Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

February 12, 2013

EMI Project No. 11-151

AECOM
999 W Town & Country Road
Orange CA 92868

Attention: Mr. Mario Montes, P.E.

Subject: ***Preliminary Geotechnical Design Report***
I-5 from SR-55 to SR-57 HOV Improvements
12-ORA-5, PM 30.0/34.0
1200000085 – 0C8900

Dear Mr. Montes:

Attached is the Preliminary Geotechnical Design Report for the subject project. The report is intended to provide preliminary geotechnical information to assist AECOM in preparing the preliminary cost estimate for the project.

Conclusions and recommendations given in this report are considered preliminary and should be verified in the future by conducting site-specific geotechnical field investigations, laboratory soil testing, and analyses.

We appreciate the opportunity to provide geotechnical services for the project. If you have any questions or require additional information please call us.

Sincerely,
EARTH MECHANICS, INC.

PROFESSIONAL GEOLOGIST MICHAEL HOSHIYAMA No. 8864 Exp. 01/31/14 STATE OF CALIFORNIA

Michael Hoshiyama, PG 8864
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LCC:lcc

PRELIMINARY GEOTECHNICAL DESIGN REPORT
I-5 from SR-55 to SR-57 HOV Improvements
12-ORA-5, PM 30.0/34.0
1200000085 – 0C8900

Prepared for:

AECOM
999 W Town & Country Road
Orange CA 92868

Prepared by:

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17800 Newhope Street, Suite B
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EMI Project Number: 11-151

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1.0 INTRODUCTION

This Preliminary Geotechnical Design Report (PGDR) presents preliminary geotechnical information for the Interstate-5 (I-5) HOV improvement project, from about State Route-55 (SR-55) to SR-57. This proposed project will provide an additional High Occupancy Vehicle (HOV) lane in each direction. The location of the project is shown on the Site Location Map (Figure 1). The purpose of this report is to provide preliminary geotechnical information to assist AECOM in preparing the preliminary engineering plans and cost estimates for the project. Pavement recommendations and soil corrosion are addressed in the Preliminary Materials Report (EMI, 2012a).

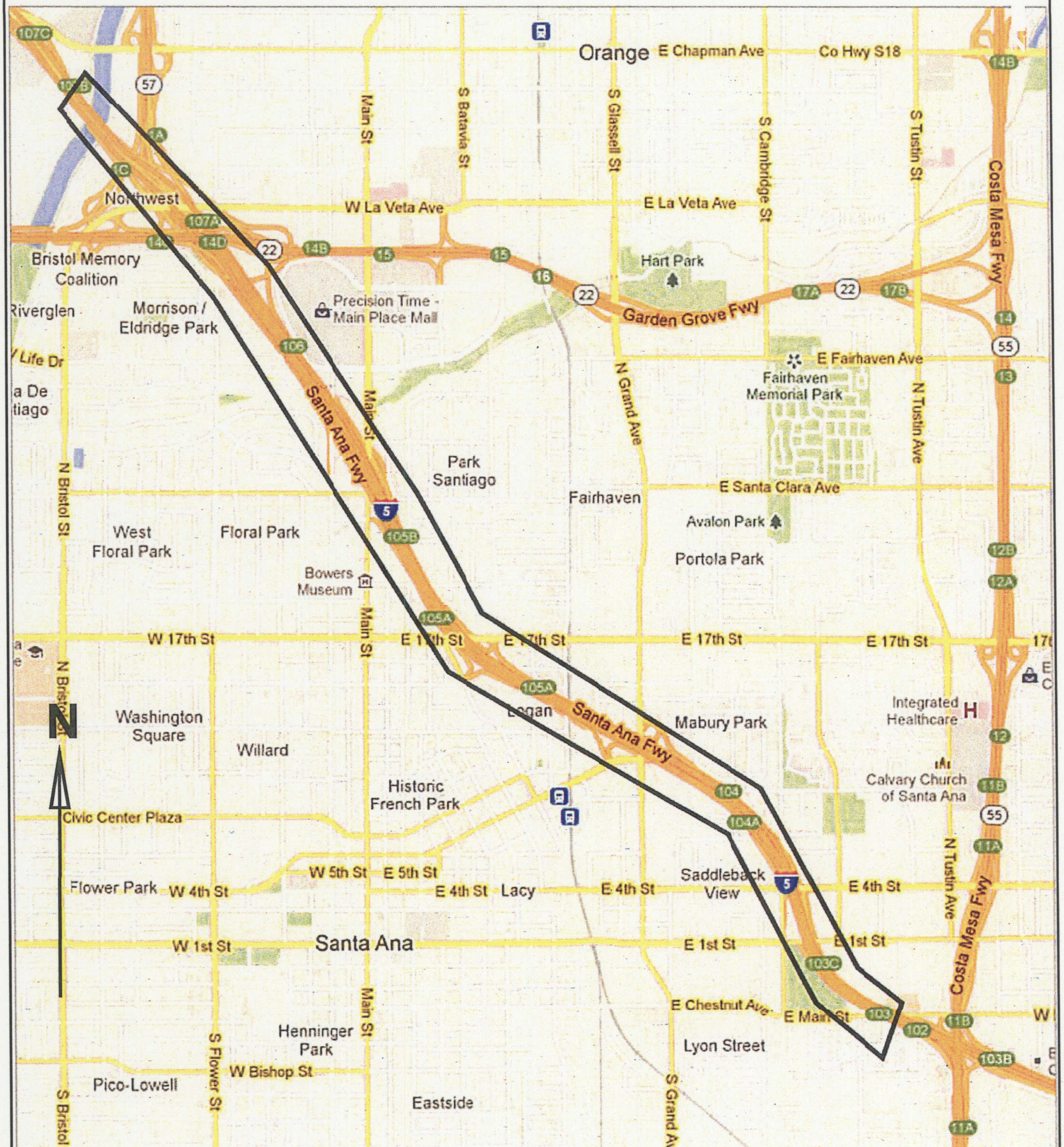
2.0 EXISTING FACILITIES AND PROPOSED IMPROVEMENTS

