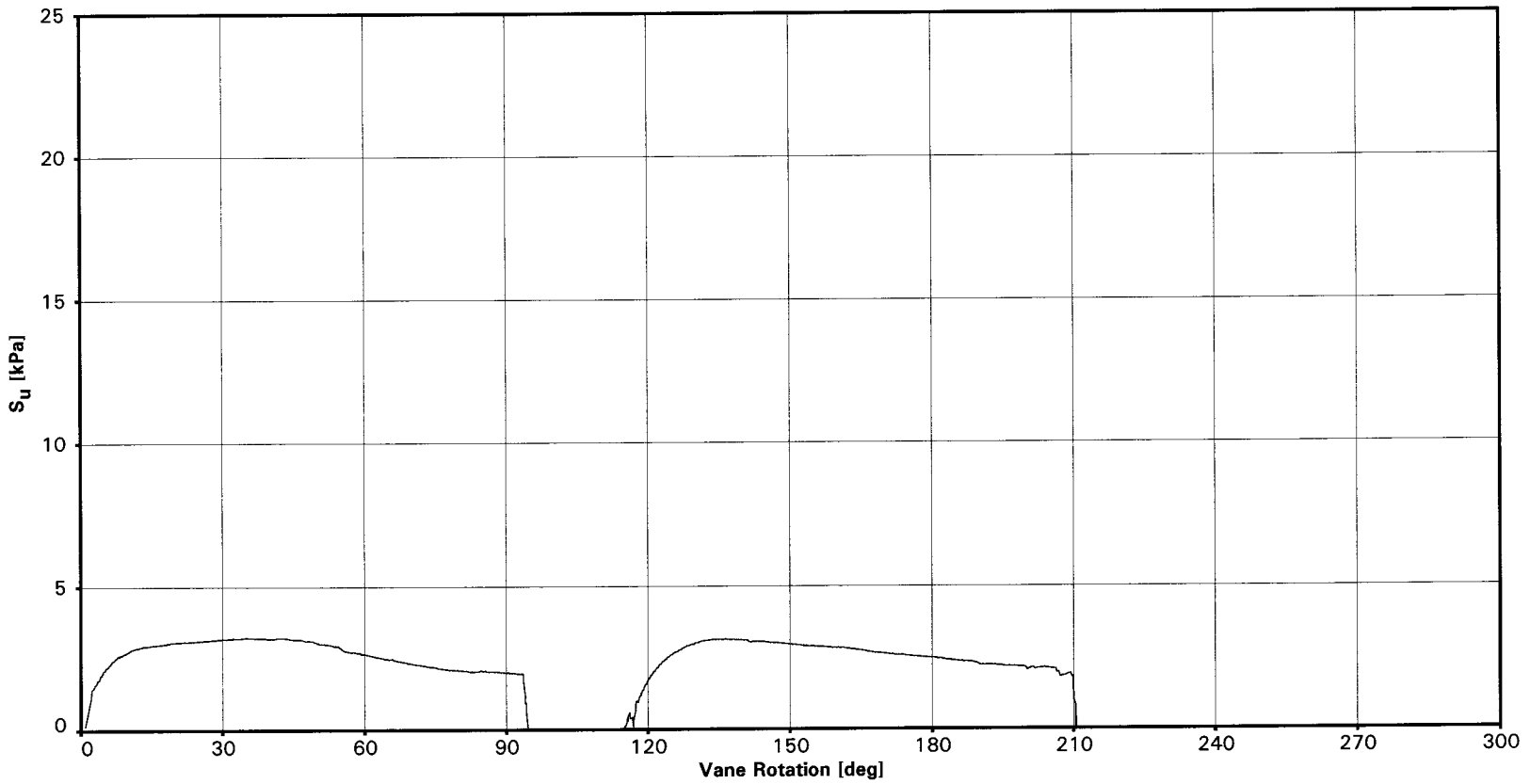
SFOBB Task Order No. 5
Project No. 98-42-0054

Vane Size used: Dolphin Large

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (HALIBUT) TEST RESULTS
Test Depth: 0.6m
Boring 98-39
SFOBB East Span Seismic Safety Project

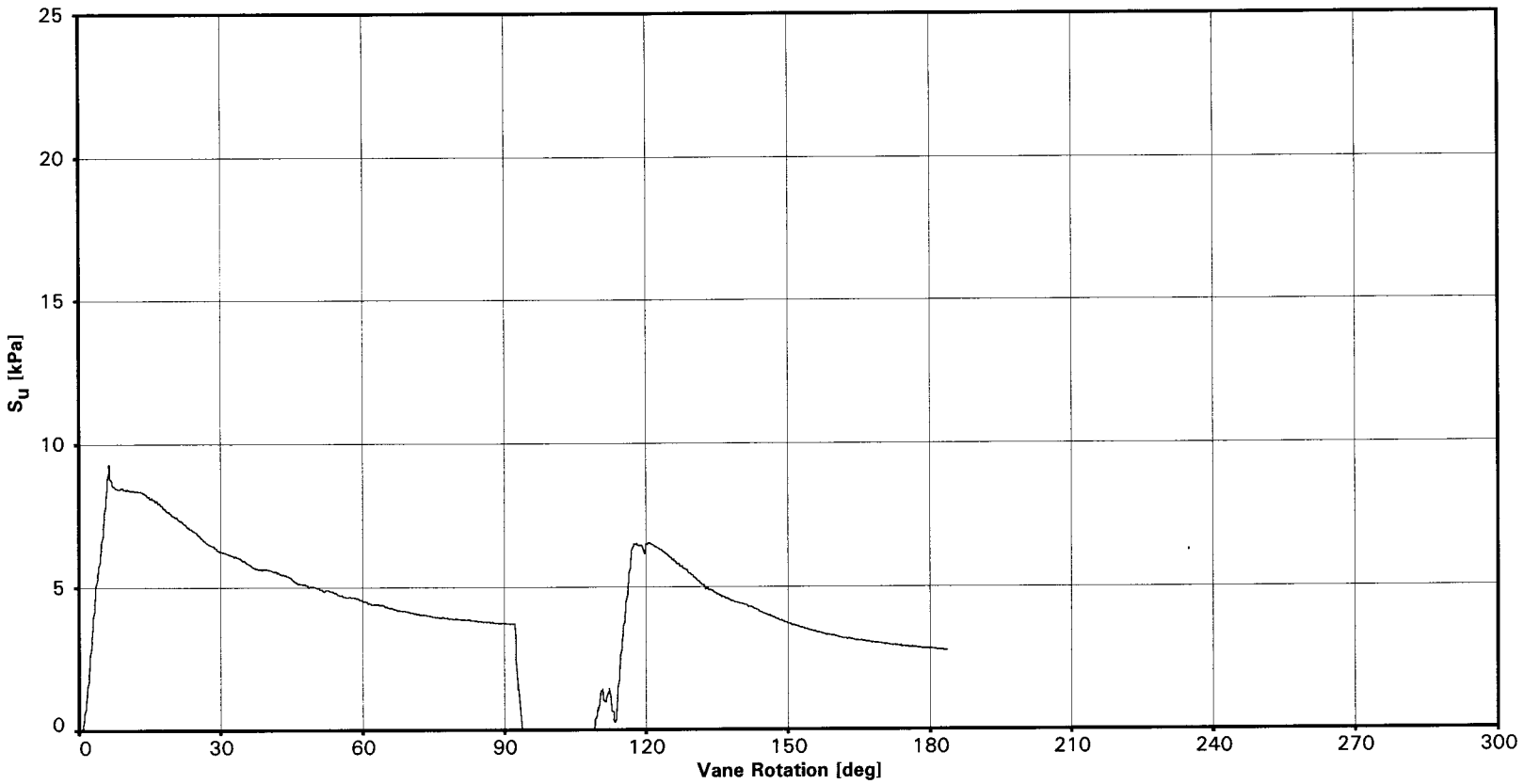
Earth Mechanics

FUGRO

PLATE 98-39.9a

Vane Size used: Dolphin Large

(30 Degrees Corresponds to 8.3% Shear Strain)



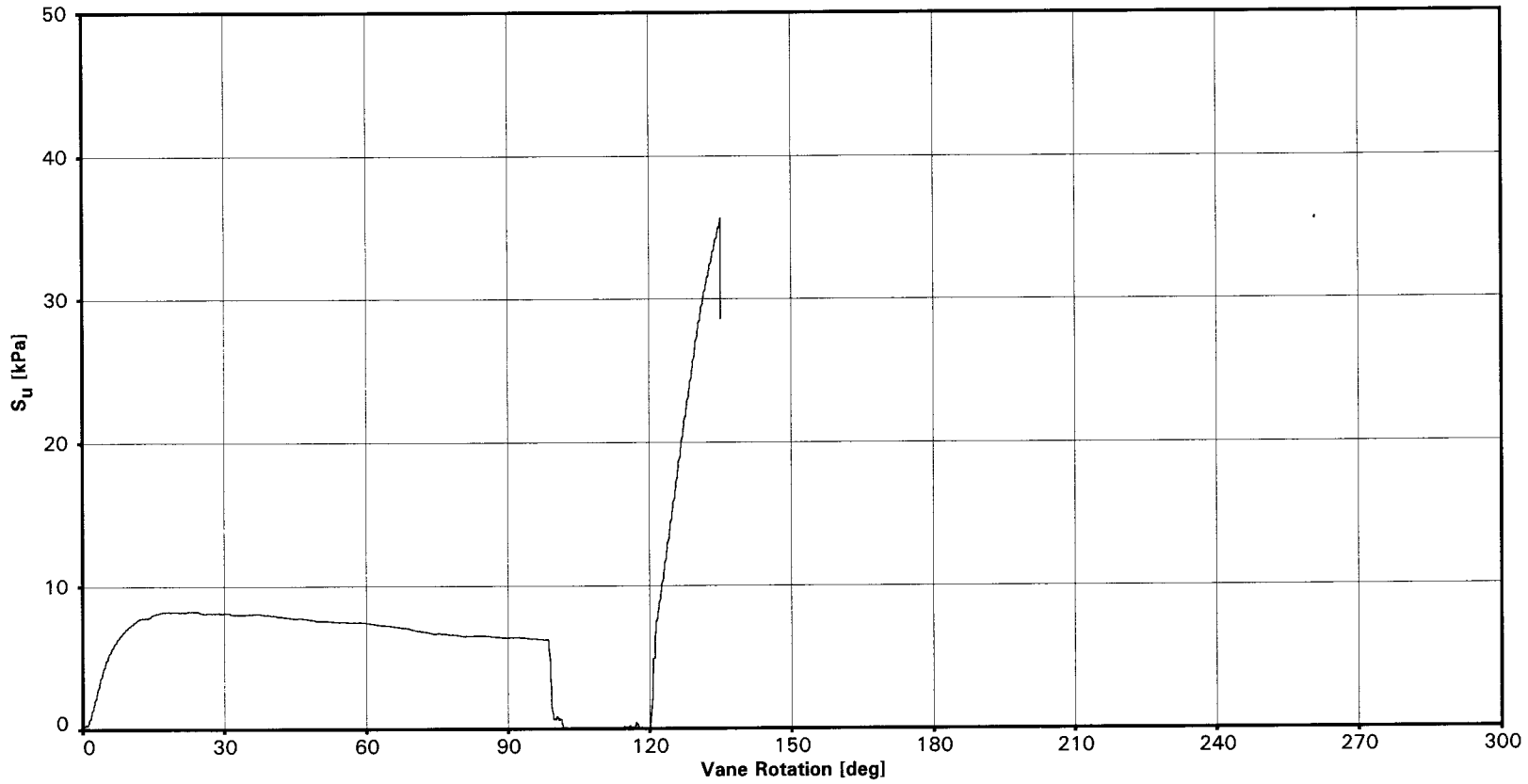
REMOTE VANE (HALIBUT) TEST RESULTS
Test Depth: 1.2m
Boring 98-39
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

Vane Size used: Dolphin Large

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (HALIBUT) TEST RESULTS
Test Depth: 1.8m
Boring 98-39
SFOBB East Span Seismic Safety Project

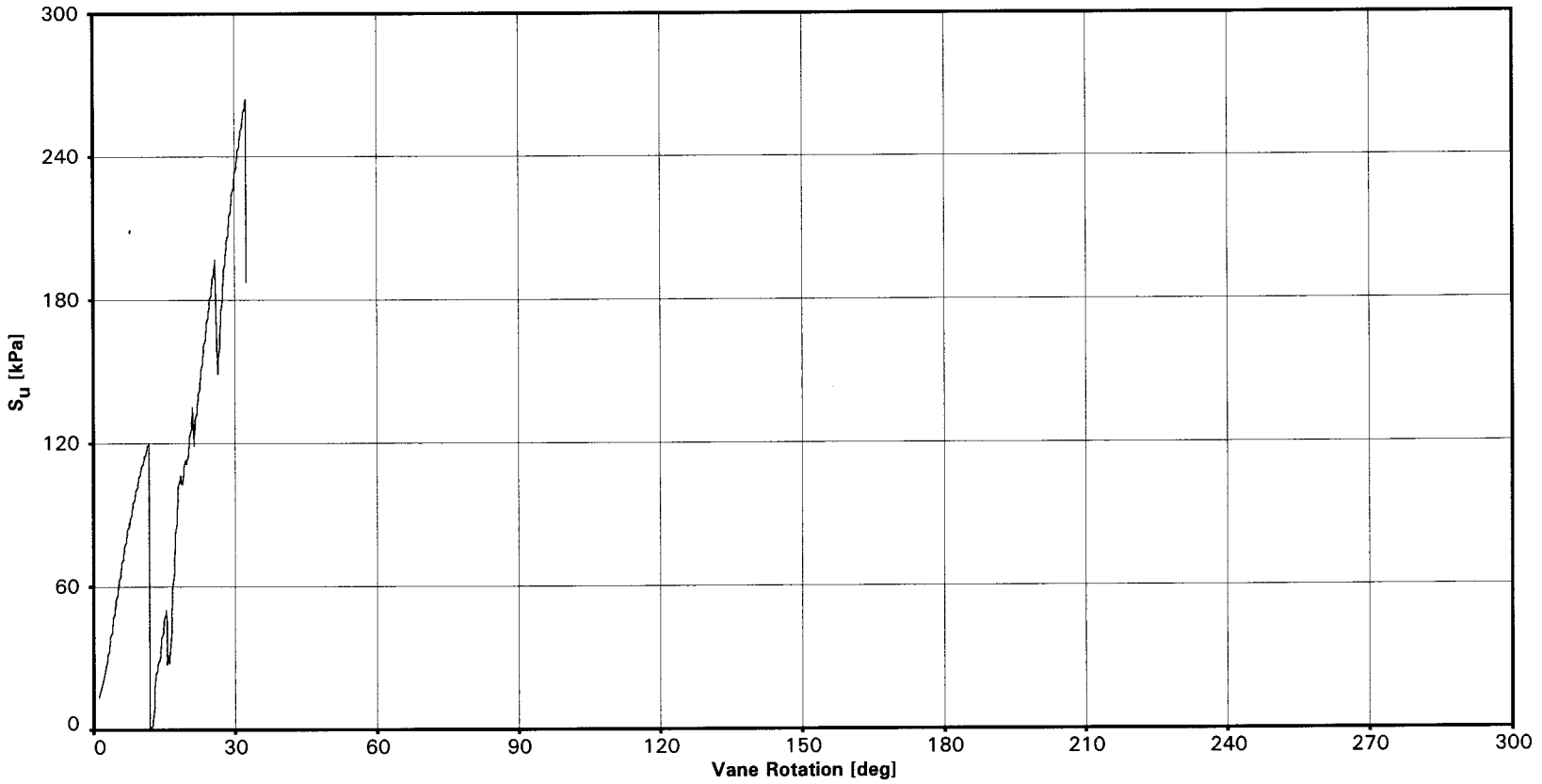
Earth Mechanics

FUGRO

SFOBB Task Order No. 5
Project No. 98-42-0054

Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depth: 39.0m
Boring 98-39
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

PLATE 98-39.9d

98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
0.2	1	43	32	18	1.76	6.2				6.7	3.1		0.8											
0.6	400													3.4										
0.6	401													3.4										
1.2	2	101	56	23	2.36	5.9	52																	H
1.2	402													9.1										
1.2	403													6.7										
1.4	3					4.0				6.7	5.4		2.1											
1.8	404													8.1										
1.8	405													35.9										
2.0	4	46	44	20	1.08																			
3.0	5	59	45	22	1.57	6.2					13.0		4.2											C
3.2	6					6.7					16.7													
3.8	7										27.1													
4.0	8	51	41	20	1.51						12.1		4.9											
4.9	10	40	33	17	1.38	7.9																		C

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.10a

Earth Mechanics

FUGRO

98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
5.0	11									22.0	31.9		12.1											
5.8	12					7.8		23.0																
5.9	13	50	29	16	2.69			19.2		11.5	22.4		4.4											
6.6	14	65	55	25	1.32	5.3									12.9		1.1							
6.9	16							22.0		23.0	21.6		4.4											
7.6	18					5.8																		
7.8	19	67	59	27	1.26					27.8	44.2		11.3											
8.5	21	70	65	28	1.13	5.2							11.1		16.9		1.0							
8.7	22									21.1	25.2	11.1												
9.3	23	19				10.6	15																	
10.7	24	23																						
10.8	25	21																						
11.1	26					10.7	9											23.9	39					
11.2	27	24																						
12.7	29	20				11.4	25																	

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.10b

Earth Mechanics

FUGRO

98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
16.6	31	50	70	23	0.58	7.1		102.9								14.6								
16.8	32								71.8		97.8													
20.3	34	31				8.9		191.5							136.9		0.8							
20.4	35							119.7			200.5													
20.9	36	44	70	25	0.42																			C
21.0	37	44	58	23	0.59						133.7													
23.8	38								191.5															
23.9	39	30	53	22	0.27										230.1	115.5	0.5							
24.1	40					9.0					222.8													
28.7	41	41	62	22	0.48	7.6									87.9		0.9							
29.0	43							91.0	95.8		143.6													
31.7	44	34	61	23	0.28			143.6																
31.9	45	34	75	23	0.22	8.4																		
32.0	46										207.9													
36.6	47								191.5															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.10c

Earth Mechanics

FUGRO

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98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
36.7	48	31	36	15	0.73	9.6		189.1								25.2								
36.9	49	31	38	16	0.67	9.6			215.5															
37.4	50	22	41	17	0.21																			C
37.5	51	24	41	17	0.30						222.8													
38.1	504													263.3										
39.2	52	27	60	24	0.10	9.8									212.9		1.7							
39.3	53								268.7		222.8													
44.0	54							131.7	172.4															
44.2	55	23	35	20	0.19	10.1									149.3	70.6	3.5							
44.3	56							107.7	119.7	166.6	143.6													
49.1	57							117.3	143.6	197.3														
49.2	58	35	49	20	0.50	8.7									145.8		3.2							
49.4	59							134.1	167.6		173.3													
53.9	60							150.8	215.5															
54.1	61	46	86	27	0.32	7.1	100								166.8		2.0							H

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.10d

Earth Mechanics

FUGRO

98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
54.3	62							153.2	191.5		222.8													
54.5	63	50	81	26	0.44						222.8													C
54.9	64	49	86	27	0.37																			
59.4	65							146.0	167.6															
59.6	66	41	67	24	0.38	7.8									188.7	54.3	2.0							
59.7	67							131.7	143.6															
64.3	68							150.8	167.6															
64.5	69	39	61	25	0.39	8.1	100								212.1		1.0							H
64.6	70							138.9	153.2		195.5													
65.1	71	40	61	26	0.40																			C
65.2	72	46	62	26	0.55																			
69.6	76							160.4	210.7															
70.0	74	28	60	22	0.17	8.3									201.7	71.5	0.9							
70.1	75							196.3	225.0															
74.5	77								303.8															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.10e

Earth Mechanics

FUGRO

98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
74.8	79	17	53	16	0.02	10.9	88		309.6						266.3		0.7							H
75.5	80	20	66	17	0.06																			C,K
75.6	81	22	40	16	0.25																			
79.6	82	31				9.9																		
79.9	83						26																	H
84.4	85	26	31	19	0.62	9.9																		
87.9	87					10.3																		
88.0	88	22	27	16	0.50		61																	
91.9	100	19				11.4	10																	
94.3	101	11					17																	
95.3	102	20				11.0									332.0		2.3							
95.4	103								350.5															
98.5	105	9	42	16		10.6	79								280.9	174.3	0.8							H
99.0	106	20	45	17	0.11																			C,K
99.1	107	19	47	15	0.11				292.1															

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-39.10f

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98-39		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
102.3	108	19					42																	H
102.6	110					11.0																		

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-39
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-39.10g

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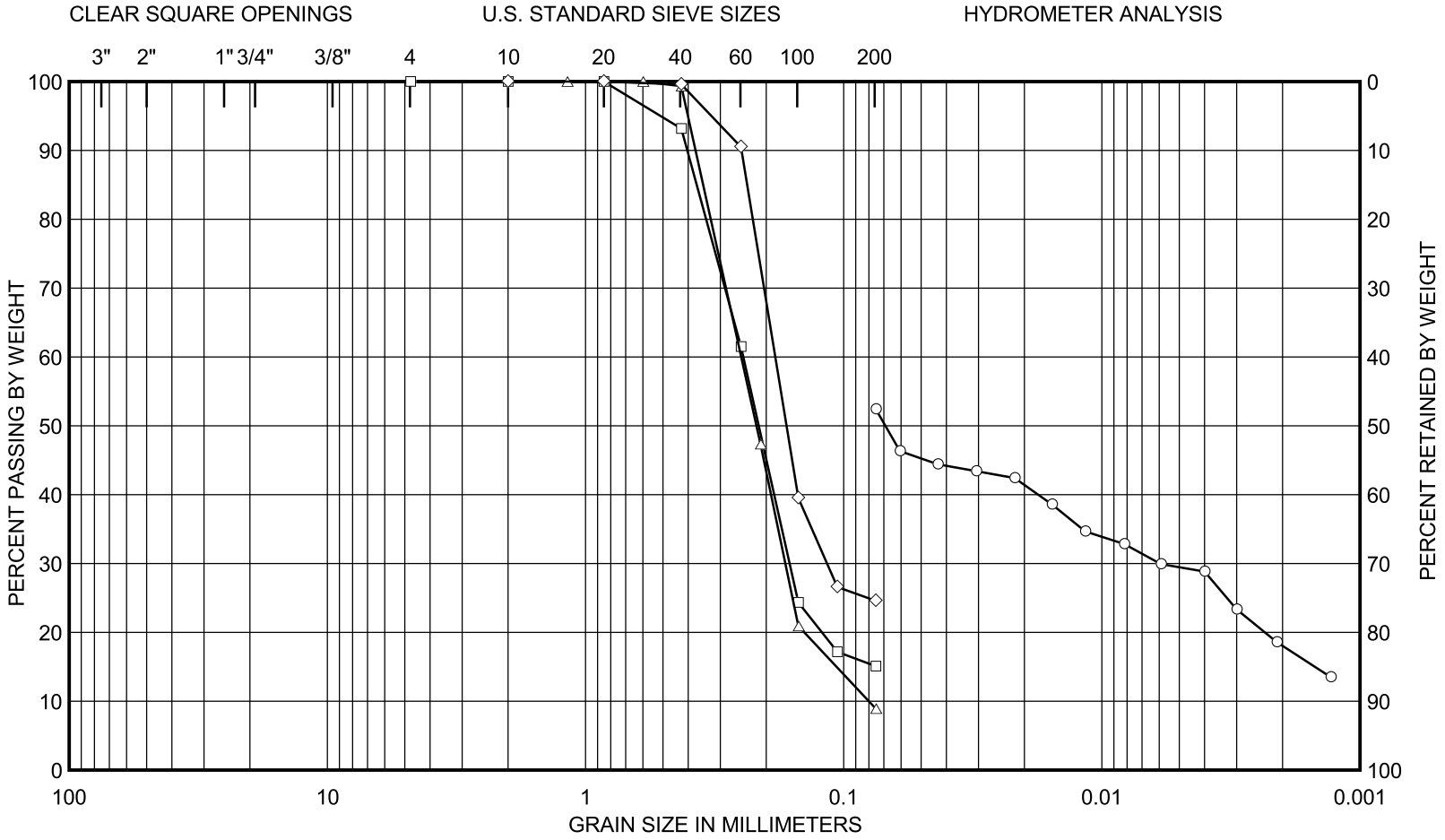

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	1.2	○—○	FAT CLAY (CH) with sand seams			0.069
23	9.3	□—□	SILTY FINE SAND (SM) with a trace of medium sand			0.21
26	11.1	△—△	FINE SAND (SP-SM) with silt	1.4	3.1	0.22
29	12.7	◇—◇	SILTY FINE SAND (SM) with clay seams			0.17

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.11a

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

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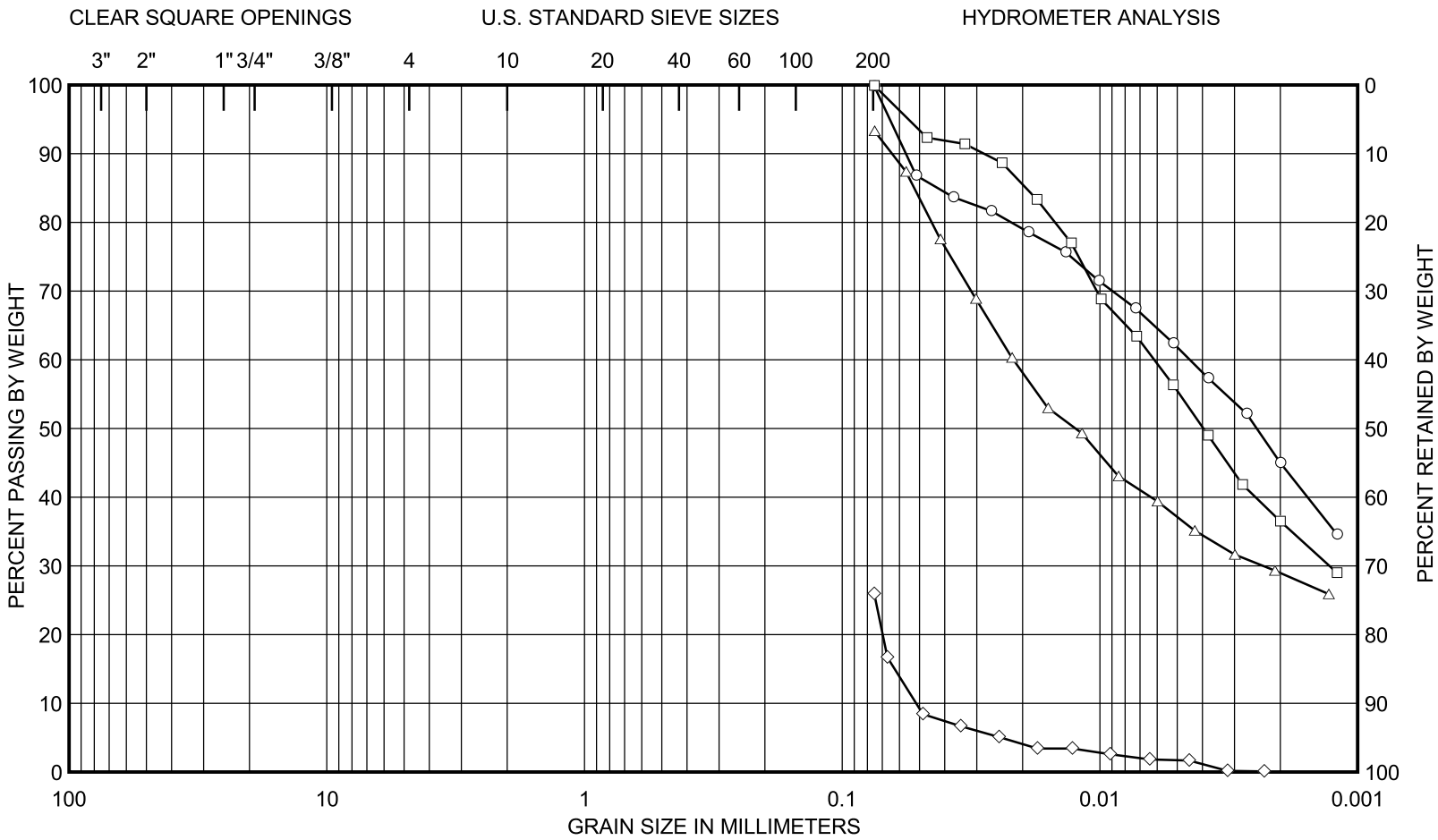

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
61	54.1	○—○	FAT CLAY (CH)			0.0025
69	64.5	□—□	FAT CLAY (CH)			0.0040
79	74.8	△—△	FAT CLAY (CH)			0.013
83	79.9	◇—◇	SILTY FINE SAND (SM) with clay seams			

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-39
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-39.11b

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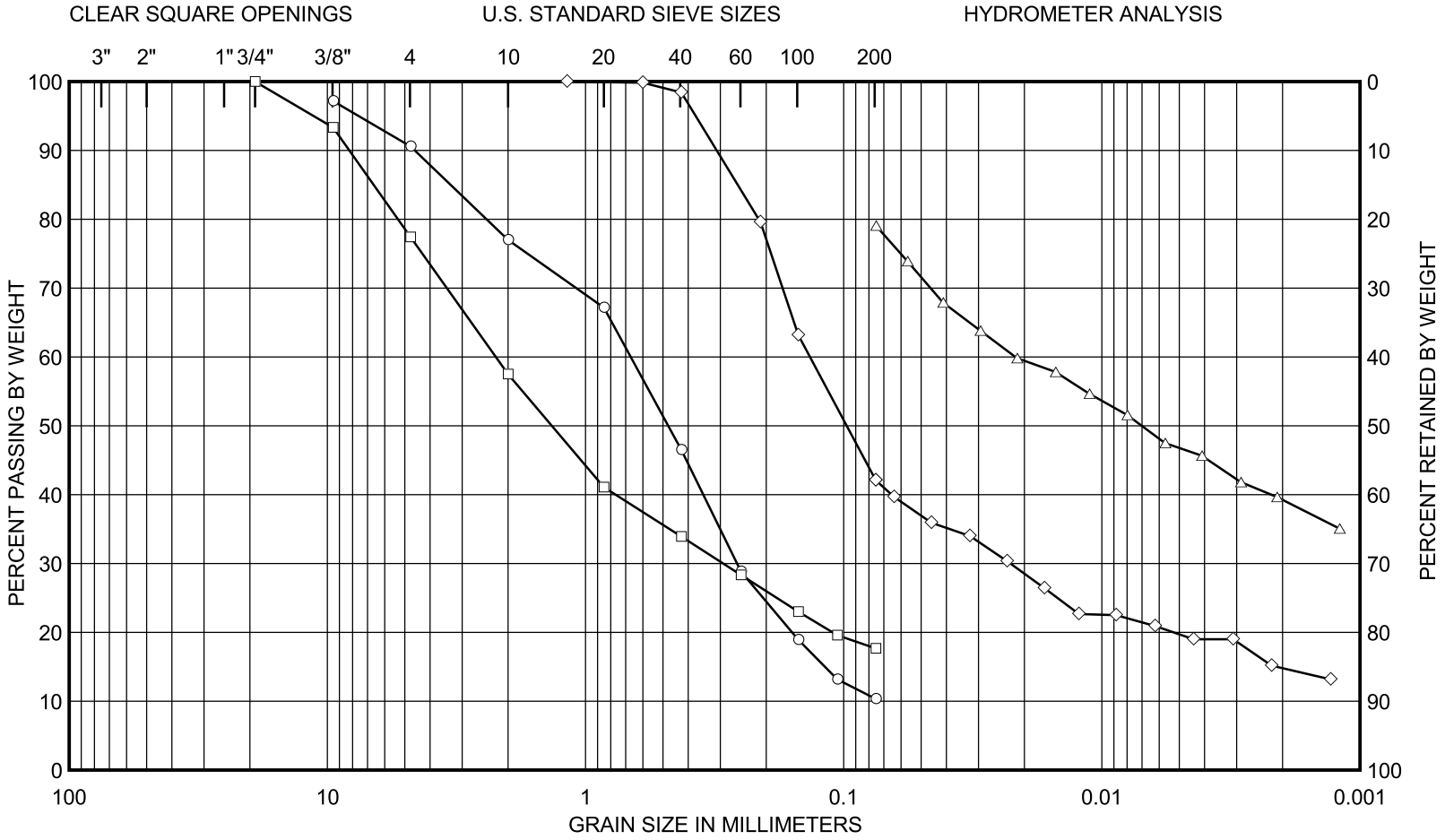

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
100	91.9	○—○	FINE TO MEDIUM SAND (SP-SM) with silt, coarse sand and a trace of fine gravel			0.48
101	94.3	□—□	SILTY FINE TO COARSE SAND (SM) with fine gravel			1.4
105	98.5	△—△	FAT CLAY (CH) with sand			0.0070
108	102.3	◇—◇	SILTY FINE SAND (SM)			0.097

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.11c

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

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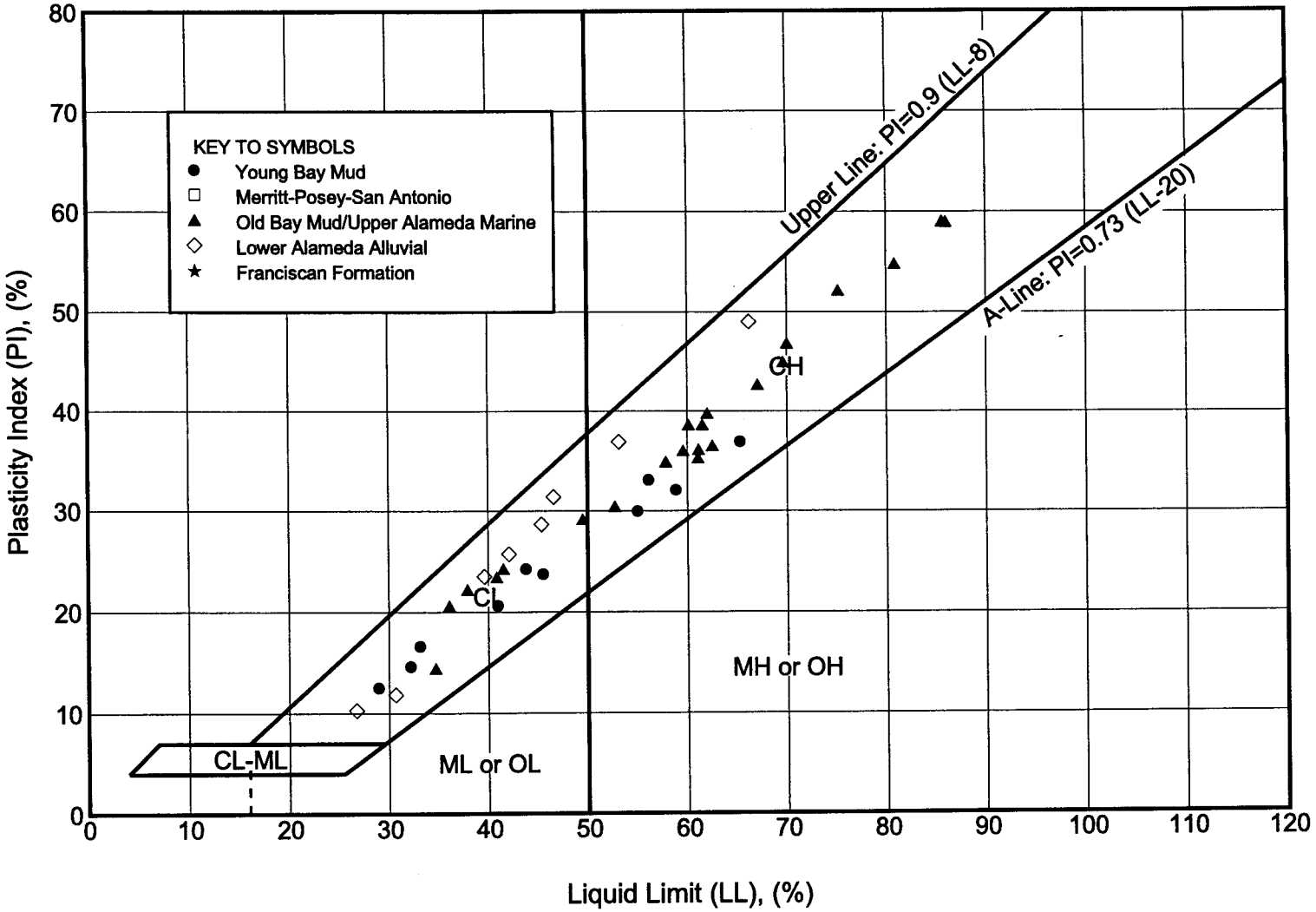
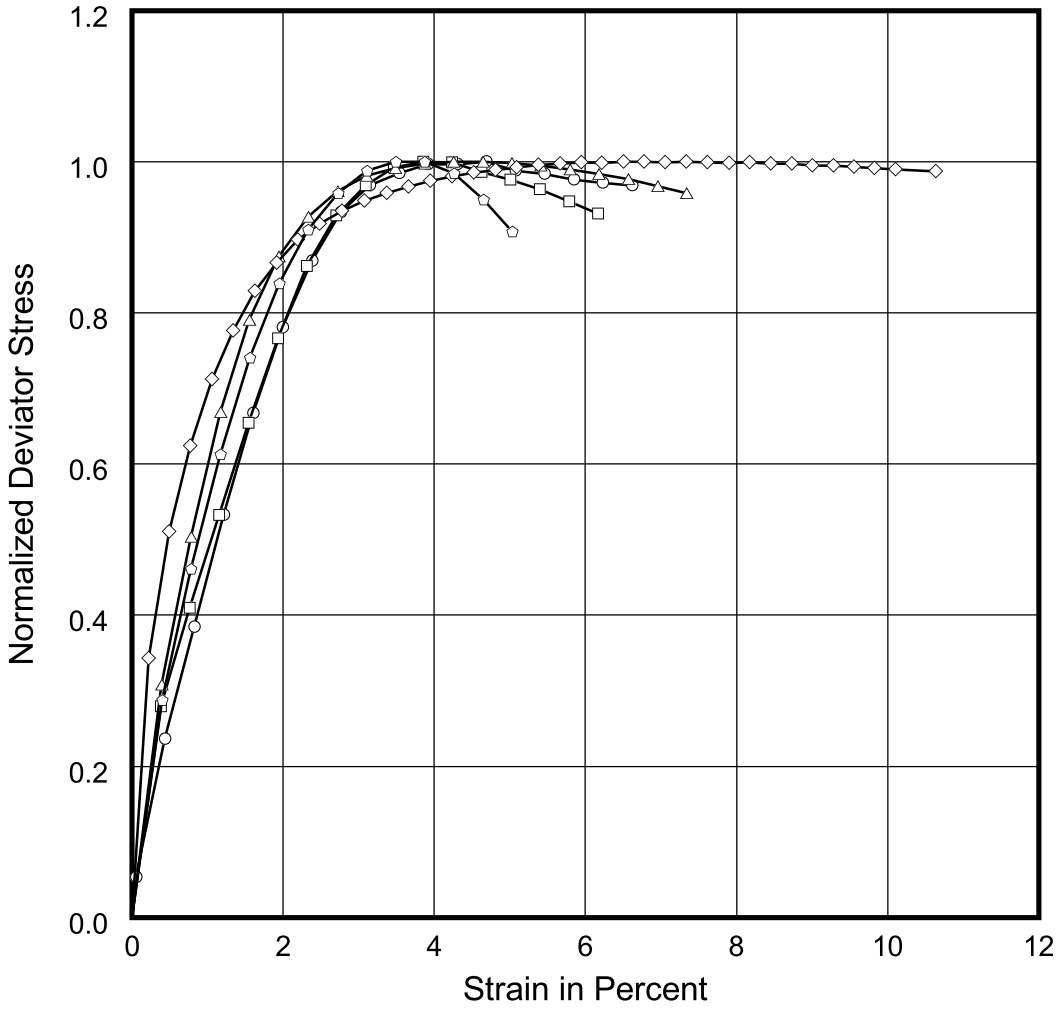


PLASTICITY CHART
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.12

Earth Mechanics

FUGRO



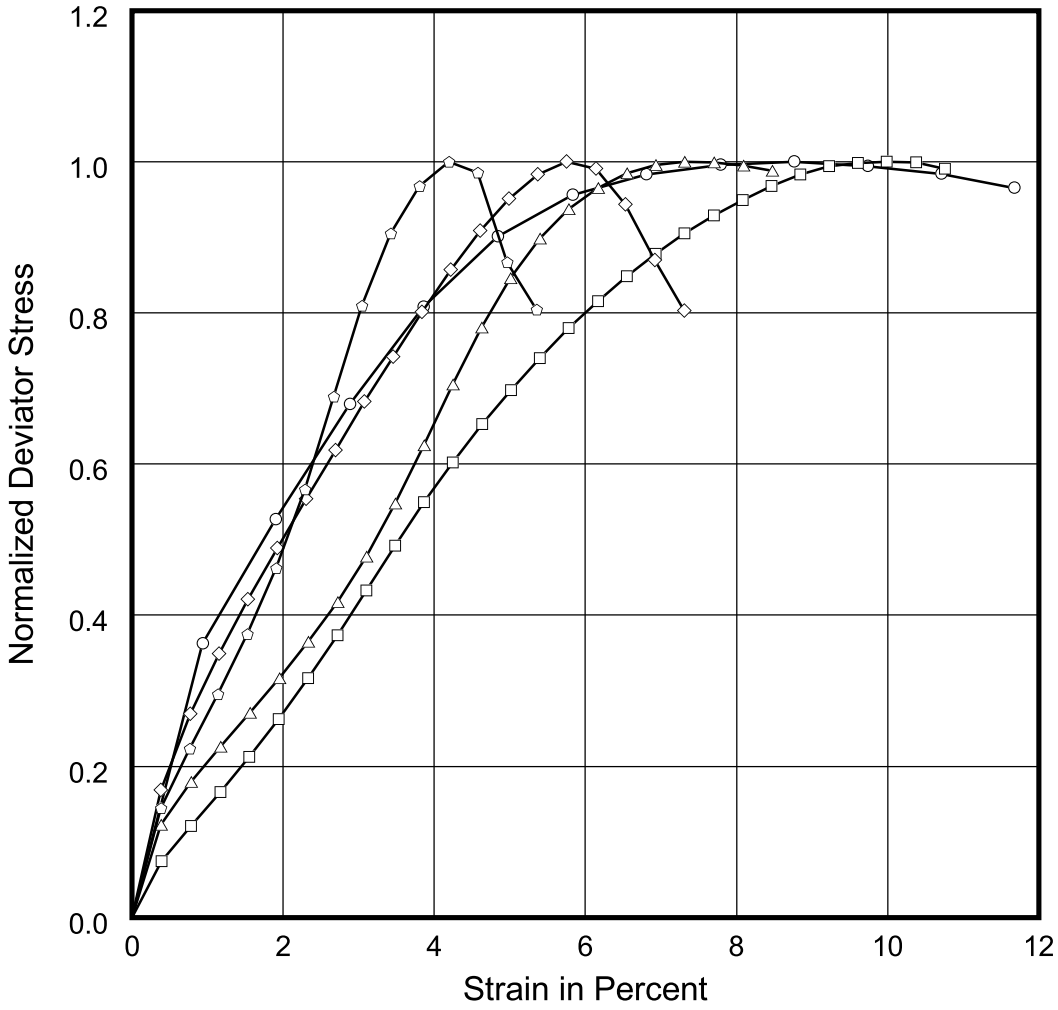
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	14	6.6	UU	207	26	1.1
□	21	8.5	UU	207	34	1.0
△	34	20.3	UU	827	274	0.8
◇	39	23.9	UU	862	460	0.5
⬠	41	28.7	UU	1000	176	0.9

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.13a



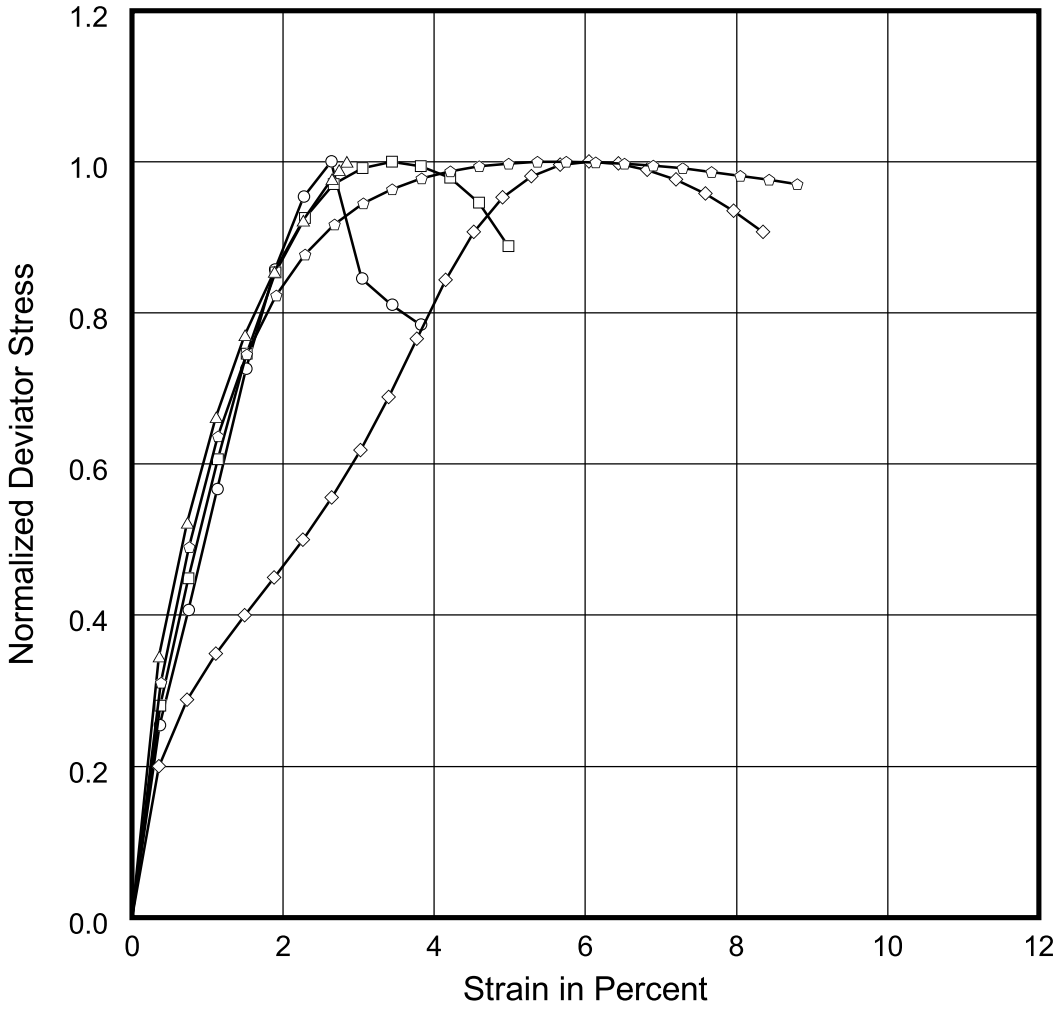
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	52	39.2	UU	1241	426	1.7
□	55	44.2	UU	1379	299	3.5
△	58	49.2	UU	1448	292	3.2
◇	61	54.1	UU	2068	334	2.0
⬠	66	59.6	UU	1724	377	2.0

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.13b



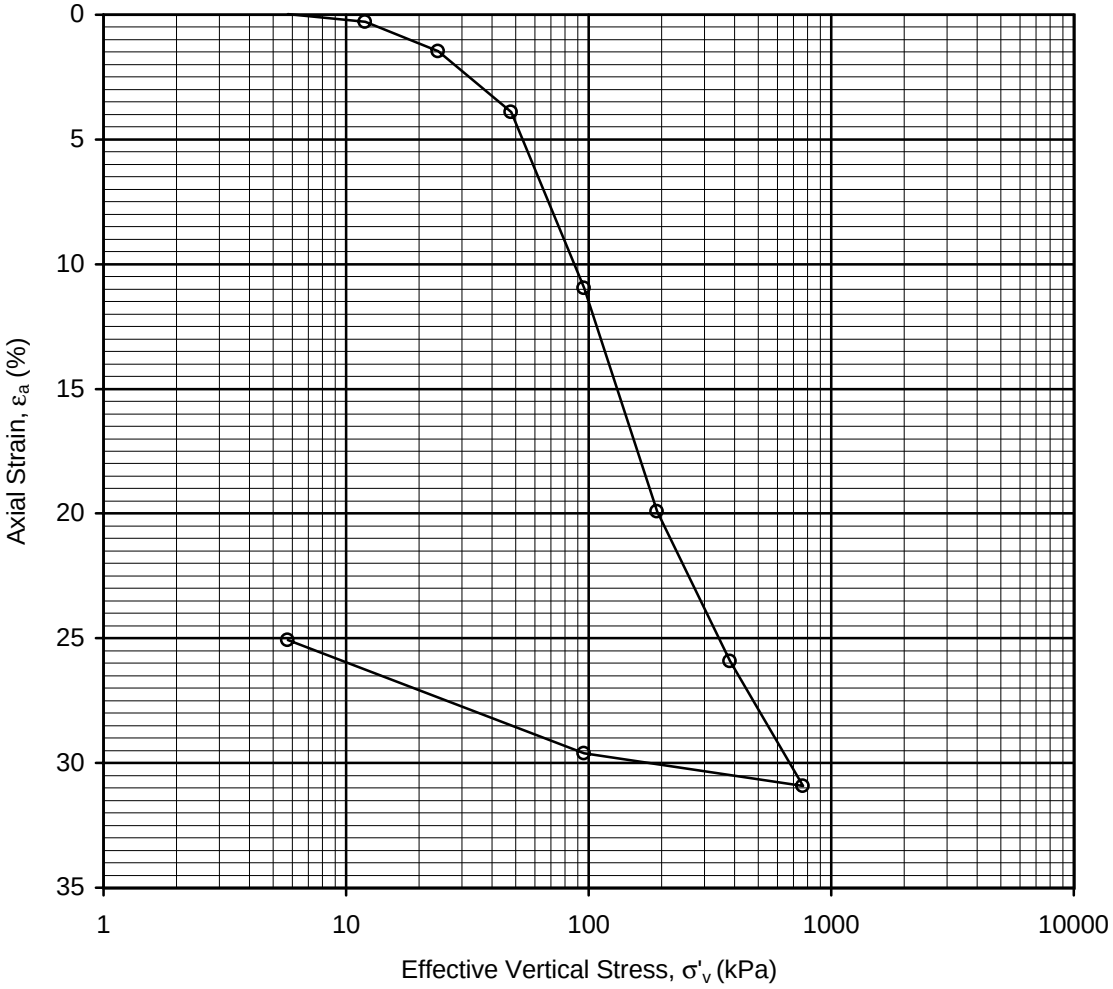
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	69	64.5	UU	1793	424	1.0
□	74	70.0	UU	1930	403	0.9
△	79	74.8	UU	2068	533	0.7
◇	102	95.3	UU	2482	664	2.3
⬠	105	98.5	UU	2482	562	0.8

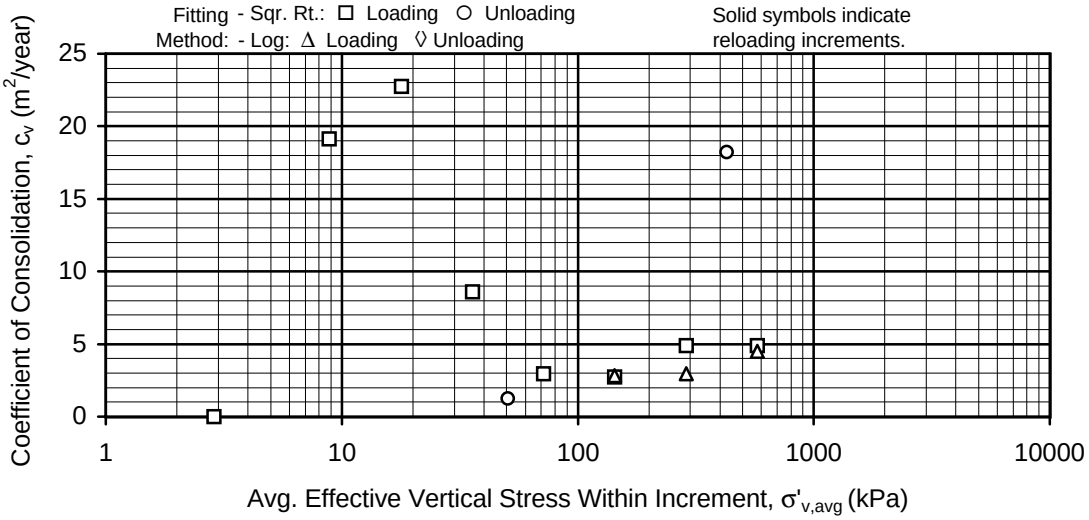
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.13c

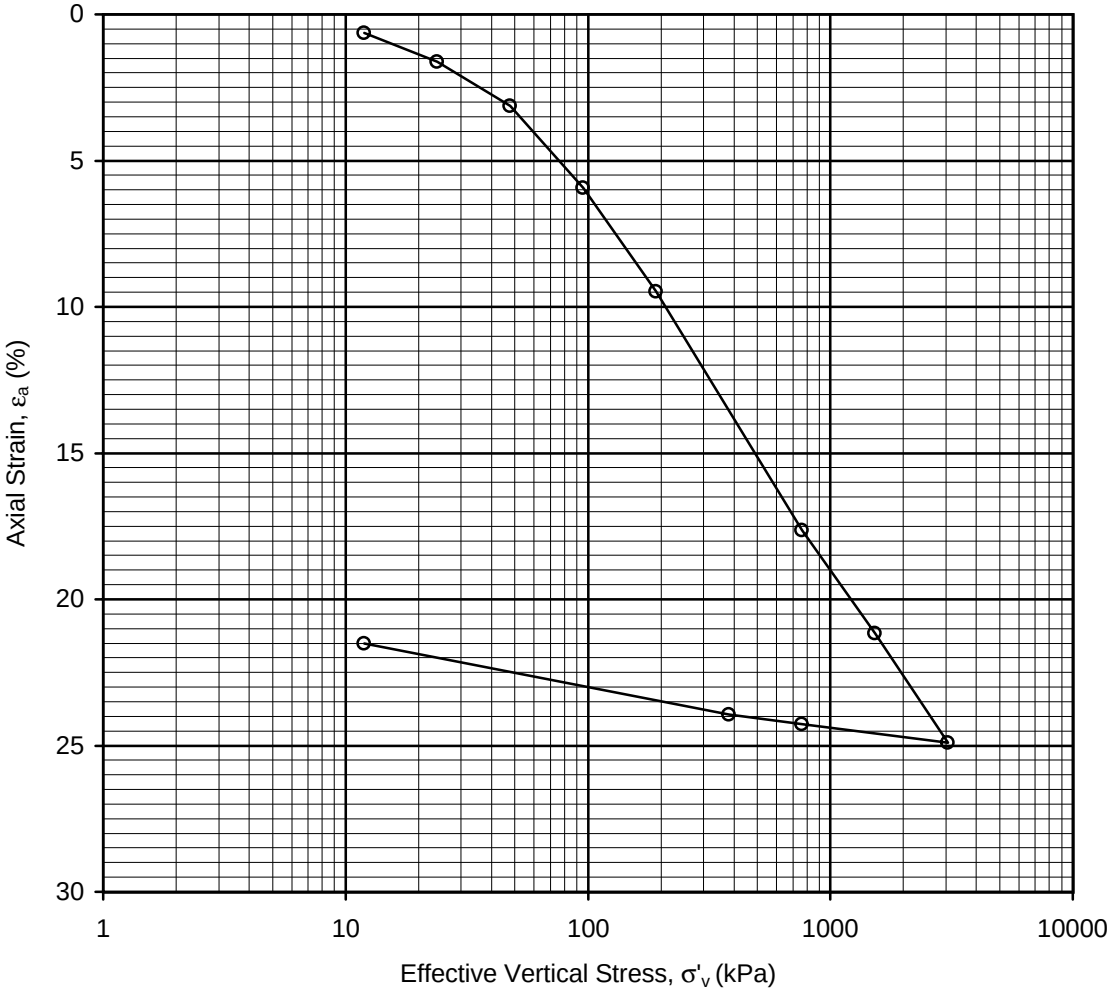


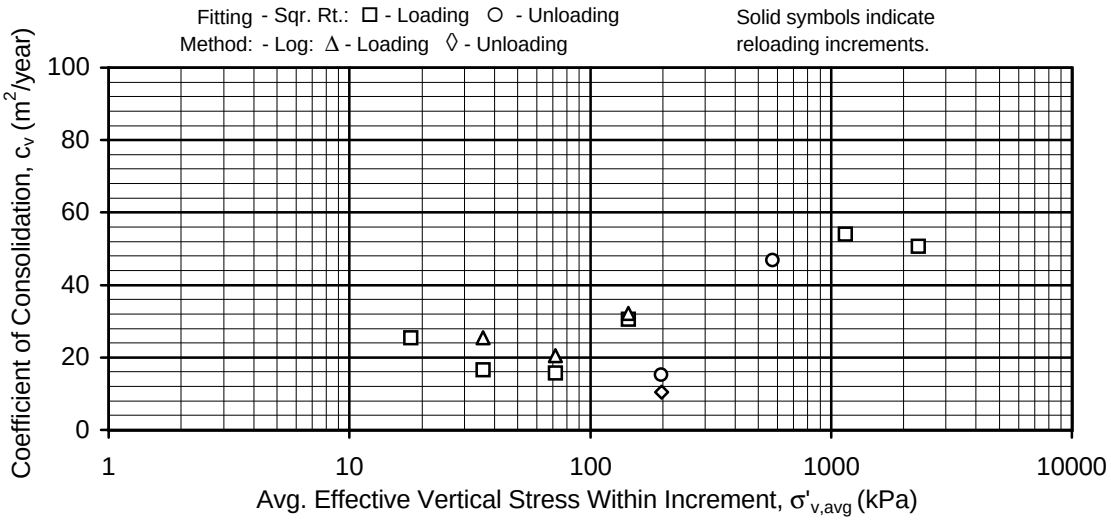


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 5 - Depth: 3.0m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14a

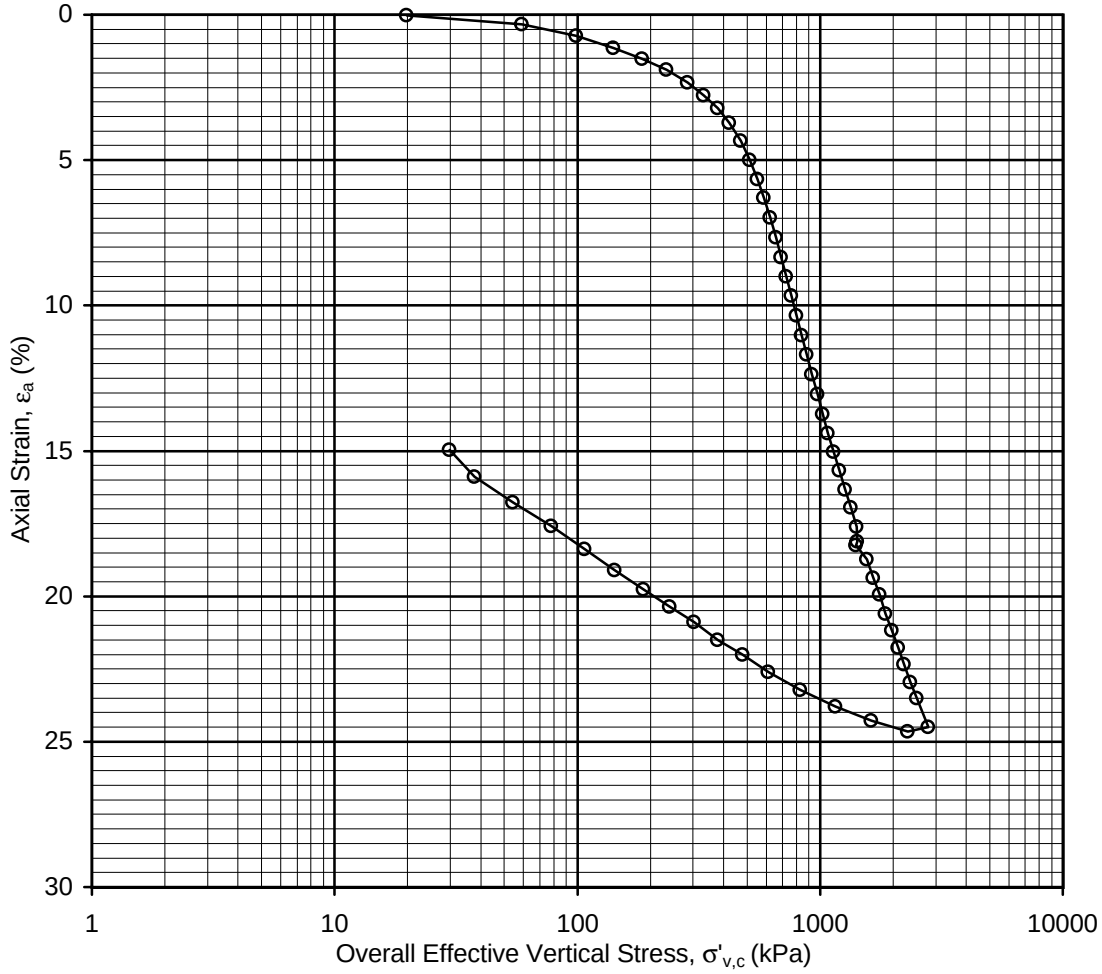


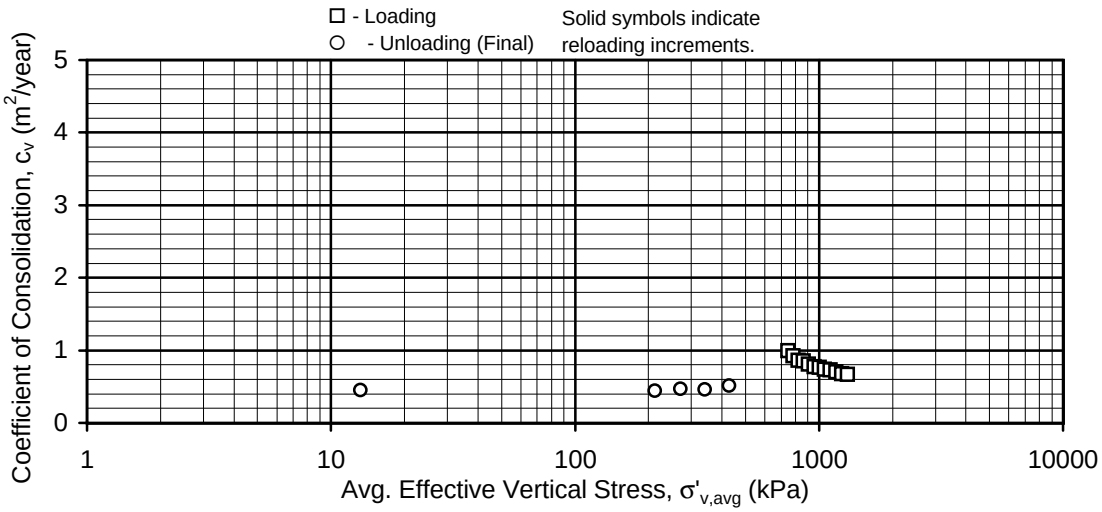


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 10 - Depth: 4.9m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14b

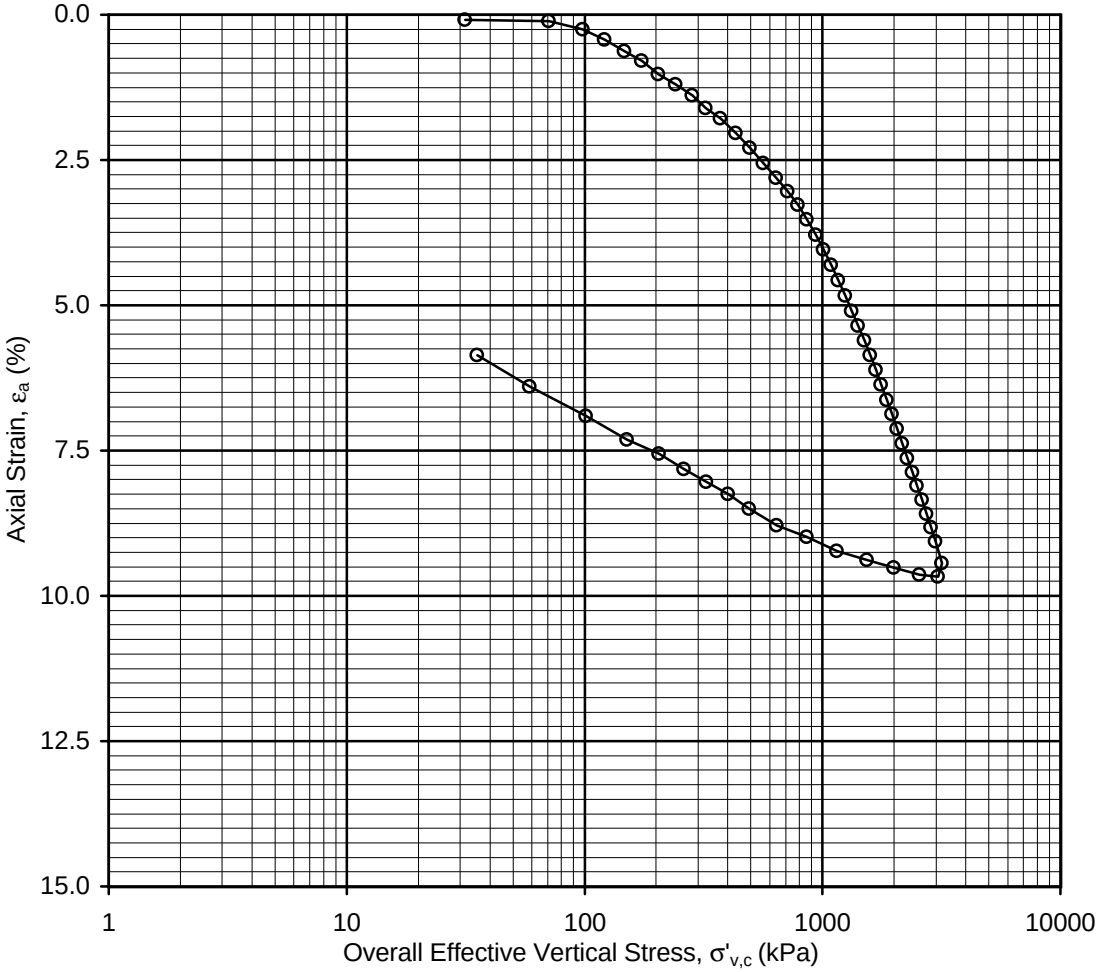


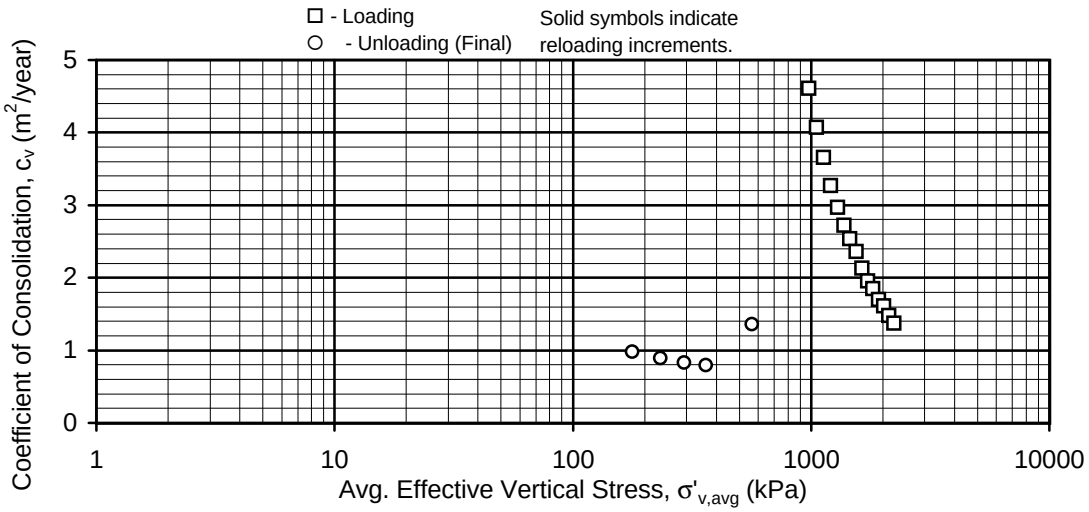


CRS CONSOLIDATION TEST RESULTS

Sample No. 36A - Depth: 20.9m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14c

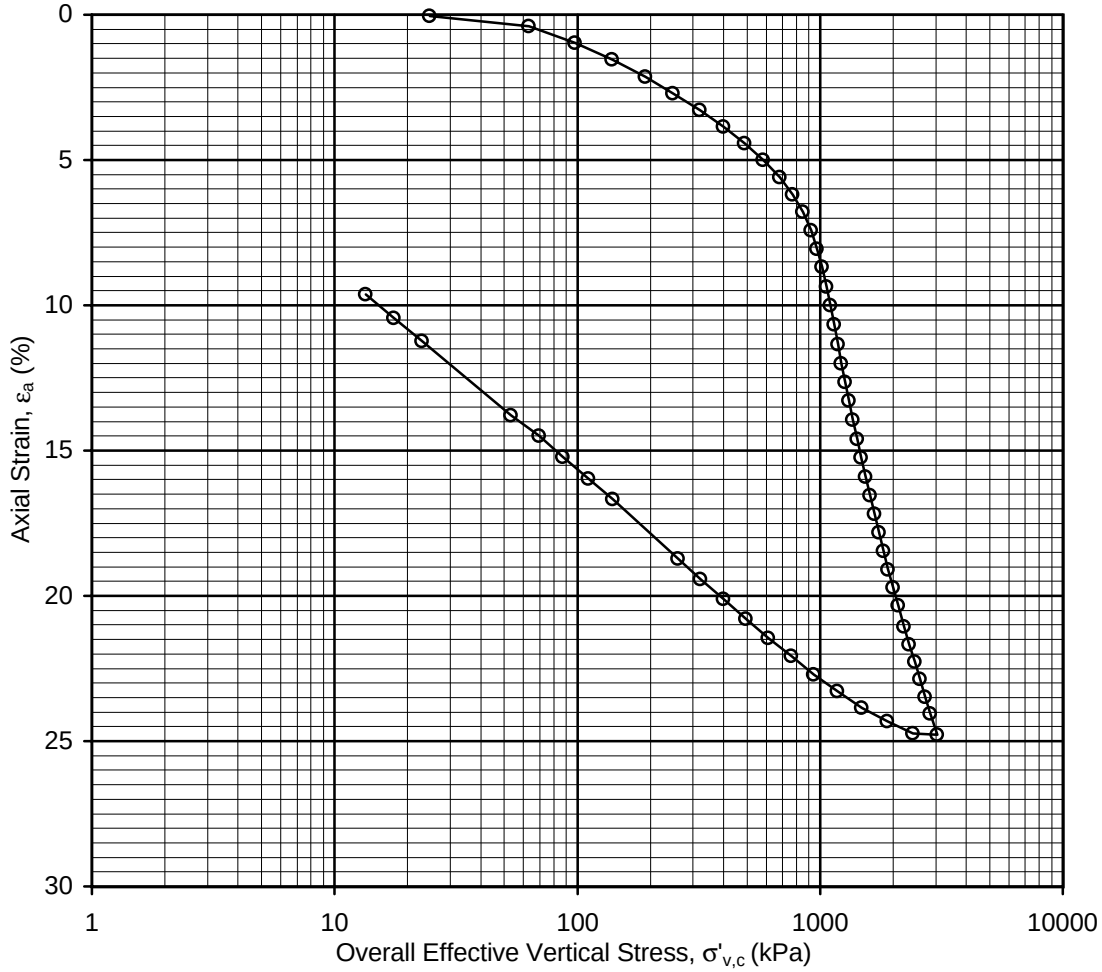


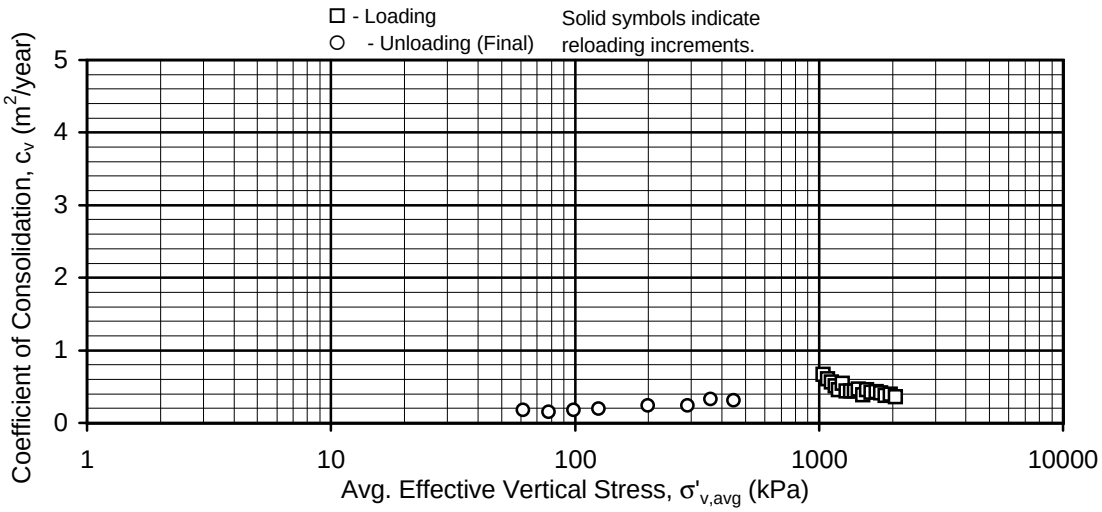


CRS CONSOLIDATION TEST RESULTS

Sample No. 50A - Depth: 37.4m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14d

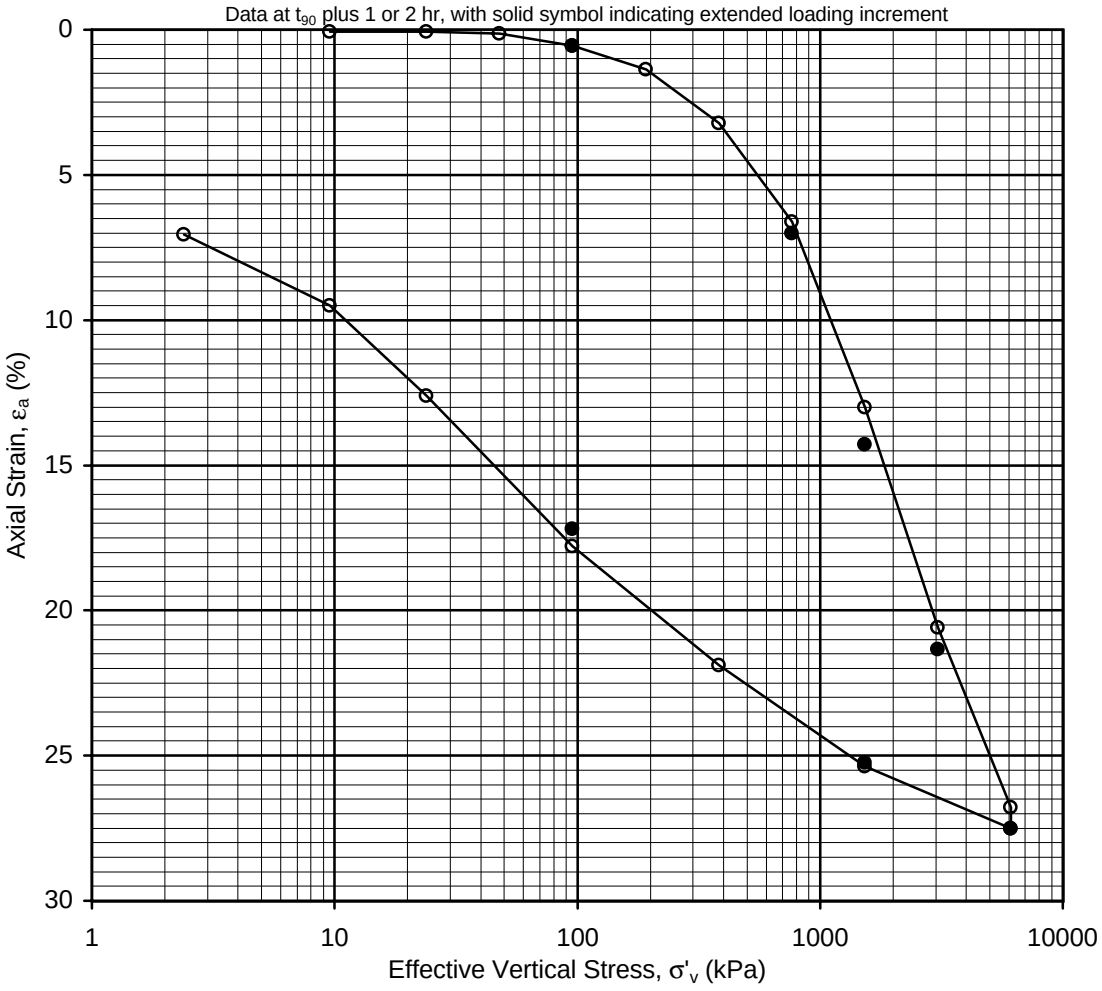


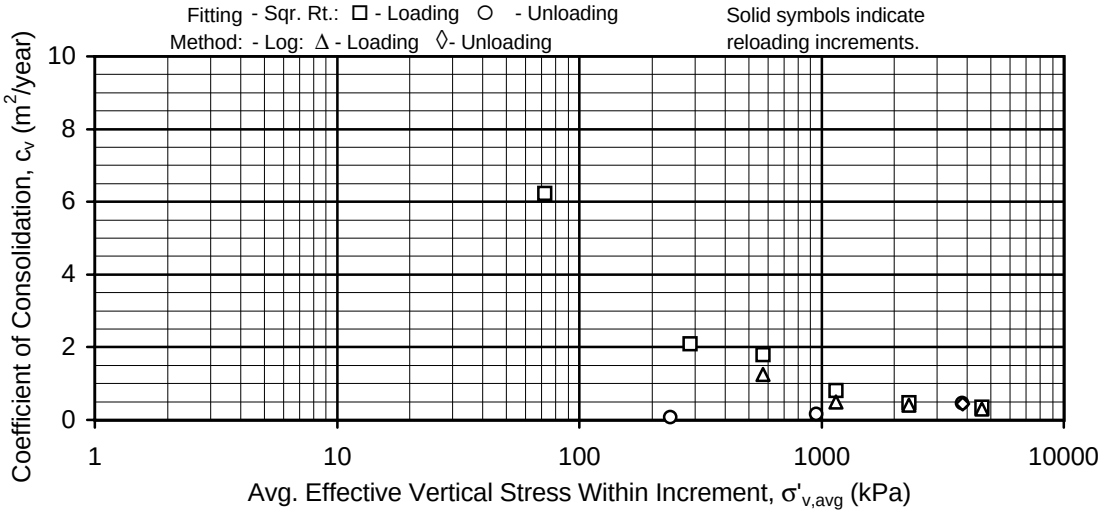


CRS CONSOLIDATION TEST RESULTS

Sample No. 63A - Depth: 54.5m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14e

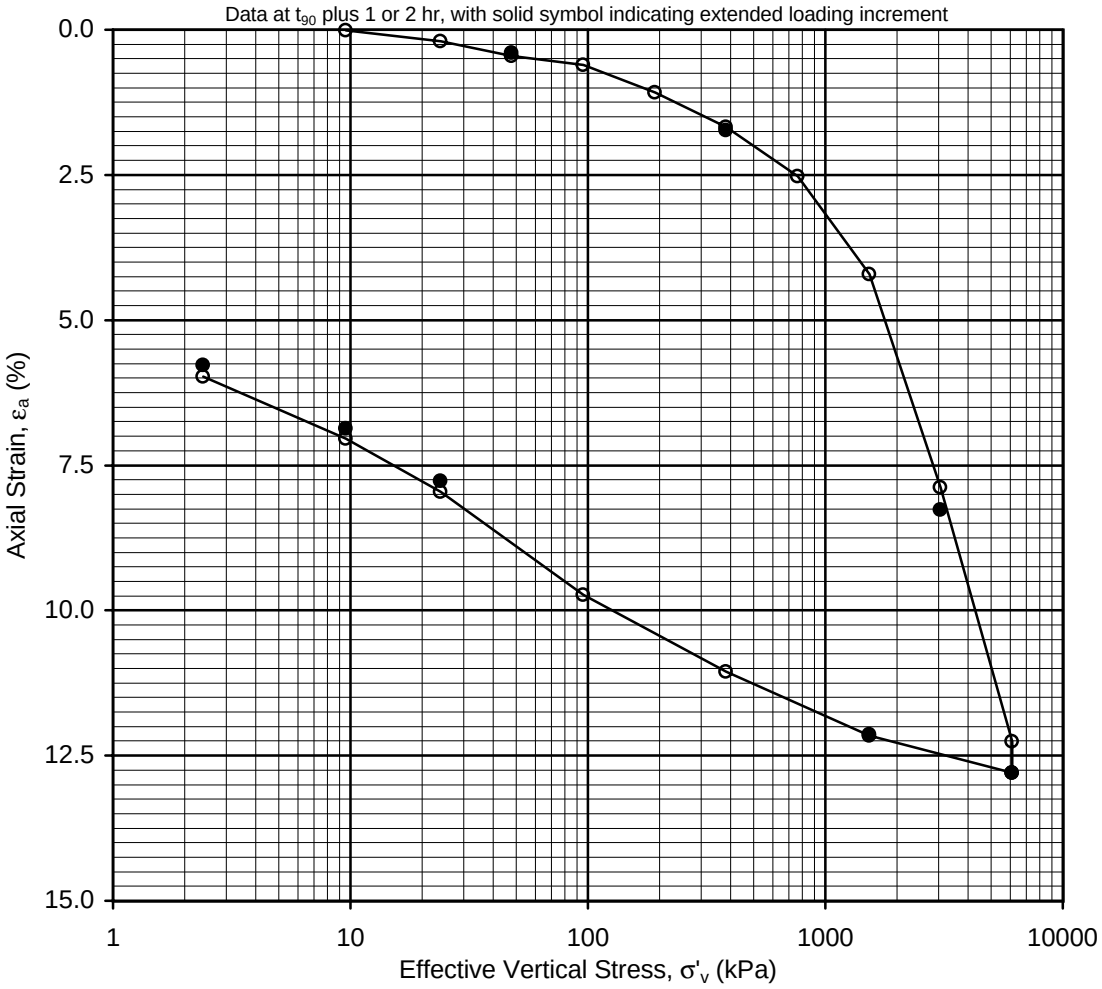


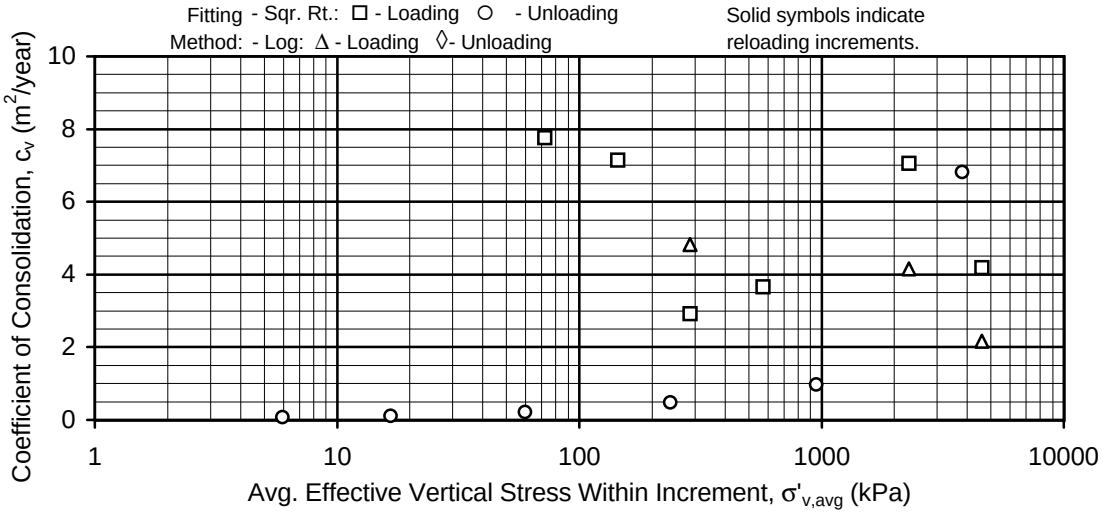


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 71 - Depth: 65.1m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14f

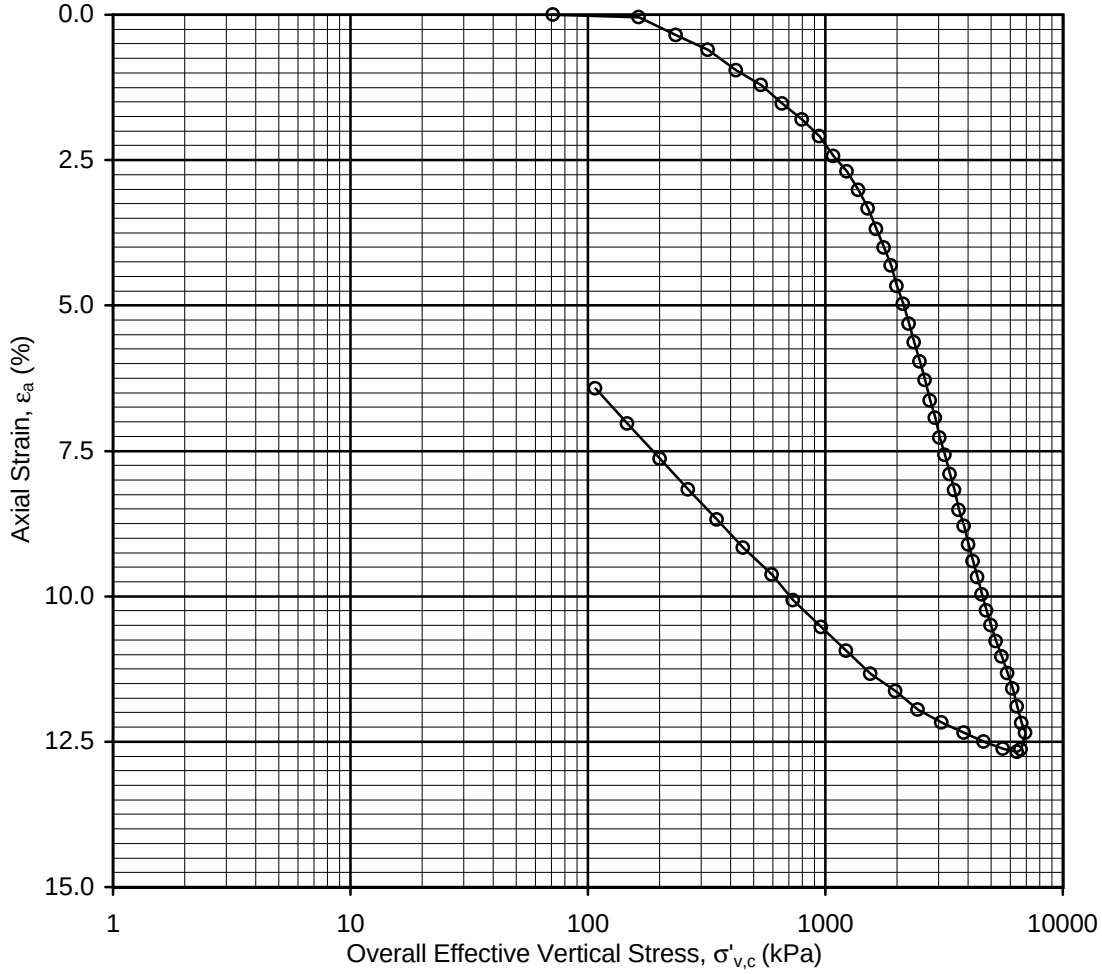


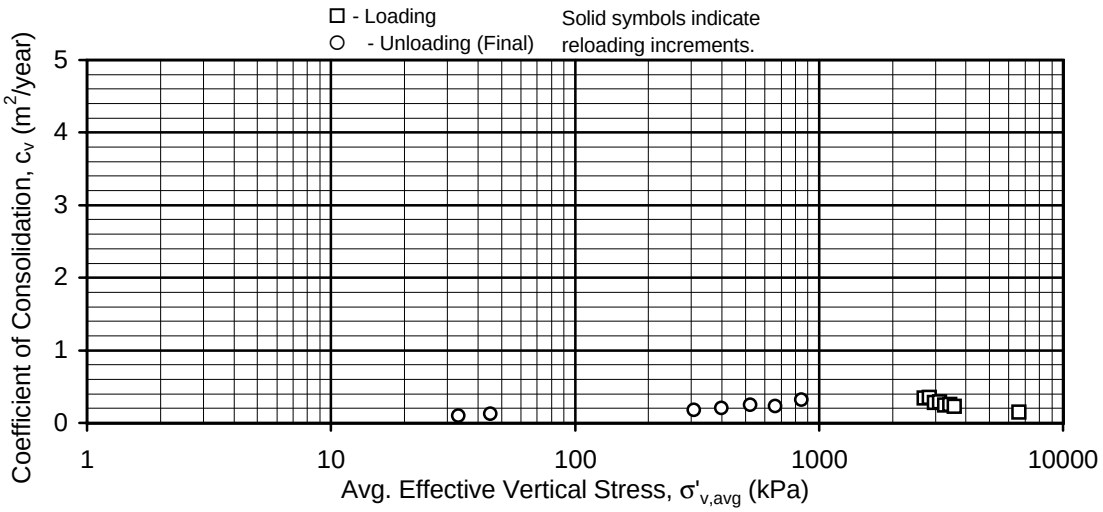


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 80- Depth: 75.5m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14g

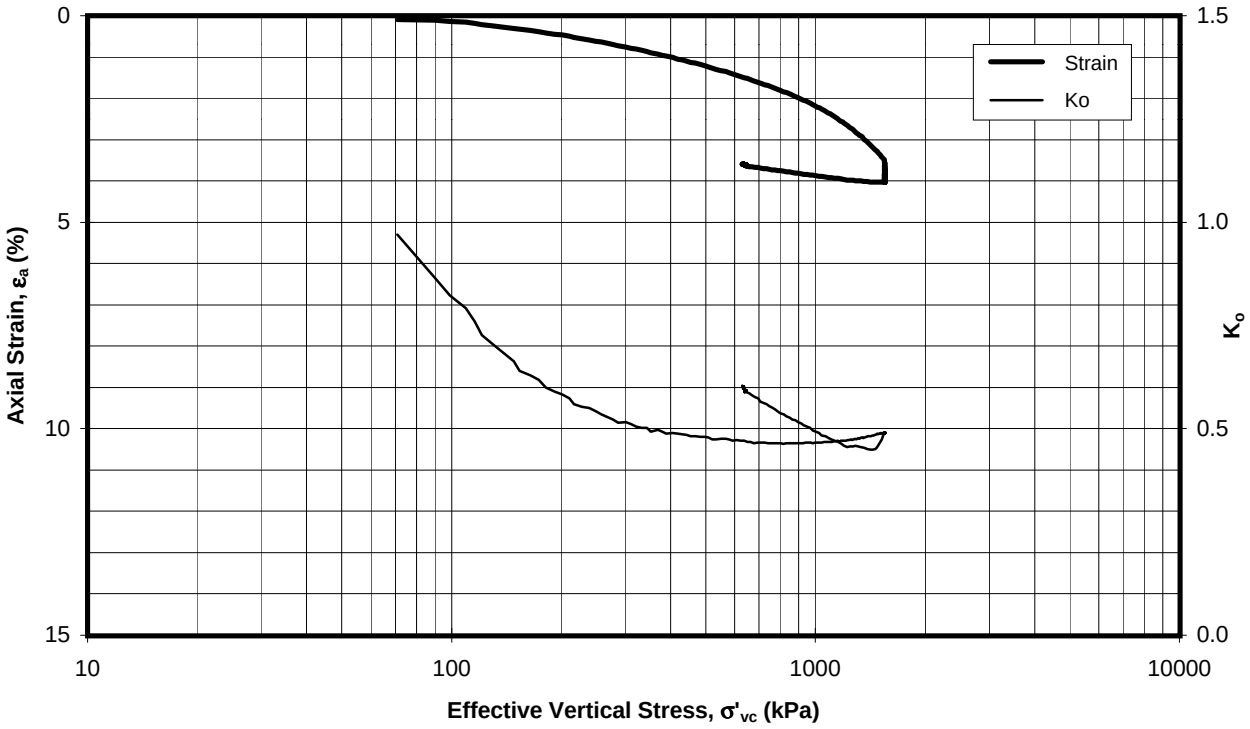


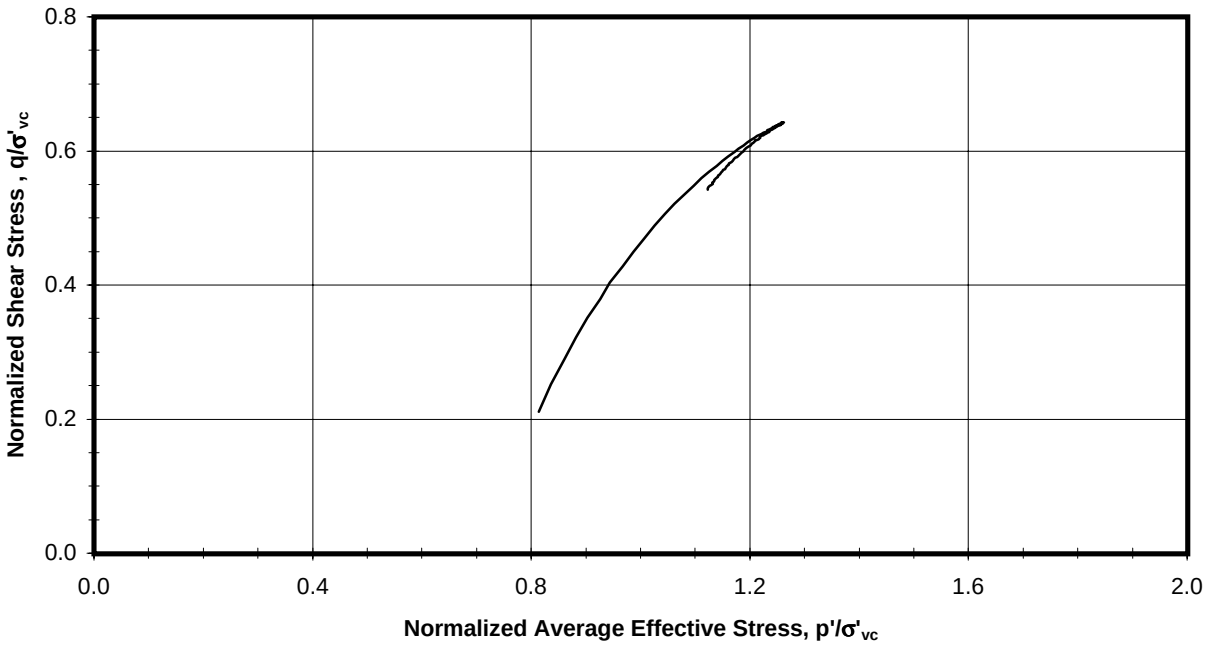


CRS CONSOLIDATION TEST RESULTS

Sample No. 106A - Depth: 99.0m
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.14h





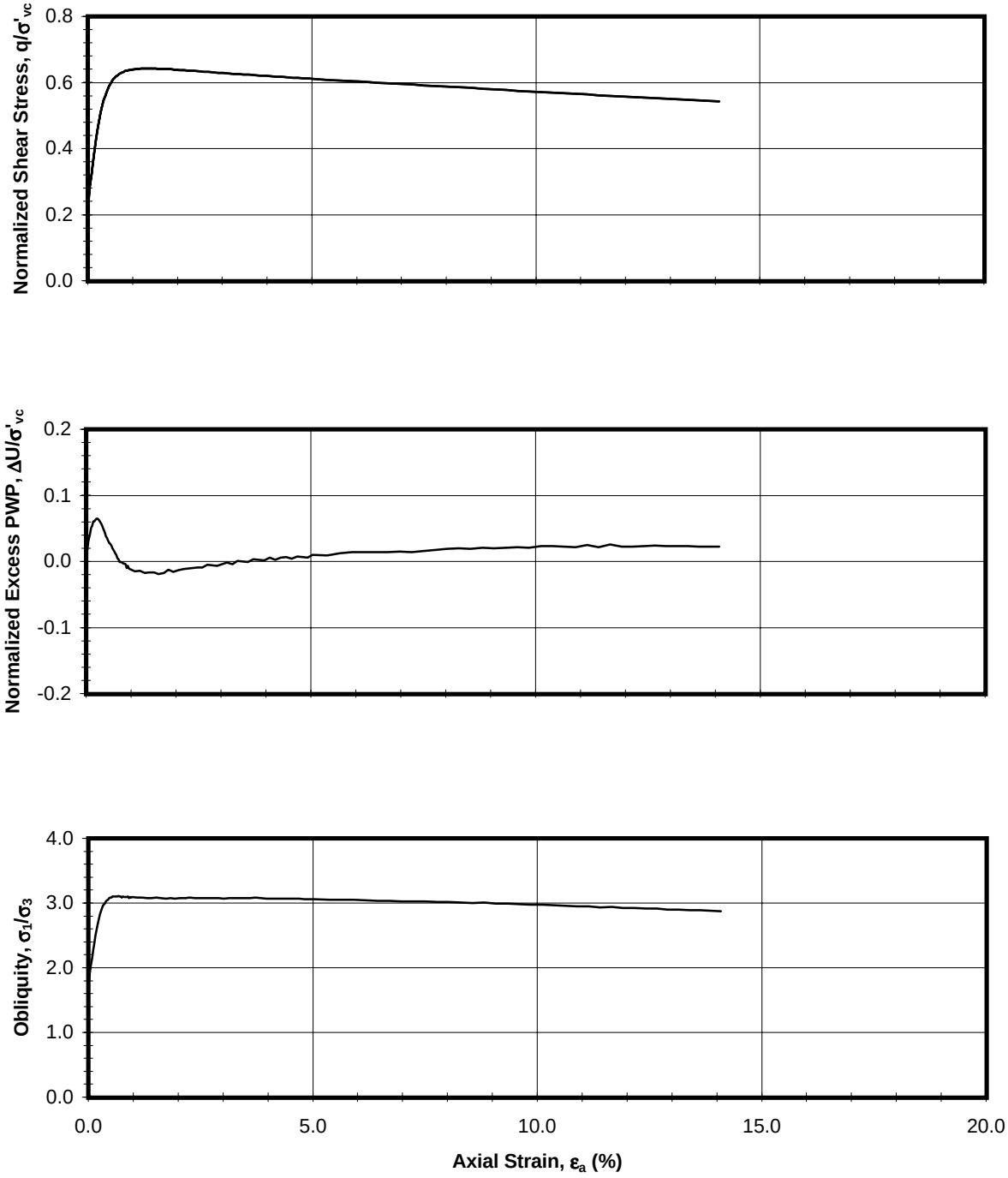
Ko CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 80 - Depth: 75.5m

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.15a.1



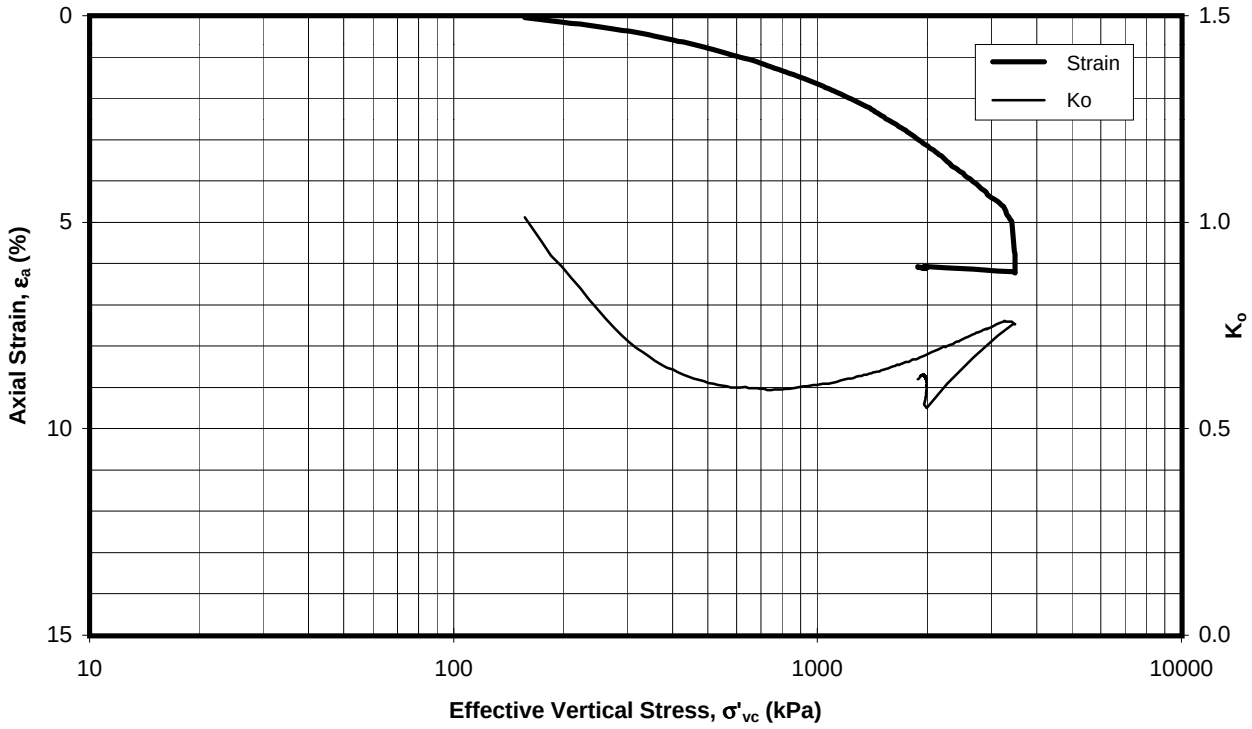
Ko CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

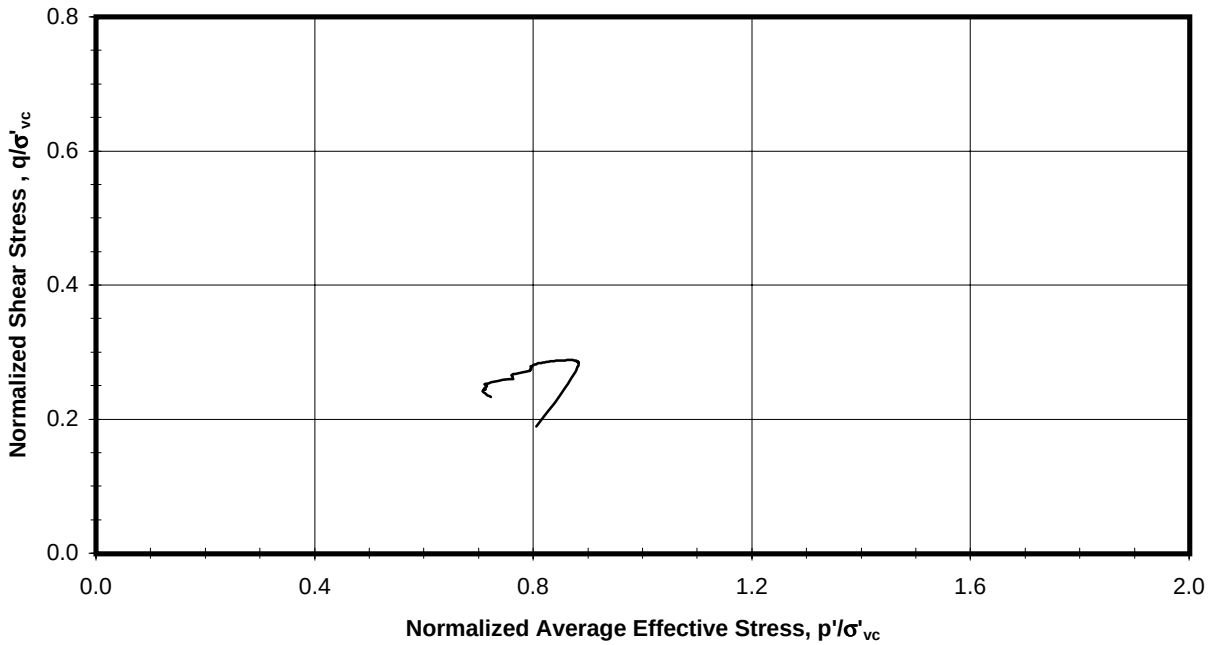
Sample No. 80 - Depth: 75.5m

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.15a.2





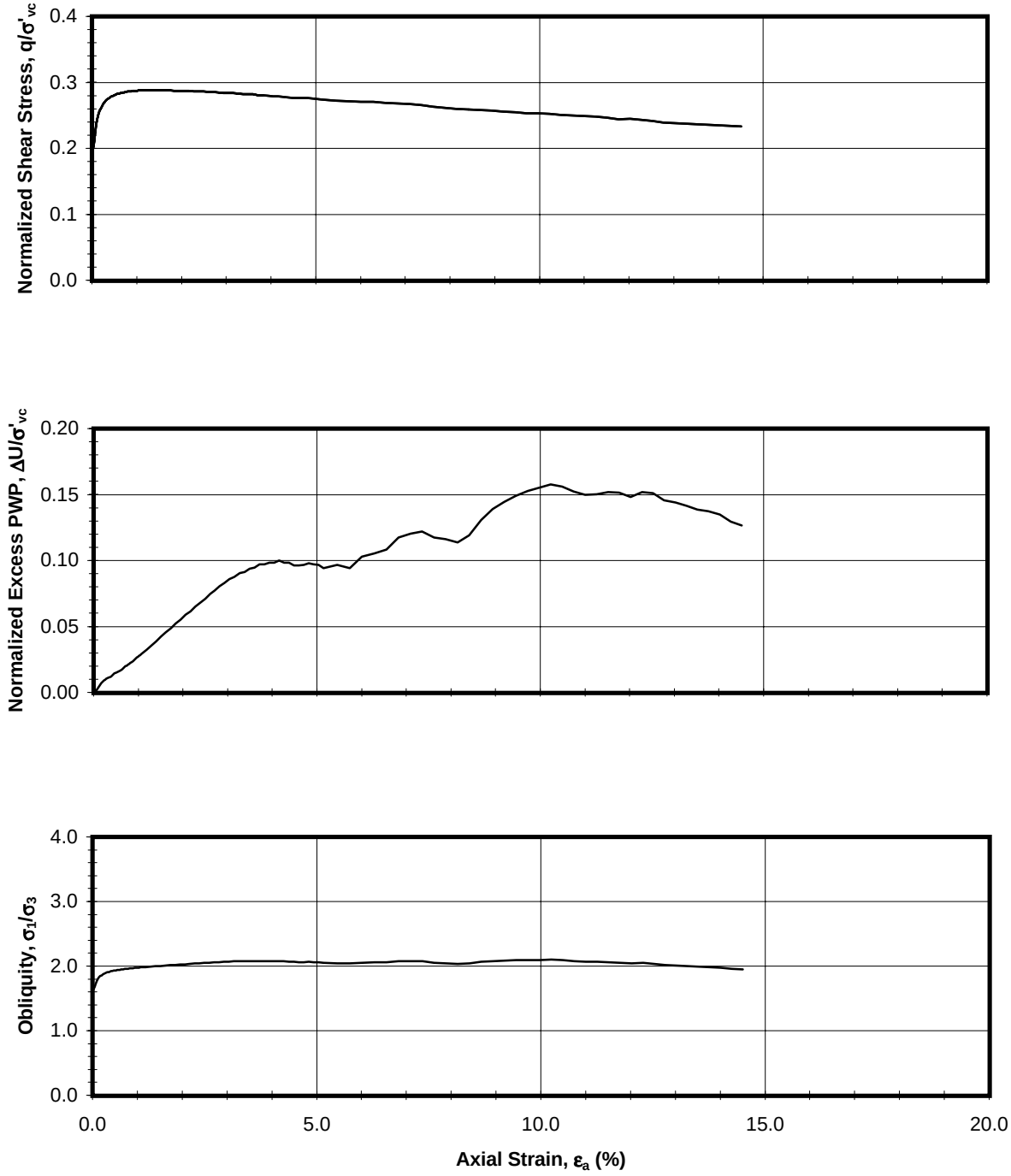
Ko CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

Sample No. 106 - Depth: 99.0m

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.15b.1



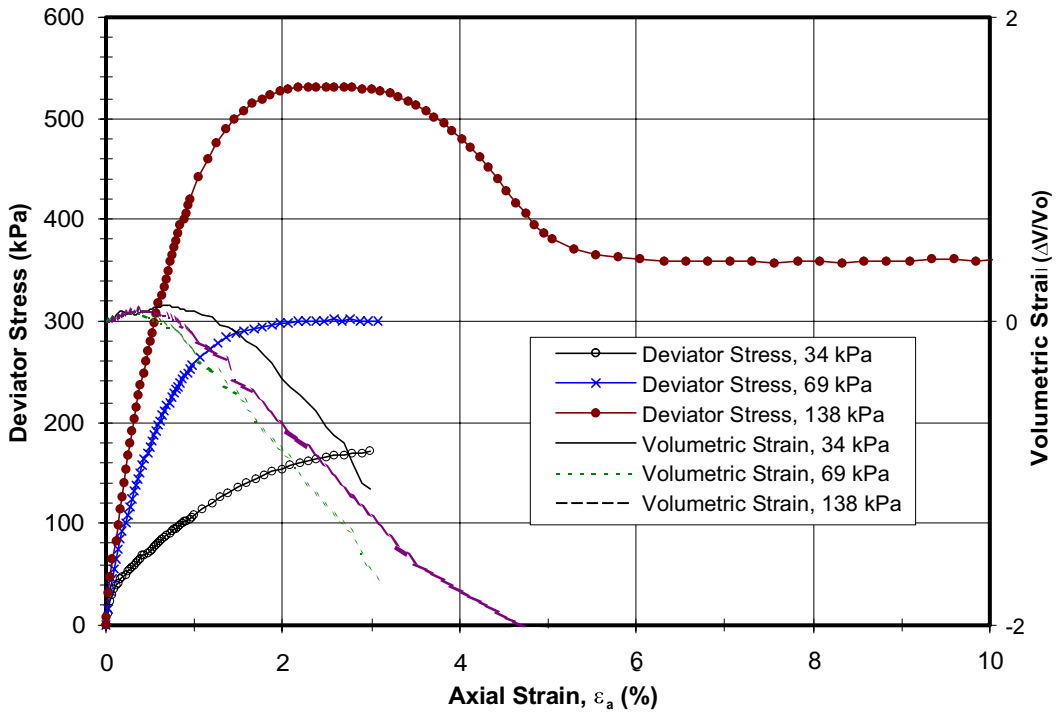
Ko CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

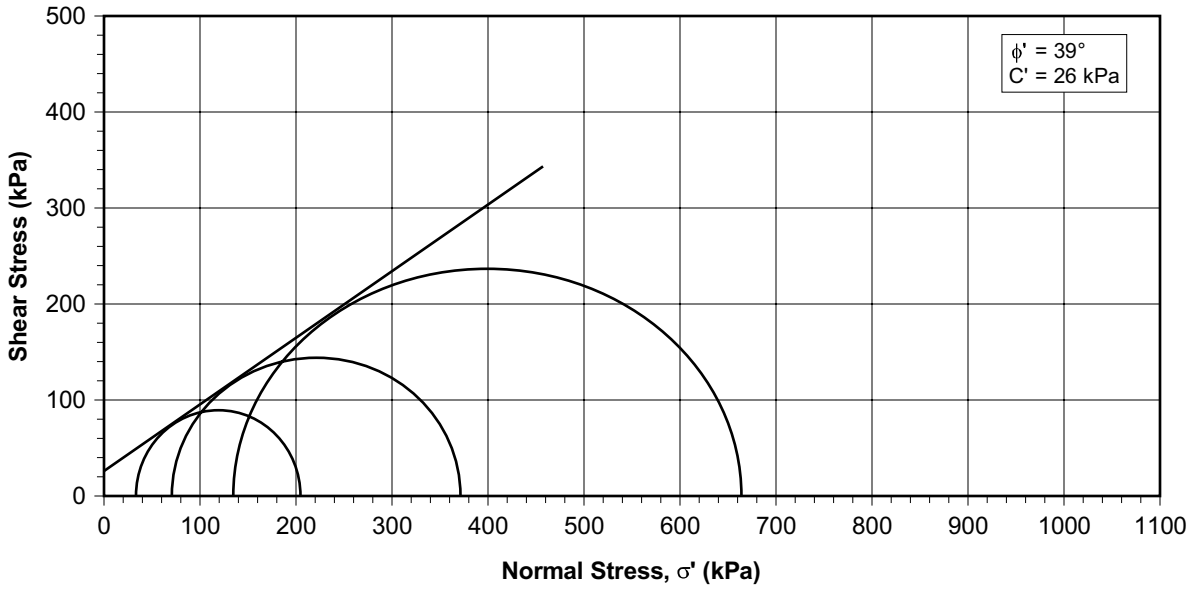
Sample No. 106 - Depth: 99.0m

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.15b.2





ISOTROPICALLY CONSOLIDATED-DRAINED TRIAXIAL COMPRESSION TEST

Sample 26 - Depth: 11.1m

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.16

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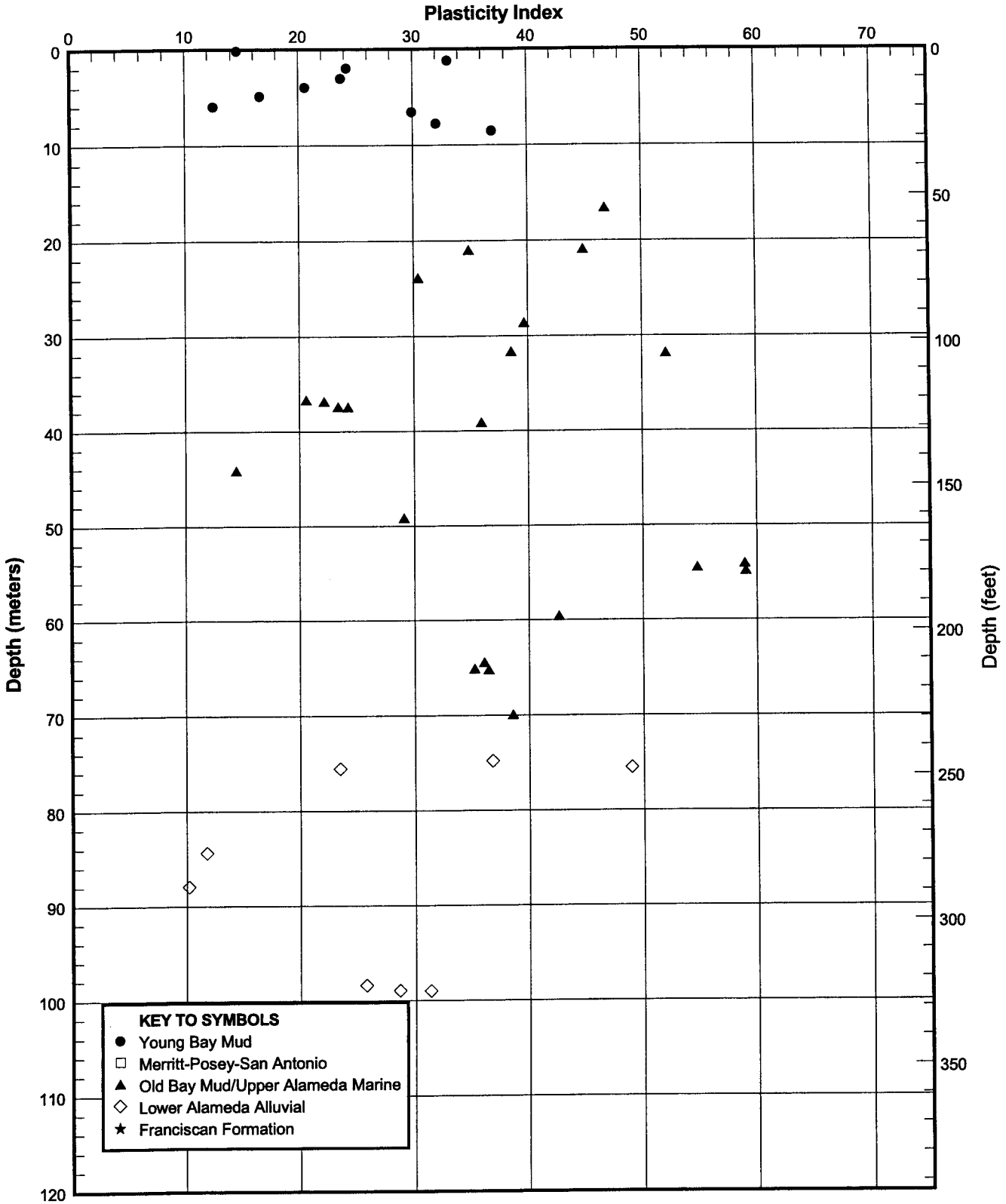
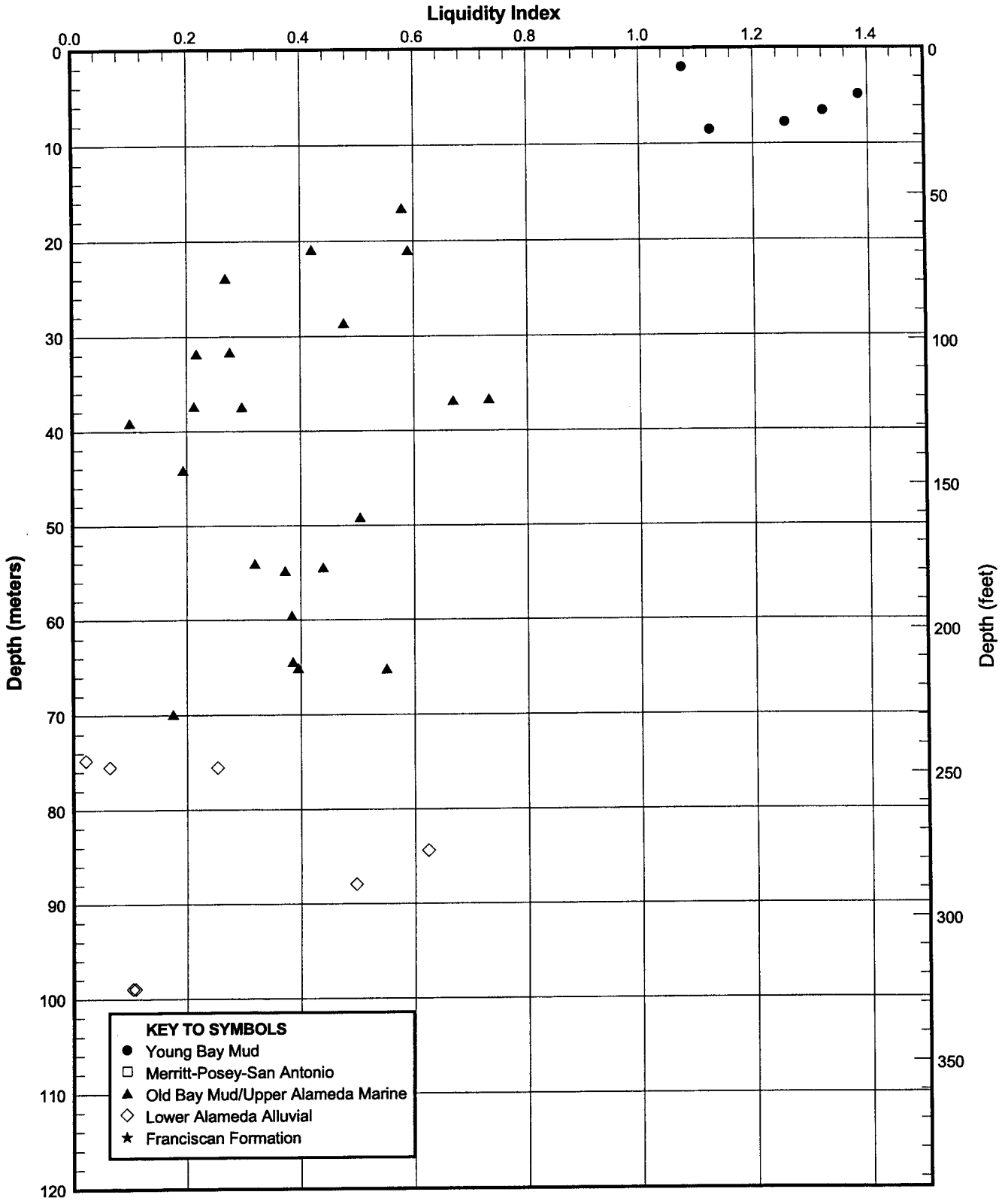
Earth Mechanics

FUGRO



PLASTICITY INDEX PROFILE
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.17

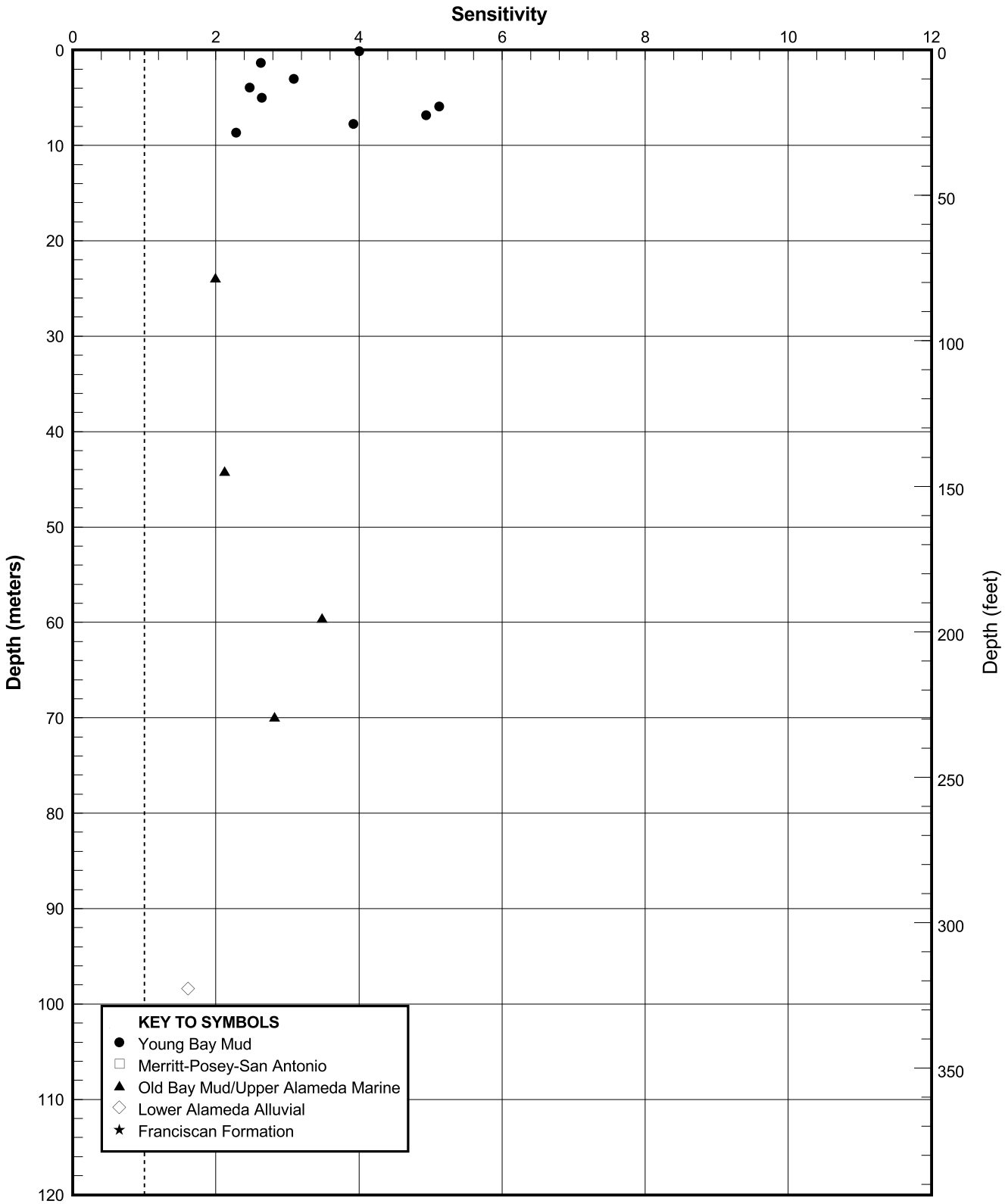


LIQUIDITY INDEX PROFILE
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.18

Earth Mechanics

FUGRO

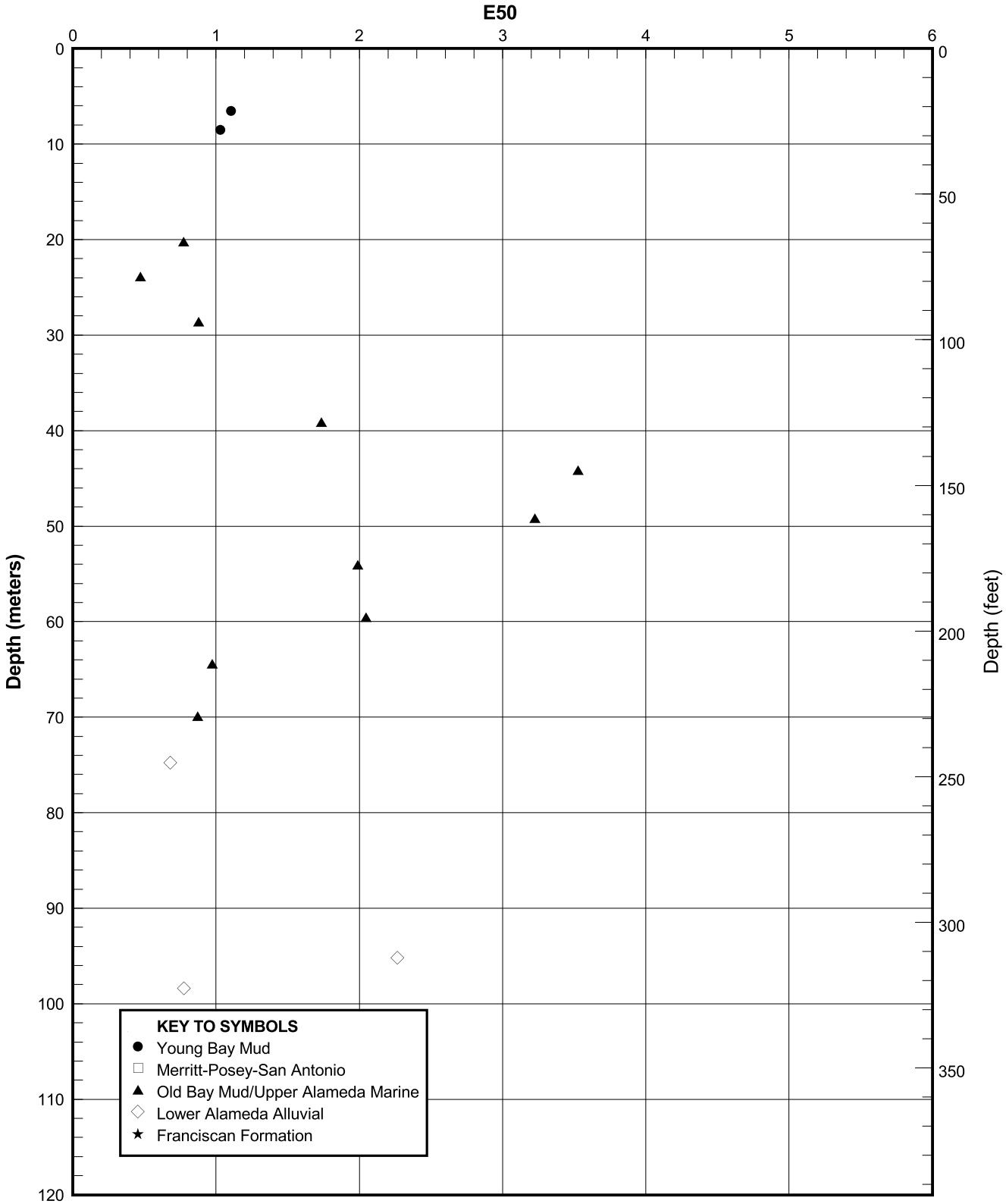


SENSITIVITY PROFILE
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.19

Earth Mechanics

FUGRO

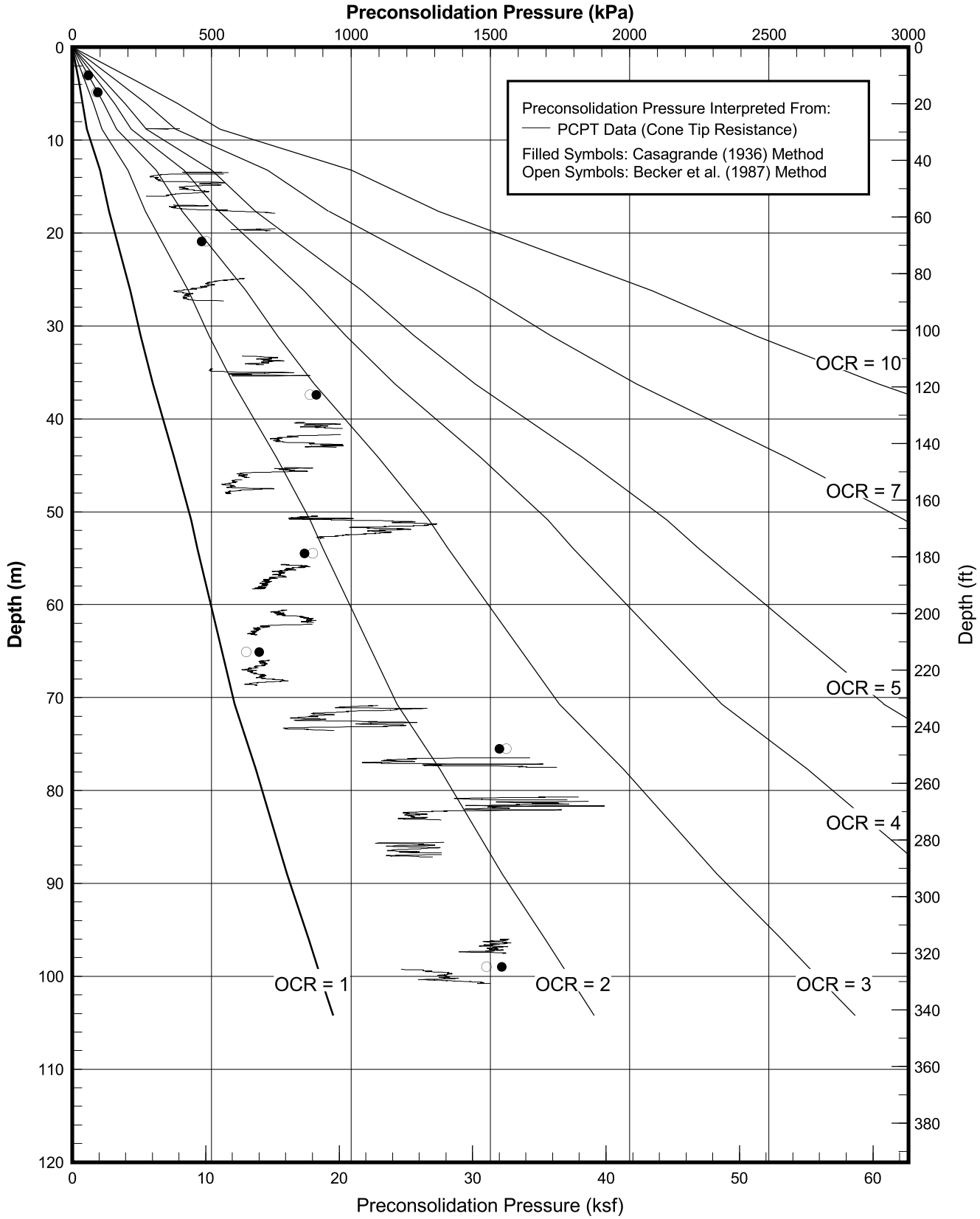


E50 PROFILE
Boring 98-39
SFOBB East Span Seismic Safety Project

PLATE 98-39.20

Earth Mechanics

FUGRO



PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA

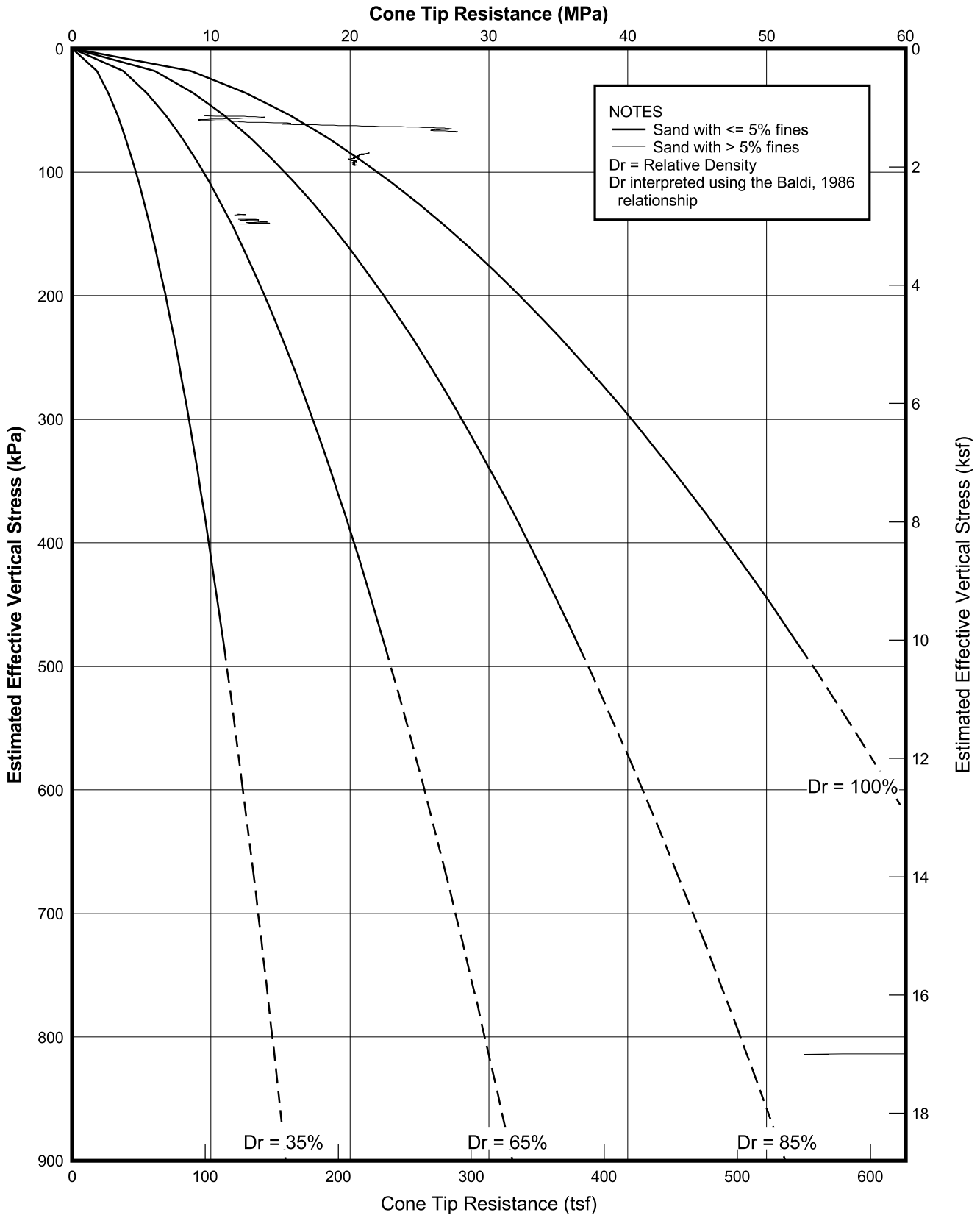
Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.21

Earth Mechanics

FUGRO



RELATIVE DENSITY INTERPRETED FROM CPT DATA

Boring 98-39

SFOBB East Span Seismic Safety Project

PLATE 98-39.22

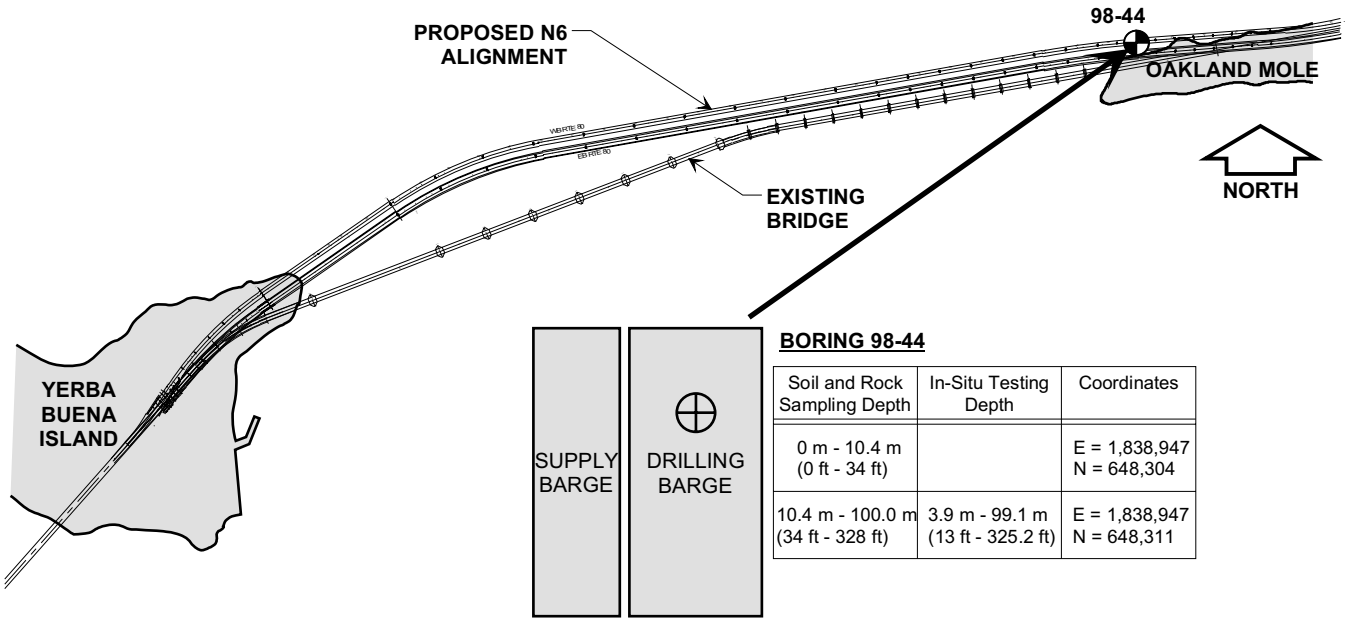
MARINE BORING 98-44

Date	Time		Description of Activity
	From	To	
November 13, 1998	0700	0800	Move barge to location 98-44. Set 4 anchors and 2 spuds.
	0800	0815	Measure water depth of 1.7m (5.7 ft) using bottom sensor. Current tide level is approximately +0.9m (+2.8 ft) MSL. Calculate mudline elevation of –0.9m (-2.9 ft) MSL.
	0815	0840	Rig up for drilling.
	0840	1020	Drill and sample from mudline to 10.4m (34 ft). Pull drill pipe to deck.
	1020	1700	Reposition barge. Reconfigure stinger.
	1700	2400	Set casing.
November 14, 1998	0000	0200	Drive stinger to 8.7m (28.5 ft).
	0200	0330	Lower drill pipe to mudline and service piston.
	0330	0600	Drill, sample, and CPT testing from mudline to 11.6m (38 ft).
	0600	0700	Perform maintenance on CPT tool. Change flow control valve.
	0700	1205	Loss of mud circulation. Drive stinger to 9.3m (30.5 ft). Barge not level due to uneven mudline.
	1205	1500	Slip joint lodged in moon pool. Pull drill pipe and casing to deck.
	1500	1720	Wait on tide to winch over. Perform maintenance on rig.
	1720	1730	Pull 2 spuds. Attempt to winch over. Barge stuck in mud.
	1730	1800	Wait on tide.
	1800	1900	Wait on tide. Attempt to winch barge over.
	1900	1930	Reposition barge. Set 2 spuds.
	1930	2400	Set casing. Reconfigure slip joint.
November 15, 1998	0000	0245	Attempt to align and drive casing. Unable to maintain plumb in casing while barge rests on sloping ground.
	0245	0615	Wait on tide.
	0615	0740	Drive stinger to 8.2m (27 ft).
	0740	0810	Drill to 7.6m (25 ft). Drill and sample from 7.6 to 9.5m (25 to 31 ft).
	0810	0850	Perform CPT pipe test. Bad flow recorded during test.
	0850	0930	Replace CPT flow control unit and metering cylinder. Perform deck test.
	0930	0935	Perform CPT pipe test.
	0935	1100	Drill, sample, and CPT testing from 9.5m (31 ft) to 14m (46 ft).
	1100	2030	Loss of circulation. Add on a length of casing and perform maintenance on mud circulation system.
	2030	2400	Drill, sample, and CPT testing from 14m (46 ft) to 18.3m (60 ft).

SUMMARY OF FIELD OPERATIONS
Boring 98-44
SFOBB East Span Seismic Safety Project

Date	Time		Description of Activity
	From	To	
November 16, 1998	0000	0015	Realign casing.
	0015	1500	Drill, sample, and CPT testing from 27.4m (90 ft) to 100m (328 ft).
	1500	1525	Pull drill pipe to deck.
	1525	1600	Commence P- and S-wave velocity logging. Short circuit in cable.
	1600	1815	Perform repair on suspension logging tool.
	1815	2000	P- and S-wave velocity logging from 80.5m (264.1 ft) to 8.5m (27.9 ft).
	2000	2045	Lower N-rod.
	2045	2200	Mix and circulate cement grout. Grout boring 98-44.
	2200	2230	Pull N-rod to deck.
	2230	2400	Pull casing to deck.
November 17, 1998	0000	0030	Pull casing to deck.
	0030	0350	Travel to Pier 50, San Francisco, to re-ballast and perform maintenance on barge.

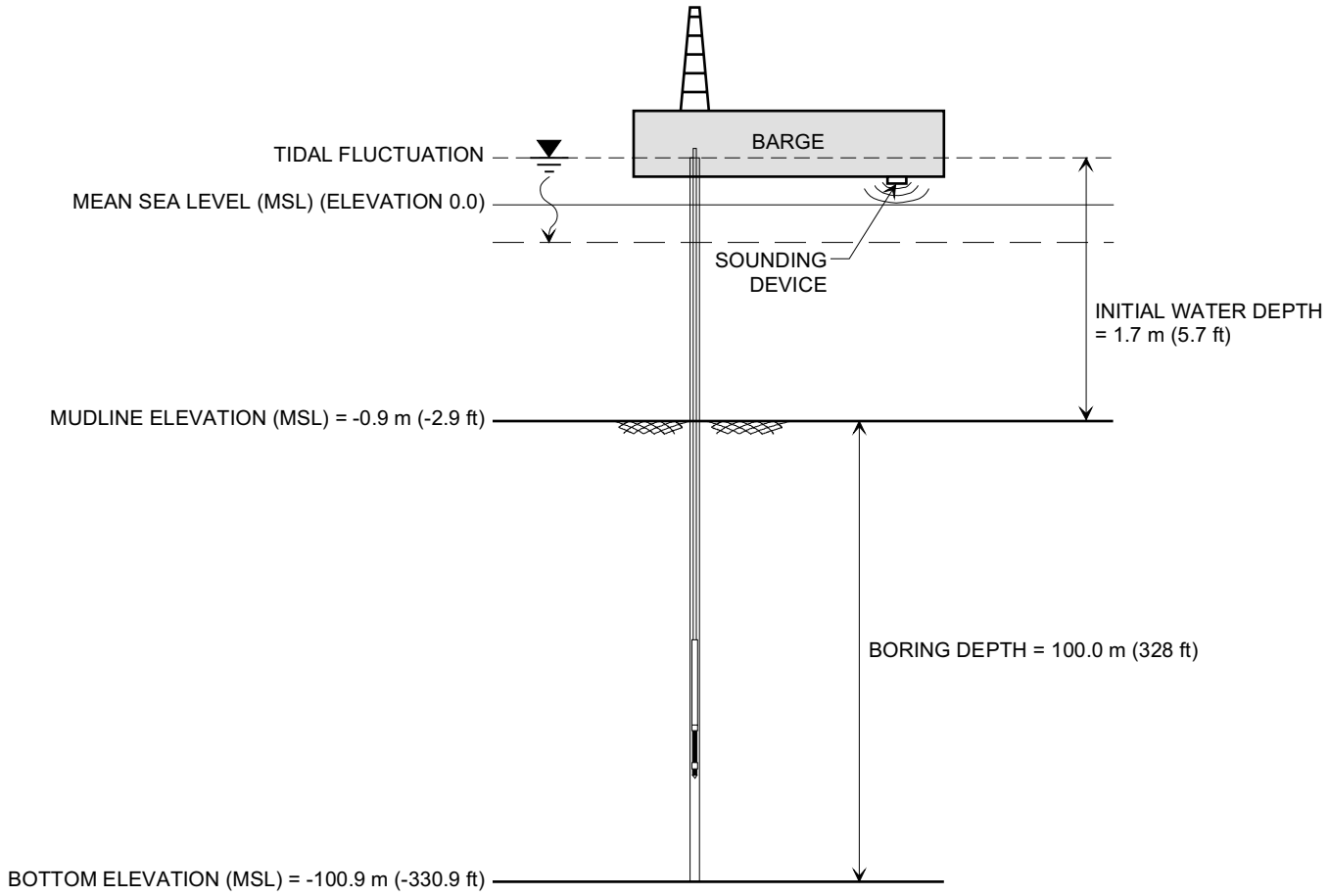
SUMMARY OF FIELD OPERATIONS
Boring 98-44
SFOBB East Span Seismic Safety Project



BORING 98-44

Soil and Rock Sampling Depth	In-Situ Testing Depth	Coordinates
0 m - 10.4 m (0 ft - 34 ft)		E = 1,838,947 N = 648,304
10.4 m - 100.0 m (34 ft - 328 ft)	3.9 m - 99.1 m (13 ft - 325.2 ft)	E = 1,838,947 N = 648,311

Coordinates in NAD83, CA Zone 3, meters.



DEPTH AND LOCATION REFERENCE MAP
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.2

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PROJECT NO: 98-42-0054
BORING: 98-44 (Oakland Shore Approach)
START DATE: 11/13/98
COMPLETION DATE: 11/17/98
DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
				WOH	Fine SAND (SP), loose, dark gray (1.3m)	I
				WOH	Fat CLAY (CH), soft to firm, olive gray.	II
				WOH	-dark gray, with silty sand layers, to 2.4m	
-4	4			WOH	-with shells and shell fragments, below 2.7m	
				WOH	-clayey sand at 3.2m	
				7/60cm	-with silt pockets, 3.7m to 7.0m	
-8	8			6/60cm		
				8/60cm		
				9/60cm	-with mica at 7.6m	
				PUSH		
				SAVE	-with mica and an H2S odor, at 9.1m (10.1m)	
				10/60cm		
-12	12			30/25cm	Silty Fine to Medium SAND (SM), very dense, greenish gray	III
				PUSH	-clay layer, 11.0m to 11.3m	
					-clay layer, 13.7m to 14.0m	
				PUSH	(15.4m)	
-16	16				Fat CLAY (CH), stiff to very stiff, greenish gray	IV
					-silt layer, 15.8m to 16.0m	
				PUSH	-with sand pockets, wood fragments, and organic matter pockets, at 18.6m	
-20	20				-with a silt layer at 19.5m (20.1m)	
					Fat CLAY (CH), very stiff, greenish gray	V
					-sand layer, 20.4m to 20.7m	
					-sand layer, 21.0m to 21.3m	
				PUSH	-with silt pockets, partings, and seams, and mica, at 22.9m	
-24	24				(25.8m)	
					Fat CLAY (CH), very stiff to hard, dark greenish gray	VI
				PUSH	-with silt pockets	
-28	28			SAVE	-sandy clay at 27.9m	
				SAVE	-with mica and shell fragments, 28.7m to 29.9m	
					See Plate 98-44.6 for detailed stratigraphy	
-32	32				(34.1m)	
				PUSH	Fat CLAY (CH), very stiff, greenish gray	VII
-36	36				-lean clay with mica, and calcareous nodules, to 34.7m	
				PUSH	-with silt pockets and partings, and with wood fragments and organic matter pockets, at 37.2m	
					(38.7m)	
-40	40				Lean CLAY (CL), very stiff to hard, greenish gray	VIII
					-with silt layers	
				PUSH	-with organic matter pockets at 42.1m	
-44	44				(43.6m)	
					Fat CLAY (CH), very stiff to hard, greenish gray	IX
				PUSH	-with silt pockets and partings, mica, and with gas blisters, at 46.9m	
-48	48			SAVE		
					(51.2m)	
-52	52				Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense, dark greenish gray (52.4m)	X
				PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	XI
					-with silt partings and mica at 52.4m	
-56	56				-silt layer, 54.1m to 54.3m	
				PUSH	-fissured, and with a few shell fragments, at 57.3m	
-60	60					
				PUSH	-with mica at 62.2m	
-64	64			SAVE		
-68	68			PUSH	-with wood fragments and organic matter pockets, below 68.0m	
-72	72					
				PUSH	-with gas blisters at 74.4m	
-76	76				(76.2m)	
					Lean CLAY (CL), hard, greenish gray	XII
					-with sand seams at 78.0m	
-80	80				-with a silt layer at 78.6m	
				PUSH	-mottled with gray, and with gas blisters, at 80.5m	
				SAVE	-with silt seams at 81.4m	
					-sand layer, 82.6m to 82.9m	
-84	84				-interlayered, silt and clay, below 82.9m (84.3m)	
				PUSH	Silty Fine SAND (SM), dense, greenish gray (86.0m)	XIII
-88	88				Lean CLAY (CL), hard, greenish gray	XIV
					-sand layer, 87.5m to 87.8m	
					-sand layer, 87.9m to 88.0m	
-92	92			30/20cm	(91.4m)	
					Fine to Medium SAND (SP), dense to very dense, greenish gray	XV
					-silty sand to 92.4m	
-96	96			30/10cm	-with a clay layer at 92.0m	
					(96.8m)	
					Fat CLAY (CH), hard, greenish gray	XVI
-100	100			PUSH	-slickensided at 99.7m	
					TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout	
-104	104					
-108	108					
-112	112					
-116	116					
-120						

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

CPT INTERVAL

PLATE 98-44.3

LOG OF BORING AND TEST RESULTS
BORING 98-44
SFOBB East Span Seismic Safety Project

Report Date: 05/03/99

FUGRO

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PROJECT NO: 98-42-0054
BORING: 98-44 (Oakland Shore Approach)

START DATE: 11/13/98
COMPLETION DATE: 11/17/98

DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
		WOH	Fine SAND (SP), loose, dark gray (1.3m)	I
-4	4	WOH WOH WOH WOH WOH	Fat CLAY (CH), soft to firm, olive gray. See Plate 98-44.6 for detailed stratigraphy	II
-8	8	7/60cm 6/60cm 8/60cm PUSH 9/60cm SAVE 10/60cm 30/25cm	(10.1m)	
-12	12	PUSH	Silty Fine to Medium SAND (SM), very dense, greenish gray -clay layer, 11.0m to 11.3m -clay layer, 13.7m to 14.0m	III
-16	16	PUSH	(15.4m)	
-20	20	PUSH	Fat CLAY (CH), stiff to very stiff, greenish gray	IV
-24	24	PUSH	(20.1m) Fat CLAY (CH), very stiff, greenish gray -sand layer, 20.4m to 20.7m -sand layer, 21.0m to 21.3m	V
-28	28	PUSH SAVE SAVE SAVE	(25.8m) Fat CLAY (CH), very stiff to hard, dark greenish gray	VI
-32	32	PUSH	(34.1m) Fat CLAY (CH), very stiff, greenish gray	
-36	36	PUSH	-lean clay with mica, and calcareous nodules, to 34.7m	VII
-40	40	PUSH	(38.7m) Lean CLAY (CL), very stiff to hard, greenish gray	VIII
-44	44	PUSH SAVE	(43.6m) Fat CLAY (CH), very stiff to hard, greenish gray	IX
-52	52	PUSH	(51.2m) (52.4m) Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense, dark greenish gray	X
-56	56	PUSH	Fat CLAY (CH), very stiff to hard, greenish gray	XI
-60	60	PUSH SAVE		
-64	64			
-68	68	PUSH	-with wood fragments and organic matter pockets, below 68.0m	
-72	72			
-76	76	PUSH	-with gas blisters at 74.4m (76.2m) Lean CLAY (CL), hard, greenish gray	XII
-80	80	PUSH SAVE		
-84	84		-sand layer, 82.6m to 82.9m (84.3m)	
-88	88	PUSH	Silty Fine SAND (SM), dense, greenish gray (86.0m) Lean CLAY (CL), hard, greenish gray -sand layer, 87.5m to 87.8m -sand layer, 87.9m to 88.0m	XIII XIV
-92	92	30/20cm	(91.4m) Fine to Medium SAND (SP), dense to very dense, greenish gray -silty sand to 92.4m -with a clay layer at 92.0m	XV
-96	96	30/10cm	(96.8m)	
-100	100	PUSH	Fat CLAY (CH), hard, greenish gray -slickensided at 99.7m	XVI
-104	104		TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout	
-108	108			
-112	112			
-116	116			
-120				

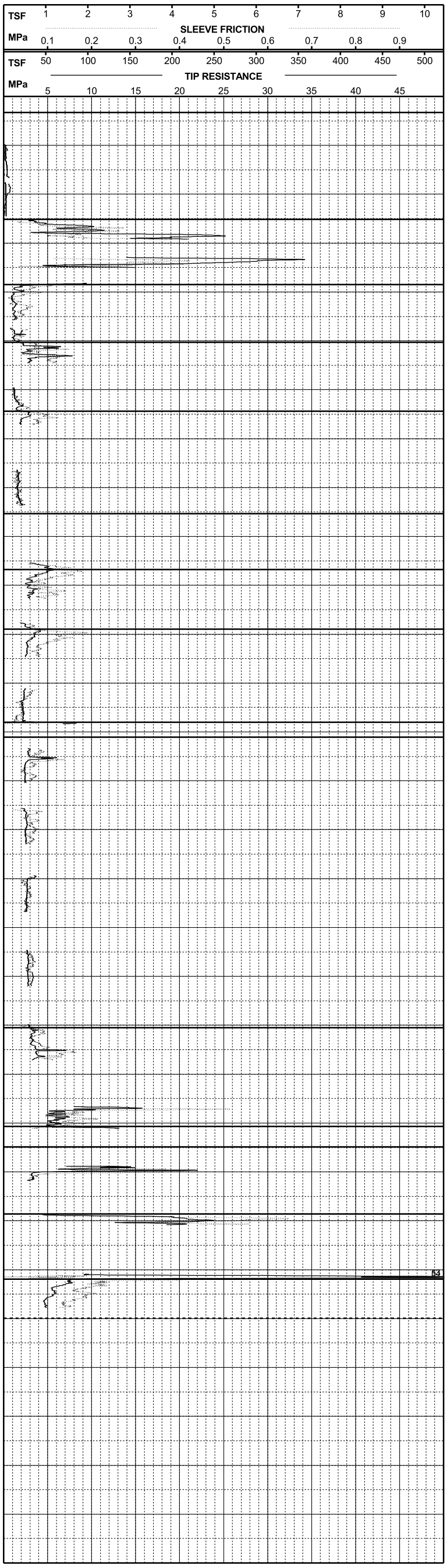

PLATE 98-44.4

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 05/03/99

FUGRO

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PROJECT NO: 98-42-0054
BORING: 98-44 (Oakland Shore Approach)
START DATE: 11/13/98
COMPLETION DATE: 11/17/98
DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
				WOH	Fine SAND (SP), loose, dark gray (1.3m)	I
-4	4			WOH	Fat CLAY (CH), soft to firm, olive gray.	II
				WOH		
				WOH		
				WOH		
				7/60cm	See Plate 98-44.6 for detailed stratigraphy	
-8	8			6/60cm		
				8/60cm		
				PUSH		
				SAVE		
				10/60cm		
				30/25cm	(10.1m)	
-12	12			PUSH	Silty Fine to Medium SAND (SM), very dense, greenish gray -clay layer, 11.0m to 11.3m -clay layer, 13.7m to 14.0m	III
				PUSH	(15.4m)	
-16	16				Fat CLAY (CH), stiff to very stiff, greenish gray -silt layer, 15.8m to 16.0m	IV
				PUSH	(20.1m)	
-20	20				Fat CLAY (CH), very stiff, greenish gray -sand layer, 20.4m to 20.7m -sand layer, 21.0m to 21.3m	V
-24	24			PUSH	(25.8m)	
-28	28			PUSH SAVE SAVE SAVE	Fat CLAY (CH), very stiff to hard, dark greenish gray -sandy clay at 27.9m -with mica and shell fragments, 28.7m to 29.9m	VI
-32	32				(34.1m)	
-36	36			PUSH	Fat CLAY (CH), very stiff, greenish gray -lean clay with mica, and calcareous nodules, to 34.7m -with silt pockets and partings, and with wood fragments and organic matter pockets, at 37.2m	VII
				PUSH	(38.7m)	
-40	40				Lean CLAY (CL), very stiff to hard, greenish gray -with silt layers	VIII
				PUSH	-with organic matter pockets at 42.1m	
-44	44				(43.6m)	
-48	48			PUSH SAVE	Fat CLAY (CH), very stiff to hard, greenish gray -with silt pockets and partings, mica, and with gas blisters, at 46.9m	IX
					(51.2m)	
-52	52			PUSH	Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense, dark greenish gray (52.4m)	X
-56	56			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -with silt partings and mica at 52.4m -silt layer, 54.1m to 54.3m -fissured, and with a few shell fragments, at 57.3m	XI
-60	60					
				PUSH SAVE	-with mica at 62.2m	
-64	64					
-68	68			PUSH	-with wood fragments and organic matter pockets, below 68.0m	
-72	72					
				PUSH	-with gas blisters at 74.4m	
-76	76				(76.2m)	
-80	80			PUSH SAVE	Lean CLAY (CL), hard, greenish gray -with sand seams at 78.0m -with a silt layer at 78.6m -mottled with gray, and with gas blisters, at 80.5m -with silt seams at 81.4m	XII
-84	84				-sand layer, 82.6m to 82.9m -interlayered, silt and clay, below 82.9m (84.3m)	
				PUSH	Silty Fine SAND (SM), dense, greenish gray (86.0m)	XIII
-88	88				Lean CLAY (CL), hard, greenish gray -sand layer, 87.5m to 87.8m -sand layer, 87.9m to 88.0m	XIV
				30/20cm	(91.4m)	
-92	92				Fine to Medium SAND (SP), dense to very dense, greenish gray -silty sand to 92.4m -with a clay layer at 92.0m	XV
-96	96			30/10cm	(96.8m)	
-100	100			PUSH	Fat CLAY (CH), hard, greenish gray -slickensided at 99.7m	XVI
-104	104				TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout	
-108	108					
-112	112					
-116	116					
-120						

SHEAR WAVE VELOCITY: ft/s 2,500 5,000; m/s 0,500 1,000 1,500 2,000
COMPRESSION WAVE VELOCITY: ft/s 2,500 5,000; m/s 500 1,000 1,500 2,000
RESISTIVITY: ohm-ft 50 100 150 200 250; ohm-m 20 40 60
NATURAL GAMMA (API UNITS): 40 80 120
CALIPER: in 2 4 6 8 10 12 14; cm 5 10 15 20 25 30 35

PLATE 98-44.5

LOG OF BORING AND TEST RESULTS
BORING 98-44
SFOBB East Span Seismic Safety Project

Report Date: 05/05/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	11/13/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-44 (Oakland Shore Approach)	**COMPLETION DATE:**	11/17/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-1				WOH	Fine SAND (SP), loose, dark gray -with shell fragments	I
	1				(1.3m)	
-2				WOH	Fat CLAY (CH), soft to firm, olive gray. -dark gray, with silty sand layers, to 2.4m	II
-3	2			WOH		
					-with shells and shell fragments, below 2.7m	
-4	3			WOH	-clayey sand at 3.2m	
					-with silt pockets, 3.7m to 7.0m	
-5	4			WOH		
-6	5			WOH		
-7	6			7/60cm		
-8	7			6/60cm		
-9	8			8/60cm	-with mica at 7.6m	
				PUSH 9/60cm		
-10	9			SAVE 10/60cm	-with mica and an H2S odor, at 9.1m	
	10				(10.1m)	
-11				30/25cm	Silty Fine to Medium SAND (SM), very dense, greenish gray -sandy clay with mica at 10.4m	III
	11				-with a clay layer at 10.8m -clay layer, 11.0m to 11.3m	
-12					-with a clay layer at 11.6m	
	12					
-13				PUSH	-with ferrous stains at 12.5m	
	13					
-14					-clay layer, 13.7m to 14.0m	
	14					
-15				PUSH	-with a few clay pockets at 14.6m	
-16	15				(15.4m)	
					Fat CLAY (CH), stiff to very stiff, greenish gray -silt layer, 15.8m to 16.0m	IV
-17	16					
-18	17					
-19	18			PUSH	-with sand pockets, wood fragments, and organic matter pockets, at 18.6m	
-20	19				-with a silt layer at 19.5m	
	20				(20.1m)	
-21					Fat CLAY (CH), very stiff, greenish gray -sand layer, 20.4m to 20.7m	V
	21				-sand layer, 21.0m to 21.3m	
-22						
	22					
-23						
	23			PUSH	-with silt pockets, partings, and seams, and mica, at 22.9m	
-24						
	24					
-25						
	25					
-26						
					(25.8m)	
-27	26				Fat CLAY (CH), very stiff to hard, dark greenish gray -with silt pockets	VI
-28	27			PUSH	-sandy clay at 27.9m	
-29	28			SAVE		
					-with mica and shell fragments, 28.7m to 29.9m	
-30	29			SAVE		
-31	30			SAVE		
-32	31					
-33	32					
-34	33					
-35	34				(34.1m)	
				PUSH	Fat CLAY (CH), very stiff, greenish gray -lean clay with mica, and calcareous nodules, to 34.7m	VII
-36	35					
-37	36					
-38	37			PUSH	-with silt pockets and partings, and with wood fragments and organic matter pockets, at 37.2m	
-39	38					
					(38.7m)	
-40	39				Lean CLAY (CL), very stiff to hard, greenish gray -with silt layers	VIII

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

CPT INTERVAL

PLATE 98-44.6a

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO:	98-42-0054	**START DATE:**	11/13/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-44 (Oakland Shore Approach)	**COMPLETION DATE:**	11/17/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-41	41			Lean CLAY (CL), very stiff to hard, greenish gray	VIII
-42	42	PUSH		-with organic matter pockets at 42.1m	
-43	43			(43.6m)	
-44	44			Fat CLAY (CH), very stiff to hard, greenish gray	IX
-45	45				
-46	46				
-47	47	PUSH		-with silt pockets and partings, mica, and with gas blisters, at 46.9m	
-48	48	SAVE			
-49	49				
-50	50				
-51	51			(51.2m)	
-52	52			Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense, dark greenish gray	X
-53	53	PUSH		(52.4m) Fat CLAY (CH), very stiff to hard, greenish gray -with silt partings and mica at 52.4m	XI
-54	54			-silt layer, 54.1m to 54.3m	
-55	55				
-56	56				
-57	57				
-58	58	PUSH		-fissured, and with a few shell fragments, at 57.3m	
-59	59				
-60	60				
-61	61				
-62	62				
-63	63	PUSH		-with mica at 62.2m	
-64	64	SAVE			
-65	65				
-66	66				
-67	67				
-68	68				
-69	69	PUSH		-with wood fragments and organic matter pockets, below 68.0m	
-70	70				
-71	71				
-72	72				
-73	73				
-74	74				
-75	75	PUSH		-with gas blisters at 74.4m	
-76	76			(76.2m)	
-77	77			Lean CLAY (CL), hard, greenish gray	XII
-78	78				
-79	79			-with sand seams at 78.0m -with a silt layer at 78.6m	
-80					

Min./ft 5 10 15 20 25 30
Min./m 20 40 60 80
CORING RATE

ID TESTS/RQD/RECOVERY(%)/EQ. BLOW COUNTS
20 40 60 80

KCF 0.03 0.04 0.05 0.06 0.07 0.08
kN/m^3 5 7 9 11
SUBMERGED UNIT WEIGHT

Frac./ft 1 2 3 4 5 6 7 8 9 10
Frac./m 5 10 15 20 25 30
FRACTURE DENSITY

PSI 5,000 10,000 15,000 20,000
MPa 20 40 60 80 100 120 140
ROCK UNCONFINED COMPRESSIVE STRENGTH

KSF 1.0 2.0 3.0 4.0 5.0 6.0 7.0
kPa 50 100 150 200 250 300 350
SOIL UNDRAINED SHEAR STRENGTH

CPT INTERVAL

PLATE 98-44.6b

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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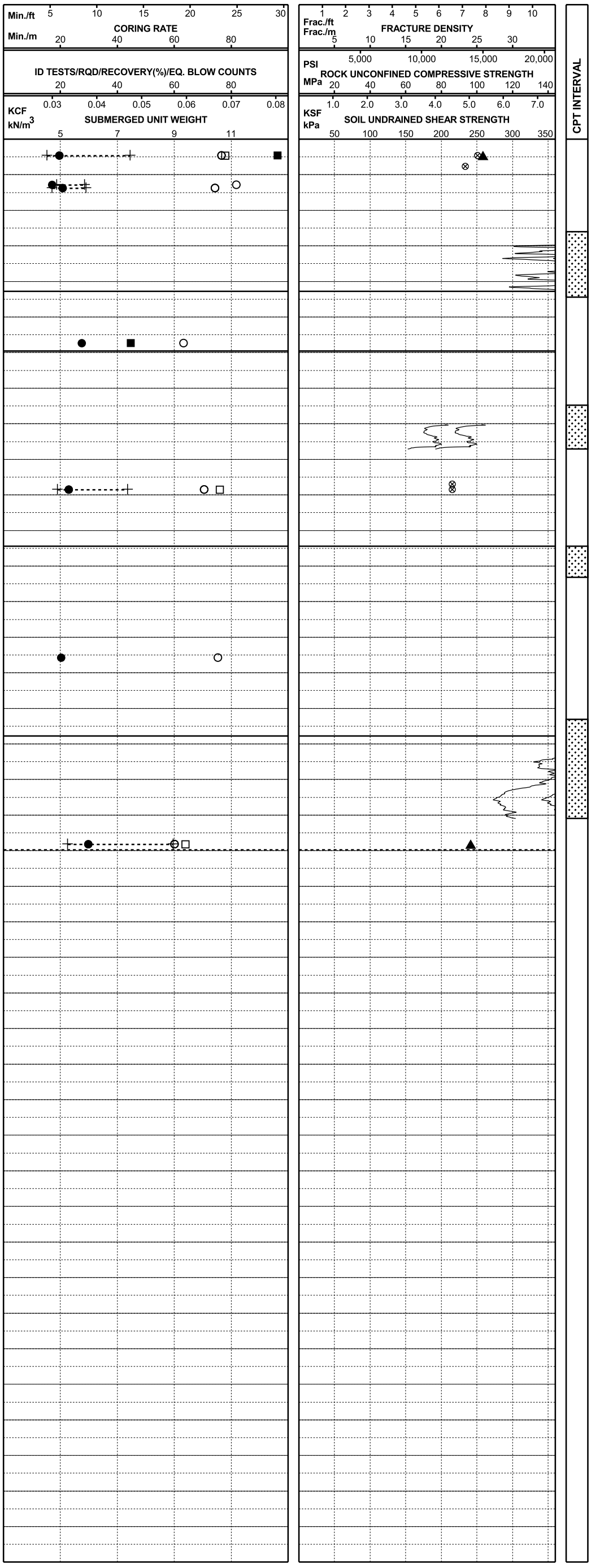
PROJECT NO:	98-42-0054	**START DATE:**	11/13/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-44 (Oakland Shore Approach)	**COMPLETION DATE:**	11/17/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-81	81			PUSH	Lean CLAY (CL), hard, greenish gray -mottled with gray, and with gas blisters, at 80.5m	
-82	82			SAVE	-with silt seams at 81.4m	
-83	83				-sand layer, 82.6m to 82.9m -interlayered, silt and clay, below 82.9m	XII
-84	84				(84.3m)	
-85	85				Silty Fine SAND (SM), dense, greenish gray	XIII
-86	86			PUSH	(86.0m)	
-87	87				Lean CLAY (CL), hard, greenish gray	
-88	88				-sand layer, 87.5m to 87.8m -sand layer, 87.9m to 88.0m	XIV
-89	89					
-90	90			30/20cm		
-91	91				(91.4m)	
-92	92				Fine to Medium SAND (SP), dense to very dense, greenish gray -silty sand to 92.4m -with a clay layer at 92.0m	XV
-93	93					
-94	94					
-95	95			30/10cm		
-96	96					
-97	97				(96.8m)	
-98	98				Fat CLAY (CL), hard, greenish gray	
-99	99					XVI
-100	100			PUSH	-slickensided at 99.7m	
-101	101				TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout	
-102	102					
-103	103					
-104	104					
-105	105					
-106	106					
-107	107					
-108	108					
-109	109					
-110	110					
-111	111					
-112	112					
-113	113					
-114	114					
-115	115					
-116	116					
-117	117					
-118	118					
-119	119					
-120						



LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

PLATE 98-44.6c

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PROJECT NO:	98-42-0054	**START DATE:**	11/13/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-44 (Oakland Shore Approach)	**COMPLETION DATE:**	11/17/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-1	1		WOH	Fine SAND (SP), loose, dark gray -with shell fragments	I
-2	2		WOH	(1.3m) Fat CLAY (CH), soft to firm, olive gray. -dark gray, with silty sand layers, to 2.4m	II
-3	3		WOH	-with shells and shell fragments, below 2.7m	
-4	4		WOH	-clayey sand at 3.2m	
-5	5		WOH	-with silt pockets, 3.7m to 7.0m	
-6	6		7/60cm		
-7	7		6/60cm		
-8	8		8/60cm	-with mica at 7.6m	
-9	9		PUSH 9/60cm		
-10	10		SAVE 10/60cm	-with mica and an H2S odor, at 9.1m	
-11	11		30/25cm	(10.1m) Silty Fine to Medium SAND (SM), very dense, greenish gray -sandy clay with mica at 10.4m -with a clay layer at 10.8m -clay layer, 11.0m to 11.3m	III
-12	12			-with a clay layer at 11.6m	
-13	13		PUSH	-with ferrous stains at 12.5m	
-14	14			-clay layer, 13.7m to 14.0m	
-15	15		PUSH	-with a few clay pockets at 14.6m	
-16	16			(15.4m) Fat CLAY (CH), stiff to very stiff, greenish gray -silt layer, 15.8m to 16.0m	IV
-17	17				
-18	18				
-19	19		PUSH	-with sand pockets, wood fragments, and organic matter pockets, at 18.6m	
-20	20			-with a silt layer at 19.5m (20.1m)	
-21	21			Fat CLAY (CH), very stiff, greenish gray -sand layer, 20.4m to 20.7m -sand layer, 21.0m to 21.3m	V
-22	22				
-23	23		PUSH	-with silt pockets, partings, and seams, and mica, at 22.9m	
-24	24				
-25	25			(25.8m)	
-26	26			Fat CLAY (CH), very stiff to hard, dark greenish gray -with silt pockets	
-27	27				
-28	28		PUSH	-sandy clay at 27.9m	VI
-29	29		SAVE	-with mica and shell fragments, 28.7m to 29.9m	
-30	30		SAVE		
-31	31		SAVE		
-32	32				
-33	33				
-34	34			(34.1m)	
-35	35		PUSH	Fat CLAY (CH), very stiff, greenish gray -lean clay with mica, and calcareous nodules, to 34.7m	VII
-36	36				
-37	37			-with silt pockets and partings, and with wood fragments and organic matter pockets, at 37.2m	
-38	38		PUSH		
-39	39			(38.7m)	
-40				Lean CLAY (CL), very stiff to hard, greenish gray -with silt layers	VIII

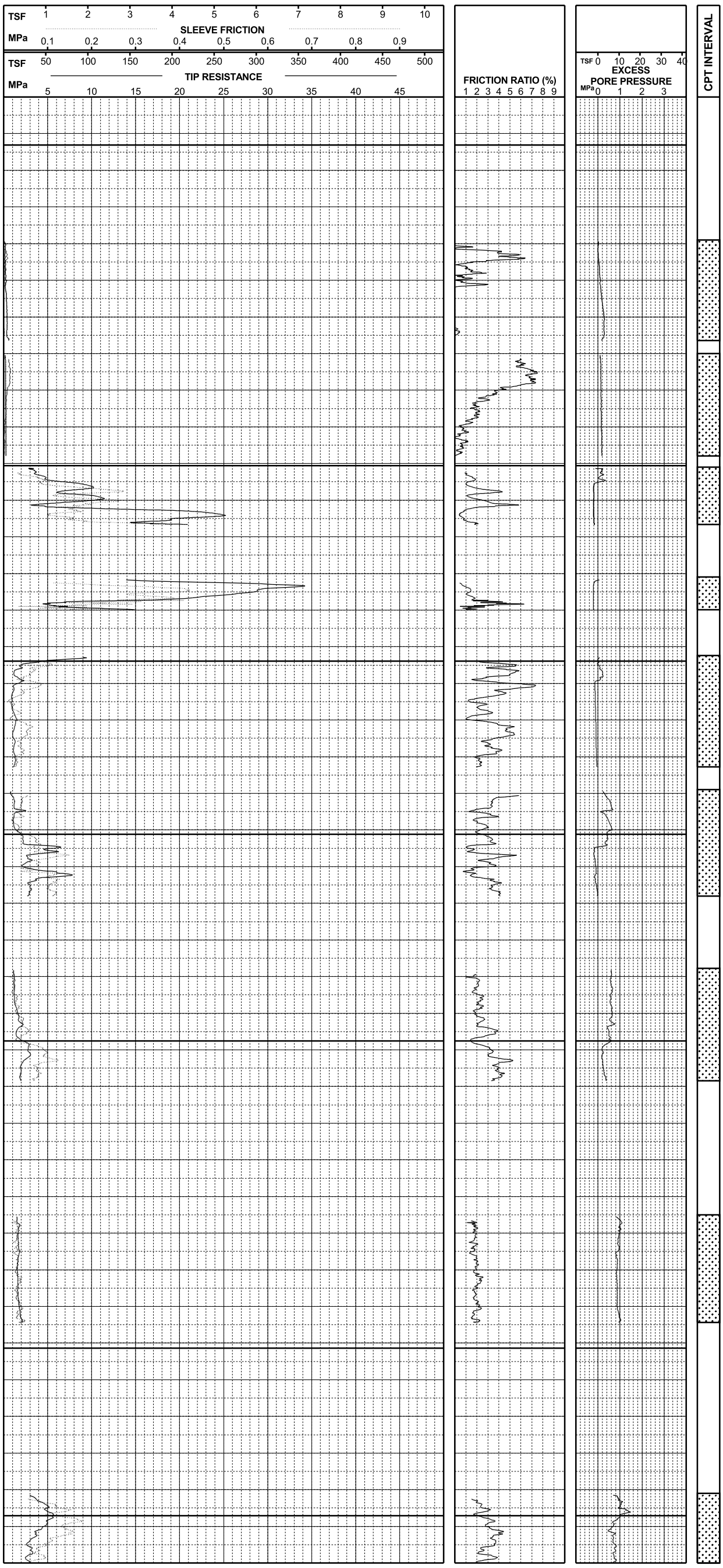

PLATE 98-44.7a

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

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PROJECT NO: 98-42-0054
BORING: 98-44 (Oakland Shore Approach)

START DATE: 11/13/98
COMPLETION DATE: 11/17/98

DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-41 to -43	41 to 42			PUSH	Lean CLAY (CL), very stiff to hard, greenish gray -with organic matter pockets at 42.1m	VIII
-43 to -44	42 to 43				(43.6m)	
-44 to -48	43 to 47			PUSH SAVE	Fat CLAY (CH), very stiff to hard, greenish gray -with silt pockets and partings, mica, and with gas blisters, at 46.9m	IX
-48 to -52	47 to 51				(51.2m)	
-52 to -53	51 to 52			PUSH	Fine to Coarse SAND (SW-SM) with silt and fine gravel, dense, dark greenish gray (52.4m)	X
-53 to -58	52 to 57			PUSH	Fat CLAY (CH), very stiff to hard, greenish gray -with silt partings and mica at 52.4m -silt layer, 54.1m to 54.3m -fissured, and with a few shell fragments, at 57.3m	XI
-58 to -63	57 to 62			PUSH		
-63 to -69	62 to 68			PUSH SAVE	-with mica at 62.2m	
-69 to -75	68 to 74			PUSH	-with wood fragments and organic matter pockets, below 68.0m	
-75 to -77	74 to 76			PUSH	-with gas blisters at 74.4m (76.2m)	
-77 to -80	76 to 79				Lean CLAY (CL), hard, greenish gray -with sand seams at 78.0m -with a silt layer at 78.6m	XII

TSF 1 2 3 4 5 6 7 8 9 10
MPa 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9
SLEEVE FRICTION

TSF 50 100 150 200 250 300 350 400 450 500
MPa 5 10 15 20 25 30 35 40 45
TIP RESISTANCE

FRICTION RATIO (%) 1 2 3 4 5 6 7 8 9

TSF 0 10 20 30 40
MPa 0 1 2 3
EXCESS PORE PRESSURE

CPT INTERVAL

PLATE 98-44.7b

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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PROJECT NO: 98-42-0054
BORING: 98-44 (Oakland Shore Approach)

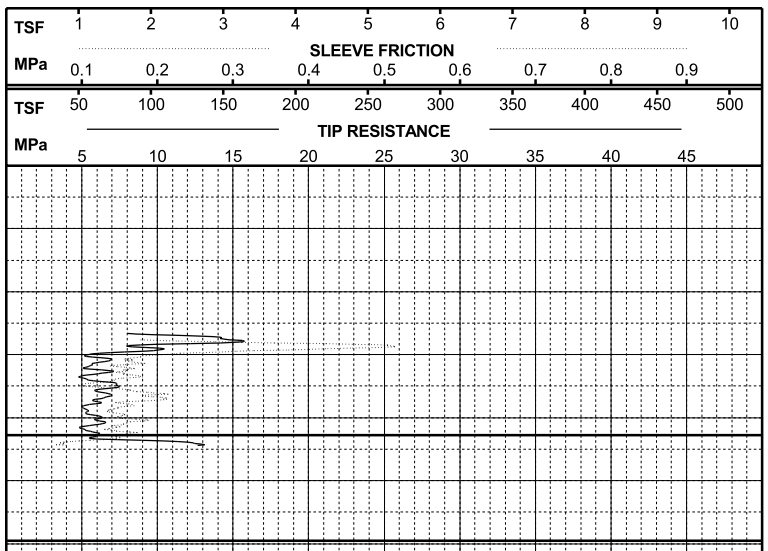
START DATE: 11/13/98
COMPLETION DATE: 11/17/98

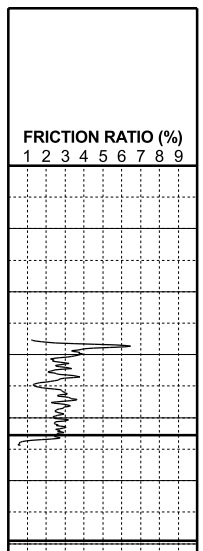
DRILLER: Fugro-McClelland Marine Geosciences
DRILLING METHOD: Rotary Sample Boring (Wet)

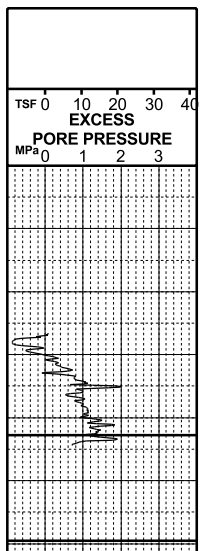
Coordinates: E1838947 N648311
CA State Plane Zone 3, NAD83, Meters

MUDLINE ELEVATION: -0.9m (MSL)

ELEVATION, m.	DEPTH, m.	SOIL TYPE	SAMPLER	BLOW COUNT	MATERIAL DESCRIPTION	STRATUM NO.
-81 to -85	81 to 84			PUSH / SAVE	Lean CLAY (CL), hard, greenish gray -mottled with gray, and with gas blisters, at 80.5m -with silt seams at 81.4m -sand layer, 82.6m to 82.9m -interlayered, silt and clay, below 82.9m	XII
					(84.3m)	
-85 to -86	84 to 86			PUSH	Silty Fine SAND (SM), dense, greenish gray	XIII
					(86.0m)	
-86 to -92	86 to 91			30/20cm	Lean CLAY (CL), hard, greenish gray -sand layer, 87.5m to 87.8m -sand layer, 87.9m to 88.0m	XIV
					(91.4m)	
-92 to -97	91 to 96			30/10cm	Fine to Medium SAND (SP), dense to very dense, greenish gray -silty sand to 92.4m -with a clay layer at 92.0m	XV
					(96.8m)	
-97 to -100	96 to 99			PUSH	Fat CLAY (CH), hard, greenish gray -slickensided at 99.7m	XVI
-100	99				TOTAL DEPTH: 100.0m BACKFILLED WITH: Cement Grout	







CPT INTERVAL

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

PLATE 98-44.7c

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PROJECT NO:	98-42-0054	**START DATE:**	11/13/98	**DRILLER:**	Fugro-McClelland Marine Geosciences
BORING:	98-44 (Oakland Shore Approach)	**COMPLETION DATE:**	11/17/98	**DRILLING METHOD:**	Rotary Sample Boring (Wet)

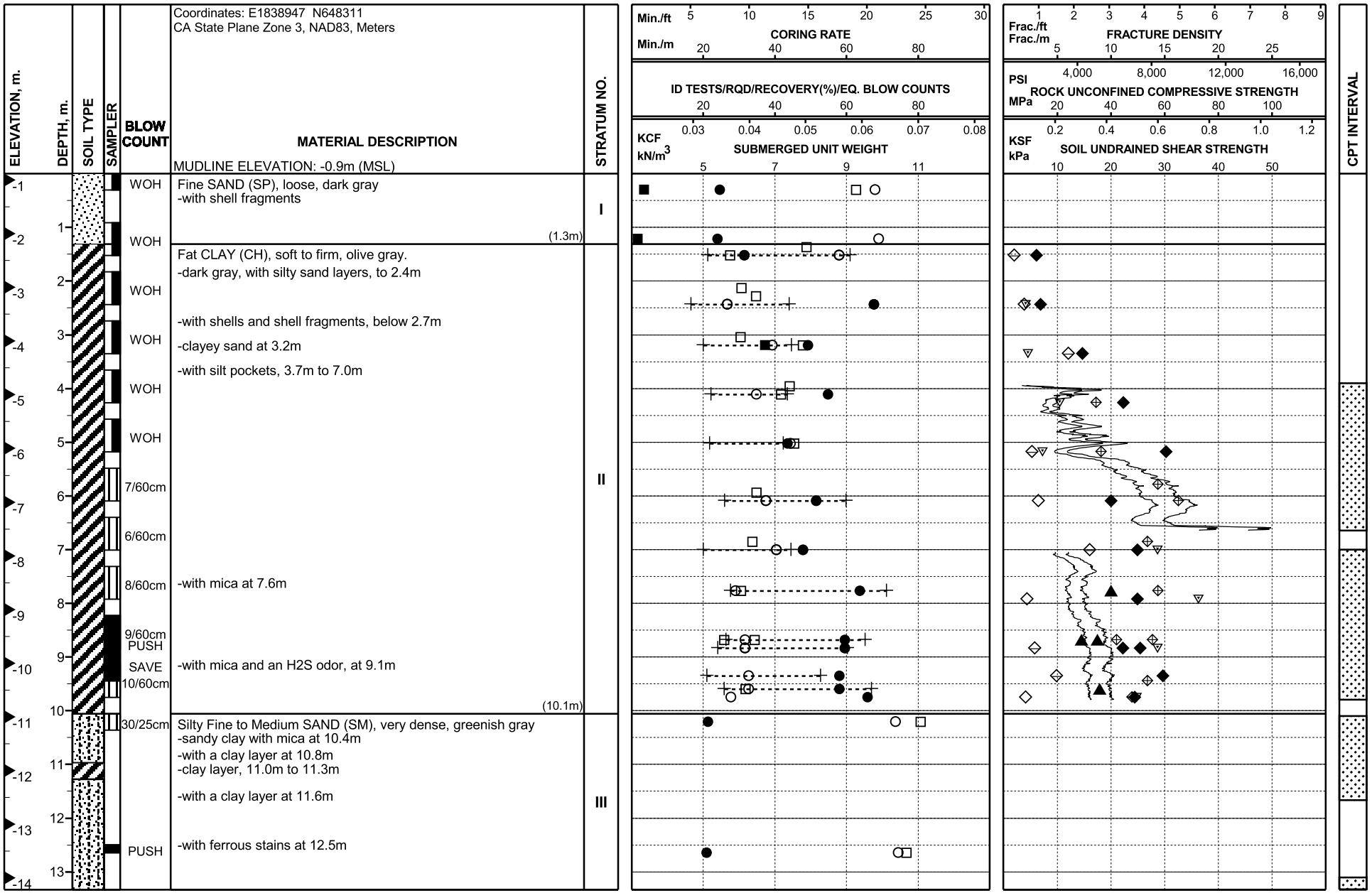

PLATE 98-44.8

LOG OF BORING AND TEST RESULTS

BORING 98-44

SFOBB East Span Seismic Safety Project

Report Date: 04/30/99

FUGRO

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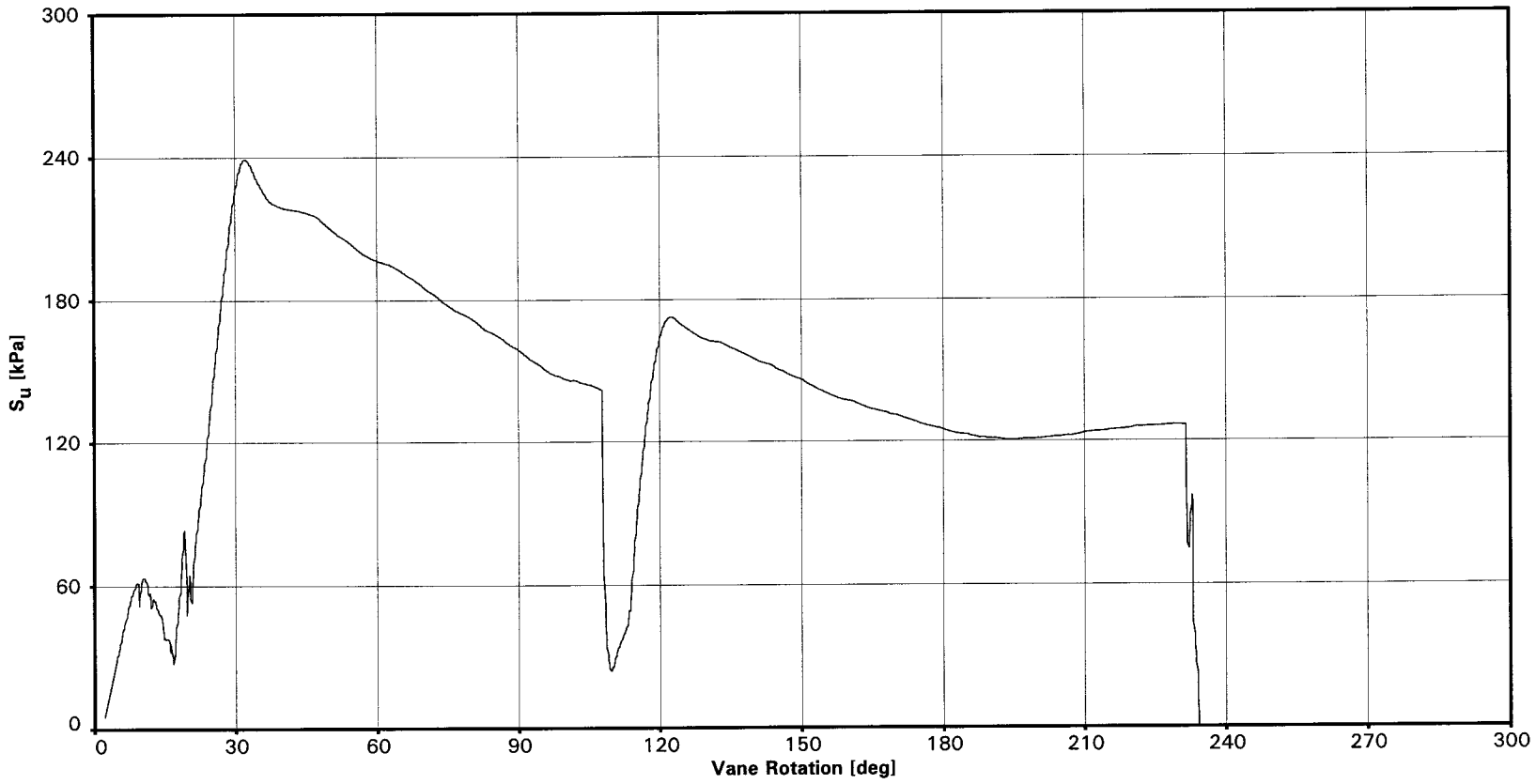
Vane Size used: Dolphin Small

(30 Degrees Corresponds to 8.3% Shear Strain)



REMOTE VANE (DOWNHOLE) TEST RESULTS
Test Depths: 35.7m and 36.3m
Boring 98-44
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
0.2	1																							
0.3	2	24				9.3	3																	
1.2	3	24					1																	
1.4	4					7.9																		
1.5	5	31	61	21	0.25	5.7					6.1		2.1											
2.1	6					6.1																		
2.3	7					6.5																		
2.4	8	68	44	17	1.86					4.2	6.9	3.8												
3.0	9					6.0																		
3.2	10	49	45	20	1.18	7.8	37																	H
3.4	11									4.6	14.7		12.1											
4.0	12					7.4																		
4.1	13	55	44	22	1.53	7.2																		
4.3	14							17.2		10.5	22.3													
5.0	16	43	42	22	1.05	7.5																		C

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.10a

Earth Mechanics

FUGRO

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
5.2	17							18.2		7.4	30.3		5.3											
5.8	18							28.7																
5.9	19					6.5																		
6.1	20	51	60	26	0.75			32.6			20.0	6.5												
6.9	22					6.4		26.8																
7.0	23	48	45	20	1.13					28.7	24.9		16.0											
7.8	25	64	71	28	0.82	6.0		28.7							20.1		1.0							
7.9	26									36.4	24.9	4.4												
8.7	28					6.4		27.8							17.5		1.6							
8.7	34	62	65	26	0.92	5.6		21.1							14.5		1.2							
8.8	29	59	60	24	0.98					28.7	22.3		5.8											
8.8	35										25.5													
9.4	36	58	53	21	1.16						29.7		9.9											C
9.4	30							26.8																
9.6	31	58	67	26	0.78	6.2									17.9		1.7							

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10b

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
9.8	32	66						23.9		24.9	24.5	4.1												
10.2	33	21				11.1																		
12.6	38	21				10.7																		
14.8	39					11.4																		
14.9	40	21					18																	
18.6	41														65.4	12.6	0.7							
18.7	42	62	86	33	0.55	6.3	99	62.2	71.8															H
18.9	43							67.0	71.8		90.3													
23.0	45	37	58	22	0.42	8.4		79.5	129.3						79.5		0.8							
23.2	46							105.3	71.8		131.6													
27.7	47							110.1	91.0															
27.9	48	41	53	21	0.61	8.1	62	98.2	95.8						115.2	30.1	0.8							H
28.0	49										132.4													
28.6	50	45	63	25	0.53						132.4													C
28.7	51	50	70	28	0.51																			

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10c

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
29.2	52										133.7													
29.3	53	42	55	24	0.57																			
29.8	54	46	59	24	0.63						132.4													C
29.9	55	45	56	23	0.64																			
34.4	56								196.3															
34.6	57	25	39	20	0.28	9.7									170.3		1.5							
34.7	58								162.8		178.2													
35.7	500													235.6										
36.3	501													170.0										
37.2	59							119.7	119.7															
37.3	60	47	60	24	0.64	7.5									98.9	47.7	0.6							
37.5	61							107.7	114.9		136.1													
42.1	62							162.8																
42.3	63	21	34	15	0.31	10.7									136.7		1.6							
42.4	64							141.2	181.9		184.4													

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10d

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
46.9	65							146.0	181.9															
47.1	66	41	86	27	0.25	7.4									169.7	93.0	0.6							
47.2	67							165.2	205.9		206.7													
47.8	68	46	77	26	0.39																			C
47.9	69	46	76	26	0.40						188.1													
52.4	70						11																	
52.6	71	41	78	28	0.26	7.9																		
52.7	72								201.1		222.8													
57.3	73								177.2															
57.5	74	46	85	29	0.29	7.4									164.5	73.6	0.9							
57.6	75							172.4	201.1		222.8													
62.2	76								177.2															
62.3	77	53	80	32	0.45	6.8									189.3		1.6							
62.5	78								181.9		222.8													
63.0	79	51	67	23	0.63																			C

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10e

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
63.1	80										222.8													
68.3	81								177.2															
68.4	82	31	62	24	0.18	8.2									218.5	57.9	0.7							
68.6	83										222.8													
74.4	84								181.9															
74.5	85	48	92	34	0.23	6.6																		
74.7	86										190.6				214.6		0.8							
80.5	87	20	45	15	0.15	10.8	96		251.2						258.4		0.5							H
80.8	89								233.7															
81.3	90	17	29	19																				C
81.4	91	21	29	17	0.31																			
85.7	92	27					45																	
89.7	93								215.5															
89.9	94	23	44	19	0.16	10.6			215.5															
94.6	95	20																						

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10f

98-44		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			REMOTE VANE (kPa)	UU TRIAXIAL			MULTI-STAGE TRIAXIAL		DIRECT SHEAR TESTS				ADDITIONAL TESTS
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	SUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)		Undist. (kPa)	Remold. (kPa)	e50 (%)	c (kPa)	phi (deg)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	
99.8	97	30	60	23	0.19	9.4									241.6		0.6							

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
SUW = Submerged Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
e50 = Strain at 50% Failure Stress
c = Effective Cohesion
phi = Effective Angle of Friction

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

Additional Tests
K = Ko Consolidated Triaxial Test

SUMMARY OF LABORATORY TEST RESULTS
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.10g

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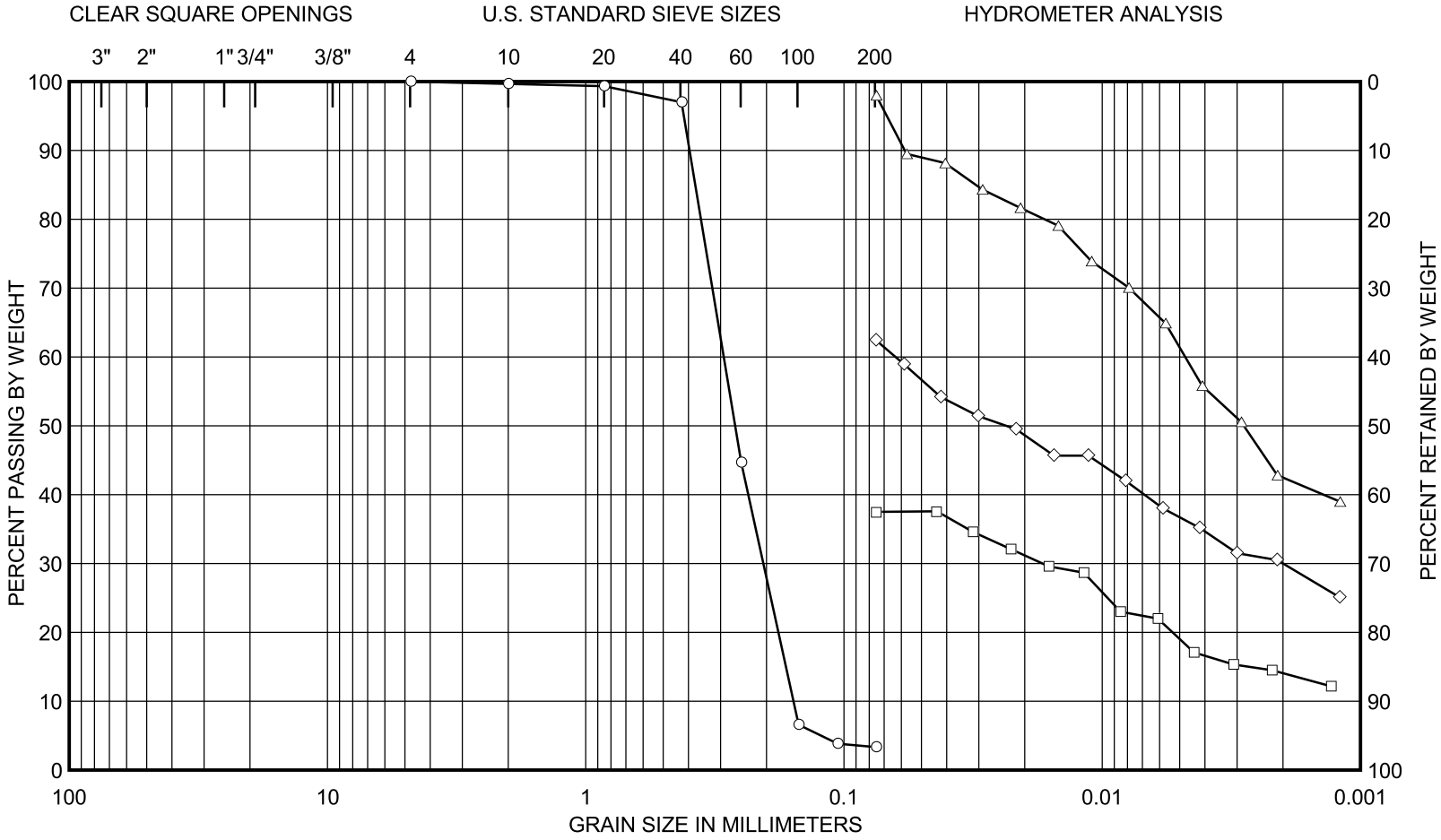

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	0.3	○——○	FINE SAND (SP) with shell fragments	0.9	1.9	0.26
10	3.2	□——□	CLAYEY SAND (SC) with shells and shell fragments			
42	18.7	△——△	FAT CLAY (CH)			0.0028
48	27.9	◇——◇	SANDY FAT CLAY (CH) with silt pockets			0.024

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-44
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

PLATE 98-44.11a

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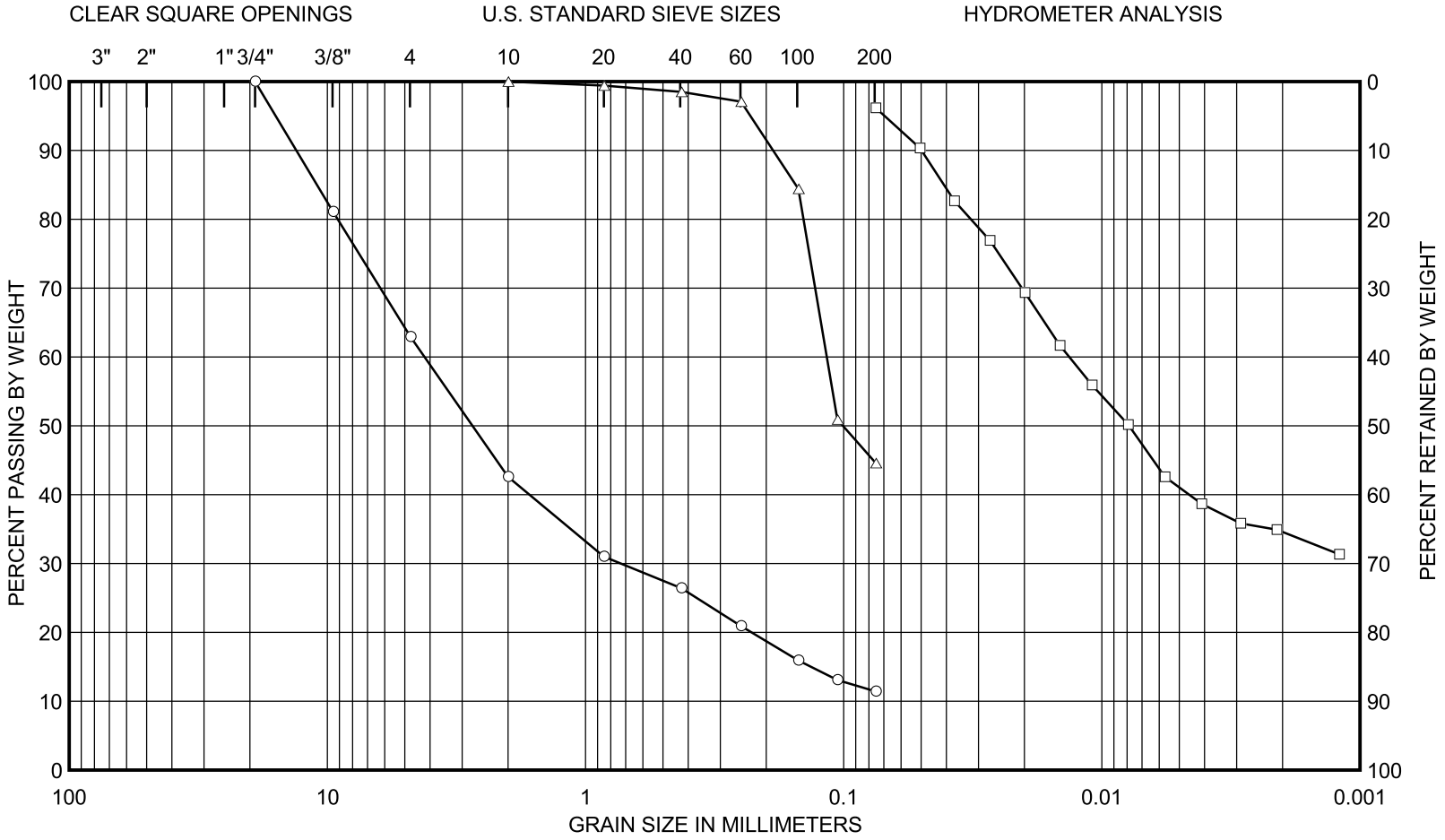

GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
70	52.4	○——○	FINE TO COARSE SAND (SW-SM) with silt and fine gravel			2.7
87	80.5	□——□	LEAN CLAY (CL)			0.0078
92	85.7	△——△	SILTY FINE SAND (SM)			0.10

GRAIN SIZE DISTRIBUTION CURVES
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.11b

SFOBB Task Order No. 5
Project No. 98-42-0054

Earth Mechanics

FUGRO

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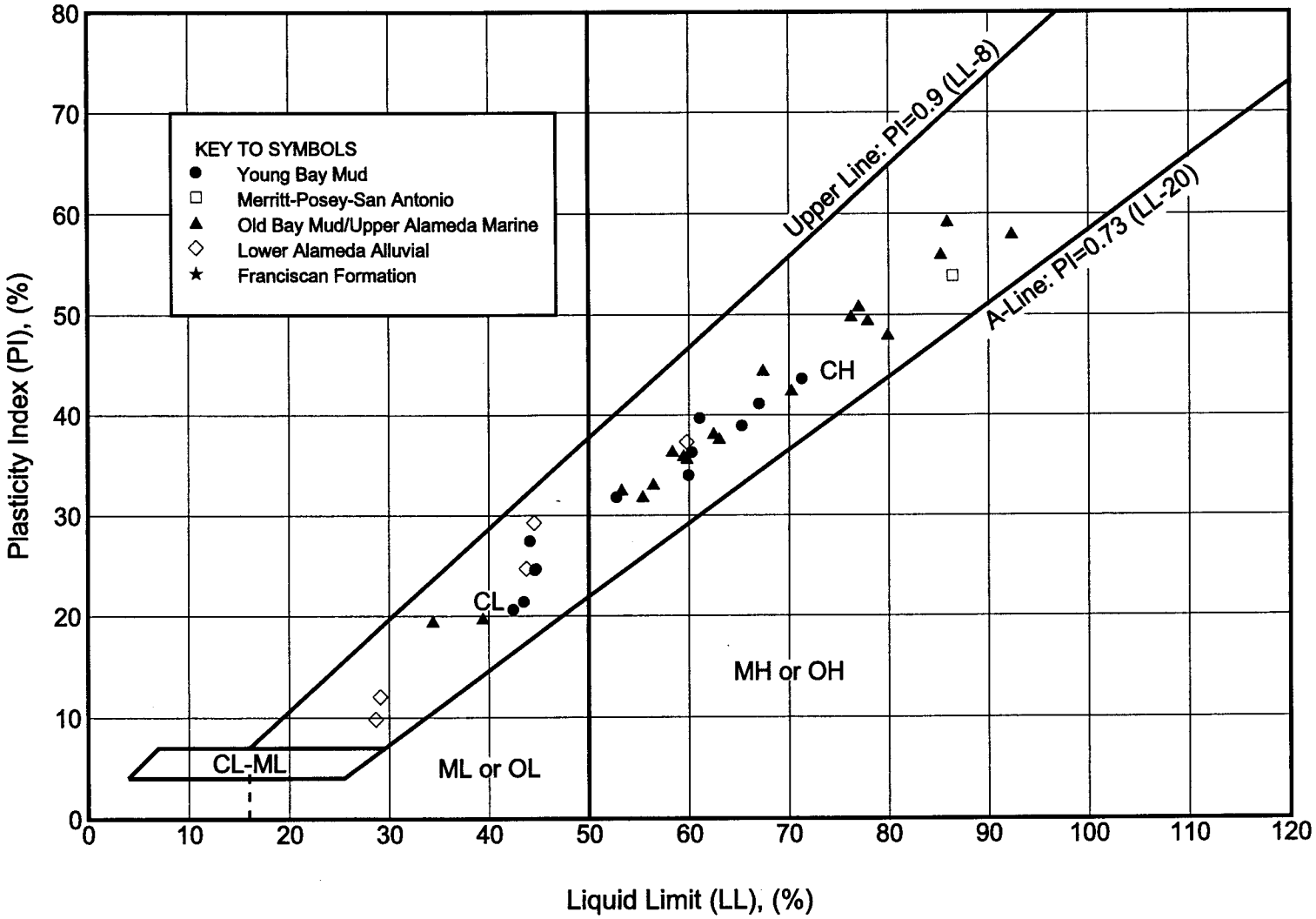
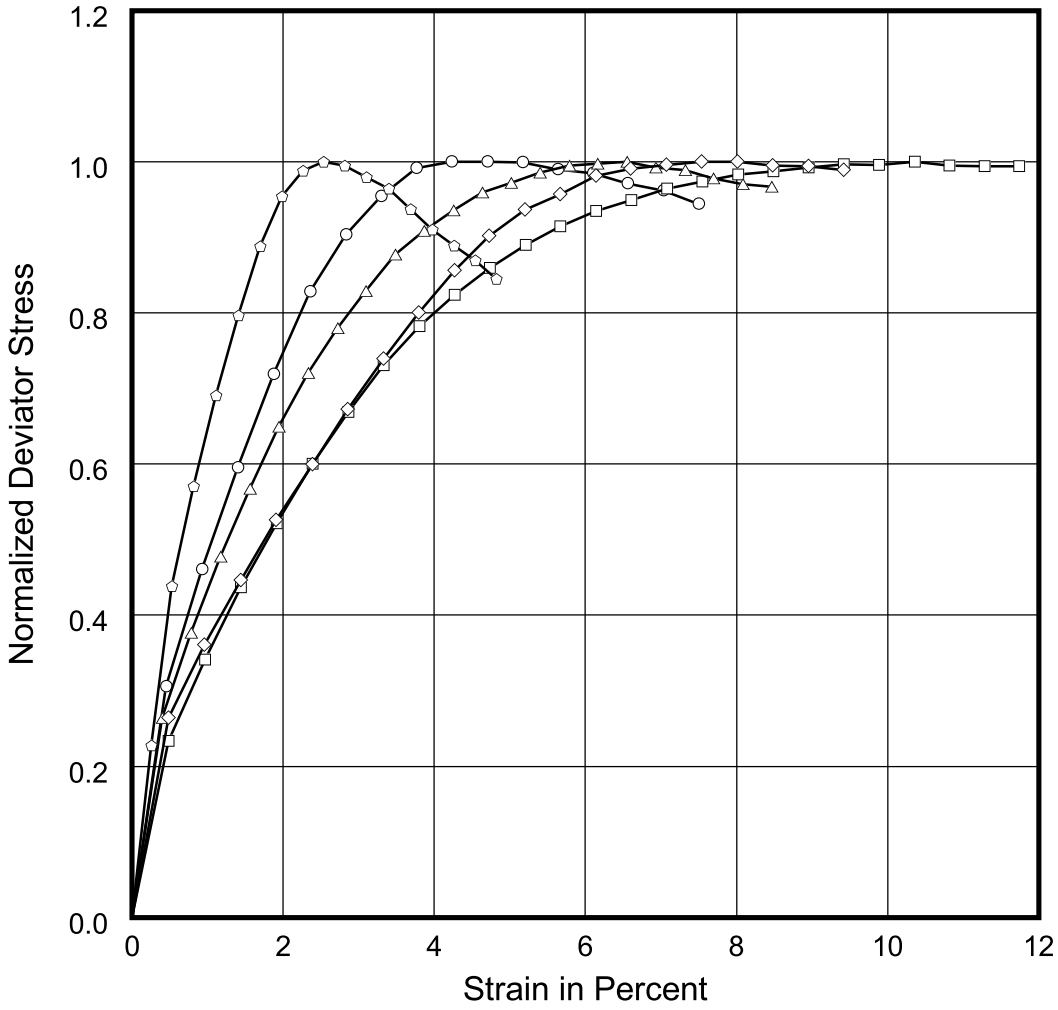


PLASTICITY CHART
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.12

Earth Mechanics

FUGRO



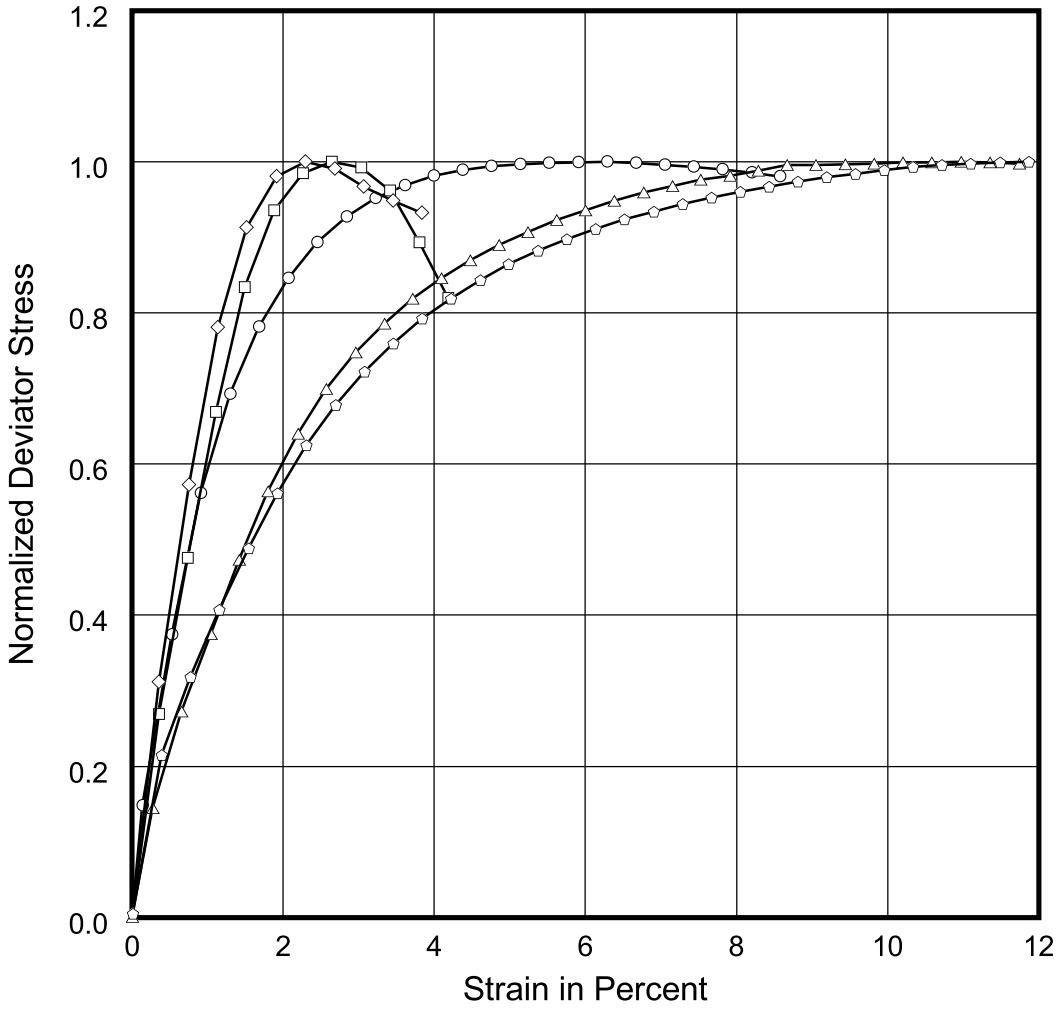
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
	25	7.8	UU	172	40	1.0
	28	8.7	UU	207	35	1.6
	34	8.7	UU	193	29	1.2
	31	9.6	UU	221	36	1.7
	41	18.6	UU	758	131	0.7

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.13a



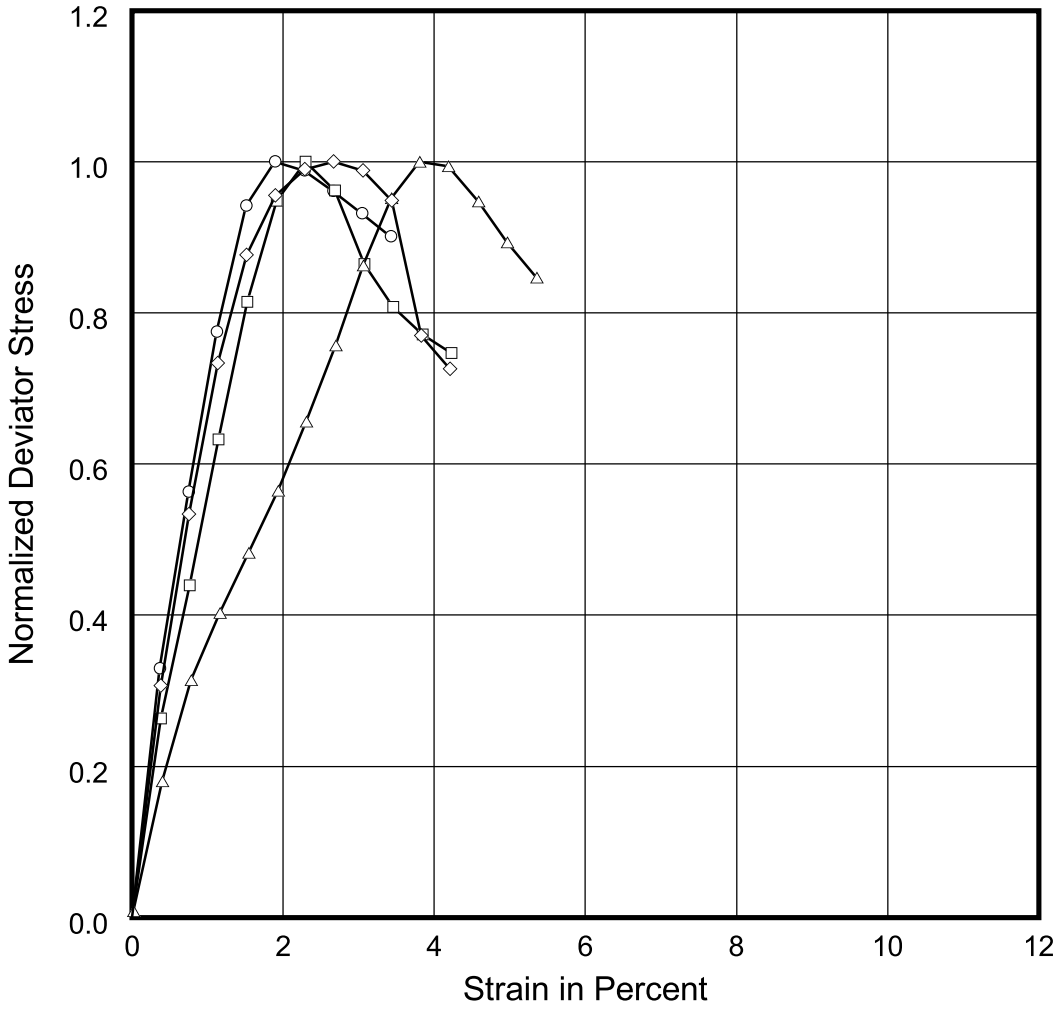
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	45	23.0	UU	517	159	0.8
□	48	27.9	UU	621	230	0.8
△	57	34.6	UU	1103	341	1.5
◇	60	37.3	UU	1172	198	0.6
⬠	63	42.3	UU	1275	273	1.6

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.13b



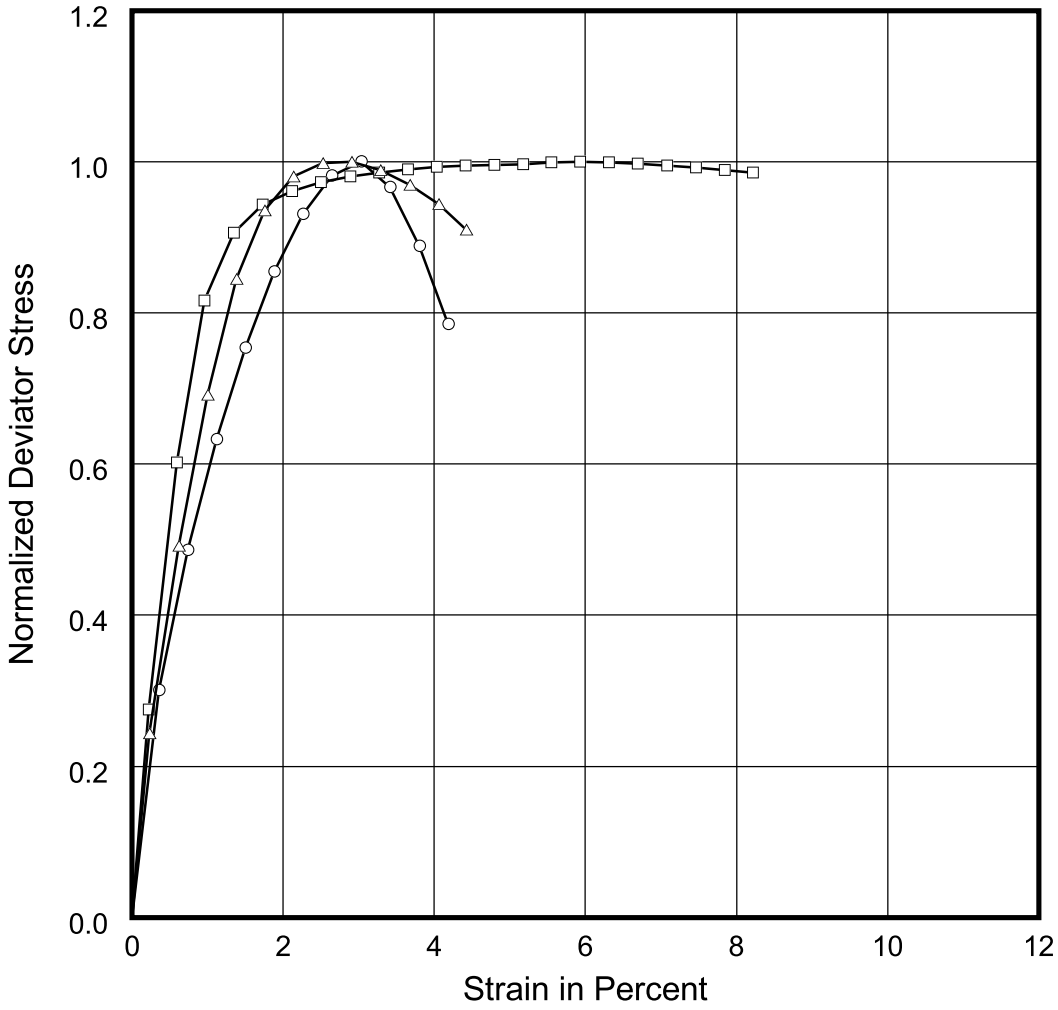
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○	66	47.1	UU	1413	339	0.6
□	74	57.5	UU	1620	329	0.9
△	77	62.3	UU	1758	379	1.6
◇	82	68.4	UU	1896	437	0.7

Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.13c



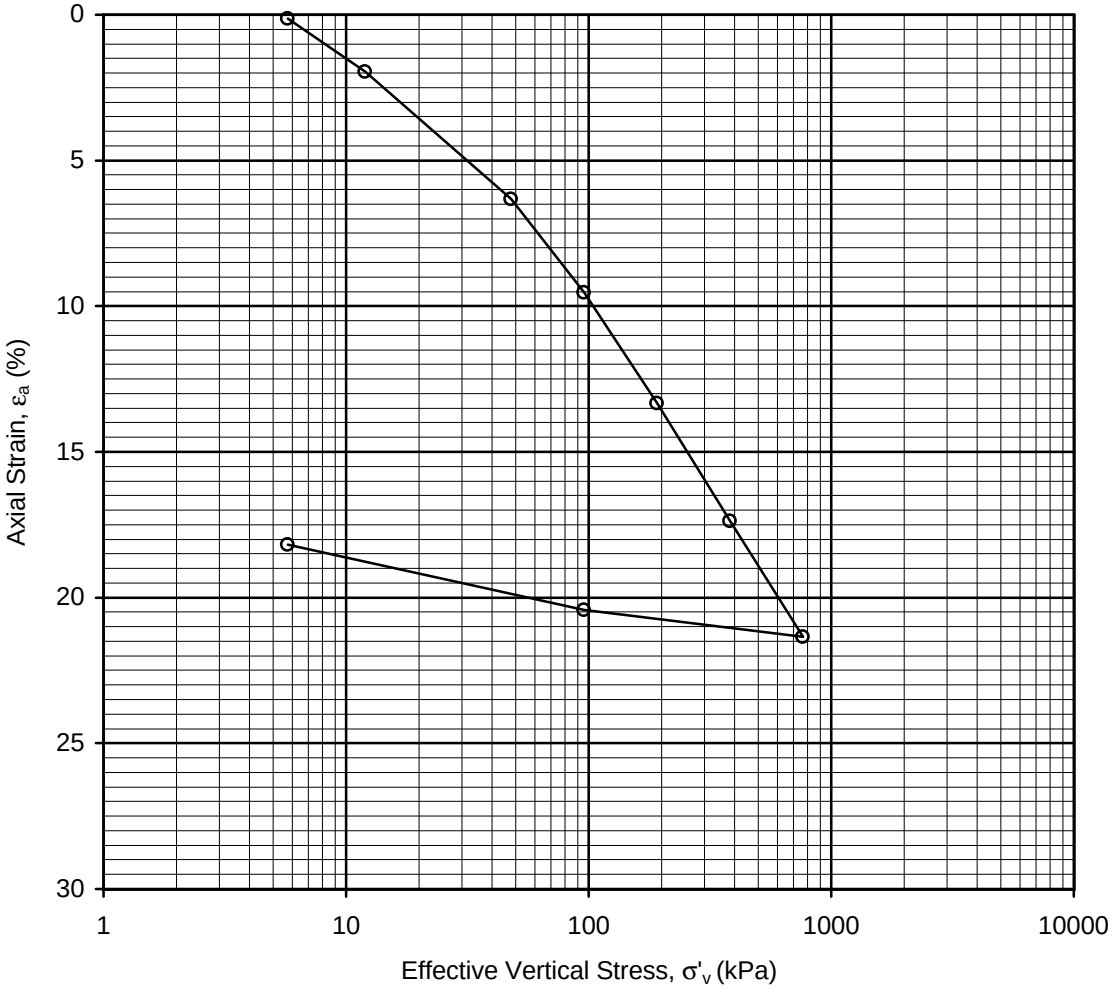
Curve	Sample No.	Depth (m)	Test Type	Confining Pressure (kPa)	Maximum Deviator Stress (kPa)	e50 (%)
○—○	86	74.7	UU	2034	429	0.8
□—□	87	80.5	UU	2172	517	0.5
△—△	97	99.8	UU	2241	483	0.6

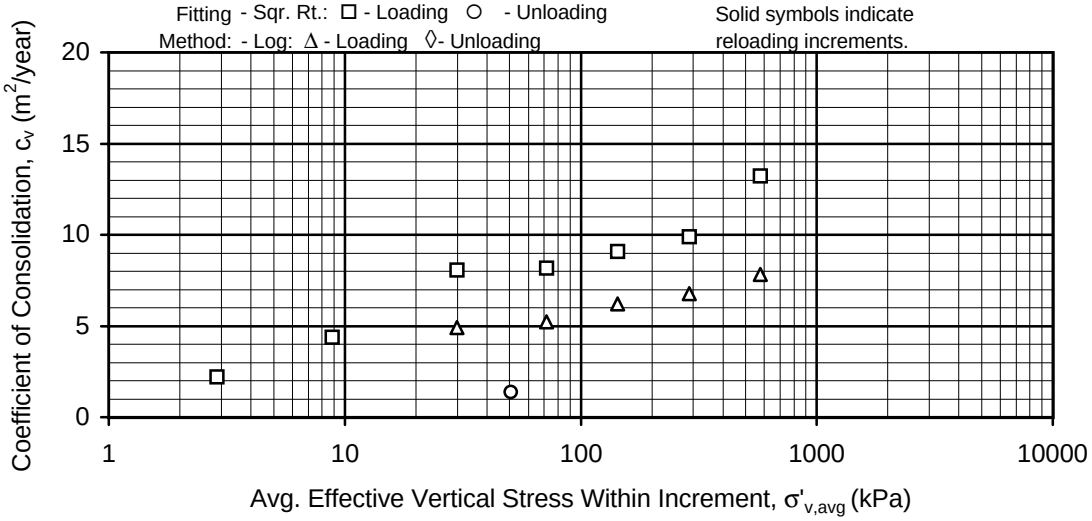
Deviator stress normalized with respect to maximum deviator stress.