2.1 Existing Facilities

The project is located on the I-5 between the SR-55 interchange and the SR-57 interchange in the Cities of Santa Ana and Orange. This location is an urban, residential and commercial area along level and rolling terrain. I-5 is designated in the National Highway System (NHS), Department of Defense Rural Interstates and Single Routing in Urban Areas and the Strategic Highway Corridor Network (STRAHNET). I-5 is a major north-south corridor that serves local traffic, regional traffic, interstate traffic, and international traffic to and from Mexico and Canada.

The existing HOV/transit-way facility in this project is separated from the general purpose traffic with a concrete barrier or double yellow striping (HOV Buffer). In the northbound (NB) direction, there are two HOV drop ramps: an off-ramp to Grand Avenue and an on-ramp from Main Street. A striping egress serving SR-22 is also provided north of Lincoln Avenue overcrossing. In the southbound (SB) direction, there are two HOV drop ramps: an on-ramp from Grand Avenue and an off-ramp to Main Street. There is also an ingress striping north of Grand Avenue under-crossing to provide access to I-5/SR-55 HOV direct connector for SB general purpose traffic. The north and south ends of the project have two HOV direct freeway-to-freeway connectors providing the following connections: NB SR-55 to NB I-5, SB I-5 to SB SR-55, SB SR-55 to SB I-5, NB I-5 to NB SR-57, and SB SR-57 to SB I-5.

Currently, within the project limits, the HOV facilities experience three bottlenecks during peak hours. In the northbound direction, bottlenecks occur where traffic merges in from the northbound SR-55 HOV direct connector below the Lincoln Avenue underpass and from the Main Street drop on-ramp. In the southbound direction, the bottleneck occurs at the merging of traffic from the southbound SR-57 HOV direct connector to the southbound I-5 HOV.



I-5 HOV Improvement Project SR-55 to SR-57	SITE LOCATION MAP	
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		Figure 1
	Project No. 11-151	Date: 12-31-12

2.2 Proposed Improvements

The proposed improvements include the addition of one HOV lane in each direction on I-5 to provide additional HOV capacity. There are two alternatives: 2A/2B and 5A/5B. Each alternative also has two Design Options: Option A and Option B. These alternatives and design options are discussed in greater details in the Project Report.

The common features for both alternatives are presented below, followed by a description of the design elements associated with each alternative and then the two Design Options:

- Slightly adjust the following entrance/exit ramp areas to accommodate the HOV widening:
  - SB I-5 Grand Avenue HOV entrance ramp
  - SB I-5 to Santa Ana Boulevard exit ramp
  - 17th Street to SB I-5 entrance ramp
  - SB I-5 to 17th Street exit ramp
  - NB I-5 to 17th Street exit ramp
  - SB I-5 to Main Street/Broadway exit ramp
  - Santa Clara Avenue to NB I-5 entrance ramp
  - Westbound (WB) State Route 22 (SR-22) to NB I-5 entrance ramp
  - Eastbound (EB) SR-22 to SB I-5 connector
  - SB I-5 to EB SR-22 connector
  - NB I-5 to NB SR-57 connector
  - Main Street to SB I-5 entrance ramp.

- Reconstruct existing or construct new retaining walls.

- Close the HOV barrier gap (between Lincoln Avenue and north of 17th Street) and relocate the existing HOV concrete barriers on the NB side of I-5 between Lincoln Avenue and the Santa Clara Avenue over-crossing entrance ramp.

- Relocate the existing center median concrete barrier at various locations to facilitate the HOV lane additions.

- Relocate the existing drainage inlets along the existing concrete barriers. These inlets would need to be removed and reconstructed in new locations accordingly.

- Relocate overhead sign structures to allow freeway widening and install new overhead sign structures.

- Construct storm water treatment best management practices (BMPs) where feasible within the existing ROW.

2.2.1 Alternative 2A

Alternative 2A proposes the following design features:

- Remove existing concrete barriers located between the HOV-1 lane and General Purpose (GP) lanes and construct new concrete barriers approximately 2 feet to 6 feet toward the existing freeway centerline.

- Add new concrete barriers to continuously separate the two HOV lanes.

- Reconstruct drainage inlets along relocated and new concrete barriers, as required.
- Add new HOV-2 lane in the GP area with continuous ingress/egress striping throughout the project limits.
- Have modified HOV-1 facility feature a modified left shoulder, the HOV-1 lane, and a modified right shoulder.
- Have HOV-2 and adjacent GP lanes consist of a modified left shoulder, the HOV-2 lane, four GP lanes, and a modified right shoulder.
- Reduce three GP lanes (in each direction) between the 17th Street to SB I-5 entrance ramp and Broadway Bridge to 11 feet to avoid widening the 17th Street undercrossing, avoid reconstructing 900 feet of sound wall on retaining wall, avoid reconstruction of the Main Street to SB I-5 entrance ramp, and to clear existing bridge columns.
- Construct California Highway Patrol (CHP) enforcement areas between 17th Street and Main Street in the SB direction and between Broadway overcrossing and SR-22 EB connector overcrossing in the NB direction and only used for the HOV-1 lane.
- Construct tie-back retaining walls on the NB and SB sides of I-5 at the Lincoln Avenue overcrossing and NB I-5 at SR-22 freeway abutment to accommodate the widening.
- Relocate five overhead cantilevered sign structures and installation of overhead sign structures for the new HOV-1 and HOV-2 lane configurations would be required.
- Reconstruct pump station inlet and stairway on SB I-5 side near Lincoln Avenue Bridge.

2.2.2 Alternative 2B

This alternative is the same as Alternative 2A except this alternative would remove the Main Street HOV drop entrance and exit ramps.

2.2.3 Alternative 5A

Alternative 5A proposes to add the new HOV-2 lane adjacent to the existing HOV-1 lane and has the following design features:

- Remove the existing concrete barriers located between the HOV-1 lane and the GP lanes providing a continuous ingress/egress striping throughout the project limits, except at bridge columns.
- Construct new SB/NB separated concrete barriers closer to the freeway centerline from the existing barrier location to make room and eliminate design exceptions.
- In each direction on the I-5, have the HOV facility feature a modified left shoulder, the two HOV-1 and HOV-2 lanes, and a modified right shoulder that exists between the HOV lanes and the GP lanes at bridge columns.
- In each direction on the I-5, provide five GP lanes, with a modified right shoulder and a modified left shoulder that exists between the GP lanes and the HOV lanes at the bridge columns.

- Construct CHP enforcement areas between 17th Street and Main Street in the SB direction and between the Broadway overcrossing and SR-22 EB connector overcrossing in the NB direction.
- Construct a tie-back retaining wall on the SB side of I-5 at the Lincoln Avenue overcrossing.
- Relocate two overhead sign structures and installation of overhead sign structures for the new HOV-1 and HOV-2 lane configurations would be required.
- Reconstruct pump station inlet and stairway on SB I-5 side near Lincoln Avenue Bridge.

2.2.4 Alternative 5B

This alternative is the same as Alternative 5A except this alternative would remove the Main Street HOV drop entrance and exit ramps.

2.2.5 Design Options

The following design options (Options A and B) may be combined with any of the above Alternatives.

Option A. This design option would close the existing I-5 SB entrance ramp at First Street and construct an entrance ramp at the Fourth Street interchange. The proposed engineering features include the following:

- Remove the existing First Street to SB I-5 entrance ramp and construct a new entrance ramp at Fourth Street to create a full diamond interchange. Remove the traffic signal at First Street and SB I-5 entrance ramp and restripe the entrance ramp to the I-5 mainline and reconstruct the gore area.
- Close NB I-5 "horseshoe" exit ramp to Mabury Street/First Street, add a second left-turn lane on the NB I-5 exit ramp to WB Fourth Street and restripe portions of the NB exit ramp at this location.
- Convert the EB Fourth Street inside through lane to a second left-turn lane to the NB I-5 entrance ramp.
- Reconfigure Mabury Street into a two-way street from Palm Street to First Street, and modify the Mabury Street/First Street intersection accordingly. Add a left-turn lane at EB First Street to NB Mabury Street. Close existing access to Mabury Street from Fourth Street.
- Restripe portions of First Street, Fourth Street, and Mabury Street to ensure operational continuity. Remove a portion of the existing slope and construct retaining (tie-back) wall in front of the existing west abutment of the First Street overcrossing and the adjacent storm water pump station.
- For the existing storm water pump station, relocate maintenance access and reconstruct stair access to the ramp shoulder.
- Install new lighting, ramp metering system, and CHP enforcement area at the new Fourth Street entrance ramp.

Option B. This design option would close the existing SB I-5 entrance ramp at First Street and construct an entrance loop ramp on the vacant parcel between First Street and Fourth Street and between Mabury Street and the SB I-5 mainline within city and Caltrans' ROW. The proposed engineering features include the following:

- Remove First Street entrance ramp and construct the new entrance loop ramp within the vacant parcel between First Street, Fourth Street, and SB I-5 mainline. Remove traffic signal at First Street and SB I-5 entrance ramp. Restripe entrance ramp to mainline and reconstruct the gore area.
- Construct two retaining walls to support exterior curve of new entrance loop ramp.
- Modify NB I-5 exit ramp to Mabury Street/First Street to remove the second ramp lane prior to the interface with Mabury Street.
- Remove a portion of the existing slope and construct retaining (tie-back) wall in front of the existing west abutment of the First Street overcrossing and the adjacent storm water pump station.
- For the existing storm water pump station, relocate maintenance access and reconstruct stair access to the ramp shoulder.
- Reconfigure Mabury Street as a two-way street and modify Mabury Street/First Street intersection accordingly. Add dual left-turn lanes at EB First Street and an exclusive right-turn lane for WB First Street to NB Mabury Street/SB I-5 entrance ramp.
- Restripe portions of First Street, South Elk Lane, and Mabury Street to ensure operational continuity.
- Install new lighting, ramp metering system, and CHP enforcement area at the new entrance loop ramp.