STRESS-STRAIN CURVES

Unconsolidated-Undrained Triaxial Compression Test
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.13d

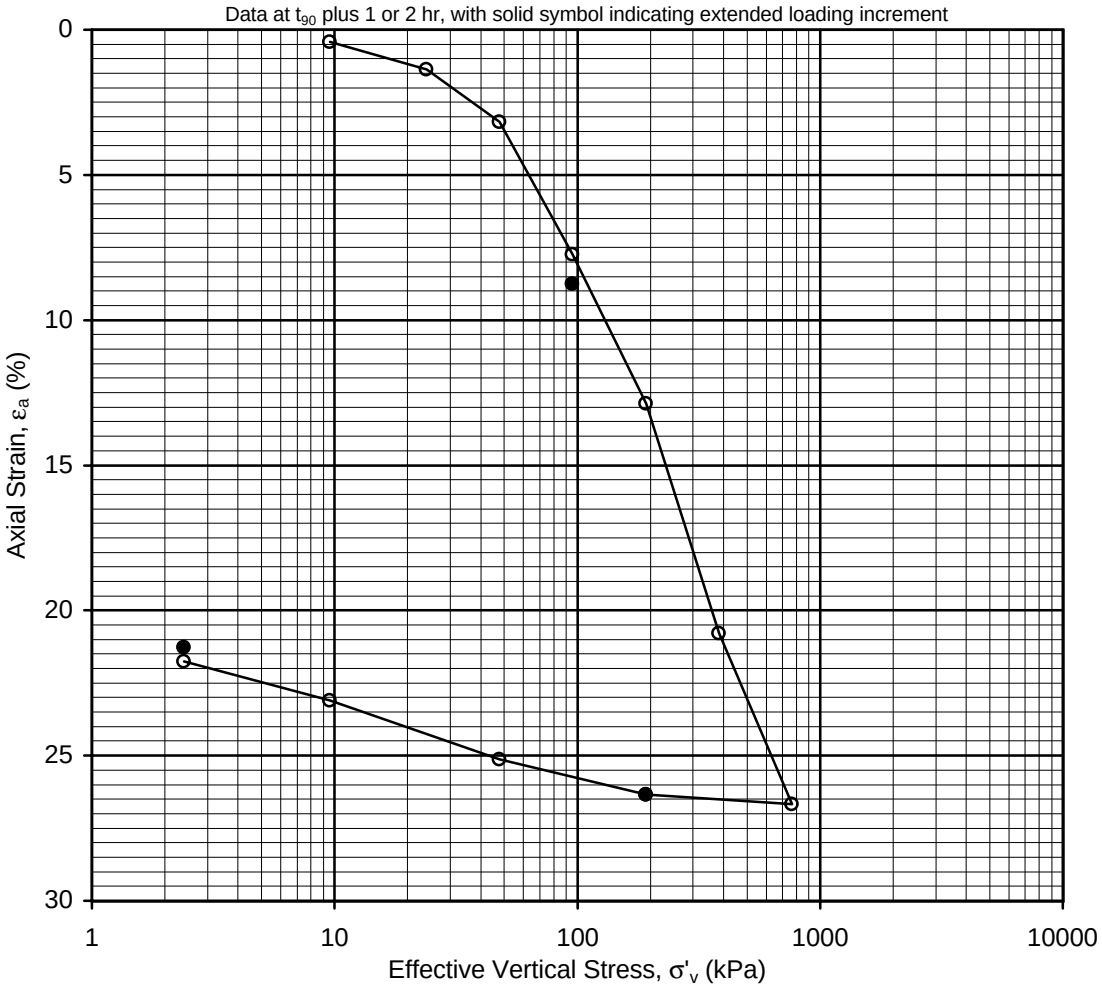


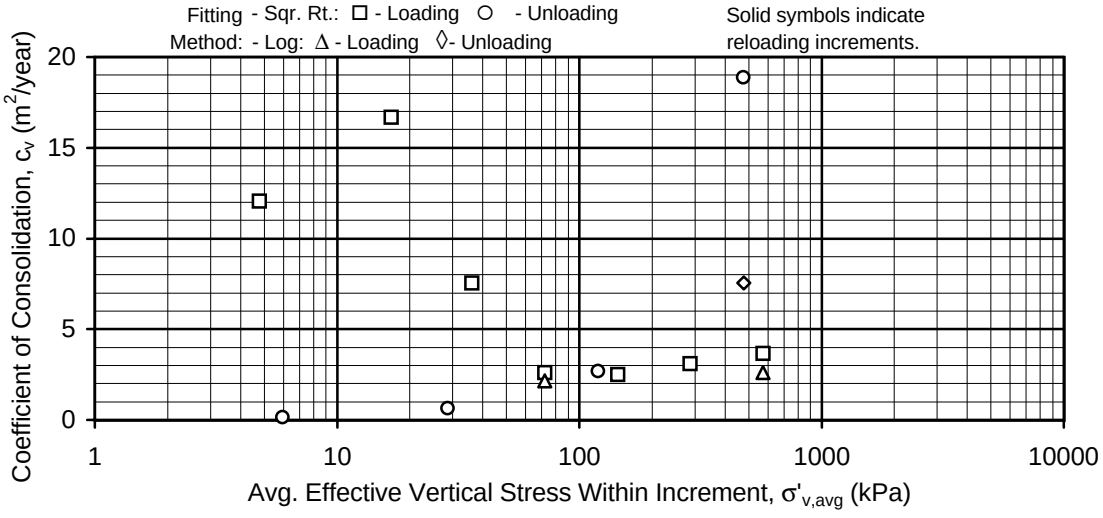


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 16 - Depth: 5.0m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14a

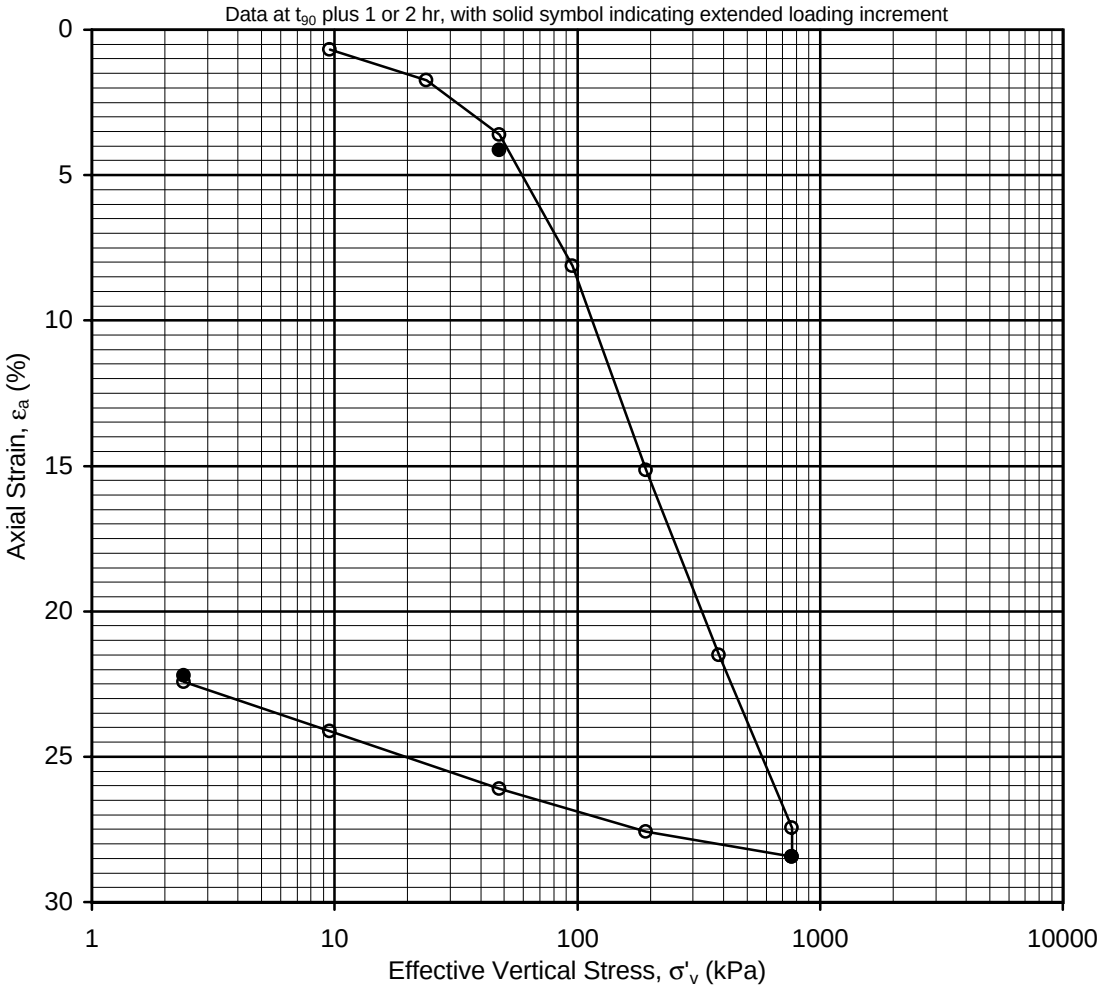


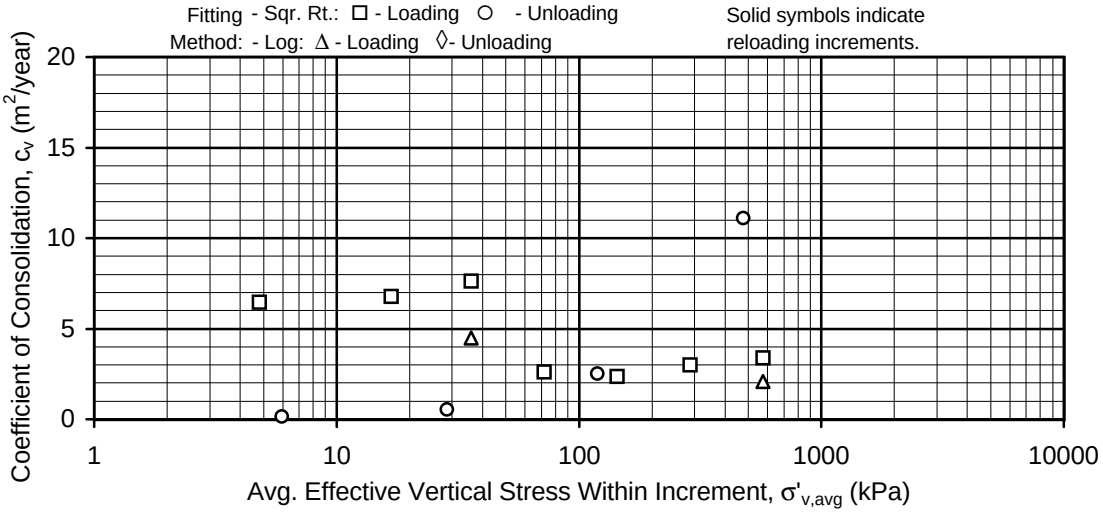


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 36A (Horizontal Loading) - Depth: 9.4m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14b

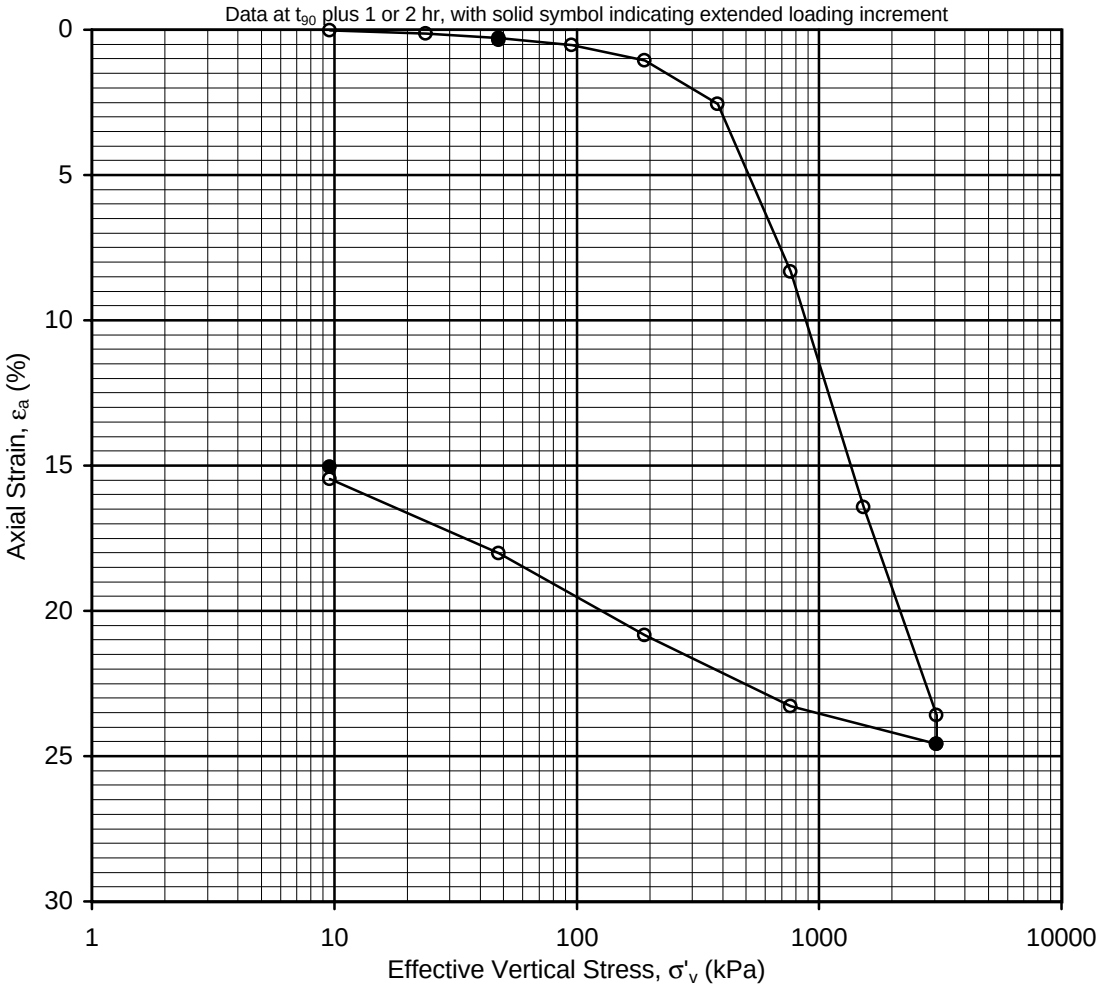


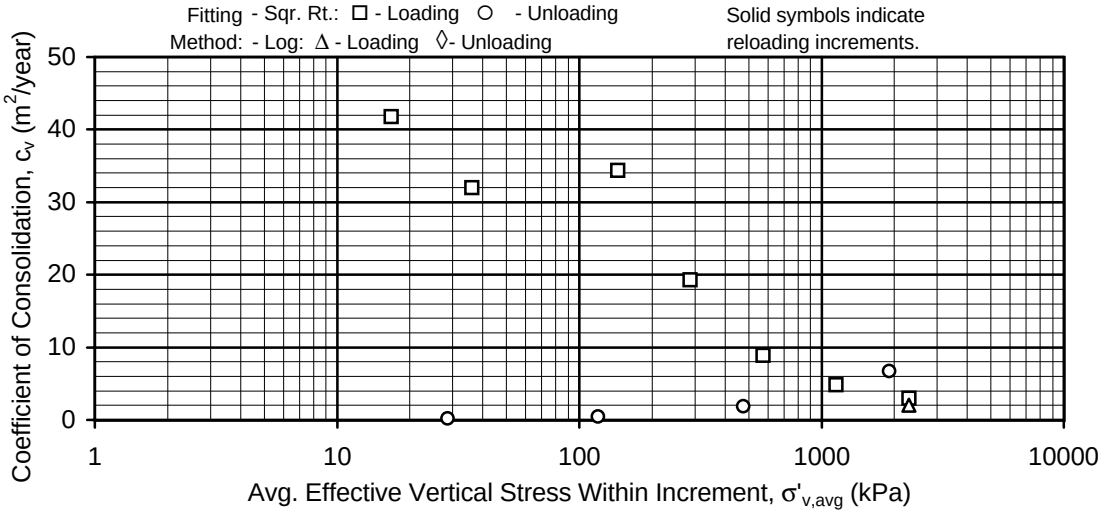


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 36B - Depth: 9.4m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14c

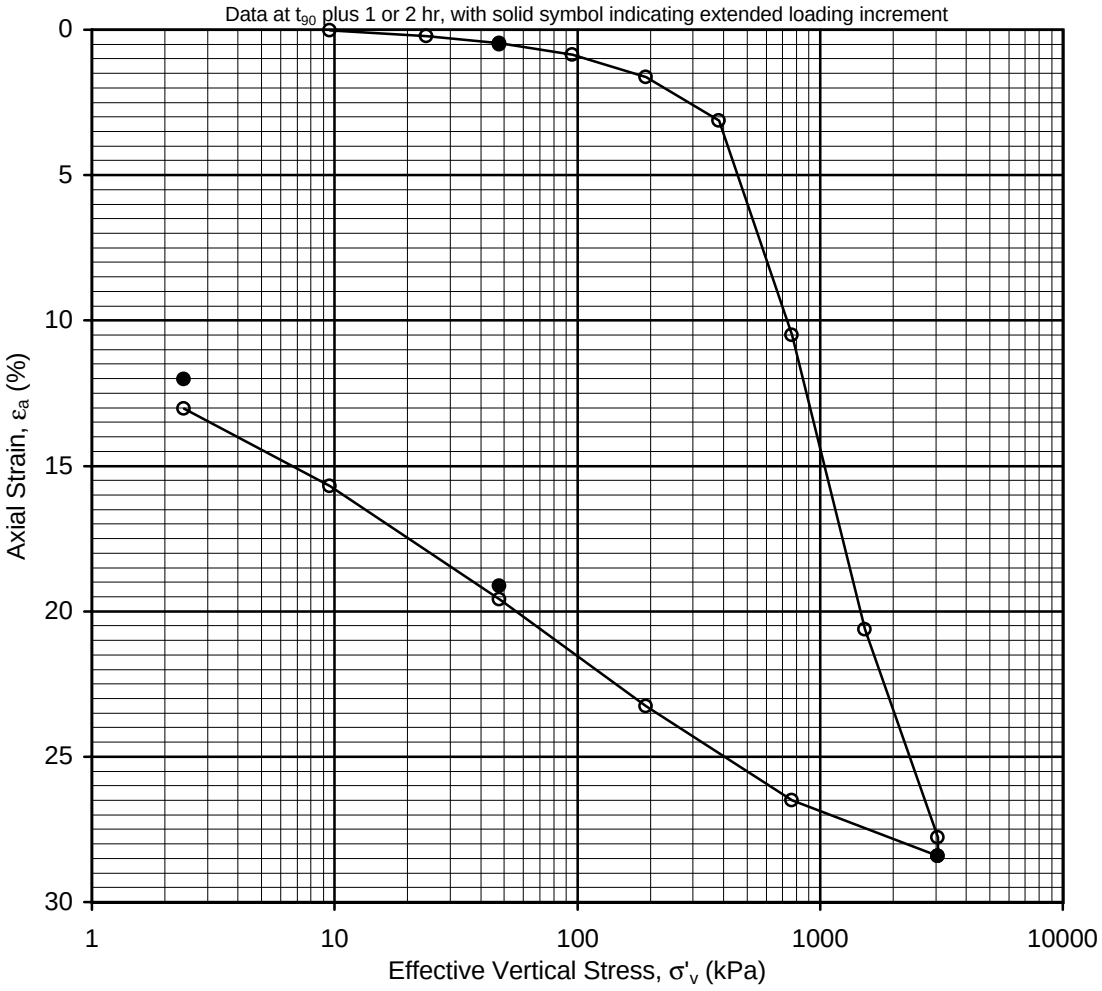


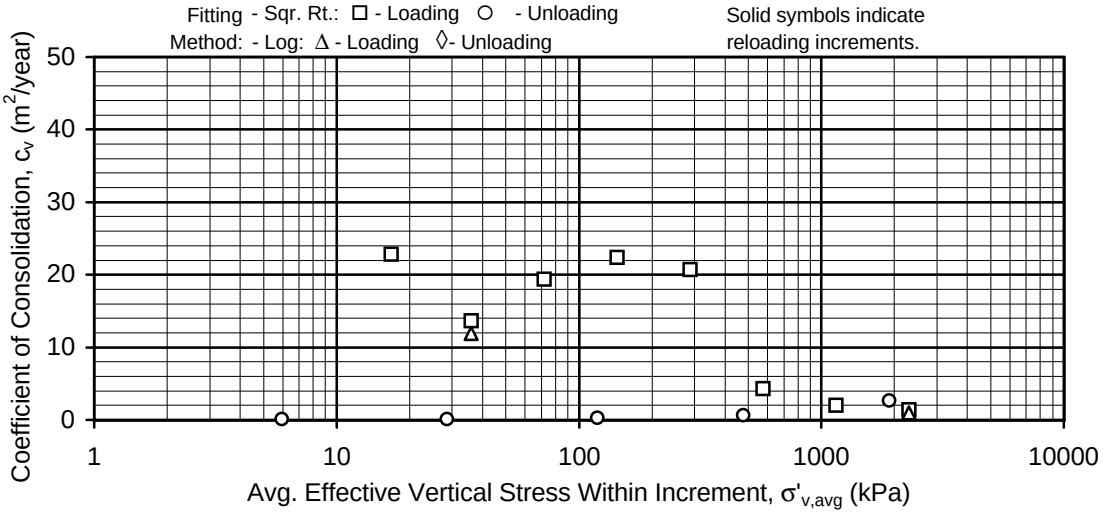


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 50A (Horizontal Loading) - Depth: 28.6m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14d

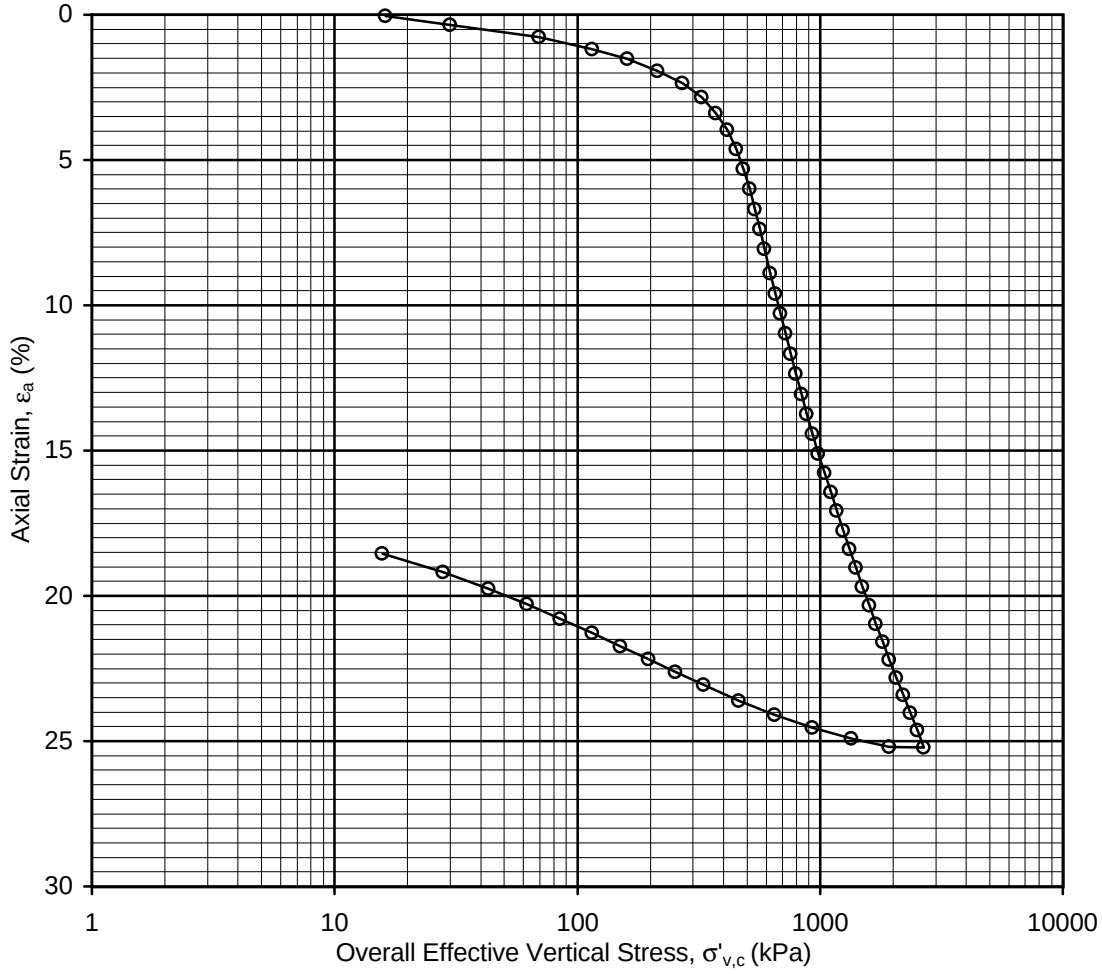


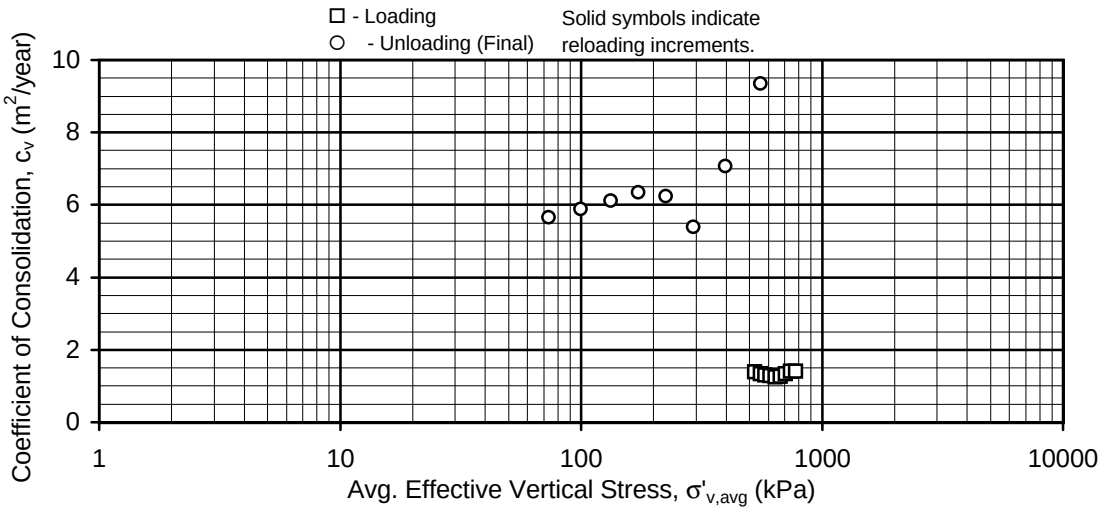


INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 50B - Depth: 28.6m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14e

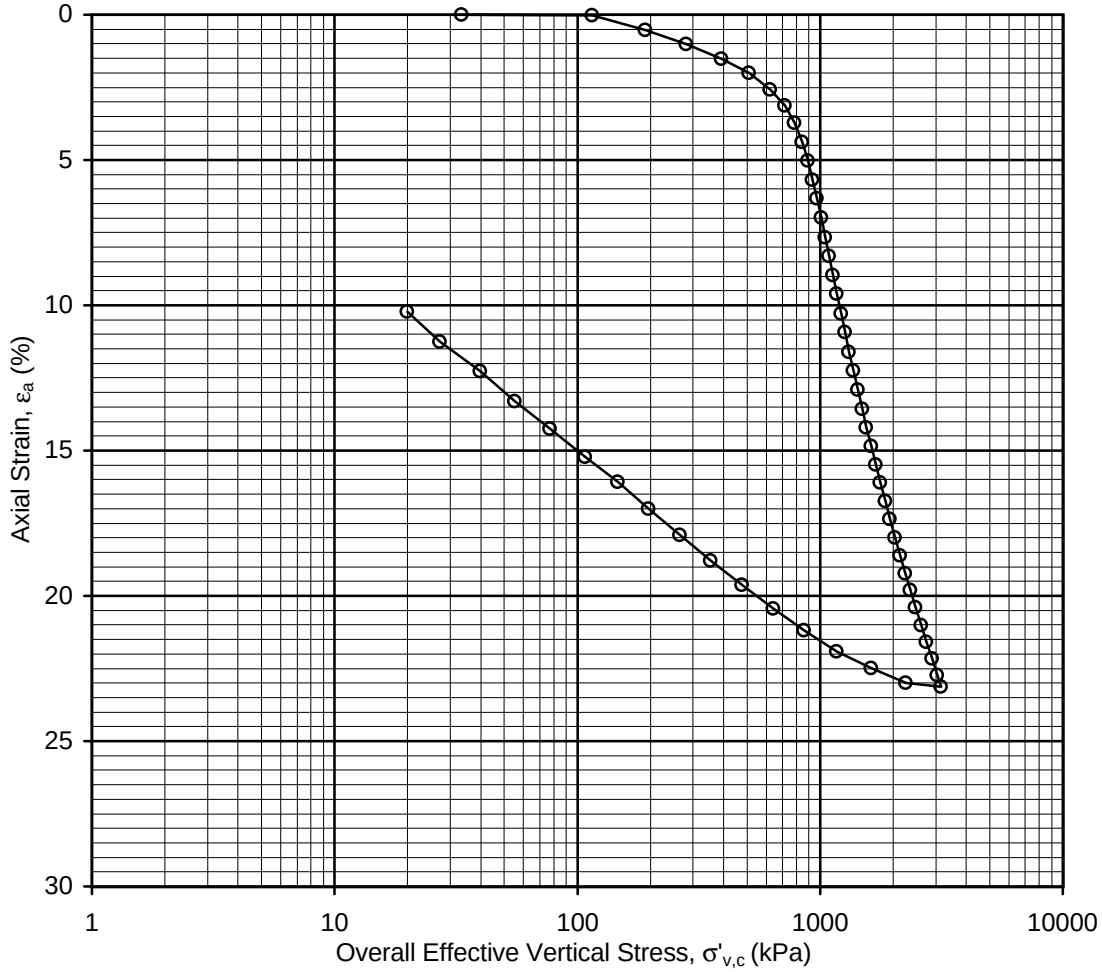


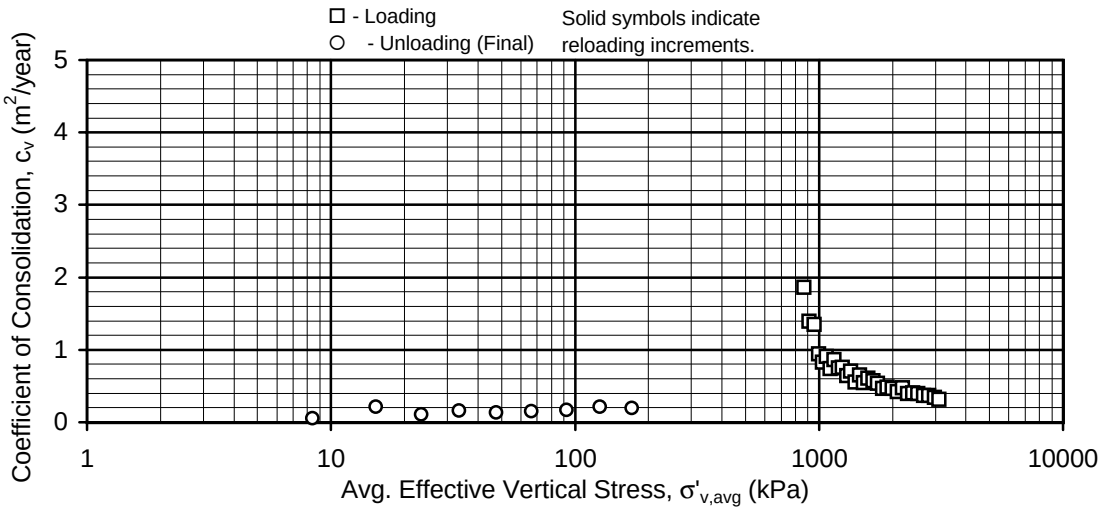


CRS CONSOLIDATION TEST RESULTS

Sample No. 54 - Depth: 29.8m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14f

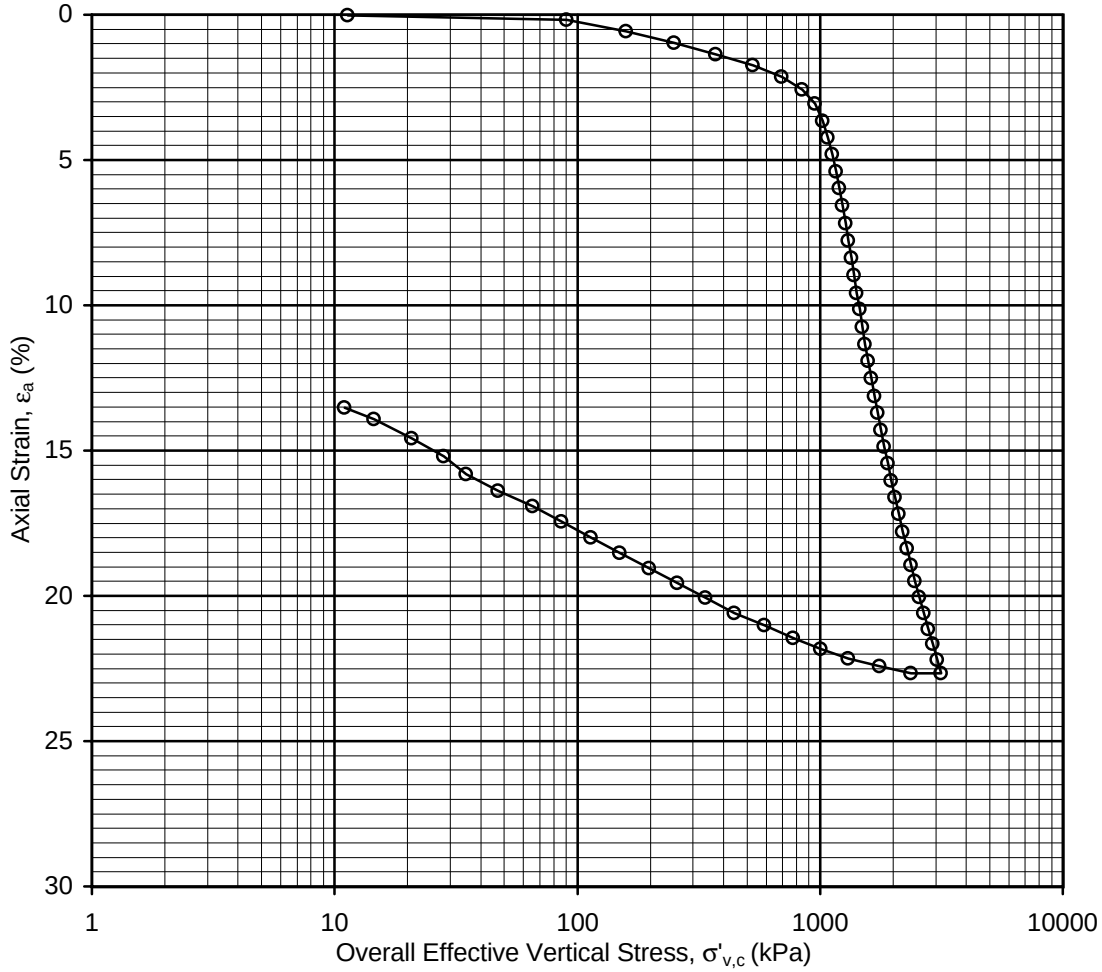


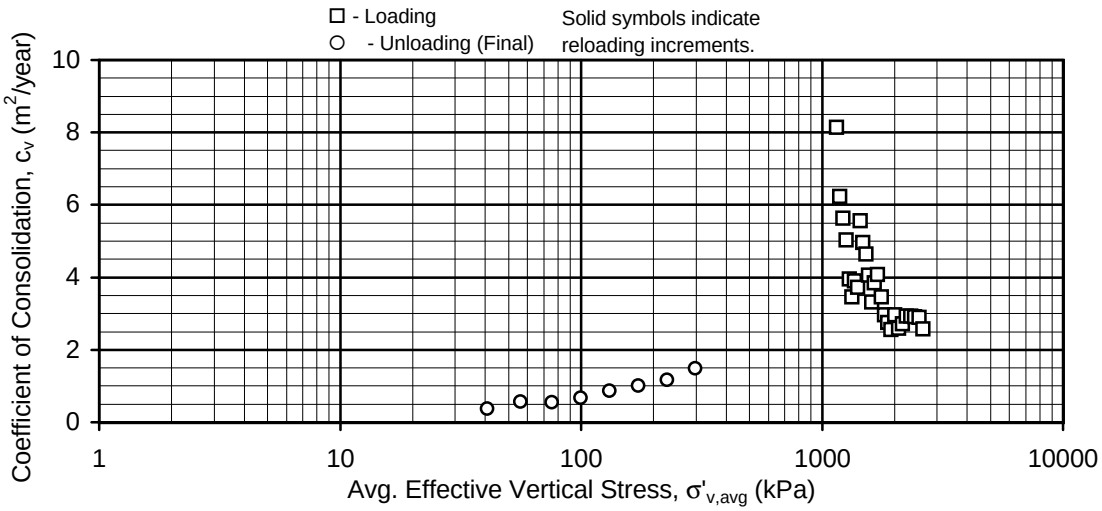


CRS CONSOLIDATION TEST RESULTS

Sample No. 68 - Depth: 47.8m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14g

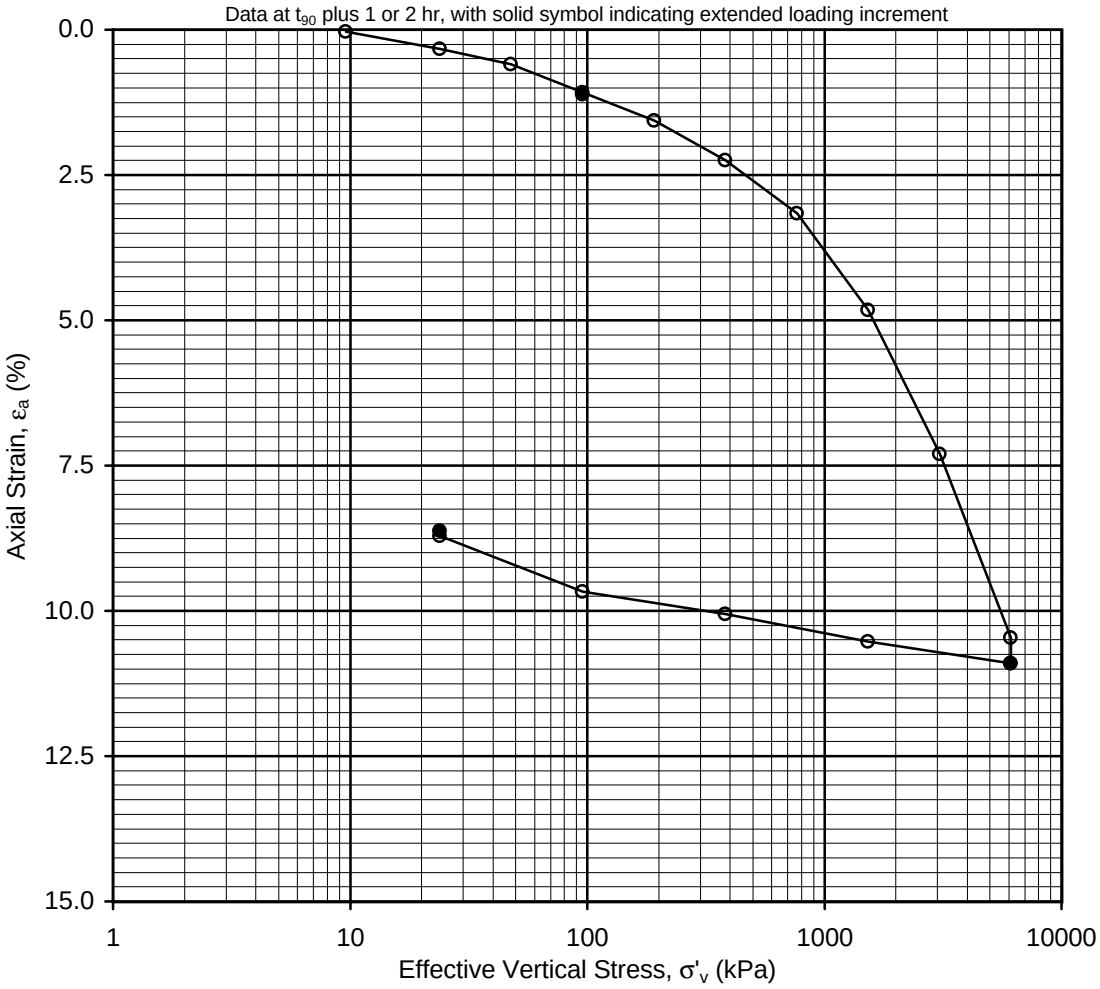


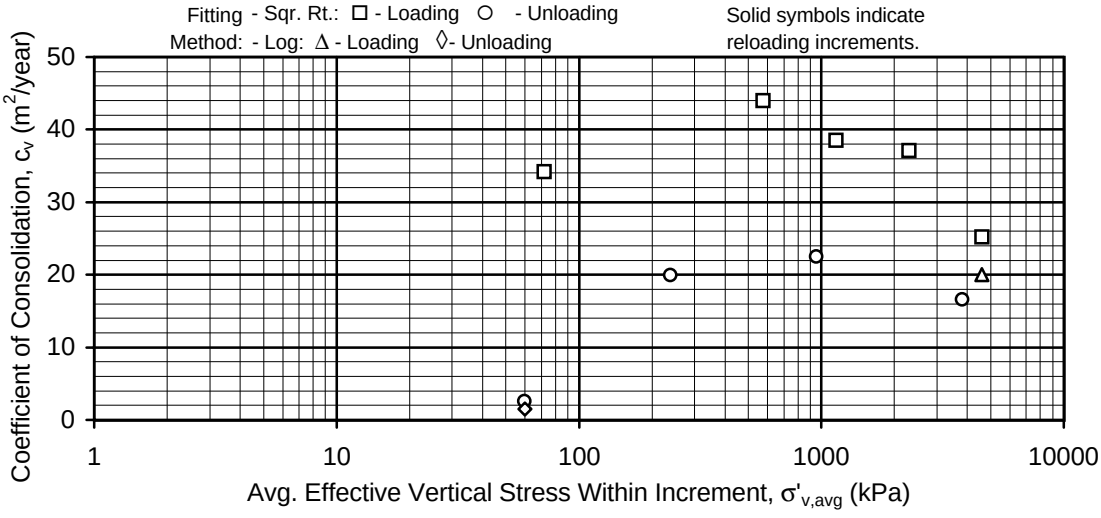


CRS CONSOLIDATION TEST RESULTS

Sample No. 79 - Depth: 63.0m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14h





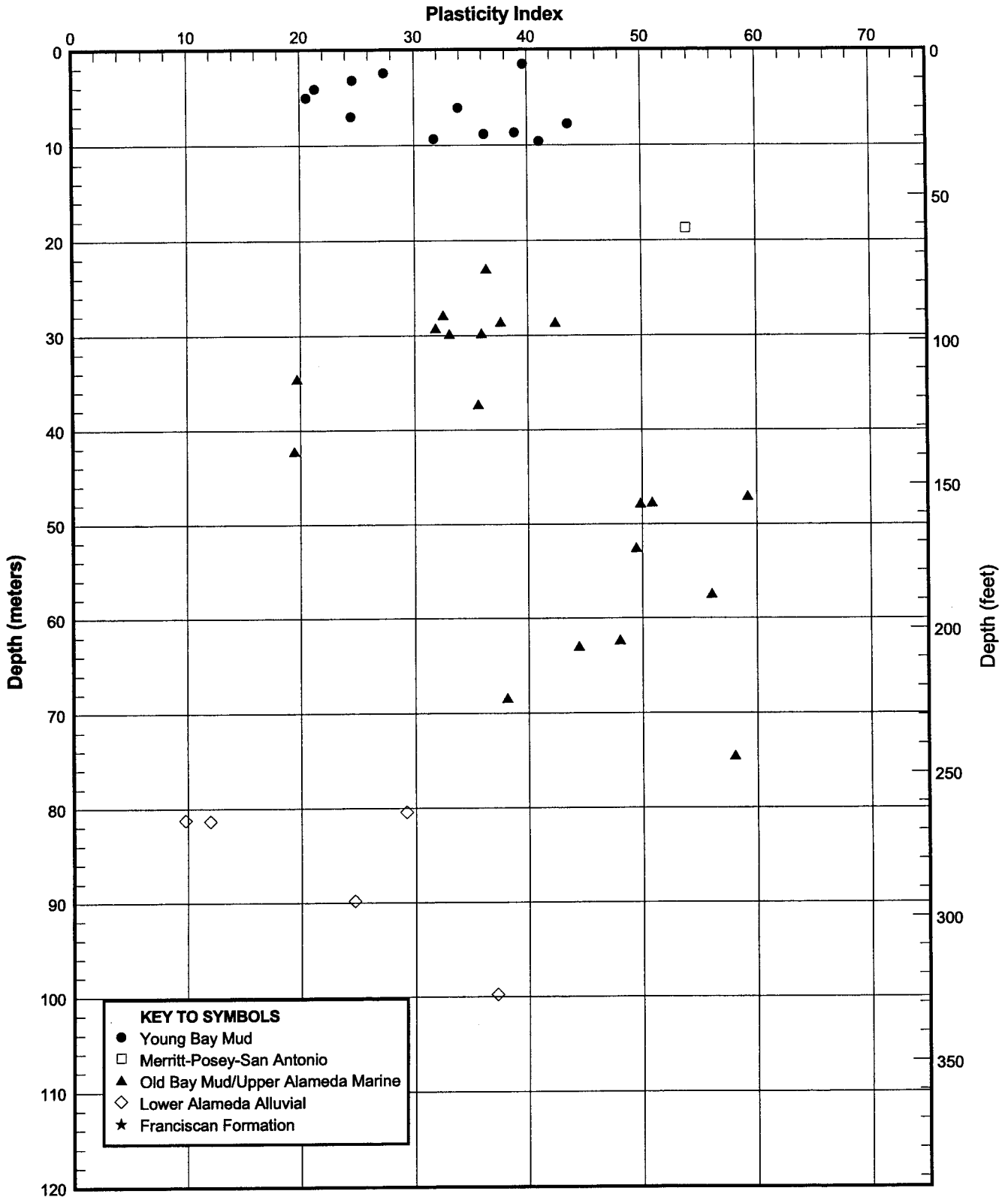
INCREMENTAL CONSOLIDATION TEST RESULTS

Sample No. 90 - Depth: 81.3m
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.14i

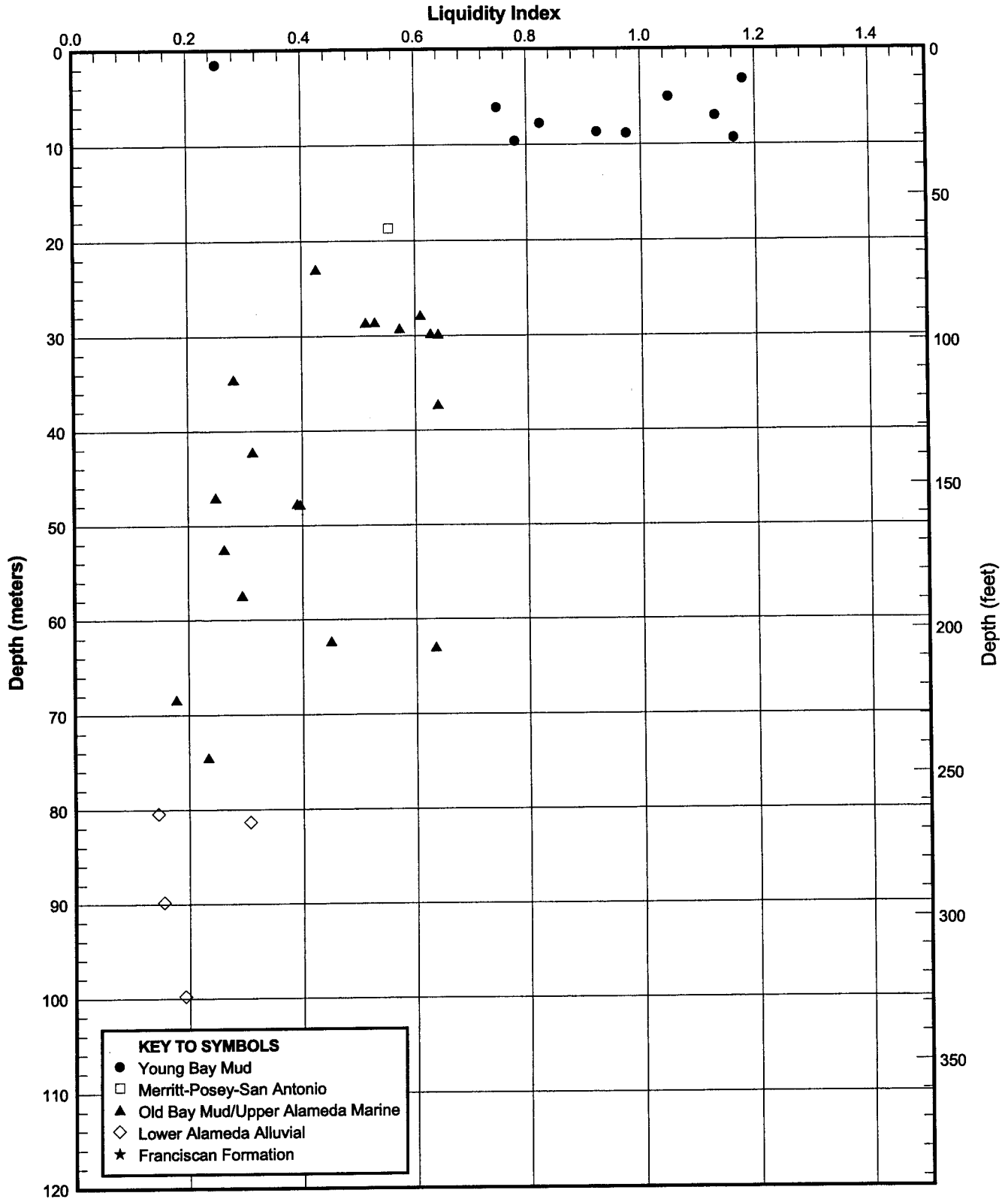
NO K_O CONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION TESTS PERFORMED FOR THIS BORING

NO ISOTROPICALLY CONSOLIDATED-DRAINED TRIAXIAL COMPRESSION TESTS PERFORMED FOR THIS BORING



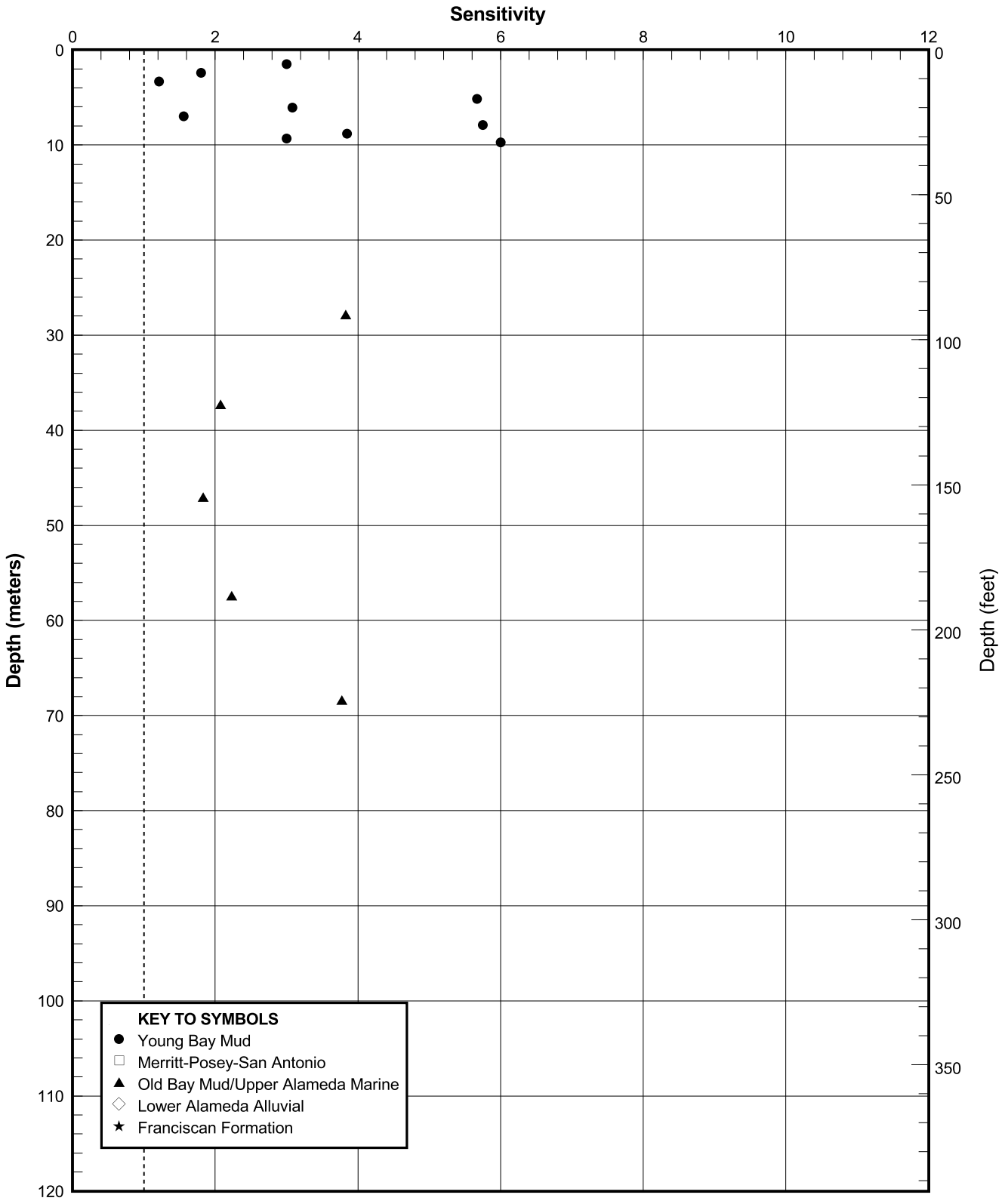
PLASTICITY INDEX PROFILE
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.17



LIQUIDITY INDEX PROFILE
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.18

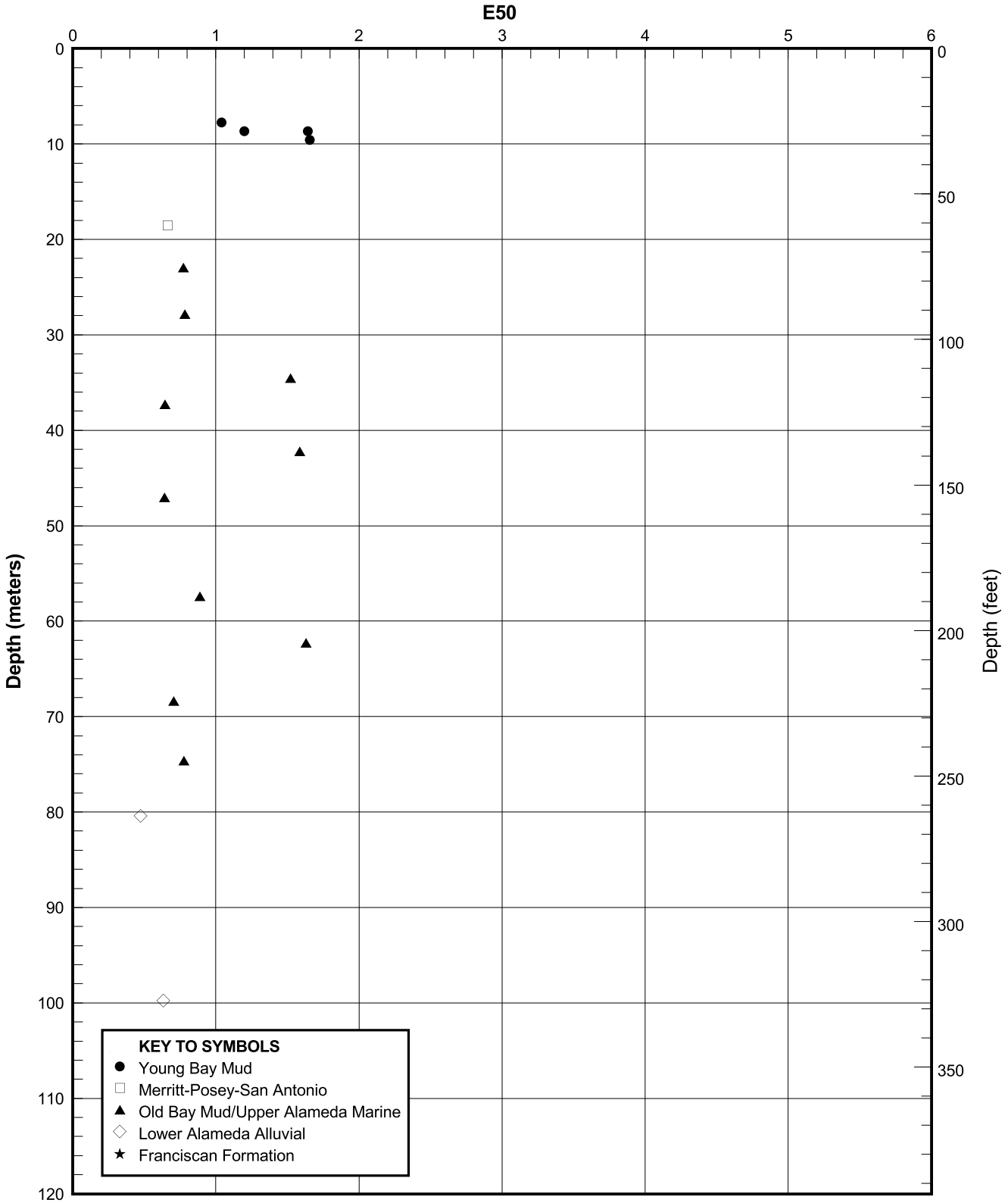


SENSITIVITY PROFILE
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.19

Earth Mechanics

FUGRO

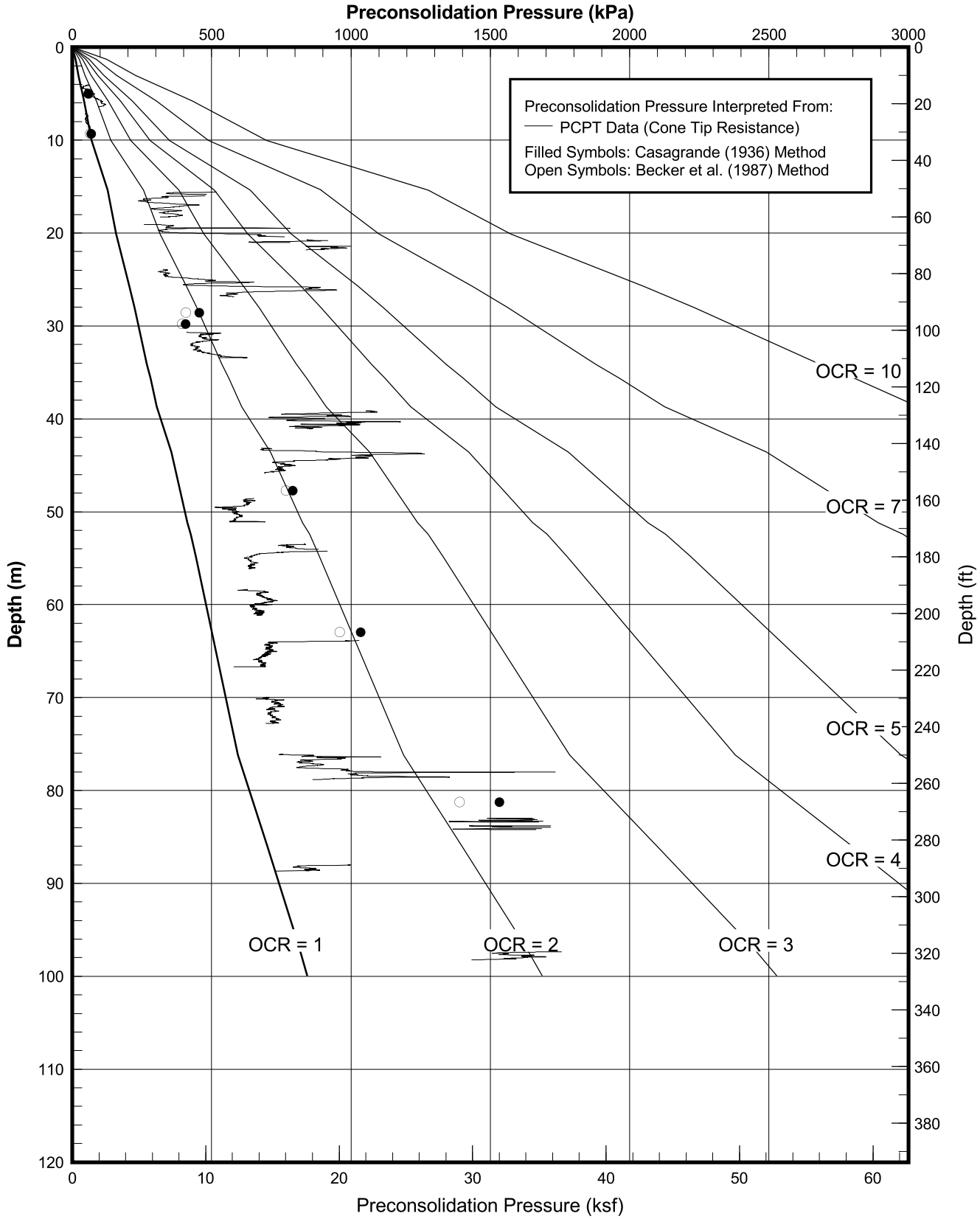


E50 PROFILE
Boring 98-44
SFOBB East Span Seismic Safety Project

PLATE 98-44.20

Earth Mechanics

FUGRO



PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA

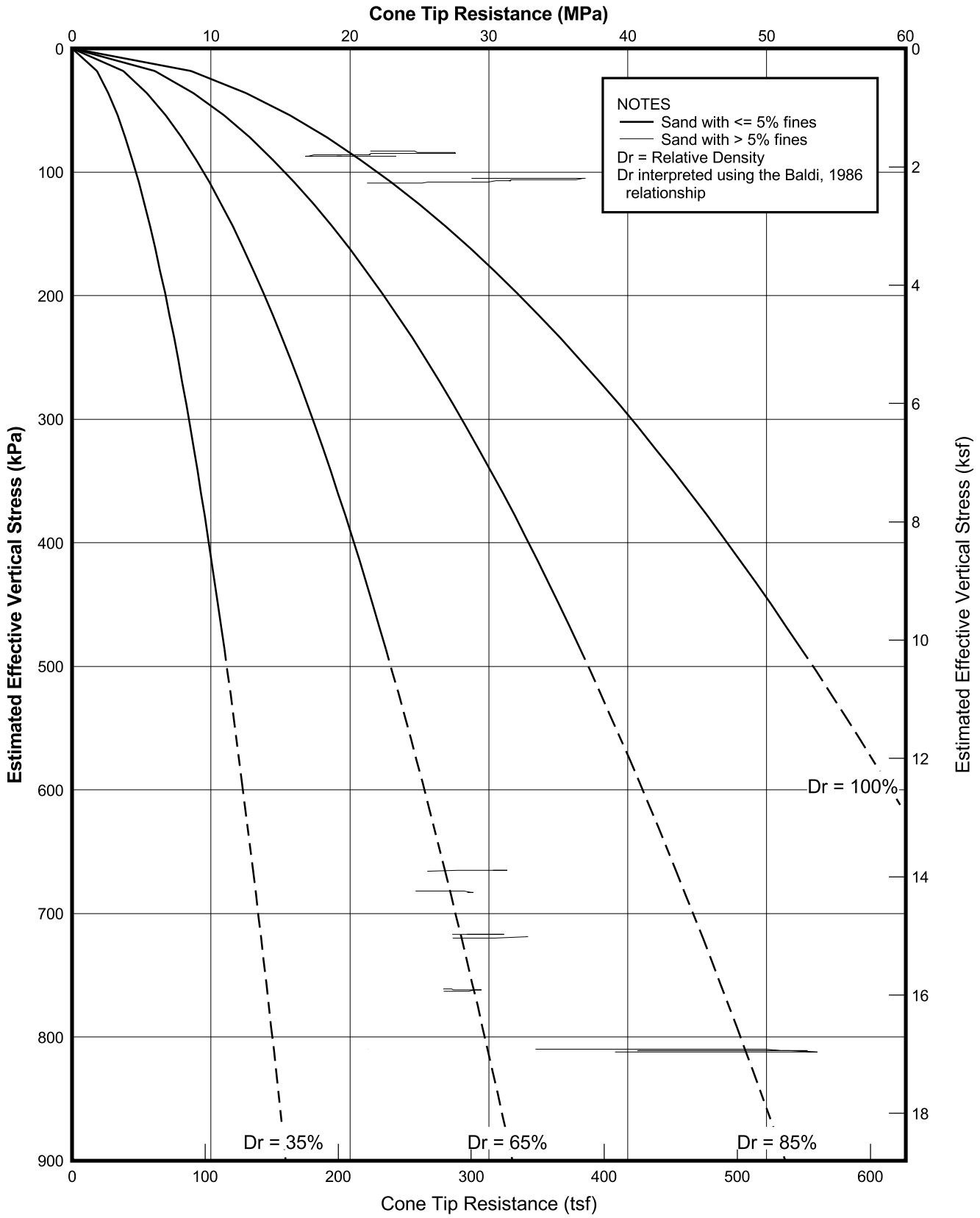
Boring 98-44

SFOBB East Span Seismic Safety Project

PLATE 98-44.21

Earth Mechanics

FUGRO



RELATIVE DENSITY INTERPRETED FROM CPT DATA

Boring 98-44

SFOBB East Span Seismic Safety Project

PLATE 98-44.22

Earth Mechanics

Fugro - Earth Mechanics
A JOINT VENTURE

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

VOLUME 3 - APPENDICES
(CPT Soundings)

Prepared for

CALIFORNIA DEPARTMENT OF TRANSPORTATION

March 2001

Earth Mechanics

Fugro - Earth Mechanics
A JOINT VENTURE

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March 5, 2001
Project No. 98-42-0058/EMI Project No. 98-145

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian
Contract Manager

Final Oakland Shore Approach Geotechnical Site Characterization
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. The majority of the Oakland Mole exploration was conducted as part of the Phase 2, Task 5 (final site characterization phase) studies of the referenced contract, although three cone penetration test (CPT) soundings were conducted as part of the earlier Phase 1, Task 3 work scope (preliminary site characterization) of the referenced contract.

The field exploration conducted on the Oakland Mole in the Spring and Fall of 1998 as part of the referenced contract included 25 soil borings (designated in the subsurface database created for the project as 98-51 through 98-75) and 9 CPT soundings (designated as 98-16 through 98-18 and 98-101 through 98-110 [several planned locations were abandoned due to electrical interference]). A total of 53 offshore tethered Seascout CPT soundings were conducted in December 1998 during seasonal high tides on the tidal flat to the north of the Oakland Mole. Fifteen all-terrain CPT soundings were conducted on the Tidal Flat to the north of the Mole in March 1999 during low tide conditions. Two trench and two pit excavations were conducted in April 1999. In Fall 2000, 11 marine Seacalf CPT soundings were performed in the vicinity of the Oakland Shore Approach to the west and northwest of the western tip of the Mole. The Seacalf CPTs were conducted as part of the Phase 3 field investigation program.

This Oakland Shore Approach Geotechnical Site Characterization report summarizes the field exploration for the Oakland Shore Approach and describes our interpretation of the geotechnical conditions based on the information collected from the exploration. Our present interpretations are based on the field data from the borings, the results of laboratory tests completed in the onshore laboratories, and the CPT soundings.

This report is provided in four volumes. Volume 1 provides the interpretational text and illustrations. Volume 2 contains 27 appendices that provide boring logs and test data from 25 land borings on the Oakland Mole and 2 marine borings offshore from the northwest tip of the Oakland Mole. Volume 3 contains the

results of the CPT soundings conducted on land, on the northern shore of the tidal flat, and offshore to the north and west of the Oakland Mole. Volume 4 contains four documents that include a preliminary study of approach fills at the Oakland Mole, studies on lateral spreading of fills at the Oakland Mole, findings from trench and pit excavations, and the advanced geotechnical laboratory studies conducted at the University of California at Berkeley.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO-EARTH MECHANICS, A Joint Venture

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Thomas W. McNeilan, C.E., G.E.
Vice President, Fugro West, Inc.

Attachment

Copies submitted: Mr. Mark Willian, Caltrans
Mr. Saba Mohan, Caltrans
Mr. Robert Price, Caltrans
Dr. Brian Maroney, Caltrans
Ms. Sharon Naramore, Caltrans
Mr. Gerry Houlahan, TY Lin/M&N
Mr. Sajid Abbas, TY Lin/M&N
Mr. Al Ely, TY Lin/M&N

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CALTRANS CONTRACT 59A0053

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

VOLUME 3 - APPENDICES
(CPT Soundings)

MARCH 2001

Prepared For:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Prepared By:

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CONE PENETRATION TEST SOUNDING DATA - VOLUME 3 2

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Marine-Based Seacalf CPT Locations and Depths 2.3

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APPENDIX 3B: Tethered Seascout CPT Data

APPENDIX 3C: Marine-Based Seacalf CPT Data

VOLUME 3
CONE PENETRATION TEST DATA APPENDIX

The exploration program for the site characterization of the Oakland Shore Approach of the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project included 25 onshore borings (10 with in situ testing), approximately 24 land-based cone penetration test (CPT) soundings, 53 marine tethered Seascout CPT soundings, and 11 marine-based Seacalf CPT soundings in the vicinity of the Oakland Shore Approach. In addition, two marine borings that were performed in the shallow water tidal flat to the north and northwest of the Mole are relevant to the characterization of the Oakland Shore Approach of the bridge. A description of the marine exploration program is provided under separate cover in the Final Marine Geotechnical Site Characterization report[1].

GEOTECHNICAL SITE CHARACTERIZATION SYNOPSIS - VOLUME 1

A general description of the Task Order No. 5, Final Oakland Shore Approach Geotechnical Site Characterization work scope is provided in Section 1.0 of Volume 1 of this report. A description of the land exploration program (drilling and CPT testing), tethered Seascout CPT program (including equipment used and field procedures,) and the marine-based Seacalf CPT sounding is presented in Section 2.0. Section 3.0 includes a description of laboratory testing equipment and procedures. The locations of the borings and CPT soundings are provided on Plates 2.1a and 2.1b, and a summary of the details of the individual exploration locations and depths is provided in Tables 2.1 through 2.3. Plates 2.1a and 2.1b and Tables 2.2 and 2.3 are provided at the end of this text for reference.

INDIVIDUAL BORING APPENDICES SYNOPSIS - VOLUMES 2A & 2B

Individual boring appendices are provided for each of the 27 borings (25 land borings and 2 marine borings) related to the Oakland Shore Approach in Volumes 2A and 2B. Those appendices include a boring log as well as the results and summaries of various in situ testing and laboratory testing data.

CONE PENETRATION TEST SOUNDING DATA – VOLUME 3

Logs of the CPT soundings are presented in Appendices A through C of Volume 3. Appendix 3A consists of data from 24 land-based CPT soundings, Appendix 3B contains CPT logs from 53 tethered marine Seascout CPT soundings, and Appendix 3C contains CPT logs from 11 marine Seacalf soundings. Land-based CPT soundings were performed using a

[1] Fugro-Earth Mechanics (2001), *Final Marine Geotechnical Site Characterization, San Francisco-Oakland Bay Bridge East Span Seismic Safety Project, Volume 1,* FWI Job No. 98-42-0054, prepared for California Department of Transportation, March 5.

15-square-centimeter (cm^2) cone deployed from a 20-ton truck on the Mole and from a track-mounted, all-terrain vehicle (ATV) on the tidal flats to the north of the Mole. Tethered Seascout CPT soundings were performed using a 1 cm^2 miniature-cone deployed from a 15-meter workboat along the tidal flats to the north of the Mole. Marine-based Seacalf soundings were performed using a 15 cm^2 cone advanced using Fugro's 10-ton, wheel drive CPT system deployed from an approximately 33-meter barge. Details of the equipment and procedures used are summarized in Section 2.0 of Volume 1 of this report.

The individual appendix plates are numbered with the sounding number. The CPT logs provide graphical plots of the data versus depth below the ground surface (land-based CPT) or mudline (tethered Seascout CPT and Seacalf CPT). Data that are shown include: a) cone tip resistance in megapascals (MPa), b) sleeve friction in MPa, c) pore pressure in MPa, and d) friction ratio in percent. Seismic velocity measurements were made in five of the truck-mounted and two ATV-mounted CPT soundings. Logs of those seven soundings also show shear wave velocity data in meters per second (m/sec). In addition to the CPT data, correlations with undrained shear strength, preconsolidation stress and relative density are included for the truck-mounted and ATV-mounted CPT soundings. Laboratory test results have been included for two ATV-mounted CPT locations (99C-12 and 99C-14) where sampling was performed. The laboratory test results include: summary of test results, grain size curves, plasticity chart, plasticity index, and liquidity index profiles. The Seacalf CPT sounding logs include estimates of undrained shear strength interpreted from CPT tip resistance for fine-grained layers.

Tip resistance and pore pressure data for the both the Seascout and Seacalf CPT soundings are referenced to the mudline elevation at the test locations. The values shown on the log have been offset to eliminate the hydrostatic head at the mudline at the time of the test. It should be noted (as described in greater detail in Section 2.0 of Volume 1) that the miniature-cone data should generally be used as a qualitative indicator of subsurface conditions. Quantitative empirical relationships derived for regular cones should be used with caution and only by individuals experienced with the miniature cone data.

Designation	Easting	Northing	Station Along "W-Line"	Offset from "W-Line" (m)	Ground Surface Elevation (m MSL)	Depth (m)	Velocity Logging with Seismic Cone	Soil Sampling
Phase 1, Spring 1998								
98-16	1838906	648241	84+12	9RT	1.5	17.3	No	No
98-17	1839051	648271	85+59	6LT	3.5	53.1	Yes	No
98-18	1839237	648298	87+47	20LT	3.2	50.0	Yes	No
Phase 2, Fall 1998								
98-101 (CPT-1)	1839011	648267	85+19	6LT	3.1	49.8	Yes	No
98-102 (CPT-2)	1839111	648300	86+52	9RT	2.1	50.2	Yes	No
98-104 (CPT-4)	1839304	648323	88+46	1RT	3.7	21.9	No	No
98-105 (CPT-5)	1839372	648313	89+13	16RT	3.6	39.1	No	No
98-110 (CPT-10)	1839489	648287	89+96	15RT	3.1	46.8	No	No
98-109 (CPT-9)	1839339	648260	88+45	26RT	3.0	48.9	Yes	No
Phase 2, All-Terrain (Spring 1998)								
99C-1	1838969	648274	85+08	23RT	-0.2	29.3	No	No
99C-2	1839037	648290	85+77	13RT	-0.6	12.1	No	No
99C-3	1839150	648311	86+91	1RT	0.1	15.5	No	No
99C-4	1839208	648316	87+50	1RT	-0.1	15.4	No	No
99C-5	1839262	648328	88+04	7RT	-0.1	15.5	No	No
99C-6	1839329	648333	88+72	7RT	-0.4	16.6	No	No
99C-7	1839384	648343	89+27	13RT	-0.6	19.8	No	No
99C-8	1839431	648353	89+75	19RT	-0.6	15.6	No	No
99C-9	1839496	648364	90+42	23LT	-0.7	15.0	No	No
99C-10	1839558	648374	91+06	23LT	-0.6	15.4	No	No
99C-11	1839139	648320	86+81	10LT	-0.4	24.4	No	No
99C-12	1839174	648323	87+16	10LT	-0.4	29.5	No	Yes
99C-13	1839205	648325	87+47	9LT	-0.4	22.6	Yes	No
99C-14	1839250	648329	87+92	9LT	-0.3	16.6	No	Yes
99C-15	1839014	648299	85+55	2LT	-0.4	11.7	Yes	No

NOTE: Electrical interference prevented data acquisition at planned CPT locations 98C-103 (CPT-3), 98C-106 (CPT-6), 98C-107 (CPT-7), and 98C-108 (CPT-8).

ON-LAND CPT LOCATIONS AND DEPTHS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

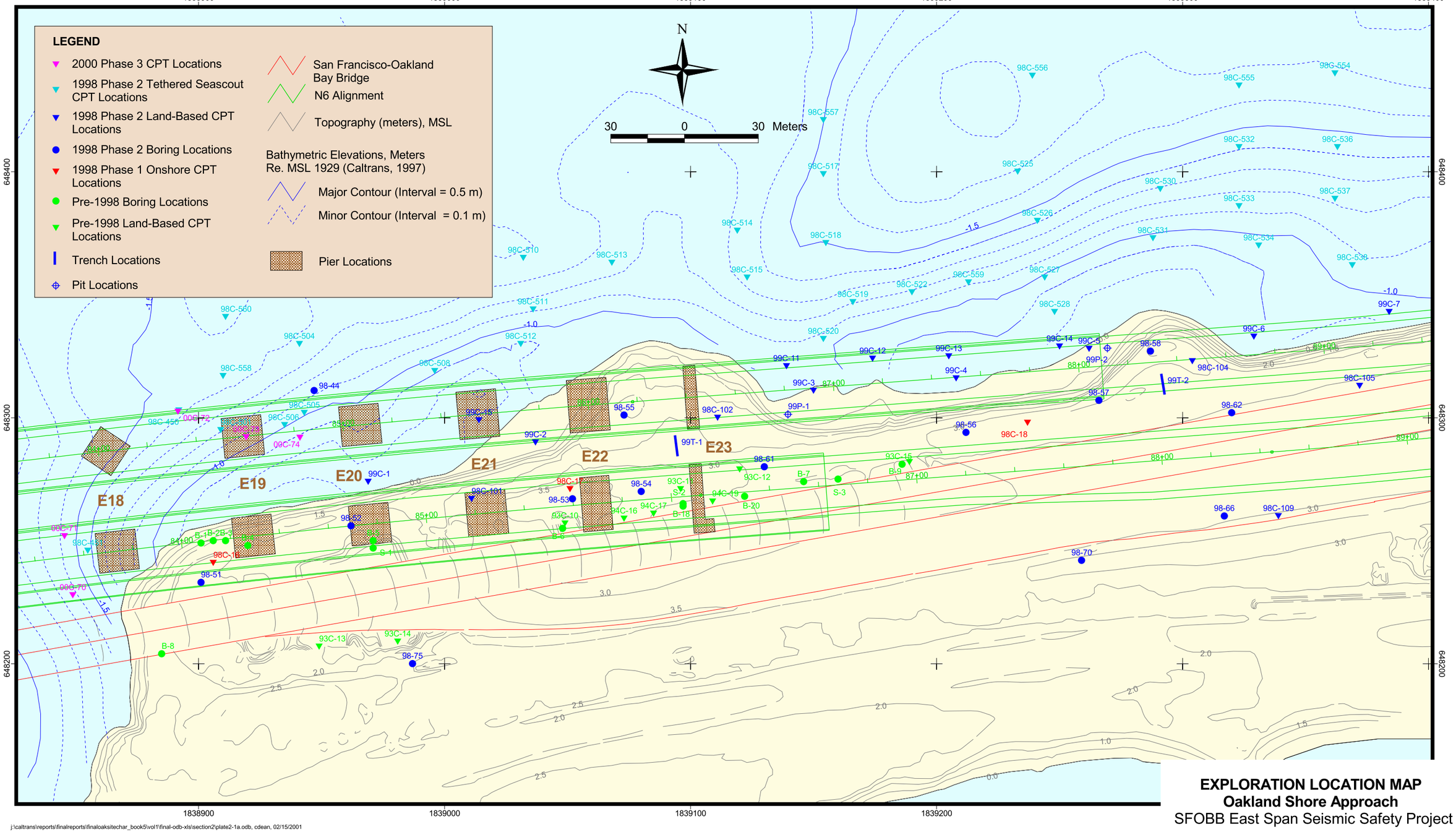
TABLE 2.2

Designation	Easting	Northing	Station	Offset (m)	Ground Surface Elevation (m MSL)	Depth (m)	Velocity Logging with Seismic Cone	Soil Sampling
September - October, 2000								
00C-64	1838758	648273	"W" Sta. 83+00	1 m Left	-2.9	50.0	No	No
00C-65	1838765	648233	"E" Sta. 82+79	1 m Right	-2.9	29.7	No	No
00C-66	1838780	648262	"W" Sta. 83+20	13 m Right	-2.6	25.1	No	No
00C-67	1838786	648232	"E" Sta. 83+0	4 m Right	-2.6	39.9	No	No
00C-68	1838806	648225	"E" Sta. 83+20	14 m Right	-2.4	42.2	No	No
00C-69	1838823	648249	"E" Sta. 83+40	8 m Left	-0.9	40.0	No	No
00C-70	1838848	648227	"E" Sta. 83+59	16 m Right	-1.6	11.9	No	No
00C-71	1838845	648251	"E" Sta. 83+59	8 m Left	-1.6	11.1	No	No
00C-72	1838891	648302	"W" Sta. 84+40	14 m Left	-1.4	51.4	No	No
00C-73	1838919	648292	"W" Sta. 84+59	No offset	-1.1	17.9	No	No
00C-74	1838941	648291	"W" Sta. 85+0	2 m Right	-0.9	12.7	No	No

MARINE-BASED SEACALF CPT LOCATIONS AND DEPTHS
Oakland Shore Approach
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO



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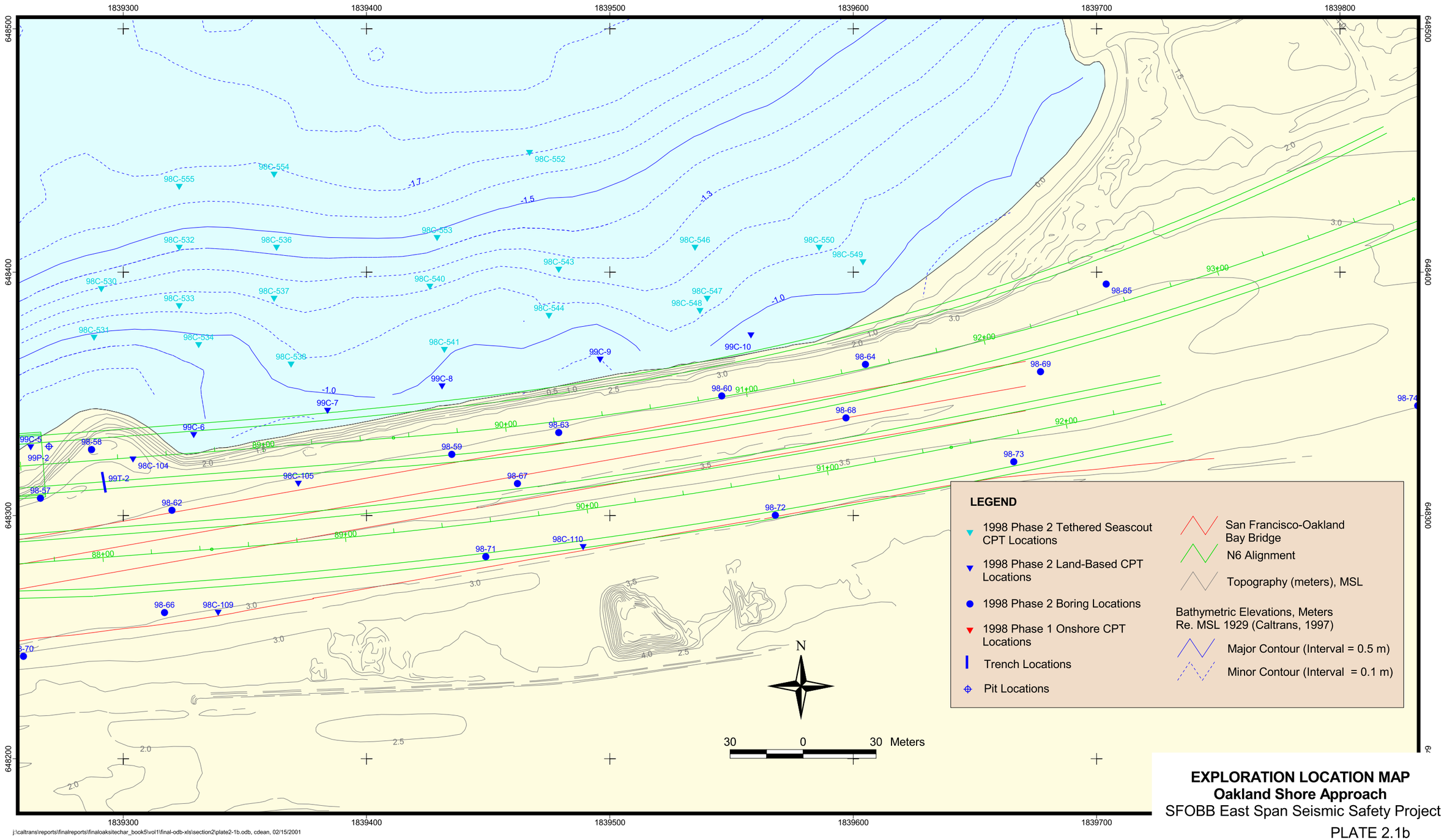
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1a

Earth Mechanics

FUGRO



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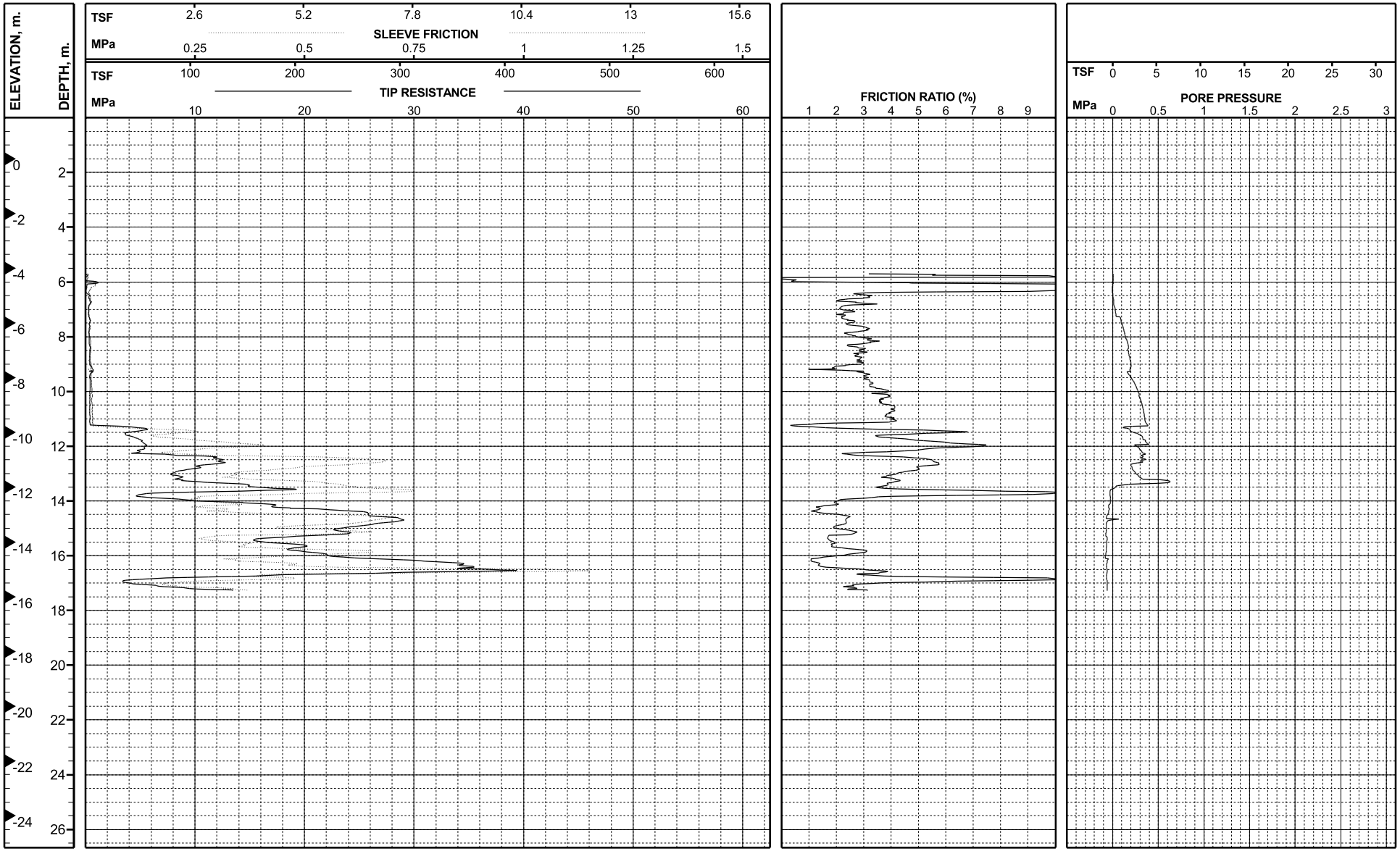
EXPLORATION LOCATION MAP
Oakland Shore Approach
SFOBB East Span Seismic Safety Project
PLATE 2.1b

APPENDIX A
LAND-BASED CPT DATA

PROJECT NO:	98-42-0058	**COORDINATES:**	E1838906 N648241 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98-16 (9m right of E. Sta 84+12)	**GROUND ELEVATION:**	1.5 m (MSL)	**TEST DATE:**	03/20/98



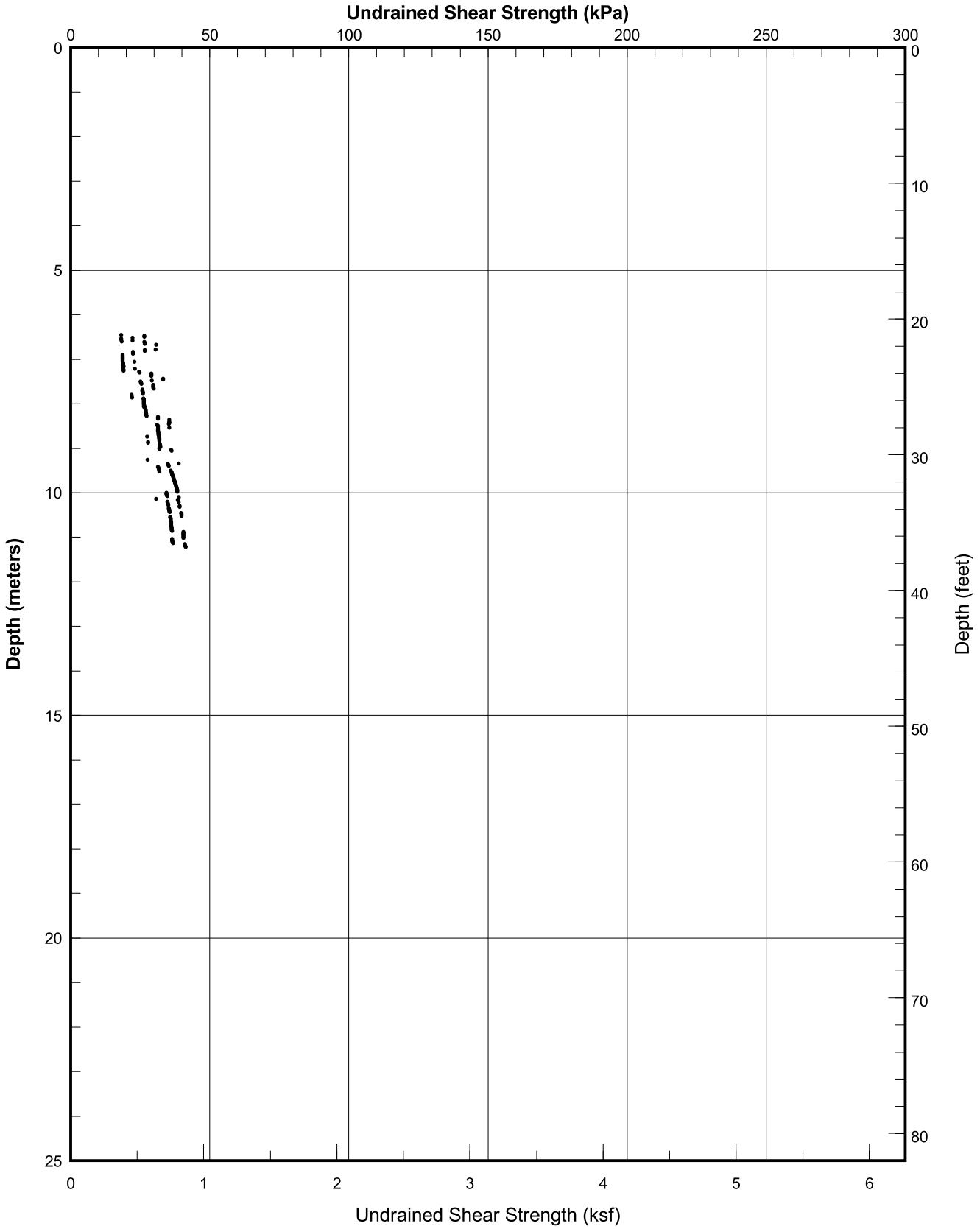
LOG OF CPT

SOUNDING 98-16

SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 98-16.1



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

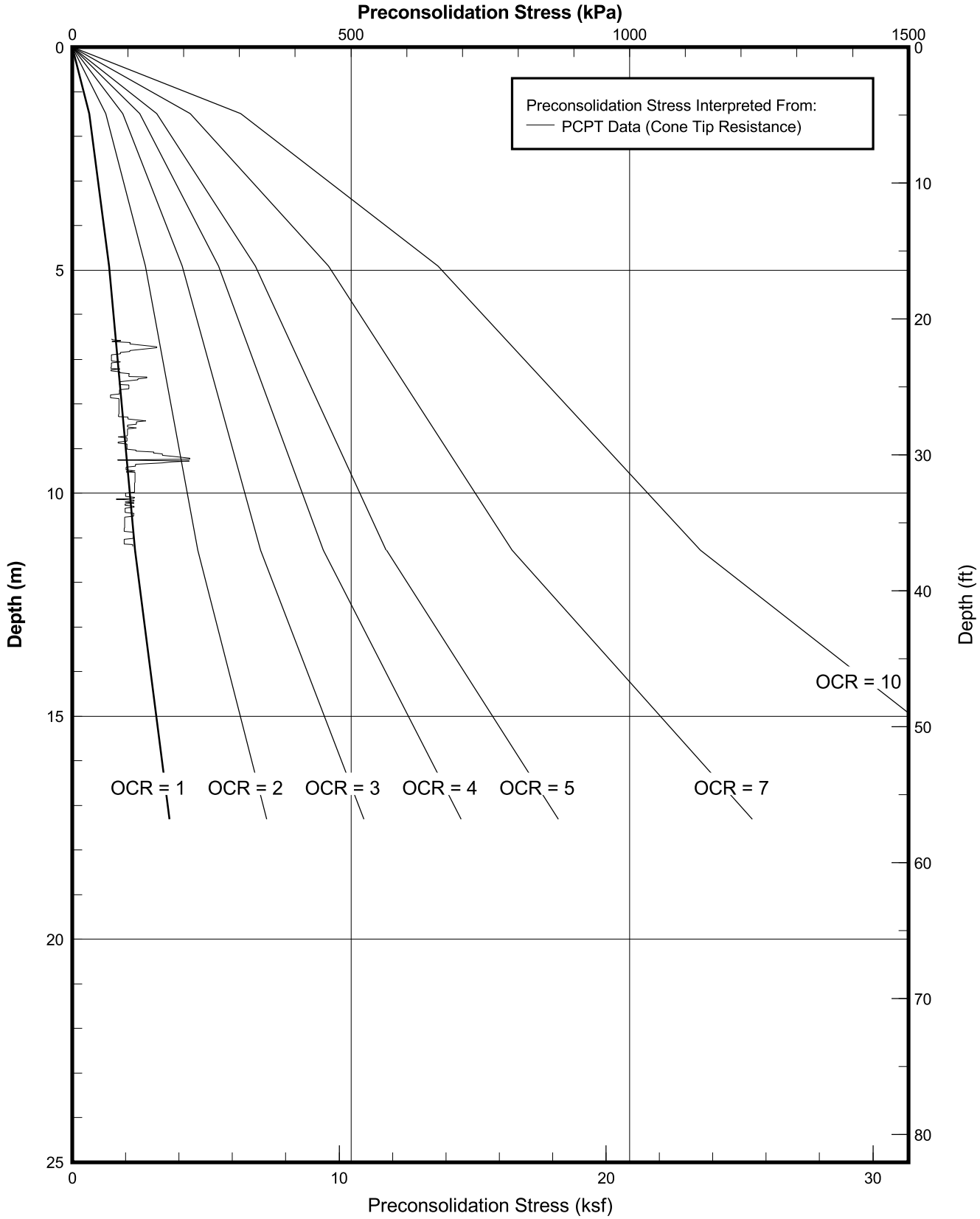
Sounding 98-16

SFOBB East Span Seismic Safety Project

PLATE 98-16.2

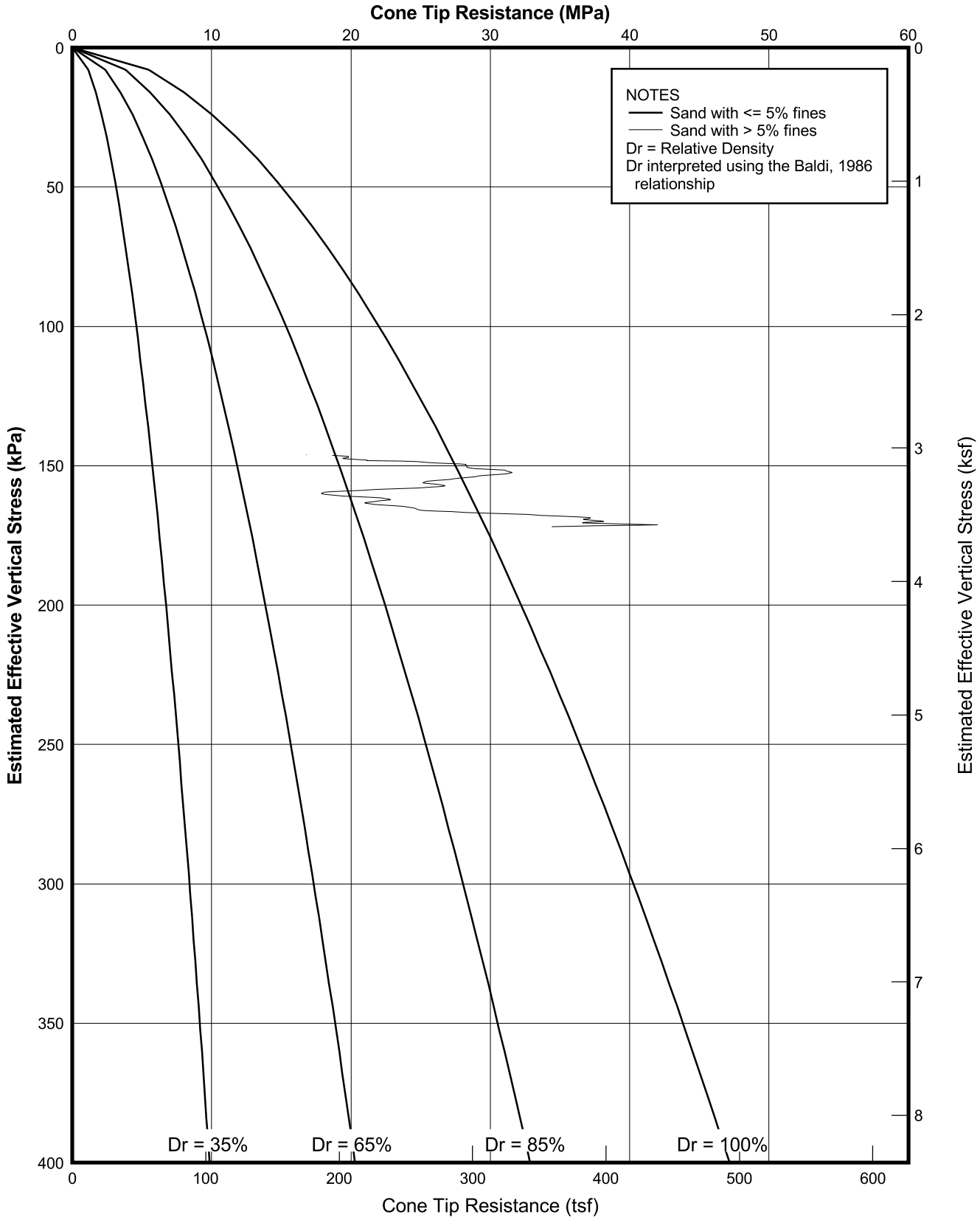
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98-16
SFOBB East Span Seismic Safety Project

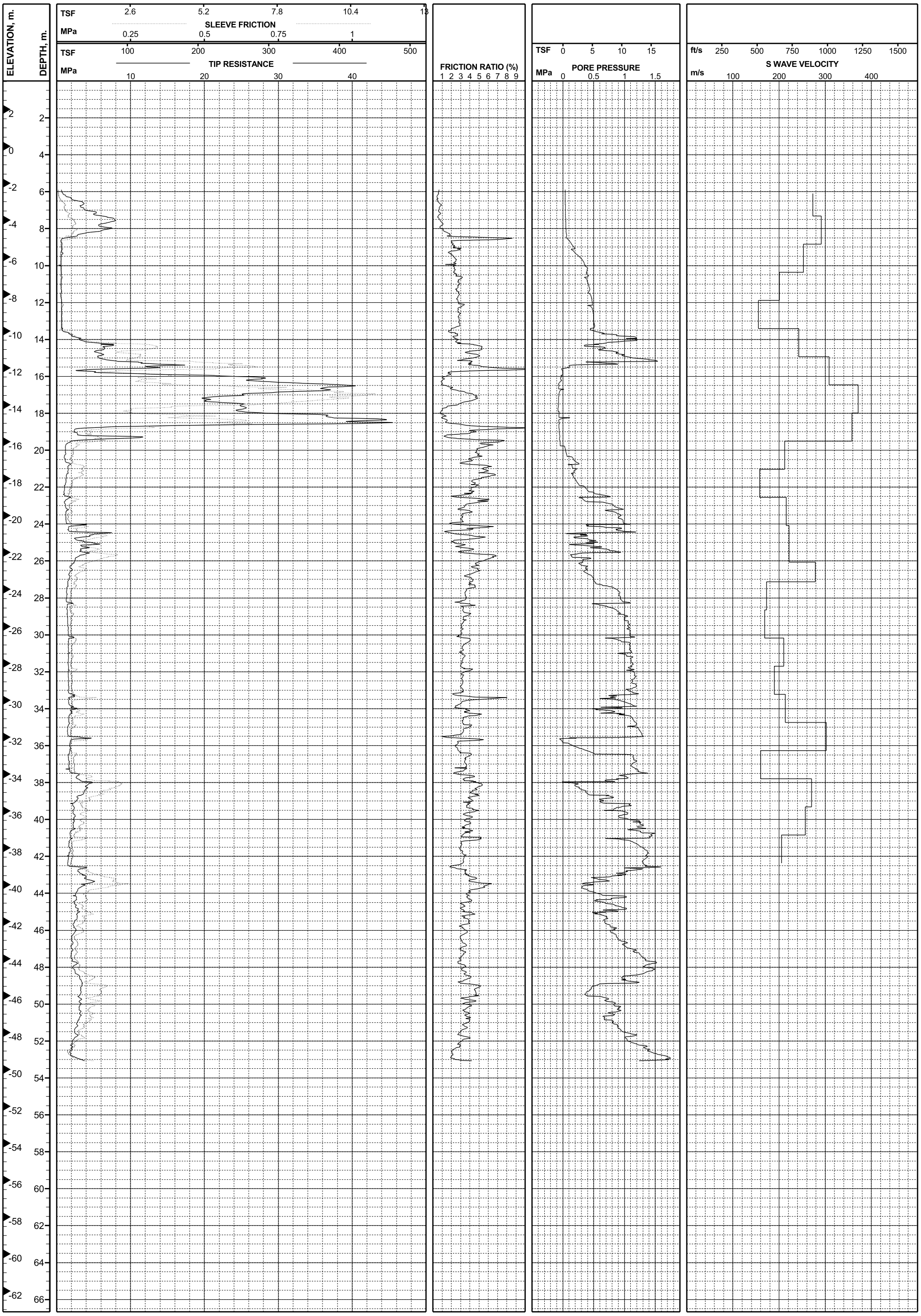
PLATE 98-16.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98-16
SFOBB East Span Seismic Safety Project

PLATE 98-16.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839051 N648271 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98-17 (6m left of E. Sta. 85+59)	**GROUND ELEVATION:**	3.5 m (MSL)	**TEST DATE:**	03/13/98



LOG OF CPT

SOUNDING 98-17

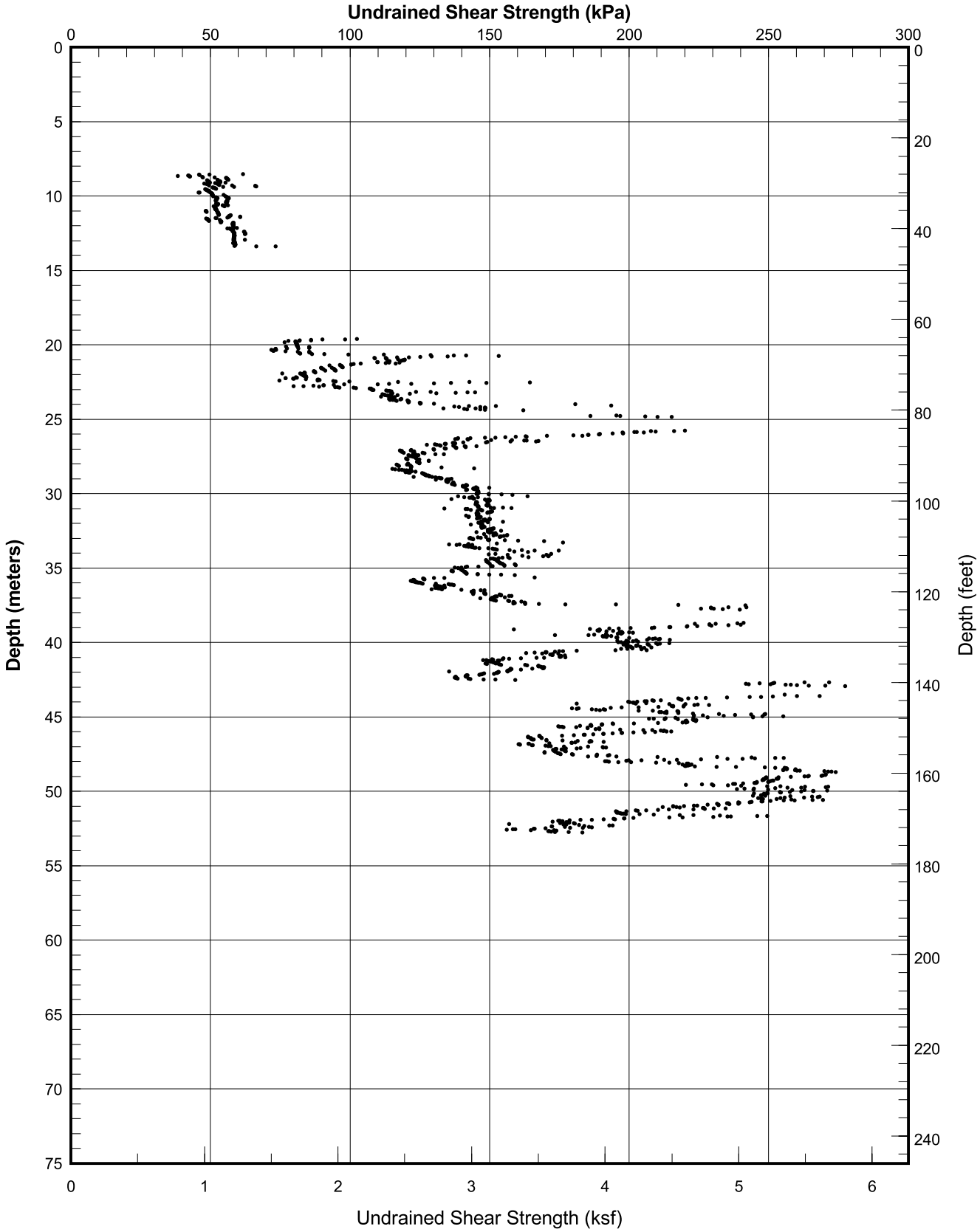
SFOBB East Span Seismic Safety Project

Report Date: 07/12/99

PLATE 98-17.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

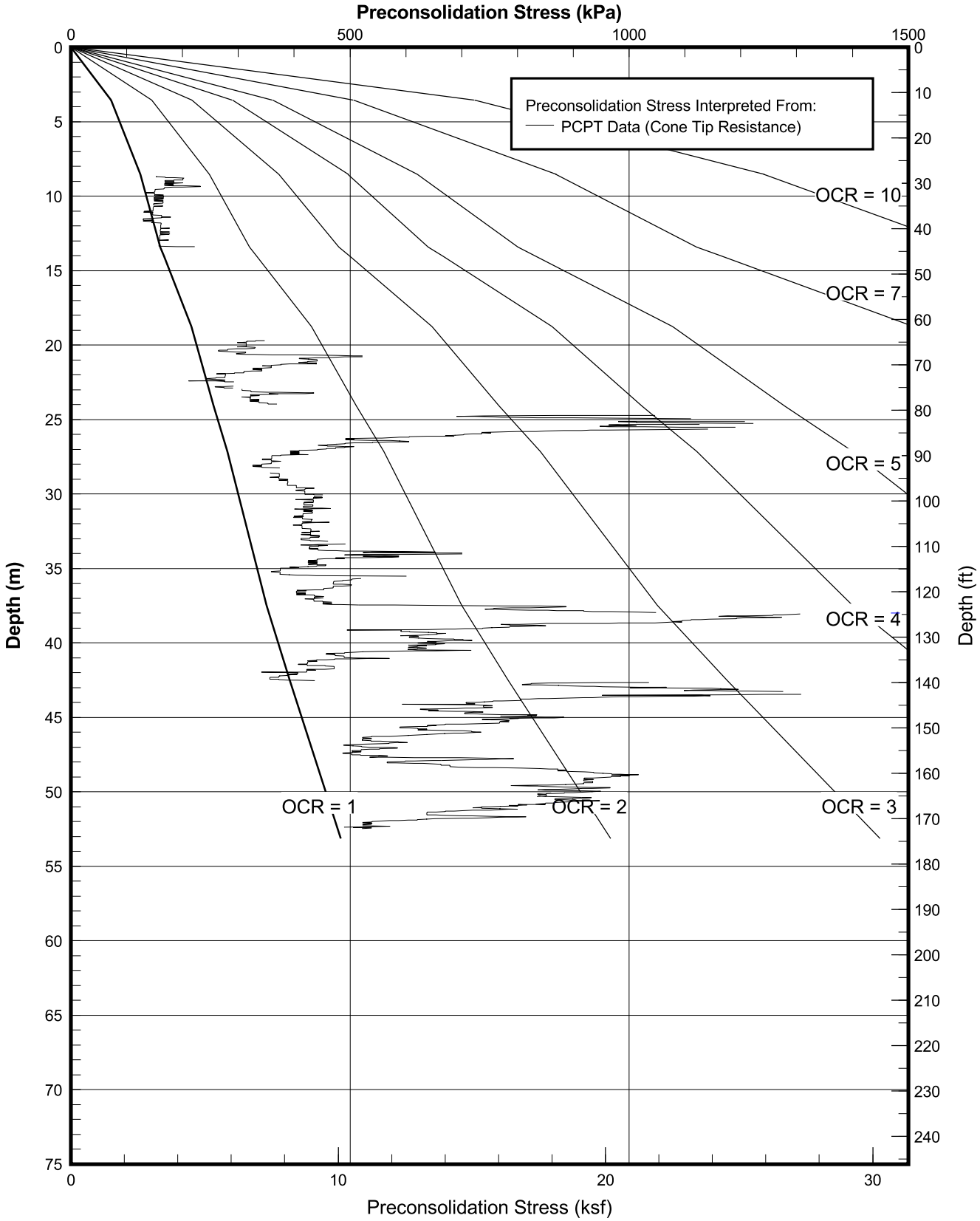
Sounding 98-17

SFOBB East Span Seismic Safety Project

PLATE 98-17.2

Earth Mechanics

FUGRO

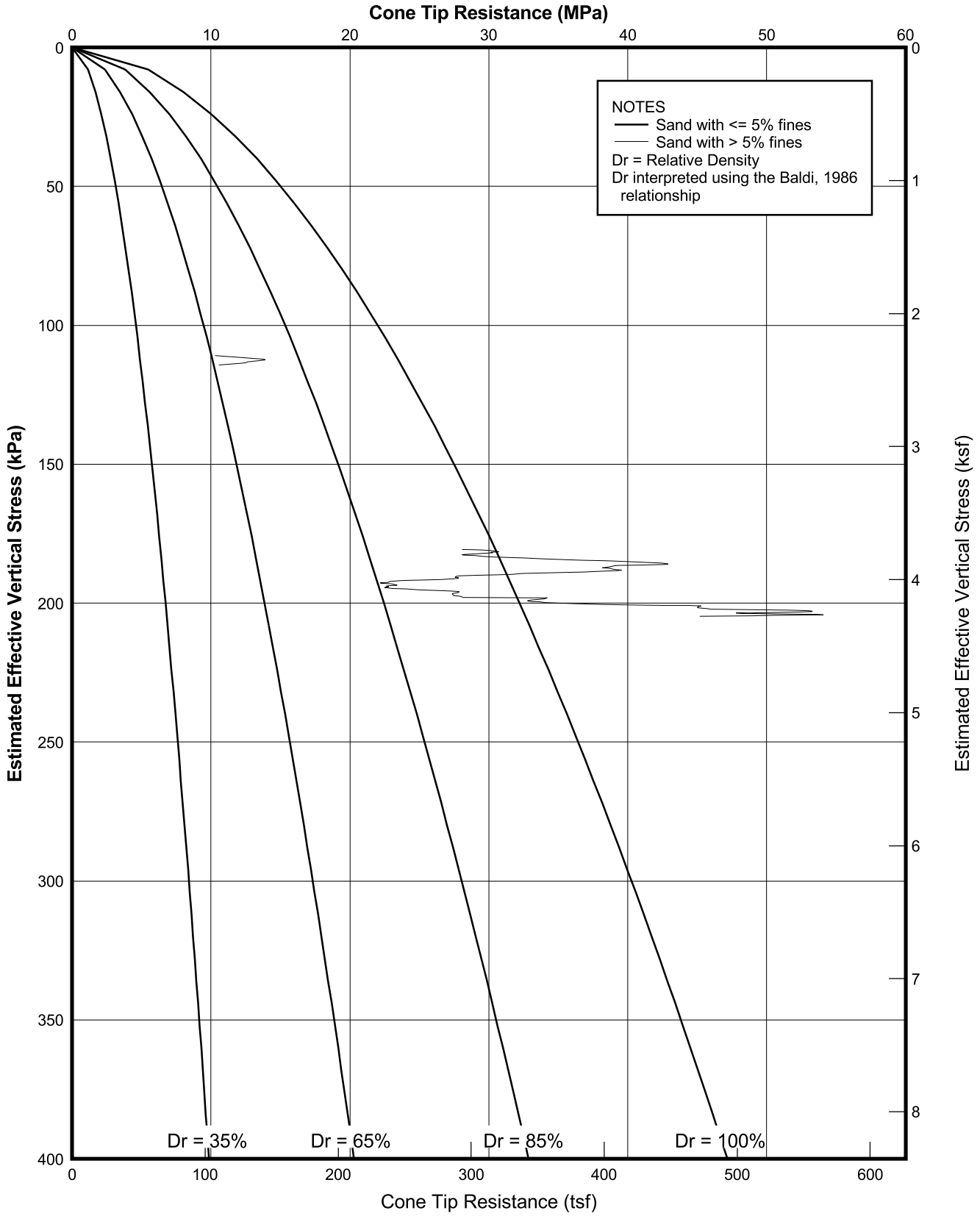


PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA

Sounding 98-17

SFOBB East Span Seismic Safety Project

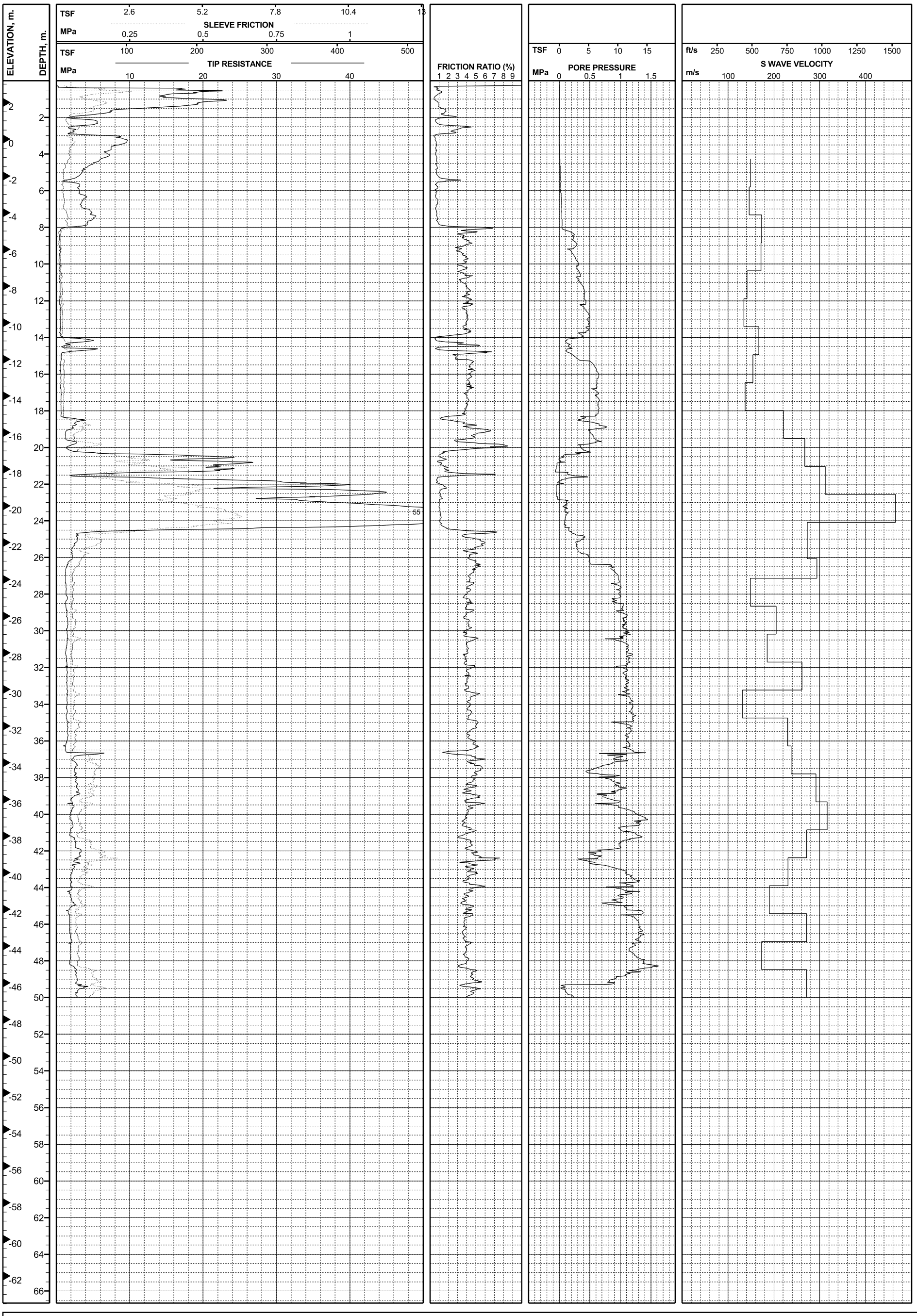
PLATE 98-17.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98-17
SFOBB East Span Seismic Safety Project

PLATE 98-17.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839237 N648298 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98-18 (20m left of E. Sta. 87+47)	**GROUND ELEVATION:**	3.2 m (MSL)	**TEST DATE:**	03/12/98



LOG OF CPT

SOUNDING 98-18

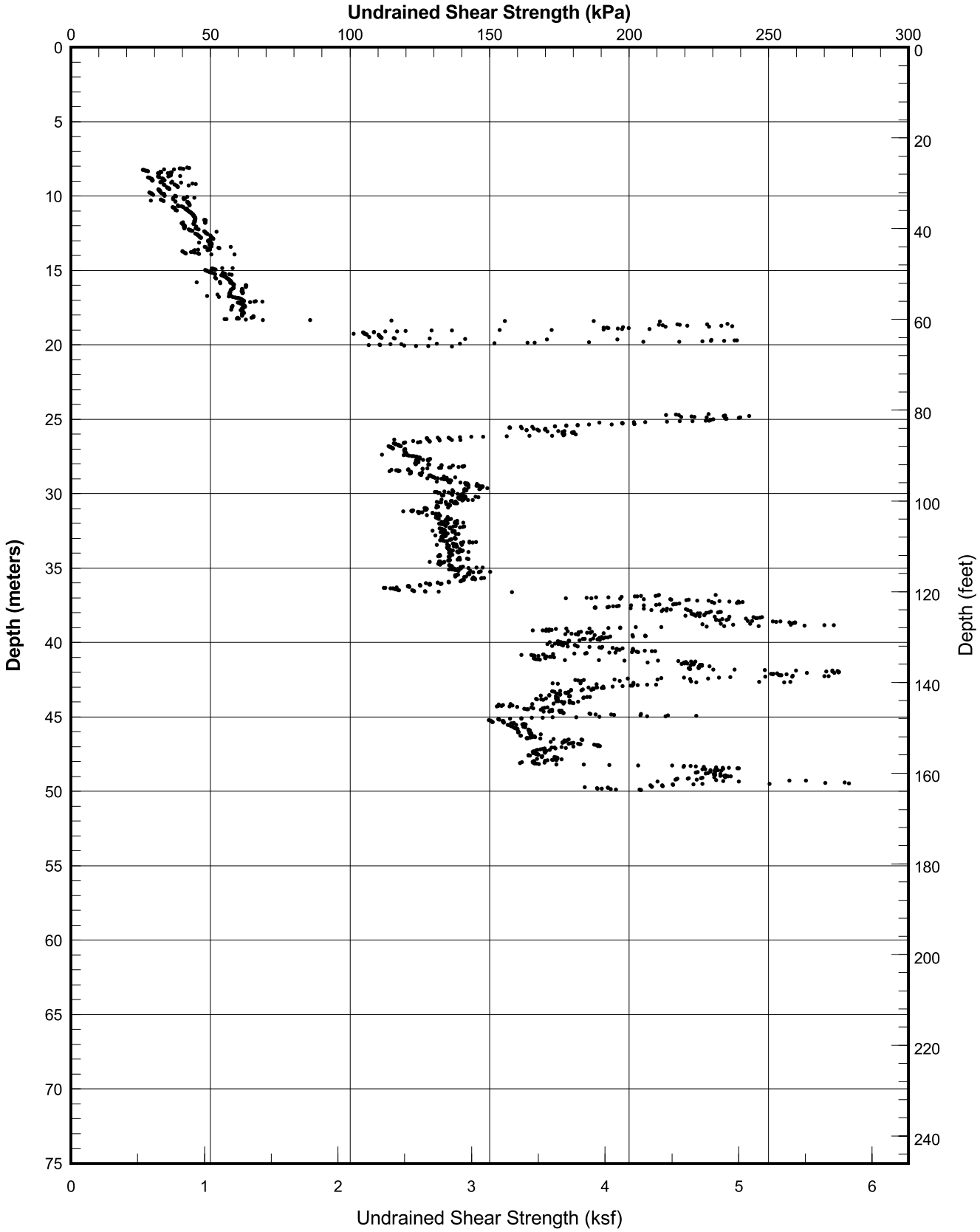
SFOBB East Span Seismic Safety Project

Report Date: 07/12/99

PLATE 98-18.1

Earth Mechanics

FUGRO

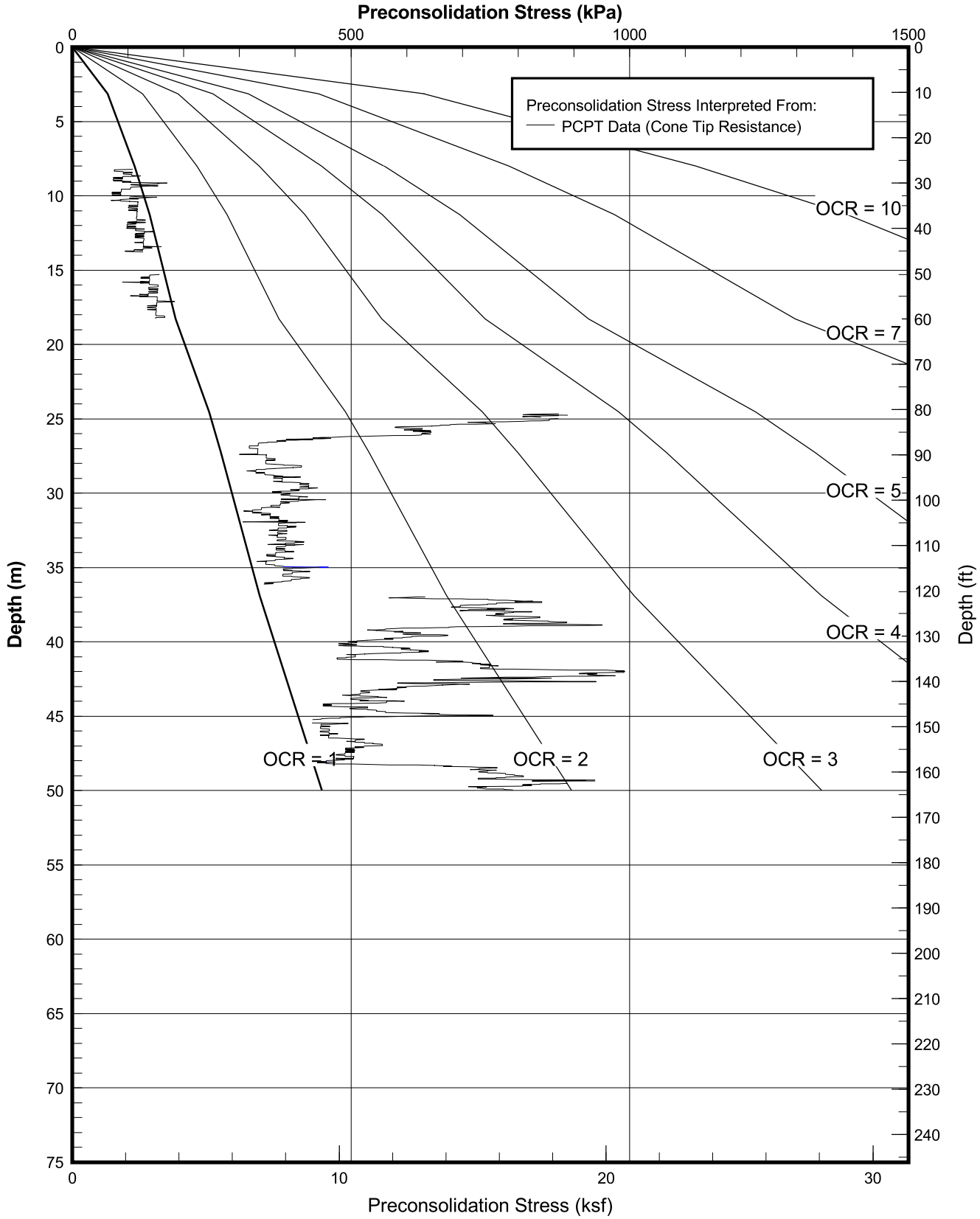


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 98-18

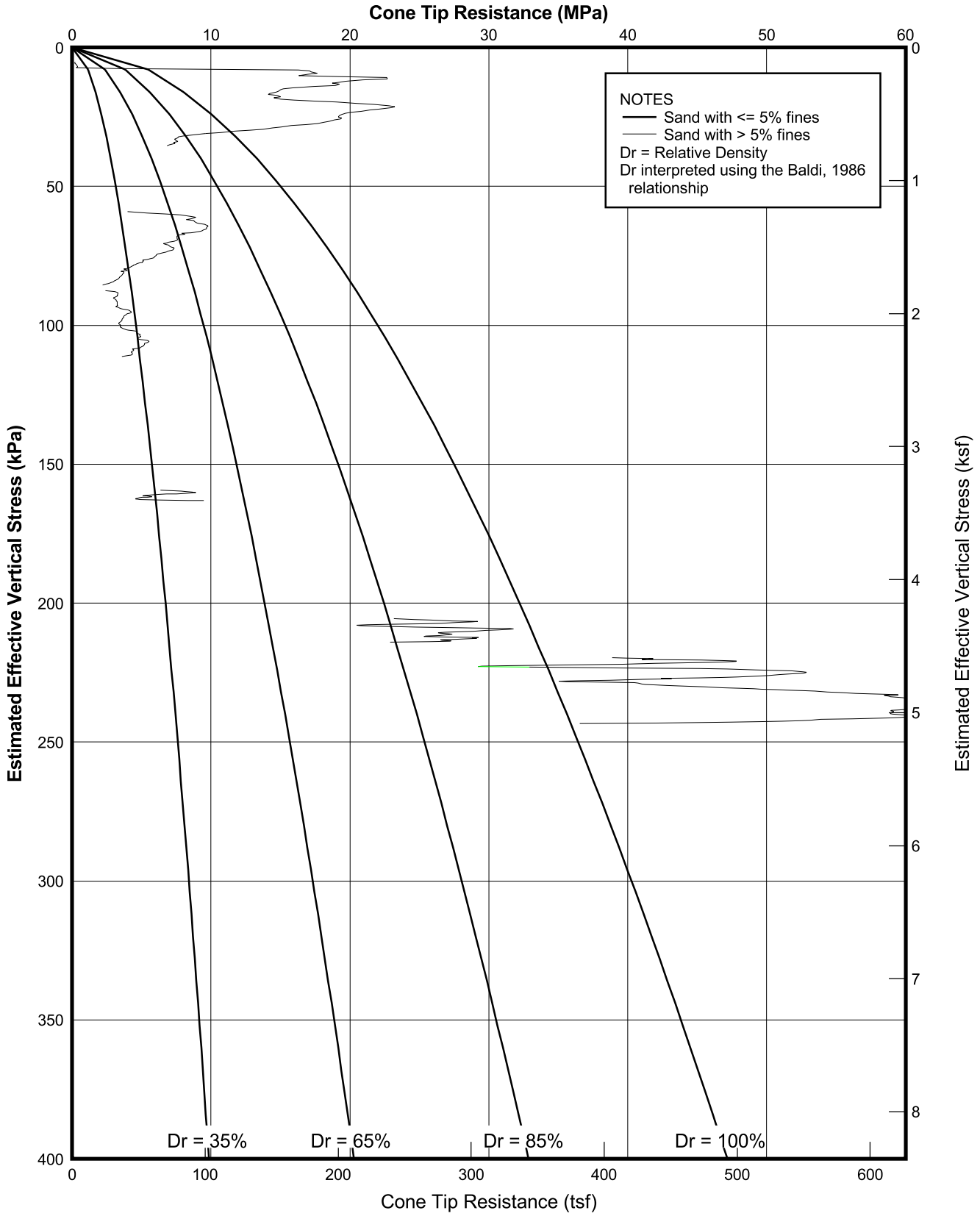
SFOBB East Span Seismic Safety Project

PLATE 98-18.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98-18
SFOBB East Span Seismic Safety Project

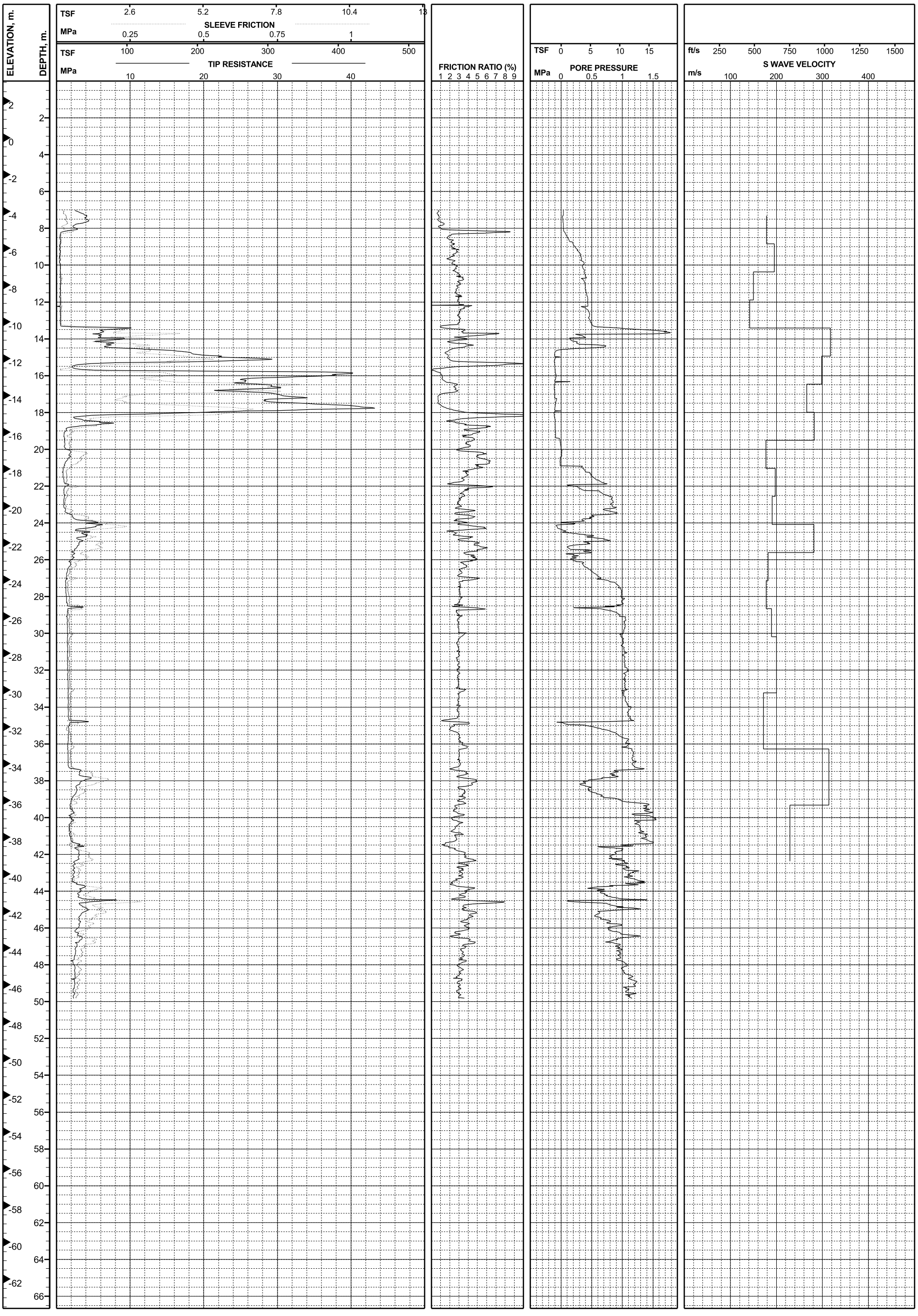
PLATE 98-18.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98-18
SFOBB East Span Seismic Safety Project

PLATE 98-18.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839011.21 N648267.35 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-101 (6m left of E. Sta. 85+19)	**GROUND ELEVATION:**	3.1 m (MSL)	**TEST DATE:**	10/17/98



LOG OF CPT

SOUNDING 98C-101

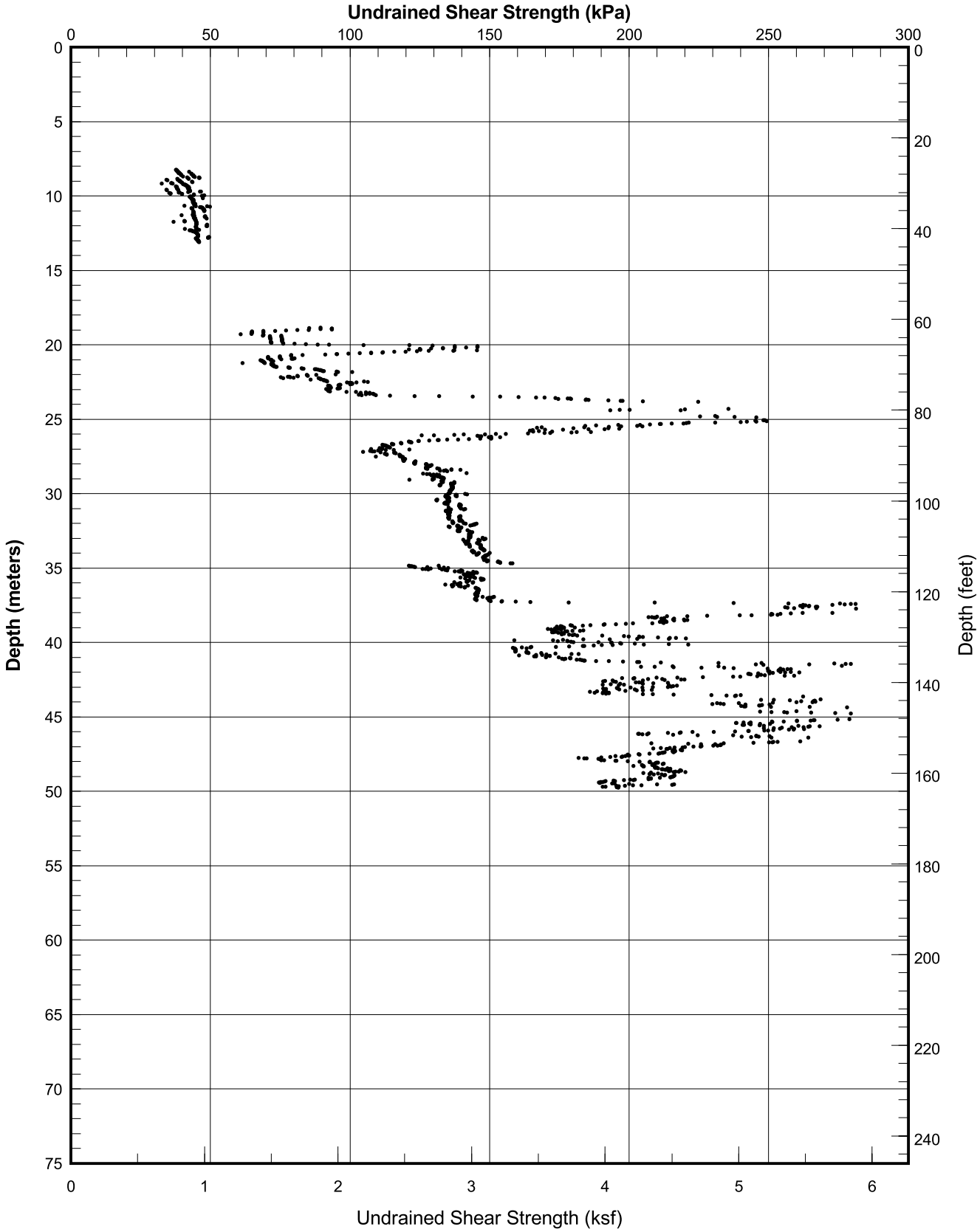
SFOBB East Span Seismic Safety Project

Report Date: 07/12/99

PLATE 98C-101.1

Earth Mechanics

FUGRO

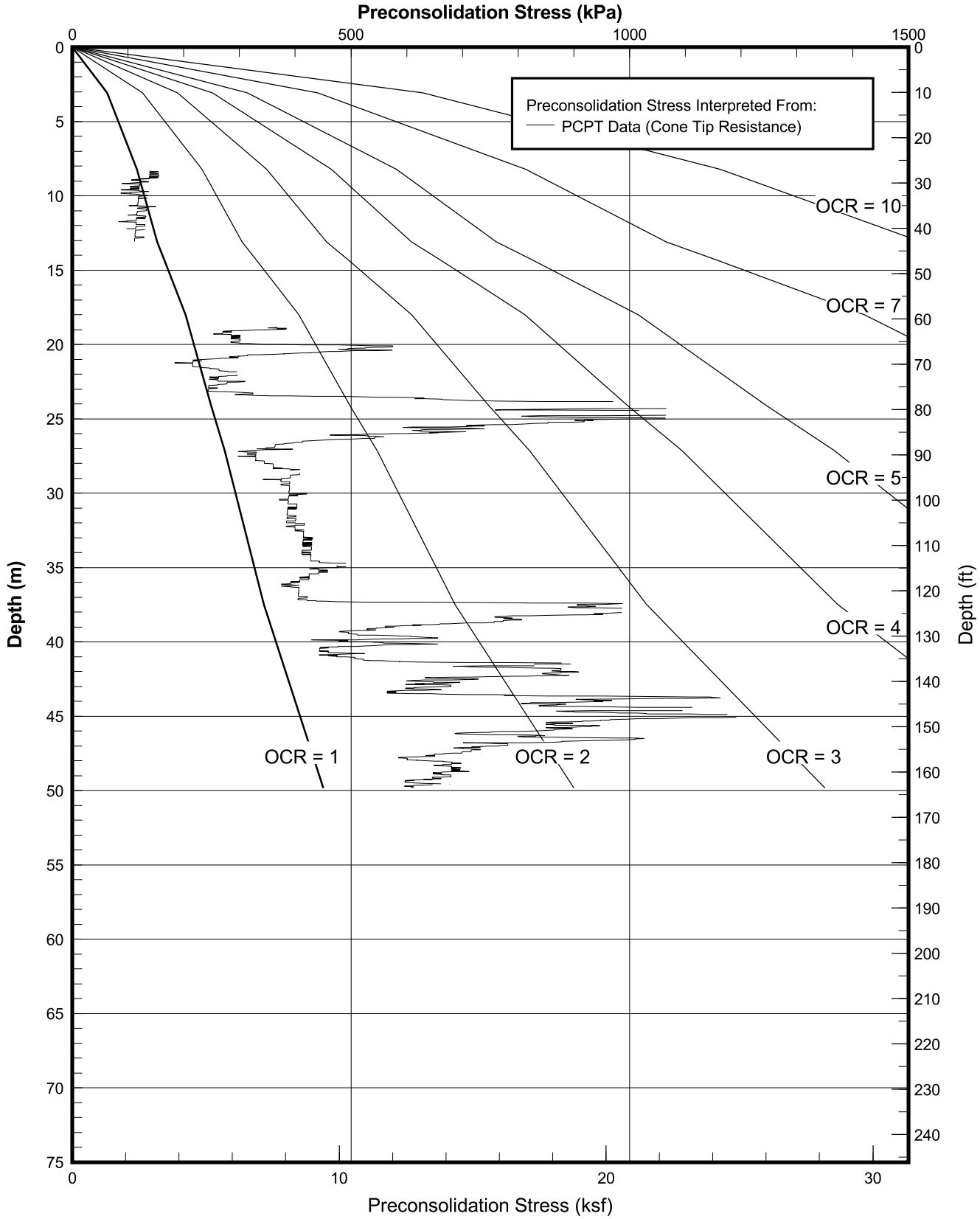


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 98C-101

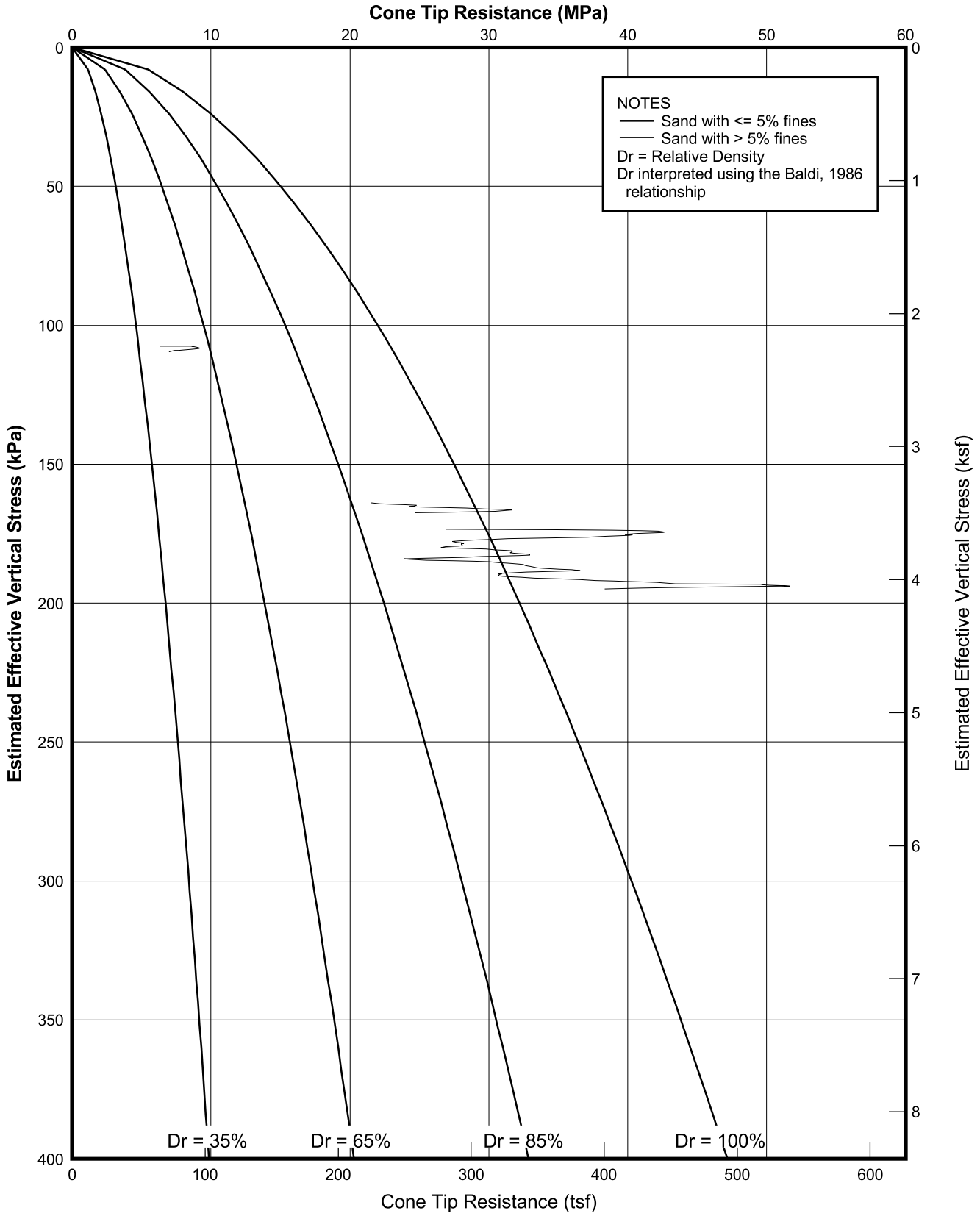
SFOBB East Span Seismic Safety Project

PLATE 98C-101.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98C-101
SFOBB East Span Seismic Safety Project

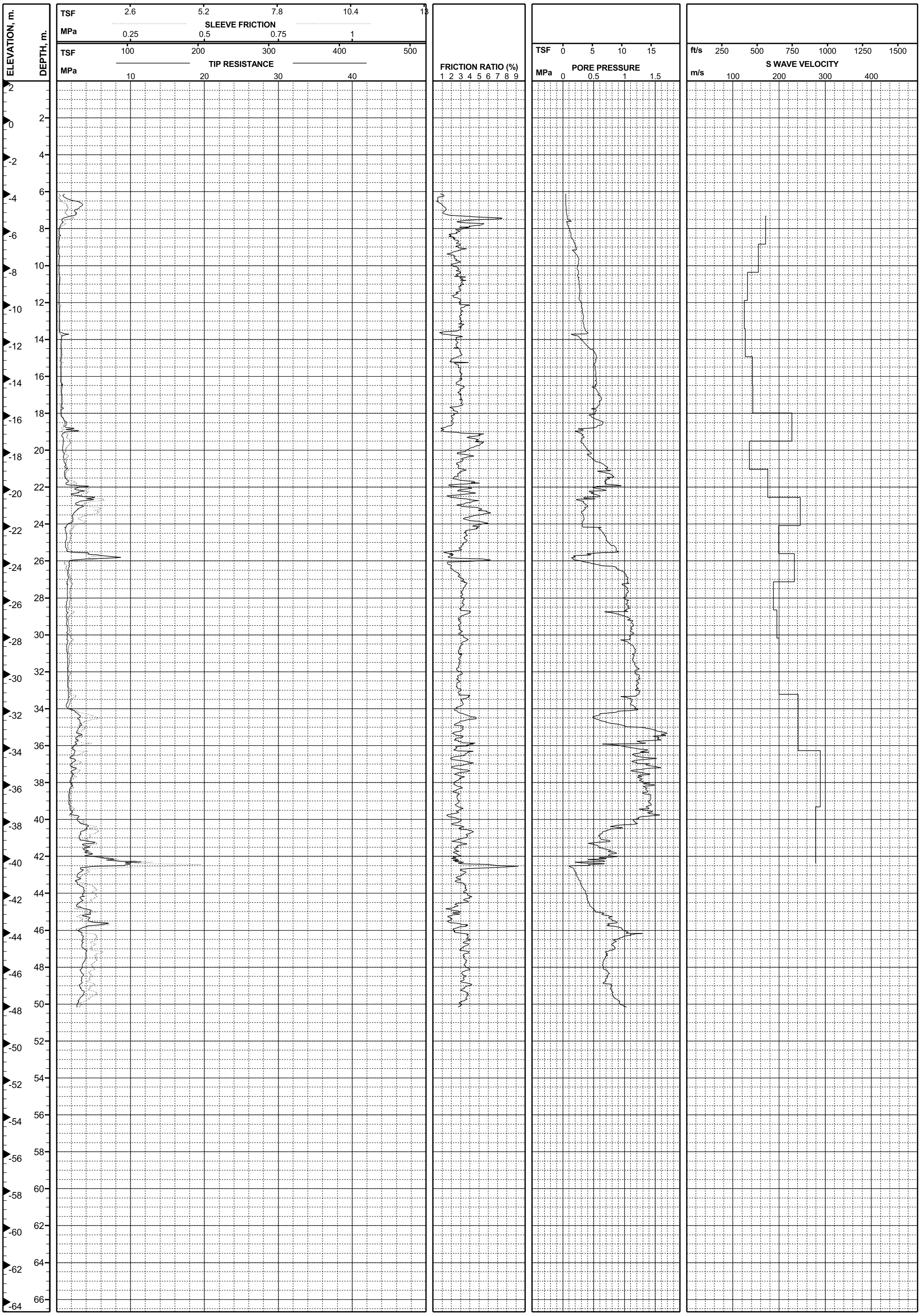
PLATE 98C-101.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98C-101
SFOBB East Span Seismic Safety Project

PLATE 98C-101.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839111 N648300 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-102 (9m right of W. Sta 86+52)	**GROUND ELEVATION:**	2.1 m (MSL)	**TEST DATE:**	10/16/98



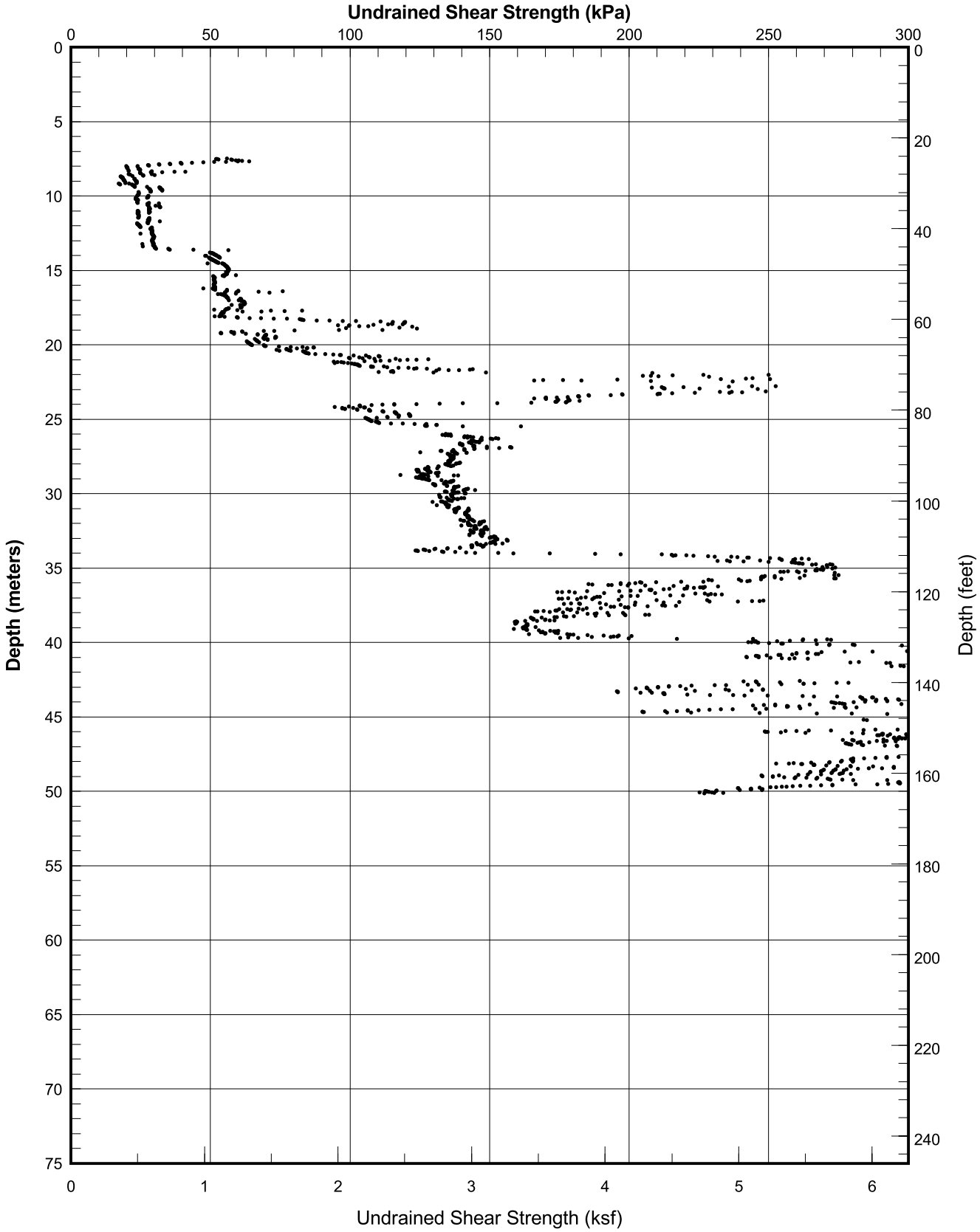
LOG OF CPT

SOUNDING 98C-102

SFOBB East Span Seismic Safety Project

Report Date: 07/12/99

PLATE 98C-102.1



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

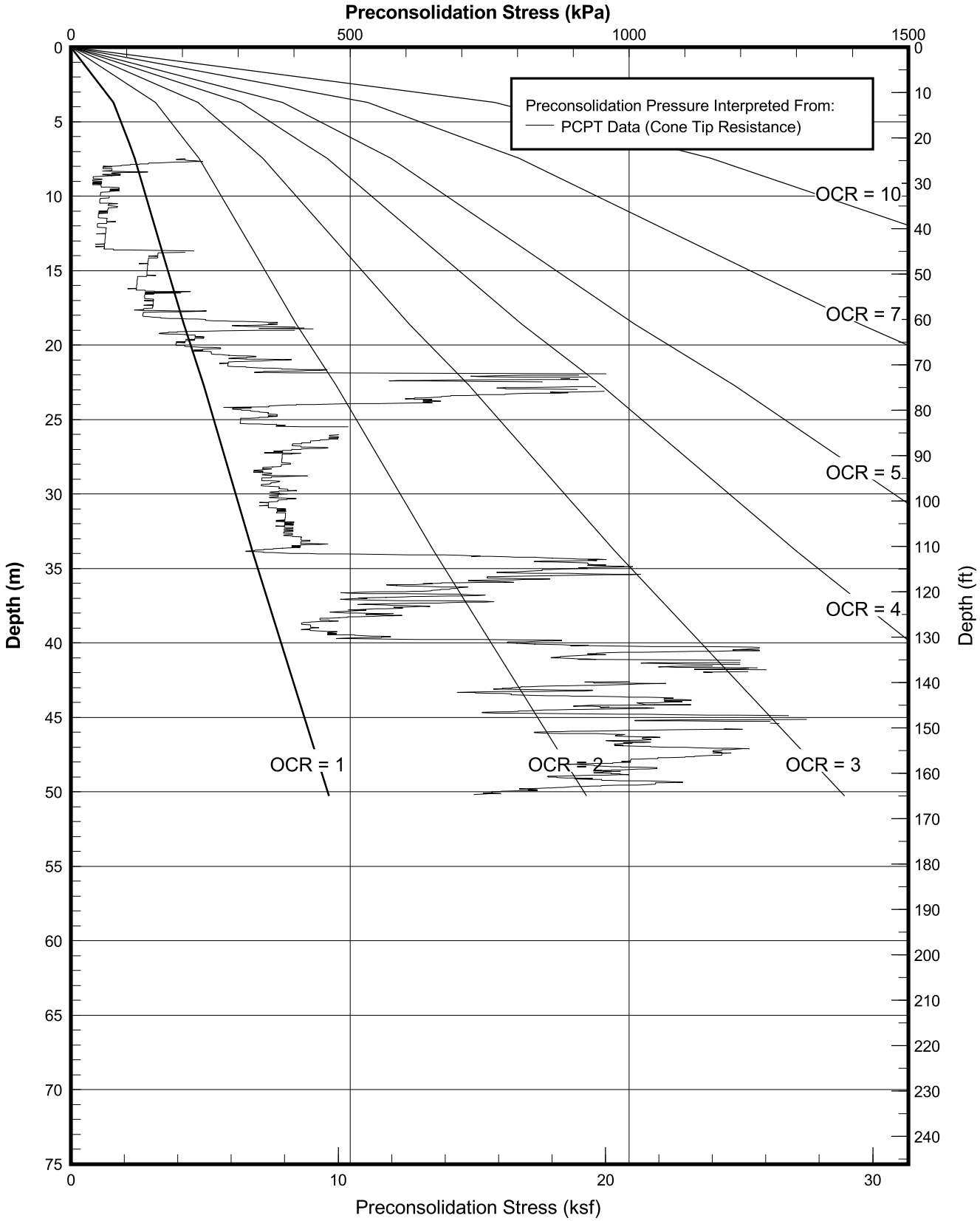
Sounding 98C-102

SFOBB East Span Seismic Safety Project

PLATE 98C-102.2

Earth Mechanics

FUGRO

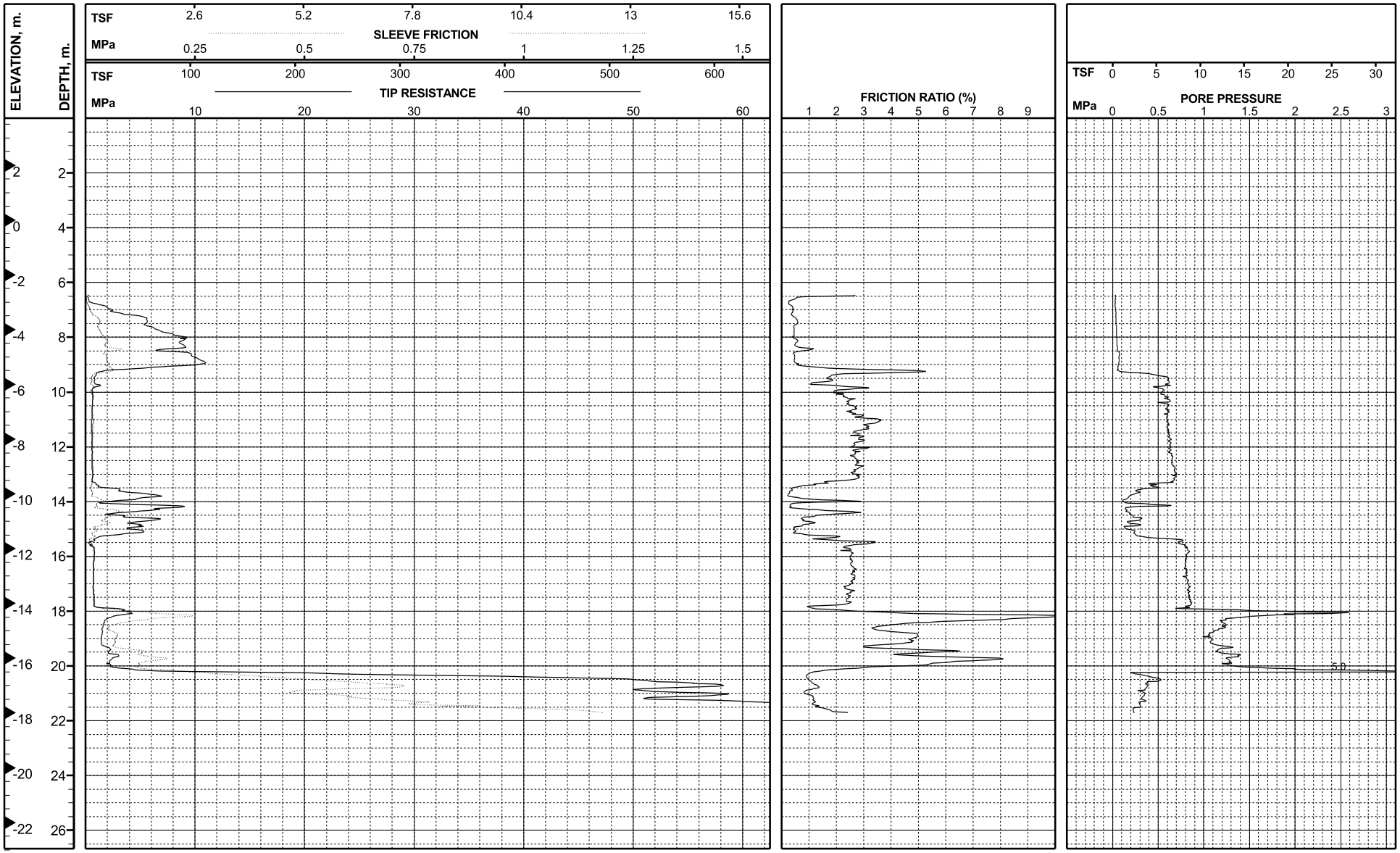


PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98C-102
SFOBB East Span Seismic Safety Project

PLATE 98C-102.3

No Relevant Relative Density Data Interpreted From This Sounding

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839304 N648323 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-104 (1m right of W. Sta 88+46)	**GROUND ELEVATION:**	3.7 m (MSL)	**TEST DATE:**	10/13/98



LOG OF CPT

SOUNDING 98C-104

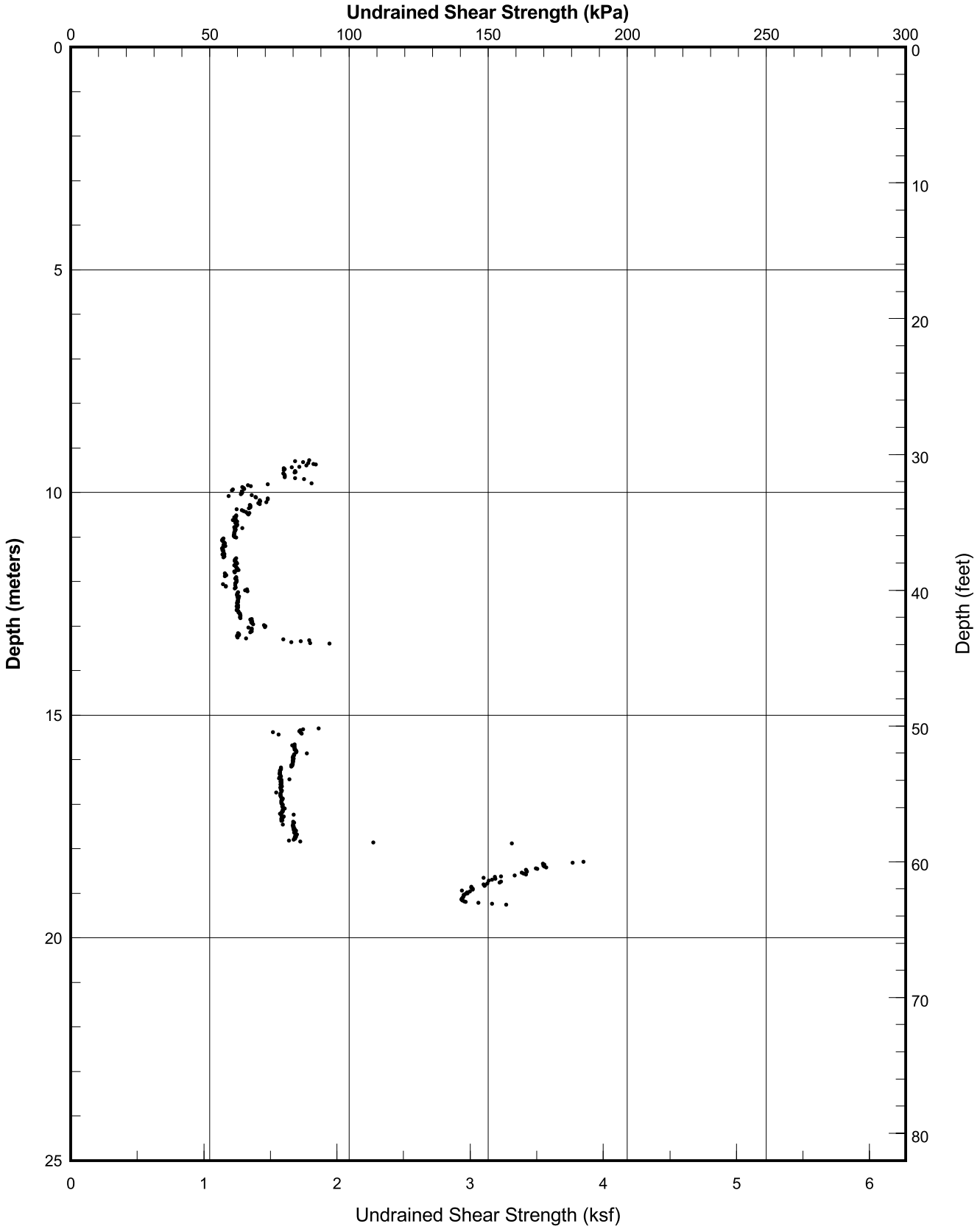
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 98C-104.1

Earth Mechanics

FUGRO

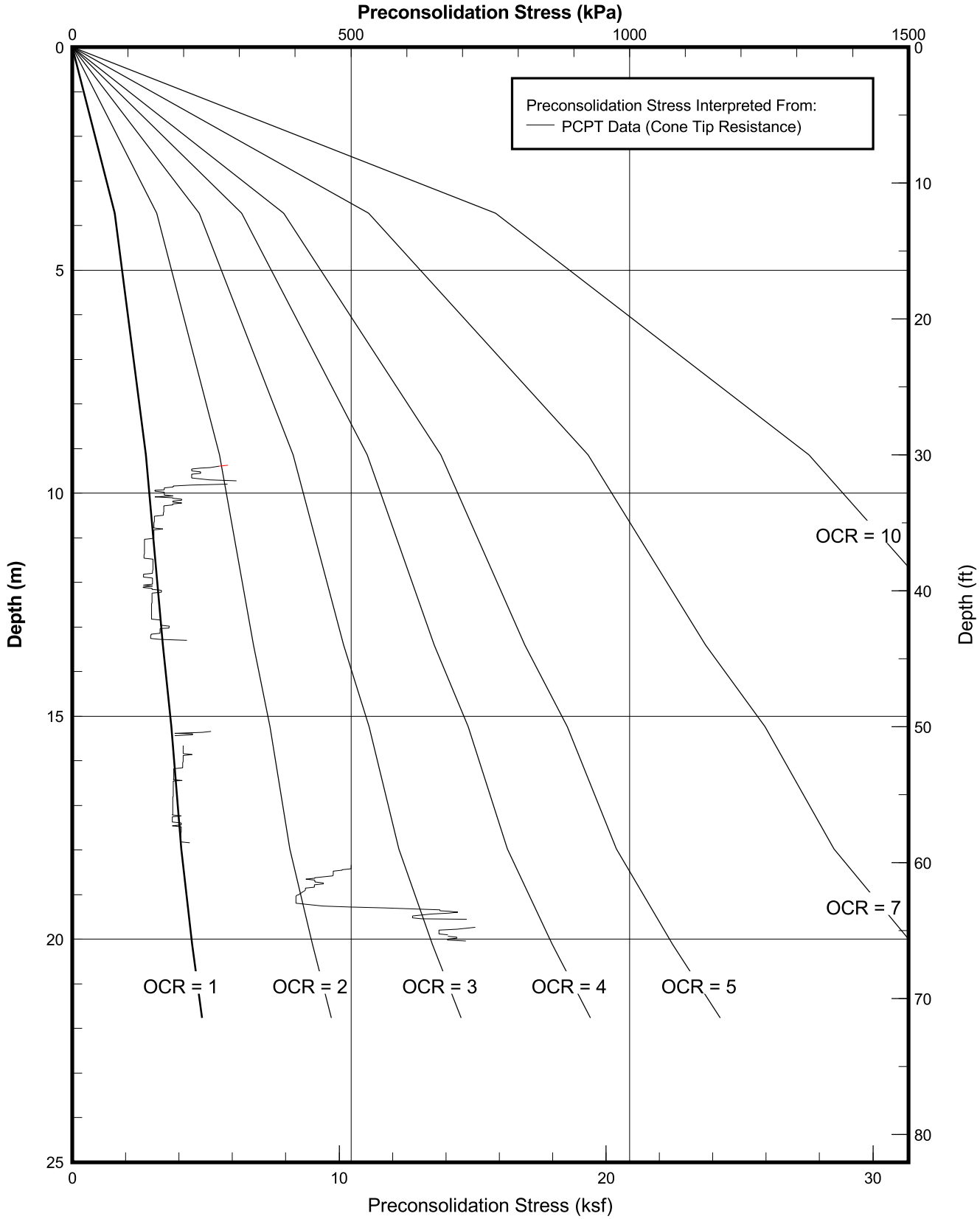


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 98C-104

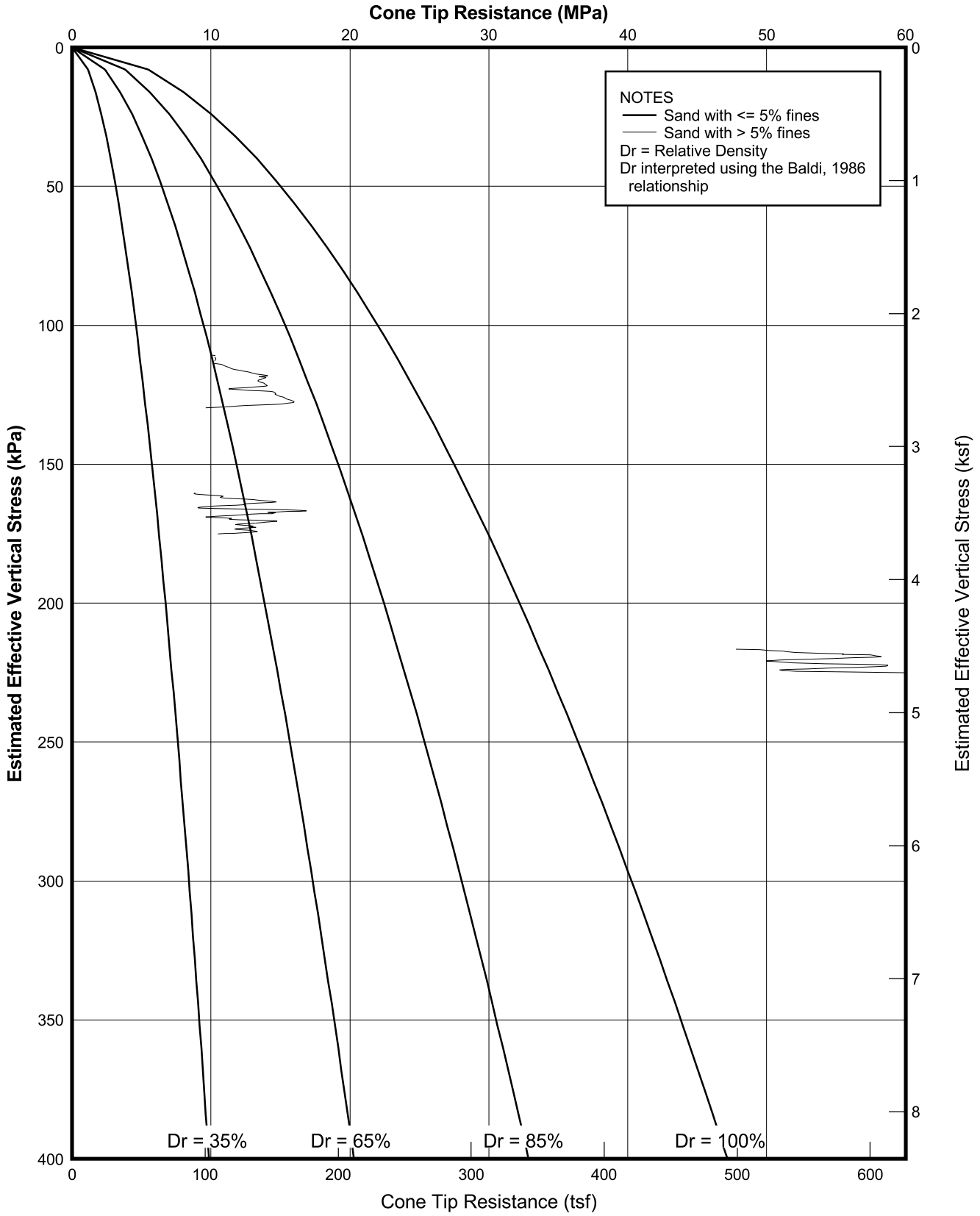
SFOBB East Span Seismic Safety Project

PLATE 98C-104.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98C-104
SFOBB East Span Seismic Safety Project

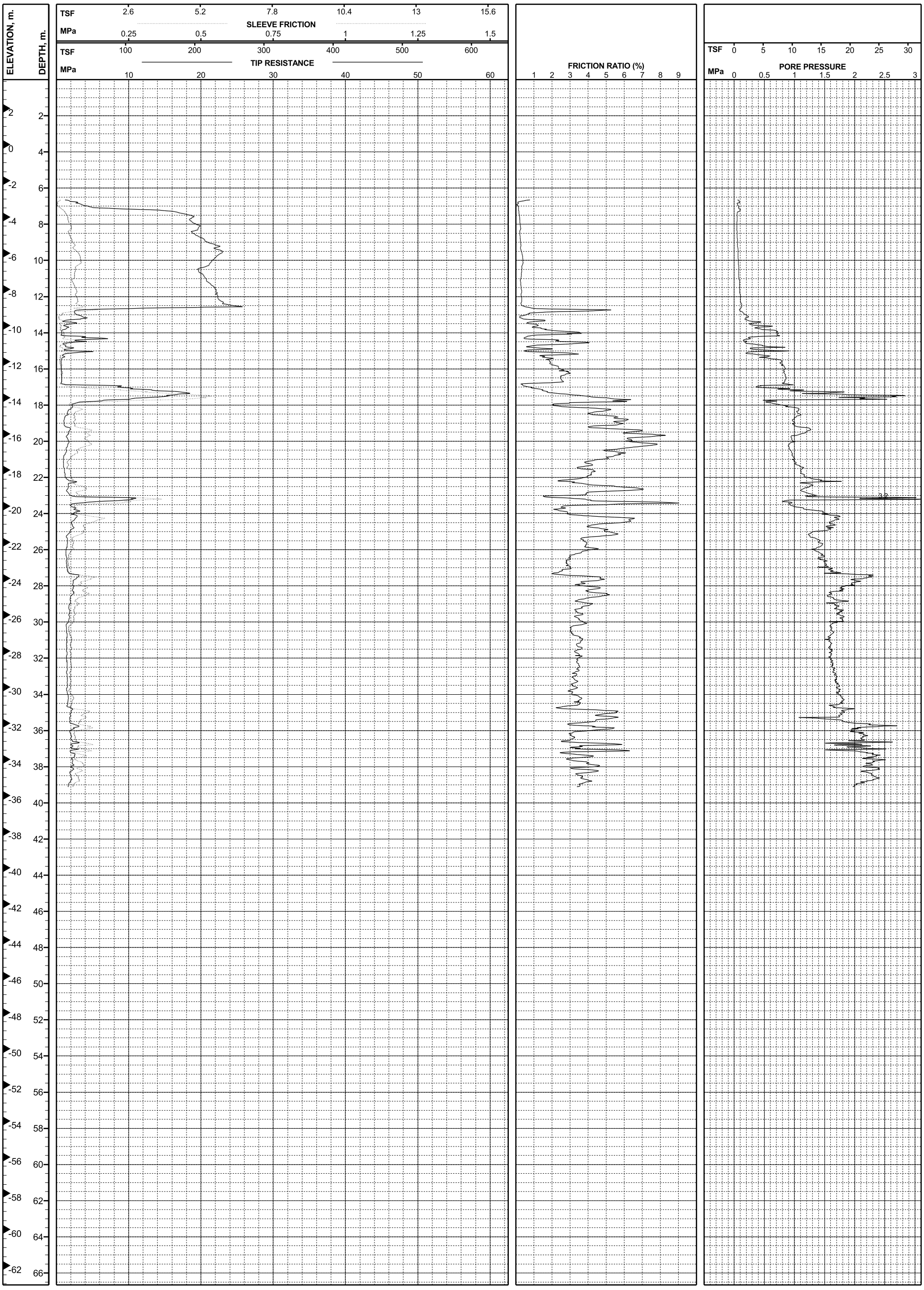
PLATE 98C-104.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98C-104
SFOBB East Span Seismic Safety Project

PLATE 98C-104.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839372 N648313 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-105 (16m right of W. Sta 89+13)	**GROUND ELEVATION:**	3.6 m (MSL)	**TEST DATE:**	10/19/98



LOG OF CPT

SOUNDING 98C-105

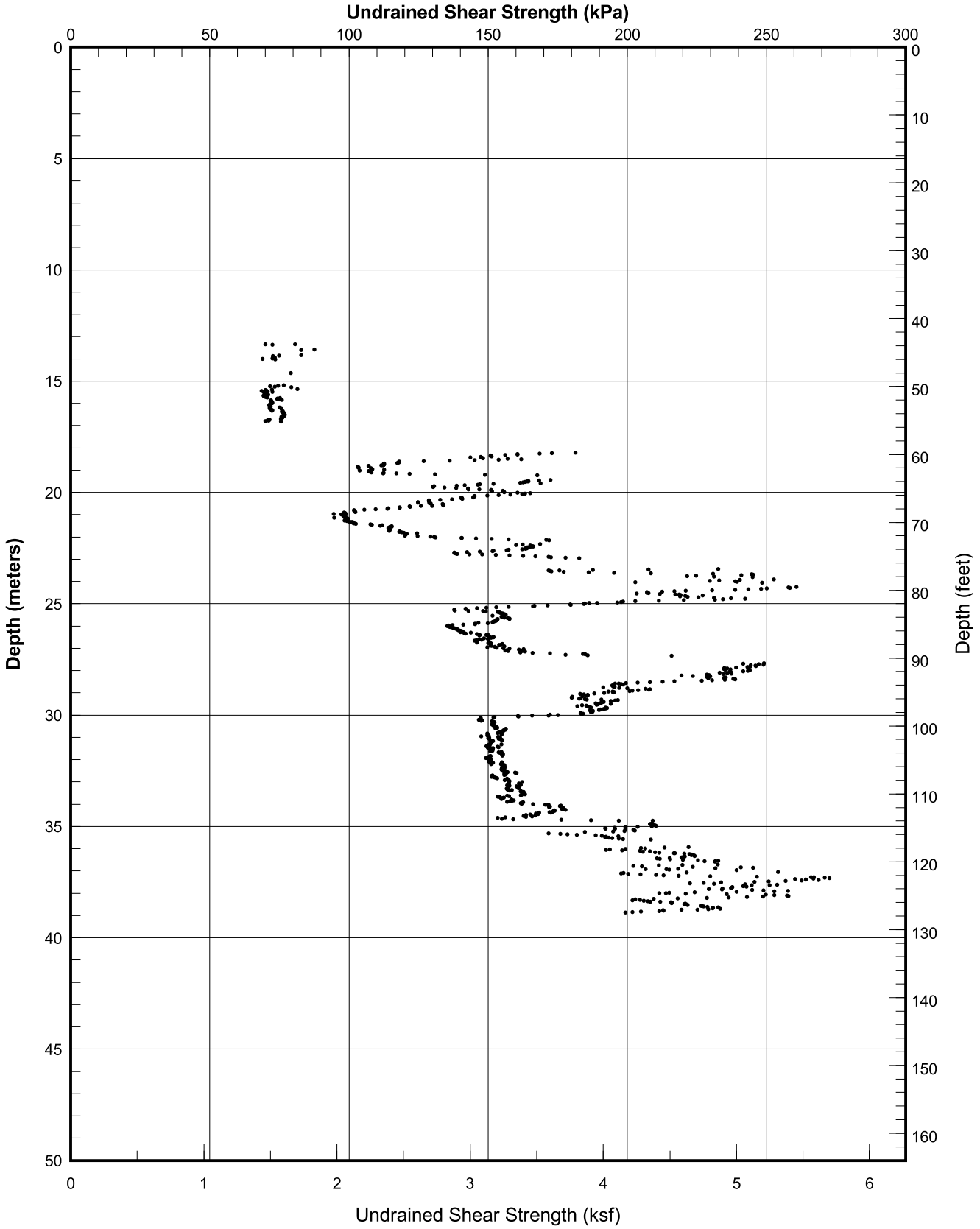
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 98C-105.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

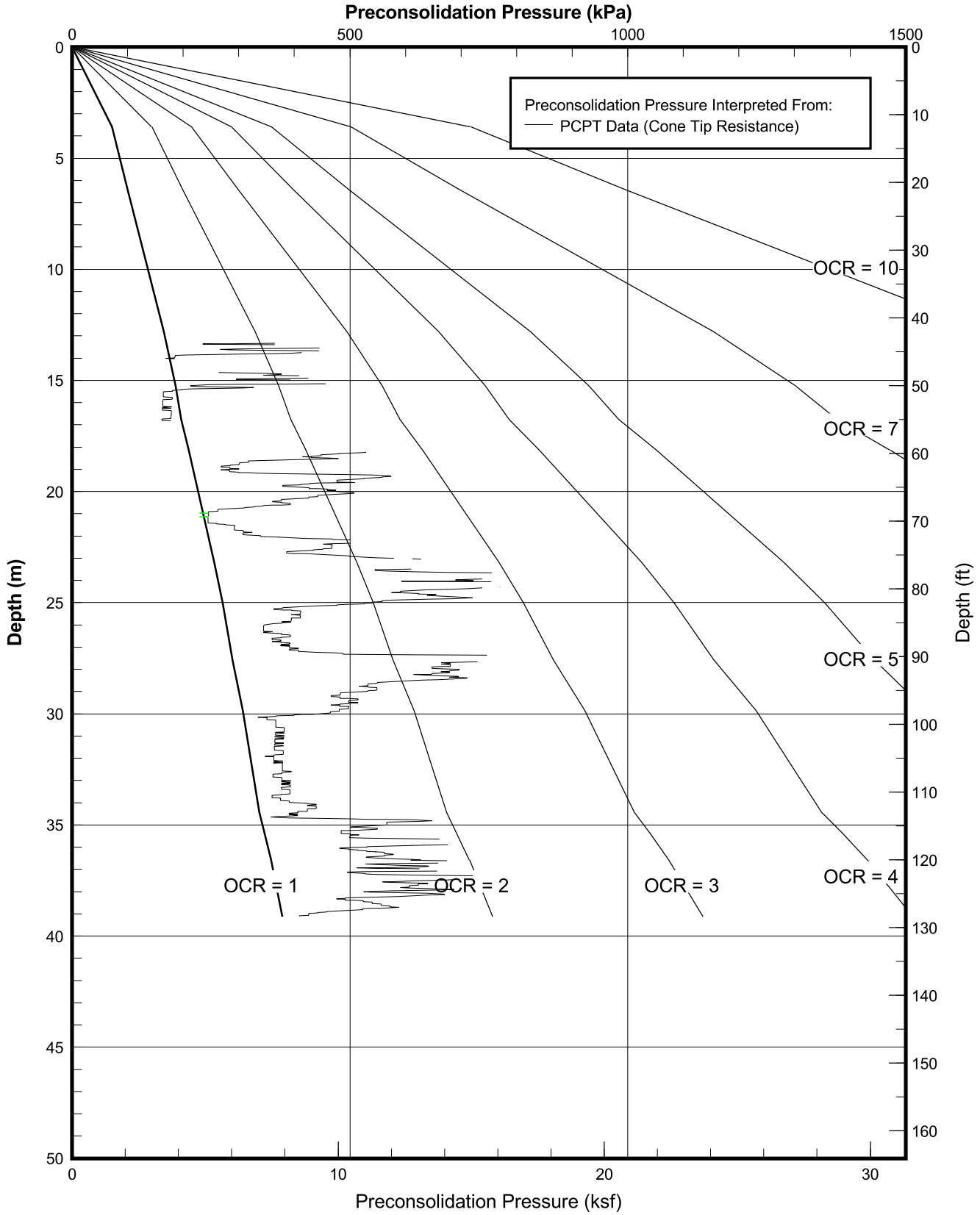
Sounding 98C-105

SFOBB East Span Seismic Safety Project

PLATE 98C-105.2

Earth Mechanics

FUGRO

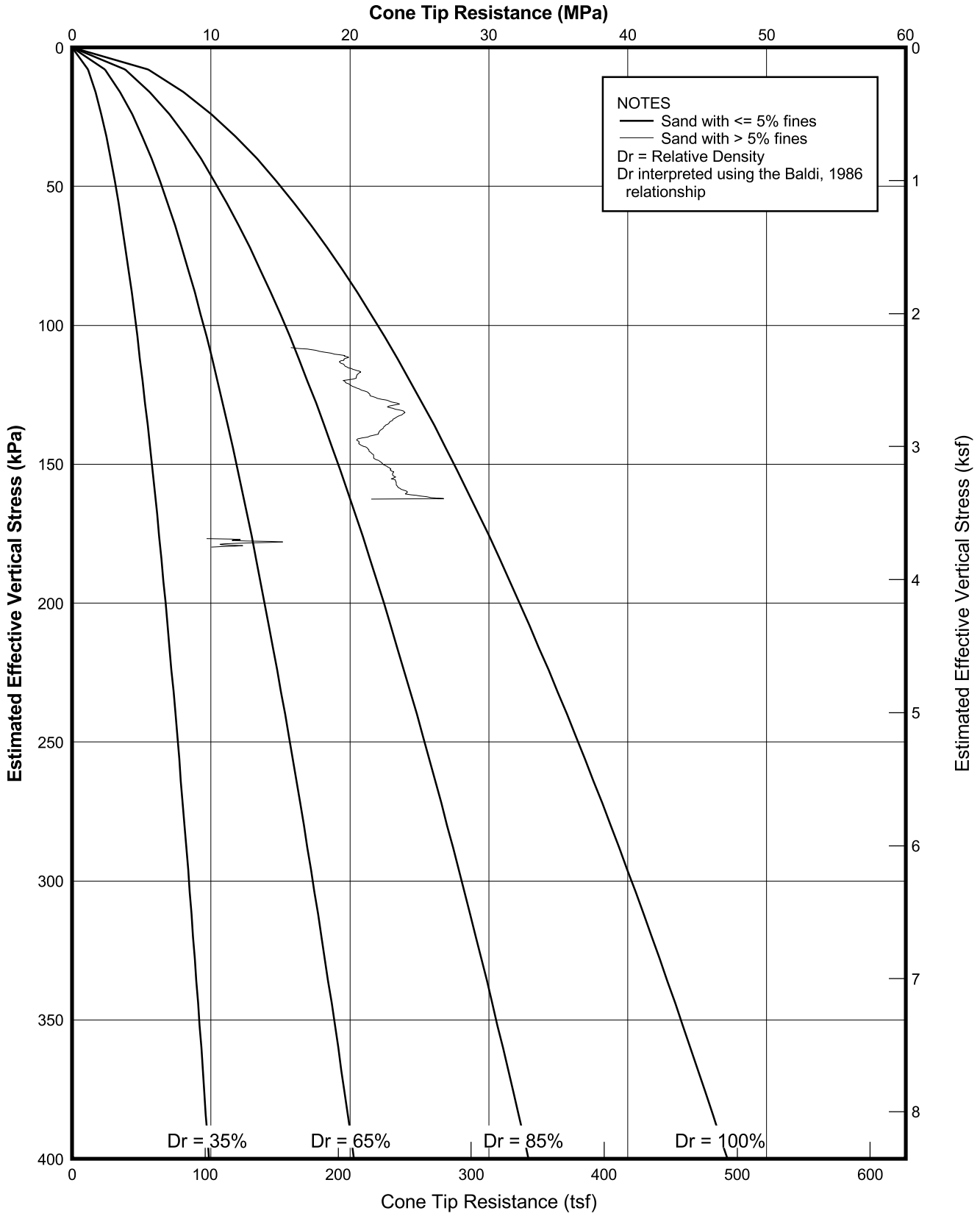


PRECONSOLIDATION PRESSURE INTERPRETED FROM CPT DATA

Sounding 98C-105

SFOBB East Span Seismic Safety Project

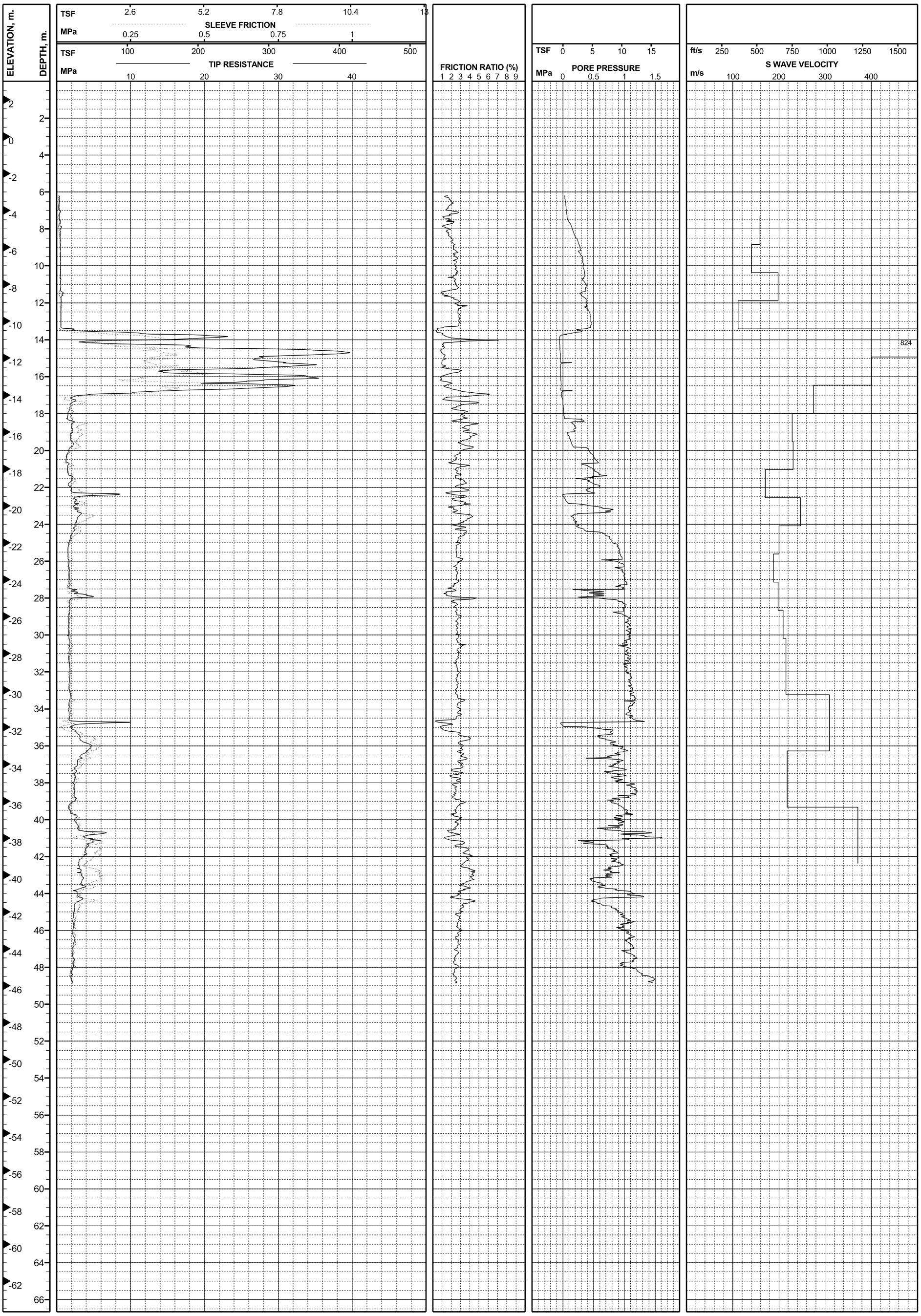
PLATE 98C-105.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98C-105
SFOBB East Span Seismic Safety Project

PLATE 98C-105.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839339 N648260 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-109 (26m right of E. Sta 88+45)	**GROUND ELEVATION:**	3.0 m (MSL)	**TEST DATE:**	10/21/98



LOG OF CPT

SOUNDING 98C-109

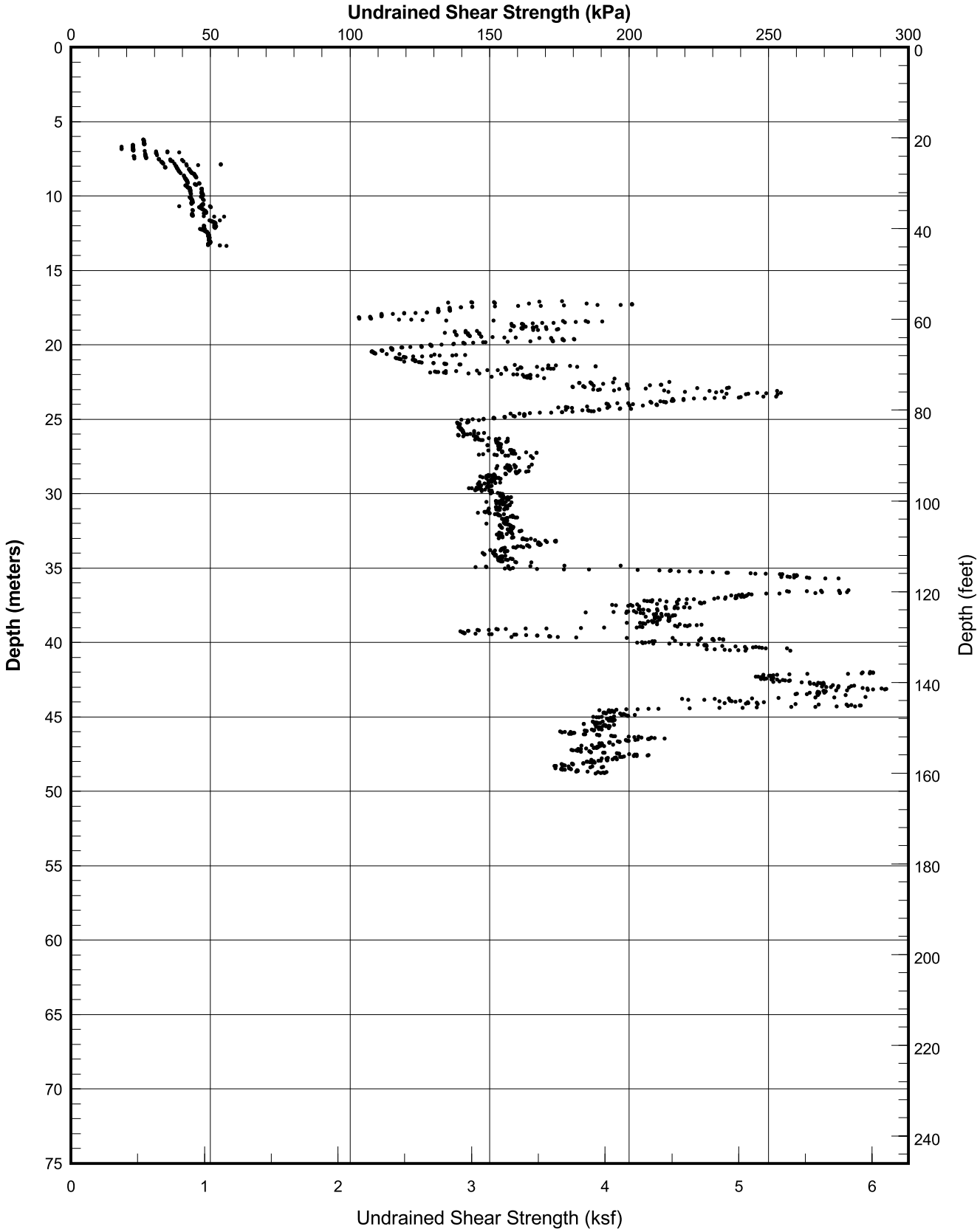
SFOBB East Span Seismic Safety Project

Report Date: 07/12/99

PLATE 98C-109.1

Earth Mechanics

FUGRO

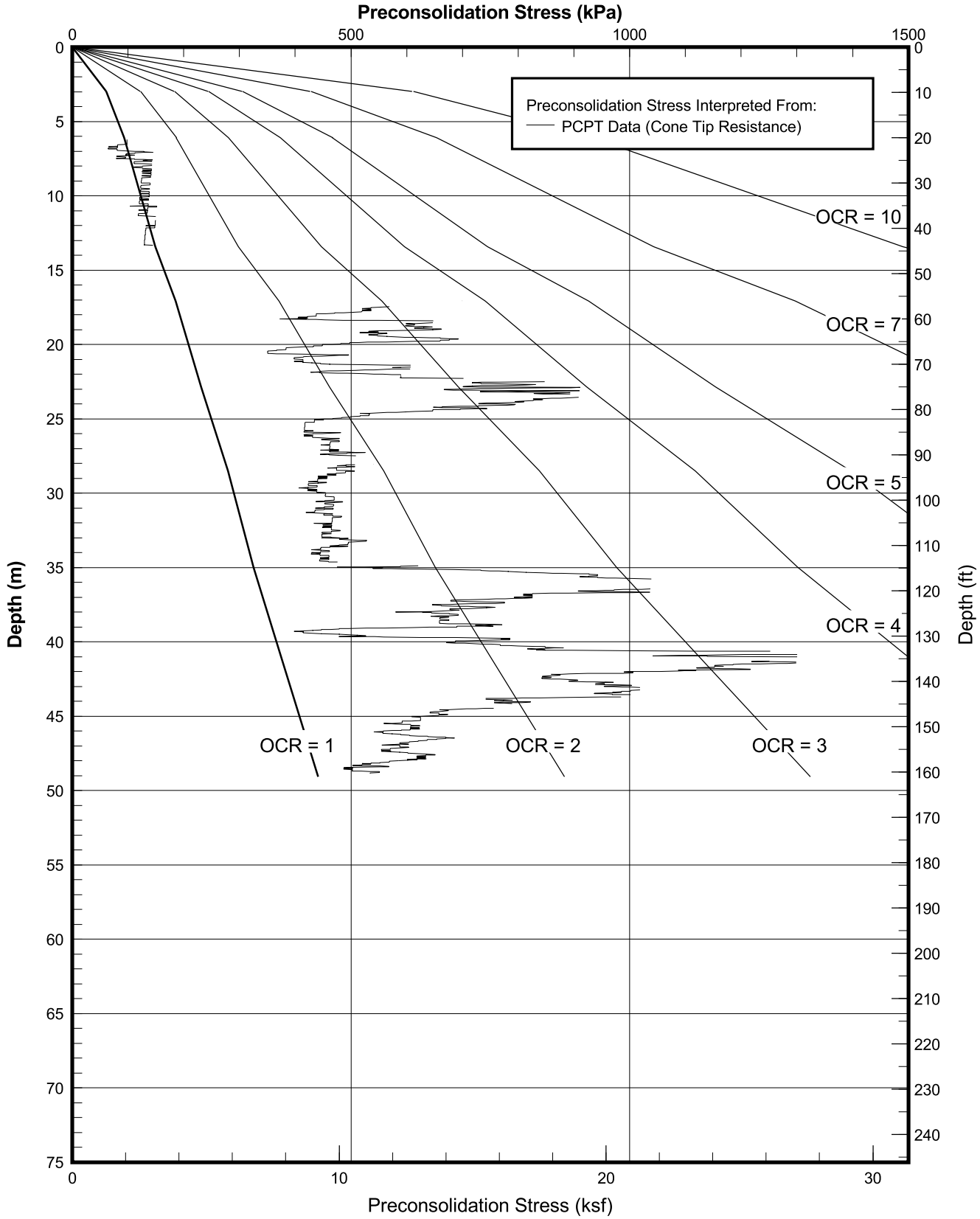


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 98C-109

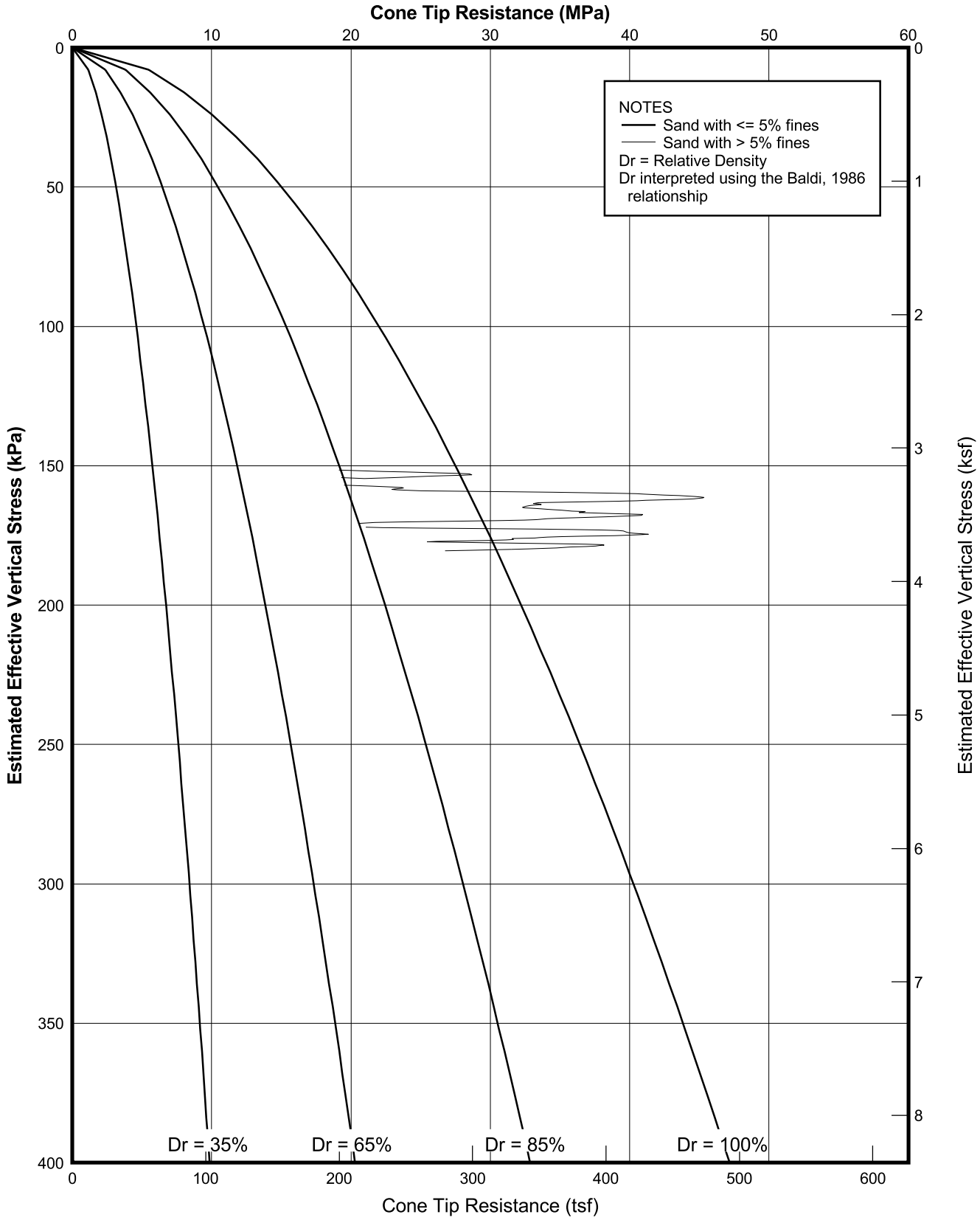
SFOBB East Span Seismic Safety Project

PLATE 98C-109.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98C-109
SFOBB East Span Seismic Safety Project

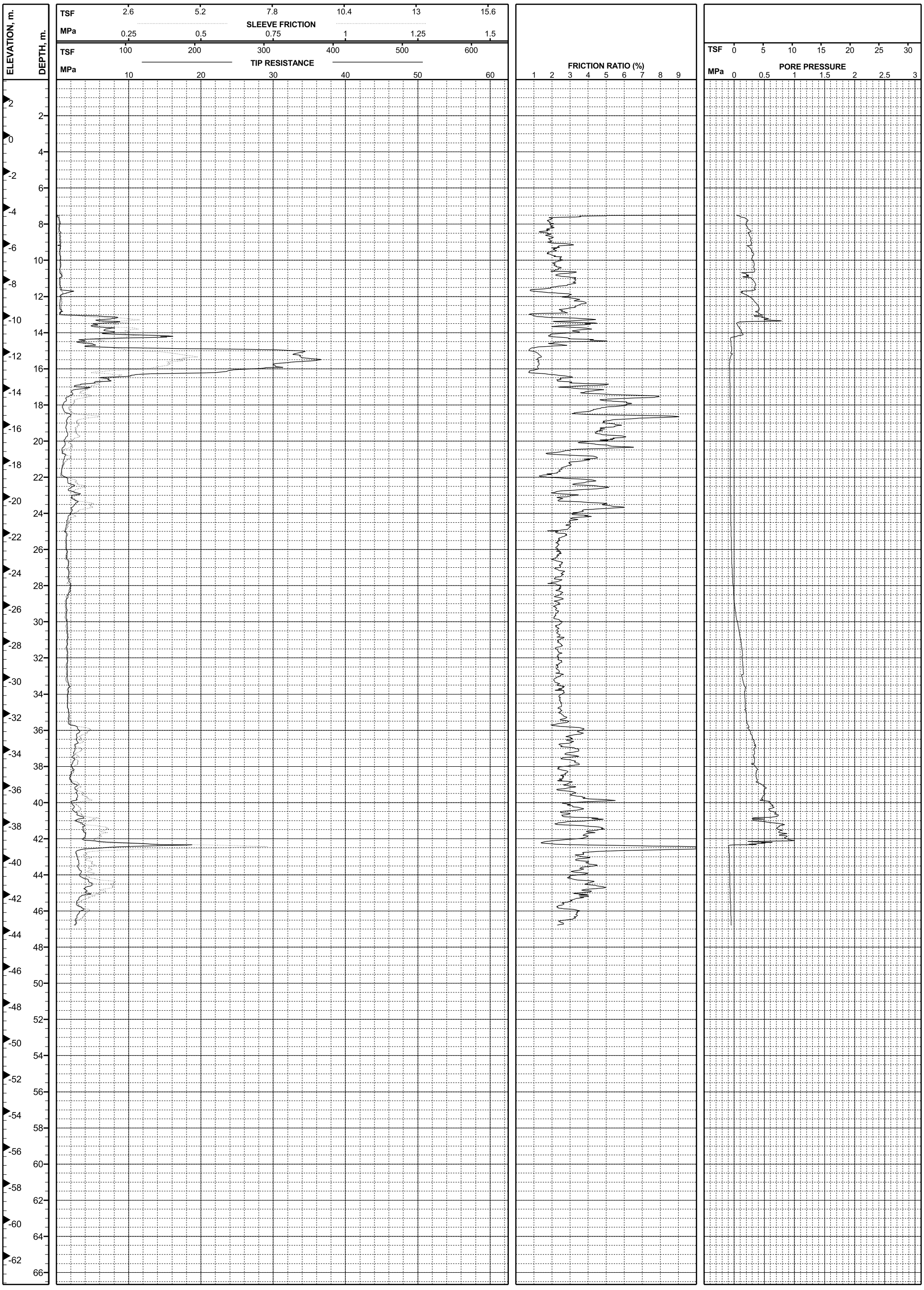
PLATE 98C-109.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98C-109
SFOBB East Span Seismic Safety Project

PLATE 98C-109.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839489 N648287 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	98C-110 (15m right of E. Sta 89+96)	**GROUND ELEVATION:**	3.1 m (MSL)	**TEST DATE:**	10/13/98



LOG OF CPT

SOUNDING 98C-110

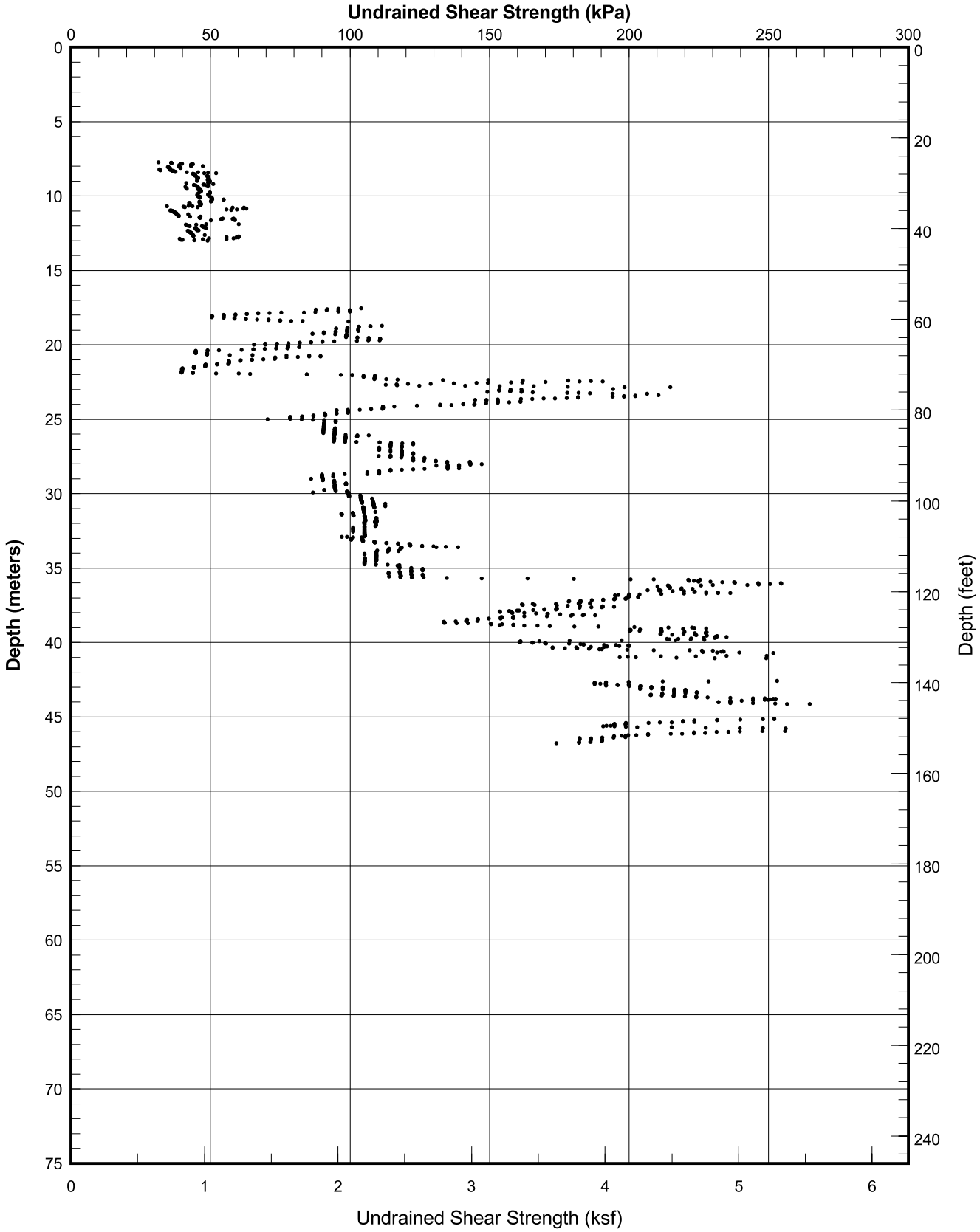
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 98C-110.1

Earth Mechanics

FUGRO

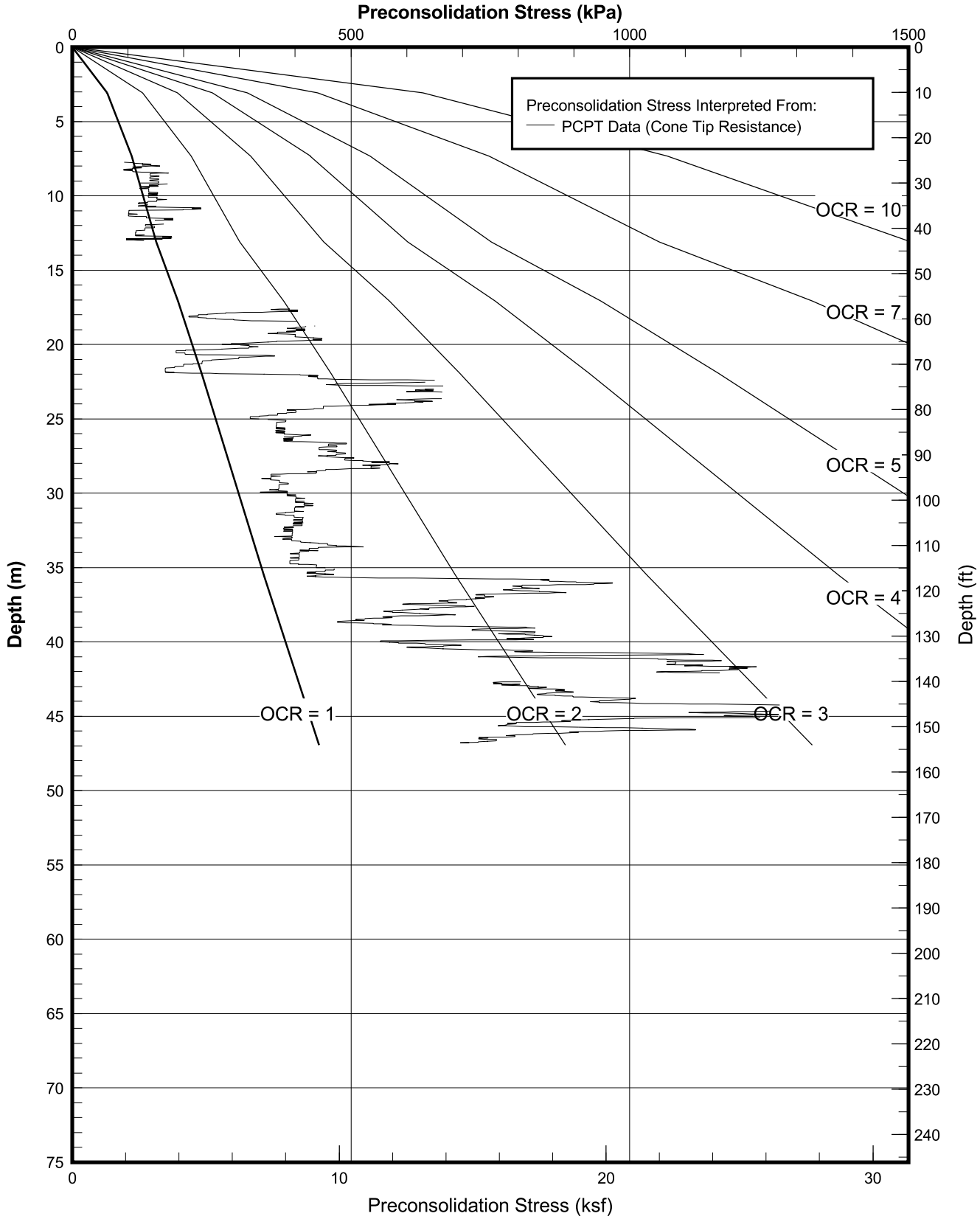


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 98C-110

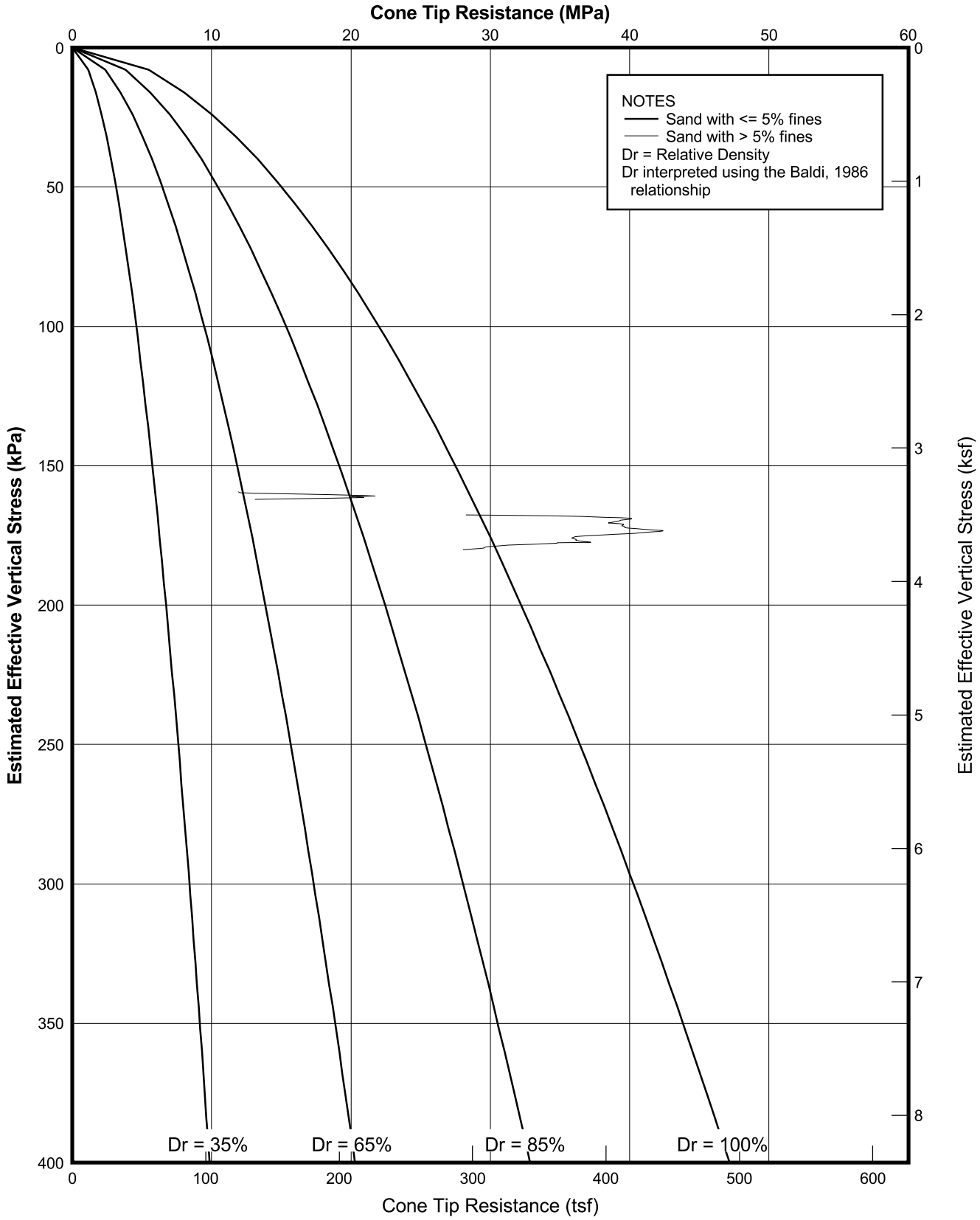
SFOBB East Span Seismic Safety Project

PLATE 98C-110.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 98C-110
SFOBB East Span Seismic Safety Project

PLATE 98C-110.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 98C-110
SFOBB East Span Seismic Safety Project

PLATE 98C-110.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1838969 N648274 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-1 (22.8m right of W. Sta 85+08)	**GROUND ELEVATION:**	-0.2 m (MSL)	**TEST DATE:**	03/15/99

ELEVATION, m. / DEPTH, m.