3.0 PHYSICAL SETTING

3.1 Climate

The weather in the Los Angeles Basin is a Mediterranean type climate with warm dry summers and mild winters. As is typical of a Mediterranean climate, most rainfall occurs in the winter months. The winter rains accompany northern Pacific storms that generally originate in the Gulf of Alaska region and sweep across California from the northwest. Occasional showers can occur during the summer months due to hot moist monsoonal air masses that spread northerly from the Gulf of Mexico and Gulf of California.

Another typical L.A. Basin weather characteristic results from the juxtaposition of cool marine waters and dry hot desert air. As the moist marine air masses drift over colder water a bank of low clouds and fog is formed which creeps inland for only a short distance before evaporating completely. Characteristically, this deck of clouds reaches inland as far as the bordering hills and mountains during the night, and then recedes to the vicinity of the coast during the day.

The average maximum temperatures in the project area are about 76 degrees Fahrenheit, and the average minimum temperatures are about 55 degrees. The warmest months are July through September when the maximum temperature averages about 83-85 degrees. The record high temperature in the project area is 110 degrees. The hottest temperatures are commonly associated with Santa Ana winds which involve adiabatic heating due to a high-pressure cell over the Great Basin in Nevada and Utah to the east. The coolest months are December through February when the average low is about 46-48 degrees. The lowest temperature recorded in the project area is 22 degrees. Freezing temperatures occur rarely in the winter months, but generally do not result in a hard freeze.

The average annual precipitation is about 13.7 inches a year with the wettest months being December through February when rainfall ranges from about 2 to 3½ inches per month. The driest months are July and August when virtually no precipitation is likely. Although snowfall is possible in the surrounding mountain ranges and rarely in the inland valleys, no snowfall is likely within the Los Angeles basin.

3.2 Topography and Drainage

The project corridor extends northwesterly along Interstate 5 from the State Route 55 to the State Route 57 in the Los Angeles Basin. The ground upon which the project is located slopes gently to the northwest. Elevations along the project corridor range from about 110 feet in the southern end to about 140 feet in the northern end.

The project corridor traverses the ancient flood plains and alluvial fans of Santiago Creek and the Santa Ana River. The major drainage in the area is the Santa Ana River which is located at the northern end of the project corridor and flows southwesterly toward the Pacific Ocean.

3.3 Regional Geology and Seismicity

3.3.1 Physiography

The site area is at the east-central portion of the Los Angeles physiographic basin, a large, relatively flat, low-lying, coastal plain surrounded by mountains on the north, east, and southeast. The western margin of the Los Angeles Basin is bordered by the sea and the Palos Verdes Hills. The eastern margin is bordered by the Puente Hills and Santa Ana Mountains.

The Los Angeles basin comprises a transition zone between the Peninsular Ranges physiographic province to the south and the Transverse Ranges province to the north. The Peninsular Ranges comprise a northwest-southeast trending group of fault-bounded ranges between the Salton Trough and the Pacific Ocean. The Transverse Ranges physiographic province comprises east-west trending ranges and valleys such as the Santa Monica Mountains, San Fernando Valley, and San Gabriel Mountains. Valleys such as the Los Angeles Basin, San Gabriel Valley, and Upper Santa Ana River Valley have characteristics compatible with both physiographic provinces and form a transition zone between the two provinces.

The Los Angeles Basin is a relatively flat coastal plain except for a series of aligned, northwesterly trending, low-elevation hills and mesas called the Newport-Inglewood Structural Zone (NISZ) which divide the basin into sub basins or plains. The Torrance Plain is west of the NISZ and the Downey and Tustin Plains are on the east. The Tustin Plain comprises the southern end of the Los Angeles Basin where it is bordered by low-elevation foothills of the Santa Ana Mountains on the east and by the San Joaquin Hills on the west. The project corridor is located in the Tustin Plain which is relatively flat and slopes gently southwesterly toward the coast.

3.3.2 Lithology and Stratigraphy

Geologic formations directly underlying the site are comprised primarily of river flood plain and alluvial fan alluvium. Materials within both these units are primarily sands with mixtures of silts, clays, and gravels. Regional studies (e.g. Morton, 2004; Morton and Miller, 1981; Durham and Yerkes, 1964; California Department of Water Resources, 1961) indicate that the site area is underlain by Quaternary sediments overlying older Quaternary and Tertiary sediments and sedimentary rocks. The surficial deposits are primarily Holocene and Pleistocene alluvial fan deposits.

3.3.3 Geologic Structure

The geologic structure at the site is characterized by flat-lying Quaternary sediments overlying gently folded Tertiary sedimentary rocks.

The nearest active or potentially active surface faults are the El Modeno, Peralta Hills and Whittier faults. The low-elevation plains and hills along the eastern margin of the Los Angeles Basin are underlain by a series of east-west trending, en echelon, faults and folds in the subsurface; the major faults within this trend are, from north to south, the Los Angeles (Las Cienegas), Santa Fe Springs, and Coyote Hills faults. This group of faults is known as the Puente Hills fault system. Other poorly known segments of this thrust fault system underlie the Richfield and Kramer hills. All of these faults are blind thrust or reverse faults that approach within about a mile or so of the ground surface. They are identified on seismic reflection geophysical data only and are below the depths of oil wells.

The Peralta Hills fault may be related to the Puente Hills fault system. The Peralta Hills fault is exposed along the south flank of the Peralta Hills where it displaces Tertiary-age rocks upward and over younger Quaternary alluvium. The fault extends westerly below the Santa Ana River channel where it creates barriers to ground-water flow. The barriers extend about to the SR-57 freeway just north of Lincoln Avenue (Morton and Miller, 1981). The location of the Peralta Hills fault is well up on the flank of the hills rather than at the base of the hills indicating that it is not the only fault responsible for uplift and folding of the Peralta Hills. There must be a deeper unknown blind thrust fault below the Peralta Hills thrust fault but this feature has never been directly identified.

The Whittier fault is a major strike slip fault that extends northwesterly along the southwest flank of the Puente Hills northeast of the site. The Whittier fault is associated with the Chino fault and the Elsinore fault and together these faults form a major fault system that extends from the Los Angeles Basin into northern Mexico.

The El Modeno fault is a north-south trending feature within Loma Ridge, one of the foothills of the Santa Ana Mountains, southeast of the site. The feature is poorly known but is known to displace Holocene soil in Loma Ridge. Although the fault is grouped with the Peralta Hills fault on the Caltrans seismic hazard map, it appears to be a discrete normal or strike-slip fault unrelated to the thrust faults of the Peralta Hills. Although the fault must be considered active because it displaces Holocene soil, the feature has a very long (thousands of years) recurrence interval.

3.3.4 Geologic Hazards

There are no steep slopes within the corridor, so landsliding is not likely. There are no identified active faults through the project area so surface fault rupture is not likely. There are no known volcanos in the site region. The site is far from the sea on elevated land so tsunamis are not a hazard.

Portions of the site in the vicinity of the Santa Ana River and Santiago Creek are identified on the State seismic hazard maps of the Anaheim, Orange and Tustin quadrangles (California Geological Survey, 1998 and 2001) as being susceptible to liquefaction.

Liquefaction. As discussed above, according to CGS (1998 and 2001), the project corridor does cross areas with potential for liquefaction. Liquefaction is a phenomenon whereby saturated granular soils lose their inherent shear strength due to increased pore water pressures, which may be induced by cyclic loading such as that caused by an earthquake. Low density granular soils, shallow groundwater, and long duration/high acceleration seismic shaking are some of the factors favorable to cause liquefaction. Liquefaction is generally considered possible when the depth to groundwater is less than about 50 feet below the ground surface.

Though CGS (1998 and 2001), estimates historical high groundwater levels to be approximately 40 feet below ground surface along the project corridor, groundwater may vary locally with potential for shallow conditions along major streams and tributaries. A site specific investigation will be required to determine the soil and groundwater conditions along the project alignment to evaluate the potential for liquefaction along the corridor.

Depending on site conditions, liquefaction has the potential to impact proposed structures along the project corridor (bridges, retaining walls, etc.). Mitigations could include lengthening of pile foundations, ground improvements and/or designing foundations to undergo larger movements. Impacts associated with liquefaction should be considered as low for pavement and embankment improvements.

3.4 Seismicity

Seismic design criteria will conform to latest Caltrans requirements. The project site is in seismically active southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, by earthquake focal-mechanism solutions, and by geodetic measurements. These data suggest compression rates of between 0.2 and 0.35 inch per year (5 and 9 mm/yr) across the greater Los Angeles area.

Historical epicenter maps show widespread seismicity throughout the Los Angeles Basin. Although historical earthquakes occur in proximity to known faults, they are difficult to directly associate with mapped faults. Part of this difficulty is due to the fact that the basin is underlain by several subsurface thrust faults (blind faults). Earthquakes in the region occur primarily as loose clusters along the Newport-Inglewood Structural Zone, along the southern margin of the Santa Monica Mountains, the southern margin of the Santa Susana and San Gabriel Mountains, and in the Coyote Hills-Puente Hills area.

The largest historical earthquake within the Los Angeles Basin was the 1933 Long Beach earthquake of M_W=6.4 (M_L = 6.3) which is generally believed to have been associated with the NISZ. The association of the 1933 event with the NISZ was based on abundant ground failures along the NISZ trend, but no unequivocal surface rupture was identified. Hauksson and Gross (1991) reevaluated the seismicity data and relocated the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

Other damaging earthquakes in the Los Angeles region include the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events. The 1971 San Fernando (M_L= 6.4, M_W=6.7) earthquake occurred along the northern margin of the San Fernando Valley and produced a surface rupture which coincided partly with a zone of mapped surface faults along the mountain-valley margin. The more-recent 1987 Whittier earthquake (M_L=5.9, M_W=5.9) and the 1994 Northridge (M_L=6.4, M_W = 6.7) earthquake were not associated with surface faulting. Such events indicate that seismic hazard analysis must consider subsurface faulting as well as surface faulting. The Whittier event occurred at a depth of about 10 miles on a northerly dipping thrust fault dipping from the Coyote Hills area, under the Repetto and Puente Hills, to below the San Gabriel Valley. The Northridge event occurred at a depth of about 12 miles on a south-dipping reverse fault below the San Fernando Valley.