SLEEVE FRICTION: TSF 2.6 5.2 7.8 10.4 13 15.6 / MPa 0.25 0.5 0.75 1 1.25 1.5

TIP RESISTANCE: TSF 100 200 300 400 500 600 / MPa 10 20 30 40 50 60

FRICTION RATIO (%): 1 2 3 4 5 6 7 8 9

PORE PRESSURE: TSF 0 5 10 15 20 25 30 / MPa 0 0.5 1 1.5 2 2.5 3

-2 2 -4 4 -6 6 -8 8 -10 10 -12 12 -14 14 -16 16 -18 18 -20 20 -22 22 -24 24 -26 26 -28 28 -30 30 -32 32 -34 34 -36 36 -38 38 -40 40 -42 42 -44 44 -46 46 -48 48 -50 50 -52 52 -54 54 -56 56 -58 58 -60 60 -62 62 -64 64 -66 66

LOG OF CPT

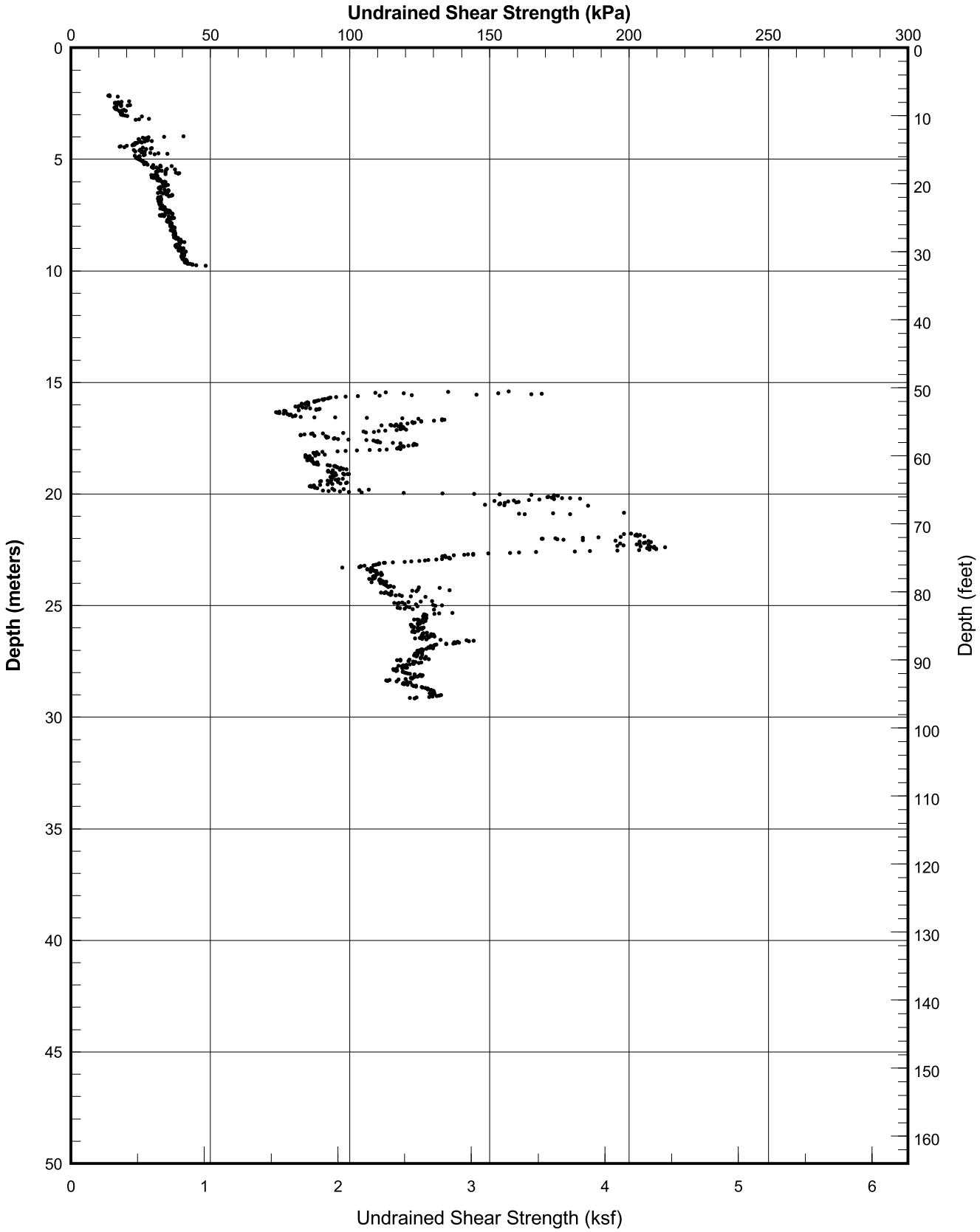
SOUNDING 99C-1

SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

FUGRO

PLATE 99C-1.1

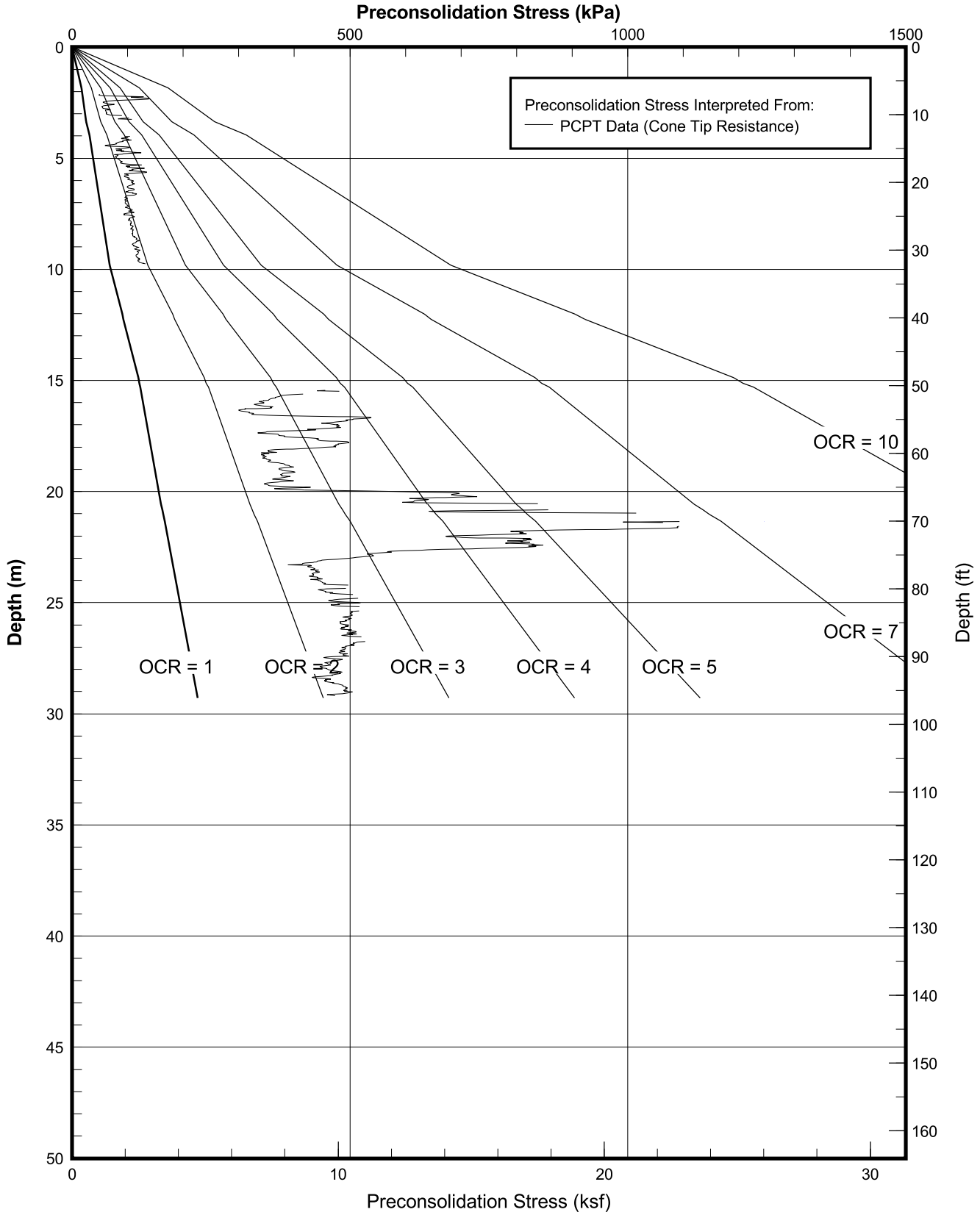


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-1

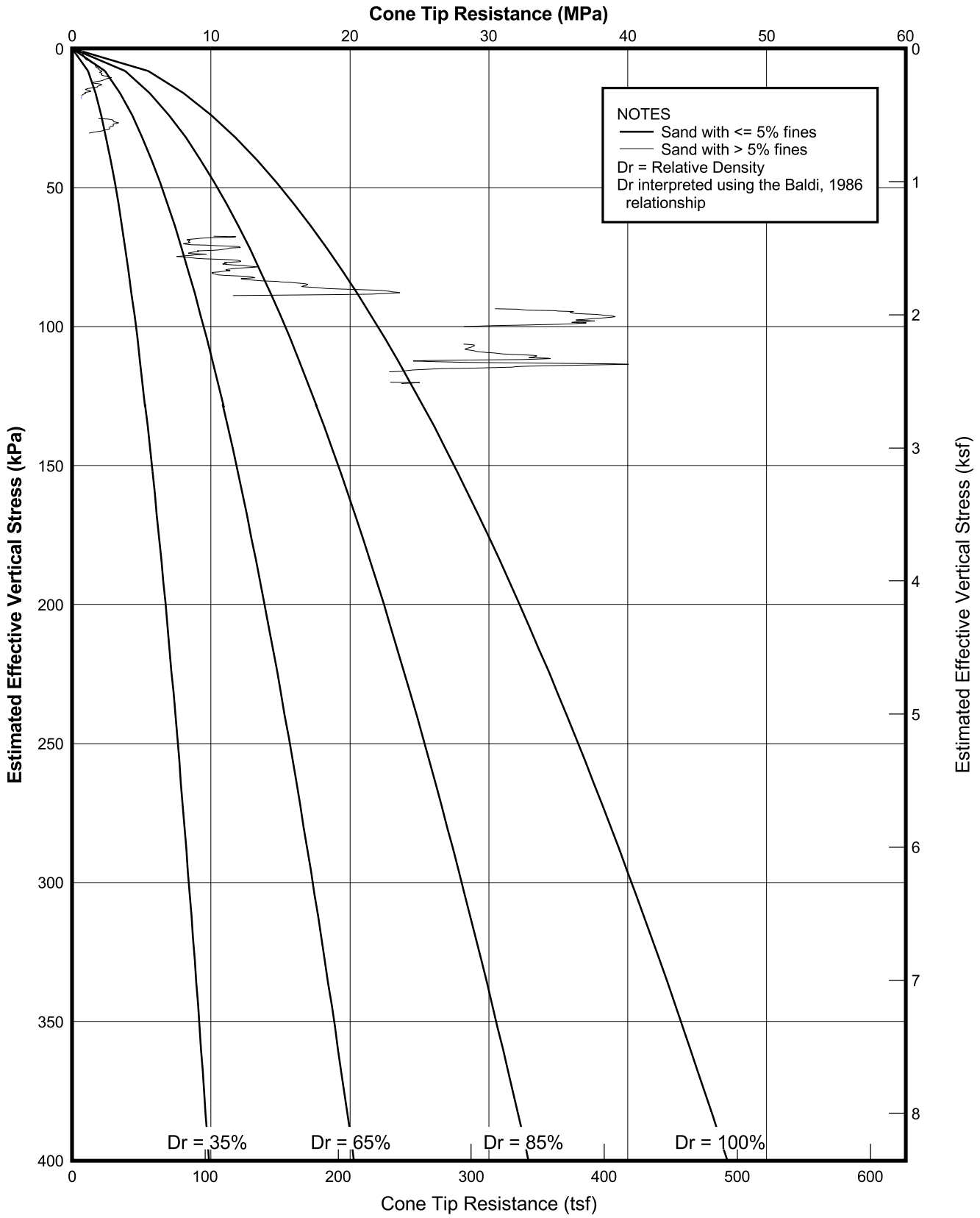
SFOBB East Span Seismic Safety Project

PLATE 99C-1.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-1
SFOBB East Span Seismic Safety Project

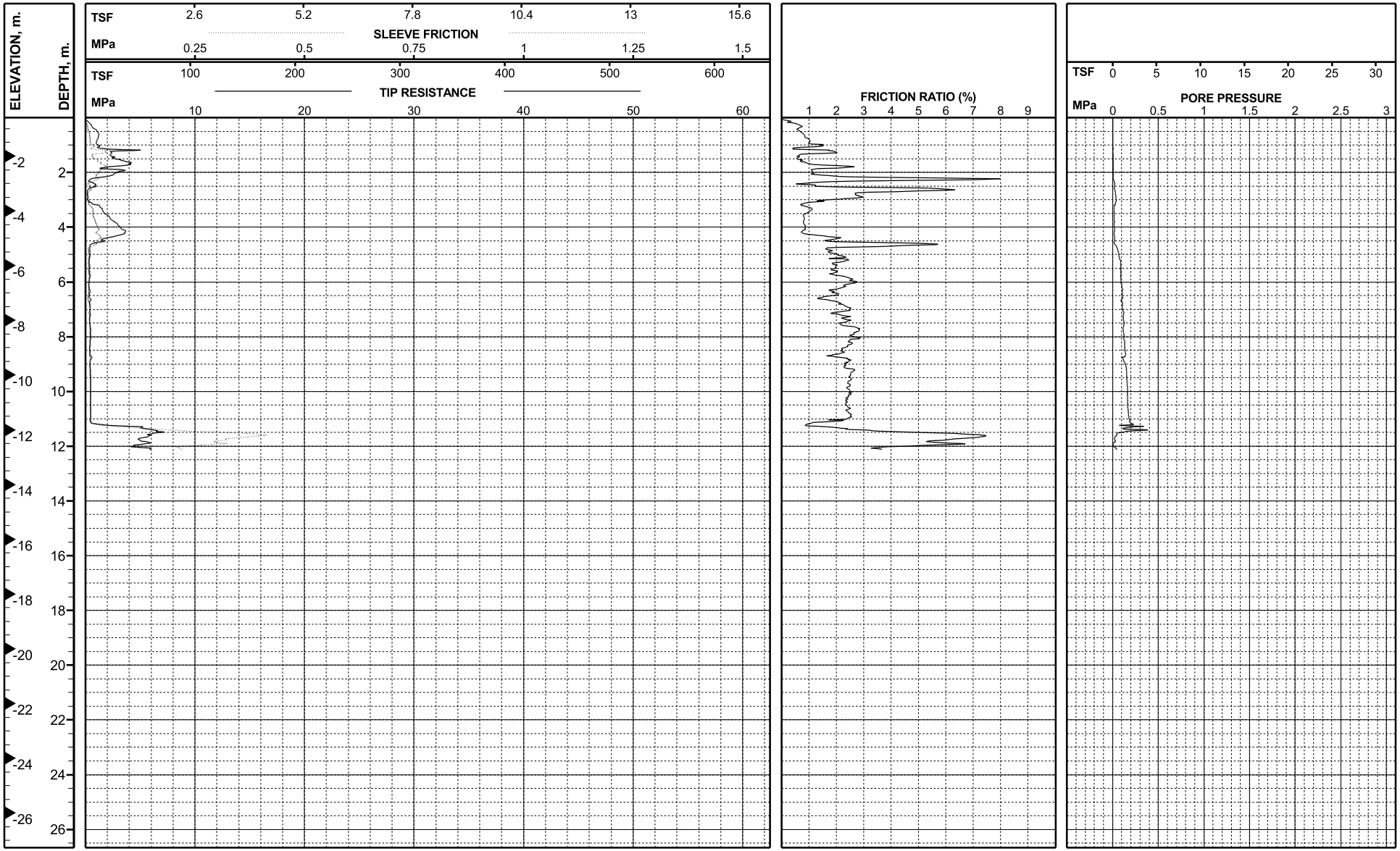
PLATE 99C-1.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-1
SFOBB East Span Seismic Safety Project

PLATE 99C-1.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839037 N648290 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-2 (13.1m right of W. Sta. 85+77)	**GROUND ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	03/18/99



LOG OF CPT

SOUNDING 99C-2

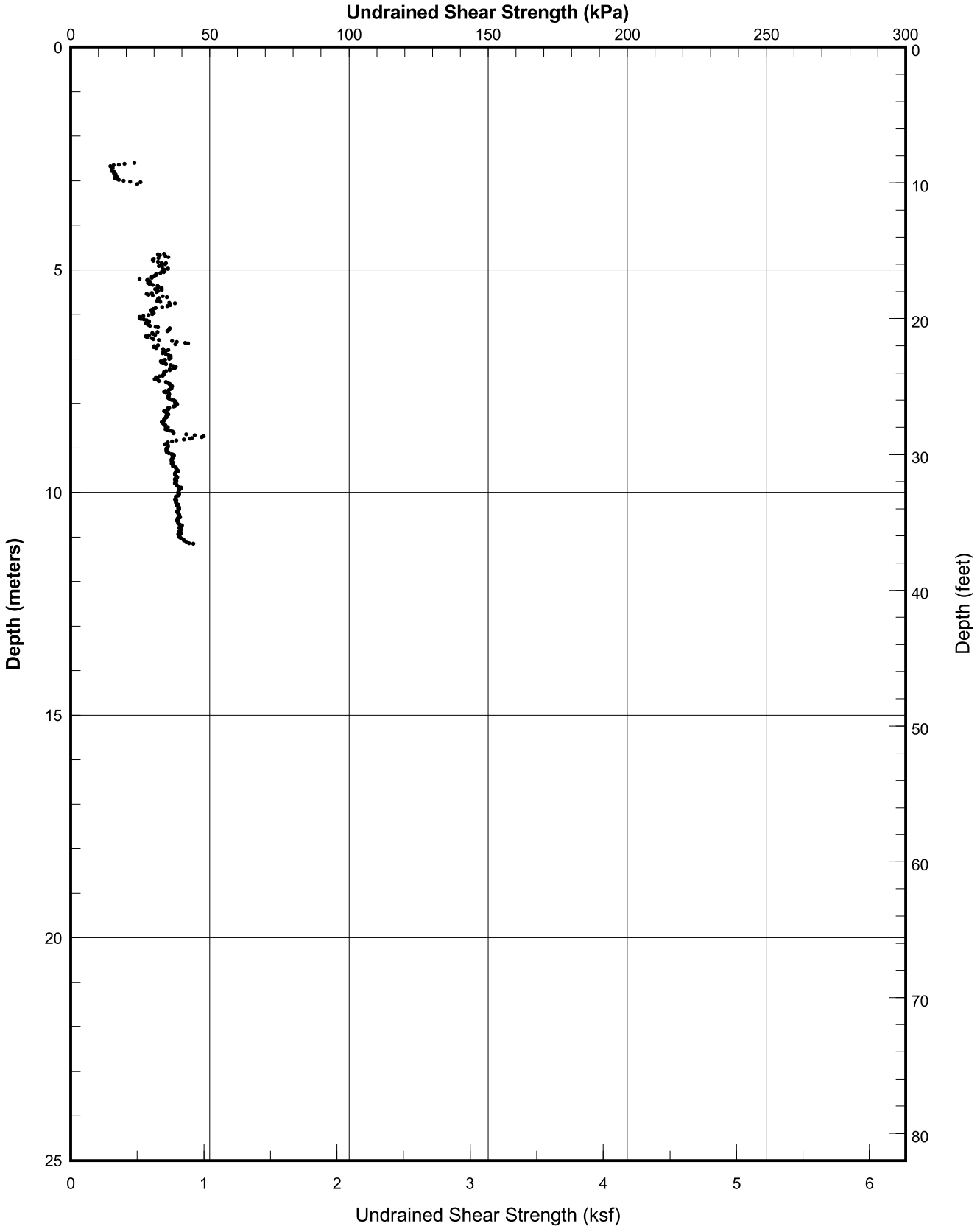
SFOBB East Span Seismic Safety Project

Report Date: 08/26/99

PLATE 99C-2.1

Earth Mechanics

FUGRO

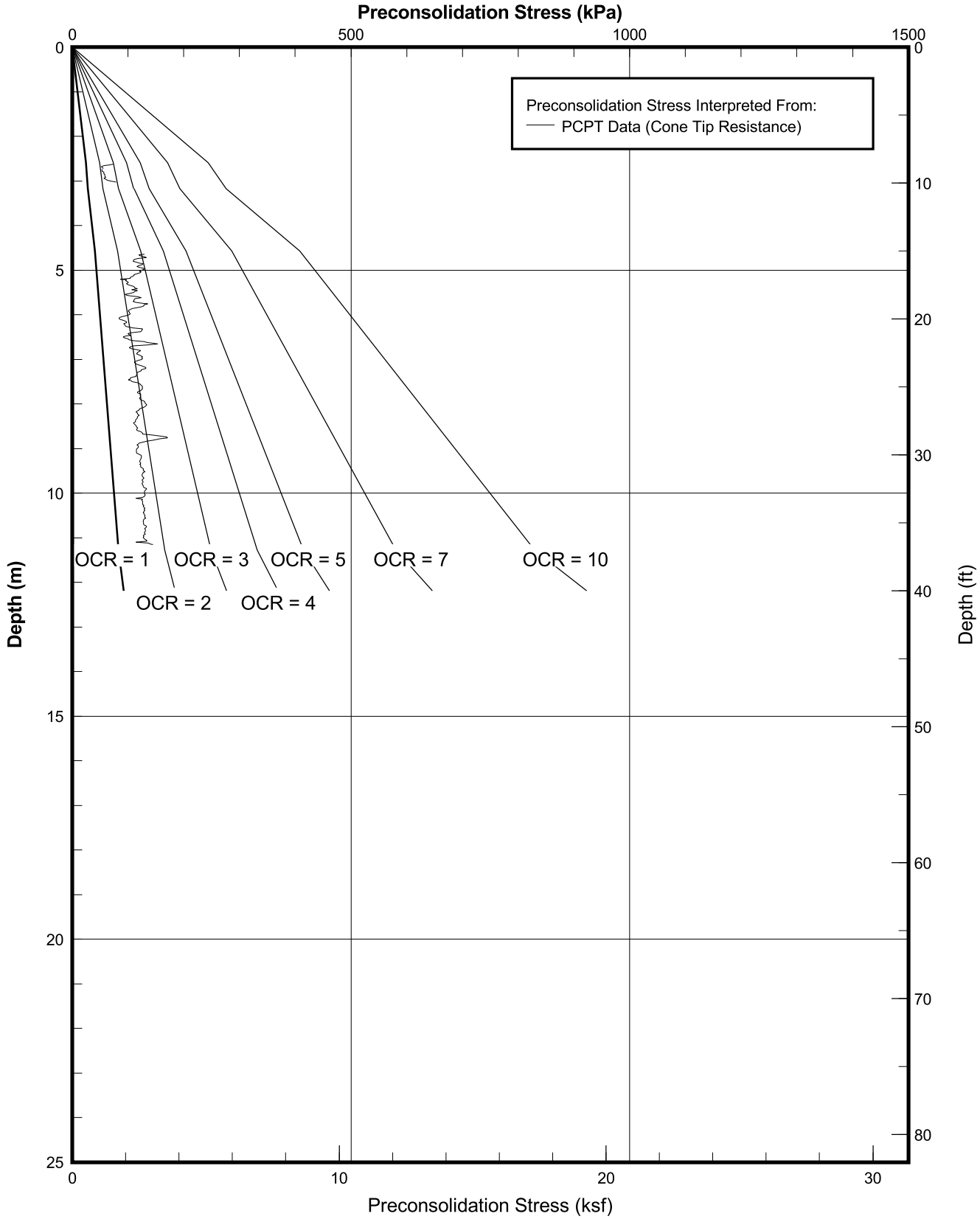


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-2

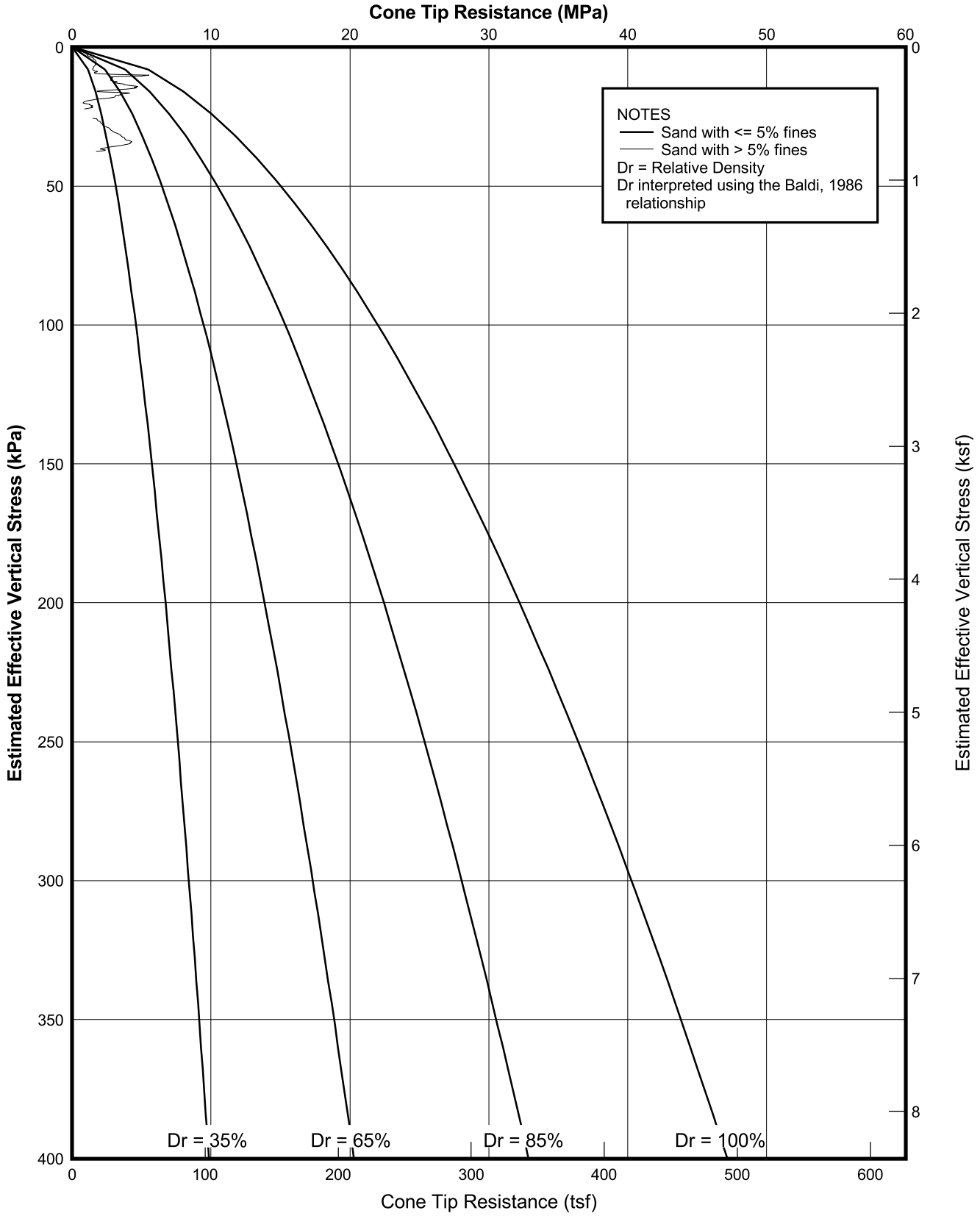
SFOBB East Span Seismic Safety Project

PLATE 99C-2.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-2
SFOBB East Span Seismic Safety Project

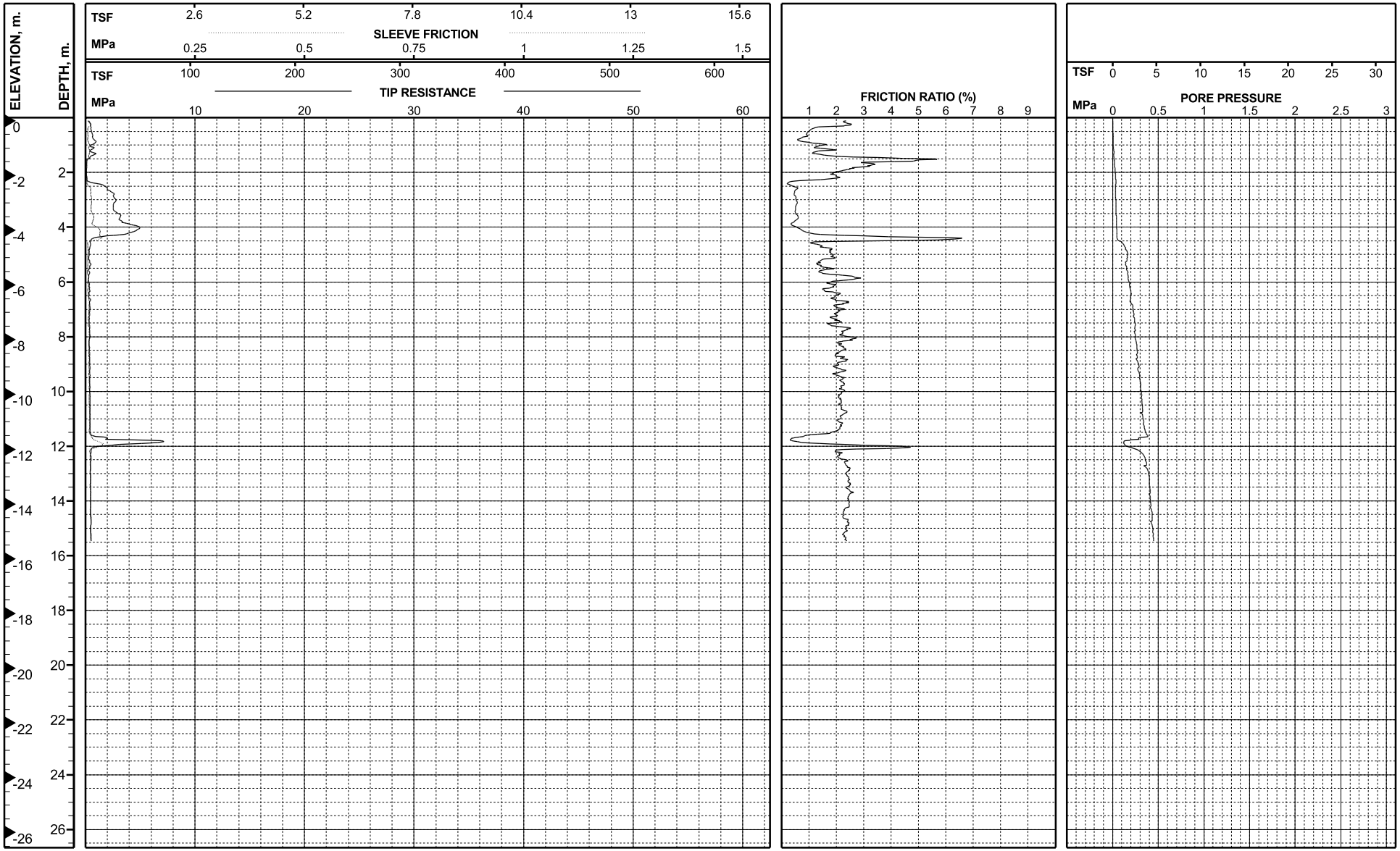
PLATE 99C-2.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-2
SFOBB East Span Seismic Safety Project

PLATE 99C-2.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839150 N648311 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-3 (1.0m right of W. Sta 86+91)	**GROUND ELEVATION:**	0.1 m (MSL)	**TEST DATE:**	03/02/99



LOG OF CPT

SOUNDING 99C-3

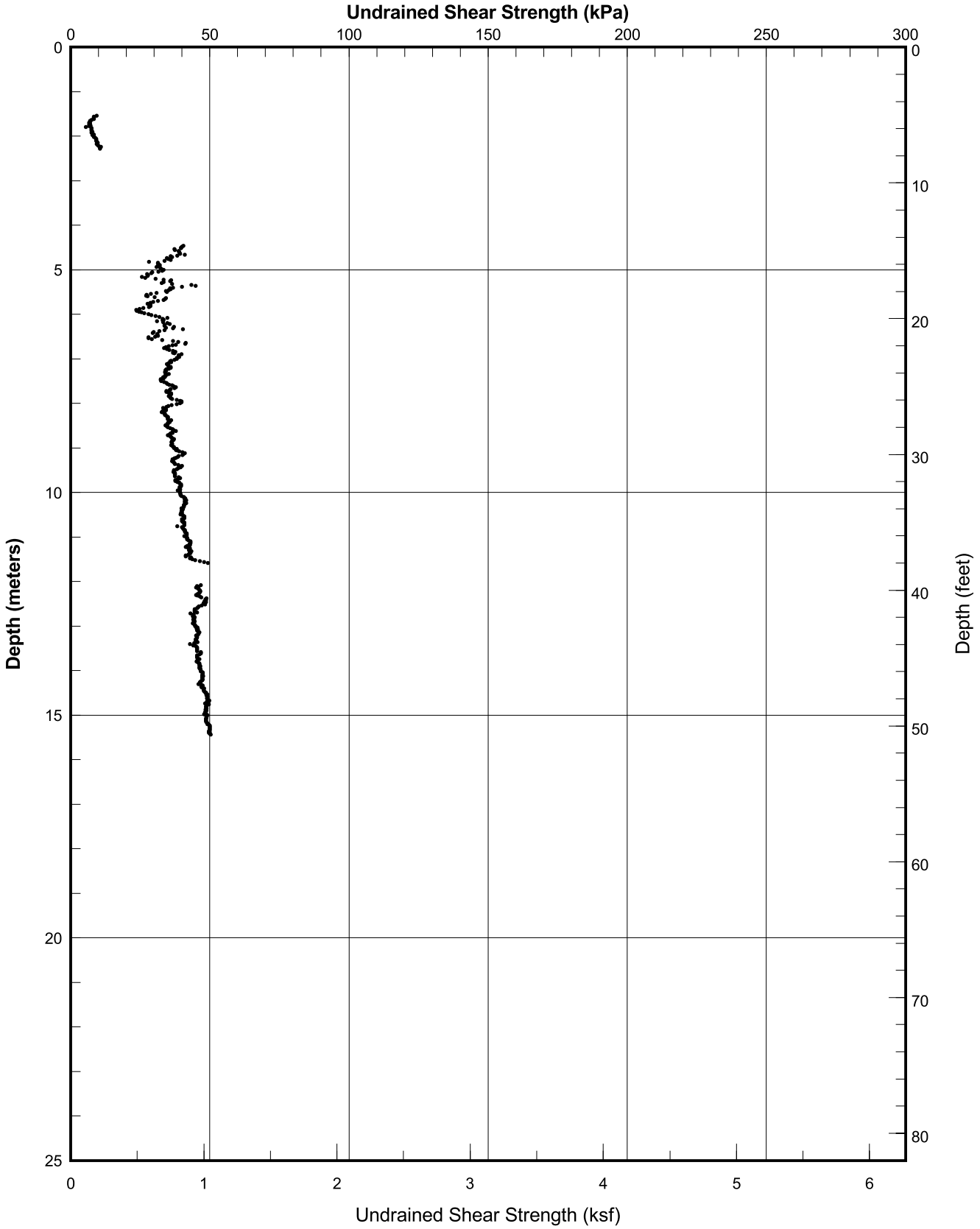
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-3.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

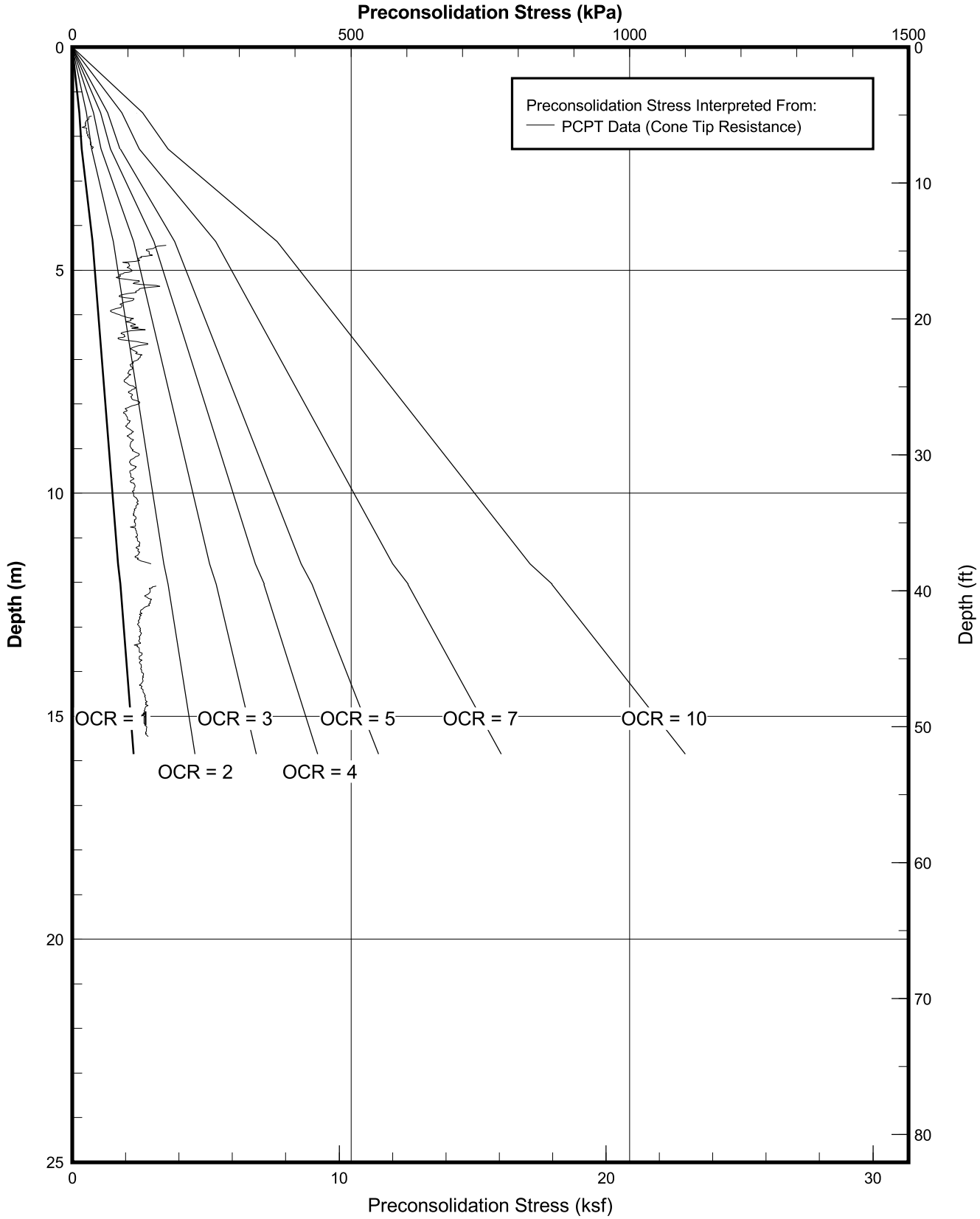
Sounding 99C-3

SFOBB East Span Seismic Safety Project

PLATE 99C-3.2

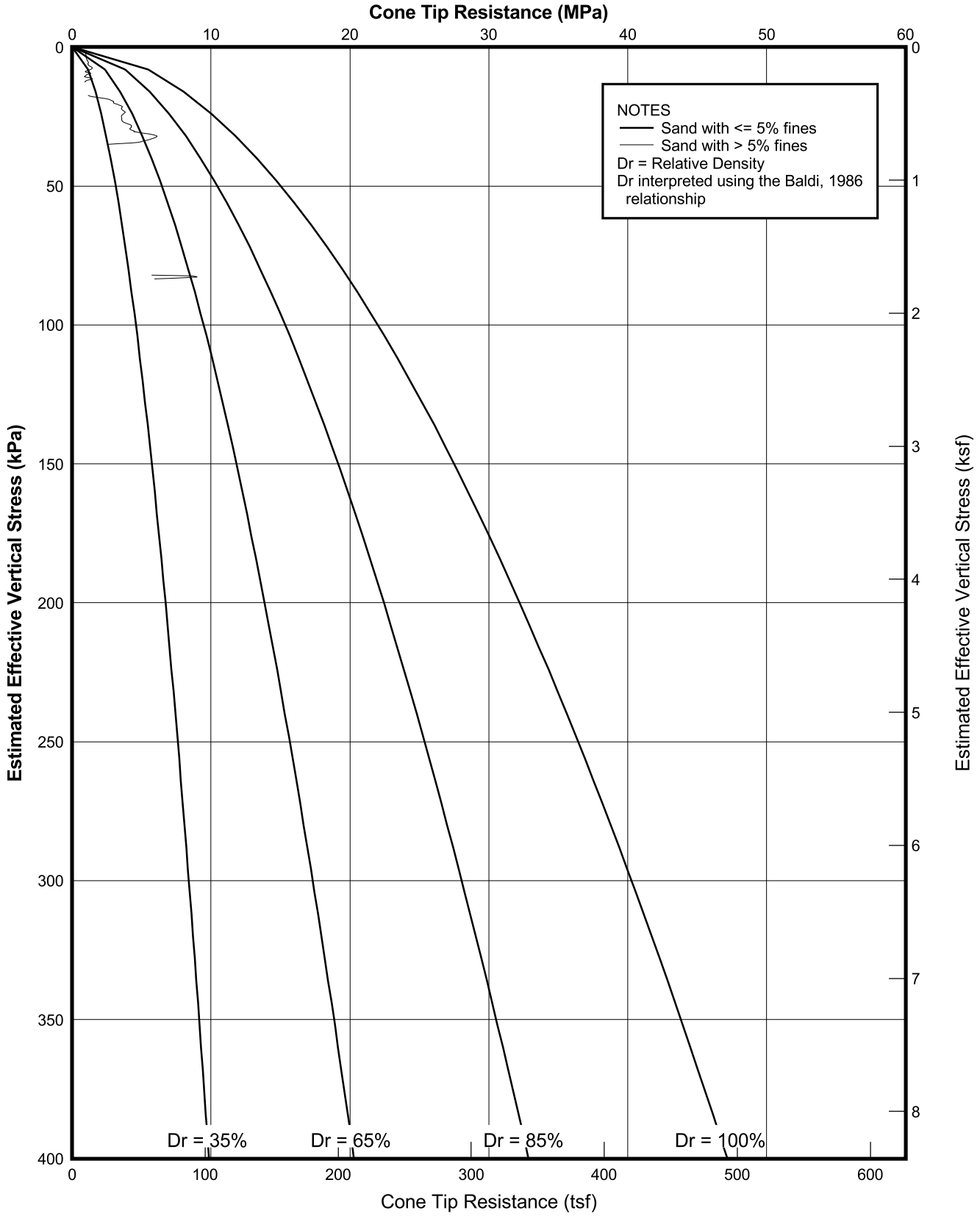
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-3
SFOBB East Span Seismic Safety Project

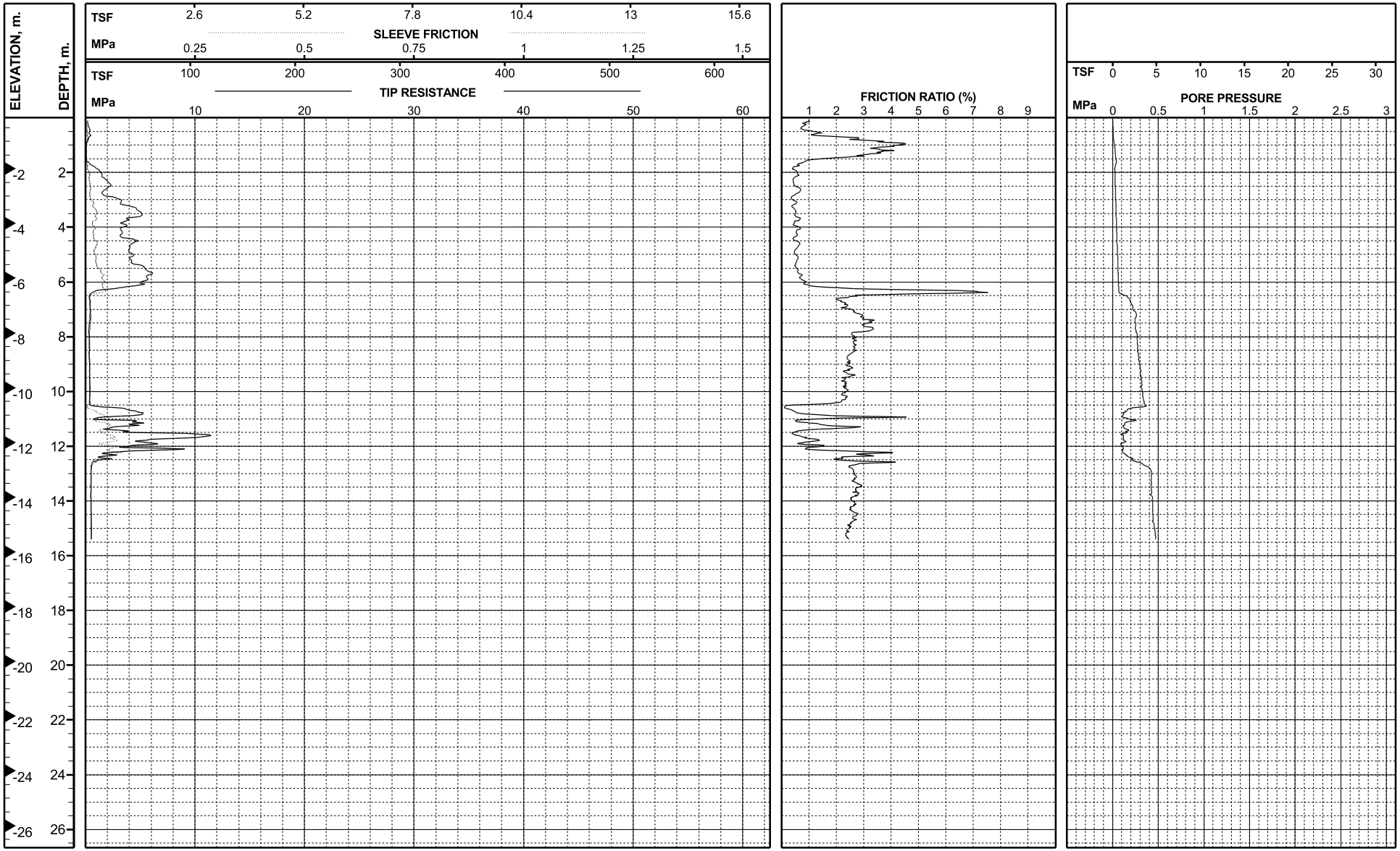
PLATE 99C-3.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-3
SFOBB East Span Seismic Safety Project

PLATE 99C-3.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839208 N648316 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-4 (0.5m right of W. Sta 87+50)	**GROUND ELEVATION:**	-0.1 m (MSL)	**TEST DATE:**	03/02/99



LOG OF CPT

SOUNDING 99C-4

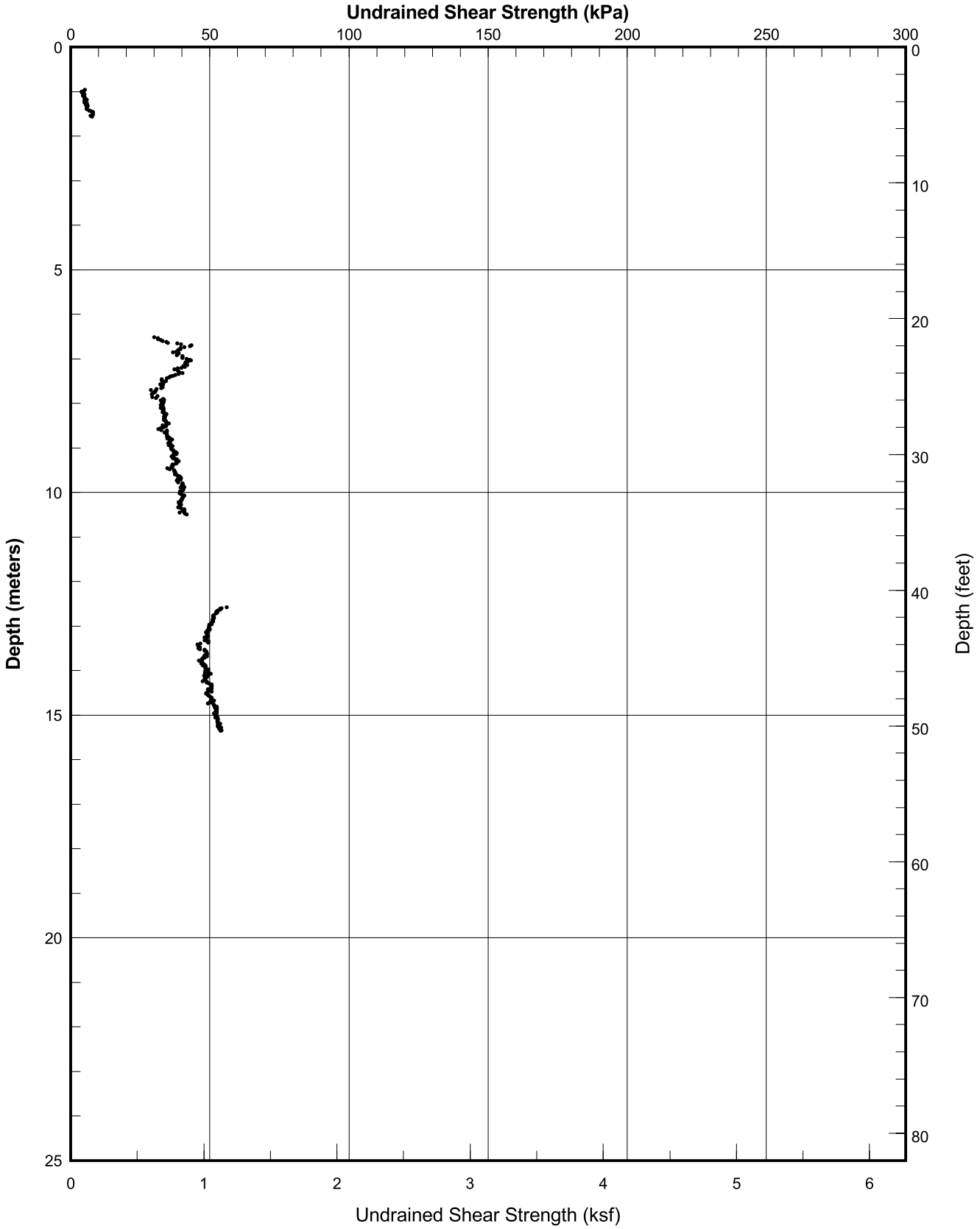
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-4.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

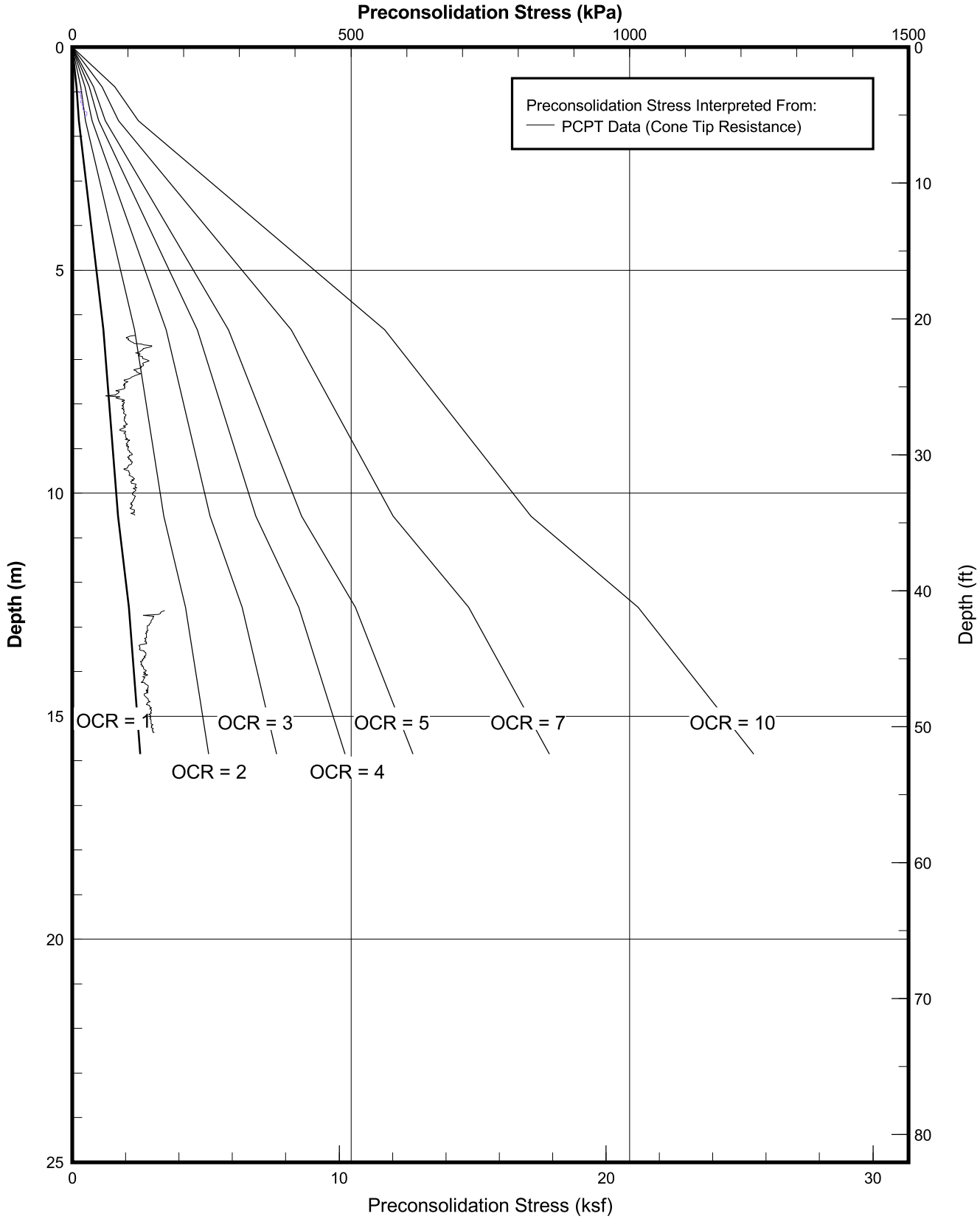
Sounding 99C-4

SFOBB East Span Seismic Safety Project

PLATE 99C-4.2

Earth Mechanics

FUGRO

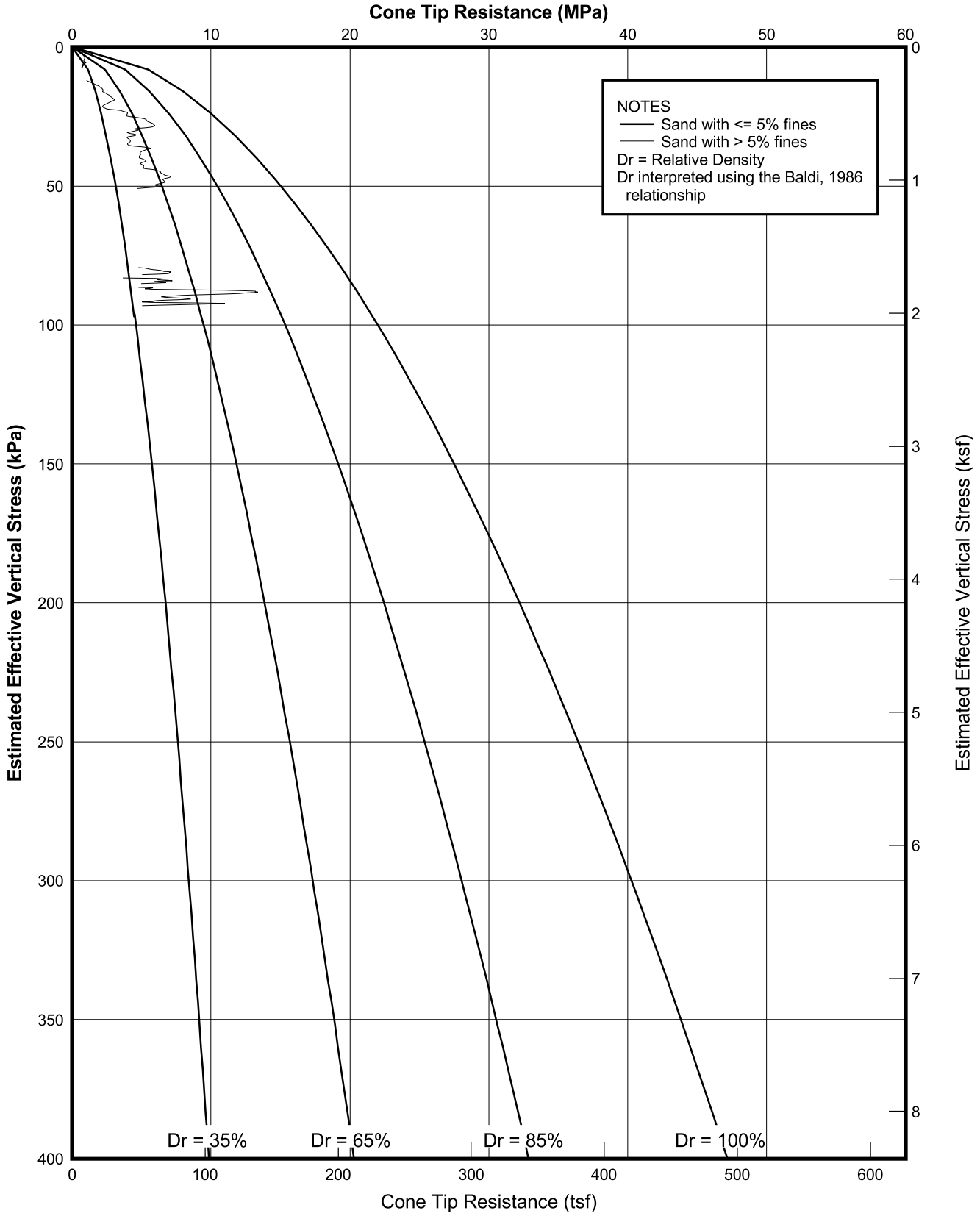


PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-4
SFOBB East Span Seismic Safety Project

PLATE 99C-4.3

Earth Mechanics

FUGRO



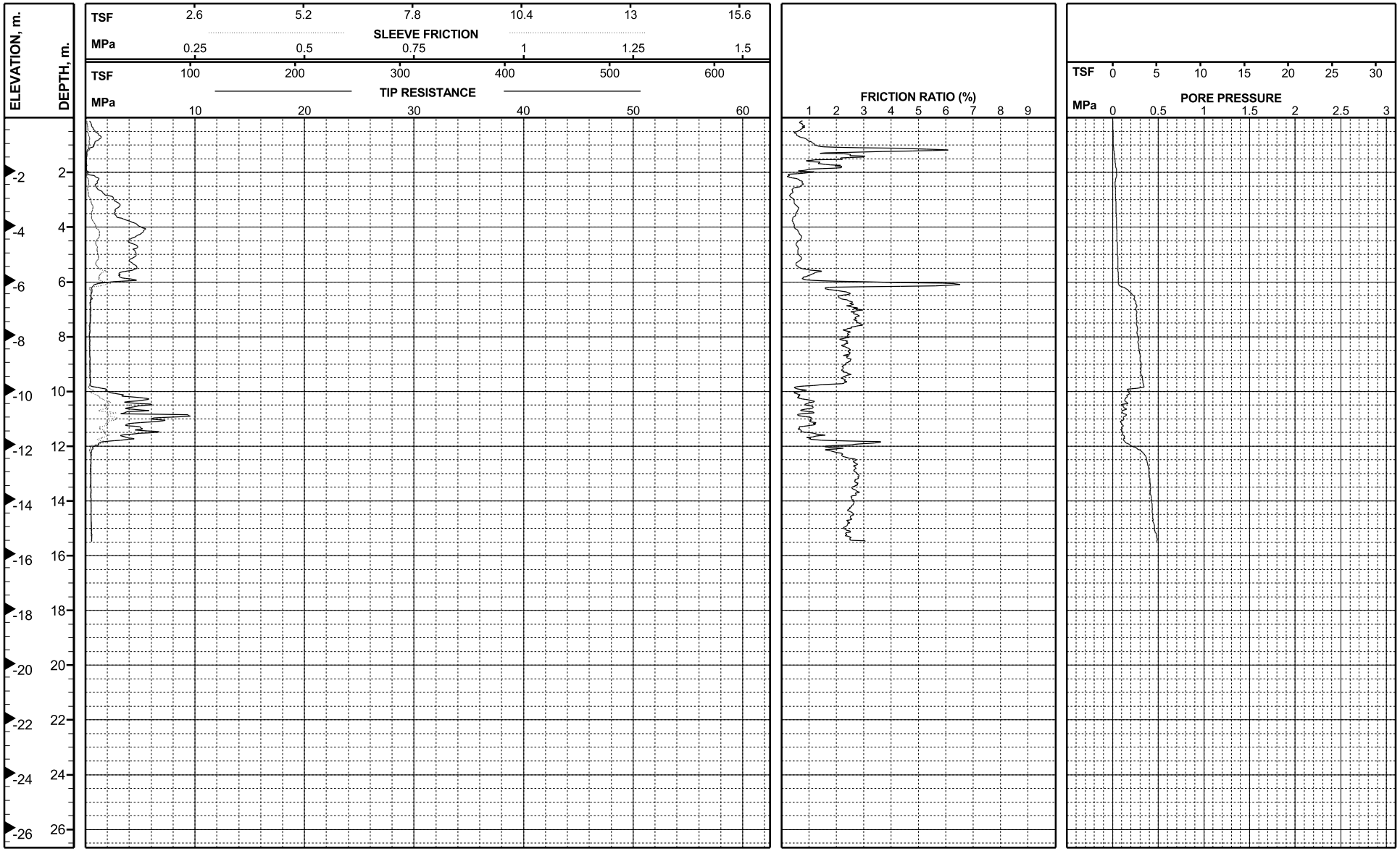
RELATIVE DENSITY INTERPRETED FROM CPT DATA

Sounding 99C-4

SFOBB East Span Seismic Safety Project

PLATE 99c-4.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839262 N648328 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-5 (7.4m left of W. Sta 88+04)	**GROUND ELEVATION:**	-0.1 m (MSL)	**TEST DATE:**	03/02/99



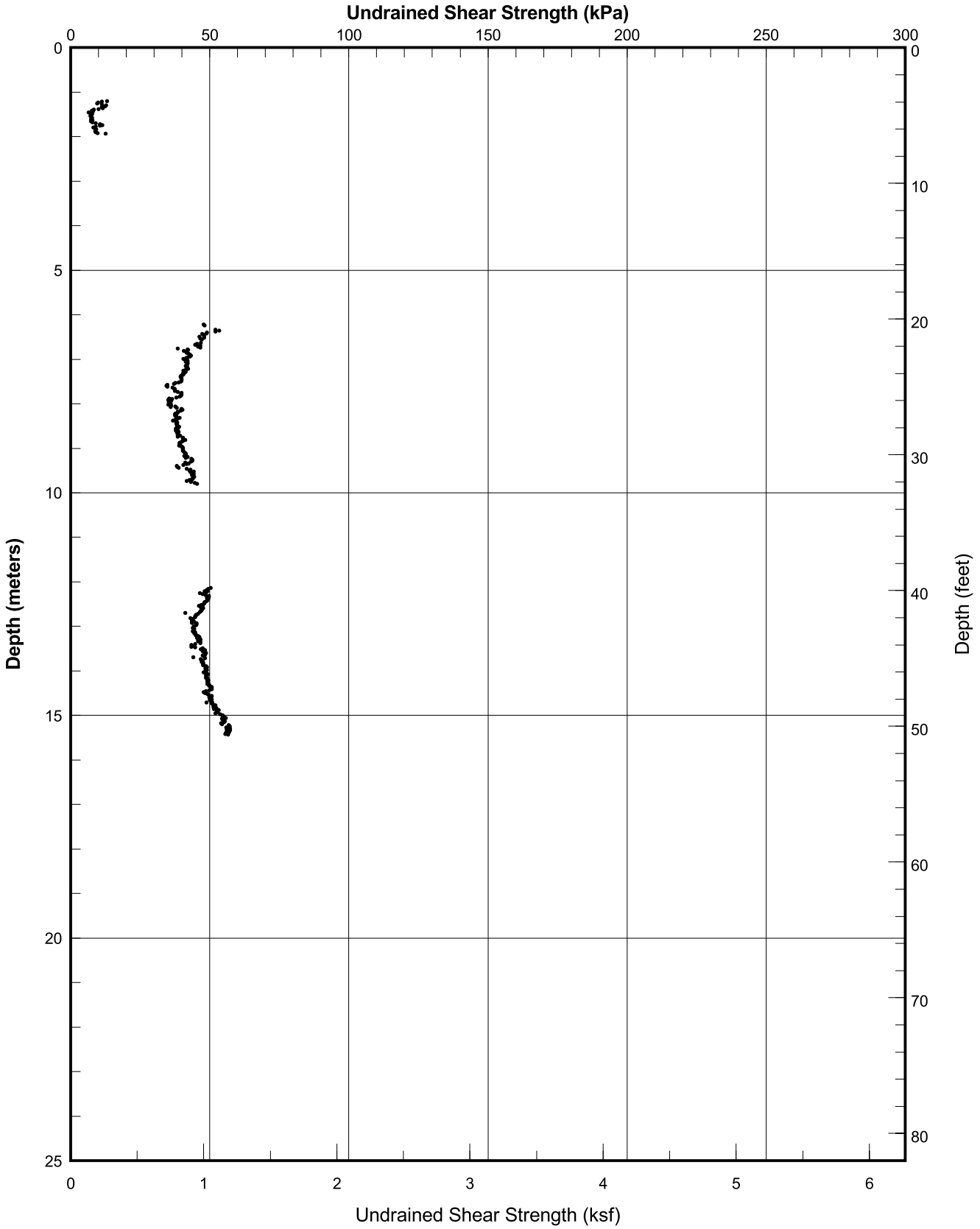
LOG OF CPT

SOUNDING 99C-5

SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-5.1



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

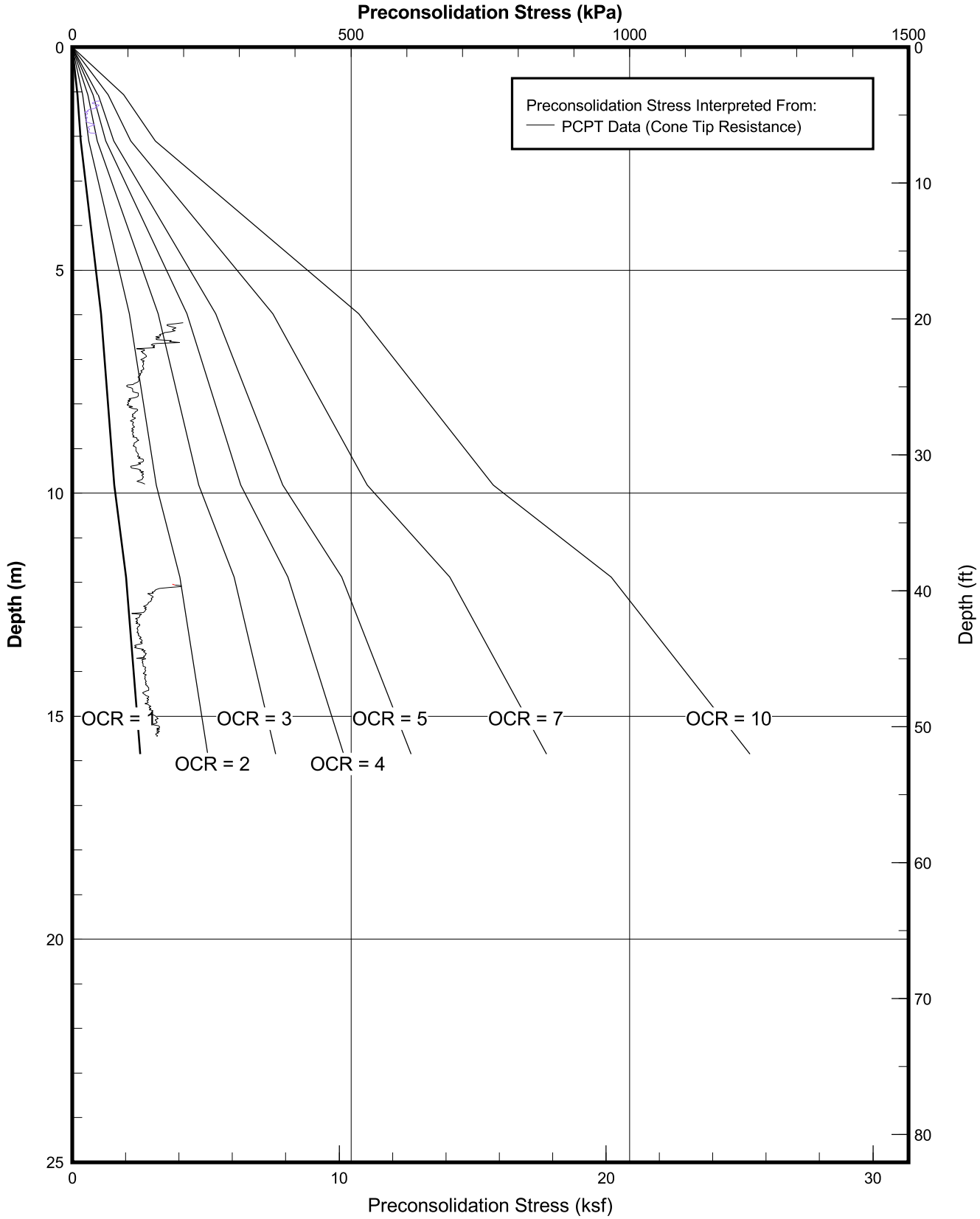
Sounding 99C-5

SFOBB East Span Seismic Safety Project

PLATE 99C-5.2

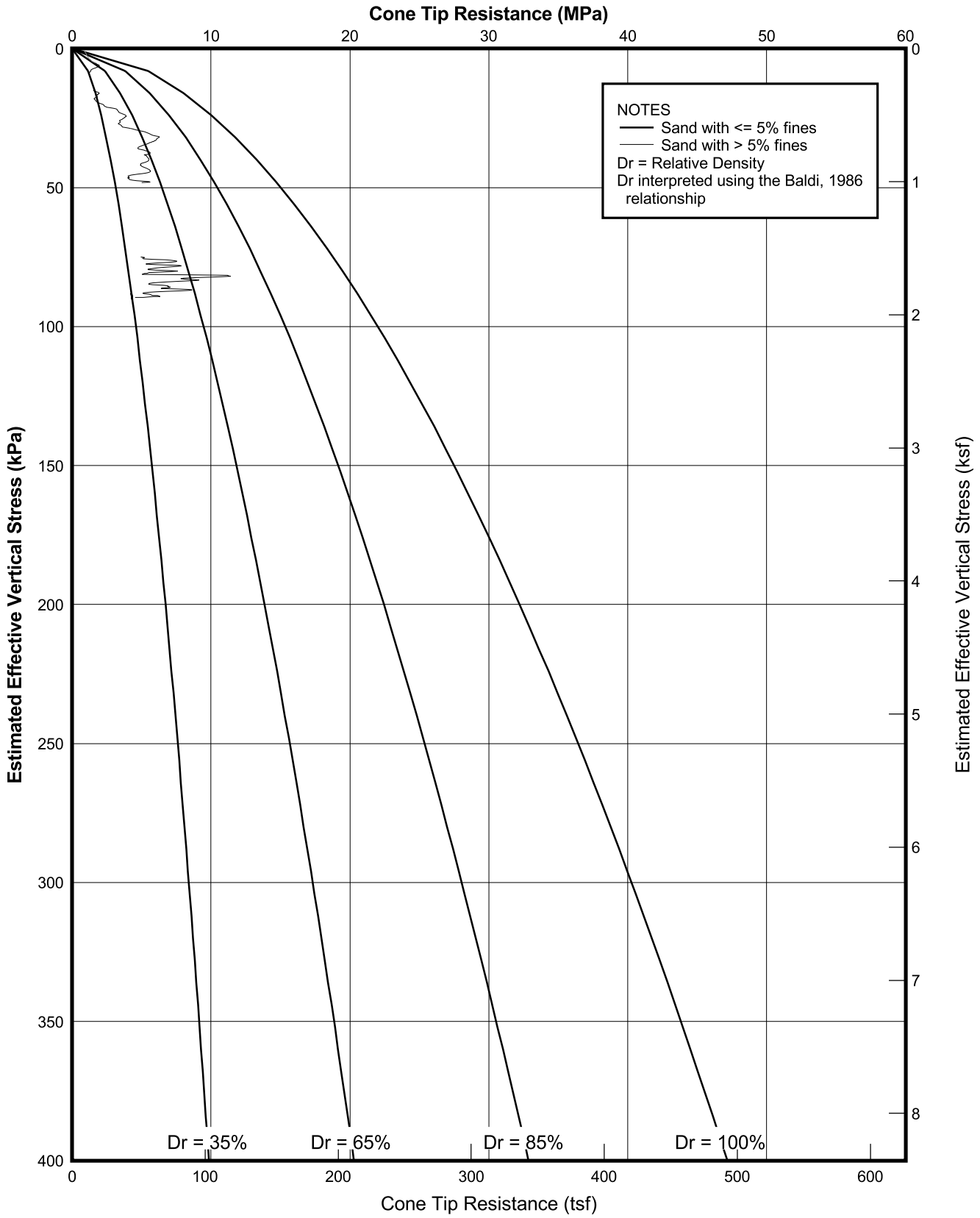
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-5
SFOBB East Span Seismic Safety Project

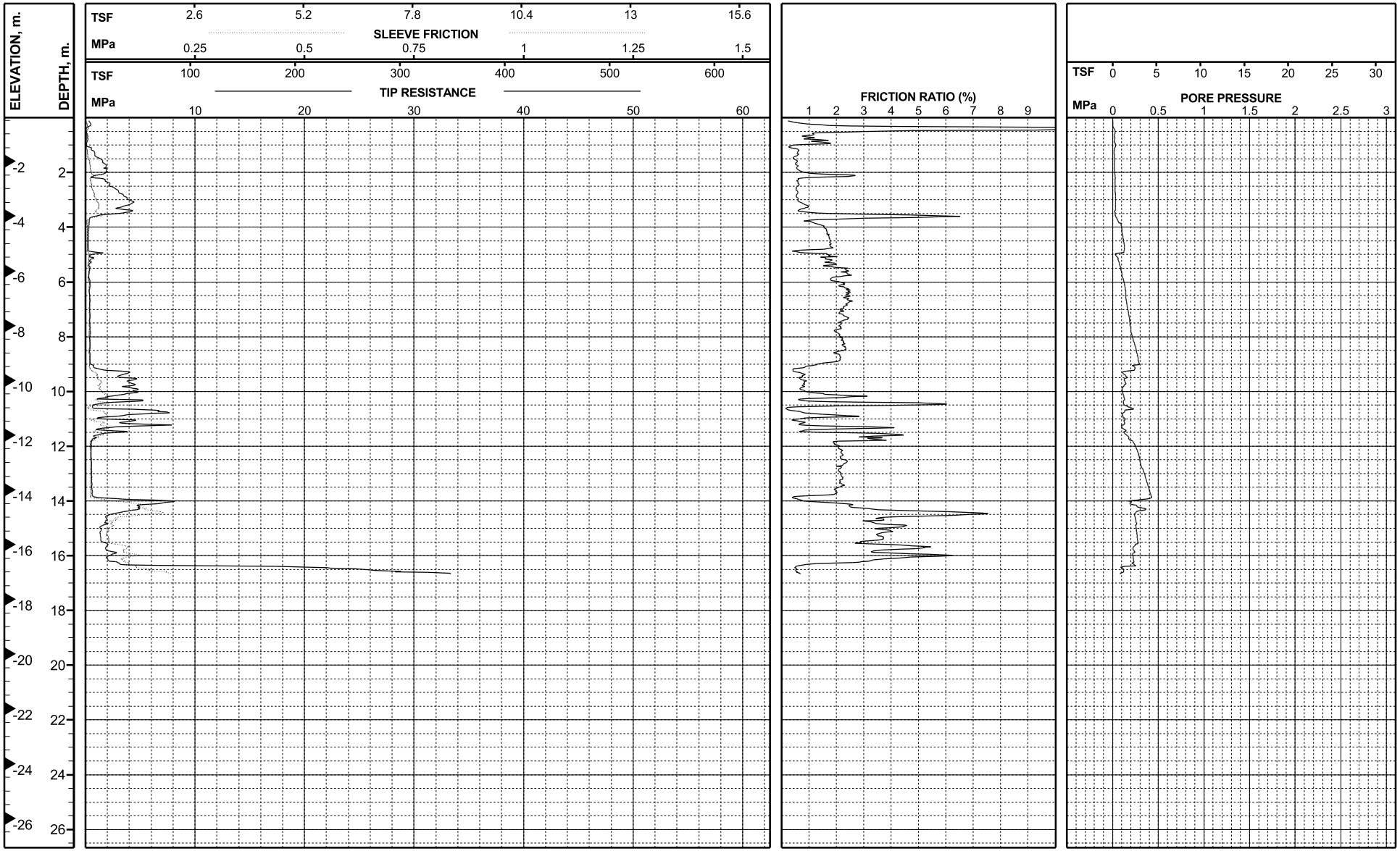
PLATE 99C-5.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-5
SFOBB East Span Seismic Safety Project

PLATE 99C-5.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839329 N648333 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-6 (7.3m left of W. Sta. 88+72)	**GROUND ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	03/03/99



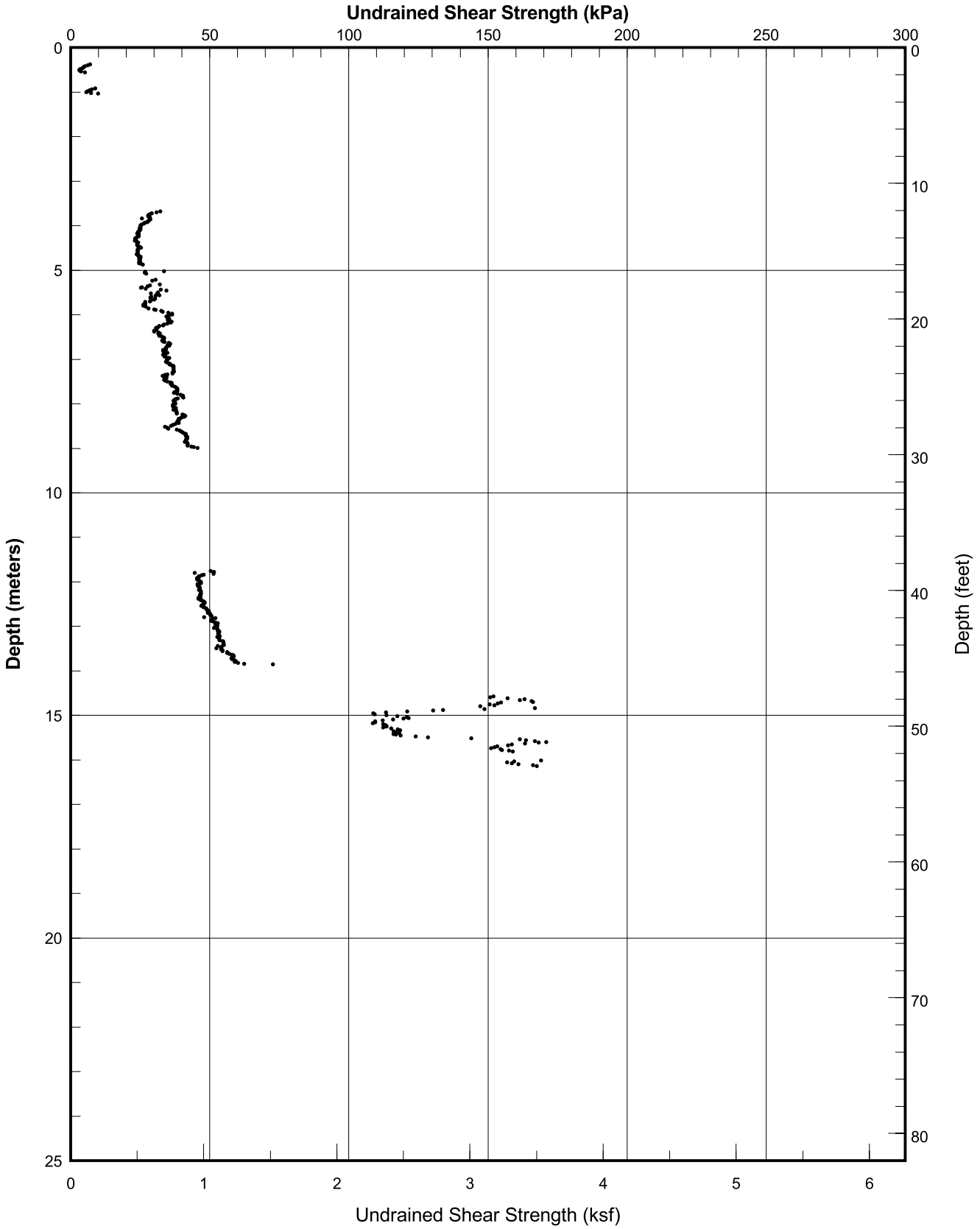
LOG OF CPT

SOUNDING 99C-6

SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-6.1

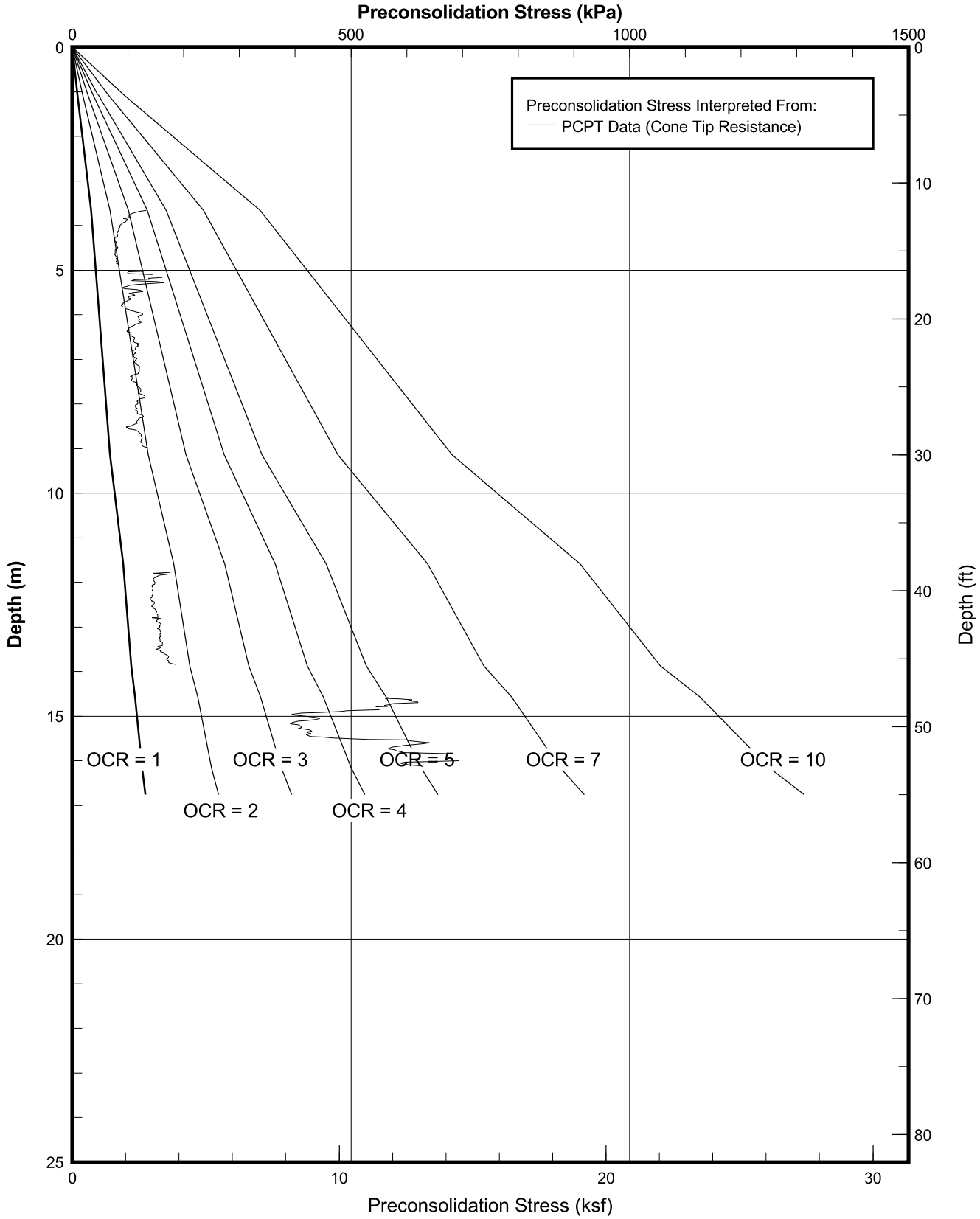


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-6

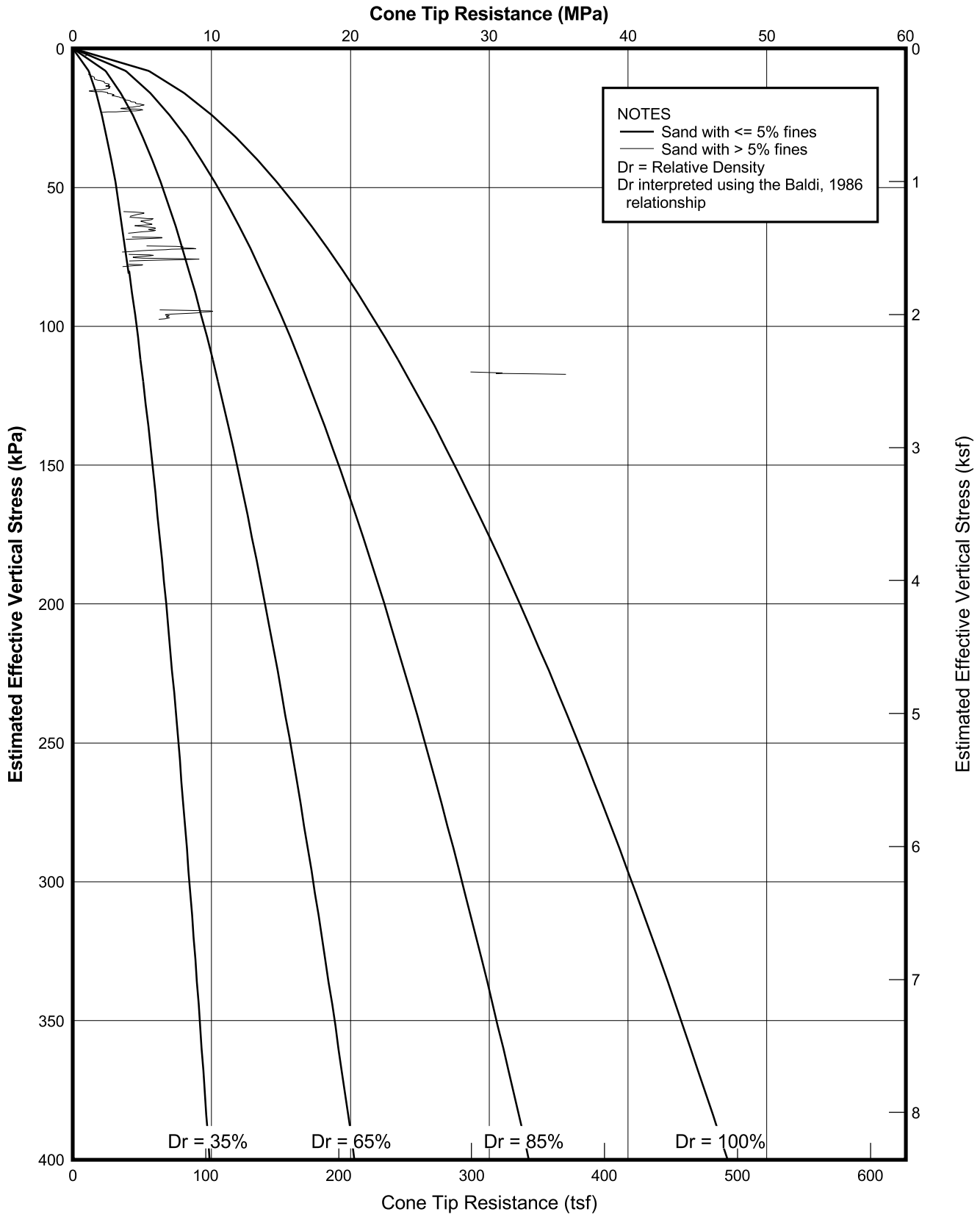
SFOBB East Span Seismic Safety Project

PLATE 99C-6.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-6
SFOBB East Span Seismic Safety Project

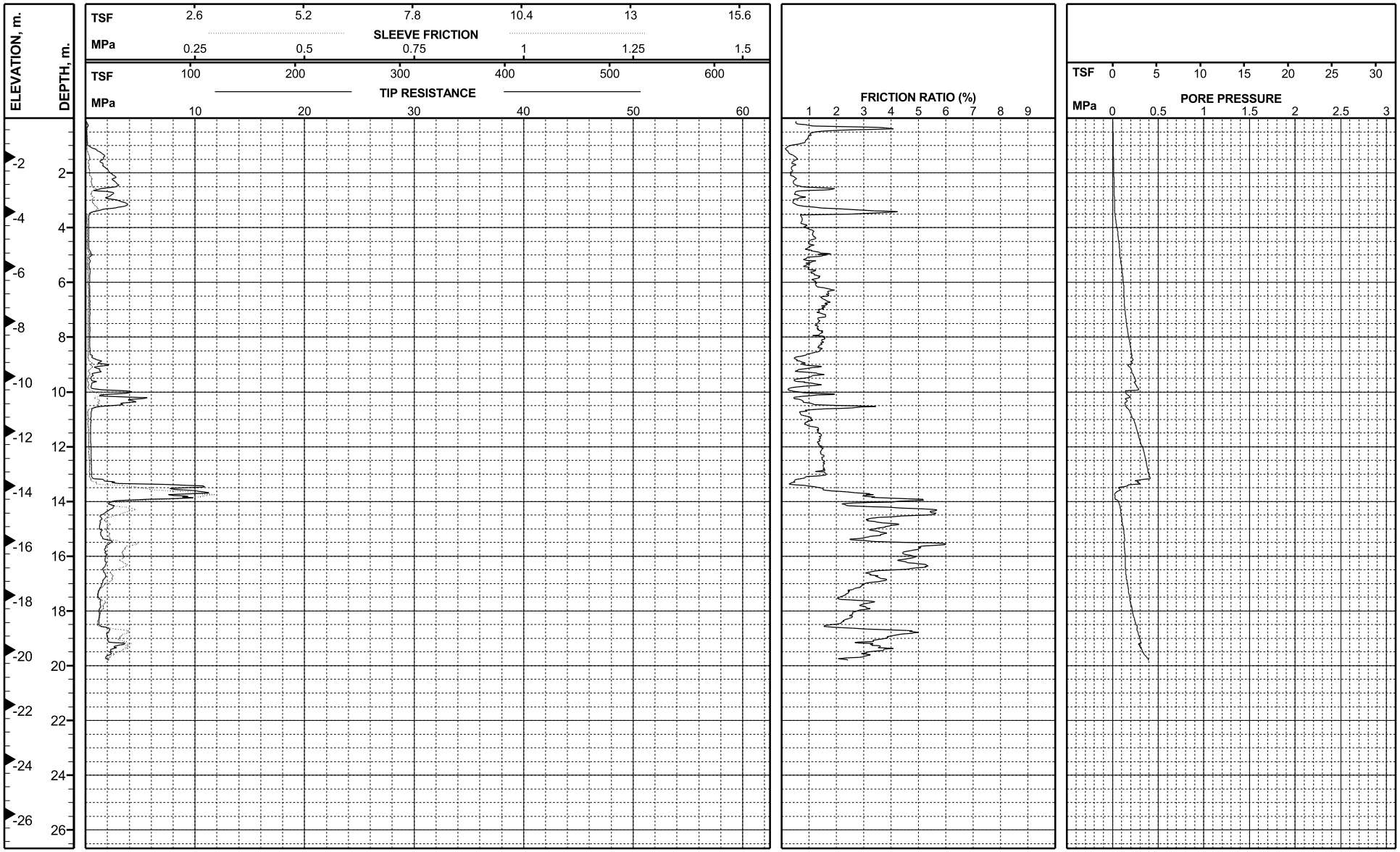
PLATE 99C-6.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-6
SFOBB East Span Seismic Safety Project

PLATE 99C-6.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839384 N648343 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-7 (13.2m left of W. Sta 89+27)	**GROUND ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	03/03/99



LOG OF CPT

SOUNDING 99C-7

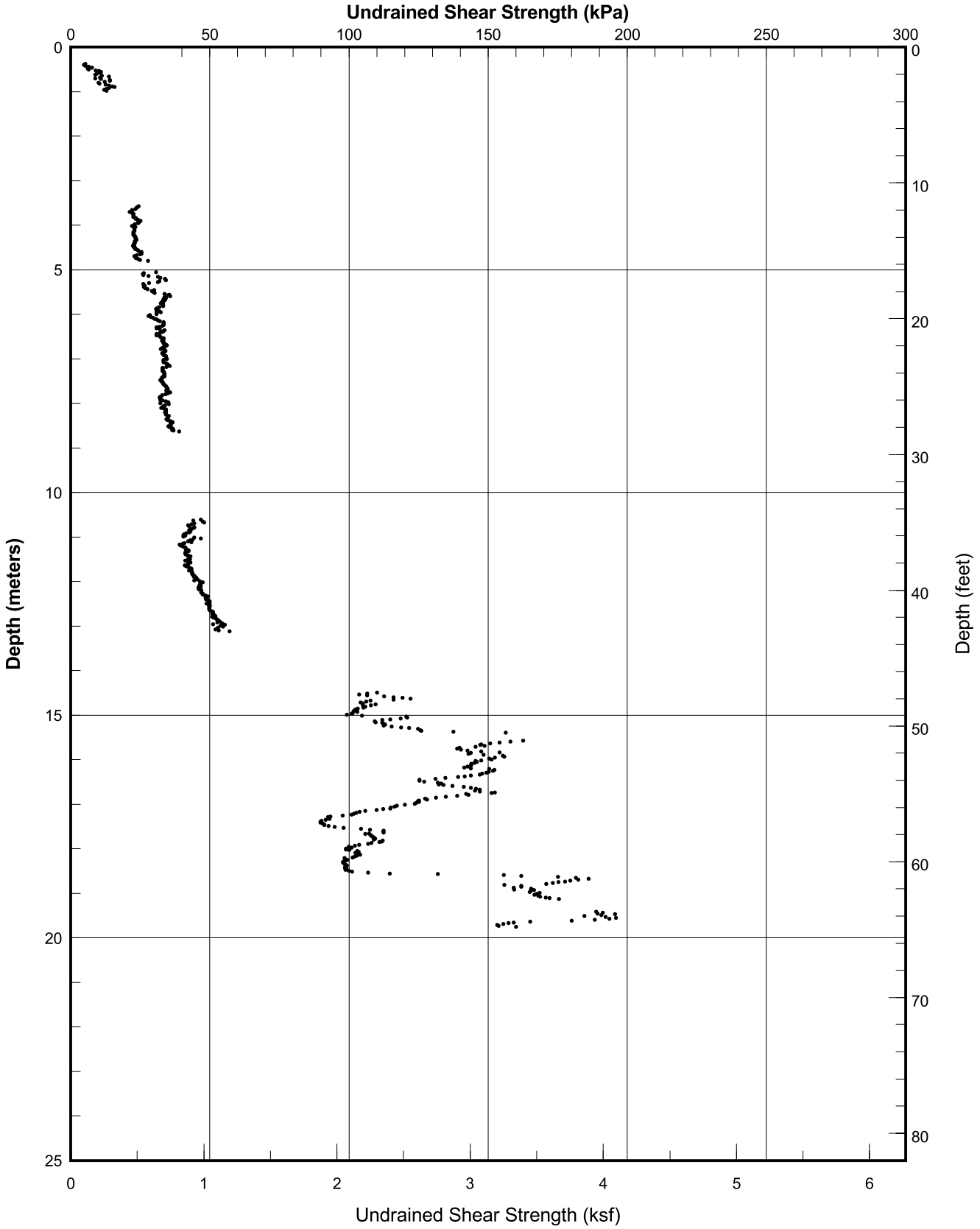
SFOBB East Span Seismic Safety Project

Report Date: 07/09/99

PLATE 99C-7.1

Earth Mechanics

FUGRO

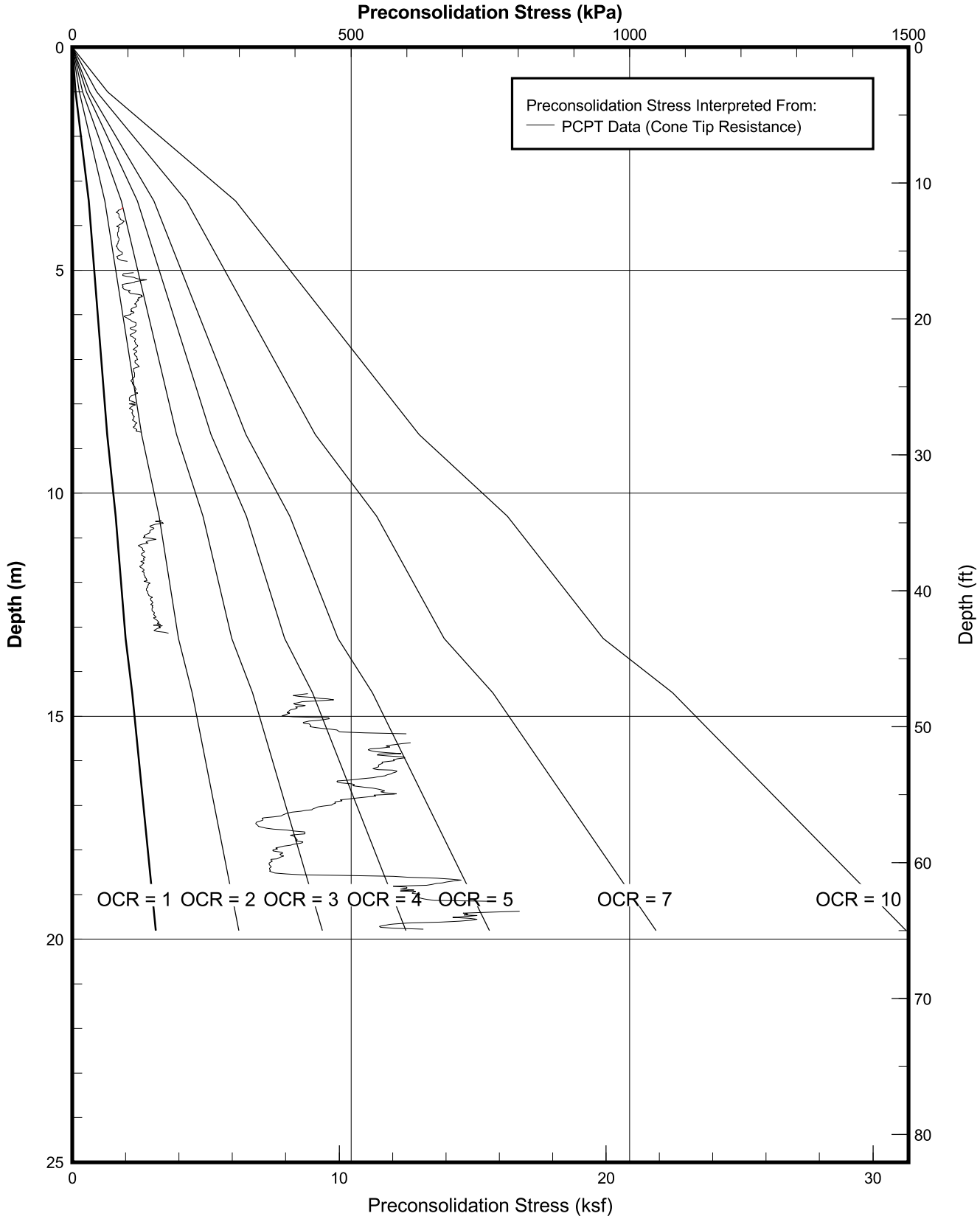


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-7

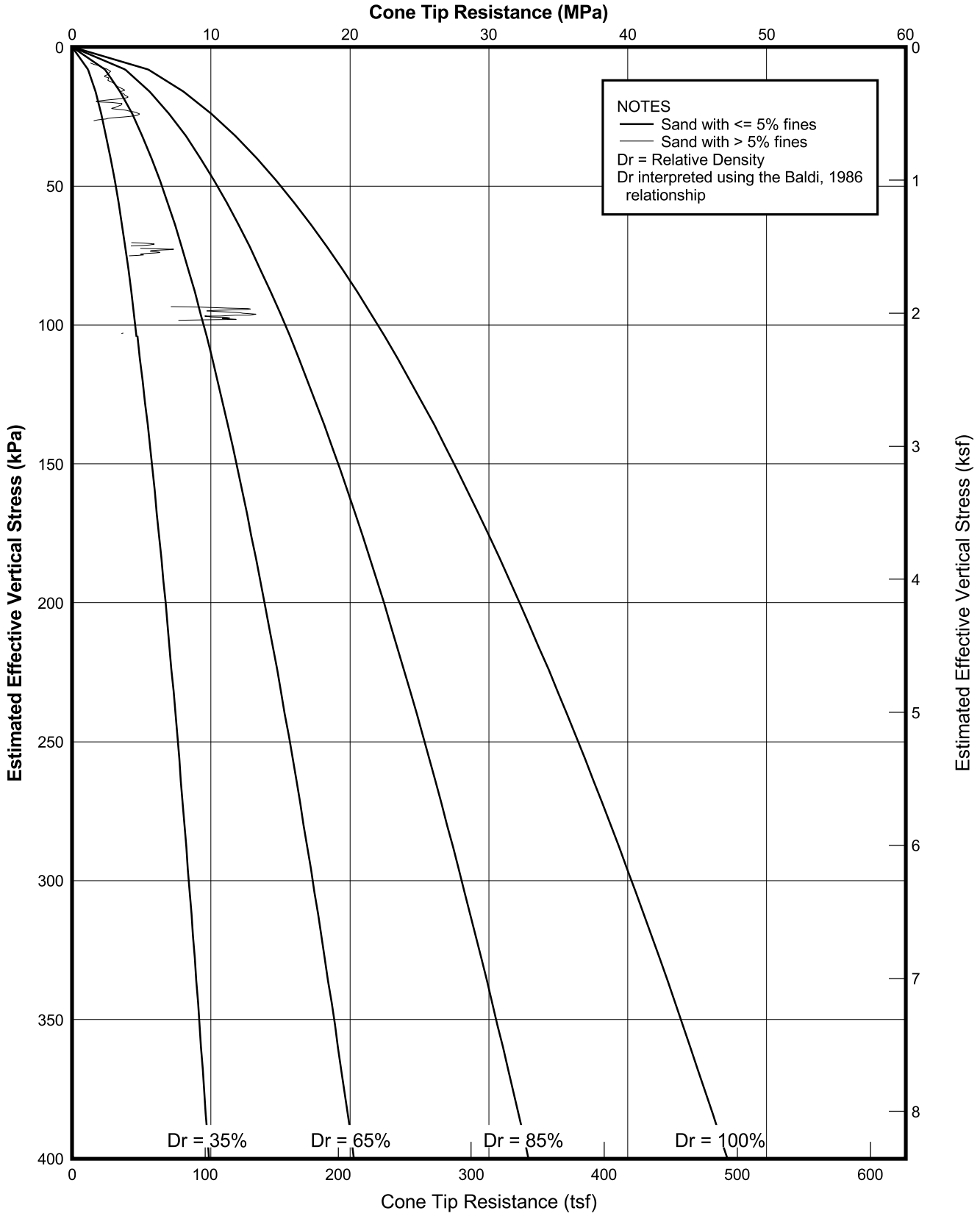
SFOBB East Span Seismic Safety Project

PLATE 99C-7.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-7
SFOBB East Span Seismic Safety Project

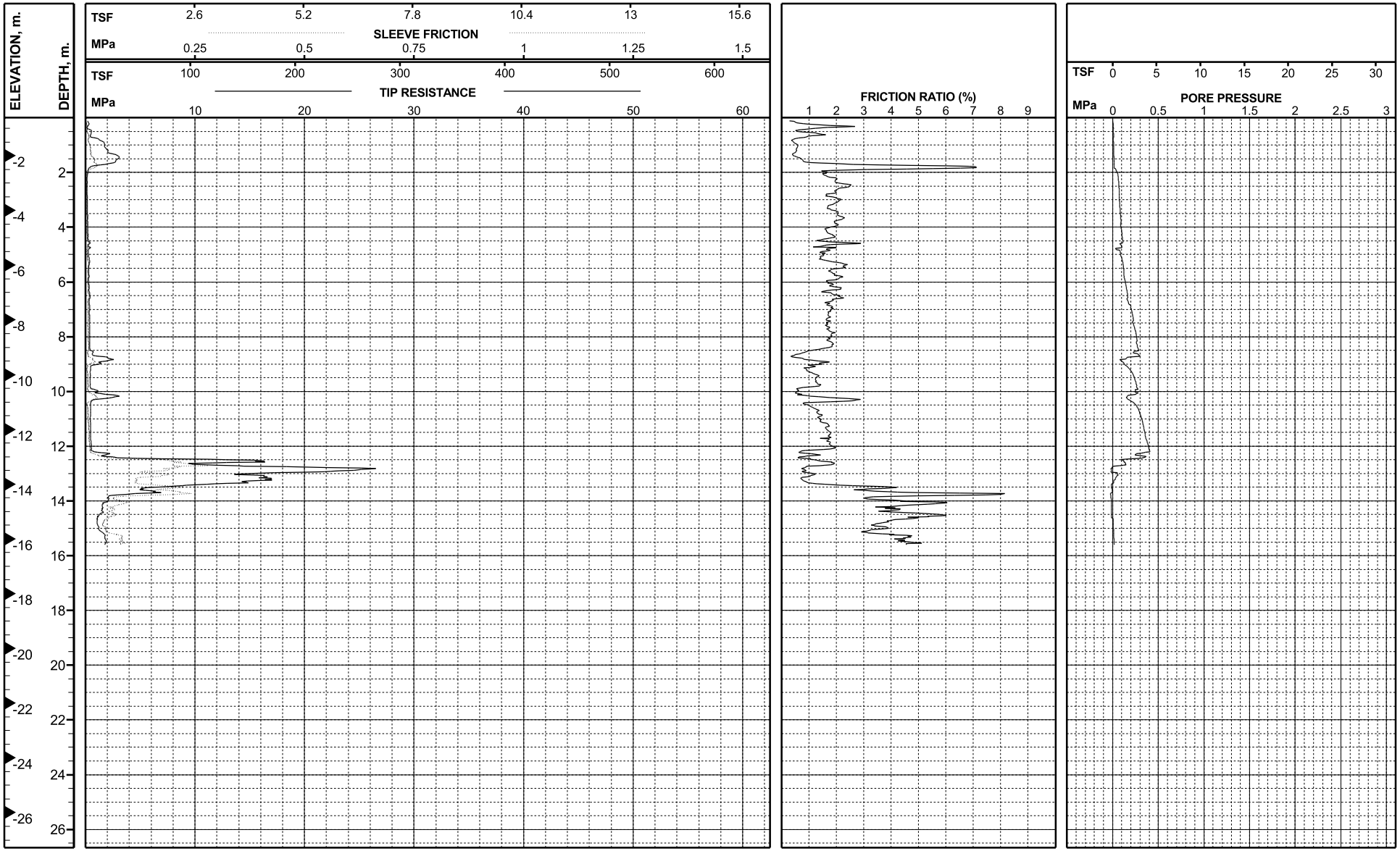
PLATE 99C-7.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-7
SFOBB East Span Seismic Safety Project

PLATE 99C-7.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839431 N648353 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-8 (19.4m left of W. Sta 89+75)	**GROUND ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	03/04/99



LOG OF CPT

SOUNDING 99C-8

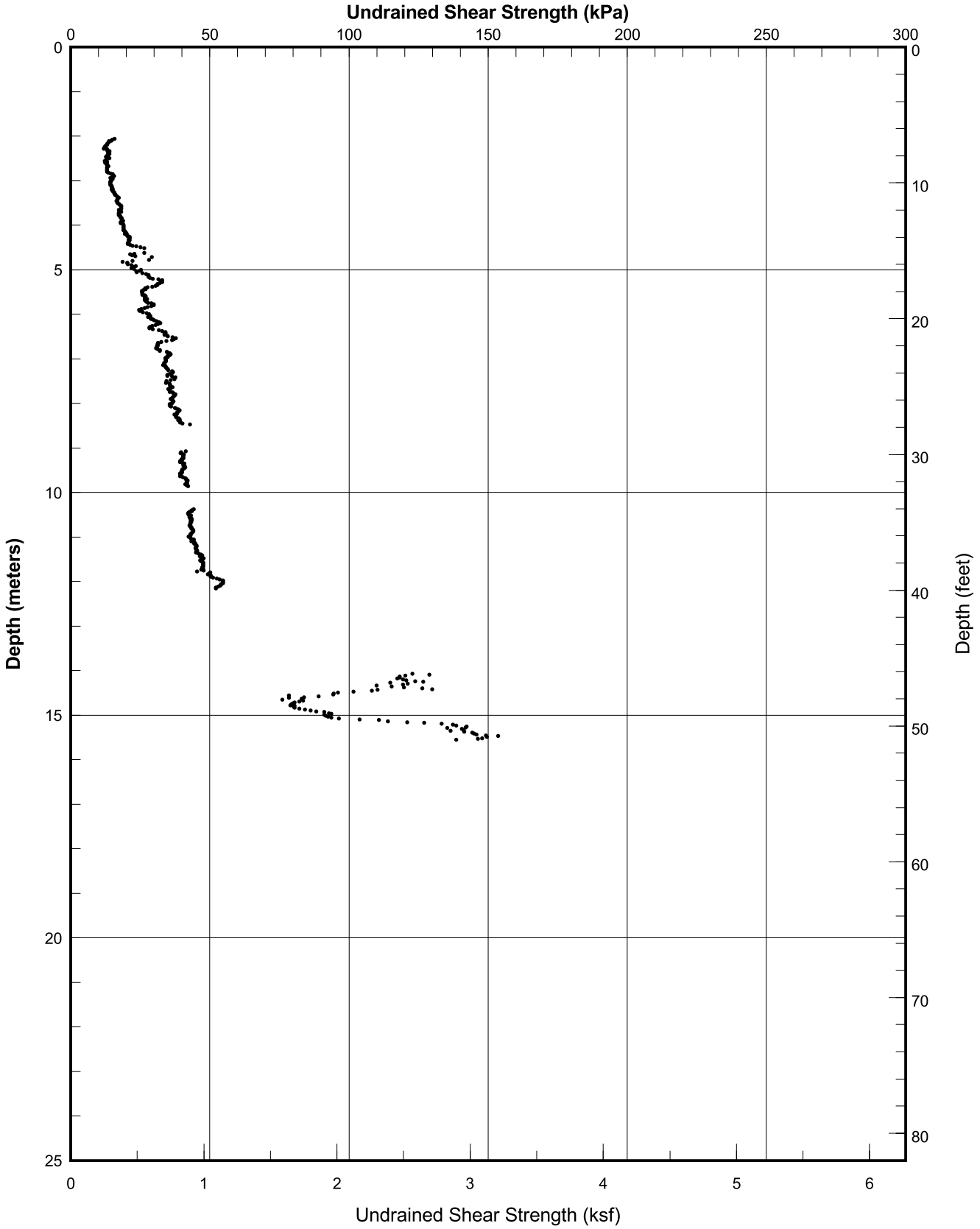
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-8.1

Earth Mechanics

FUGRO

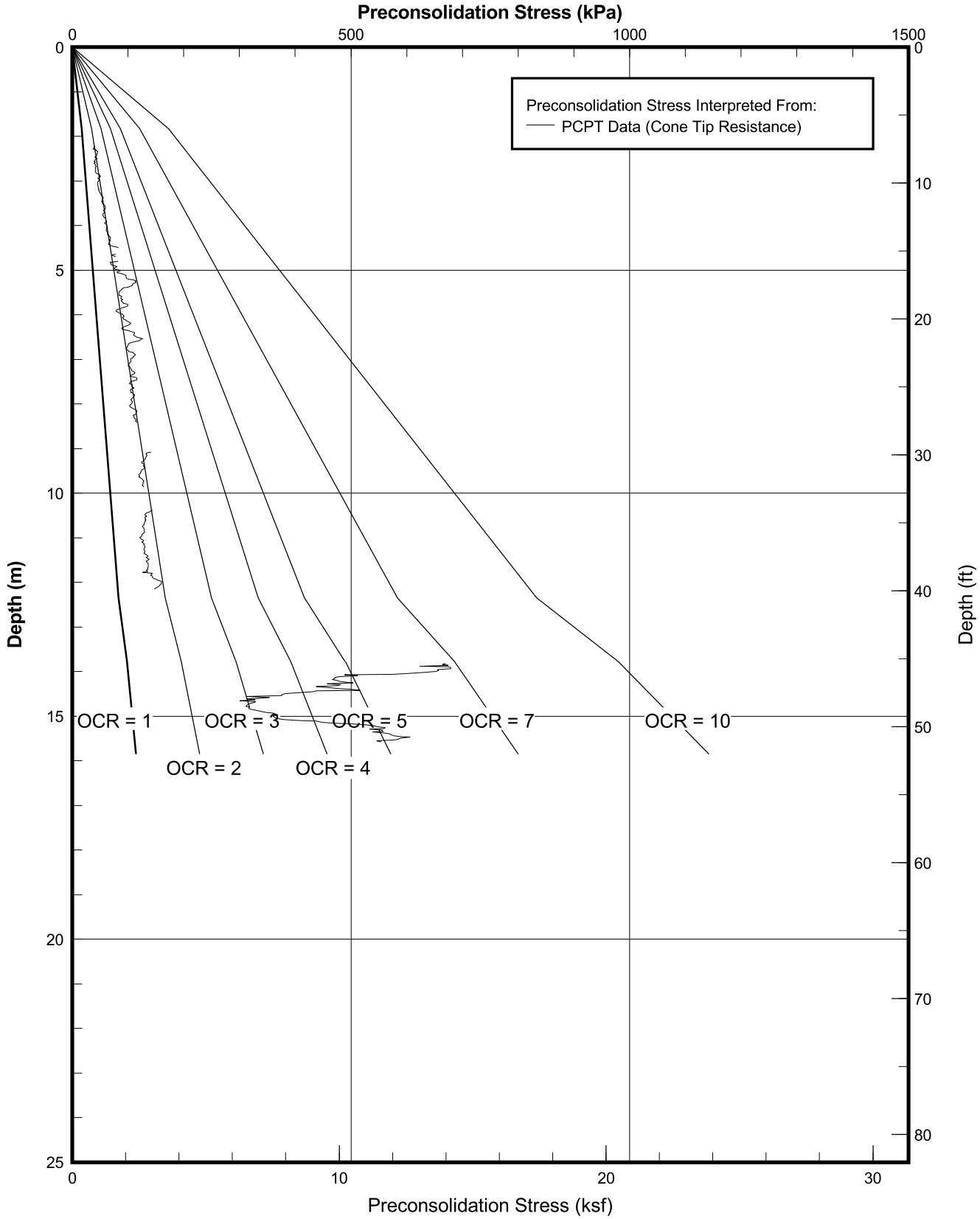


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-8

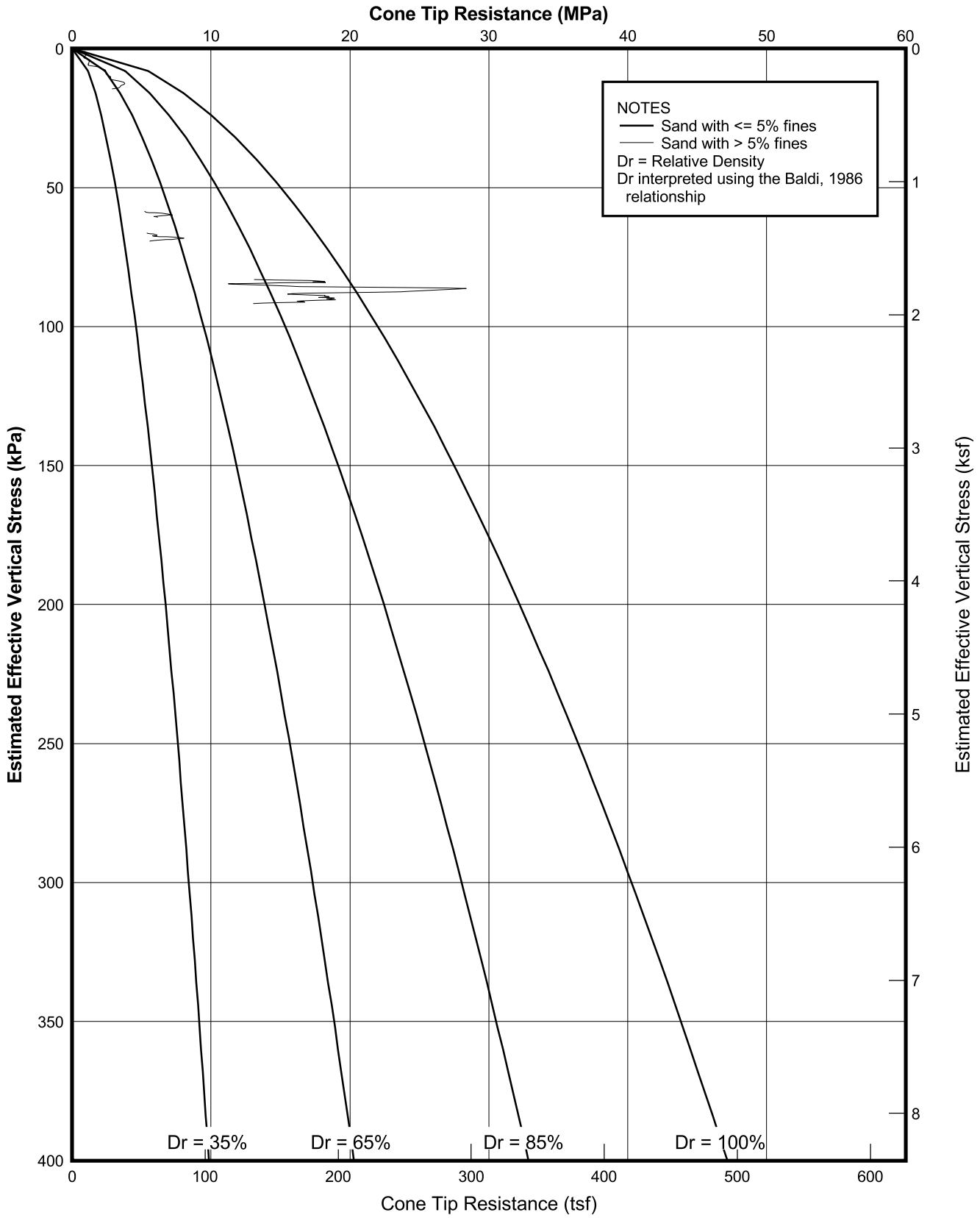
SFOBB East Span Seismic Safety Project

PLATE 99C-8.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-8
SFOBB East Span Seismic Safety Project

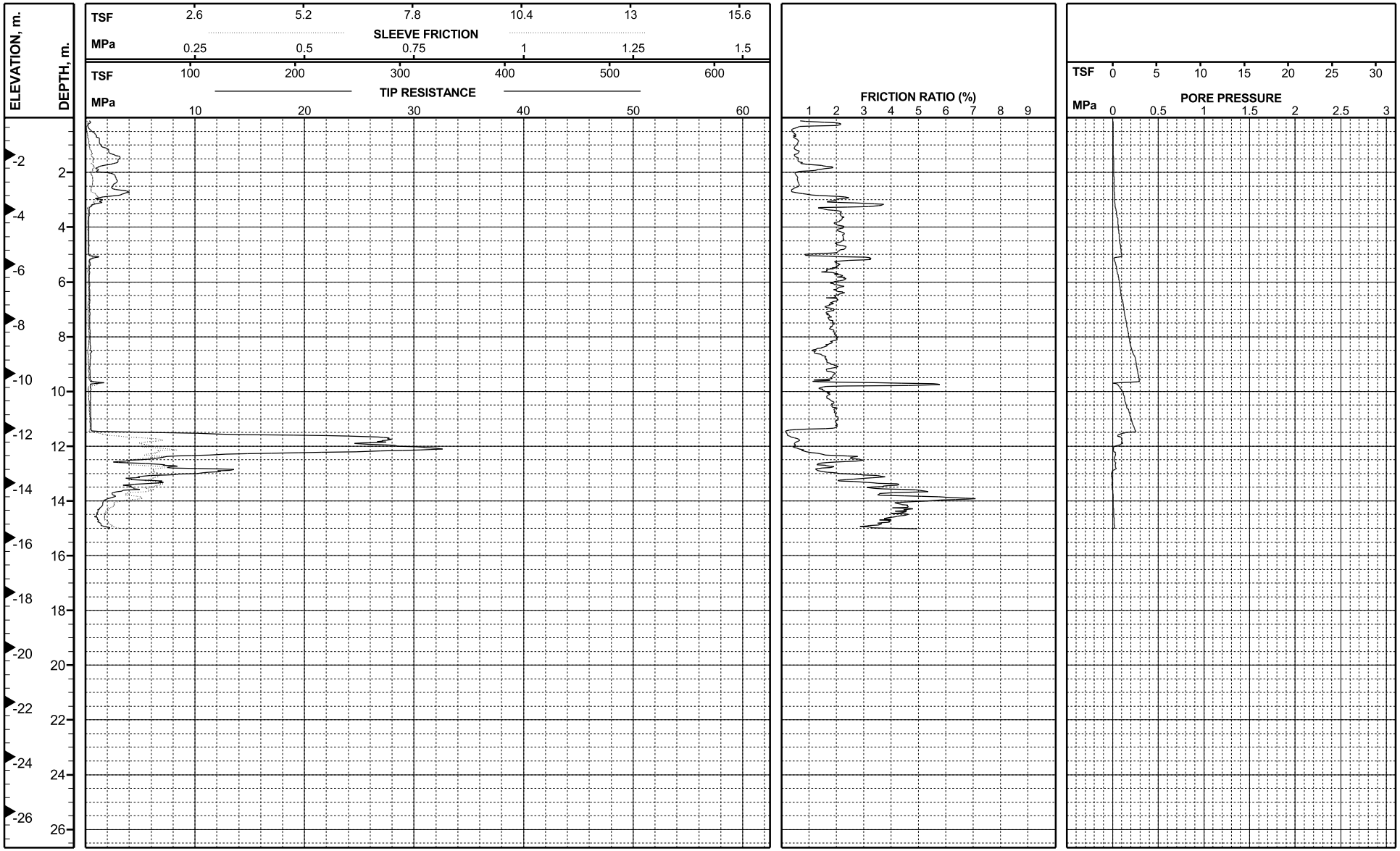
PLATE 99C-8.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-8
SFOBB East Span Seismic Safety Project

PLATE 99C-8.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839496 N648364 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-9 (22.9m left of W. Sta 90+42)	**GROUND ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	03/03/99



LOG OF CPT

SOUNDING 99C-9

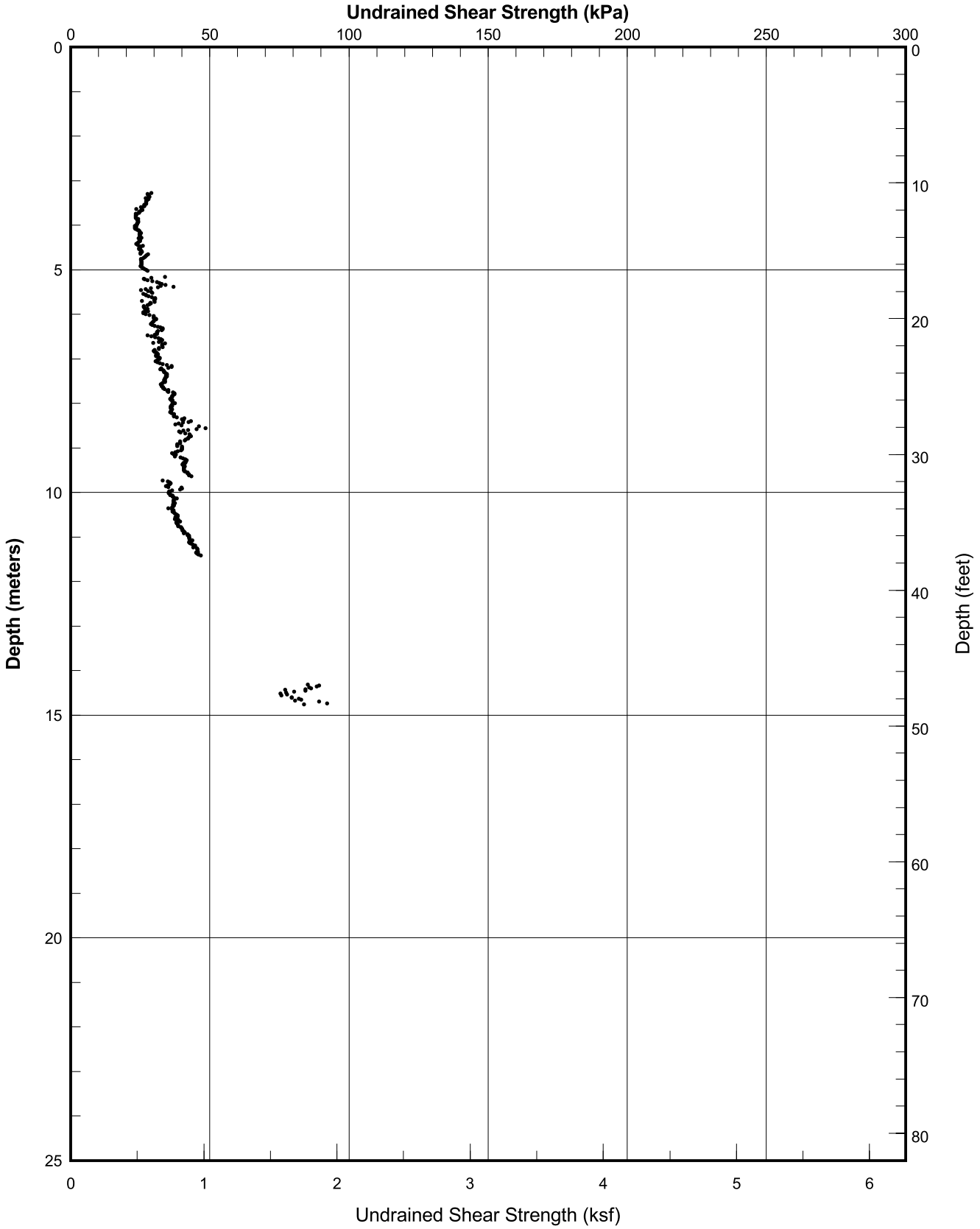
SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-9.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

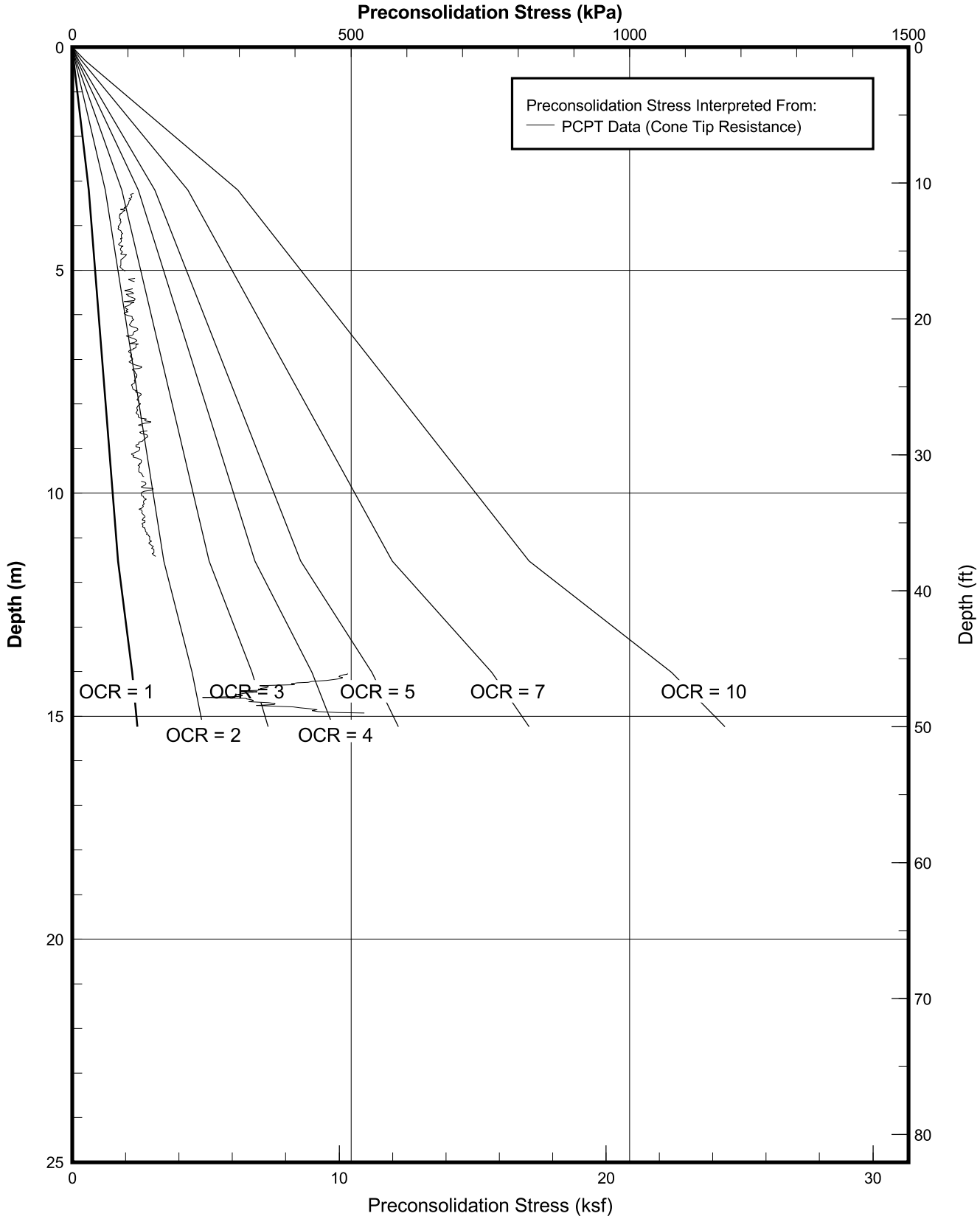
Sounding 99C-9

SFOBB East Span Seismic Safety Project

PLATE 99C-9.2

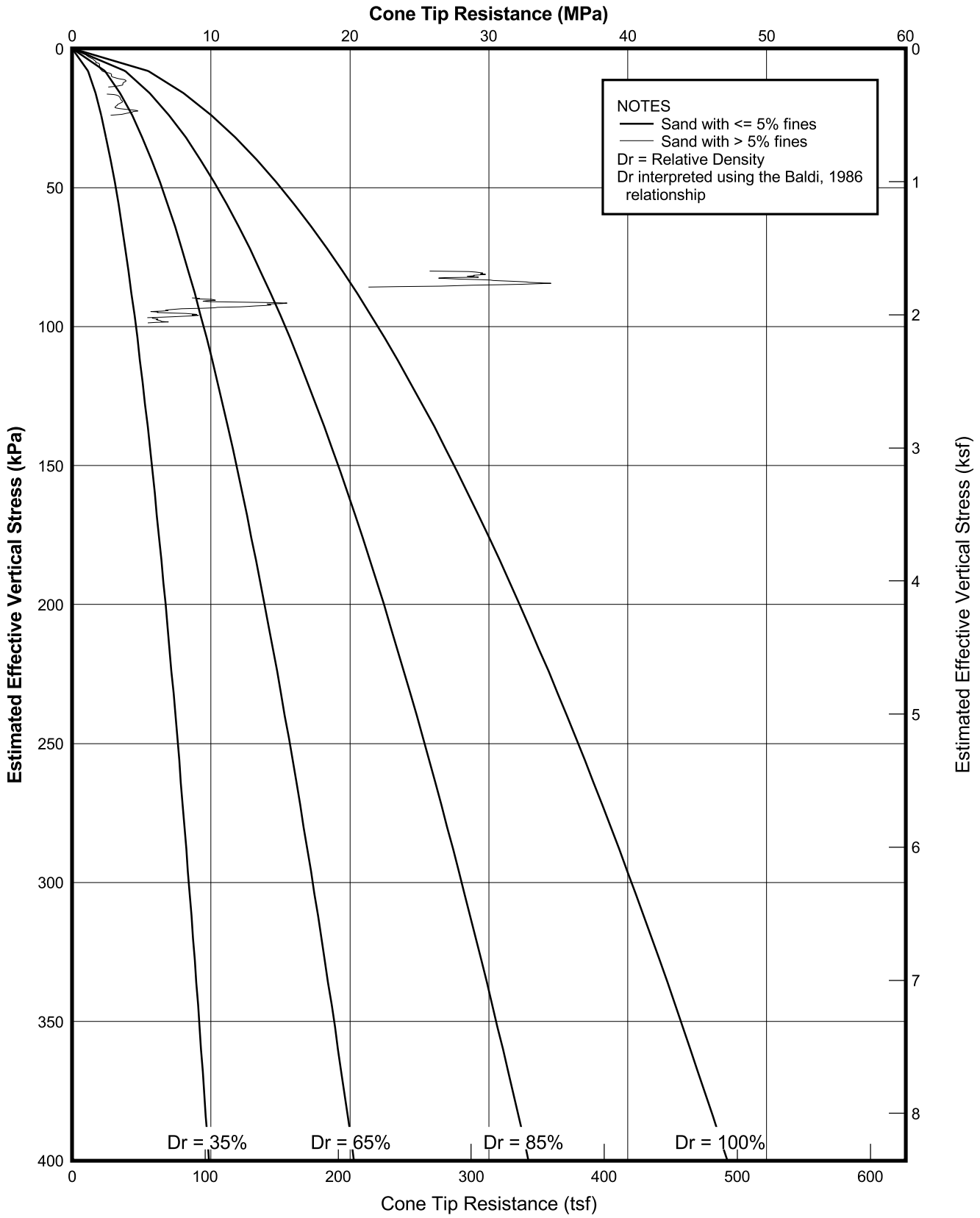
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-9
SFOBB East Span Seismic Safety Project

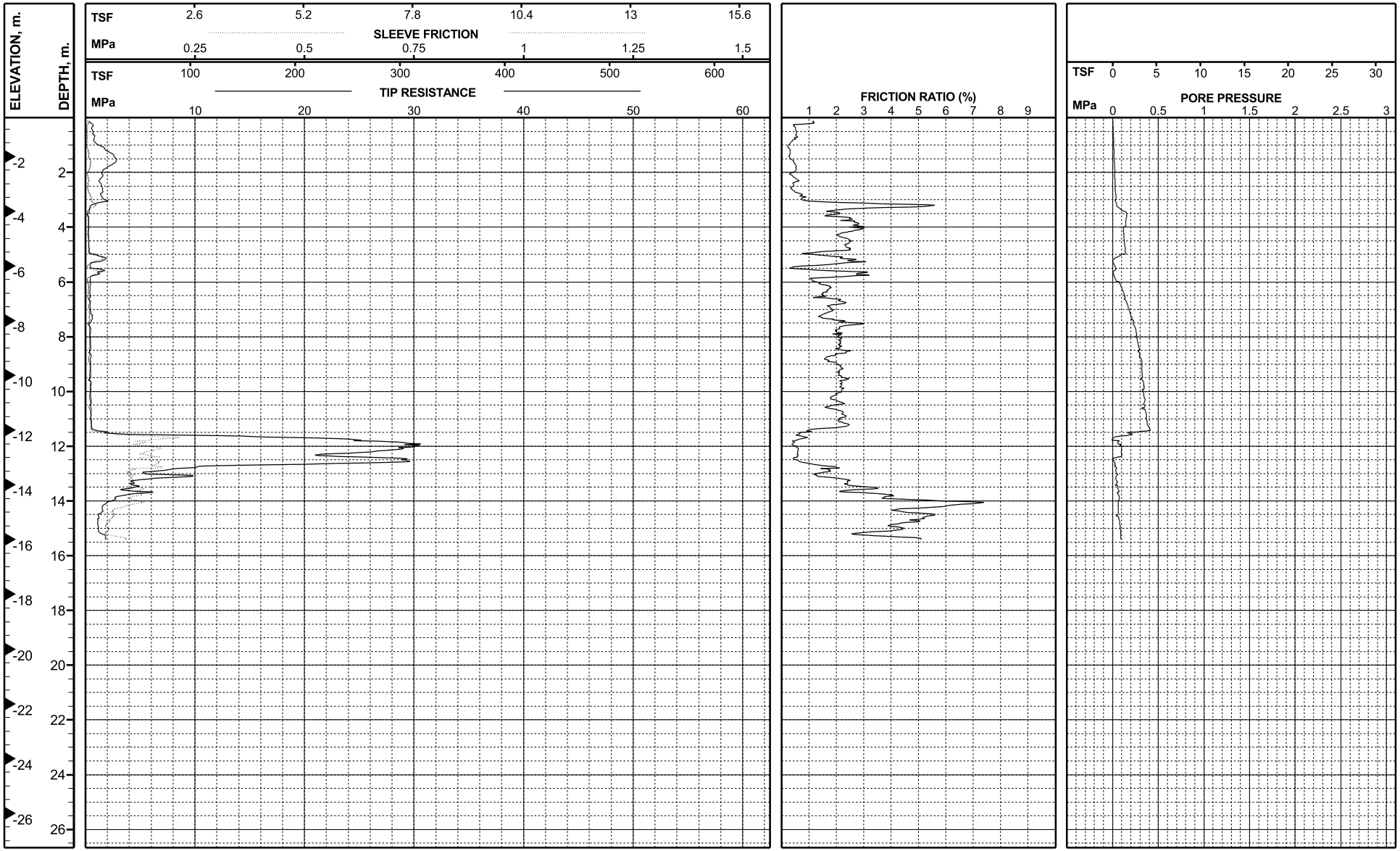
PLATE 99C-9.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-9
SFOBB East Span Seismic Safety Project

PLATE 99C-9.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839558 N648374 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-10 (22.7m left of W. Sta 91+06)	**GROUND ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	03/02/99



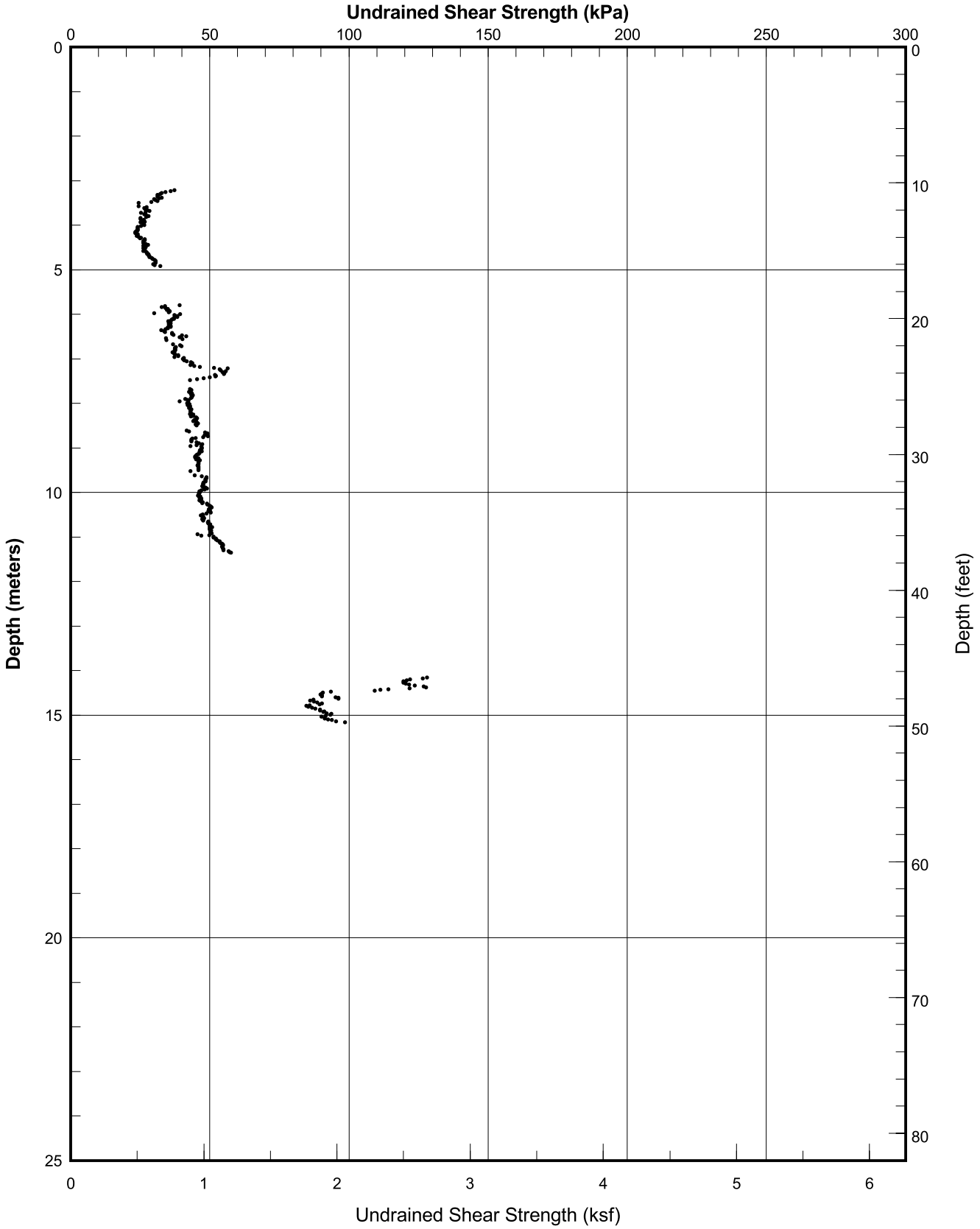
LOG OF CPT

SOUNDING 99C-10

SFOBB East Span Seismic Safety Project

Report Date: 07/06/99

PLATE 99C-10.1



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

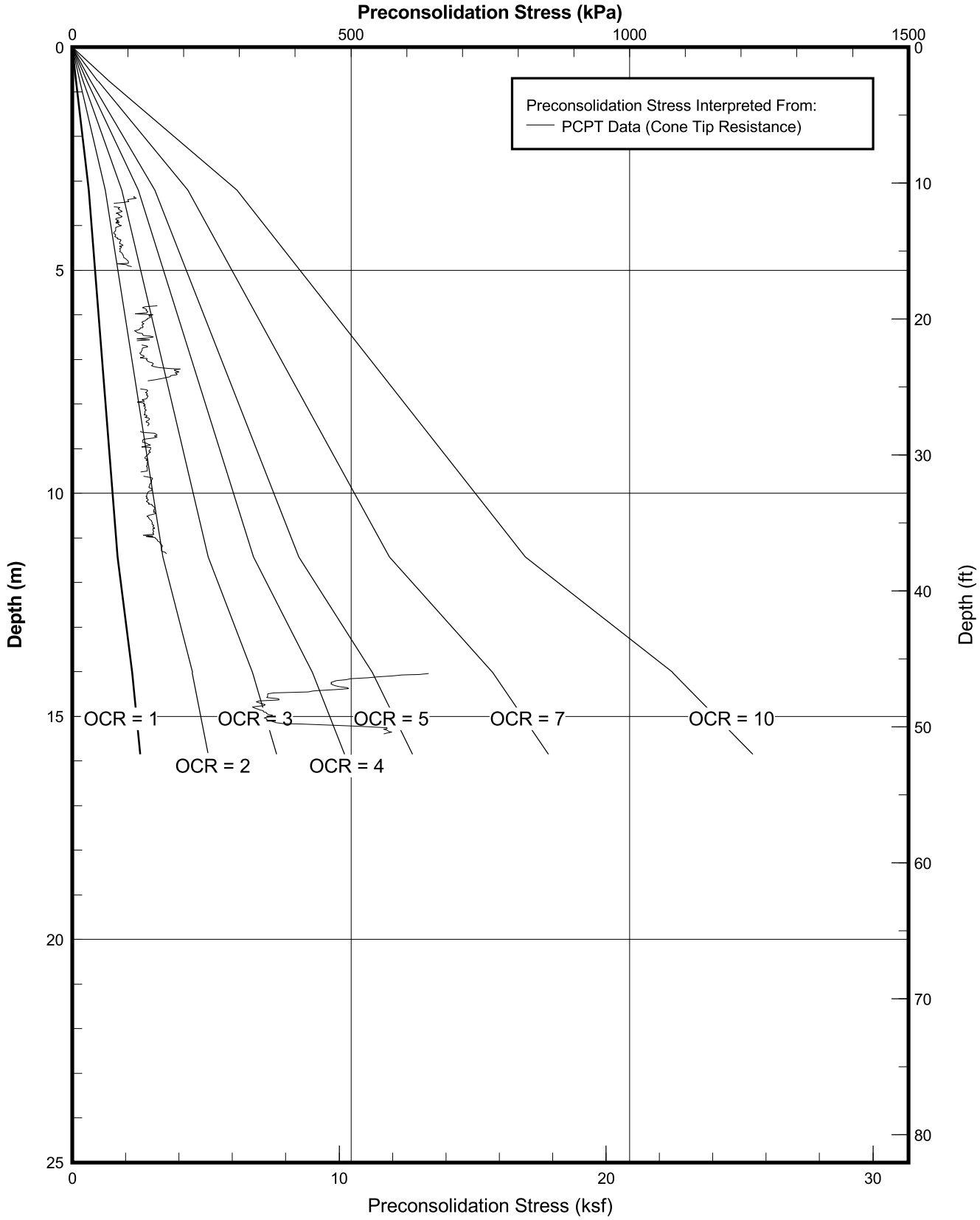
Souding 99C-10

SFOBB East Span Seismic Safety Project

PLATE 99C-10.2

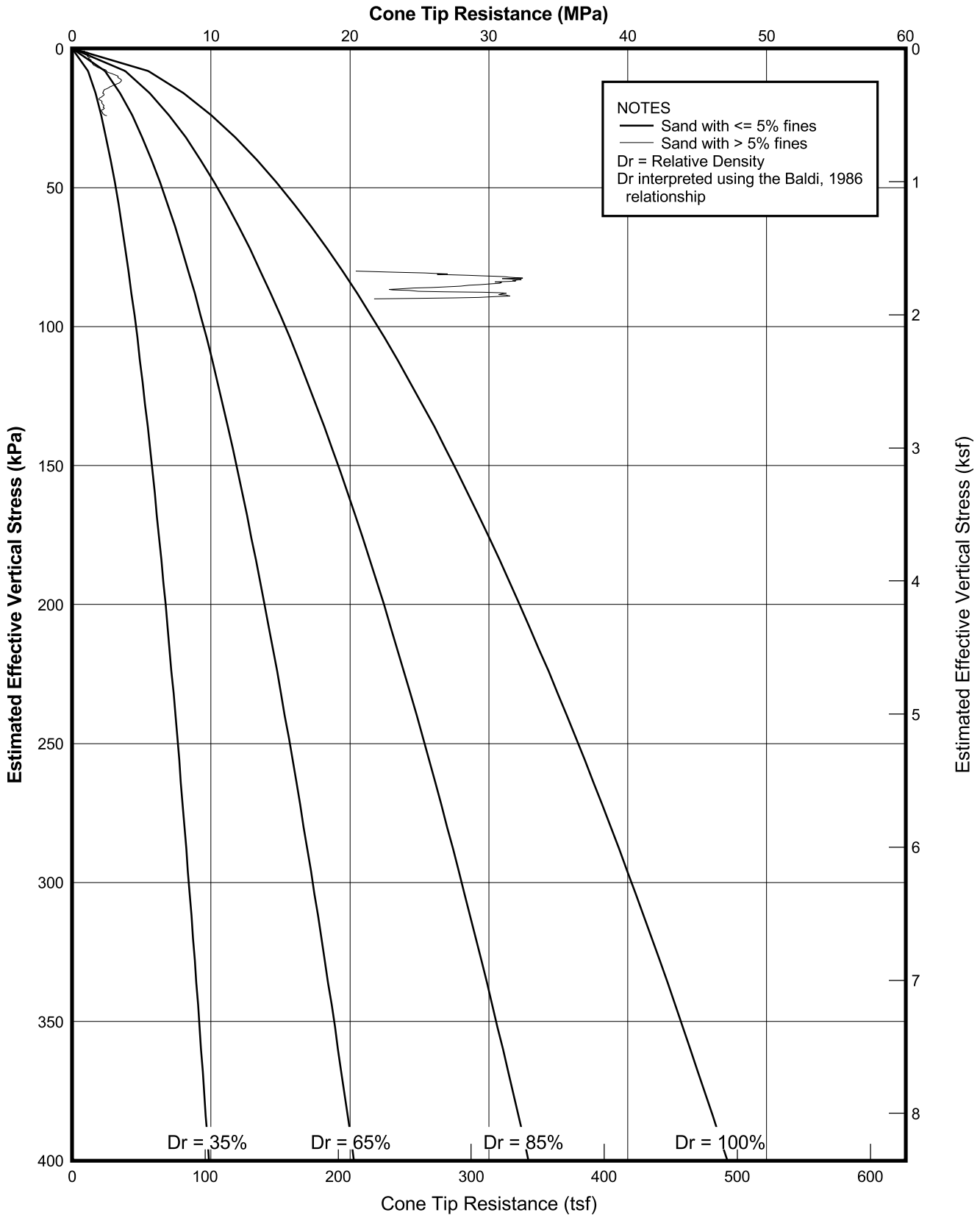
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-10
SFOBB East Span Seismic Safety Project

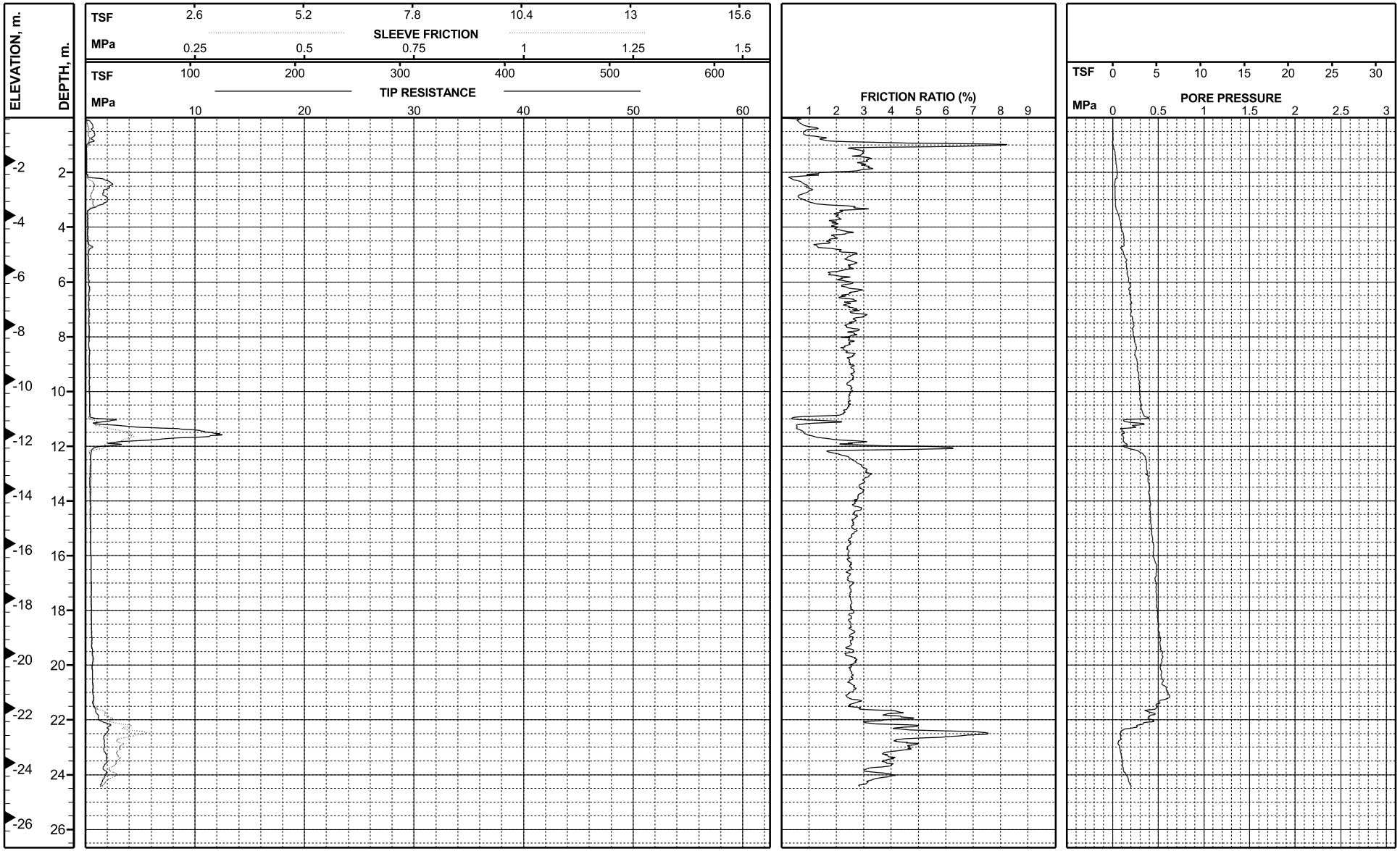
PLATE 99C-10.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-10
SFOBB East Span Seismic Safety Project

PLATE 99C-10.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839139 N648320 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-11 (9.7m left of W. 86+81)	**GROUND ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	03/17/99



LOG OF CPT

SOUNDING 99C-11

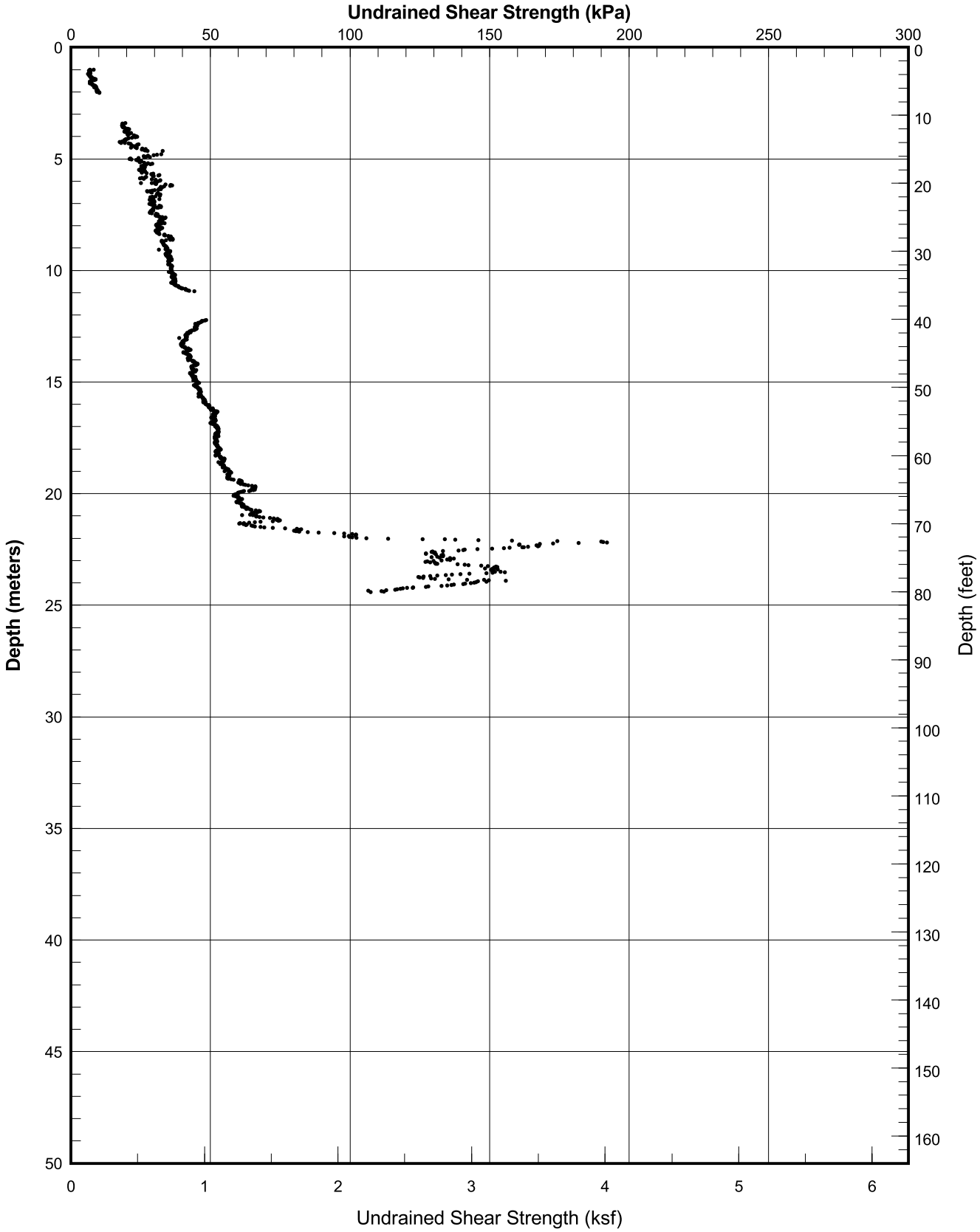
SFOBB East Span Seismic Safety Project

Report Date: 08/26/99

PLATE 99C-11.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

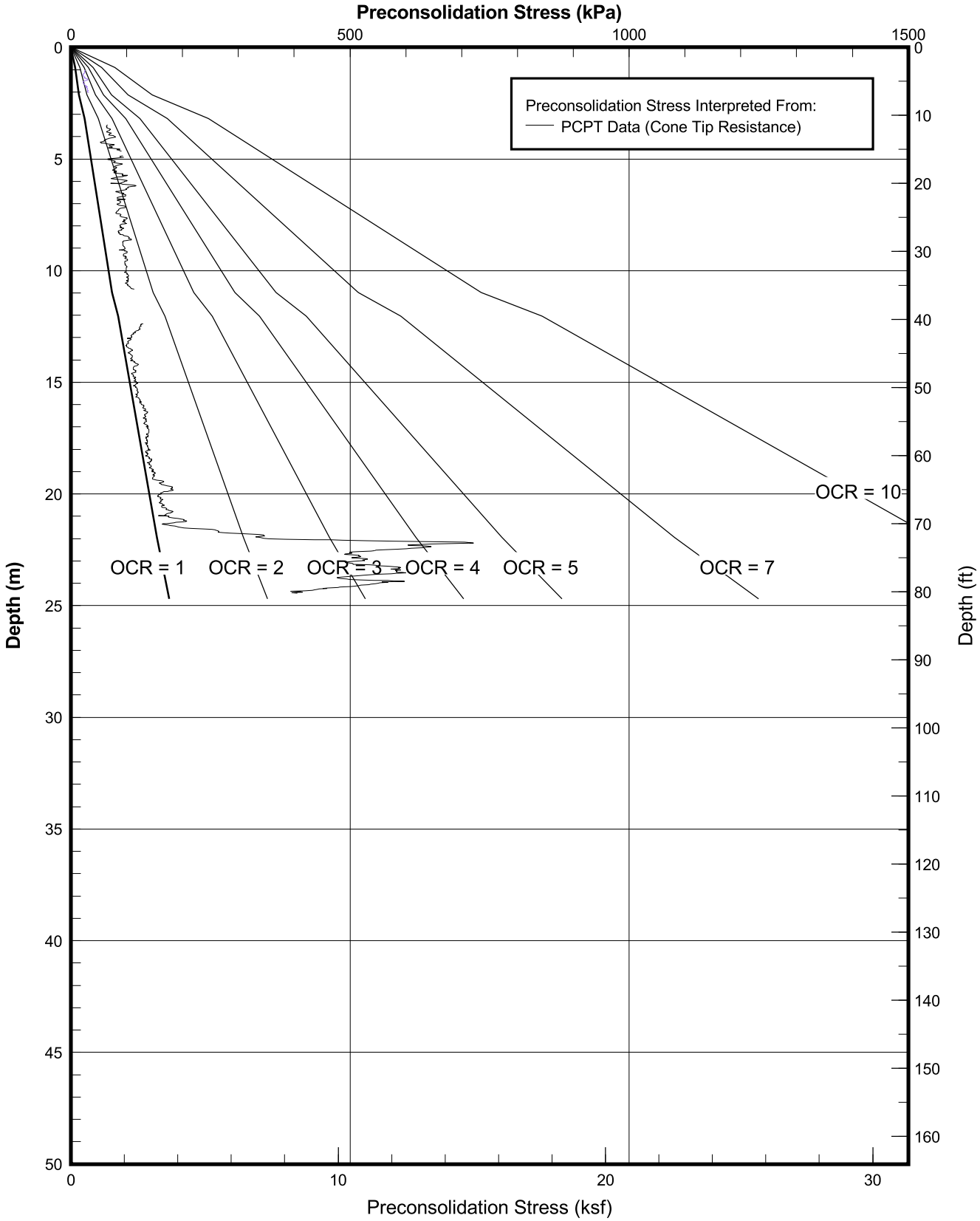
Sounding 99C-11

SFOBB East Span Seismic Safety Project

PLATE 99C-11.2

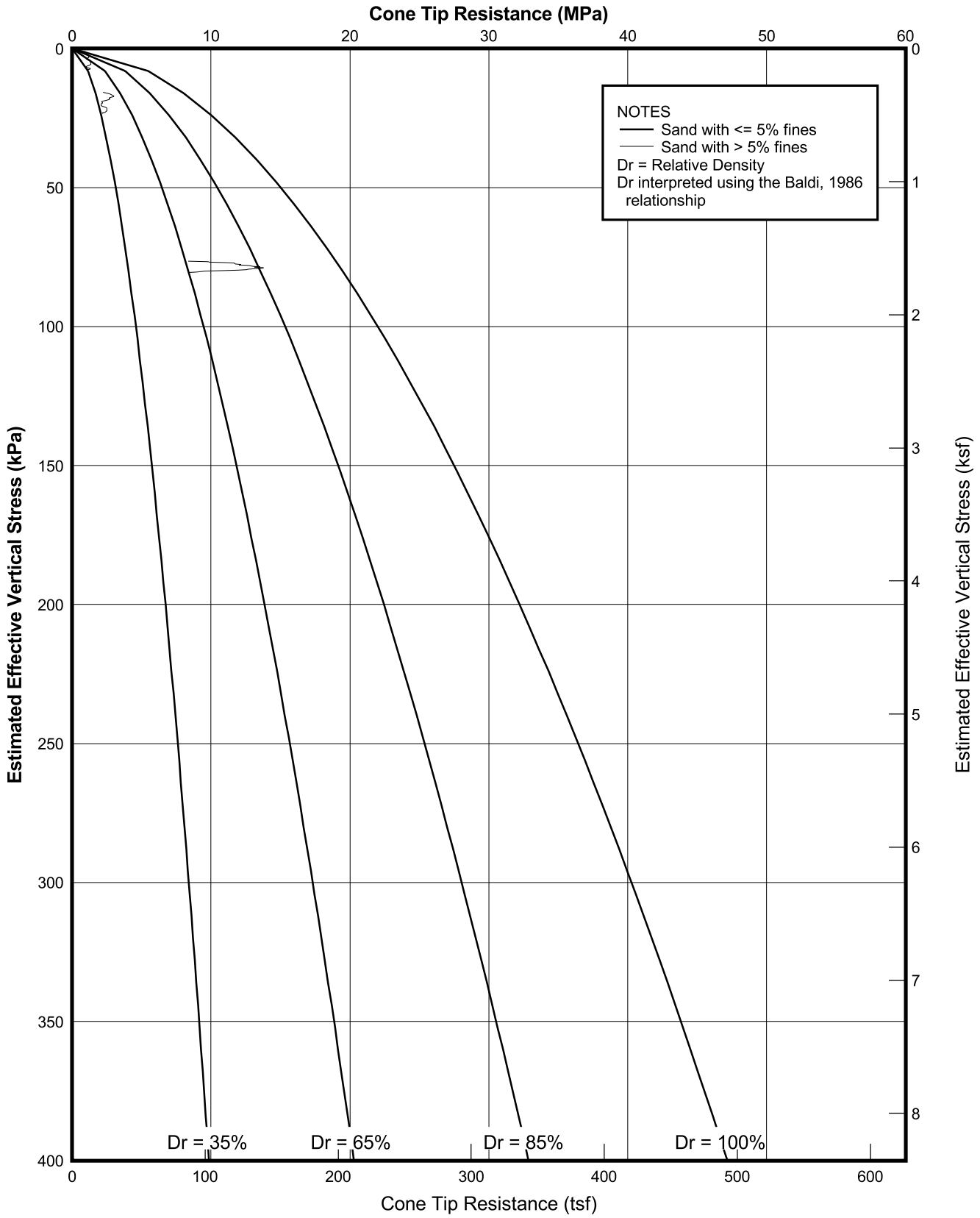
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-11
SFOBB East Span Seismic Safety Project

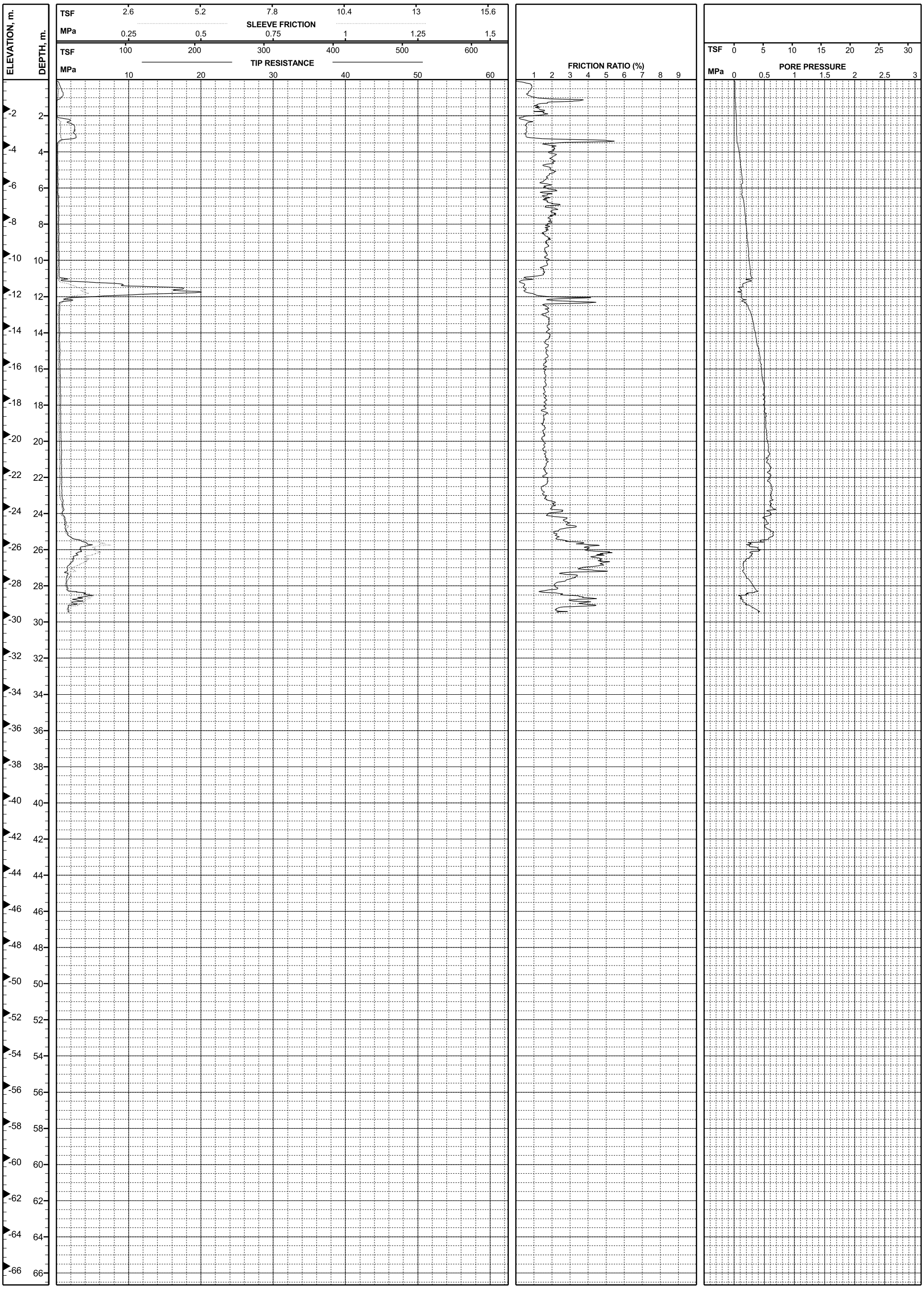
PLATE 99C-11.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-11
SFOBB East Span Seismic Safety Project

PLATE 99C-11.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839174 N648323 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-12 (10.0m left of W. Sta 87+16)	**GROUND ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	03/15/99



LOG OF CPT

SOUNDING 99C-12

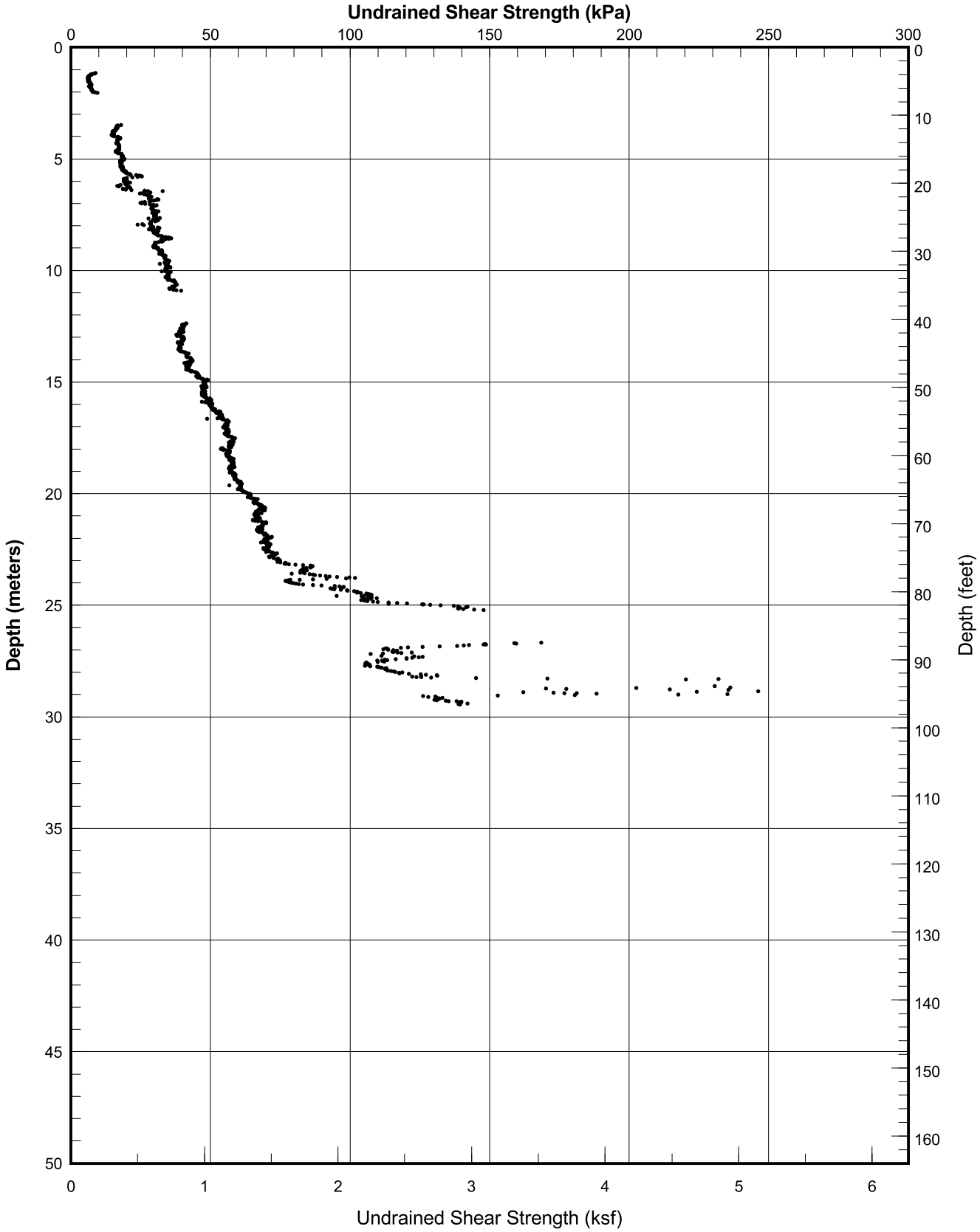
SFOBB East Span Seismic Safety Project

Report Date: 08/26/99

PLATE 99C-12.1

Earth Mechanics

FUGRO

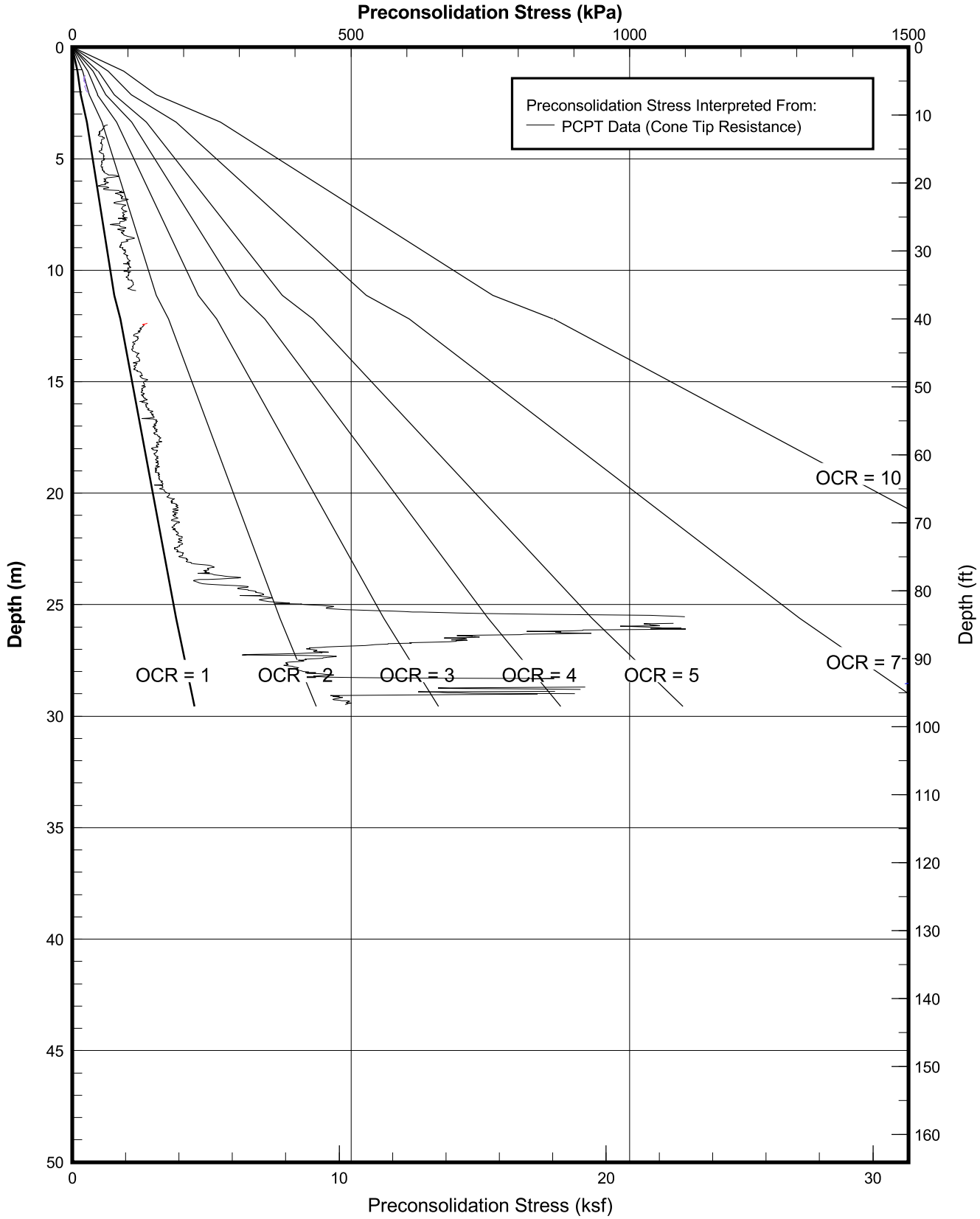


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-12

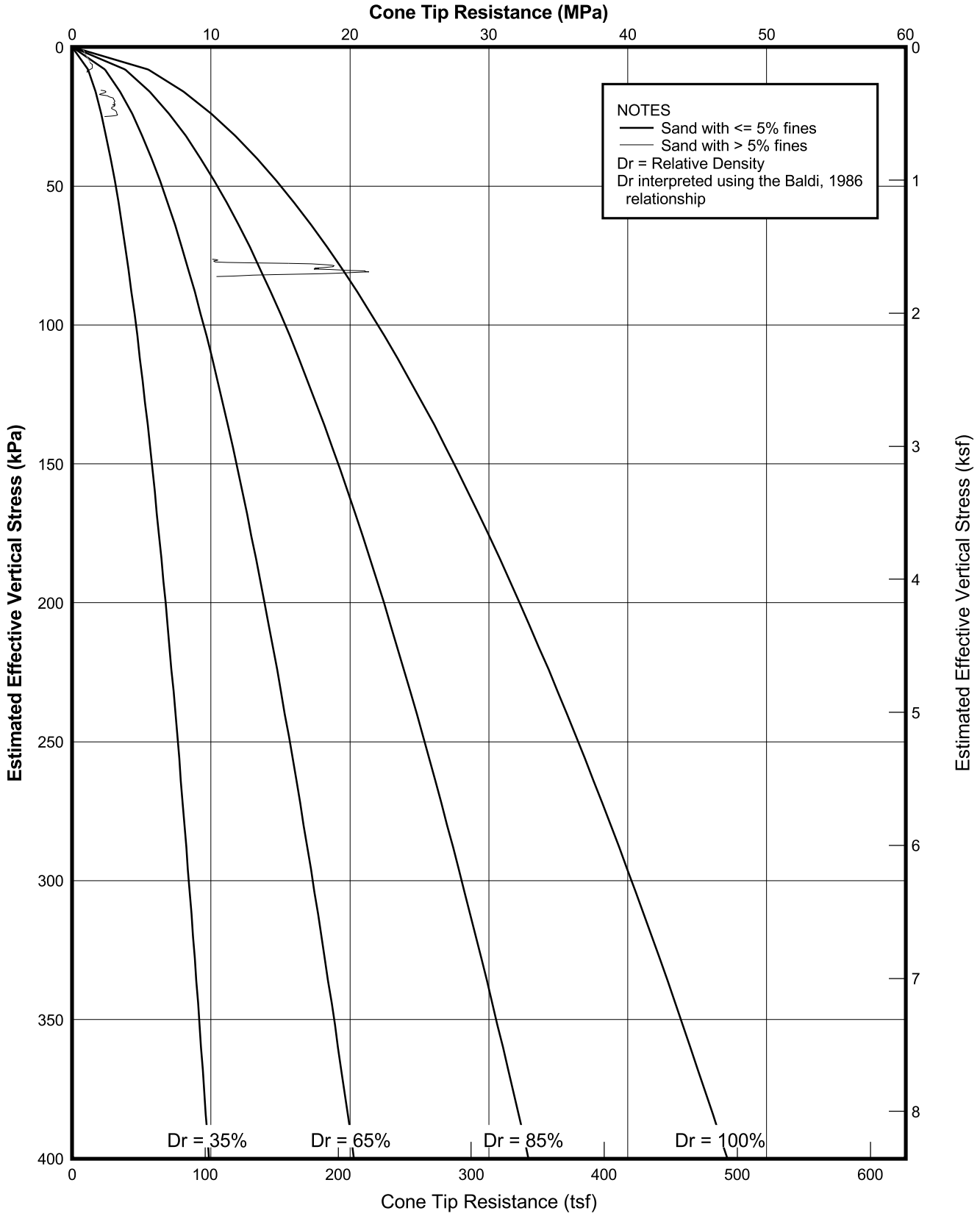
SFOBB East Span Seismic Safety Project

PLATE 99C-12.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-12
SFOBB East Span Seismic Safety Project

PLATE 99C-12.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-12
SFOBB East Span Seismic Safety Project

PLATE 99C-12.4

99C-12		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			UU TRIAXIAL		DIRECT SHEAR TESTS				CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)	Undist. (kPa)	Remold. (kPa)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.8	1	67	62	24	1.12		75																				2.65
3.0	2						3																				
4.0	3	75	71	29	1.09		98																				2.67
5.5	4	75	91	31	0.72		98																				2.72

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

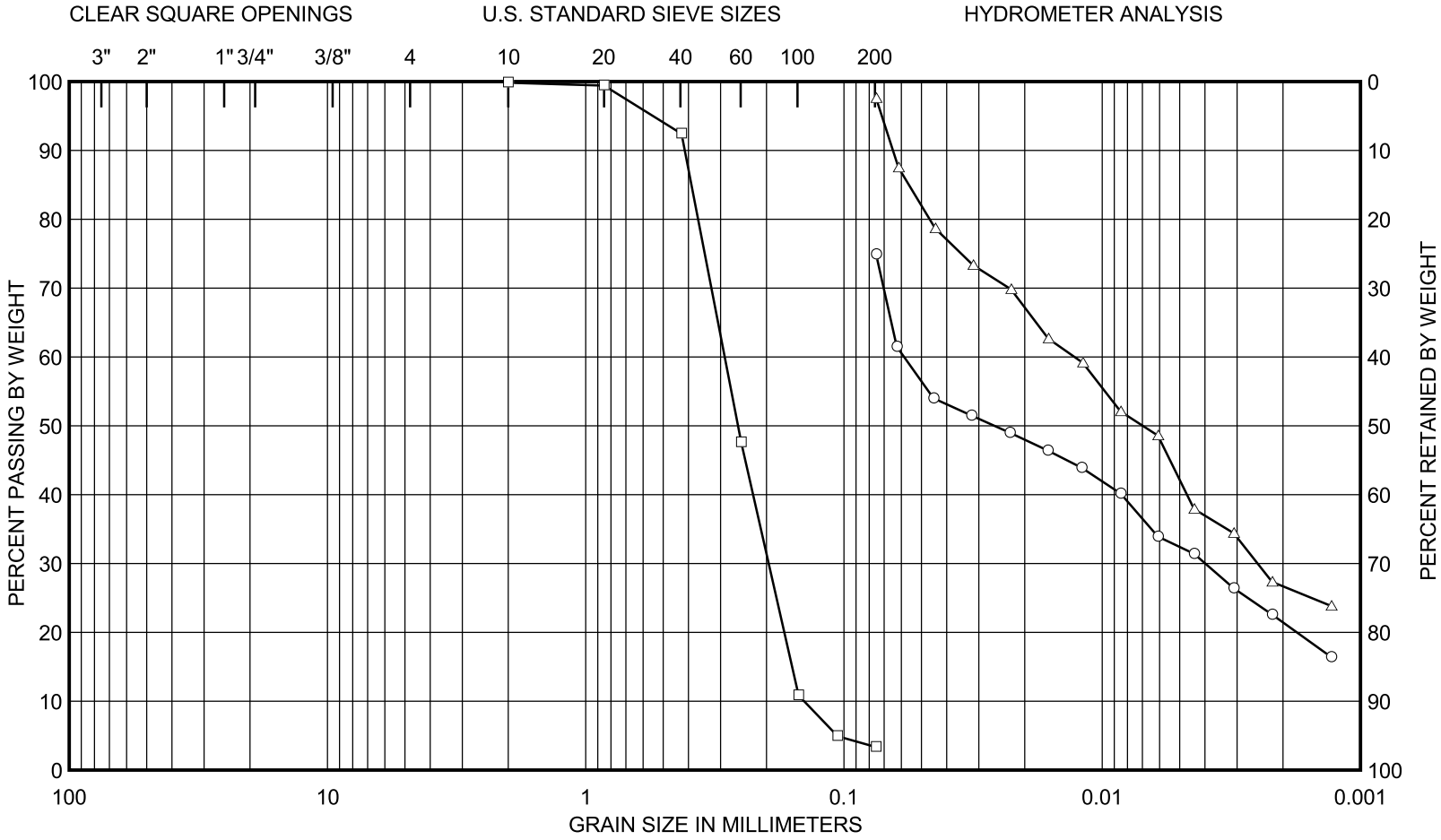
Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Sounding 99C-12
SFOBB East Span Seismic Safety Project