Another significant earthquake in the region was the 1812 earthquake which caused damage at the San Juan Capistrano Mission. The location and magnitude of the 1812 earthquake are unknown but geological studies (Jacoby et al., 1987; Fumal et al., 1993; Weldon et al., 2004) postulated that it did not occur in the Capistrano area, but rather was a large (M> 7.0) distant event on the San Andreas fault in the Wrightwood area of the San Gabriel Mountains.

The earliest documented earthquake in the region was reported by the Portola expedition as they camped along the Santa Ana River in 1769. This event has been attributed by various geoscientists to just about every fault in the area but it could very well have been a distant event that shook a wide area, as did the 1971 San Fernando, the 1987 Whittier, and the 1994 Northridge events, as well as many other more-distant events (for example, 1992 Landers event).

A recent magnitude 5.4 (M_W) earthquake occurred on 29 July 2008 below the Puente Hills northeast of the site at a depth of about 10 miles. This event was a reverse type fault with a left- lateral component of slip. The causative fault is unknown. The epicenter is between the Whittier and Chino faults. The orientation of the preferred focal plane of the focal mechanism solution is somewhat compatible with the Whittier fault. The Whittier fault may have a reverse component of slip but is believed to be primarily a right-lateral fault. Furthermore, dip of the preferred focal plane and the distribution of aftershocks are not very compatible with the Whittier fault. The northerly dipping buried thrust faults under the Peralta Hills, Richfield Hills, or Kraemer Hills could have been the source because the preferred focal plane dips northeasterly similar to the northerly dipping faults. However, the distribution of the aftershocks does not seem compatible with the orientations of these faults.

As discussed, the project corridor is located within the vicinity of numerous active faults with a history of seismicity. As a result, the potential for ground shaking should be anticipated along the project alignment. During the design phase, a site specific seismic evaluation will be required to assess the impacts related to ground motion on any proposed corridor structures. The project corridor does not cross any active faults and is not located within an Alquist Priolo Fault Hazard Zone. Thus, the potential for fault related ground rupture should be considered low.

3.5 Surface Water

Under the natural regime, much of the project corridor was within the flood plains of Santiago Creek and the Santa Ana River. However, the natural surface drainage has been highly modified and the rivers are now largely confined within concrete/rip rap-lined aqueducts.

Scour. This site is located within an area that is presently improved; roadway surfaces are paved and drainage is controlled by engineered facilities. Therefore, scour is not considered a design issue.

Erosion. Surficial soils within the project area contain some amount of cohesive fines; therefore, the soils are not easily eroded. However, slope areas that may consist of sandy surficial soils (with little to no cohesive fines) are susceptible to rilling, piping, and accelerated erosion. In general, the erosion potential of soils within the project area is considered low to moderate; however, provisions for site drainage, slope planting and other measures in accordance with Caltrans requirements should be fulfilled to provide adequate protection against erosion. To minimize erosion of slopes, surface water should not be directed to flow over slope faces. Faces of finished slopes should be planted as soon as possible, after grading is completed, to minimize erosion.

3.6 Subsurface Soil Conditions

The project alignment is underlain by Quaternary-age alluvial deposits. The upper part of the alluvium consists of modern stream channel, alluvial fan, and flood plain sediments underlain by bedrock of predominantly Tertiary-age marine and Mesozoic sedimentary rocks which in turn overlie crystalline igneous and metamorphic basement rocks at depth. The Tertiary formations include, from youngest to oldest, Pliocene-age Fernando, Pico, and Capistrano formations, the Miocene-age Puente, Monterey, and Topanga formations, and the Eocene Vaqueros/Sespe formation. Most of these formations crop out in the hills surrounding the project area but are deep below the area of interest to this project. In general, materials within the alluvial deposits are primarily sands with mixtures of silts, clays, and gravels.

The subsurface materials below the project alignment consist of layers of clayey silt, sandy silt, lean clay, sandy clay, silty sand and clayey sand underlain by interbedded layers of sand with silt, sand and gravel.

3.7 Groundwater

The depth to groundwater is poorly known along the project corridor. The California Geological Survey (1997, 1998) estimates the historically highest (i.e. shallowest) groundwater within the project corridor to be approximately 40 feet deep. The Orange County Water District (2011) indicates the depth to the principal aquifer underlying the site is greater than 100 feet. Groundwater is anticipated to fluctuate seasonally as a result of several factors including rainfall, irrigation, temperature, land use and other factors. Also, localized shallow groundwater conditions may be encountered near major streams and tributaries (Santa Ana River and Santiago Creek). As a result, a site specific investigation will be required to determine groundwater conditions at site specific structure locations. Concrete seal course can be used to control groundwater during foundation construction in localized shallow groundwater areas. Based on the above information, controlling groundwater level using temporary or permanent pumping stations does not appear to be warranted.