Earth Mechanics
FUGRO

j:\caltrans\99C-12 08/33/YY



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
1	1.8	○——○	FAT CLAY (CH)			0.026
2	3.0	□——□	FINE SAND (SP) with a trace of medium sand	0.9	2.0	0.26
4	5.5	△——△	FAT CLAY (CH)			0.0070

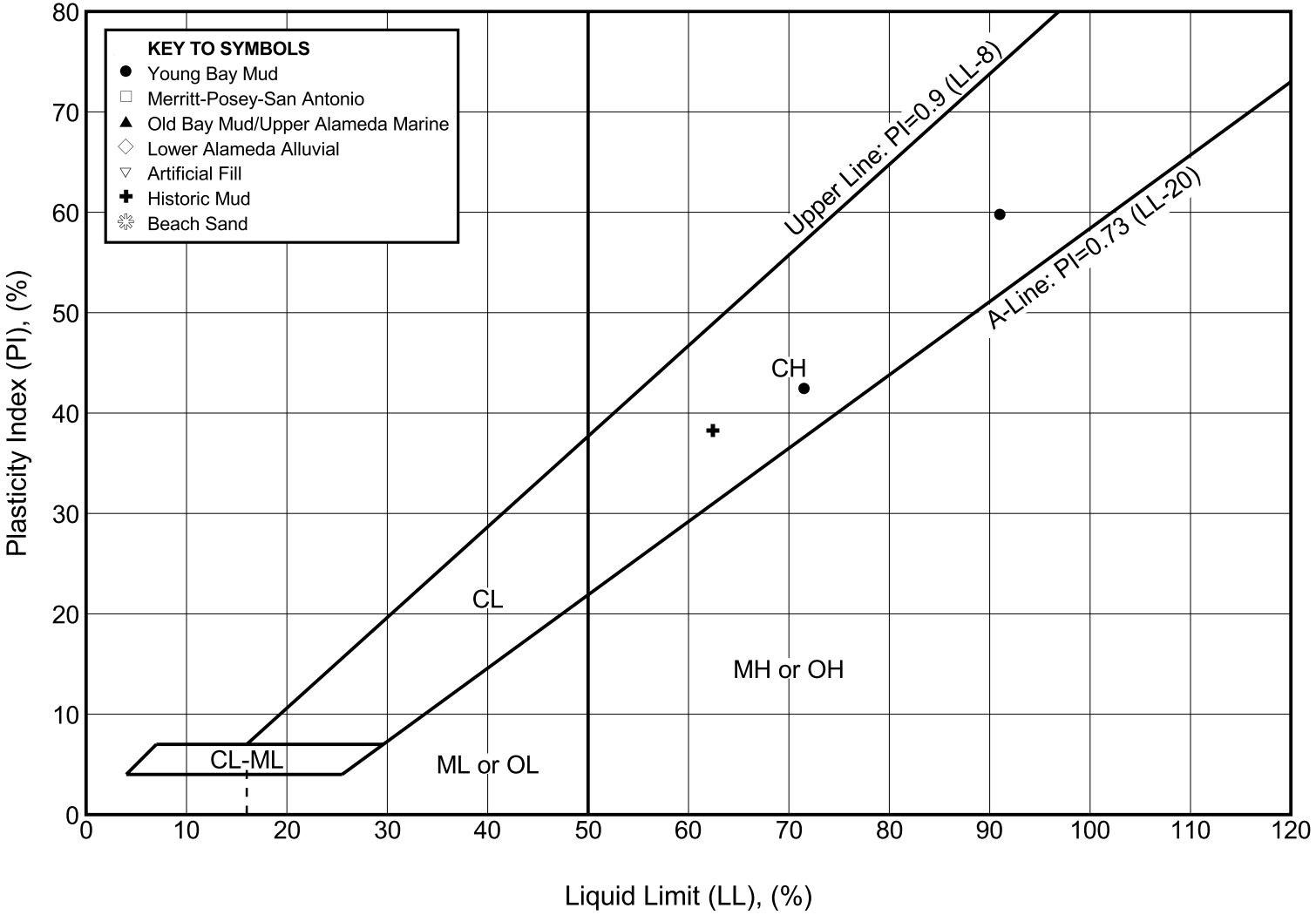
GRAIN SIZE DISTRIBUTION CURVES
Sounding 99C-12
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

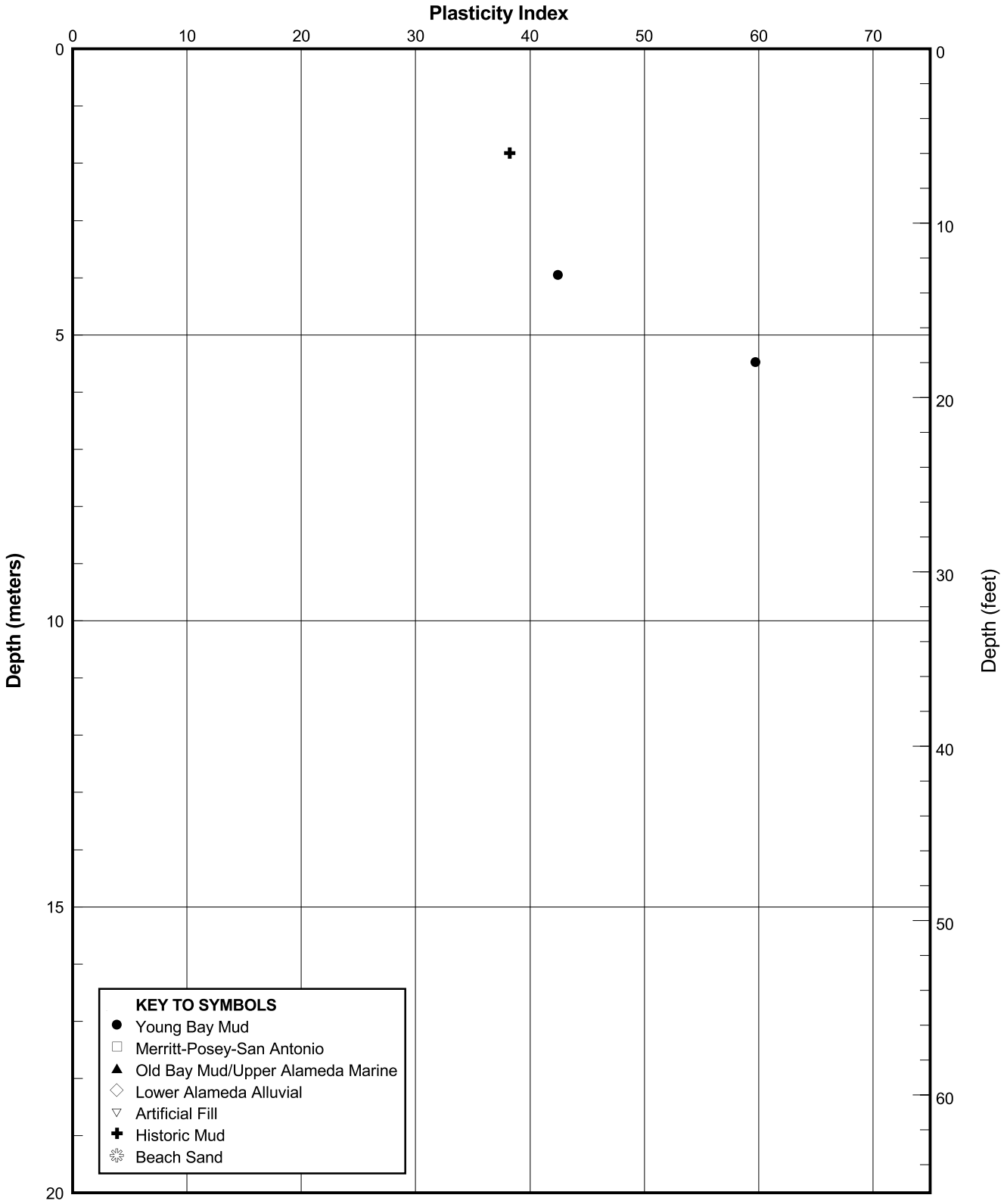
PLATE 99C-12.6



PLASTICITY CHART
Sounding 99C-12
SFOBB East Span Seismic Safety Project

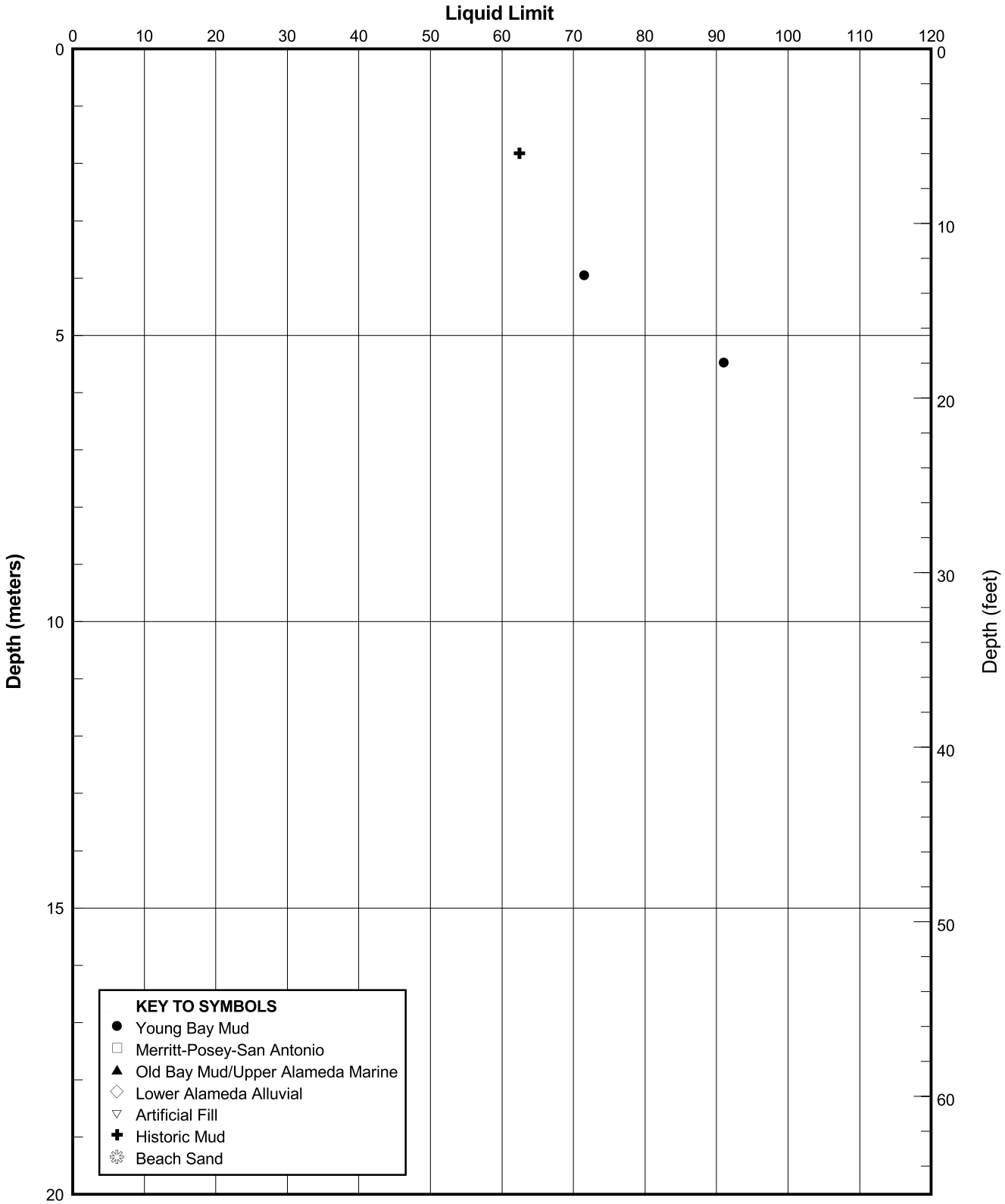
PLATE 99C-12.7

j:\caltrans\ 08/33/YY



PLASTICITY INDEX PROFILE
Sounding 99C-12
SFOBB East Span Seismic Safety Project

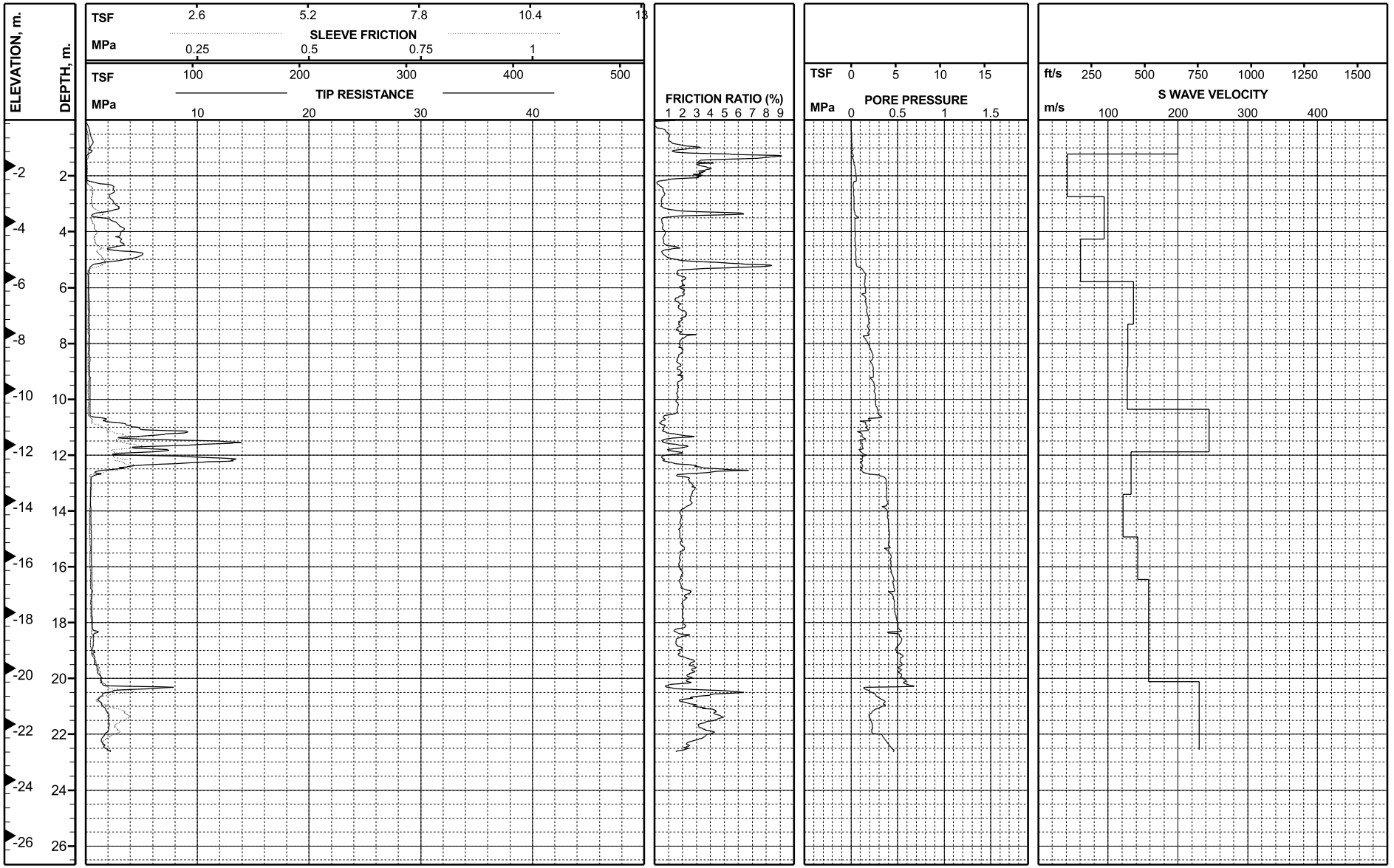
PLATE 99C-12.8



LIQUID LIMIT PROFILE
Sounding 99C-12
SFOBB East Span Seismic Safety Project

PLATE 99C-12.9

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839205 N648325 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-13 (8.7m left of W. Sta. 87+47)	**GROUND ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	03/16/99



LOG OF CPT

SOUNDING 99C-13

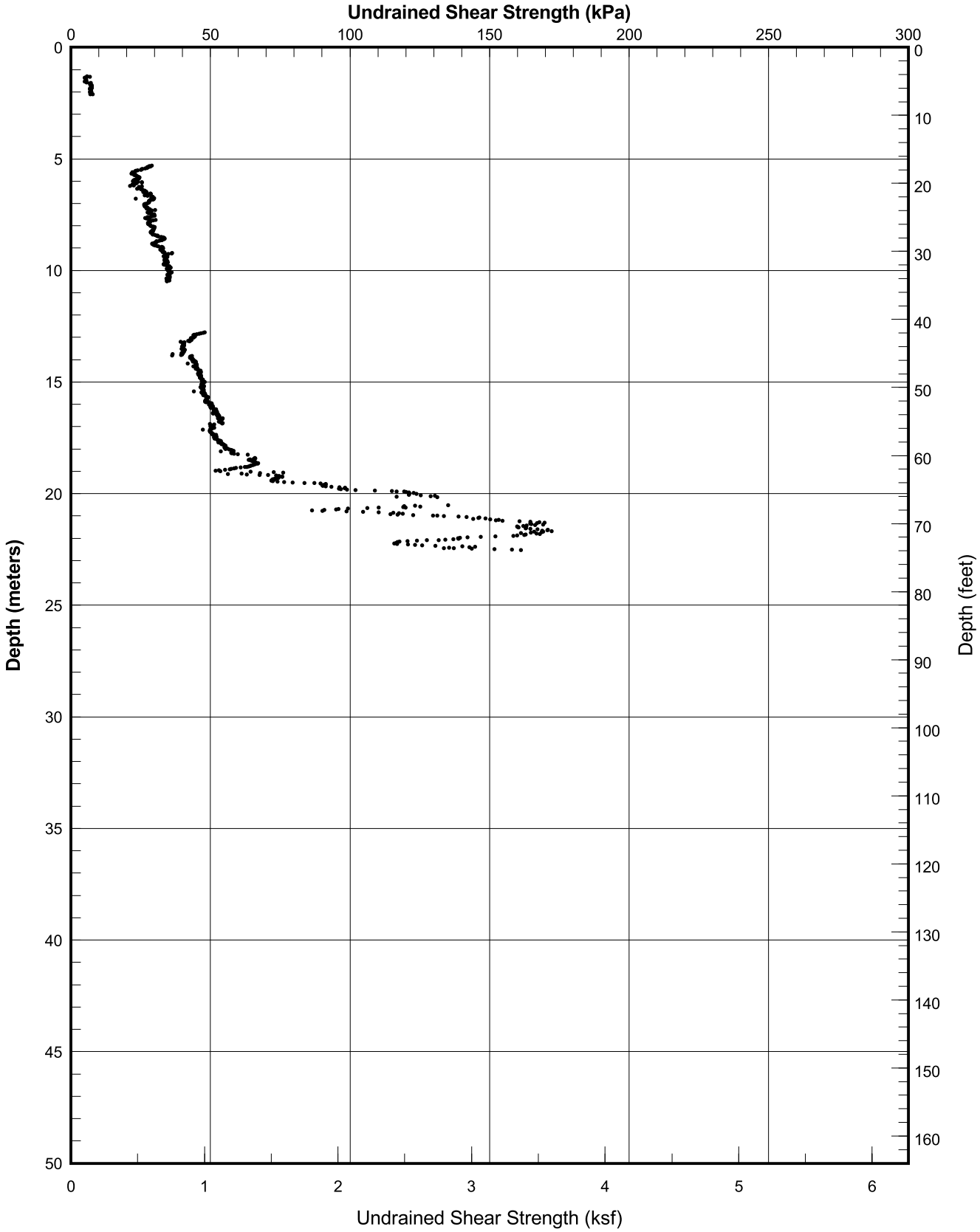
SFOBB East Span Seismic Safety Project

Report Date: 08/26/99

PLATE 99C-13.1

Earth Mechanics

FUGRO

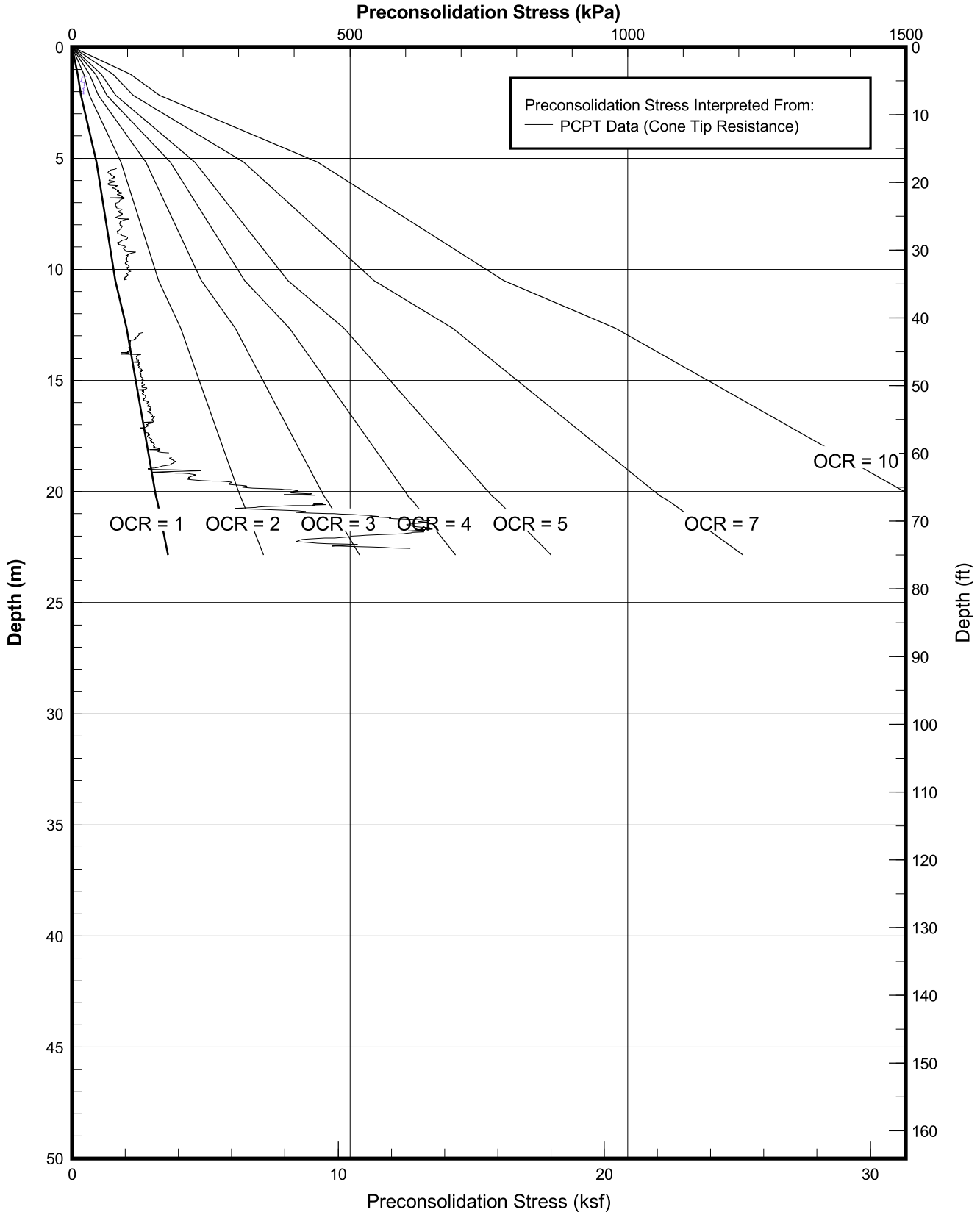


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-13

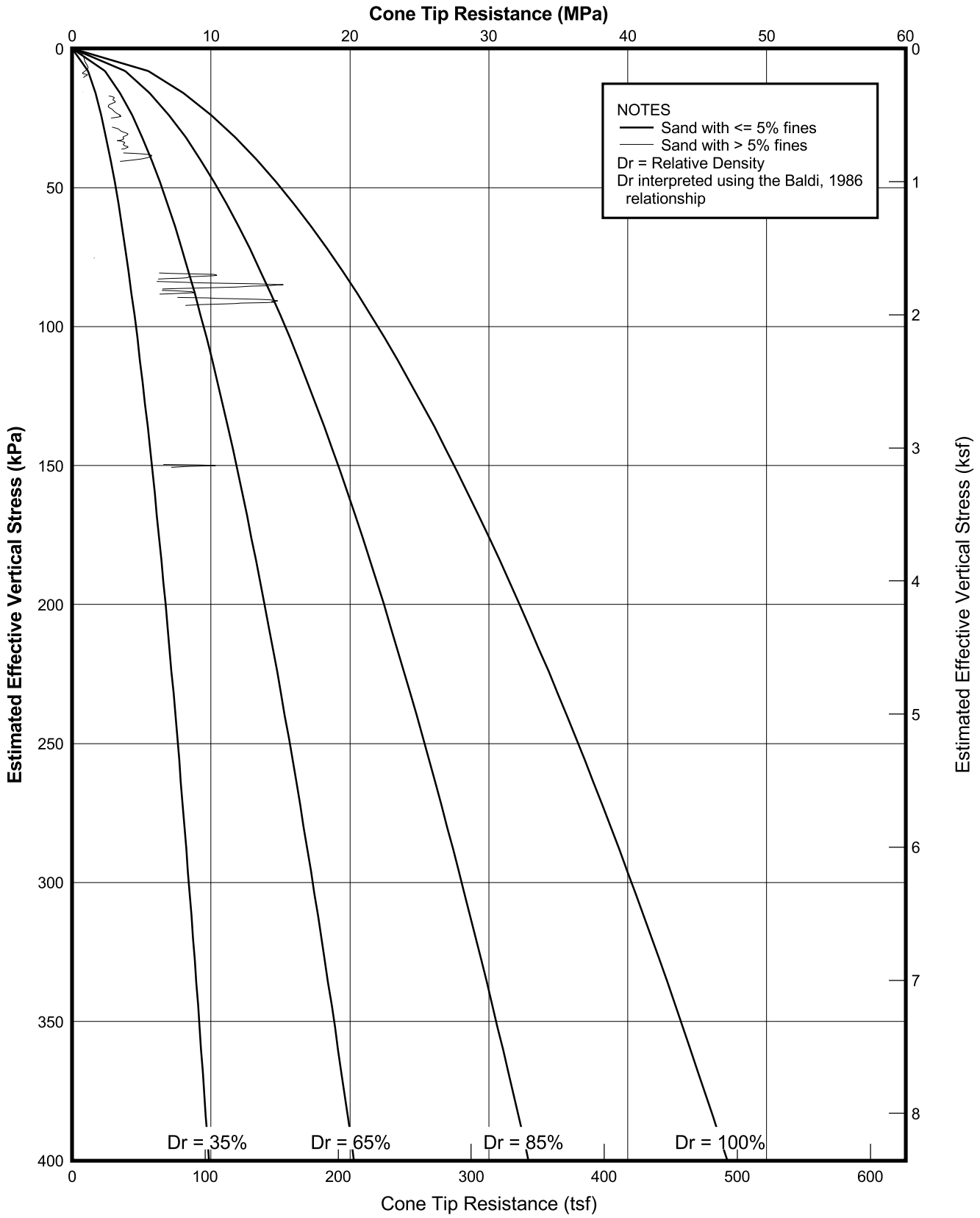
SFOBB East Span Seismic Safety Project

PLATE 99C-13.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-13
SFOBB East Span Seismic Safety Project

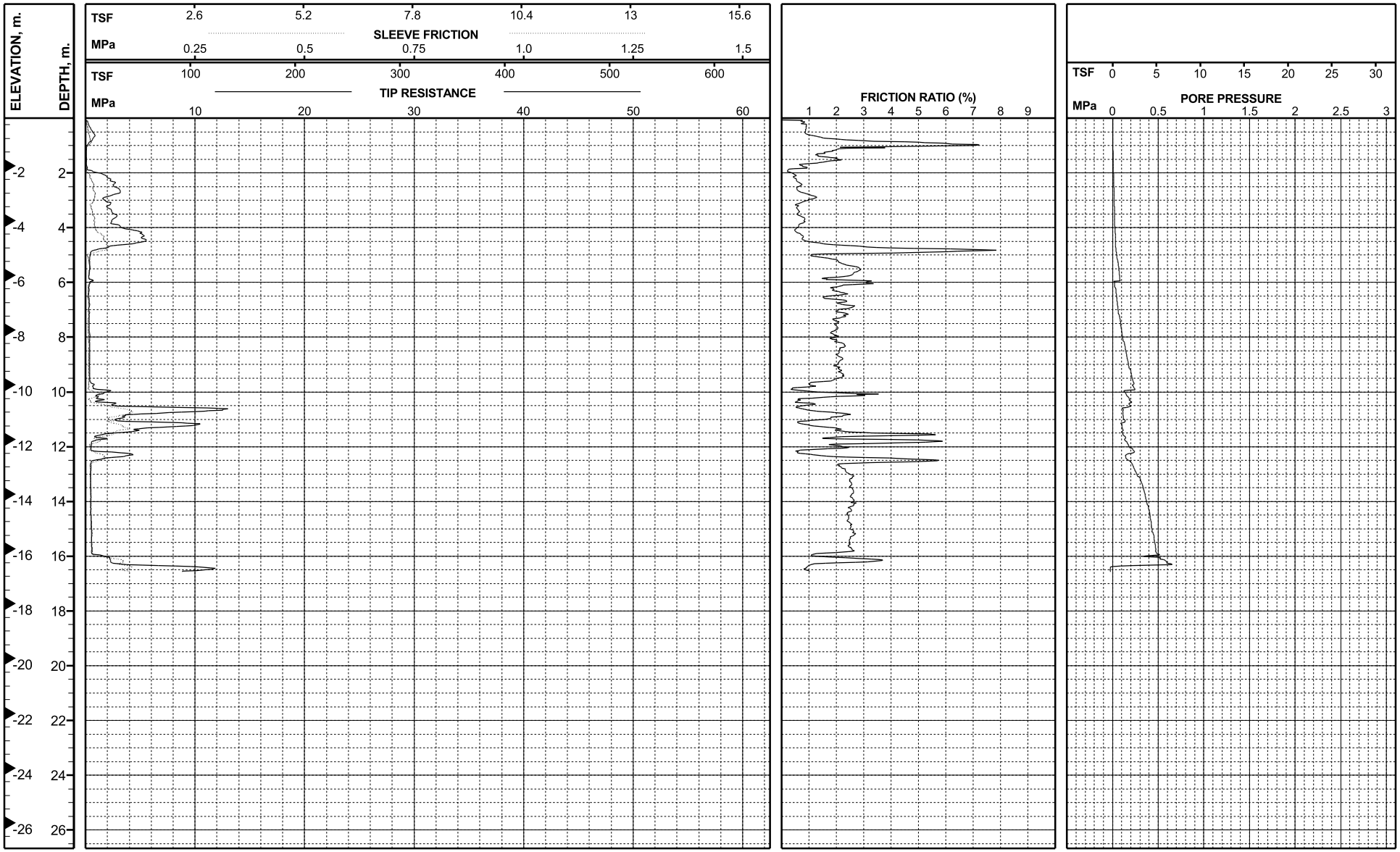
PLATE 99C-13.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-13
SFOBB East Span Seismic Safety Project

PLATE 99C-13.4

PROJECT NO:	98-42-0058	**COORDINATES:**	E1839250 N648329 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-14 (9.3m left of W. Sta. 87+92)	**GROUND ELEVATION:**	-0.3 m (MSL)	**TEST DATE:**	03/18/99



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

SOUNDING 99C-14

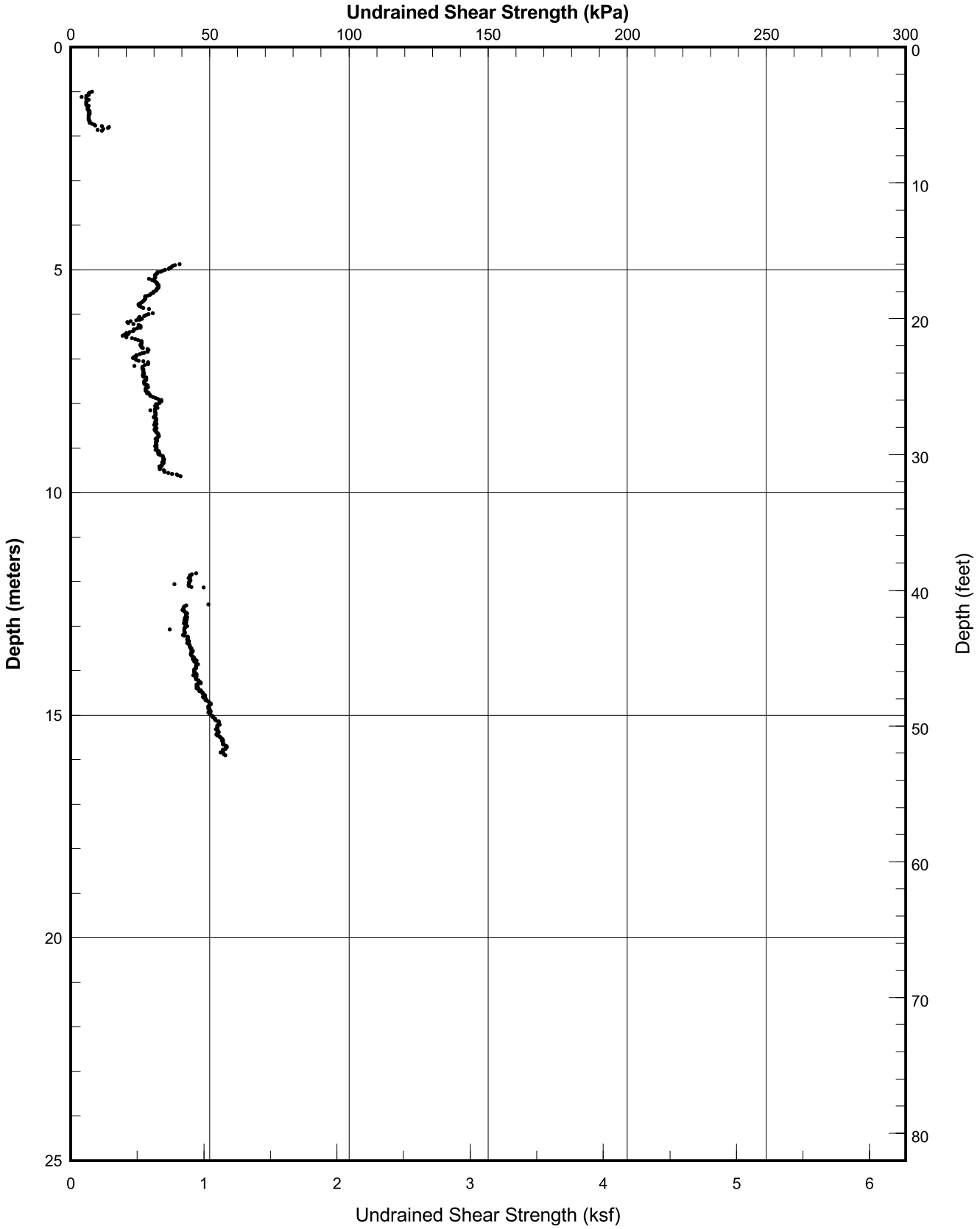
SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PLATE 99C-14.1

Earth Mechanics

FUGRO



UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

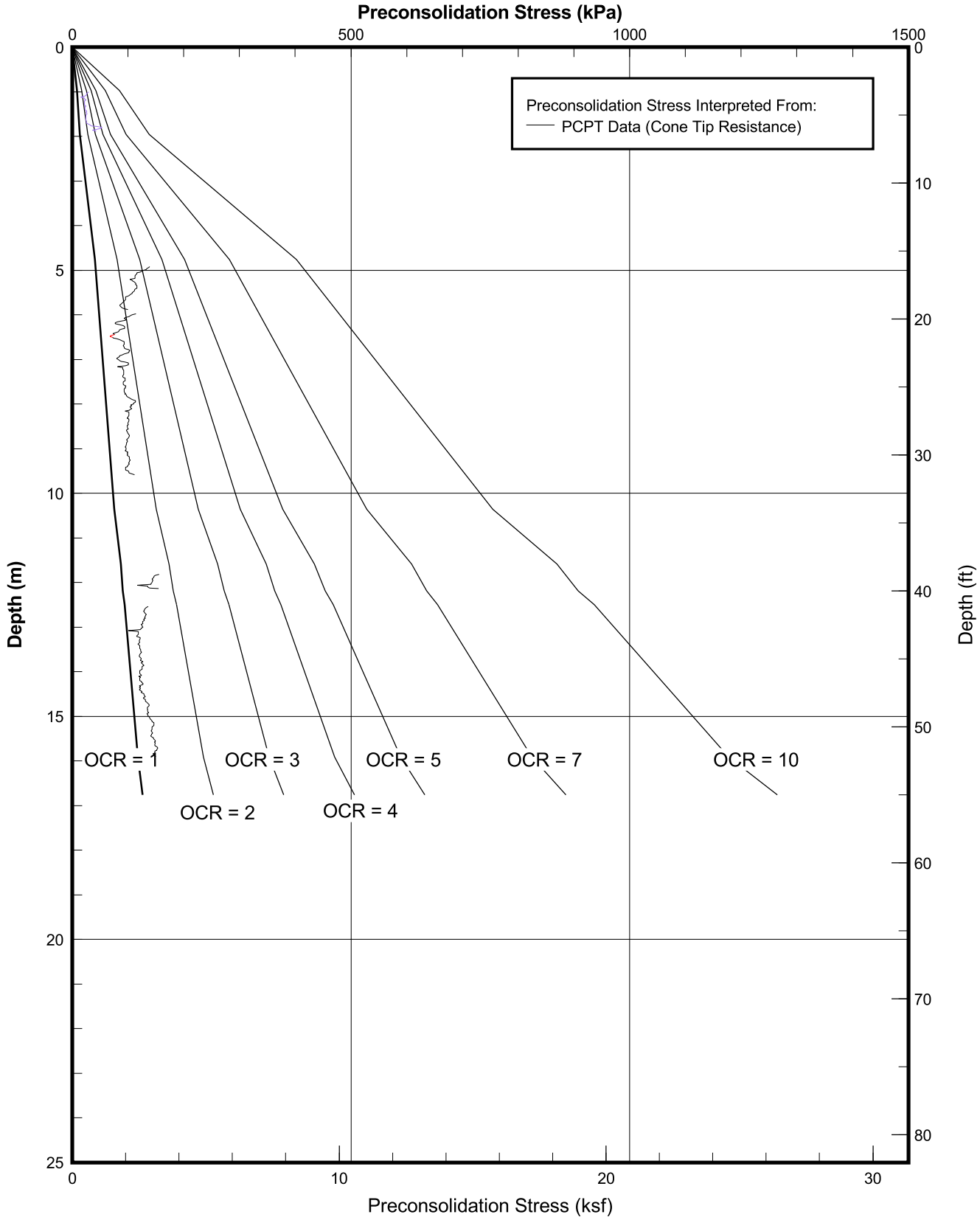
Sounding 99C-14

SFOBB East Span Seismic Safety Project

PLATE 99C-14.2

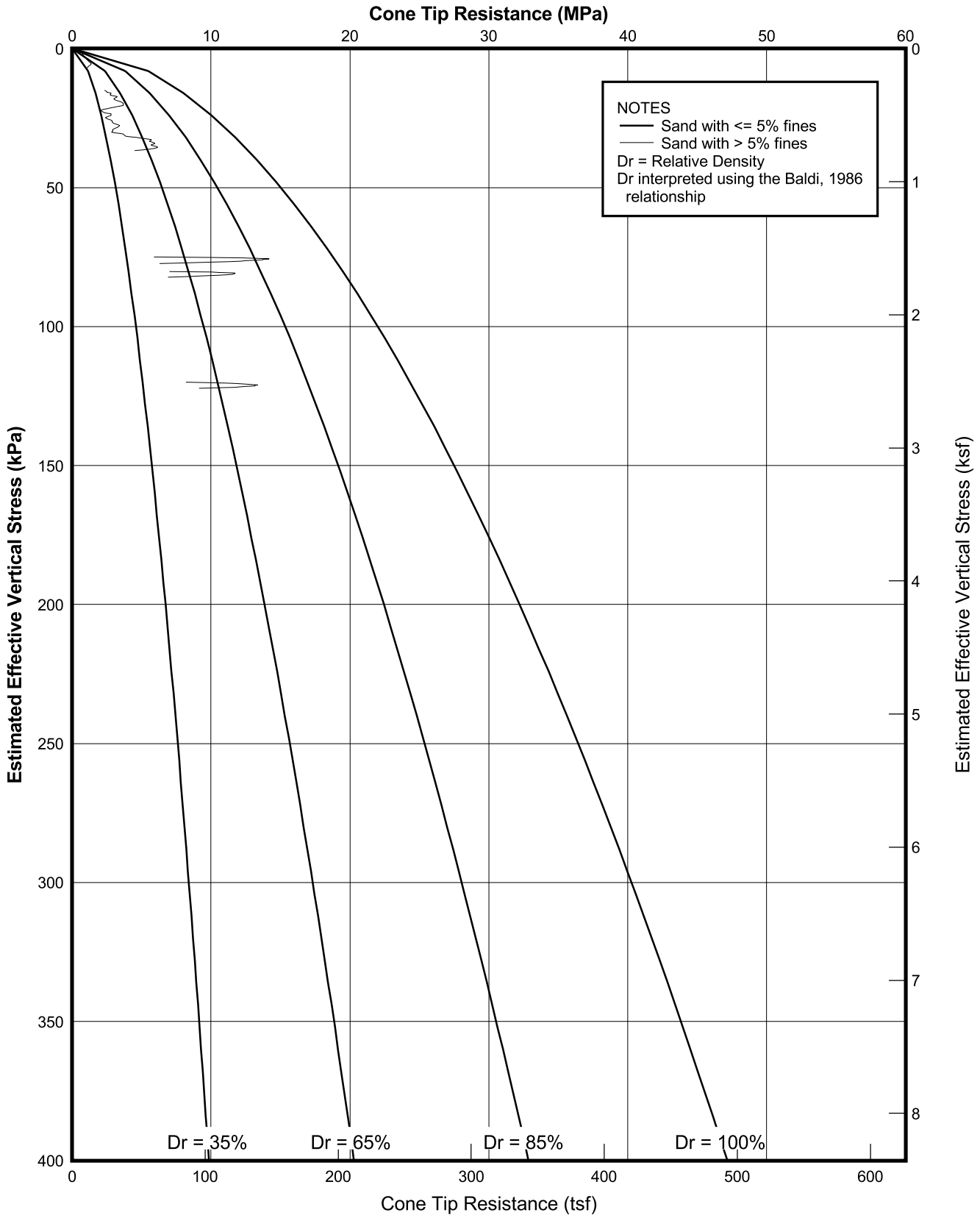
Earth Mechanics

FUGRO



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-14
SFOBB East Span Seismic Safety Project

PLATE 99C-14.3



RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-14
SFOBB East Span Seismic Safety Project

PLATE 99C-14.4

99C-14		IDENTIFICATION TESTS						STRENGTH ESTIMATE			MINIATURE VANE TESTS			UU TRIAXIAL		DIRECT SHEAR TESTS				CORROSIVITY TESTS				COMPACTION TESTS		ADDITIONAL TESTS	SPECIFIC GRAVITY
DEPTH (m)	Sample No.	MC (%)	LL (%)	PL (%)	LI	TUW (kN/m3)	Fines (%)	Torvane (kPa)	Pocket Pen. (kPa)	Fall Cone (kPa)	Undist. (kPa)	Remold. (kPa)	Resid. (kPa)	Undist. (kPa)	Remold. (kPa)	Peak c (kPa)	Peak phi (deg)	Post Peak c (kPa)	Post Peak phi (deg)	R (o-cm)	pH	Cl (ppm)	SO4 (ppm)	Max DD (kN/m3)	OMC (%)		
1.5	1	86	92	38	0.88																						2.84
1.5	2						26																				
3.0	3						9																				
5.5	4	69	80	31	0.78		97																				2.76
7.3	5	1061	49	25	43.01		94																				

Identification Tests
MC = Moisture Content
LL = Liquid Limit
PL = Plastic Limit
LI = Liquidity Index

Identification Tests
TUW = Total Unit Weight
Fines = % Passing No. 200 Sieve

Strength Tests
UU = Unconsolidated Undrained
c = Effective Cohesion
phi = Effective Angle of Friction

Corrosivity Tests
R = Resistivity (ohm-cm)
pH = pH
Cl = Chloride Content
SO4 = Sulfate Content

Additional Tests
H = Hydrometer
C = Consolidation Test
RC = Resonant Column
CS = Cyclic Simple Shear

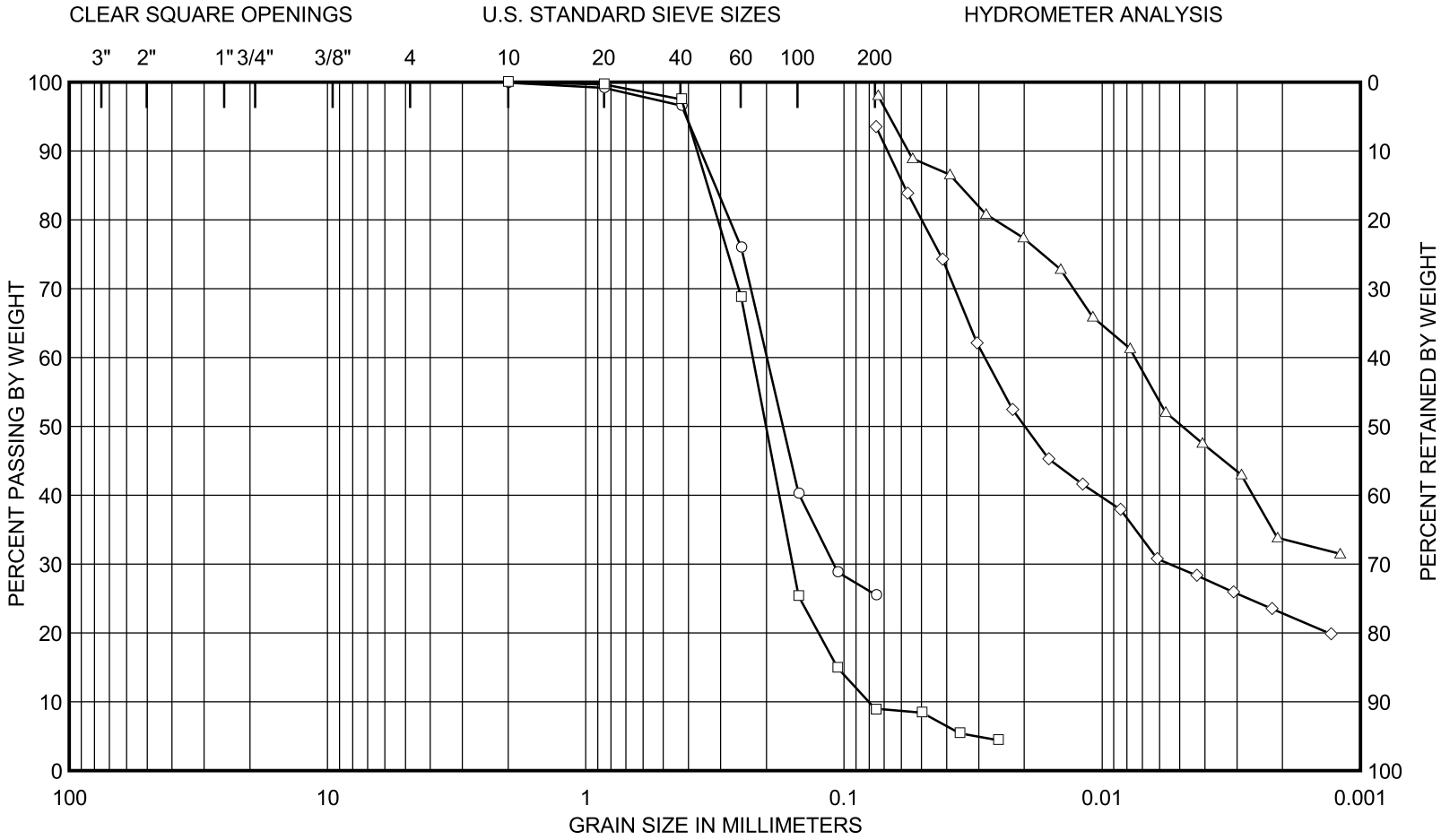
Additional Tests
K = Ko Consolidated Triaxial Test

\+ Soil : Strength exceeds capacity of measuring device
Rock: Sample broke along discontinuity; (Intact sample would have greater strength)

SUMMARY OF LABORATORY TEST RESULTS
Sounding 99C-14
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO



GRAVEL		SAND			SILT (nonplastic)
COARSE	FINE	COARSE	MEDIUM	FINE	to CLAY (plastic)

SAMPLE NO.	DEPTH (m)	CURVE	CLASSIFICATION	Cc	Cu	D50 (mm)
2	1.5	○—○	SILTY FINE SAND (SM)			0.17
3	3.0	□—□	FINE SAND (SP-SM) with silt	1.4	2.8	0.20
4	5.5	△—△	FAT CLAY (CH)			0.0049
5	7.3	◇—◇	FAT CLAY (CH)			0.020

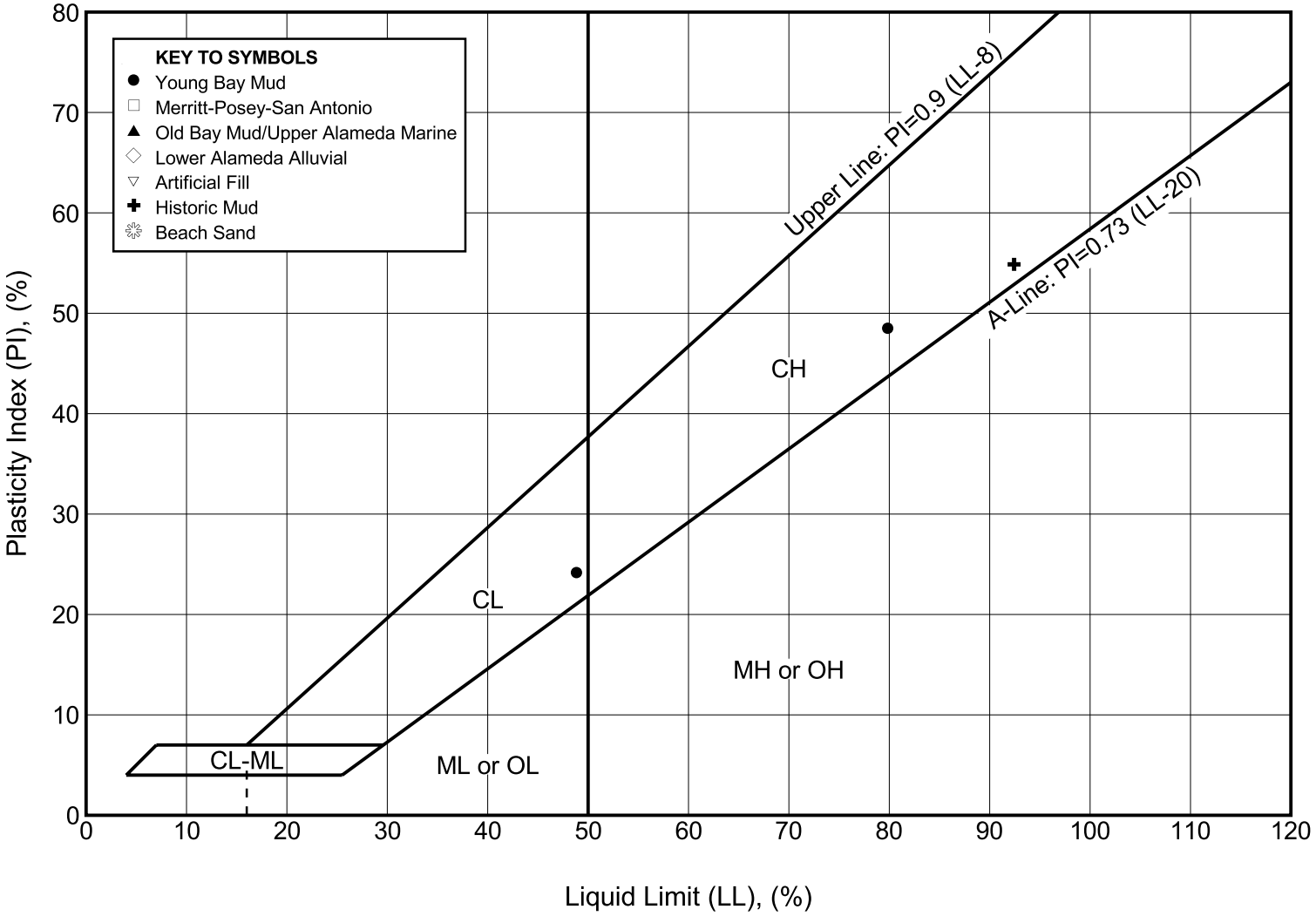
GRAIN SIZE DISTRIBUTION CURVES
Sounding 99C-14
SFOBB East Span Seismic Safety Project

SFOBB Task Order No. 5
Project No. 98-42-0058

Earth Mechanics

FUGRO

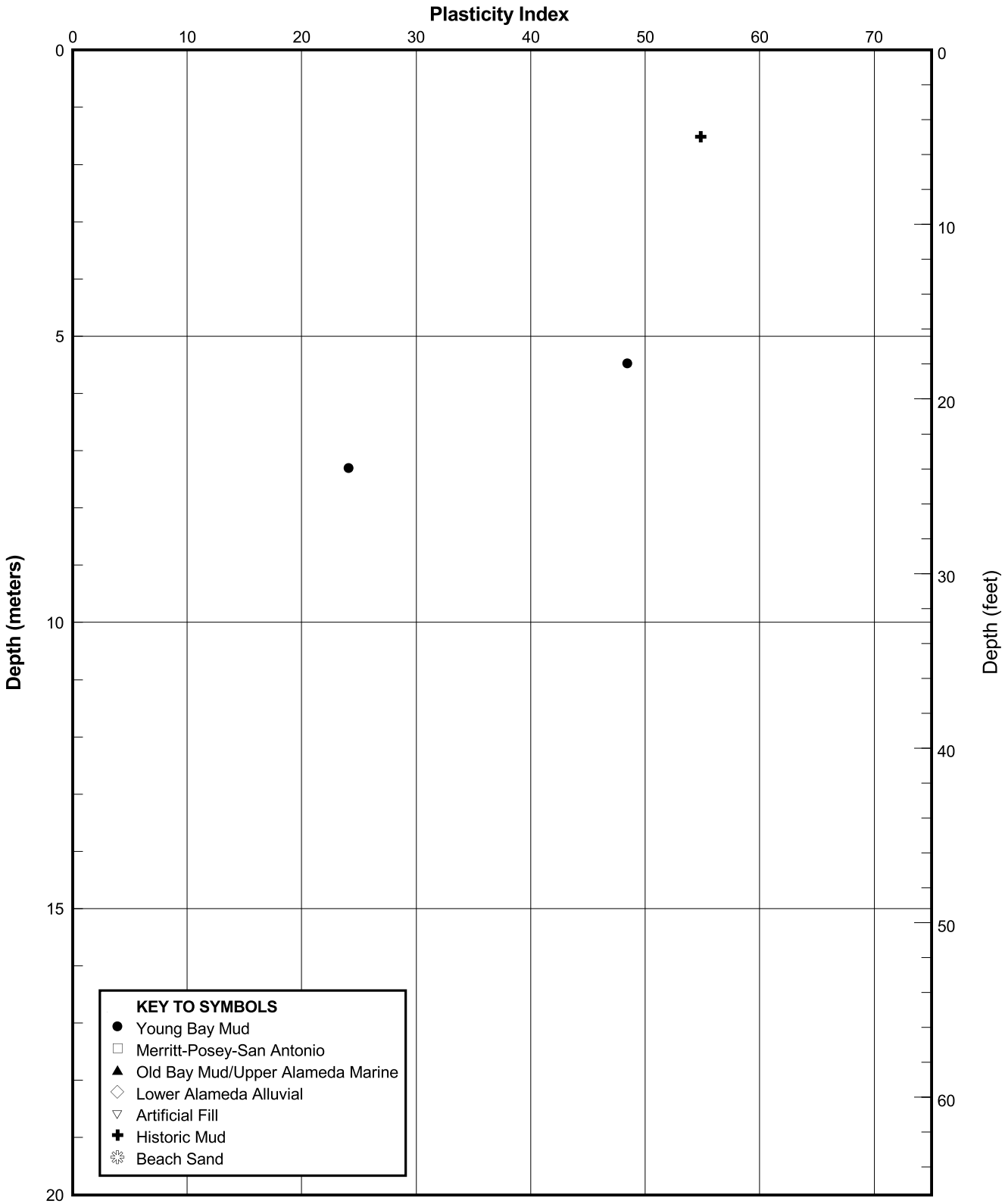
PLATE 99C-14.6



PLASTICITY CHART
Sounding 99C-14
SFOBB East Span Seismic Safety Project

Earth Mechanics

FUGRO

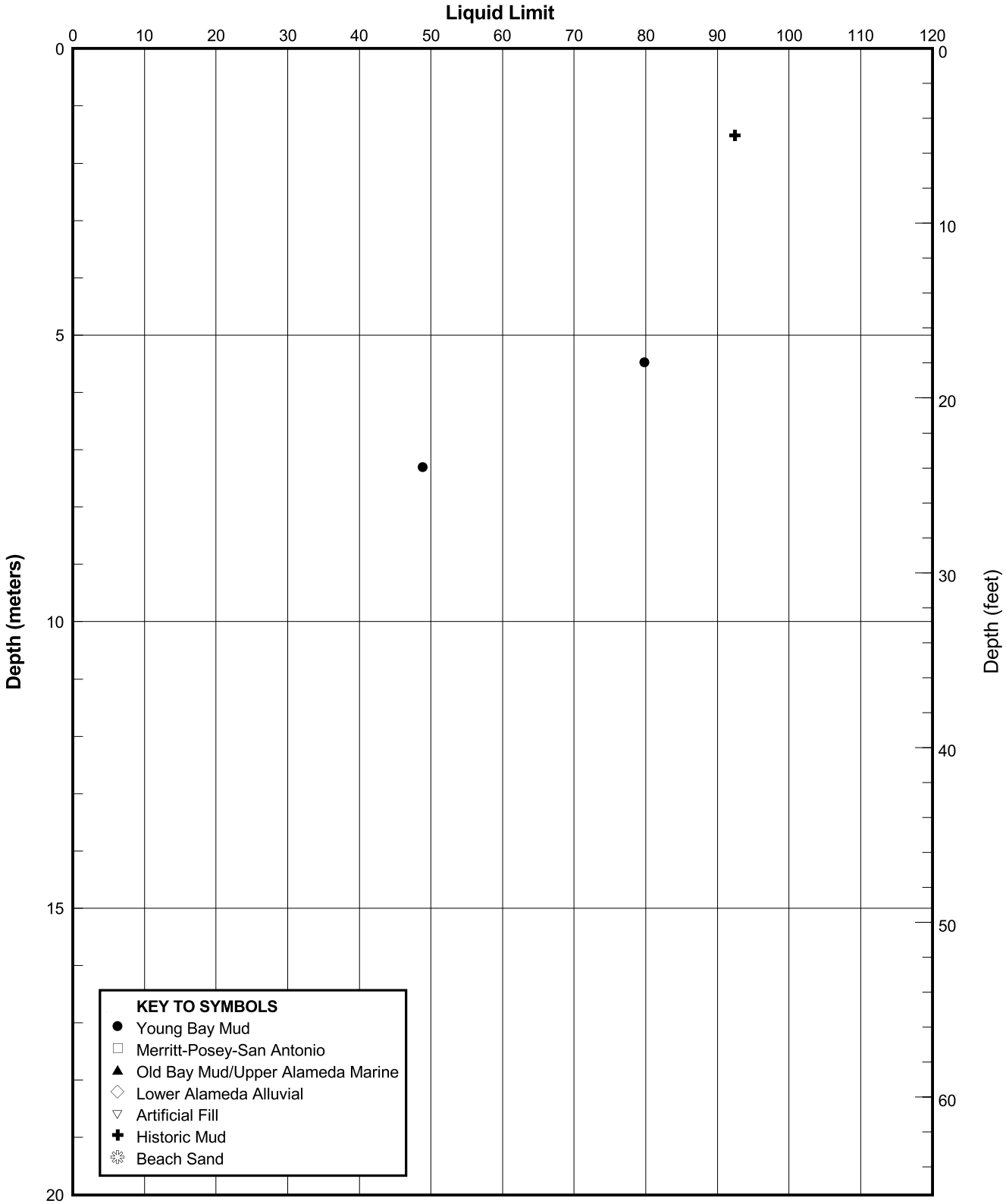


PLASTICITY INDEX PROFILE
Sounding 99C-14
SFOBB East Span Seismic Safety Project

PLATE 99C-14.8

Earth Mechanics

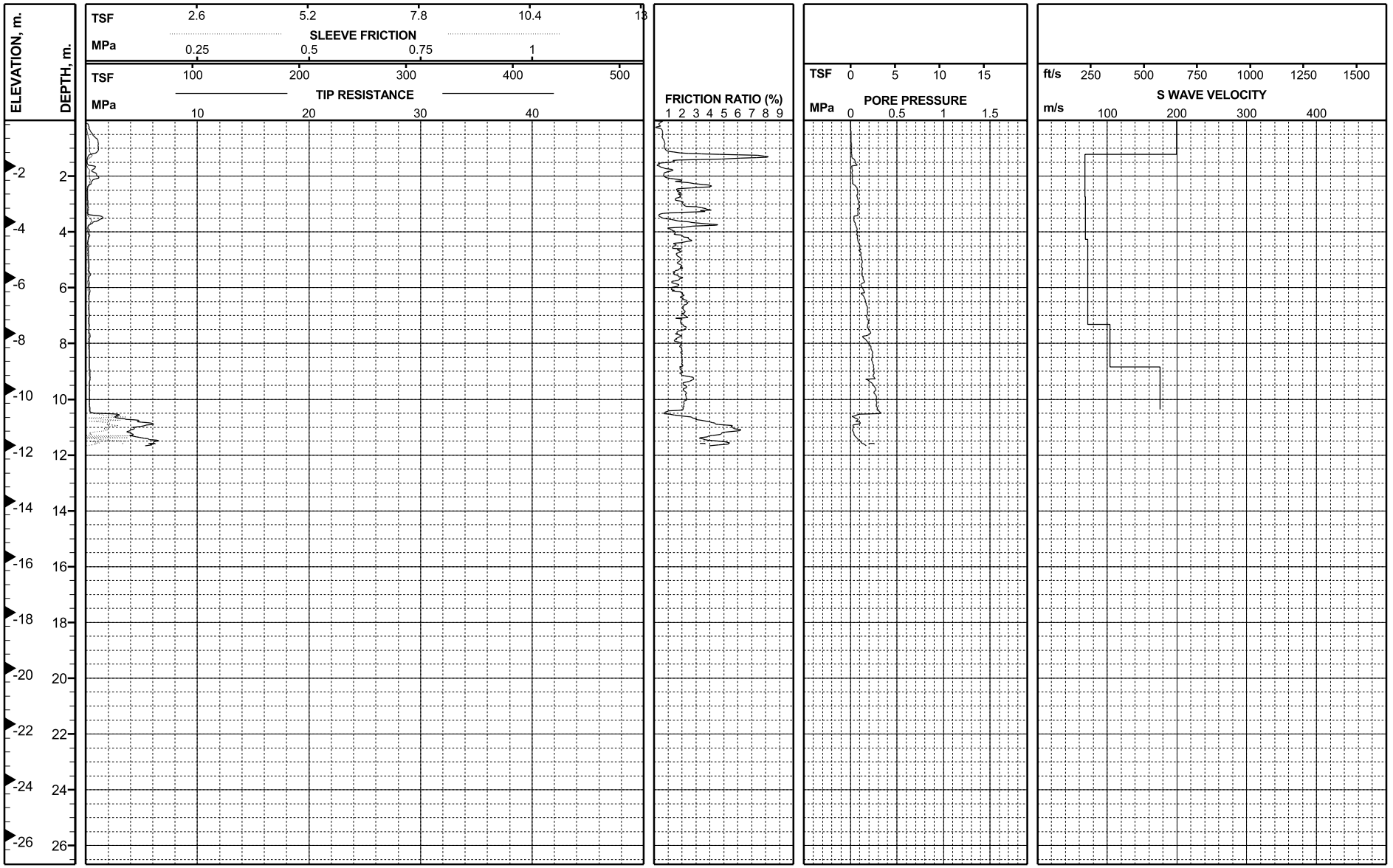
FUGRO



LIQUID LIMIT PROFILE
Sounding 99C-14
SFOBB East Span Seismic Safety Project

PLATE 99C-14.9

PROJECT NO:	98-42-	**COORDINATES:**	E1839014 N648299 CA State Plane Zone 3, NAD83, Meters	**VEHICLE:**	Fugro Geosciences
EXPLORATION NO.:	99C-15 (2.1m right of W. Sta. 85+55)	**GROUND ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	03/17/99



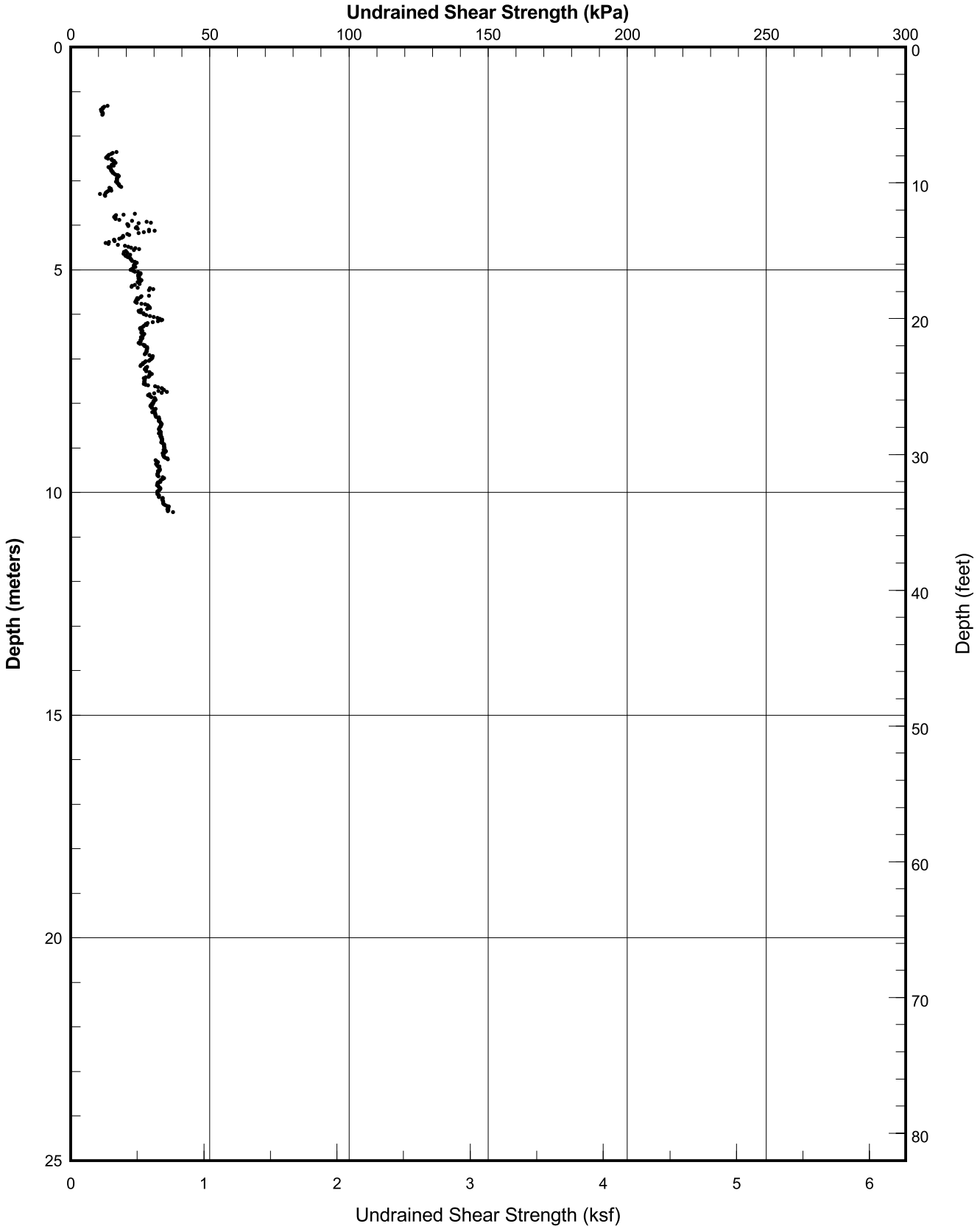
LOG OF CPT

SOUNDING 99C-15

SFOBB East Span Seismic Safety Project

Report Date: 08/26/99

PLATE 99C-15.1

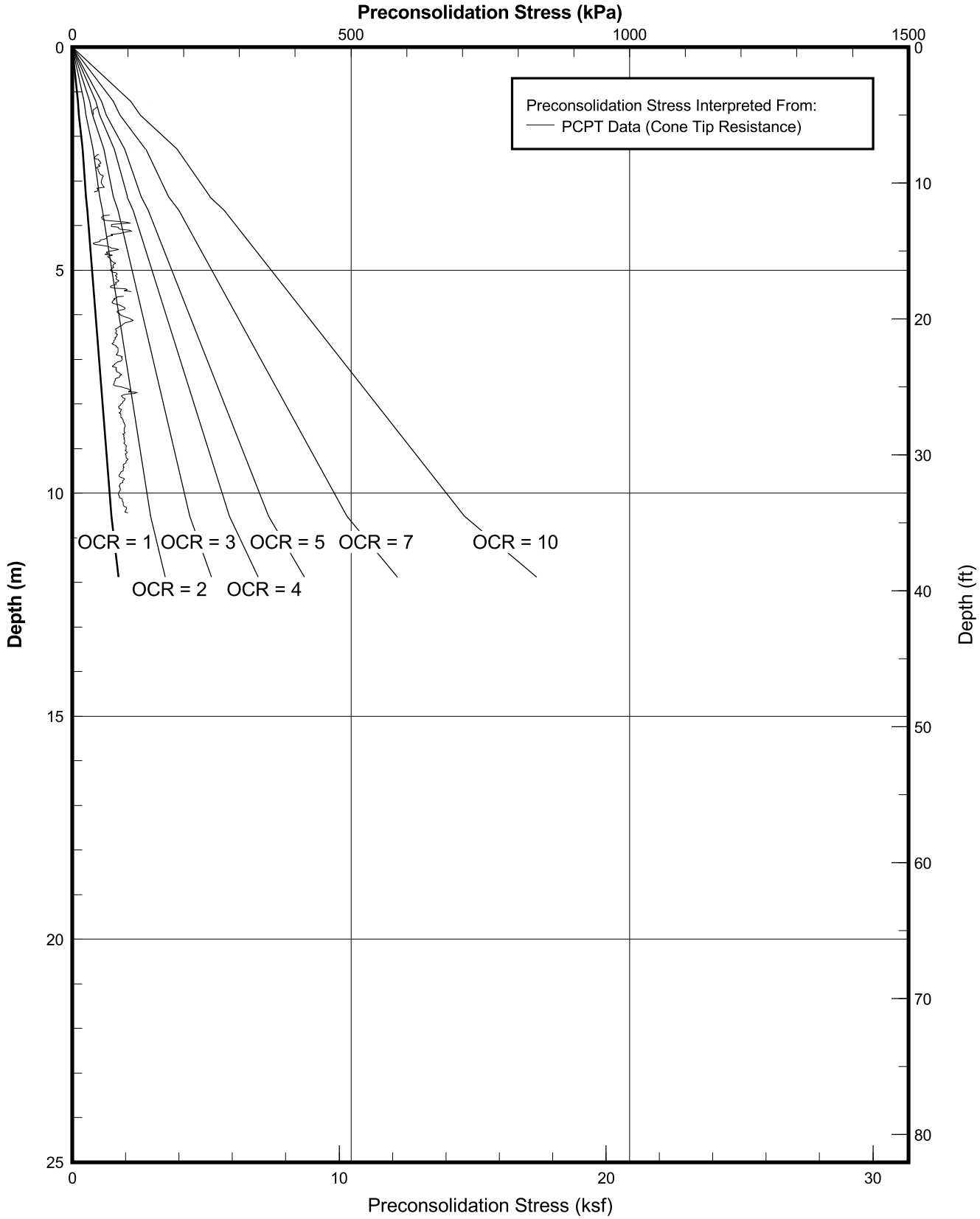


UNDRAINED SHEAR STRENGTH PROFILE INTERPRETED FROM CPT TIP RESISTANCE (Nk=12)

Sounding 99C-15

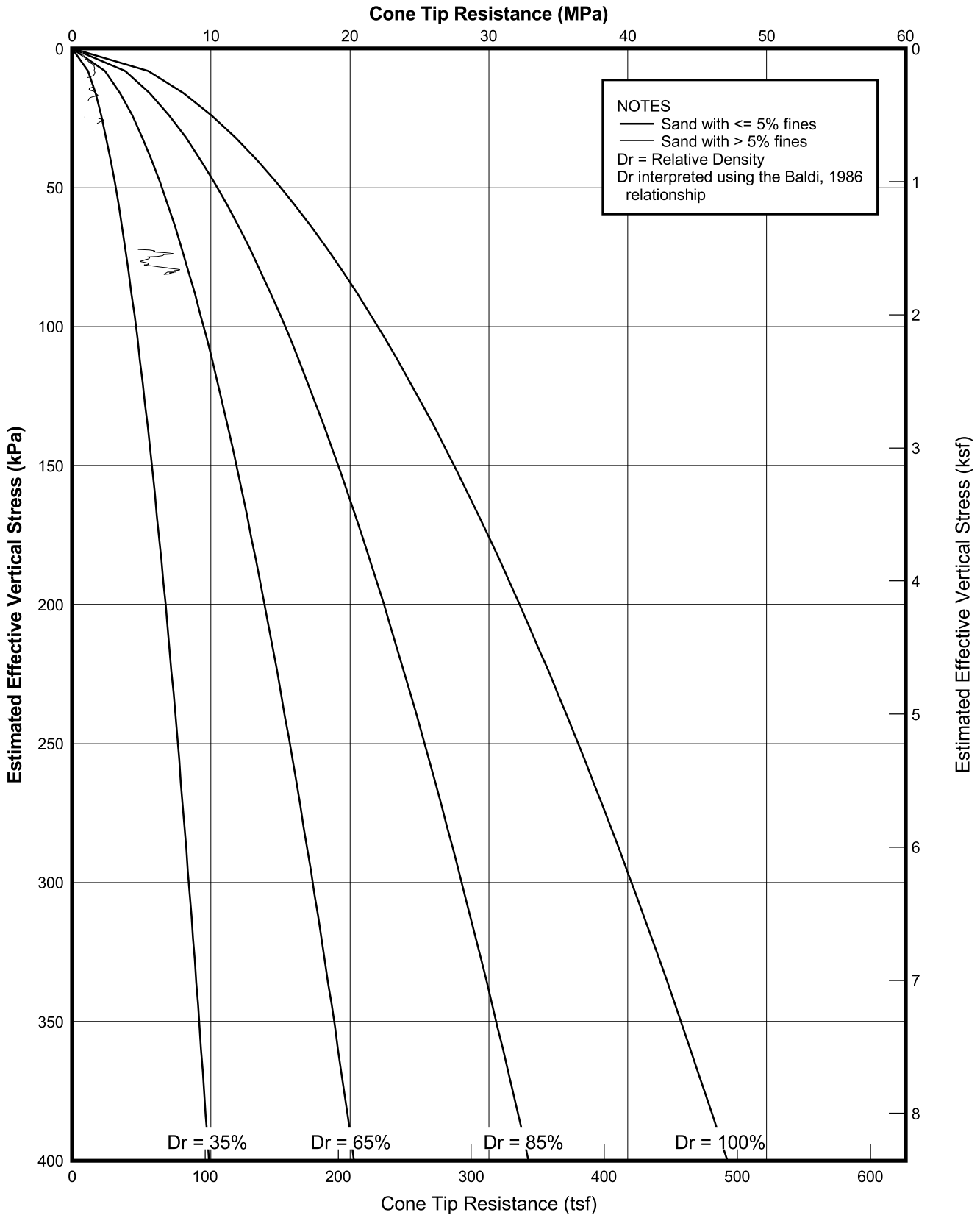
SFOBB East Span Seismic Safety Project

PLATE 99C-15.2



PRECONSOLIDATION STRESS INTERPRETED FROM CPT DATA
Sounding 99C-15
SFOBB East Span Seismic Safety Project

PLATE 99C-15.3

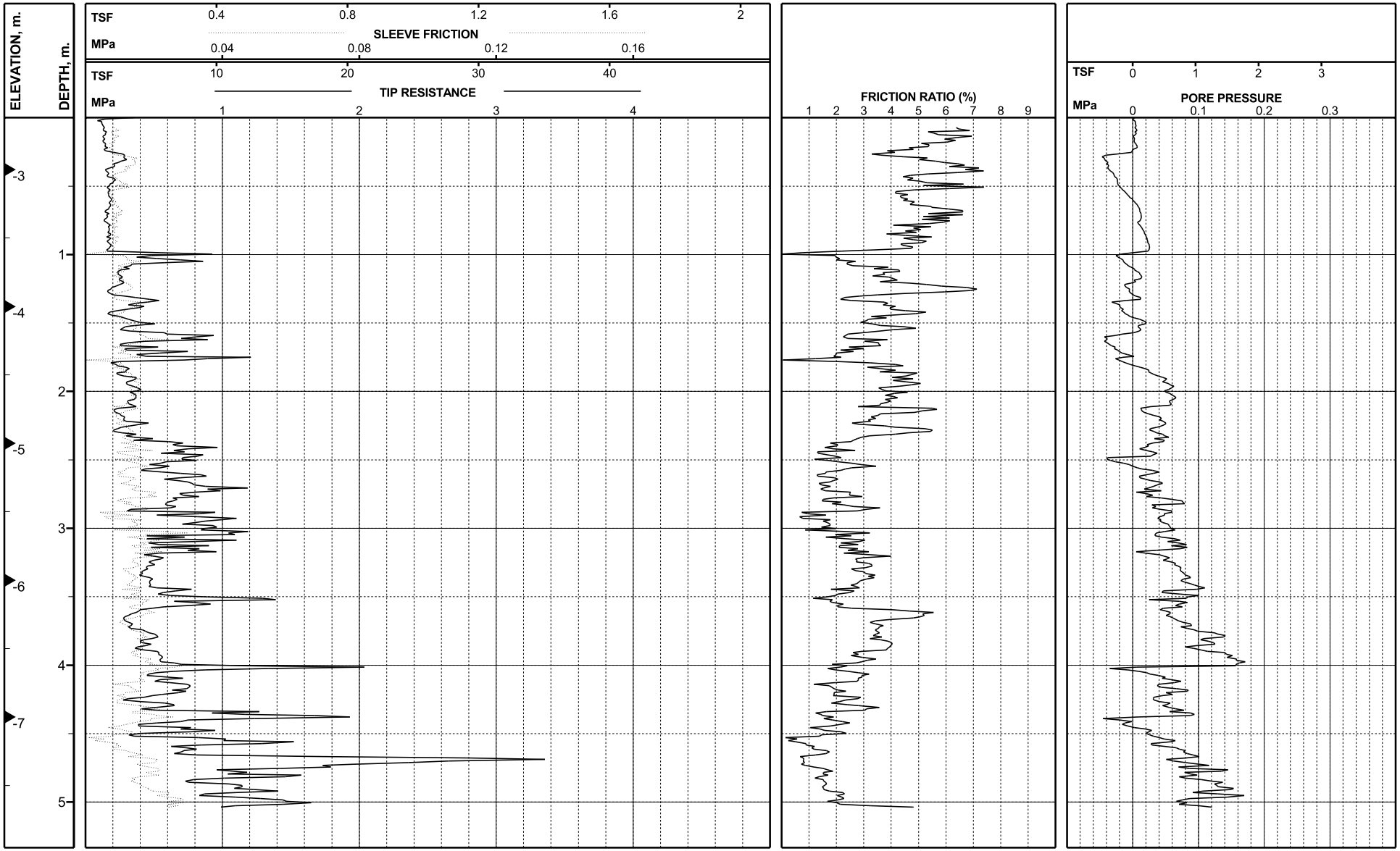


RELATIVE DENSITY INTERPRETED FROM CPT DATA
Sounding 99C-15
SFOBB East Span Seismic Safety Project

PLATE 99C-15.4

APPENDIX B
TETHERED SEASCOUT CPT DATA

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838757 N648272 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-446 (W. Sta. 82+96)	**MUDLINE ELEVATION:**	-2.6 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

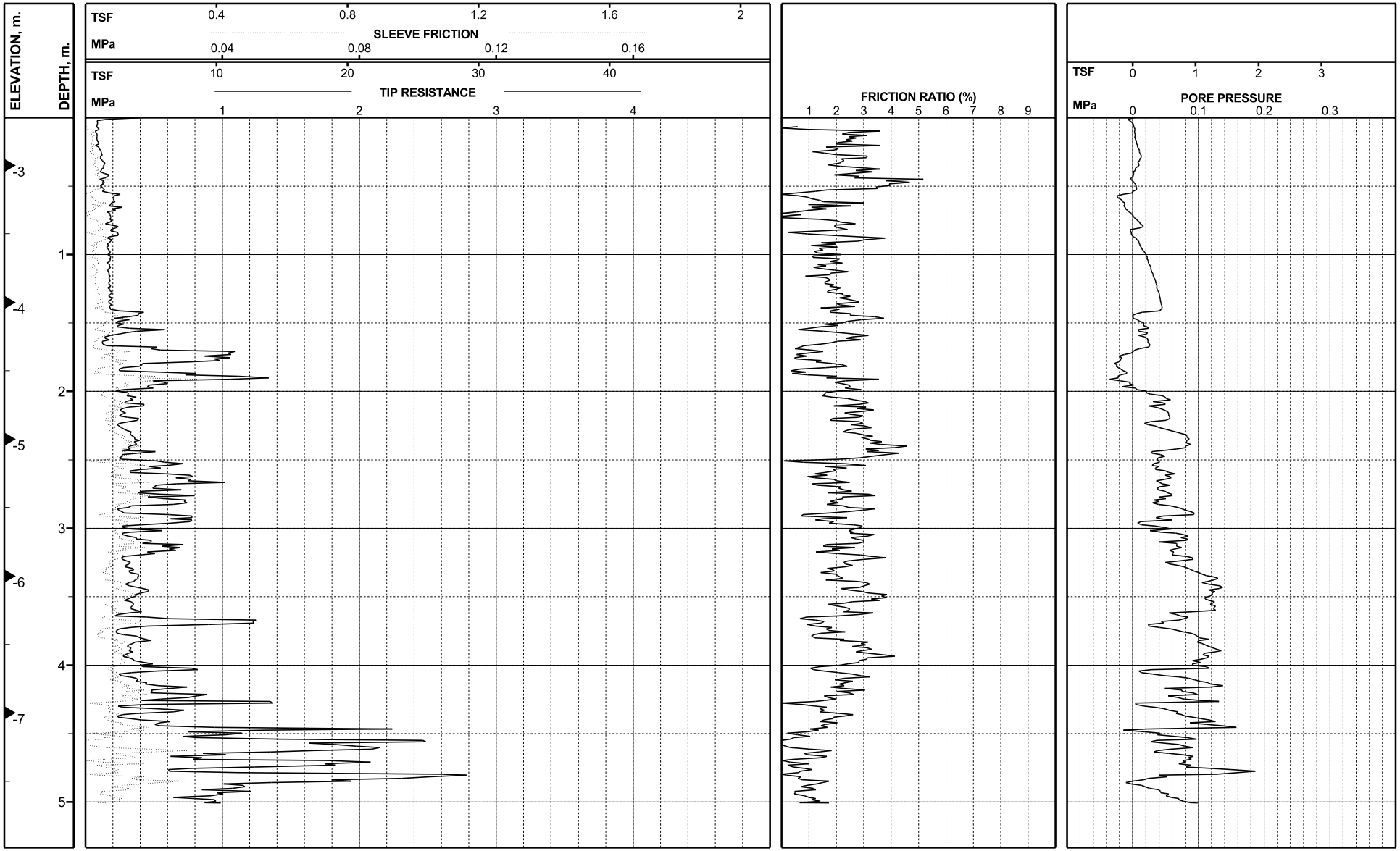
TETHERED SEASCOUT SOUNDING 98C-446

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838762 N648241 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-447 (8m left of E. Sta. 82+69)	**MUDLINE ELEVATION:**	-2.7 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

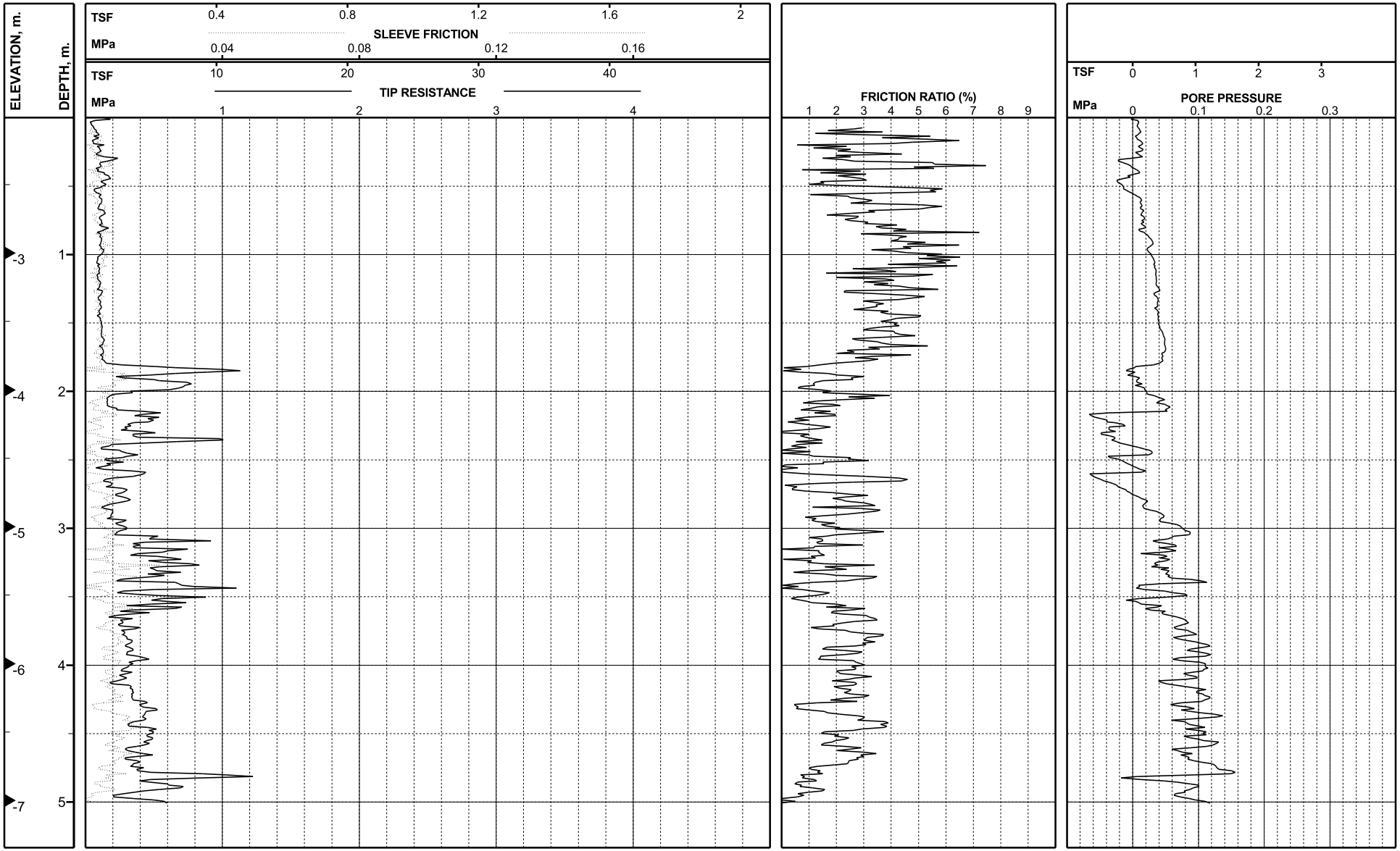
TETHERED SEASCOUT SOUNDING 98C-447

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838808 N648270 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-448 (9m right of W. Sta. 83+47)	**MUDLINE ELEVATION:**	-2.0 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

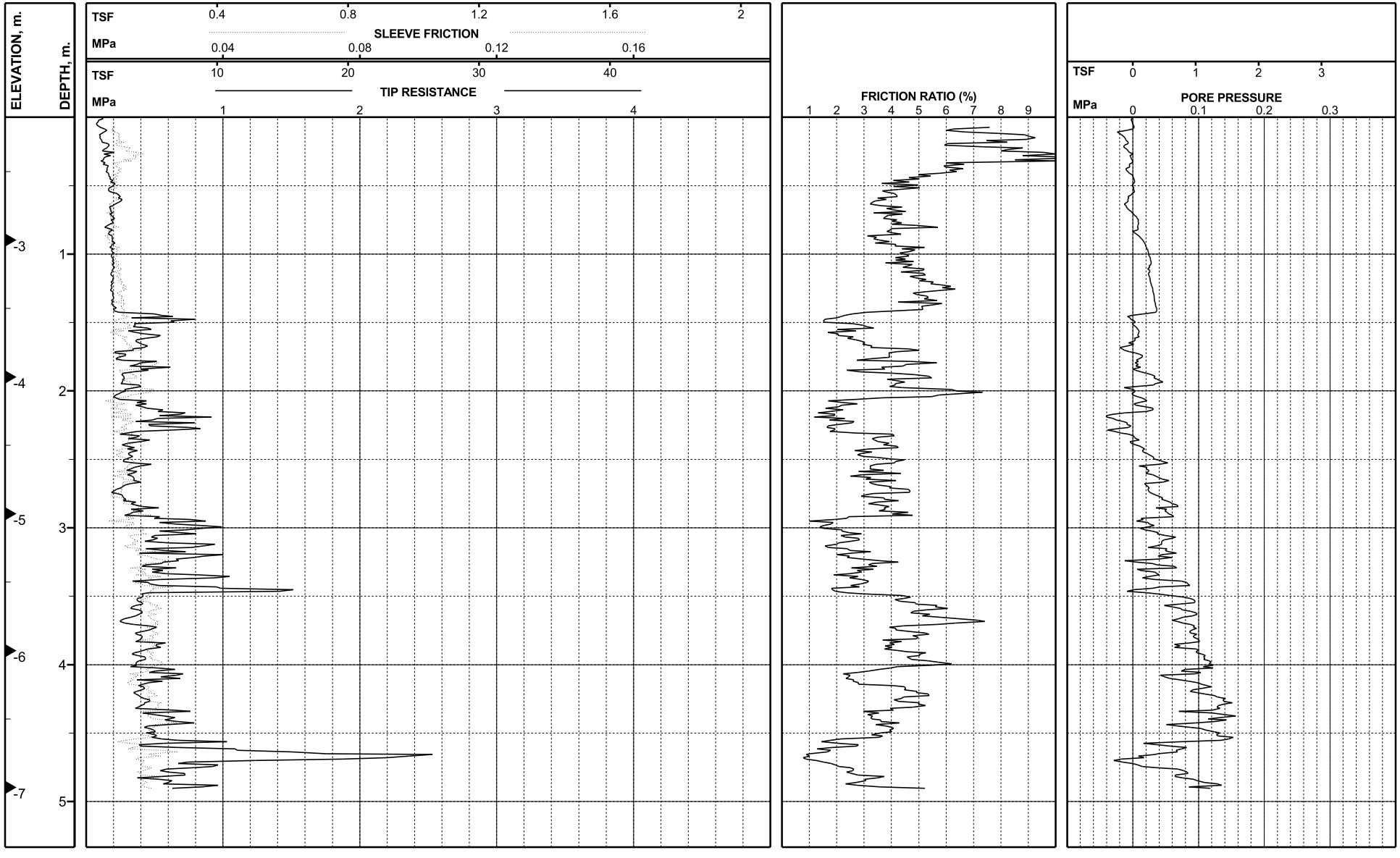
TETHERED SEASCOUT SOUNDING 98C-448

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838807 N648239 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-449 (1m right of E. Sta. 60+47)	**MUDLINE ELEVATION:**	-2.1 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

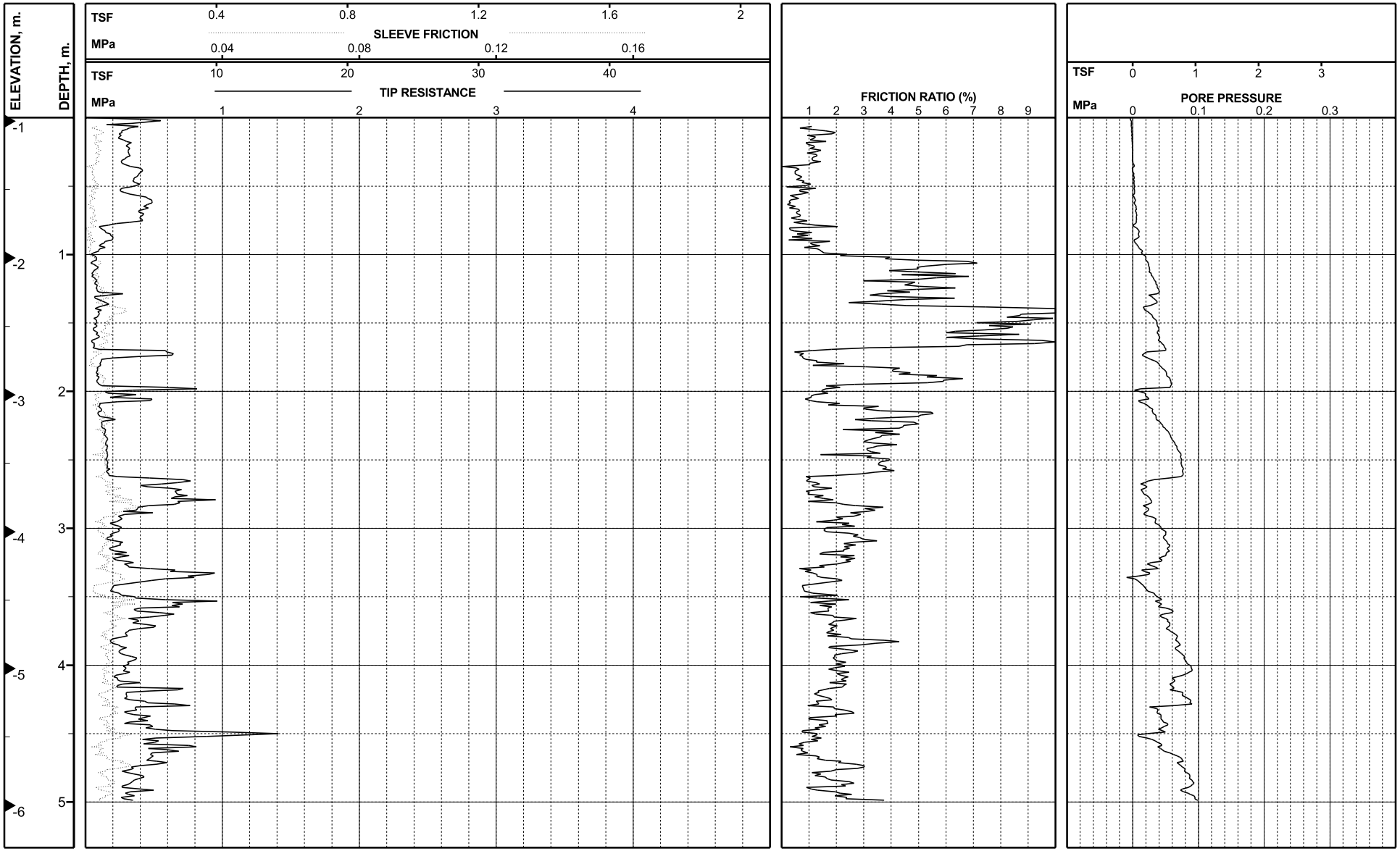
TETHERED SEASCOUT SOUNDING 98C-449

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838892 N648303 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-450 (14m left of W. Sta. 84+34)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

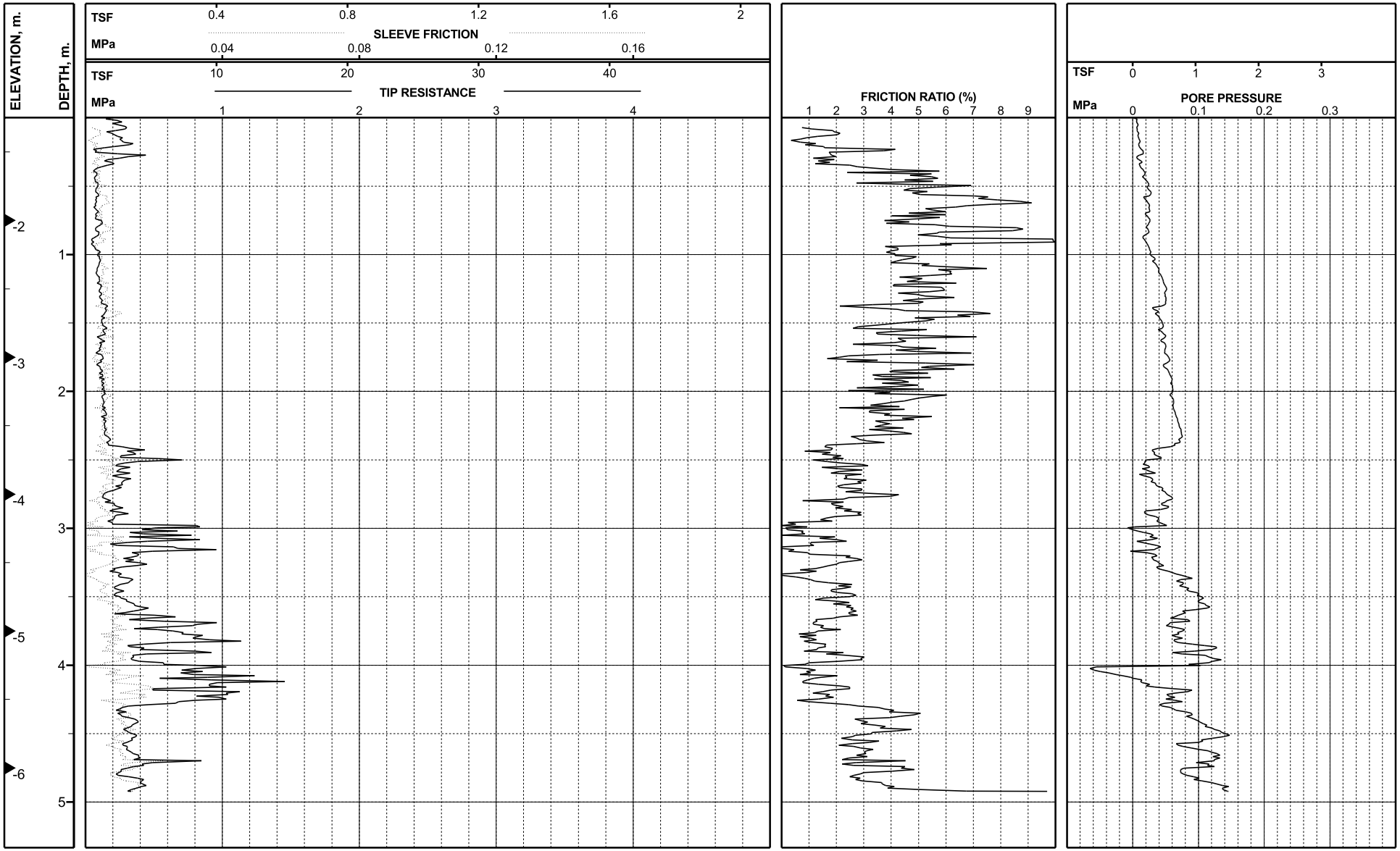
TETHERED SEASCOUT SOUNDING 98C-450

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838855 N648246 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-451 (2m right of E. Sta. 59+99)	**MUDLINE ELEVATION:**	-1.2 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

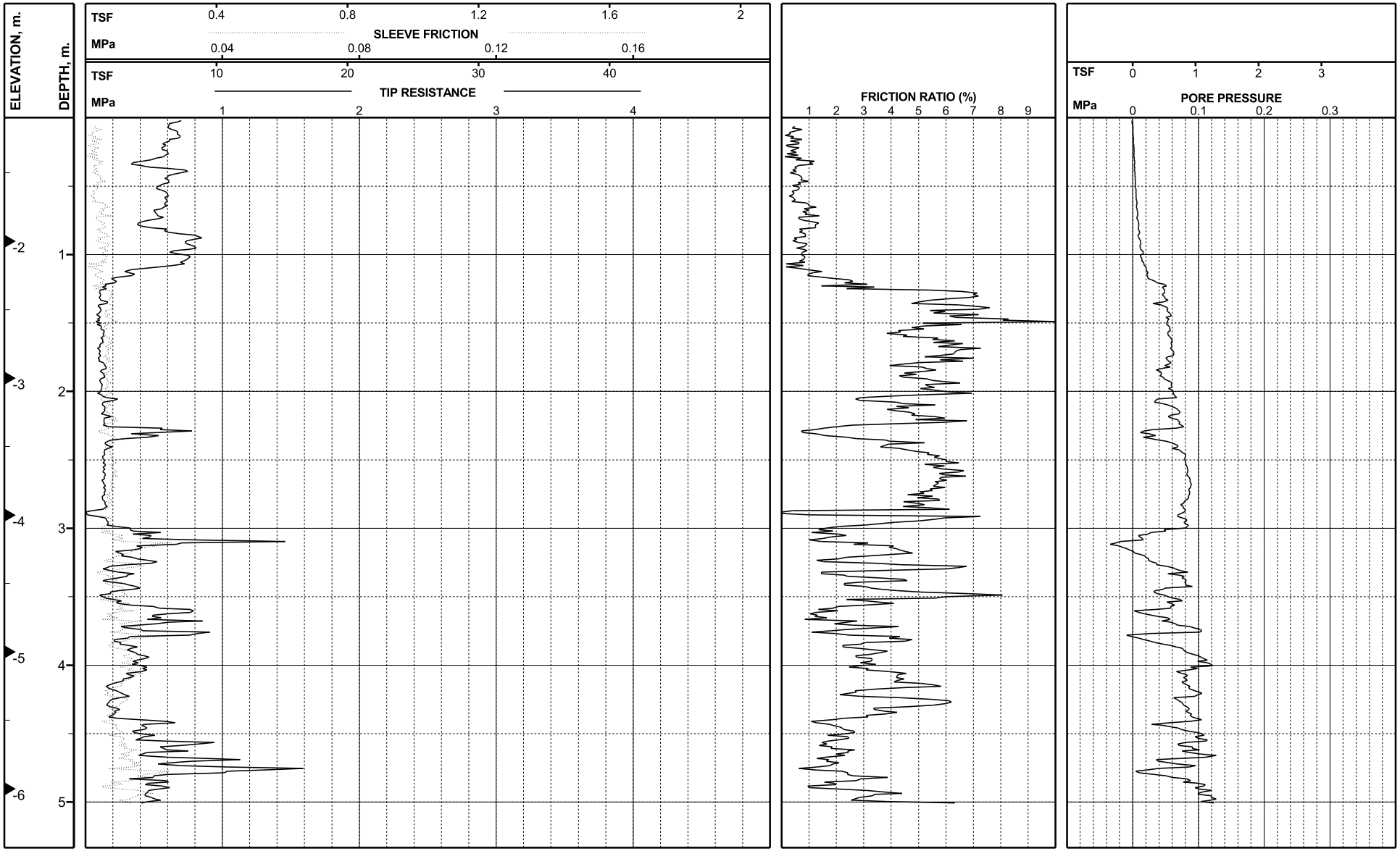
TETHERED SEASCOUT SOUNDING 98C-451

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838909 N648295 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-501 (4m left of W. Sta. 84+50)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

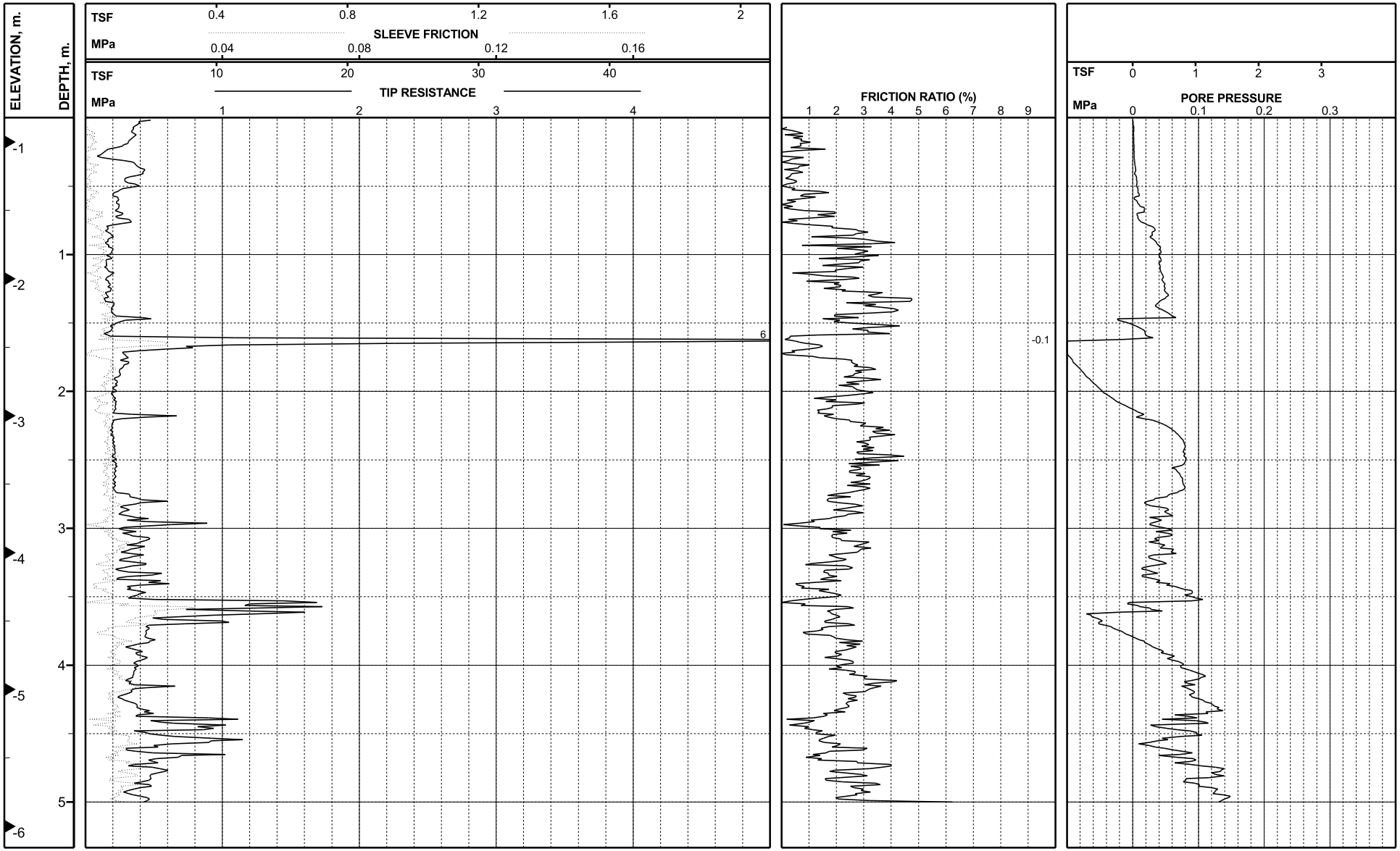
TETHERED SEASCOUT SOUNDING 98C-501

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838941 N648351 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-503 (57m left of W. Sta. 84+87)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

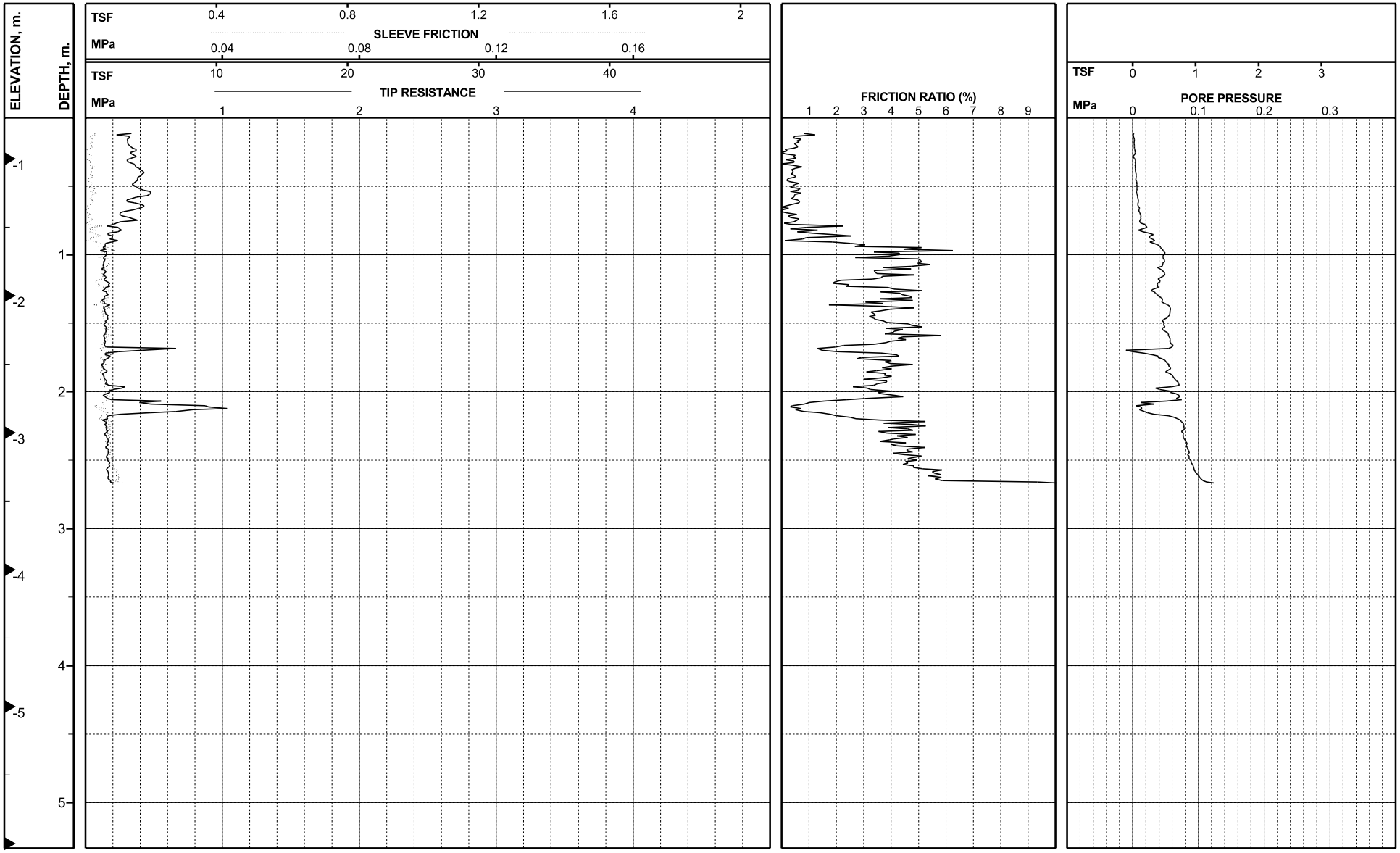
TETHERED SEASCOUT SOUNDING 98C-503

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838941 N648330 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-504 (36m left of W. Sta. 84+85)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

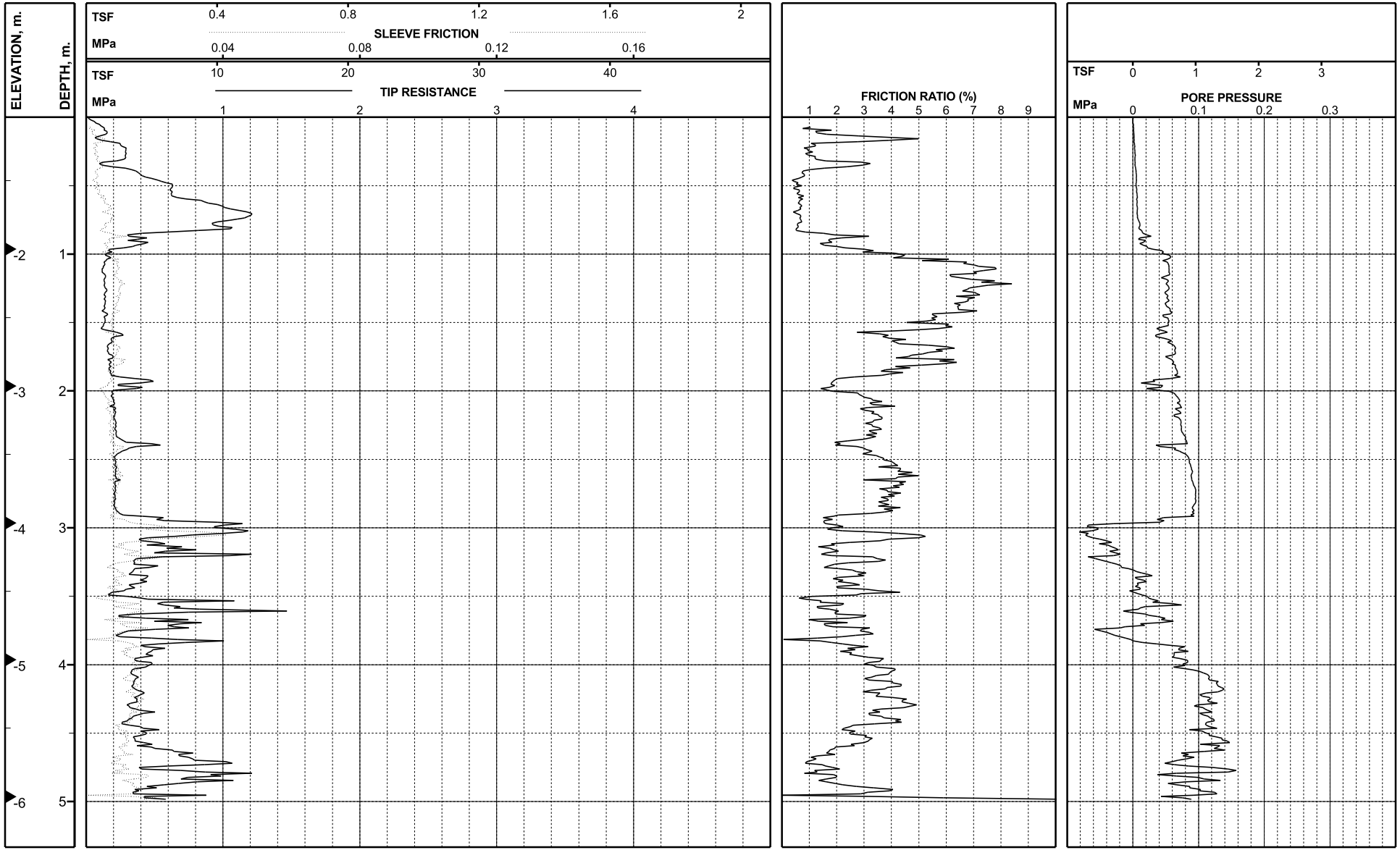
TETHERED SEASCOUT SOUNDING 98C-504

SFOBB East Span Seismic Safety Project

Report Date: 08/29/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838943 N648302 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightening
EXPLORATION NO.:	98C-505 (7m left of W. Sta. 84+84)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

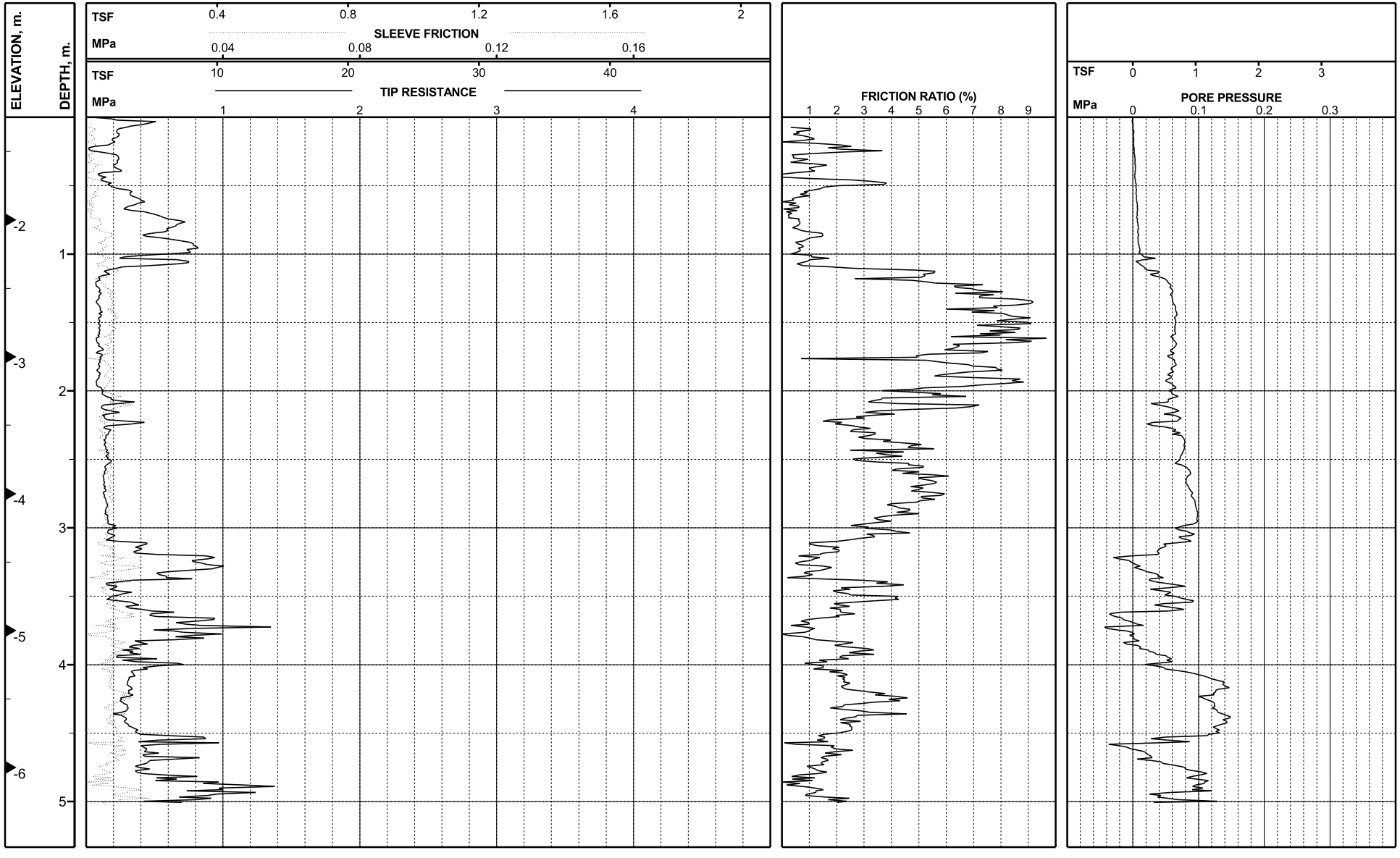
TETHERED SEASCOUT SOUNDING 98C-505

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838935 N648297 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-506 (3m left of W. Sta. 84+76)	**MUDLINE ELEVATION:**	-1.2 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

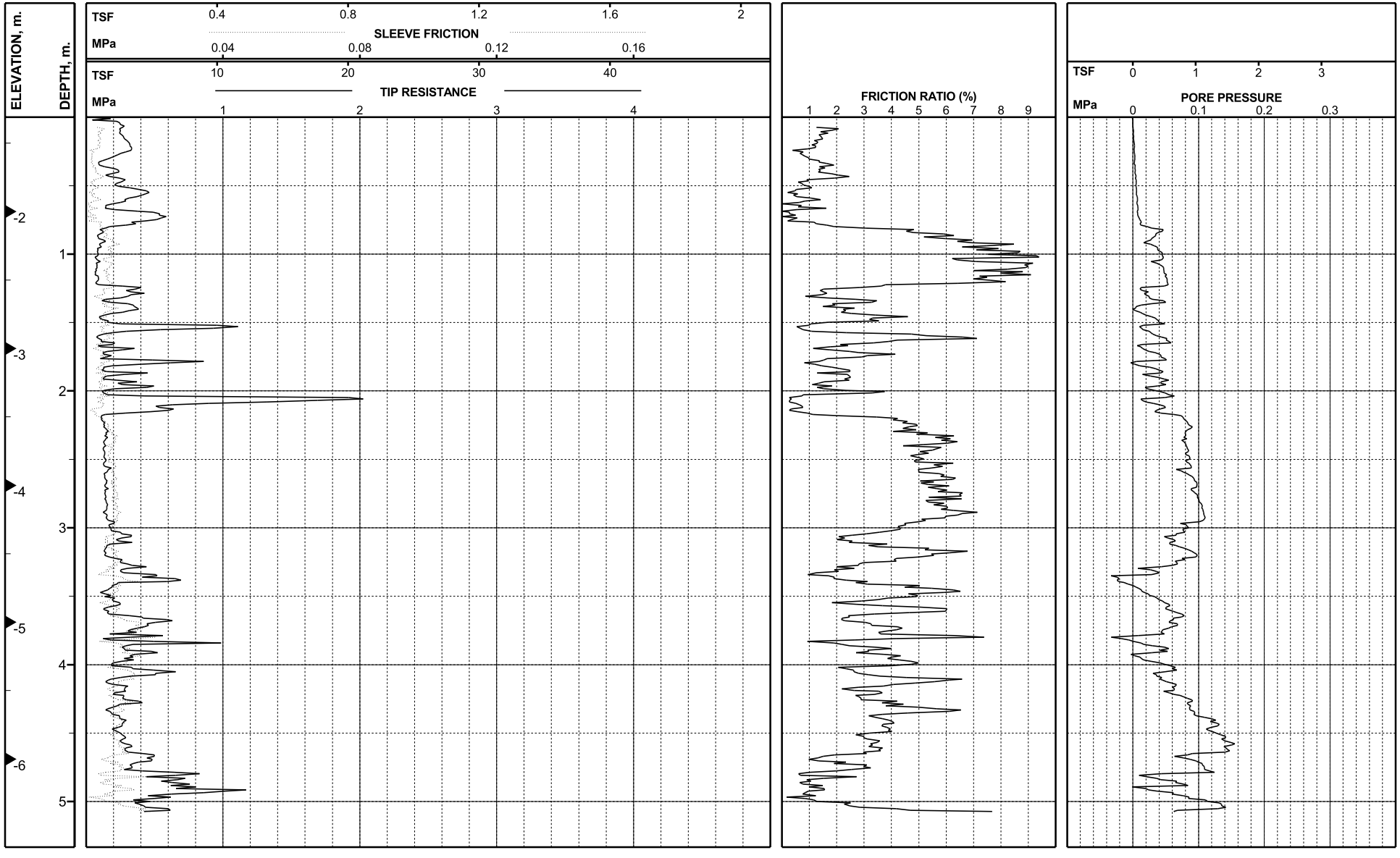
TETHERED SEASCOUT SOUNDING 98C-506

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838996 N648319 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-508 (19m left of W. Sta. 85+39)	**MUDLINE ELEVATION:**	-1.3 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

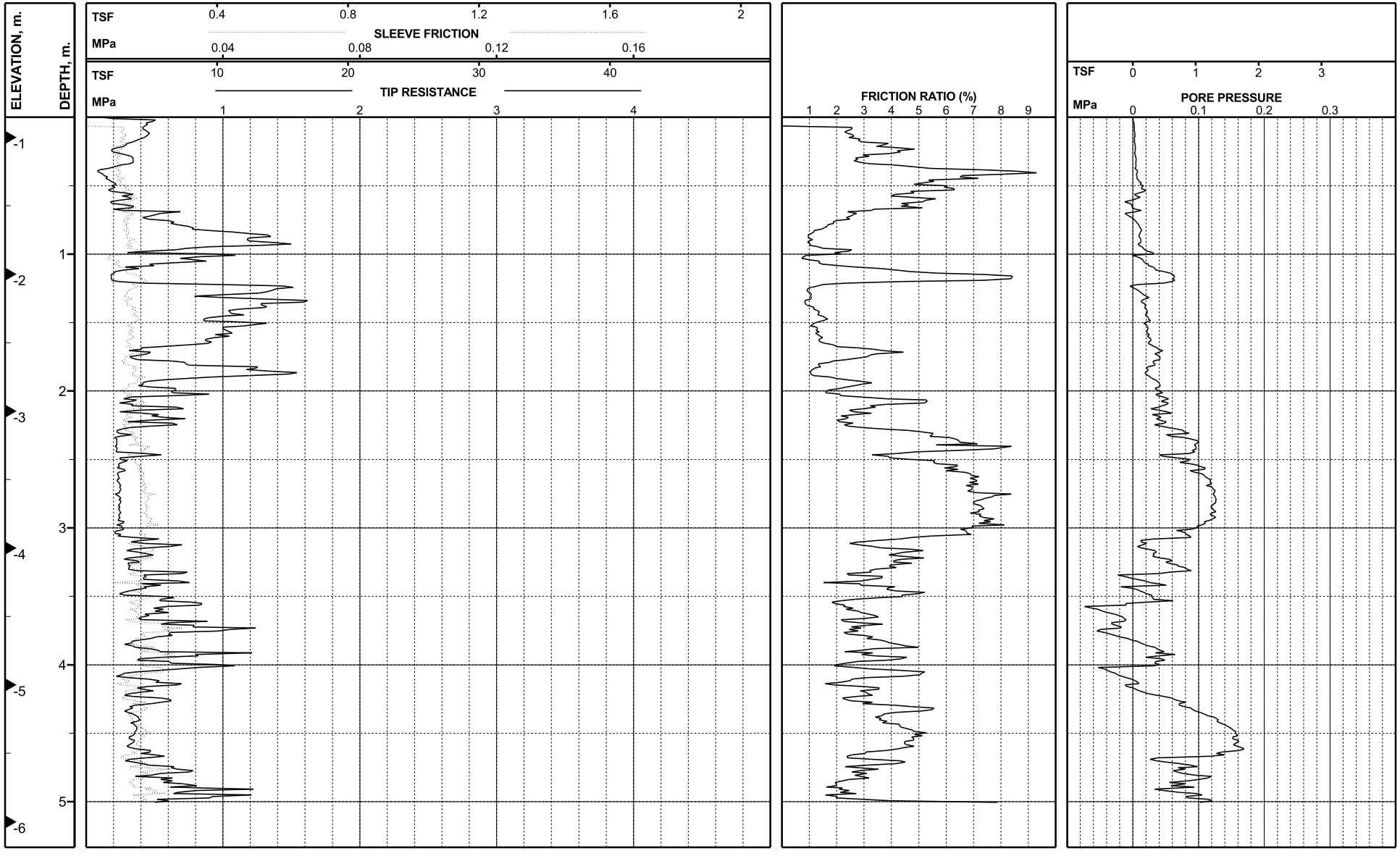
TETHERED SEASCOUT SOUNDING 98C-508

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839032 N648365 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-510 (62m left of W. Sta. 85+78)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

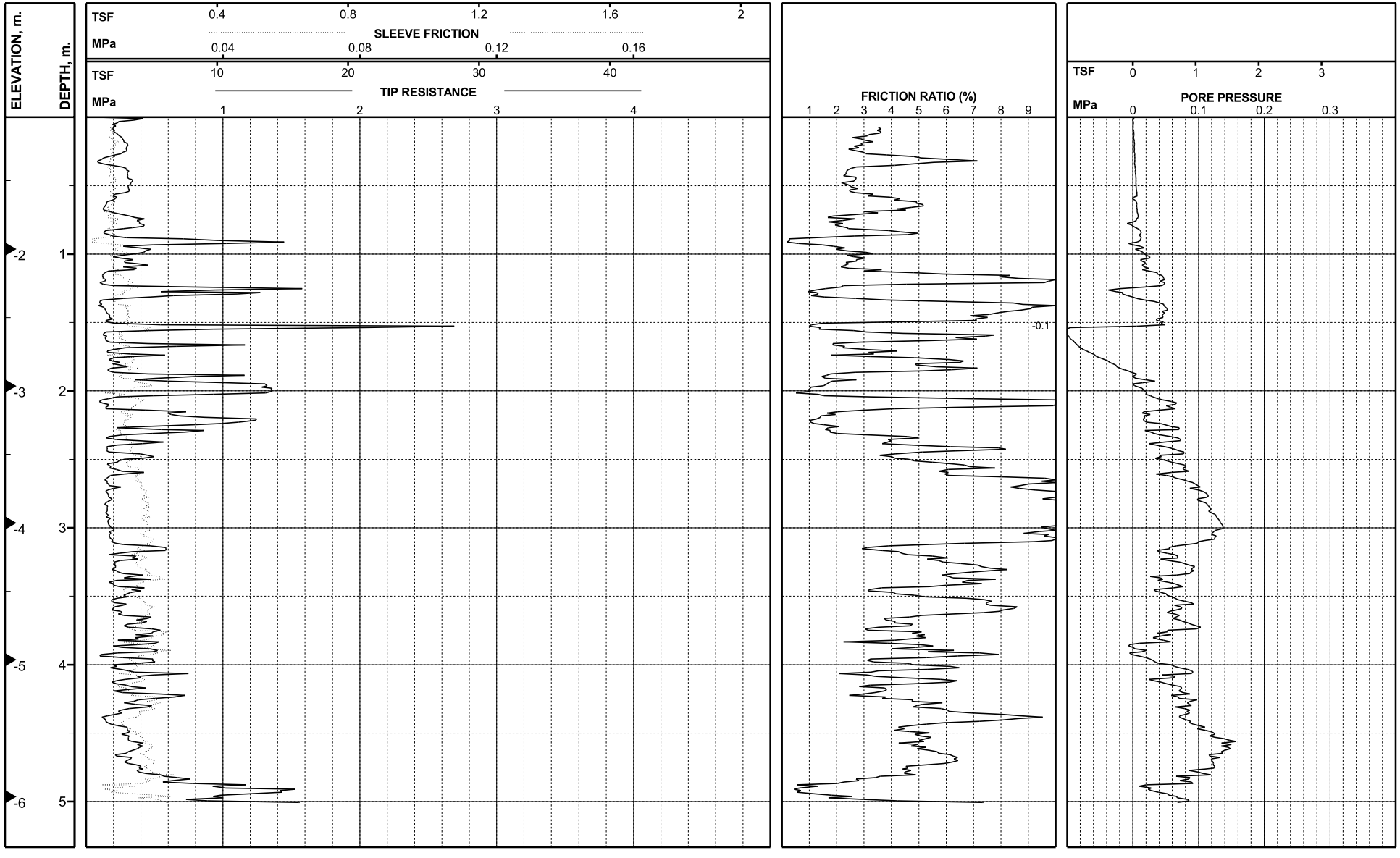
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-510

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839036 N648344 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-511 (41m left of W. Sta. 85+81)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

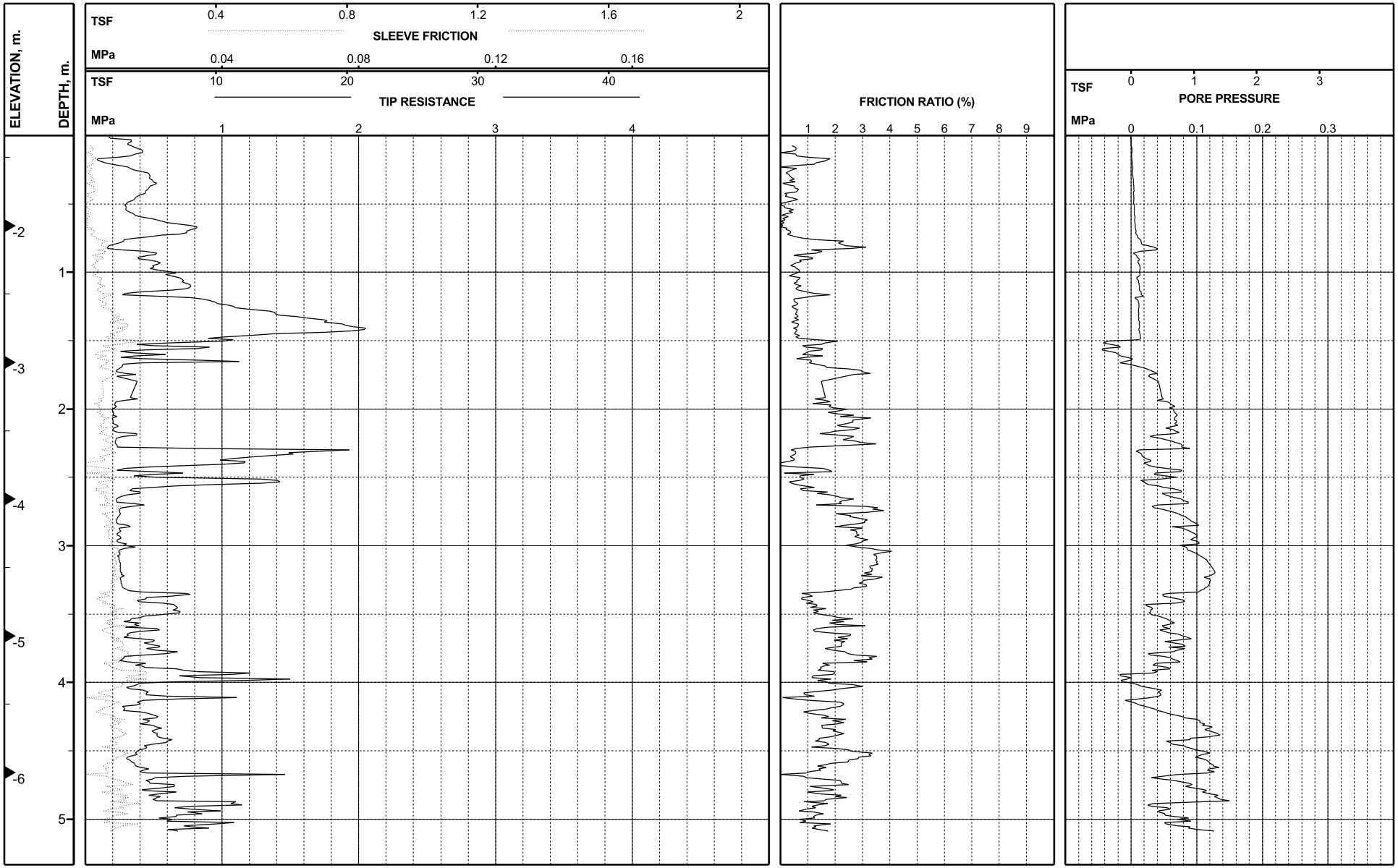
TETHERED SEASCOUT SOUNDING 98C-511

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839031 N648330 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
SOUNDING:	98C-512 (27m left of W. Sta. 85+74)	**MUDLINE ELEVATION:**	-1.3 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-512

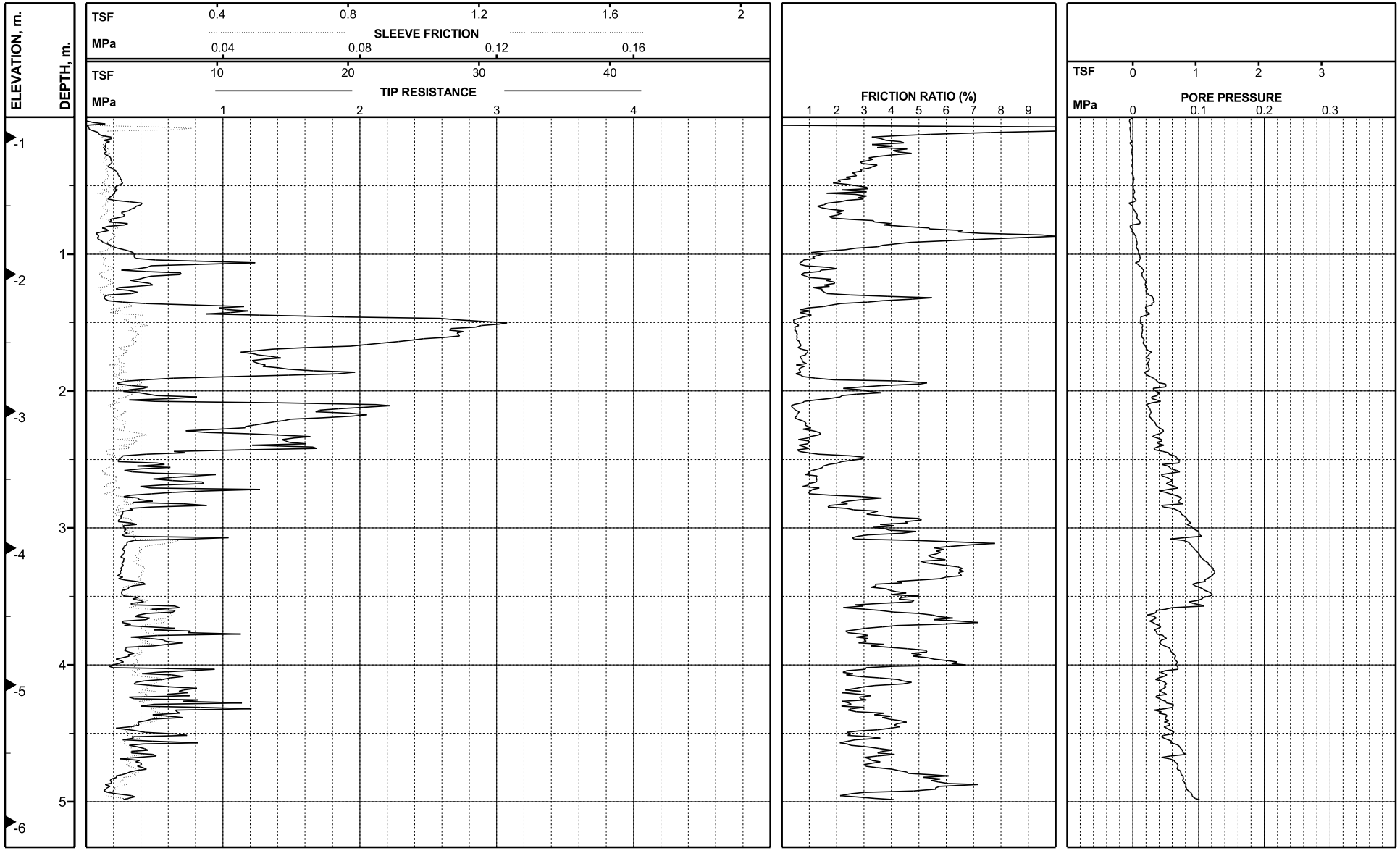
SFOBB East Span Seismic Safety Project

Report Date: 02/19/01

FUGRO

j:\caltrans\reports\finalreports\finaloaksitechar_book5\vol3\vol3_b\odb\98c-512.odb

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839068 N648363 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-513 (57m left of W. Sta. 86+14)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

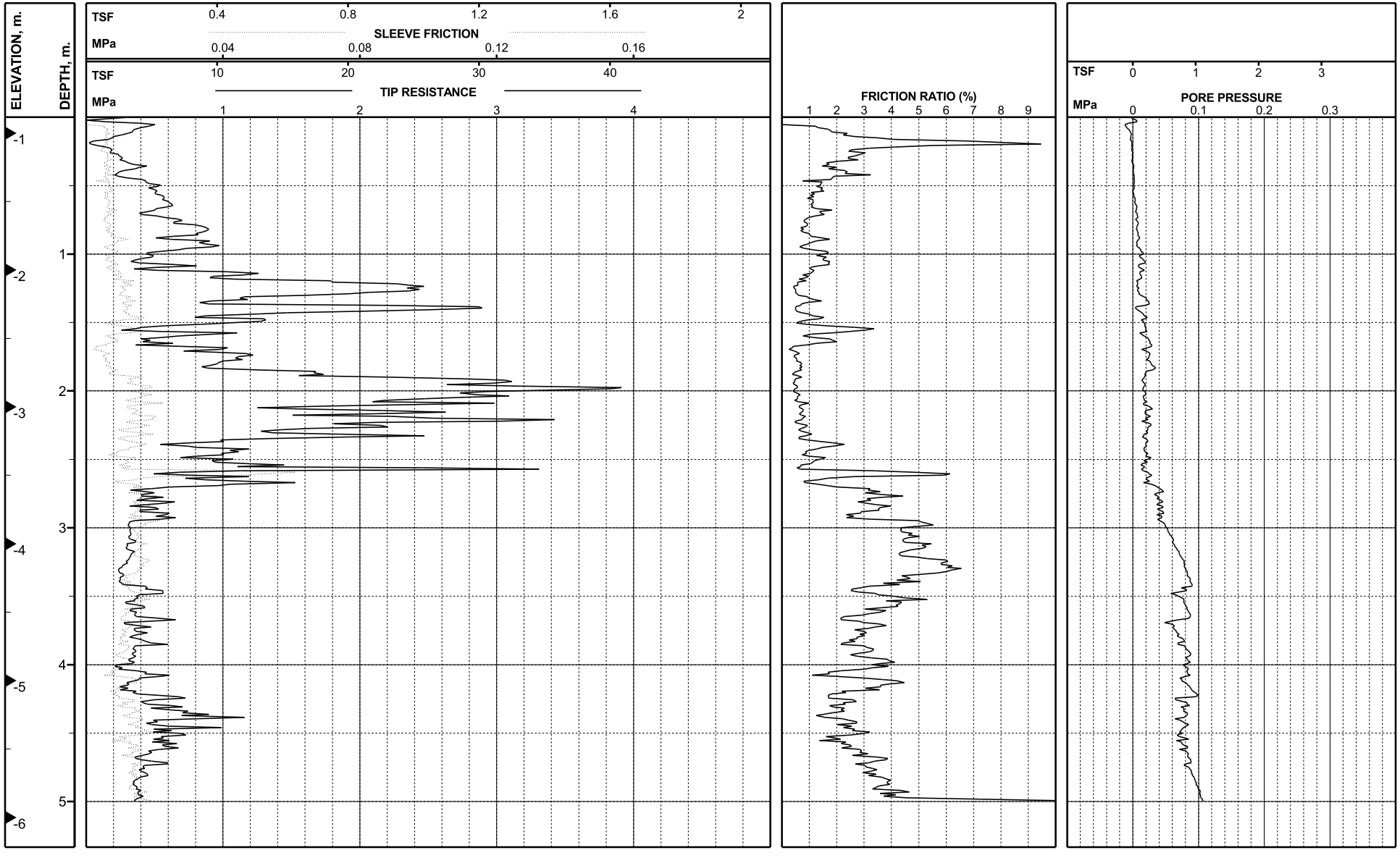
TETHERED SEASCOUT SOUNDING 98C-513

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839119 N648376 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-514 (66m left of W. Sta. 86+65)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

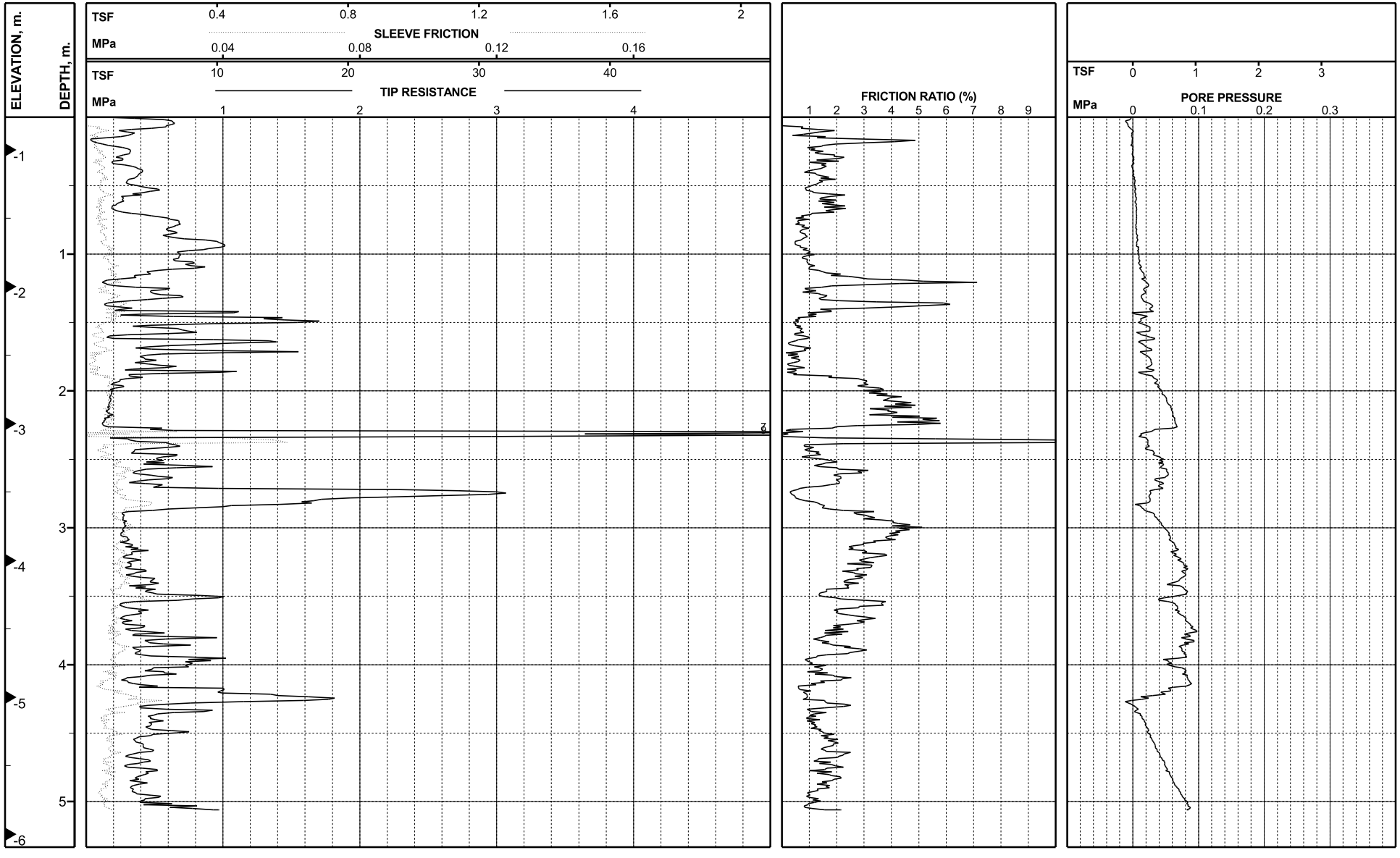
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-514

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839123 N648357 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-515 (46m left of W. Sta. 86+68)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

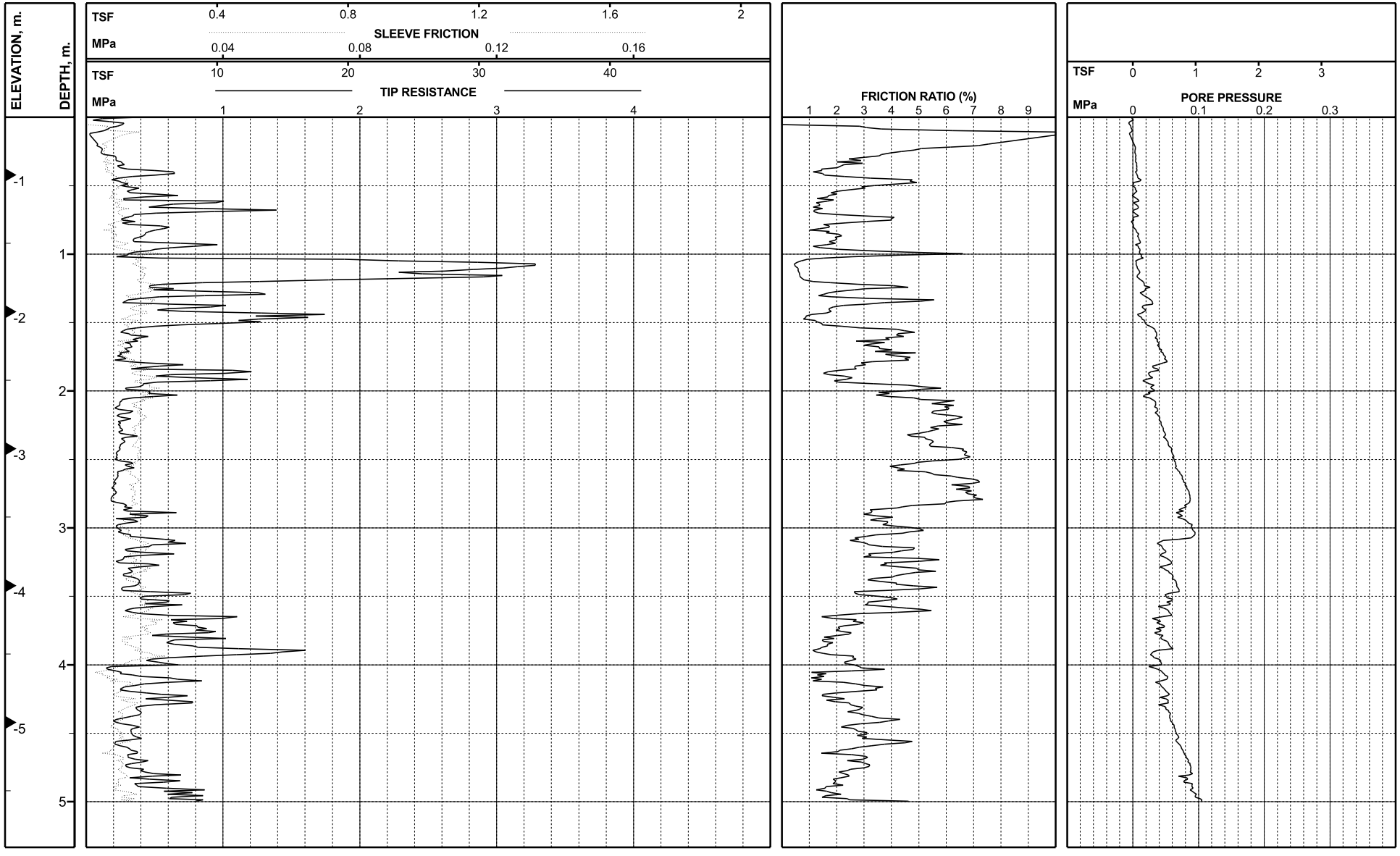
TETHERED SEASCOUT SOUNDING 98C-515

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839154 N648399 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-517 (86m left of W. Sta. 87+02)	**MUDLINE ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

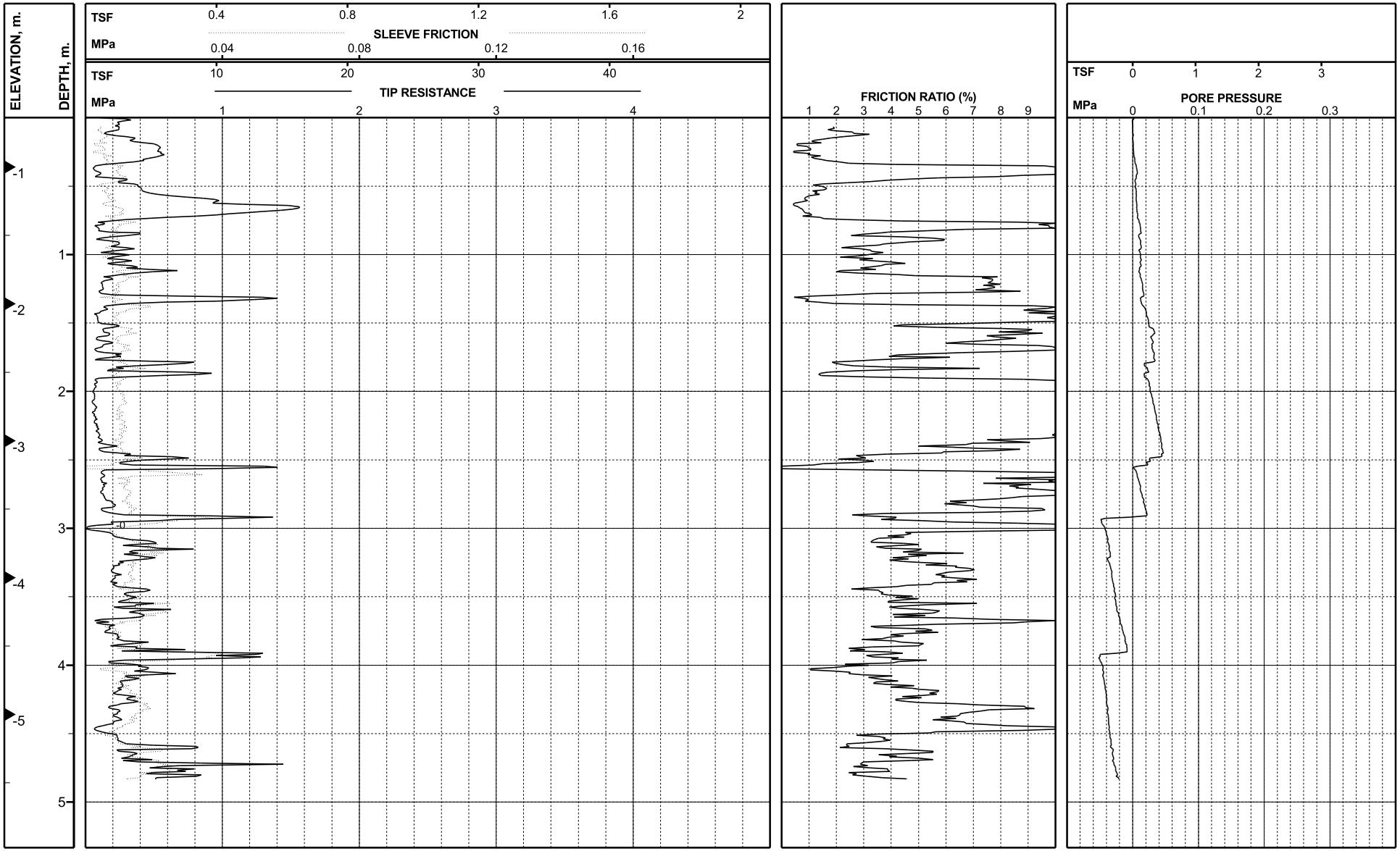
TETHERED SEASCOUT SOUNDING 98C-517

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839155 N648371 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-518 (58m left of W. Sta. 87+01)	**MUDLINE ELEVATION:**	-0.6 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

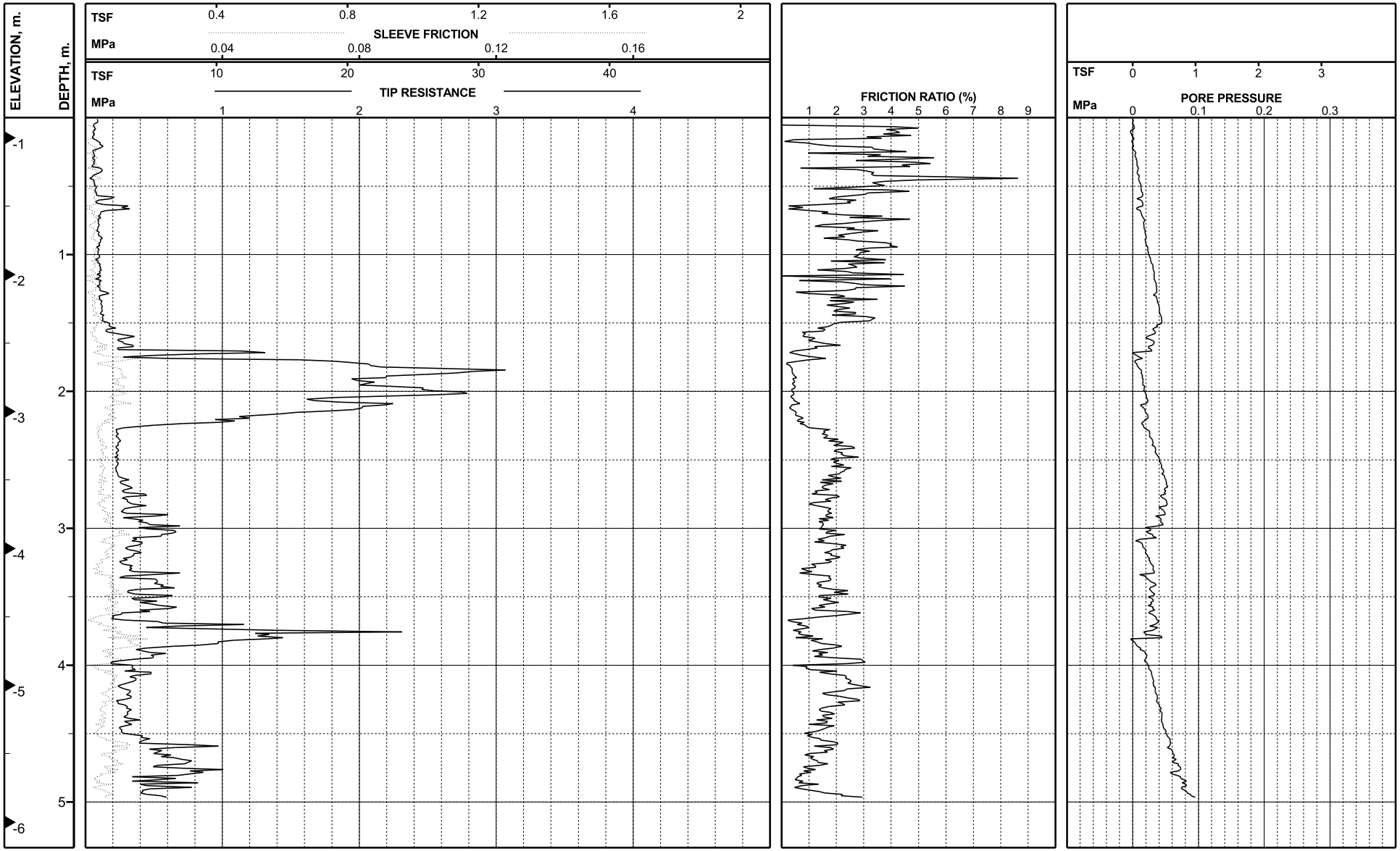
TETHERED SEASCOUT SOUNDING 98C-518

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839166 N648347 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-519 (33m left of W. Sta. 87+10)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

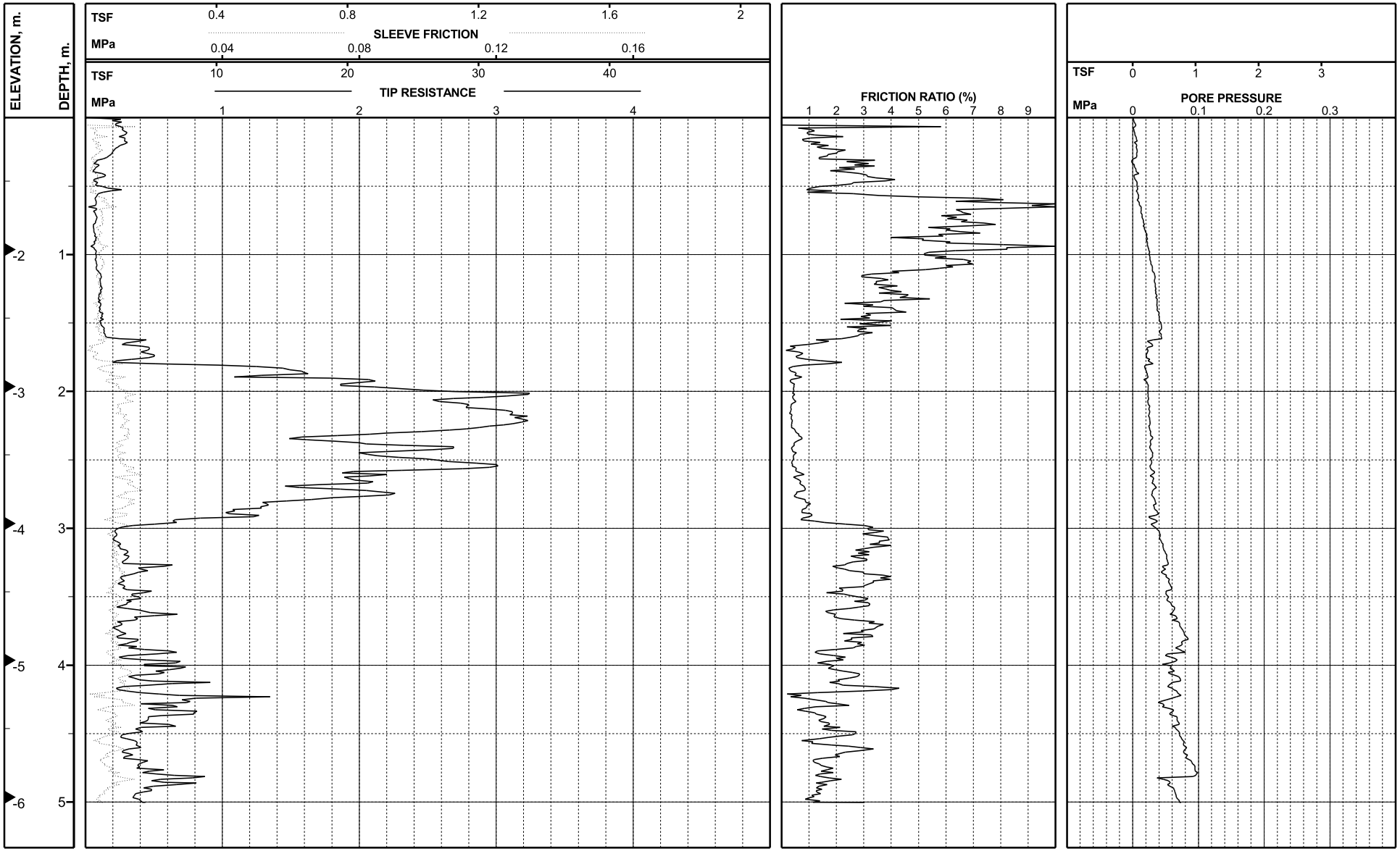
TETHERED SEASCOUT SOUNDING 98C-519

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839154 N648332 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-520 (20m left of W. Sta. 86+97)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/17/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

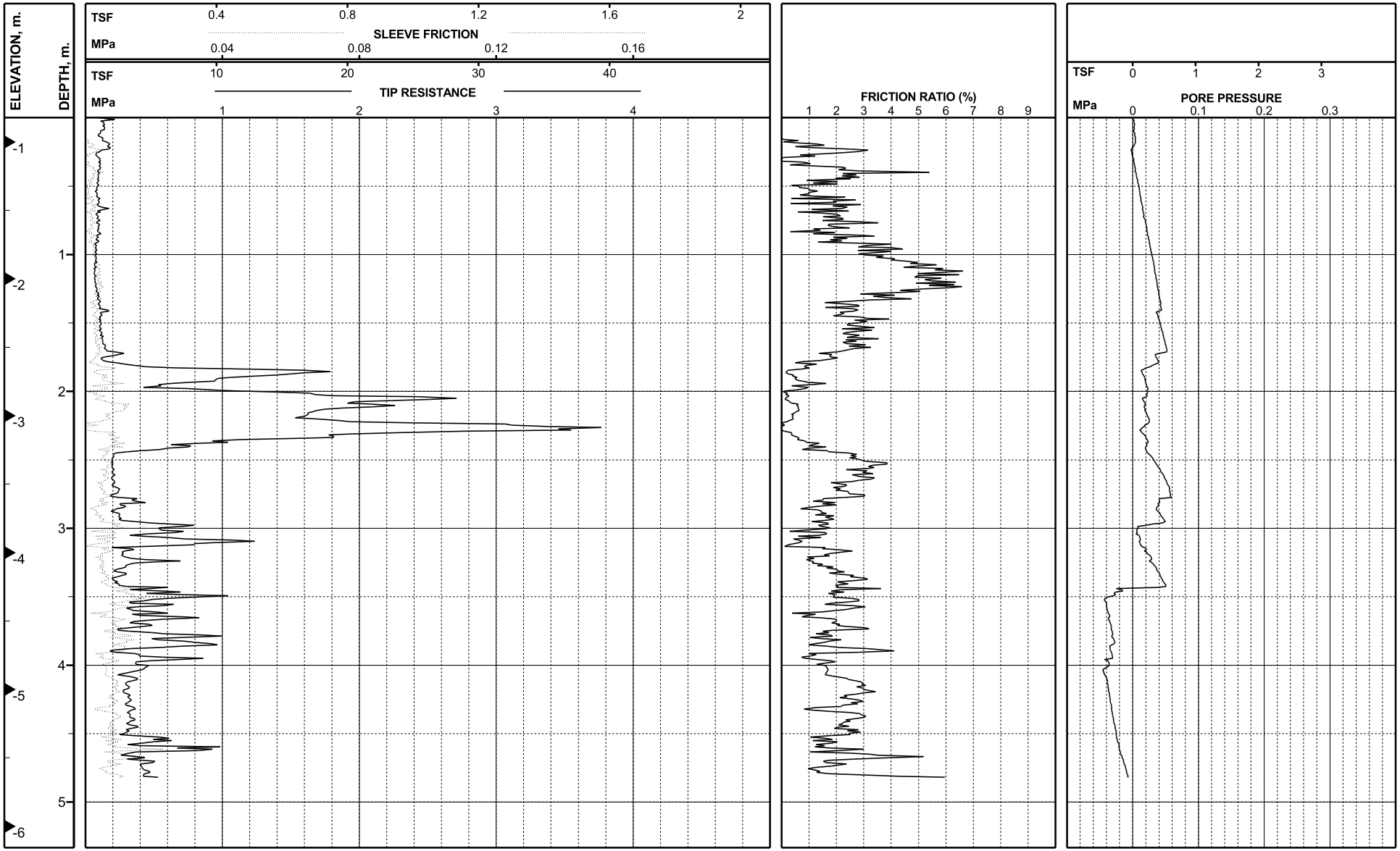
TETHERED SEASCOUT SOUNDING 98C-520

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839190 N648351 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-522 (36m left of W. Sta. 87+35)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

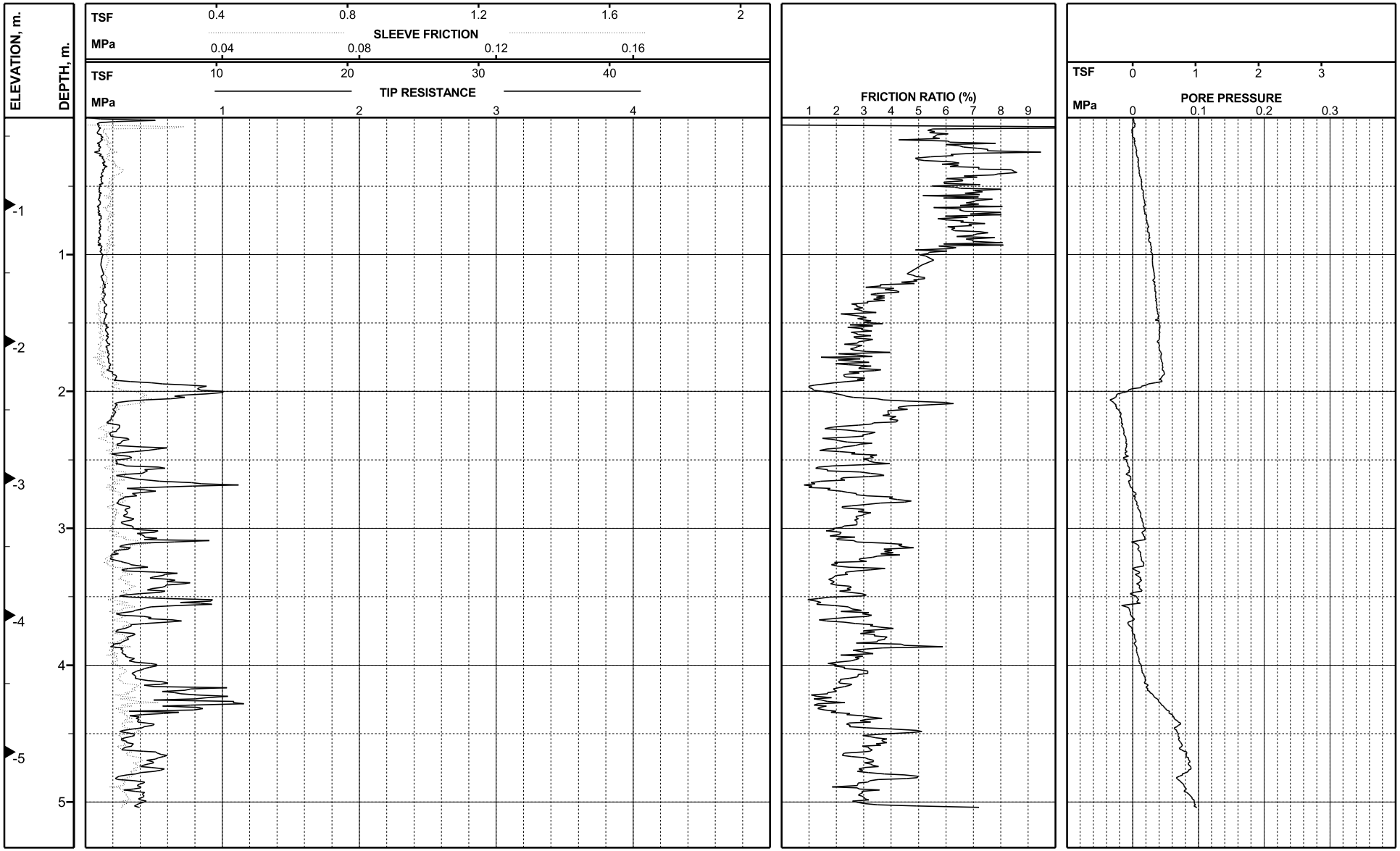
TETHERED SEASCOUT SOUNDING 98C-522

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839233 N648400 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-525 (81m left of W. Sta. 87+81)	**MUDLINE ELEVATION:**	-0.4 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

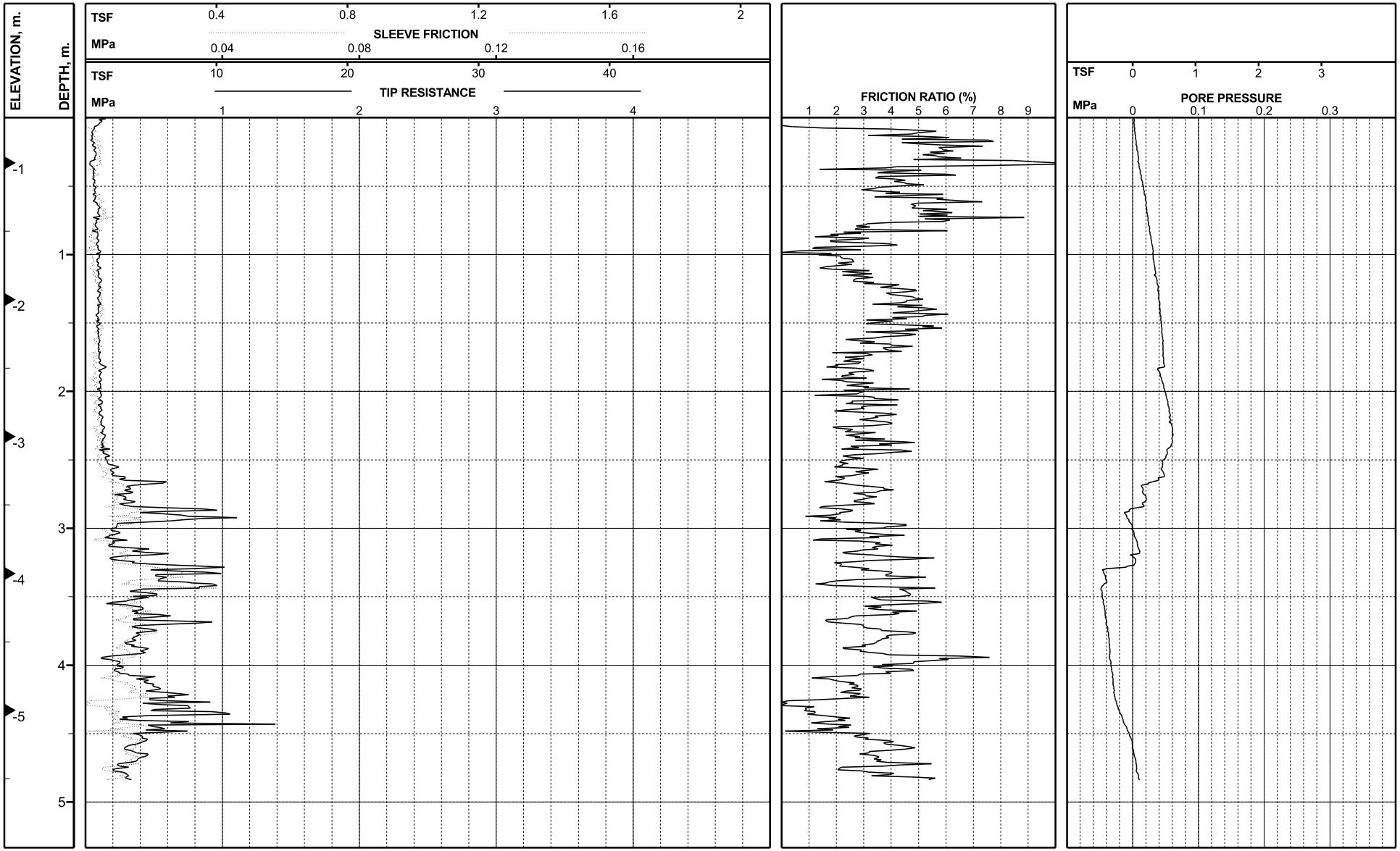
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-525

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839241 N648380 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-526 (61m left of W. Sta. 87+87)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

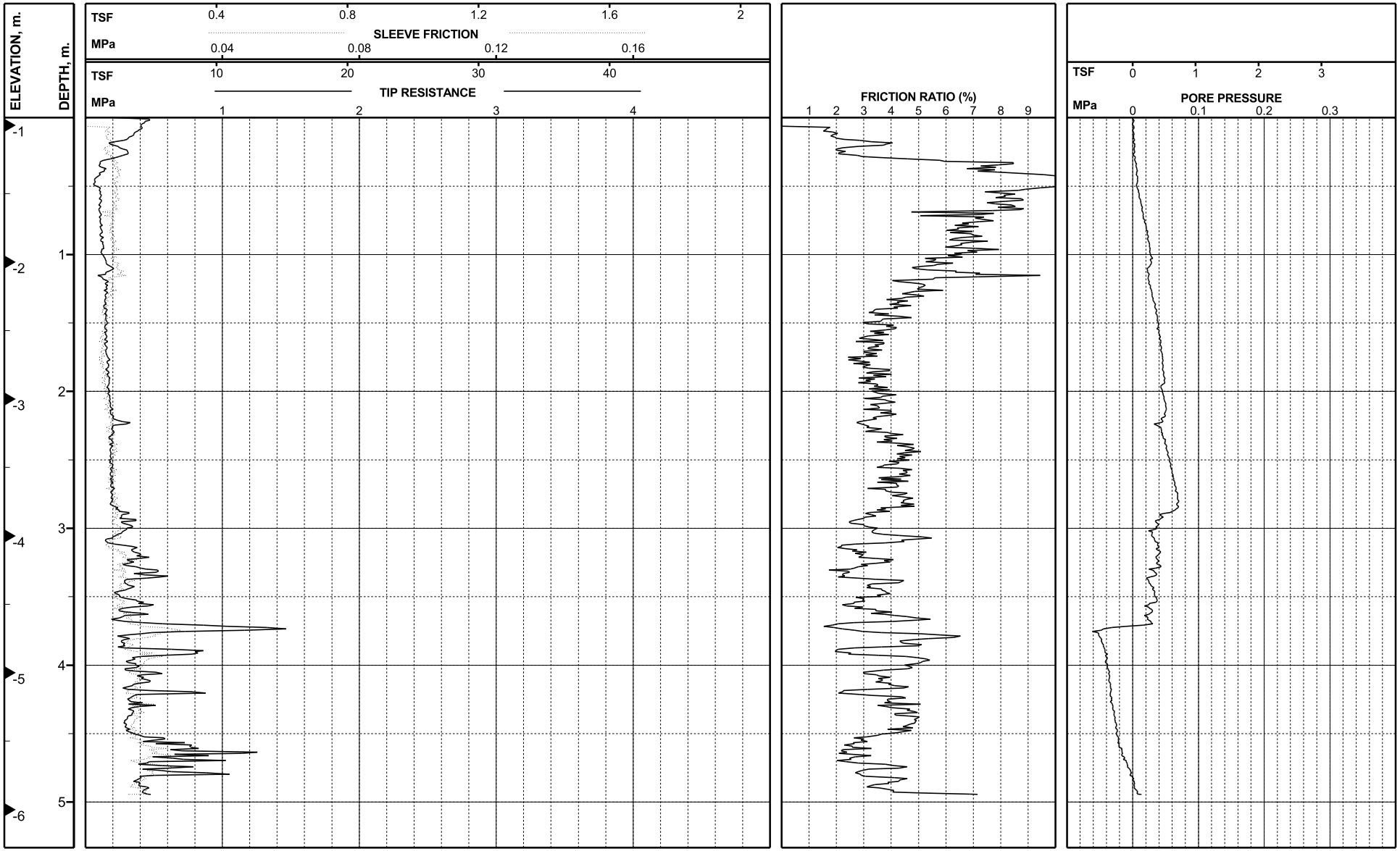
TETHERED SEASCOUT SOUNDING 98C-526

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839244 N648357 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-527 (38m left of W. Sta. 87+89)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

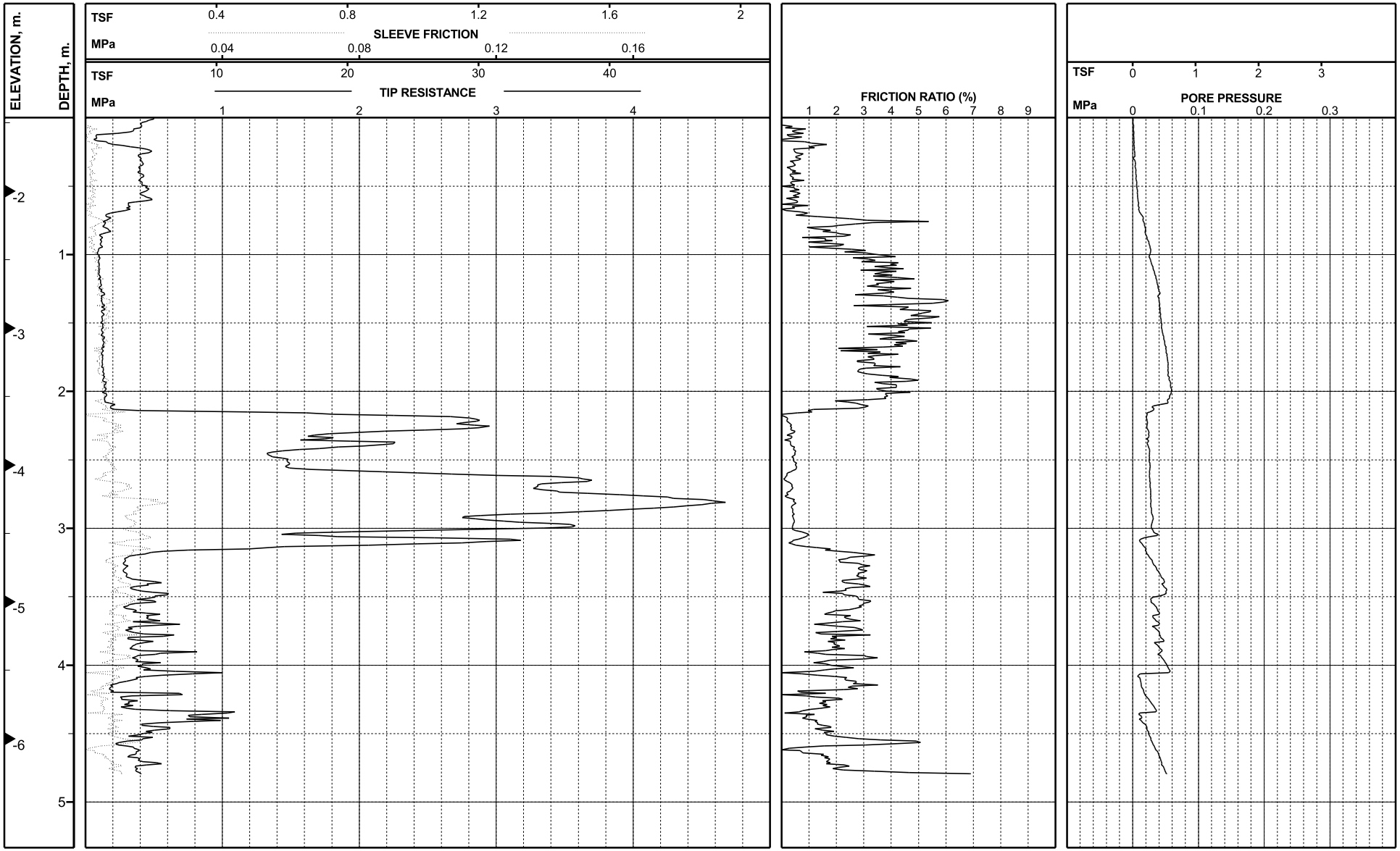
TETHERED SEASCOUT SOUNDING 98C-527

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839248 N648343 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-528 (23m left of W. Sta. 87+91)	**MUDLINE ELEVATION:**	-1.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

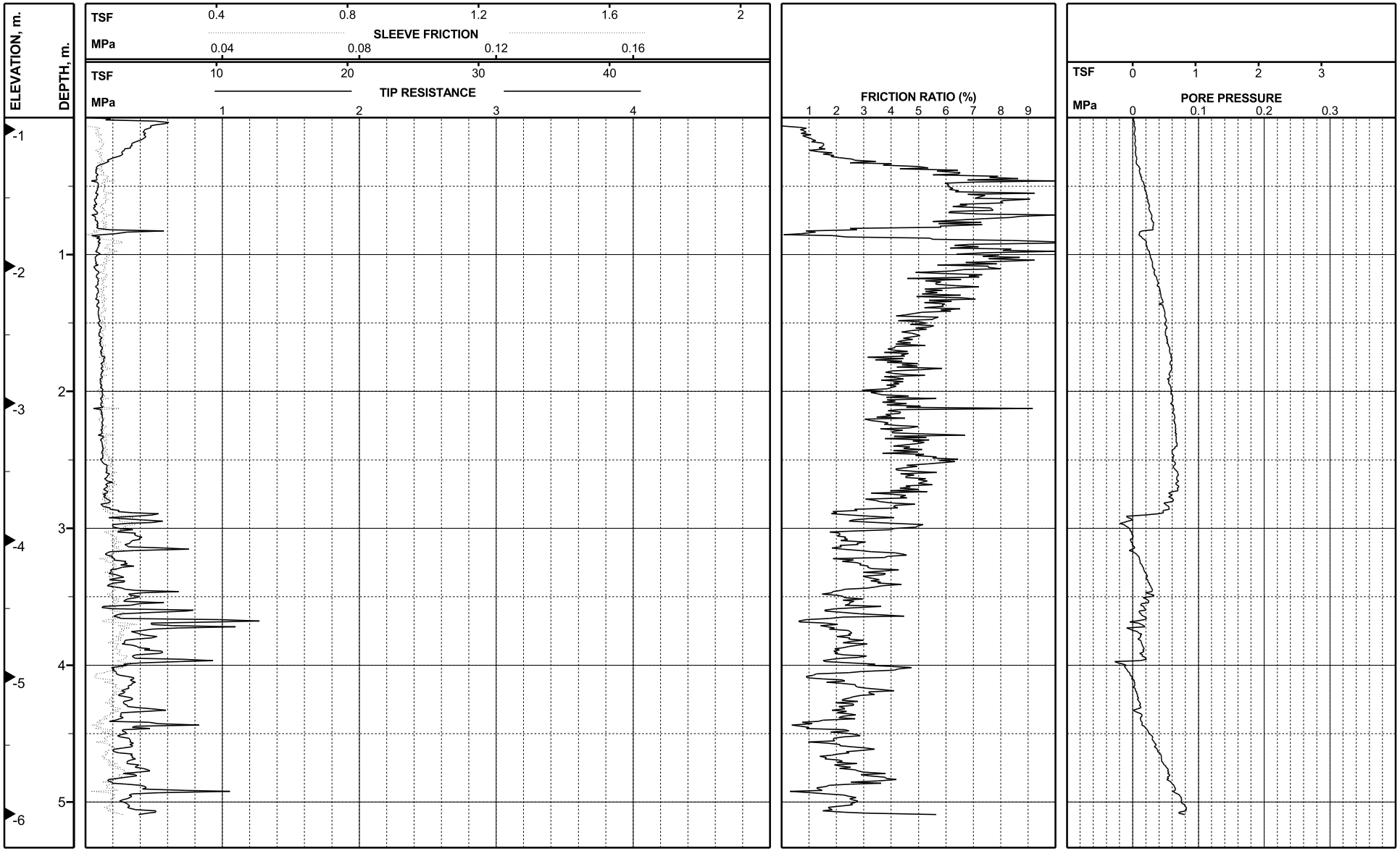
TETHERED SEASCOUT SOUNDING 98C-528

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839291 N648393 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-530 (70m left of W. Sta. 88+39)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

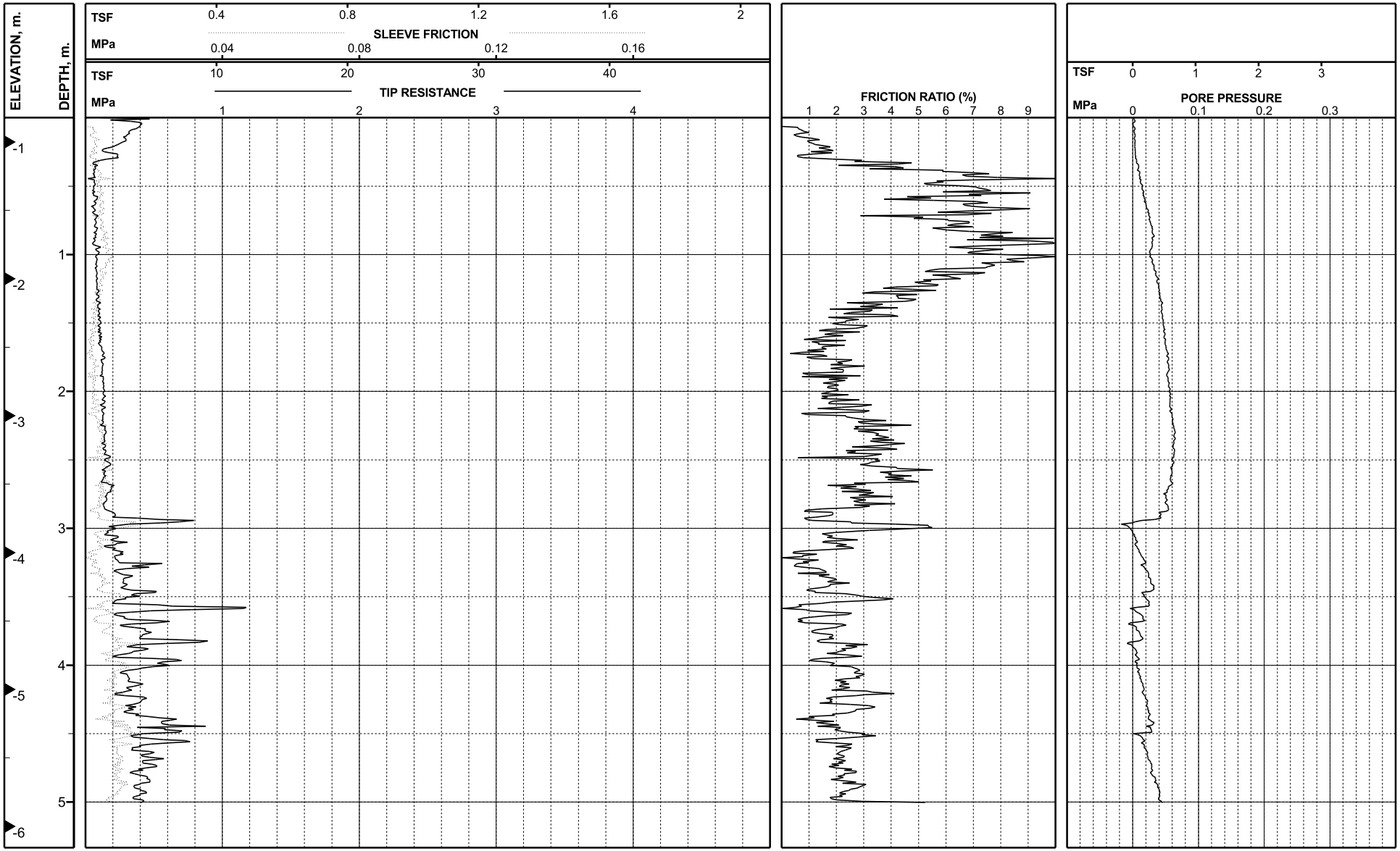
TETHERED SEASCOUT SOUNDING 98C-530

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839288 N648373 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-531 (51m left of W. Sta. 88+34)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

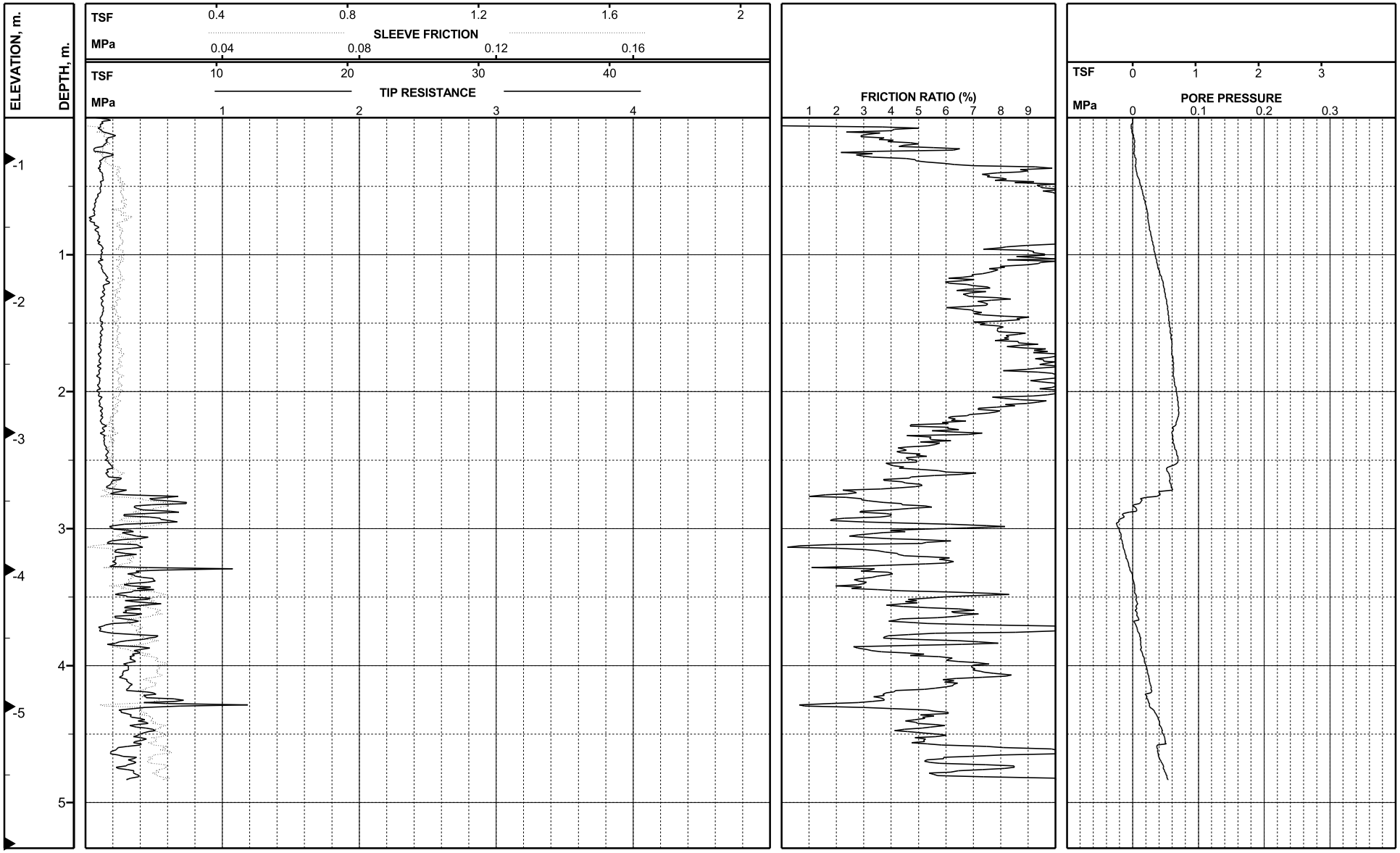
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-531

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839323 N648410 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-532 (84m left of W. Sta. 88+71)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

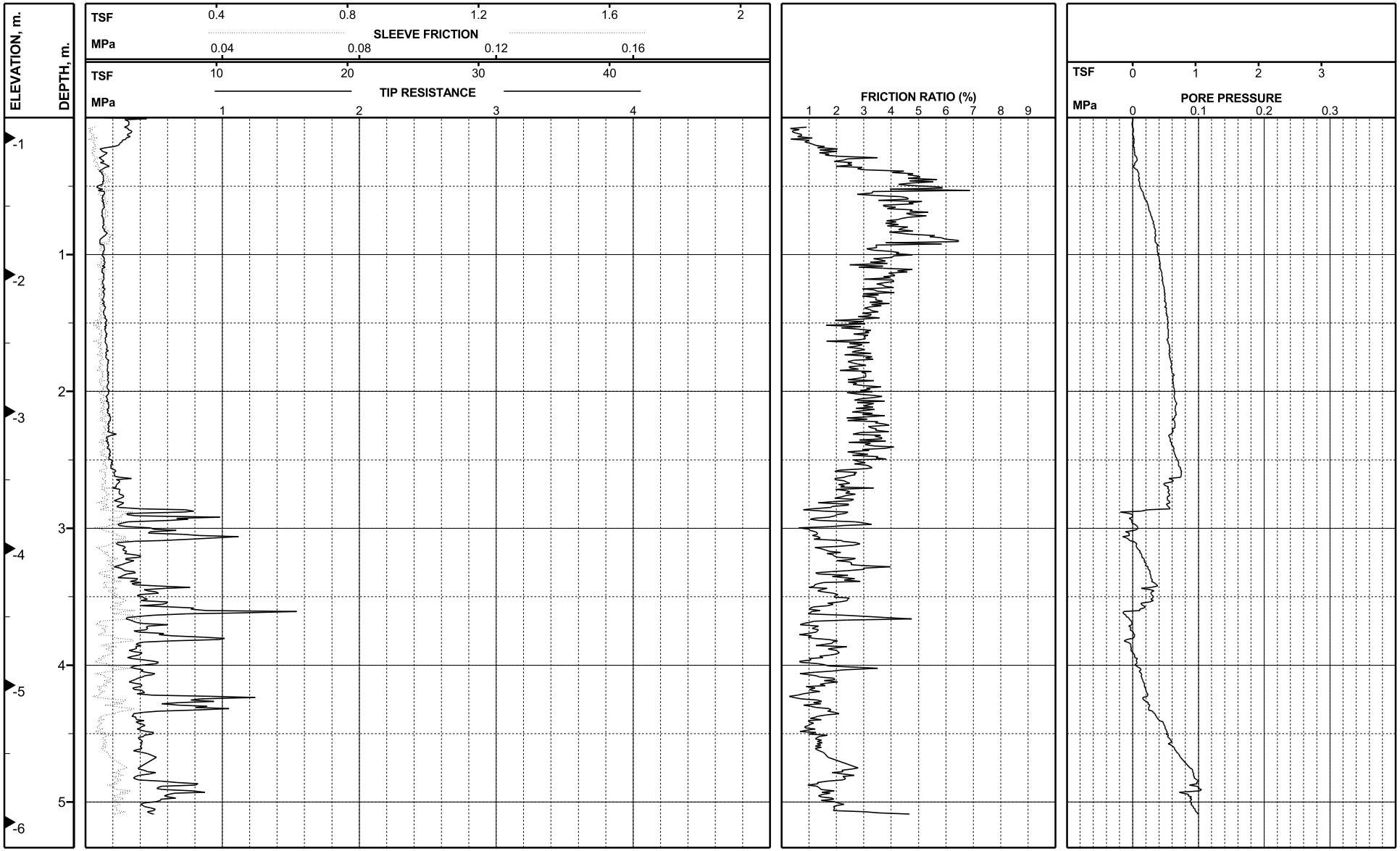
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-532

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839323 N648386 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-533 (60m left of W. Sta. 88+69)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

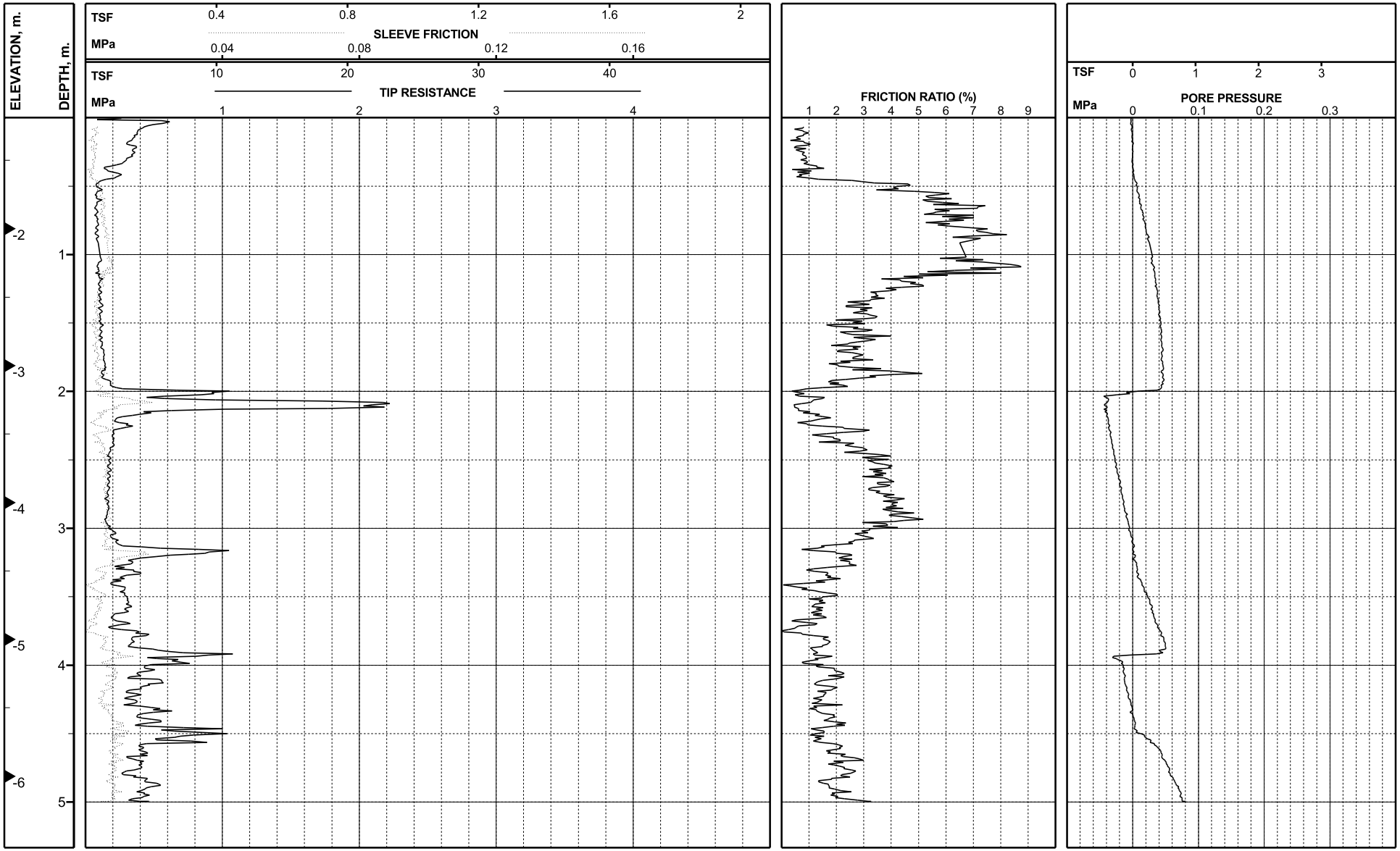
TETHERED SEASCOUT SOUNDING 98C-533

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839331 N648370 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-534 (44m left of W. Sta.88+77)	**MUDLINE ELEVATION:**	-1.2 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

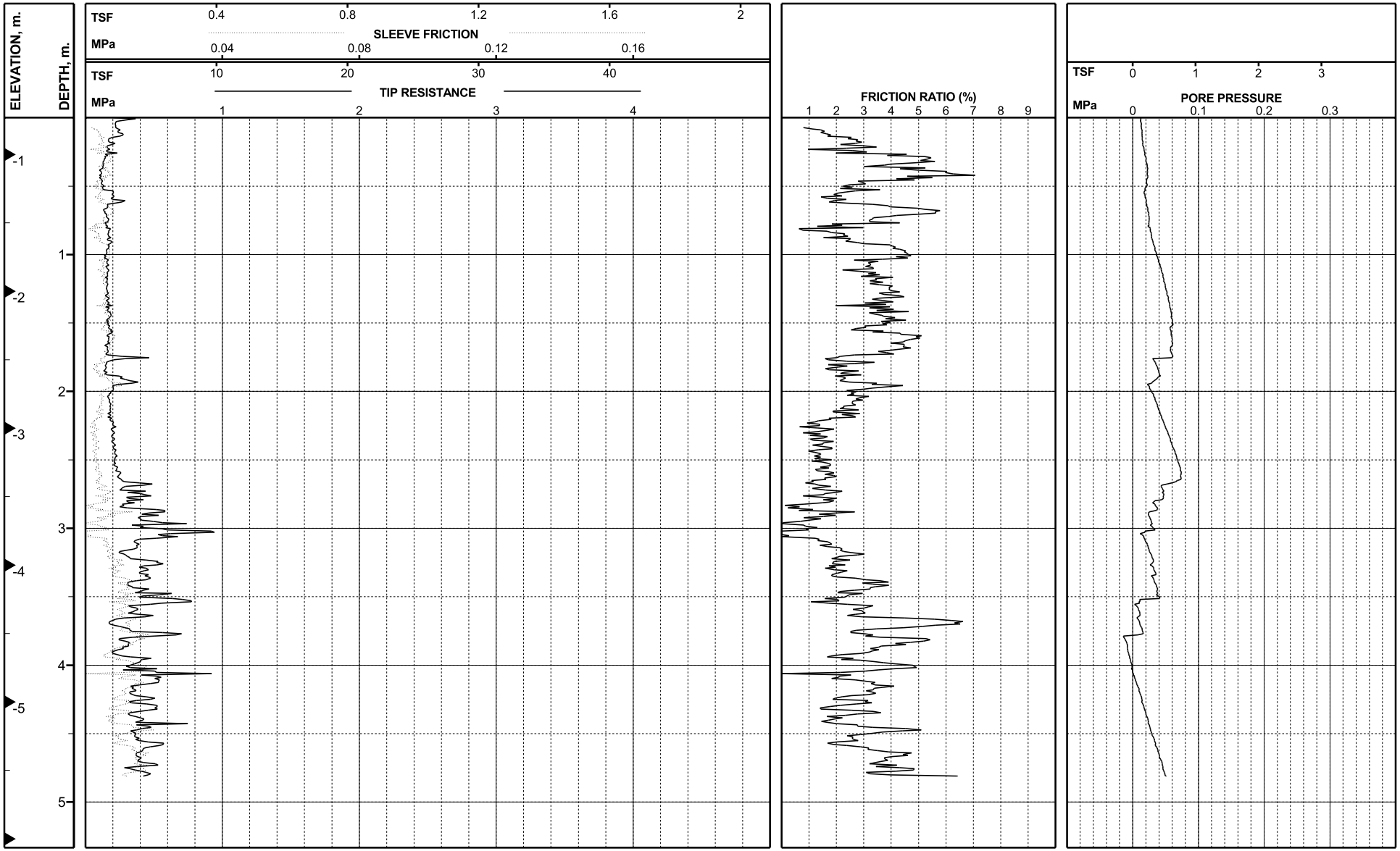
TETHERED SEASCOUT SOUNDING 98C-534

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839363 N648410 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-536 (81m left of W. Sta. 89+11)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

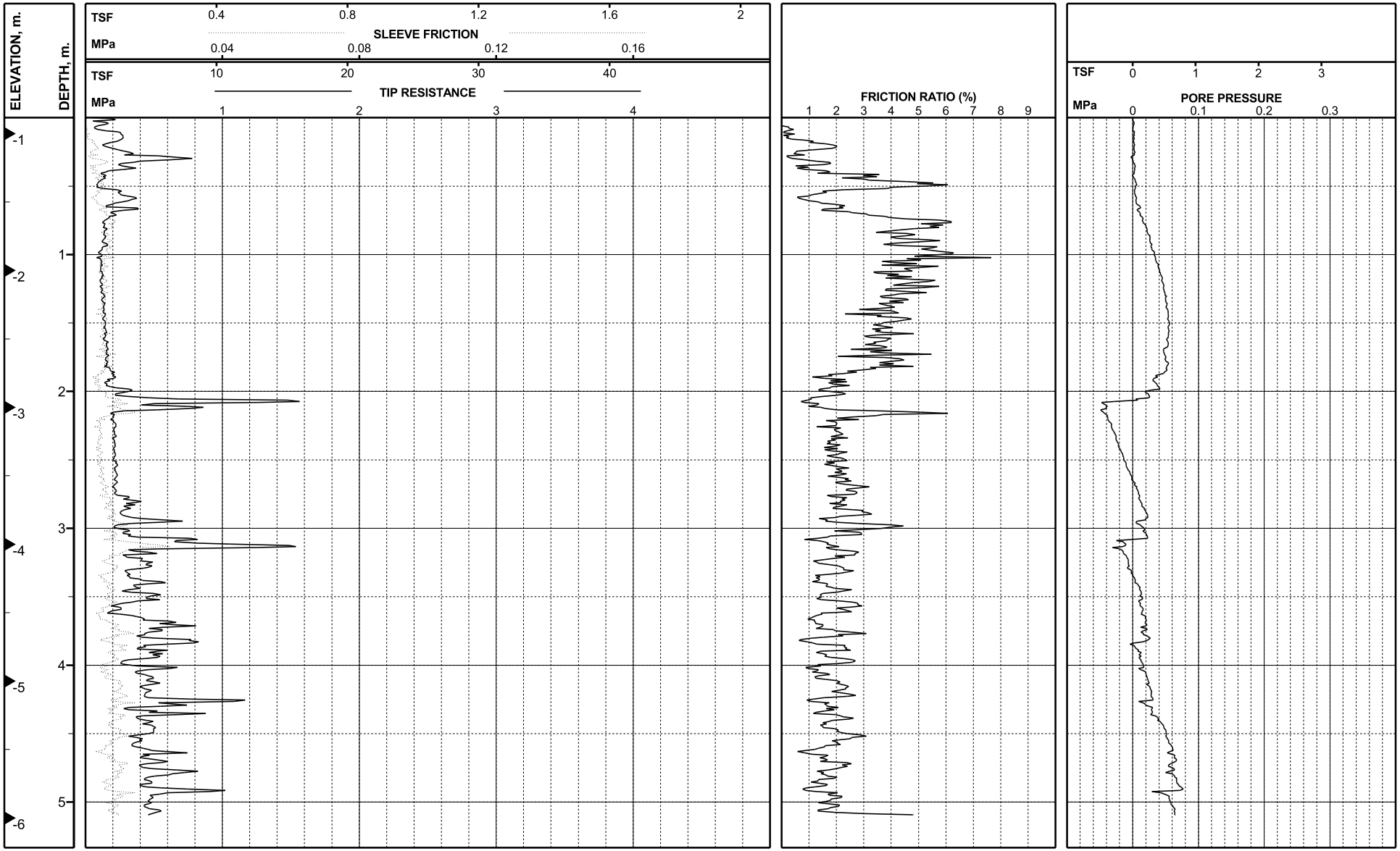
TETHERED SEASCOUT SOUNDING 98C-536

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839362 N648389 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-537 (61m left of W. Sta. 89+08)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