3.8 Soil Corrosivity

Based on our experience, fine-grained soils (silts and clays) are the typical soil types responsible for corrosive site conditions. Since onsite soils within the project area are composed of both coarse-grained sandy soils and fine-grained silts and clays, soil corrosivity may become a design issue. Results obtained from our evaluation of the corrosivity of onsite soils and preliminary recommendations on culvert materials have been addressed in the Preliminary Materials Report (EMI, 2012a). A soil corrosion study should be performed during the design phase of the project.

4.0 MATERIAL SOURCES

Numerous commercial suppliers for sand, gravel, aggregate base, and concrete are located in Orange County, which will be identified during the PS&E phase of the project. Pulverizing existing pavement, during construction, might be performed. Pulverized AC and Portland cement concrete can be used as aggregate base assuming the pulverized material is processed and meets the quality requirements of Aggregate Base (AB) specified in the Caltrans Standard Specifications (2010). Caltrans must approve the use of pulverized material for AB.

5.0 MATERIAL DISPOSAL

According to the project civil designer, import material is not required. This project is expected to generate earth materials that will require off-site disposal. Disposal sites were not investigated for the project.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Earthwork

Earthwork should be conducted in accordance with Section 19 of the Caltrans Standard Specifications (2010). In areas where compacted fill will be placed, the existing compressible surficial materials including topsoil, loose or soft alluvium or fill soil, dry or saturated soil, and otherwise unsuitable materials must be removed prior to fill placement. A minimum overexcavation of 2 feet is recommended within areas to receive fill; the overexcavation should extend horizontally a minimum distance of 2 feet from edges of new fills or structures. Fill placed on sloping ground should be properly keyed and benched into existing ground and placed as specified in Caltrans Standard Specifications. Overexcavations should be observed by qualified geotechnical personnel to verify that firm and unyielding bottoms are exposed. Overexcavated areas should be cleaned of loose materials and debris and should be observed to be firm and unyielding before receiving fill.

Excavations are anticipated to be performed within existing artificial fill and alluvium. These on-site materials can be excavated using conventional heavy-duty earth-moving equipment and the materials are not expected to pose a rippability problem.

6.2 Soil Expansion Potential

On-site soils are fine-grained silts and clays to coarse-grained sands. The sandy soils are anticipated to be non-expansive or have a very low expansion potential. The silts and clays are anticipated to have a medium to high expansion potential. Soil expansion potential should be evaluated during PS&E for the project.

6.3 Soil Erosion Potential

Since the native soils are anticipated to be predominantly fine- to coarse-grained sands, the soils can suffer moderate to severe erosion. However, by incorporating selective grading and adhering to provisions for site drainage, and slope planting, the potential for surface soil erosion can be minimized.

6.4 Liquefaction Potential and Seismically-Induced Settlement

Liquefaction is the loss of shear strength in generally cohesionless, saturated soils when the pore-water pressure induced in the soil by a seismic event becomes equal to or exceeds the overburden pressure. Primary factors influencing liquefaction potential include: groundwater elevation, soil type and grain-size distribution, relative density of soil, initial confining pressure, and intensity and duration of ground shaking. Soils most susceptible to liquefaction are saturated low-density sands and silty sands within 50 feet of the ground surface.

The Seismic Hazard Zone map of Tustin Quadrangle Map (CGS, 2001) and Orange Quadrangle Map (CGS, 1998) for the subject site shows that the project area crosses through areas with potential for liquefaction in the vicinity of the Santa Ana River and Santiago Creek. Any proposed structures (bridges, retaining walls, etc.) in these liquefaction potential zones may be susceptible to liquefaction and subsequent seismic settlement. Though, impacts associated with liquefaction and seismic settlement should be considered as low for pavement and embankment improvements located in liquefaction potential zones. For structures, mitigations could include lengthening of pile foundations, ground improvements and/or designing foundations to undergo larger movements.

6.5 Embankment Settlement

Based on our discussions with the civil designers, there is no widening of the existing fill embankments. Therefore, embankment settlement is not a design issue.

6.6 Stability of Embankment Slopes

Based on our discussions with the civil designers, there is no widening of the existing fill embankments. Therefore, this project does not impact global stability of the existing fill slopes.

6.7 Cut Slopes

Requirement in Topic 304 of the Caltrans HDM (2012) is not directly applicable to cut slopes. However, to improve safety and reduce slope erosion, the same requirement should be applied to cut slopes from a geotechnical point of view. Therefore, cut slopes should not be constructed steeper than 4H:1V. However, like fill slopes, constructing cut slopes with inclinations of 4H:1V or flatter is based on the assumptions that adequate space is available, that there are no physical obstructions interfering with the slope, and that earthwork costs are not prohibitive. Where space is limited by right-of-way or other physical constraints, or when cut quantities and associated earthwork costs become unreasonable, stable cut slopes can be constructed with inclinations steeper than 4H:1V.

The most critical cut section is located near Station 933+00 in the northbound direction. It has a proposed wall height of about 7 feet retaining a 2H:1V cut slope for a total height of about 23 feet. For this critical cut section, our calculations in Appendix A indicate that this cut slope is expected to be globally stable assuming no adverse geologic conditions exist.