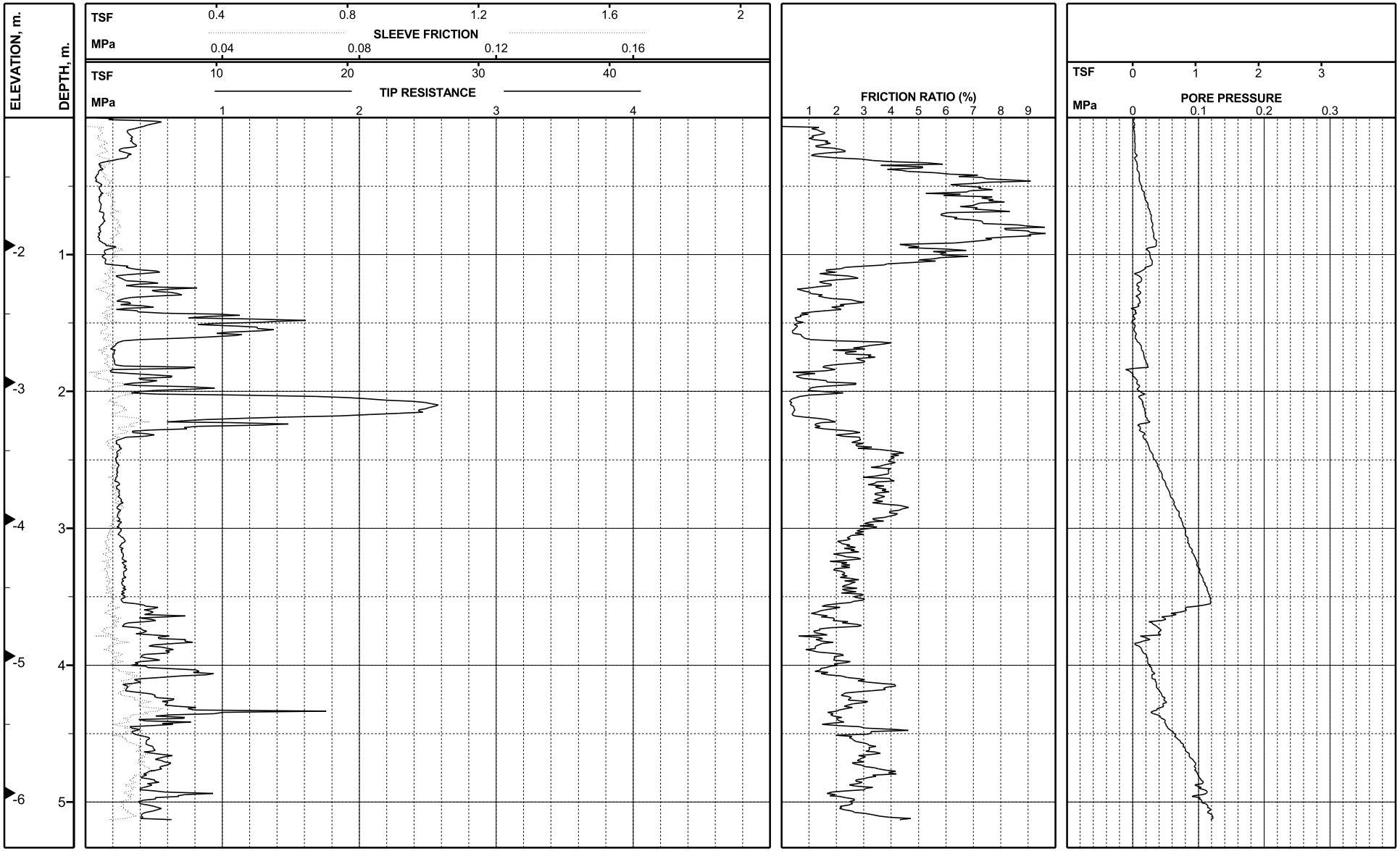
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-537

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839369 N648362 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-538 (34m left of W. Sta. 89+13)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

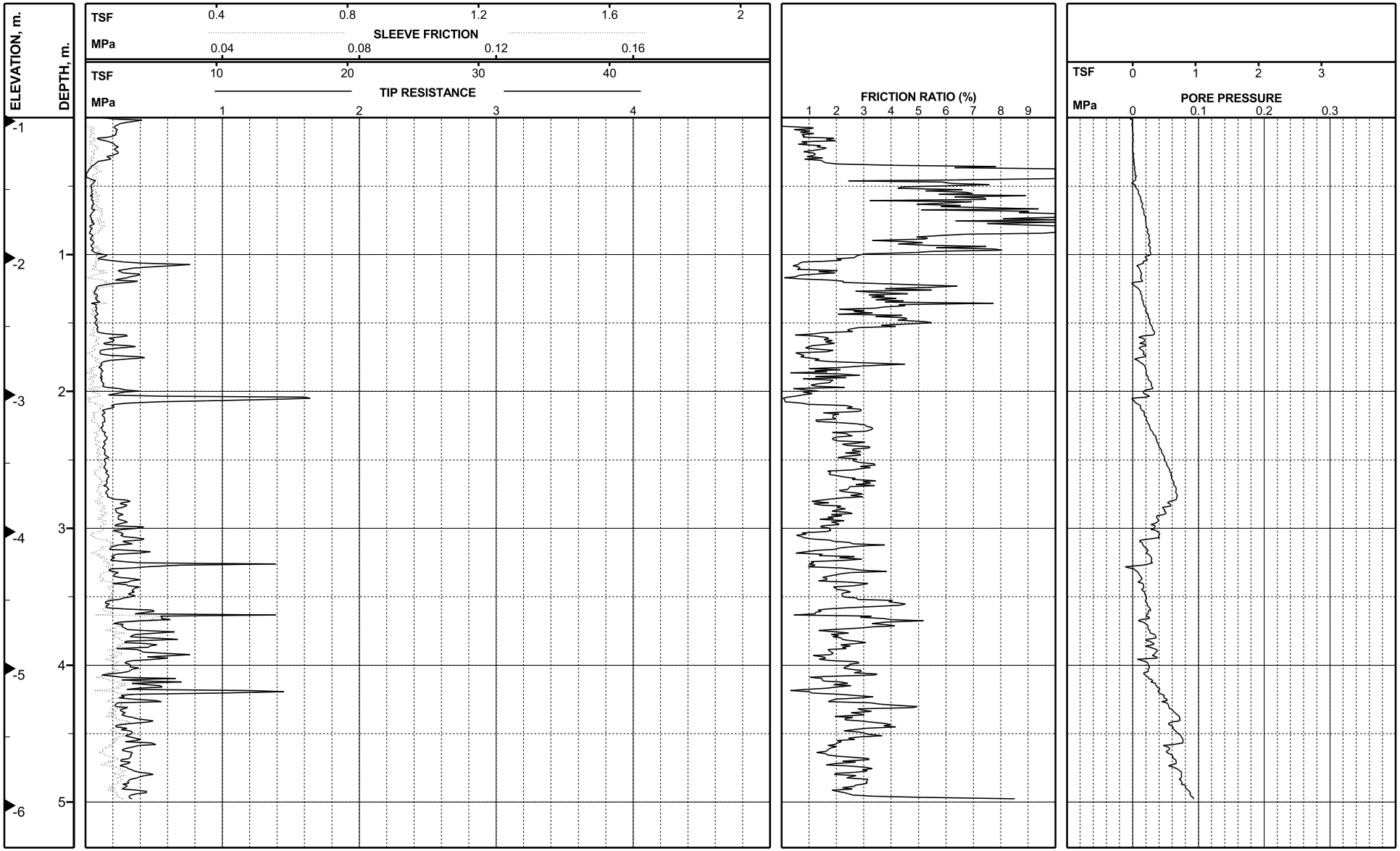
TETHERED SEASCOUT SOUNDING 98C-538

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839426 N648394 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-540 (60m left of W. Sta. 89+73)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

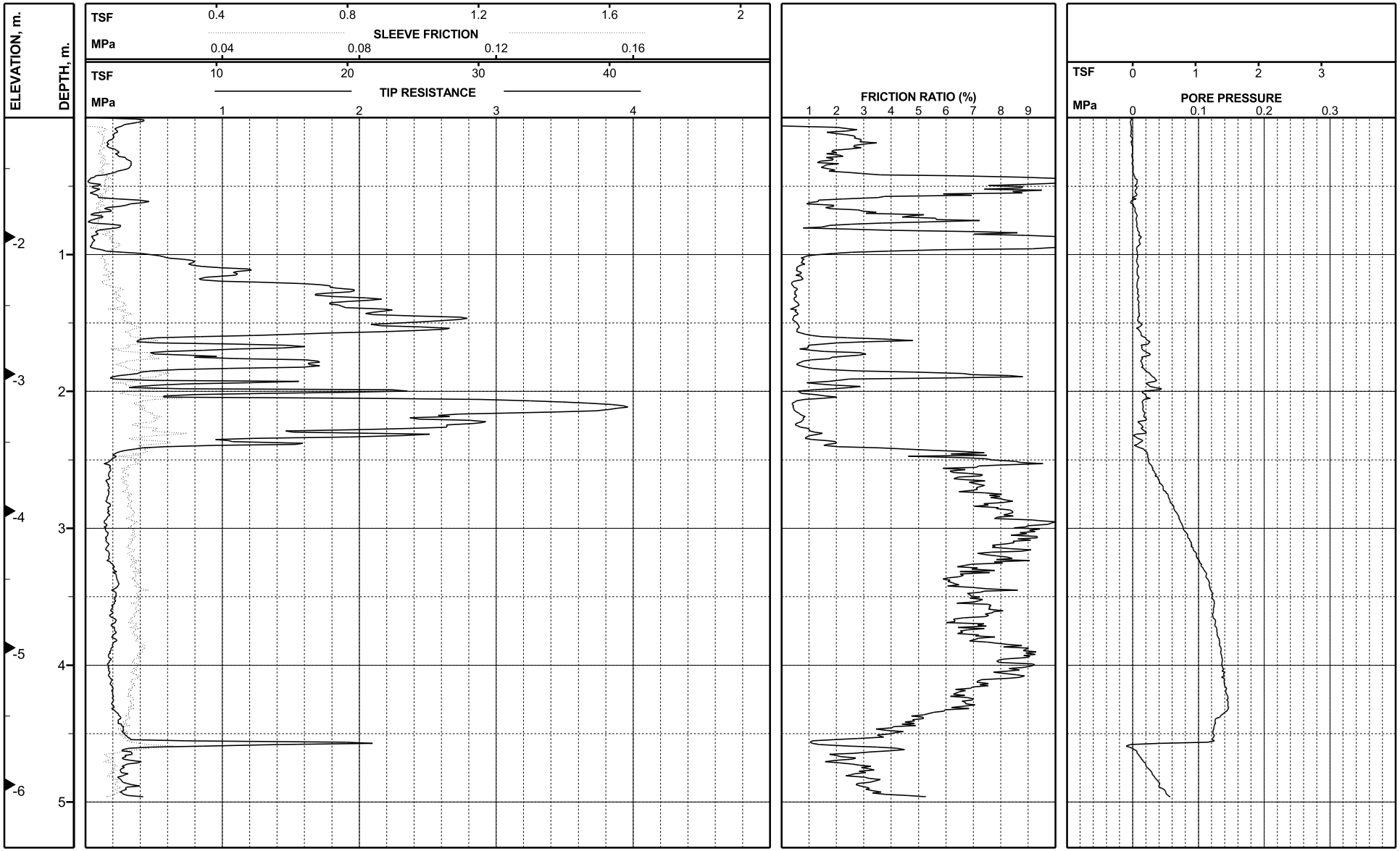
TETHERED SEASCOUT SOUNDING 98C-540

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839432 N648368 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-541 (34m left of W. Sta.89+77)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

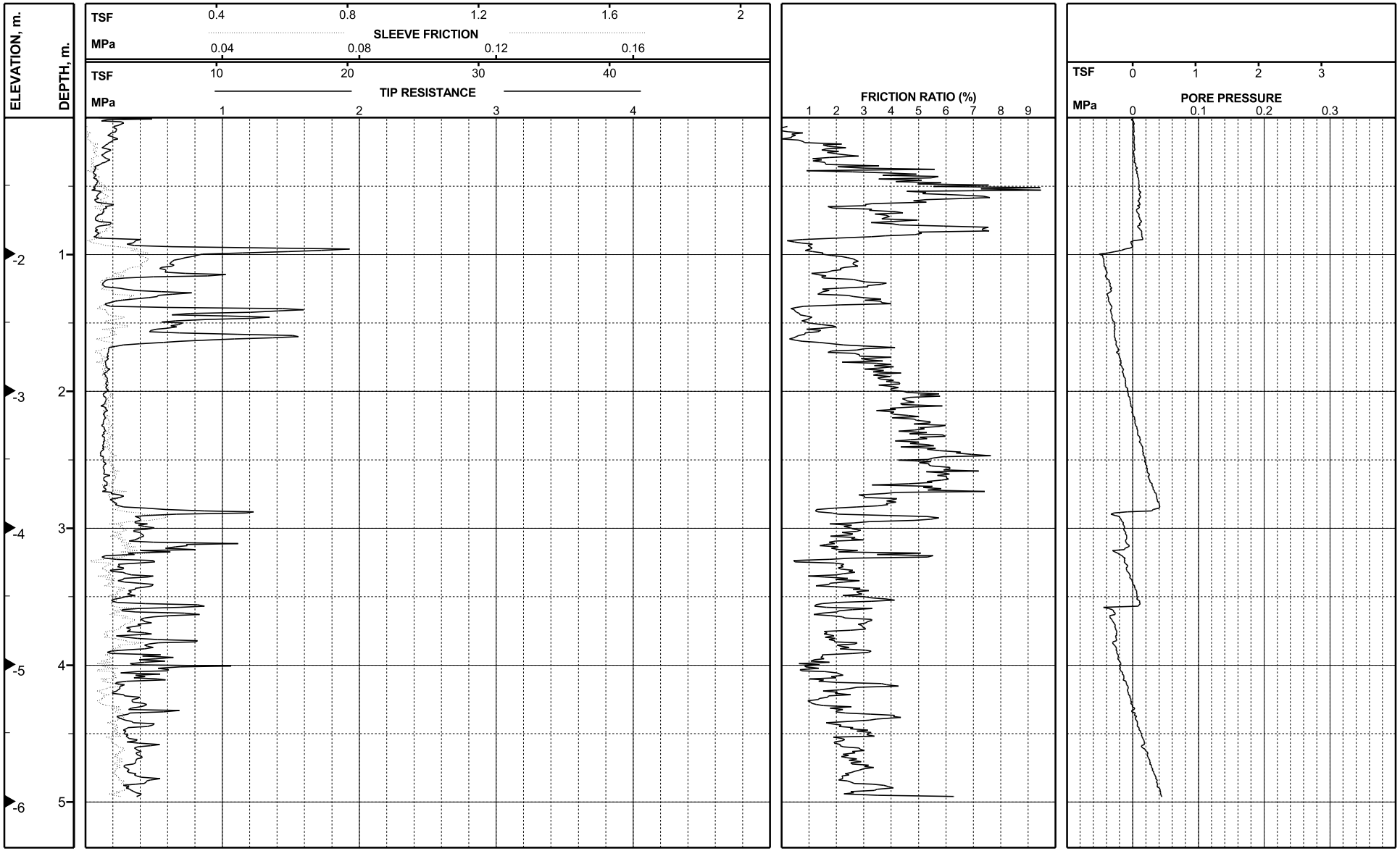
TETHERED SEASCOUT SOUNDING 98C-541

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839479 N648401 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-543 (62m left of W. Sta. 90+30)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

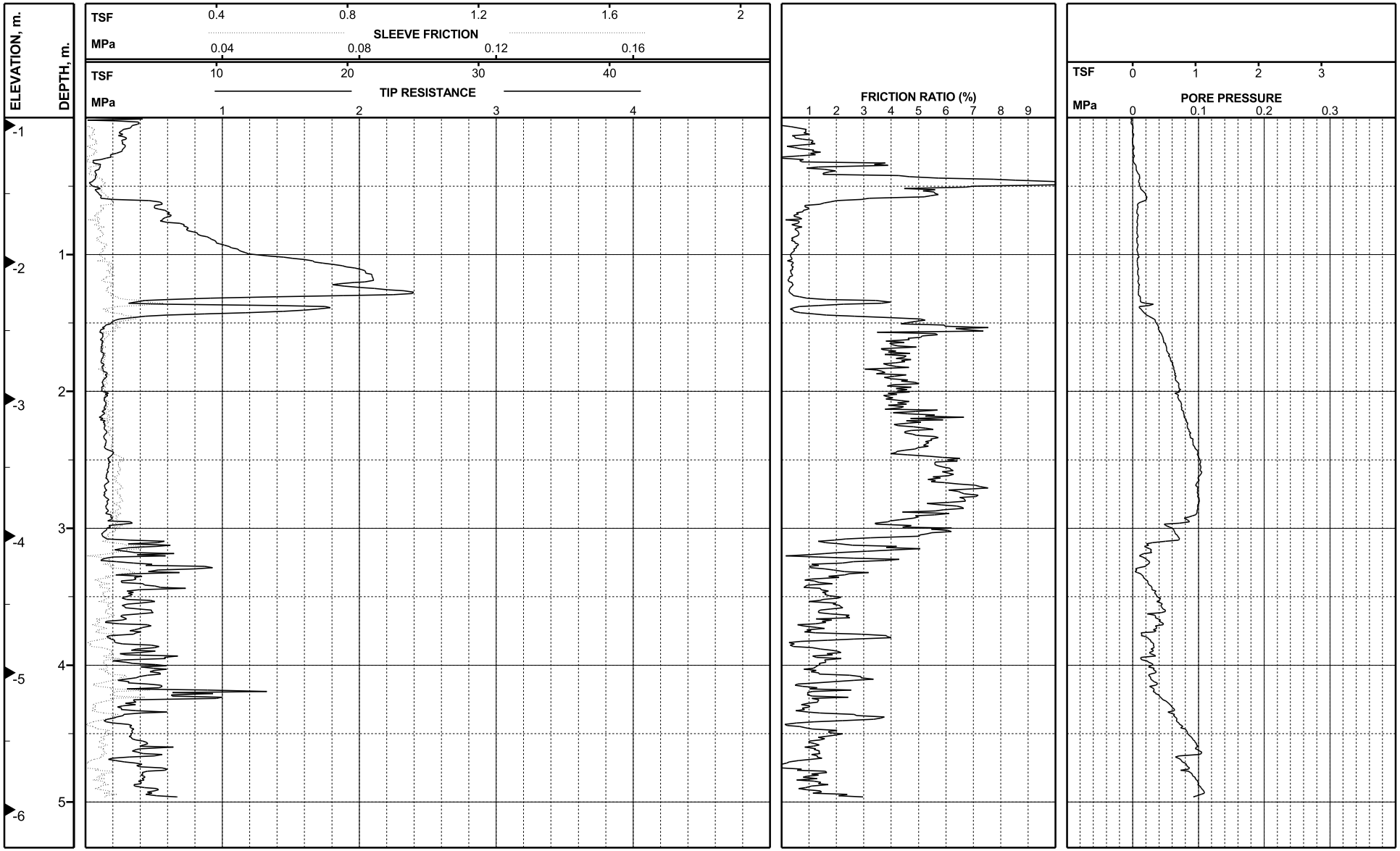
TETHERED SEASCOUT SOUNDING 98C-543

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839475 N648382 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-544 (44m left of W. Sta. 90+24)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

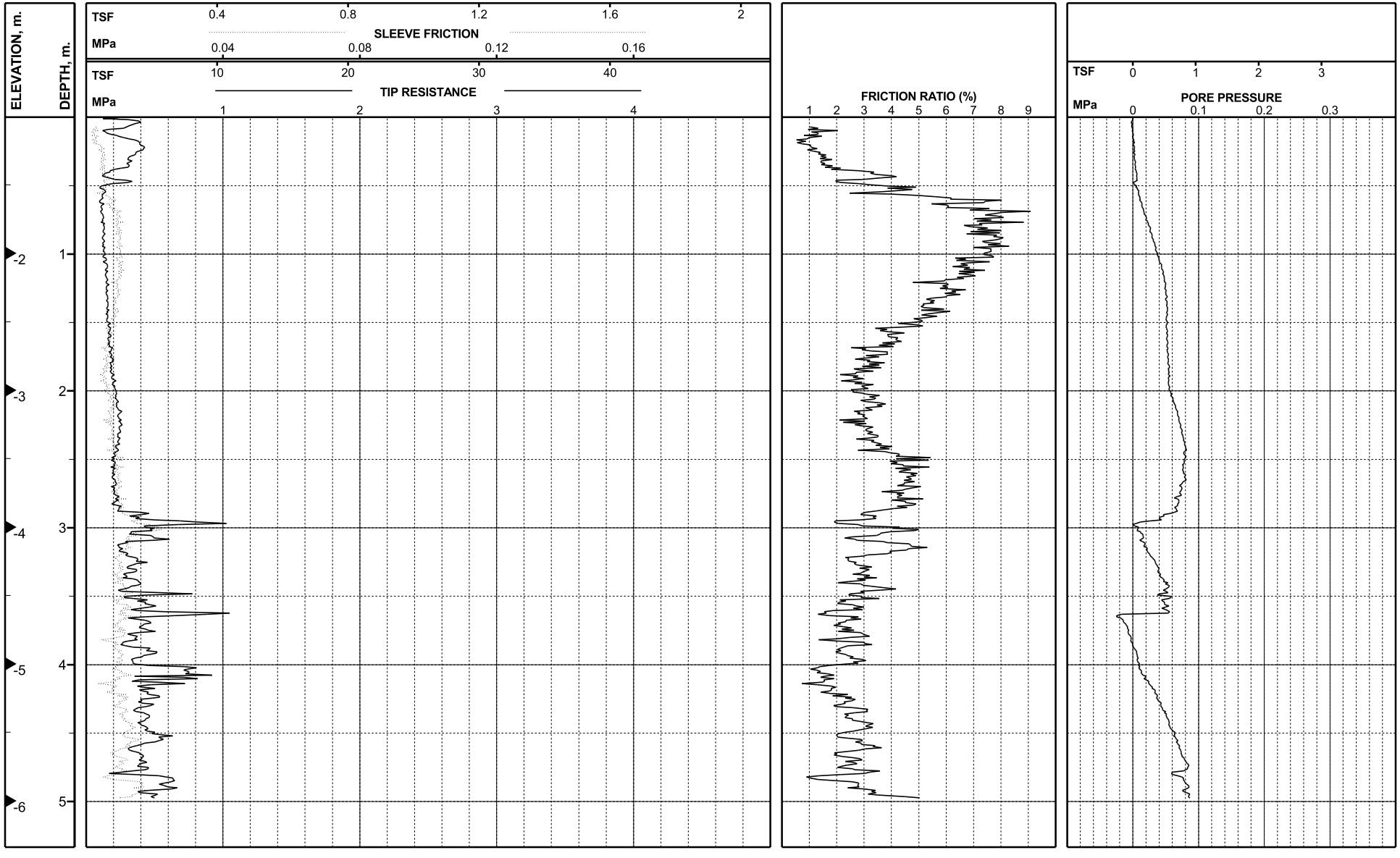
TETHERED SEASCOUT SOUNDING 98C-544

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839535 N648410 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-546 (62m left of W. Sta. 90+89)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

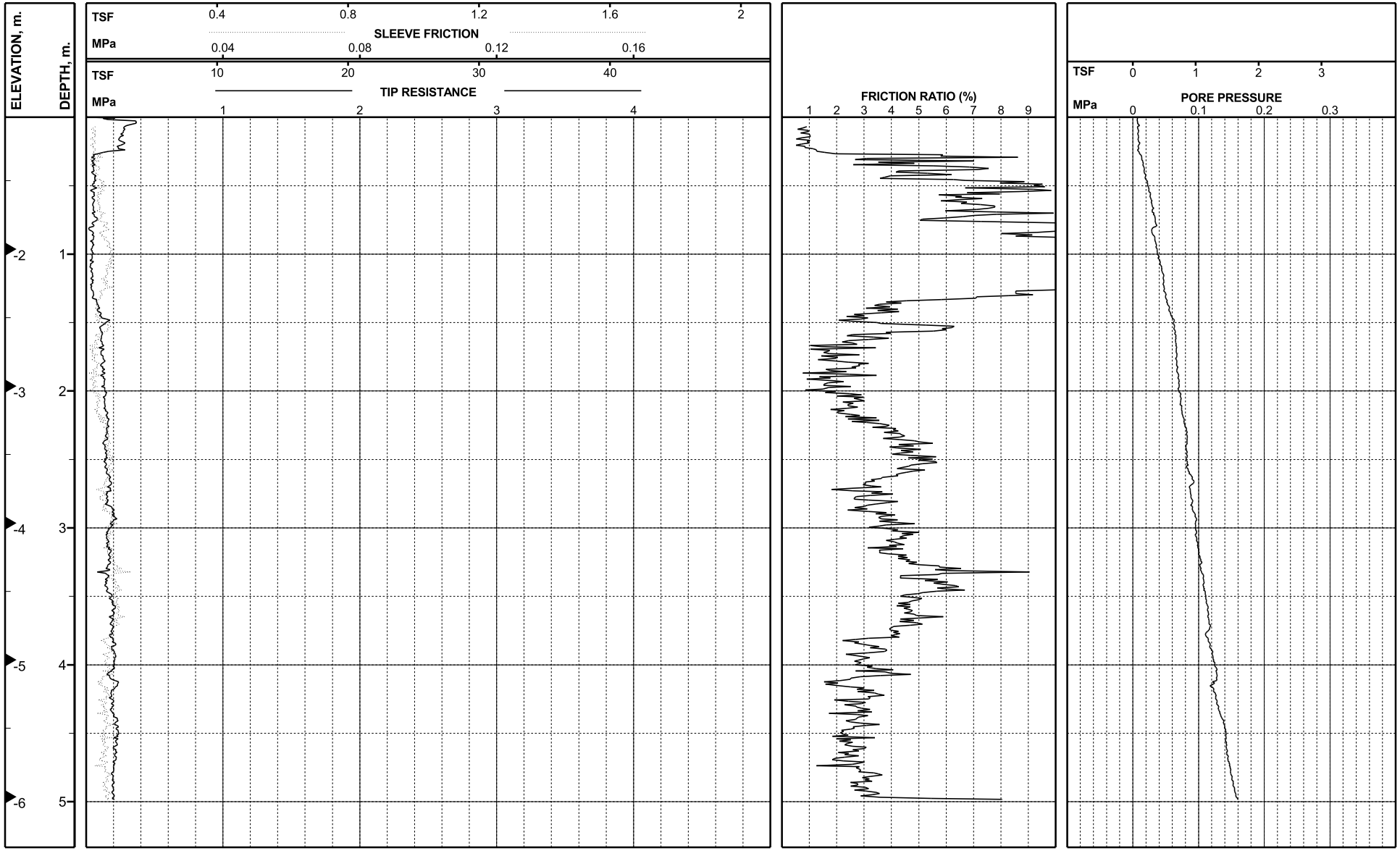
TETHERED SEASCOUT SOUNDING 98C-546

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839540 N648389 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-547 (40m left of W. Sta. 90+91)	**MUDLINE ELEVATION:**	-1.0 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

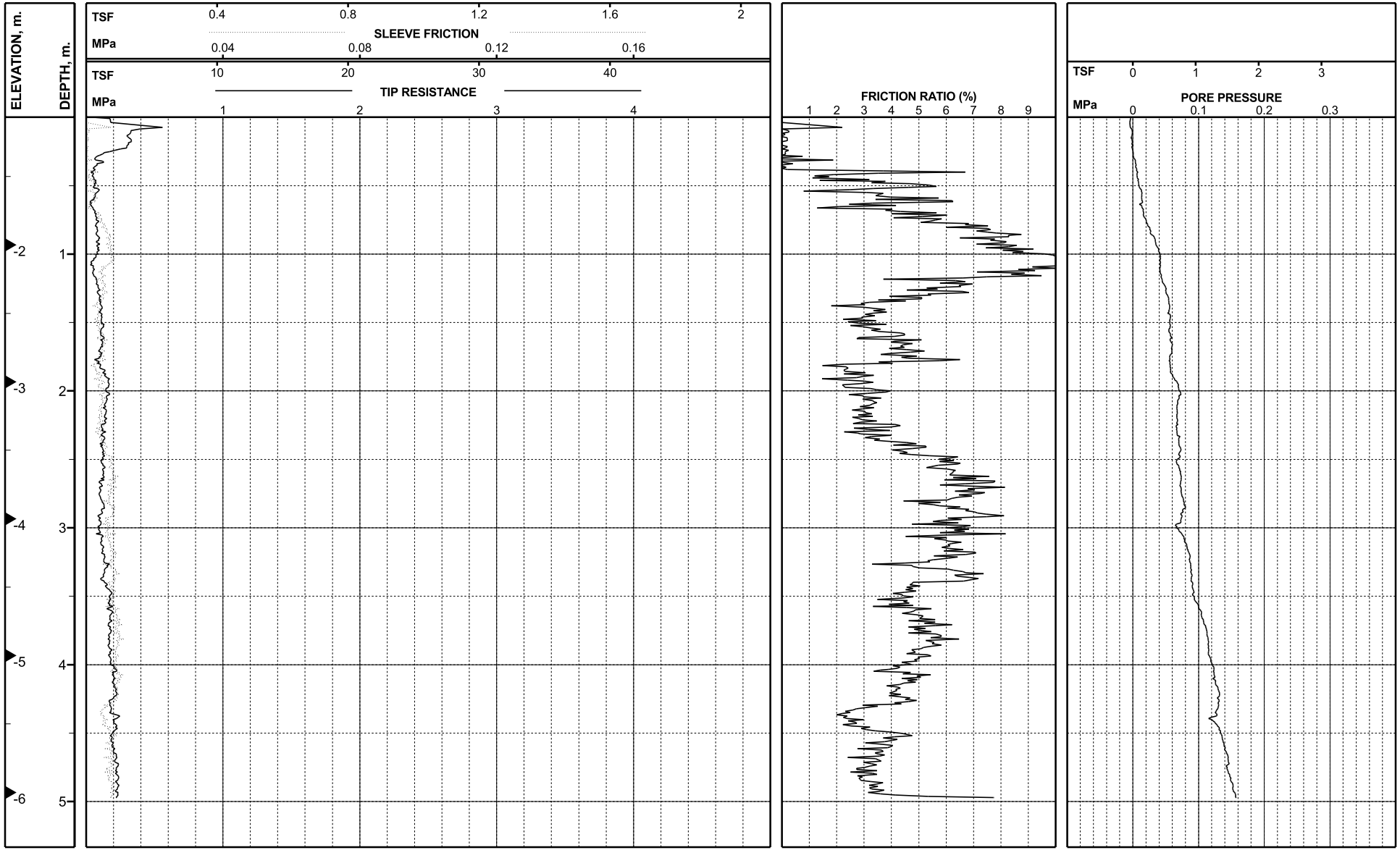
TETHERED SEASCOUT SOUNDING 98C-547

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839537 N648384 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-548 (36m left of W. Sta. 90+86)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

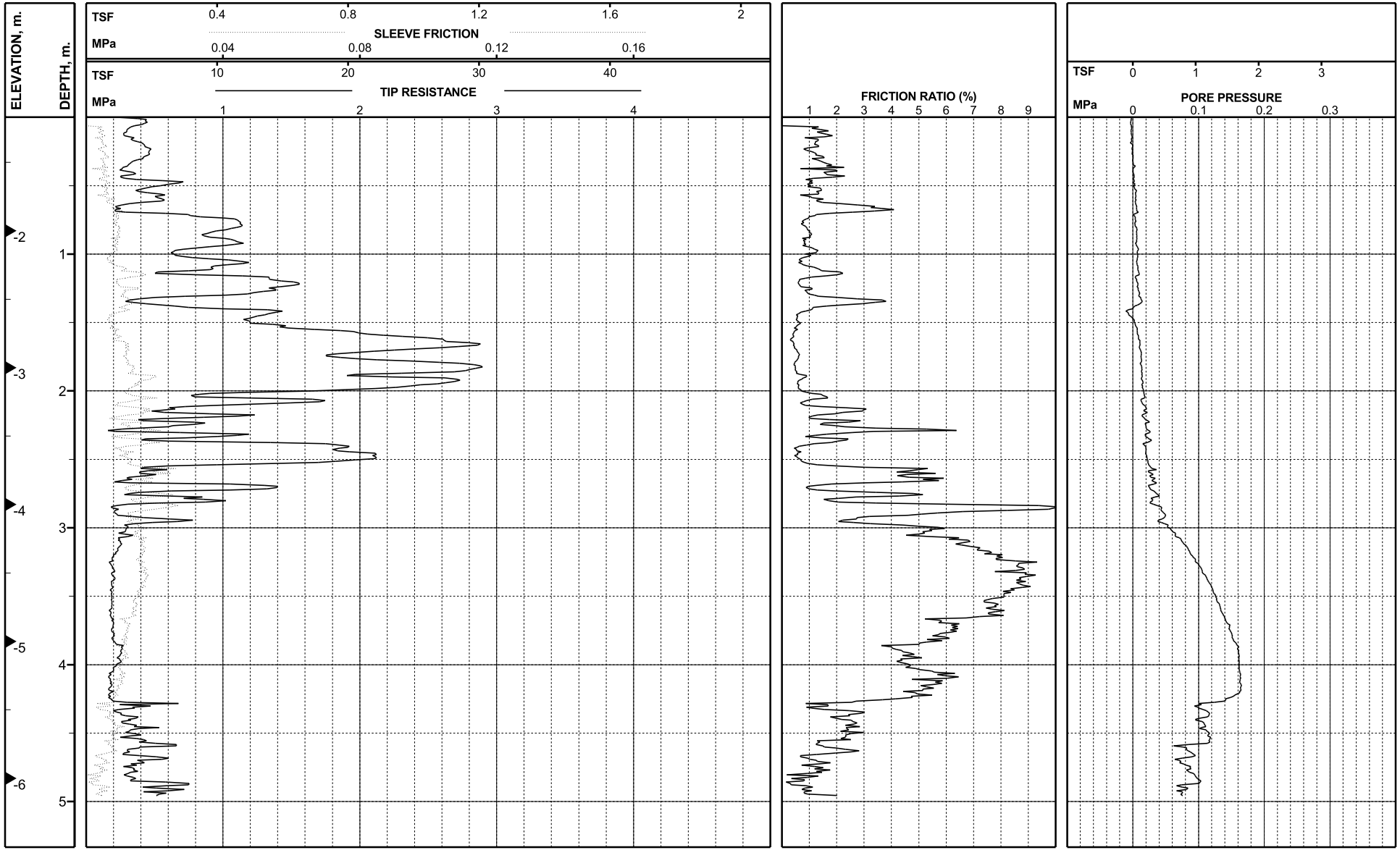
TETHERED SEASCOUT SOUNDING 98C-548

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839604 N648404 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightening
EXPLORATION NO.:	98C-549 (42m left of W. Sta. 91+58)	**MUDLINE ELEVATION:**	-1.2 m (MSL)	**TEST DATE:**	12/18/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

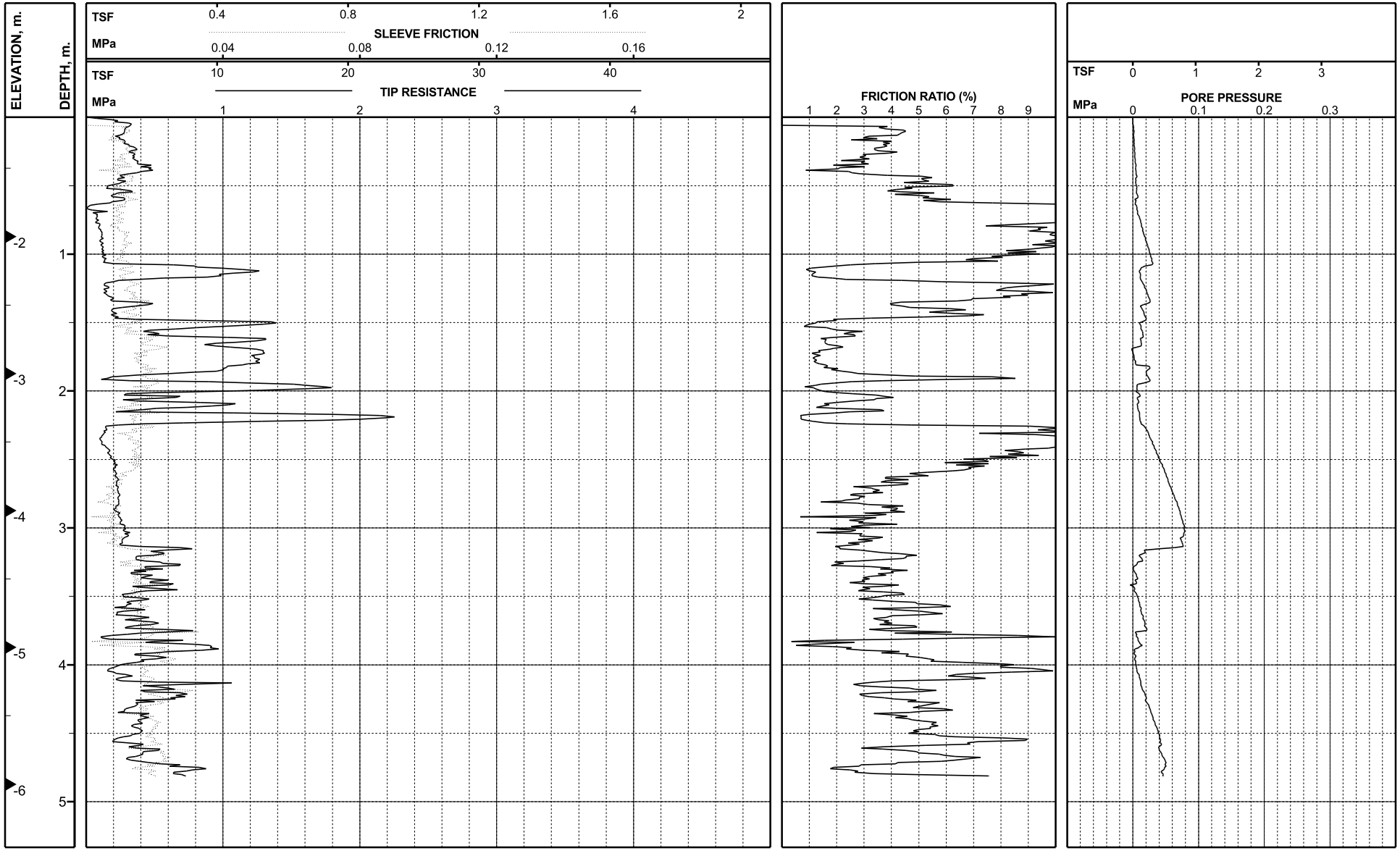
TETHERED SEASCOUT SOUNDING 98C-549

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839586 N648410 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-550 (53m left of W. Sta. 91+41)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

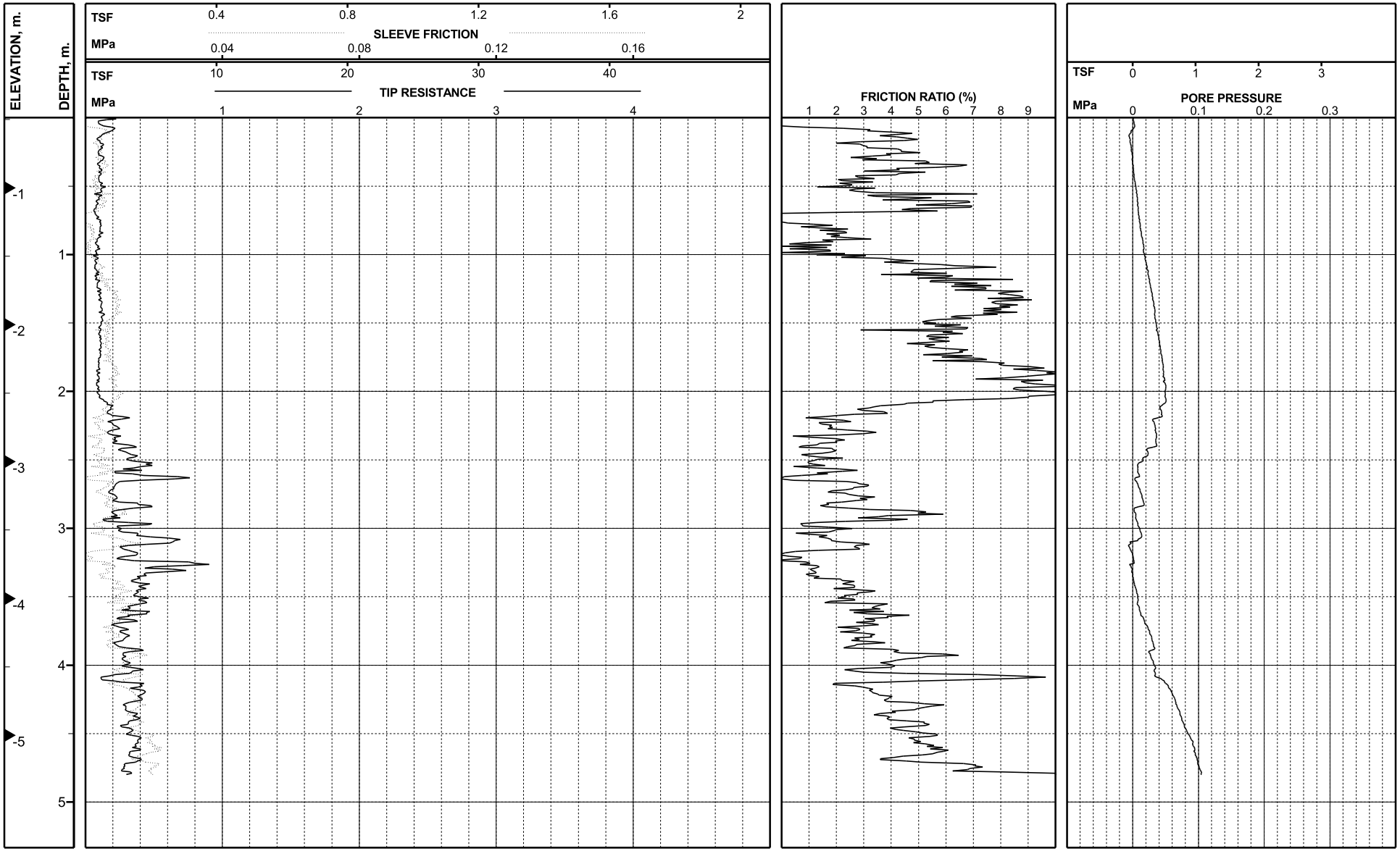
TETHERED SEASCOUT SOUNDING 98C-550

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839467 N648449 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-552 (111m left of W. Sta. 90+24)	**MUDLINE ELEVATION:**	-0.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

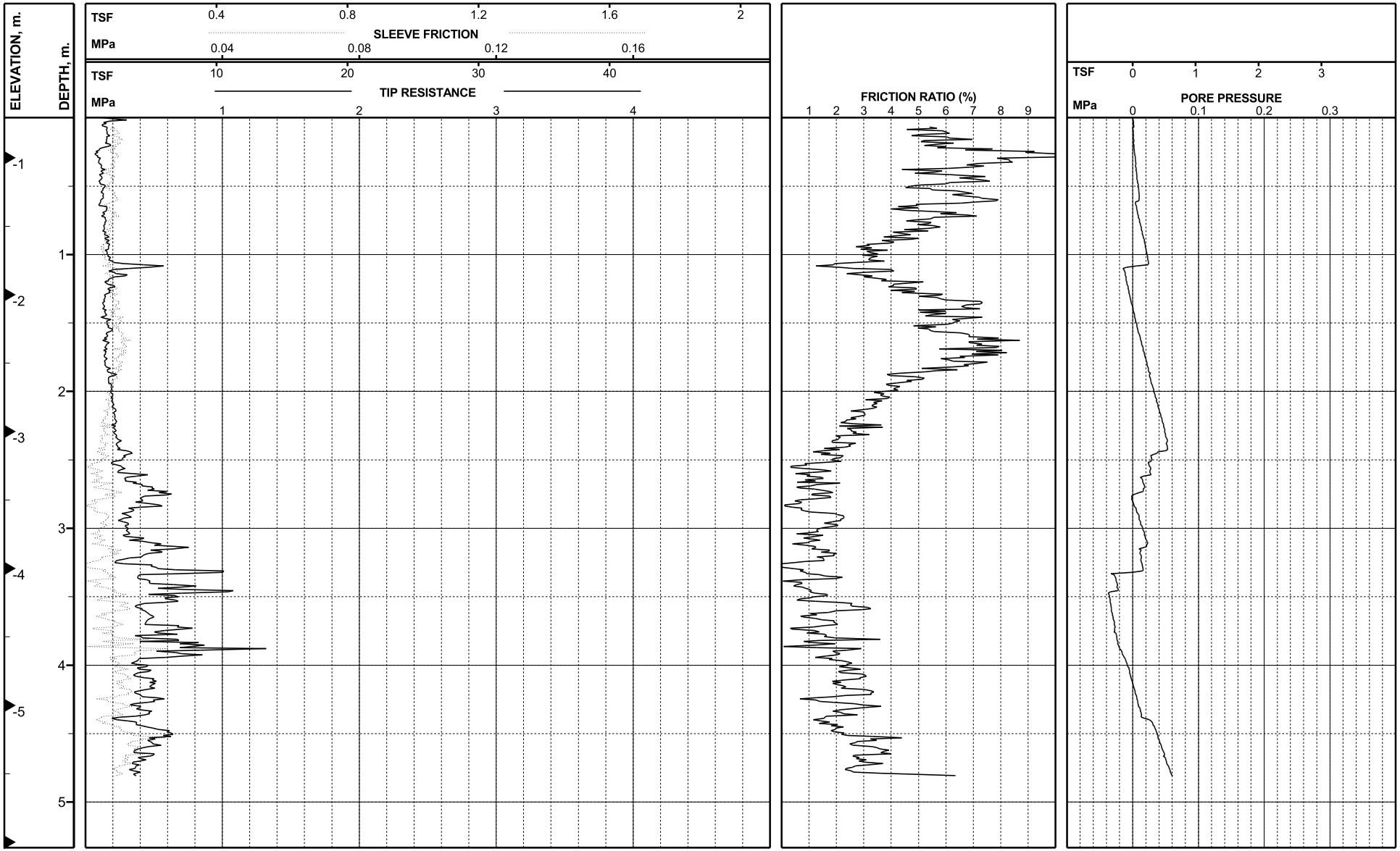
LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-552

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839429 N648414 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-553 (81m left of W. Sta. 89+78)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/15/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

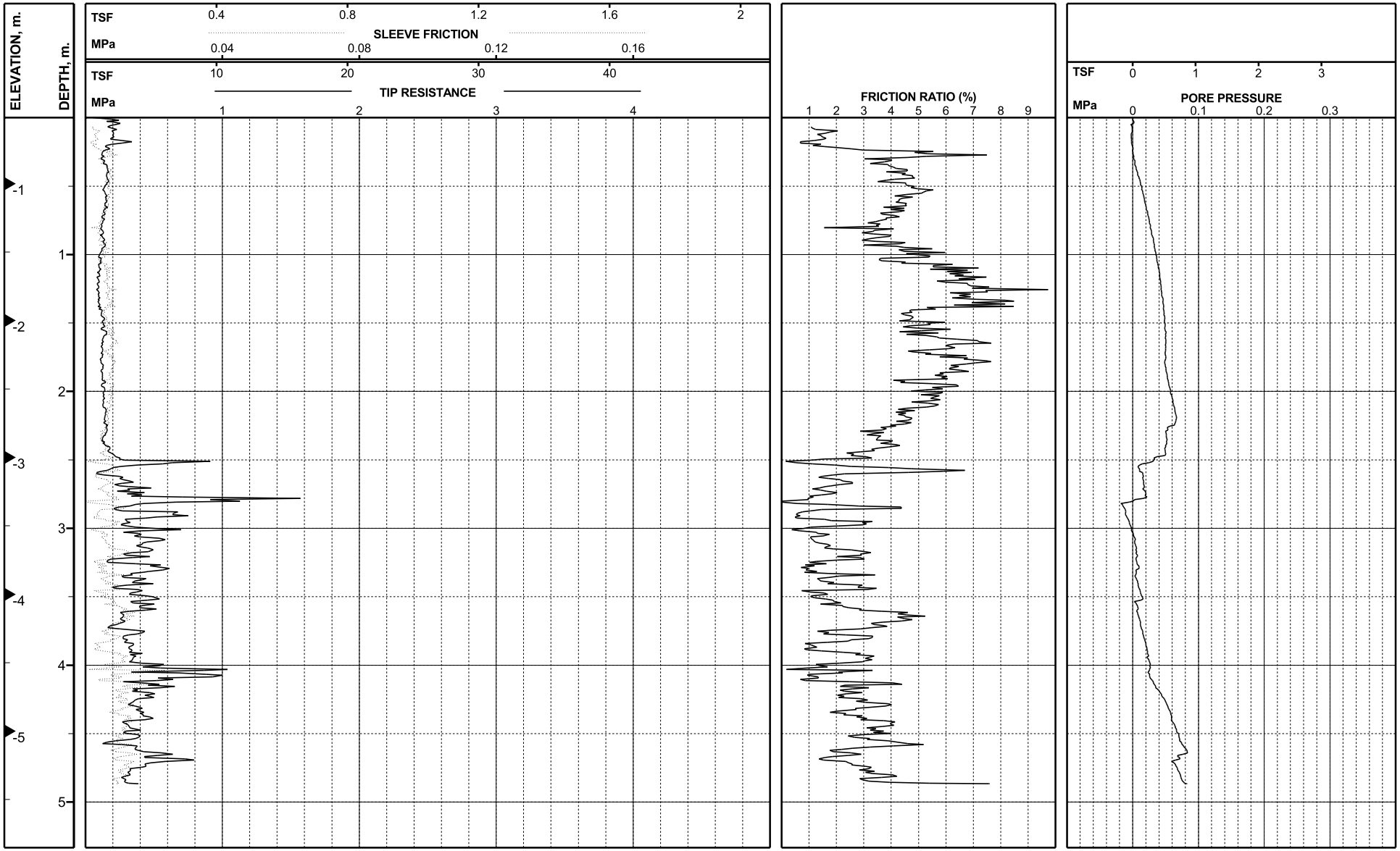
TETHERED SEASCOUT SOUNDING 98C-553

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839362 N648440 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-554 (112m left of W. Sta. 89+12)	**MUDLINE ELEVATION:**	-0.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

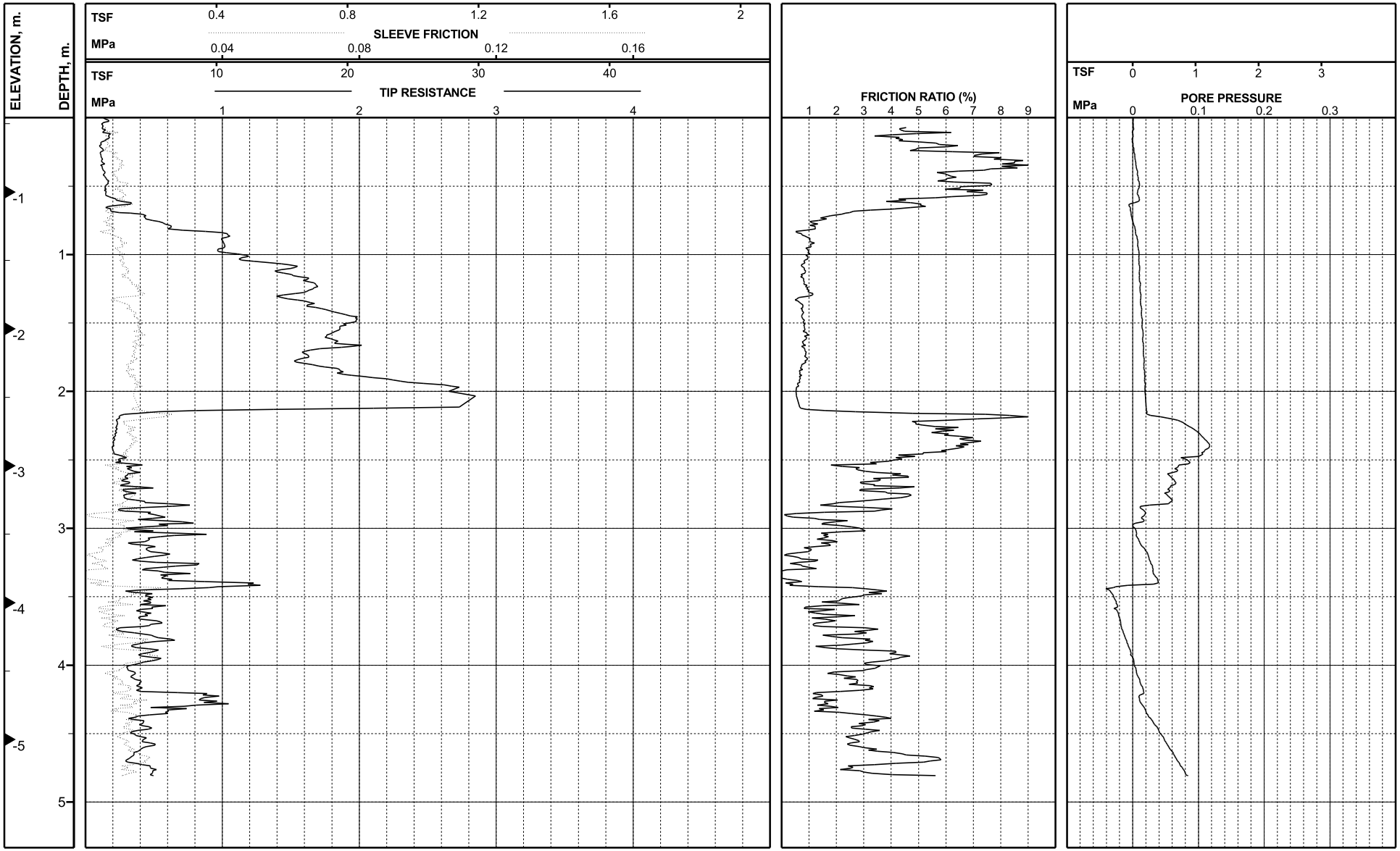
TETHERED SEASCOUT SOUNDING 98C-554

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839323 N648435 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-555 (109m left of W. Sta. 88+74)	**MUDLINE ELEVATION:**	-0.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

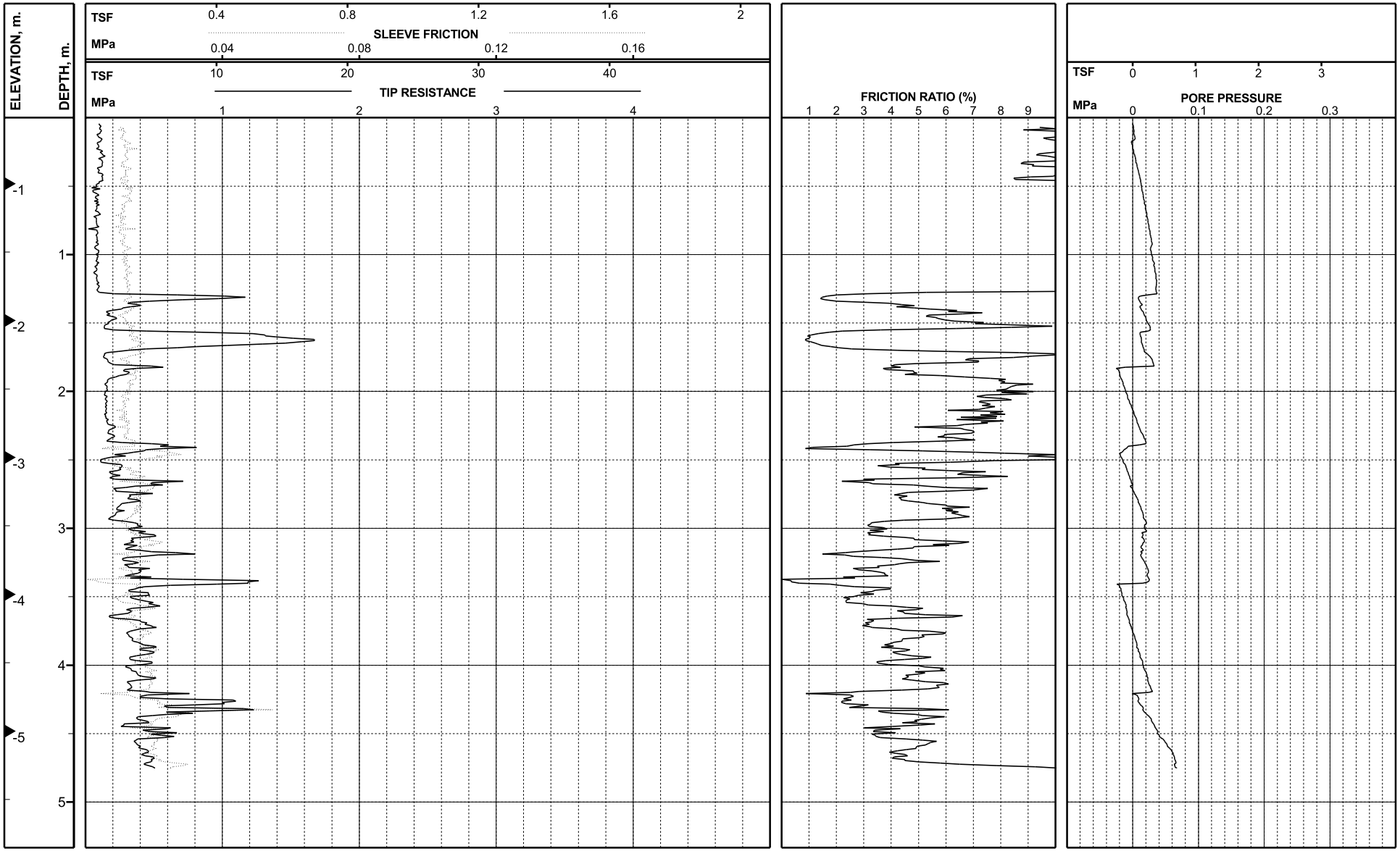
TETHERED SEASCOUT SOUNDING 98C-555

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839239 N648439 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-556 (120m left of W. Sta. 87+89)	**MUDLINE ELEVATION:**	-0.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

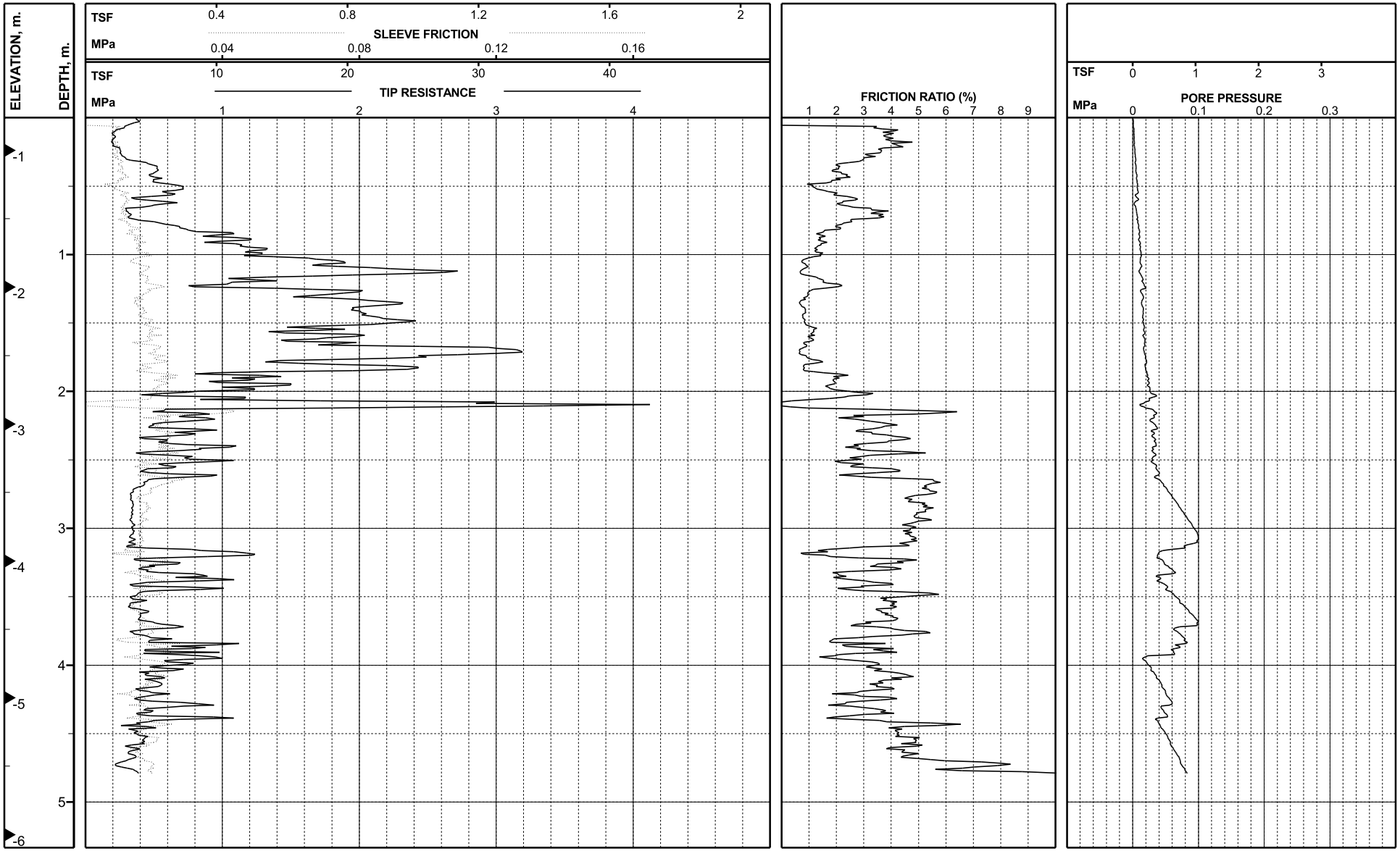
TETHERED SEASCOUT SOUNDING 98C-556

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839154 N648421 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-557 (109m left of W. Sta. 87+04)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

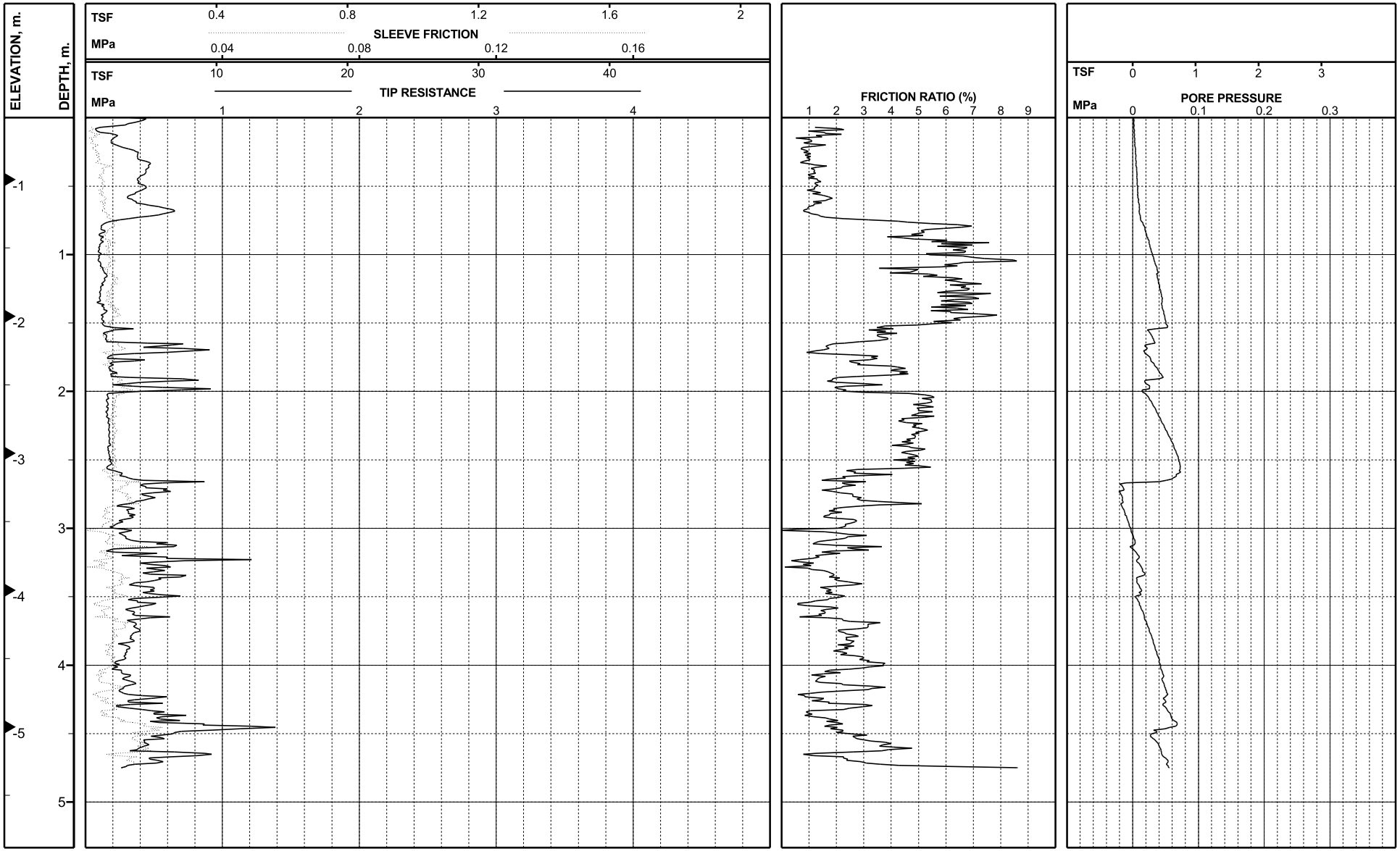
TETHERED SEASCOUT SOUNDING 98C-557

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838910 N648317 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-558 (26m left of W. Sta. 84+53)	**MUDLINE ELEVATION:**	-0.5 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

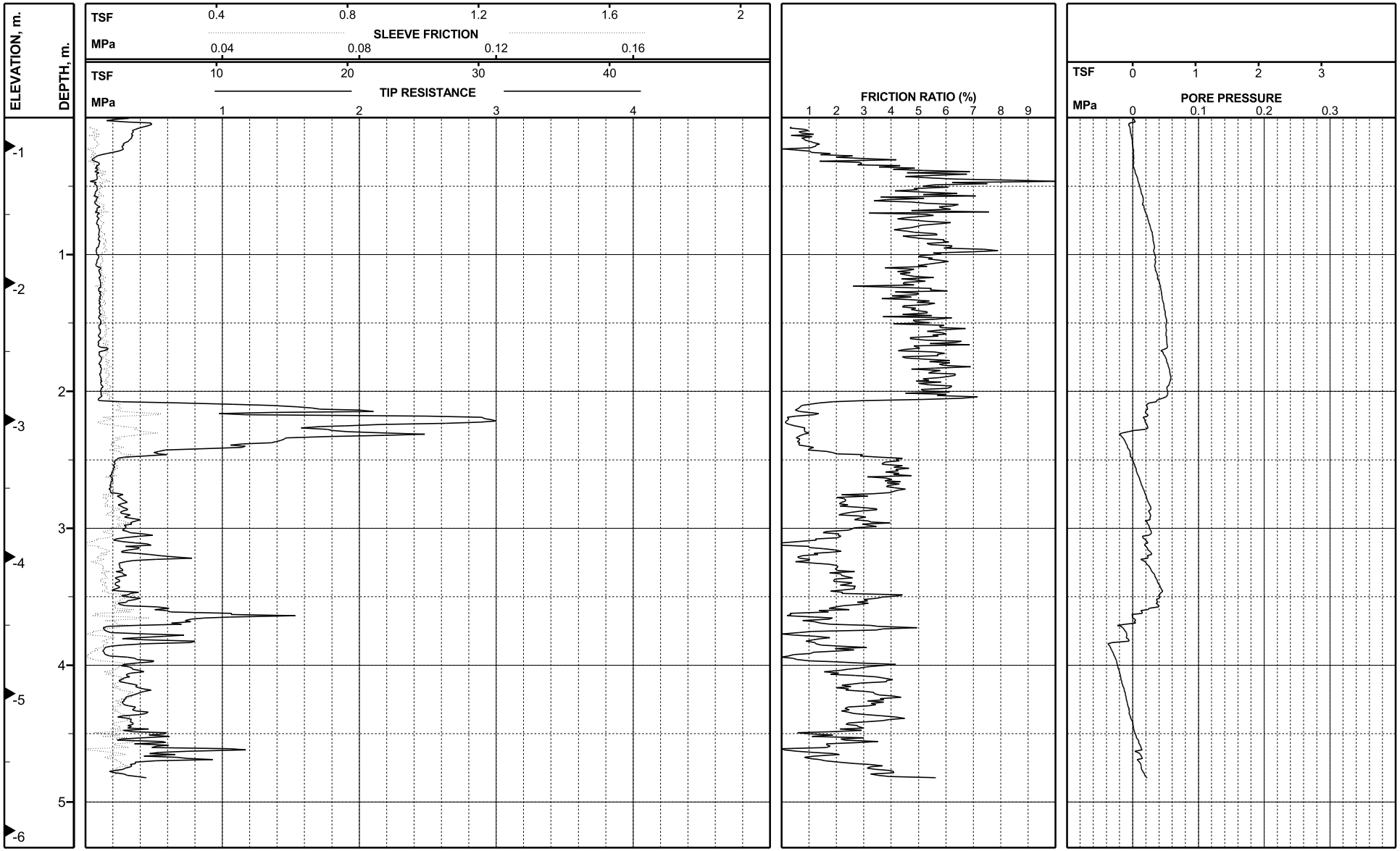
TETHERED SEASCOUT SOUNDING 98C-558

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1839213 N648355 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-559 (38m left of W. Sta.87+58)	**MUDLINE ELEVATION:**	-0.8 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

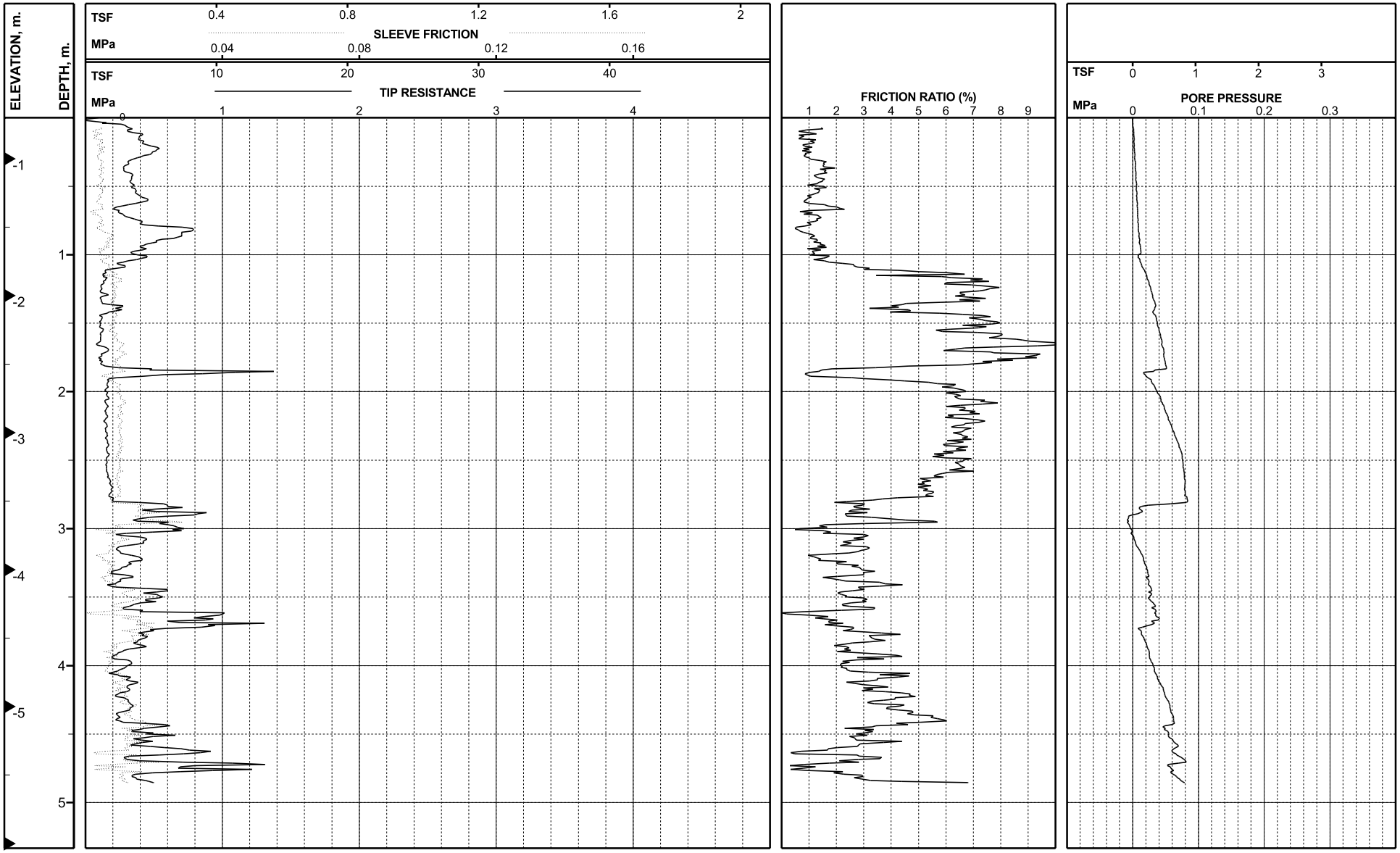
TETHERED SEASCOUT SOUNDING 98C-559

SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

PROJECT NO:	98-42-0054	**COORDINATES:**	E1838911 N648341 CA State Plane Zone 3, NAD83, Meters	**VESSEL:**	MV White Lightning
EXPLORATION NO.:	98C-560 (50m left of W. Sta. 84+57)	**MUDLINE ELEVATION:**	-0.7 m (MSL)	**TEST DATE:**	12/19/98



NOTE: SeaScout CPT uses 1 sq. cm cone

LOG OF CPT

TETHERED SEASCOUT SOUNDING 98C-560

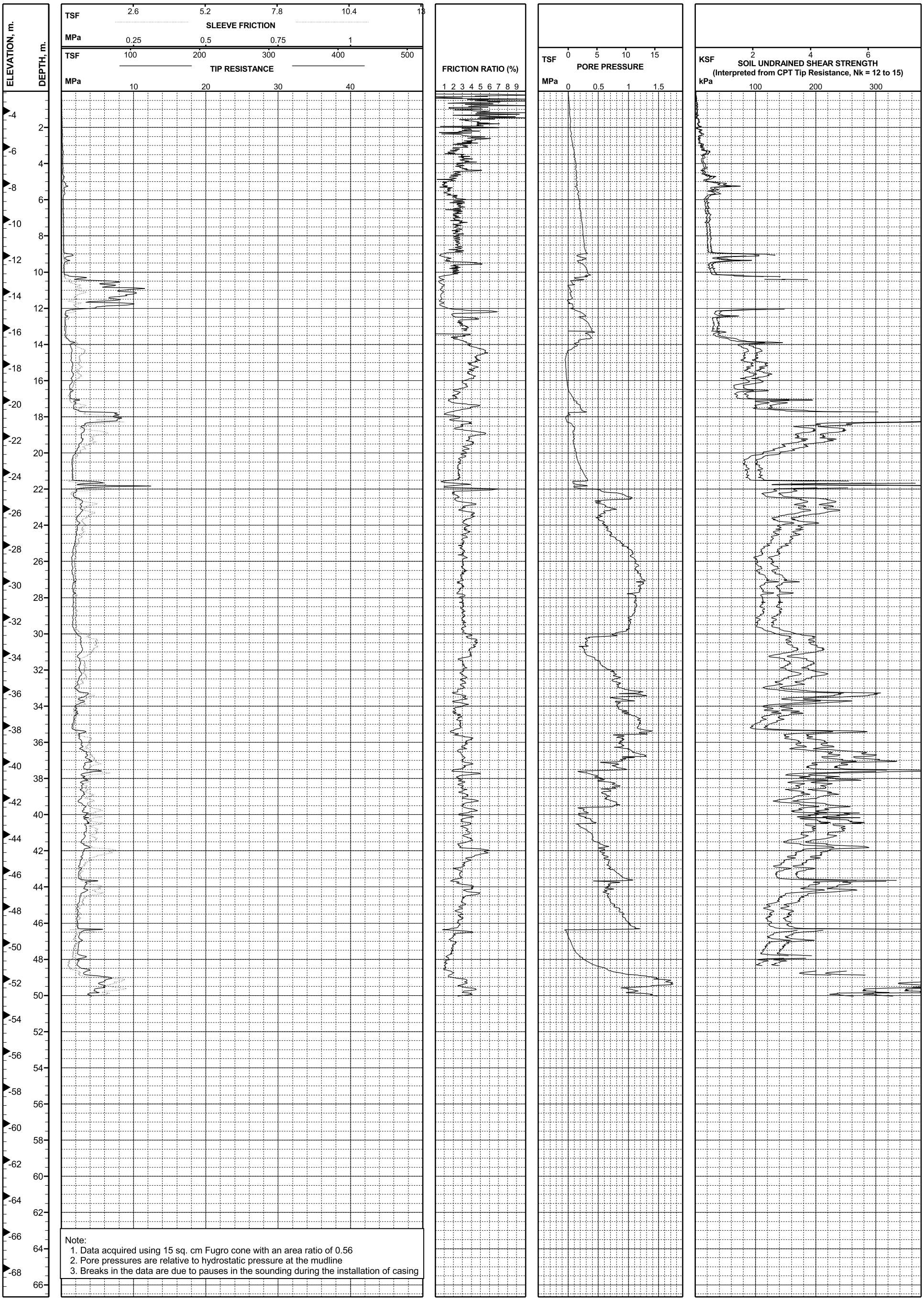
SFOBB East Span Seismic Safety Project

Report Date: 08/30/99

FUGRO

APPENDIX C
MARINE-BASED SEACALF CPT DATA

PROJECT NO: 98-42-0059
SOUNDING: 00C-64 (1 m Left of "W" Stn. 83+00)
COORDINATES: E1838758 N648273 CA State Plane Zone 3, NAD83, meters
MUDLINE ELEVATION: -2.9 m (MSL)
OPERATOR: Fugro-McClelland Marine Geosciences
TEST DATE: 09/24/00



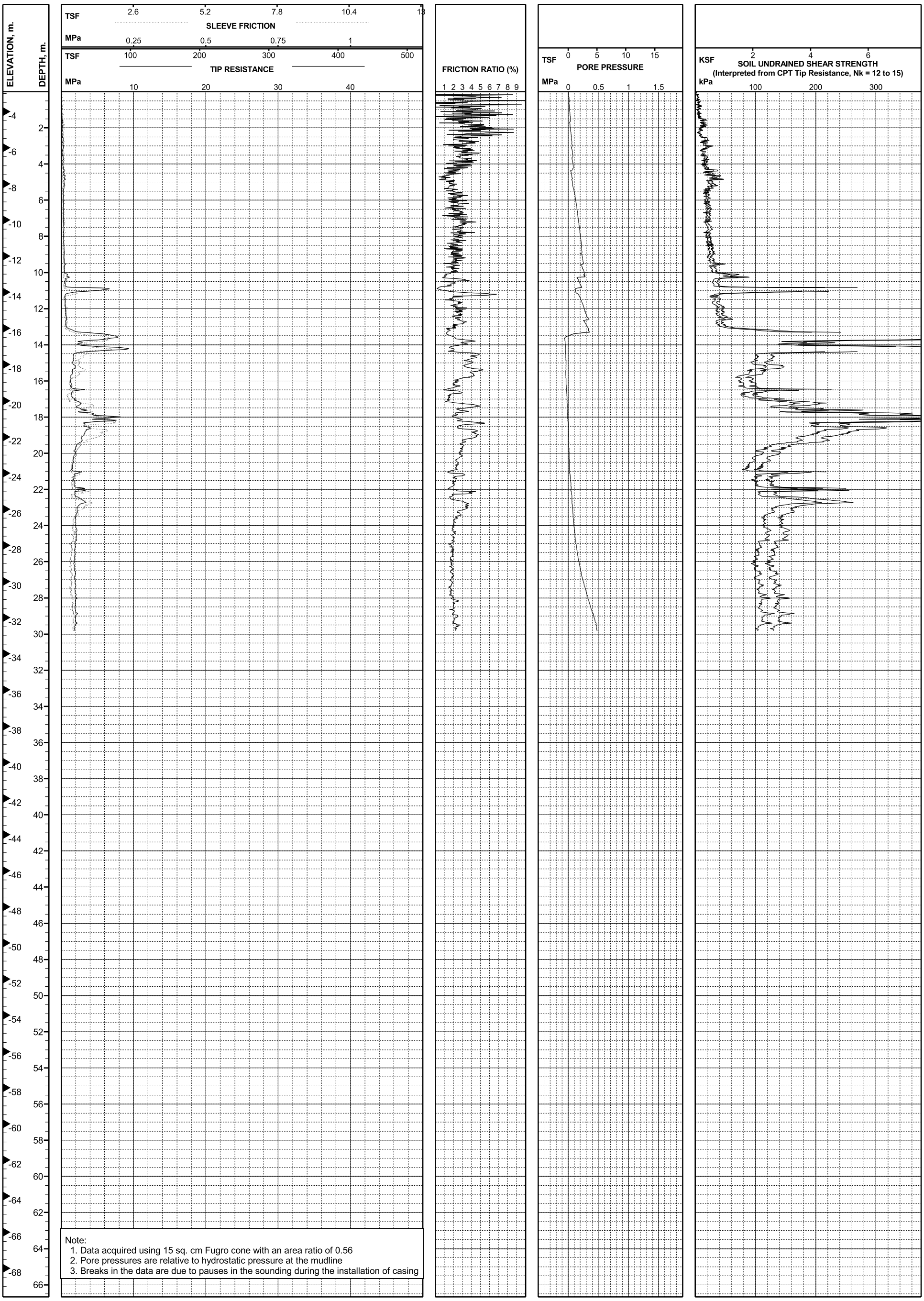
Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT
SOUNDING 00C-64
SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-64

PROJECT NO: 98-42-0059
SOUNDING: 00C-65 (1 m Right of "E" Stn. 82+79)
COORDINATES: E1838765 N648233 CA State Plane Zone 3, NAD83, meters
MUDLINE ELEVATION: -2.9 m (MSL)
OPERATOR: Fugro-McClelland Marine Geosciences
TEST DATE: 09/26/00



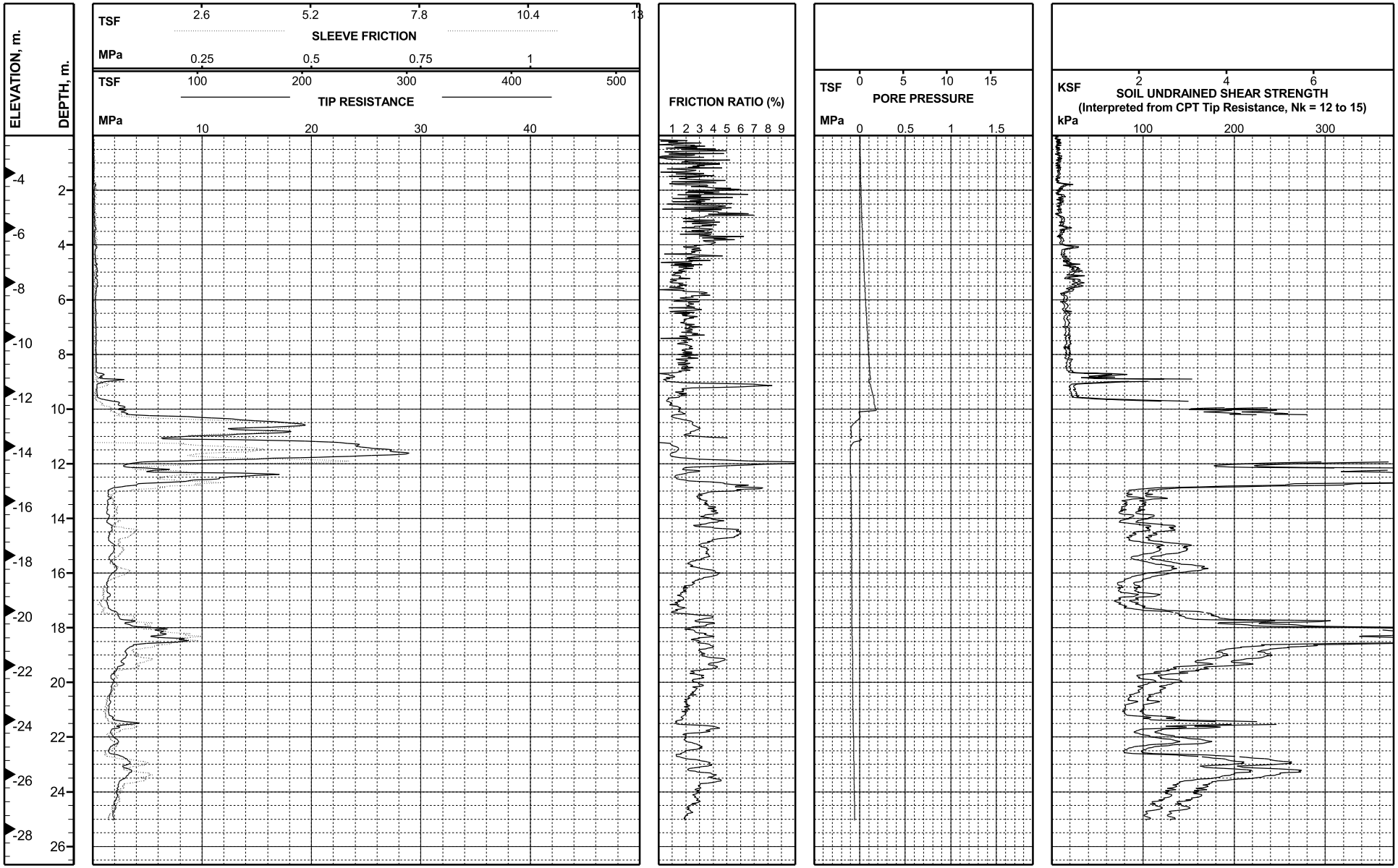
Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT
SOUNDING 00C-65
SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-65

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838780 N648262 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-66 (13 m Right of "W" Stn. 83+20)	**MUDLINE ELEVATION:**	-2.6 m (MSL)	**TEST DATE:**	09/25/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

Report Date: 02/08/01

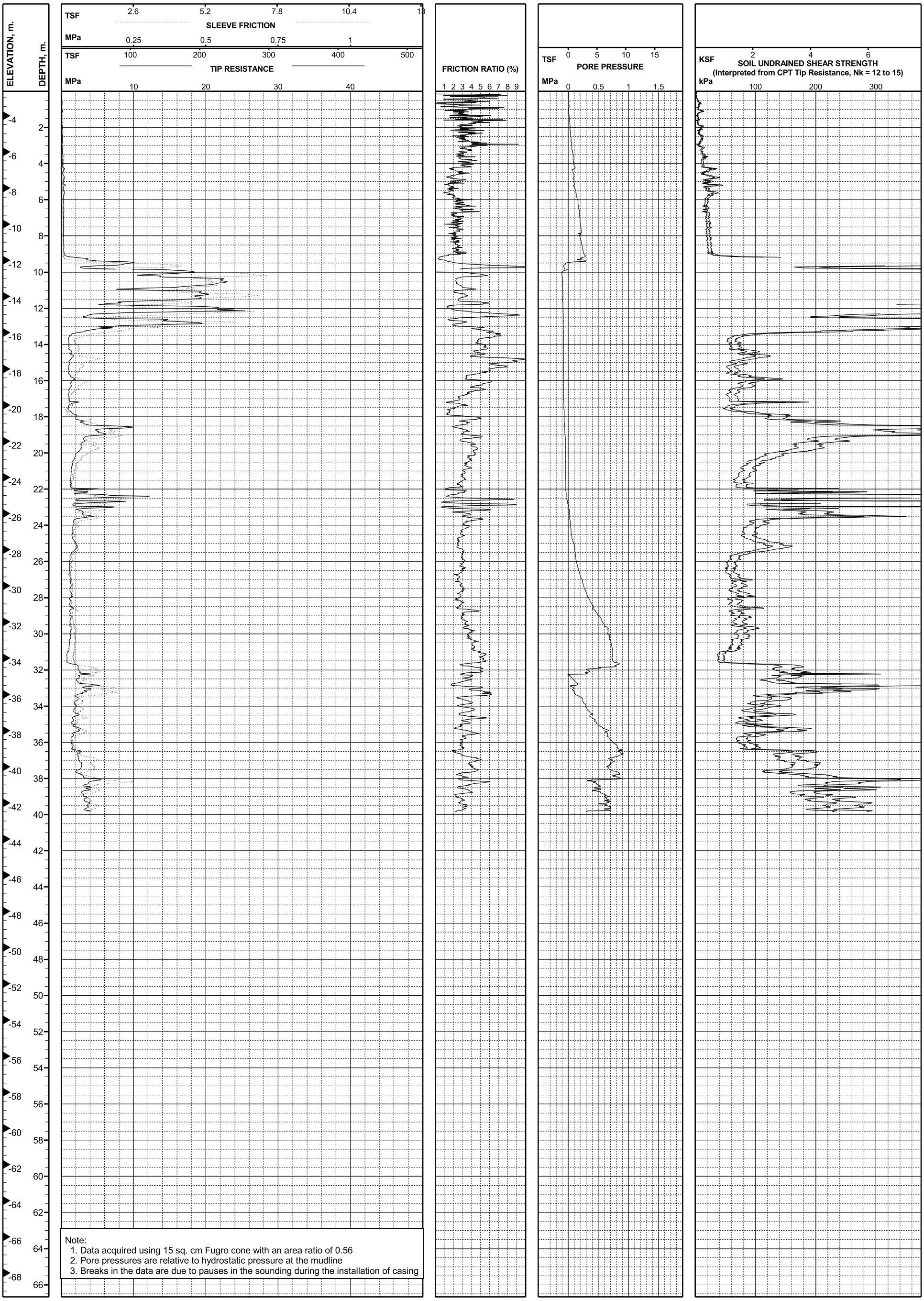
LOG OF CPT

SOUNDING 00C-66

SFOBB East Span Seismic Safety Project

PLATE 00C-66

PROJECT NO: 98-42-0059
SOUNDING: 00C-67 (4 m Right of "E" Stn. 83+00)
COORDINATES: E1838787 N648232 CA State Plane Zone 3, NAD83, meters
MUDLINE ELEVATION: -2.6 m (MSL)
OPERATOR: Fugro-McClelland Marine Geosciences
TEST DATE: 09/25/00



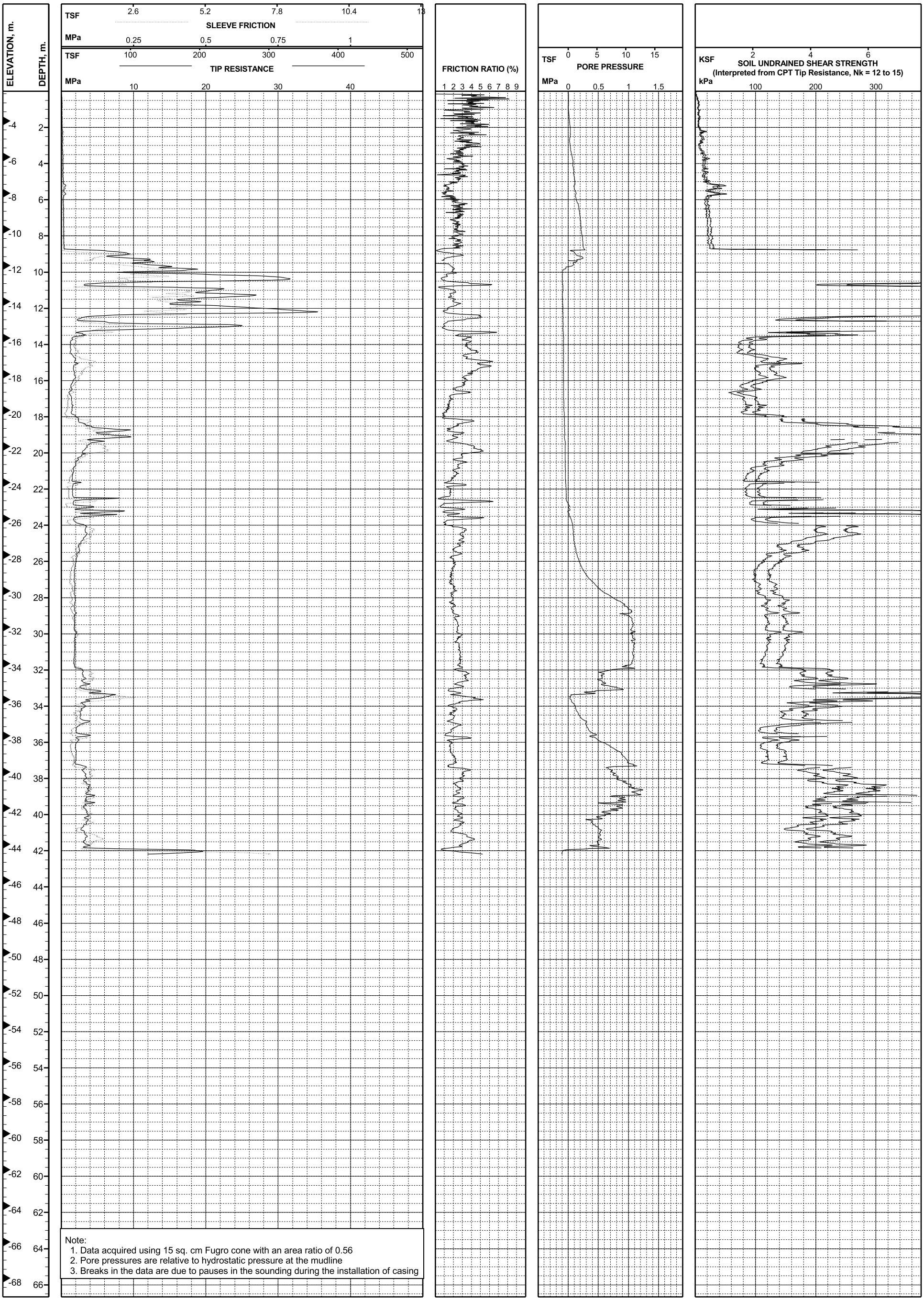
Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT
SOUNDING 00C-67
SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-67

PROJECT NO: 98-42-0059
SOUNDING: 00C-68 (14 m Right of "E" Stn. 83+20)
COORDINATES: E1838806 N648225 CA State Plane Zone 3, NAD83, meters
MUDLINE ELEVATION: -2.4 m (MSL)
OPERATOR: Fugro-McClelland Marine Geosciences
TEST DATE: 09/24/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT
SOUNDING 00C-68
SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-68

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838824 N648249 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-69 (8 m Left of "E" Stn. 83+40)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	09/24/00

ELEVATION, m. / DEPTH, m.

SLEEVE FRICTION
TSF: 2.6 5.2 7.8 10.4 13
MPa: 0.25 0.5 0.75 1

TIP RESISTANCE
TSF: 100 200 300 400 500
MPa: 10 20 30 40

FRICTION RATIO (%)
1 2 3 4 5 6 7 8 9

PORE PRESSURE
TSF: 0 5 10 15
MPa: 0 0.5 1 1.5

SOIL UNDRAINED SHEAR STRENGTH
(Interpreted from CPT Tip Resistance, Nk = 12 to 15)
KSF: 2 4 6
kPa: 100 200 300

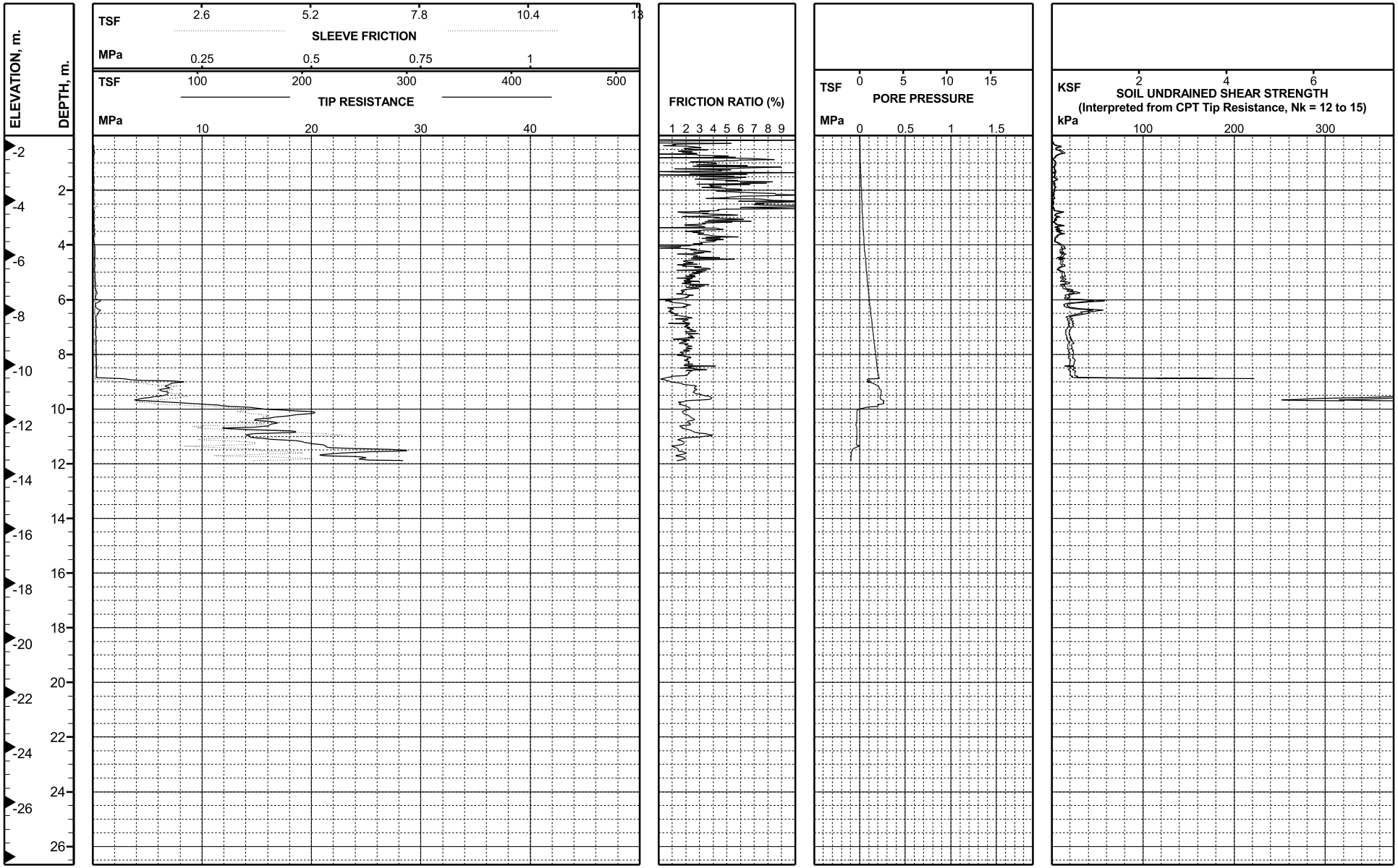
Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT
SOUNDING 00C-69
SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-69

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838849 N648228 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-70 (16 m Right of "E" Stn. 83+59)	**MUDLINE ELEVATION:**	-1.6 m (MSL)	**TEST DATE:**	09/24/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

Report Date: 02/08/01

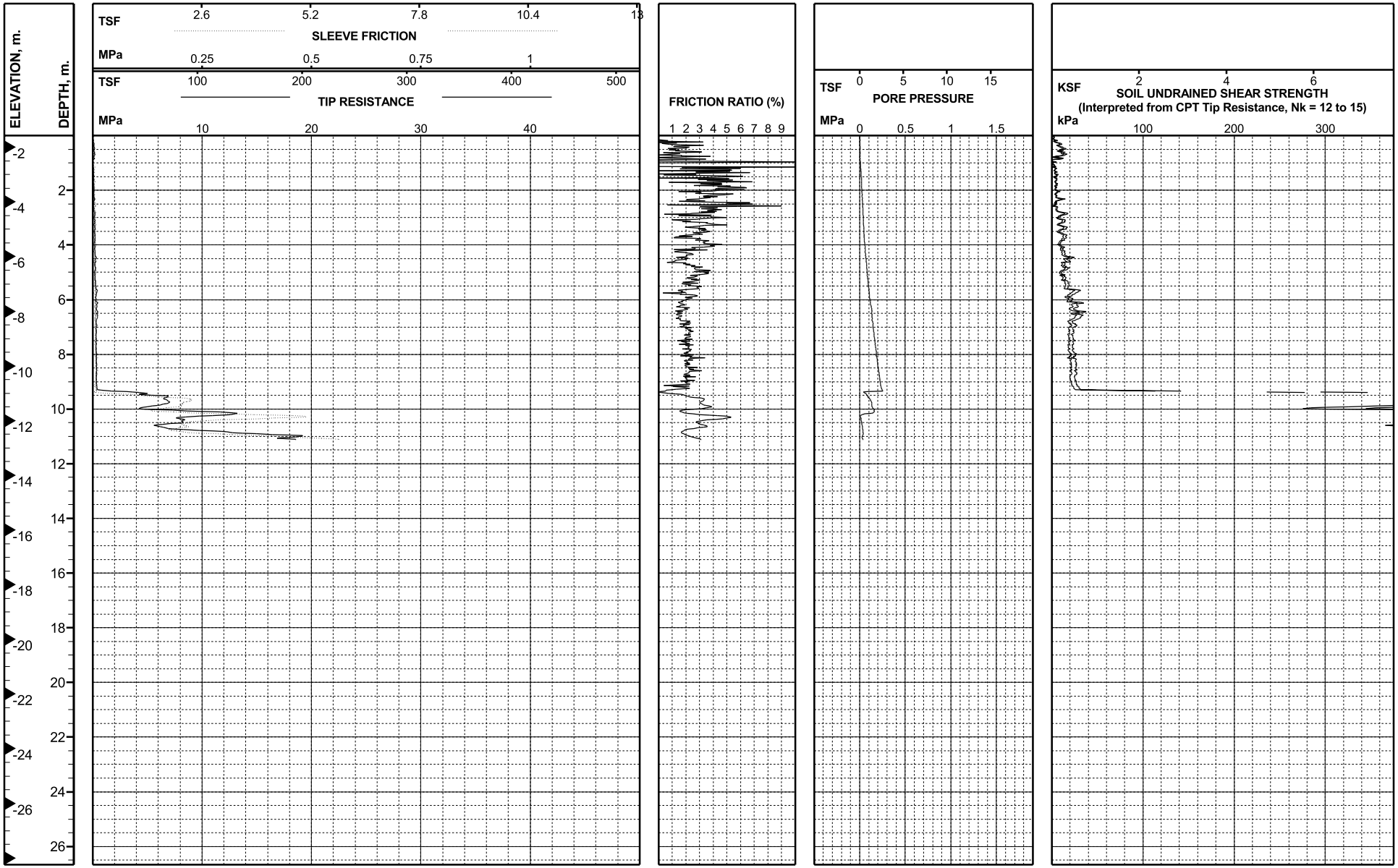
LOG OF CPT

SOUNDING 00C-70

SFOBB East Span Seismic Safety Project

PLATE 00C-70

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838846 N648252 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-71 (8 m Left of "E" Stn. 83+59)	**MUDLINE ELEVATION:**	-1.6 m (MSL)	**TEST DATE:**	09/24/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

Report Date: 02/08/01

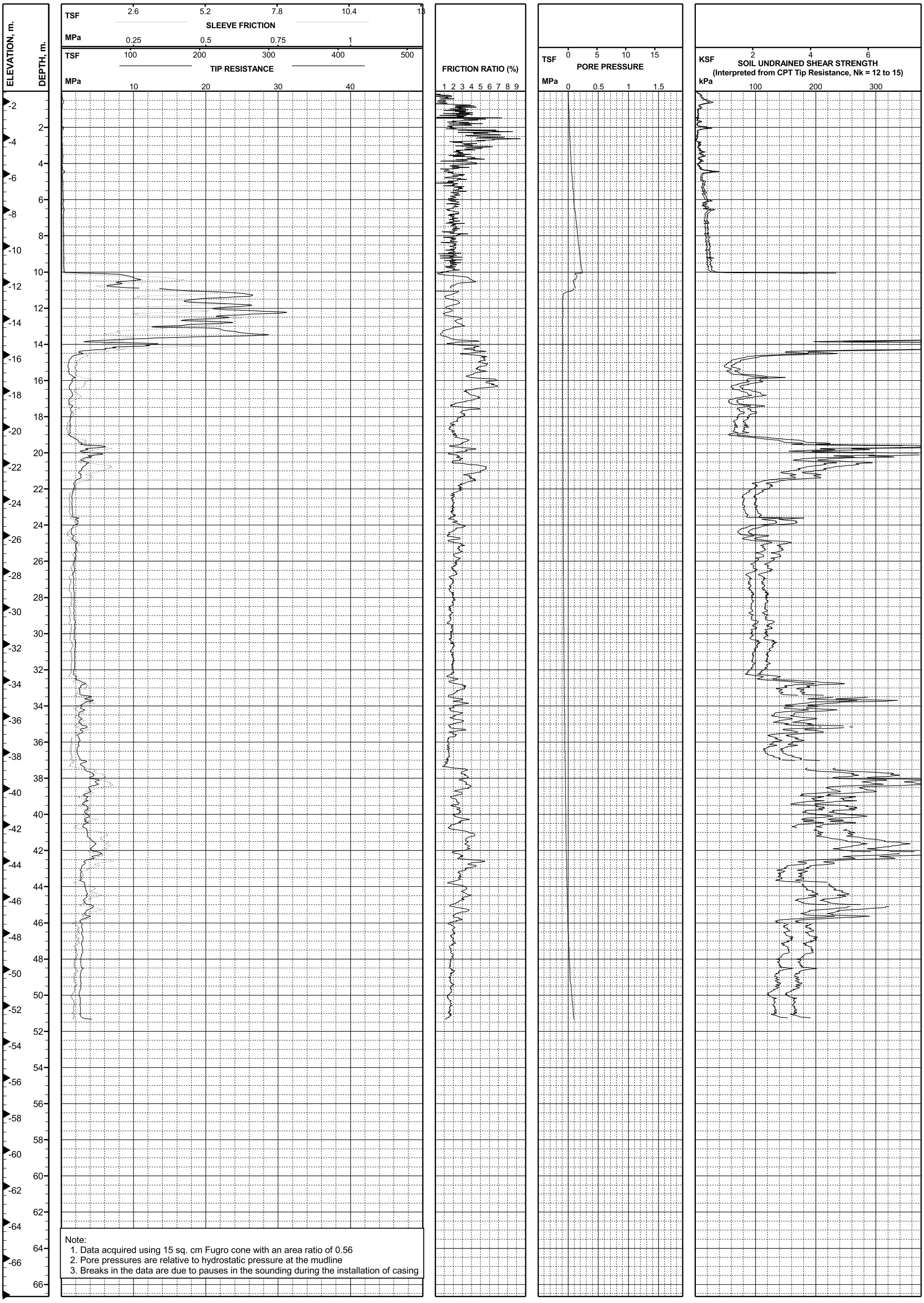
LOG OF CPT

SOUNDING 00C-71

SFOBB East Span Seismic Safety Project

PLATE 00C-71

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838892 N648302 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-72 (14 m Left of "W" Stn. 84+40)	**MUDLINE ELEVATION:**	-1.4 m (MSL)	**TEST DATE:**	09/23/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

LOG OF CPT

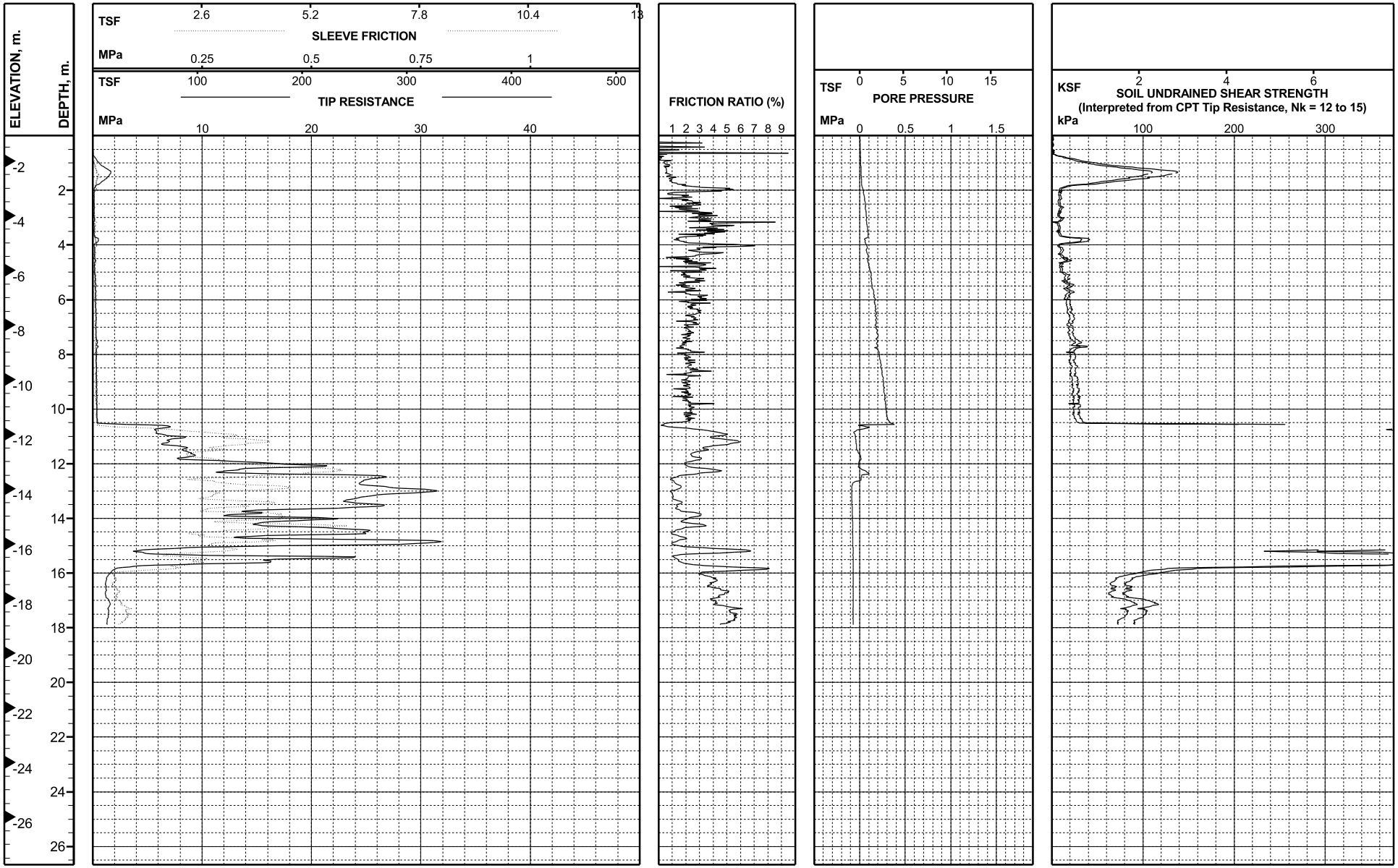
SOUNDING 00C-72

SFOBB East Span Seismic Safety Project

Report Date: 02/07/01

PLATE 00C-72

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838919 N648292 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-73 (W Stn. 84+59)	**MUDLINE ELEVATION:**	-1.1 m (MSL)	**TEST DATE:**	09/24/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

Report Date: 02/08/01

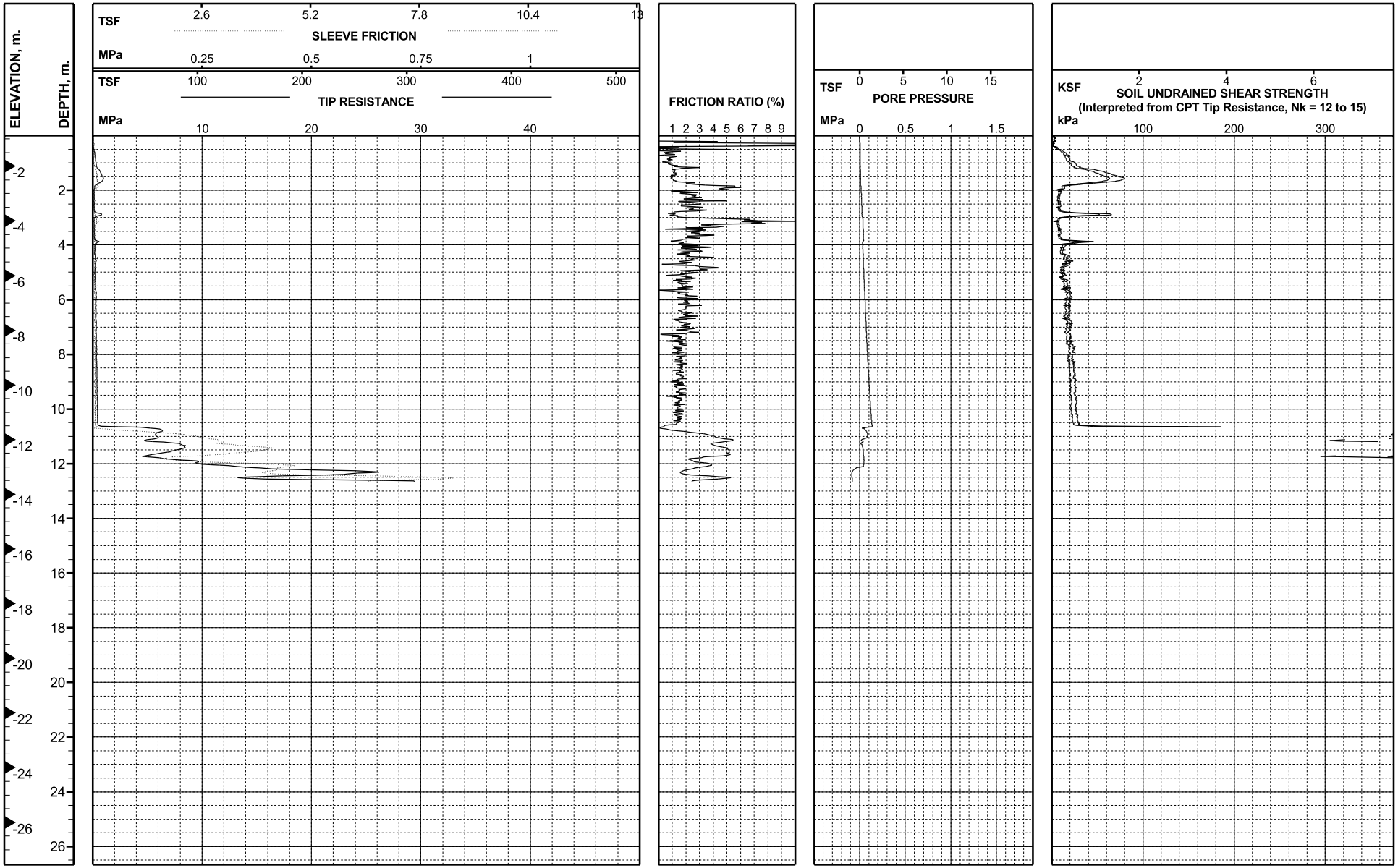
LOG OF CPT

SOUNDING 00C-73

SFOBB East Span Seismic Safety Project

PLATE 00C-73

PROJECT NO:	98-42-0059	**COORDINATES:**	E1838941 N648292 CA State Plane Zone 3, NAD83, meters	**OPERATOR:**	Fugro-McClelland Marine Geosciences
SOUNDING:	00C-74 (2 m Right of "W" Stn. 85+00)	**MUDLINE ELEVATION:**	-0.9 m (MSL)	**TEST DATE:**	09/25/00



Note:
1. Data acquired using 15 sq. cm Fugro cone with an area ratio of 0.56
2. Pore pressures are relative to hydrostatic pressure at the mudline
3. Breaks in the data are due to pauses in the sounding during the installation of casing

Report Date: 02/08/01

LOG OF CPT

SOUNDING 00C-74

SFOBB East Span Seismic Safety Project

PLATE 00C-74

Earth Mechanics

Fugro - Earth Mechanics
A JOINT VENTURE

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

VOLUME 4 - ADDITIONAL REPORTS
(Fugro-EM Project Memorandums and UC Berkeley Report)

Prepared for

CALIFORNIA DEPARTMENT OF TRANSPORTATION

March 2001

Earth Mechanics

Fugro - Earth Mechanics
A JOINT VENTURE

7700 Edgewater Drive, Suite 848
Oakland, California 94621
Tel: (510) 633-5100
Fax: (510) 633-5101

March 5, 2001
Project No. 98-42-0058/EMI Project No. 98-145

California Department of Transportation
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Attention: Mr. Mark Willian
Contract Manager

Final Oakland Shore Approach Geotechnical Site Characterization
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

The geologic and geotechnical studies for the San Francisco-Oakland Bay Bridge (SFOBB) East Span Seismic Safety Project are being conducted by Fugro-Earth Mechanics (a joint venture of Fugro West, Inc., and Earth Mechanics, Inc.) under California Department of Transportation (Caltrans) Contract 59A0053. The majority of the Oakland Mole exploration was conducted as part of the Phase 2, Task 5 (final site characterization phase) studies of the referenced contract, although three cone penetration test (CPT) soundings were conducted as part of the earlier Phase 1, Task 3 work scope (preliminary site characterization) of the referenced contract.

The field exploration conducted on the Oakland Mole in the Spring and Fall of 1998 as part of the referenced contract included 25 soil borings (designated in the subsurface database created for the project as 98-51 through 98-75) and 9 CPT soundings (designated as 98-16 through 98-18 and 98-101 through 98-110 [several planned locations were abandoned due to electrical interference]). A total of 53 offshore tethered Seascout CPT soundings were conducted in December 1998 during seasonal high tides on the tidal flat to the north of the Oakland Mole. Fifteen all-terrain CPT soundings were conducted on the Tidal Flat to the north of the Mole in March 1999 during low tide conditions. Two trench and two pit excavations were conducted in April 1999. In Fall 2000, 11 marine Seacalf CPT soundings were performed in the vicinity of the Oakland Shore Approach to the west and northwest of the western tip of the Mole. The Seacalf CPTs were conducted as part of the Phase 3 field investigation program.

This Oakland Shore Approach Geotechnical Site Characterization report summarizes the field exploration for the Oakland Shore Approach and describes our interpretation of the geotechnical conditions based on the information collected from the exploration. Our present interpretations are based on the field data from the borings, the results of laboratory tests completed in the onshore laboratories, and the CPT soundings.

This report is provided in four volumes. Volume 1 provides the interpretational text and illustrations. Volume 2 contains 27 appendices that provide boring logs and test data from 25 land borings on the Oakland Mole and 2 marine borings offshore from the northwest tip of the Oakland Mole. Volume 3 contains the

results of the CPT soundings conducted on land, on the northern shore of the tidal flat, and offshore to the north and west of the Oakland Mole. Volume 4 contains four documents that include a preliminary study of approach fills at the Oakland Mole, studies on lateral spreading of fills at the Oakland Mole, findings from trench and pit excavations, and the advanced geotechnical laboratory studies conducted at the University of California at Berkeley.

On behalf of the project team, we appreciate the opportunity to contribute to Caltrans' design of the new bridge to replace the existing SFOBB East Span. Please call if we can answer any questions relative to the information presented in the enclosed report.

Sincerely,

FUGRO-EARTH MECHANICS, A Joint Venture

Roger Howard, Jr., P.E.
Project Engineer, Fugro West, Inc.

Jacob Chacko, P.E.
Project Engineer, Fugro West, Inc.

Mike Kapuskar, P.E.
Project Manager, Earth Mechanics, Inc.

Thomas W. McNeilan, C.E., G.E.
Vice President, Fugro West, Inc.

Attachment

Copies submitted: Mr. Mark Willian, Caltrans
Mr. Saba Mohan, Caltrans
Mr. Robert Price, Caltrans
Dr. Brian Maroney, Caltrans
Ms. Sharon Naramore, Caltrans
Mr. Gerry Houlahan, TY Lin/M&N
Mr. Sajid Abbas, TY Lin/M&N
Mr. Al Ely, TY Lin/M&N

SAN FRANCISCO-OAKLAND BAY BRIDGE
EAST SPAN SEISMIC SAFETY PROJECT

CALTRANS CONTRACT 59A0053

REVISED FINAL
OAKLAND SHORE APPROACH
GEOTECHNICAL SITE CHARACTERIZATION REPORT

VOLUME 4 - ADDITIONAL REPORTS
(Fugro-EM Project Memorandums and UC Berkeley Report)

MARCH 2001

Prepared For:

CALIFORNIA DEPARTMENT OF TRANSPORTATION
Engineering Service Center
Office of Structural Foundations
5900 Folsom Boulevard
Sacramento, California 95819-0128

Prepared By:

FUGRO-EARTH MECHANICS
A Joint Venture
7700 Edgewater Drive, Suite 848
Oakland, California 94621

CONTENTS

VOLUME 4 - ADDITIONAL REPORTS

FUGRO-EARTH MECHANICS

- Project Memorandum, Preliminary Study of Approach Fills at Oakland Mole
- Project Memorandum, Studies on Lateral Spreading of Fills at Oakland Mole
- Project Memorandum, Findings From Trench and Pit Excavations on Oakland Mole (Updated)

UNIVERSITY OF CALIFORNIA AT BERKELEY

- Geotechnical Testing for the East Bay Crossing of the San Francisco-Oakland Bay Bridge

PROJECT MEMORANDUM
(DECEMBER 11, 1998)

PROJECT MEMORANDUM
PRELIMINARY STUDY OF APPROACH FILLS AT OAKLAND MOLE

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

MEMORANDUM

To: Dr. Brian Maroney / Caltrans
Mr. Ade Akinsanya / Caltrans
Mr. Reid Buell, Mr. John Thorne, Mr. Ronnie Gu / Caltrans
Mr. John Vitorelo / Caltrans
Mr. Hooshmand Nikoui / Caltrans

Copy: Mr. Al Ely, Mr. Gerry Houlahan / TYLin-Moffatt &Nichol
Mr. Jal Birdy / TYLin-Moffatt & Nichol
Mr. Tom McNeilan, Mr. Tim Dunne / Fugro-EMI
Mr. Tony Dover / Fugro-EMI

From: Hubert Law, Robert Pyke, Po Lam, M. Kapuskar / Fugro-EMI

Date: December 11, 1998

Subject: Preliminary Study of Approach Fills at Oakland Mole
SFOBB East-Span Replacement
Update with Response to Review Comments
Fugro-EMI T.O.#5 - Supplement 1

Gentlemen:

We are submitting this interim memo describing our preliminary study of the feasibility of using a wedge of fill on the north side of the Oakland Mole to support the west-bound approach. The purpose of this study is to determine the feasibility of the proposed fill option and to assist in a cost comparison of the slab-on-pile option versus the fill option. If the fill option is adopted by Caltrans, further studies will be needed to finalize design.

It has been recognized at the onset of the project that there are some key geotechnical issues (e.g. soil liquefaction, site stability and lateral spread) that need to be addressed which also require more quantitative evaluation. Presently, laboratory testing including consolidation testing and dynamic behavior testing of the soft bay mud soils are on-going which will aid these quantitative evaluations. Also, a special exploration program in the shallow waters at the north side of the Oakland Mole using the Fugro Seascout tethered CPT unit is scheduled for next week of December 14, 1998 which will provide key information needed for these evaluations.

Under our original contract, these items will be reported in a Draft Phase-2 Site Characterization Report to be submitted at the end of January or in February, 1999. In addition, more detailed pile survivability and pile capacity evaluations need to be conducted when pile design efforts of the structural designers have progressed further so that the pile type, pile details and loading demand

are better defined and can be made available to Fugro-EMI. The issue of lateral spread and site stability was not meant to be an item to be addressed in this interim memo originally, because, to some extent they do not have a major impact on the cost of construction to either fill or structural alternative. The primary focus, from a geotechnical perspective was for EMI to assess the consolidation characteristics of the soft bay mud to appreciate the feasibility of the fill option at Oakland Mole and its impact on construction schedule for the Bay Bridge east span (which can impact cost).

The original memorandum on the present preliminary study of the Oakland Mole has been presented to Caltrans and the Civil and Structural Designers on November 20, 1998, which essentially established that it would be feasible (within the window of construction) to adopt a fill option for the approaches, and also provided some conceptual information for cost estimate evaluation by T.Y. Lin. Last Monday (December 9, 1998), we have received review comments from Mr. Al Ely of T.Y. Lin and Mr. John Vitrorelo and Mr. Hooshmand G-Nikoui of Caltrans District 4 regarding this memo. Many of the comments focused on the site stability and lateral spread issues which were not the original intent of the memorandum. In addition, we were requested to address the pros and cons of the two options in relation to the lateral spread issue. Since receipt of the above requests, we have stepped up our efforts to address site stability and lateral spread issues at the Oakland Mole. In the following update, we are providing additional geotechnical cross sections with shear strength and blow count data to Caltrans and the designers that can be used as the starting point to appreciate site stability issues (these section are preliminary and will be updated when Seascout tethered CPT data become available). Because of the dynamic nature of this topic and the fact that these issues are currently being discussed with various parties (Peer Review are scheduled for December 14), we have elected to provide the following update on the original memorandum to address the comments by T.Y. Lin and District 4 in part. Further comments regarding lateral spread issues and a list of the pros and cons for the two proposed design options will be provided shortly.

Construction of the Existing Mole

Based on Caltrans Annual Construction Reports, the construction of a northern extension to the then existing Key System mole started on Jan. 8, 1934. Figure 1 shows the proposed cross section of the northern extension. The westerly 2,000 feet was needed at an earlier date for building the approaches to the bridge proper and here fill was placed directly on the bay bottom. Elsewhere work began with dredging out about 10 ft of the mud from the bay bottom. Material for the new fill was dredged from the Oakland Outer Harbor. The new fill was built in three stages. The first-stage fill was placed to El. +3 ft. MLLW (0± ft MSL). Upon completion of the first-stage fill, a temporary bulkhead 4 ft in height was constructed during periods of low tide. This bulkhead served the dual purpose of reducing the amount of rock needed to retain further fill and retaining the second stage of the fill which was then placed to El. +7 ft. The second stage fill served as a roadway for the operation of the rock contractor. Core rock was moved into position beyond the temporary bulkhead to an elevation slightly above El. +7 ft. Face rock was then placed on the exposed face and the remainder of the core rock was placed to between El. +13 and +15 ft. This roughly shaped wall was then backed with sand to prevent excess leakage through it during the pumping of the third-stage fill. This final stage was placed to an elevation sufficiently above the grade line of El. +13 ft to allow for the anticipated settlement and

consolidation that the fill would take in the years to come. The remainder of the face rock was then placed by dumping from the top of the fill. The dredged fill was completed on Dec. 28, 1934 with a total of 3,823,728 cubic yards having been pumped.

Settlement of Existing Fill

Figure 2 shows the settlement of the fill along the mole after 1, 5 and 20 years after the construction. It appears that the settlement varies almost directly with the thickness of the underlying Young Bay Mud. After 20 years, the average settlement is approximately 10 percent of the thickness of Young Bay Mud. The ultimate settlement could be more than that shown in Figure 2 because the settlement during the placement of fill was not recorded and the status of consolidation after 20 years is not known.

Failure of Mole Fill

During the construction of the mole fill north of the Toll Plaza in the winter of 1947-1948, the underlying mud failed. In order to understand the nature of the failure, a series of holes were bored through the area of failure. Figure 3 presents a cross section through this failed area. At the time of failure the fill sank at least 20 feet. In places the mud thrust itself upward through the previous sand fill.

Current Field Investigation

The current field investigation program on the Oakland Mole consists of 10 rotary wash borings and 6 completed CPT soundings as shown in the plan view map of Figure 4 and summarized in the soil cross section profile along the longitudinal direction of Figure 5B. Our review of the site data suggests that the site soil condition can be grouped into 4 segments (see Figure 4). The surficial site soil conditions (i.e. presence or absence of the Merritt sands) are affected by the presence of a paleochannel (Segment II) where the Merritt sands have been eroded and the Young Bay Mud would consequently be thickest. In Segments I and III, the Merritt sand is relatively thick, whereas in Segment IV, this layer is appears to thin out in the easterly direction. In the transverse direction, all the units generally dip in a northerly direction. Cross sections in the transverse direction, representative for each of the four segments are presented in Figures 5b through 5e.

The thickness of the existing fills is about 25 feet, and the thickness of Young Bay Mud is typically 30 ft in the area of interest. The soils investigation was recently completed during the week of Nov. 13. Soil samples retrieved from the Young Bay Mud are currently being tested and the results are not available at this time. Thus, our preliminary studies of settlement and consolidation were based on data available in the literature and our files. Further field data with particular relevance to edge stability will be obtained using a mini-cone rig.

Proposed Fill for West Bound Approach

A schematic construction sequence for fill placement is shown in Figure 6. Some schematic cross-sections for the west-bound approach fill is illustrated in Figures 6A and 6B. These figures

are generic in nature and actual fill volume calculation will need to be based on the actual Caltrans topographic data which vary along the approach alignment. Figures 5B to 5E are provided (based on Caltrans topography data) to allow some appreciation of the actual fill volume at four selected station locations. Other schemes have been studied but this sequence represents the presently preferred scheme.

This scheme would involve the following steps:

1. Drive sheet piles to prevent unraveling of the existing mole during removal of the rock dike in Step 2;
2. Remove existing facing rock and dike;
3. Place geogrid and filter fabric, anchored to existing mole, with outer edge of filter fabric upturned to limit contamination of Bay waters;
4. Place first stage fill, topped by 1 foot thick gravel blanket that would provide both an all-weather working surface and drainage from the subsequent wick drain installation;
5. Install wick drains as indicated in Figures 6A and 6B;
6. Place second stage fill including surcharge;
7. Remove surcharge prior to roadway construction; and
8. Place rock on exterior face.

Provisions should be made in the estimate for monitoring the stability of the edge of the first stage fill and for monitoring the settlement of the surcharged fill.

We have examined settlements of the proposed fill for two cross sections, one at Sta. 88+80 and other at Sta. 90+00, as shown in Figures 7 and 8. At each section, six locations were selected for settlement analyses. We used a compression index (C_c) of 1.0 and a coefficient of consolidation (C_v) of 10 ft^2/year to compute the amount of settlement and the rate of settlement. The ultimate settlements shown in Figures 7 and 8 have been computed using the vertical stress increments that result from enlarging the existing fill. Tables 1 and 2 present the complete computation process. The ultimate settlement at the edge of the existing roadway is expected to be in the order of 6 inches.

Since the wick drains would be installed in a regular pattern, the rate of settlement can be estimated using the theory of radial consolidation for a single wick drain. Although the horizontal permeability is typically 2 to 5 times larger than the vertical permeability, we elected to use the same coefficient of consolidation in the radial direction as in the vertical direction. With this assumption we conservatively estimate that 90% primary consolidation would be reached within 1 year assuming that the wick drains are installed at 3-ft spacing. Because final consolidation is reached asymptotically, it would be advisable to add an additional 3 ft of surcharge above the final grade (as shown in Figures 6A and 6B). Removal of the surcharge at the end of the construction period would minimize further settlements. We understand that in fact 20 months might be available for the surcharge period. Surcharging for this period of time should eliminate most of future settlements due to primary consolidation. At the end of primary consolidation, there may still be secondary consolidation (which is more difficult to mitigate for a fill option). However, the amount of settlement associated with the secondary consolidation is typically at least one order of magnitude smaller than that of the primary consolidation. Further,

any secondary consolidation would proceed at much the same rate as the secondary consolidation under the existing mole so the differential settlements would be minimal. Data from a nearby site (Watergate) suggests secondary consolidation rates on the order of ¼ inch per year.

Locations where the structure meets the roadway (which will exist for either the fill or slab approach alternative) are areas where concentration of differential displacements will occur and the designers would need to address this issue (e.g. use of approach slab, variable thickness light weight fills, etc. would be beneficial).

Proposed Fill for East Bound Approach

The settlement of the eastbound approach fill was estimated in a similar manner assuming use of ordinary-weight fill. Figure 9 shows the settlements for new fill assuming a maximum of 8 feet fill above the existing grade. The time for consolidation is the same as for the westbound fill using wick drains with a 3-ft spacing (i.e., 90% consolidation within 1 year). There should be no settlement associated with the primary consolidation where the fill touches down to the existing grade.

If lightweight fill such as cellular concrete were to be used, it would be possible to design the fill so that there is no net increase in vertical stress, and thus no primary consolidation would be expected. For example, using cellular concrete with a unit weight of 30 lb/ft^3 that is 4 times lighter than the existing fill, one could excavate 2 ft of the existing fill and replace it with 8 ft of lightweight fill.

The lightweight fill approach is technically the preferred option for the eastbound approach, and Caltrans has relevant experience using lightweight fill on several other projects. The settlement of the underlying clay is unavoidable if regular fill is used and this may be an important issue for the existing pavement because a major portion of the new abutment is situated at the existing westbound roadway.

ARS Criteria for Oakland Mole Slab on Pile Structures

The cost for the slab on pile structures will depend on the seismic loading criteria. Two modes of seismic loading need to be considered: (1) the conventional inertial structural load (i.e. ARS) and (2) kinematic earth pressure load induced by permanent ground movement. The later mode of loading relates to the displacement capacity of the piles (very often at the in-ground hinge zone) and specialized pile survivability analyses are needed to address this mode of loading. As discussed in the beginning of this memorandum, further follow-up studies are needed on this topic.

To develop the ARS criteria for the Oakland Mole, we have made use of the six sets of SEE motions (Earth Mechanics Seismic Ground Motion Report dated November 24, 1998) in site response analyses using the SHAKE program. For the small diameter piles (24-inch concrete piles from T.Y. Lin), force transfer from the ground to the structure will be at a shallow depth and freefield mudline motion would provide a good indication of the level of shaking for the slab-on-pile structure option at Oakland Mole. Figure 10 presents the spectra from the

conducted site response analyses at Oakland Mole along with the recommended smooth ARS criteria. The Phase 1 ARS criteria adopted for design of the main bridge has also been shown for comparison. Figure 11 provides a tabulation of the corresponding ARS curve coordinates.

Attachments

(1) Excerpts from Annual Construction Reports, 1934, 1935, 1936, 1937
(2) Original Contract Documents for Dredger Fill, 1933

Table 1. Settlement Analysis at Oakland Mole West Bound Fill Approach at Station 88+80 11/13/98

		Control Location					
	Unit	1	2	3	4	5	6
Specific Gravity of Bay Mud, Gs		2.66	2.66	2.66	2.66	2.66	2.66
Saturated Unit Wt of Bay Mud	lb/ft^3	94.00	94.00	94.00	94.00	94.00	94.00
Compression Index, Cc		1.00	1.00	1.00	1.00	1.00	1.00
Coefficient of Consolidation (vert), Cv	ft^2/yr	10.00	10.00	10.00	10.00	10.00	10.00
Thickness of Bay Mud	ft	30.00	30.00	30.00	30.00	30.00	30.00
Depth Below Original Mudline	ft	20.00	20.00	20.00	20.00	20.00	20.00
Effective Unit wt of Bay Mud	lb/ft^3	31.60	31.60	31.60	31.60	31.60	31.60
Initial Vertical Effective Stress before Exist Fill	lb/ft^2	632	632	632	632	632	632
Unit Wt of Fill x Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under Fill		0	0	0.05	0.1	0.6	0.85
Stress Increment Due to Existing Fill	lb/ft^2	0	0	95	191	1144	1620
Stress at End of Existing Fill Construction	**lb/ft^2**	**632**	**632**	**727**	**823**	**1776**	**2252**
Initial Void Ratio Before Existing Fill		1.92	1.92	1.92	1.92	1.92	1.92
Final Void Ratio After Existing Fill		1.92	1.92	1.86	1.81	1.47	1.37
Ultimate Settlement due to Existing Fill	ft	0.00	0.00	0.63	1.18	4.61	5.67
Settlement in 1 year	ft	0.000	0.000	0.075	0.141	0.553	0.680
Settlement in 2 year	ft	0.000	0.000	0.107	0.200	0.784	0.964
Settlement in 6 year	ft	0.000	0.000	0.169	0.318	1.244	1.531
Settlement in 21 year	ft	0.000	0.000	0.363	0.682	2.673	3.289
Unit Wt of Fill x New & Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under New & Exist Fill		0.1	0.6	0.85	0.9	0.95	0.95
Stress Increment Due to New & Exist Fill	lb/ft^2	191	1144	1620	1715	1811	1811
Stress at End of New Fill Construction	**lb/ft^2**	**823**	**1776**	**2252**	**2347**	**2443**	**2443**
Initial Void Ratio Before New Fill		1.92	1.92	1.86	1.81	1.47	1.37
Final Void Ratio After New Fill		1.81	1.47	1.37	1.35	1.33	1.33
Ultimate Settlement due to New Fill	**ft**	**1.18**	**4.61**	**5.15**	**4.87**	**1.68**	**0.45**
Settlement in 3 months	ft	0.588	2.305	2.575	2.435	0.841	0.223
Settlement in 6 months	ft	0.941	3.687	4.121	3.896	1.345	0.358
Settlement in 9 months	ft	1.058	4.148	4.636	4.383	1.513	0.402
Settlement in 12 months	ft	1.082	4.240	4.739	4.480	1.547	0.411
Settlement in 15 months	ft	1.117	4.379	4.893	4.626	1.597	0.425

T	U
0.011	0.12
0.022	0.17
0.067	0.27
0.233	0.58

Wick Drain Spacing
3 ft

T	U
0.278	0.5
0.556	0.8
0.833	0.9
1.111	0.92
1.389	0.95

Table 2. Settlement Analysis at Oakland Mole West Bound Fill Approach at Station 90+00 11/13/98

	Unit	Control Location					
		1	2	3	4	5	6
Specific Gravity of Bay Mud, Gs		2.66	2.66	2.66	2.66	2.66	2.66
Saturated Unit Wt of Bay Mud	lb/ft^3	94.00	94.00	94.00	94.00	94.00	94.00
Compression Index, Cc		1.00	1.00	1.00	1.00	1.00	1.00
Coefficient of Consolidation (vert), Cv	ft^2/yr	10.00	10.00	10.00	10.00	10.00	10.00
Thickness of Bay Mud	ft	30.00	30.00	30.00	30.00	30.00	30.00
Depth Below Original Mudline	ft	20.00	20.00	20.00	20.00	20.00	20.00
Effective Unit wt of Bay Mud	lb/ft^3	31.60	31.60	31.60	31.60	31.60	31.60
Initial Vertical Effective Stress before Exist Fill	lb/ft^2	632	632	632	632	632	632
Unit Wt of Fill x Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under Fill		0	0.05	0.1	0.45	0.65	0.85
Stress Increment Due to Existing Fill	lb/ft^2	0	95	191	858	1239	1620
Stress at End of Existing Fill Construction	**lb/ft^2**	**632**	**727**	**823**	**1490**	**1871**	**2252**
Initial Void Ratio Before Existing Fill		1.92	1.92	1.92	1.92	1.92	1.92
Final Void Ratio After Existing Fill		1.92	1.86	1.81	1.55	1.45	1.37
Ultimate Settlement due to Existing Fill	ft	0.00	0.63	1.18	3.83	4.84	5.67
Settlement in 1 year	ft	0.000	0.075	0.141	0.459	0.581	0.680
Settlement in 2 year	ft	0.000	0.107	0.200	0.650	0.823	0.964
Settlement in 6 year	ft	0.000	0.169	0.318	1.033	1.307	1.531
Settlement in 21 year	ft	0.000	0.363	0.682	2.219	2.809	3.289
Unit Wt of Fill x New & Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under New & Exist Fill		0.05	0.2	0.65	0.85	0.87	0.9
Stress Increment Due to New & Exist Fill	lb/ft^2	95	381	1239	1620	1658	1715
Stress at End of New Fill Construction	**lb/ft^2**	**727**	**1013**	**1871**	**2252**	**2290**	**2347**
Initial Void Ratio Before New Fill		1.92	1.86	1.81	1.55	1.45	1.37
Final Void Ratio After New Fill		1.86	1.72	1.45	1.37	1.36	1.35
Ultimate Settlement due to New Fill	**ft**	**0.63**	**1.51**	**3.82**	**2.11**	**1.08**	**0.23**
Settlement in 3 months	ft	0.313	0.755	1.908	1.057	0.538	0.114
Settlement in 6 months	ft	0.501	1.209	3.053	1.691	0.861	0.182
Settlement in 9 months	ft	0.564	1.360	3.434	1.902	0.968	0.205
Settlement in 12 months	ft	0.577	1.390	3.511	1.945	0.990	0.210
Settlement in 15 months	ft	0.595	1.435	3.625	2.008	1.022	0.217

T	U
0.011	0.12
0.022	0.17
0.067	0.27
0.233	0.58

Wick Drain Spacing
3 ft

T	U
0.278	0.5
0.556	0.8
0.833	0.9
1.111	0.92
1.389	0.95

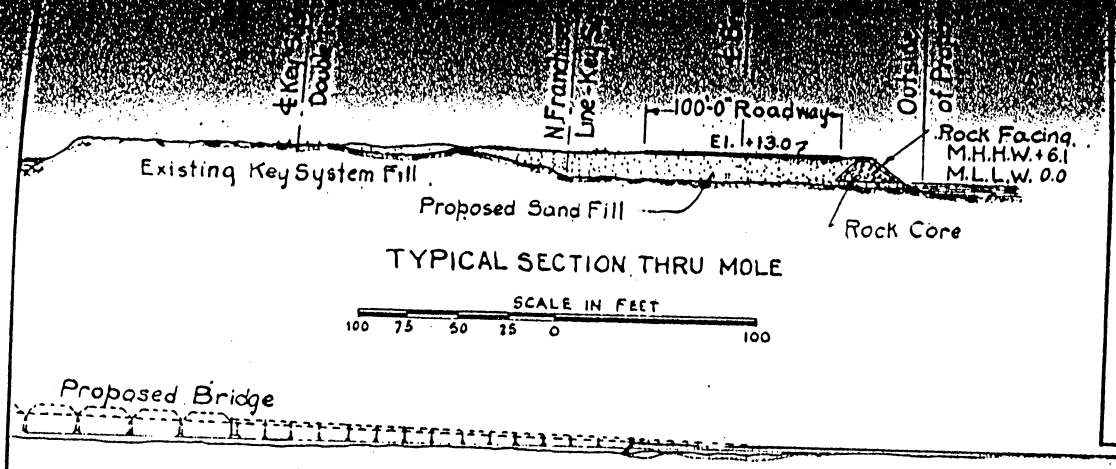
Table 3. Settlement Analysis at Oakland Mole East Bound Fill Approach at Station 87+00 11/13/98

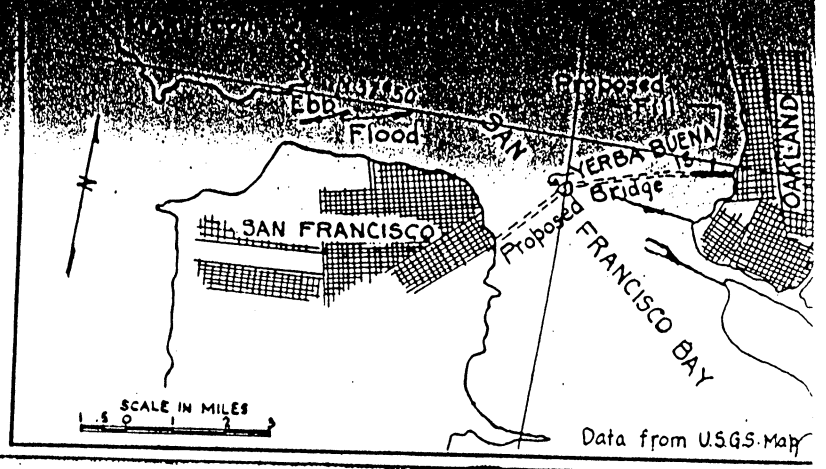
		Control Location					
	Unit	1	2	3	4	5	6
Specific Gravity of Bay Mud, Gs		2.66	2.66	2.66	2.66	2.66	2.66
Saturated Unit Wt of Bay Mud	lb/ft^3	94.00	94.00	94.00	94.00	94.00	94.00
Compression Index, Cc		1.00	1.00	1.00	1.00	1.00	1.00
Coefficient of Consolidation (vert), Cv	ft^2/yr	10.00	10.00	10.00	10.00	10.00	10.00
Thickness of Bay Mud	ft	30.00	30.00	30.00	30.00	30.00	30.00
Depth Below Original Mudline	ft	20.00	20.00	20.00	20.00	20.00	20.00
Effective Unit wt of Bay Mud	lb/ft^3	31.60	31.60	31.60	31.60	31.60	31.60
Initial Vertical Effective Stress before Exist Fill	lb/ft^2	632	632	632	632	632	632
Unit Wt of Fill x Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under Fill		0.03	0.1	0.55	0.8	0.9	0.9
Stress Increment Due to Existing Fill	lb/ft^2	57	191	1048	1525	1715	1715
Stress at End of Existing Fill Construction	**lb/ft^2**	**689**	**823**	**1680**	**2157**	**2347**	**2347**
Initial Void Ratio Before Existing Fill		1.92	1.92	1.92	1.92	1.92	1.92
Final Void Ratio After Existing Fill		1.88	1.81	1.50	1.39	1.35	1.35
Ultimate Settlement due to Existing Fill	ft	0.39	1.18	4.36	5.48	5.85	5.85
Settlement in 1 year	ft	0.046	0.141	0.524	0.657	0.703	0.703
Settlement in 2 year	ft	0.066	0.200	0.742	0.931	0.995	0.995
Settlement in 6 year	ft	0.104	0.318	1.178	1.479	1.581	1.581
Settlement in 21 year	ft	0.224	0.682	2.531	3.177	3.396	3.396
Unit Wt of Fill x New & Exist Fill Height	lb/ft^2	1906	1906	1906	1906	1906	1906
Normalized Stress under New & Exist Fill		0.1	0.65	0.8	0.9	0.9	0.9
Stress Increment Due to New & Exist Fill	lb/ft^2	191	1239	1525	1715	1715	1715
Stress at End of New Fill Construction	lb/ft^2	823	1871	2157	2347	2347	2347
Unit Wt of Fill x Abutment Height	lb/ft^2	880	880	880	880	880	880
Normalized Stress under Abutment Fill		0	0	0.1	0.65	0.65	0.25
Stress Increment Due to Abutment Fill	lb/ft^2	0	0	88	572	572	220
Stress at End of New & Abutment Fill Constr	**lb/ft^2**	**823**	**1871**	**2245**	**2919**	**2919**	**2567**
Initial Void Ratio Before New Fill		1.88	1.81	1.50	1.39	1.35	1.35
Final Void Ratio After New Fill		1.81	1.45	1.37	1.26	1.26	1.31
Ultimate Settlement due to New Fill	**ft**	**0.80**	**3.82**	**1.51**	**1.65**	**1.21**	**0.50**
Settlement in 3 months	ft	0.400	1.908	0.756	0.826	0.604	0.248
Settlement in 6 months	ft	0.640	3.053	1.210	1.322	0.967	0.397
Settlement in 9 months	ft	0.720	3.434	1.361	1.487	1.088	0.447
Settlement in 12 months	ft	0.736	3.511	1.391	1.520	1.112	0.457
Settlement in 15 months	ft	0.760	3.625	1.437	1.570	1.149	0.472

T	U
0.011	0.12
0.022	0.17
0.067	0.27
0.233	0.58

Wick Drain Spacing
3 ft

T	U
0.278	0.5
0.556	0.8
0.833	0.9
1.111	0.92
1.389	0.95





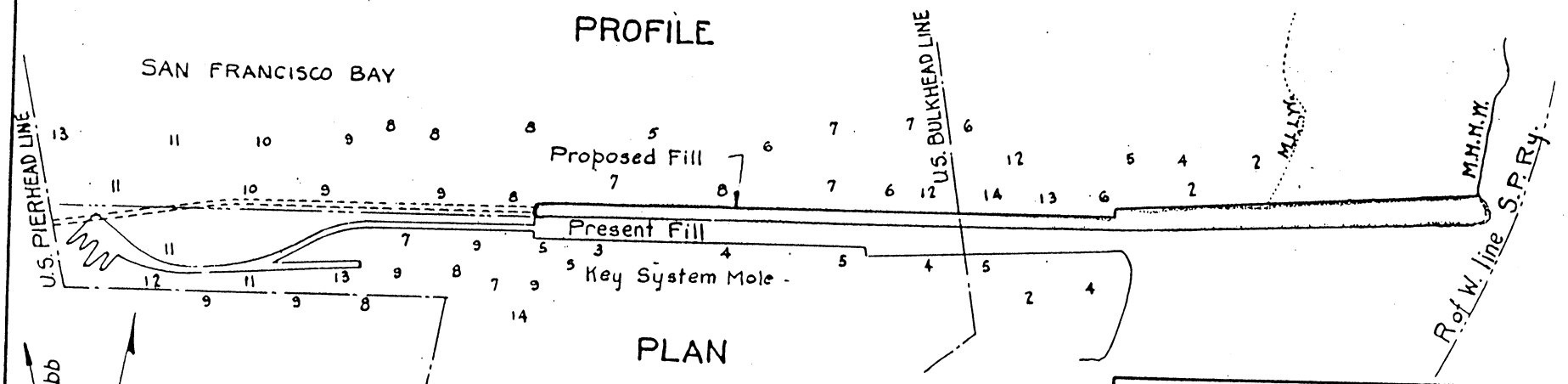


FIGURE 1

STATE OF CALIFORNIA
DEPARMENT OF PUBLIC WORKS
SAN FRANCISCO-OAKLAND BAY BRIDGE
PROPOSED FILL

To accompany application for Federal Authority
Dated August 26, 1932

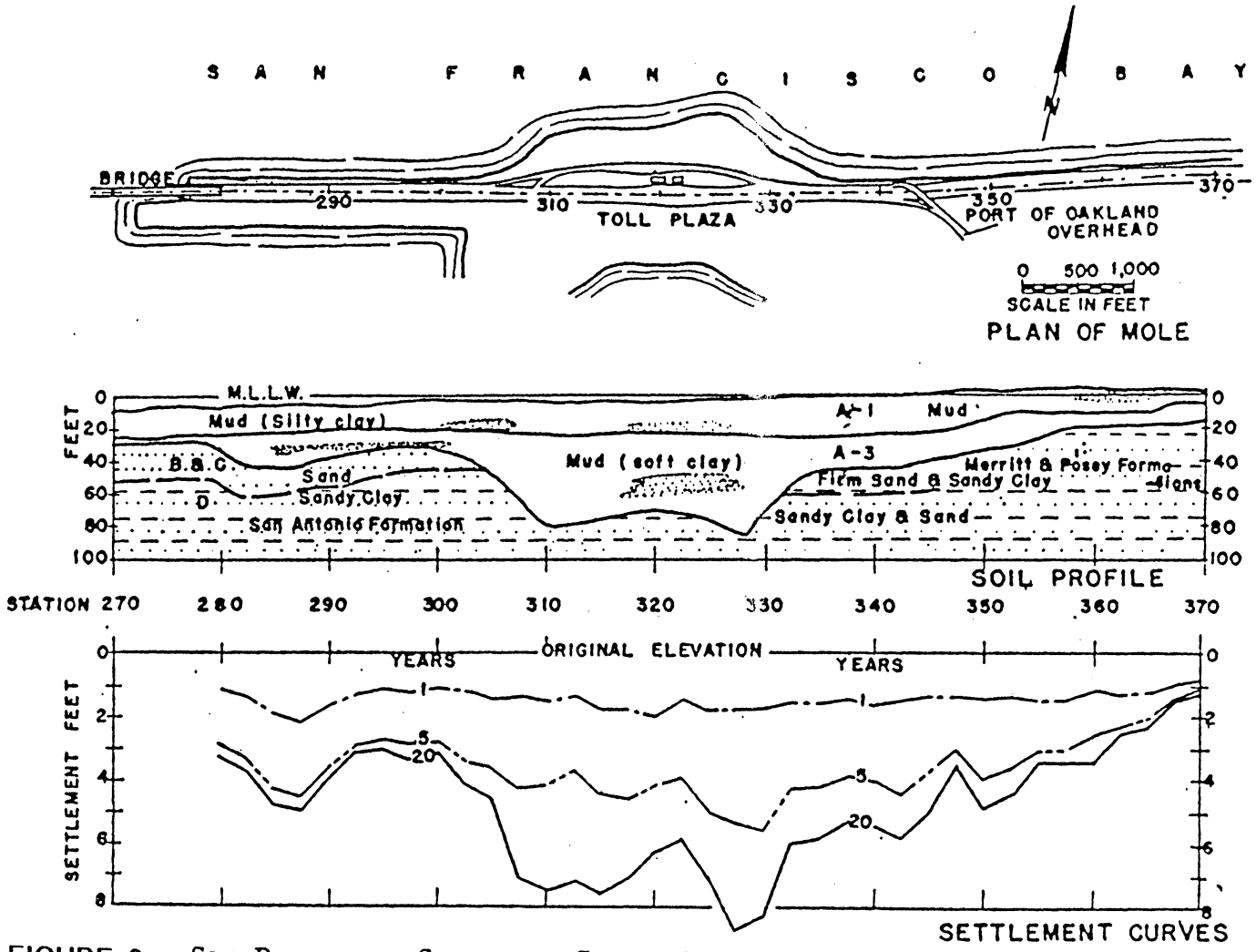


FIGURE 2 —Soil Profile and Settlement Curves, East Bay Mole, San Francisco-Oakland Bay Bridge

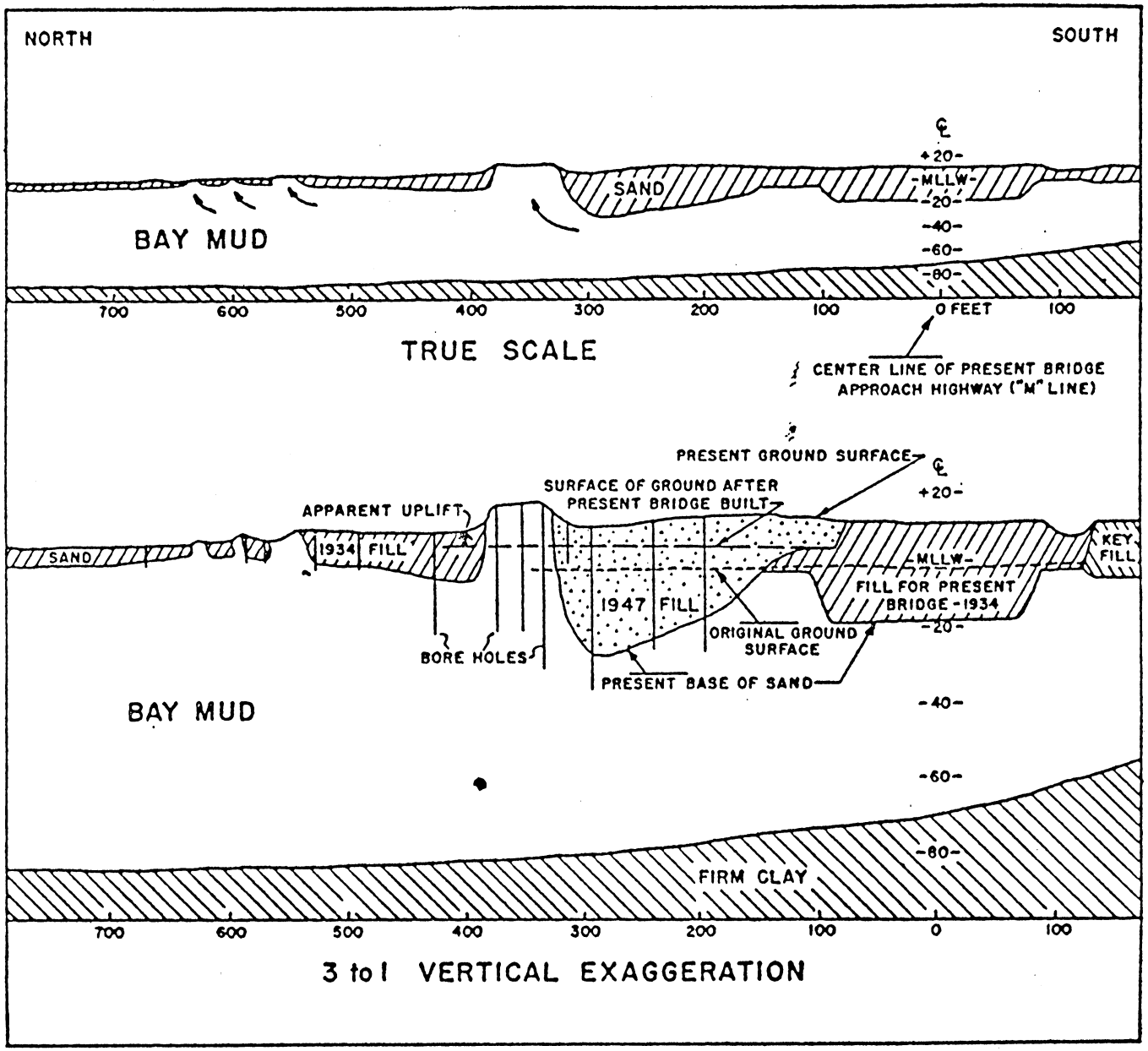


FIGURE 3.—Profile of Sediments Near Place of Failure, Toll Plaza, San Francisco-Oakland Bay Bridge

Scale in feet.

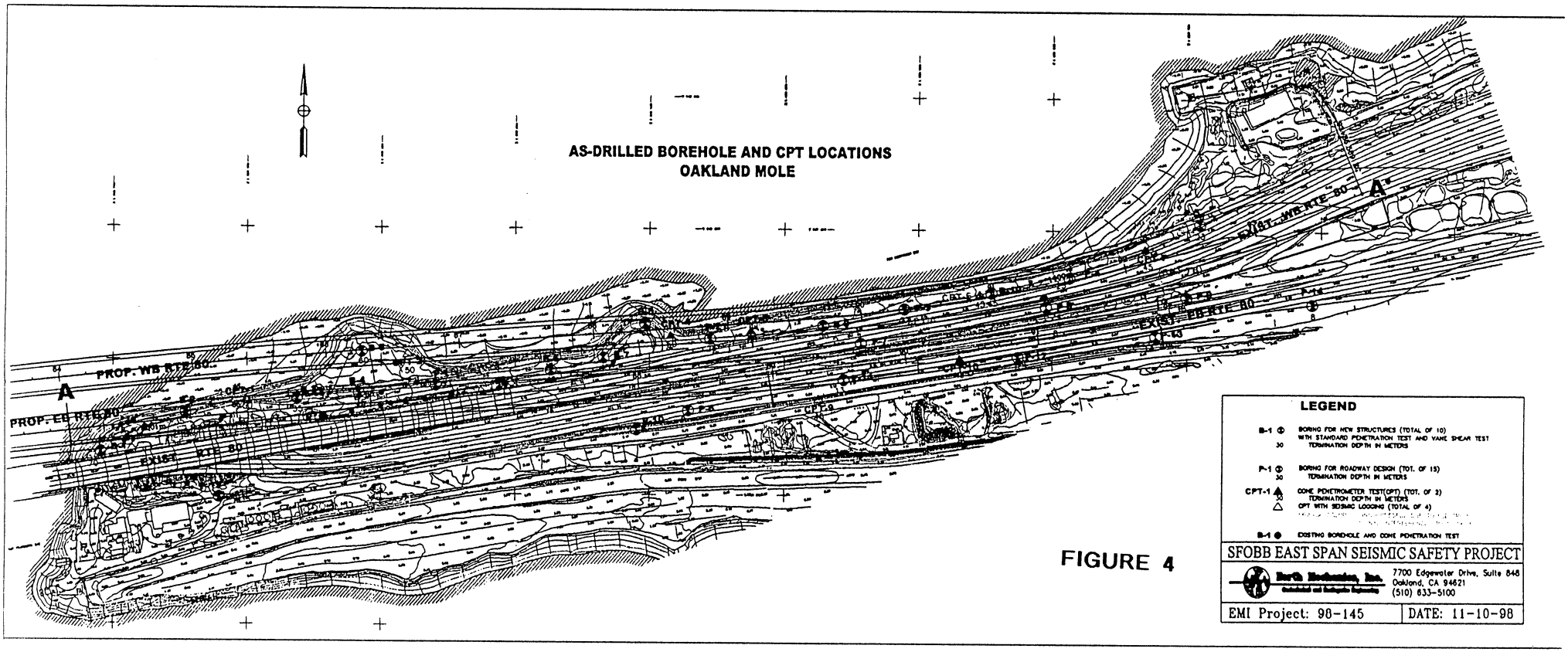

AS-DRILLED BOREHOLE AND CPT LOCATIONS
OAKLAND MOLE
PROP. WB RTE 80
PROP. EB RTE 80
EXIST. WB RTE 80
EXIST. EB RTE 80
A
A'
LEGEND
B-1 BORING FOR NEW STRUCTURES (TOTAL OF 10) WITH STANDARD PENETRATION TEST AND VANE SHEAR TEST
30 TERMINATION DEPTH IN METERS
P-1 BORING FOR ROADWAY DESIGN (TOT. OF 15)
30 TERMINATION DEPTH IN METERS
CPT-1 CONE PENETROMETER TEST(CPT) (TOT. OF 3)
30 TERMINATION DEPTH IN METERS
CPT WITH SEISMIC LOGGING (TOTAL OF 4)
B-1 EXISTING BOREHOLE AND CONE PENETRATION TEST
SFOBB EAST SPAN SEISMIC SAFETY PROJECT
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
7700 Edgewater Drive, Suite 848
Oakland, CA 94621
(510) 633-5100
EMI Project: 98-145
DATE: 11-10-98

FIGURE 4

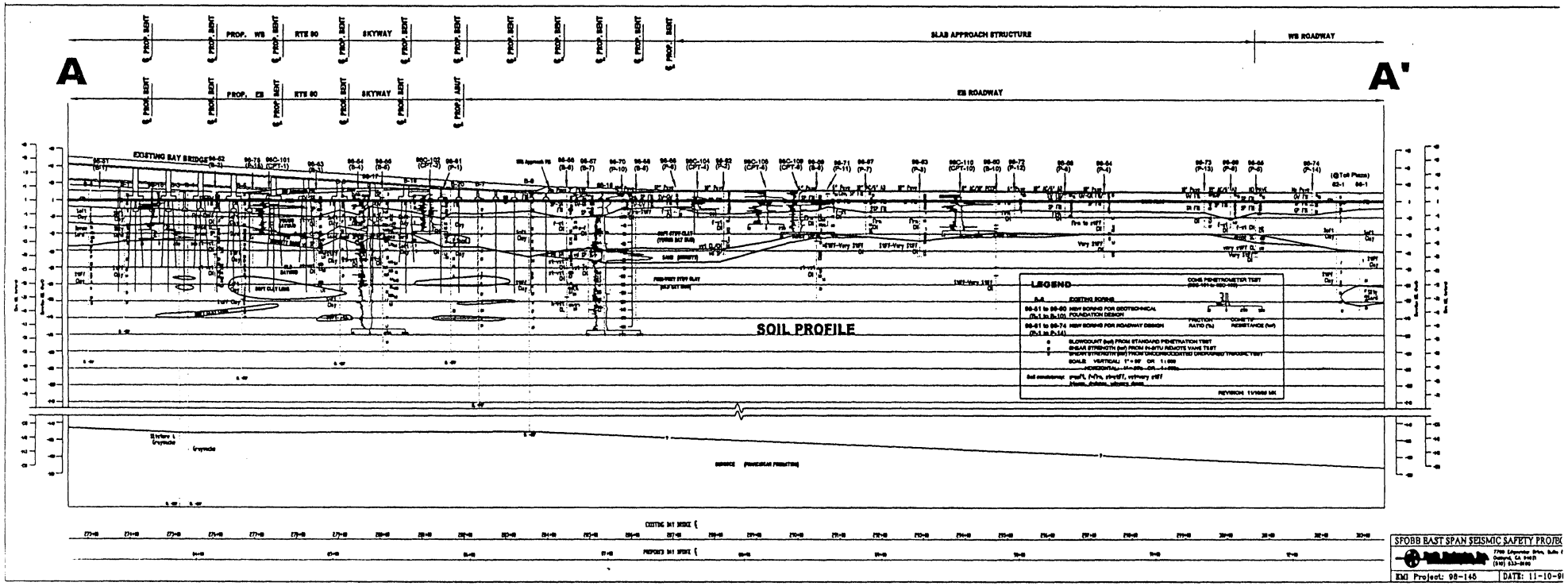
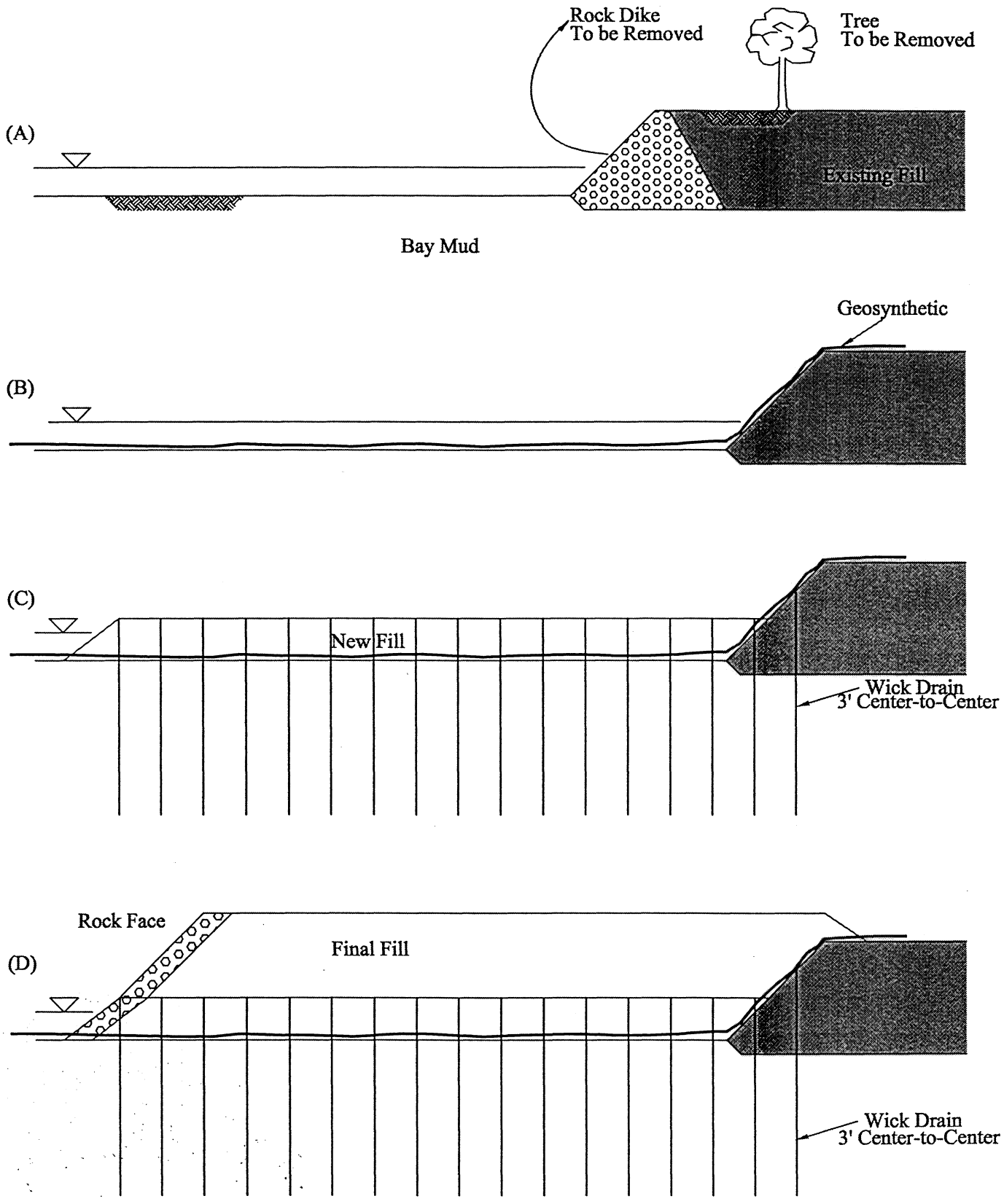

A
A'
PROP. WB
RTE 80
SKYWAY
PROP. EB
SLAB APPROACH STRUCTURE
WB ROADWAY
EB ROADWAY
EXISTING BAY BRIDGE
SOIL PROFILE
LEGEND
SFOBB EAST SPAN SEISMIC SAFETY PROJECT
EMI Project: 98-145
DATE: 11-10-9

FIGURE 5



NEW S.F.-OAKLAND BAY BRIDGE

POSSIBLE CONSTRUCTION SEQUENCE

FIGURE 6

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

Project No. 98-107

Date: 11-10-98

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17660 Newhope Street, Suite E, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project SFOBB. OAKLAND MOLE Project No. _____

By Hubert Date 12-2-98 Checked By _____ Date _____ Sheet ____ of ____

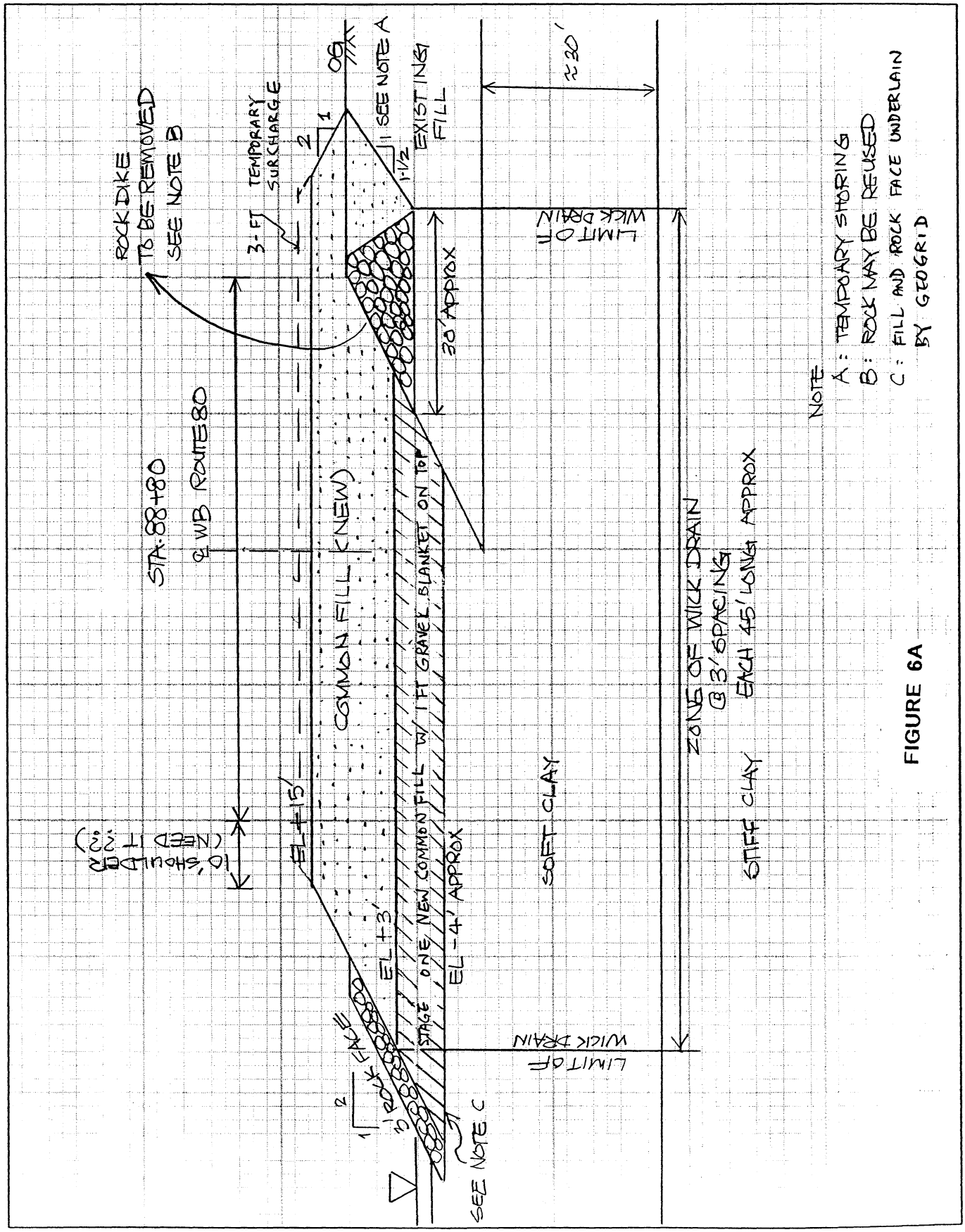


FIGURE 6A

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

17660 Newhope Street, Suite E, Fountain Valley, CA 92708
(714) 751-3826, Fax (714) 751-3928

Project SFOBB OAKLAND MOLE Project No. _____

By HUBERT Date 12-2-98 Checked By _____ Date _____ Sheet ____ of ____

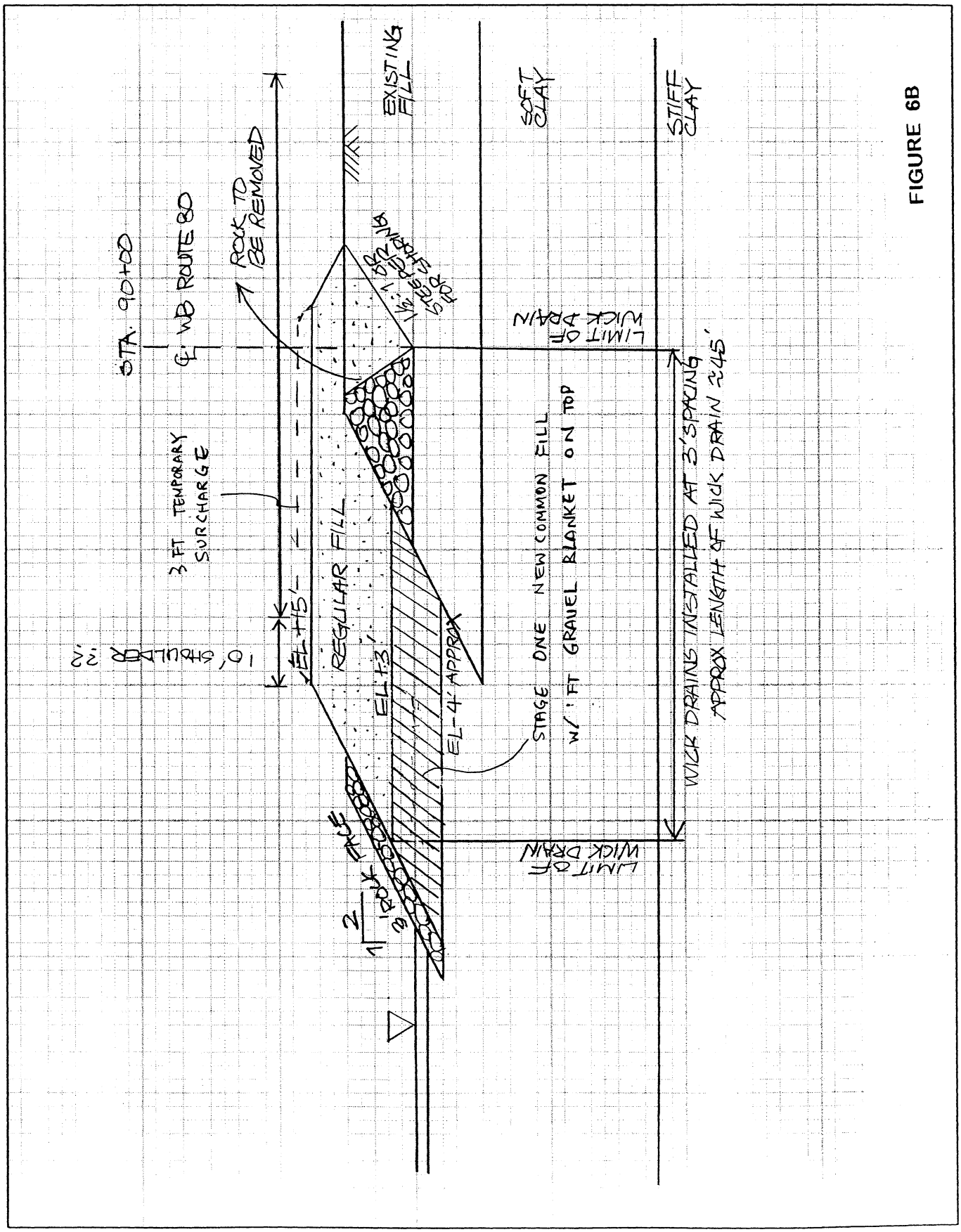
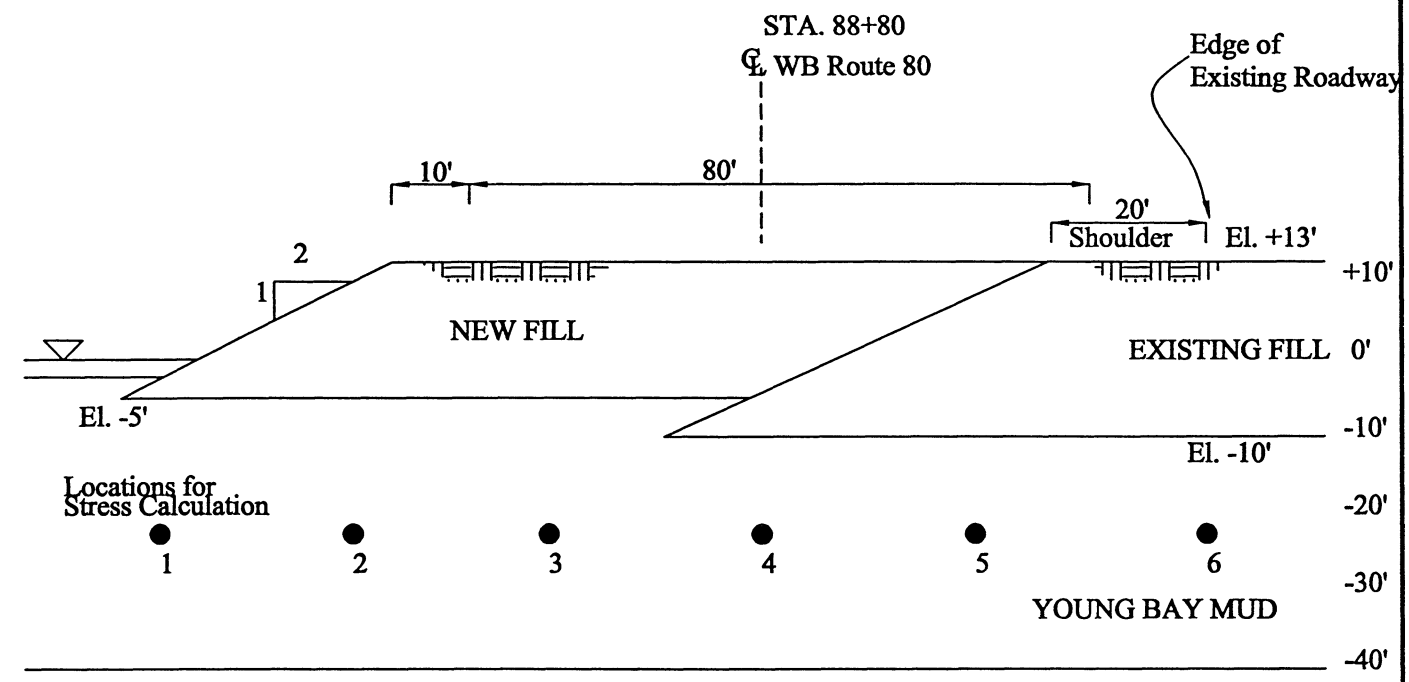
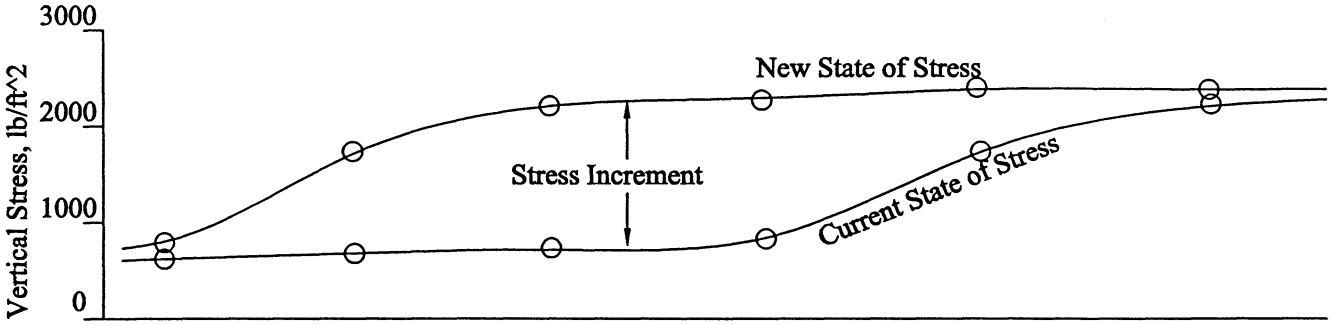
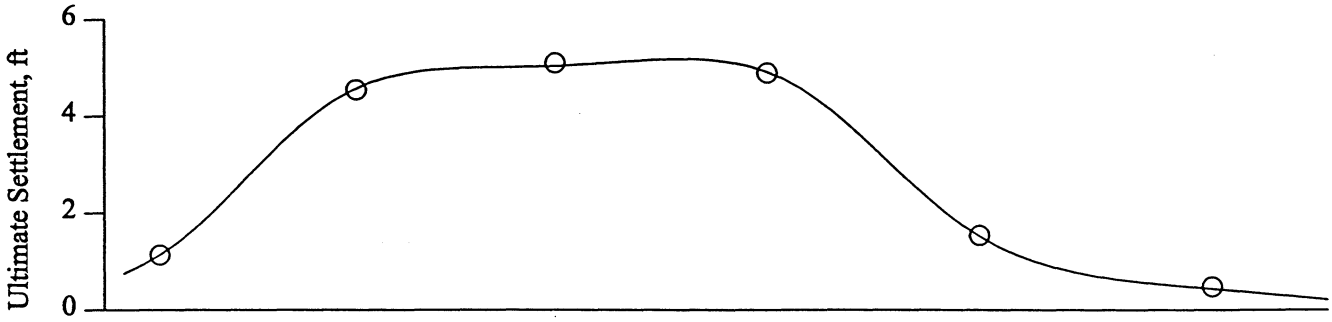


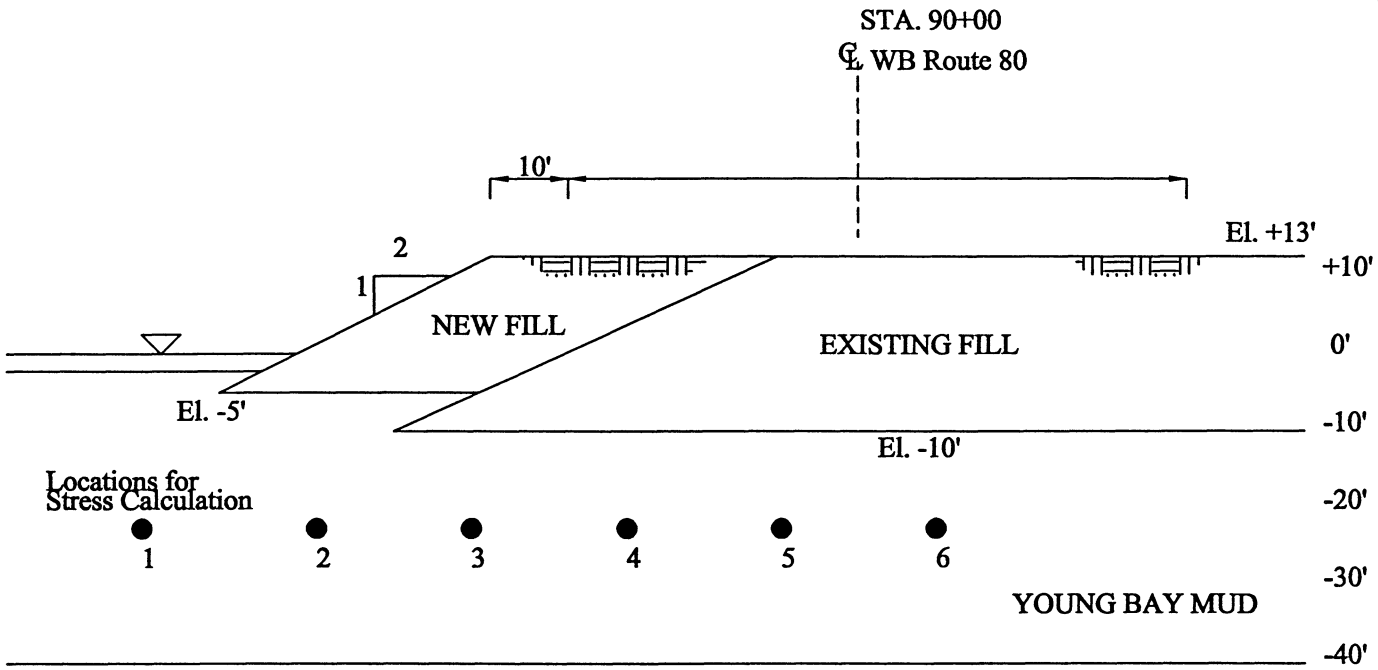
FIGURE 6B

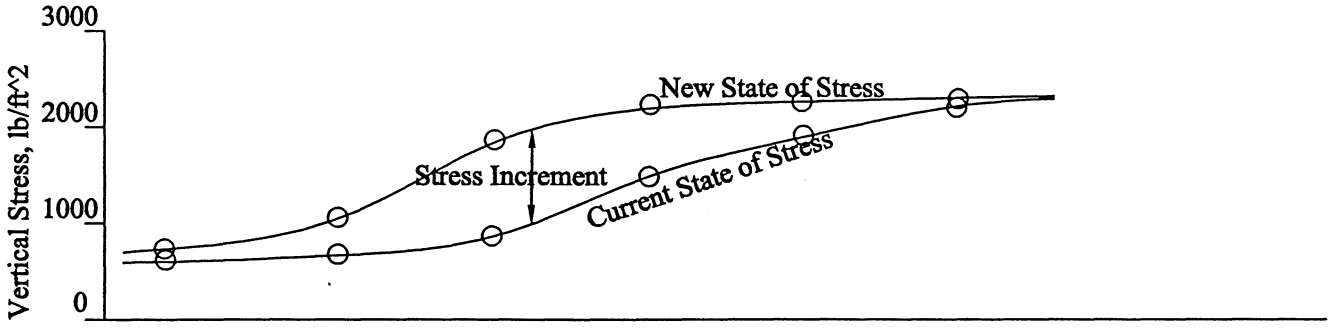


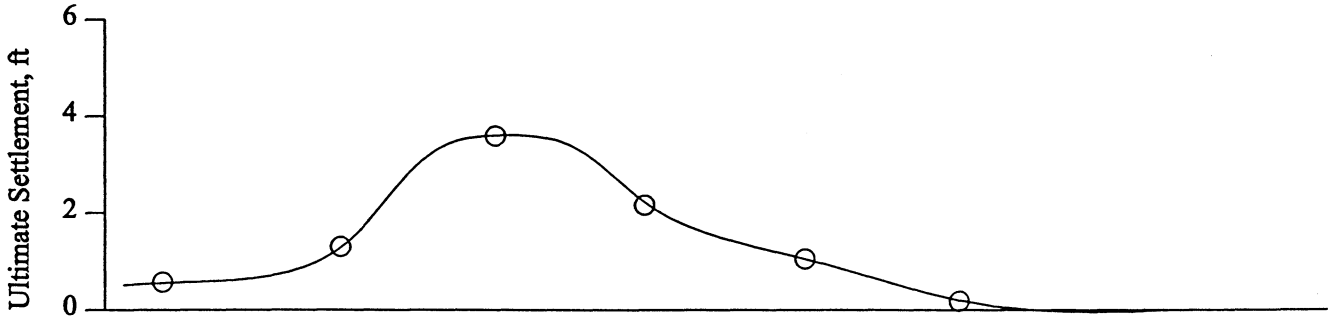




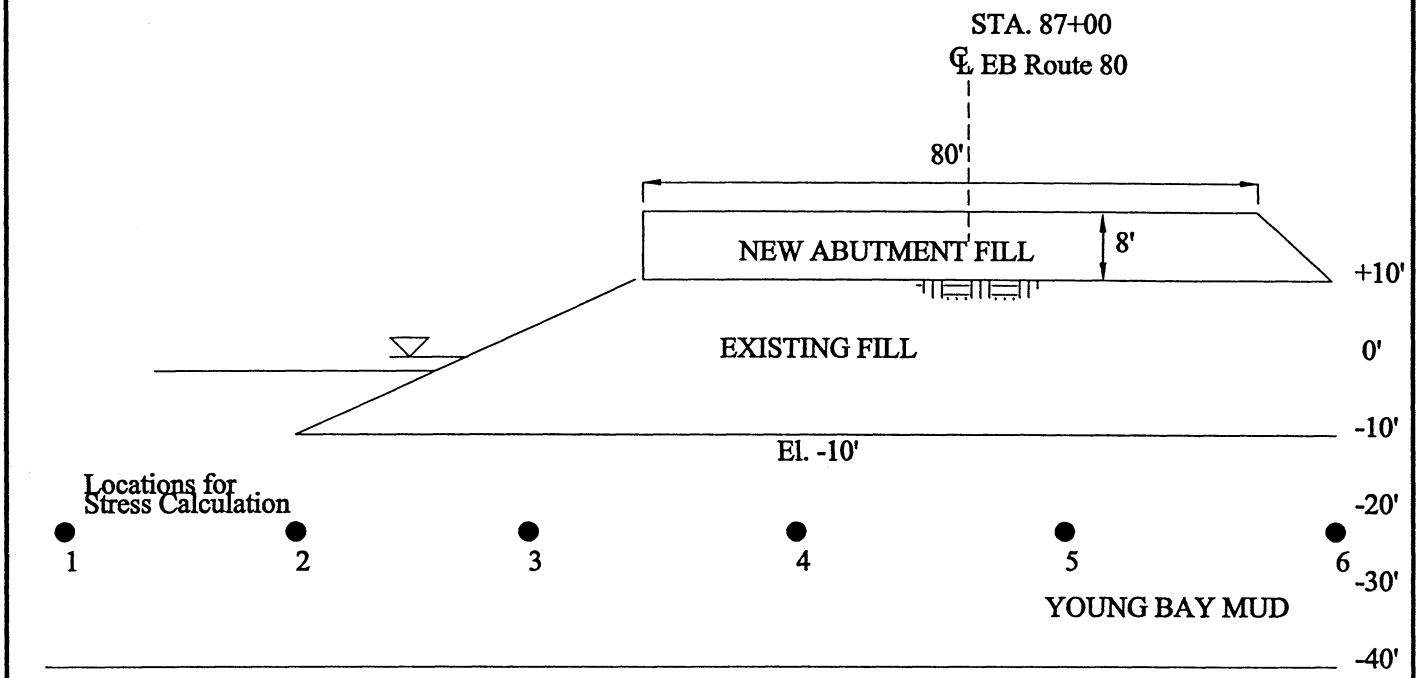
NEW S.F.-OAKLAND BAY BRIDGE	CONSOLIDATION OF WB NEW FILL @ STA 88+80 OAKLAND MOLE FIGURE 7
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	Project No. 98-107 | Date: 11-10-98

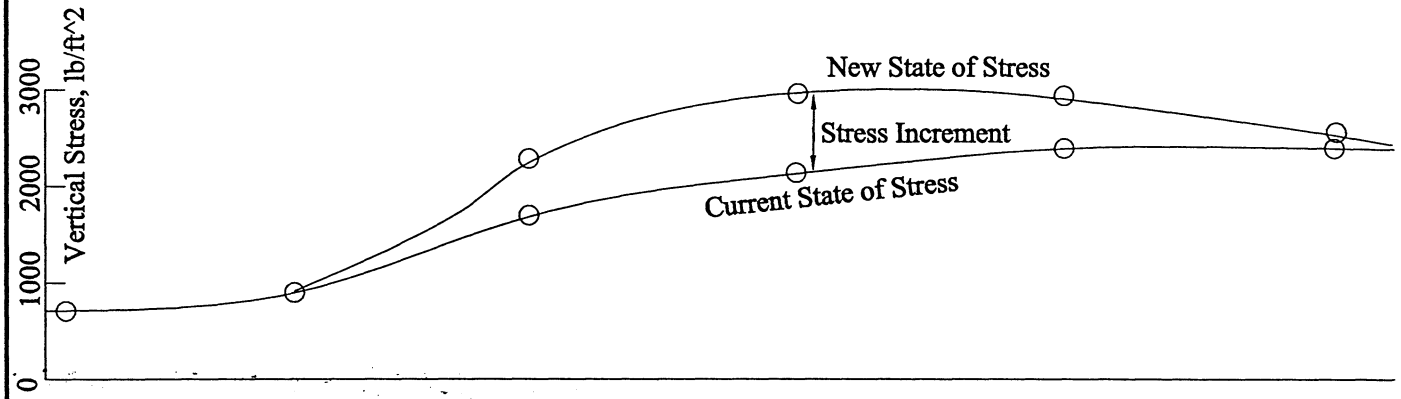


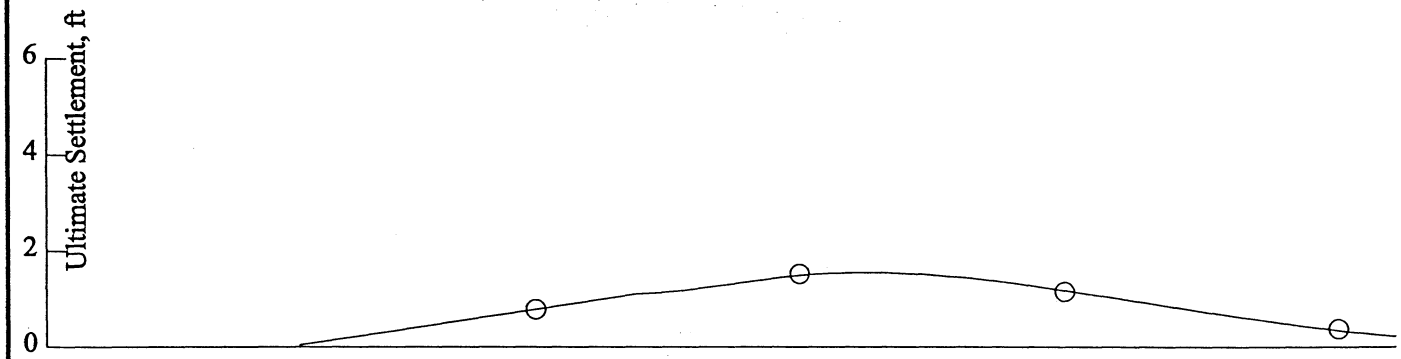




NEW S.F.-OAKLAND BAY BRIDGE	CONSOLIDATION OF WB NEW FILL @ STA 90+00 OAKLAND MOLE **FIGURE 8**
Earth Mechanics, Inc. Geotechnical & Earthquake Engineering	Project No. 98-107 | Date: 11-10-98







NEW S.F.-OAKLAND BAY BRIDGE

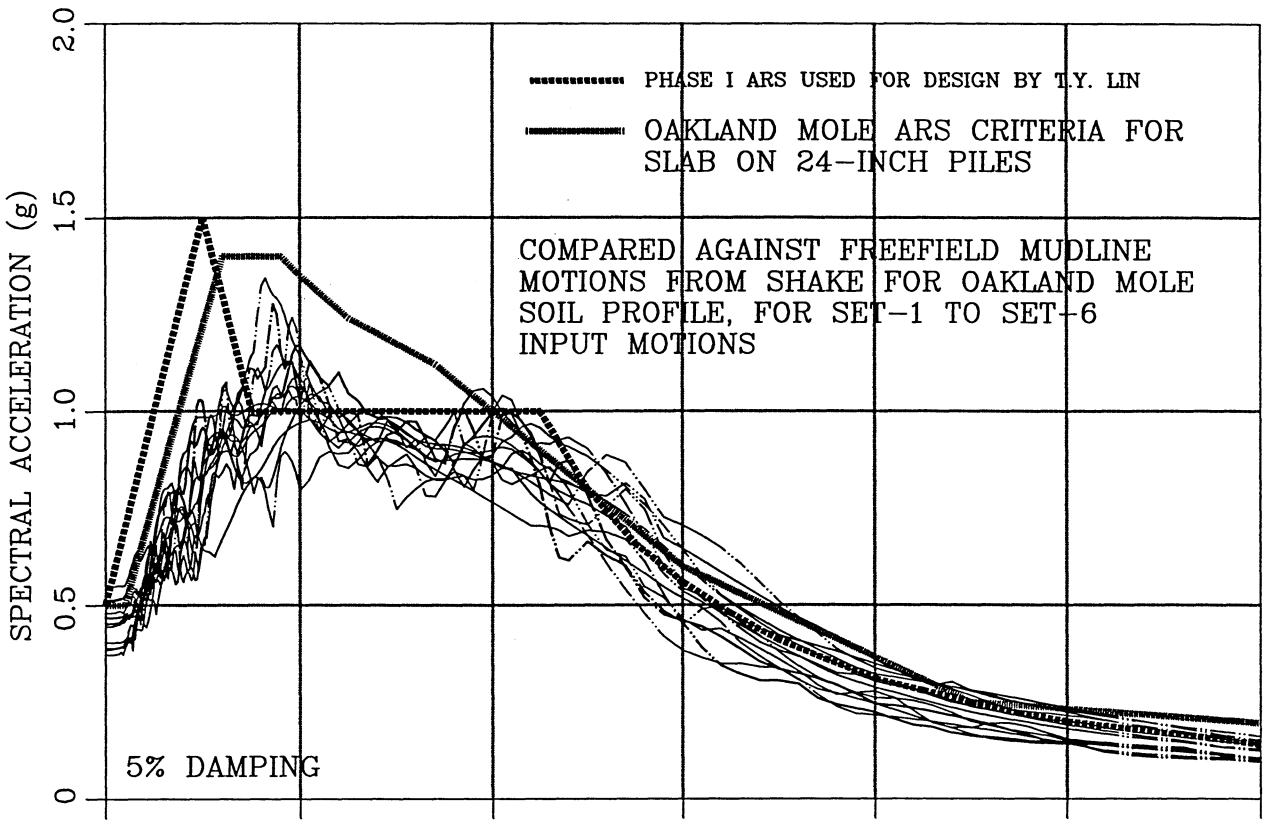
Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

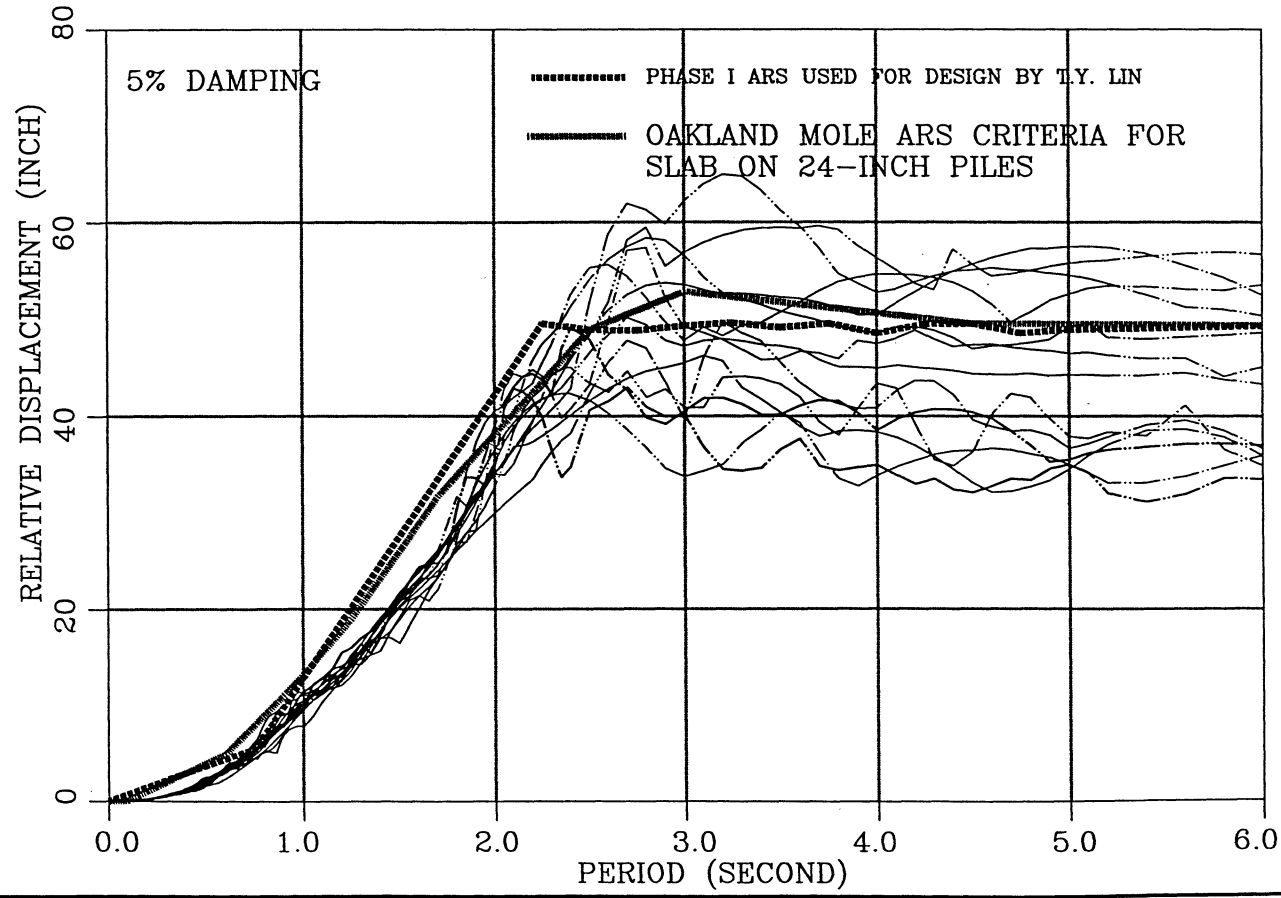
CONSOLIDATION OF EB NEW FILL @ STA 87+00
OAKLAND MOLE

FIGURE 9

Project No. 98-107

Date: 11-10-98

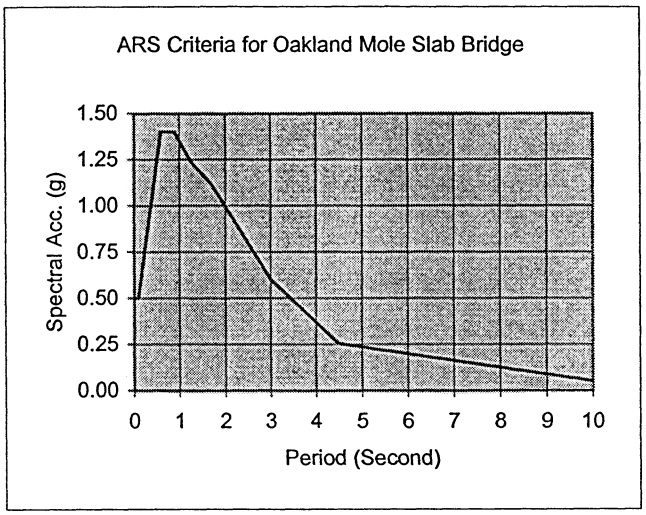




Earth Mechanics, Inc. NEW BAY BRIDGE		ARS CRITERIA FOR OAKLAND MOLE
EMI Project No.: 97-146	Date: 8/22/98	FIGURE 10

ARS Criteria for Oakland Mole Slab Bridge

N	Period (Second)	PSA (g)	Rd (cm)	Rd (in)
1	0.01	0.50	0.0	0.00
2	0.10	0.50	0.1	0.05
3	0.60	1.40	12.5	4.93
4	0.90	1.40	28.2	11.10
5	1.00	1.35	33.6	13.21
6	1.25	1.24	48.2	18.96
7	1.70	1.12	80.2	31.57
8	2.50	0.80	124.3	48.94
9	3.00	0.60	134.3	52.89
10	4.50	0.25	127.4	50.17
11	10.00	0.05	124.3	48.94



N	Period (Second)	Rd (in)
1	0.01	0.00
2	0.10	0.05
3	0.60	3.43
4	0.90	11.10
5	1.00	13.21
6	1.25	18.96
7	1.70	31.57
8	2.50	48.94
9	3.00	52.89
10	4.50	50.17
11	10.00	48.94

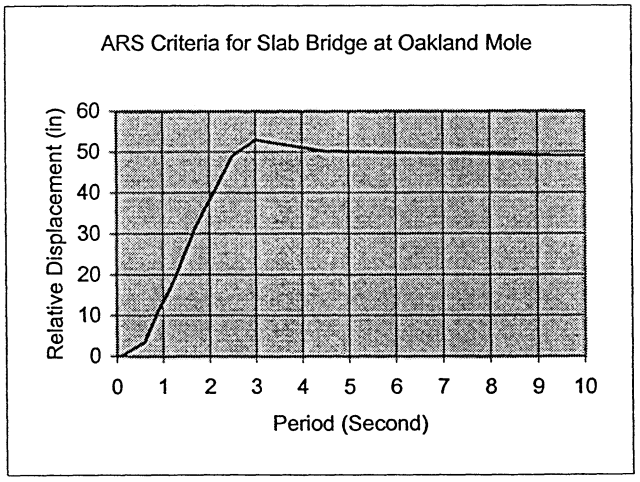


FIGURE 11

Annual Construction Reports
1934, 1935, 1936, 1937

FIRST ANNUAL PROGRESS REPORT SAN FRANCISCO OAKLAND BAY BRIDGE

JULY 1, 1934

Extracted From 1st Annual Report, July 1, 1934

The concrete is placed with electric vibrators, only a minor amount of hand tamping, etc., being employed.

This general setup has been found to work very dependably and satisfactorily on the whole.

PROGRESS AND STATUS

	Start Work	Excavation Complete	Piles Complete	Sealed	July 1, 1934 % Pier Complete
E23	2- 5-34	3-20-34	4-25-34	5- 9-34	80%
E23A	4-13-34	4-25-34	5- 4-34	5-23-34	50%
E24	4- 5-34	5-14-34	5-24-34	6- 5-34	75%
E24A	4-25-34	5-14-34	6-15-34	6-18-34	40%
E25	(Crib for cofferdam partly built—started 6-19-34)				
E25A—No work					

The schedule of the work (revised) calls for the completion of the work in three stages.

	Pier E23	Pier E33	Entire Contract
Scheduled date	June 25, 1934	October 23, 1934	February 21, 1934
Probable date	July 10, 1934	November 10, 1934	December 10, 1934

While the preliminary stages of the contract are somewhat behind schedule, it appears that the contract as a whole will be completed considerably ahead of time.

PRESENT STATUS OF WORK

Pier	Cofferdam	Excavation	Piling	Seal	Elev. Concrete	Per Cent Complete
E23	Complete being pulled	Complete	Complete	Comp.	36' above sea level	80%
E23A	Complete	Complete	Complete	Comp.	5.2' below sea level	50%
E24	Complete	Complete	Complete	Comp.	to 10' above	75%
E24A	Complete	Complete	Complete	Comp.		40%
E25	Guide Frame built. No other piers started.					
Value of contract bid items						$253,665

The value of work done to last monthly estimate, June 20, 1934, was $55,849.27, or 22 per cent of the whole, with 34 per cent of the time elapsed. This lag in time should be rapidly compensated during the future progress of the work, the most difficult stages having been completed.

Contractor is the Clinton Construction Co. of California, the officers of which are:

W. B. Brinker, President.
Albert Huber, Vice President.
Wm. Joyner, Secretary-Treasurer.

Approach Construction

The progress on the approaches to the San Francisco-Oakland Bay Bridge during its first year of construction work was confined to that section which traverses portions of San Francisco Bay along the northerly side of the Key System mole from its westerly end toward the Oakland shore and northerly along this

shore to the foot of Folger Avenue, Berkeley. Work was begun on this section of the project first due to the advisability of giving these fills as long a time as possible in which to attain the major portion of the settlement expected.

Boring Test Location of Fill

In order that a more stable fill might be constructed, the Berkeley Water Front Co. was awarded a contract under which they made 16 three-inch borings along the center line of the approach adjacent to the Key Mole. Undisturbed samples of the underlying strata to a depth of from 40 to 90 feet were taken on these borings and tests made upon them by the Sacramento testing laboratory to determine the weight per cubic foot, percentage moisture, percentage consolidation under various loadings, coefficient of friction and mechanical analysis of the materials. From this and earlier data taken from observations, obtained by District IV, Division of Highways on various fills placed for highway routes under its jurisdiction along the shores of San Francisco Bay, it was possible to design a fill which would be more stable and cause less difficulty from settlement than fills made previously.

Rock Wall Protects Sand Fill

On December 14, 1933, the American Dredging Co. was awarded the contract for making the dredger sand fill at a cost of $869,063.32. It was hoped that a contract could be awarded at this same time for the construction of a rock wall protection for the sand fill, but the bid totals were so high that it was deemed inadvisable to accept any bid because of the necessity of keeping the cost of the approaches to the bridge within the $6,600,000 set up for them by the State Legislature, and accepted by the Reconstruction Finance Corporation.

New bids were called on a revised typical section and decreased rock quantities, and the contract was awarded on December 29, 1933, to Fredrickson and Watson Construction Co., Fredrickson Bros. and the Basalt Rock Co. at a cost of $274,687.50. The dates for completion of the above contracts are June 14, 1935, and June 27, 1935, respectively, although present progress indicates actual completion dates of February or March, 1935.

The work being done under the dredger fill and rock wall contracts are inseparable in regard to economy and practicability of construction. Economical placing of rock could not be done from barges nor could it be placed upon a semi-liquid foundation such as the bay bottom found in this close vicinity.

Rock and Sand Fill Jointly

In turn a dredger sand fill could not be placed to an elevation of 13 feet above mean lower low water without a restraining barrier to keep it within bounds, and prevent its being washed out by the tides after placing. For these reasons it was imperative that the contractors so arrange their operations that there would be no conflict or delay in the work. It was so arranged, and to date everything has worked out very smoothly.

Actual construction was started on January 8, 1934, when the dredge "Harris" started pumping material for the approach fill. It is a 24-inch suction dredge, one of the most powerful in the United States, and has 750 hp. at the cutter, with an overload capacity of 1600 hp. It develops 3000 hp. at the pump and is capable of 3500 hp. The dredge is a very economical plant, having an all electric "Scherbins Control," which gives wide pumping latitude and can be operated at a pressure up to 155 pounds per square inch. With a discharge velocity of 14 feet per second it pumps an average of 11 per cent solids. On June 19th a record output was obtained of 25,400 cubic yards in 23 hours pumping time, or about 1100 cubic

3500 hp. Dredger

yards per hour. This was accomplished with a 12,000-foot or 2¼-mile length of pipe line without a booster.

The material for the fill is being taken from an area in the Oakland Outer Harbor north of the present channel, and is giving the Port of Oakland an excellent turning basin and channel varying in width from 1200 to 1800 feet. The material taken from this area contains an average of 75 per cent fine sand and makes an ideal fill. The fill is built in three stages or lifts; the bay bottom having been dredged of a portion of the mud under the highway proper before filling is begun. In general, the first operation on the work has been to dredge out about 10 feet of the mud from bay bottom, except at the end of the Key System mole and in places where a good foundation was found on the surface. The best design indicated that it would be desirable to have the dredging carried to a depth greater than 10 feet where old, mud-filled channels crossed the highway but limitation of the amount of money available for use on this work made it impossible to do this.

Sand Fill in Three Lifts

The westerly 2000 feet of the fill was needed, on February 1st, for the use of the bridge contractor building the steel and concrete approach spans to the bridge proper, and so was built up as fast as possible, without danger of slides, and delivered to the above contractor in February, 1934.

Dredging out of the mud and placing it alongside the highway was started at the end of the above section, and has been completed throughout the remainder of the mole and to a point northerly along the bay shore 400 feet north of the Judson Manufacturing Company's property, 846,500 cubic yards of mud or 90 per cent of this contract item, having been dredged to date.

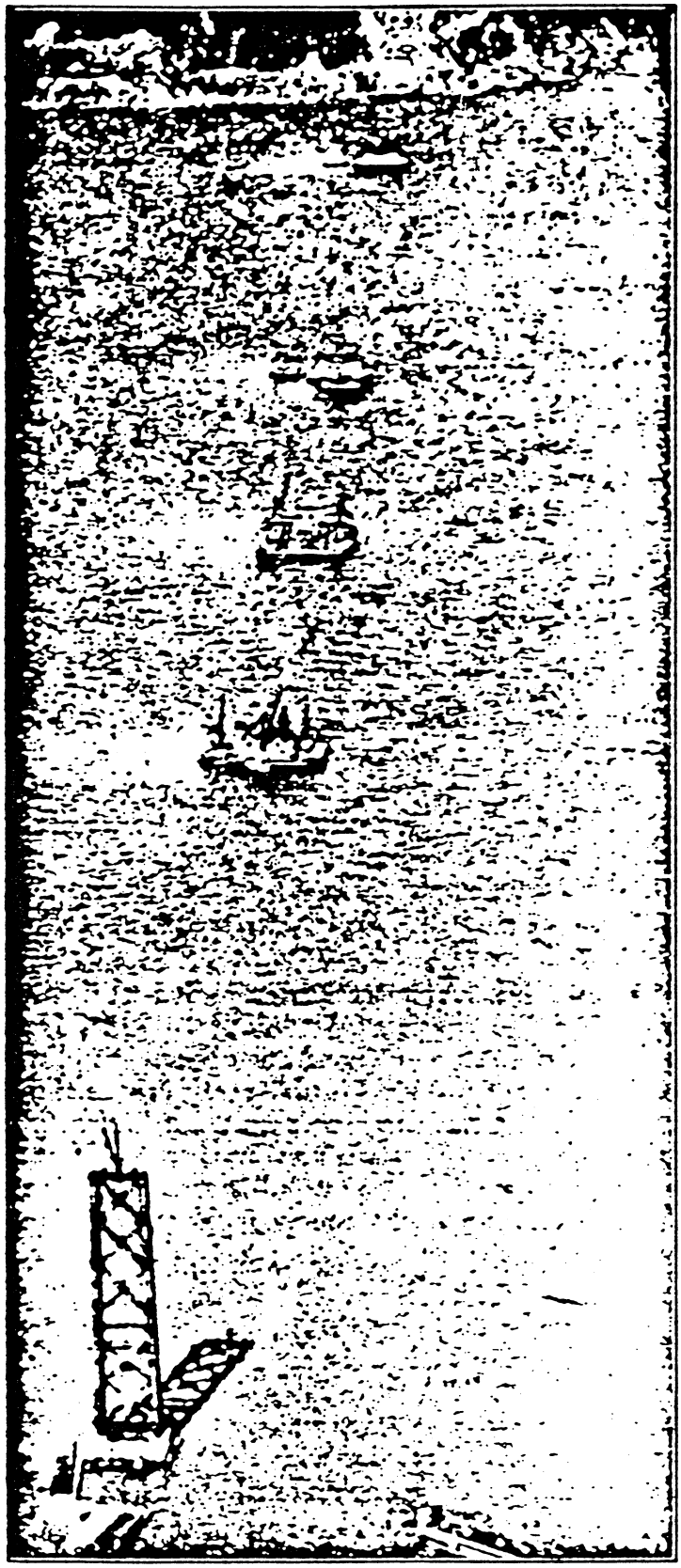
In the process of this work, it was necessary to remove a 38-foot section of the Twenty-second and Thirty-sixth streets lateral sewers, above the flow line, in order to allow passage of the dredge into the portion of the highway between the Oakland outfall sewer and the present mole. These were rebuilt upon completion of the dredging. This work was done by the dredge *Richmond* which is an 18-inch all electric suction dredge.

The first stage of fill was placed to an elevation of +3 mean lower low water. Suspended mud and light clays washed from the sand pumped to the fill and redeposited from the dredging out operation formed mud waves ahead of the toe of the fill, at times, and caused considerable trouble at the outlet to the Oakland outfall sewer, making it necessary to keep the dredge *Richmond* near on standby service to keep the channel open until this section of the fill was complete. Every precaution was also taken to keep the outfall sewer from being moved laterally. This stage of the fill has been placed throughout the mole section to date.

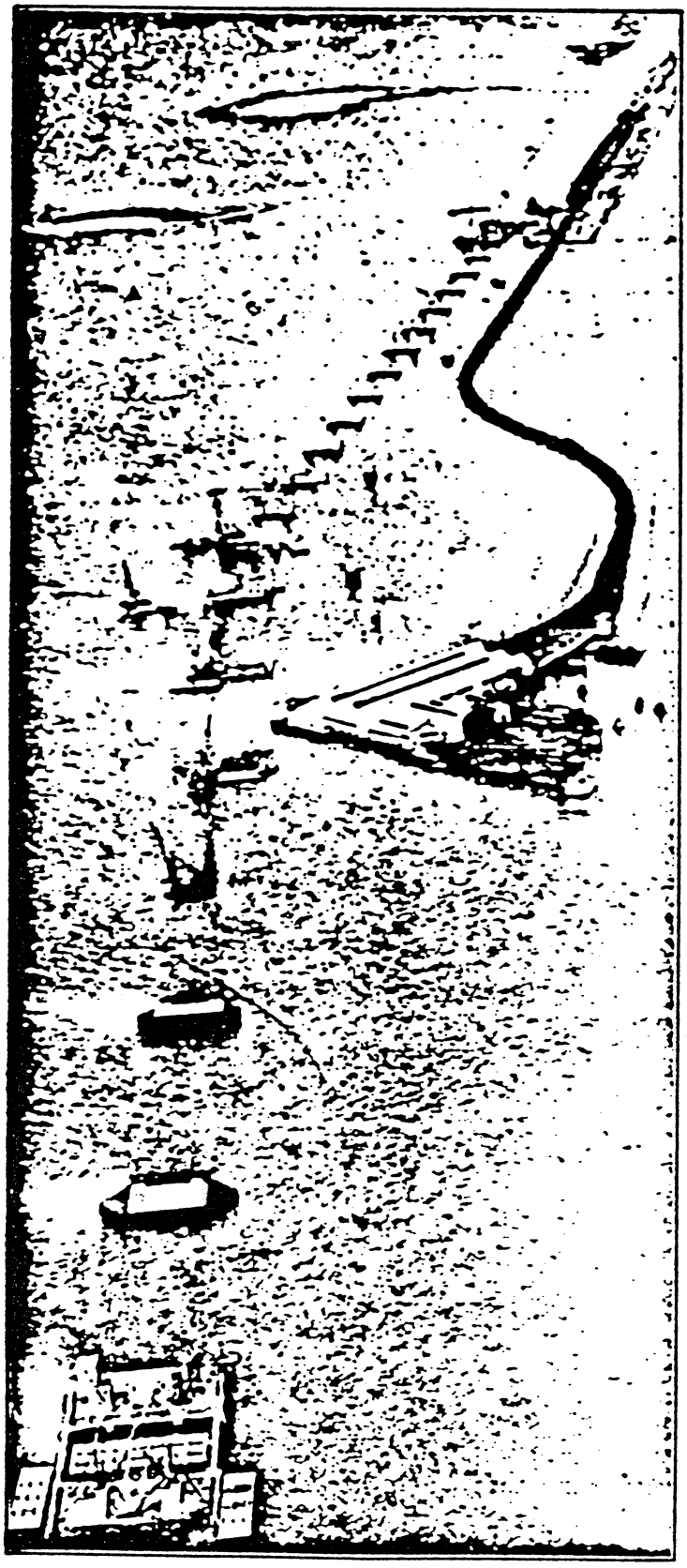
Upon completion of the first stage of the fill a temporary bulkhead, four feet in height, was constructed during the low stages of the tides. This bulkhead served the dual purpose of reducing the amount of core rock necessary in the rock wall facing for the fill and retaining the second stage of the fill which was then placed to an elevation of +7. This second stage in turn served as a roadway for the operation of the rock contractor, and over which 75 hp. caterpillars and 25 to 30-ton capacity Le Tourneau wagons, equipped with eight oversize pneumatic tires, were able to operate a few hours after pumping on this stage had ceased.

Temporary Bulkhead for Sand

Core rock was moved into position beyond the temporary bulkhead to an elevation slightly above +7 by four Le Tourneau wagons, and bulldozed into shape.



Status of West Bay Crossing July 1, 1914



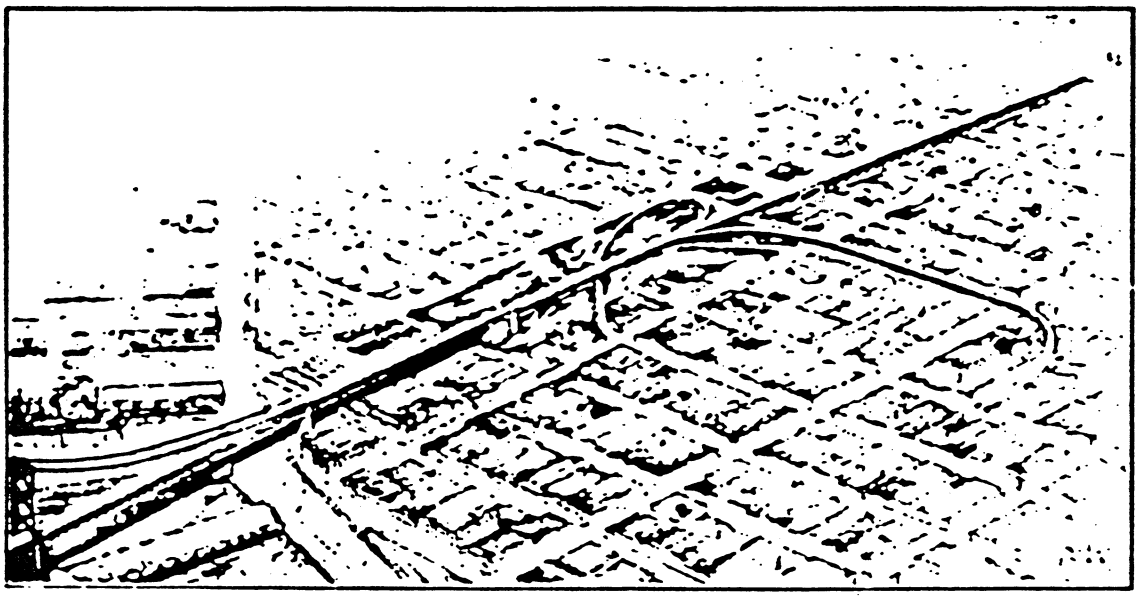
Status of East Bay Crossing July 1, 1934

When this was completed, face rock was placed on the exposed face, and then the remainder of the core rock needed for the wall was placed to the final grade elevation between +13 and +15. This roughly shaped wall was then backed with sand to prevent excess leakage through it during the pumping of the third stage of filling.

The placement of the remainder of the face rock to complete the wall was deferred until the third or final stage of fill had been pumped to grade in order that the rock might be placed by dumping from Le Tourneau wagons rather than by the more expensive method of hand placing by crane or shovel.

...ge Back on Fill

The rock contractor has furnished rock on a guaranteed maximum specific weight basis of 145 pounds for core rock and 150 pounds for face rock. This rock has been furnished from the Napa quarry of the Basalt Rock Co. and a portion of the core rock from the Richfield Quarry in Richmond. The rock was shipped by barge and unloaded into bunkers on a temporary timber pile dock by means of a 2½-yard floating clamshell derrick.



Drawing of San Francisco automobile approaches

...nd and Rock Fill
...s Complete

The contractor has placed the entire section of wall from the beginning of the fill, at the end of the mole, to the outfall sewer outlet including a short section necessary to maintain a sewage outlet channel. This section contains about 56,700 tons of core rock and 29,200 tons of face rock and represents 40 per cent of the work to be done under this contract. It was completed on May 19, 1934, 26 per cent of the contract time having elapsed. The contractor's equipment has been removed from the job until the dredger fill shall have been completed along the mole section before resuming operations, as no wall will be placed along the outfall sewer.

Placing of the third or final stage of the fill was delayed as long as possible after completion of the second stage; not sufficiently long, however, to conflict with the well-timed and planned schedule of the dredging operations. This stage was placed to an elevation sufficiently above the grade line of +13 feet to allow for the anticipated settlement and consolidation that the fill will take in the years to come.

This portion of the fill was made by placing cross dykes along the fill about 2200 feet apart, which with the dykes along either side of the fill, formed a series of settling basins.

The dredger pipe was set at one cross dyke and a spillway outlet of four 24-inch pipes laid at the next dyke to allow the water from the dredger pipe line to escape after the sand which it carried had been deposited in the basin formed. In several places along the line of the rock wall the concentration of this weight added to the wet sand under it caused the material to slip out and leave a low spot in the fill.

These holes were filled later by bulldozing material into them when it was certain that the sand had stabilized. This final stage has been completed along the entire mole section.

2,408,000 Cubic Yards of Sand Dumped Into Fill

The dredging contractor has pumped 2,408,000 cubic yards of sand from the Oakland Outer Harbor to the approach fill which represents 66 per cent of the contract quantity. The entire contract is 63 per cent complete and only 37 per cent of the contract time elapsed.

As a part of the right of way agreement with the Paraffine Companies in Emeryville, where the highway cuts through their property, it was agreed that a double 9 foot by 9 foot concrete subway would be built to allow passage of their trucks from the plant to the waterfront property and export docks. The contract for this job was let on April 7, 1934, to Healy-Tibbitts Construction Co. for $26,433.50.

To date the cofferdam, excavation, driving of piles and forms for the floor slab have been completed. Pouring of concrete will start within the next week. As regards cost this structure is 38 per cent complete, while 70 per cent of the contract time has elapsed.

In the drafting room plans are now being prepared for the traffic distribution structure in the east bay in the hope that it may be advertised for contract in November, 1934. Plans for the San Francisco approaches are getting well along for advertisement at an early date.

The approaches to the San Francisco-Oakland Bay Bridge are being financed from the State Highway Construction Fund, Primary North, from the appropriation of $6,600,000 made by the State Legislature in 1933 to be expended at the rate of $1,650,000 per year.

SECOND ANNUAL PROGRESS REPORT SAN FRANCISCO OAKLAND BAY BRIDGE

JULY 1, 1935

[Division of Highways Contracts Nos. 64TC16, 84TC1–64TC26 and 64TC29; and Bridge Contract Nos. 20 and 20-A]

Extracted from 2nd Annual Report

The East Bay approaches to the San Francisco-Oakland Bay Bridge involve the following contracts:

64TC6 [No. 20], The American Dredging Company, $869,063.32, for the construction of the dredger fill from the Key Mole east to Emeryville and thence northerly to Berkeley; and

64TC8 [No. 20-A], Fredrickson & Watson Construction Co., and Fredrickson Brothers, $274,687.50, for the rock retaining wall for Contract No. 20; and

64TC16, Healy-Tibbitts Construction Company, $26,433.50, for subway beneath the fill opposite Emeryville.

84TC1–64TC26, Barrett & Hilp, $1,026,780, for the East Bay interlacing distribution viaducts at Emeryville.

64TC29, J. F. Knapp, $117,478, for the construction of a concrete subway under the Southern Pacific tracks at Folger Avenue, Berkeley.

(In the first Annual Report the first three contracts mentioned above were described in detail.)

During the past year, the approach construction work has progressed at a rapid pace, with projects under way on both sides of the Bay.

The dredger fill, which was described at considerable length in the previous report, was completed on December 28, 1934, with a total of 3,823,728 cubic yards having been pumped.

Considerable attention was given to subsidence studies, to determine the rate of settlement, especially along the mole line, where firm material was at varying depths, in some cases being quite deep. The settlement rates were plotted on charts, showing the rates with each stage of fill placed. Each additional stage increased the rate of settlement, due to the added load.

From these studies it was possible to compute the future rate of settlement, and estimate the additional height necessary to provide sufficient material, so that when the completed project reached a state of equilibrium with the major subsidence complete, the top of the fill would be approximately to the ultimate grade. In some locations, where the underlying soft material was quite deep, the fill was placed as much as eight feet above the ultimate grade. Settlement records taken after completion of the project until the present time, have confirmed the studies made, and the results have checked the computations very closely.

The Rock Wall contract was completed on April 5, 1935, and the final quantity of rock placed amounted to 101,750 tons of core rock, and 95,403 tons of face rock. This work was prosecuted in an orderly fashion, and was completed well ahead of the contract limit.

The access subway for the Paraffine Companies, under contract to Healy-Tibbitts Construction Company, will be finished within the next month, being at the present time about 95 per cent complete.

On May 22, 1935, Barret and Hilp commenced work on the Distribution Structure, which crosses the tracks of the Key System, Southern Pacific, and Santa Fe Railways at the east end of the mole.

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This interlacing structure, which contains 1.6 miles of roadway, also affects sixteen grade separations. All travel on the Distribution Structure will be unidirectional, or one-way traffic, which minimizes the driving hazards.

On June 8, 1935, J. F. Knapp commenced work on the Folger Avenue Subway. This structure crosses under the tracks of the Southern Pacific Company at Folger Avenue in the city of Berkeley, providing a 44-foot width of pavement.

Falsework is being installed for supporting the railroad tracks during construction, and excavation for the structure will soon commence.

Plans for the central branch of the East Bay Approaches are under way, and the San Pablo Avenue undergrade crossing will soon be advertised for bids. As soon as possible thereafter, the plans for the south branch will be completed and that project advertised for contract.

In addition to the approaches to the bridge, which are financed by the $6,600,000 appropriated for that purpose by the State Legislature, the Division of Highways is building a system of extensions, which includes Harrison, Bryant, Tenth and Potrero Streets in San Francisco, and Moss Avenue and the East Shore Highway in Alameda County. These improvements are financed from regular gas tax funds allocated to the projects.

Bridge Railway

The San Francisco-Oakland Bay Bridge will provide facilities for the transportation of more than 30,000,000 train passengers annually, a large part of whom will be commuters, numbering about 50,000, who live in Alameda County and now go to San Francisco by the combination East Bay electric railways and ferryboats. In the future the transportation will be by the same East Bay electric lines, which, however, are to be extended over the bridge to a terminal in San Francisco. The bridge was designed as much for this great mass of commuting traffic as for the motorist traffic.

The Citizens' Financial Advisory Committee to the California Toll Bridge Authority, a committee of representative citizens of the cities around the Bay region, recommended to the Toll Bridge Authority that the authority provide for an electric railway over the bridge on the same self-liquidating basis upon which the bridge proper is being constructed, and that the California Toll Bridge Authority should acquire statutory power to own, operate and lease cars, trains and other equipment over and in connection with the bridge; and, further, that the existing East Bay lines be given leases on the Authority's railway over the bridge so that the present East Bay cars might, instead of terminating at the ferry slips on the east shore, cross the bridge to a terminal in San Francisco and return.

It was recommended that contracts be drawn between the California Toll Bridge Authority and the Key System and Southern Pacific Companies, owners of the East Bay lines, at a toll sufficient to pay interest on and progressively amortize the capital investment.

Several sites for the terminal in San Francisco were proposed and were given thorough engineering analyses. Considerations in the location of the terminal were: passenger comfort and convenience, capital investment, proximity to the destinations of the commuters, traffic congestion, damage to adjoining property,

THIRD ANNUAL PROGRESS REPORT SAN FRANCISCO OAKLAND BAY BRIDGE

..JULY 1, 1936..

Extracted From 3rd Annual Report, July 1, 1936

side roads were 99 per cent completed. Selected base material was placed on part of the side roads, with paving scheduled to start early in July. The contract is scheduled for completion by September 1, 1936.

PERSONNEL

The contract for this work is held by J. F. Knapp of Oakland, California, of which Otto Parlier is Associate and Superintendent. V. A. Endersby is Resident Engineer.

Mole Paving (Contract No. 84TC4)

Sixty-foot Pavement

This contract covers the paving of the mole fill, extending from the east end of the bridge to the distribution structure and thence extending north to the west end of the Folger Avenue underpass. East of the toll plaza the cross-section has a 60-foot pavement to accommodate traffic from the upper deck of the bridge, and two 22-foot pavements, one on either side of the roadway, separated from the main roadway by curbed parkways five and one-half feet in width. East of the toll plaza the present contract includes two 32-foot asphalt concrete pavements, separated by a five and one-half-foot curbed parkway strip in the center. Space is provided for future widening of these pavements when necessary. Between the distribution structure and the Folger Avenue underpass to the north, there are two 21-foot asphalt concrete, one-way pavements, separated by a center parkway six feet in width.

Ten-foot wide rock shoulders, oil treated, are to be provided adjacent to all outside lanes of all the roadways involved.

Work started on this contract in November of 1935, and was 55 per cent completed on June 30, 1936.

PERSONNEL

The contract for this work is held by the Hanrahan-Wilcox Corporation. E. G. Poss is District Construction Engineer with L. G. Marshall as Resident Engineer.

Ashby Avenue Connection (Contract No. 84TC8)

This project involves the construction of a concrete pavement 47 feet wide and 56 feet wide between concrete curbs with eight-foot sidewalk spaces on either side, extending from the east end of the Folger Avenue underpass to a connection with Ashby Avenue at Ninth Street in Berkeley—a total length of 0.3 mile.

Work started on this contract in May of 1936, and was approximately 35 per cent completed on June 30, 1936.

The contract is held by L. C. Seidel. E. G. Poss is District Construction Engineer with L. G. Marshall as Resident Engineer.

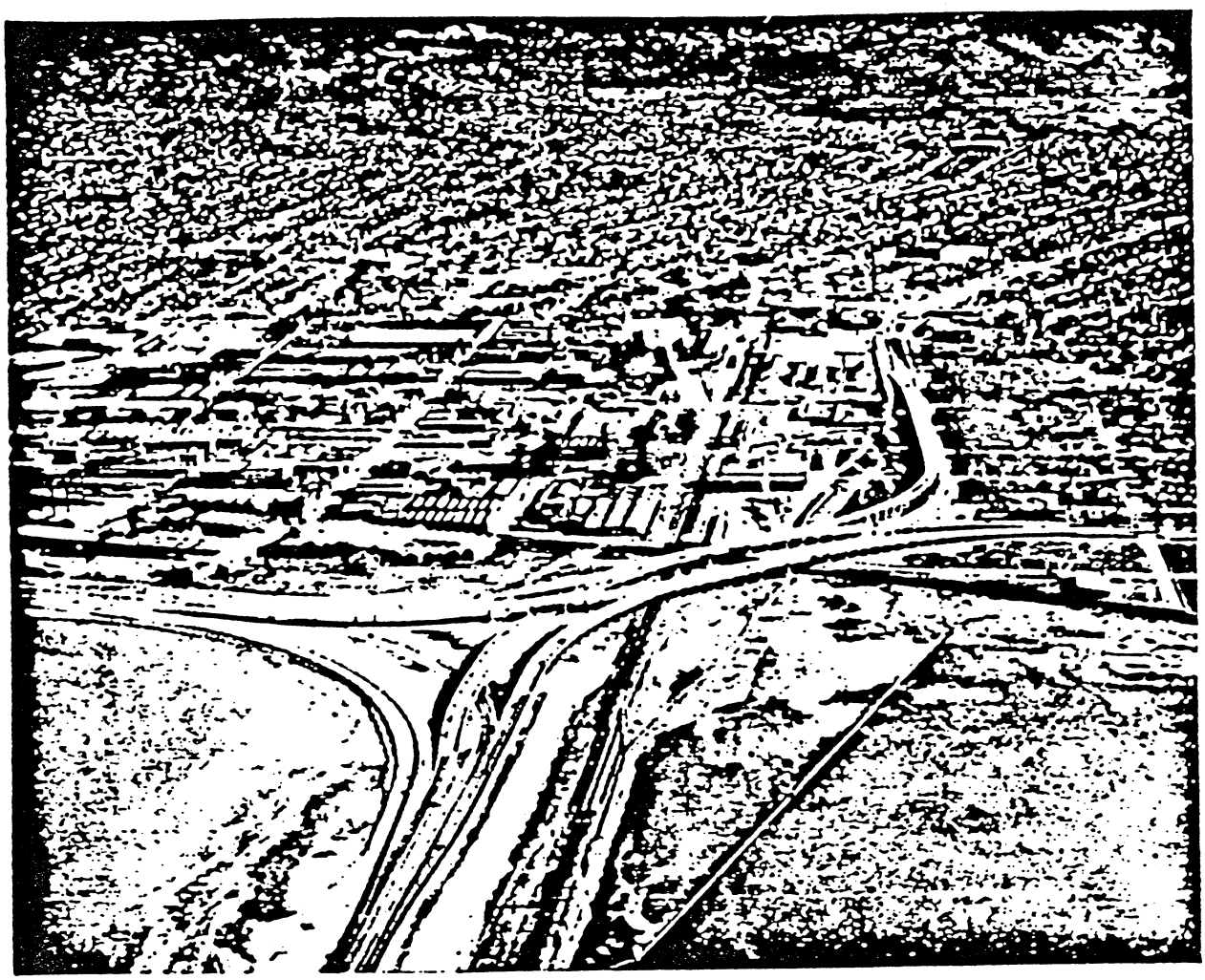
Cypress Street Improvement (Contract 84TC10)

This project covered paving from the southerly approach to the distribution structure at Thirty-fourth Street to the intersection of Seventh and Cypress Streets in Oakland, a distance of 1.4 miles. Beween Thirty-fourth and Eighteenth Streets the paving involves an asphalt concrete surface 40 feet in width, two eight-foot oiled and screened rock borders. Between Eighteenth and Seventh Streets the asphalt concrete pavement is 60 feet in width, with eight-foot Portland cement concrete gutters and curbs on either side, providing a completed 76-foot roadway between curbs.

FOURTH ANNUAL
PROGRESS
REPORT
SAN FRANCISCO
OAKLAND
BAY BRIDGE

. . JULY 1, 1937 . .

Extracted From 4th Annual Report July 1, 1937



Aerial View of Bay Bridge Structure, December 1, 1936

San Pablo Underpass (Contract 84TC3)

At the beginning of the fiscal year, with this project 84 per cent complete, the only remaining work consisted of the paving of the side roads adjacent to the Underpass. This was completed on August 4, 1936.

Mole Paving (Contract 84TC4)

By June 30, 1936, this project was approximately 55 per cent complete. Rapid progress was continued throughout the early month of the fiscal year, with the major portion of the work completed in time for the opening of the bridge. The final cleanup was deferred until after the opening, so that all efforts could be directed toward consummation of the paving work. The project was recommended for acceptance on November 25, 1936, two weeks after the official bridge opening.

Ashby Avenue Connection (Contract 84TC8)

This project was 35 per cent complete at the end of the fiscal year. The balance of the work was rapidly prosecuted and completed on August 27, 1936.

Cypress Street Improvement (Contract 84TC10)

This project was briefly described in Volume III. At the beginning of the fiscal year actual construction work had not been started. Bids were taken on June 24, 1936, and the contract was awarded to the Hanrahan Company.

Original Contract Document for Dredger Fill for the Existing Fill 1933

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

SPECIAL PROVISIONS PROPOSAL AND CONTRACT

FOR CONSTRUCTING A

DREDGER FILL

IN

ALAMEDA COUNTY BETWEEN THE WESTERLY END OF THE KEY MOLE FILL AND THE FOOT OF FOLGER AVE., BERKELEY; DISTRICT IV, EAST BAY APPROACH, SAN FRANCISCO-OAKLAND BAY BRIDGE.

For Use in Connection With Standard Specifications Dated January, 1930.

CONTRACT No._____

1933

CALIFORNIA STATE PRINTING OFFICE
HARRY HAMMOND, STATE PRINTER
SACRAMENTO, 1933

7817

Alameda County East Bay Bridge Approach

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

NOTICE TO CONTRACTORS

Sealed proposals will be received at the office of the State Highway Engineer, Public Works Building, Sacramento, California, until 2 o'clock p.m. on November 15, 1933, at which time they will be publicly opened and read, for construction in accordance with the specifications therefor, to which special reference is made, of portions of State Highway as follows:

Alameda County, between the westerly end of the Key Mole fill, and the foot of Folger Ave. in Berkeley, East Bay Approach, San Francisco-Oakland Bay Bridge, about four and one-tenth (4.1) miles in length, to be graded by dredging and placing selected dredger material fill.

STATE HIGHWAY ENGINEER'S ESTIMATE.

Item 1.	100	lineal feet removing and reconstructing existing 6′ 0″ by 6′ 2″ sewer.
Item 2.	50	lineal feet removing and reconstructing existing 3′ 6″ by 3′ 6″ sewer.
Item 3.	946,000	cubic yards dredging.
Item 4.	3,625,000	cubic yards dredger sand fill.
Item 5.	7,990	cubic yards structure excavation.
Item 6.	498	cubic yards Class "A" Portland cement concrete (structures).
Item 7.	47,600	pounds bar reinforcing steel (structures).
Item 8.	2,560	lineal feet furnishing untreated Douglas fir piles.
Item 9.	84	each, driving piles.
Item 10.	430	lineal feet 8″ vitrified sewer pipe.
Item 11.	976	lineal feet 12″ vitrified sewer pipe.
Item 12.	140	lineal feet 24″ vitrified sewer pipe.
Item 13.	520	lineal feet 30″ vitrified sewer pipe.
Item 14.	356	lineal feet 18″ corrugated metal pipe.
Item 15.	366	lineal feet 24″ corrugated metal pipe.

Item 16. 190 lineal feet 36″ corrugated metal pipe.

Item 17. 4 each, cutting openings in existing concrete sewer.

Item 18. 215 stations finishing roadway.

SUPPLEMENTAL ITEM.

(Note: This item will not be included when comparing bids.)

Item 19. 140,000 cubic yards dredger sand fill (private fill on property of Paraffine Companies, Inc.).

The State will furnish corrugated metal pipe and tidegates as more explicitly set forth in the special provisions.

In accordance with the provisions of Chapter 397, Statutes of 1931, the Department of Public Works has ascertained the general prevailing rate of wages applicable to the work to be done to be as follows:

Classification	Rate per hour
Laborer	$0.60
Tractor driver (30 h.p.)	0.96
Tractor driver (60 h.p. to 80 h.p.)	1.10
Carpenter	1.00
Carpenter's helper	0.80
Truck driver (15,500 or less)	0.82
Truck driver (over 15,500)	0.96
Power shovel or crane operator	1.25
Oiler	0.82
Grader operator	0.82
Roller operator	1.25
Driller	0.82
Blacksmith	1.00
Blacksmith's helper	0.80
Powderman	0.82
Reinforcing steel worker	1.125
Mechanic (trouble shooter)	0.88
Handyman	0.60
Leverman	1.10
Machinist	1.10
Machinist's helper	0.80
Rigger	1.10
Cranesman	1.10
Assistant engineer	0.95
Assistant electrician	0.85
Fireman	0.80
Levee foreman	0.85
Levee man	0.70
Deck hand	0.80
Mate	0.80
Towboat operator	0.80
Launchman	0.80
Confidential clerk	0.75
Any classification omitted herein not less than	0.60
Overtime	one and one-half (1½) times the above rates
Sundays and holidays (except watchmen, guards and flagmen)	double the above rates

The Director of the Department of Industrial Relations has determined that the classifications of leverman, mate, towboat operator, confidential clerk, levee foreman, assistant engineer and assistant electrician enumerated above shall be exempt from the application of the provisions of an act establishing a thirty hour week on public works as more specifically set forth in Section 4, article (c), "Laws to be Observed," of the special provisions.

The foregoing quantities are approximate only, being given as a basis for the comparison of bids, and the Department of Public Works does not, expressly or by implication, agree that the actual amount of work will correspond therewith, but reserves the right to increase or decrease the amount of any class or portion of the work, as may be deemed necessary or expedient by the said Department of Public Works.

All bids are to be compared on the basis of the State Highway Engineer's estimate of the quantities of work to be done.

Proposal forms will be issued only to those Contractors who have furnished a verified statement of experience and financial condition in accordance with the provisions of Chapter 788, Statutes of 1933, and whose statements so furnished are satisfactory to the Department of Public Works.

Bids will not be accepted from a Contractor who has not been licensed in accordance with the provisions of Chapter 791, Statutes of 1929, as amended, or to whom a proposal form has not been issued by the Department of Public Works.

The attention of bidders is directed to the special provisions covering subletting and assigning the contract and to the use of domestic materials.

Plans may be seen, and forms of proposal, bonds, contract and specifications may be obtained at the said office, and they may be seen at the offices of the District Engineers at Los Angeles and San Francisco, at the office of the San Francisco-Oakland Bay Bridge, and at the office of the Associated General Contractors in San Francisco.

Contractors are urged to investigate the location, character and quantity of work to be done.

Detailed information concerning the proposed work may be obtained from the San Francisco-Oakland Bay Bridge office.

No bid will be received unless it is made on a blank form furnished by the State Highway Engineer. The special attention of prospective bidders is called to the "Proposal Requirements and Conditions" annexed to the blank form of proposal, for full directions as to bidding, etc.

The Department of Public Works reserves the right to reject any or all bids.

DEPARTMENT OF PUBLIC WORKS,
DIVISION OF HIGHWAYS,

C. H. PURCELL,
State Highway Engineer.

Dated November 3, 1933.

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

PROPOSAL REQUIREMENTS AND CONDITIONS.

(a) Contents of Proposal Forms.—Prospective bidders will be furnished with proposal forms which will state the location and description of the contemplated construction and will show the approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished, with a schedule of items for which unit bid prices are asked. All special provisions will be grouped together and attached to the proposal form.

(b) Approximate Estimate.—The quantities given in the notice to Contractors, proposal and contract forms are approximate only, being given as a basis for the comparison of bids, and the Department of Public Works does not, expressly or by implication, agree that the actual amount of work will correspond therewith, but reserves the right to increase or decrease the amount of any class or portion of the work, or to omit portions of the work as may be deemed necessary or expedient by the Engineer.

(c) Examination of Plans, Specifications, Special Provisions and Site of Work.—The bidder is required to examine carefully the site of, and the proposal, plans, specifications and contract forms for the work contemplated, and it will be assumed that the bidder has investigated and is satisfied as to the conditions to be encountered, as to the character, quality, and quantities of work to be performed and materials to be furnished, and as to the requirements of the Standard Specifications, the special provisions and the contract. It is mutually agreed that submission of a proposal shall be considered prima facie evidence that the bidder has made such examination.

(d) Proposal Forms.—All proposals must be made upon blank forms to be obtained from the State Highway Engineer at his office, Public Works Building, Sacramento. Proposal forms are numbered serially and are not transferable. The bidder must submit his proposal on the form furnished to him. Proposals submitted on forms other than the one issued to the bidder will be disregarded. All proposals must give the prices proposed, both in writing and figures, and must be signed by the bidder, with his address. If the proposal is made by an individual, his name and post-office address must be shown. If made by a firm or partnership, the name and post-office address of each member of the firm or partnership must be shown. If made by a corporation, the proposal must show the name of the State under the laws of which the corporation was chartered and the names, titles, and business addresses of the president, secretary, and treasurer.

(e) Rejection of Proposals Containing Alterations, Erasures or Irregularities.—Proposals may be rejected if they show any alterations of form, additions not called for, conditional or alternate bids, incomplete bids, erasures, or irregularities of any kind.

(f) Bidder's Guaranty.—All bids shall be presented under sealed cover and shall be accompanied by cash, cashier's check or a certified check made payable to the Director of Public Works, for an amount equal to at least ten per cent (10%) of the amount of said bid and no bid shall be considered unless such cash, cashier's check or certified check is inclosed therewith.

(g) Time of Opening.—Sealed proposals, addressed to the State Highway Engineer, and endorsed:

"Proposal for Constructing a Portion of the East Bay Approach to the San Francisco-Oakland Bay Bridge in Alameda County—Dredging"

will be received by the State Highway Engineer and will be publicly opened and read at the time and place stated in the notice to Contractors.

(h) Withdrawal of Proposals.—Any bid may be withdrawn at any time prior to the hour fixed in the notice to Contractors for the opening of bids, provided that a request in writing executed by the bidder or his duly authorized representative for the withdrawal of such bid is filed with the Director of Public Works or the State Highway Engineer. The withdrawal of a bid shall not prejudice the right of a bidder to file a new bid.

(i) Public Opening of Proposals.—Proposals will be opened and read publicly at the time and place indicated in the notice to Contractors. Bidders or their authorized agents are invited to be present.

(j) Disqualification of Bidders.—More than one proposal from an individual, a firm or partnership, a corporation or an association under the same or different names, will not be considered. Reasonable ground for believing that any bidder is interested in more than one proposal for the work contemplated will cause the rejection of all proposals in which such bidder is interested. If there is reason for believing that collusion exists among the bidders, none of the participants in such collusion will be considered in future proposals. Proposals in which the prices obviously are unbalanced may be rejected. Contracts will be awarded only to responsible bidders capable of performing the class of work contemplated.

(k) Competency of Bidders.—Before receiving proposal forms, prospective bidders must file with the Department of Public Works a statement of their financial condition and previous construction experience on a standard form which can be secured from the State Highway Engineer at his office, Public Works Building, Sacramento, in accordance with the provisions of Chapter 788, Statutes of 1933. Proposal forms will not be furnished to prospective bidders who have not qualified by submitting the above statement of their financial condition and construction experience.

Proposal forms will not be furnished to any prospective bidder who has not been prequalified as above provided at least five (5) days prior to the date fixed for opening bids for the work on which said bidder intends to submit a bid.

Bidders will not be required to submit the plan and equipment statement specified in Section 2, article (k), of the Standard Specifications with their proposals for the work herein contemplated.

(l) Material Guaranty.—Before any contract is awarded, the bidder may be required to furnish a complete statement of the origin, composition, and manufacture of any or all materials to be used in the construction of the work, together with samples, which samples may be subjected to the tests provided for in the Standard Specifications or in the special provisions to determine their quality and fitness for the work.

AWARD AND EXECUTION OF CONTRACT.

(a) **Award of Contract.**—The right is reserved to reject any and all proposals. The award of the contract, if it be awarded, will be to the lowest responsible bidder whose proposal complies with all the requirements prescribed. The award, if made, will be made within thirty (30) days after the opening of the proposals.

(b) **Return of Bidders' Guaranties.**—Within ten (10) days after the award of the contract, the Department of Public Works will return the proposal guaranties accompanying such of the proposals which are not to be considered in making the award. All other proposal guaranties will be held until the contract has been finally executed, after which they will be returned to the respective bidders whose proposals they accompany.

(c) **Contract Bonds.**—The Contractor shall furnish two good and sufficient bonds executed as surety by a corporation or corporations authorized to issue surety bonds in the State of California, as provided by Chapter 788, Statutes of 1933. Each of the said bonds shall be executed in a sum equal to at least one-half of the contract price. One of the said bonds shall guarantee the faithful performance of the said contract by the Contractor; and the other of the said bonds shall be furnished as required by the terms of an act entitled

> "An act to secure the payment of the claims of persons employed by contractors upon public works, and the claims of persons who furnish materials, supplies, teams, implements or machinery used or consumed by such contractors in the performance of such works, and prescribing the duties of certain public officers with respect thereto," approved May 10, 1919, as amended.

Whenever any surety or sureties on any such bonds, or on any bonds required by law for the protection of the claims of laborers and material men, becomes insufficient, or the Director of Public Works has cause to believe that such surety or sureties has become insufficient, he may demand in writing of the Contractor such further bond or bonds or additional surety, not exceeding that originally required, as in his opinion is necessary, considering the extent of the work remaining to be done. Thereafter no payment shall be made upon such contract to the Contractor or any assignee of the Contractor until such further bond or bonds or additional surety has been furnished.

(d) **Execution of Contract.**—The contract shall be signed by the successful bidder and returned, together with the contract bonds, within eight (8) days, not including Sundays, after the bidder has received notice that the contract has been awarded. No proposal shall be considered binding upon the State until the execution of the contract.

(e) **Failure to Execute Contract.**—Failure to execute a contract and file acceptable bonds as provided herein within eight (8) days, not including Sundays, after the bidder has received notice that the contract has been awarded shall be just cause for the annulment of the award and the forfeiture of the proposal guaranty. If the successful bidder refuses or fails to execute the contract, the Director of Public Works may award the contract to the second lowest responsible bidder. If the second lowest responsible bidder refuses or fails to execute the contract, the Director of Public Works may award the contract to the third lowest responsible bidder. On the failure or refusal of the second or third lowest responsible bidder, to whom any such contract is so awarded, to execute the same such bidders' guaranties shall be likewise forfeited to the State. The work may then be readvertised or may be constructed by day labor as the Director may decide.

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

SPECIAL PROVISIONS FOR CONSTRUCTING A PORTION OF A STATE HIGHWAY IN THE COUNTY OF ALAMEDA, BETWEEN THE WESTERLY END OF THE KEY MOLE FILL AND THE FOOT OF FOLGER AVE., BERKELEY; DISTRICT IV, EAST BAY APPROACH, SAN FRANCISCO-OAKLAND BAY BRIDGE.

(Annexed to Contract No._____.)

Section 1. Plans and Specifications.—The work embraced herein shall be done in accordance with the Standard Specifications of the Department of Public Works, Division of Highways, dated January, 1930, in so far as the same may apply and in accordance with the following special provisions.

In case of conflict between the Standard Specifications and these special provisions, the special provisions shall take precedence over and be used in lieu of such conflicting portions.

Identical plans will cover the work of this contract and a coincident contract for constructing rock wall and riprap. All work shown upon these plans, excepting the rock wall and riprap, shall apply to and come under the provisions of this contract, subject to the modifications of these special provisions.

Section 2. Progress of the Work and Time for Completion.—The Contractor shall begin work within fifteen (15) days after receiving notice that the contract has been approved by the Attorney General or the attorney appointed and authorized to represent the Division of Highways, and shall diligently prosecute the same to completion before the expiration of

four hundred fifty (450)

consecutive days (Sundays and legal holidays excluded) from the date of said approval.

SECTION 3. GENERAL.

(a) Subletting and Assignment.—The Contractor shall give his personal attention to the fulfillment of the contract and shall keep the work under his control. The Contractor shall perform with his own organization and with the assistance of workmen under his immediate superintendence, work of a value not less than eighty per cent (80%) of the value of all work embraced in the contract. The value of the work sublet or subcontracted shall be determined by multiplying the number of units sublet of any contract item by the unit price as set forth in the contract. If any subdivision of a contract unit is sublet or subcontracted, the entire unit shall be considered as sublet or subcontracted.

Before any work is started on a subcontract, the Contractor shall file with the State Highway Engineer at his office, Public Works Building, Sacramento, a written statement showing the work to be sublet or subcontracted, giving the names of the subcontractors and the description of each portion of the work to be so sublet or subcontracted.

The above provisions shall supplement the provisions of Section 8, article (a), "Subletting and Assignment," of the Standard Specifications.

(b) Repair of Equipment.—The work of installing, assembling, repairing or reconditioning, or other work of any nature on machinery, equipment or tools used in or upon the work to be performed under this contract shall be considered a part of the work to be performed hereunder and any laborers, workmen or mechanics working on such machinery, equipment or tools, unless employed by bona fide commercial repair shops, garages, blacksmith shops or machine shops, which have been established and operating on a commercial basis for a period of at least two months prior to the award of the contract, shall be subject to the requirements relating to wages, hours of labor and selection of labor set forth in these special provisions.

(c) Construction Code.—The Contractor will be expected to comply with any code of fair competition governing the construction industry, approved under the authority of the provisions of the National Industrial Recovery Act, and any State statutes relating thereto, and any violation of such code or statute will be reported to the proper authorities.

(d) Material Plants.—The construction, erection and operation of material production, proportioning, or mixing plants from which material is used wholly on this contract or on contracts under the supervision of the Department of Public Works shall be considered a part of the work to be performed under the contract and any laborers, workmen or mechanics working on such plants shall be subject to the requirements relating to wages, hours of labor and selection of labor set forth in these special provisions.

SECTION 4. LAWS TO BE OBSERVED.

(a) Alien Labor.—The Contractor shall forfeit as penalty to the State of California ten dollars ($10) for each alien knowingly employed in the execution of the contract, by him or by any subcontractor under him, upon any of the work herein mentioned, for each calendar day, or portion thereof, during which such alien is permitted or required to labor in violation of the provisions of an act entitled

> "An act to prohibit the employment of aliens by contractors and subcontractors on all public work, except in certain cases of extraordinary emergency, providing for the reporting of such cases of extraordinary emergency and the keeping of records of the citizenship of workers employed upon public work and the inspection of such records by the proper officials, providing for a forfeiture for each calendar day, or portion thereof, any alien is knowingly permitted to work on public work and for a stipulation to this effect in the contract, and providing other penalties for violation of the provisions thereof," approved May 25, 1931.

(b) Prevailing Wage.—The Contractor shall forfeit as penalty to the State of California ten dollars ($10) for each laborer, workman, or mechanic employed, for each calendar day, or portion thereof, such laborer, workman, or mechanic is paid less than the general prevailing rate of wages hereinafter stipulated for any work done under the attached contract, by him, or by any subcontractor under him in violation of the provisions of an act entitled

> "An act to provide for the payment of not less than the general prevailing rate of wages on public works, and not less than the general prevailing rate of wages for legal holiday and overtime work on public works, providing for the ascertainment of such general prevailing rate by the public body awarding the contract and its insertion in the contract and call for bids for the contract, providing for the keeping of records of the wages paid all workers engaged in public work and the inspection of such records by the proper public officials, providing for a forfeiture for each calendar day, or portion thereof, any worker is paid less than the said rate and for a stipulation to this effect in the contract, and providing other penalties for violation of the provisions thereof," Chapter 397, Statutes of 1931.

In accordance with the provisions of Chapter 397, Statutes of 1931, as quoted by title above, the Department of Public Works has ascertained the

general prevailing rate of wages applicable to the work to be done to be as follows:

Classification	Rate per hour
Laborer	$0.60
Tractor driver (30 h.p.)	0.96
Tractor driver (60 h.p. to 80 h.p.)	1.10
Carpenter	1.00
Carpenter's helper	0.80
Truck driver (15,500 or less)	0.82
Truck driver (over 15,500)	0.96
Power shovel or crane operator	1.25
Oiler	0.82
Grader operator	0.82
Roller operator	1.25
Driller	0.82
Blacksmith	1.00
Blacksmith's helper	0.80
Powderman	0.82
Reinforcing steel worker	1.125
Mechanic (trouble shooter)	0.88
Handyman	0.60
Leverman	1.10
Machinist	1.10
Machinist's helper	0.80
Rigger	1.10
Cranesman	1.10
Assistant engineer	0.95
Assistant electrician	0.85
Fireman	0.80
Levee foreman	0.85
Levee man	0.70
Deck hand	0.80
Mate	0.80
Towboat operator	0.80
Launchman	0.80
Confidential clerk	0.75
Any classification omitted herein not less than	0.60
Overtime	one and one-half (1½) times the above rates
Sundays and holidays (except watchmen, guards and flagmen)	double the above rates

The Director of the Department of Industrial Relations has determined that the classifications of leverman, mate, towboat operator, confidential clerk, levee foreman, assistant engineer, and assistant electrician enumerated above shall be exempt from the application of the provisions of an act establishing a thirty hour week on public works as more specifically set forth in Section 4, article (c), "Laws to be Observed," of these special provisions.

The fifth paragraph of Section 7, article (a), "Laws to be Observed," of the Standard Specifications in words and figures following:

> "The minimum compensation to be paid for labor on the work to be performed by the contractor or by any subcontractors on the work shall not be less than two dollars ($2) per day,"

is hereby canceled, in accordance with Chapter 396, Statutes of 1931, approved May 25, 1931, repealing "An act fixing the minimum rate of compensation for labor on public work," approved March 9, 1897.

(c) Hours of Labor.—The Contractor shall forfeit as penalty to the State of California ten dollars ($10) for each laborer, workman, or mechanic, except as otherwise noted in article (b) above, employed in the execution of the contract by him or by any subcontractor under him for each calendar day of each week during which such laborer, workman or mechanic is required or permitted to labor more than thirty hours in violation of the provisions of an act entitled

"An act to add a new section to the Penal Code to be numbered 653c-1, relating to the hours of labor on public works during the present emergency whether such work is done by contract or otherwise, providing penalties for violations of its provisions, and declaring the urgency thereof," Chapter 632, Statutes of 1933.

Attention is called to Chapter 1144, Statutes of 1931, approved June 19, 1931, amending section 653c of the Penal Code relating to the hours of labor on public work.

Attention is also called to Chapter 41, Statutes of 1893, approved February 27, 1893, providing that every person employed in any occupation of labor shall be entitled to one day's rest in seven.

(d) Registration of Contractors.—Before submitting bids, Contractors shall be licensed in accordance with the provisions of Chapter 791, Statutes of 1929, as amended.

(e) Domestic Materials.—Only such unmanufactured articles, materials and supplies as have been mined or produced in the United States, and only such manufactured articles, materials and supplies as have been manufactured in the United States, substantially all from articles, materials and supplies mined, produced or so manufactured, as the case may be, in the United States, shall be used in the performance of the contract in accordance with the provisions of an act entitled

"An act to require the use of materials and supplies substantially produced in the United States in public works and for public purposes," Chapter 226, Statutes of 1933.

Any person, firm or corporation who fails to comply with the provisions of the act shall not be awarded any contract to which the act applies for a period of three years from date of violation.

(f) Codes of Fair Competition.—In accordance with the provisions of the California Industrial Recovery Act, Chapter 1039, Statutes 1933, the Contractor shall give a preference of fifteen per cent (15%) to supplies, articles and materials mined, produced, manufactured, or supplied in observance of any code of fair competition approved, prescribed or issued under Title I of the National Industrial Recovery Act, or under the California Industrial Recovery Act, or in pursuance of any agreement entered into or approved under said laws, or in conformity with the terms prescribed in any licenses issued under said laws, as the case may be, and which concerns such trade or industry and subdivision thereof as may be involved.

Any Contractor who furnishes materials or supplies for public use or on public works in violation of the above provision shall not be entitled to payment for the materials or supplies furnished to the extent of such violation.

(g)) Delay or Default of Contractor.—If at any time in the opinion of the Director of Public Works the Contractor has failed to supply an adequate working force, or material of proper quality, or has failed in any other respect to prosecute the work with the diligence and force specified in and by the terms of the contract, said Director may, after written notice of at least five days to the Contractor, specifying the defaults to be remedied, provide any such labor or materials and deduct the cost thereof from any moneys due or thereafter to become due to the Contractor under the contract.

If said Director shall consider that such failure is sufficient ground for such action, he may give written notice to the Contractor and the Contractor's surety or sureties, of at least five days, that if such default or defaults be not remedied the Contractor's control over the said work will be terminated, and in case such default is not so remedied within the time specified in said notice, the Contractor's control shall terminate as of said time, and thereupon the

said Director, or his duly authorized representatives, may take possession of all or any part of the Contractor's materials, tools, equipment, and appliances upon the premises and use the same for the purpose of completing said contract, and may complete said work, doing all or any part thereof by day's labor or by employing another Contractor or Contractors on informal contracts, or both. Such informal contracts shall only be awarded after a proposal form has been prepared, a copy thereof served upon the said Contractor, and three days allowed thereafter so that said Contractor may have opportunity to cause others to bid. Any person may bid on such informal contracts who is prequalified therefor as provided herein. None of the provisions of Chapter 788, Statutes of 1933, except as to prequalification, shall apply to the award of such informal contracts.

In case the control of the Contractor over such contract is terminated, or in case the Contractor abandons the work, he shall not be entitled to receive any further balance of the amount to be paid under the contract until the same shall be fully completed, at which time, if the unpaid balance shall exceed the amount expended by the State in finishing the work, together with all damages sustained or to be sustained by the State, the excess not otherwise required by law to be retained shall be paid to the Contractor, but if such expense and damages exceed the unpaid balance, the Contractor and his surety shall be liable to the State therefor.

On the completion of the contract, the original Contractor shall be entitled to the return of all his unused materials, and his equipment, tools, and appliances, except that he shall have no claim on account of usual and ordinary depreciation, loss, and wear and tear.

Any notice above provided for may be served on the Contractor personally, or on his agent having charge of the work, or by registered mail addressed to such Contractor or agent, or if such Contractor or agent can not be located or their addresses are unknown, then by posting such notice in a conspicuous place upon the premises of the work.

SECTION 5. STATE FURNISHED MATERIALS.

The State will furnish corrugated metal pipe and tidegates for use under these special provisions.

The materials above specified will be delivered by freight or truck to any available freight siding or water shipment point designated by the Contractor in Berkeley, Oakland or Emeryville.

DESCRIPTION OF WORK.

Section 6. The work to be done consists, in general, of constructing a graded roadbed of variable width, involving dredging out of underlying mud to depths of from six feet (6′) to fifteen feet (15′) below the mud surface level, and wasting within the limits and at the locations shown on the plans, or designated by the Engineer; placing a dredger fill from a specified source of supply to a completed average height of approximately thirteen feet (13′) above mean lower low water, to be retained upon the waterward side by a rock retaining wall which is to be placed under a separate contract progressively with the work herein contemplated.

Sections of Oakland's Twenty-second Street, Thirty-sixth Street and Yerba Buena Avenue outfall concrete sewers may require removal and reconstruction to provide dredger access for the work proposed.

Corrugated metal pipe culverts are to be installed, existing and new sewers are to be connected and extended through the highway fill, tidegates are to be installed and concrete culvert structures with and without piles are to be constructed, all as shown on the plans, as hereinafter specified, and as directed by the Engineer.

SECTION 7. COOPERATION, RESPONSIBILITY FOR DAMAGE AND PERMITS.

(a) Cooperation and Responsibility.—The Contractor's attention is directed to Section 5, article (f), "Cooperation of Contractor," and to Section 7, article (h), "Responsibility for Damage," of the Standard Specifications. Sections of highway adjacent to this contract will be under construction during the progress of the work herein contemplated. Contractors shall cooperate with each other to the end that any hindrance or delay to the work may be avoided.

(b) Permits.—The State will obtain all government permits necessary for the prosecution of this work, but all permits necessary for construction access or operations required by municipalities, port authorities, commercial firms or private property owners shall be arranged for and obtained by the Contractor.

CONSTRUCTION DETAILS.

SECTION 8. MISCELLANEOUS ITEMS.

(a) Other Coincident Construction Within the Limits of This Contract:

(1) The Contractor on Contract No. 7 of the San Francisco-Oakland Bay Bridge for superstructure has been promised the completed fill and wall (except for subsidence) between Stations M 273+16 and M 290 by February 1, 1934, for storage space, and yard layout. There will later be let between Station M 273+16 and M 284 other contracts for portions of bridge work during the time limit set for completion of this work; also contracts for Toll Plaza construction, Stations M 320 to 324.

(2) At the Paraffine Companies Inc. plant, approximately at Stations C 33 to C 40, there will be a concrete subway under construction and rearrangement of plant facilities under separate contract or contracts, before, during which, and after, it will be essential to keep the Paraffine Companies' water shipment channel, wharves, docks and water supply lines free and clear from obstruction and operating at all times.

(3) There will be rearrangement, reconstruction, or new construction of other plant facilities on the MC and C lines under separate contract.

(4) A rock retaining wall contract, with identical limits as to general location and time, will progress with and become an integral part of the dredger fill herein specified.

The Contractor shall cooperate completely, and coordinate his work so as to cause no delay to, or interference with, any of the coincident work outlined, and shall assist in every way possible in planning his work so as to promote the progress of the project as a whole. The Engineer will act as an advisory coordinator on the project as a whole, and in case of dispute his decision shall be final.

In case it should be feasible or desirable to include any of the work outlined under paragraphs (2) and (3) in this contract, the Contractor will be required by the Engineer to perform portions or all of said work as extra work as provided in Section 9, article (d) of the Standard Specifications.

(b) Order of Work and Progress.—The Contractor will be required to complete to finished grade elevation, subject to future subsidence, that section of work between the beginning of the project and Station M 290 by February 1, 1934.

The work shall progress by stages or lifts as hereinafter specified continuously from Station M 290 to the end of the project, excepting at the

Paraffine Companies' plant where it may be necessary to delay the completion of the fill for rearrangement of plant facilities. That section of fill north from Station C 40 to the end of the project may be placed at any time within the time limit specified for completion of the contract, after the construction of the rock wall, and necessary culverts and sewers have been provided for.

The Contractor's attention is directed to the fact that certain sections of the fill and rock wall will subside greatly during the construction period. The Contractor will be required to place additional fill material from time to time at locations designated by the Engineer.

The Contractor will be required to furnish a plant of sufficient capacity to place an average amount of dredger fill of two hundred fifty thousand (250,000) cubic yards per month.

The plant for dredging in the roadway section shall be of such type and capacity as to complete the project as planned without hindrance or delay to the orderly progress of the fill construction and completion of the project as a whole.

The Contractor's attention is directed to Section 4, article (g), of these Special Provisions, "Delay or Default of Contractor."

(c) Removal or Replacement of Excess Material.—Should the Contractor, during the progress of the work, remove excess material or place excess material outside the limits as staked by the Engineer, subject to the allowable variations specified herein for the class of work being performed, it shall be at the Contractor's expense and shall be subject to such penalties as provided herein. Should the Contractor lose, dump, throw overboard, or otherwise place any portions of plant, equipment or material which may be dangerous to or obstruct navigation, he shall recover and remove such obstructions immediately at his own expense, and shall absolve the State from any and all claims for damages to municipalities, port authorities, commercial firms, private property owners and the Federal government.

(d) Navigation.—The Contractor shall comply with all requirements of the Federal Government with regard to navigation in transporting materials and equipment to and from the site of the work. Proper lights shall be kept upon all floating plants connected with the work, and the Contractor shall be responsible for all damages resulting from any neglect or failure in this respect.

(e) Free Movement of Tides Across Right of Way.—The Contractor's attention is directed to the tide flat areas lying easterly of the highway between Station C 6+00 to Station C 22+00 and Station C 44+00 to Station C 72+25. There are large operating commercial plants adjacent to the shore line confronting these tide flat areas which obtain supplies of salt water at stages of high tide for use in their manufacturing processes. Culvert openings under the contract have been planned sufficient in size to maintain large reservoirs of water in these areas until such time as the land may be reclaimed.

The Contractor shall so plan his work in the construction of culvert structures and fill as to insure free movement of tide waters from one side of the highway to the other equal to or greater than that provided by the structures contemplated herein under this contract, subject to revision or enlargement as determined by the Engineer.

(f) Obstructions.—Minor obstructions within the highway right of way shall be removed at the Contractor's expense. The Port of Oakland pipe and trestle at Station M 314 and all miscellaneous buildings adjacent to the Oakland outfall sewer between Stations M 346 and M 363 and the boat house Station C 71+00 shall be removed and disposed of as shown on the plans. The cost of removing these obstructions shall be considered as included in the prices paid

for the other items of work and no additional allowance will be made therefor. An advertising sign at Station MC_2 381+00, an old pile and timber dock at Station NC 375 an 8″ salt water line on frame bent trestle Station C 65, and all obstructions except at the Paraffine Companies plant, will be removed by others, or by the State, prior to the time that the adjacent highway area is required for construction under this contract. In case these have not been removed by such time, in order that there be no delay to the work contemplated herein, they shall be removed by the Contractor, if so ordered by the Engineer, and the removal thereof will be paid for as extra work as provided in Section 9, article (d) of the Standard Specifications.

(g) Temporary Bulkhead at Toll Plaza.—A temporary bulkhead for retaining the dredger sand fill at the location, and according to the general design shown on the plans, or other acceptable design submitted by the Contractor and approved by the Engineer, shall be constructed and maintained as required during the construction of the fill at the Toll Plaza location until such time as a contract has been let by the State for construction of the Toll Plaza buildings and structures, at which time the Contractor will be relieved from any further responsibility for said bulkhead and fill at this specific location. The cost of constructing this bulkhead shall be considered as included in the prices paid for the other items of work and no additional allowance will be made therefor.

(h) Protection of Oakland Outfall Sewer.—The Contractor shall take every precaution during dredging of roadway areas, and during construction of dredger fill, toward protecting from displacement or damage all portions of the main Oakland outfall sewer from Station M 343+60 to the easterly shoreline, including the Twenty-second Street, Thirty-sixth Street and Yerba Buena Avenue sewers. The general construction of these sewers is shown on the plans.

The State will assume full responsibility for damage to the sewers provided the Contractor does not deviate from current instructions in force from the Engineer as to the manner in which the construction work is to be prosecuted adjacent to said sewers.

The plan and method for constructing the highway section adjacent to these sewers as herein outlined and specified, is thought to be the safest and most economical manner for prosecuting this work. Should it become apparent during the progress of the work, that damage to the sewer be imminent, the plan and method of constructing this section of highway may be altered at the direction of the Engineer and the Contractor shall conduct his operations accordingly.

Such changes or alterations as may be required involving contract units of work will be paid for at the unit prices as bid, unless, in the opinion of the Engineer, such chanages materially increase or decrease the cost of performing the work, in which case a supplemental and equitable agreement of such cost between the Contractor and the Engineer will be made.

If, through carelessness or negligence on the part of the Contractor, or failure to follow current instructions, then in effect from the Engineer, the sewer be damaged, the Contractor shall immediately repair the damaged portions, and shall maintain the sewer in operation, without cost to the State.

Should the sewer be damaged due to no fault, neglect, or failure to follow the current instructions of the Engineer, the Contractor shall immediately repair the damaged portions and maintain the sewer in full operation, in which case such work will be paid for as extra work as provided in Section 9, article (d) of the Standard Specifications.

(i) Soundings of Mud Depths Under Highway Area.—The State has made soundings and taken samples of the mud underlying the highway area and has taken soundings and samples from the proposed sources of supply for dredger sand fill.

Any information or data obtained by the State will be made available to the Contractor, but the State does not guarantee, or assume any liability for, any properties or physical characteristics. The Contractor is assumed to have investigated thoroughly, prior to submitting his bid, the characteristics of these materials, their depths and location, and shall base his work upon the data so obtained.

SECTION 9. REMOVAL AND RECONSTRUCTION OF EXISTING SEWERS (FOR DREDGING).

(a) Items Involved.—Items 1 and 2 of this contract provide for the removal and reconstruction of sections of the existing Twenty-second Street, Thirty-sixth Street and Yerba Buena Avenue, Oakland outfall sewers at approximately Stations M 346+82, M 363+26 and MC_1 377+40.

(b) Payment in Lieu of Reconstructing Sewers.—The State would prefer that these sewers be not disturbed if possible, and should the Contractor be able to so plan his work as to accomplish the results desired without disturbing any portion or all of these sewers, then, and in that event, the State will allow the payment of the amount bid by the Contractor for that portion of the work which the Contractor has eliminated from these items. The allocation made in the Engineer's estimate upon which such payment will be based, is as follows:

Item 1. 50 lineal feet of 22nd Street sewer M 346 + 82.
50 lineal feet of 36th Street sewer M 363 + 26.

Item 2. 50 lineal feet of Yerba Buena Ave. sewer MC_1 377 + 40.

Should the Contractor elect to do the necessary work by means not requiring the removing and reconstructing of any portion or all of these sewers, the payment allowed by the State as specified herein, for such portion or portions of the work so omitted, shall be in lieu of any and all costs to the Contractor involved in rearranging his plant, equipment, materials, and construction methods and no additional allowance will be made therefor.

Should the Contractor, in altering his plant, equipment, material, or construction methods for elimination of any portion or portions of the work as herein specified, damage any portion or portions of these sewers, such damage shall be repaired by the Contractor at his own expense and the payment allowed to the Contractor by the State for the elimination of the portion or portions of the work involved shall be full compensation for all such damages and all claims arising therefrom.

(c) Removal and Reconstruction as Planned.—Should the Contractor elect to remove portions or all of these sections of sewers he shall remove only such lengths as will enable his equipment to safely pass through the sewer involved. The Contractor shall maintain in operation any or all of such sewers removed to the full satisfaction of the Engineer, and the City of Oakland, and at such time as the occupancy of his plant in this area shall have been terminated, he shall replace the section so removed to the full satisfaction of the Engineer and the City of Oakland, or he shall reconstruct the sewers in accordance with the design shown on the plans of Class "A" concrete, reinforced as shown, to the full satisfaction of the Engineer and the City of Oakland.

Payment for removal and reconstruction of the section or sections of sewers involved shall be based on the actual length removed and shall include full compensation for all labor, plant, equipment, piles, concrete, reinforcing and all other materials required for removing, maintaining in operation, and reconstruction of such sewers.

SECTION 10. STRUCTURES.

(a) General.—Subject to the requirements of Section 8, article (e) of these special provisions, or the maintaining in operation of present sewers as herein

specified, installation of pipe and structures shall be made at such stage of the work as may be directed by the Engineer, but shall, in general, be deferred until the highway fill has been completed to at least mean higher high water, or until the major portion of anticipated subsidence has been realized.

(b) Structure Excavation.—Structure excavation and backfill shall conform to the provisions of Section 11, articles (o) to (r) inclusive, of the Standard Specifications as herein modified.

Payment will be based upon the combined quantities of excavation and backfill for all pipes, sewers, and structures contemplated under this contract at the unit price per cubic yard bid by the Contractor for this work.

(c) Installing Corrugated Metal Pipe.—Corrugated metal pipe, band couplers, fittings, and tidegates will be furnished by the State and shall be installed by the Contractor at the locations shown on the plans, or designated by the Engineer, in accordance with the requirements of Section 36, articles (l), (m) and (p) of the Standard Specifications, except as herein modified.

Those sections of pipe to be placed through the rock wall shall be installed by the Contractor under this contract in cooperation with the Contractor for the rock work during such rock wall construction, to the elevations determined by the Engineer to be proper considering probable subsidence to ultimate desirable flow line grade. The end toward the fill shall be plugged temporarily until such time as the fill shall have been completed to a stage where the Engineer deems it advisable to, and orders the connection to, and installation of, the remaining portion of the pipe through the fill.

Full compensation for hauling and placing tidegates shall be considered as included in the prices paid for the other items of work, and no additional allowance will be made therefor.

(d) Concrete Structures.—Concrete shall be Class "A" as specified in Section 29, "Portland Cement Concrete," of the Standard Specifications.

Concrete structures shall be constructed in accordance with the provisions of Section 26, "Concrete Structures," of the Standard Specifications. There is a fresh water main along the Key Route Mole fill, and fresh water connections are located at the Judson Manufacturing and Paraffine Companies' plants. The Contractor shall make all arrangements for obtaining a satisfactory water supply.

(e) Reinforcing Steel.—Reinforcing steel shall conform to the requirements of Section 30, "Reinforcement," of the Standard Specifications, as herein modified.

Intermediate grade steel shall be used for bar reinforcement in lieu of structural grade as specified in Section 30, article (b), of the Standard Specifications.

The following table shall supersede and be used in lieu of the table in Section 30, article (l), of the Standard Specifications for calculating the weights of reinforcing steel to be paid for:

Size	Weight per lineal foot, deformed square
½"	0.86
1"	3.44
1⅛"	4.35
1¼"	5.37

Size	Weight per lineal foot, deformed round
¼"	0.17
⅜"	0.38
½"	0.68
⅝"	1.06
¾"	1.52
⅞"	2.07
1"	2.70

The following paragraph shall supplement Section 30, article (d), of the Standard Specifications.

The mill shall tag each bundle of reinforcing steel with an identifying mill tag, showing the name of the mill and the melt or heat number. This tag shall be preferably a metal tag attached with a lead seal and placed in an exposed position for easy identification by the Inspector.

(f) Timber Piles.—Timber piles shall be Douglas Fir, untreated, and shall be furnished and driven in accordance with the provisions of Section 39, "Timber Piles," of the Standard Specifications.

(g) Sewers.—Vitrified clay pipe shall conform to the requirements set forth in Section 38, articles (a) and (b) of the Standard Specifications as herein modified.

The dimensions for double strength vitrified salt-glazed sewer pipe of standard manufacture shall be substituted for and used in lieu of the dimensions specified in Section 38, article (b), of the Standard Specifications.

Joints shall conform to the requirements of Section 38, article (d) of the Standard Specifications.

Sewers, the placing of which may be delayed until the highway fill has reached a stage of completion, or near completion, shall be laid in accordance with the provisions of Section 38, article (c) of the Standard Specifications.

Those sewers which involve connection to, and extension of, existing sewers which must be maintained in continuous operation shall be laid to conform to the following general provisions: Where dredging of roadway area is involved, they shall not be laid or extended until such dredging has been completed, and the highway fill constructed to the maximum elevation possible without clogging or interfering with present sewer operation. The sewer shall then be laid through the fill on a timber cradle and grout bed as shown on the plans. Where dredging of the roadway is not involved the Contractor shall first excavate underlying mud to firm foundation as determined by the Engineer, and shall then backfill with selected coarse sand to a height sufficient to thoroughly imbed the timber cradle in the sand, after which the pipe shall be laid in a grout bed as shown on the plans. Selected sand backfill will be paid for as extra work as provided in Section 9, article (d) of the Standard Specifications in lieu of the unit price bid for structure backfill.

Full responsibility shall be assumed by the Contractor for any or all disturbances or damage to the sewer in completing the highway fill.

The price paid per lineal foot for the various sizes of vitrified sewer pipe in place shall include full compensation for furnishing and placing the pipe, cementing the joints, furnishing and placing the timber cradle and grout bed, maintaining the flow of existing sewers, and all incidental work connected therewith. The excavation and backfill of the trench will be measured and paid for as provided in Section 11, articles (o) to (r), of the Standard Specifications, except that the furnishing and placing of selected sand backfill will be paid for as extra work as above provided.

(h) Drop Inlets and Cutting Sewer Openings.—Drop inlets shall be of the side inlet type with concrete cover as shown on the plans.

At locations shown on the plans or designated by the Engineer for drop inlet connections to the Twenty-second Street, Thirty-sixth Street, or Yerba Buena outfall sewers, round openings eighteen inches in diameter shall be cut into the top or side of these sewers. Openings shall be neat and uniform with reinforcing steel cut off or bent into adjacent new concrete or grout. Pipe or inlet connection shall be plastered with 1 to 2 cement sand mortar and flared in the direction of sewer flow. Payment will be made at the unit

price bid per opening and shall include full compensation for furnishing all materials, equipment and labor involved in cutting the openings as herein specified.

SECTION 11. DREDGING.

(a) Scope of Work.—Dredging, within the highway area, shall be at the locations and to the depths and dimensions shown on the plans and cross-sections, subject to the conditions herein specified.

(b) Plant and Progress.—The plant and progress of the work shall conform to the requirements of Section 8, article (b), of these special provisions.

(c) Obstructions.—Obstructions above the water line are shown on the plans. The State assumes no responsibility for any obstruction below the water and mud line such as sunken vessels, equipment, piles, and so forth.

(d) Alteration of Quantities Due to Adjacent Existing Improvements.—Should it become apparent that the dredging work as planned is endangering or undermining the adjacent Key Mole fill, or the adjacent Oakland outfall sewer, the State reserves the right to decrease the width of, or eliminate the dredging herein contemplated in order to protect these improvements, and payment will be based upon the decreased quantities as set forth in article (b), of the attached Proposal Requirements and Conditions.

(e) Overdepth Dredging and Side Slopes.—To cover unavoidable inaccuracies of dredging processes, material actually removed to a depth of not more than one foot below the depth specified will be estimated and paid for at the contract price.

Side slopes shall be approximately one vertical to two horizontal. The Contractor will not be required to dredge the side slopes strictly to the theoretical line, but may approximate the side slopes by a series of steps between the bottom of the excavation and the mud surface level, the material actually removed within these steps to provide the required side slopes. An overdepth of one foot measured vertically on a parallel slope will be allowed in computing limiting amounts of side slope dredging. Material from beyond the limits herein described will be deducted from the amount dredged as excessive dredging and will not be paid for.

Dredging quantities shown on the plans and included in the estimate are computed to the neat lines as shown on the profile and cross-sections and do not include the allowable overdepth quantities.

(f) Disposal of Excavated Material.—Excavated material shall be disposed of in the areas shown on the plans. Adjacent to and northerly of the Oakland outfall sewer the material excavated from the M line shall be deposited so as to provide a fill of uniform height with flat natural slopes toward the sewer, with the approximate toe of slope at the sewer. High point of this waste fill should be above high water.

After placing the highway fill on both sides of the sewer as shown on the typical section, the excavated material from the MC and C lines shall be placed between the northerly slope of the highway fill and the high ridge of waste from the M line as herein specified and as shown on the typical section for this portion of work adjacent to the sewer.

The Contractor shall take every precaution to insure against water pockets adjacent to and endangering the Oakland outfall sewer in disposing of excavated material and shall keep the outlet and channel to open water clear at all times.

All provisions as to dredging and disposal herein shall be subject to the requirements of Section 8, article (h) of these special provisions.

A portion of the material excavated from the MC line shall be disposed of adjacent to the Key Route fill and easterly shore line as shown on the plans.

(g) Dredged Area to Be Filled Immediately.—The Contractor shall so conduct his operations as to fill the dredged highway area with dredger sand fill to mean lower low water as closely behind the dredging as plant operation will permit.

(h) Measurement and Payment.—The material removed will be measured by the cubic yard in place by means of soundings or sweepings taken shortly before and shortly after dredging. Monthly deductions for excessive overdepth and side slope dredging will be made and monthly progress payments will be based upon these measurements.

In case unstable formations are encountered and the methods herein outlined do not appear to give reliable results, average hourly rates of pumping as determined from similar operating conditions for other portions of the work, for a period of 48 hours, will be applied through the unstable section, at the discretion of the Engineer, and will be based on actual time operated as determined from Inspector's daily reports.

The price paid per cubic yard for dredging shall include full compensation for furnishing all labor, materials, tools and equipment and doing all the work involved in dredging and disposing of material as herein specified.

SECTION 12. DREDGER SAND FILL.

(a) Source of Supply.—The material for this contract item shall be obtained within the general limits as shown on the plans. The State reserves the right to select the best quality material available within this area, dredging to depth of 45 feet below mean lower low water in case the class of material so obtained justifies this depth. In dredging this area the Contractor shall make every effort to obtain an average material from the bottom of the excavation to the mud line.

(b) Plant and Progress.—The plant and progress of the work shall conform to the requirements of Section 8, article (b) of these special provisions.

(c) Obstructions.—The State assumes no responsibility for any obstructions, submerged or otherwise, within this area.

(d) Construction of Fill in Stages.—The Contractor shall construct the fill in lifts or stages, the order of which shall vary on different sections of the work, as tentatively shown on the typical sections.

From the beginning of the project to the westerly end of the Oakland outfall sewer the first stage shall be to place the fill on a gradually northerly descending slope so that the elevation at the outer toe of the rock wall, subsequently to be placed, will be at approximate mean lower low water elevation. The rock contractor will then place the first stage of rock wall to slightly above mean higher high water elevation, after which the second lift or stage of the fill shall be placed to the level of this portion of wall. Successive stages thereafter, for both fill and rock wall, shall be in lifts of from four feet to seven feet depending upon the amount of subsidence obtained or anticipated.

For the MC and C line sections, where dredging of highway area is first involved, the stage construction will be similar to that of the outer Mole line as shown on the typical sections. From approximate Station C 20 + 00 to the Paraffine Companies' channel the fill shall be constructed in two lifts only. From approximate Station C 40 + 00 to the northerly end of the project the fill may be constructed to its full height in a single lift.

The first stage of fill construction along the Oakland outfall sewer shall be to place material discharging directly on top of the sewer with slopes not

to exceed one vertical to ten horizontal northerly of the sewer coincident with placing stabilizing material south of the sewer. Successive stages will thence progress southerly as shown on the typical sections.

(e) Subsidence and Construction Grade Line.—The stage construction herein outlined has been specified in order to promote subsidence through the orderly consolidation of the underlying strata of soft material without the loss of any of the rock wall or fill material through lateral displacement. It is highly desirable that as much time as possible be allowed to elapse between the successive stages of construction, consistent with the required progress of the project as a whole, in order to produce the utmost stability possible. The Contractor shall give every assistance possible toward determining the actual subsidence that has taken place through consolidation between these stages of construction. Any expense to the Contractor in this connection will be paid for as extra work as provided in Section 9, article (d), of the Standard Specifications.

During the progress of the work the State may elect to do, either under separate contract or as extra work under this contract, experimental work with vertical drains, for promoting orderly consolidation and stabilization of the fill, but such work will not be allowed to interfere with the regular contract work.

Due to anticipated heavy subsidence on sections of this fill, the fill may be constructed to a high grade line varying in height with the anticipated ultimate total subsidence over a period of years. This actual construction grade line will depend upon the consolidation obtained during the stage construction of the fill consistent with a factor of safety due to possible overloading and consequent lateral heave or displacement of the fill. The theoretical grade line shown on the plans will be used as a guide in construction only.

(f) Quantities Shown on the Plans.—Quantities shown on the plans are anticipated embankment quantities obtained by increasing the theoretical embankment section for anticipated consolidation and possible displacement. The loss ratio applied to the quantities shown on the plans has been estimated at twenty per cent, since it is desirable to eliminate all the clay possible from the sandy clay source deposit.

(g) Side Slopes on Shoreward Side and Riprap. The side slopes on the shoreward side of the C line shall be constructed one vertical to four horizontal. As soon as the shoreward side has been constructed as specified to a height above mean higher high water the rock Contractor shall be permitted to place the necessary riprap on these slopes.

(h) Measurement and Payment.—The material dredged from the source of supply will be measured by the cubic yard in place by means of soundings or sweepings taken shortly before and shortly after dredging and monthly progress payments will be based upon these measurements.

The price paid per cubic yard for dredger sand fill shall include full compensation for furnishing all labor, materials, tools and equipment and doing all the work involved in dredging, transporting, and placing the material in the highway fill as herein specified.

SECTION 13. PRIVATE FILL OF PARAFFINE COMPANIES, INC.

Pursuant to the right of way agreement with Paraffine Companies, Inc., the State has agreed to obtain a bid for constructing a private fill under this contract, between the highway fill and the Paraffine Companies' present fill and bulkhead. The bid for constructing the private fill may be accepted or rejected at the discretion of the Paraffine Companies, Inc. This item is not being used

as a basis for comparison of bids but the State reserves the right to include it in or exclude it from the contract.

If the State elects to include this work in this contract, the fill may be constructed coincident with the highway fill, provided such construction is performed in a manner that will not cause upheaval or displacement of soft underlying material from the Paraffine Companies' property into the highway right of way.

In accordance with the agreement, the material shall be obtained from the same source of supply as the highway fill. It has been agreed that the yardage involved in this fill is one hundred forty thousand (140,000) cubic yards and in case this work is performed by the Contractor, payment will be made by the State and will be based upon that quantity at the unit price bid by the Contractor per cubic yard for this item of work. Any variations or differences as to actual quantities involved in this private property area will be absorbed in the highway fill, the one hundred forty thousand (140,000) cubic yards being deducted from the total quantities dredged for combined highway and Paraffine Companies' fill, payment by the State for highway fill being based upon the net balance.

SECTION 14. FINISHING ROADWAY.

After the fill has been completed the Contractor shall, with a road grader, blade the surface over the entire roadway width to a smooth, slightly crowned and well drained section to the satisfaction of the Engineer. No hand work will be required.

Payment will be based on the unit price bid per station of 100 feet for finishing roadway and shall include full compensation for all labor, materials, tools, implements, and equipment, and performing all incidental work necessary to finish the roadway as specified.

PROJECT MEMORANDUM
(AUGUST 25, 1999)

PROJECT MEMORANDUM
STUDIES ON LATERAL SPREADING OF FILLS AT OAKLAND MOLE

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

MEMORANDUM

To: Mr. Thomas Shantz, Mr. John O'Leary/ Caltrans
Dr. Brian Maroney/ Caltrans
Mr. Ade Akinsanya/ Caltrans
Mr. Reid Buell, Mr. John Thorne, Mr. Ronnie Gu / Caltrans
Dr. Abbas Abghari, Dr. Mahmoud Khojasteh / Caltrans

Copy: Dr. I. M. Idriss / Peer Review
Mr. Al Ely, Mr. Gerry Houlahan / TYLin-Moffatt&Nichol
Mr. Jal Birdy / TYLin-Moffatt&Nichol
Mr. Tom McNelian, Mr. Tim Dunne / Fugro-EMI
Dr. Robert Pyke/Fugro-EMI

From: Hubert Law

Date: August 25, 1999

Subject: Studies on Lateral Spreading of Fills at Oakland Mole
SFOBB East-Span Replacement

Gentlemen:

This memo summarizes geotechnical studies conducted so far on lateral spreading of the existing fills and proposed new fills at the Oakland Mole subjected to earthquake loading. The analyses only considered free-field conditions without presence of nearby structures at vicinity of the slope. Several cross sections were chosen for the lateral spreading studies, namely, Station 88+00 (existing fill), Station 86+89 (proposed light weight fill), and Station 86+34 (proposed light weight fill).

Two possible failure modes were postulated in these studies: one mode of failure mechanism is shearing deformation in the Young Bay Mud and the other relates to soil liquefaction and associated lateral spreading in the existing fill. Separate studies were conducted to address potential settlements associated with consolidation of the Young Bay Mud under the proposed new fill, and the findings have been documented in our draft memo dated November 20, 1998 and the final memo dated December 11, 1998.

Subsurface Conditions

The phase II site investigation program on the Oakland Mole consists of 25 soil borings and 9 conventional CPT soundings conducted on land and more than 40 tethered Seascout CPT

soundings conducted in the tidal flat to the north of the existing mole. Figure 1 shows the locations of all the borings. A large area immediately next to the shoreline appears to be covered by surficial beach sands. Though the Seascout CPTs were conducted within as close as 30 meters to the edge of the existing rock dike in a shallow water, the extend and nature of this sand were not fully explored by the Seascout CPTs. Additional CPTs were probed in this area using an all-terrain vehicle that is track and buggy mounted. Also, trenching within the beach sands immediately next to the mole took place in the first week of March to explore an extent of the material. Subsurface conditions near Stations 88+00, 86+34 and 86+89 are depicted in Figures 2 to 4.

Stress-Strain Behavior of the Young Bay Mud

Six soil sampling tubes from the Young Bay Mud have been tested at the University of California, Berkeley to investigate a stress-strain behavior under large cyclic strains and post-earthquake properties. The experimental program consisted of testing pairs of specimens from a given sampling tube. One of the specimens was sheared monotonically from a virgin state, while the other was cyclically loaded with a specified strain amplitude and number of cycles and then monotonically sheared again without allowing to reconsolidate the specimen. The purpose is to understand the stress-strain behaviors before and after an earthquake.

All the tests were performed using wire-reinforced membranes to provide lateral restraint. Table 1 summarizes the test results. The monotonic loading was conducted at a loading rate of 1% of shear strain per minute. The cyclic loading was conducted for 25 strain-controlled cycles at a frequency of 0.2 Hz with single amplitude shear strains ranging from 1% to 3%. Figures 5 to 10 show the stress strain curves for monotonic shearing (before and after cyclic test) and the cyclic stress histories. Some samples have in-situ measurements to compare against.

Table 1 Summary of Cyclic Shear Testing Program on YBM

Boring No.	Sample Pair	Depth	Static Shear Strength (Pre-Cyclic)	Cyclic Strain	Initial Cyclic Stress	Final Cyclic Stress @ 25th Cycle	Static Shear Strength (Post Cyclic)
(-)	(-)	(m)	(kPa)	(%)	(kPa)	(kPa)	(kPa)
98-55	1	10.98	45	1	40	33	42
98-52	2	10.98	50	2	52	33	50
98-59	3	9.15	47	1	45	33	56
98-60	4	10.98	48	1.5	45	33	48
98-56	5	18.60	72	3	73	45	60
98-62	6	12.50	51	3	52	33	47

In general, the monotonic tests conducted after cyclic shearing show comparable or smaller static shear strengths compared to the tests conducted on the virgin specimens except the sample pair No 3. The reduction in static shear strength is less than 17%, but the effect is not very obvious for those samples with the cyclic amplitude of less than 3% shear strain. All the tests reveal a flatter initial slope of the stress-strain curve for the specimens that have a prior cyclic stress history.

Idriss et al., (1980) have studied stress-strain-strength behavior of clays under earthquake and wave loading conditions to understand strain-rate effects on Icy Bay Mud from Alaska. They used two frequencies (1 Hz and 0.05 Hz) to conduct cyclic loading in a laboratory and reported that the cyclic shear stress with a 1 Hz frequency is about 68 % higher than the static shear stress at 2 percent shear strain. Even with a 0.05 Hz frequency, their tests show a 46% increase over the static shear stress.

The strain-rate effects were indeed inherent in our cyclic simple shear tests conducted at the U. C. Berkeley as some increase in cyclic shear stress can be seen when it is compared with the monotonic test at the same strain level. However, very limited numbers of cyclic tests were conducted on the Young Bay Mud to draw meaningful conclusions on the strain-rate effects from our own set of tests. We propose to use 40% increase from the static shear strength to account for strain-rate effects for the Young Bay Mud in dealing with site stability and lateral spreading issues.

Lateral Spreading in the Young Bay Mud

The framework of analysis to compute seismically-induced ground deformations has been based on the Newmark's sliding method. The procedure consists of three steps as shown in Figure 11 illustrating an earth slope that is free to move in the direction of the bluff. These three steps can be summarized as:

(1) Calculation of a yield acceleration for the block under investigation using shear strength acting at the bottom of the shear plane (resisting force)

(2) Calculation of a seismic coefficient time history of the block subjected to seismic loading taking into account the geometry and compliance of the slope (driving force)

(3) Double integration of the difference between the seismic coefficient and the yield acceleration to obtain permanent deformations

We have considered three potential failure blocks, and all the sliding planes pass through the Young Bay Mud. The sizes of the block are 25 feet, 50 feet and 100 feet measured from the slope face. Limit equilibrium analysis was adopted to compute yield acceleration using the following strength scenarios:

- Using static undrained shear strengths as measured in the field

- Increasing the static undrained shear strengths by 40% to account for the strain rate effects
- Using remolded strengths to account for degradation

The seismic coefficient time histories of the potential failure blocks were computed for the six reference rock motions developed for the project. We have used QUAD4M computer program to compute the seismic coefficient time histories, which were taken as the shear force acting on the bottom surface of the pre-defined block divided by the total weight of the block.

Newmark's integration was then performed for all six motions. Since the procedure only allows for one-sided movement, permanent deformations were also evaluated by changing the polarity of the earthquake motions. Effectively, twelve permanent displacement time histories were computed for each block. The following different yield accelerations were considered in the Newmark's integration:

- Using a constant yield acceleration corresponding to static undrained strengths
- Using a constant yield acceleration corresponding to 40% increase over the static undrained shear strength to account for the strain rate effects
- Starting with a yield acceleration corresponding to 1.0 times or 1.4 times static undrained strengths and then switching to a lower yield acceleration corresponding to remolded shear strengths when the block displacement exceeds 6 inches

Liquefaction Potential of the Existing Fill

A liquefaction potential of the fill was studied using the relationship between cyclic stress ratio causing liquefaction and standard penetration resistance $(N_1)_{60}$. The in-situ blow count measurements at the Oakland Mole were taken with a cathead system and typical rope with two turns about the cathead that would deliver approximately 60% of the theoretical free fall hammer energy to the drill stem. Therefore the blow-counts as measured in the field are already $(N)_{60}$-values, but they must be corrected to account for effective overburden stress to develop the final standard and corrected penetration resistance $(N_1)_{60}$ at a hypothetical overburden stress of 1 ton per square foot.

Cone penetration tests were also conducted at several locations in the existing fills. Equivalent blow counts can be obtained roughly by dividing the cone tip resistance Q_t in terms of tons per square foot with a factor of 4 (i.e., $N \approx Q_t/4$). From all the in-situ measurements in the existing fills, the typical values of $(N_1)_{60}$ range from 10 to 20 blows per foot. For magnitude 7.5 earthquakes, the fills are considered susceptible to liquefaction.

Lateral Spreading of the Existing Fill

The procedure to evaluate lateral spreading in the fill was similar to the method adopted for the Young Bay Mud. As in the case of sliding in the Young Bay Mud, three soil blocks were analyzed for sliding deformation in the fills. The yield accelerations of the three failure blocks were computed with the drained shear strengths as well as the undrained residual strengths of the fill. A shear strength of 600 psf was selected as the undrained residual strength using on the curve relating undrained residual strength versus equivalent clean sand SPT blow counts as suggested by Idriss (1998) based on case histories (See Figure 12). Some parametric studies were also conducted with a residual undrained strength of 800 psf for a few cases.

Presentation of Results

The results of lateral spreading studies are presented in the appendices as follows:

Appendix	Location	Soil Conditions
Appendix A	STA 88+00	Existing Fills (Grade @ El +13')
Appendix B	STA 86+89	Proposed Light Weight Fill, γ_{fill} = 40 pcf (Grade @ El +20')
Appendix C	STA 86+34	Proposed Light Weight Fill, γ_{fill} = 40 pcf (Grade @ El +23')
Appendix D	STA 86+34	Proposed Light Weight Fill, γ_{fill} = 31 pcf (Grade @ El +23')

Each station was analyzed to two failure mechanisms; sliding in the Young Bay Mud and in the fills. Three soil blocks with six ground motions were examined for different strength scenarios.

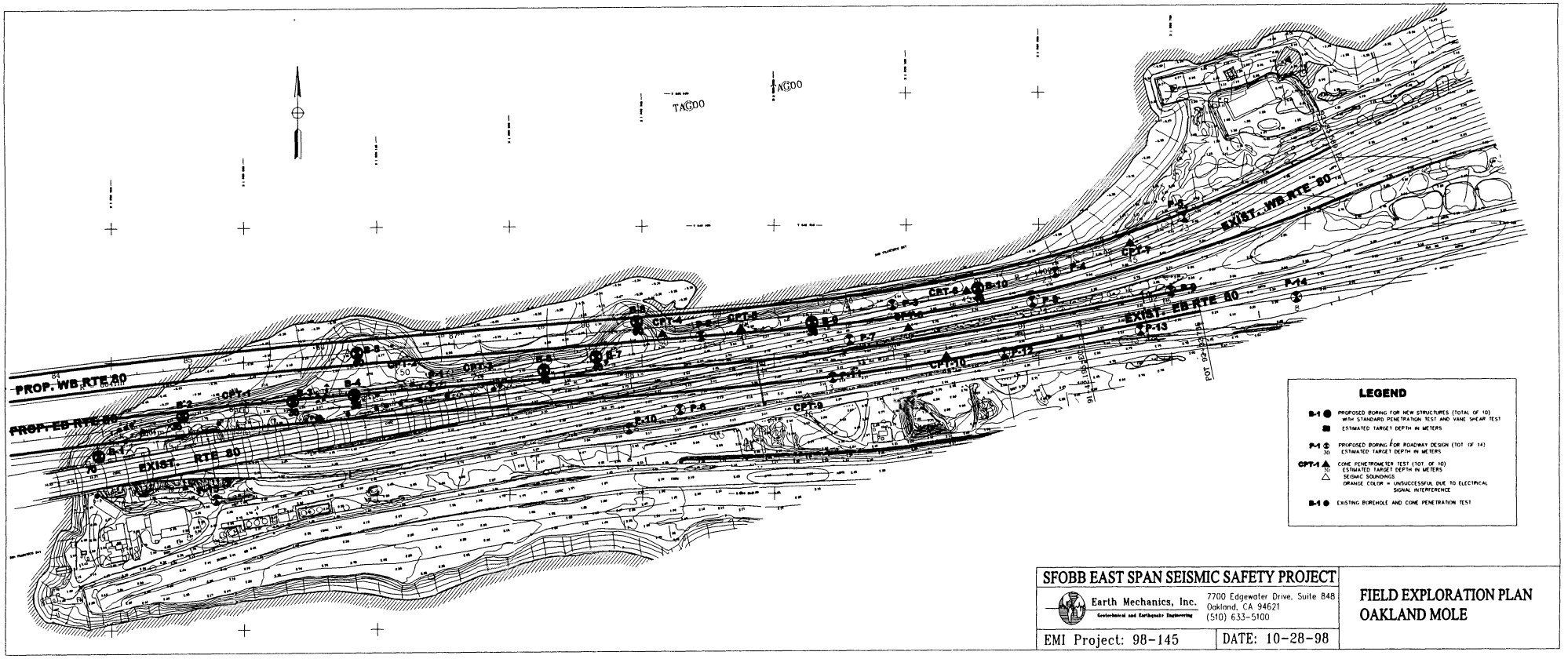
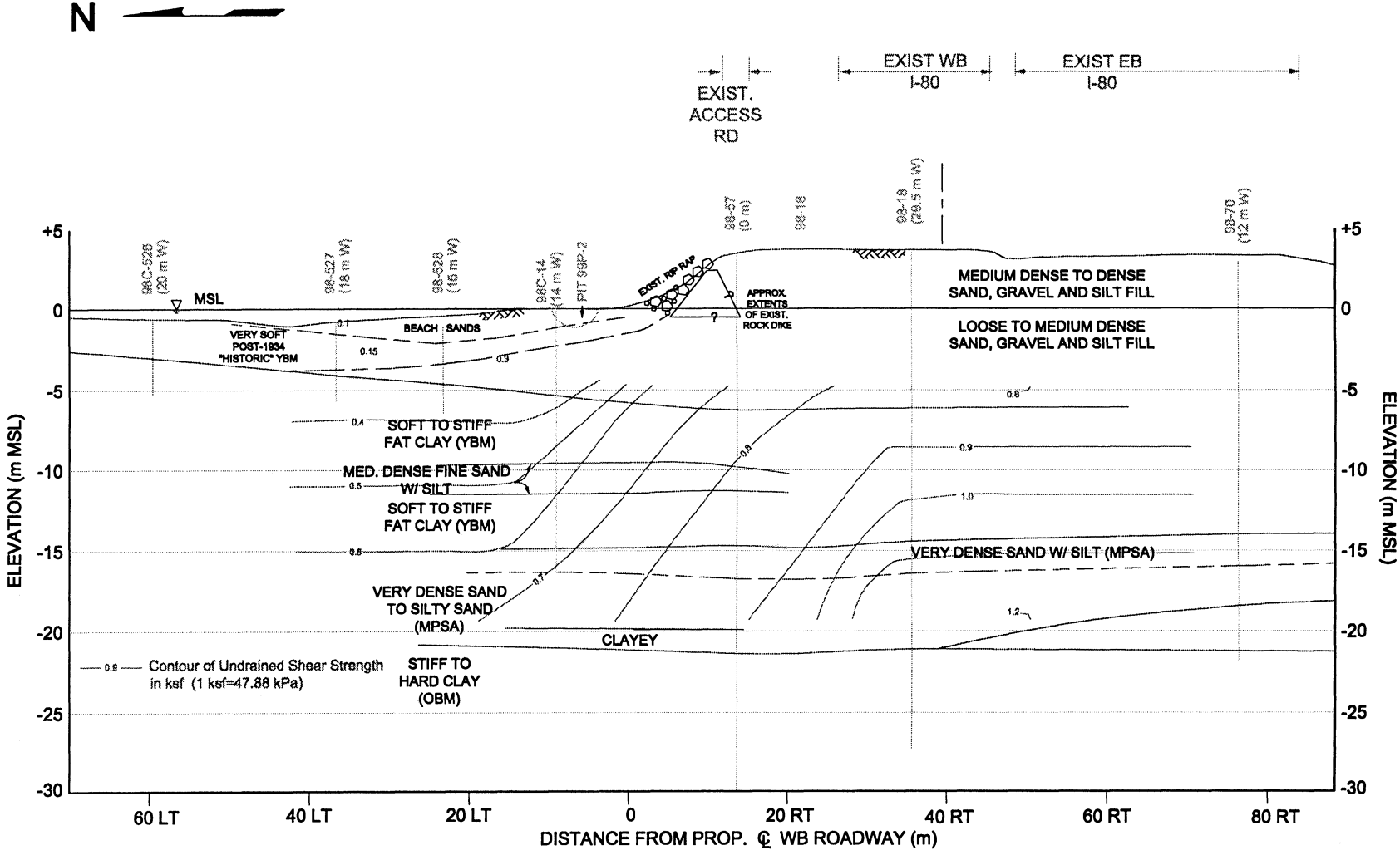

PROP. WB RTE 80
PROP. EB RTE 80
EXIST. RTE 80
EXIST. WB RTE 80
EXIST. EB RTE 80
TAG00
LEGEND
B-1 PROPOSED BORING FOR NEW STRUCTURES (TOTAL OF 10) WITH STANDARD PENETRATION TEST AND VANE SHEAR TEST
ESTIMATED TARGET DEPTH IN METERS
P-1 PROPOSED BORING FOR ROADWAY DESIGN (TOT OF 14) ESTIMATED TARGET DEPTH IN METERS
CPT-1 CONE PENETROMETER TEST (TOT OF 10) ESTIMATED TARGET DEPTH IN METERS
SEISMIC SOUNDINGS
ORANGE COLOR = UNSUCCESSFUL DUE TO ELECTRICAL SIGNAL INTERFERENCE
B-1 EXISTING BOREHOLE AND CONE PENETRATION TEST
SFOBB EAST SPAN SEISMIC SAFETY PROJECT
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
7700 Edgewater Drive, Suite 848
Oakland, CA 94621
(510) 633-5100
FIELD EXPLORATION PLAN
OAKLAND MOLE
EMI Project: 98-145
DATE: 10-28-98

Figure 1



SOIL CROSS SECTION
PROP. WB STA 88+00

Figure 2

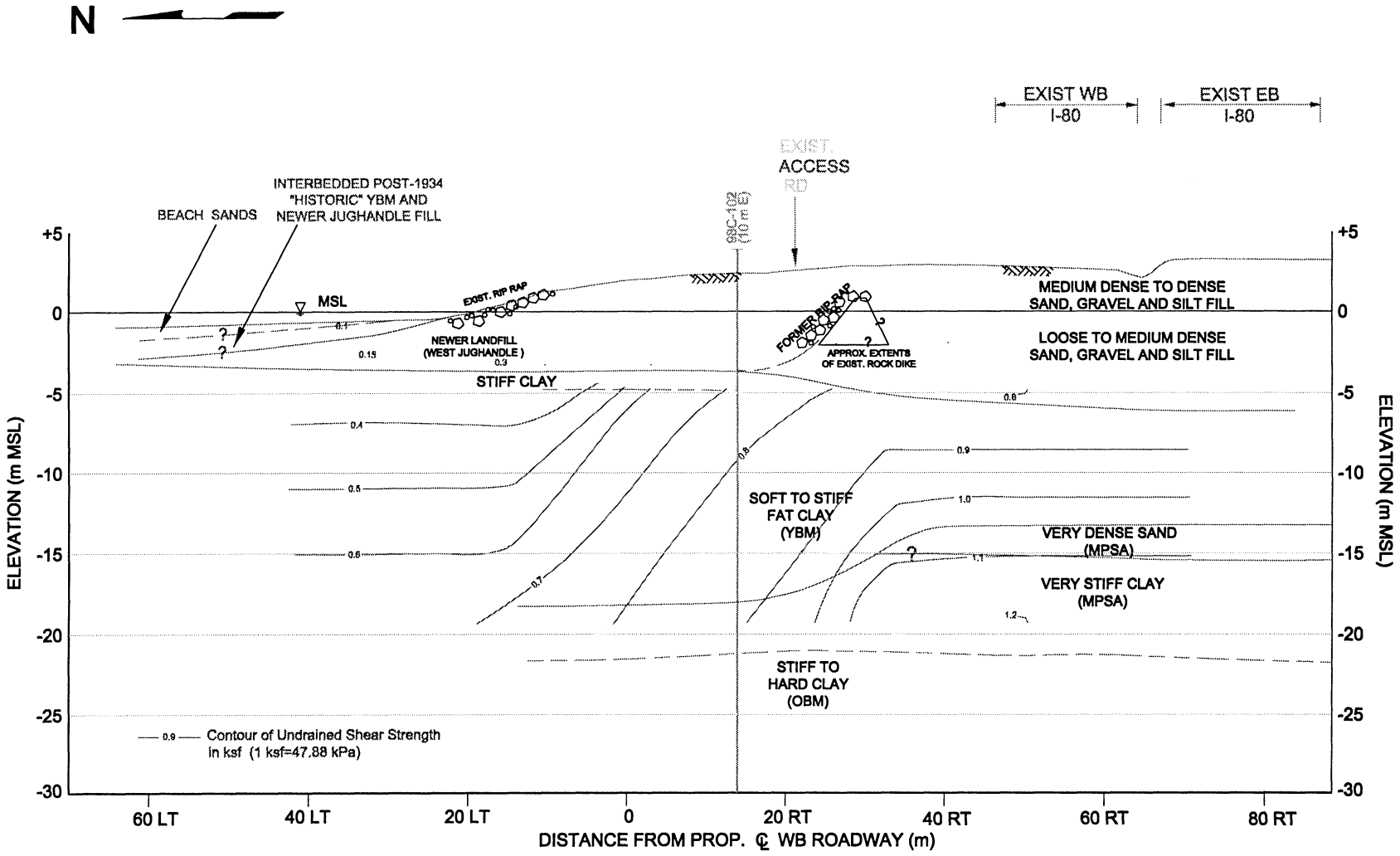


Figure 3

SOIL CROSS SECTION
PROP. WB STA 86+34

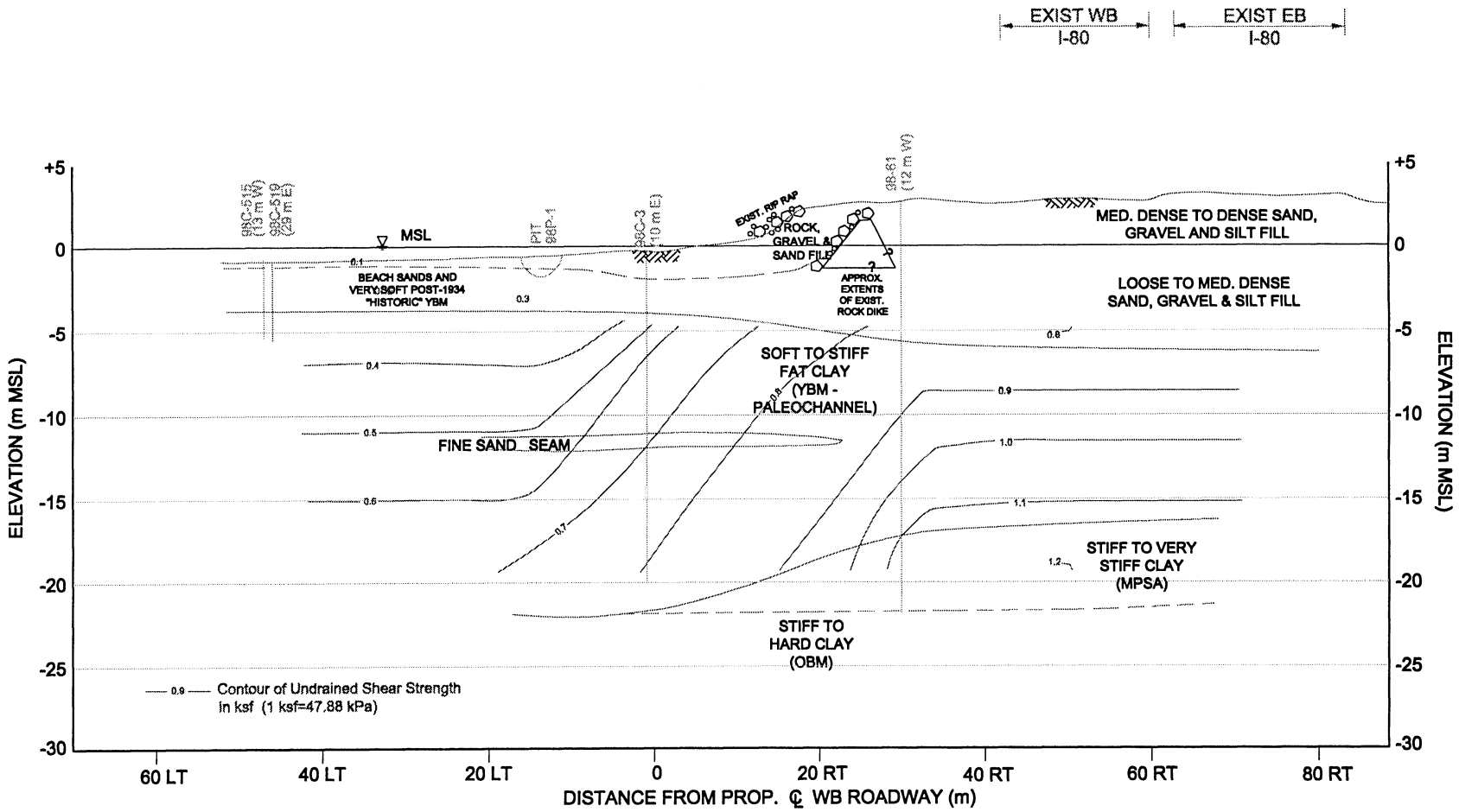
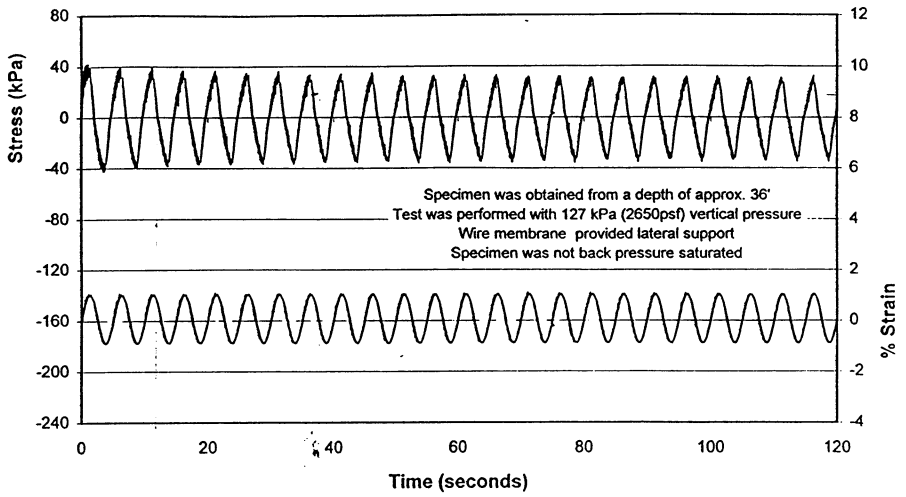


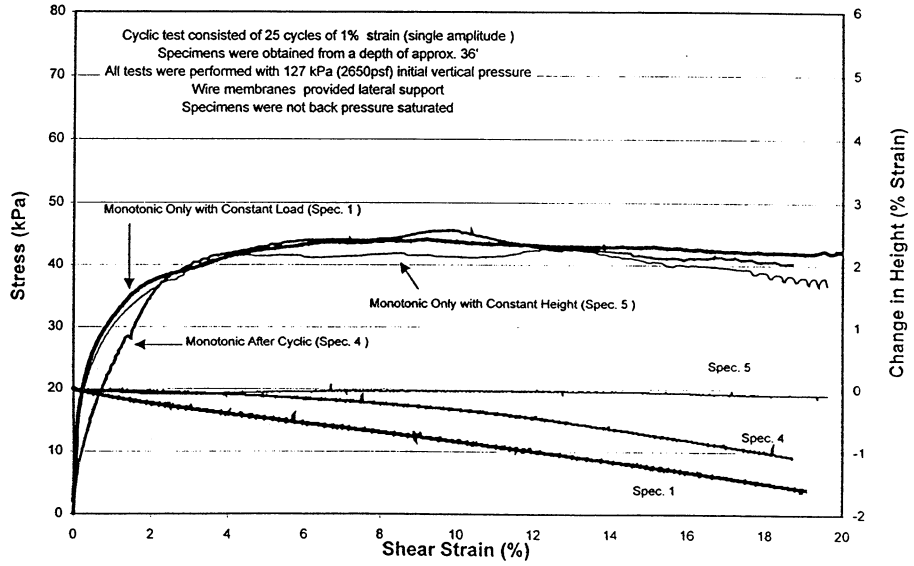
Figure 4

SOIL CROSS SECTION
PROP. WB STA 86+89

98-55

SFOBB Boring B-5 Specimen 4
Cyclic Test to 1% Strain (Single Amplitude)





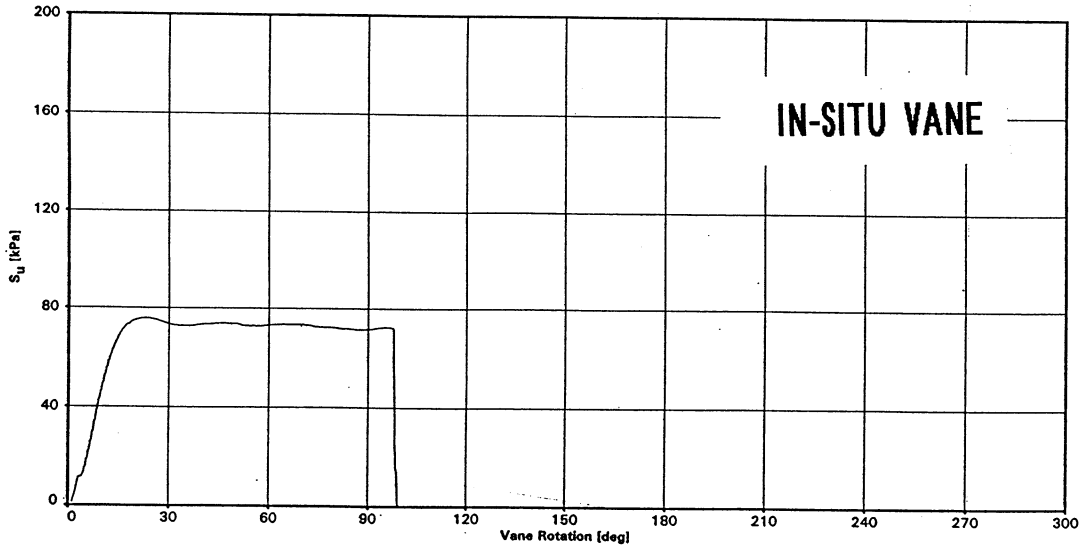
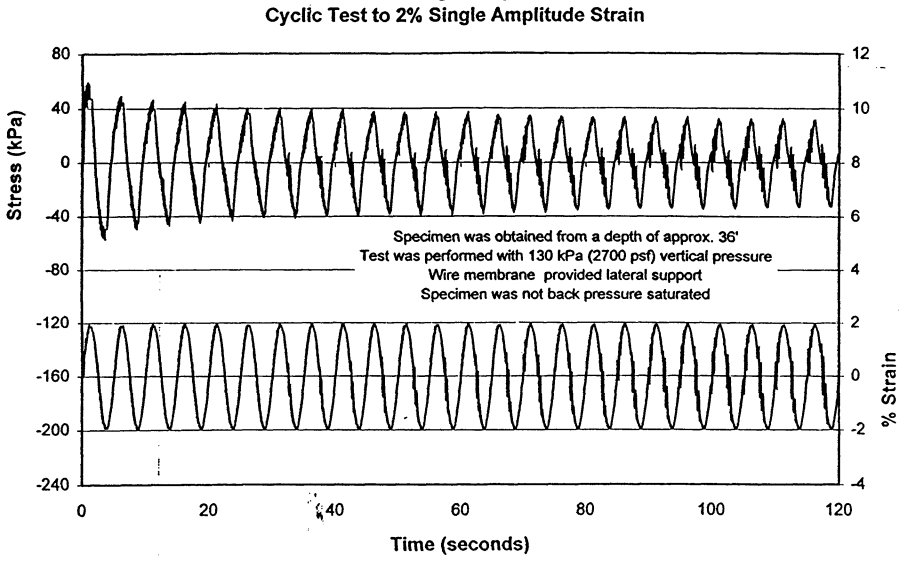


Figure 5

98-52



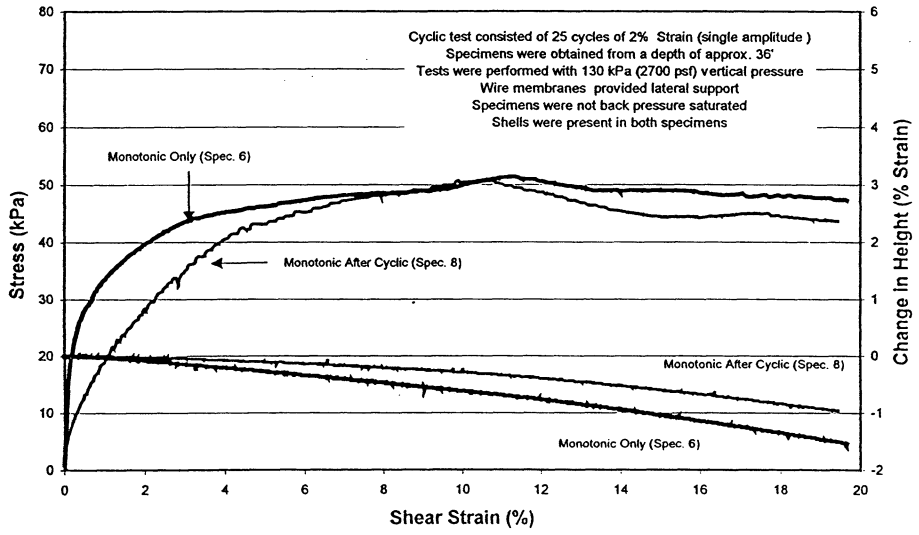
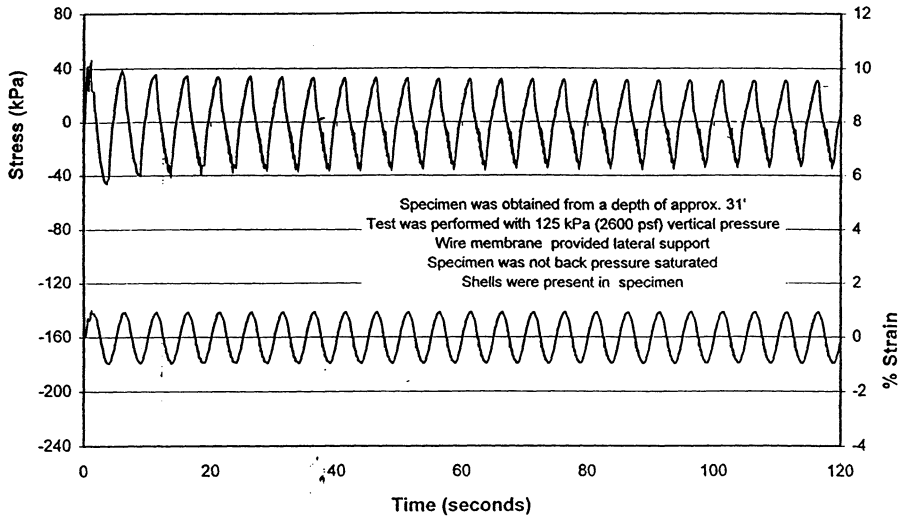


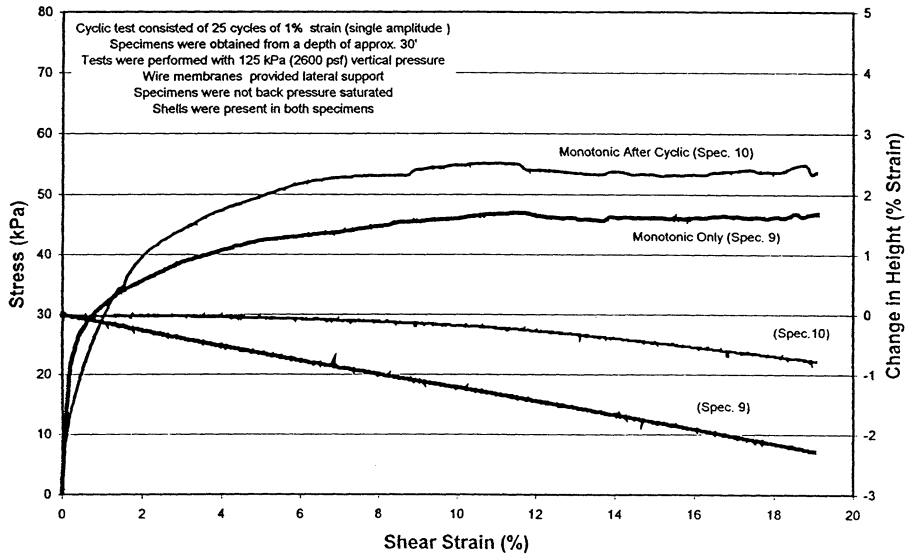
Figure 6

98-59

SFOBB Boring ~~B-9~~ Specimen 10

Cyclic Test to 1% Single Amplitude Strain





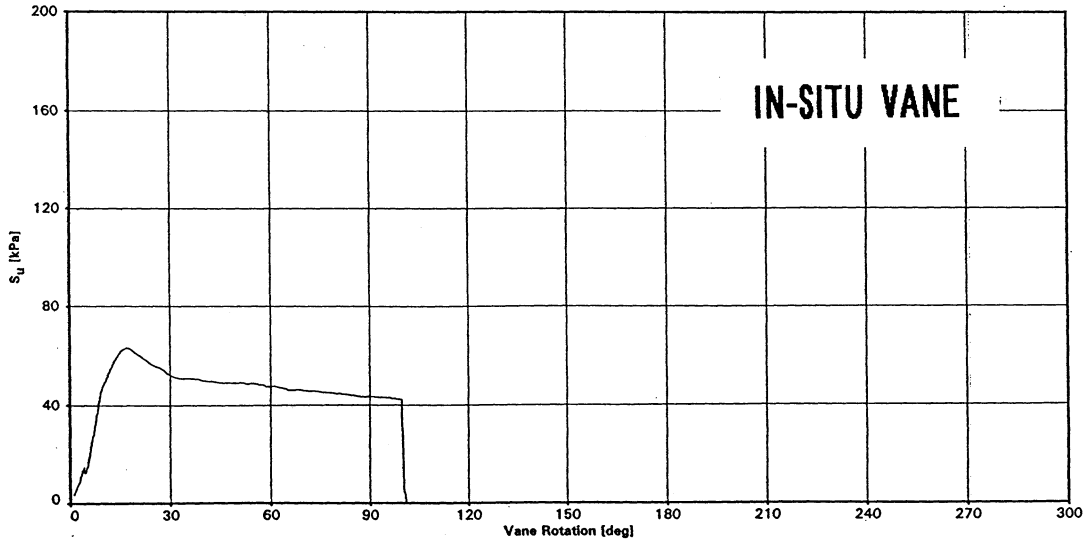
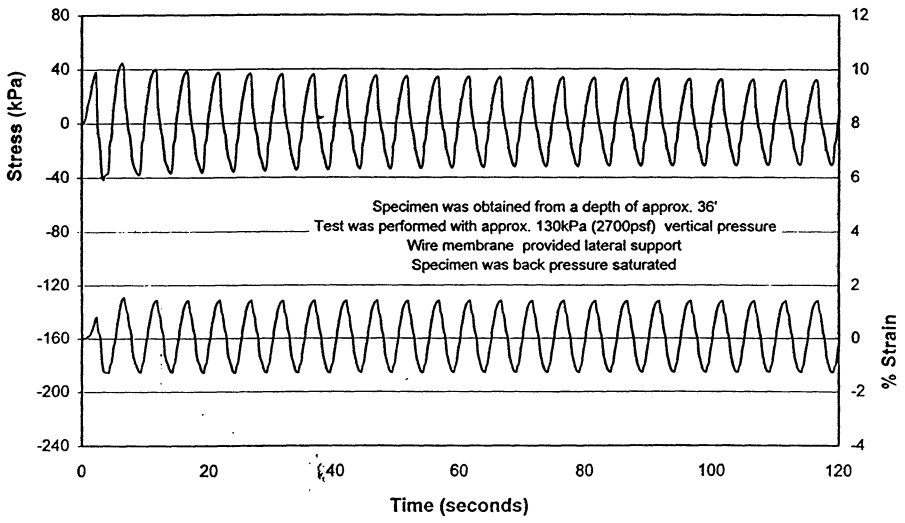


Figure 7

98-60

SFOBB Boring B-10 Specimen 13
Cyclic Test to 1.5% Strain (Single Amplitude)



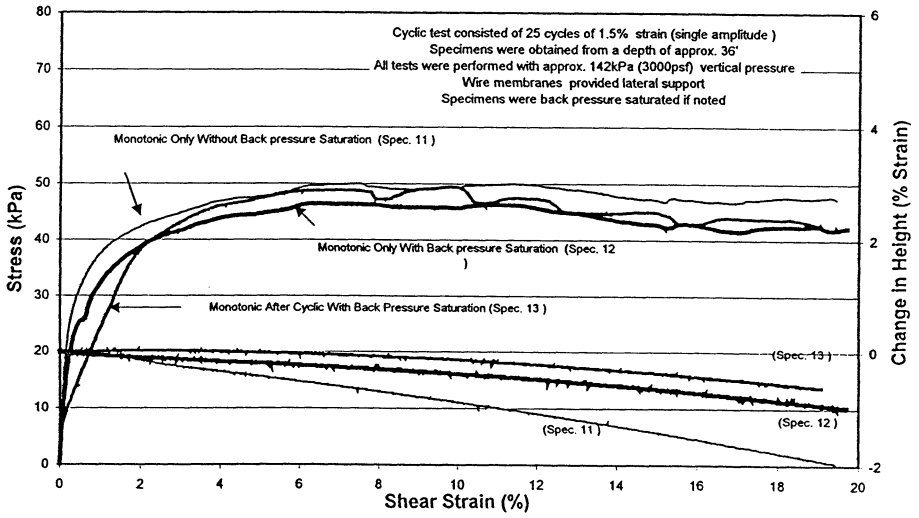
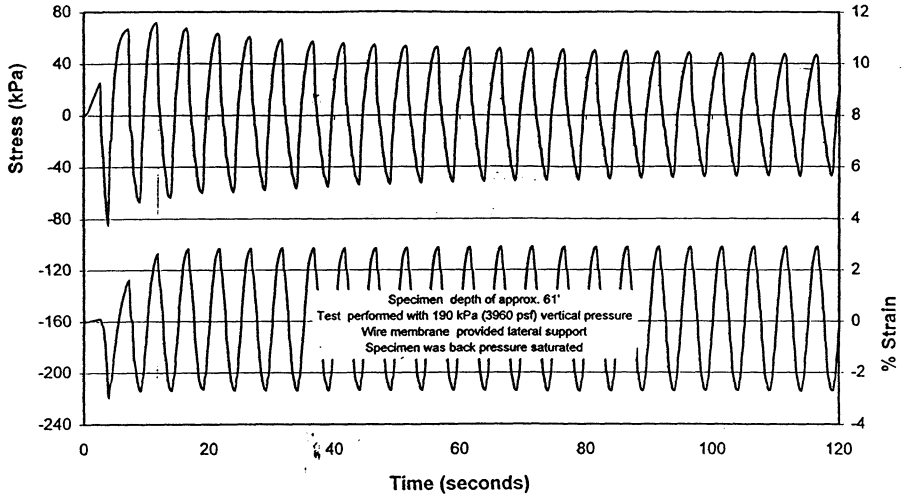
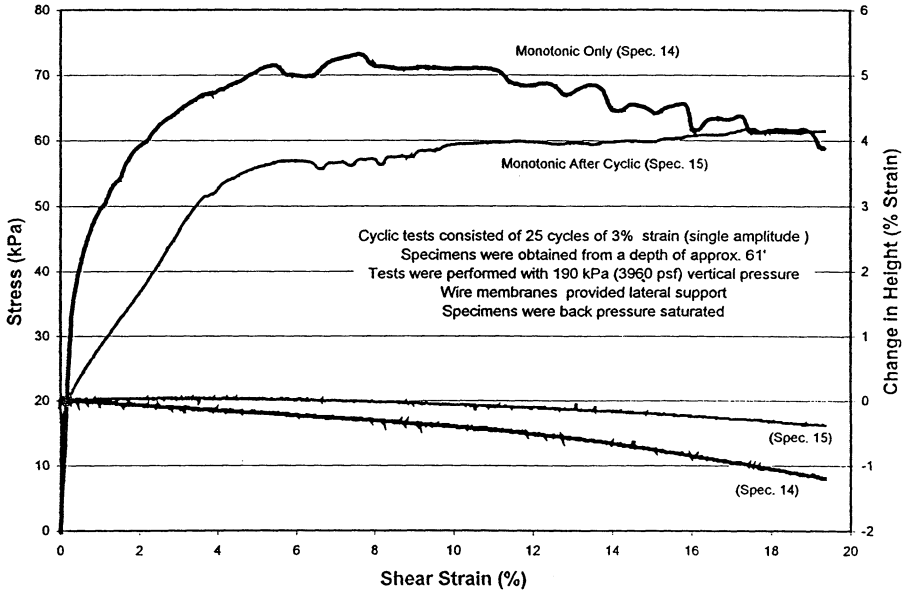


Figure 8

98-56

SFOBB Boring ~~B-6~~ Specimen 15
Cyclic Test to 3% Single Amplitude Strain





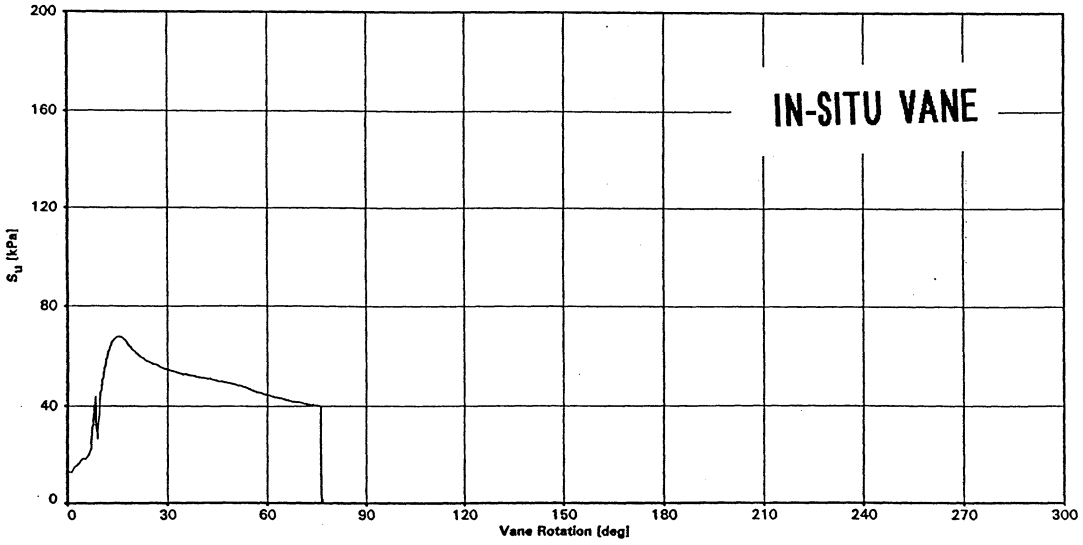
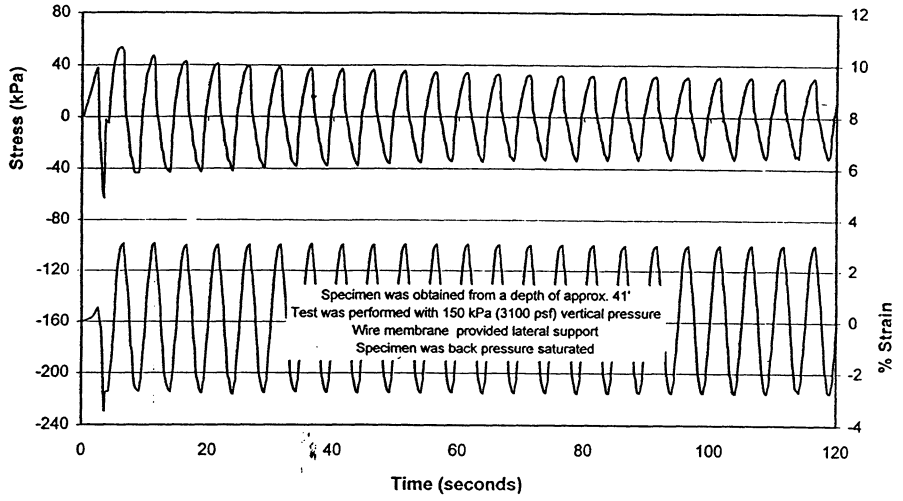
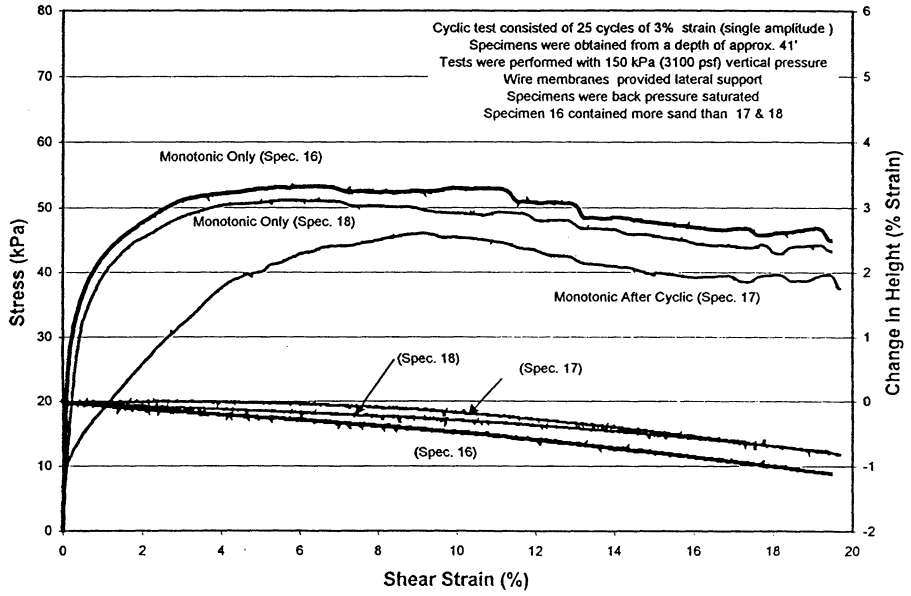


Figure 9

98-62

SFOBB Boring ~~P-2~~ Specimen 17
Cyclic Test to 3% Single Amplitude Strain





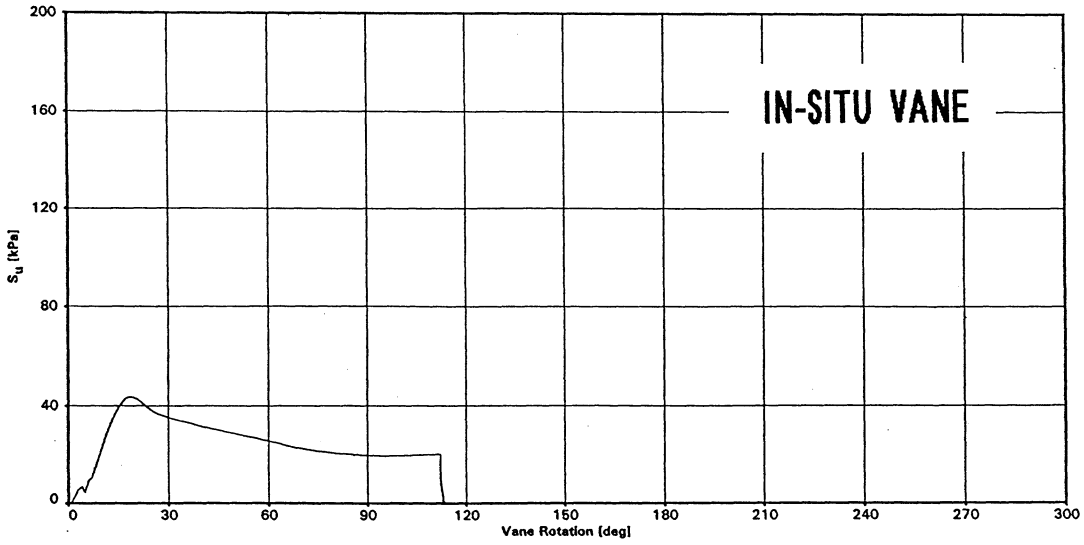
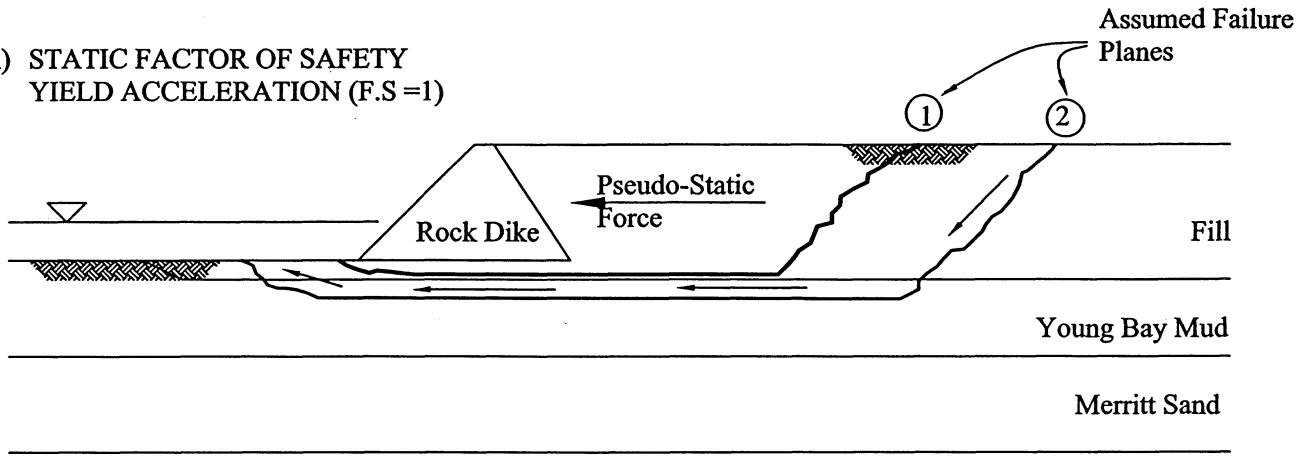
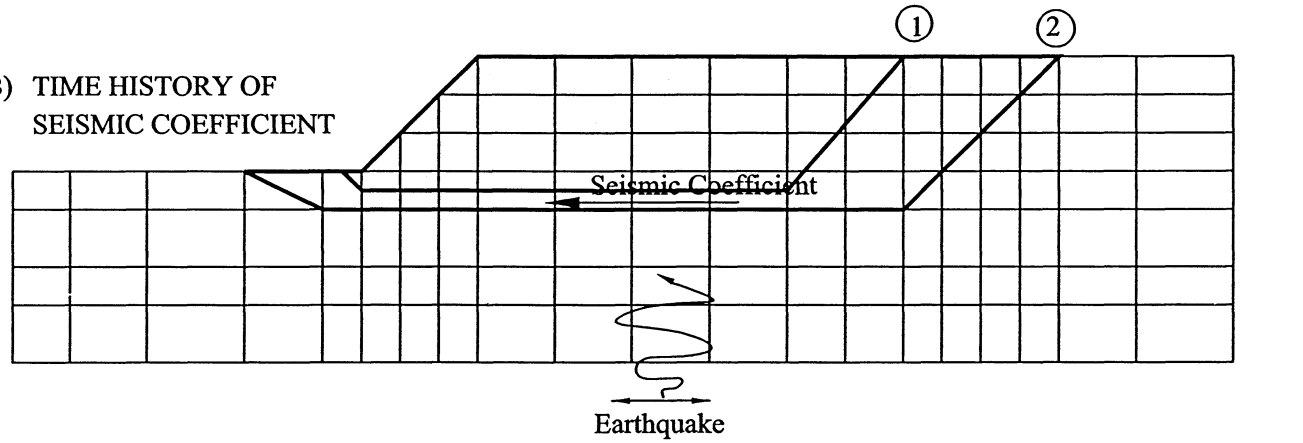


Figure 10

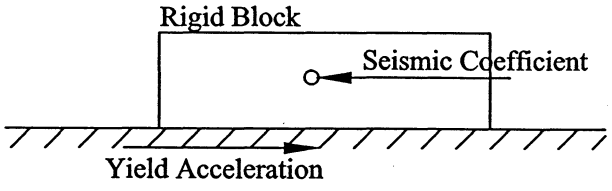
(A) STATIC FACTOR OF SAFETY
YIELD ACCELERATION (F.S =1)

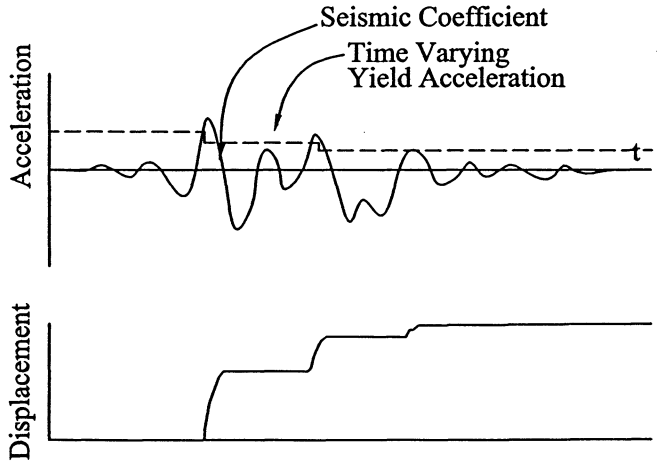


(B) TIME HISTORY OF
SEISMIC COEFFICIENT



(C) NEWMARK SLIDING ANALYSIS





NEW S.F.-OAKLAND BAY BRIDGE

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

PROPOSED PROCEDURE FOR EVALUATION OF OAKLAND MOLE SITE STABILITY

Figure 11

Project No. 98-107

Date: 1-12-99

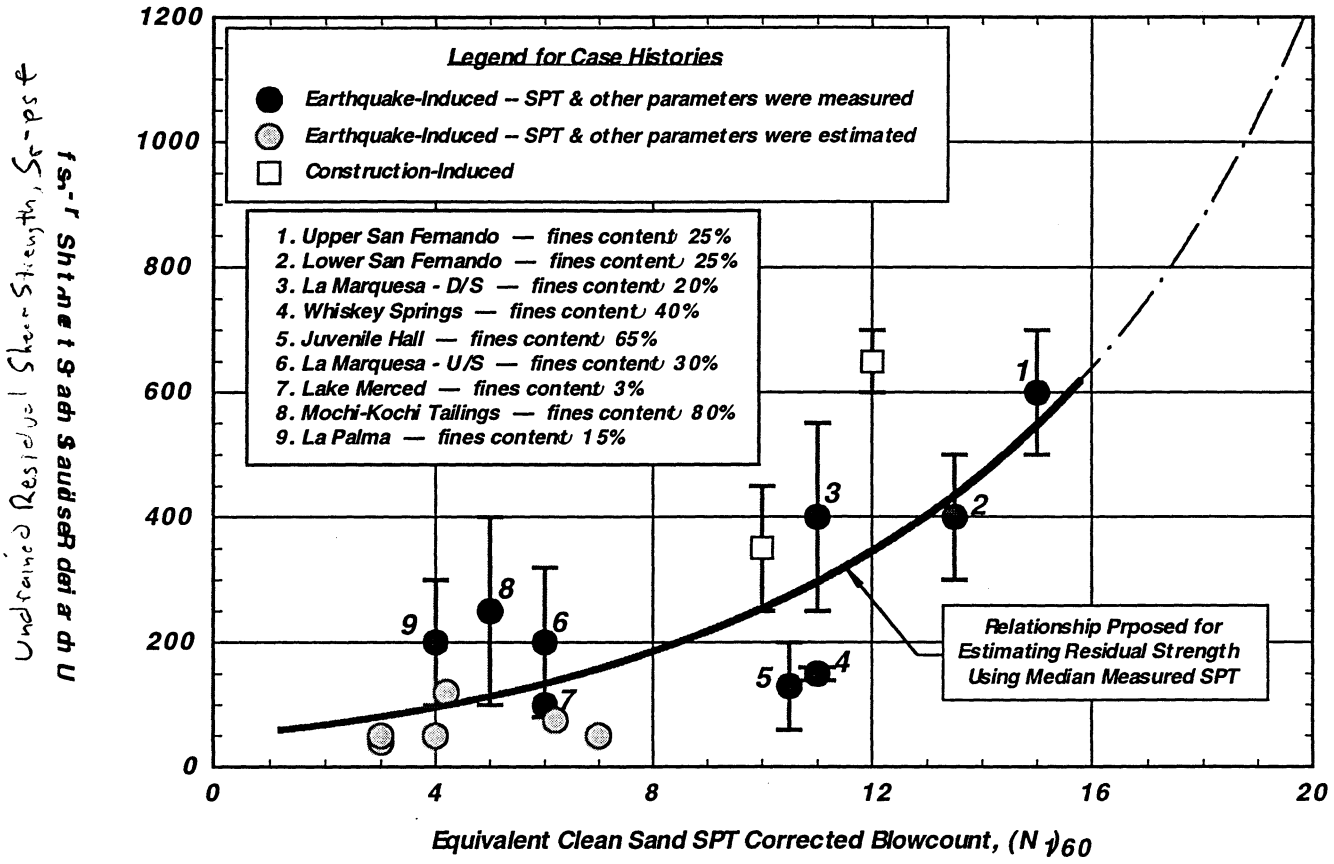


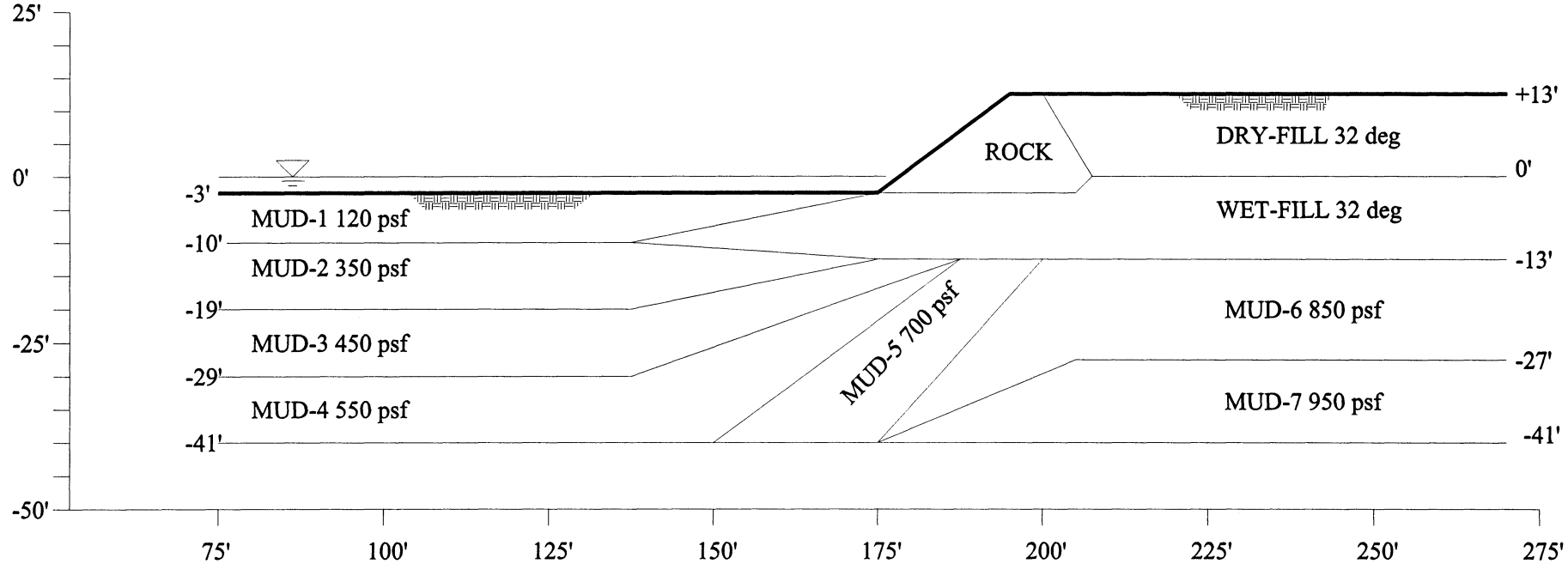
Fig. 14 Undrained Residual Strength, Sr, versus Equivalent Clean Sand SPT Corrected Blowcount Based on Field Case Studies Published by Seed (1987) and by Seed & Harder (1990)

Note: *The undrained residual shear strength should not exceed the drained strength.*

Figure 12

APPENDIX A

Appendix A
Station 88+00
Existing Fill (Grade At El. +13')



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

NEW S.F.- OAKLAND BAY BRIDGE

Project No. 98-107

Date: 6-10-98

IDEALIZED SOIL PROFILE AT
OAKLAND SHORE APPROACH
STA. 88+00

Figure

TABLE 1 Summary of Pseudo Static Analyses for YBM 4/25/99

Block	Block Size, Measured from Shore	1.0*Su (1)		1.4*Su (2)		0.33*Su (3)		0.80*Su (4)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	2.06	0.22	2.8	0.33	1.3	0.05	1.97	0.17
Block 2	50'	2.75	0.22	3.52	0.32	1.43	0.053	2.38	0.17
Block 3	100'	3.83	0.22	4.87	0.31	1.78	0.057	3.21	0.17

Note:
(1) Using static shear strength
(2) Using dynamic shear strength, i.e., strain rate effects (increase shear strength by 40%)
(3) Using residual shear strength (reduce shear strength to 33%)
(4) Using residual shear strength (reduce shear strength to 80%)

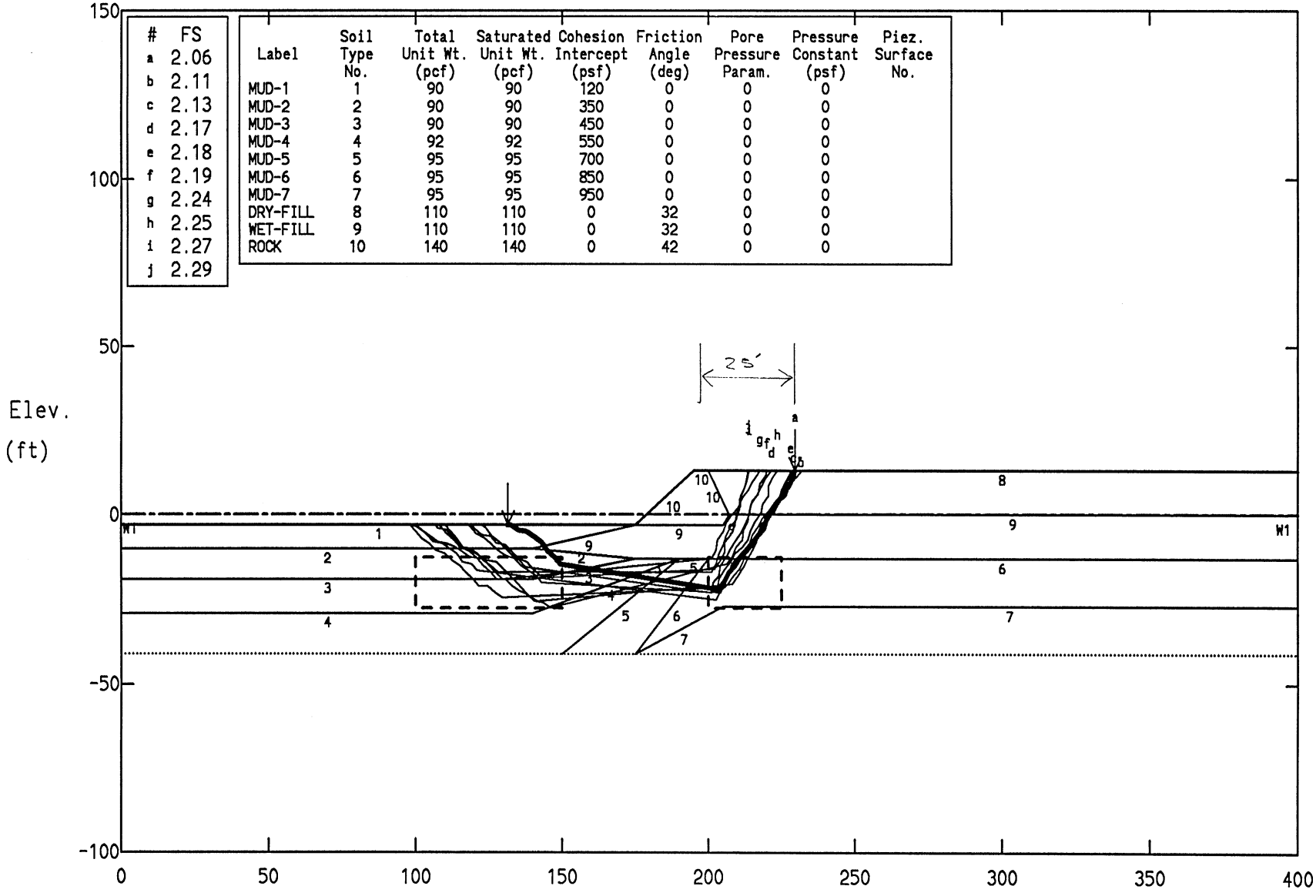
TABLE 2 Summary of Newmark Sliding Analyses for YBM

Ground Motion	Permanent Displacement, inches														
	Static Strength (1)			Static Followed By Residual (2)			Dynamic Strength (3)			Dynamic Followed By Residual (4)			Dynamic Followed By Residual (5)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	4	3	2	4	3	2	0	0	0	0	0	0	0	0	0
SET-1 (-)	9	7	6	62	50	33	1	1	1	1	1	1	1	1	1
SET-2 (+)	8	7	6	95	75	56	2	2	2	2	2	2	2	2	2
SET-2 (-)	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SET-3 (+)	7	6	5	130	107	5	1	1	1	1	1	1	1	1	1
SET-3 (-)	4	3	2	4	3	2	0	0	0	0	0	0	0	0	0
SET-4 (+)	20	18	16	87	74	60	9	8	7	64	54	42	12	11	9
SET-4 (-)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SET-5 (+)	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
SET-5 (-)	3	2	2	3	2	2	0	0	0	0	0	0	0	0	0
SET-6 (+)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SET-6 (-)	14	13	11	63	50	36	4	3	3	4	3	3	4	3	3
minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
maximum	20	18	16	130	107	60	9	8	7	64	54	42	12	11	9
average	6	5	4	37	30	16	1	1	1	6	5	4	2	2	1

Note:
(1) Using constant static strength
(2) Using static strength followed by residual strength (0.33*Su) when deformation exceeds 6 inches
(3) Using dynamic strength
(4) Using dynamic strength followed by residual strength (0.33*Su) when deformation exceeds 6 inches
(5) Using dynamic strength followed by residual strength (0.80*Su) when deformation exceeds 6 inches

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:CLAY1.PLT 02-09-99 4:26pm



#	FS
a	2.06
b	2.11
c	2.13
d	2.17
e	2.18
f	2.19
g	2.24
h	2.25
i	2.27
j	2.29

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	

PCSTABL5M FSmin=2.06 X-Axis (ft)

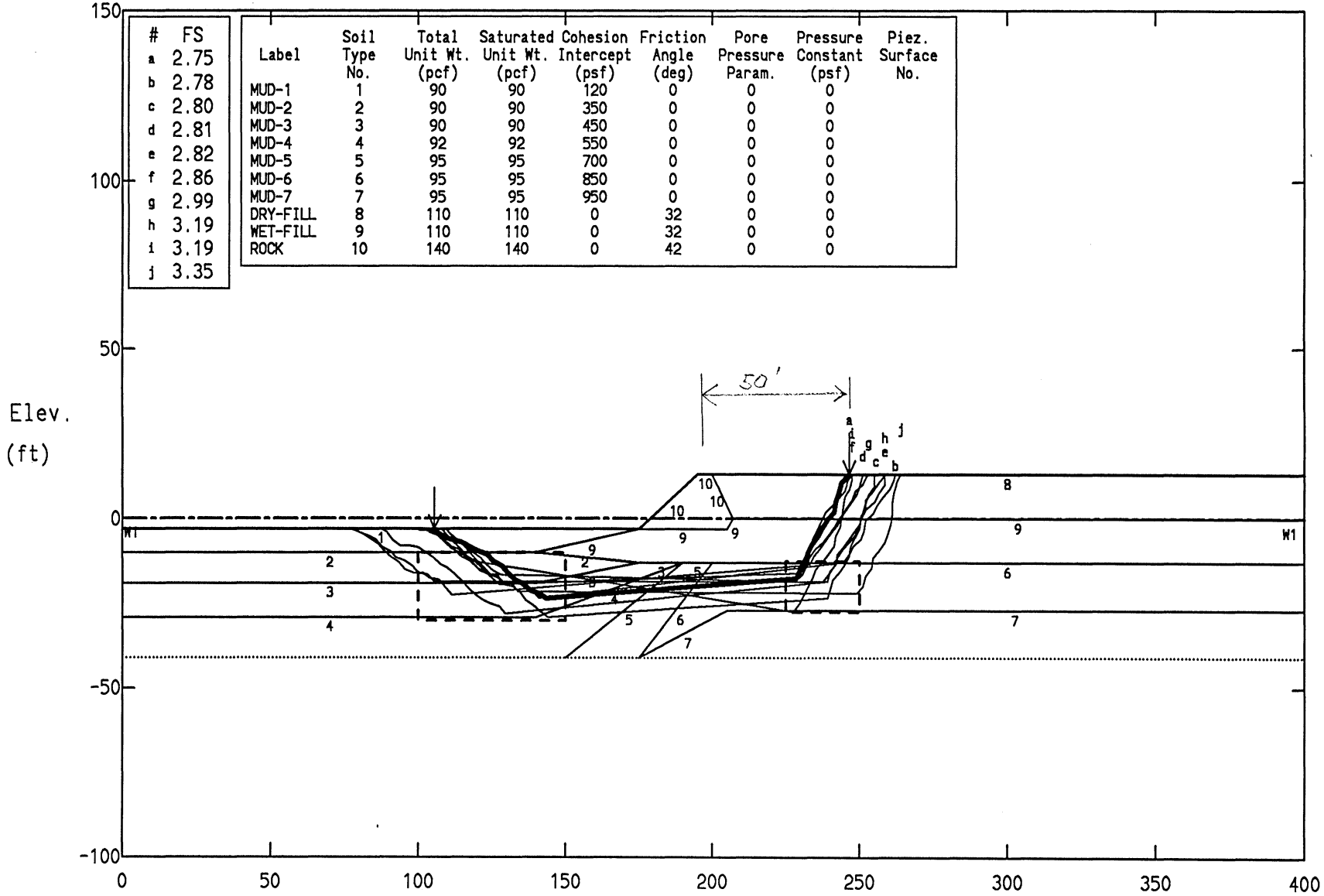
Factors Of Safety Calculated By The Modified Janbu Method

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:CLAY2.PLT 02-09-99 4:27pm

#	FS
a	2.75
b	2.78
c	2.80
d	2.81
e	2.82
f	2.86
g	2.99
h	3.19
i	3.19
j	3.35

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	



PCSTABL5M FSmin=2.75 X-Axis (ft)

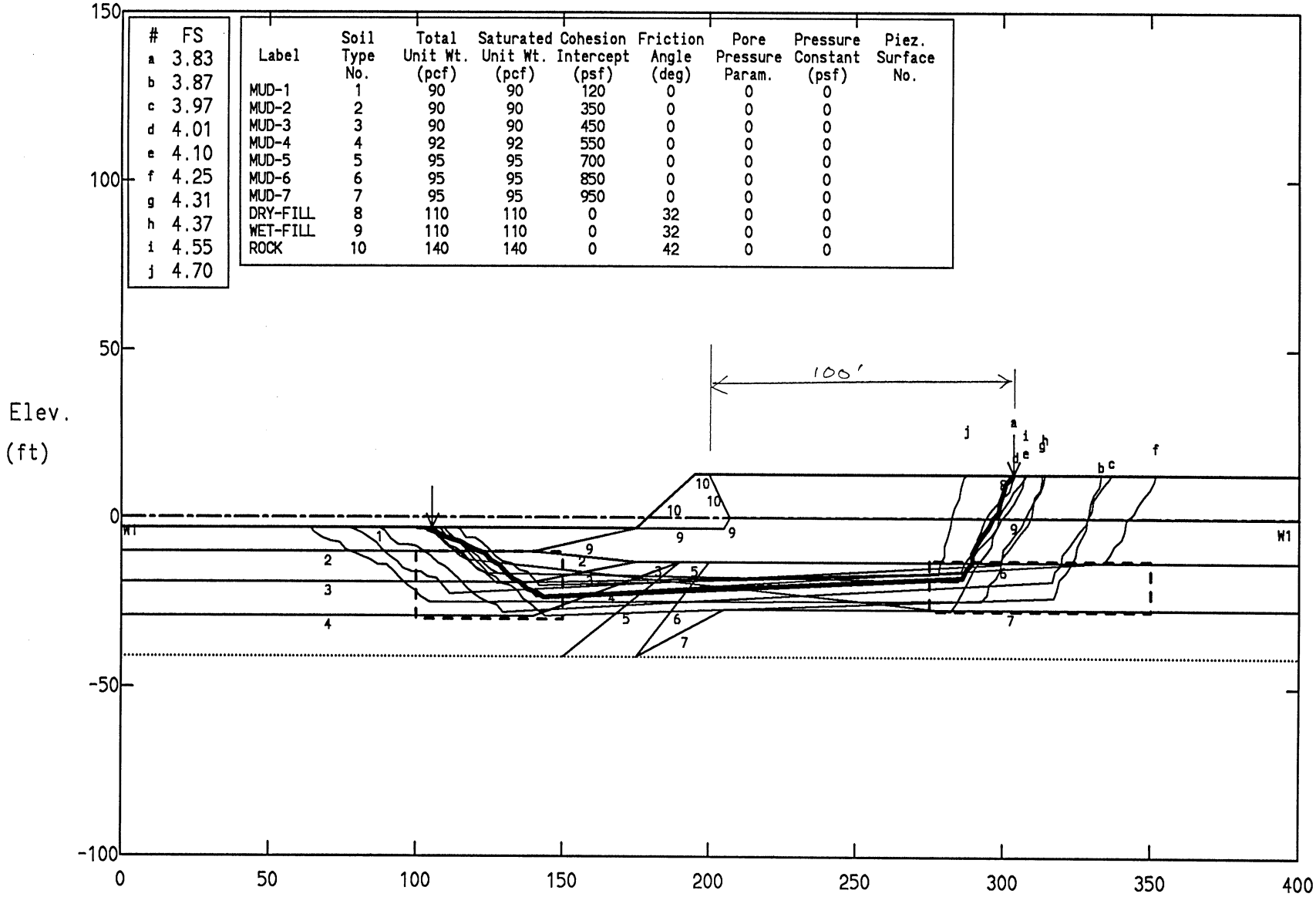
Factors Of Safety Calculated By The Modified Janbu Method

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:CLAY3.PLT 02-09-99 5:02pm

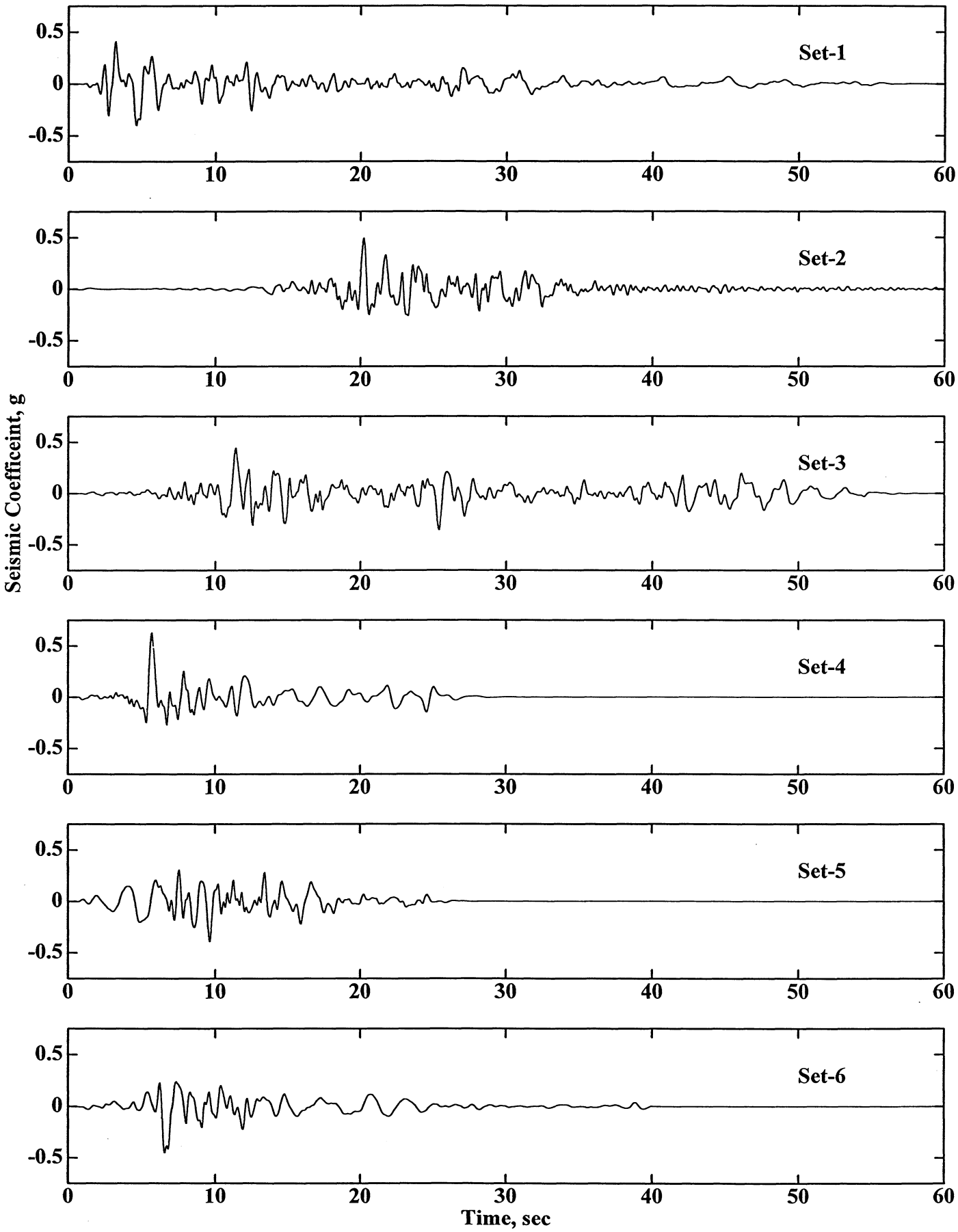
#	FS
a	3.83
b	3.87
c	3.97
d	4.01
e	4.10
f	4.25
g	4.31
h	4.37
i	4.55
j	4.70

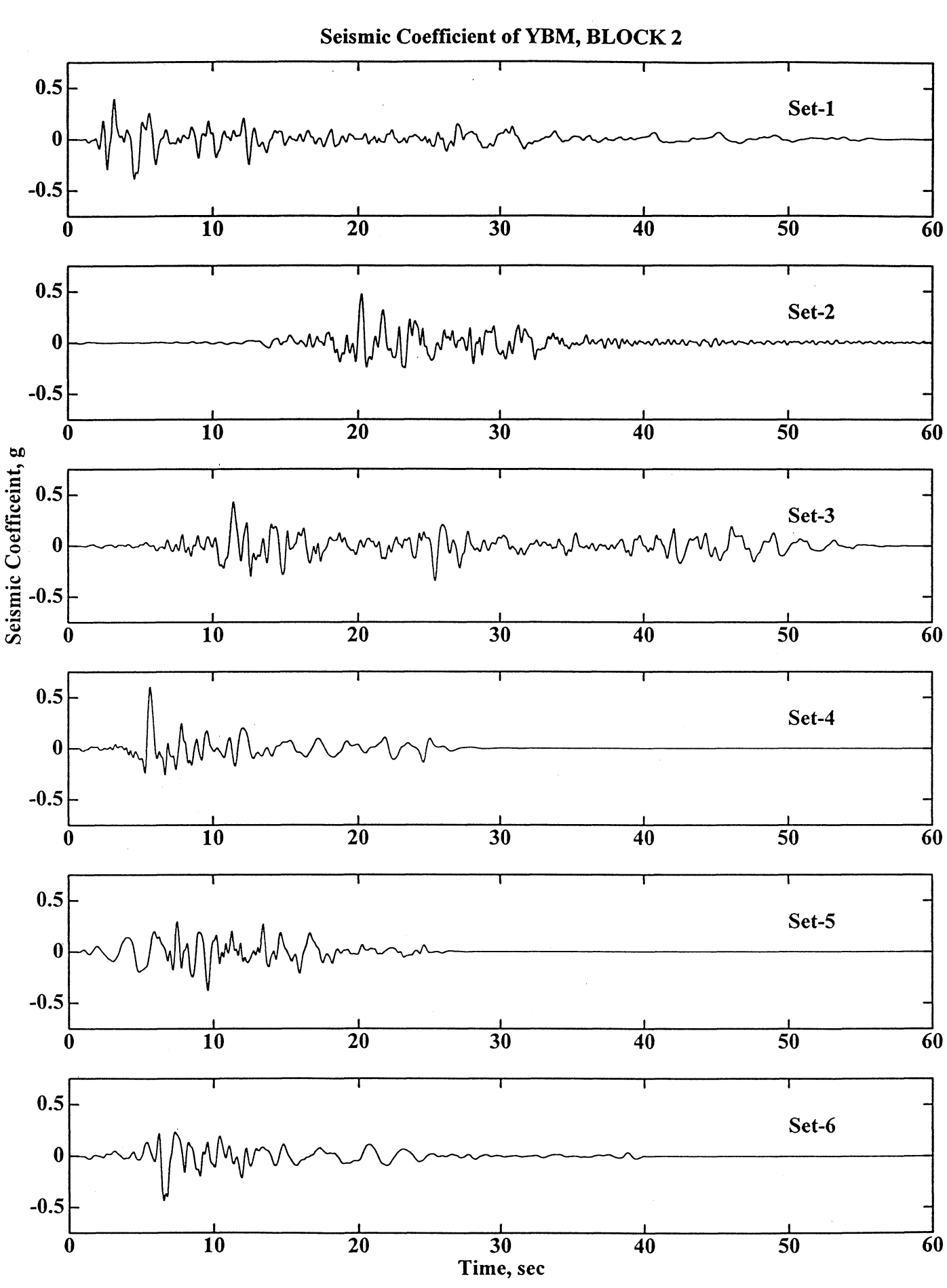
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	

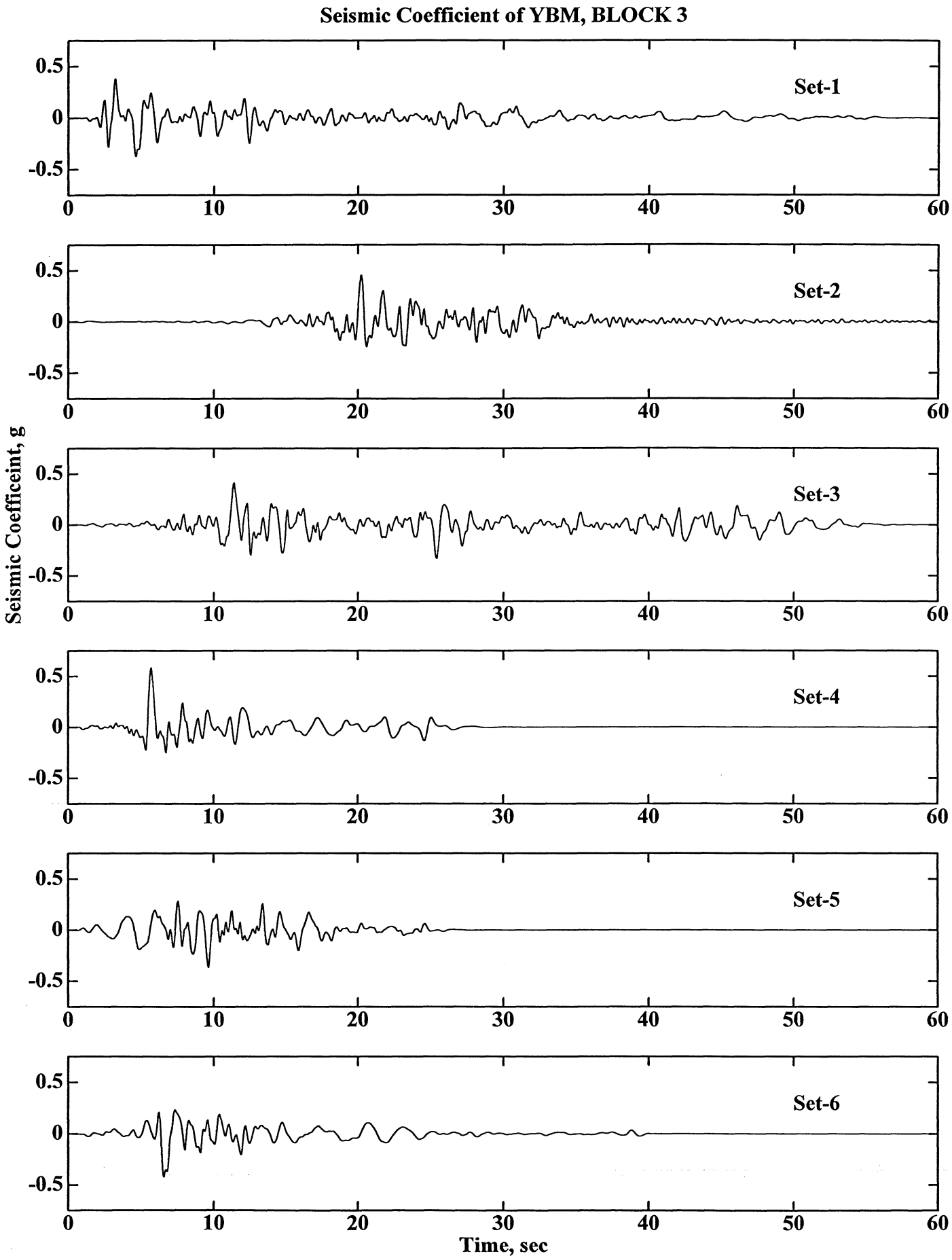


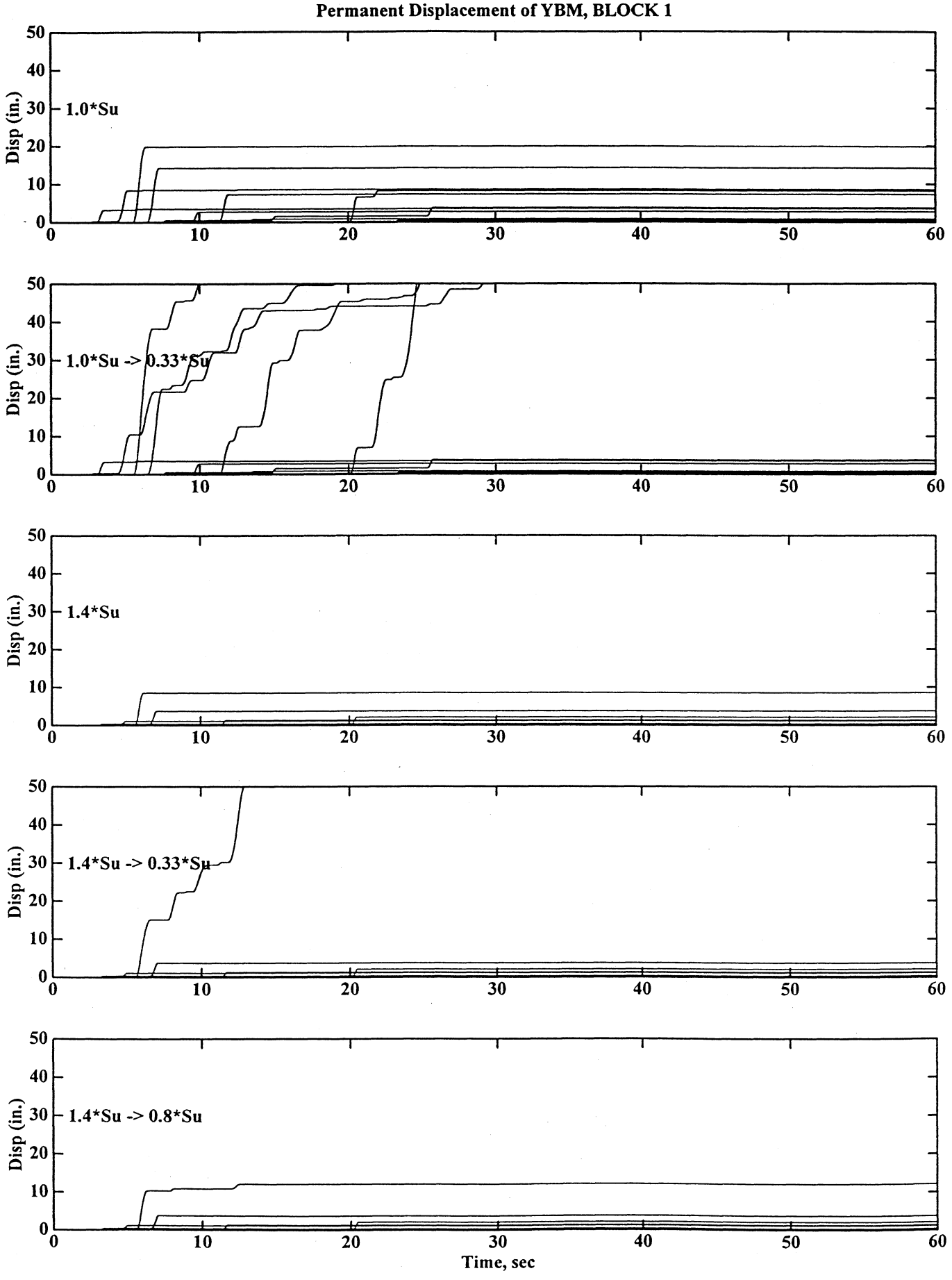
PCSTABL5M FSmin=3.83 X-Axis (ft)

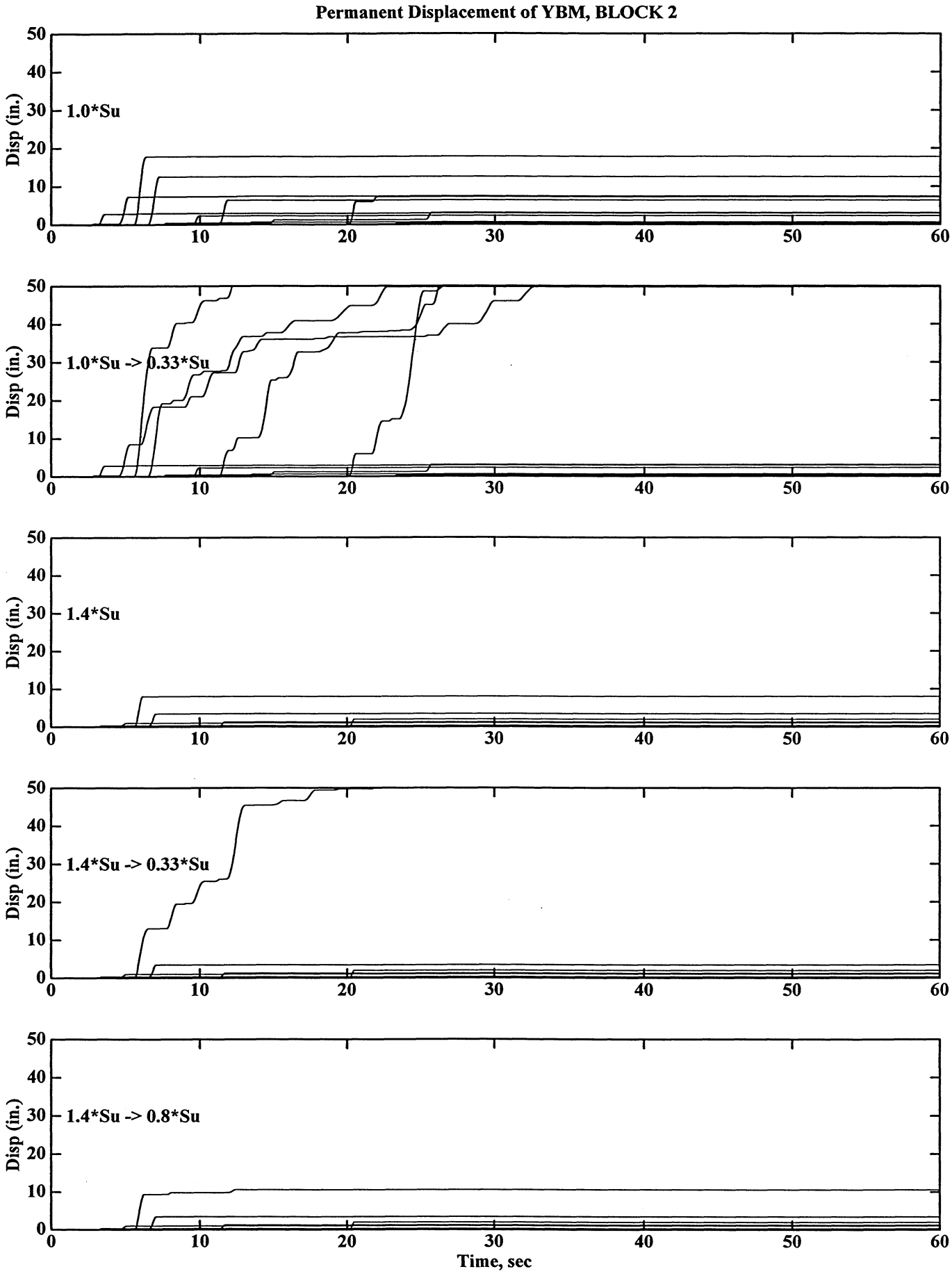
Factors Of Safety Calculated By The Modified Janbu Method


Seismic Coefficient of YBM, BLOCK 1
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
Seismic Coefficeint, g
Time, sec
0.5
0
-0.5
0
10
20
30
40
50
60


Seismic Coefficient of YBM, BLOCK 2
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
Seismic Coefficeint, g
Time, sec
0.5
0
-0.5
0
10
20
30
40
50
60


Seismic Coefficient of YBM, BLOCK 3
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
Seismic Coefficeint, g
Time, sec
0.5
0
-0.5
0
10
20
30
40
50
60


Permanent Displacement of YBM, BLOCK 1
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
0
10
20
30
40
50
60
Time, sec


Permanent Displacement of YBM, BLOCK 2
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
0
10
20
30
40
50
60
Time, sec

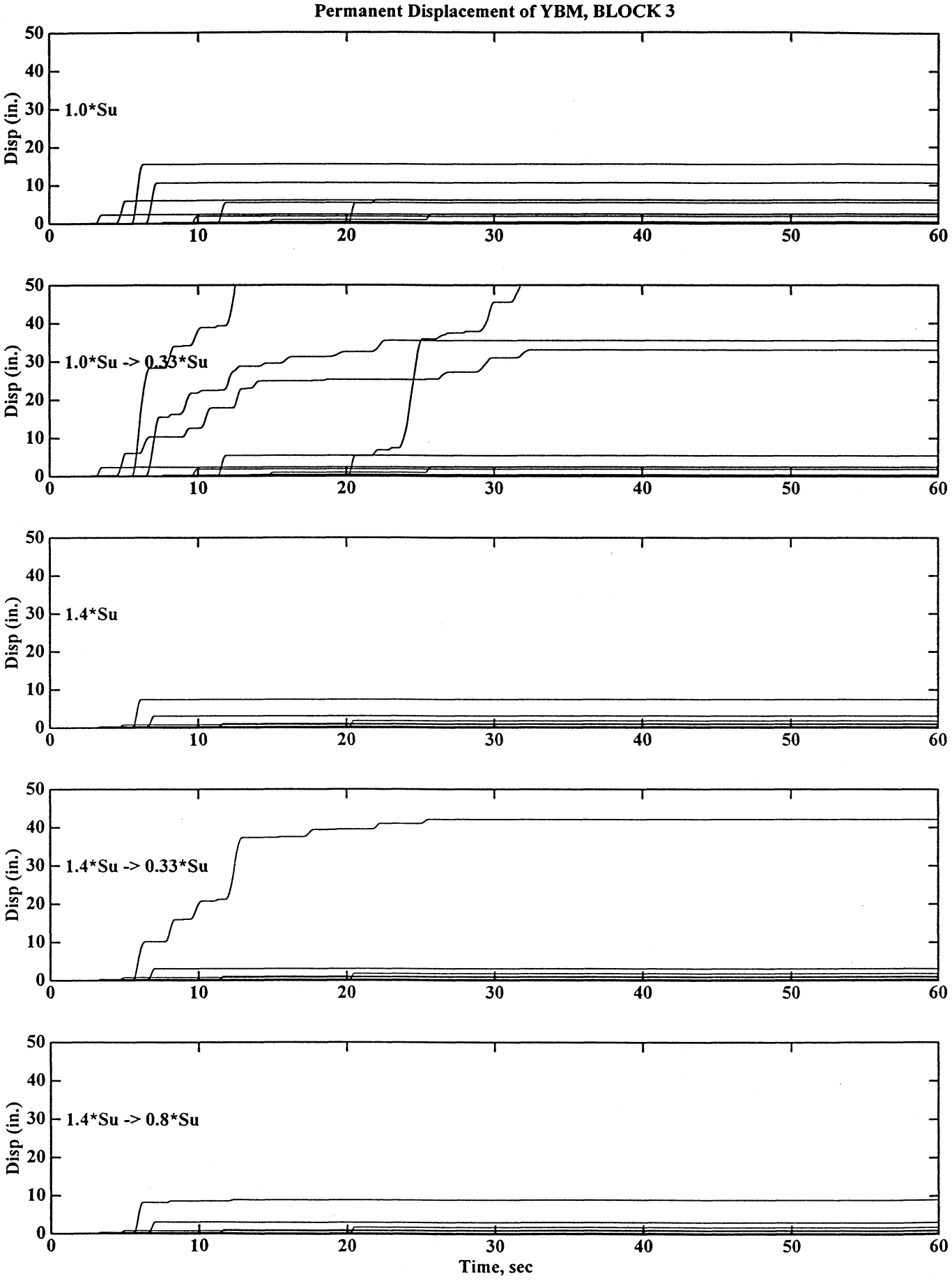

Permanent Displacement of YBM, BLOCK 3
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
0
10
20
30
40
50
60
Time, sec

TABLE 3 Summary of Pseudo Static Analyses for FILL

Block	Block Size, Measured from Shore	Drained Strength (1)		Residual Strength (2)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	3.65	0.49	2.53	0.26
Block 2	50'	4.91	0.47	3.03	0.25
Block 3	100'	7.98	0.43	4.48	0.24

Note:
(1) Using drained shear strength of sand
(2) Using residual shear strength of sand in fill below watertable (Su=600 psf)

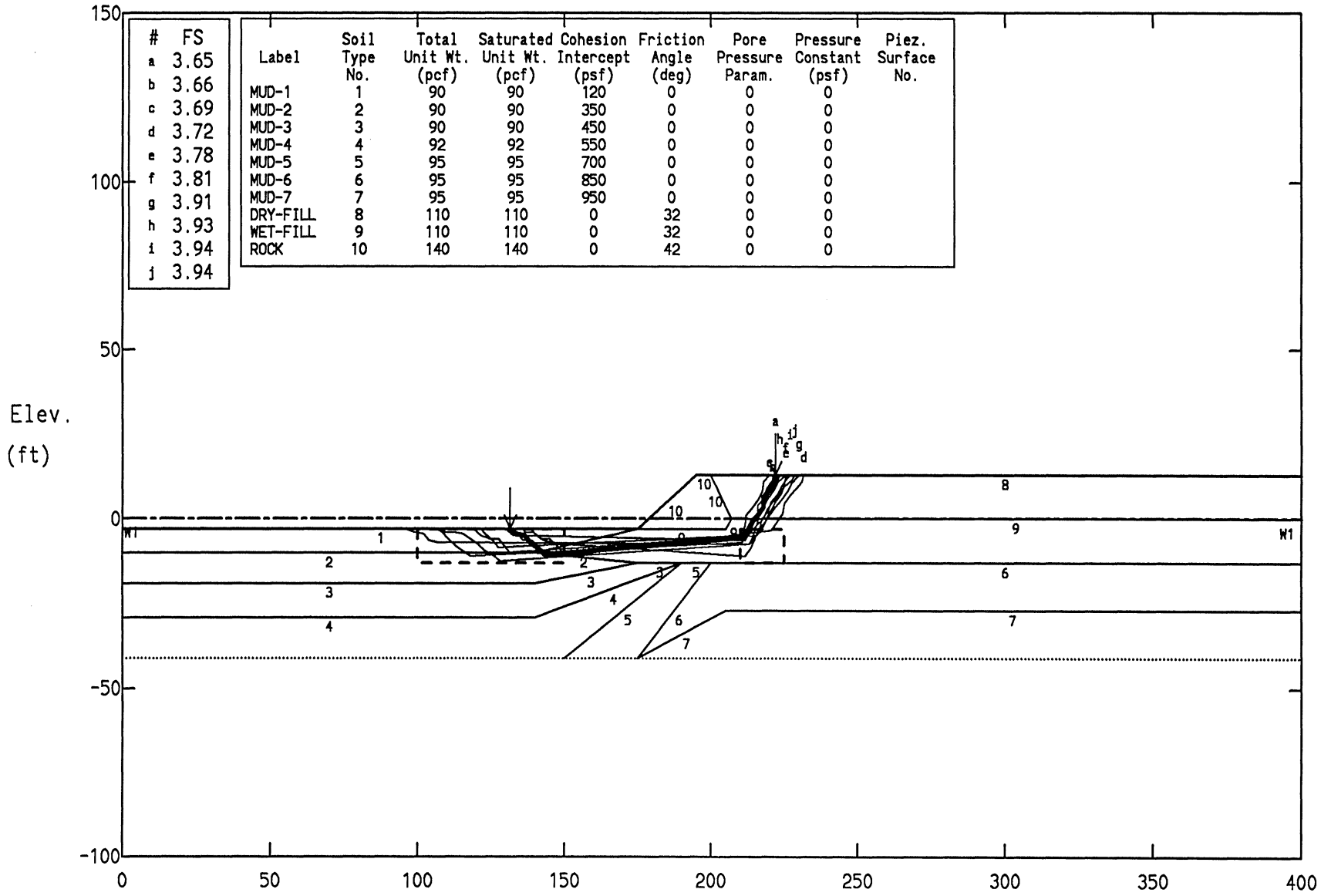
TABLE 4 Summary of Newmark Sliding Analyses for FILL

Ground Motion	Permanent Displacement, inches					
	Drained Strength (1)			Residual Strength (2)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	0	0	0	5	4	3
SET-1 (-)	0	0	0	12	10	8
SET-2 (+)	1	0	0	10	9	8
SET-2 (-)	0	0	0	1	1	0
SET-3 (+)	0	0	0	9	8	7
SET-3 (-)	0	0	0	5	4	3
SET-4 (+)	5	4	4	26	23	19
SET-4 (-)	0	0	0	0	0	0
SET-5 (+)	0	0	0	1	1	1
SET-5 (-)	0	0	0	4	3	2
SET-6 (+)	0	0	0	0	0	0
SET-6 (-)	0	0	0	19	17	13
minimum	0	0	0	0	0	0
maximum	**5**	**4**	**4**	**26**	**23**	**19**
average	1	0	0	8	7	5

Note:
(1) Using constant drained shear strength of sand (unliquefied strength)
(2) Using constant residual shear strength of sand (liquefied strength)

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:FILL1.PLT 02-11-99 1:49pm



#	FS
a	3.65
b	3.66
c	3.69
d	3.72
e	3.78
f	3.81
g	3.91
h	3.93
i	3.94
j	3.94

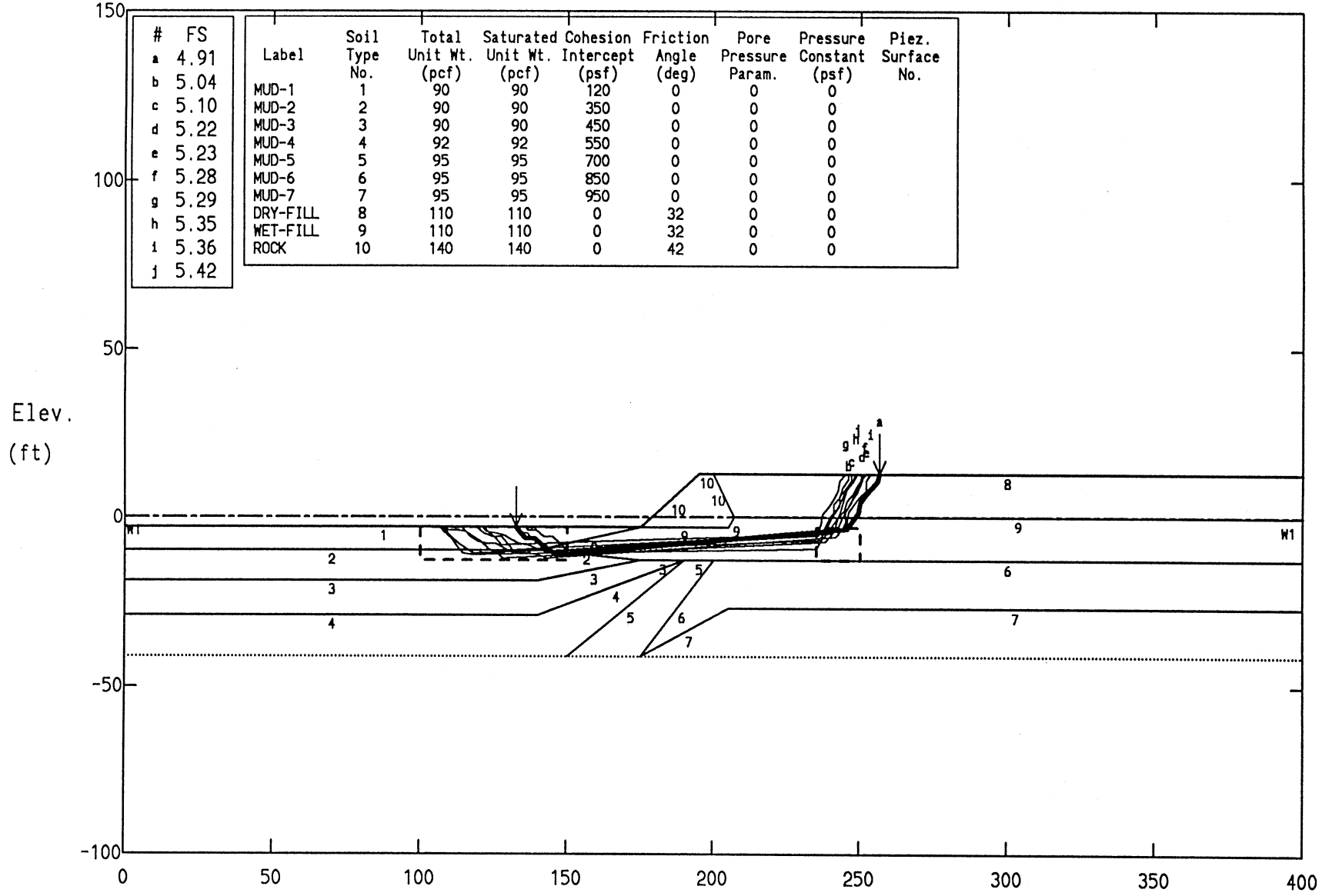
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	

PCSTABL5M FSmin=3.65 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:FILL2.PLT 02-11-99 1:51pm



#	FS
a	4.91
b	5.04
c	5.10
d	5.22
e	5.23
f	5.28
g	5.29
h	5.35
i	5.36
j	5.42

Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	

PCSTABL5M FSmin=4.91 X-Axis (ft)

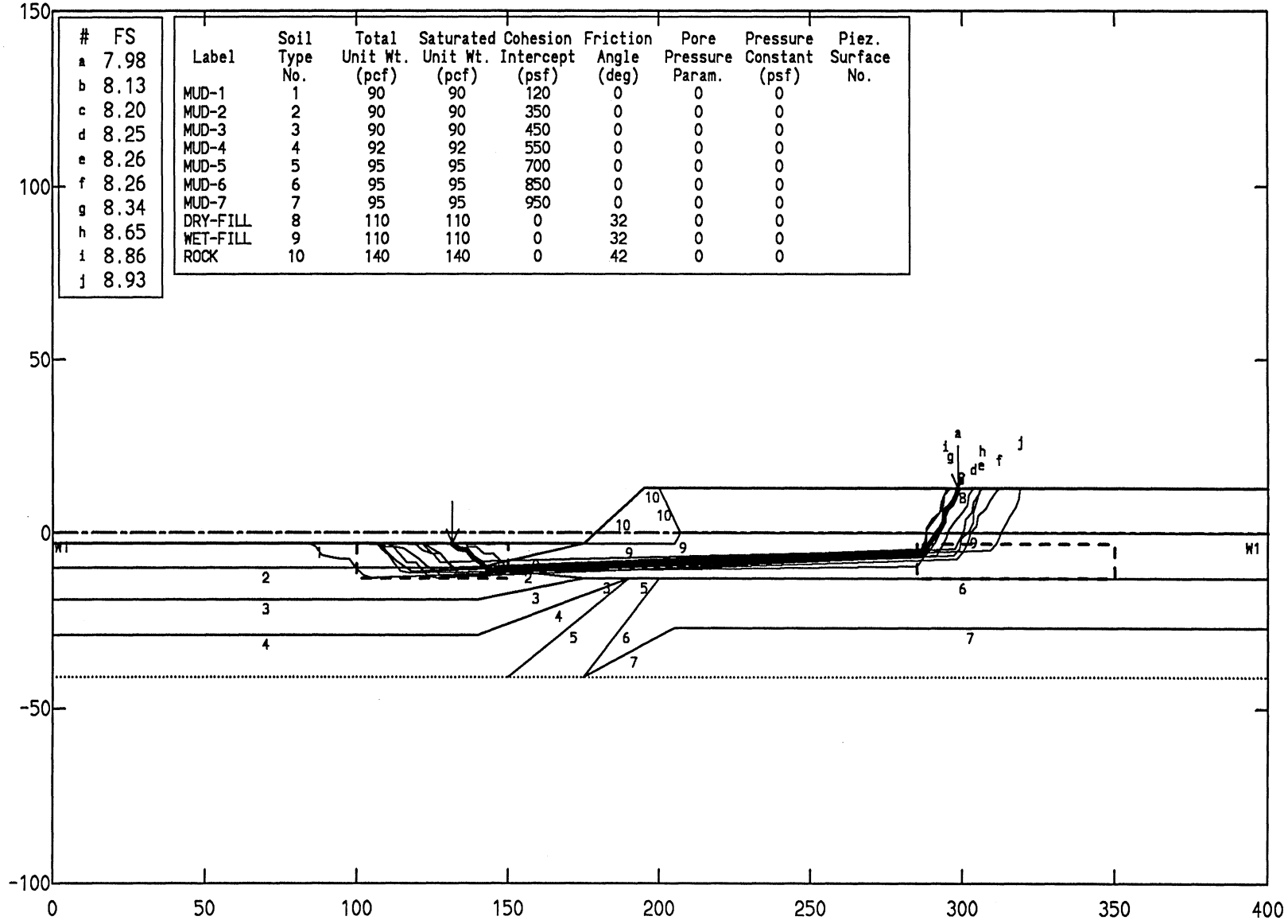
Factors Of Safety Calculated By The Modified Janbu Method

OAKLAND MOLE, SECTION E-E', 2-9-99 LATERAL SPREADING STUDIES

Ten Most Critical. D:FILL3.PLT 02-11-99 1:52pm

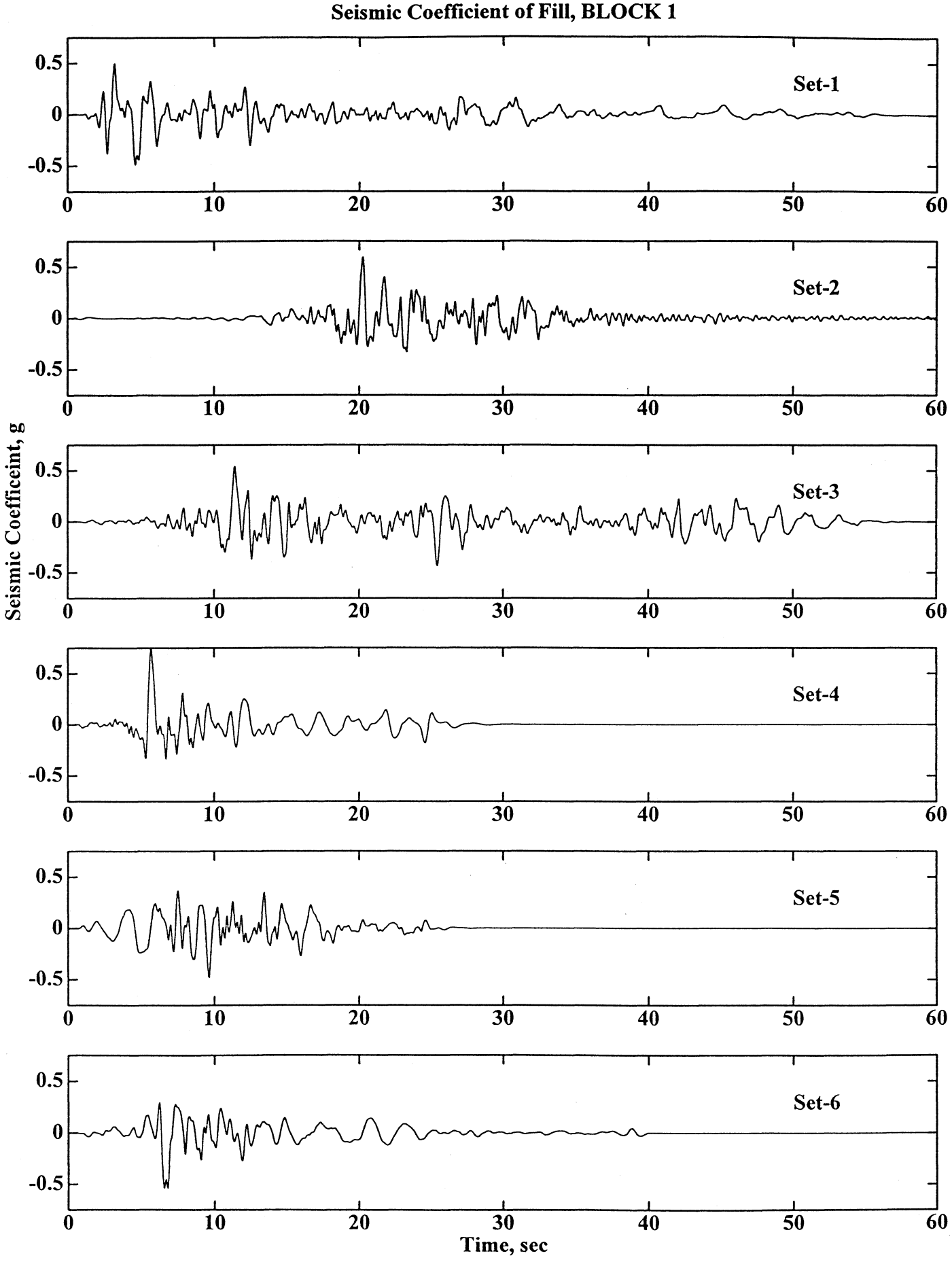
#	FS
a	7.98
b	8.13
c	8.20
d	8.25
e	8.26
f	8.26
g	8.34
h	8.65
i	8.86
j	8.93

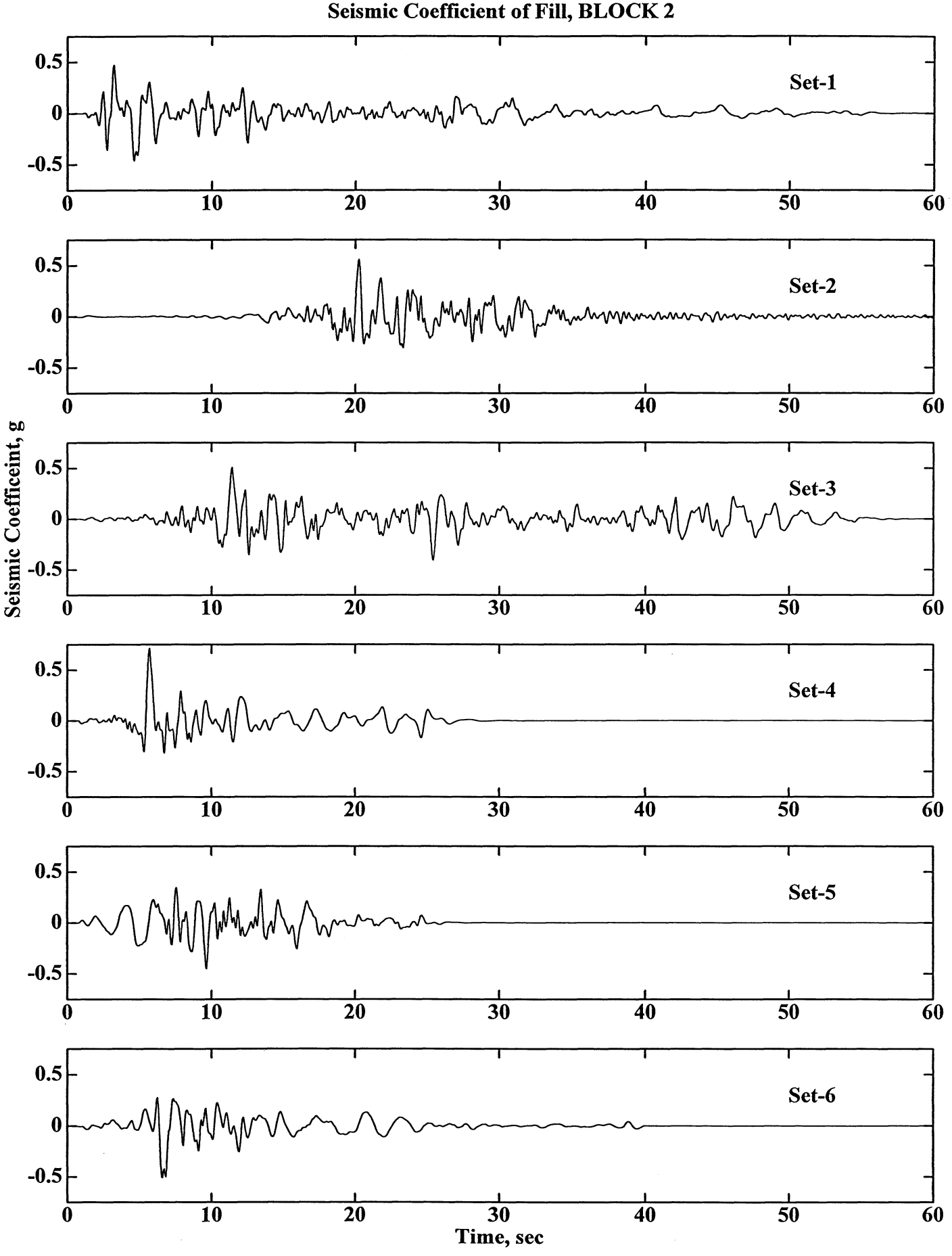
Label	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
MUD-1	1	90	90	120	0	0	0	
MUD-2	2	90	90	350	0	0	0	
MUD-3	3	90	90	450	0	0	0	
MUD-4	4	92	92	550	0	0	0	
MUD-5	5	95	95	700	0	0	0	
MUD-6	6	95	95	850	0	0	0	
MUD-7	7	95	95	950	0	0	0	
DRY-FILL	8	110	110	0	32	0	0	
WET-FILL	9	110	110	0	32	0	0	
ROCK	10	140	140	0	42	0	0	

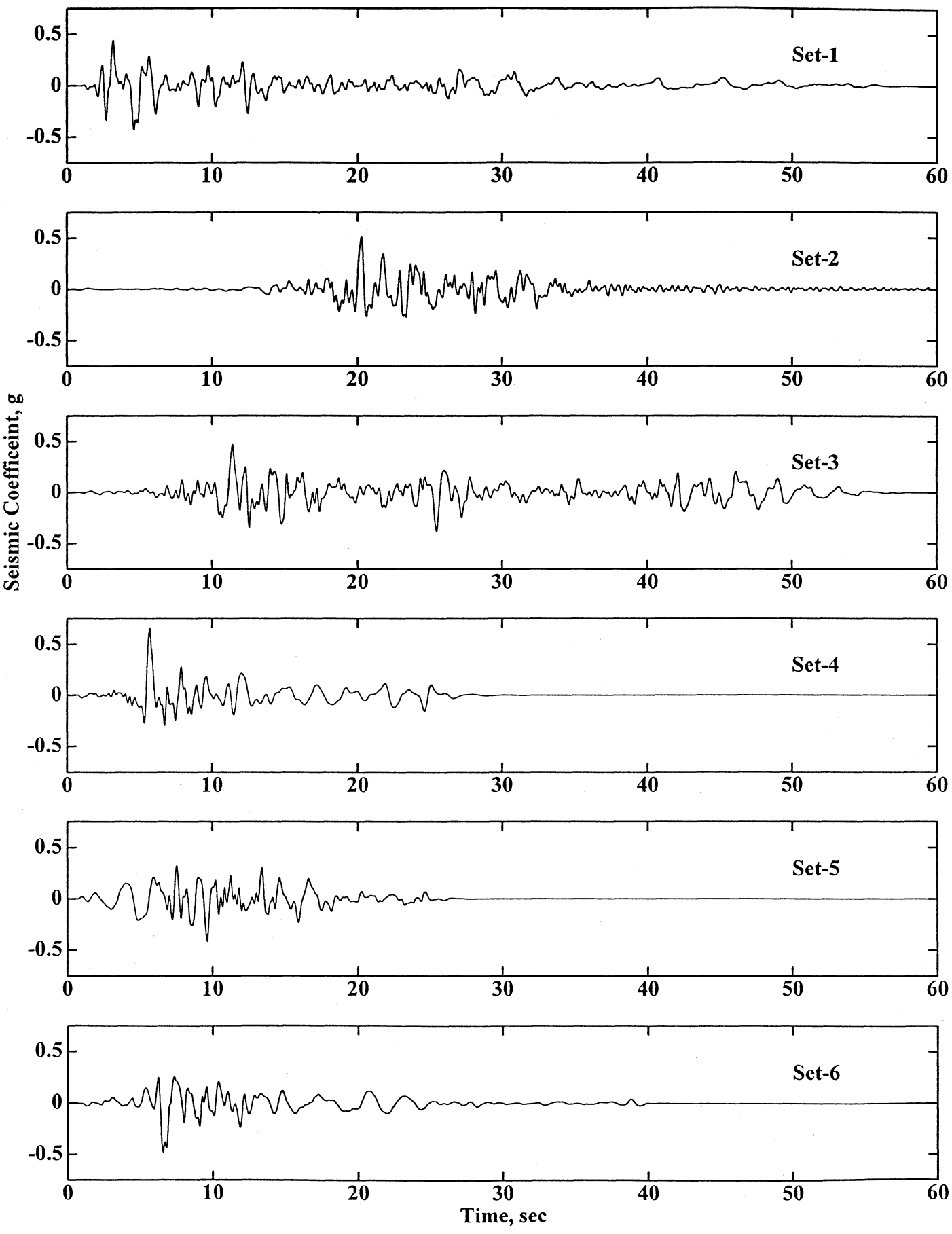


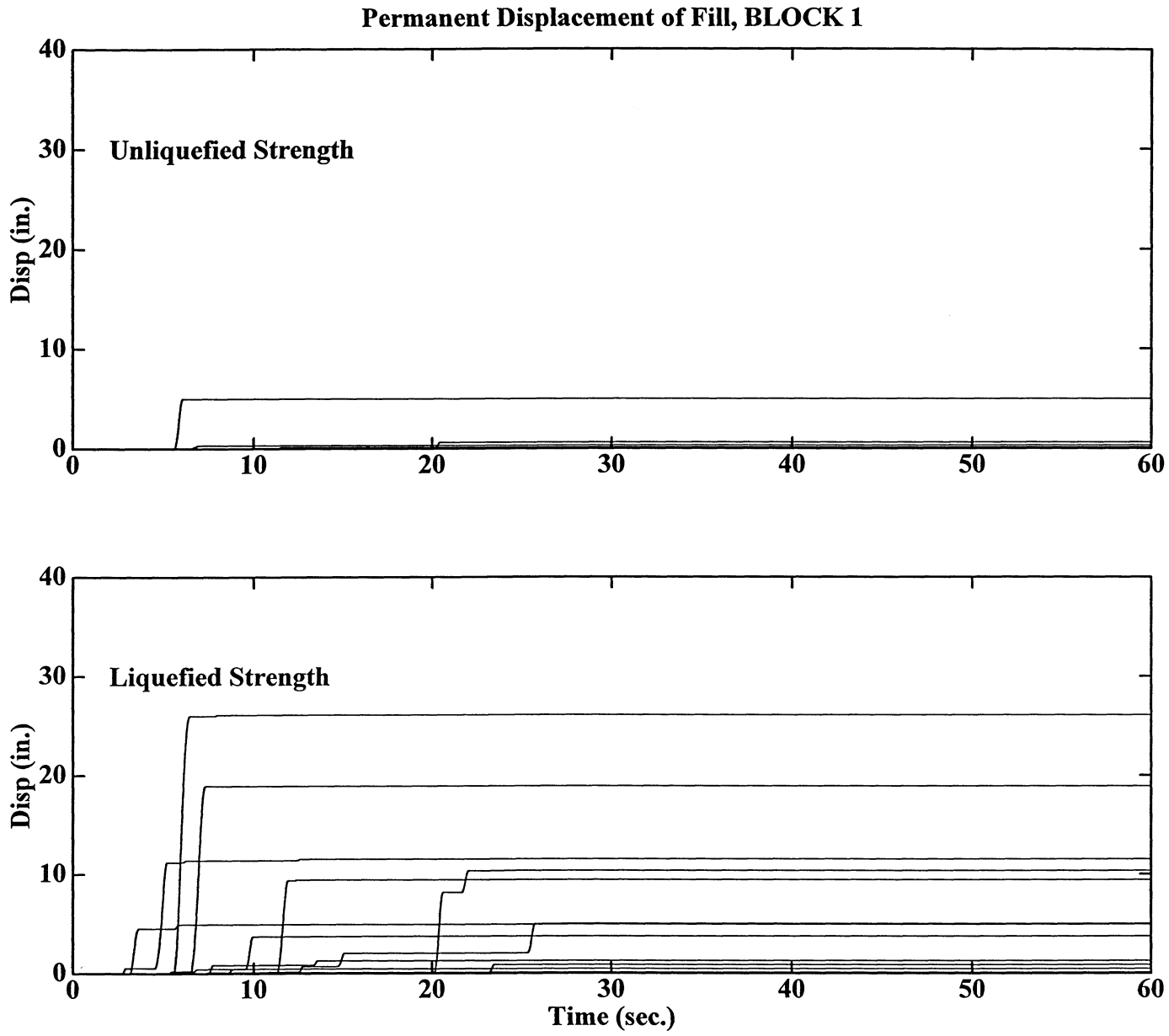
PCSTABL5M FSmin=7.98 X-Axis (ft)

Factors Of Safety Calculated By The Modified Janbu Method

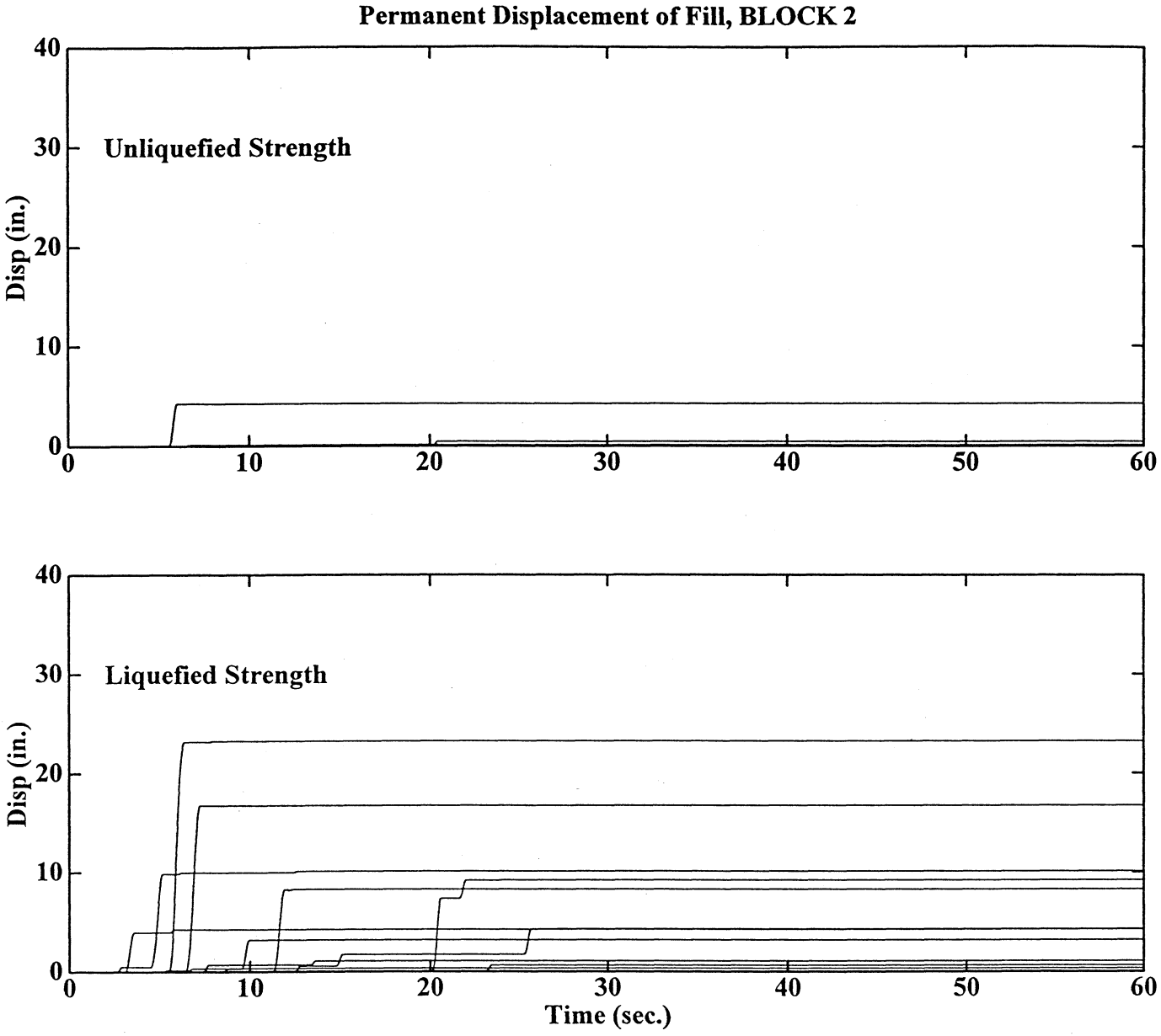

Seismic Coefficient of Fill, BLOCK 1
Seismic Coefficeint, g
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
0.5
0
-0.5
0
10
20
30
40
50
60
Time, sec

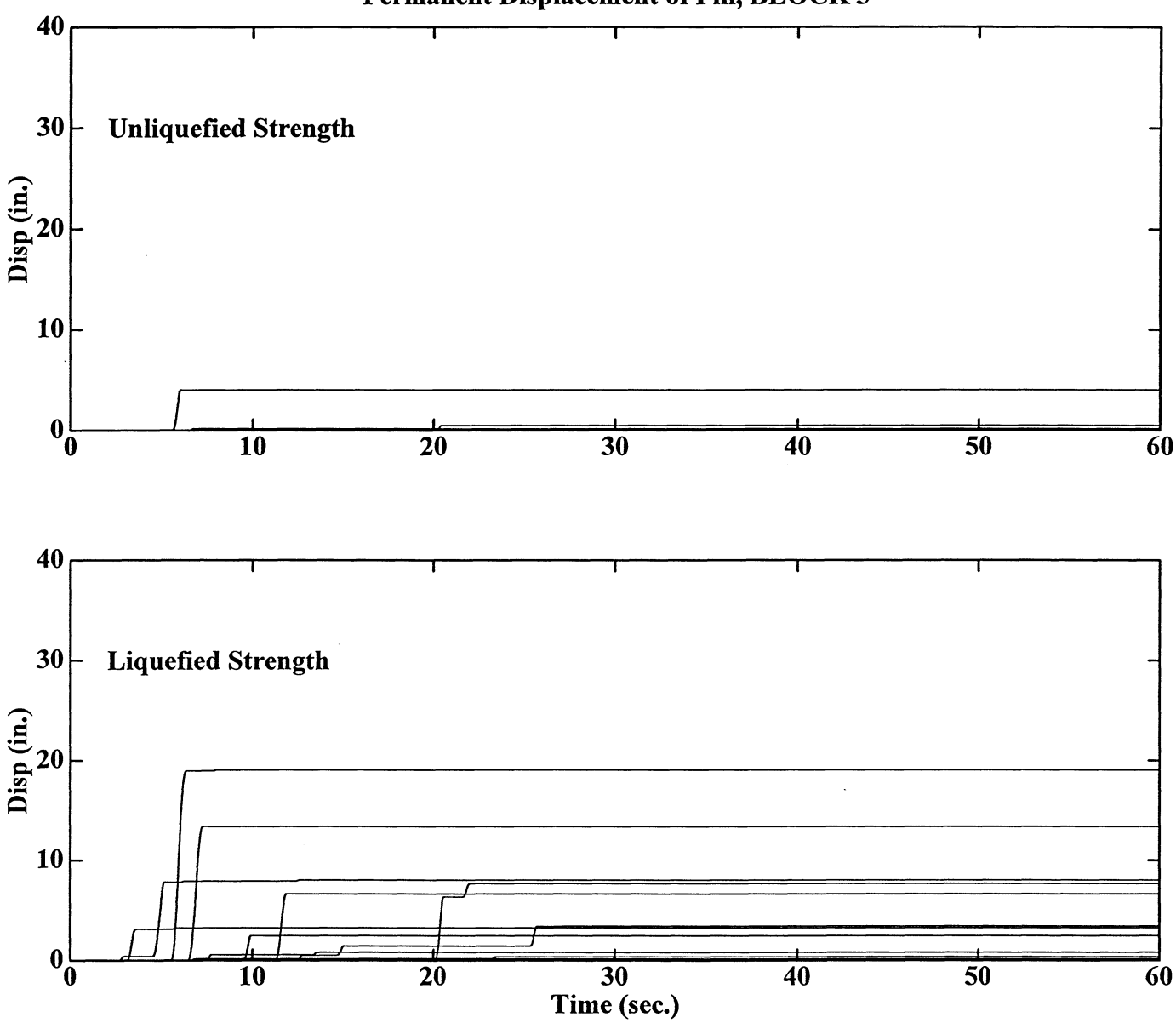

Seismic Coefficient of Fill, BLOCK 2
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
0.5
0
-0.5
0
10
20
30
40
50
60
Seismic Coefficeint, g
Time, sec


Seismic Coefficient of Fill, BLOCK 3
Seismic Coefficeint, g
Set-1
Set-2
Set-3
Set-4
Set-5
Set-6
0.5
0
-0.5
0
10
20
30
40
50
60
Time, sec


Permanent Displacement of Fill, BLOCK 1
Unliquefied Strength
Disp (in.)
0
10
20
30
40
0
10
20
30
40
50
60

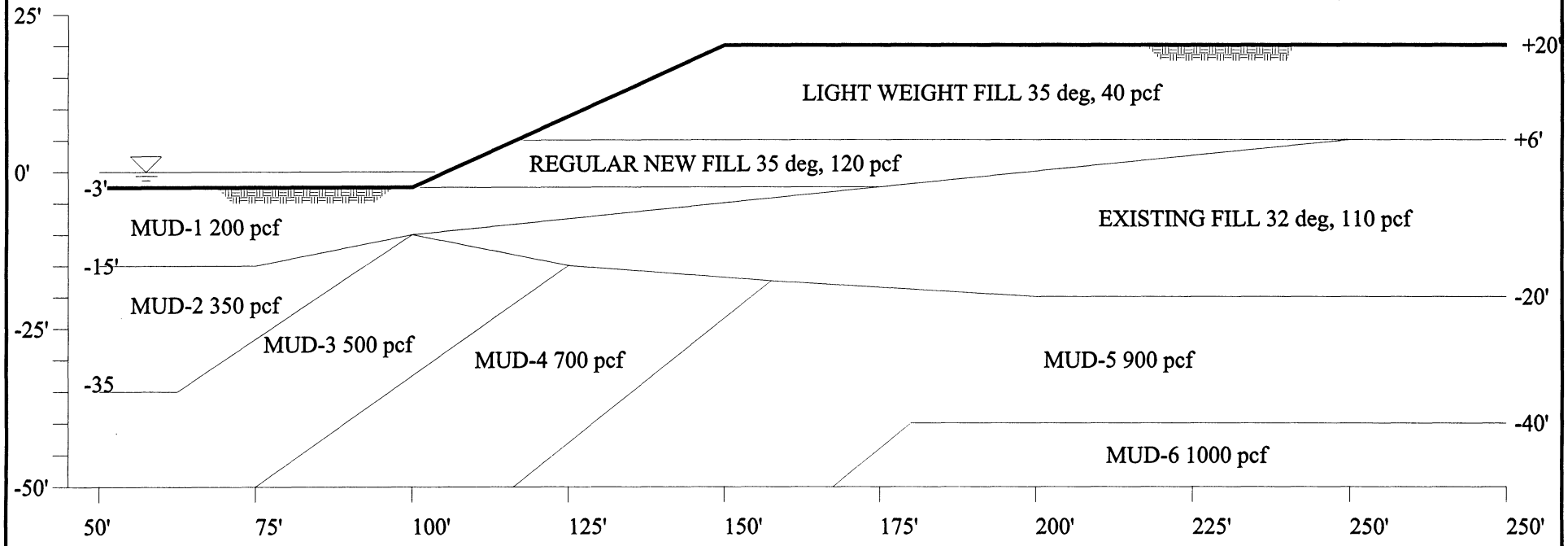
Liquefied Strength
Disp (in.)
0
10
20
30
40
0
10
20
30
40
50
60
Time (sec.)


Permanent Displacement of Fill, BLOCK 2
Unliquefied Strength
Liquefied Strength
Disp (in.)
Disp (in.)
Time (sec.)
0
10
20
30
40
50
60


Permanent Displacement of Fill, BLOCK 3
Unliquefied Strength
Liquefied Strength
Disp (in.)
Time (sec.)
0
10
20
30
40
50
60

APPENDIX B

Appendix B
Station 86+89
Proposed Light Weight Fill, γ_{fill} = 40 pcf (Grade at El. +20')



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

NEW S.F.- OAKLAND BAY BRIDGE

Project No. 98-107

Date: 6-10-98

IDEALIZED SOIL PROFILE AT
OAKLAND SHORE APPROACH
STA. 86+89

Figure

TABLE 1 Summary of Pseudo Static Analyses for YBM (with light weight fill) 4/19/99

Block	Block Size, Measured from Shore	1.0*Su		1.4*Su		0.33*Su	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	2.36	0.19	2.9	0.27	1.31	0.05
Block 2	50'	2.97	0.19	3.56	0.27	1.52	0.06
Block 3	100'	3.36	0.19	4.34	0.26	1.72	0.06

Note:
(1) Using static shear strength
(2) Using dynamic shear strength (increase shear strength by 40%)
(3) Using residual shear strength (reduce shear strength to 33%)

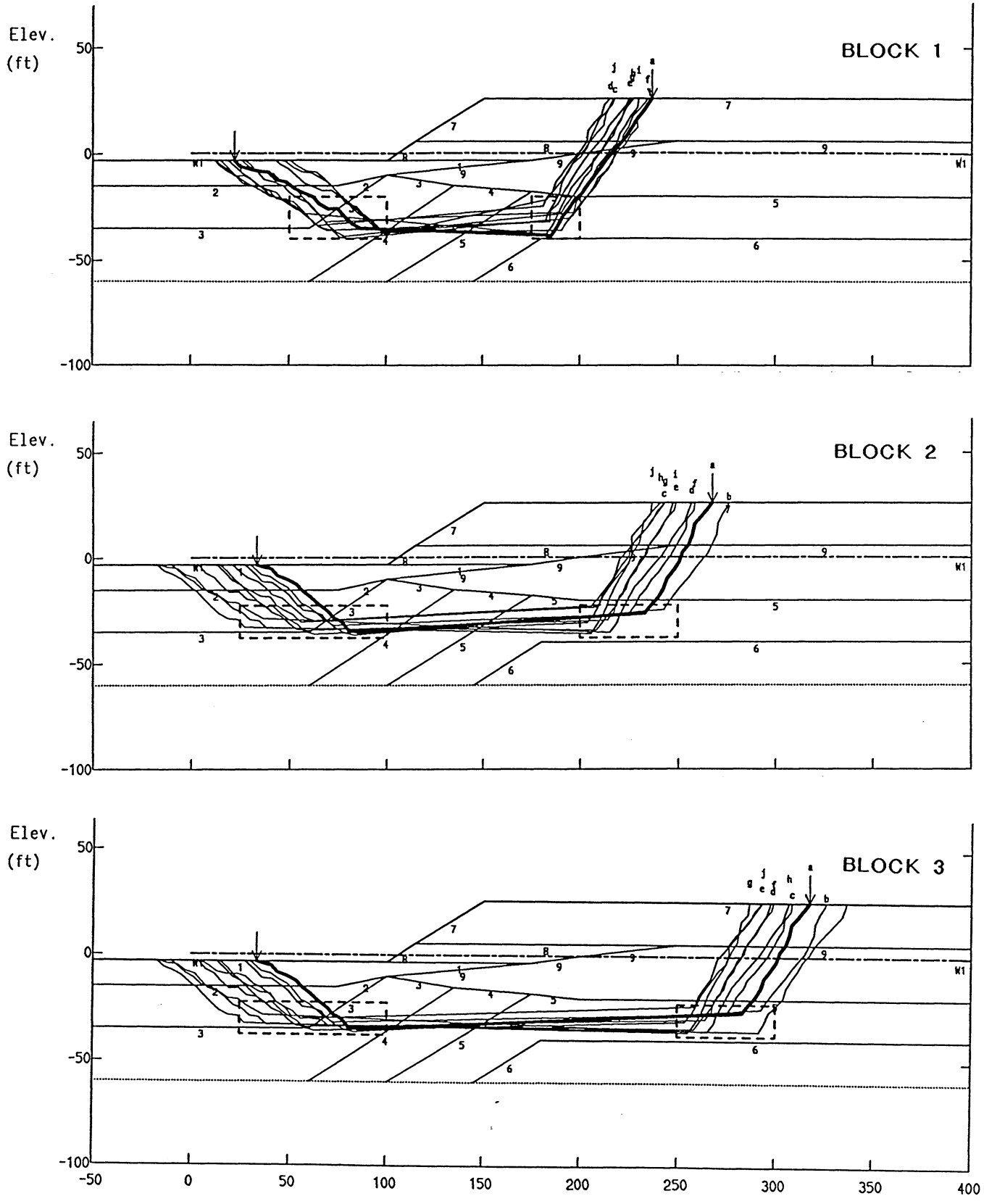
TABLE 2 Summary of Newmark Sliding Analyses for YBM (w/ light weight fill)

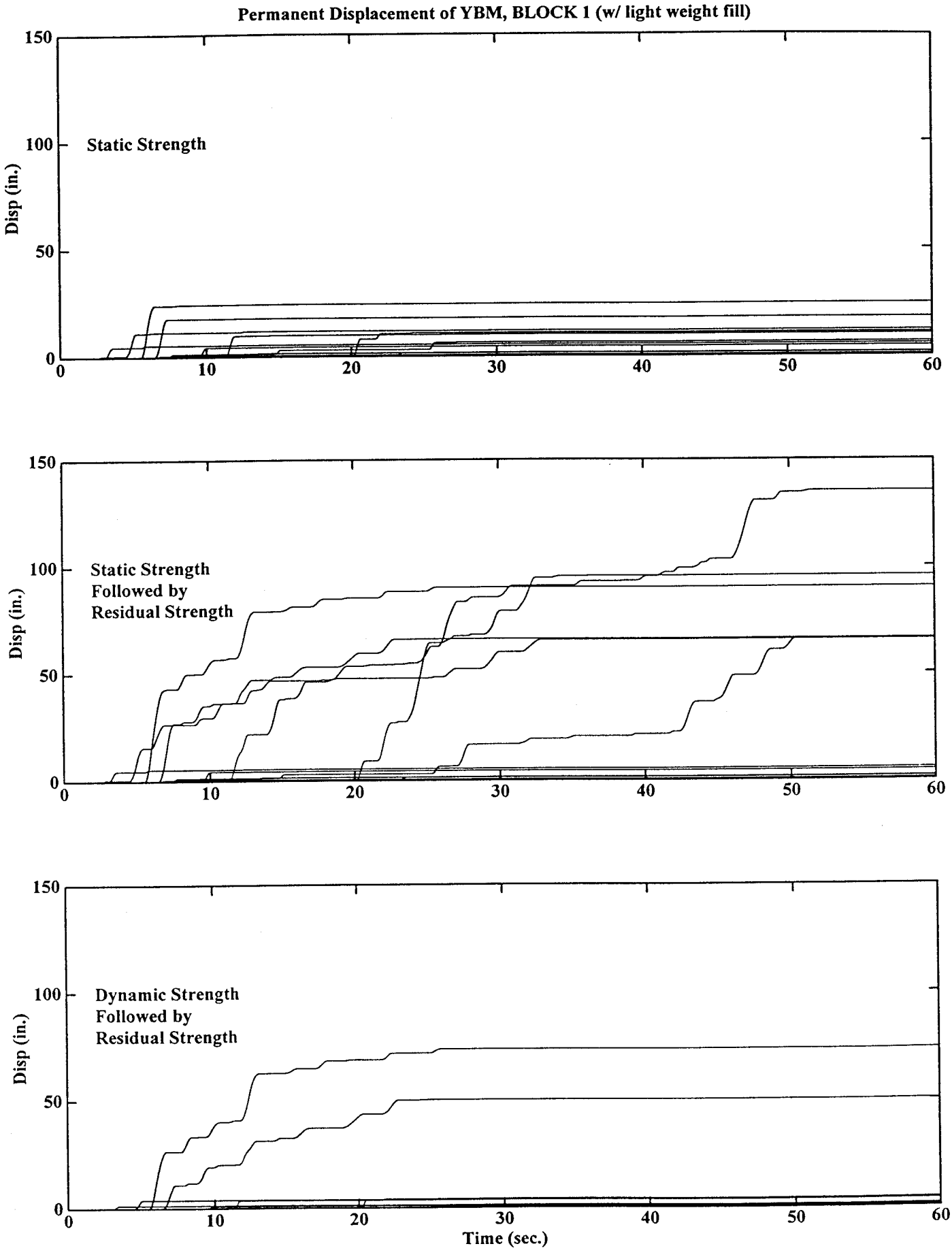
Ground Motion	Permanent Displacement, inches								
	Static Strength (1)			Static Followed By Residual (2)			Dynamic Followed By Residual (3)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	5	5	4	5	5	4	1	1	1
SET-1 (-)	12	11	10	66	45	40	4	3	3
SET-2 (+)	11	10	9	95	74	67	4	4	4
SET-2 (-)	2	1	1	2	1	1	0	0	0
SET-3 (+)	10	9	8	135	94	82	4	3	3
SET-3 (-)	6	6	5	66	6	5	1	1	1
SET-4 (+)	24	23	20	90	70	64	74	55	50
SET-4 (-)	1	0	0	1	0	0	0	0	0
SET-5 (+)	2	1	1	2	1	1	0	0	0
SET-5 (-)	4	4	3	4	4	3	1	1	1
SET-6 (+)	1	1	1	1	1	1	0	0	0
SET-6 (-)	18	16	15	66	45	39	50	30	26
minimum	1	0	0	1	0	0	0	0	0
maximum	**24**	**23**	**20**	**135**	**94**	**82**	**74**	**55**	**50**
average	8	7	6	44	29	26	12	8	7

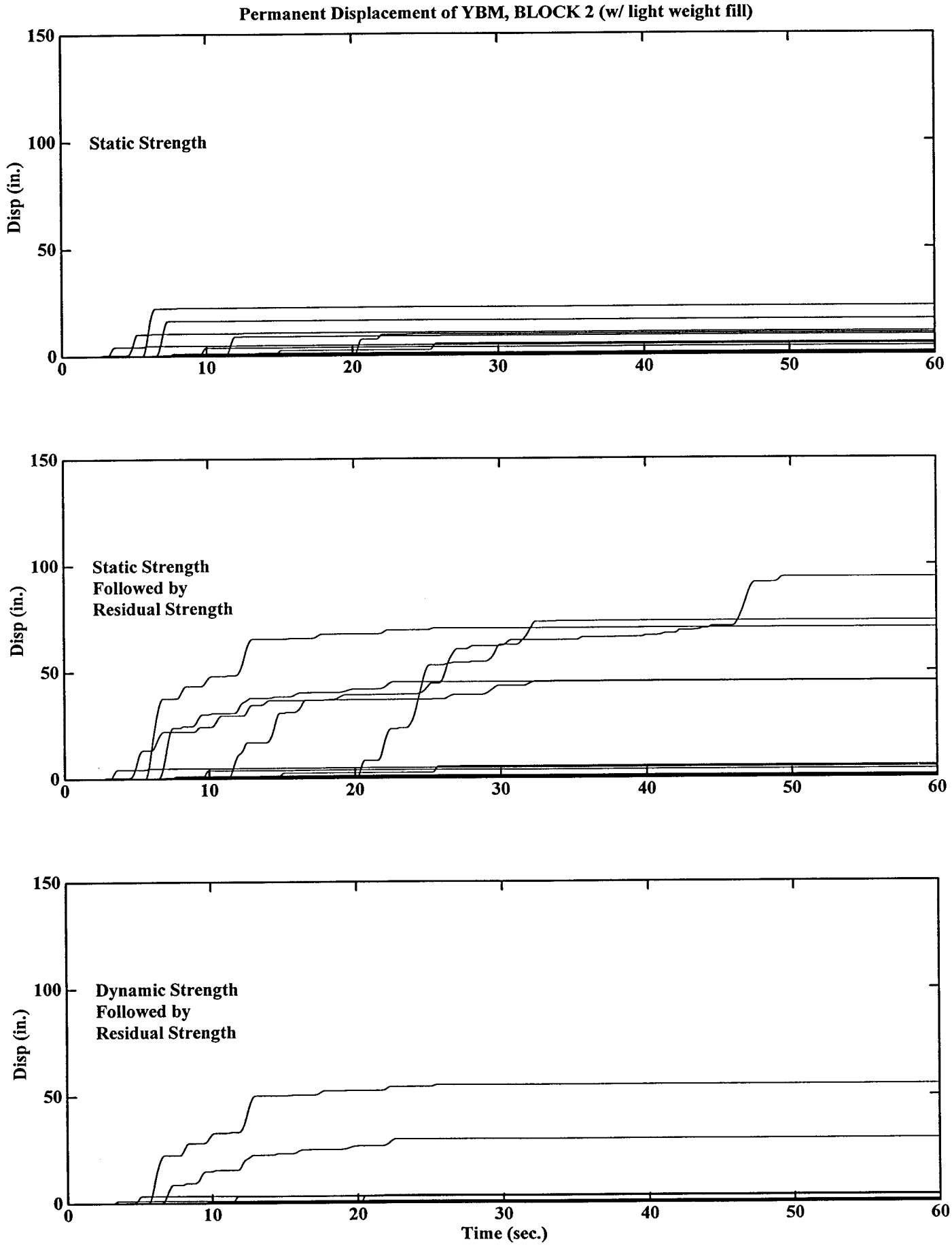
Note:
(1) Using constant static strength
(2) Using static strength followed by residual strength when deformation exceeds 6 inches
(3) Using dynamic strength followed by residual strength when deformation exceeds 6 inches

LATERAL SPREADING IN YBM

WITH LIGHT WEIGHT FILL OPTION




Permanent Displacement of YBM, BLOCK 1 (w/ light weight fill)
Static Strength
Static Strength
Followed by
Residual Strength
Dynamic Strength
Followed by
Residual Strength
Disp (in.)
Time (sec.)
0
50
100
150
10
20
30
40
60


Permanent Displacement of YBM, BLOCK 2 (w/ light weight fill)
Static Strength
Static Strength
Followed by
Residual Strength
Dynamic Strength
Followed by
Residual Strength
Disp (in.)
Time (sec.)
0
50
100
150
10
20
30
40
60

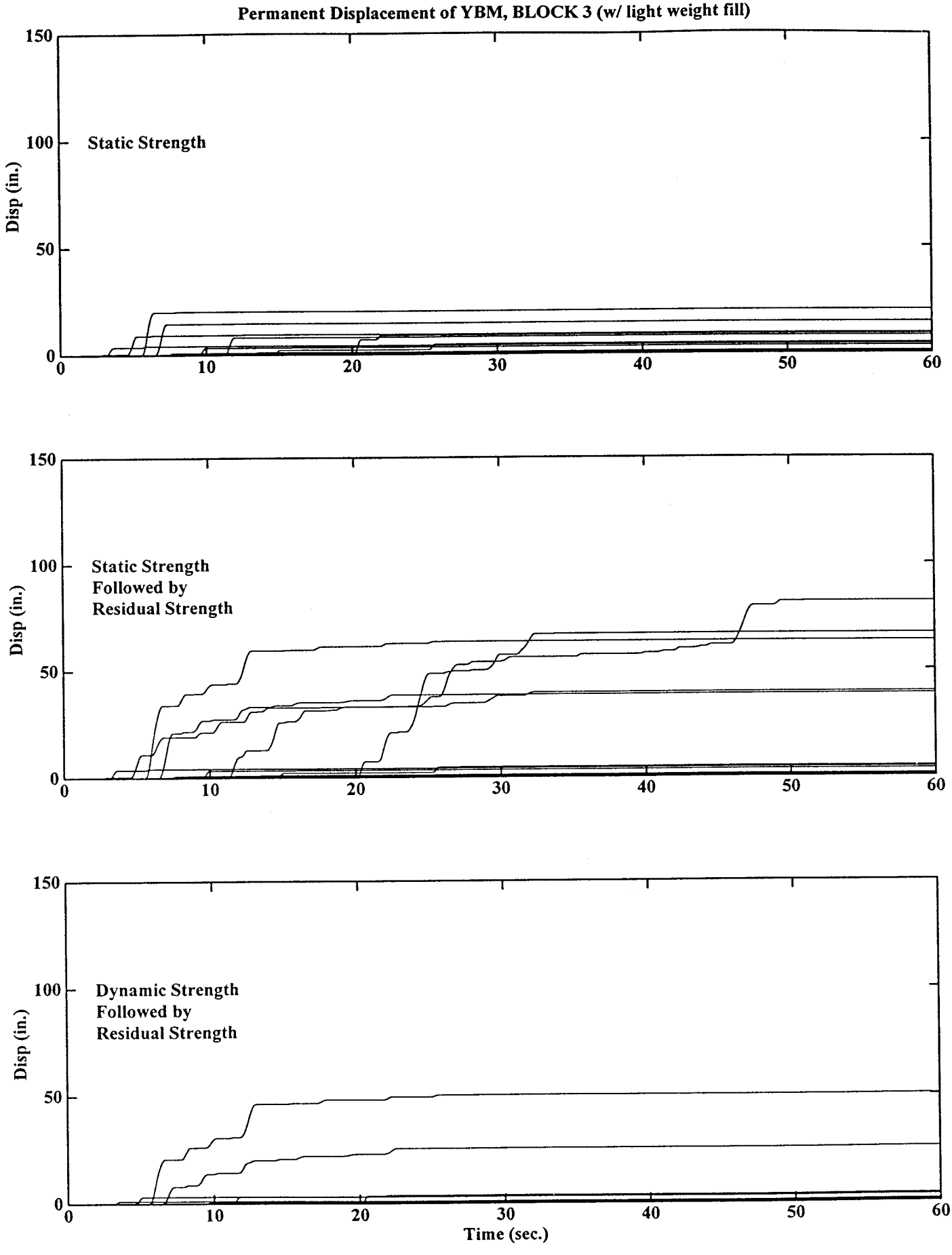

Permanent Displacement of YBM, BLOCK 3 (w/ light weight fill)
Static Strength
Disp (in.)
Static Strength
Followed by
Residual Strength
Disp (in.)
Dynamic Strength
Followed by
Residual Strength
Disp (in.)
Time (sec.)
0
50
100
150
0
10
20
30
40
50
60

TABLE 3 Summary of Pseudo Static Analyses for FILL (w/ light weight fill)

Block	Block Size, Measured from Shore	Drained Strength (1)		600 psf (2)		800 psf (3)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	4.33	0.39	2.73	0.22	3.26	0.28
Block 2	50'	5.28	0.4	3.2	0.22	3.93	0.28
Block 3	100'	6.99	0.41	4.03	0.21	5.08	0.28

Note:
(1) Using drained shear strength of sand
(2) Using residual shear strength of sand in fill below watertable (Su=600 psf)
(2) Using residual shear strength of sand in fill below watertable (Su=800 psf)

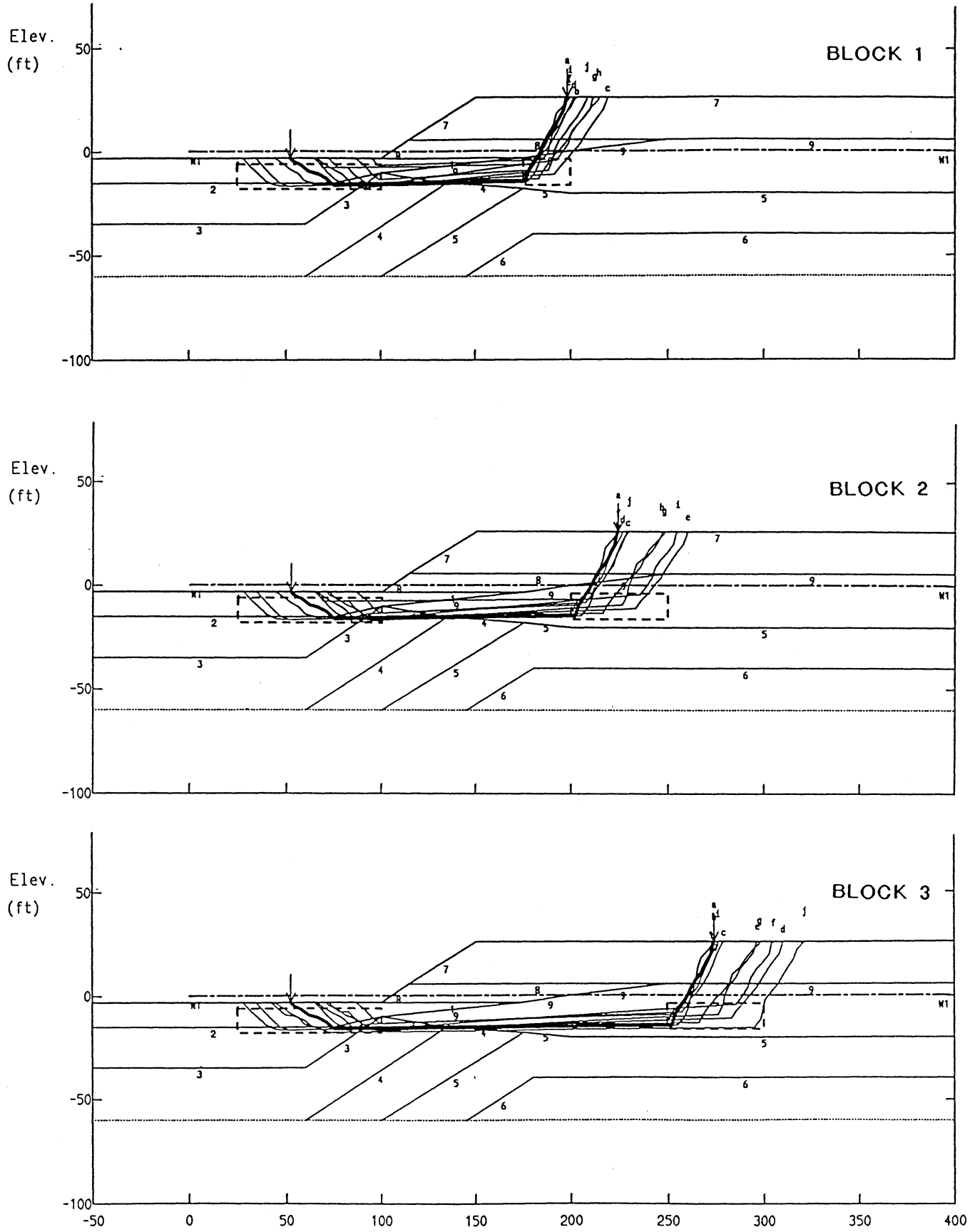
TABLE 4 Summary of Newmark Sliding Analyses for FILL (w/ light weight fill)

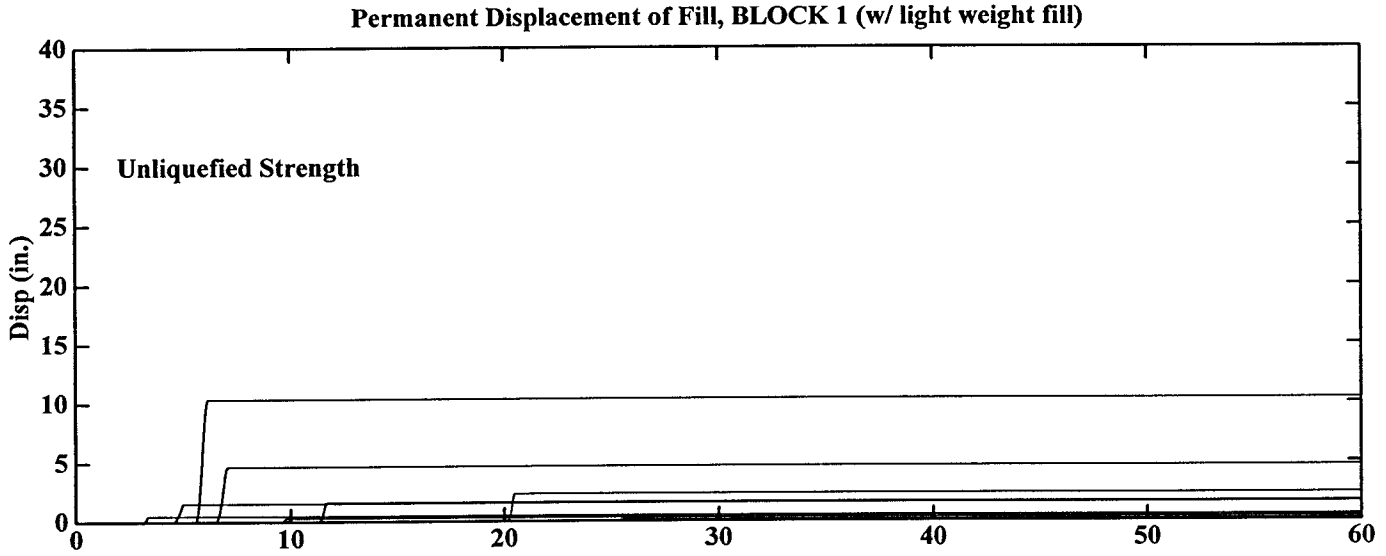
Ground Motion	Permanent Displacement, inches								
	Drained Strength (1)			Residual Strength of 600 psf (2)			Residual Strength of 800 psf (3)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	0	0	0	8	7	5	3	3	2
SET-1 (-)	2	0	0	16	14	12	9	7	5
SET-2 (+)	2	2	1	15	12	11	8	7	5
SET-2 (-)	0	0	0	2	2	1	0	0	0
SET-3 (+)	2	1	0	14	12	10	7	6	4
SET-3 (-)	0	0	0	9	7	6	3	2	1
SET-4 (+)	10	8	5	34	29	25	22	19	15
SET-4 (-)	0	0	0	1	1	1	0	0	0
SET-5 (+)	0	0	0	2	2	2	1	0	0
SET-5 (-)	0	0	0	7	5	4	2	2	1
SET-6 (+)	0	0	0	2	1	1	0	0	0
SET-6 (-)	5	3	1	25	21	18	15	13	9
minimum	0	0	0	1	1	1	0	0	0
maximum	**10**	**8**	**5**	**34**	**29**	**25**	**22**	**19**	**15**
average	2	1	1	11	9	8	6	5	4

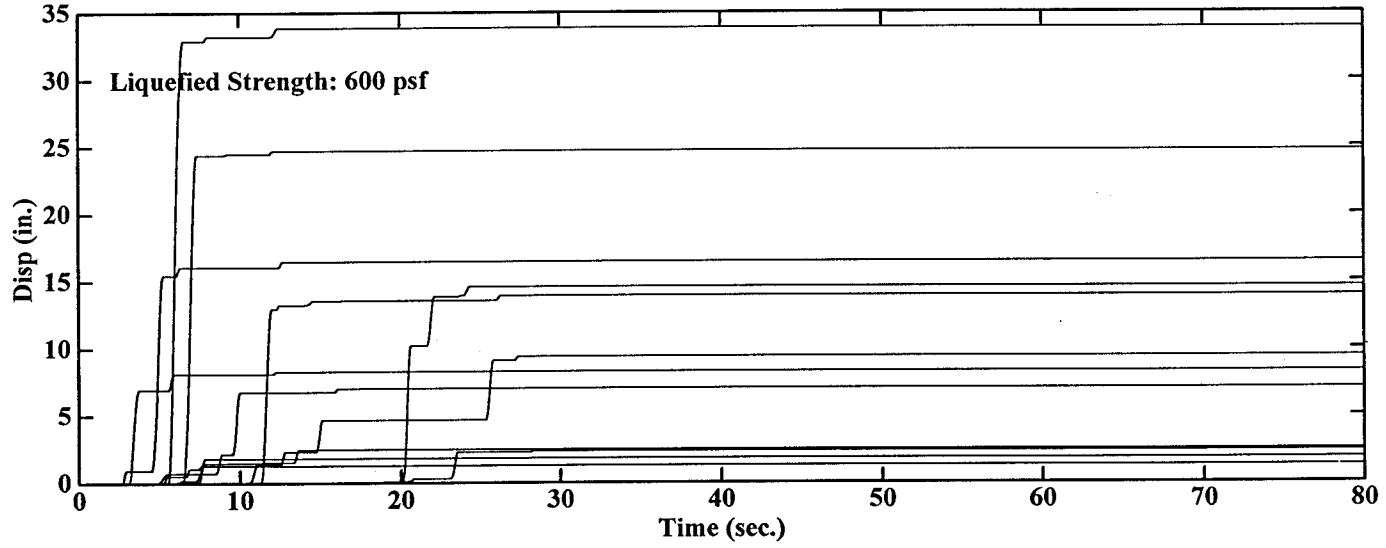
Note:
(1) Using constant drained shear strength of sand (unliquefied strength)
(2) Using constant residual shear strength of sand (liquefied strength of 600 psf)
(3) Using constant residual shear strength of sand (liquefied strength of 800 psf)

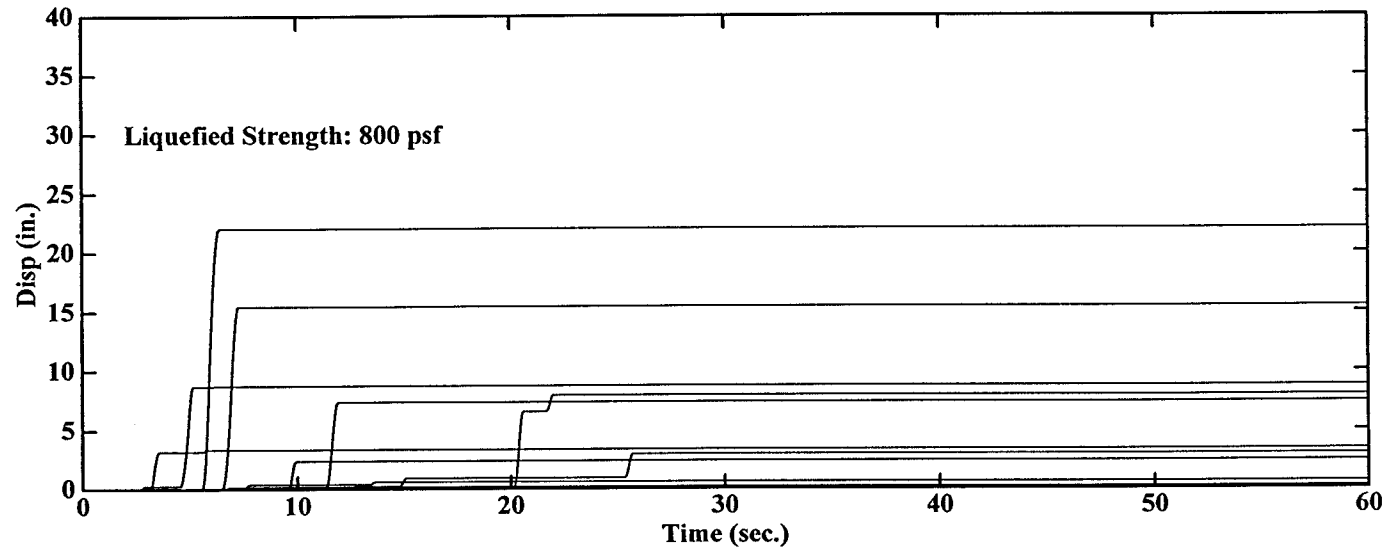
LATERAL SPREADING IN FILL

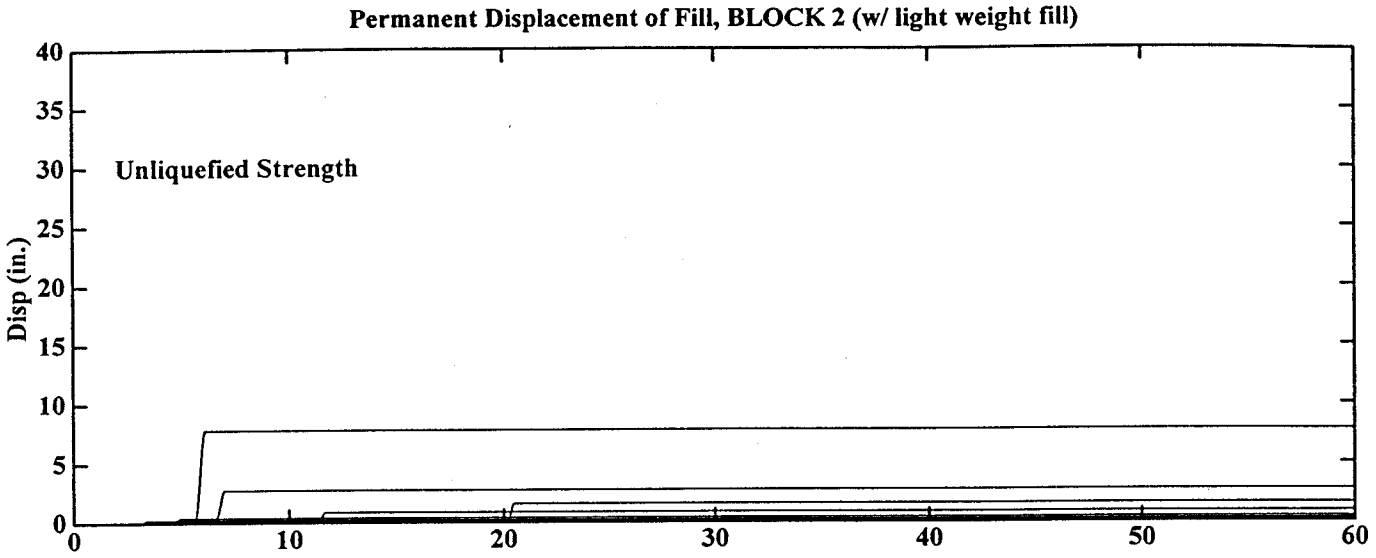
WITH LIGHT WEIGHT FILL OPTION

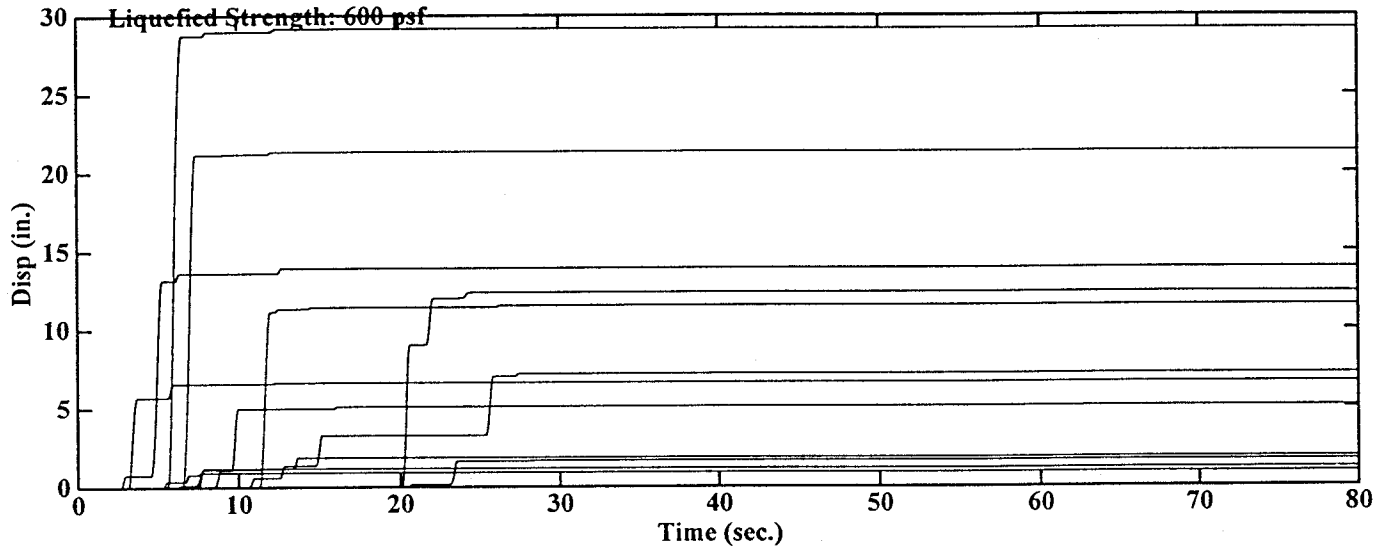


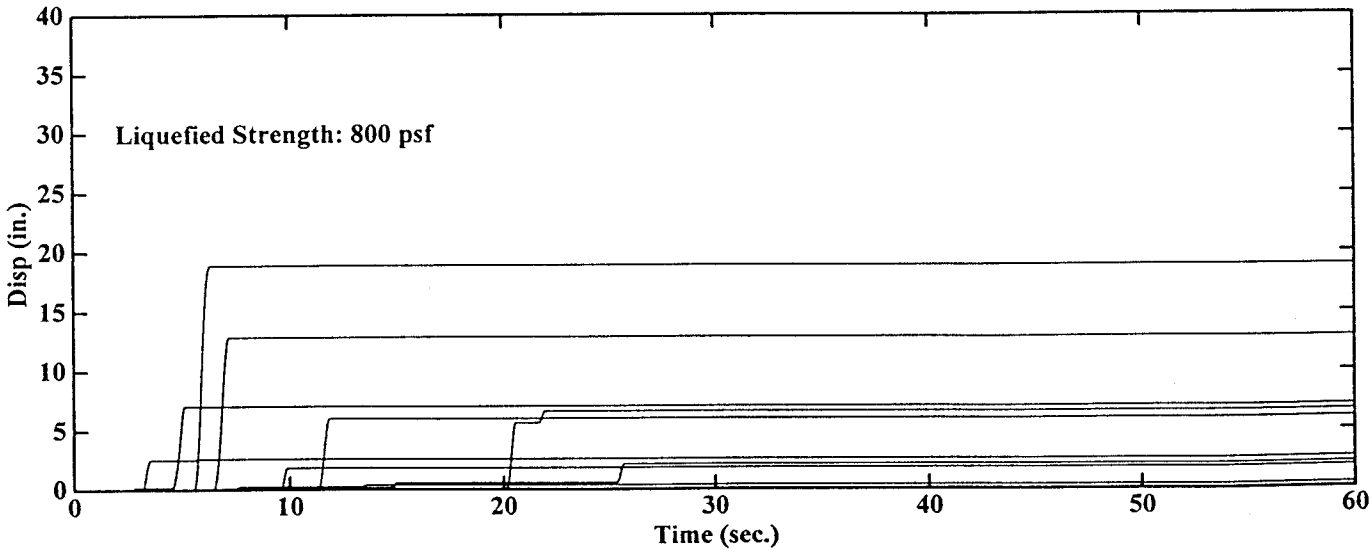

Permanent Displacement of Fill, BLOCK 1 (w/ light weight fill)
Unliquefied Strength
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60

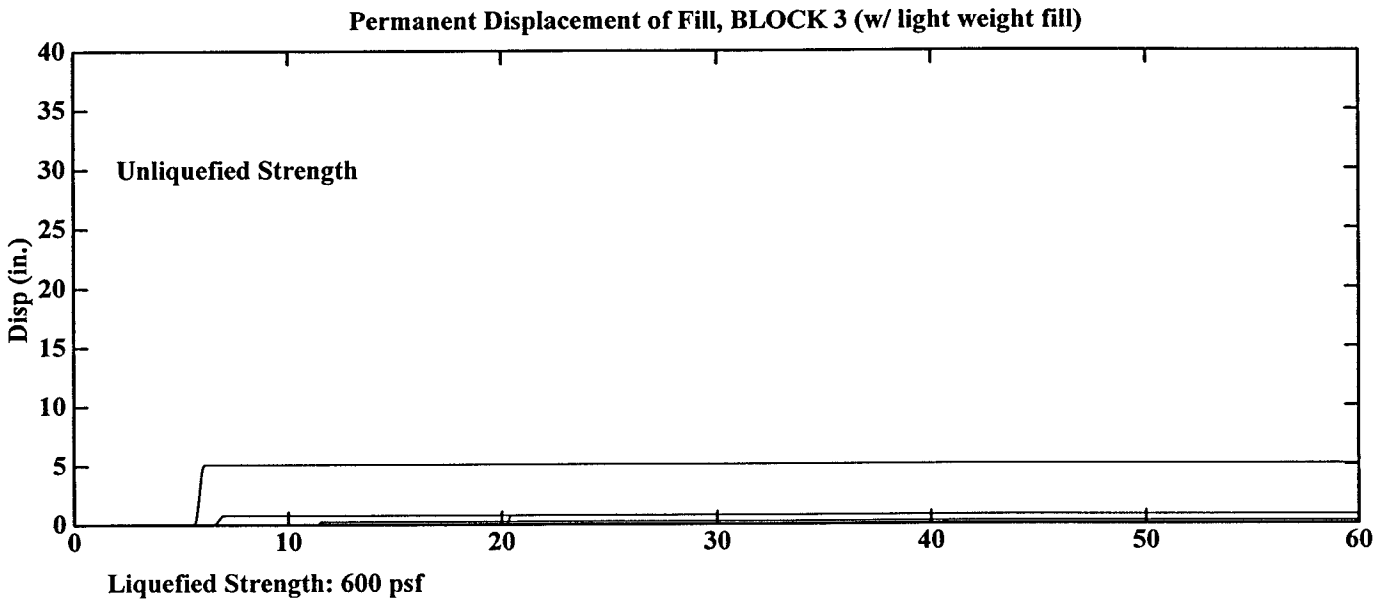

Liquefied Strength: 600 psf
Disp (in.)
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
70
80
Time (sec.)


Liquefied Strength: 800 psf
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
Time (sec.)

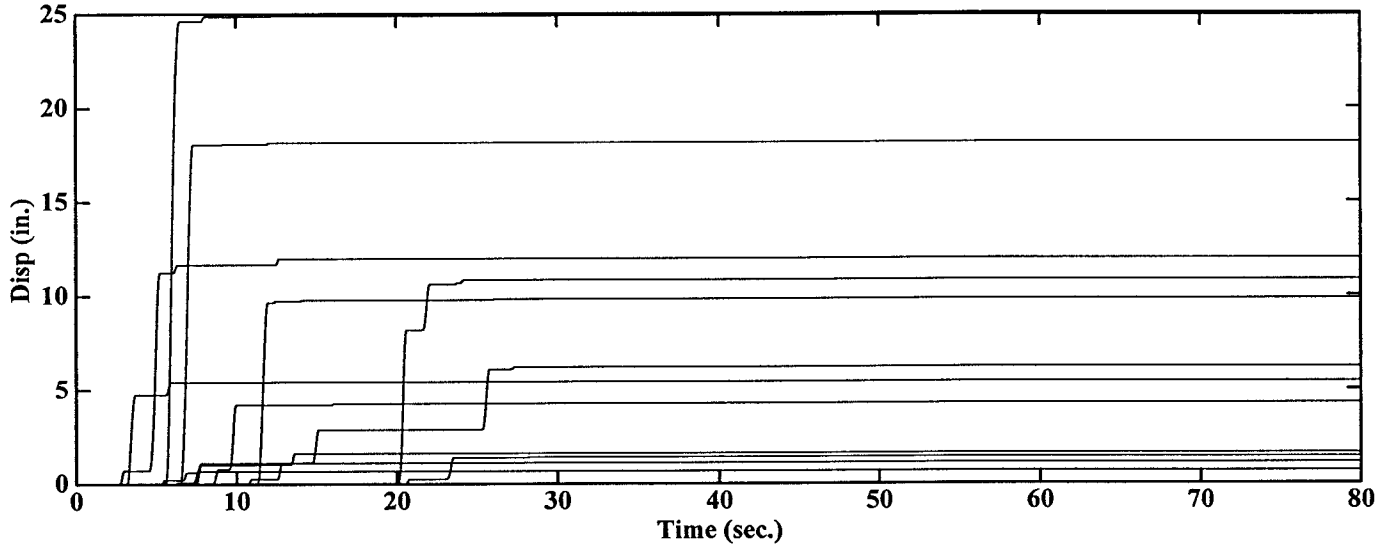

Permanent Displacement of Fill, BLOCK 2 (w/ light weight fill)
Unliquefied Strength
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60

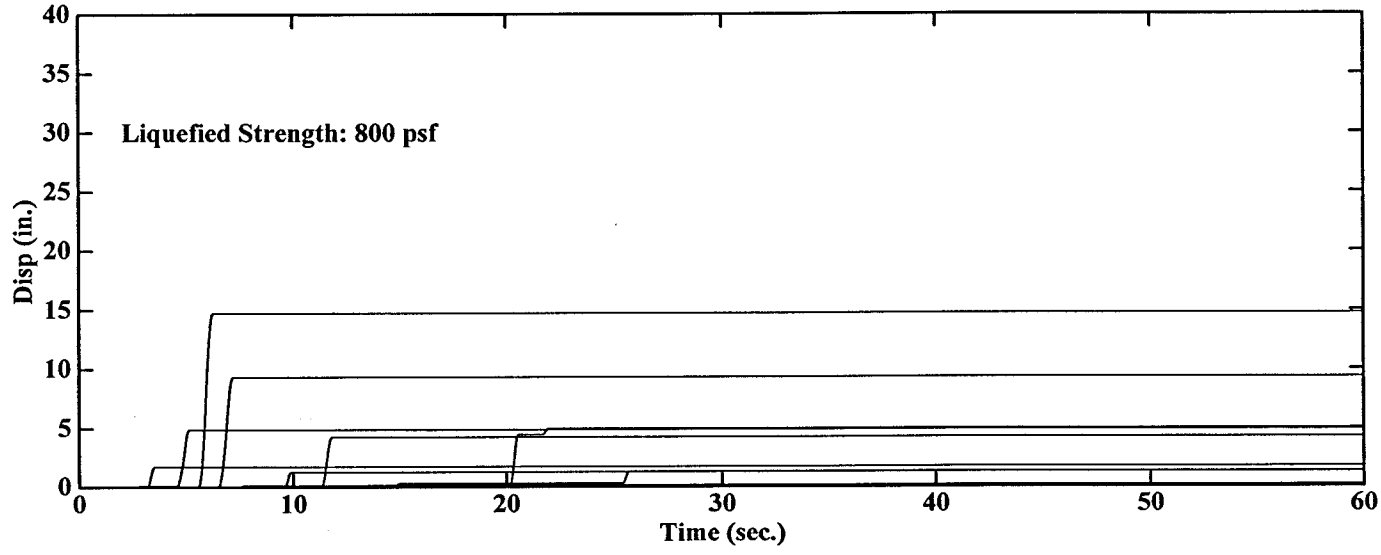

Liquefied Strength: 600 psf
Disp (in.)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
Time (sec.)


Liquefied Strength: 800 psf
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
Time (sec.)



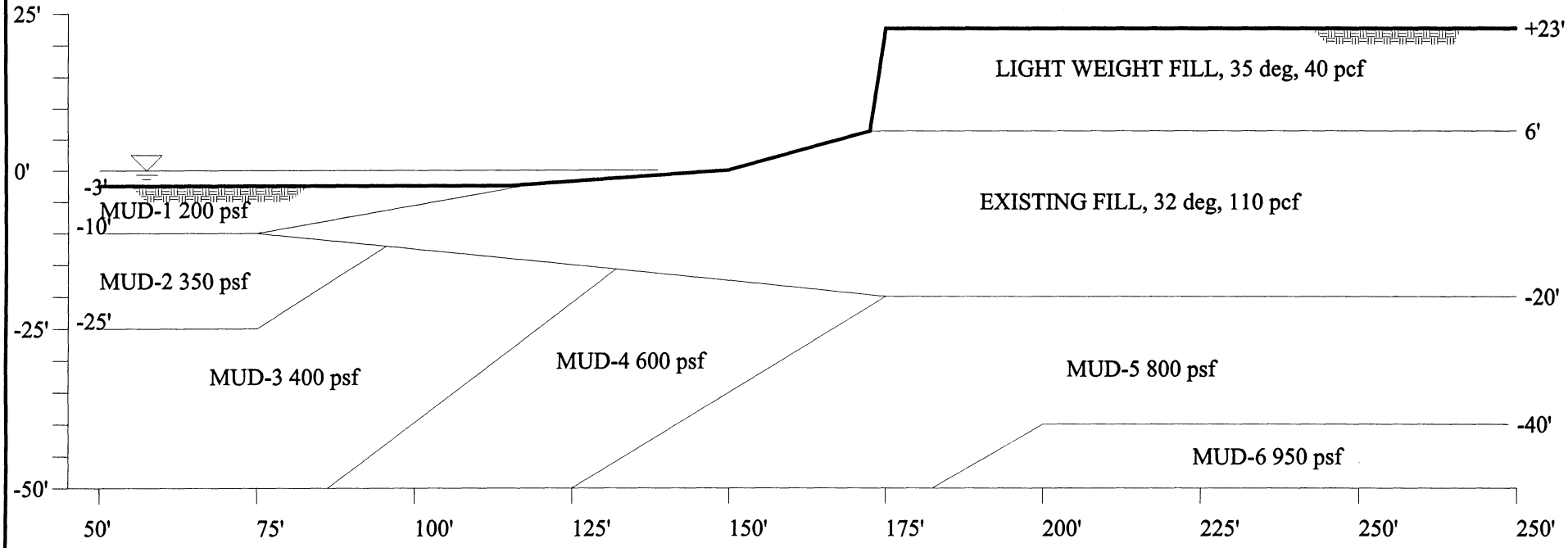
Liquefied Strength: 600 psf





APPENDIX C

Appendix C
Station 86+34
Proposed Light Weight Fill, γ_{fill} = 40 pcf (Grade at El. +23')



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

NEW S.F.- OAKLAND BAY BRIDGE

Project No. 98-107

Date: 6-10-98

IDEALIZED SOIL PROFILE AT OAKLAND SHORE APPROACH STA. 86+34

Figure

TABLE 1 Summary of Pseudo Static Analyses for YBM (w/ light weight fill at Sta. 86+34) 5/13/99

Block	Block Size, Measured from Shore	1.0*Su (1)		1.4*Su (2)		0.33*Su (3)		0.80*Su (4)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	2.08	0.16	2.56	0.23	1.28	0.04	1.84	0.13
Block 2	50'	2.36	0.16	2.95	0.23	1.37	0.04	2.07	0.13
Block 3	100'	2.87	0.155	3.7	0.23	1.49	0.04	1.84	0.13

Note:
(1) Using static shear strength
(2) Using dynamic shear strength, i.e., strain rate effects (increase shear strength by 40%)
(3) Using residual shear strength (reduce shear strength to 33%)
(4) Using residual shear strength (reduce shear strength to 80%)

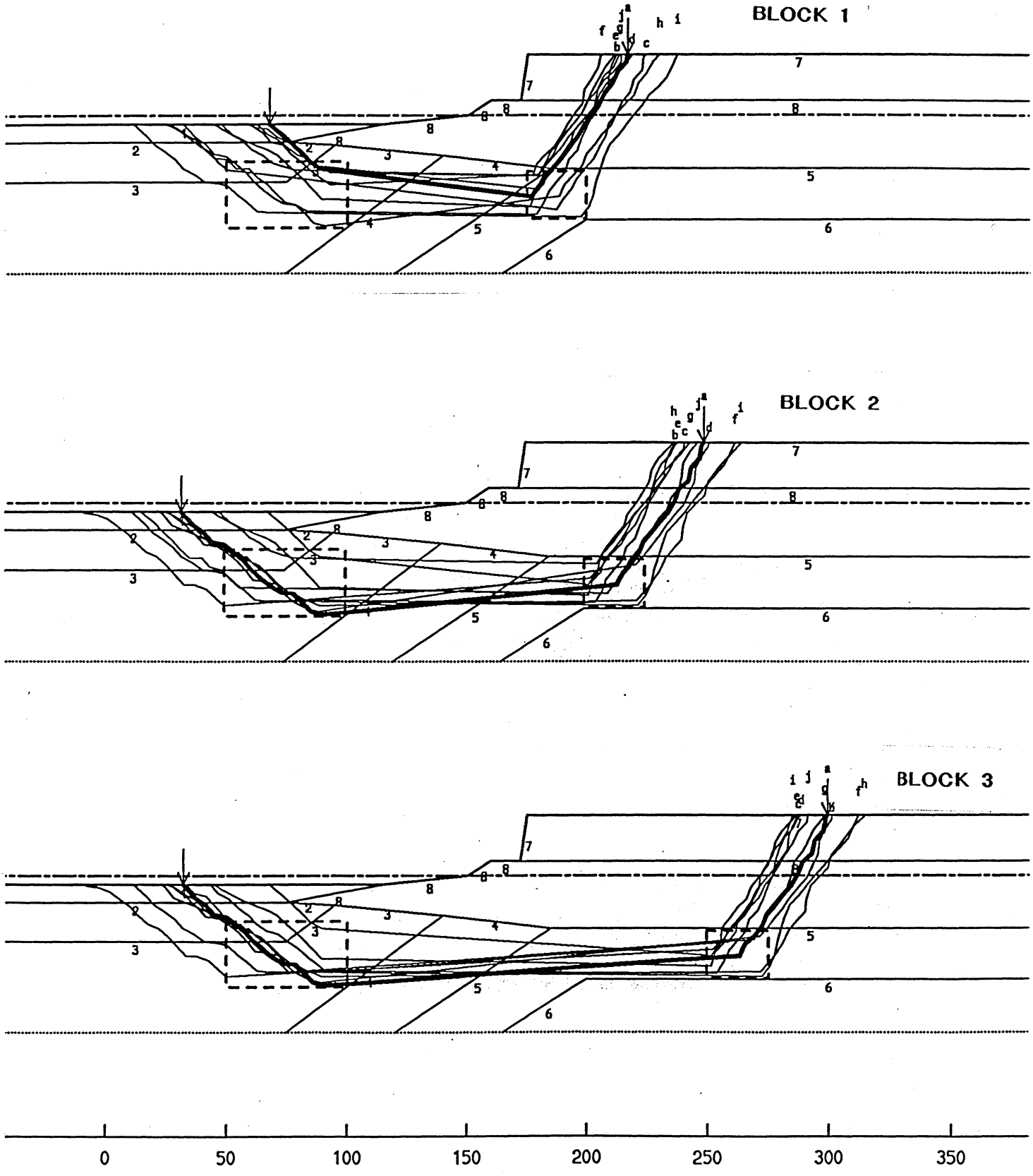
TABLE 2 Summary of Newmark Sliding Analyses for YBM (w/ light weight fill at Sta. 86+34)

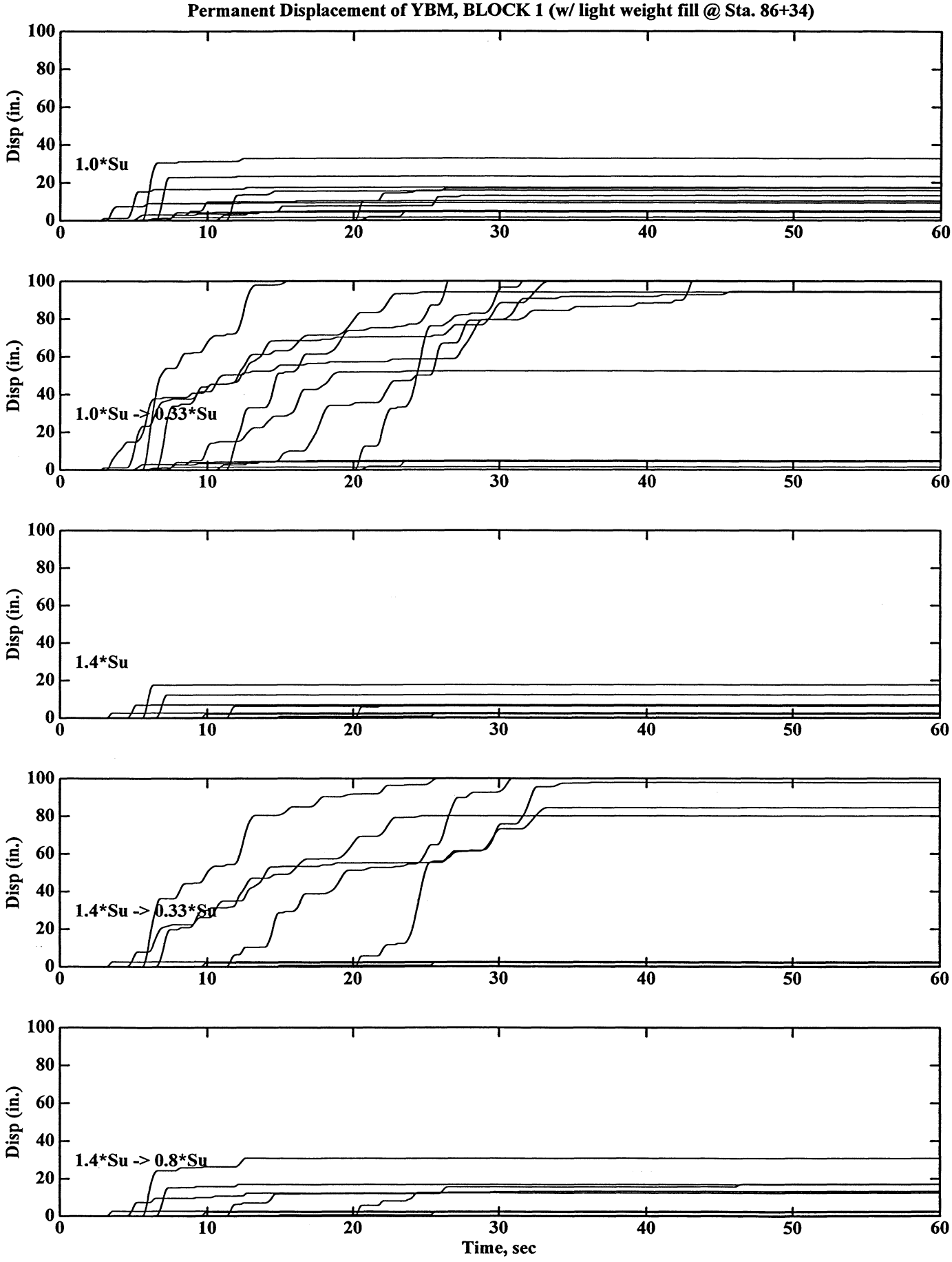
Ground Motion	Permanent Displacement, inches														
	Static Strength (1)			Static Followed By Residual (2)			Dynamic Strength (3)			Dynamic Followed By Residual (4)			Dynamic Followed By Residual (5)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	9	8	8	95	86	76	3	2	2	3	2	2	3	2	2
SET-1 (-)	17	16	15	100	92	83	7	6	5	85	77	5	12	11	5
SET-2 (+)	16	14	14	119	112	104	7	6	5	98	89	5	13	11	5
SET-2 (-)	5	4	4	5	4	4	0	0	0	0	0	0	0	0	0
SET-3 (+)	17	15	15	186	174	159	6	6	5	164	6	5	17	6	5
SET-3 (-)	13	11	11	149	137	125	3	2	2	3	2	2	3	2	2
SET-4 (+)	33	30	28	118	110	100	18	16	15	100	93	84	31	28	24
SET-4 (-)	2	1	1	2	1	1	0	0	0	0	0	0	0	0	0
SET-5 (+)	5	4	4	5	4	4	0	0	0	0	0	0	0	0	0
SET-5 (-)	10	9	8	52	47	42	2	2	1	2	2	1	2	2	1
SET-6 (+)	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0
SET-6 (-)	23	22	20	94	87	78	12	11	10	80	73	64	17	15	13
minimum	2	1	1	2	1	1	0	0	0	0	0	0	0	0	0
maximum	33	30	28	186	174	159	18	16	15	164	93	84	31	28	24
average	13	12	11	77	71	65	5	4	4	45	29	14	8	6	5

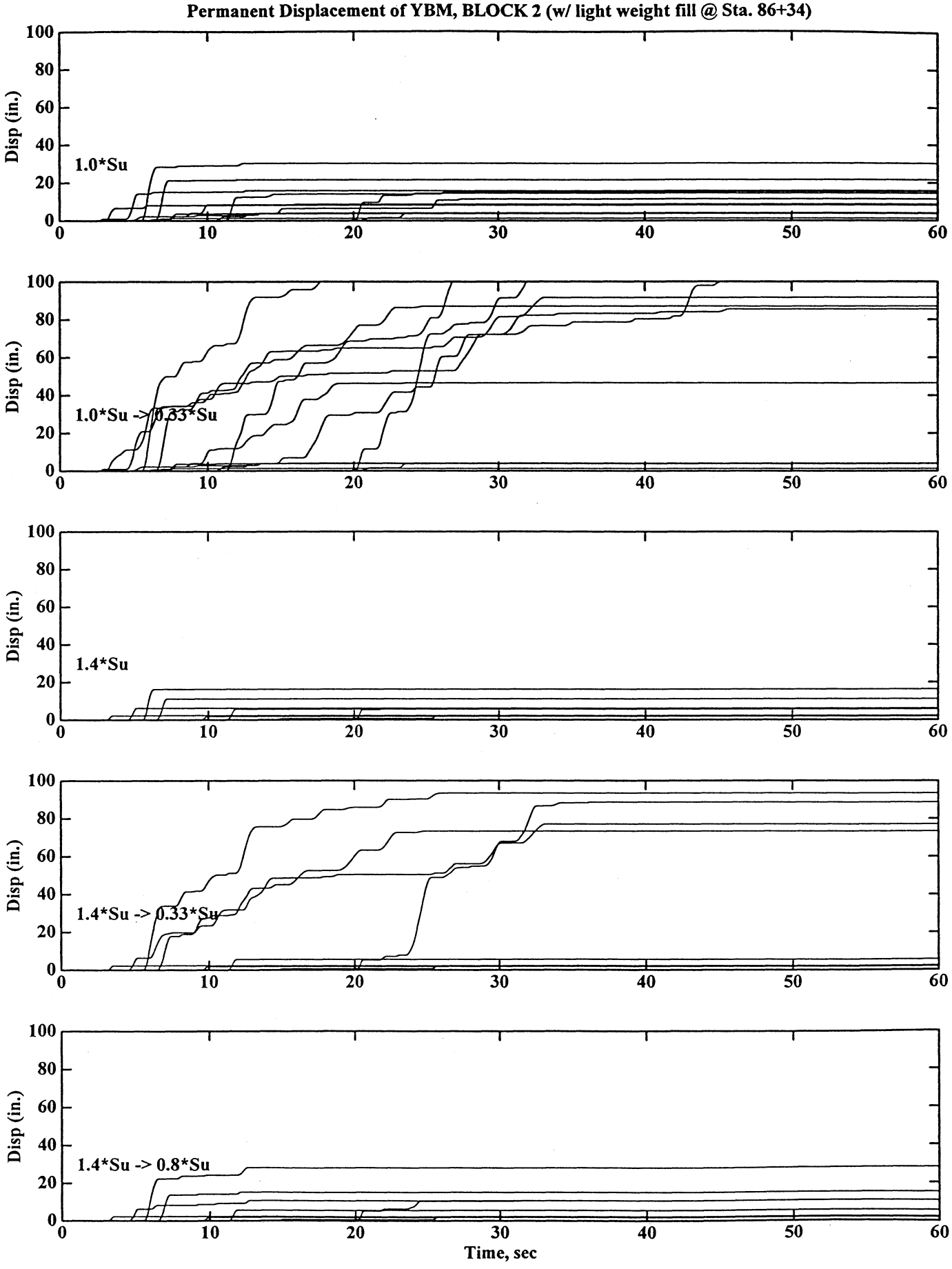
Note:
(1) Using constant static strength
(2) Using static strength followed by residual strength (0.33*Su) when deformation exceeds 6 inches
(3) Using dynamic strength
(4) Using dynamic strength followed by residual strength (0.33*Su) when deformation exceeds 6 inches
(5) Using dynamic strength followed by residual strength (0.80*Su) when deformation exceeds 6 inches

LIGHT WEIGHT FILL @ STA. 86-34

LATERAL SPREADING IN YBM




Permanent Displacement of YBM, BLOCK 1 (w/ light weight fill @ Sta. 86+34)
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
Time, sec
0
10
20
30
40
50
60
0
20
40
60
80
100


Permanent Displacement of YBM, BLOCK 2 (w/ light weight fill @ Sta. 86+34)
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
Time, sec
0
10
20
30
40
50
60
0
20
40
60
80
100

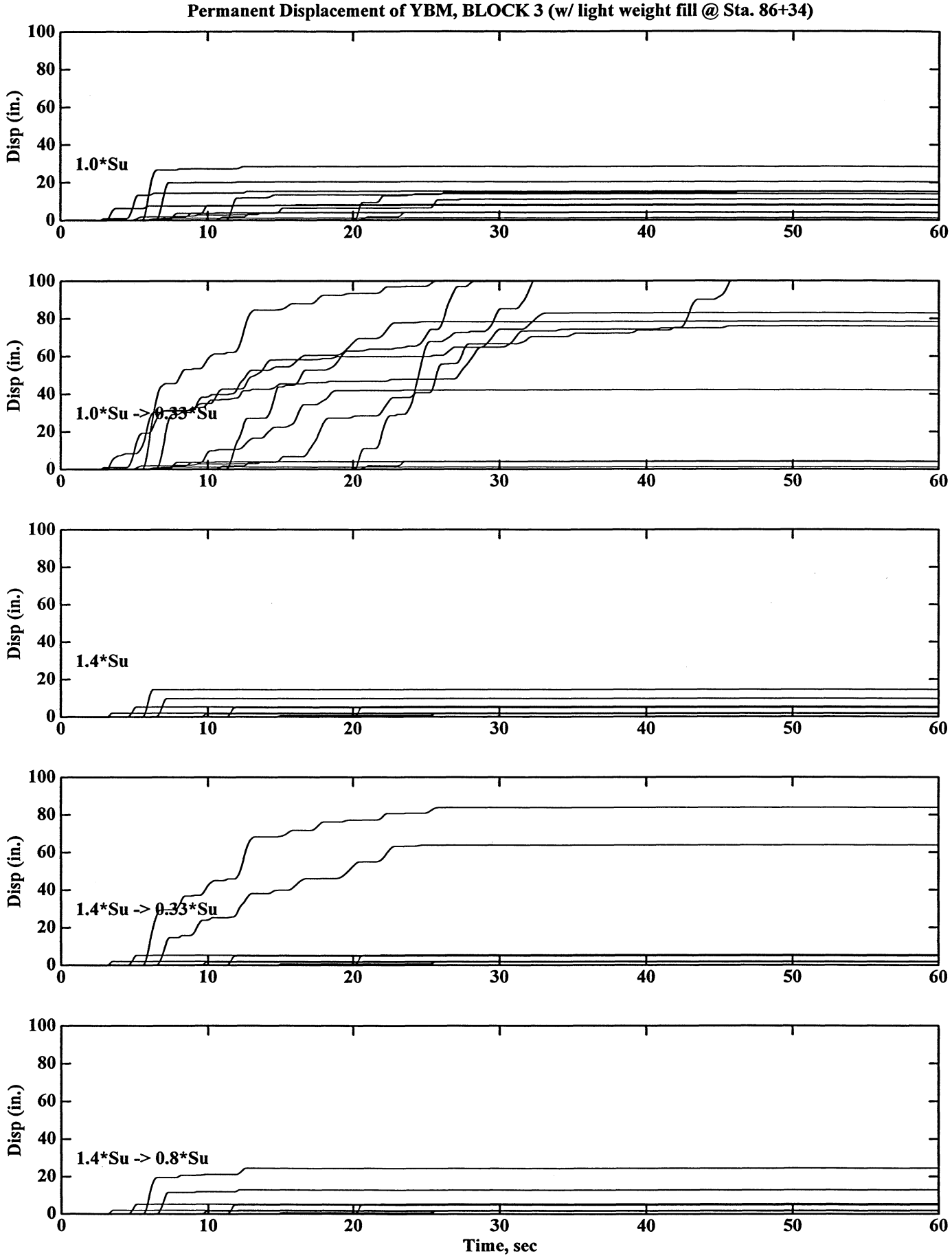

Permanent Displacement of YBM, BLOCK 3 (w/ light weight fill @ Sta. 86+34)
Disp (in.)
1.0*Su
1.0*Su -> 0.33*Su
1.4*Su
1.4*Su -> 0.33*Su
1.4*Su -> 0.8*Su
Time, sec
0
10
20
30
40
50
60
0
20
40
60
80
100

TABLE 3 Summary of Pseudo Static Analyses for FILL (w/ light weight fill at Sta. 86+34)

Block	Block Size, Measured from Shore	Drained Strength (1)		600 psf (2)		800 psf (3)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	4.17	0.45	2.34	0.25	2.92	0.32
Block 2	50'	5.11	0.45	2.78	0.23	3.5	0.3
Block 3	100'	6.78	0.41	3.6	0.22	4.6	0.28

Note:
(1) Using drained shear strength of sand
(2) Using residual shear strength of sand in fill below watertable (Su=600 psf)
(2) Using residual shear strength of sand in fill below watertable (Su=800 psf)

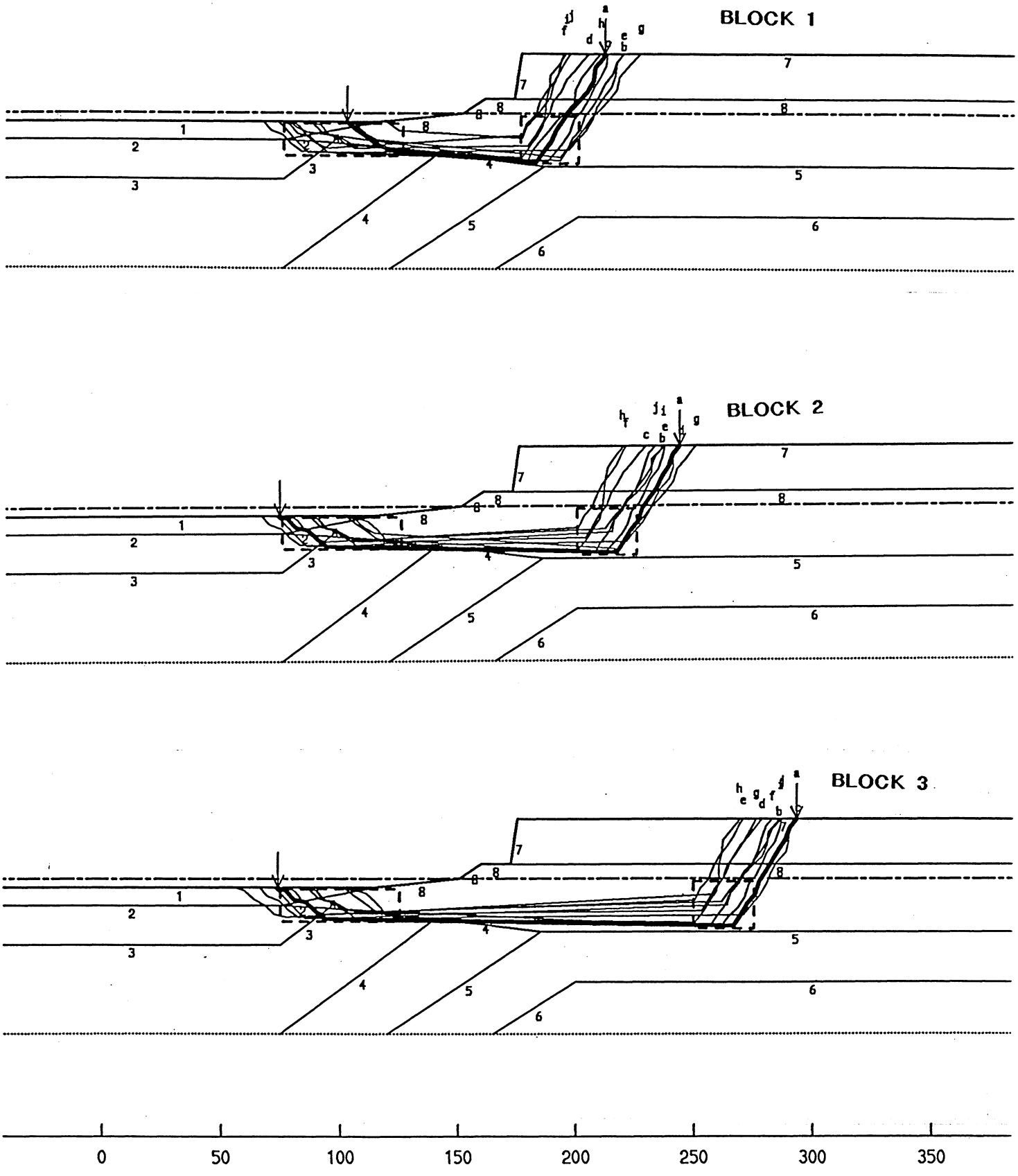
TABLE 4 Summary of Newmark Sliding Analyses for FILL (w/ light weight fill at Sta. 86+34)

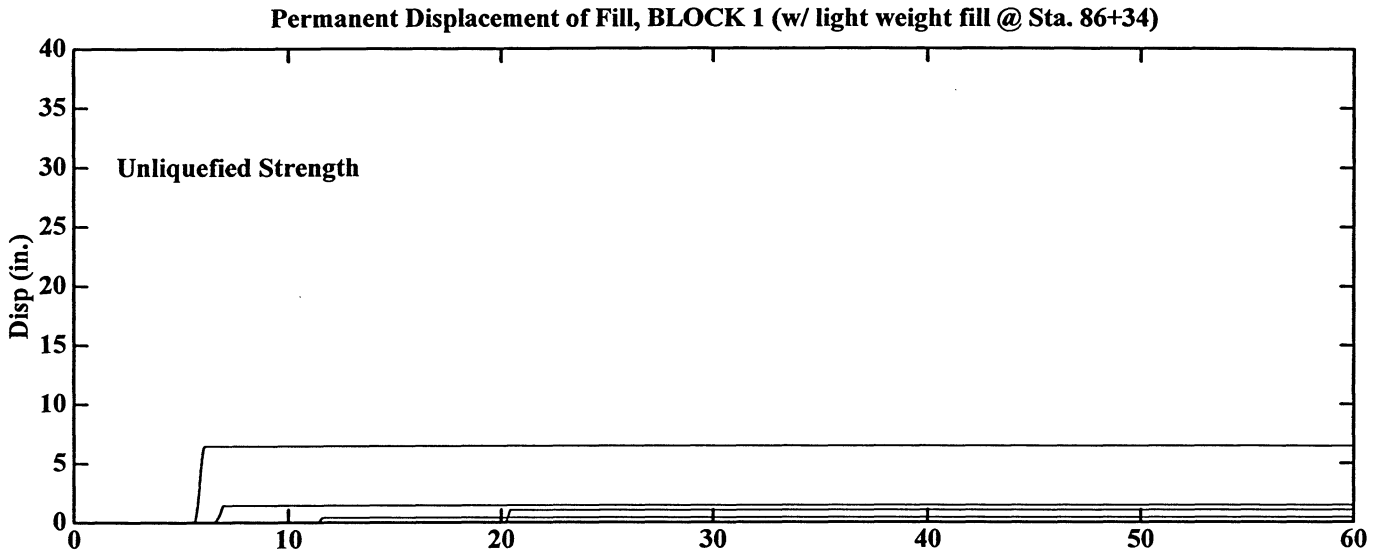
Ground Motion	Permanent Displacement, Inches								
	Drained Strength (1)			Residual Strength of 600 psf (2)			Residual Strength of 800 psf (3)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	0	0	0	5	6	5	2	2	2
SET-1 (-)	0	0	0	12	12	11	5	6	5
SET-2 (+)	1	1	1	11	11	10	5	5	5
SET-2 (-)	0	0	0	1	1	1	0	0	0
SET-3 (+)	0	0	0	10	10	9	5	5	4
SET-3 (-)	0	0	0	5	6	5	1	1	1
SET-4 (+)	6	5	5	27	27	23	17	16	15
SET-4 (-)	0	0	0	1	1	0	0	0	0
SET-5 (+)	0	0	0	1	2	1	0	0	0
SET-5 (-)	0	0	0	4	4	4	1	1	1
SET-6 (+)	0	0	0	0	1	1	0	0	0
SET-6 (-)	1	1	1	20	20	17	11	11	9
minimum	0	0	0	0	1	0	0	0	0
maximum	**6**	**5**	**5**	**27**	**27**	**23**	**17**	**16**	**15**
average	1	1	1	8	8	7	4	4	4

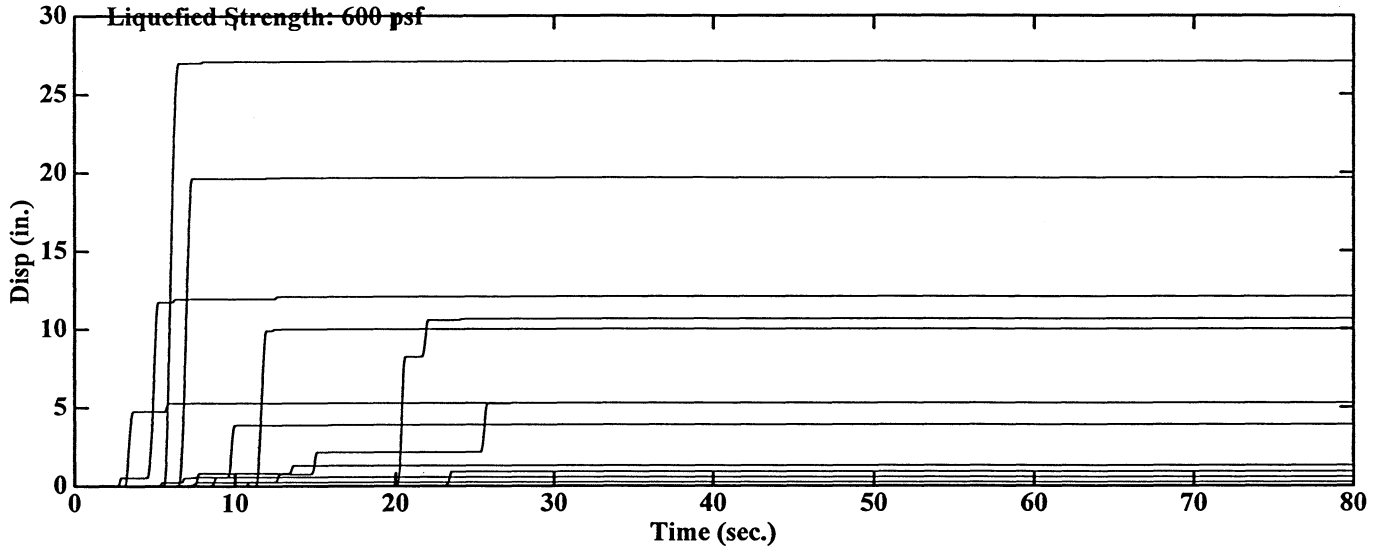
Note:
(1) Using constant drained shear strength of sand (unliquefied strength)
(2) Using constant residual shear strength of sand (liquefied strength of 600 psf)
(3) Using constant residual shear strength of sand (liquefied strength of 800 psf)

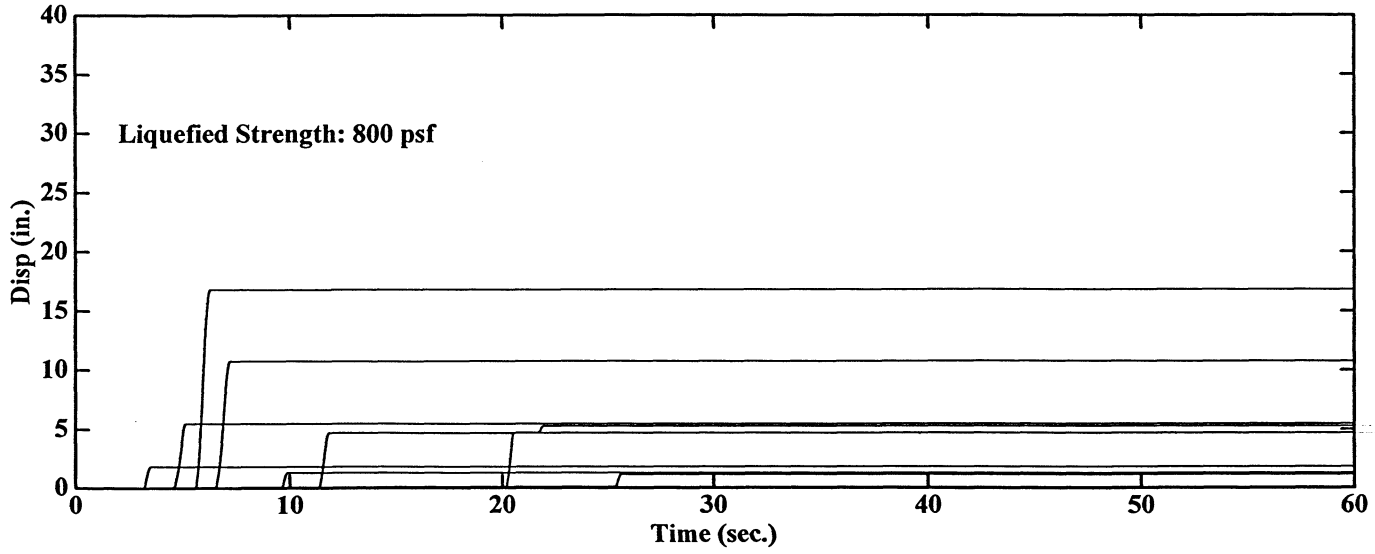
LIGHT WEIGHT FILL @ STA. 86-34

LATERAL SPREADING IN FILL

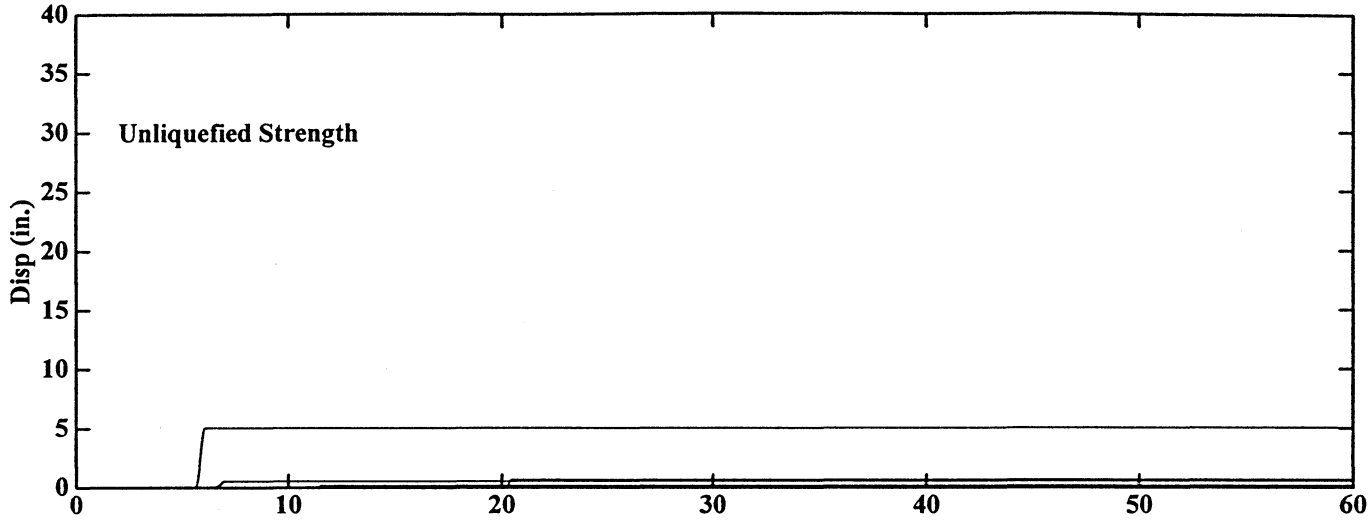


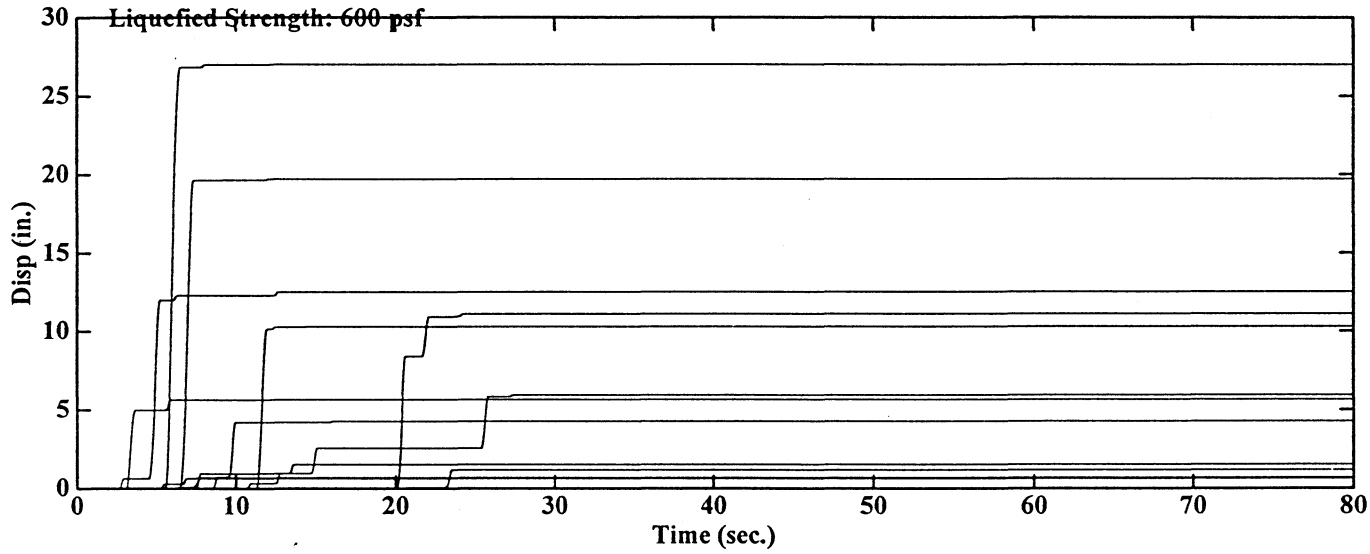

Permanent Displacement of Fill, BLOCK 1 (w/ light weight fill @ Sta. 86+34)
Unliquefied Strength
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60

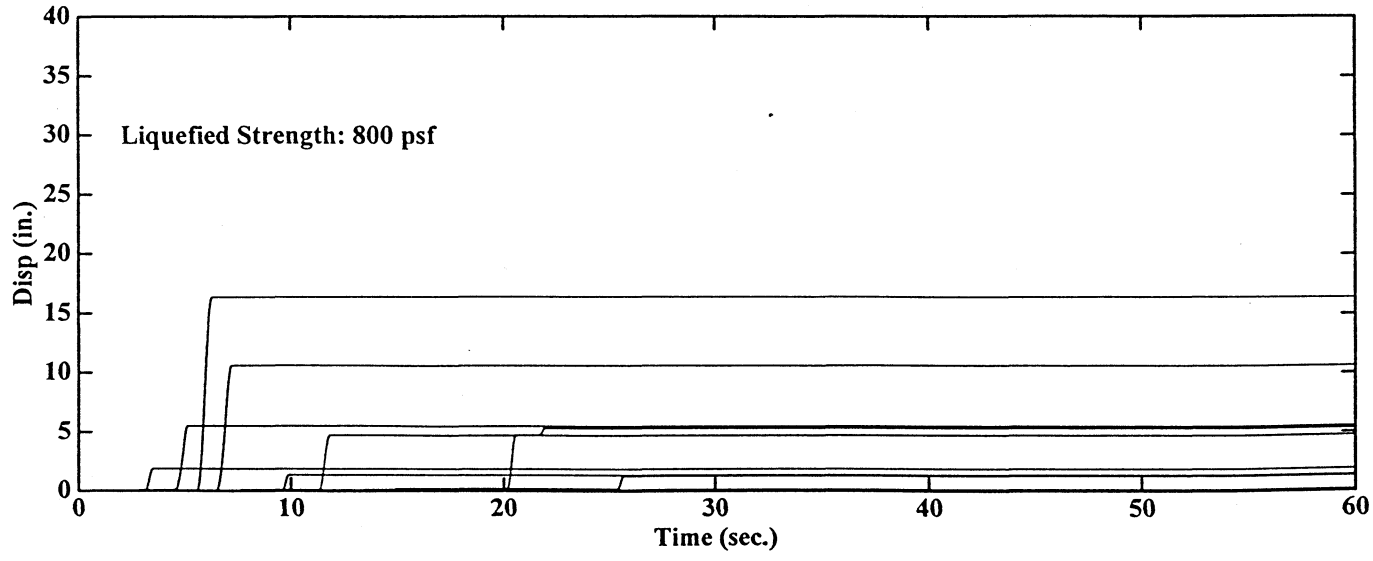

Liquefied Strength: 600 psf
Disp (in.)
0
5
10
15
20
25
30
0
10
20
30
40
50
60
70
80
Time (sec.)

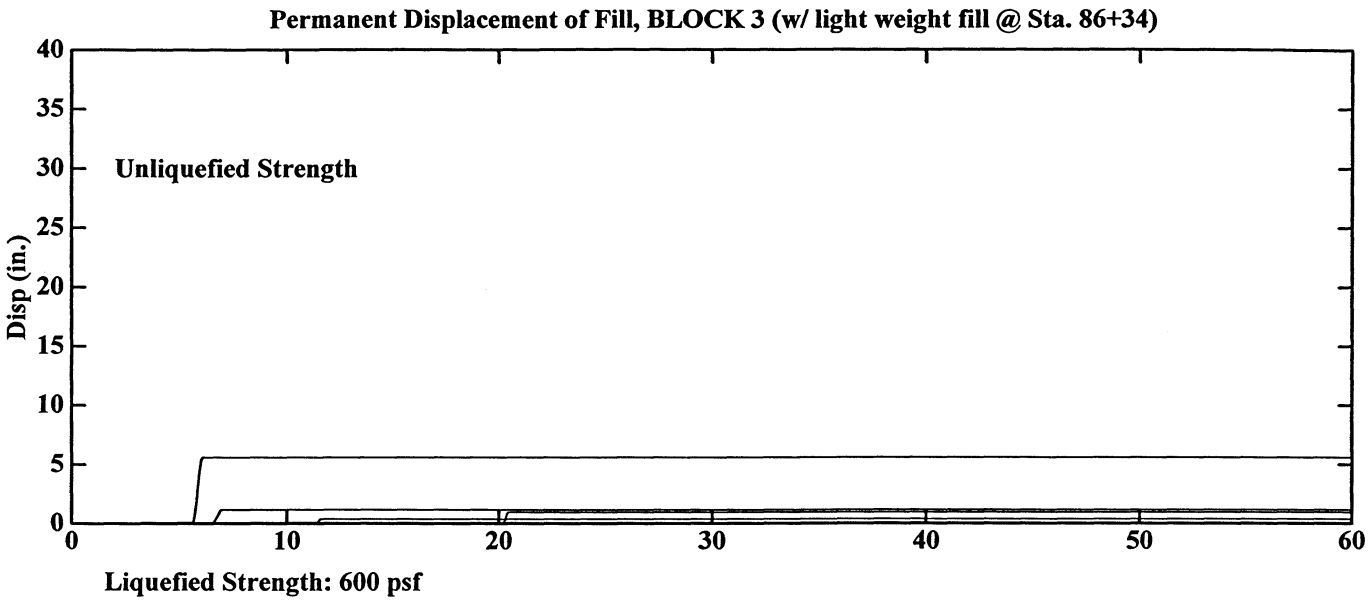

Liquefied Strength: 800 psf
Disp (in.)
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
Time (sec.)

Permanent Displacement of Fill, BLOCK 2 (w/ light weight fill @ Sta. 86+34)

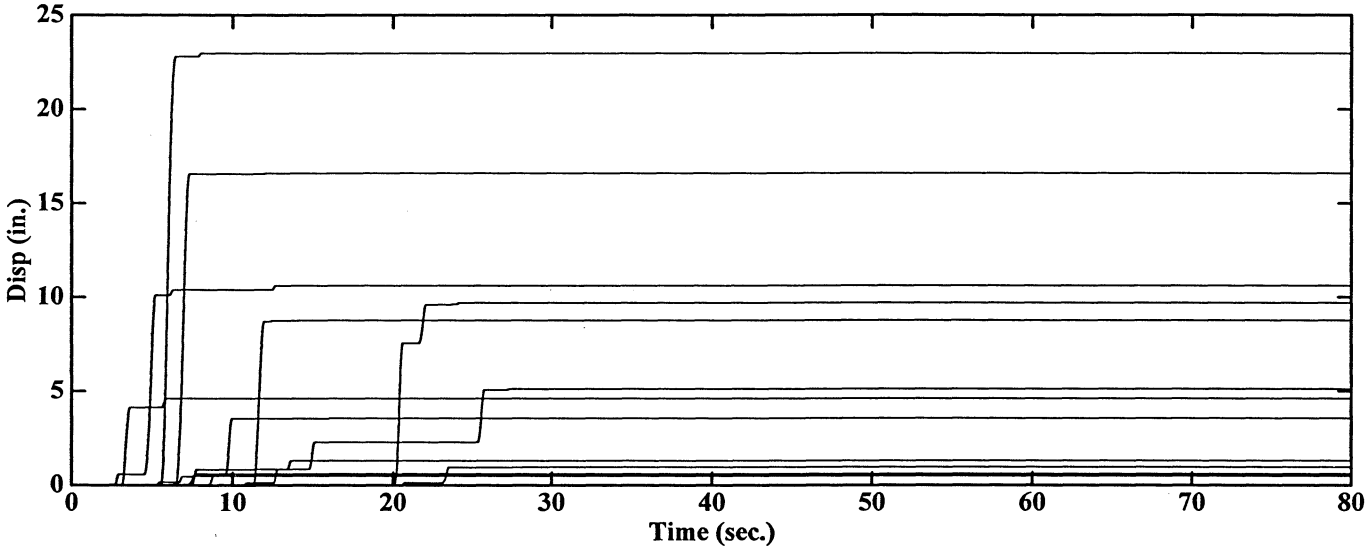


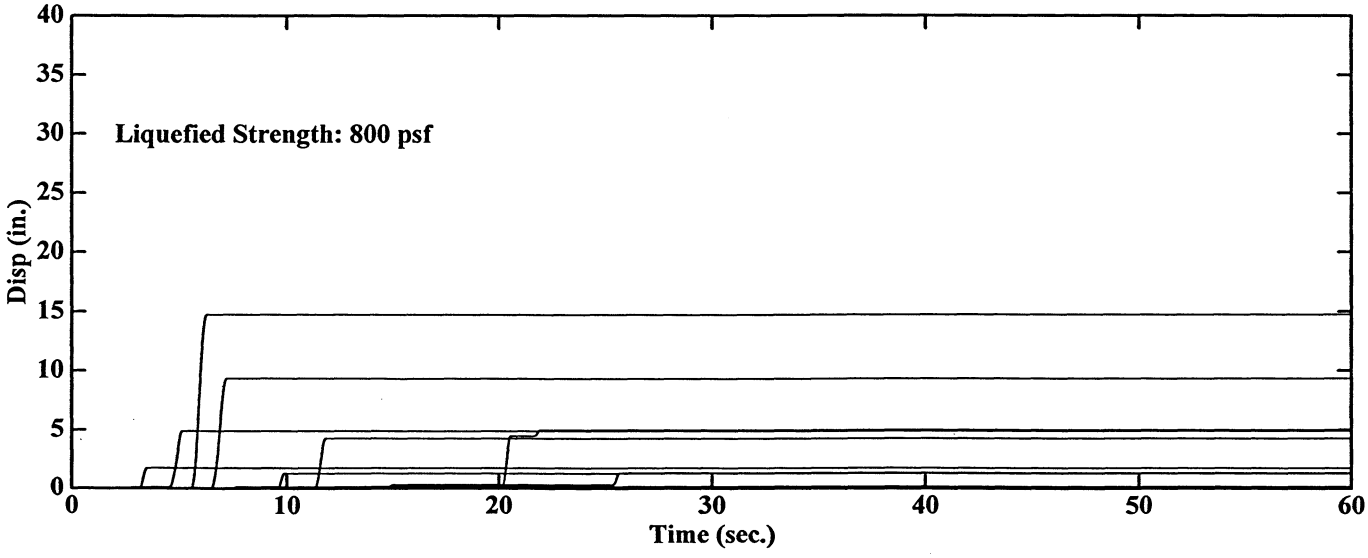






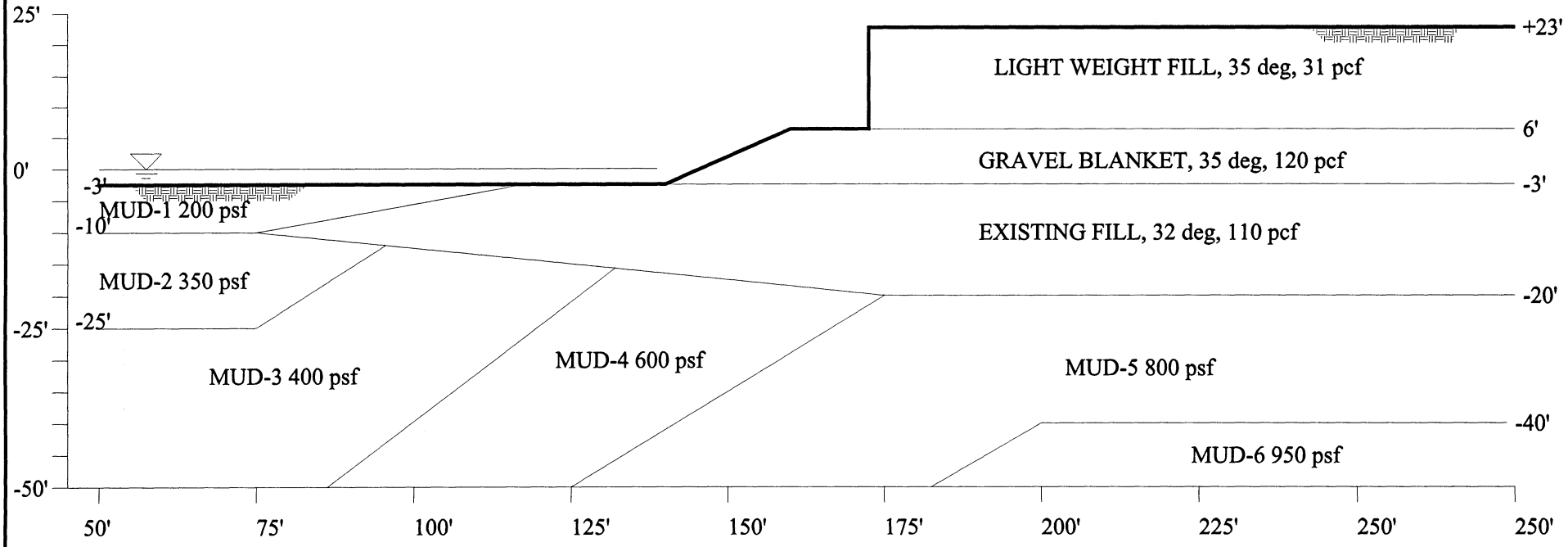
Liquefied Strength: 600 psf





APPENDIX D

Appendix D
Station 86+34
Proposed Light Weight Fill, γ_{fill} = 31 pcf (Grade at El. +23')



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

NEW S.F.- OAKLAND BAY BRIDGE

Project No. 98-107 | Date: 6-10-98

IDEALIZED SOIL PROFILE AT OAKLAND SHORE APPROACH STA. 86+34

Figure

TABLE 3 Summary of Pseudo Static Analyses for FILL (w/ light weight fill at Sta. 86+34)

Block	Block Size, Measured from Shore	Drained Strength (1)		600 psf (2)		800 psf (3)		1000 psf (4)	
		Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g	Static F.S.	Yield Acc., g
Block 1	25'	3.54	0.49	2.35	0.26	2.75	0.34	3.15	0.41
Block 2	50'	4.28	0.46	2.75	0.25	3.26	0.32	3.76	0.39
Block 3	100'	5.95	0.45	3.5	0.23	4.29	0.31	5.07	0.38

Note:
(1) Using drained shear strength of sand
(2) Using residual shear strength of sand in fill below watertable (Su=600 psf)
(3) Using residual shear strength of sand in fill below watertable (Su=800 psf)
(4) Using residual shear strength of sand in fill below watertable (Su=1000 psf)

TABLE 4 Summary of Newmark Sliding Analyses for FILL (w/ light weight fill with gravel blanket at Sta. 86+34)

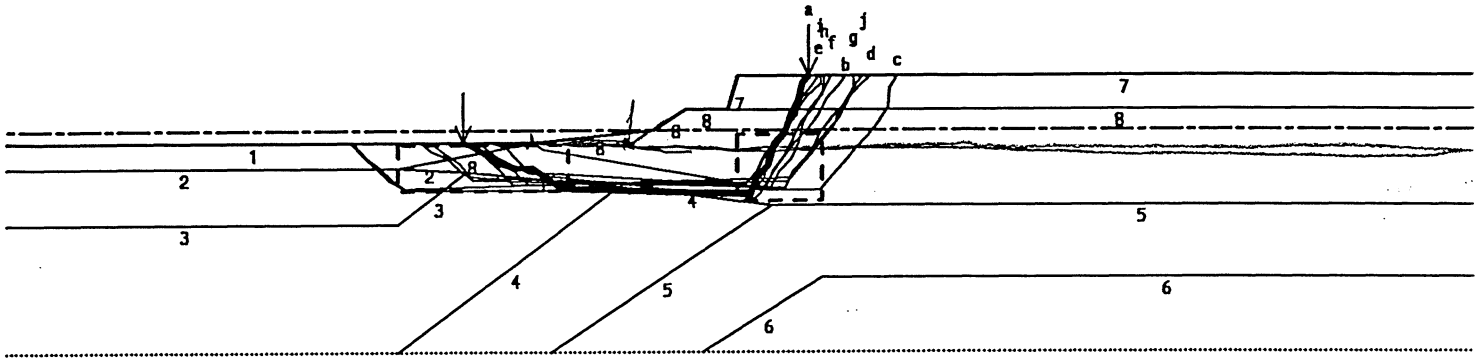
Ground Motion	Permanent Displacement, inches											
	Drained Strength (1)			Residual Strength of 600 psf (2)			Residual Strength of 800 psf (3)			Residual Strength of 1000 psf (4)		
	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3	Block 1	Block 2	Block 3
SET-1 (+)	0	0	0	5	4	4	1	1	1	0	0	0
SET-1 (-)	0	0	0	11	10	9	4	4	3	1	1	0
SET-2 (+)	0	1	0	10	9	9	4	4	3	2	2	1
SET-2 (-)	0	0	0	1	1	1	0	0	0	0	0	0
SET-3 (+)	0	0	0	9	8	8	4	4	3	1	1	1
SET-3 (-)	0	0	0	4	4	4	1	1	1	0	0	0
SET-4 (+)	4	5	3	25	23	21	15	14	12	9	9	7
SET-4 (-)	0	0	0	0	0	0	0	0	0	0	0	0
SET-5 (+)	0	0	0	1	1	1	0	0	0	0	0	0
SET-5 (-)	0	0	0	3	3	3	1	1	1	0	0	0
SET-6 (+)	0	0	0	0	0	0	0	0	0	0	0	0
SET-6 (-)	0	0	0	18	17	15	9	9	7	3	3	2
minimum	0	0	0	0	0	0	0	0	0	0	0	0
maximum	4	5	3	25	23	21	15	14	12	9	9	7
average	0	0	0	7	7	6	3	3	2	1	1	1

Note:
(1) Using constant drained shear strength of sand (unliquefied strength)
(2) Using constant residual shear strength of sand (liquefied strength of 600 psf)
(3) Using constant residual shear strength of sand (liquefied strength of 800 psf)
(4) Using constant residual shear strength of sand (liquefied strength of 1000 psf)

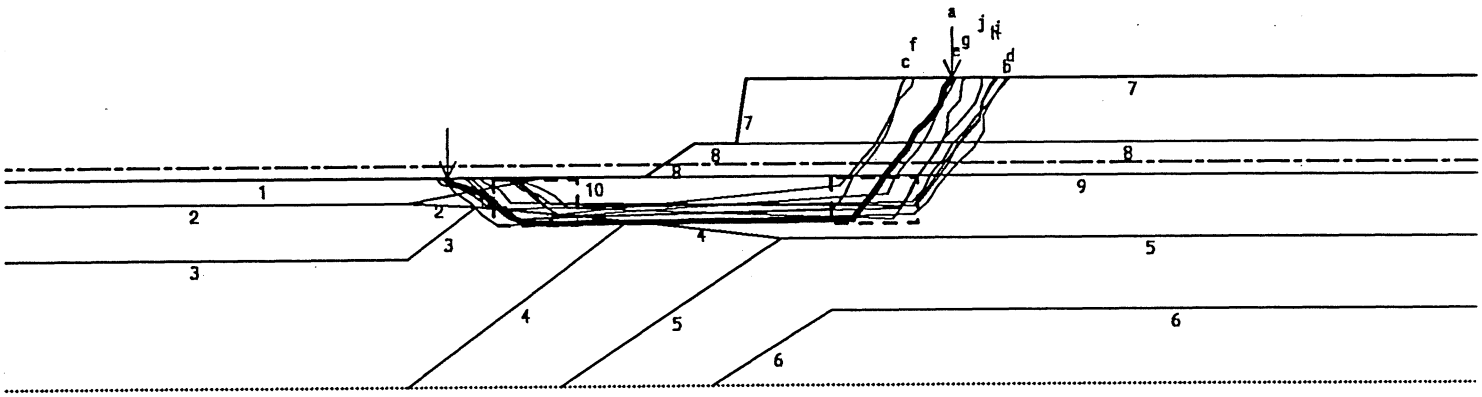
LATERAL SPREADING IN FILL @ STA 86-34

LIGHT WEIGHT FILL WITH GRAVEL BLANKET

BLOCK 1



BLOCK 2



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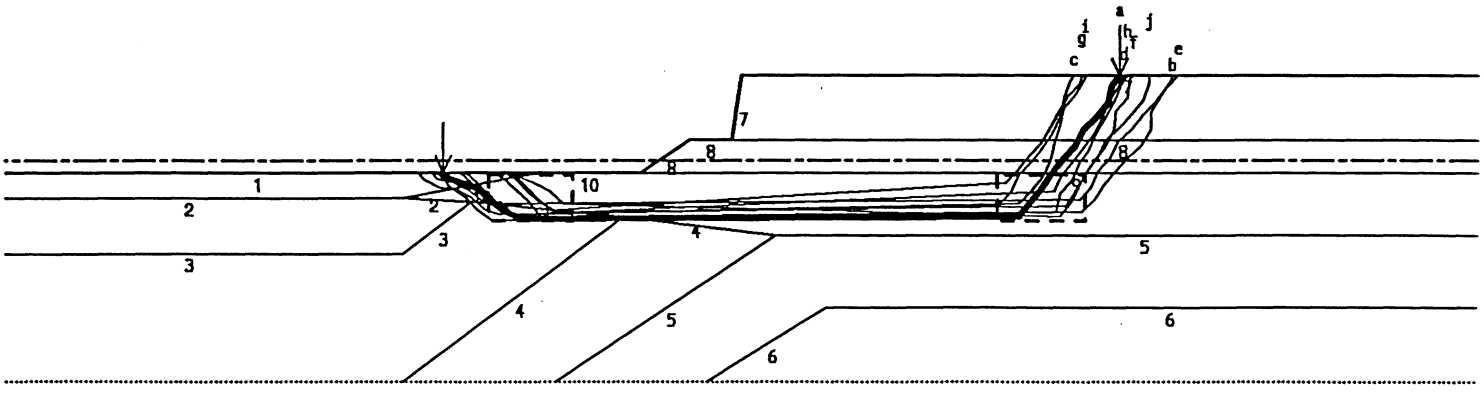
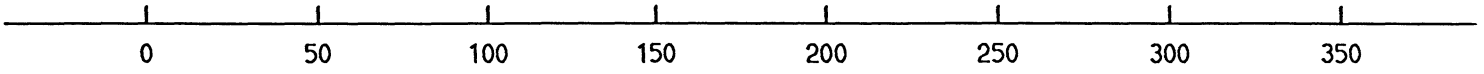
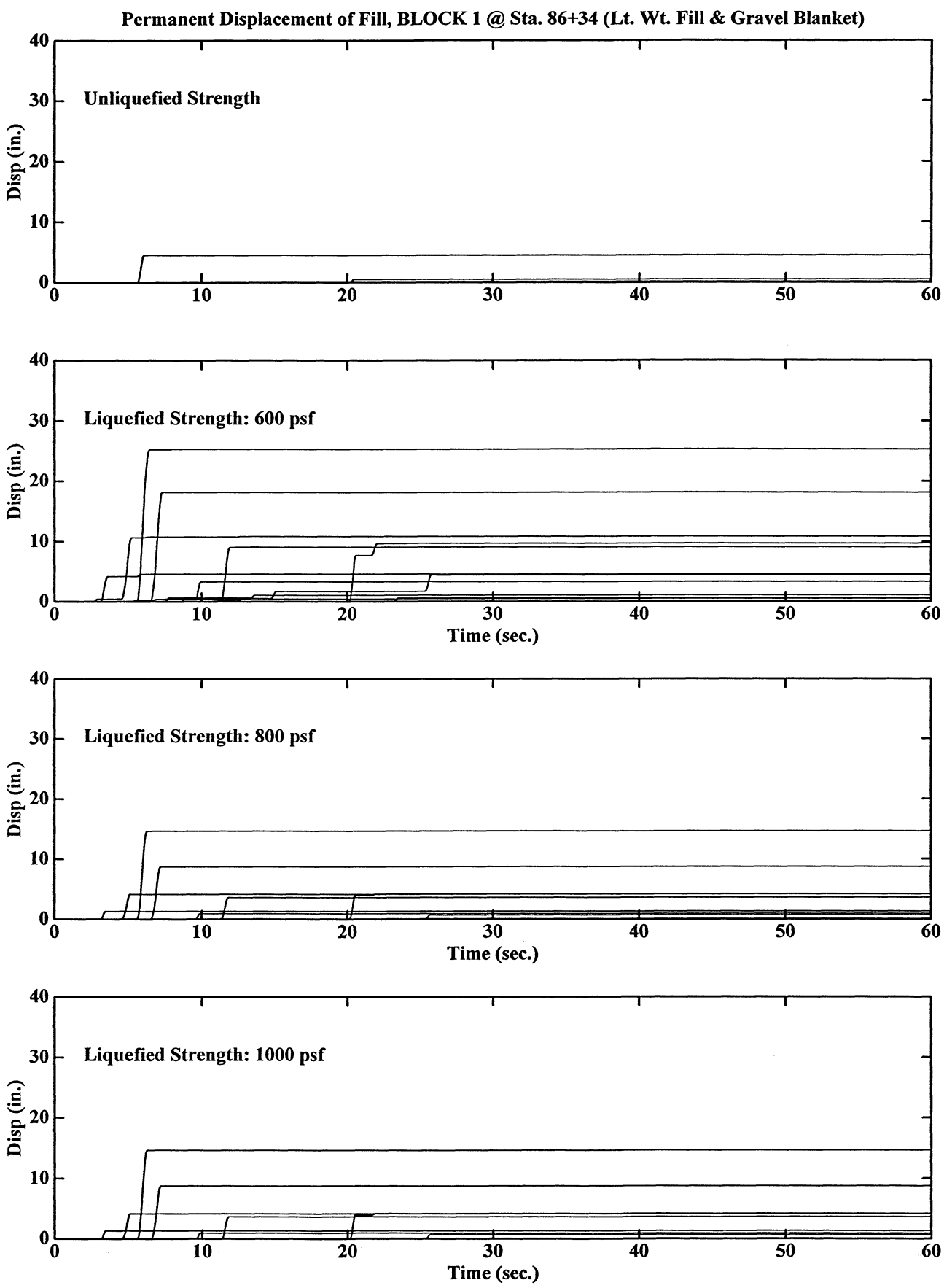
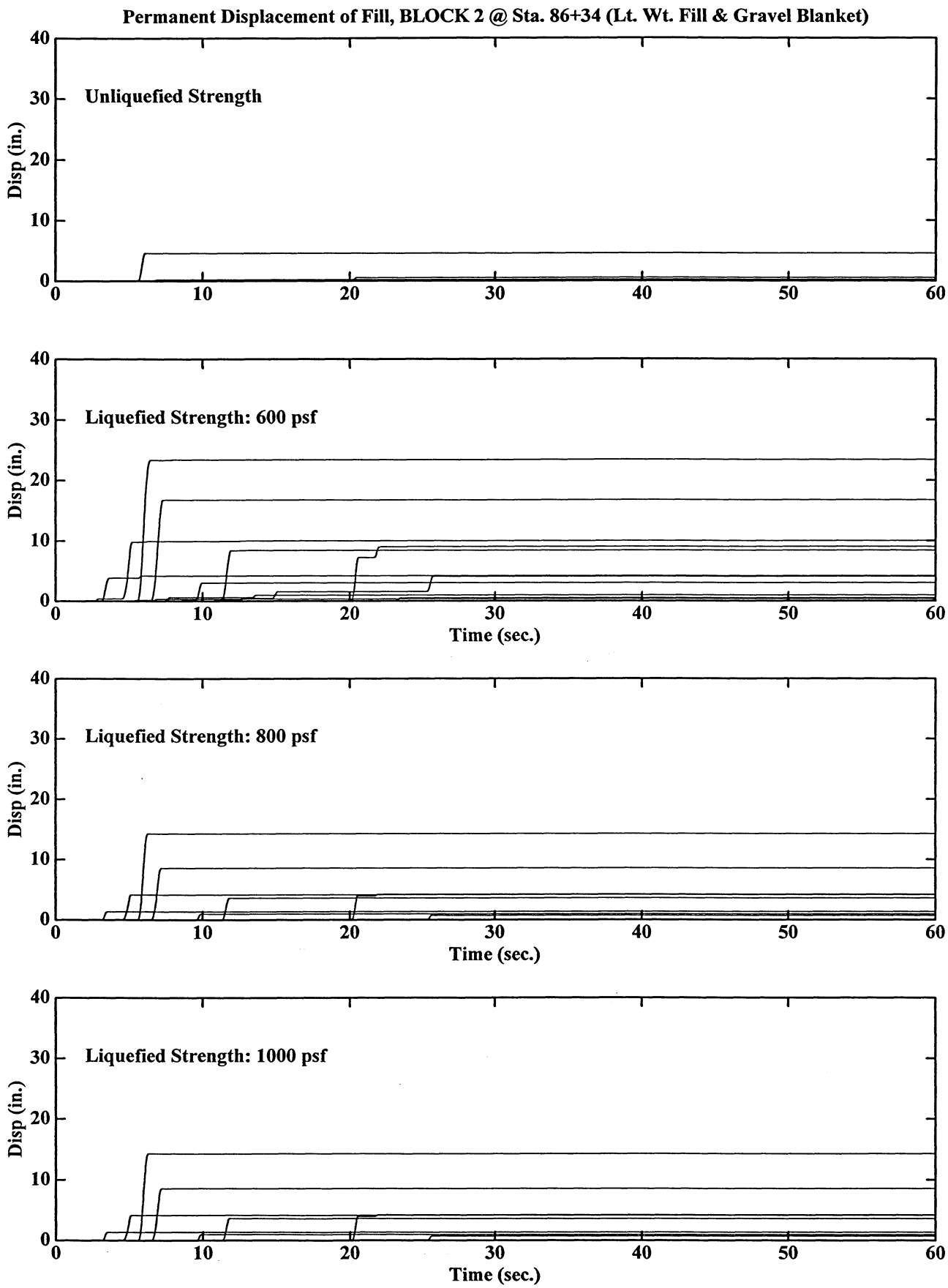
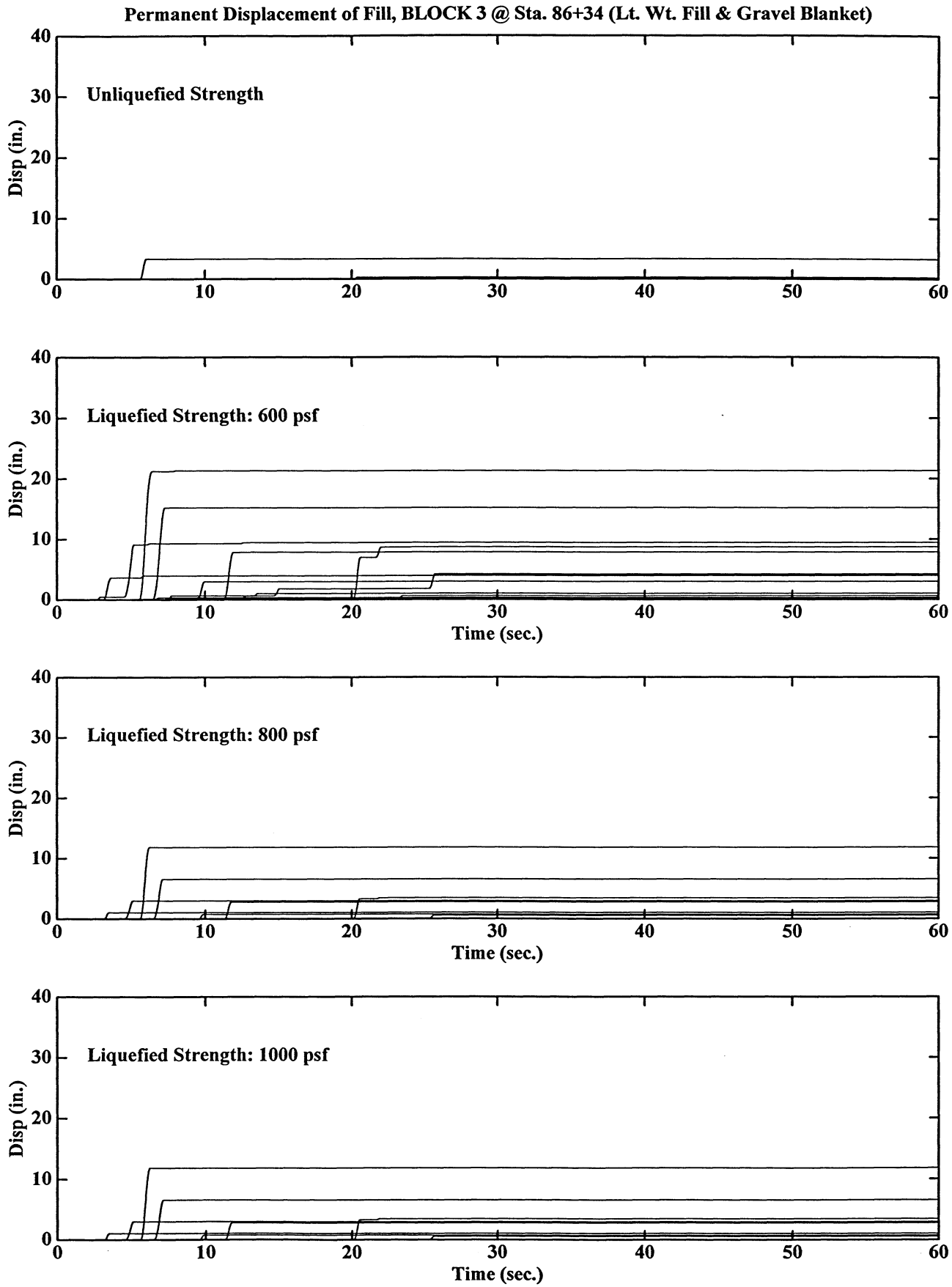





Permanent Displacement of Fill, BLOCK 1 @ Sta. 86+34 (Lt. Wt. Fill & Gravel Blanket)
Unliquefied Strength
Liquefied Strength: 600 psf
Liquefied Strength: 800 psf
Liquefied Strength: 1000 psf
Disp (in.)
Time (sec.)
0
10
20
30
40
50
60


Permanent Displacement of Fill, BLOCK 2 @ Sta. 86+34 (Lt. Wt. Fill & Gravel Blanket)
Unliquefied Strength
Liquefied Strength: 600 psf
Liquefied Strength: 800 psf
Liquefied Strength: 1000 psf
Disp (in.)
Time (sec.)
0
10
20
30
40
50
60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Unliquefied Strength
Liquefied Strength: 600 psf
Liquefied Strength: 800 psf
Liquefied Strength: 1000 psf
Disp (in.)
Time (sec.)
0
10
20
30
40
50
60

PROJECT MEMORANDUM
(APRIL 15, 1999)

PROJECT MEMORANDUM
FINDINGS FROM TRENCH AND PIT EXCAVATIONS ON OAKLAND MOLE (UPDATED)

April 15, 1999

Caltrans ESC, OSF
5900 Folsom Blvd, P.O. Box 19128
Sacramento, CA 95819-0128

To: Mr. Mark Willian, Contract Manager

From: Mike Kapuskar/EMI; Saverio Siciliano/EMI

Subject: Findings from Trench and Pit Excavations on Oakland Mole (updated)
SFOBB East Span Seismic Safety Project

Dear Mr. Willian:

On April 8 and 9, 1999, EMI performed two trench excavations on the Oakland Mole for the purpose of visual inspection and verification of the location, extent and composition of the pre-1950 rock dike presently buried beneath the existing northern slopes. This investigation was done as an extension of the work already performed for the Oakland Mole for this project. The existence, location and condition of the rock dike affects the design and construction of the proposed new SFOBB east approach structures or fills.

In addition, two pits were excavated per Caltrans' request in the beach areas at the north slopes. The purpose of these pits was to verify maximum unshored excavation depths and to determine whether removal of the (potentially liquefiable) beach sands was a feasible option.

This memorandum describes this investigation and presents our current findings. This information will be included in the Draft Site Characterization Report for the Oakland Mole. If you have any questions, please contact Mike Kapuskar or Saverio Siciliano, Earth Mechanics, Inc. (EMI), at (510) 633-5100 or (714) 751-3826.

1.0 TRENCH EXCAVATIONS

1.1 Description of Excavations

The locations of the trenches are shown on the attached plan. The locations were approximately in line with the visible northern slopes to the west and the east of the jughandles, reflecting the presumed location of a buried rock dike placed during the construction of part of the fill during the 1930's.

Trench 99T-1 was excavated on the western jughandle, at the north edge of pavement of the existing Caltrans maintenance road. Trench 99T-2 was cut inside the area circumscribed by the Caltrans road (the eastern jughandle), the site of presently proposed Abutment E30W. Both trenches were oriented in a north-south trend. The trenches were cut using a track-mounted excavator (Hyundai 290LC) with a 14.2-m (46.7 ft) reach and a 0.6-m (2-ft) wide bucket. This rig was selected to cut pits in the adjacent beach areas between the jughandles (see Section 2.0). The materials excavated were temporarily stockpiled on plastic sheeting to prevent cross-contamination of underlying soils.

The trenches were backfilled with the on-site soil and rock materials in lifts and compacted by tapping using the excavator bucket. Compaction led to some loss in total volume due to the loose consistency of original on-site soils, which was compensated for using soil borrowed from areas adjacent to the trench. At completion of the work, the original ground conditions was restored as well as possible.

To-scale trench cross sections are attached showing the approximate configuration of the cuts and the subsurface materials encountered.

1.2 Observations Trench 99T-1 on Western Jughandle

This trench was excavated in the morning of April 9 under fair weather conditions. The present ground surface at this location is at El. +3.0 m (+10 ft). Surficial material removed from above the rock dike was post-1950's debris material consisting of some moist soil with silt, gravel and cobbles, clay, brick, glass (bottles and light bulbs), wood. Other debris included demolition debris such as broken concrete, concrete reinforcement, metal wire and steel cable, a 0.9-m (3-ft) segment of metal sheet piling (probably from original key construction), a 1.5 cm (5-ft) segment of 460-mm (18") diameter pipe, and rubber floormats.

Rip-rap about 0.6 to 1.2-m (2 to 4-ft) in dimension was encountered at about 1.5 to 1.7 (5 to 5½ ft) depth below the ground surface at the south end of the trench. Individual pieces of rip-rap were removed and are shown on the photos.

The crest of the northern rock slope face was found at about 3 m (10 ft) north of the existing edge of pavement, and the slope had a gradient of approximately 1.4H:1V. Excavation proceeded down the rock face and resulted in substantial extension of the trench towards the north. The rock dike materials encountered consisted of many 300 to 600 mm (12" to 24") and fewer smaller rock pieces (see attached photos) to at least 2.6 m (8.5 ft) depth. Groundwater was encountered at this depth which matched the tide level El. of about +0.27 m (+0.9 ft) at the time of this excavation. Shoring was then installed to this depth. Further attempts to excavate below this depth resulted in substantial progressive caving in the trench segment adjacent to the shoring plates, increasing the trench width from 0.6 to 2.9 m (2 to 9.5 ft), and excavation was discontinued.

The trench was partially backfilled and then cut back to the south along the top of the dike in an attempt to locate the south face of the dike. Several large rock rip-rap boulders were exposed at 1.5 to 1.7 m (5' to 5'-6") depth. A buried utility pipe was encountered at a depth of 0.76 m (30") below ground running 1.1 m (3'-6") parallel to the edge of pavement of the Caltrans road. Manual excavation proceeded carefully below the pipe to expose more of the rip-rap boulders at the same elevation. One large 1.2-m (4-ft) boulder was removed from the top of dike. The underlying rock predominantly consisted of 300 to 600 mm (12" to 24") cobbles with fewer smaller-size cobble fragments and pebbles. The attached photos show the sizes encountered.

1.3 Observations in Trench 99T-2 on Eastern Jughandle

This trench was cut in the morning of April 8 down to a depth of about 3.65 m (12 ft). Weather conditions were light to moderate rain, few minutes of hail, and icy winds, following three prior days of moderate to heavy rain. The present ground surface elevation at this location varies from +3.1 to 3.7 m. The total length of the trench was 12 m, spanning most of the ground inside the road turn-around loop.

The soils excavated above the rock dike consisted of moist silty sand material with small to pebble-size gravel. The top of the buried dike was encountered at the south side of the trench merely 0.7 m (28") depth below existing ground. The northern crest of this dike was found at 9.1 m (30 ft) north of the edge of pavement. The slope had a gradient of approximately 1.4H:1V. The surface of the dike consisted of cobbles 300 to 600 mm (12" to 24") in size and smaller pebble-size gravel pieces.

The north face of the buried dike was exposed and individual cobbles removed. The trench was extended towards the north as the excavation proceeded down the dike's face. At about 12-ft depth below existing grade, groundwater was encountered, which was about 0.5 m (1'-7") depth below the adjacent tide level El. of about +0 m MSL at the time of the excavation. At this depth, sand mixed with some blue-olive green mud was encountered and the excavator's bucket did not find any more rock, indicating the base of buried rock (at least at the north side) was reached at about 3.65 m (12 ft) depth. The trench width increased from 0.6 m to more than 3 m wide due to progressive caving of saturated soils at the bottom of the west and east trench walls and deeper excavation was discontinued.

To locate the back side of the dike, the excavation was then progressively cut back to the south along the top of the dike and was stopped at a buried electrical utility pipe running about 0.9 m (3 ft) parallel to the edge of pavement of the Caltrans road. The surficial dike material was the same as that found along the north face.

2.0 PIT EXCAVATIONS

2.1 Description of Excavations

Per Caltrans request, two pits were excavated in the tidal flat beach area between the two jughandles. The purpose of the pits was to verify how deep the cut would stay open unshored, and whether removal of the (potentially liquefiable) beach sands was a feasible option. The locations are shown on the attached plan. The excavations were made by the long-reach excavator from on-shore per CE permit requirements.

2.2 Observations and Findings in Pit 99P-1 near Western Jughandle

This pit was excavated from the Western jughandle upslope near the site of the all-terrain CPT 99C-3 previously completed by Fugro (see photos). The excavation was performed around noon to 1:15pm on April 9 under fair weather and near-low tide conditions. The soils excavated consisted of gray sands with occasional trash (plastic containers, bottles, metal cable) and interbedded below 0.3 m depth with some Young Bay Mud. Two cohesive lumps of clay and sand approximately 0.5 m (18") in maximum dimension were removed from the bottom of the pit.

After further excavation, water collected at the bottom of the pit and the pit walls caved back in. At this stage, the pit was oval in shape with a larger dimension of about 4.5 m (15 ft). Tension cracks formed about 0.3 to 0.9 m (1 to 3 ft) back from the edge of the pit.

The maximum excavation depth at the center of the pit was measured using a plastic rod (with the tip floating inside the bottom sand-clay unit) to be about 1.7 m (5'-6"). The water collecting in the pit was pumped from the pit using a 150 mm (6") diameter trash pump and discharged back into the bay as allowed by the CE permit. The purpose of the pumping test was to observe the stability of the drained sands of the open cut (simulating the effect of lower tide levels). The excavation depth at the center of the pit, with the tip floating again pushed inside the bottom sand-clay unit, was measured again after pumping to be about 2.2 m (7'-3"). The pit walls flowed back as the water level rose to back to the previous level encountered before pumping to about 1.5 m (5 ft depth).

The pit was backfilled with the soils removed. The location was revisited the next day and there were no evident signs of this location after it had been washed over after one high tide cycle.

2.3 Observations and Findings in Pit 99P-2 near Eastern Jughandle

This pit was excavated from the eastern jughandle upslope and the location is at the site of the all-terrain CPT 99C-5 previously completed by Fugro. The excavation was performed around 9:30 to 10:00am on April 8 under fair weather and near-low tide conditions. The soils removed consisted of gray beach sands interbedded below 4 ft depth with some Young Bay Mud. After further excavation to about 2.1 m (7 ft), the pit walls caved back in. The pit at this stage was circular in shape with a diameter of about 5.5 m (18 ft), and tension cracks formed about 0.3 to 0.6 m (1 to 2 ft) back from the circumference of the pit.

Water collected at the bottom of the pit at a measured depth of 1.3 m (4'-3"). The maximum excavation depth was measured using a plastic rod (with the tip floating inside the bottom sand-clay unit) to be about 1.7 m (5'-6") at the center of the pit.

The pit was backfilled with the soils removed. This location was also revisited the next day and it was found that it had also been washed over after one high tide cycle.

3.0 SUMMARY OF FINDINGS

The former rock dikes placed before the 1950's were left in place in the two jughandle areas. Our observations on the configuration and composition of the buried dikes are schematically summarized in Plate 2 and compared to a "typical" configuration shown on historical records as included with EMI's feasibility report (1998). Based on this comparison, the following findings are made.

3.1 Rock Dike Configuration

The dikes are approximately in line with the visible slopes west and east of the jughandles. The dike configuration at the eastern jughandle is similar to that shown in construction records, with differences in elevation of only about 0.3 m (1 ft). This indicates that the dike materials in this area do not appear to have not settled relative to the Mole sand fills, but rather have settled since construction together with the fills. Based on recent adjacent borehole information, up to about 4 to 5.5 m of sand fills underlie the dike in either of the two areas.

Depth to top of dike. There is considerable variation in the depth of the dike below ground. At the western jughandle, the dike is found about 0.9 m (3 ft) deeper below existing ground, (which is only slightly lower than at the eastern jughandle). Based on the limited investigation, it can be extrapolated that rip-rap and rock dike materials can be expected within the upper 1.8 m (6 ft) of the present Mole fills.

Height. The thickness of the rock dike was measured to be about 3 m (10 ft) at the eastern jughandle (which corresponds with construction records) and in excess of 2.4 m (8 ft) in the western jughandle. Based on these limited measurements and one construction record, it is extrapolated that the bottom of the dike is expected at 3.6 to 4.9 m (12 to 16 ft) depth below existing grade.

Gradients. This dikes are roughly shaped. The north dike face has a gradient of about 1.5:1, somewhat steeper than the north slopes presently visible to the west and east of the jughandles. The south face remains unconfirmed as those zones were blocked in both trenches by an underground high-voltage electrical utility line running parallel to the existing Caltrans maintenance roadway and could not be excavated safely with the bucket. The back face slopes back below the existing Caltrans maintenance road and is likely to have a steeper gradient, such as 1:1 as indicated on the construction record.

3.2 Composition of Dike Material

Face rock. The dike is typically covered at the top with angular and rounded rock rip-rap material about 0.6 to 1.2 m (2 to 4 ft) in size, which may have been removed in places such as the eastern jughandle to allow new fills to be added and the surface to be graded. Less or no large rip-rap was found along the north face.

No rip-rap is expected at the steeper south face where they would be less likely to stay in place and finer-grained rock and sand filter material was used to retain the hydraulically pumped sandy Mole fills behind them. Some larger-size material may have been removed at the top and north face at either jughandle (in the 1950's and more recently during construction of the turn-around fills) to allow the jughandle fills to be added and the surface to be graded. Break-up or removal of the face rock is necessary for proposed pilecap construction or installation of piles.

Core material. The dike core materials exposed and excavated below the rip-rap were composed of quarry-run size rounded and angular rock cobbles predominantly 300 to 600 mm (12" to 24") in size, with smaller broken cobbles and fill soils filling the voids.

3.3 Jughandle Fills

Between 1934 and the late 1940s, the mudflat area to the north and northwest of the current toll plaza was progressively filled.

Western jughandle. By 1957, the northern edge of the Mole near the western tip had been filled out to the north to form a new "pad" of approximately 30 by 60 meters (100 by 200 ft). The western fill jughandle is in an area where early photos from 1936 show a docking pier. By 1963, the portion of the western end of the Mole beneath the SFOBB bridge had been extended to the west by about 90 m (300 ft).

The western jughandle north of the present Caltrans fenceline consists of non-engineered loose fill soils (placed in the 1950's) with varying amounts of organic material, gravel and cobbles, and abundant unconsolidated debris material. The materials on top of the buried dike south of the fenceline consisted of soils with roots and gravel. Large-size debris may be encountered in during excavation of these fills, and break-up and/or removal is required for proposed pilecap construction or installation of deep foundations. Environmental soil testing was not performed. Caving occurred at depths as small as 1.2 m (4 ft) and shoring is required.

Eastern jughandle. The eastern jughandle at proposed "W" Station 88+30 presently serves as a turn-around area for the present Caltrans maintenance road and is believed to have been created in the late 1960's. This area is built on loose to medium dense granular soils with pebble and cobble-size gravel and some debris material. A lens of baymud was encountered at 3.65 m (12 ft) depth in the sand fills. Only one large piece of rip-rap was encountered during excavation. Some break-up or removal of this face rock may be necessary for proposed pilecap construction or installation of piles. Some caving occurred below 1.5-m (5-ft) depth and shoring is required for deeper excavations.

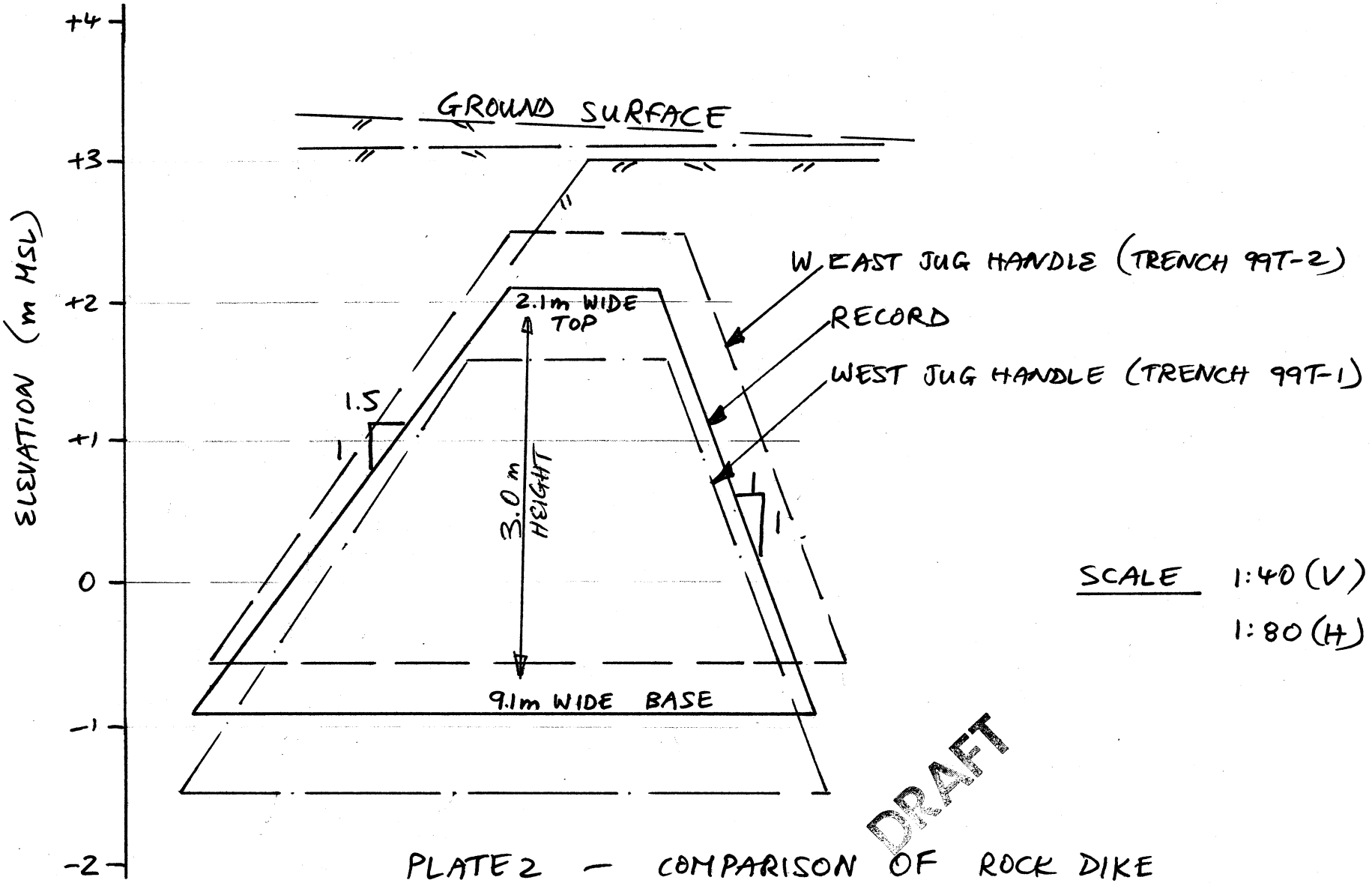
3.4 Pits in Tidal Flats

The materials excavated from the pits consisted of medium to coarse clean to silty sands with some interbeds of Young Bay mud at the bottom. The maximum achievable depth of both pits excavations was about 1.5 m (5 ft). The maximum cut depth is controlled by the tide water level and by the seepage of water from the Mole fill slope through coarser seams of sand exposed during pit excavation.

Attachments:

Plate 1, Plan of trench and pit locations
Plate 2, Comparison of dike configurations
Log for Trench 99T-1
Log for Trench 99T-2

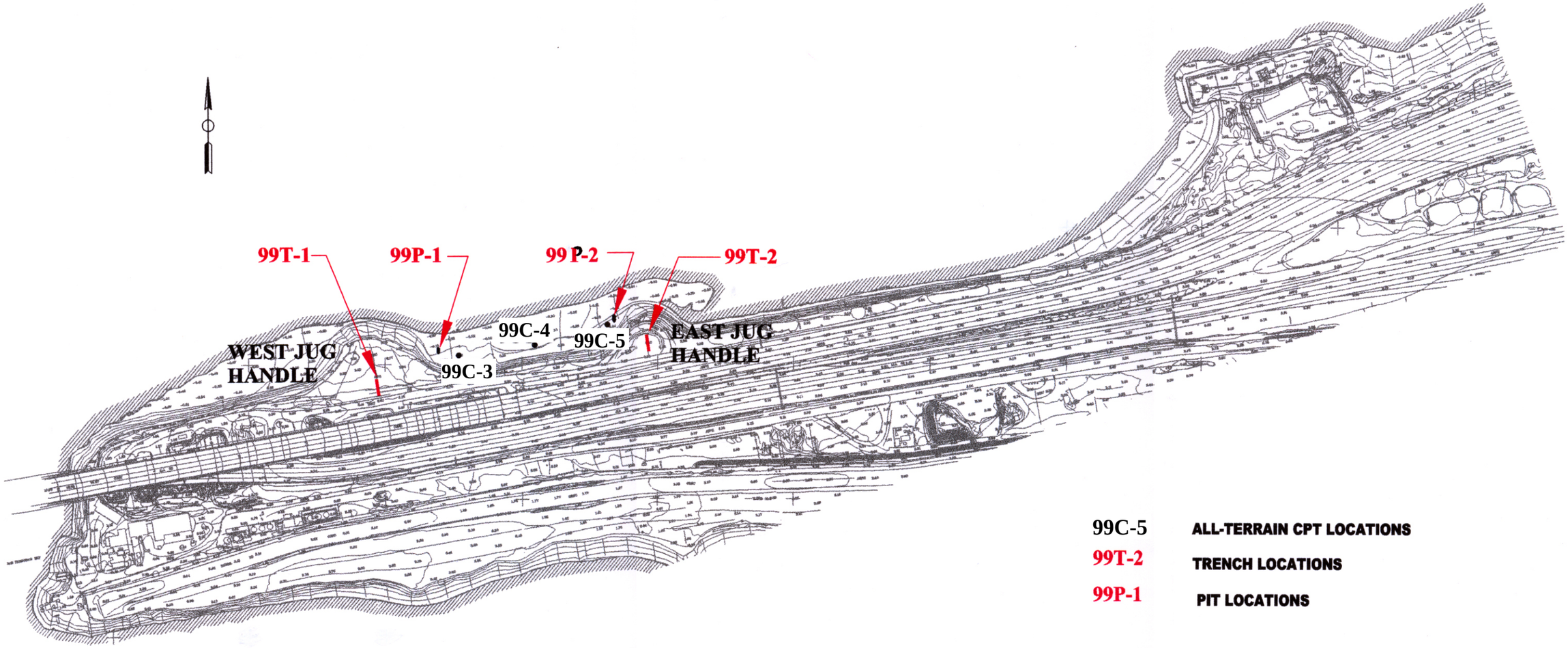
AMPAD
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS



DRAFT

PLATE 2 — COMPARISON OF ROCK DIKE CONFIGURATIONS.

SGOBB T.O.S, MOLE | 98-145 MK | 4/13/99



99C-5 ALL-TERRAIN CPT LOCATIONS

99T-2 TRENCH LOCATIONS

99P-1 PIT LOCATIONS

PLAN
1:3000

50 m 25 0 25 50 m

SFOBB EAST SPAN SEISMIC SAFETY PROJECT

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering
7700 Edgewater Drive, Suite 848
Oakland, CA 94621
(510) 633-5100

EMI Project: 98-145 | DATE: 4/12/99

TRENCH LOG

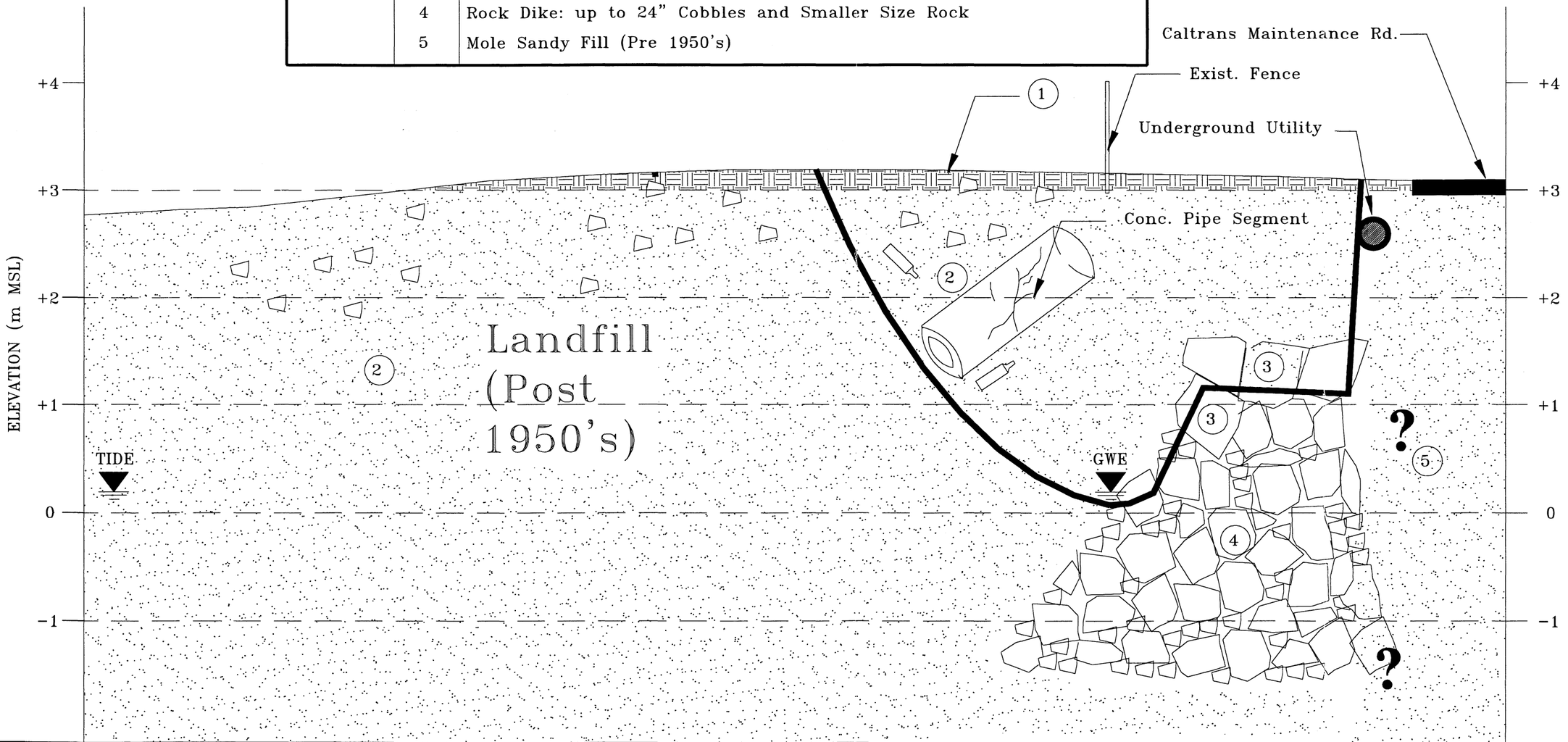
Trench No. 99T-1		Surface Elev.: +3.1m MSL	Slope Level
Location: W Jug-handle (Oakland Mole)		Trench Depth: 3.6 m	Trend N-S
Logged By: SS/MK	Date: 09 APR 1999	Equipment: Hyundai 290LC	Time: 07:30-12:00

GEOLOGIC ATTITUDES	GEOL. UNIT	DESCRIPTION
	1	Tree chips ground cover/vegetation
	2	Sand: Brown, Moist, Dense, Fine Grained with Few Pebbles and Cobbles and Landfill Debris (Post 1950's).
	3	Rock Dike: Large Angular Boulders ±3' in Size.
	4	Rock Dike: up to 24" Cobbles and Smaller Size Rock
	5	Mole Sandy Fill (Pre 1950's)

N

1m
0 2m

Note: GWE Changes with Time According to Tide . Elev. Shown Refers Only to Time of Ecavation.



Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

HORIZONTAL SCALE: 1:80
VERTICAL SCALE: 1:40

SFOBB EAST SPAN SEISMIC SAFETY PROJECT

Project No. 98-145 Date: 4/12/99

LOG OF EXCAVATION, TRENCH 99T-1, WEST JUG-HANDLE, OAKLAND MOLE (looking East)

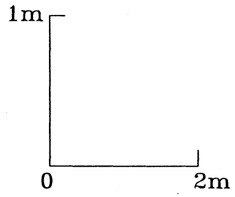
TRENCH LOG

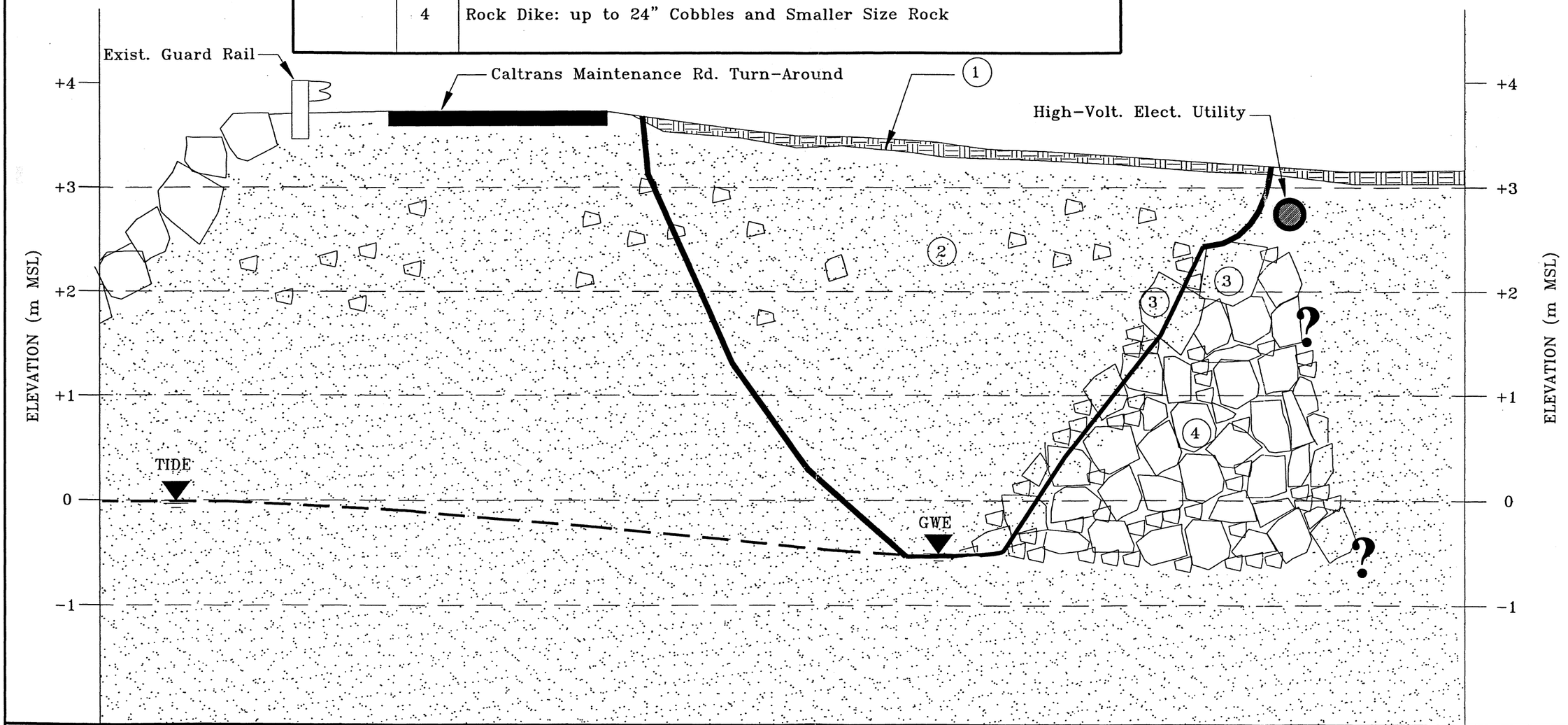
Trench No. 99T-2		Surface Elev.: +3.1m MSL	Slope 5%
Location: E Jug-handle (Oakland Mole)		Trench Depth: 3.6 m	Trend N-S
Logged By: SS/MK	Date: 08 APR 1998	Equipment: Hyundai 290LC	Time: 07:30-11:30

GEOLOGIC ATTITUDES	GEOL. UNIT	DESCRIPTION
	1	Tree chips ground cover
	2	Sand: Brown, Moist, Dense, Fine Grained with Few Pebbles and Cobbles
	3	Rock Dike: Large Angular Boulders ±3' in Size.
	4	Rock Dike: up to 24" Cobbles and Smaller Size Rock

N

Note: GWE Changes with Time According to Tide . Elev. Shown Refers Only to Time of Ecavation.





Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

HORIZONTAL SCALE: 1:80
VERTICAL SCALE: 1:40

SFOBB EAST SPAN SEISMIC SAFETY PROJECT

Project No. 98-145 Date: 4/12/99

LOG OF EXCAVATION, TRENCH 99T-2, EAST JUG-HANDLE, OAKLAND MOLE (looking East)

View of north slope between two jug handles (Looking E)

Panoramic view of area between two jug handles, 1 of 9 (Looking E)

Panoramic view of area between two jug handles, 2 of 9 (Looking S)

Panoramic view of area between two jug handles, 3 of 9 (Looking S)

Panoramic view of area between two jug handles, 4 of 9 (Looking S)

Panoramic view of area between two jug handles, 5 of 9 (Looking S)

Panoramic view of area between two jug handles, 6 of 9 (Looking S)

Panoramic view of area between two jug handles, 7 of 9 (Looking S)

Panoramic view of area between two jug handles, 8 of 9 (Looking SW)

Panoramic view of area between two jug handles, 9 of 9 (Looking W)

Older (pre-1950's) rip-rap on north slope between jug handles (Looking S)

Newer rip-rap (post-1950's) on west jug handle

Trench 99T-1 Before excavation (Looking N)

Trench 99T-1 During initial excavation (Looking N)

West jug handle (Looking NE)

Trench 99T-1 Location on west jug handle (Looking NE)

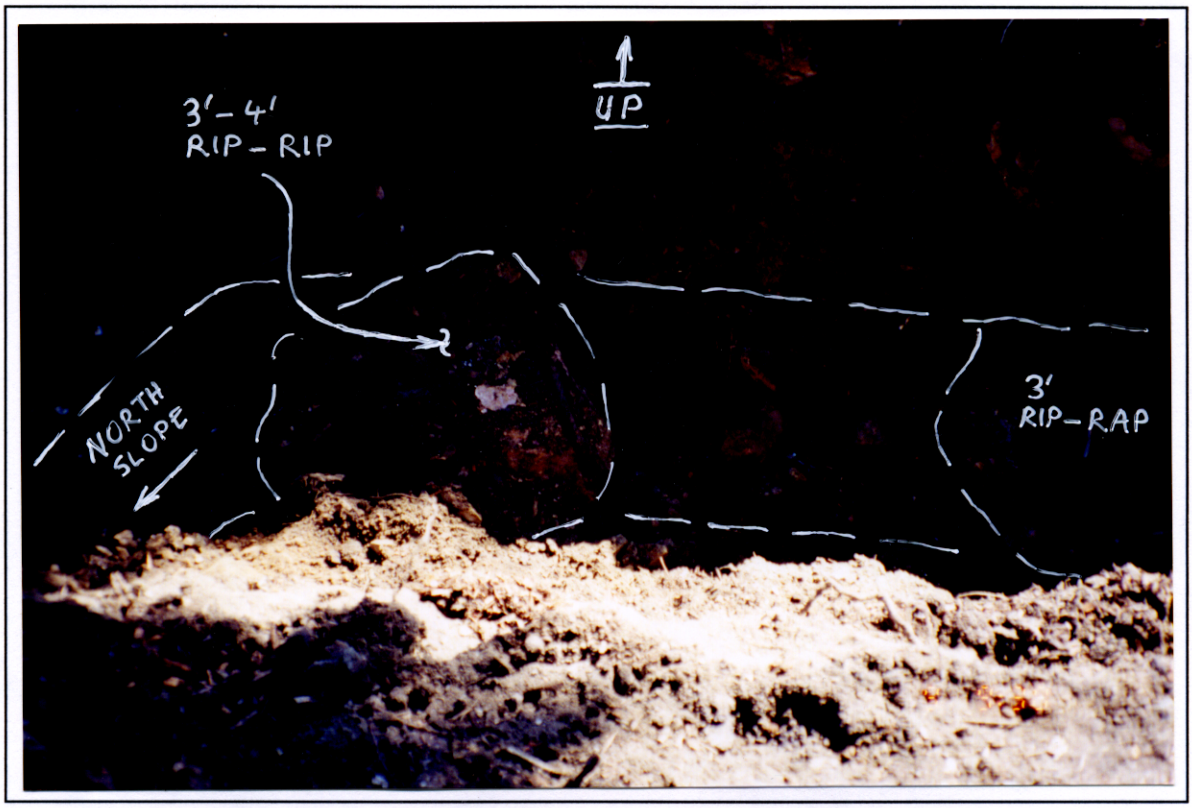
Trench 99T-1 Buried rock dike (Looking S)

Trench 99T-1 Dike material from north face of buried rock dike

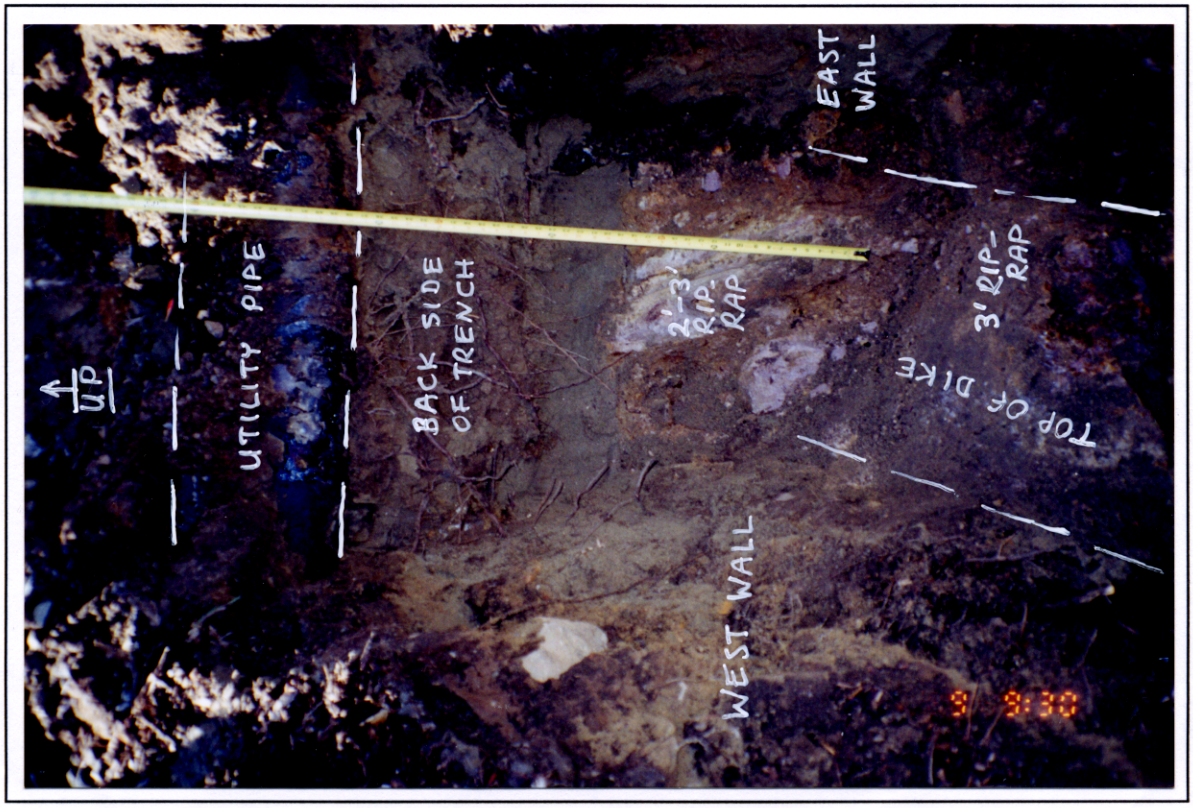
PHOTO SHEET
SFOBB EAST SPAN SEISMIC SAFETY PROJECT
EMI PROJECT NO. 98-145

Trench 99T-1 Plywood shoring installation

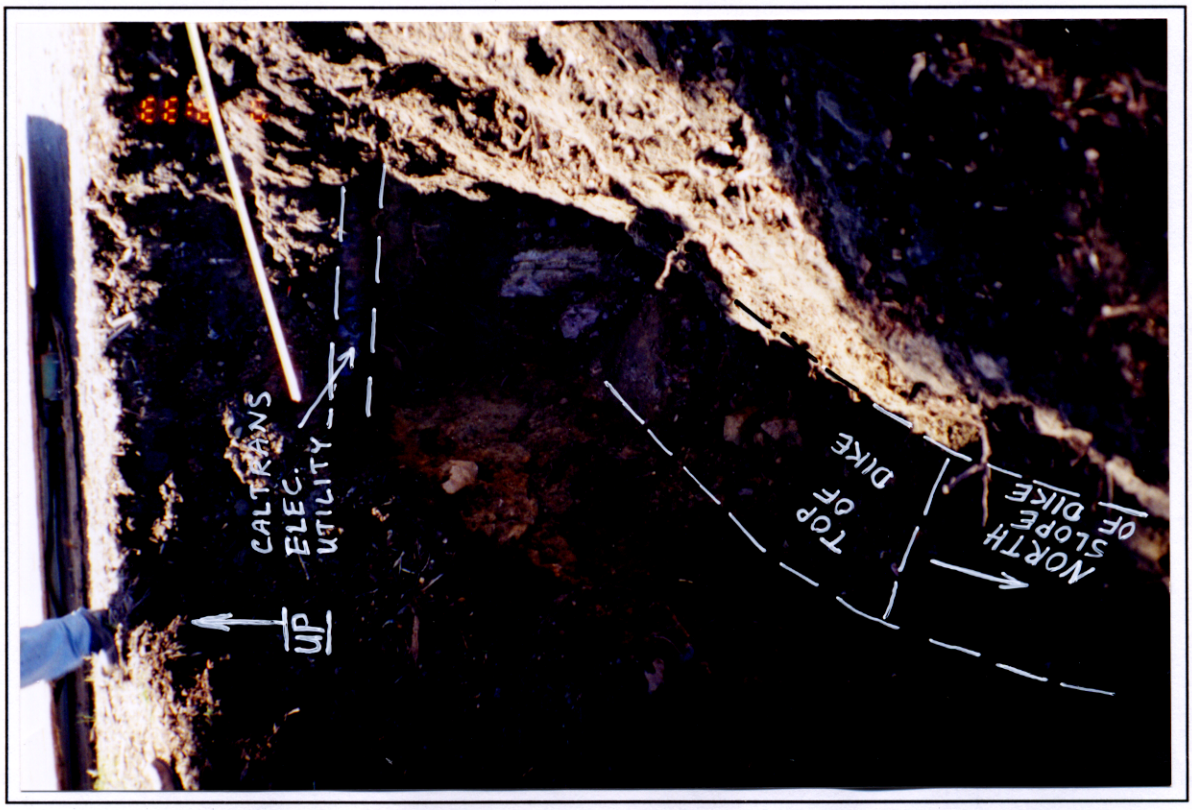
Shoring in-place on trench 99T-1 (Looking N)



Trench 99T-1 Close up of previous photo showing rip-rap size



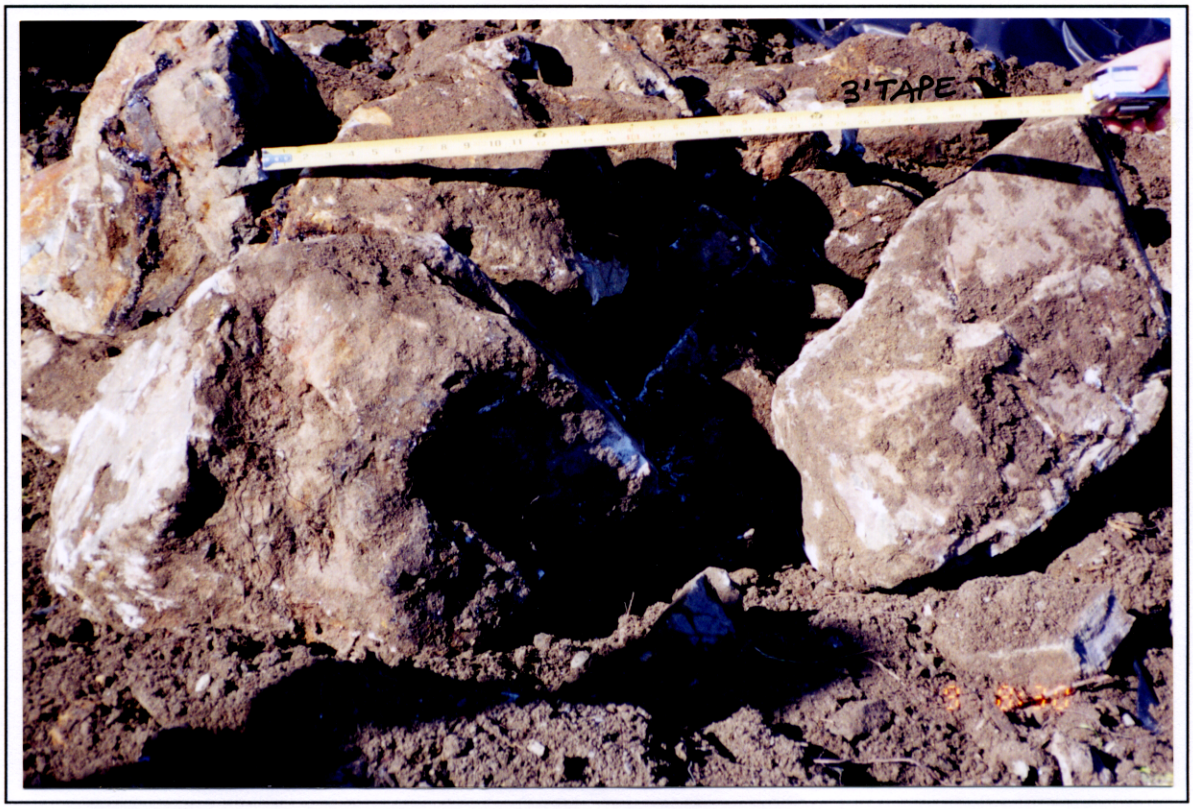
Trench 99T-1 Close up of south side of trench



Trench 99T-1 Top and face of buried rock dike (Looking S)

Trench 99T-1 Close up of previous photo showing rip-rap size

Trench 99T-1 Rock dike material



Trench 99T-1 Rock dike material

Trench 99T-1 One large (4') and some smaller boulders of rip-rap from top of buried dike

Trench 99T-1 One 3' to 4' boulder from north face of buried rock dike

Trench 99T-1 Excavated materials

Trench 99T-1 Debris material and soil from above buried rock dike

Trench 99T-1 Rip-rap from face and top of buried rock dike

Trench 99T-1 Rip-rap from top of buried rock dike

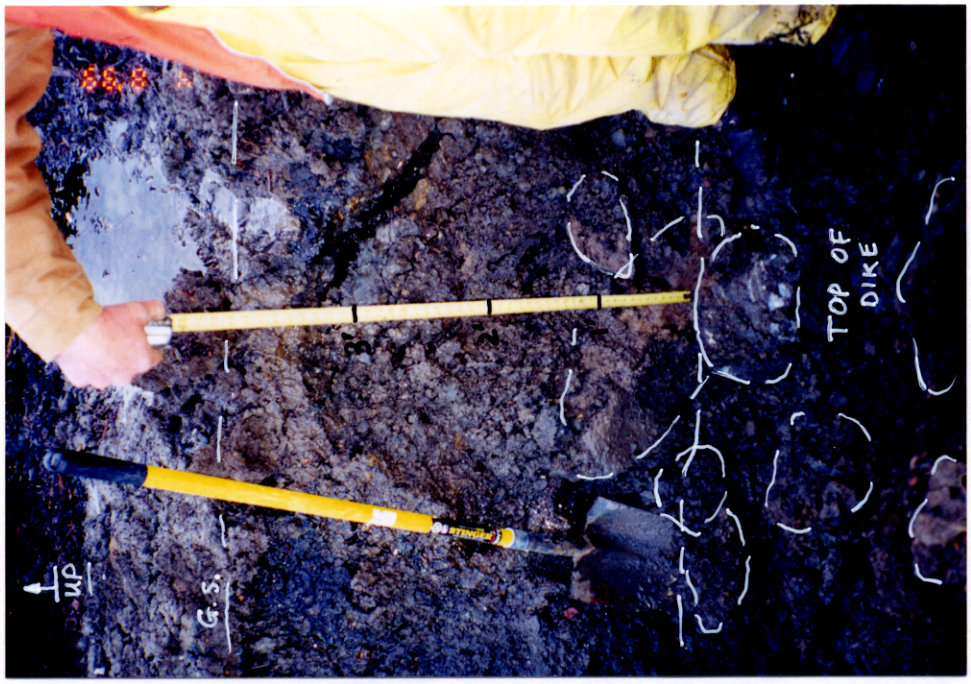
Trench 99T-1 Rock dike material

Trench 99T-1 Rock dike material

Trench 99T-2 (Looking SW)

Trench 99T-2 (Looking E)

Trench 99T-2 (Looking S)

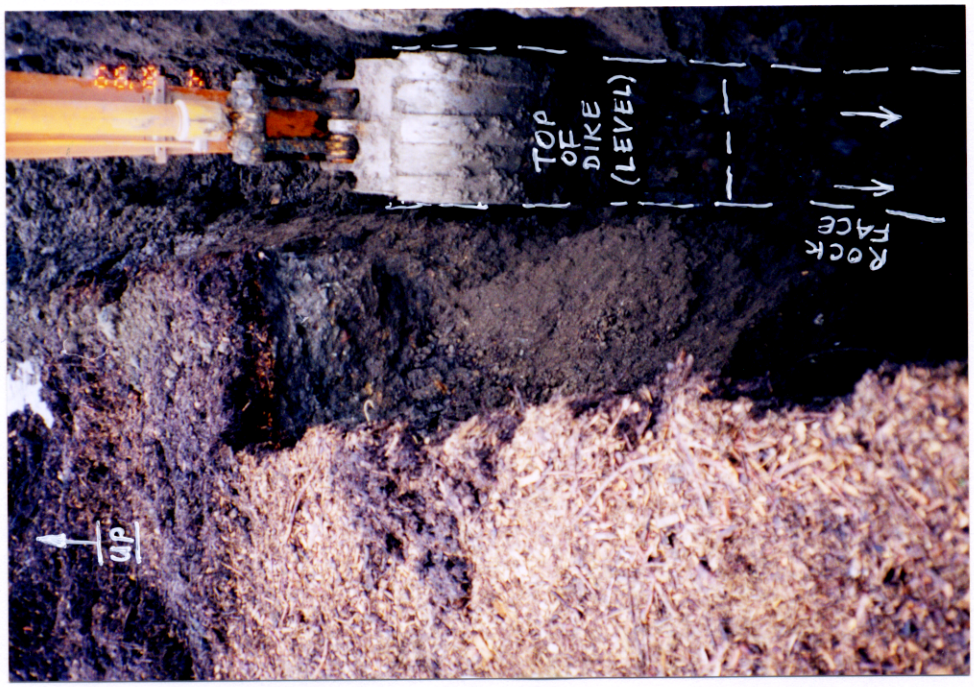


Trench 99T-2 Top of buried dike (Looking E)

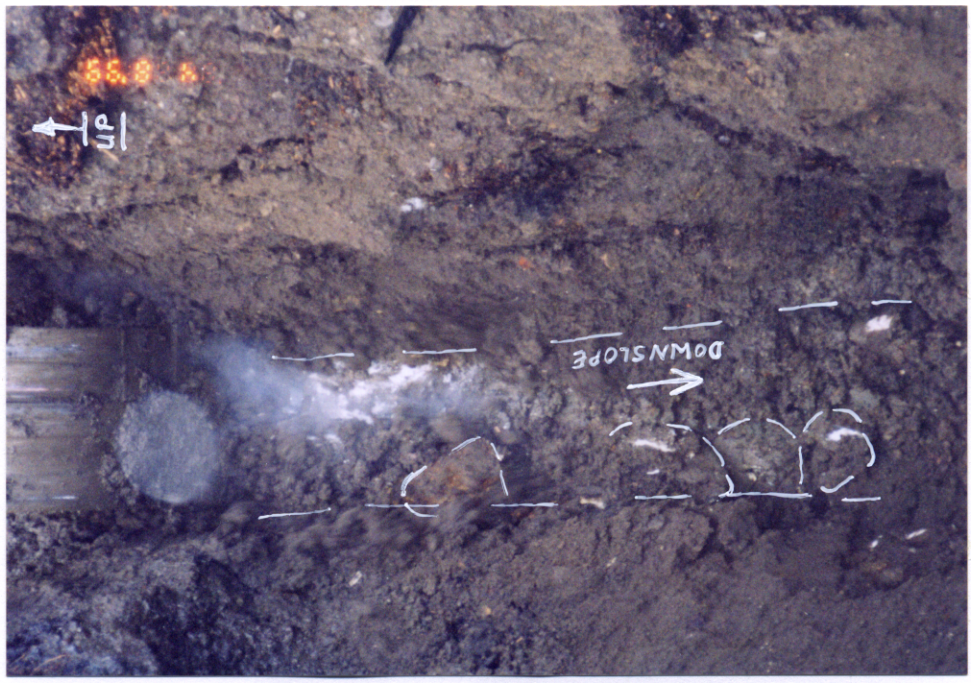
Trench 99T-2 Top of dike (Looking N)

Trench 99T-2 Typical dike material from north face and top of rock dike

Trench 99T-2 Surficial jug handle fill soils



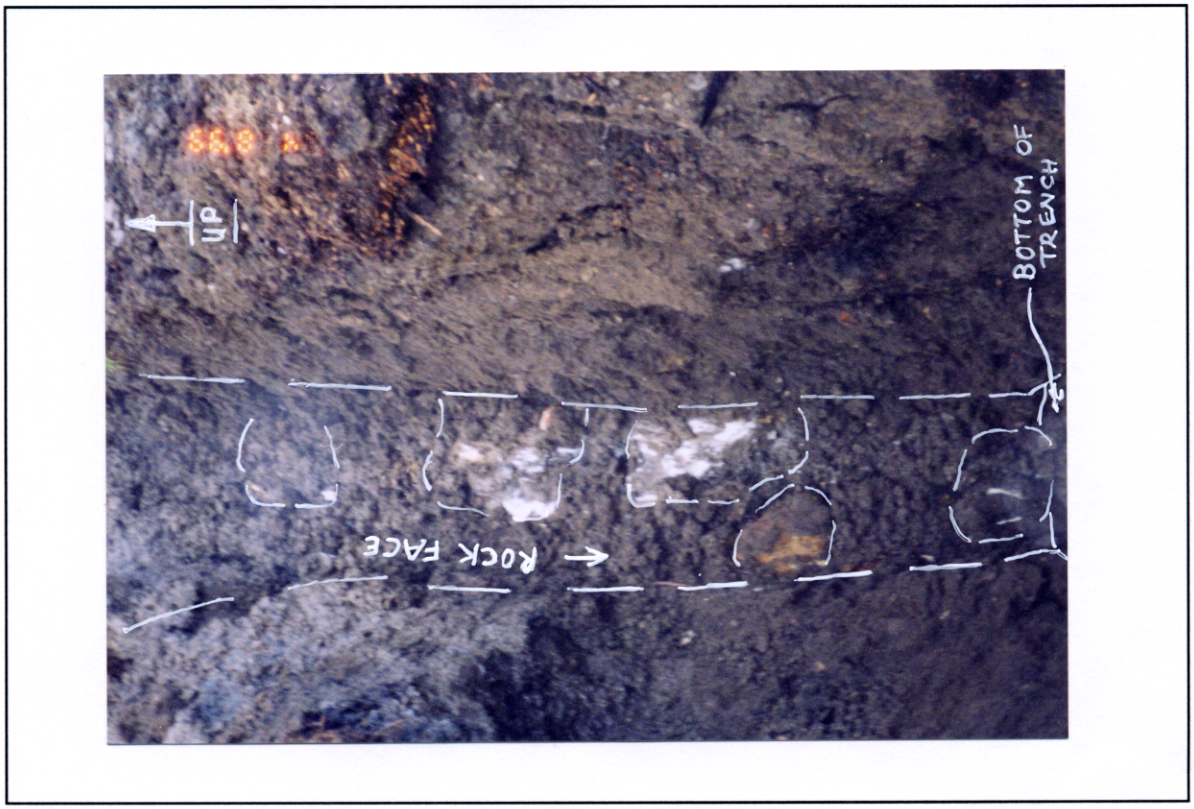
Trench 99T-2 Top and north-facing slope of dike (Looking S)



Trench 99T-2 North-facing slope of dike (Looking S)

Trench 99T-2 North-facing slope of dike (Looking down)

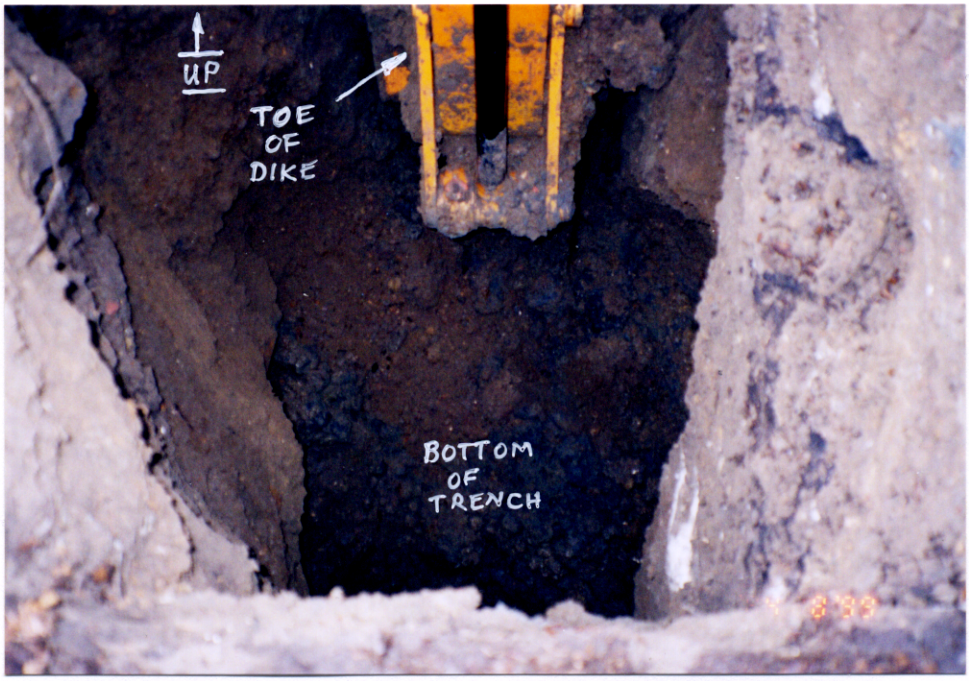
Trench 99T-2 North-facing slope of dike (Looking S)



Trench 99T-2 North-facing slope of dike (Looking S)

Trench 99T-2 Largest face rock encountered

Trench 99T-2 Typical dike core material encountered beneath face of dike



Trench 99T-2 Mixture of sand and blue mud encountered at bottom of trench at 12' depth

Pit 99P-1 Before excavation started (Looking E)

Pit 99P-1 During excavation (Looking E)

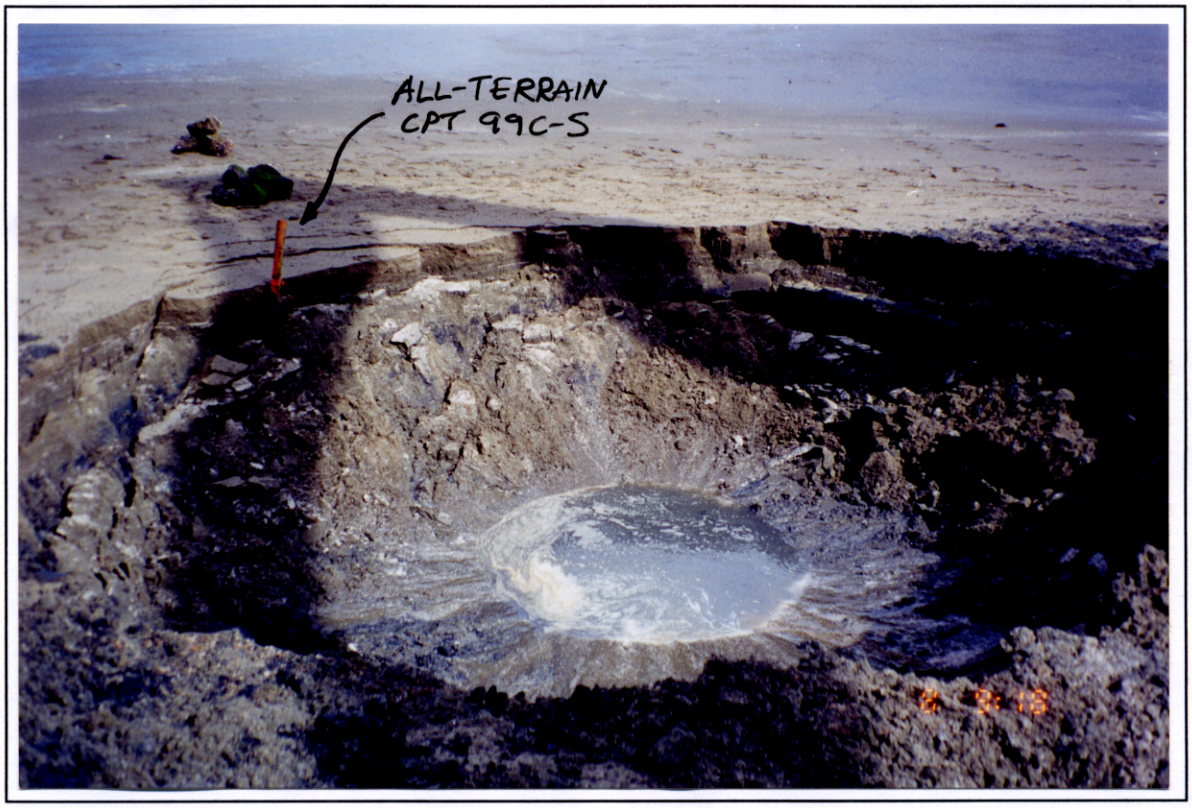
PHOTO SHEET
SFOBB EAST SPAN SEISMIC SAFETY PROJECT
EMI PROJECT NO. 98-145

Pit 99P-1 After pumping

Detail of 6" diameter trash pumping equipment

Pit 99P-2 (looking E)

Pit 99P-2 (Looking N)



Pit 99P-2 (Looking N)

Pit 99P-2 measuring excavation depth

UC BERKELEY REPORT

UNIVERSITY OF CALIFORNIA AT BERKELEY
GEOTECHNICAL TESTING FOR
THE EAST BAY CROSSING OF THE
SAN FRANCISCO-OAKLAND BAY BRIDGE

U. C. Berkeley Geotechnical Testing for the East Bay Crossing of the San Francisco-Oakland Bay Bridge

for
Earth Mechanics, Inc.
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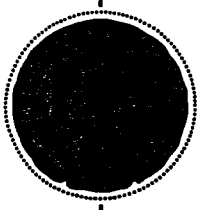
U. C. Berkeley Geotechnical Group

February 1999



GEOTECHNICAL ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

UNIVERSITY OF CALIFORNIA • BERKELEY

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UC Berkeley Geotechnical Testing for the East Bay Crossing

1 Testing Program

1.1 Introduction

The geotechnical testing presented in this report was performed for Earth Mechanics, Inc., to assist them in characterizing the likely consolidation and seismic response of the soils beneath the Oakland Mole for the proposed alignment of the new span of the San Francisco-Oakland Bay Bridge. The project was administered through a Service to Industry Agreement with the University's Earthquake Engineering Research Center, and the actual testing was performed by Graduate Student Researchers Ann Marie Kammerer (simple shear testing) and Christopher Hunt (consolidation testing) under the supervision of laboratory director Dr. Michael Riemer. The testing conditions and parameters were selected based on discussions with Hubert Law of Earth Mechanics and Robert Pyke, a consultant for the project.

The purpose of the simple shear testing was to investigate the possible effects of large cyclic straining, such as might be caused by a significant seismic event, on the subsequent stress-strain properties of the soil. To assess this directly, the testing program was designed around testing pairs of specimens from a given sampling tube, which would ideally be identical in composition with each other. One of the specimens would simply be sheared monotonically, while the other would first be cyclically loaded with a specified strain amplitude and number of cycles, then monotonically sheared without allowing the pore pressures from the cyclic loading to dissipate. This approach therefore intends to provide a "Before, and Immediately After an Earthquake" picture of the stress-strain response, provided that the specimens are similar and that the testing conditions adequately model those acting in the field. The procedures and results from this portion of the testing program are presented in Section 2.

The consolidation testing performed as part of this project was focused specifically on attempting to identify the time rate of consolidation under conditions of predominantly lateral drainage. This is a relatively unusual property to measure experimentally, though it is widely agreed that the permeability, and thus also the rate of consolidation, are likely to be substantially different in soils which are deposited in horizontal layers. To make direct comparison with conventional consolidation tests on vertically oriented specimens, it would be ideal to obtain block samples and trim specimens from vertical planes into oedometer rings for testing. As such

samples were not available for this testing program, an alternative method was developed. This method utilized the conventional Shelby tube samples available to measure the rate of radial consolidation to applied isotropic stress increments. The procedures, method of interpretation and results of these tests are discussed in Section 3.

1.2 Materials Tested

In the current testing program, soil from seven different sampling locations were chosen for characterization (B2, B5, B6, B7, B9, B10 and P2, based on numbering system employed during sampling and logging). A total of fifteen specimens were successfully tested in simple shear (3 more than the 12 initially planned), while four specimens were tested in radial consolidation. Table 1.1 shows the specimen numbers, the test types, properties and other pertinent information relating to each of them. It should be noted that the "material type" as noted on the table is an estimate based on visual/manual identification only, and that further index testing of the specimens might prove useful for investigating the relationship between material variations and the testing results. From our observations in the lab, however, the material appears somewhat coarser than the 'Bay Mud' from most other sites with which we have testing experience. This observation is supported by the relatively low water contents and high dry densities of the tested specimens.

Nine sample tubes from the Oakland mole were delivered to the UCB soils laboratory by personnel of Earth Mechanics, Inc. All simple shear and consolidation testing was performed on these samples. Since delivery, the samples have been stored in a specially designed "wet room" that maintains a cool, dark, humid environment to prevent moisture changes that could result in either desiccation or loss of soil suction. Preliminary field logs, site maps, and x-rays taken of samples P-2 and P-3 were also provided by Earth Mechanics, Inc.

As testing was performed at the in-situ stress state, appropriate vertical effective stresses had to be calculated prior to testing. The soil profiles, unit weight data and water table locations from the preliminary field logs provided by Earth Mechanics were used for this purpose. Unit weights for each layer were calculated in the following way. Where unit weights were provided and the values showed scatter about a central value throughout the layer, the mean value was used for the entire layer. For layers where the unit weights appeared to trend up or down (as in many of the clay layers) a best-fit line was determined for the layer. Where no unit weight data was

provided, the unit weight values provided for layers in adjacent boreholes that had the same description and approximately the same depth were used. Where no unit weight data was provided and similar layers in adjacent borings either did not exist or did not provide unit weights, conservative estimates of the unit weights were made from experience with similar materials. The water table depths provided on the boring logs were assumed to be correct. The calculated effective vertical stress at each depth was plotted to check for reasonableness. Figure 1.1 is an example of the plots developed. Total vertical stress, effective vertical stress, unit weights, and graphical representations of soil type are all shown. The sample and water table positions are also indicated on the figure.

Table 1.1: Samples used in the testing program, and their characteristics

Boring	Sample #	Test Type	γ_t (pcf)	WC (%)	γ_d (pcf)	Material Type
B2	10	MSS	107	54	69	Clay w/shells
		CSS MSS	106	50	71	Clay w/shells
B5	10	MSS	110	45	76	Silty Clay
		CSS MSS	110	48	75	Silty Clay
		MSS	111	76	47	Silty Clay
B6	26	MSS	104	60	65	Clay
		CSS MSS	100	60	62	Clay
B7	12	RC	108	47	73	Clay, w/ silt, shells
B9	8	MSS	116	39	83	Clay w/shells
		CSS MSS	116	40	83	Clay w/shells
		RC	114	40	81	Clay, very silty, large shells
B10	10	MSS	110	49	74	Clay w/silt
		MSS	109	50	73	Clay w/silt
		CSS MSS	110	49	73	Clay w/silt, sand
		RC	113	45	78	Clay, very silty
P2	15	MSS	113	42	80	Sandy Clay
		CSS MSS	111	46	76	Clay w/sand
		MSS	109	51	72	Clay w/shells, sand
		RC	111	47	75	Clay, w/ silt seams and sand

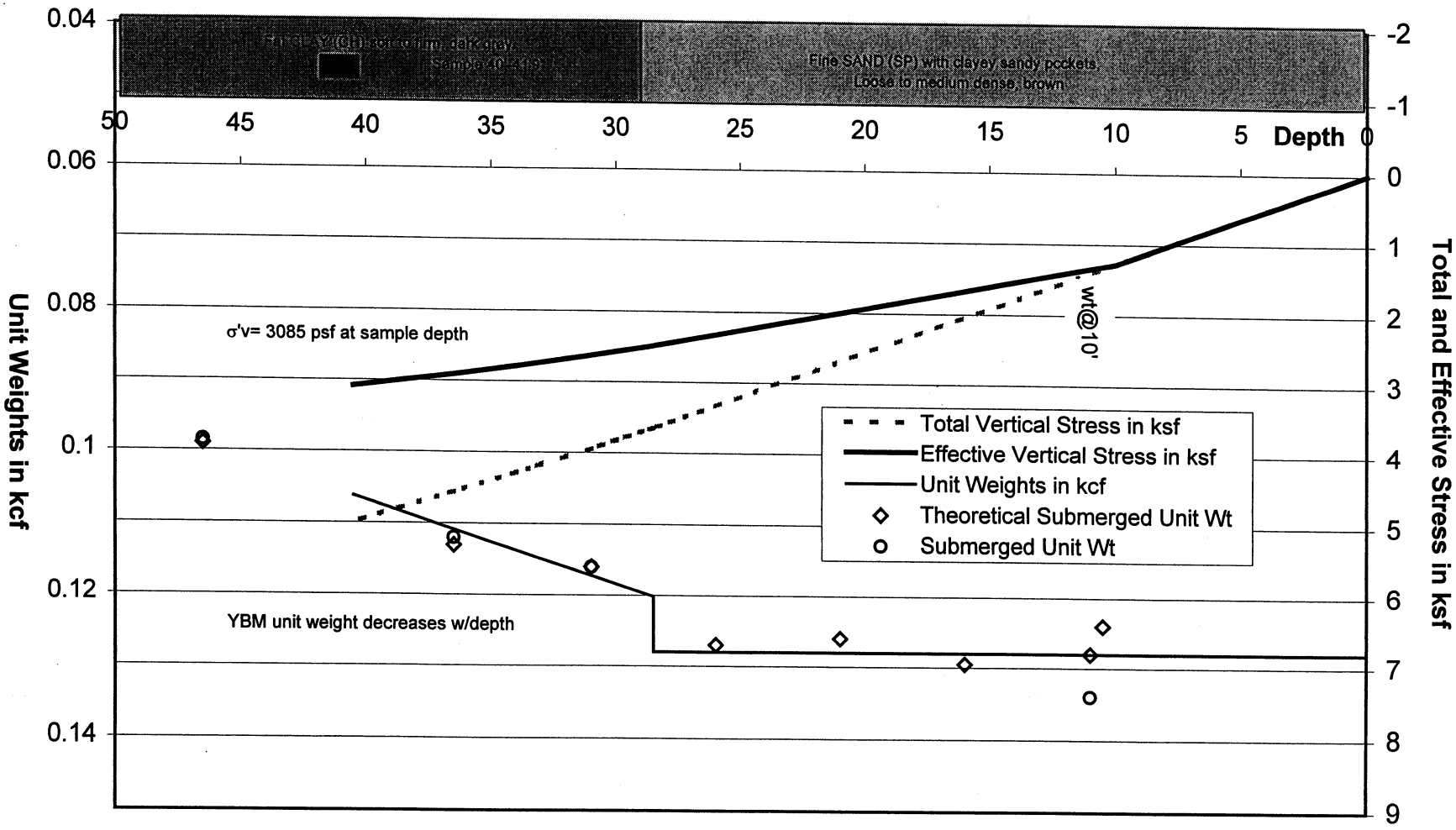

Figure 1.1: Calculation of In-situ Stress State for Boring P-2

2 Simple Shear Testing

2.1 General Considerations for Simple Shear Testing

For a saturated element of soil at some depth below a level ground surface, and below the water table, the initial conditions are usually assumed to include: (1) a major principal stress equal to the vertical effective stress, (2) a minor principal stress equal to the lateral effective stress, and (3) a pore pressure dictated by the hydrostatic conditions. During seismic loading of such an element, if the specimen response is assumed to be undrained, cycles of horizontal shear stress (τ_h) produce shear strains (γ) and may generate excess pore pressures (u). During this loading, there can be no lateral normal strain, as the soil element is surrounded by similarly loaded soil on all sides. There can also be no change in height, since there are no changes in volume or cross-sectional area. At the same time, the total vertical stress also remains unchanged, as the density and depth of overburden are constant.

While simple shear testing does a good job of modeling the application of shear stresses due to seismic loading, it often does not simultaneously achieve the conditions of constant volume and constant total vertical stress. In the conventional type of simple shear test popularized by the Norwegian Geotechnical Institute, the specimen circumference is contained in a wire reinforced membrane. Vertical loads are applied to reproduce the consolidation stresses, while the wire membrane enforces an essentially K_0 condition and the lateral stresses develop accordingly. During cyclic loading of specimens, no effort is made to insure saturation – instead, the testing is performed while keeping the specimen height constant, thereby maintaining constant volume. No pore pressures are measured directly, they are instead inferred from the changes in vertical stresses observed while maintaining the height. In this manner, liquefaction behavior could be investigated in dry sands, by noting the total loss of vertical (and consequently, horizontal) stress. An underlying assumption to this approach, however, is that any generation of pore pressures would be uniformly distributed throughout the soil specimen. Any reduction in the overall vertical load must be a global one, and cannot replicate the softening of a particular seam within the specimen in cases where such localization would be the natural failure mode.

In discussions with Robert Pyke about the current testing program, the possibility of failure due to localized pore pressure generation emerged as a substantial concern. The testing equipment

and procedures used in the program were chosen to allow that failure mode to control the soil response if present. The primary feature of the UC Berkeley simple shear testing device (shown in Plate 2.1) that permits such testing is the ability to apply independent chamber pressures and back pressures to the specimen, in a manner directly analogous to conventional triaxial testing systems. This allows back pressure saturation of specimens, which ensures a truly saturated response, and also permits the user to apply lateral effective stresses to augment those carried by the wire reinforcement. Pneumatic actuators on the device, controlled by closed-loop servo valves linked to the computer, allow either load or displacement control in the vertical and shear directions. In the current testing program, the flexibility of this system allowed us to perform the cyclic and monotonic shear tests under a variety of conditions, and in particular allowed the soil to develop pore pressures in whatever parts of the specimen were most vulnerable to seismic loading: this was accomplished by testing the specimens using wire reinforced membranes, back pressure saturating them, and carrying out the tests under constant vertical load. Other tests were performed under more conventional test conditions, both to investigate the effects of these conditions on the results, and to make sure that some critical mode of behavior was not being overlooked.

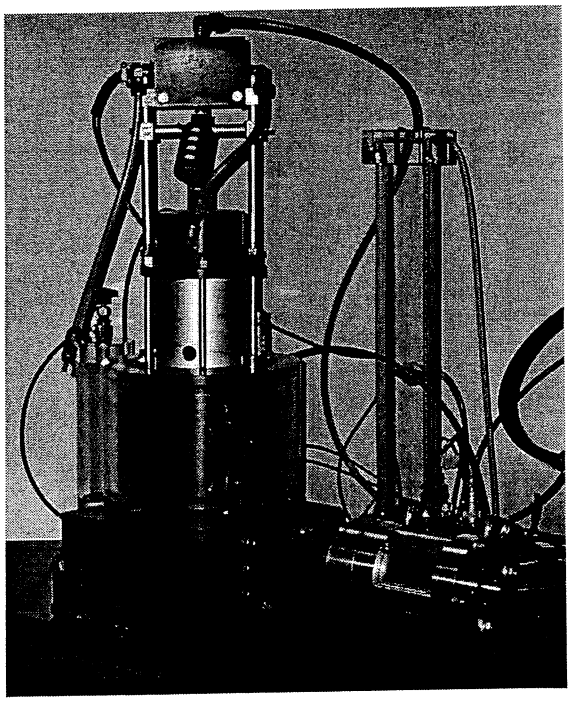

Plate 2.1: Photograph of simple shear device, showing chamber and pneumatic actuators.

2.2 Specimen Preparation and Testing Procedures

Table 2.1 shows the 15 specimens tested, the borings from which they were taken, and summarizes the testing conditions for the simple shear portion of the testing program. All the tests were performed using wire-reinforced membranes, which are used to provide lateral restraint to the specimen, and hence enforce essentially K_0 conditions as the sample is consolidated under axial load. The first eight specimens (numbers 1 through 11) were tested without the addition of any back pressure to improve saturation (i.e. conventional preparation), while the final seven were back pressure saturated using the chamber and back pressure described in 2.1. "B values" of 0.95 were routinely obtained through the reinforced membranes after application of one to two atmospheres of back pressure, suggesting that saturation was obtained, and that truly undrained conditions could be imposed during shearing. In order to allow localizations within the specimens, as noted earlier, most of the tests were performed under constant vertical load conditions, though specimen 5 was tested under constant height conditions for comparison.

Table 2.1: Testing conditions applied during simple shear tests.

Spec #	Boring	Test Types	γ_d (pcf)	BP	Material Type	$\sigma'_{v,con}$ (psf)	Notes on Tests
1	B5	M	76	N	Silty Clay	2650	
4		C (1%) M	75	N	Silty Clay		
5		M	76	N	Silty Clay		constant height
6	B2	M	69	N	Clay w/shells	2700	
8		C (2%) M	-	N	Clay w/shells		
9	B9	M	83	N	Clay w/shells	2600	large shell at edge
10		C (1%) M	83	N	Clay w/shells		
11	B10	M	74	N	Clay w/silt	2700	Unsaturated
12		M	73	Y	Clay w/silt		Saturated
13		C(1.5%) M	73	Y	Clay w/silt, sand		
14	B6	M	65	Y	Clay	3960	
15		C (3%) M	62	Y	Clay		
16	P2	M	80	Y	Sandy Clay	3100	sandier than 17, 18
17		C (3%) M	76	Y	Clay w/sand		
18		M	72	Y	Clay w/shells, sand		to confirm 16

Because of the possible disturbance of the samples due to in-situ vane shear testing, the first six inches of soil from each sampler was removed and inspected. To prepare a specimen, a disk of soil approximately 0.9 inches high is extruded and removed from the remaining sample. The soil is placed between the end caps used in the simple shear device and trimmed to the diameter of the wire-reinforced membrane using a special trimming device. The membrane is applied to the sample and sealed to the caps with rubber o-rings. The weight of the sample can then be determined. Drain lines are attached to the end caps and a vacuum (of lesser value than the calculated horizontal effective stress) is applied to seat the caps and remove air from the specimen. The height of the specimen under the vacuum is measured. While maintaining the vacuum, the specimen is seated in the simple shear device and the initial vertical LVDT reading is correlated with the height of the sample. For the remainder of the testing procedures, the vertical LVDT reading can be used to determine the current height of the sample.

A small seating load is imposed on the top of the sample and the vacuum is slowly reduced. If the test is not back pressure saturated, the vacuum is removed completely. If back pressure saturation is desired, the vacuum is reduced until the effective stress reaches a predetermined value. The value chosen is based on the requirements of the test. An effective stress of 10 kPa was used for the saturated tests. The external chamber that is then placed on the device. The cell pressure is increased to the chosen effective stress while the vacuum is removed. The drain line is then attached to a back pressure source. The cell and back pressures are slowly raised such that the effective stress remains constant at 10 kPa. Once the back pressure reaches approximately 100 kPa, B value checks are performed after each new increment of pressure is added. This process is continued until the B value reaches 0.95 or better.

Consolidation to the calculated vertical effective stress then occurs once the appropriate additional vertical load is added. The applied lateral effective stress of 10 kPa is assumed to simply reduce the stress developed in the wires of the membrane, and does not alter the lateral effective stress under the K_0 consolidation conditions. The specimen is allowed to consolidate until a full log-cycle of secondary compression has occurred (evaluated based on the square root of time method). The B value is again checked to assure saturation. The specimen is then tested as required while keeping the valve on the drainage line closed. For the specimens that were truly saturated, this valve enforced undrained conditions, though of course for specimens without full saturation, air bubbles within the specimen/system would provide partial drainage of any pore

pressures developed. Cyclic loading consisted of 25 strain-controlled cycles at a frequency of 0.2 Hz, with single amplitude shear strains ranging from 1% to 3%, as requested. In order to capture the effects of any localization in pore pressure generation, monotonic tests were run immediately after the cyclic tests. Monotonic tests were strain controlled at a rate of 1%/minute, a value commonly associated with Unconsolidated-Undrained (UU) triaxial tests on clay soils to simulate "rapid" shearing.

2.3 Results of Simple Shear Testing

The results of individual simple shear tests are plotted in Appendix A, in terms of the cyclic loading histories and monotonic stress strain behavior. These results are summarized in Figures 2.1-2.6, on which are compiled the monotonic shear stress (τ) vs. shear strain (γ) curves obtained from the specimens for a given sample. For example, Figure 2.1 shows the (τ)-(γ) plots for specimens #1, #4 and #5, all taken from Boring B-5. In spite of the inevitable differences due to variability between specimens, these figures show a reasonably consistent effect of cyclic loading on the subsequent shear response. At small strains, those specimens which had been cyclically loaded showed a much softer/weaker response than those simply sheared monotonically, while at large strains (> 8-12%) there is relatively little effect of the previous cyclic loading. Figure 2.7 shows the cyclic loading from specimen #17 (in the form of the first and last of the 15 cycles) superimposed on the subsequent static loading. From this figure it is clear that the softened initial response of this specimen to static loading is due directly and predictably to its earlier cyclic straining - once the strain exceeds that developed in the cyclic loading, the specimen stiffens and approximates its statically sheared counterpart (for example, specimen #8 in Fig. 2.2)

Figures 2.8 and 2.9 show the effect of the saturation process on the cyclic response of the specimens. For the unsaturated specimens (Fig. 2.8), the cyclic loading produced larger changes in the height of the specimen than for the saturated specimens (Fig. 2.9), while the recorded values of excess pore pressure were substantially larger and developed earlier in the saturated specimen, as would be expected. These same trends were observed in the monotonic tests as well, and suggest that the saturation of the specimens substantially improved the modeling of the assumed field conditions, showing reasonably constant height and constant vertical loads up to shear strains of at least 10% to 12%, though at larger strains the constant height condition degraded somewhat as the specimens were substantially deformed.

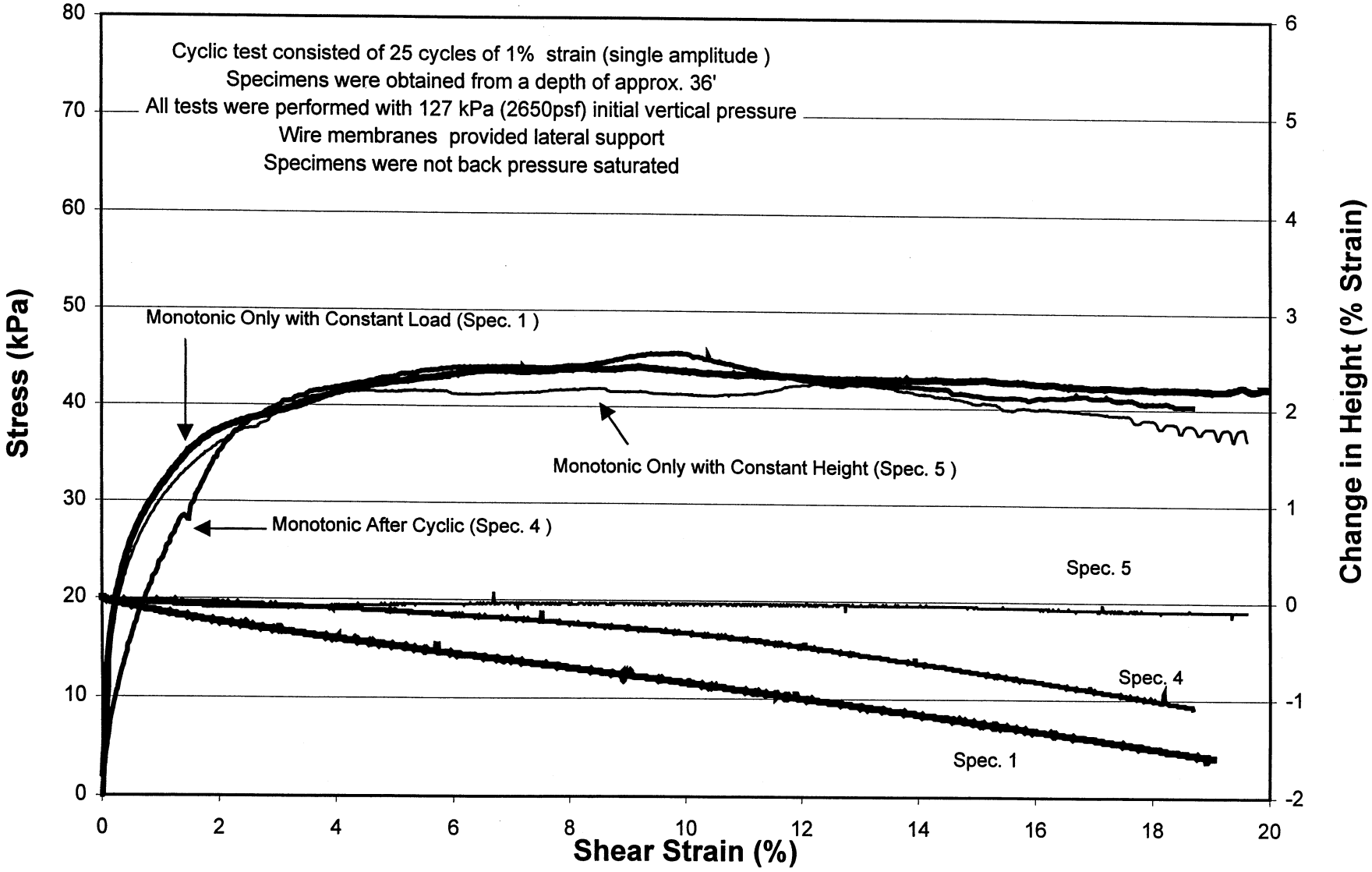

Figure 2.1: Stress-Strain Plots for Specimens from Boring B-5, Sample 10

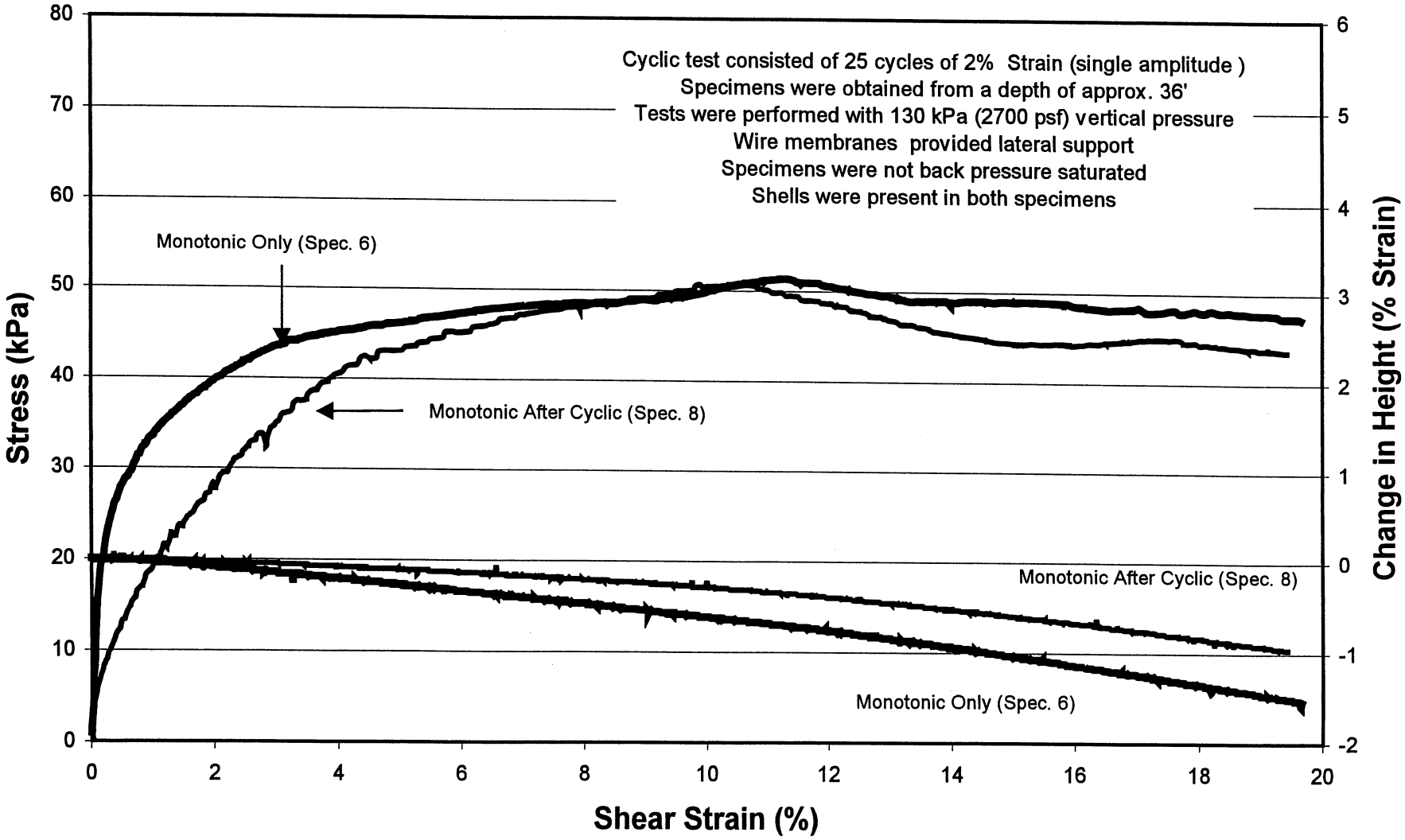

Figure 2.2: Stress-Strain Plots for Specimens from Boring B-2, Sample 10

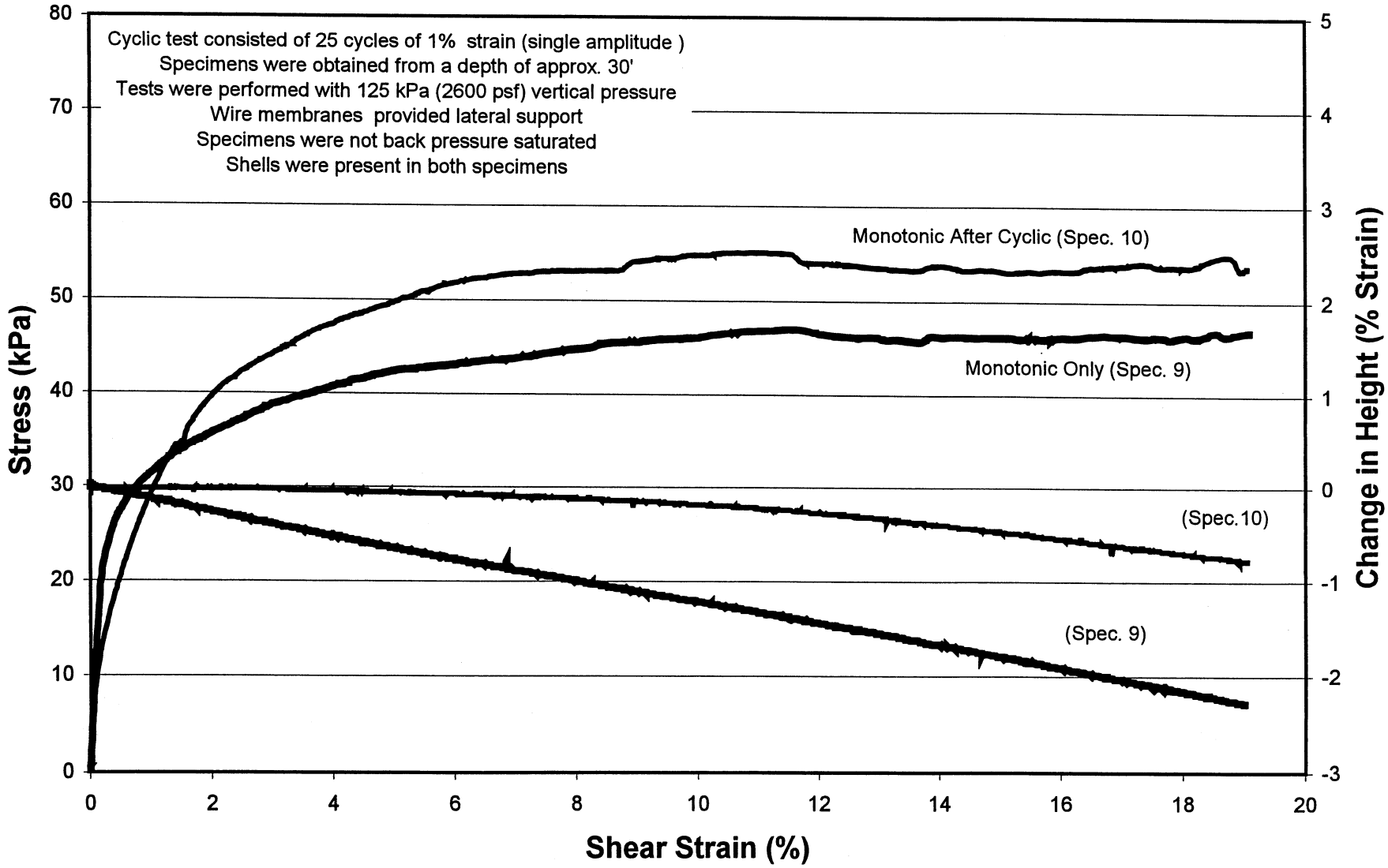

Figure 2.3: Stress-Strain Plots for Specimens from Boring B-9, Sample 8

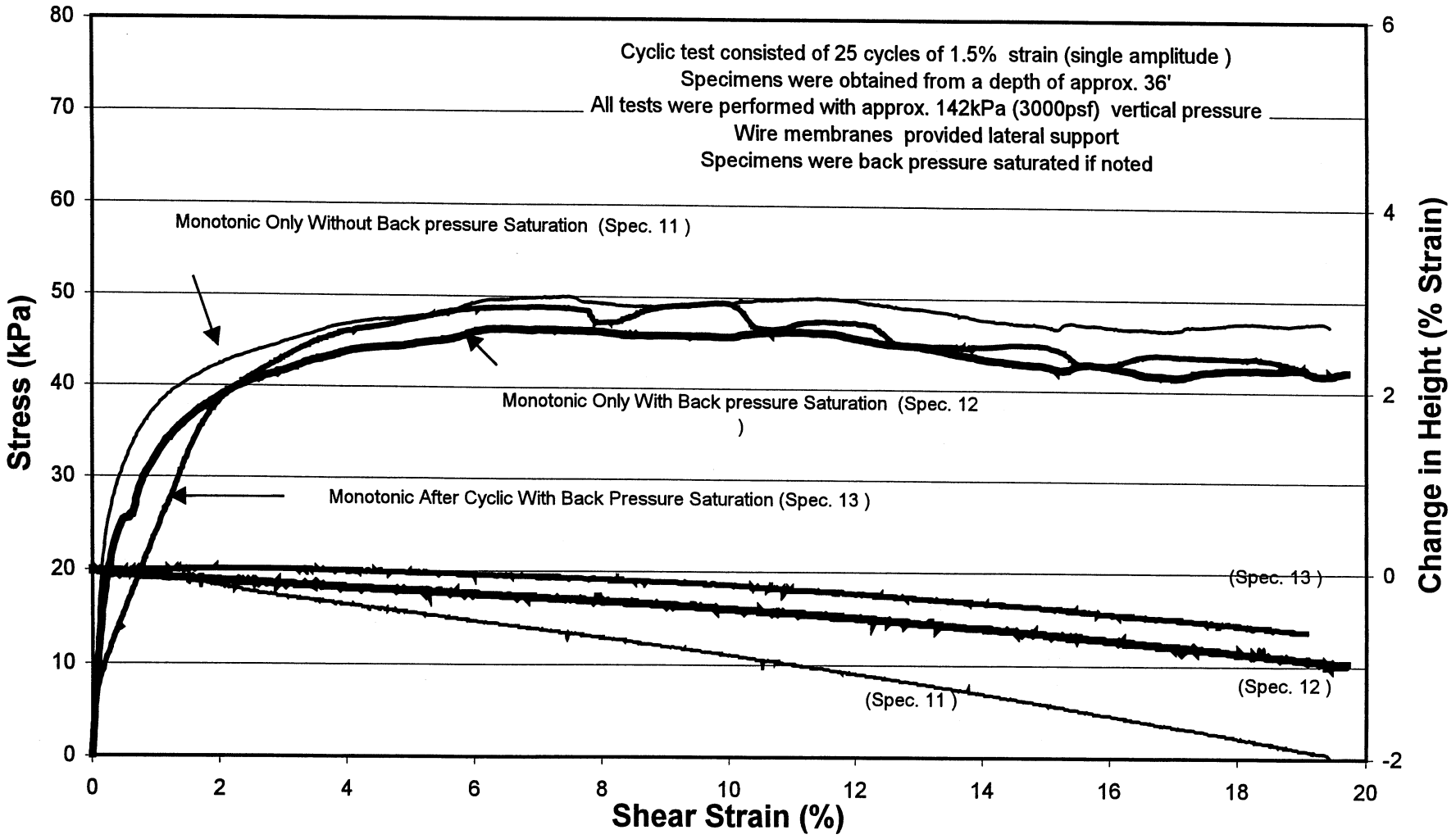

Figure 2.4: Stress-Strain Plots for Specimens from Boring B-10, Sample 10

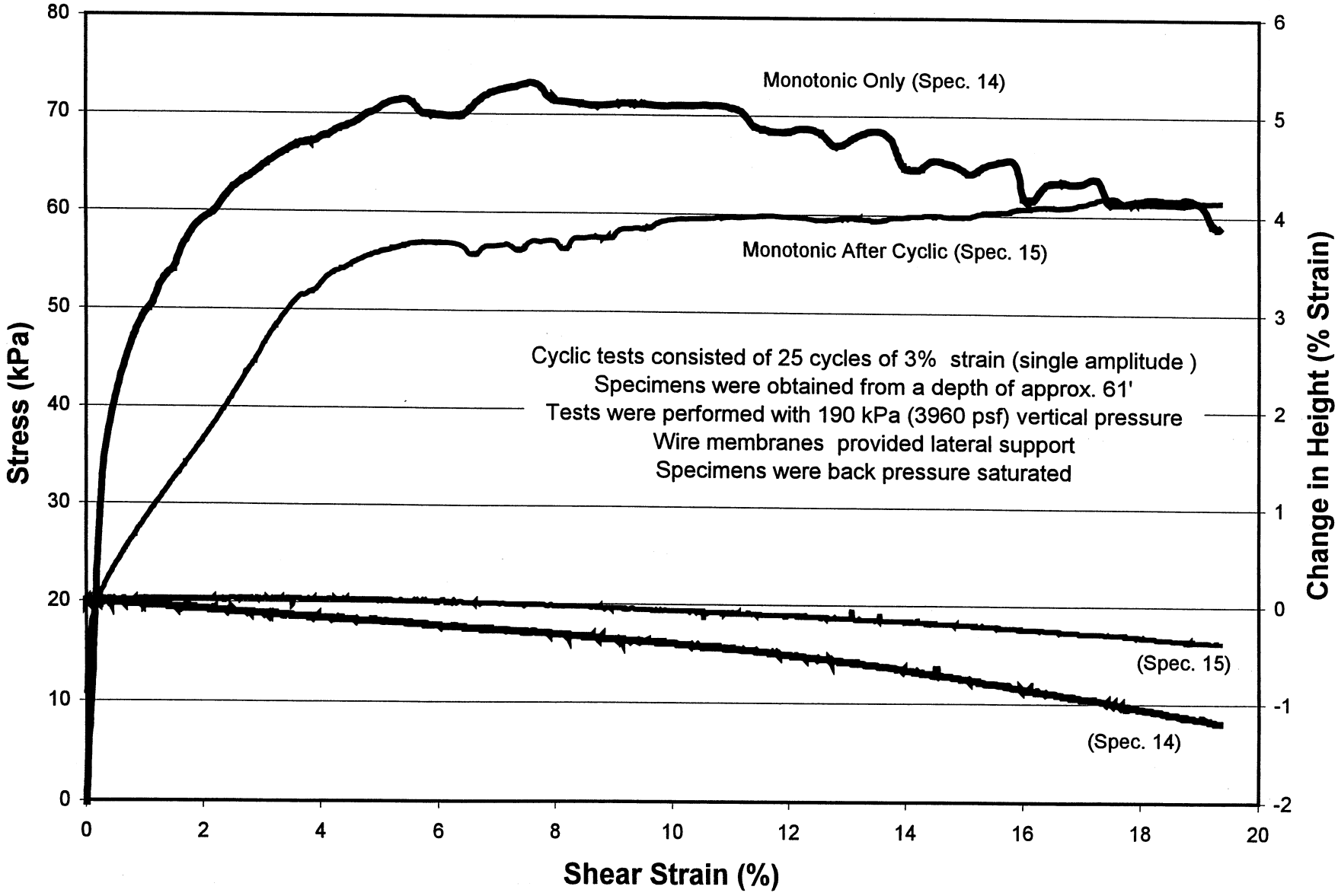

Figure 2.5: Stress-Strain Plot for Specimens from Boring B-6, Sample 26

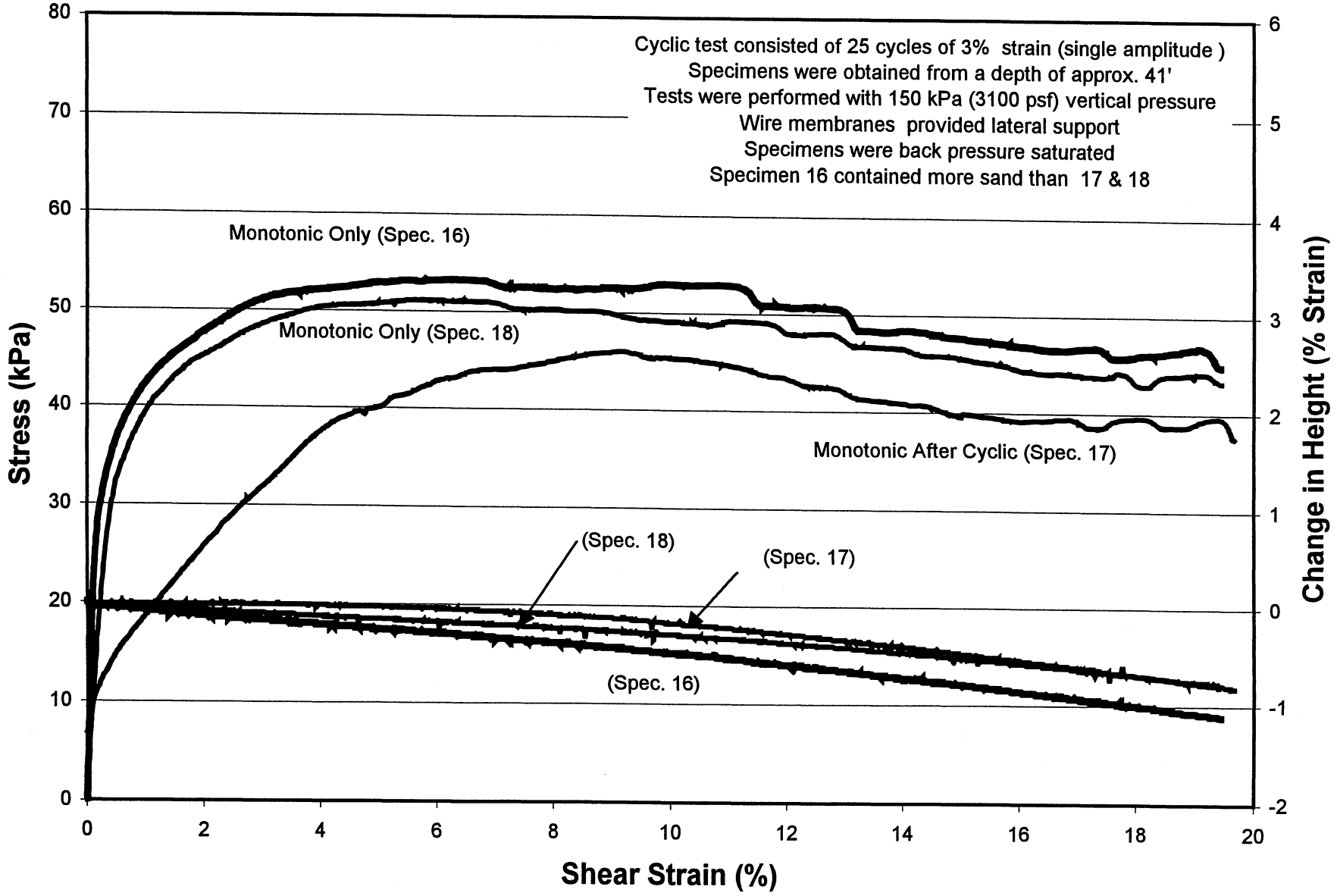

Figure 2.6: Stress-Strain Plots for Specimens from Boring P-2, Sample 15

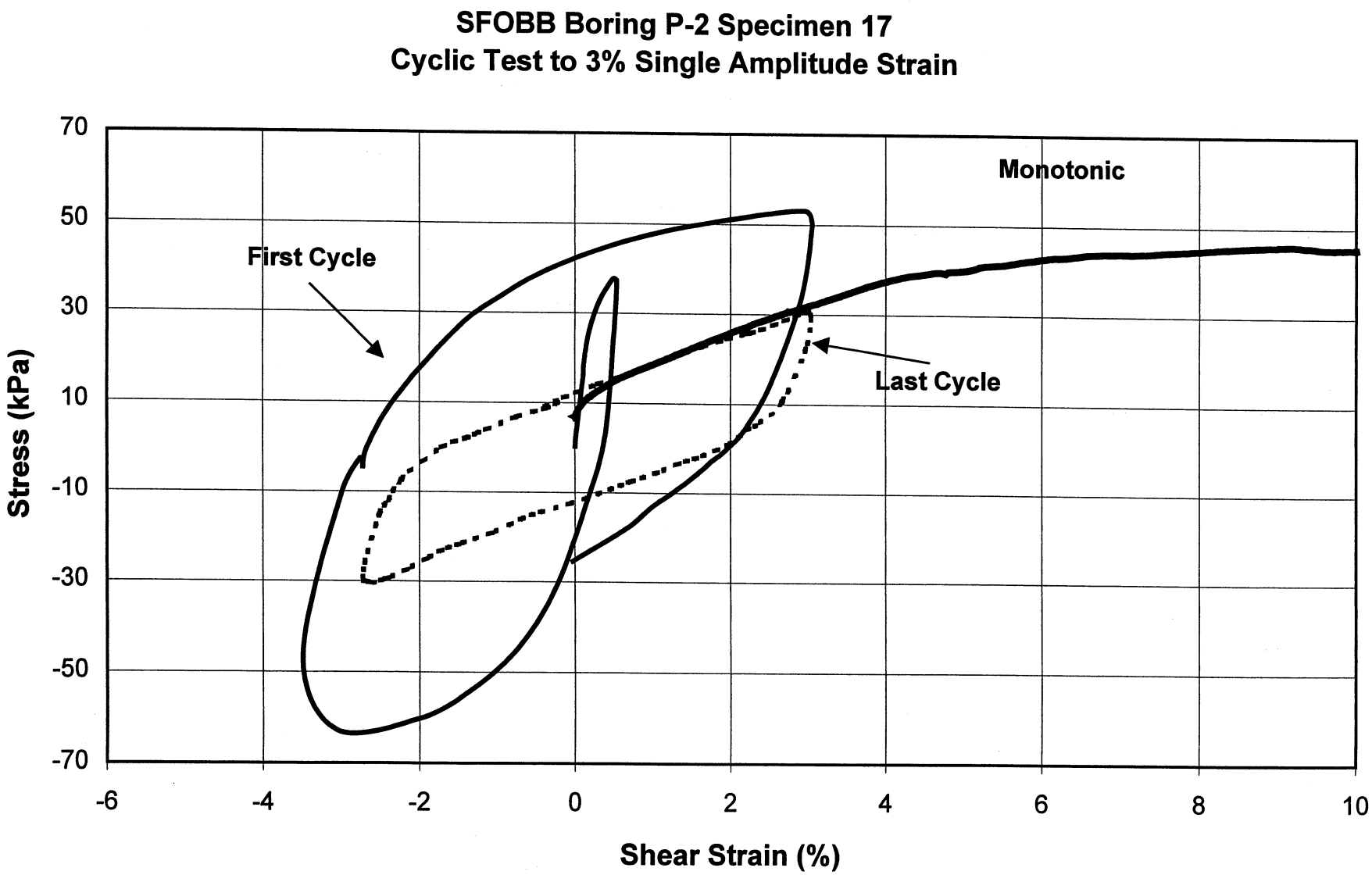

Figure 2.7: Comparison of first and last hysteresis loops with response in subsequent monotonic test

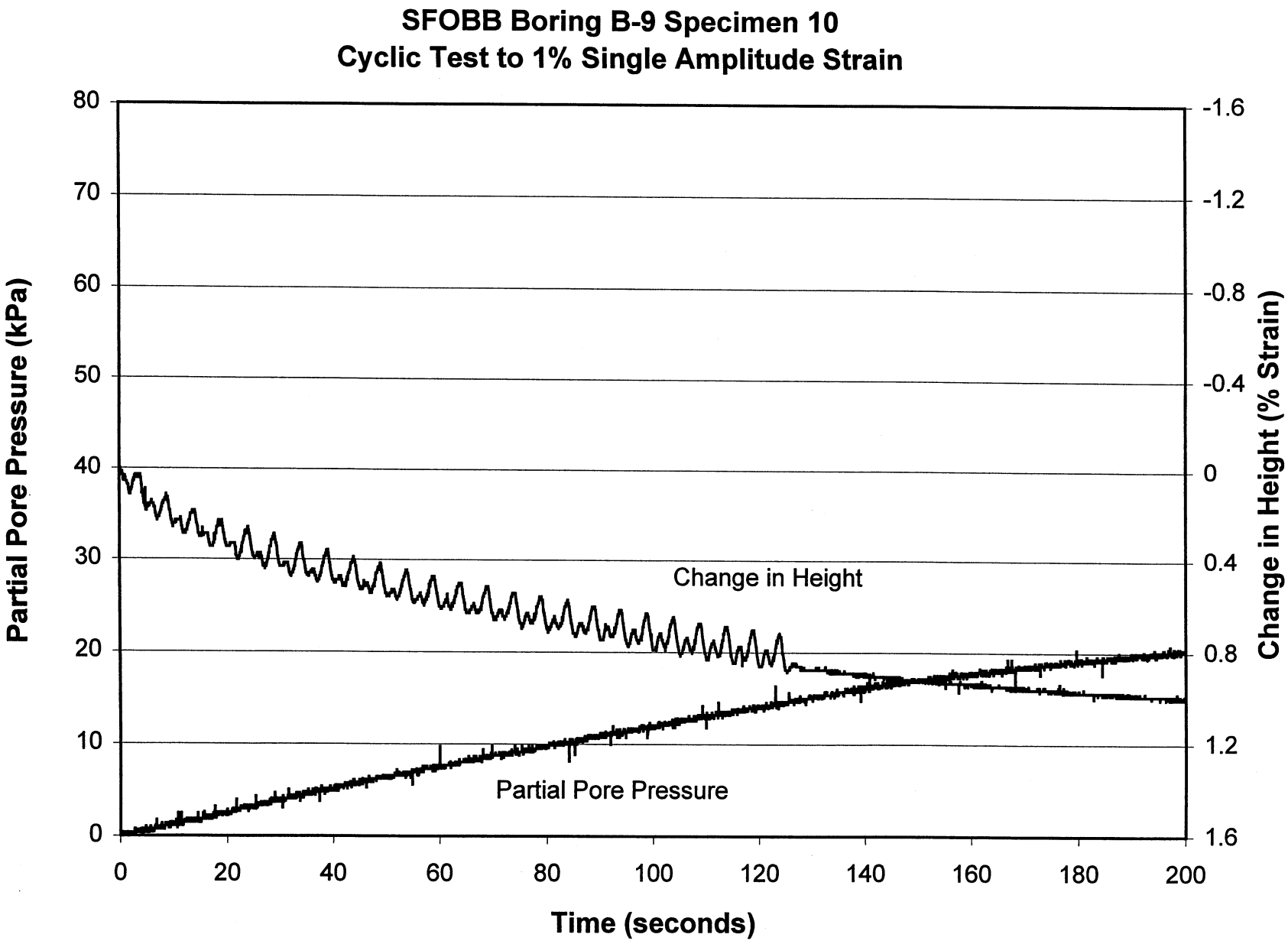

Figure 2.8: Time histories of load, height and measured pore pressure in an unsaturated cyclic test.

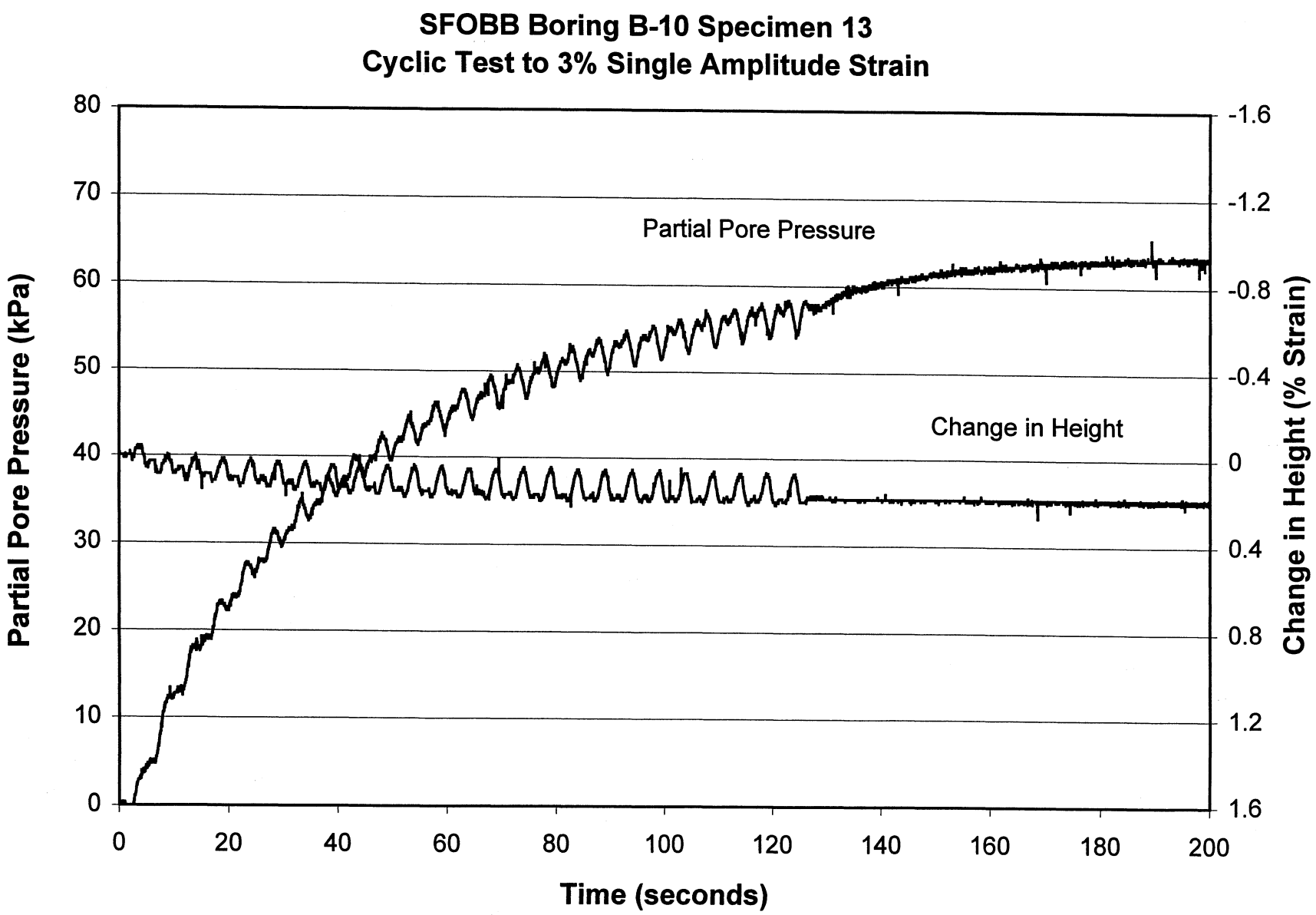

Figure 2.9: Time histories of load, height and measured pore pressure in a saturated cyclic test

3 Consolidation Testing

3.1 General considerations

As suggested by Robert Pyke, the focus of the consolidation testing performed at UC Berkeley has been directed toward investigating the ***rate*** of consolidation that could be expected when pore pressures are allowed to dissipate horizontally, as would be the case with the installation of wick drains in the field. Rather than conventional oedometer tests, therefore, which are designed to consolidate horizontal slices of a tube sample using vertical drainage, this testing program employed a modification of triaxial test equipment to measure the consolidation response of large cylindrical specimens to isotropic increases in stress.

Apparent advantages of this approach stem from the substantial height of the specimen, which both improves the likelihood of obtaining a representative sample in soils expected to have horizontal layering, and minimizes whatever end effects do occur due to non-radial flow. One apparent disadvantage is that while the flow is horizontal, it is radially outward, or ***divergent***, rather than toward a central drain, which is the situation in the field. Another disadvantage which becomes apparent very quickly is the substantial drainage path, which is approximately three times that of a conventional 1-D vertical test, and which slows down the testing process substantially. Less obviously, but perhaps more importantly, the time curve is likely to be heavily affected by the soil that is most severely disturbed in the sampling process – the outer surface of the sample, which may be smeared as the sampling tube pushes through it while advancing down into the soil.

3.2 Specimen Preparation and Testing Procedures

The first two specimens, from B-9 and B-10, were prepared by extruding soil from the desired Shelby tube (approximately 7.2 cm in diameter) and trimming the ends for a sample length slightly greater than 15 cm. Each was then placed between two full-sized porous stones, but a sheet of plastic was introduced between the soil and stone at each end, effectively preventing vertical flow of water into the stones. Strips of filter paper (also known as "Bishop's pajamas") were wrapped around the circumference of the specimen, taking care to fully overlap the edge of the porous stone at each end. A conventional triaxial membrane was then placed over the specimen, and saturation procedures performed (the bottom end of the sample represented in figure 3.1 shows this testing setup). Isotropic increments of consolidation pressure were then

applied using increments of chamber pressure, and both axial and volumetric strains were recorded over time. The in situ stress states of the specimens were estimated and loading schedules created such that the first consolidation increment would be fully in reconsolidation (less than the lateral stress in the field), the second would be just into normal compression (greater than the vertical stress in the field), and any subsequent increments would be normally consolidated (Table 3.1).

Upon evaluating results from the first two samples and calculating unexpectedly low values of the horizontal coefficient of consolidation, a modified test (Fig. 3.1) was developed to examine consolidation rates on the same sample using both divergent flow (radially outward) as in the first two tests, and convergent flow (radially inward), as would occur with wick drains or stone columns in the field. Sample tubes from P-2 and B-7 were selected and cut to a height of roughly 18 cm. While still in the tube, the soil was cored with a device similar to a miniature sampling tube with an outside diameter of nearly 11 mm. The specimens were then extruded and trimmed to approximately the same height as the previous two samples. The exterior surface of the specimen from B-7 was trimmed, reducing the diameter of the sample by approximately 2 mm, in order to investigate the influence which sampling-induced smear might be having on divergent flow. A small plug of remolded soil was inserted into the core at the base of each sample, and the cores were then filled with fine sand. Each sample was placed on a full-sized porous stone with a sheet of plastic in between to block the vertical flow path. Strips of filter paper were wrapped around the circumference of the specimens. The filter paper was sized so as to overlap the porous stone at the bottom end of the sample, while not quite extending to the full height of the specimen. In this fashion, the drainage valve connected to the lower end cap of the triaxial cell would drain the filter paper (divergent flow), while the valve connected to the upper end cap would drain the sand core (convergent flow). Addition of a conventional membrane completed the setup and testing proceeded as with the first two specimens, except that all but the last consolidation increment were performed with convergent drainage (Table 3.1).

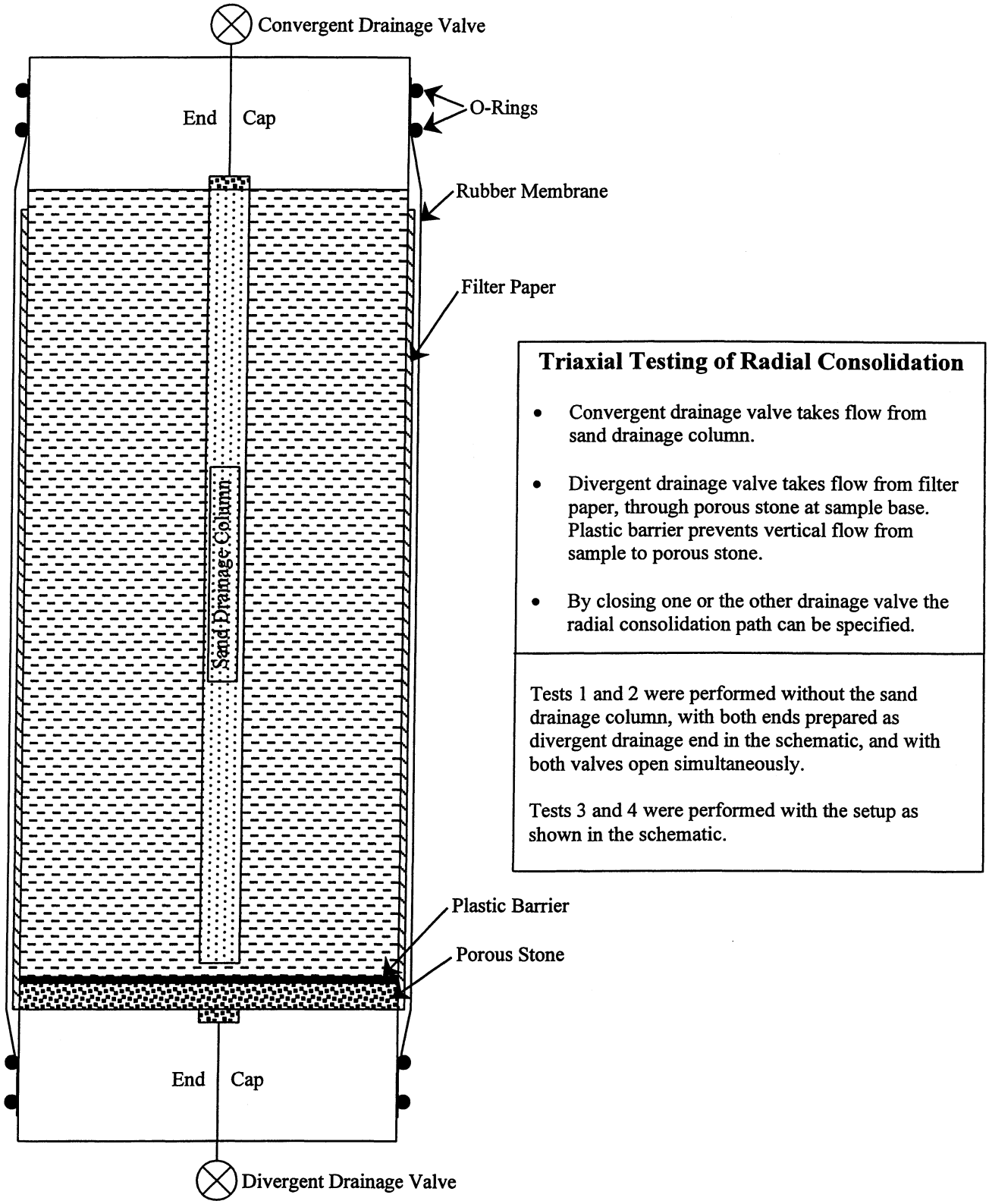

Figure 3.1: Radial Consolidation Testing Schematic

Table 3.1: Overview of consolidation testing performed

Boring	Sample #	Test Type*1	WC (%)	Material Type	σ'_{vi} (kPa)	σ'_{hi} *2 (kPa)	Isotropic Loading Increments (kPa)			
							1*3	2	3	4
P-2	15	C/D	47	Clay, silt seams, some sand	148	74	50-70 conv	70-150 conv	150-200 conv	200-250 div
B-7	12	C/D	47	Clay w/ silt, shells	160	80	50-80 conv	80-160 conv	160-210 conv	210-260 div
B-9	8	D	40	Clay, very silty, large shells	120	60	50-60 div	60-125 div	125-200 div	n/a
B-10	10	D	45	Clay, very silty	135	68	50-65 div	65-135 div	135-205 div	n/a

*1- D = Divergent drainage only C/D = Convergent and Divergent drainage capabilities
*2- Assuming $K_0 = 0.5$
*3- All samples were saturated at 50 kPa isotropic effective stress

3.3 Interpretation of Time Curves

Terzaghi's (1943) classic theory gives the well-known equation for vertical consolidation of soils:

$$c_v \cdot \frac{\partial^2 u}{\partial z^2} = \frac{\partial u}{\partial t} \tag{3.1}$$

where c_v is the vertical coefficient of consolidation. Standard solutions to this equation show the percent consolidation of a soil specimen or layer as a function of a dimensionless time factor, T, which can be used to back-calculate c_v for the soil in question as:

$$c_v = \frac{T_{90}}{t_{90}} H^2 \tag{3.2}$$

where T_{90} and t_{90} are the time factor and the time, respectively, corresponding to 90% consolidation and H is the thickness of the sample. The choice of 90% consolidation corresponds to the square root of time curve-fitting method by Taylor (1948) for determining t_{90} from laboratory data. In this method the laboratory consolidation data is plotted versus the square root of time, a linear fit is drawn through the early part of the data, the abscissa of this line is multiplied by 1.15 and t_{90} is selected as the point where this multiplied line intersects the plotted data. The corresponding T_{90} for vertical consolidation is 0.848. Alternatively, T_{50} and t_{50} are typically used with the logarithm of time method originally proposed by Casagrande, but this approach is rarely used in relation to radial consolidation.

For radial consolidation, these equations instead become:

$$c_h \cdot \left(\frac{\partial^2 u}{\partial r^2} + \frac{1}{r} \cdot \frac{\partial u}{\partial r} \right) = \frac{\partial u}{\partial t} \tag{3.3}$$

$$c_h = \left(\frac{T_{90}}{t_{90}} \right) \cdot r_e^2 \tag{3.4}$$

where c_h is the horizontal coefficient of consolidation and can be determined through solution of Eqs. 3.3 and 3.4 for the particular geometry of the specimen (r_e is the effective radius of the sample) and the boundary conditions specified by the method of testing (divergent or convergent) being used.

Barron (1948) developed radial flow solutions for analyzing consolidation through the use of sand drains in the field. Barron presented solutions for two consolidation scenarios. In free strain the load is assumed uniform across the horizontal plane of influence of the drain and the soils closest to the drain typically consolidate faster than those at greater distance. In the second case, equal vertical strain, the strains on any horizontal plane are assumed equal, and no differential settlement occurs. Berry and Wilkinson (1969) used Barron's solutions for free strain convergent flow to a central sand drain to develop a modified version of Taylor's (1948) square root of time method for determining T_{90} and t_{90}. Sridharan et al. (1996) developed a similar method using Barron's equal vertical strains solution for convergent flow. McKinlay (1961) presented another Taylor-type curve-fitting technique for the case of divergent flow, developed from solutions to heat flow in an infinitely long, homogeneous cylinder, presented by Carslaw and Jaeger (1946, 1986). Several other researchers (Escario and Uriel, 1961; Trautwein et al., 1981) have looked at these and other techniques for determining c_h for various conditions, but most end by recommending some form of Taylor's method. Very few researchers have attempted to use a logarithm of time method for determining c_h (Silveira, 1953).

For divergent drainage under free strain conditions, McKinlay (1961) recommends plotting the laboratory data versus time to a power of 0.465, multiplying the abscissa of the linear fit by 1.22, and using T_{90} equal to 0.335. Fig. 3.2 shows this technique applied to the sample from B-10, producing a c_h value of 2.9 ft^2/yr. However, as this is a simplified curve-fitting technique, it was deemed best to reproduce the actual theoretical curve taken from Carslaw and Jaeger (1986) and attempt to match the laboratory data to this curve. Fig. 3.3 shows this process, in which the

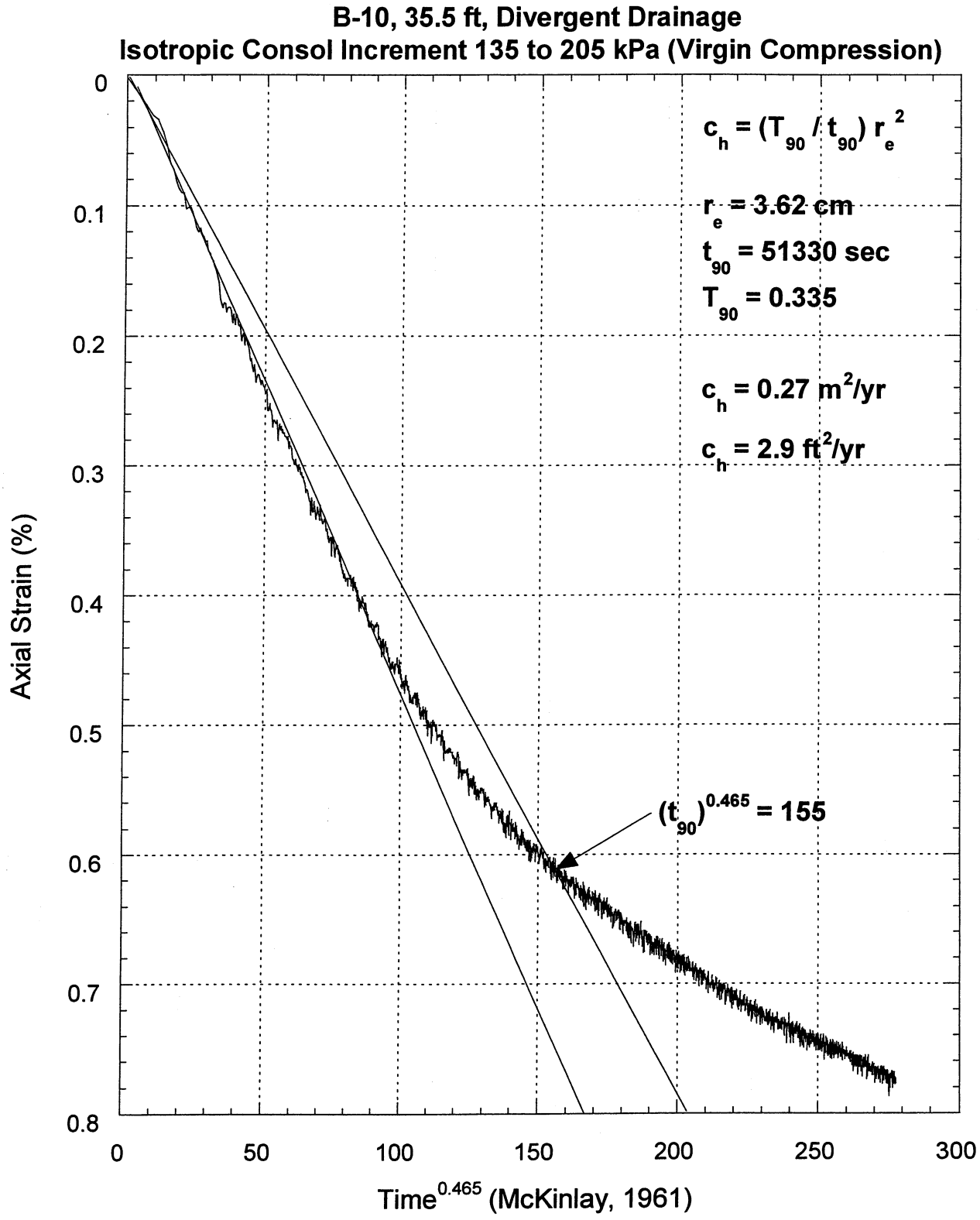

Figure 3.2: Divergent Drainage Simplified Method

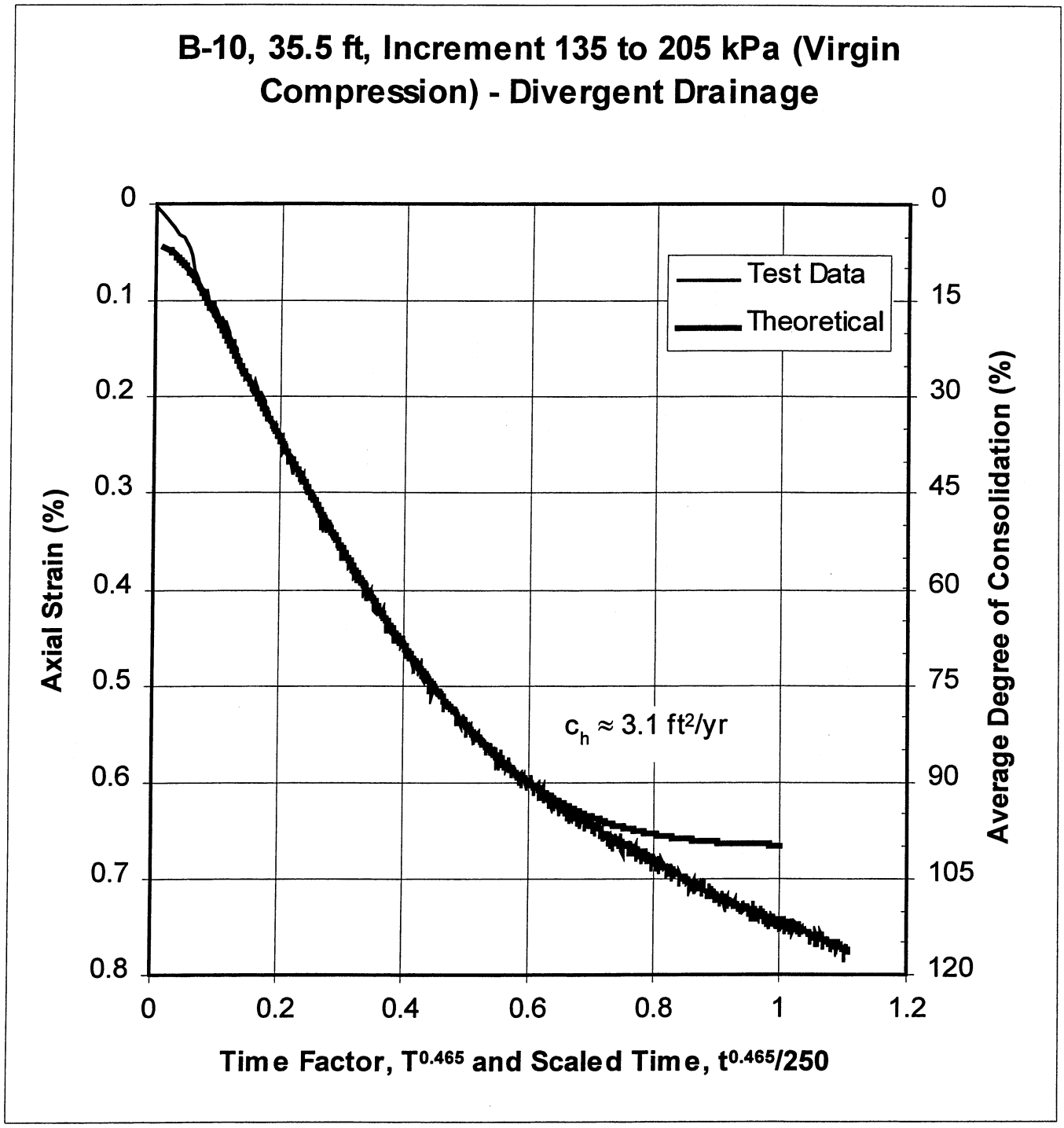

Figure 3.3: Divergent Drainage Curve Fitting Method

laboratory time, t, has been scaled to match the time factor, T, yielding a c_h value of 3.1 ft^2/yr. Secondary compression is quite evident in this figure as the laboratory data falls below the theoretical curve for primary consolidation. In cases where the laboratory data and the theoretical curve diverge prior to reaching 90% consolidation, t_{90} is taken as the equivalent laboratory time on the theoretical curve at 90%, thus minimizing the influence of secondary compression. In general, the divergent drainage tests were found to match theoretical curves well and thus reported values of c_h are determined from this technique rather than McKinlay's method.

For convergent drainage under free strain conditions, Berry and Wilkinson (1969) plot the laboratory data versus the square root of time, use a multiplier of 1.17, and provide a plot of the time factor T versus the average degree of consolidation in the sample for various values of n, where n is the ratio of the diameter of the sample being tested to the diameter of the sand drain. They cannot provide a single value of T_{90} for the convergent drainage case because the ability of the soil to consolidate is dependent on the capacity of the sand drain, which makes T_{90} a function of the ratio n. Sridharan et al. (1996) produce very similar results to Berry and Wilkinson, using square root of time and a multiplier of 1.17, but using time factor T versus degree of consolidation plots based on the equal vertical strain solutions from Barron (1948). It has been shown (Leonards, 1962) that for values of n greater than 5, the free strain and equal vertical strain solutions are approximately equal. The two samples tested with convergent drainage in this study had n values greater than 5 and thus the technique of Sridharan et al. (1996) was used, given that the equations defining the theoretical curves of percent consolidation versus time factor, T, as a function of n are simpler for equal vertical strain versus free strain.

Fig. 3.4 shows the laboratory data from B-7 versus the theoretical curve for convergent drainage with n equal to 6.5. Due largely to the difference in the early portions of the two curves, it was not possible to match the curves well. Most likely these differences are due to layering within the actual sample versus the theoretical curve which assumes a homogeneous material. Thus, in the actual sample silt seams consolidate faster than the clay layers, increasing the initial rate of consolidation, while the latter portion of the data represents more of the interaction between the clay and the silt and is likely dominated by the clay consolidation rate. With this assumption, the simplified method proposed by Sridharan et al. (1996) was deemed suitable as the linear fit to

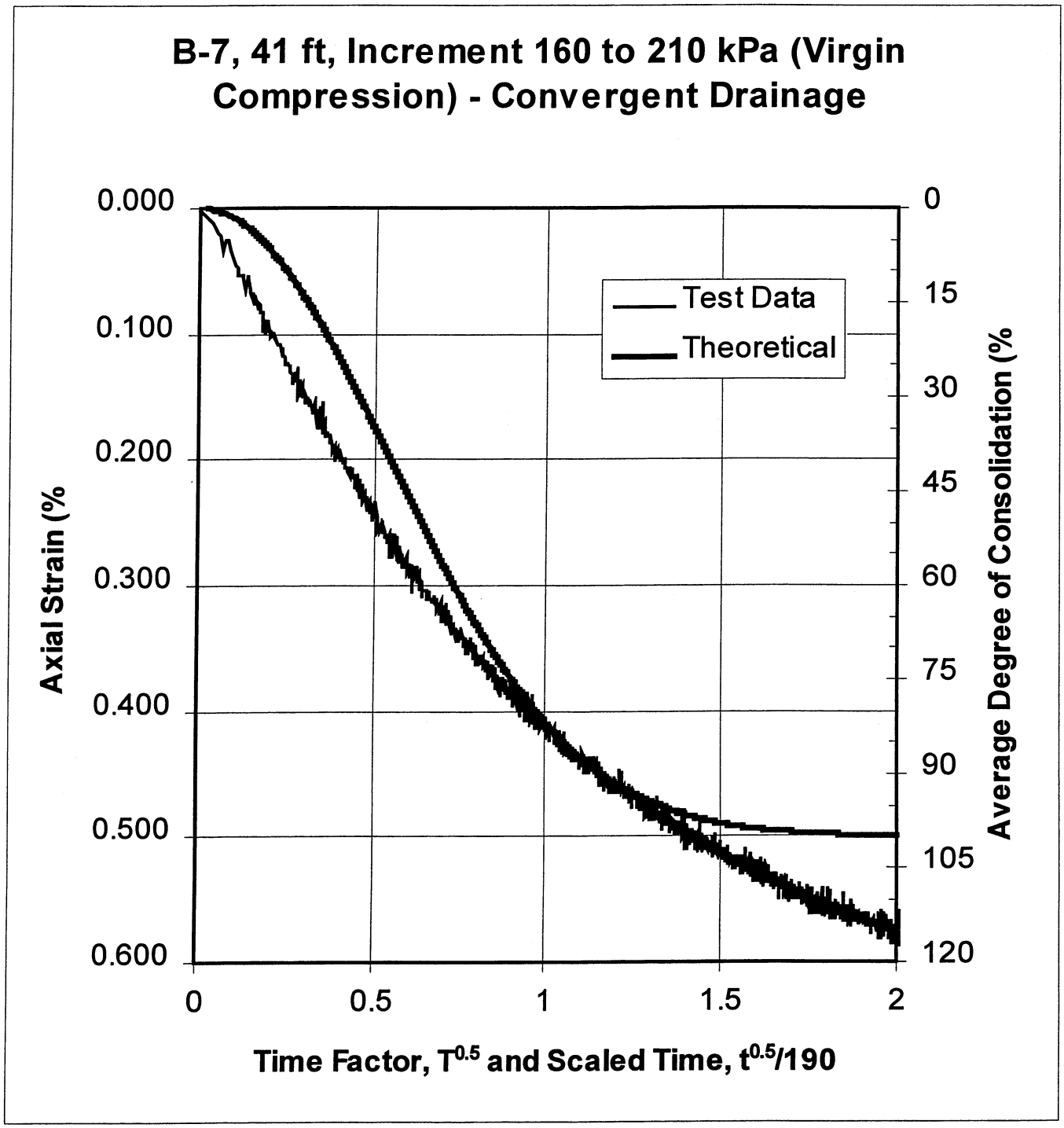

Figure 3.4: Convergent Drainage Curve Fitting Method

the curve is best in the 20% to 60% consolidation range, not the early part of the test. Fig. 3.5 shows use of this technique on the same B-7 laboratory data, resulting in a c_h value of 19 ft^2/yr.

3.4 Results of consolidation testing

The first two specimens, tested with divergent drainage only, yield values for normally consolidated conditions of c_h of 3.1 to 3.2 ft^2/year (from B-10 at 35.5 ft depth) and 10.2 to 10.3 ft^2/year (from B-9 at 30.5 ft depth). These values are somewhat below expectations, considering that we usually assume higher horizontal vs. vertical permeability in such sediments, and that the material seems to be coarser than other San Francisco bay deposits that have values of the vertical coefficient of consolidation, c_v, in the range of 8 to 10 ft^2/yr. Our assumption is that a combination of filter paper and sampling induced smear led to these reduced values of c_h.

The third and fourth consolidation tests were built to investigate the effects of these factors by consolidating the samples with different drainage paths – both divergent and convergent. The samples from B-7 at 41 ft and P-2 at 40 ft yielded divergent c_h values of 0.8 ft^2/yr and 0.5 ft^2/yr respectively. These abnormally low values are assumed due to restricted flow capacity of the filter paper, which produced a more severe effect for these samples than in the first two tests because drainage was limited to one end of the sample only. This phenomenon was in fact observed earlier by Rowe (1959). Convergent drainage values of c_h, while somewhat difficult to interpret, were estimated at 19 ft^2/yr and 39 ft^2/yr for B-7 and P-2 respectively, yielding much more reasonable values.

Table 3.2: Results of consolidation tests

Boring	Sample #	Test Type	Isotropic Loading Increment (kPa)	c_h (ft^2/yr)
P-2	15	Convergent	150-200	39
B-7	12	Convergent	160-210	19
P-2	15	Divergent	200-250	0.5
B-7	12	Divergent	210-260	0.8
B-9	8	Divergent	125-200	11
B-10	10	Divergent	135-205	3

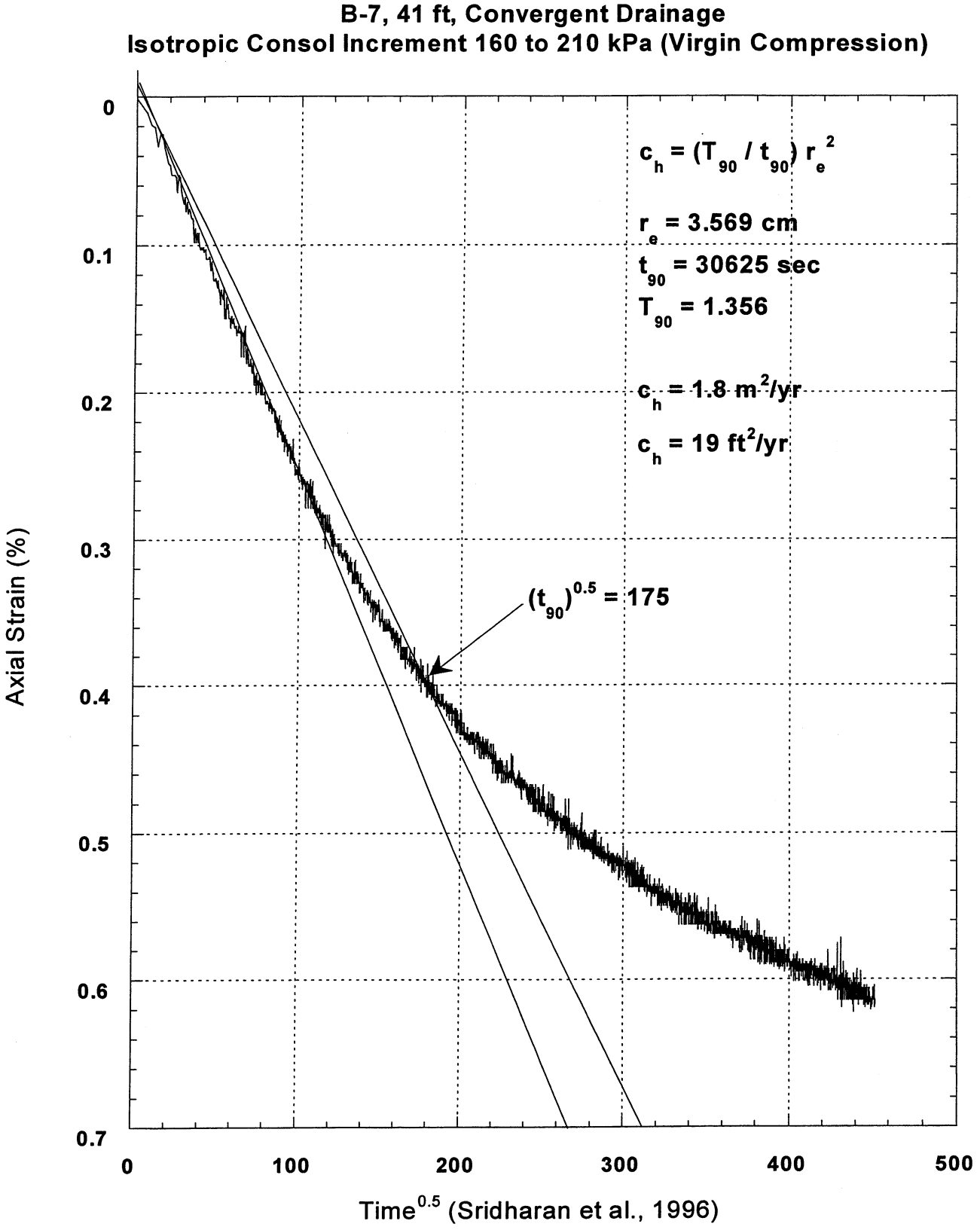

Figure 3.5: Convergent Drainage Simplified Method

In summary, it became apparent during the consolidation testing of the final two specimens (from P-2 and B-7) that the presence of filter paper on the circumference of the soil was probably not sufficient to provide a free draining boundary, and was in fact restricting the consolidation flow from the soil. As such, it seems wise to discount the values of c_h obtained from the divergent drainage conditions, and rely more directly on the higher values obtained from the convergent cases.

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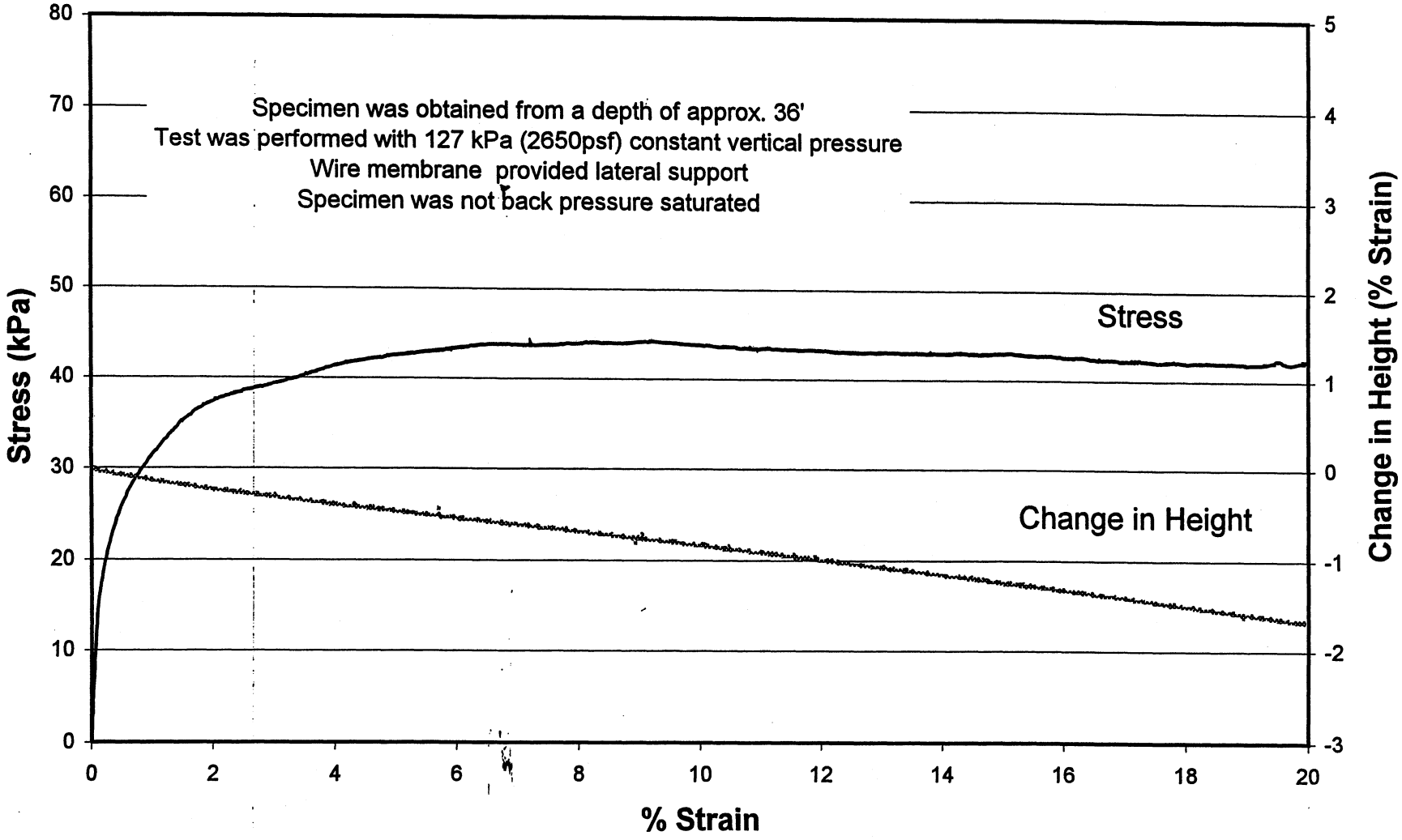
APPENDIX A

Simple Shear Testing Results

SFOBB Boring B-5 Specimen 1
Monotonic Test Only



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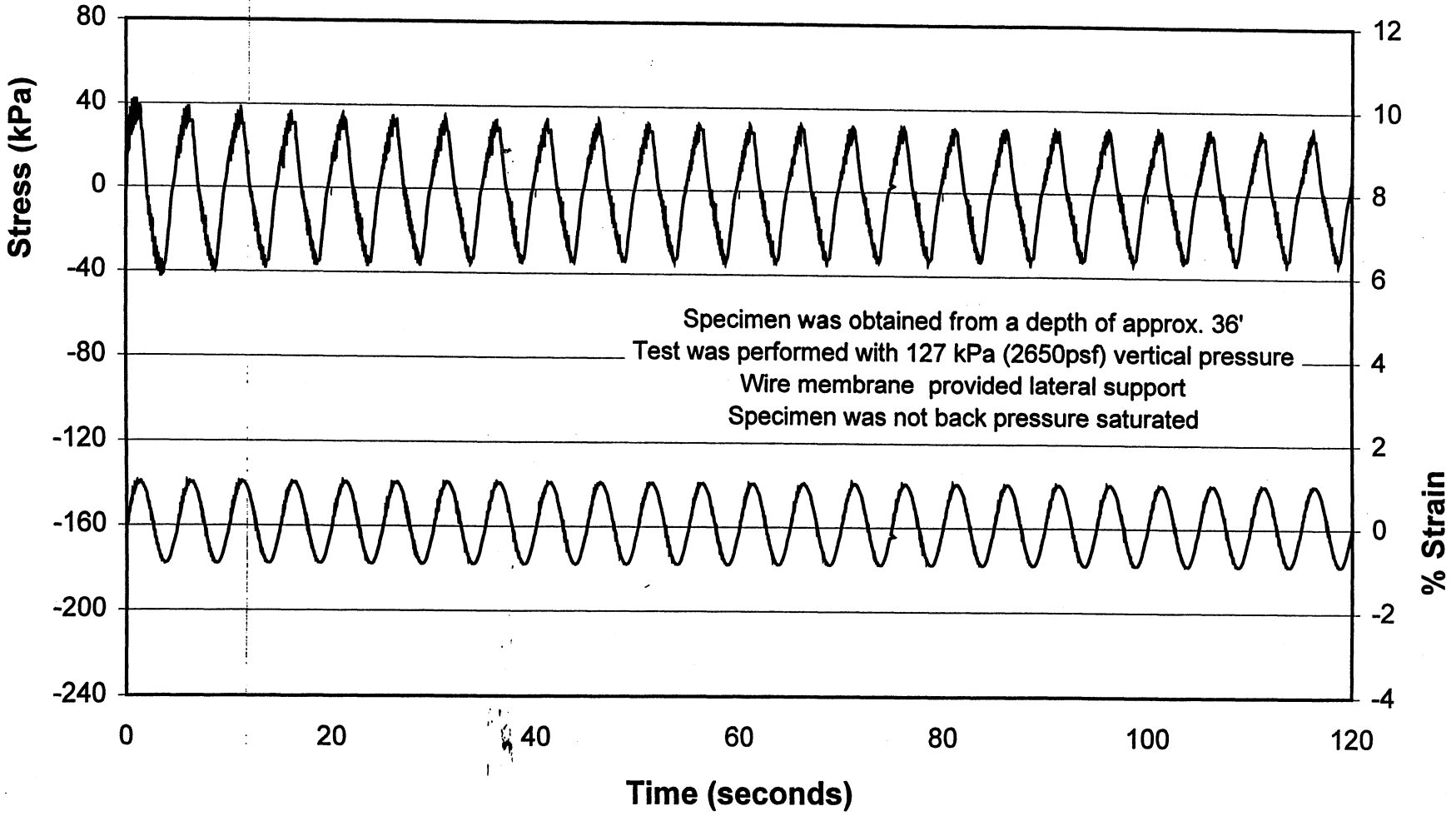
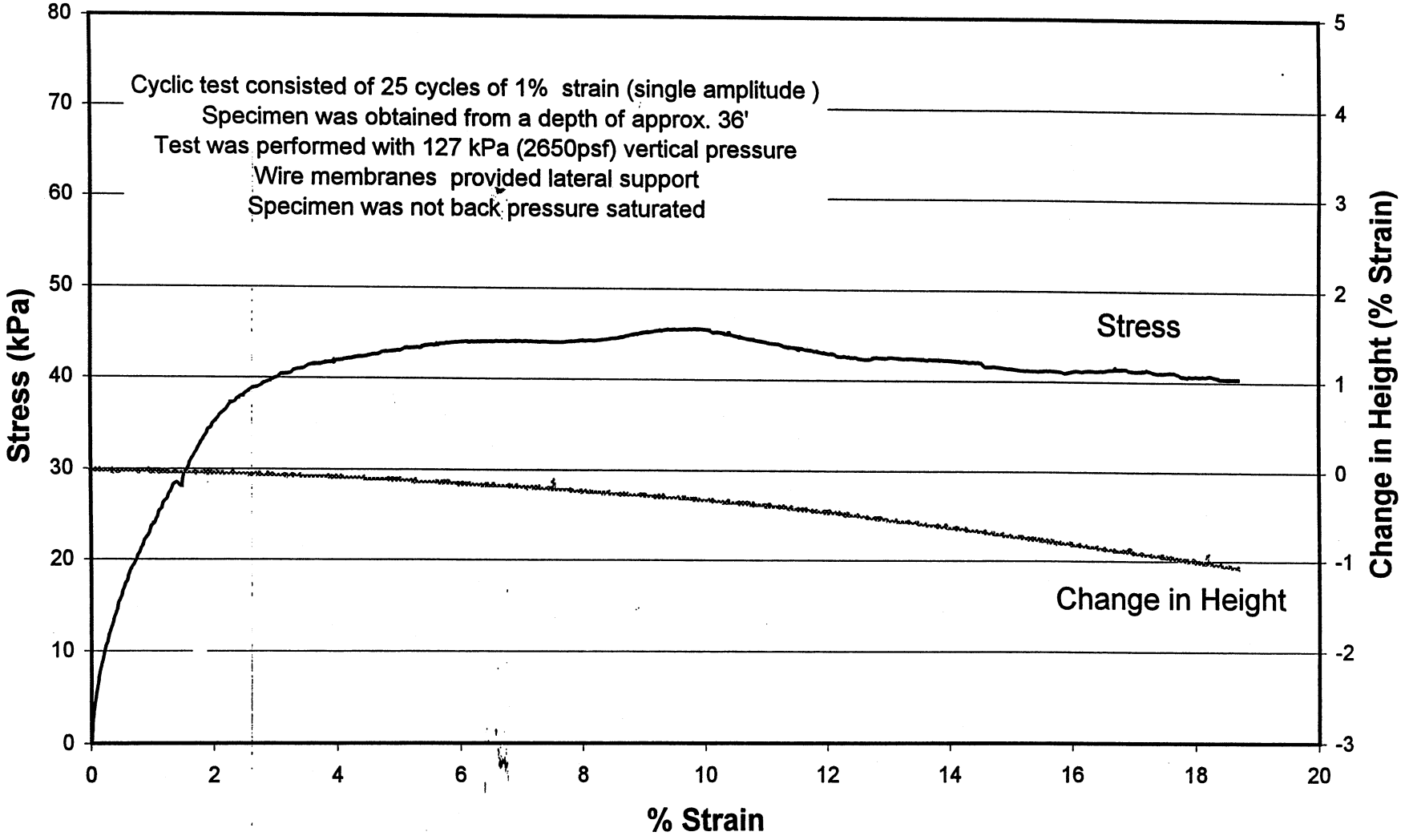
SFOBB Boring B-5 Specimen 4
Cyclic Test to 1% Strain (Single Amplitude)



SFOBB Boring B-5 Specimen 4
Monotonic Test after Cyclic Test



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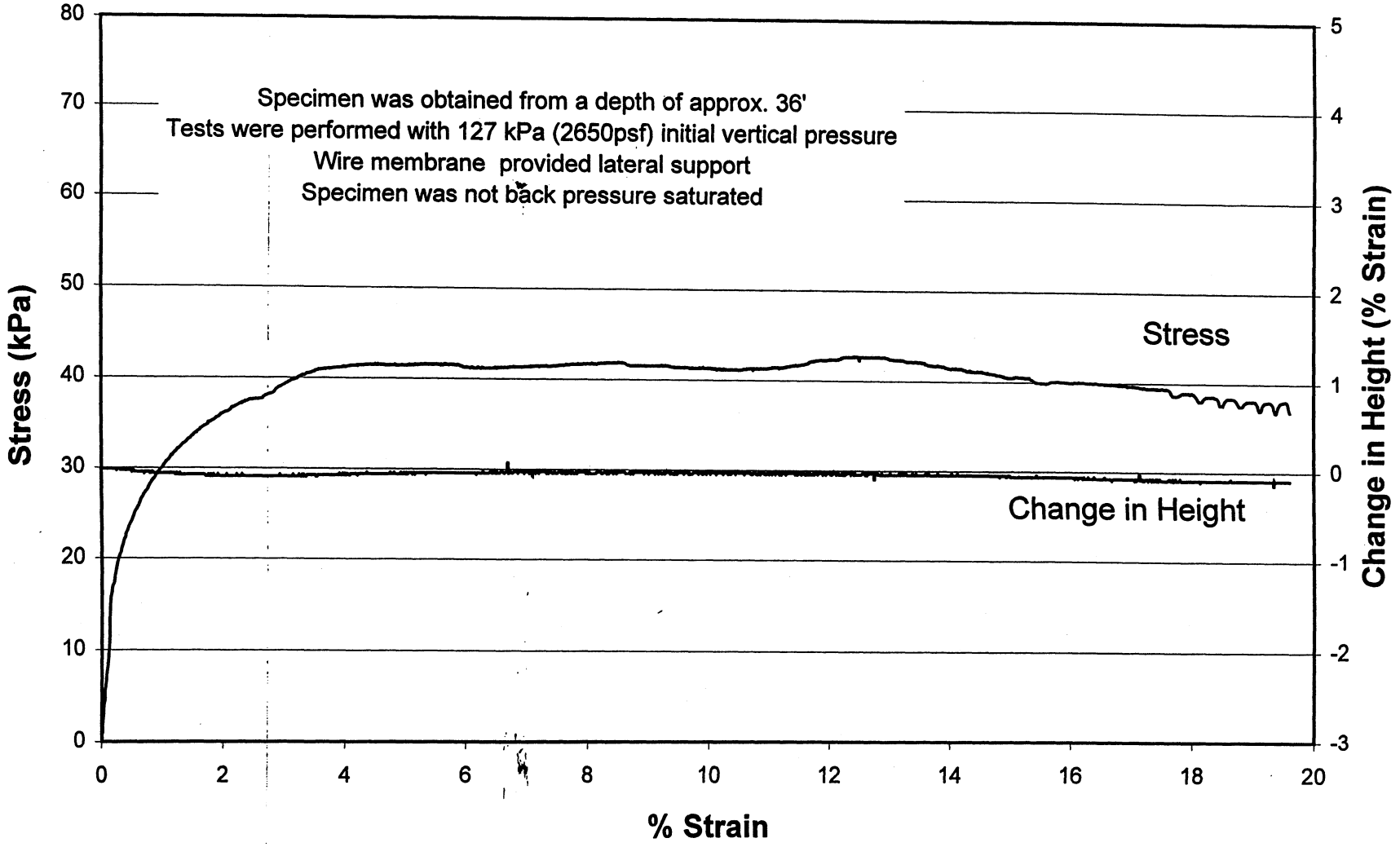
SFOBB Boring B-5 Specimen 5
Monotonic Test Under Constant Vertical Height



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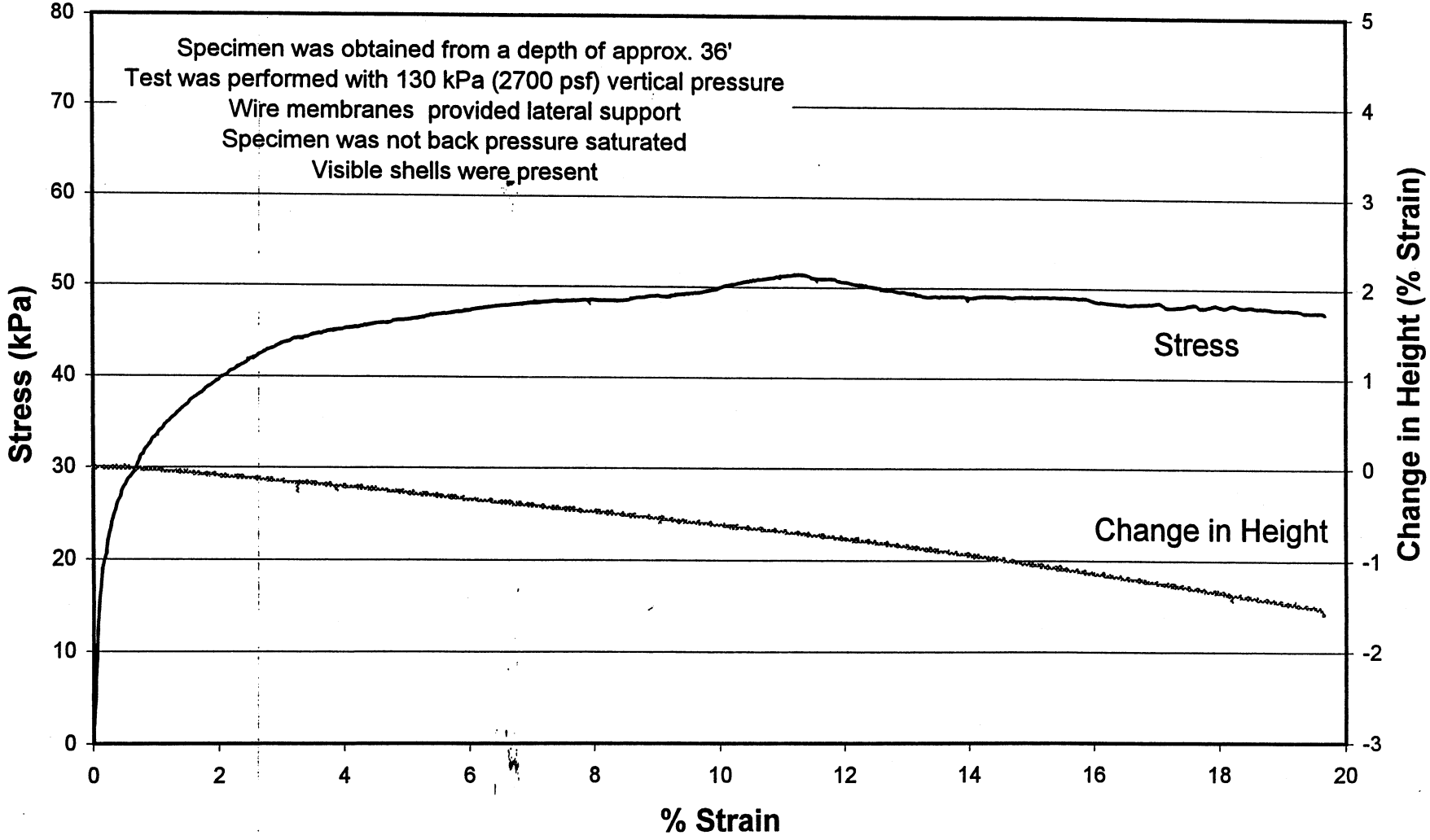
SFOBB Boring B-2 Specimen 6
Monotonic Test Only



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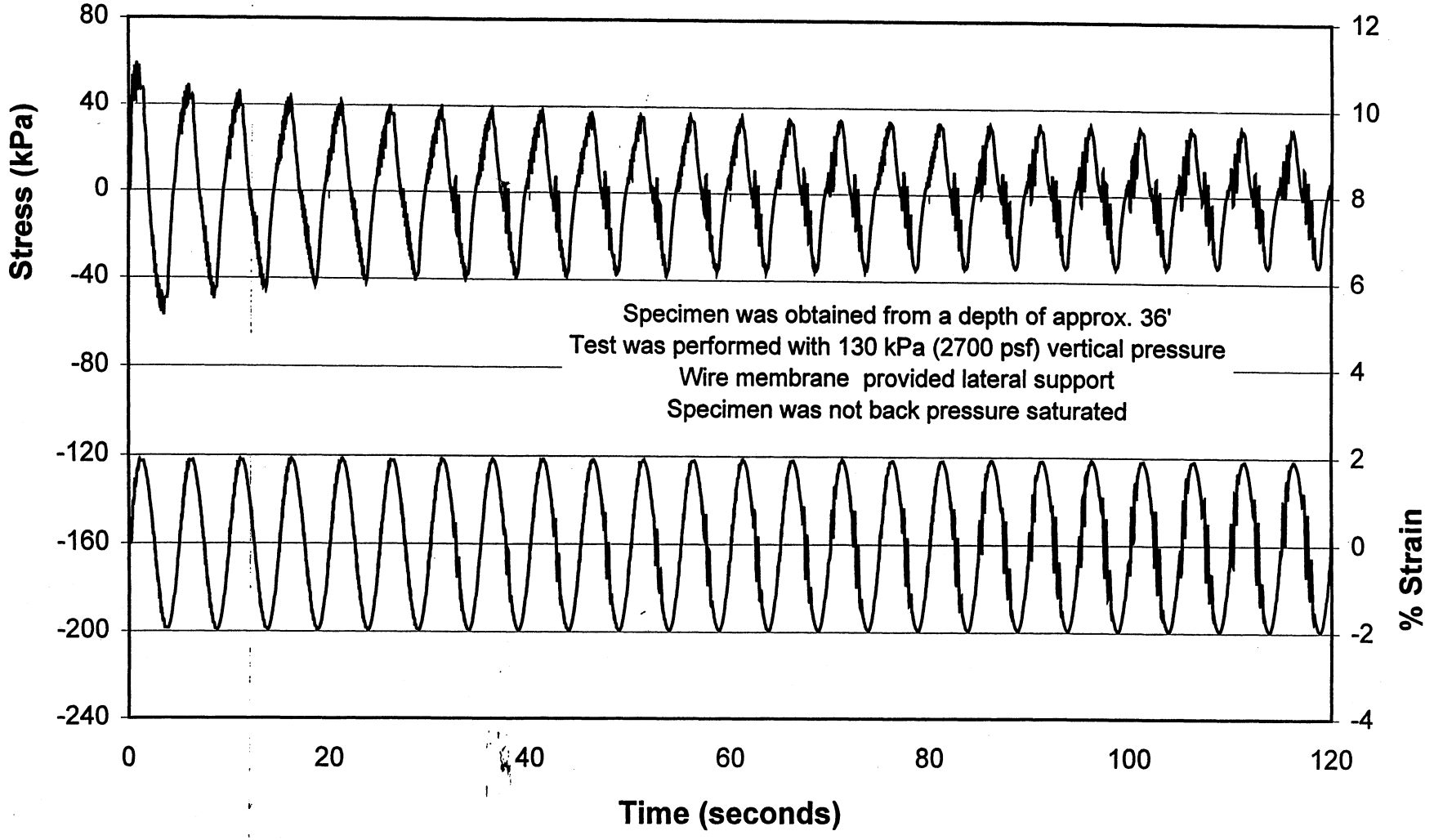
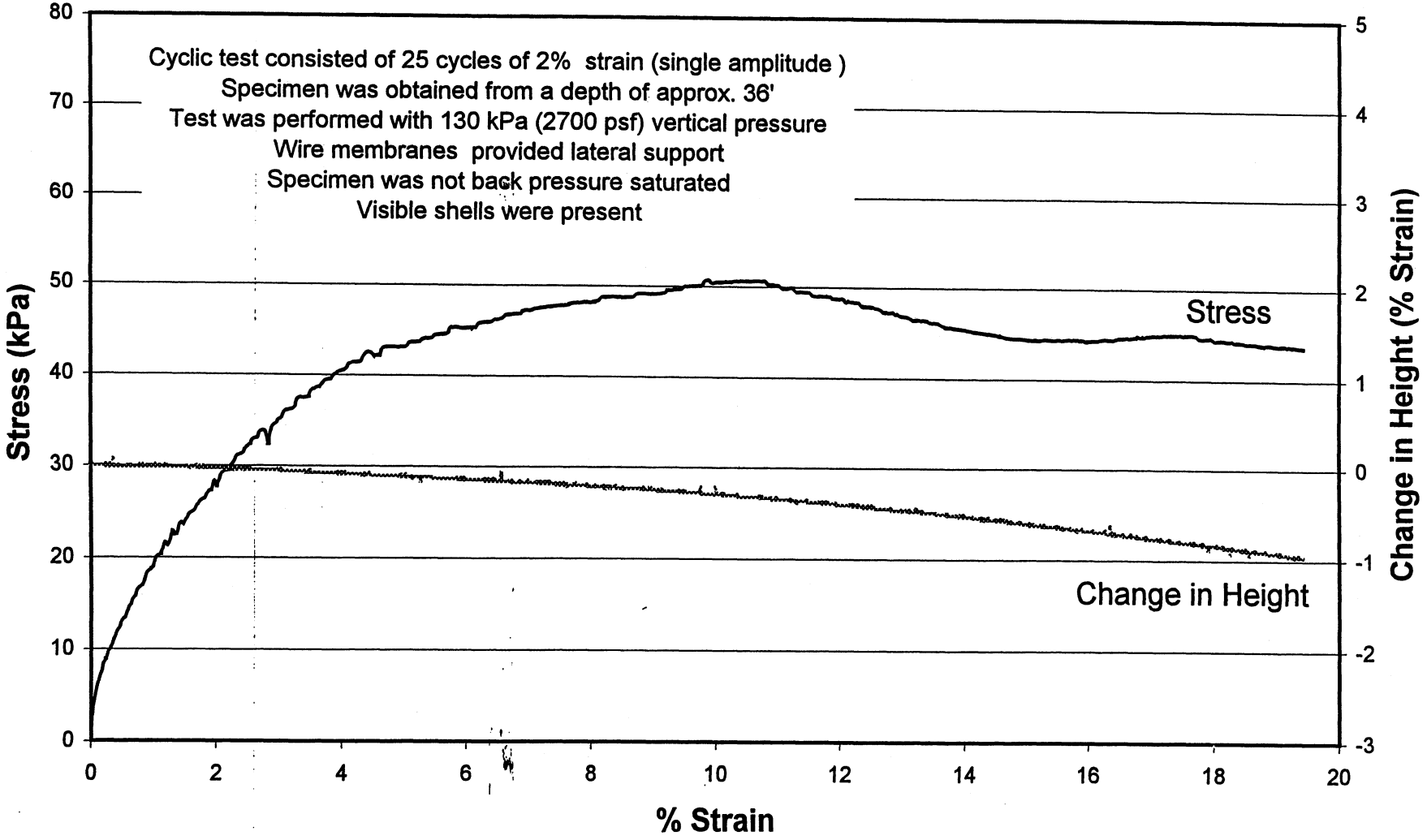
SFOBB Boring B-2 Specimen 8
Cyclic Test to 2% Single Amplitude Strain



SFOBB Boring B-2 Specimen 8
Monotonic Test After Cyclic



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SFOBB Boring B-9 Specimen 9
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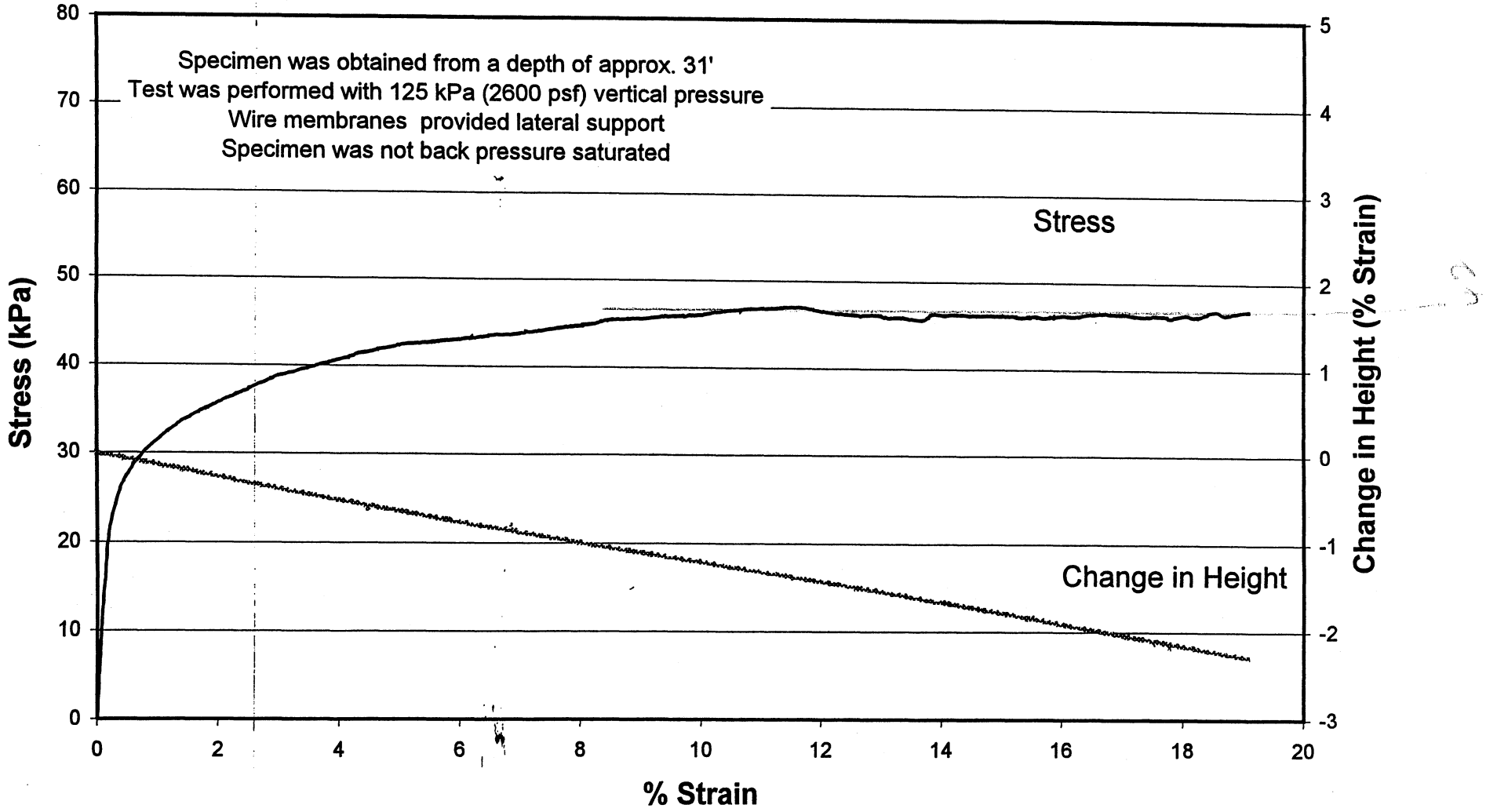

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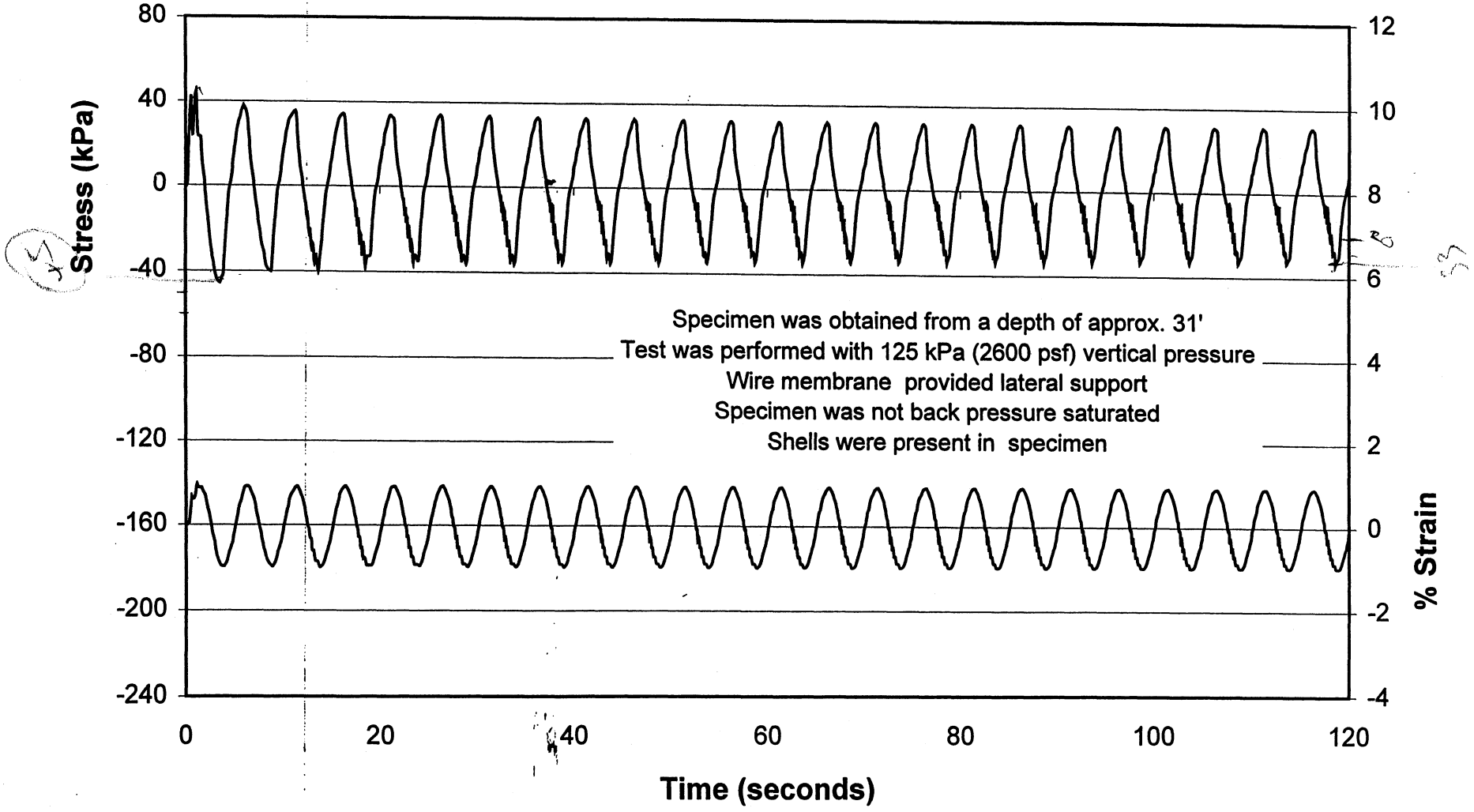
SFOBB Boring B-9 Specimen 10
Cyclic Test to 1% Single Amplitude Strain



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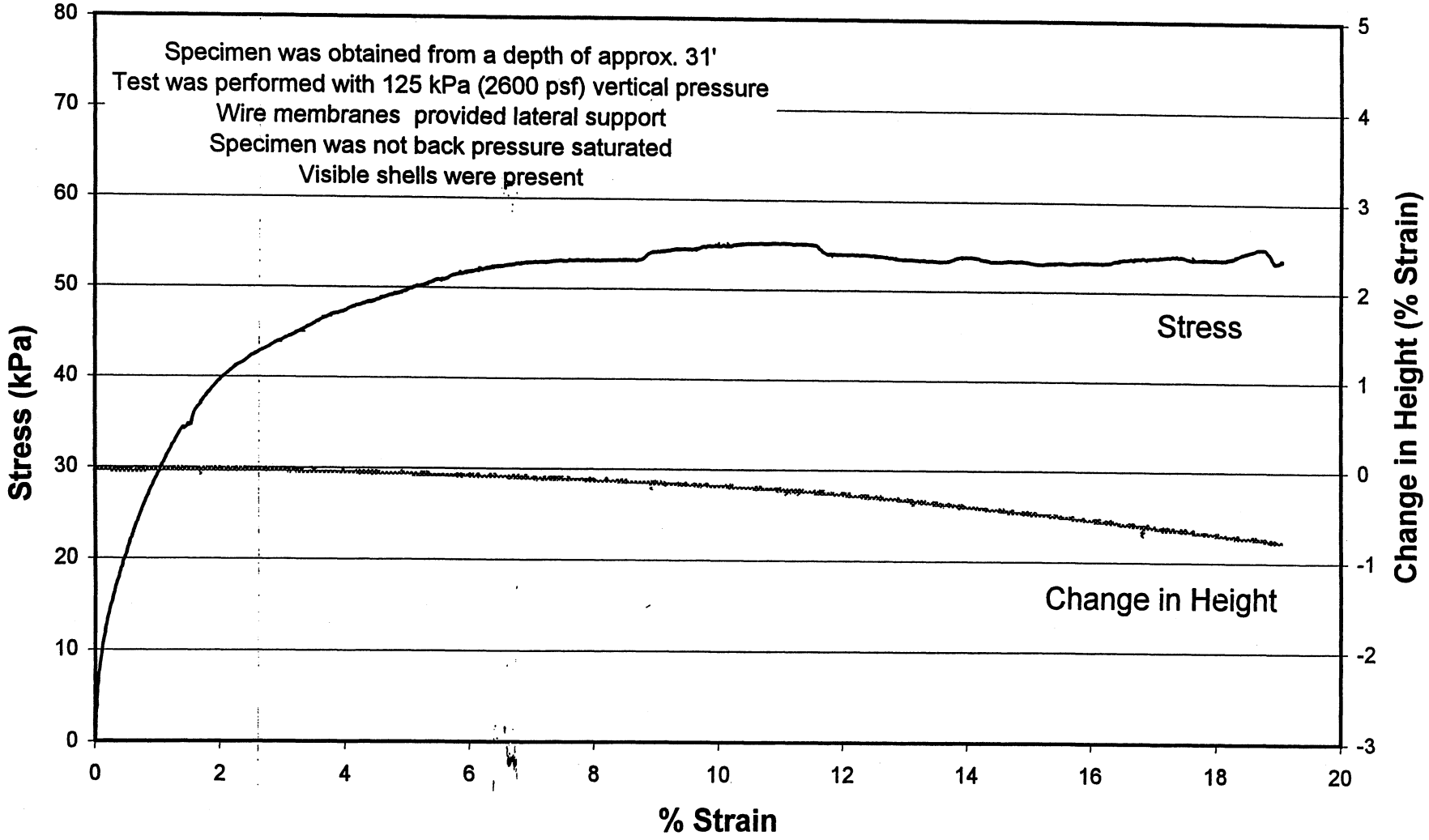
SFOBB Boring B-9 Specimen 10
Monotonic Test After Cyclic



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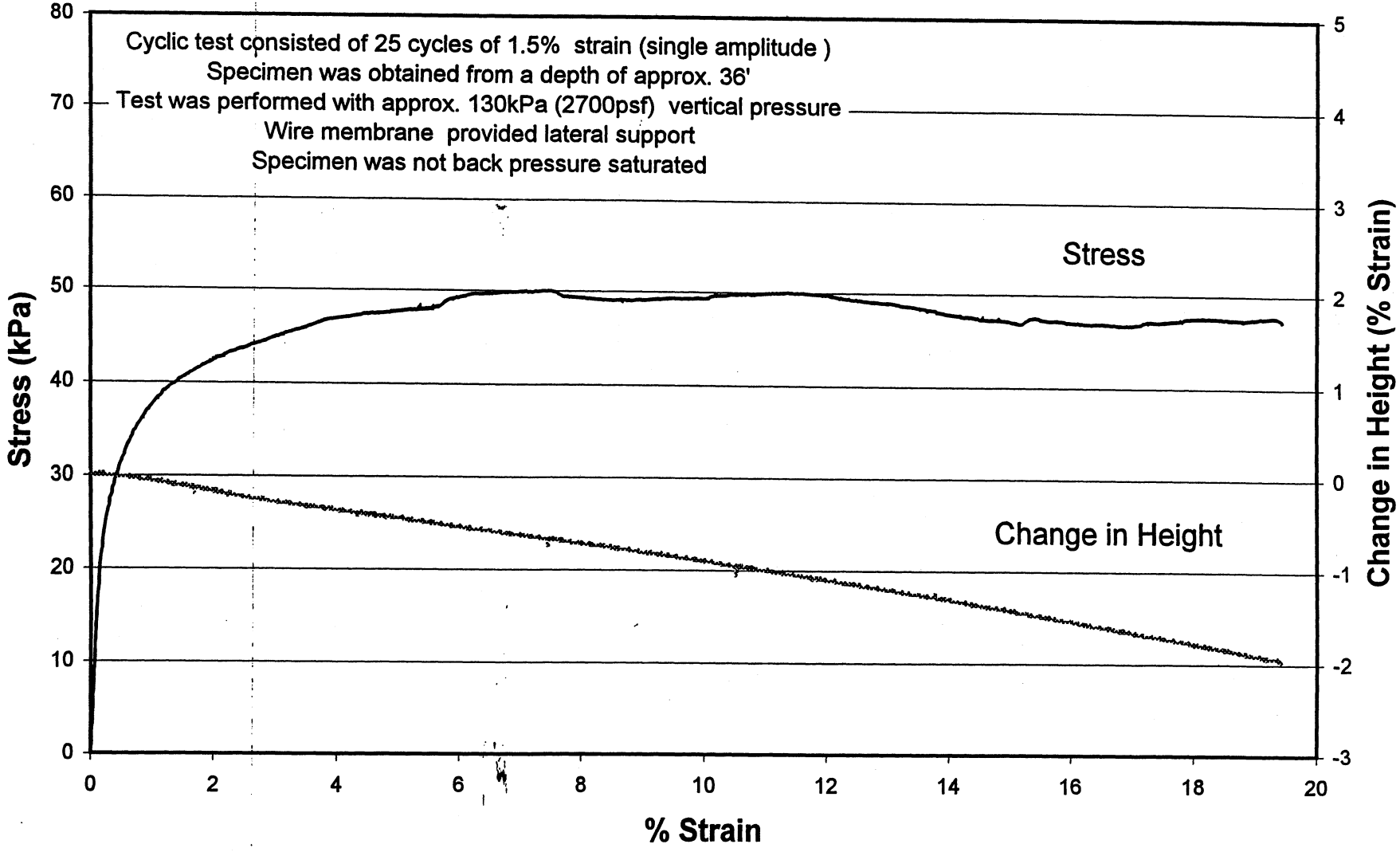

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SFOBB Boring B-10 Specimen12
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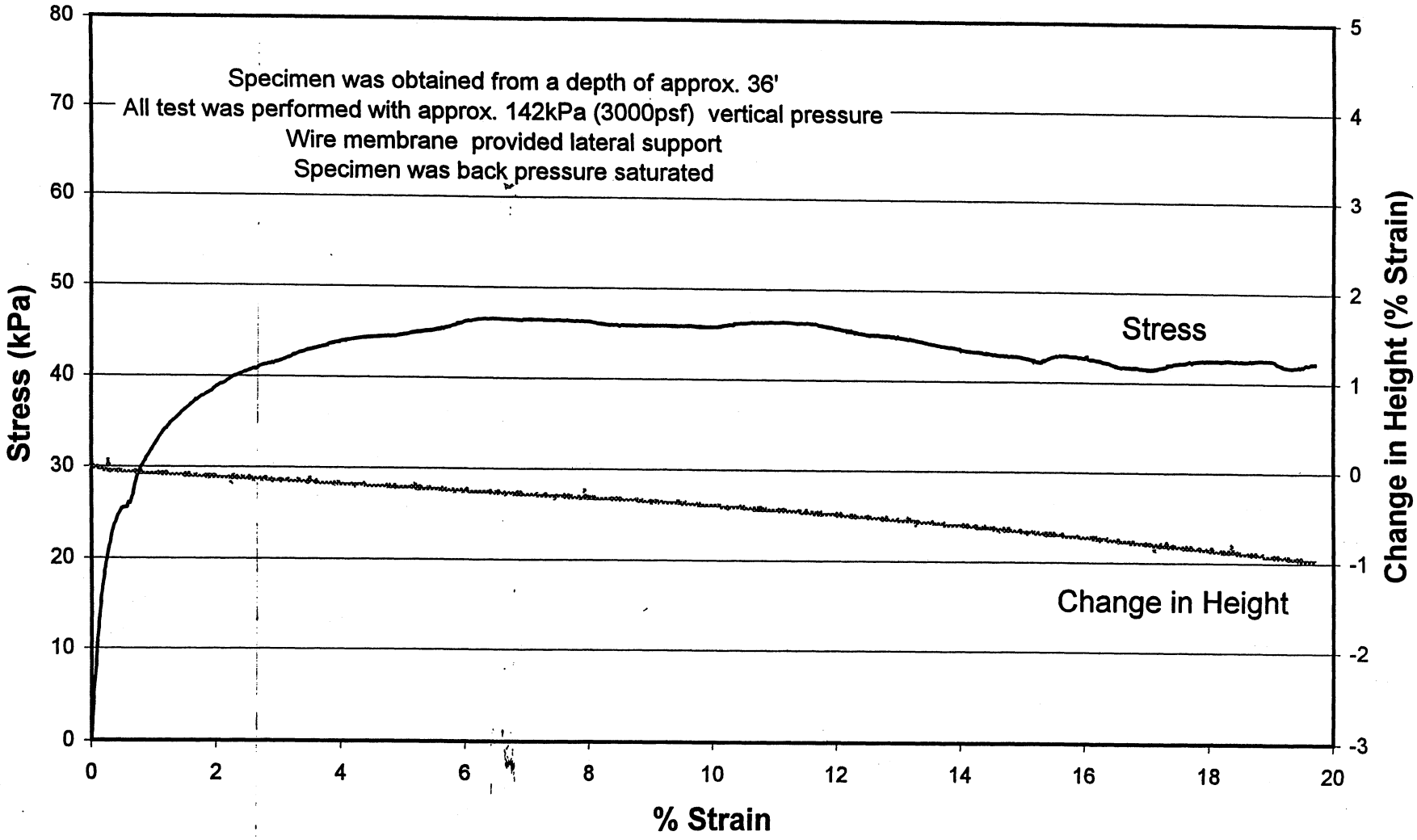

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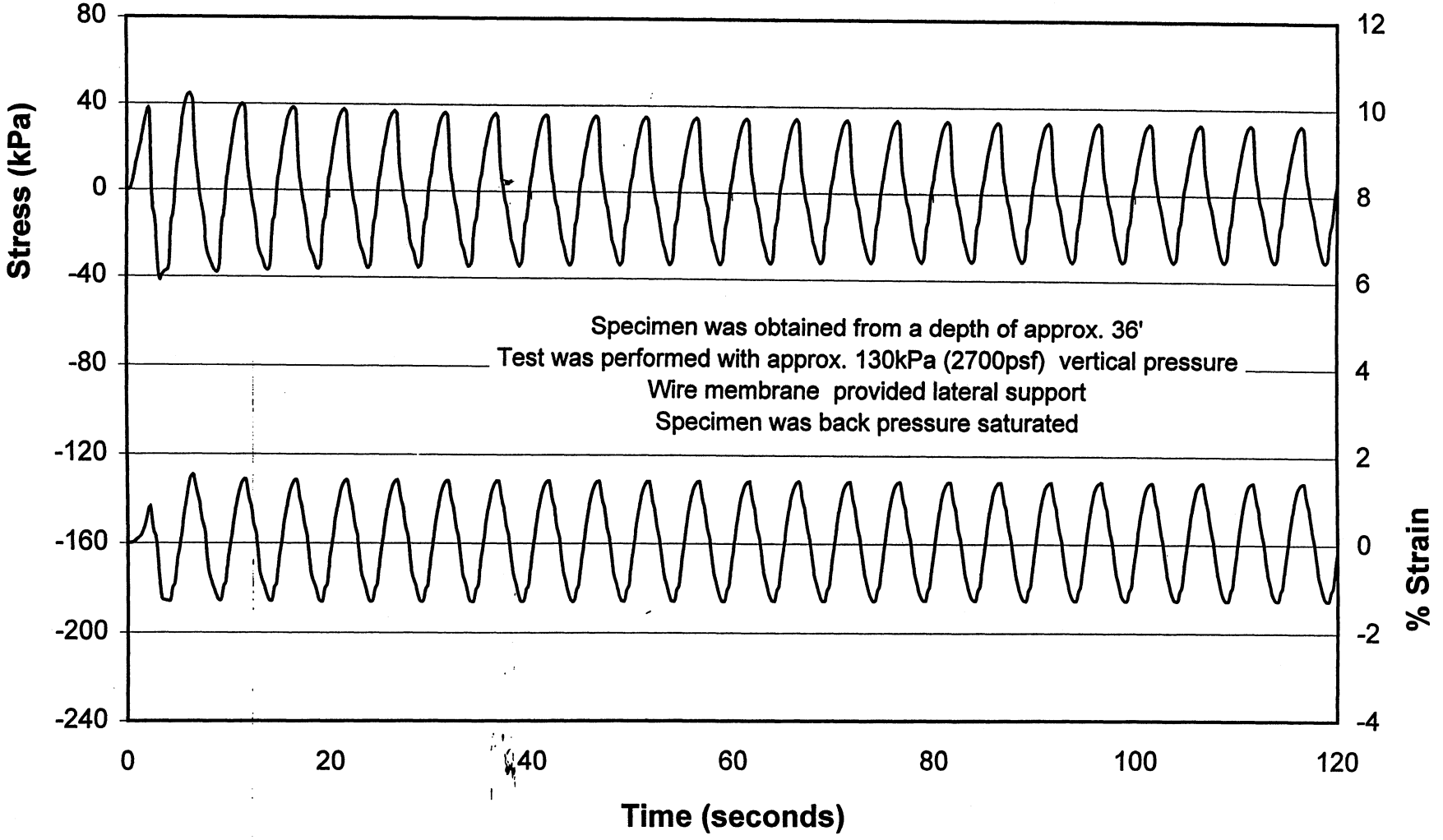
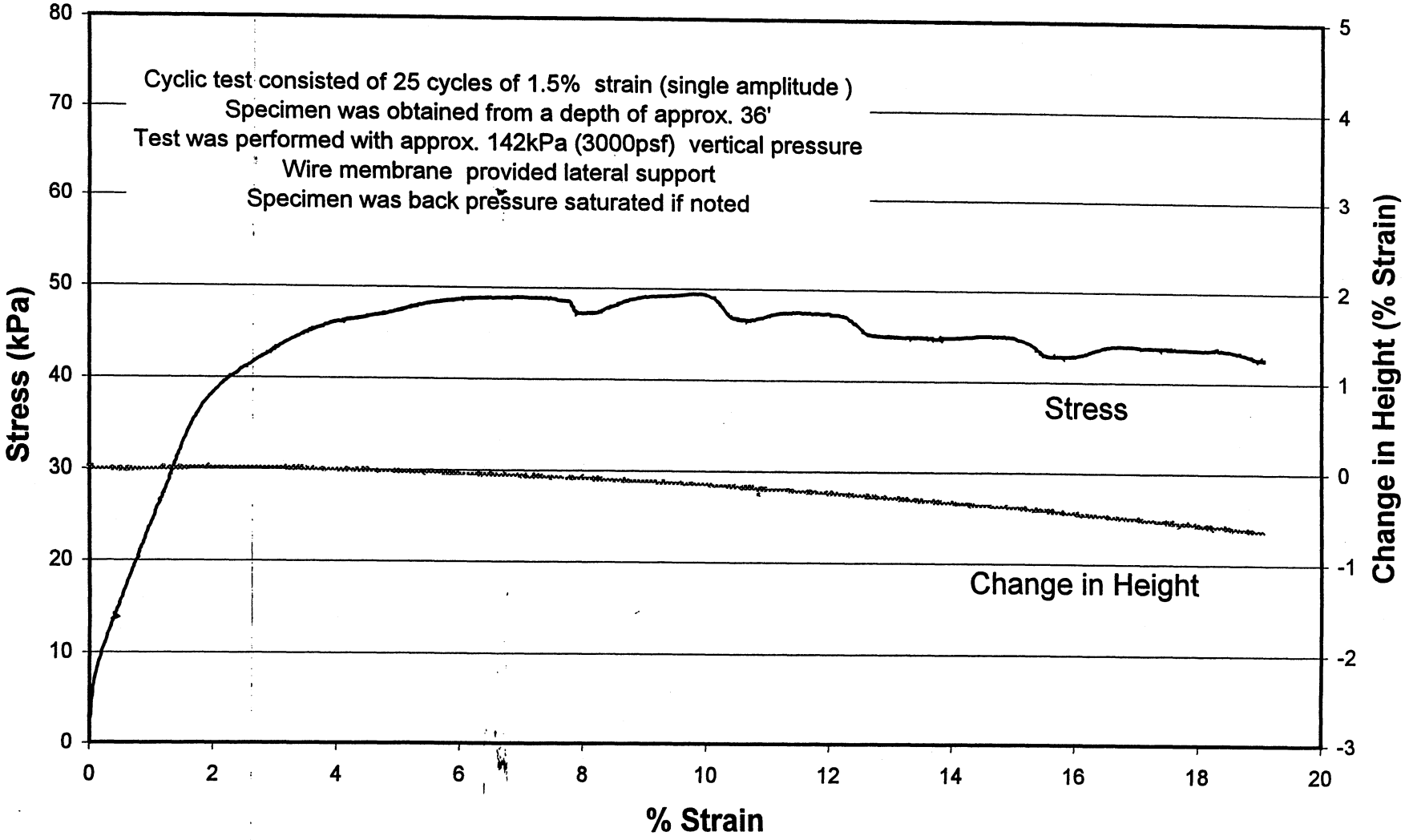
SFOBB Boring B-10 Specimen 13
Cyclic Test to 1.5% Strain (Single Amplitude)



SFOBB Boring B-10 Specimen 13
Monotonic Test After Cyclic Test



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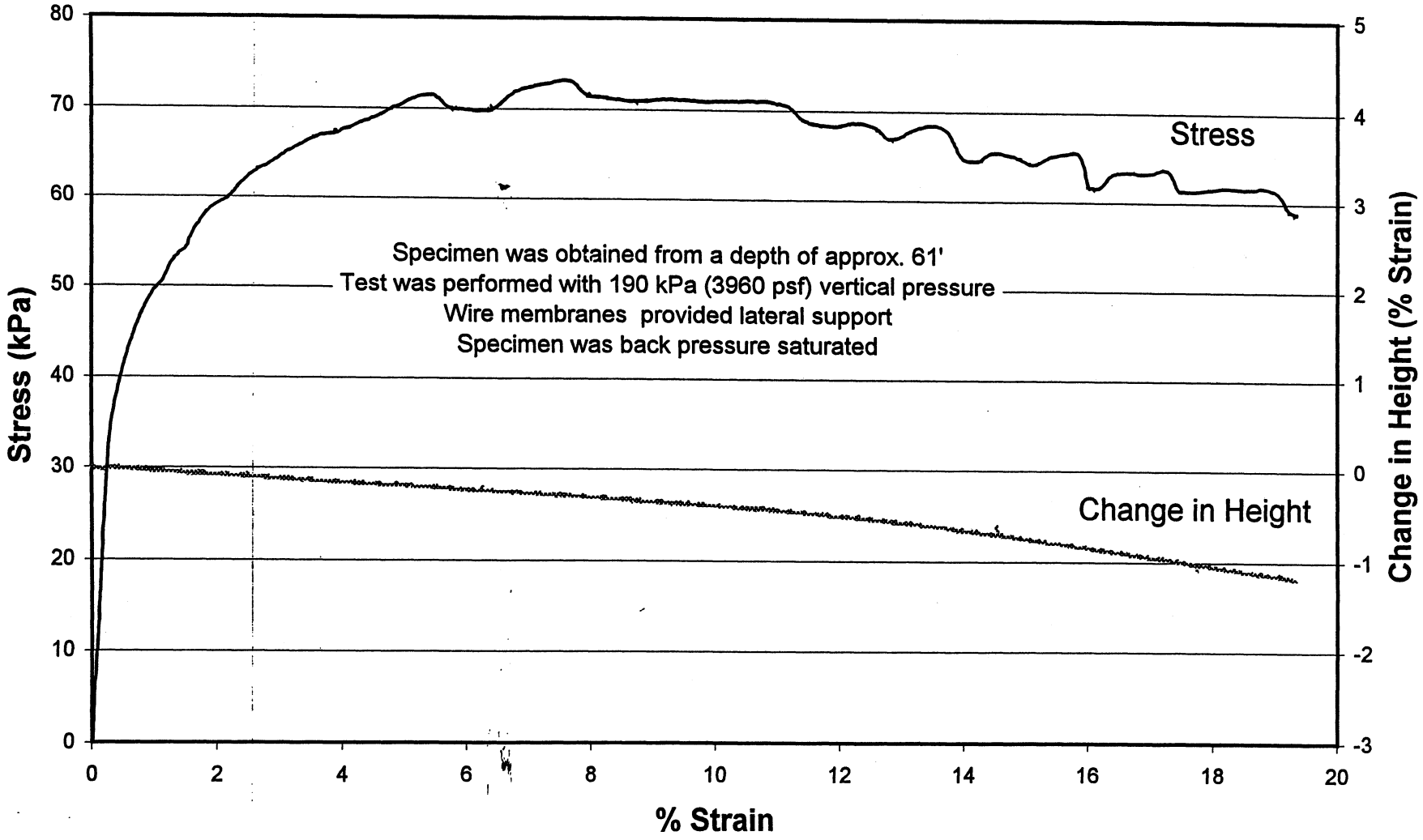

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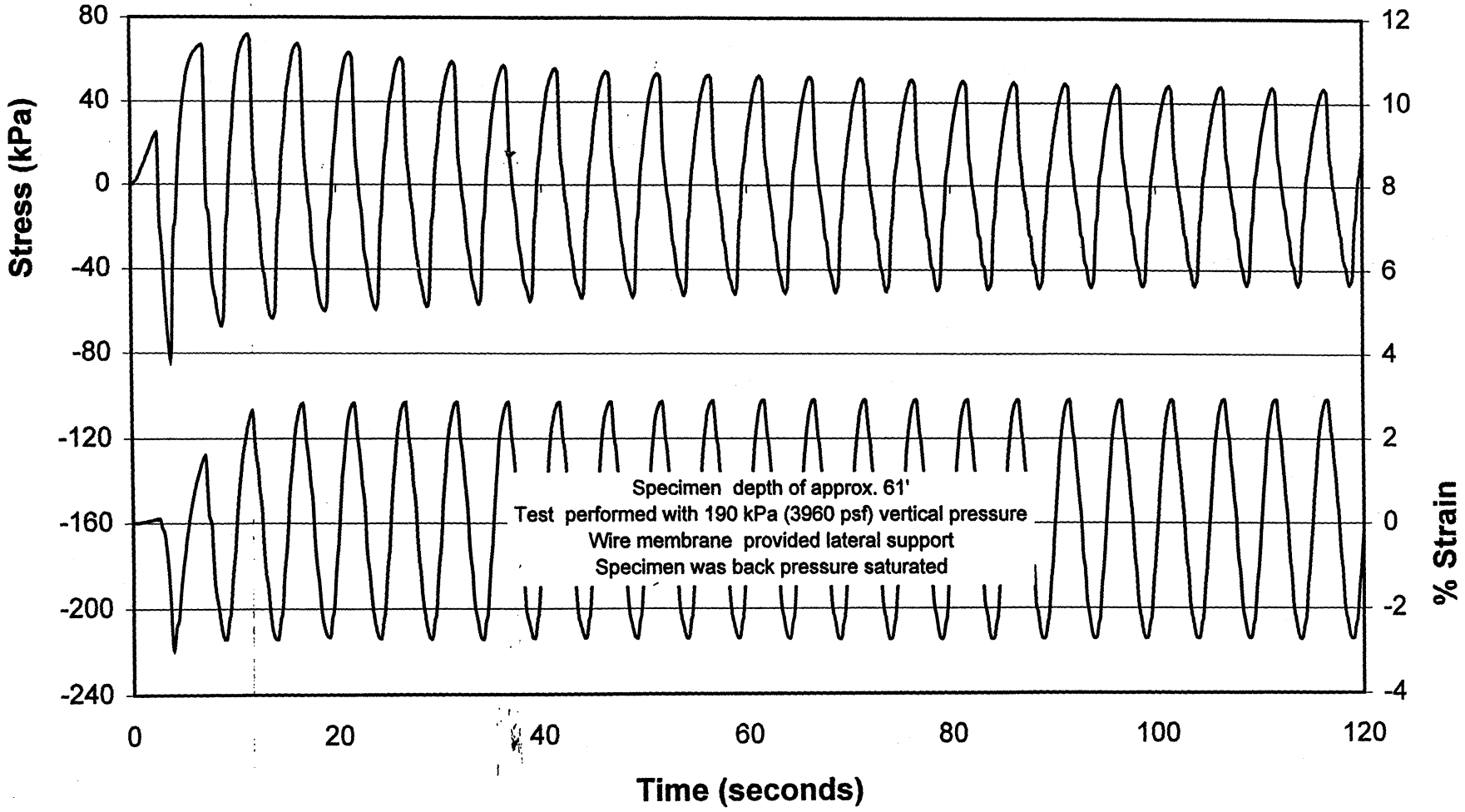
SFOBB Boring B-6 Specimen 15
Cyclic Test to 3% Single Amplitude Strain



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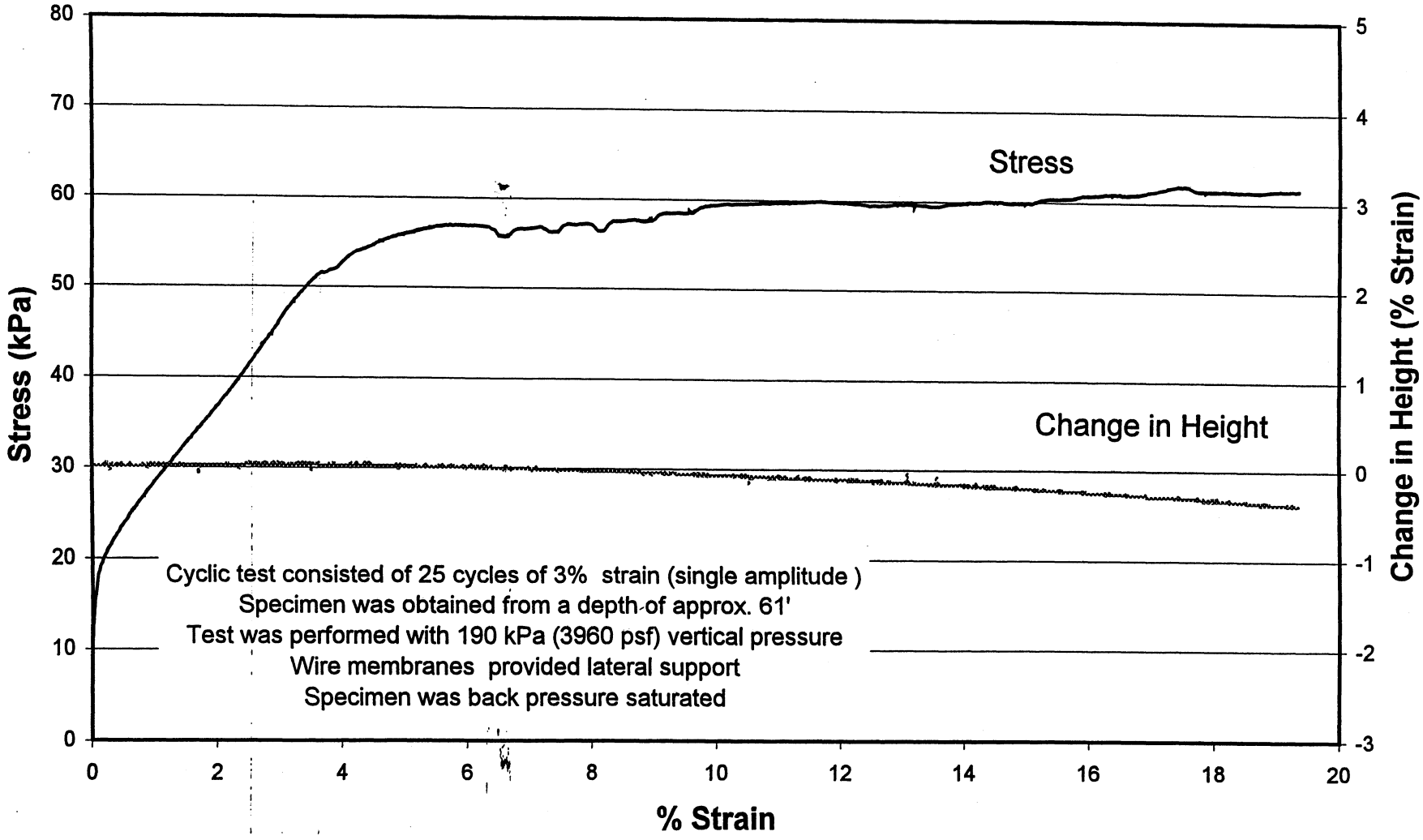
SFOBB Boring B-6 Specimen15
Monotonic Test After Cyclic



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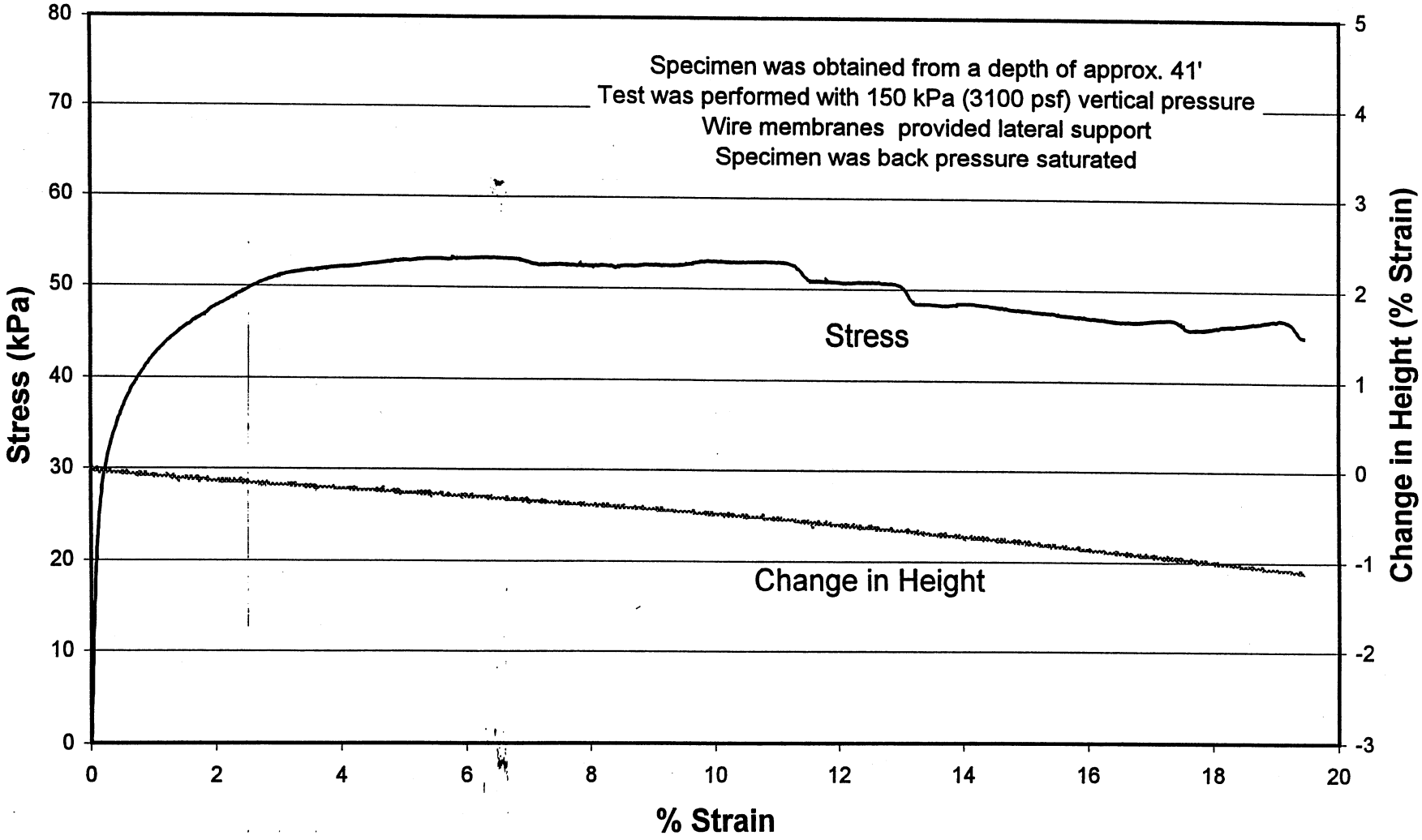
SFOBB Boring P-2 Specimen 16
Monotonic Test Only



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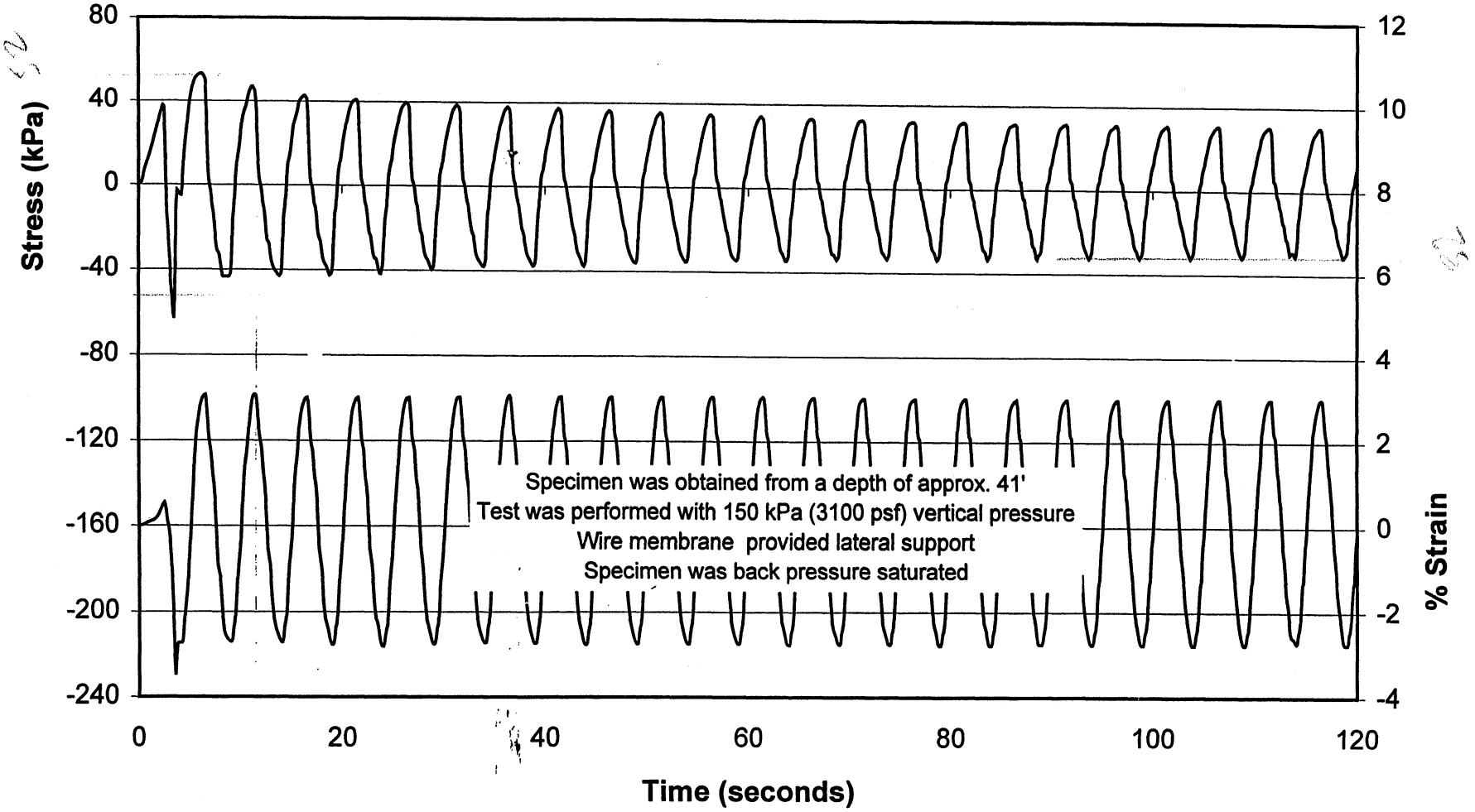
SFOBB Boring P-2 Specimen 17
Cyclic Test to 3% Single Amplitude Strain



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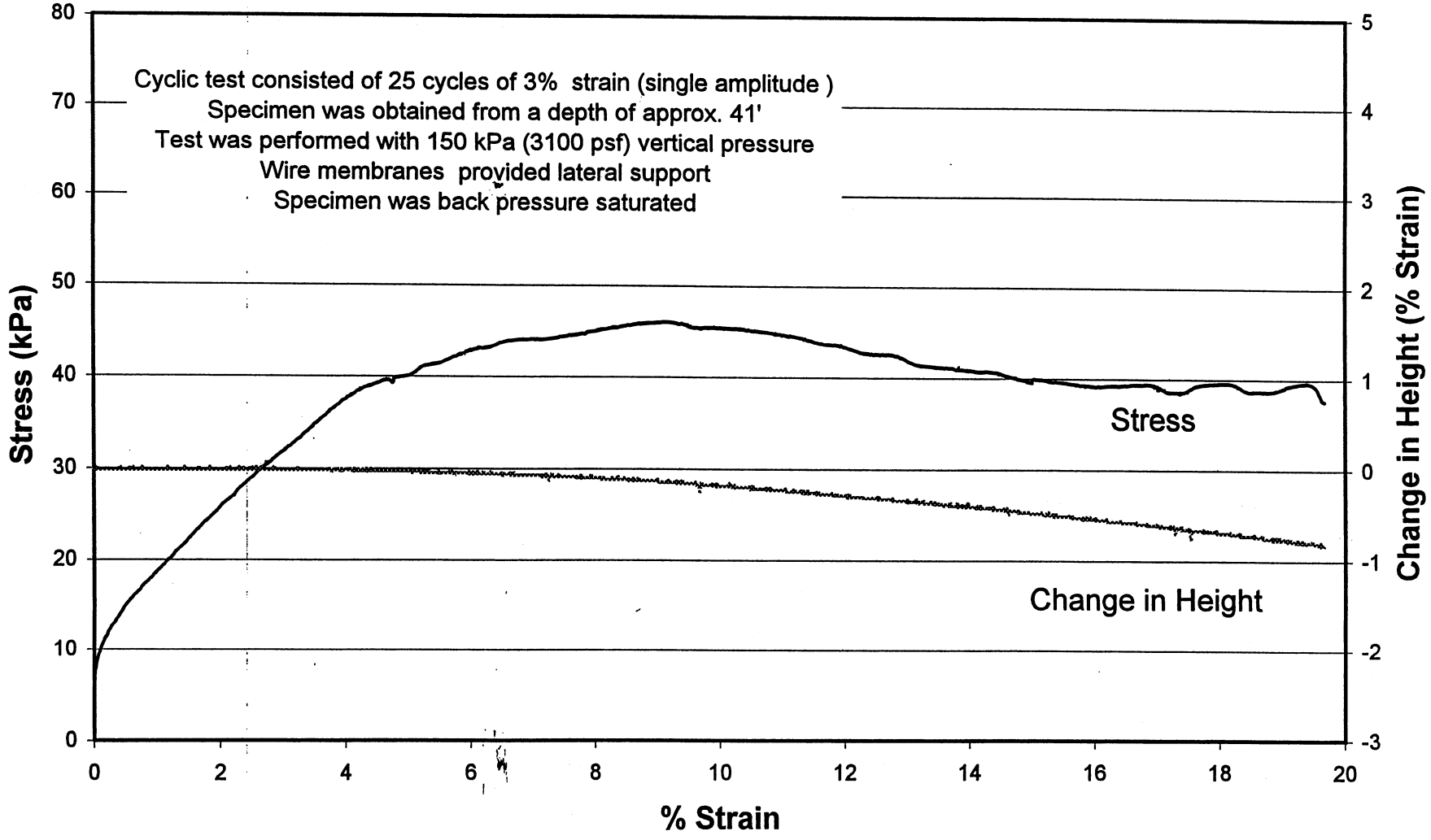
Summary Plots.xls

SFOBB Boring P-2 Specimen 17
Monotonic Test After Cyclic



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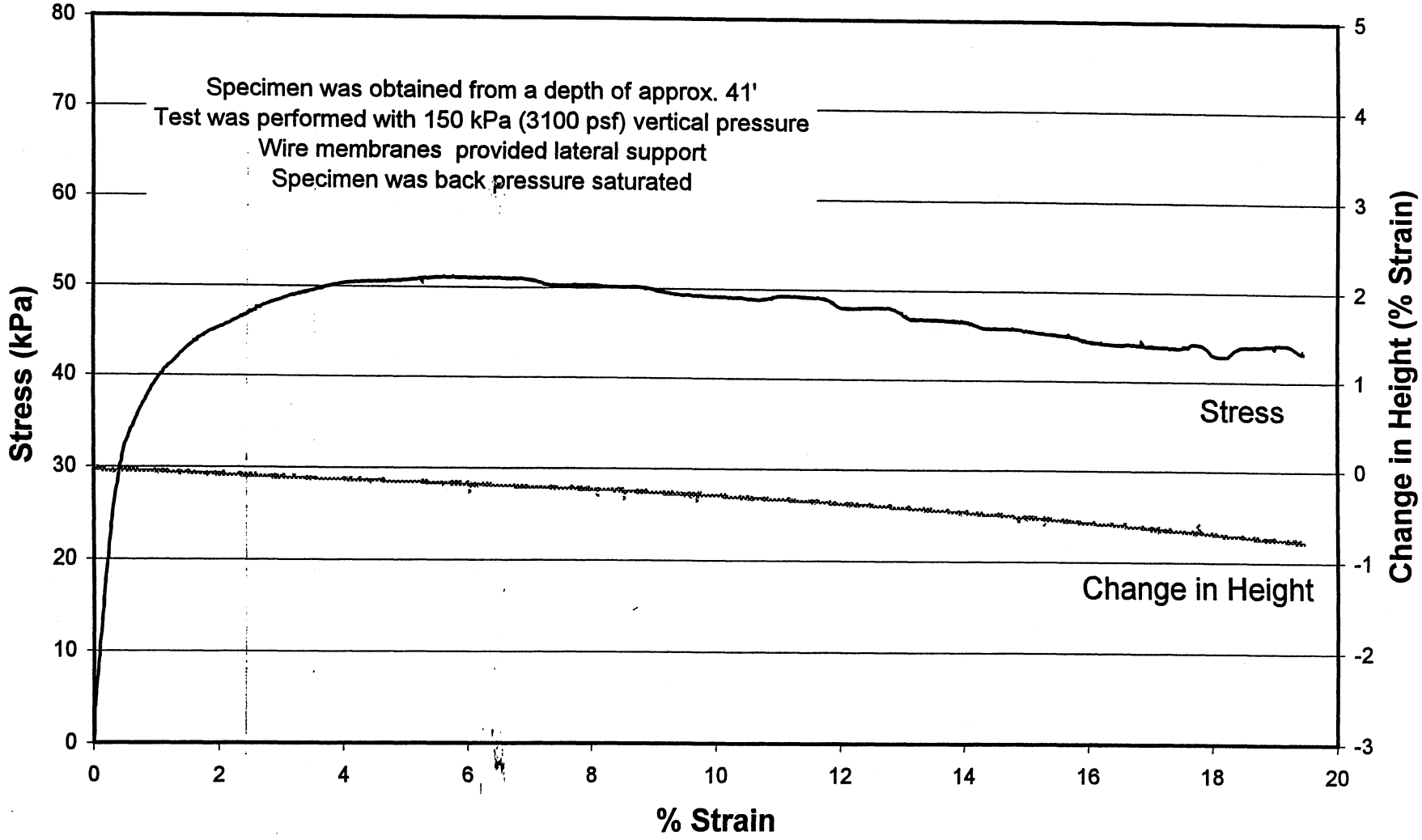
BBMONO17.xls

SFOBB Boring P-2 Specimen 18
Monotonic Test Only



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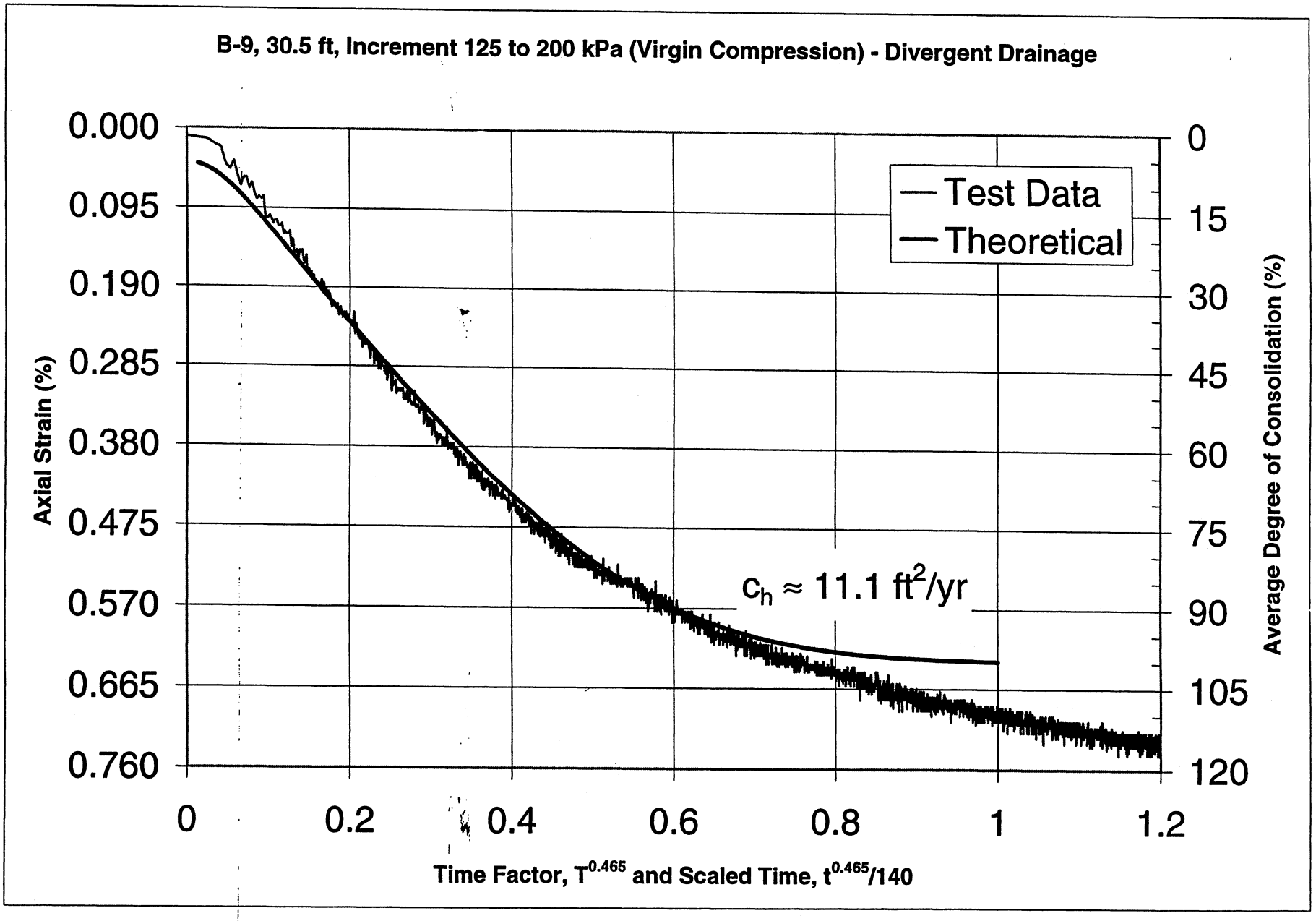
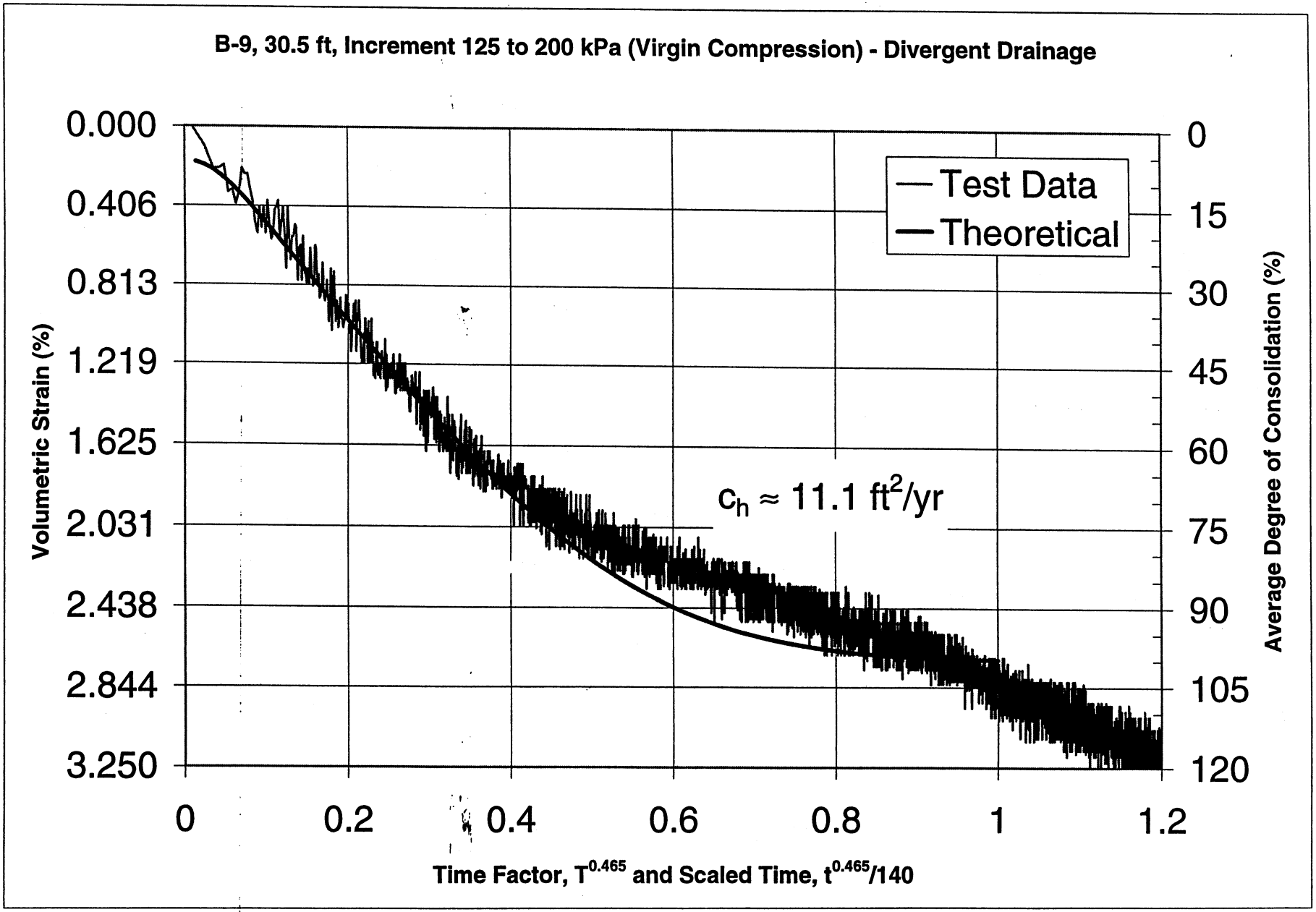
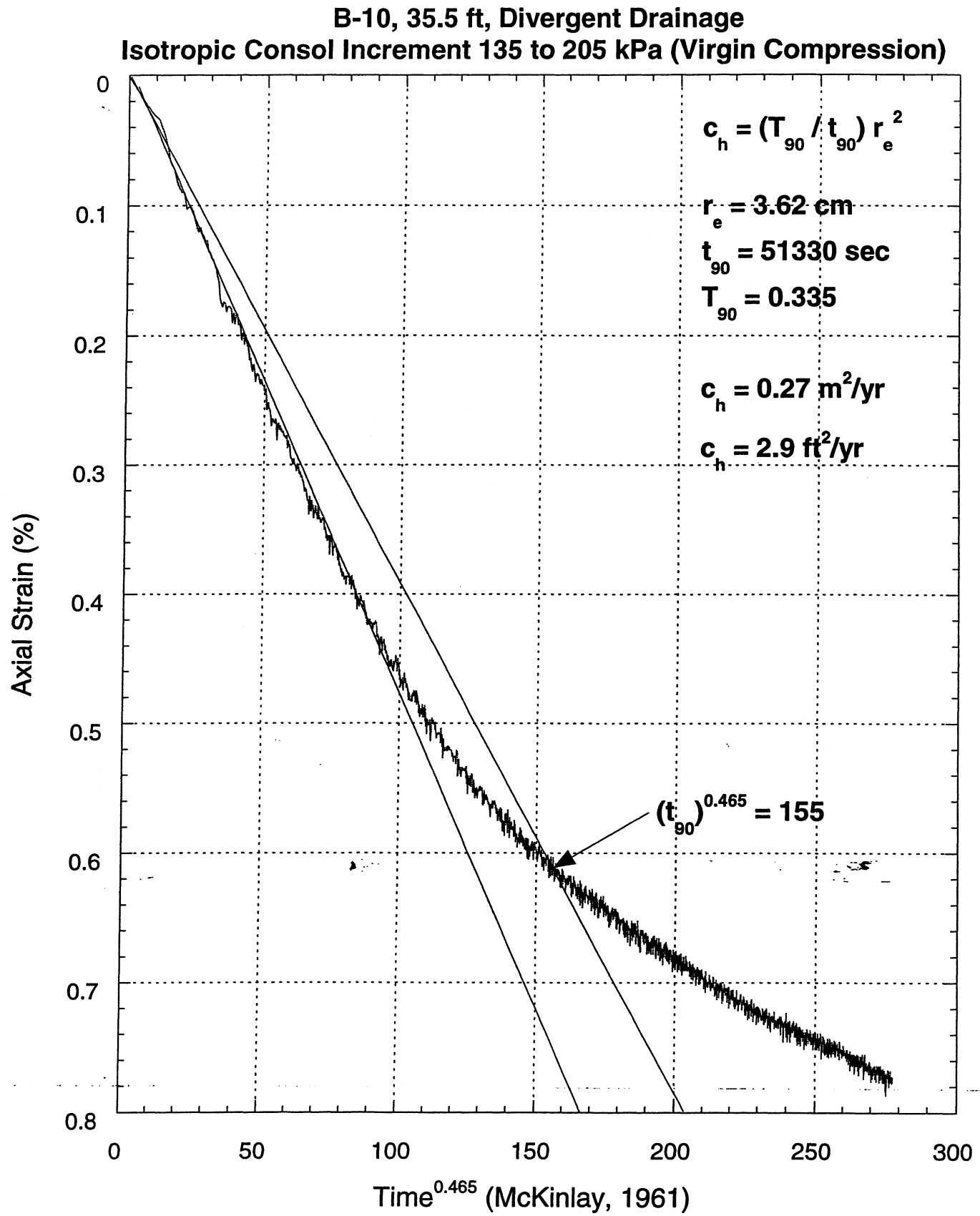
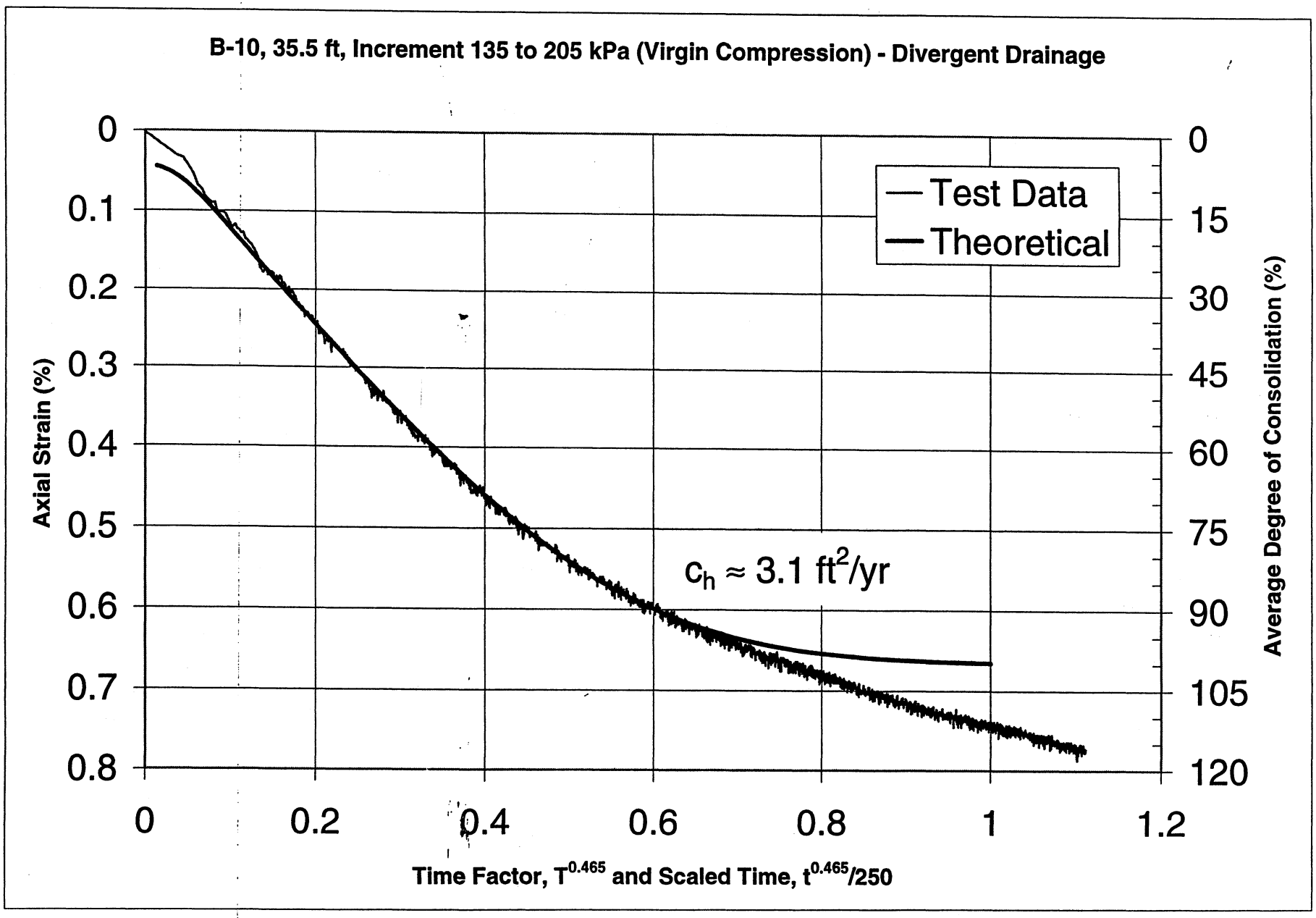
APPENDIX B

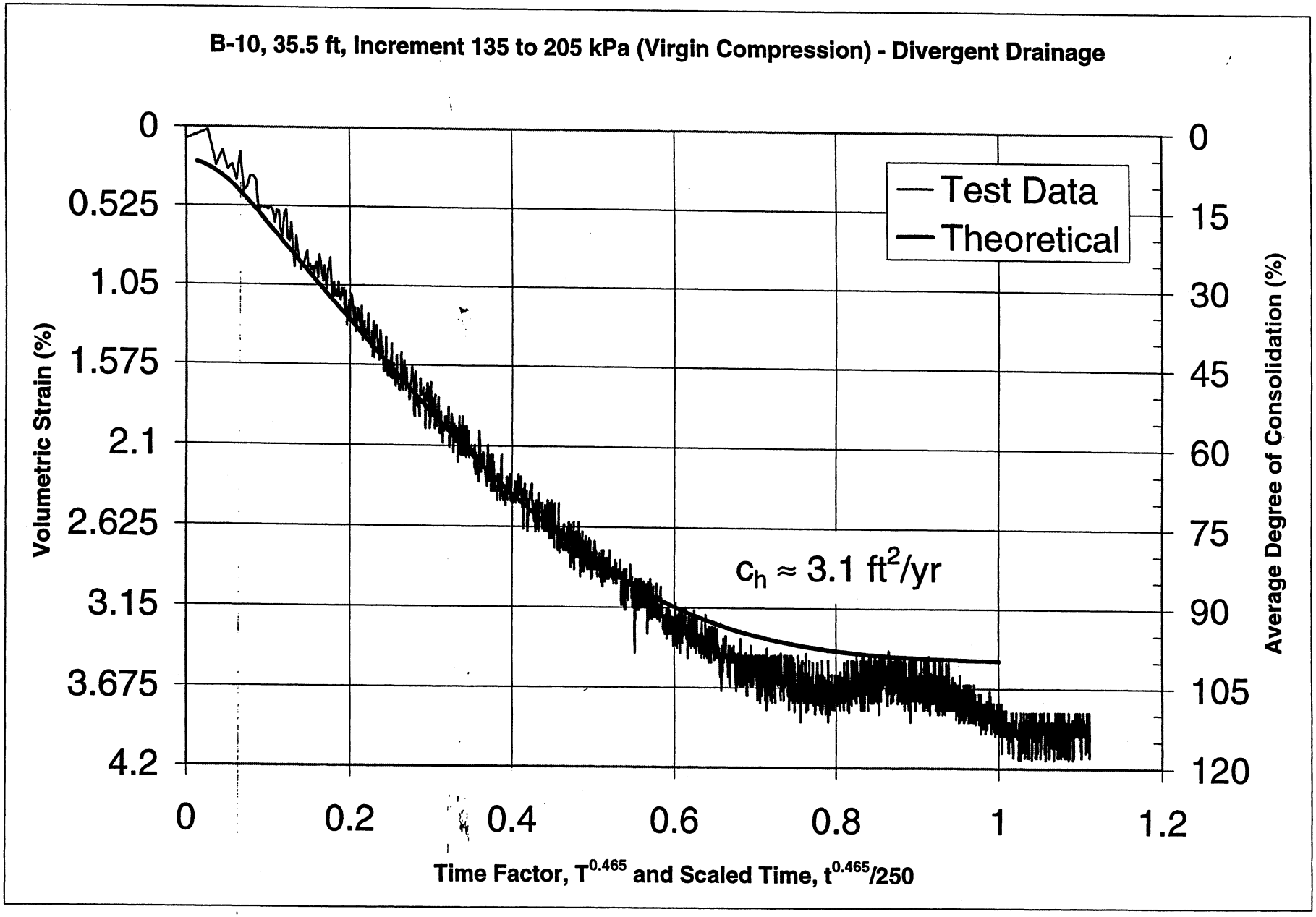
Consolidation Testing Results

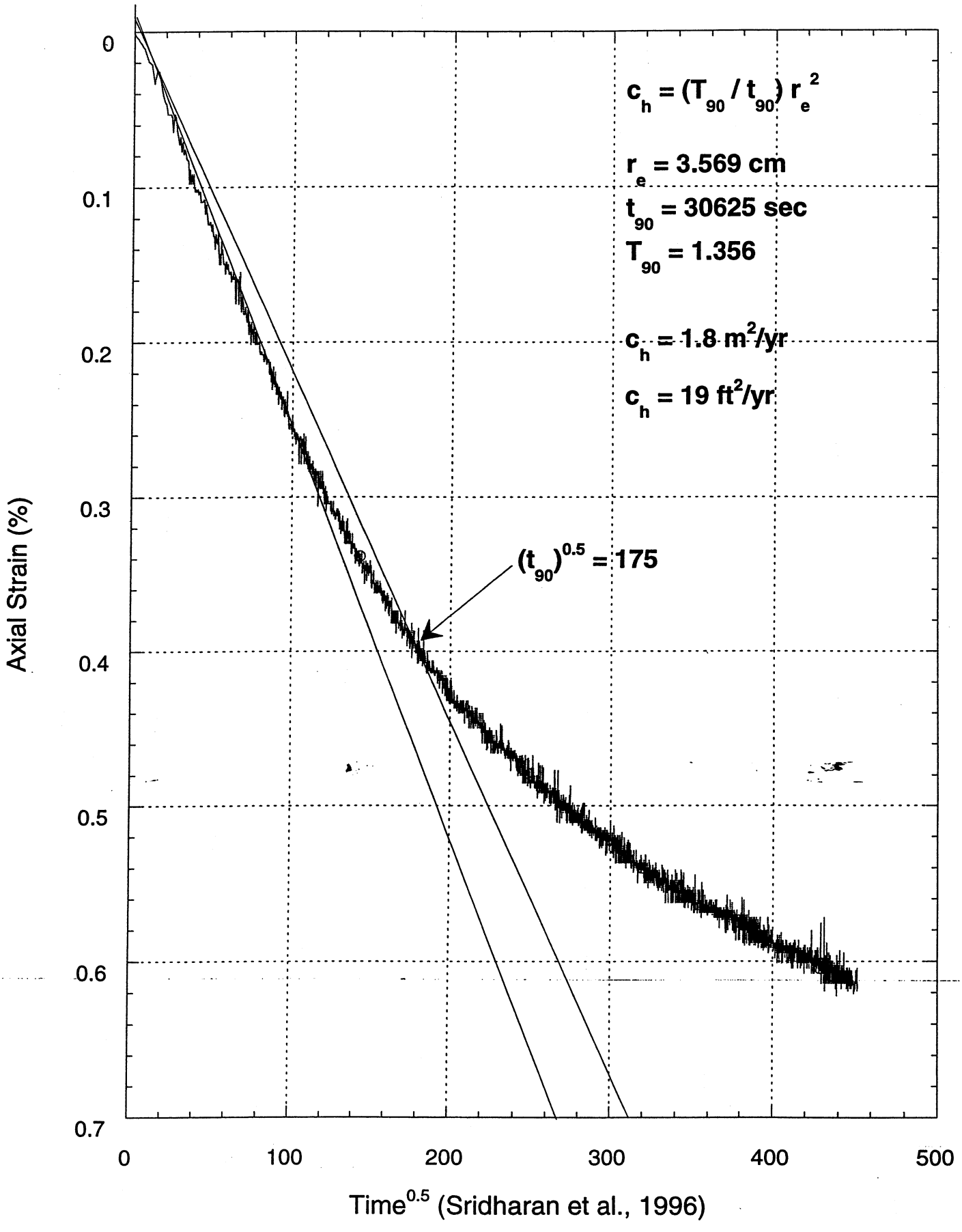

B-9, 30.5 ft, Increment 125 to 200 kPa (Virgin Compression) - Divergent Drainage
Test Data
Theoretical
$c_h \approx 11.1$ ft^2/yr
Axial Strain (%)
0.000
0.095
0.190
0.285
0.380
0.475
0.570
0.665
0.760
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/140$

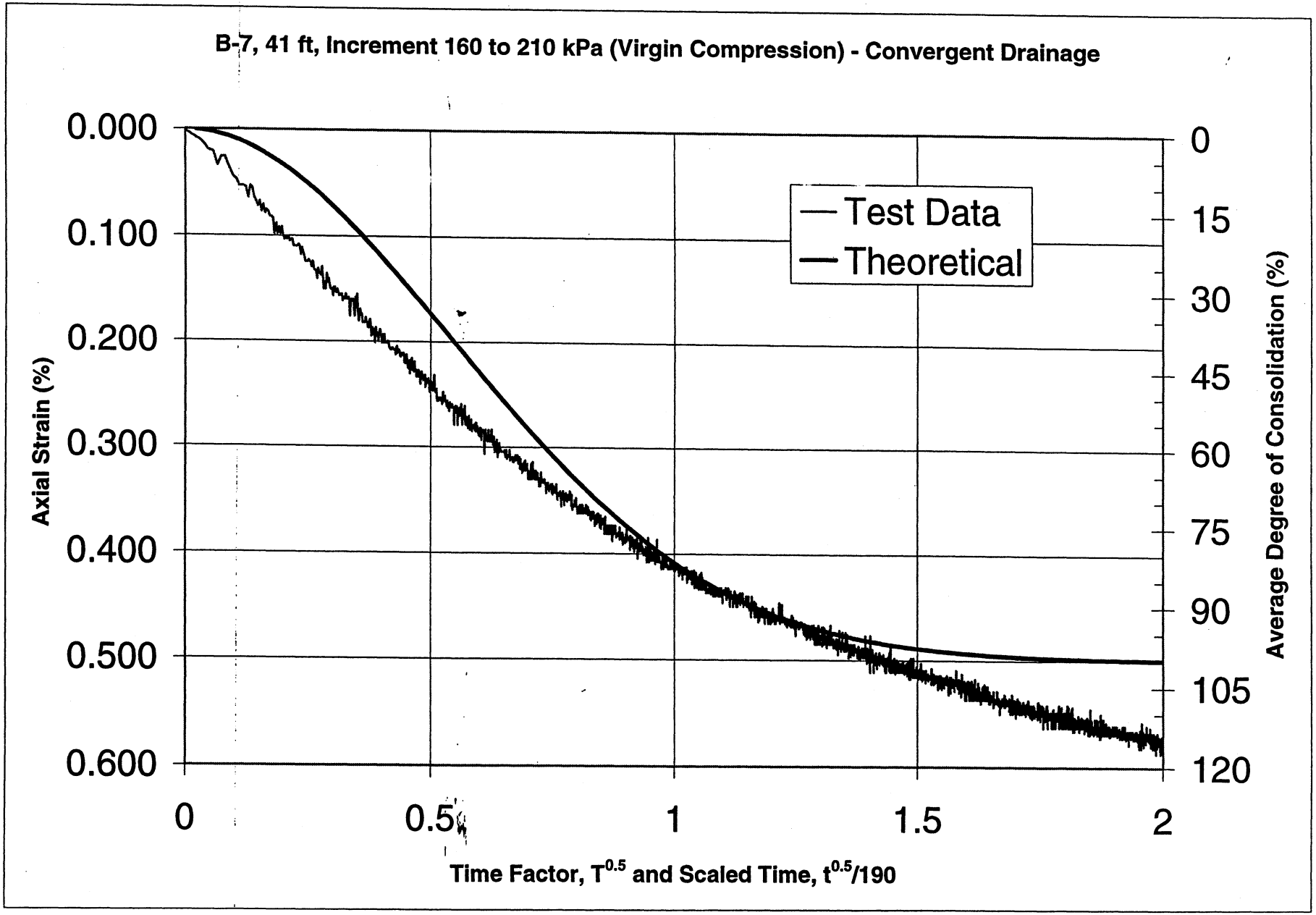

B-9, 30.5 ft, Increment 125 to 200 kPa (Virgin Compression) - Divergent Drainage
Volumetric Strain (%)
0.000
0.406
0.813
1.219
1.625
2.031
2.438
2.844
3.250
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
Test Data
Theoretical
$c_h \approx 11.1$ ft^2/yr
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/140$

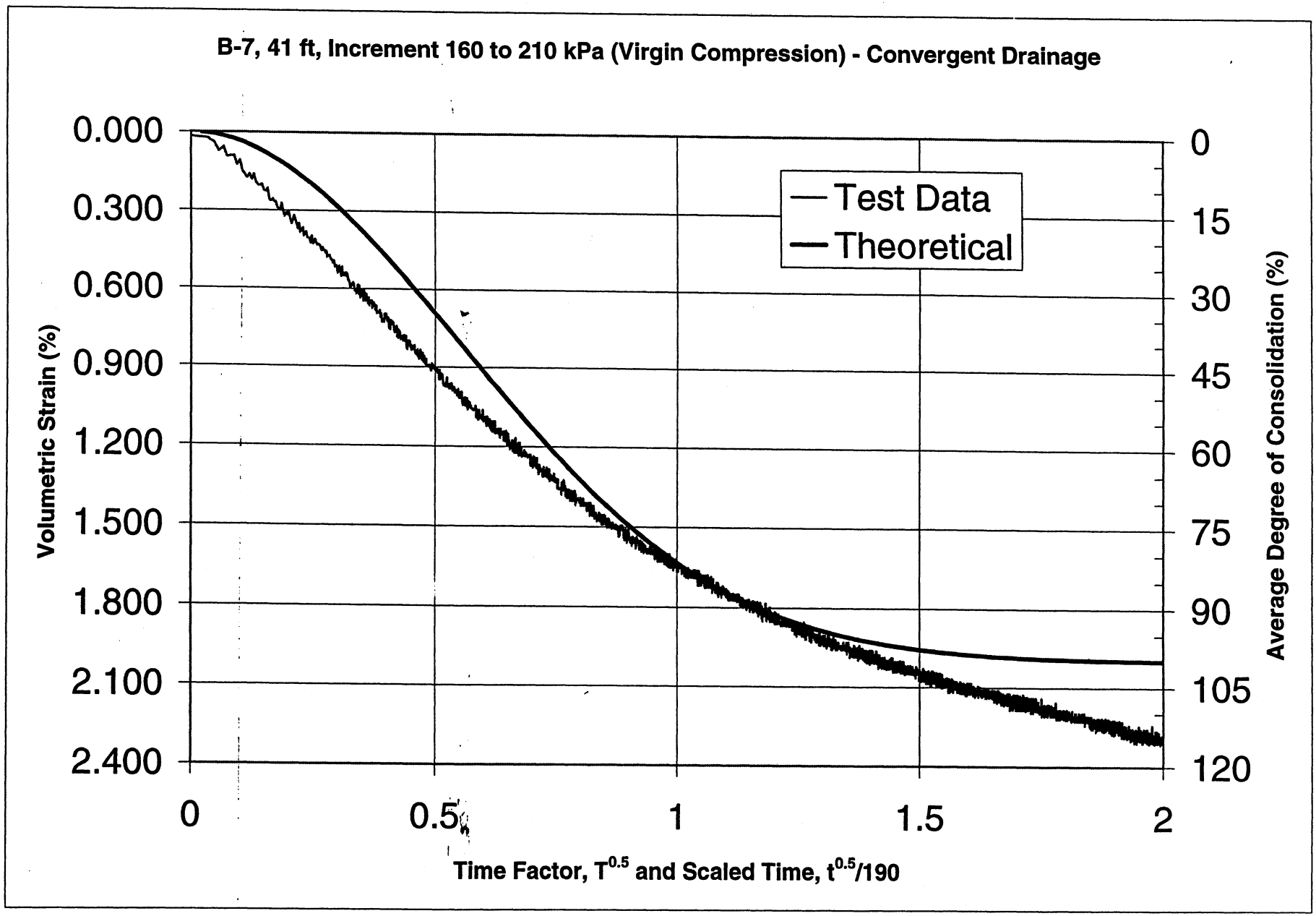

B-10, 35.5 ft, Divergent Drainage
Isotropic Consol Increment 135 to 205 kPa (Virgin Compression)
$c_h = (T_{90} / t_{90}) r_e^2$
$r_e = 3.62$ cm
$t_{90} = 51330$ sec
$T_{90} = 0.335$
$c_h = 0.27$ m^2/yr
$c_h = 2.9$ ft^2/yr
$(t_{90})^{0.465} = 155$
Axial Strain (%)
Time$^{0.465}$ (McKinlay, 1961)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
50
100
150
200
250
300

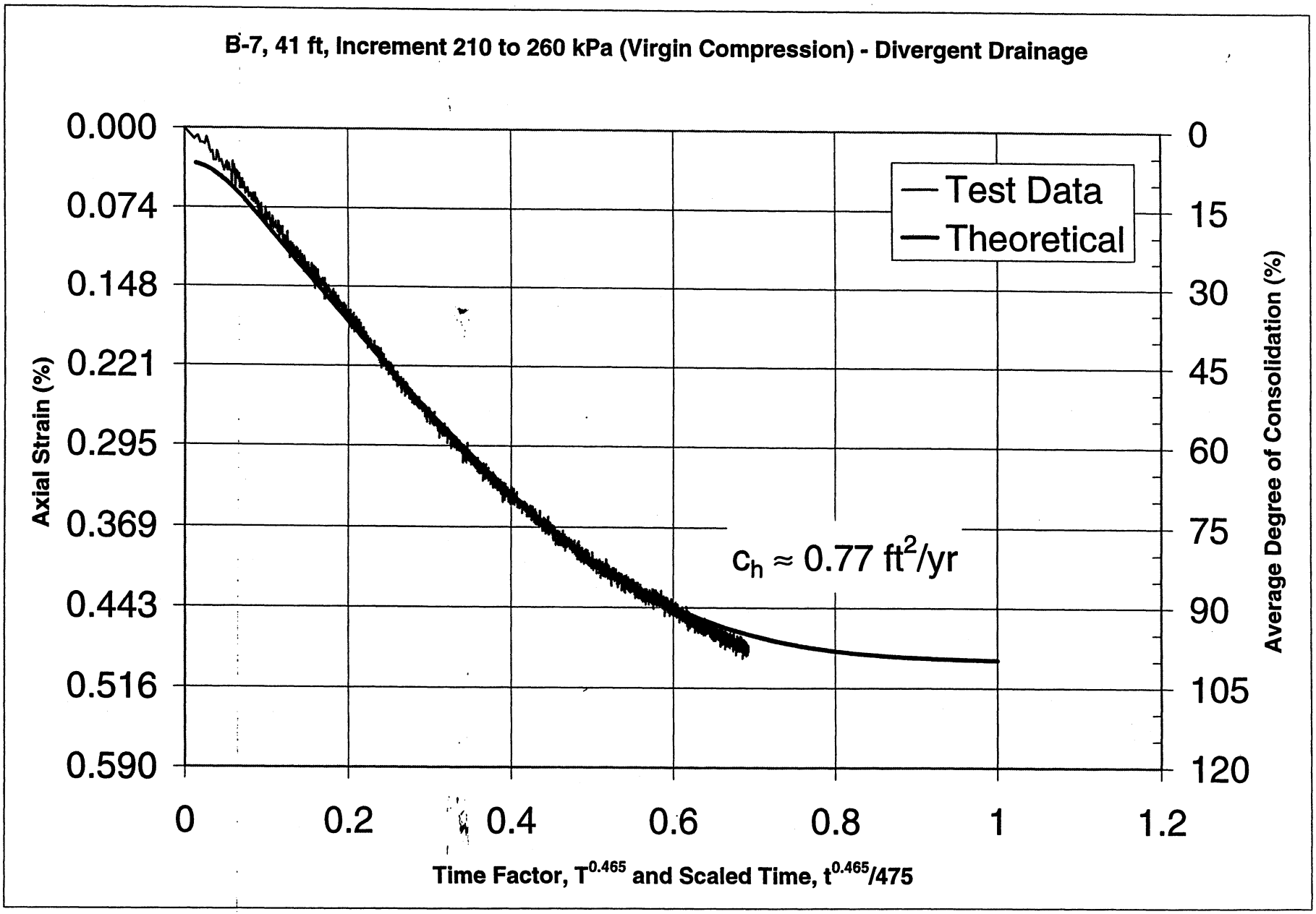

B-10, 35.5 ft, Increment 135 to 205 kPa (Virgin Compression) - Divergent Drainage
Test Data
Theoretical
$c_h \approx 3.1$ ft^2/yr
Axial Strain (%)
Average Degree of Consolidation (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
15
30
45
60
75
90
105
120
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/250$

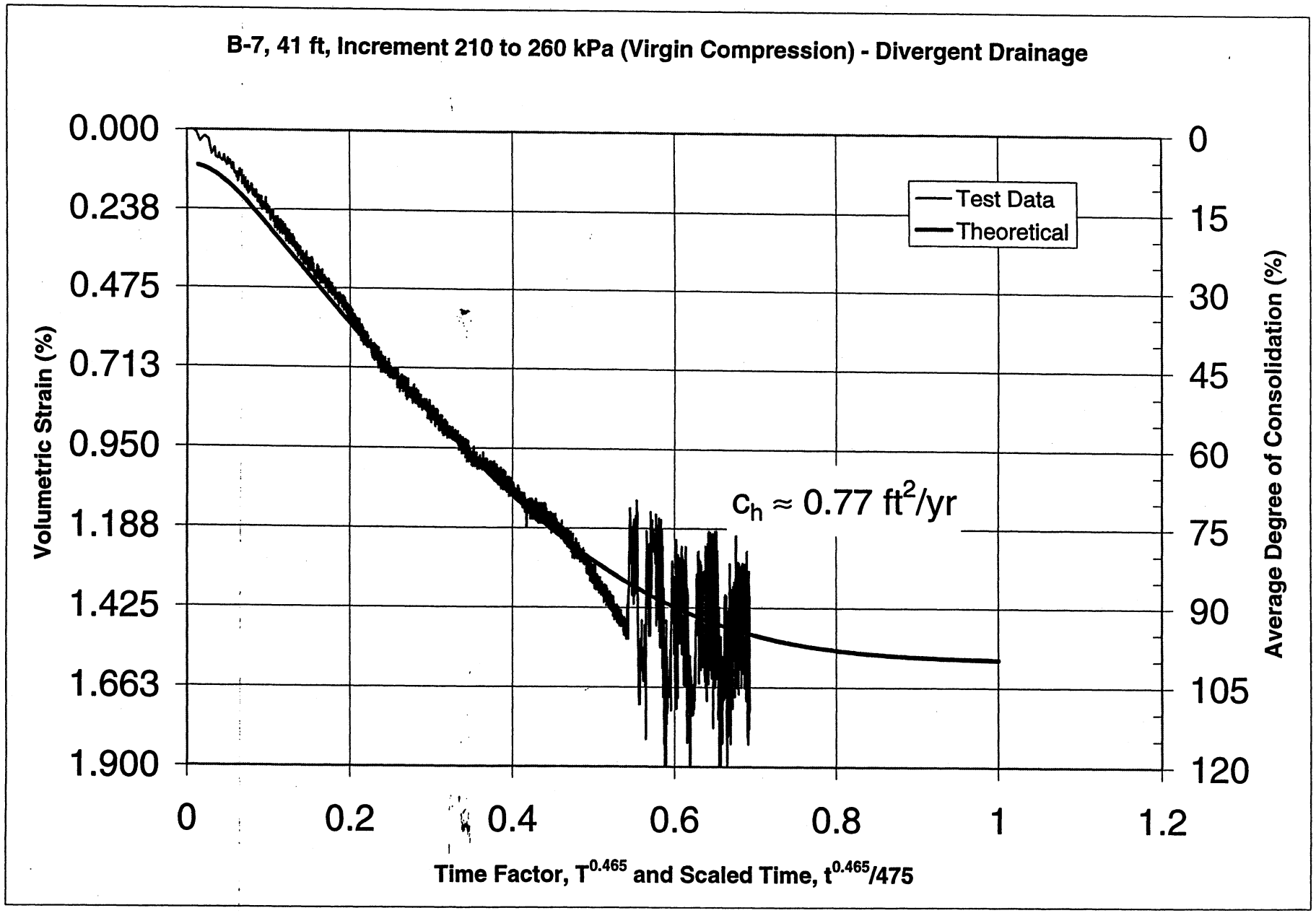

B-10, 35.5 ft, Increment 135 to 205 kPa (Virgin Compression) - Divergent Drainage
Test Data
Theoretical
$c_h \approx 3.1$ ft^2/yr
Volumetric Strain (%)
0
0.525
1.05
1.575
2.1
2.625
3.15
3.675
4.2
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/250$

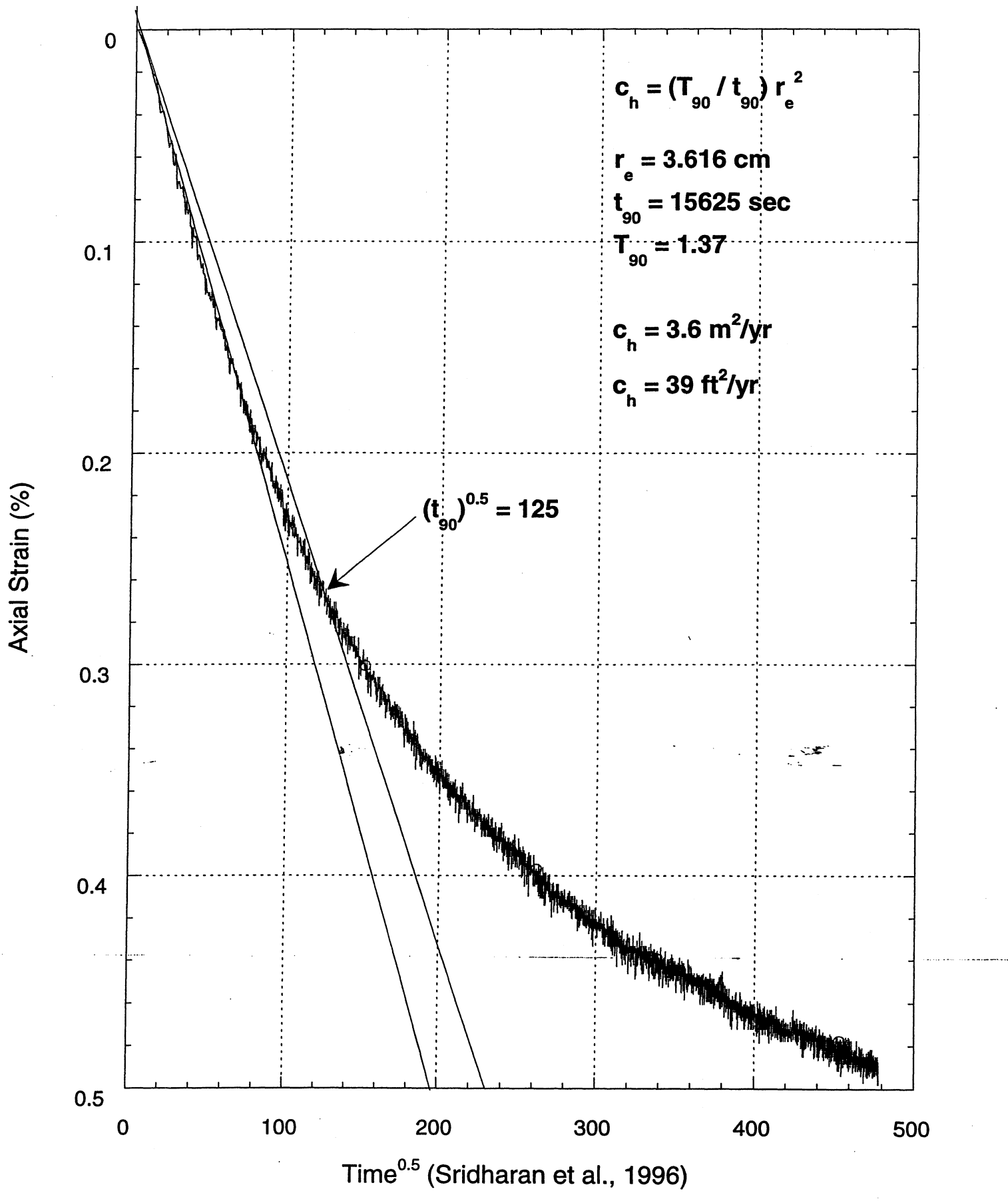

B-7, 41 ft, Convergent Drainage
Isotropic Consol Increment 160 to 210 kPa (Virgin Compression)
$c_h = (T_{90} / t_{90}) r_e^2$
r_e = 3.569 cm
t_{90} = 30625 sec
T_{90} = 1.356
c_h = 1.8 m^2/yr
c_h = 19 ft^2/yr
$(t_{90})^{0.5}$ = 175
Axial Strain (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
100
200
300
400
500
Time$^{0.5}$ (Sridharan et al., 1996)

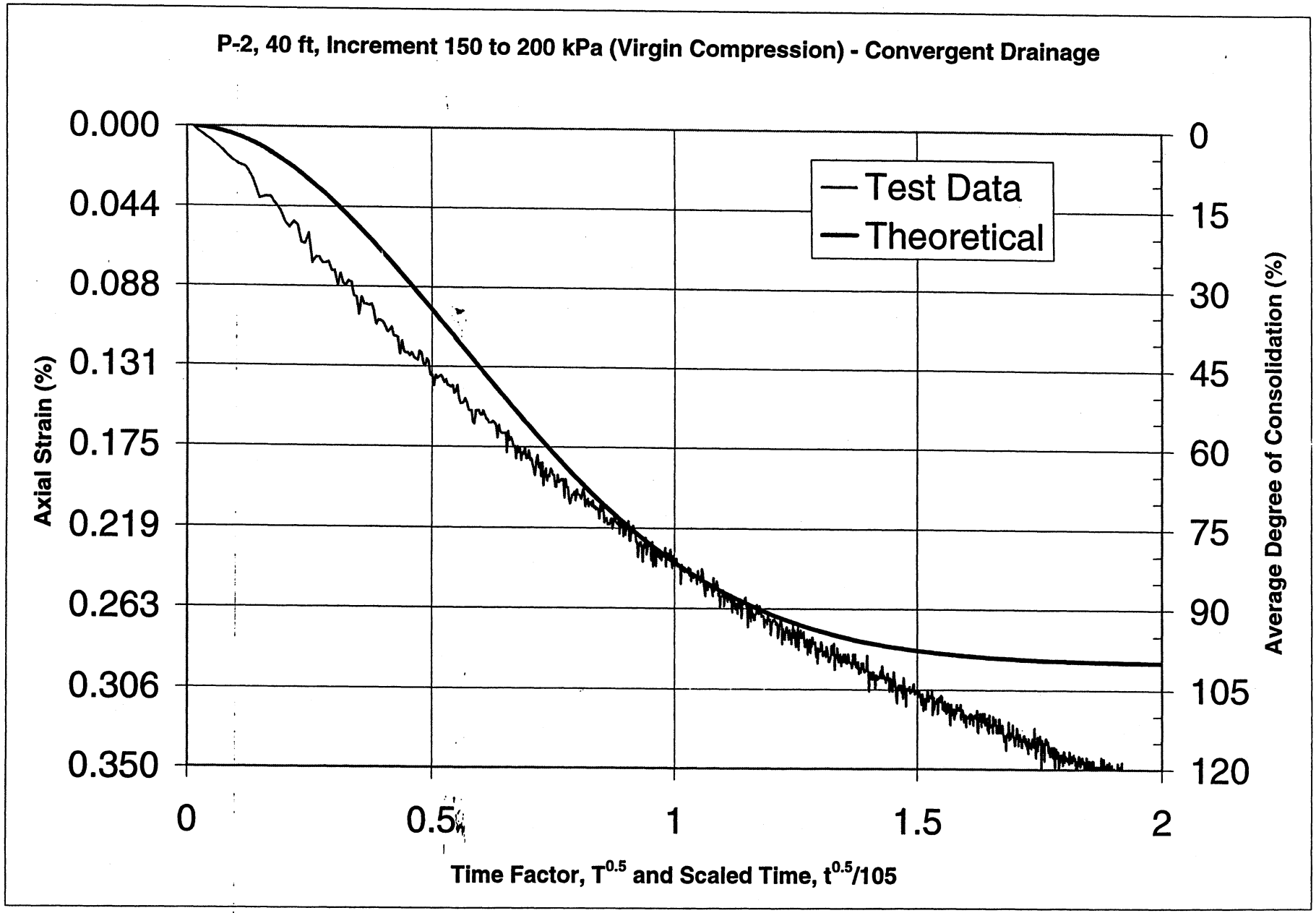

B-7, 41 ft, Increment 160 to 210 kPa (Virgin Compression) - Convergent Drainage
Test Data
Theoretical
Axial Strain (%)
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
0
0.5
1
1.5
2
Time Factor, T^0.5 and Scaled Time, t^0.5/190

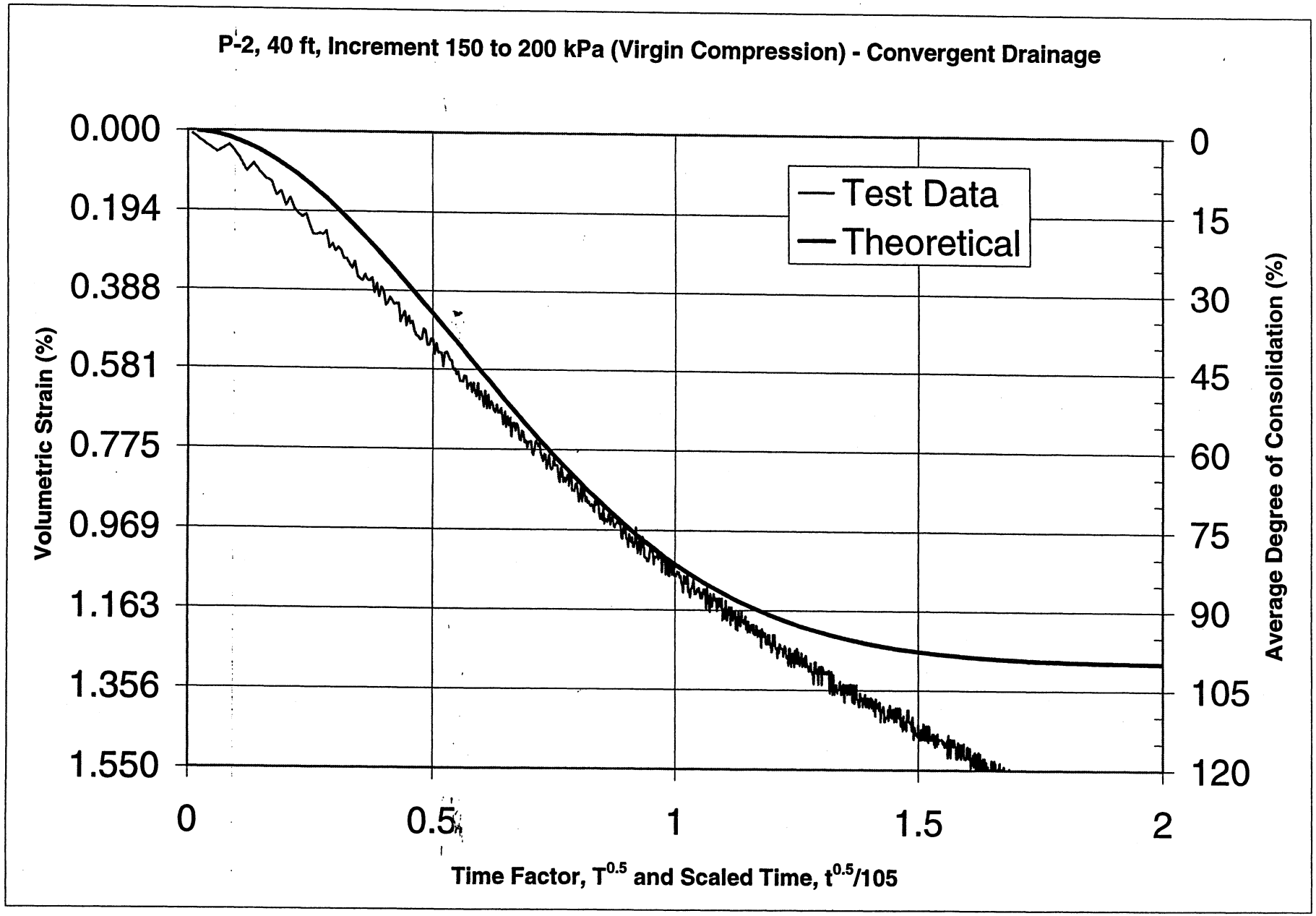

B-7, 41 ft, Increment 160 to 210 kPa (Virgin Compression) - Convergent Drainage
0.000
0.300
0.600
0.900
1.200
1.500
1.800
2.100
2.400
Volumetric Strain (%)
0
15
30
45
60
75
90
105
120
Average Degree of Consolidation (%)
Test Data
Theoretical
0
0.5
1
1.5
2
Time Factor, T^0.5 and Scaled Time, t^0.5/190

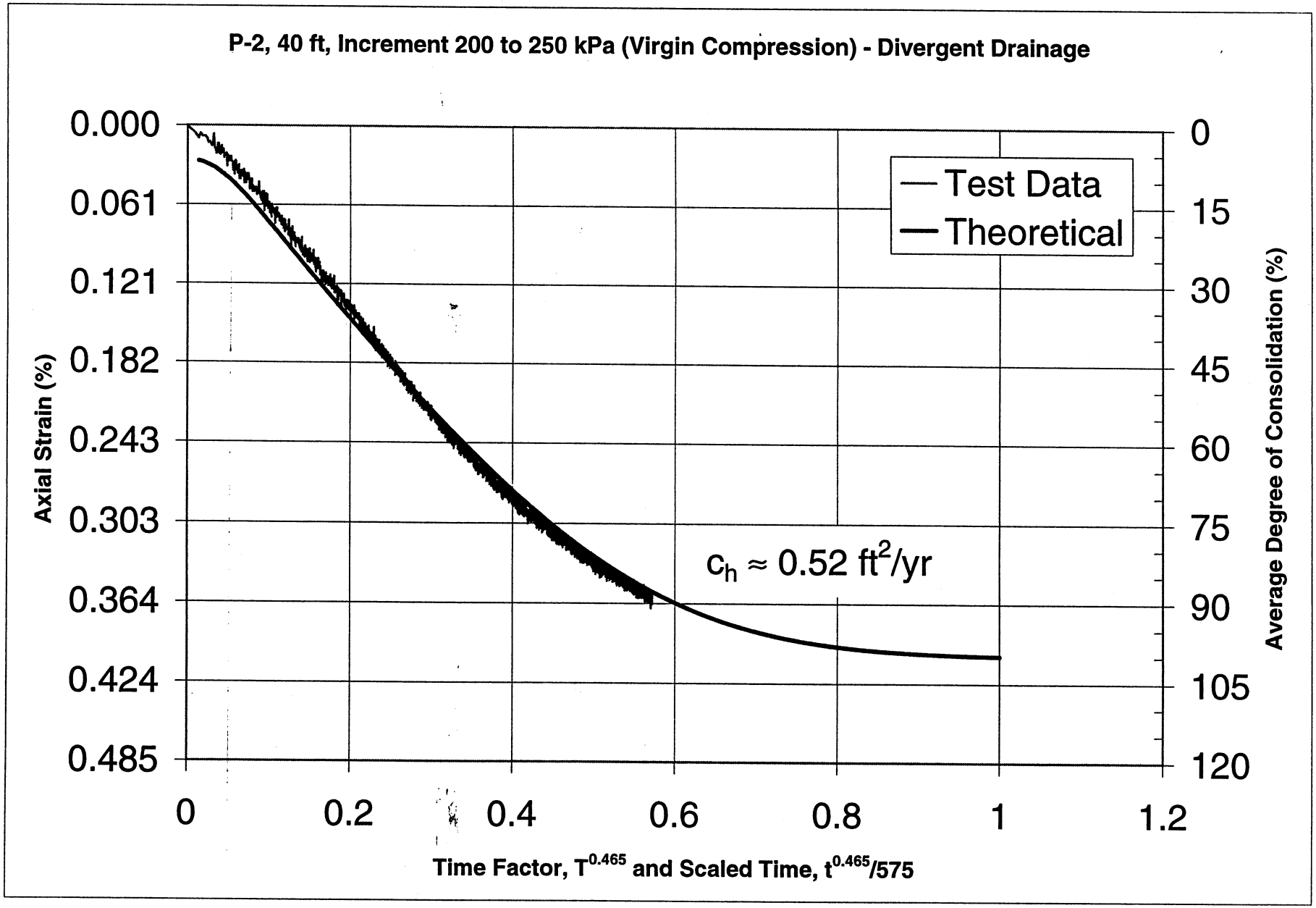

B-7, 41 ft, Increment 210 to 260 kPa (Virgin Compression) - Divergent Drainage
0.000
0.074
0.148
0.221
0.295
0.369
0.443
0.516
0.590
Axial Strain (%)
0
15
30
45
60
75
90
105
120
Average Degree of Consolidation (%)
Test Data
Theoretical
$c_h \approx 0.77$ ft^2/yr
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/475$

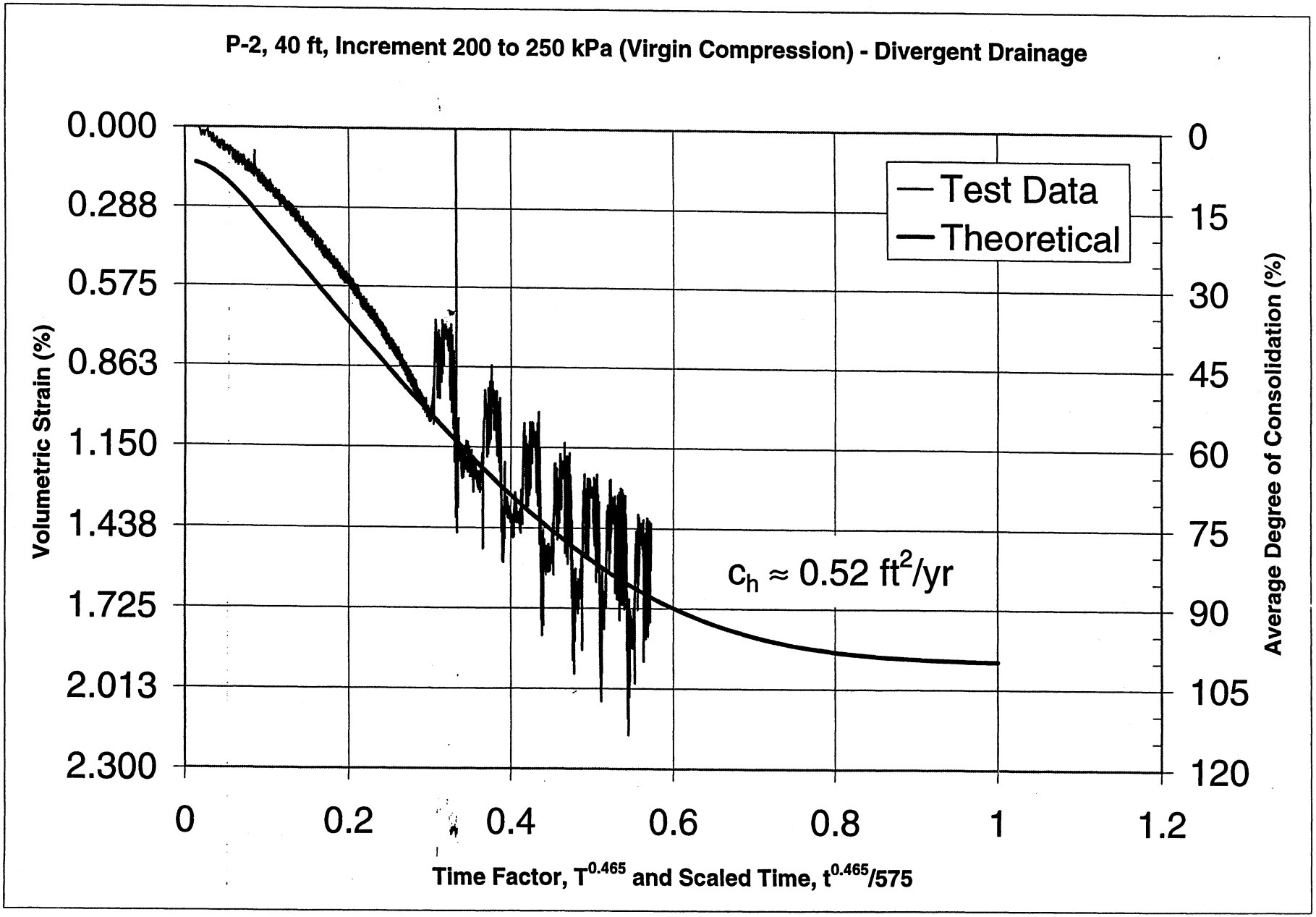

B-7, 41 ft, Increment 210 to 260 kPa (Virgin Compression) - Divergent Drainage
Volumetric Strain (%)
0.000
0.238
0.475
0.713
0.950
1.188
1.425
1.663
1.900
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
Test Data
Theoretical
$c_h \approx 0.77$ ft^2/yr
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/475$


P-2, 40 ft, Convergent Drainage
Isotropic Consol Increment 150 to 200 kPa (Virgin Compression)
$c_h = (T_{90} / t_{90}) r_e^2$
r_e = 3.616 cm
t_{90} = 15625 sec
T_{90} = 1.37
c_h = 3.6 m²/yr
c_h = 39 ft²/yr
$(t_{90})^{0.5}$ = 125
Axial Strain (%)
0
0.1
0.2
0.3
0.4
0.5
0
100
200
300
400
500
Time$^{0.5}$ (Sridharan et al., 1996)


P-2, 40 ft, Increment 150 to 200 kPa (Virgin Compression) - Convergent Drainage
Test Data
Theoretical
Axial Strain (%)
0.000
0.044
0.088
0.131
0.175
0.219
0.263
0.306
0.350
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
0
0.5
1
1.5
2
Time Factor, T^0.5 and Scaled Time, t^0.5/105


P-2, 40 ft, Increment 150 to 200 kPa (Virgin Compression) - Convergent Drainage
Test Data
Theoretical
Volumetric Strain (%)
0.000
0.194
0.388
0.581
0.775
0.969
1.163
1.356
1.550
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
0
0.5
1
1.5
2
Time Factor, T^0.5 and Scaled Time, t^0.5/105


P-2, 40 ft, Increment 200 to 250 kPa (Virgin Compression) - Divergent Drainage
0.000
0.061
0.121
0.182
0.243
0.303
0.364
0.424
0.485
Axial Strain (%)
0
15
30
45
60
75
90
105
120
Average Degree of Consolidation (%)
Test Data
Theoretical
$c_h \approx 0.52$ ft^2/yr
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/575$


P-2, 40 ft, Increment 200 to 250 kPa (Virgin Compression) - Divergent Drainage
Volumetric Strain (%)
0.000
0.288
0.575
0.863
1.150
1.438
1.725
2.013
2.300
Average Degree of Consolidation (%)
0
15
30
45
60
75
90
105
120
Test Data
Theoretical
$c_h \approx 0.52\ ft^2/yr$
0
0.2
0.4
0.6
0.8
1
1.2
Time Factor, $T^{0.465}$ and Scaled Time, $t^{0.465}/575$