Global and surficial stability of all cut slopes will require evaluation during the PS&E phase of the project.

6.8 Earth Retaining Structures

According to the Layout Sheets provided by the civil designers, retaining structures are proposed at the following locations:

1) a tieback wall is proposed underneath the First Street OC at Abutment 1. This wall is approximately 125 feet long with a maximum wall height of about 12 feet in Design Option A and 15 feet in Design Option B,

2) L-shaped cantilevered retaining walls are proposed in front of the existing abutments underneath the Lincoln Avenue UP. Wall lengths are about 52 and 76 feet in front of Abutments 1 and 4, respectively; corresponding maximum wall heights are about 11 and 13.5 feet,

3) tieback walls are proposed in front of the existing abutments underneath the Lincoln Avenue OC. Wall lengths are about 65 and 56 feet in front of Abutments 1 and 4, respectively; corresponding maximum wall heights are about 12 and 14 feet,

4) a tieback wall is proposed below the Abutment-5 wingwall of the E22-S5/S57-S5 Connector Separation to retain the sloping embankment. This wall is approximately 170 feet long with a maximum wall height of about 5 feet,

5) For Alternative 2A/2B, cantilevered walls are proposed along the NB and SB directions of I-5 near Lincoln Avenue with wall length varying from 1400 to 1650 feet; NB direction only near the Main Street Off-Ramp with a wall length of about 1250 feet; and NB direction only at SR-22 with a wall length of about 400 feet,

6) For Alternative 5A/5B, cantilevered walls are proposed along the NB and SB directions of I-5 near Lincoln Avenue with wall length varying from 1400 to 1650 feet; and along the median between Main Street and Broadway with a wall length of about 1350 feet,

7) For Design Option A, a 750-foot long cantilevered wall is proposed at the Fourth Street SB entrance ramp, and

8) For Design Option B, a 200-foot and a 600-foot long cantilevered wall are proposed at the First Street SB Loop entrance ramp.

Items (1) to (4) on the above list are non-standard walls and preliminary foundation design recommendations are presented in separate Structure Preliminary Geotechnical Reports (SPGR's) (EMI, 2012b, c and d).

For the remaining walls on the above list (Items 5 to 8), spread footings are expected to be suitable for supporting standard Caltrans retaining walls for wall height less than or equal to 16 feet with one to three feet of overexcavation and recompaction. For wall heights greater than 16 feet, driven piles are recommended. Driven pile type can be either precast concrete or steel HP-piles; final driven pile type should be selected using site-specific soil borings data collected during the PS&E phase. For cost estimating purposes and a nominal resistance of 180 and 280 kips, pile lengths for standard Caltrans precast concrete piles (Alt. X) are 36 and 44 feet, respectively; corresponding steel HP-pile lengths are 43 and 53 feet. Standard Caltrans HP pile sections are HP 10x42 and HP 10x57 for nominal resistance of 180 and 280 kips, respectively. The above spread footing and driven pile preliminary design calculations are included in Appendix A.

The above recommendations will be confirmed using exploratory boreholes performed along alignments of proposed retaining walls.

6.9 Hazardous Waste Considerations

If for any reason hazardous or toxic materials are believed to exist within the project area, an environmental specialist should be consulted.

6.10 Future Geotechnical Investigations

EMI recommends excavating numerous exploratory borings throughout the project area, during the PS&E phase of the project, to investigate site-specific soils and conditions and to collect samples of subsurface soils for laboratory testing. The locations and depths of the borings should be selected once the locations and extent of proposed improvements have been finalized.

Soil samples recovered during the future geotechnical field investigations should be tested to determine soil type, soil shear strength, compressibility characteristics, Sand Equivalent, R-value, compaction characteristics and corrosion potential.

7.0 LIMITATIONS

This PGDR is intended for use by AECOM, Orange County Transportation Authority, and the California Department of Transportation for improvements proposed at I-5 between about SR-55 and SR-57. This report is based on the project as described herein and the available published subsurface information. The described earth materials and subsurface conditions are presumed to be representative of the project site.

Data, opinions, and recommendations contained herein are applicable to the project which is the subject of this report. Data, opinions, and recommendations herein have no applicability to any other design elements or to any other locations, and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

Services performed by EMI were conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions. No other representation, expressed or implied, and no warranty or guarantee is included or intended.

8.0 REFERENCES

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Appendix A

Design Calculations

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phone: (714)751-3826, Fax (714)751-3928

Project: I5 Between SR-55 and SR-57 | Project No. 11-151
By CY | Date 12/21/2012 | Check by ______ | Date ______ | Sheet ______

Idealized Soil Profile near Lincoln Ave

EL (ft)	soil description	γ' (pcf)	Avg N-Value	φ (degree)	c (psf)	aparent density consistency	Depth (ft)
+147.0							0.0
	Silty Sand, Silt, Sand, Silty Clayey	115	14	31.0	150	medium dense	
+115.0							32.0
	Sand, Clayey Sand, Silty Sand	120	18	32.0	100	medium dense	
+100.0							47.0
	Sand, Clayey Sand, Silty Sand	57.6	18	32.0	100	medium dense	
+85.0							62.0
	Sand, Clayey Sand, Silty Sand	63.6	35	36.0	50	dense	
+50.0							97.0

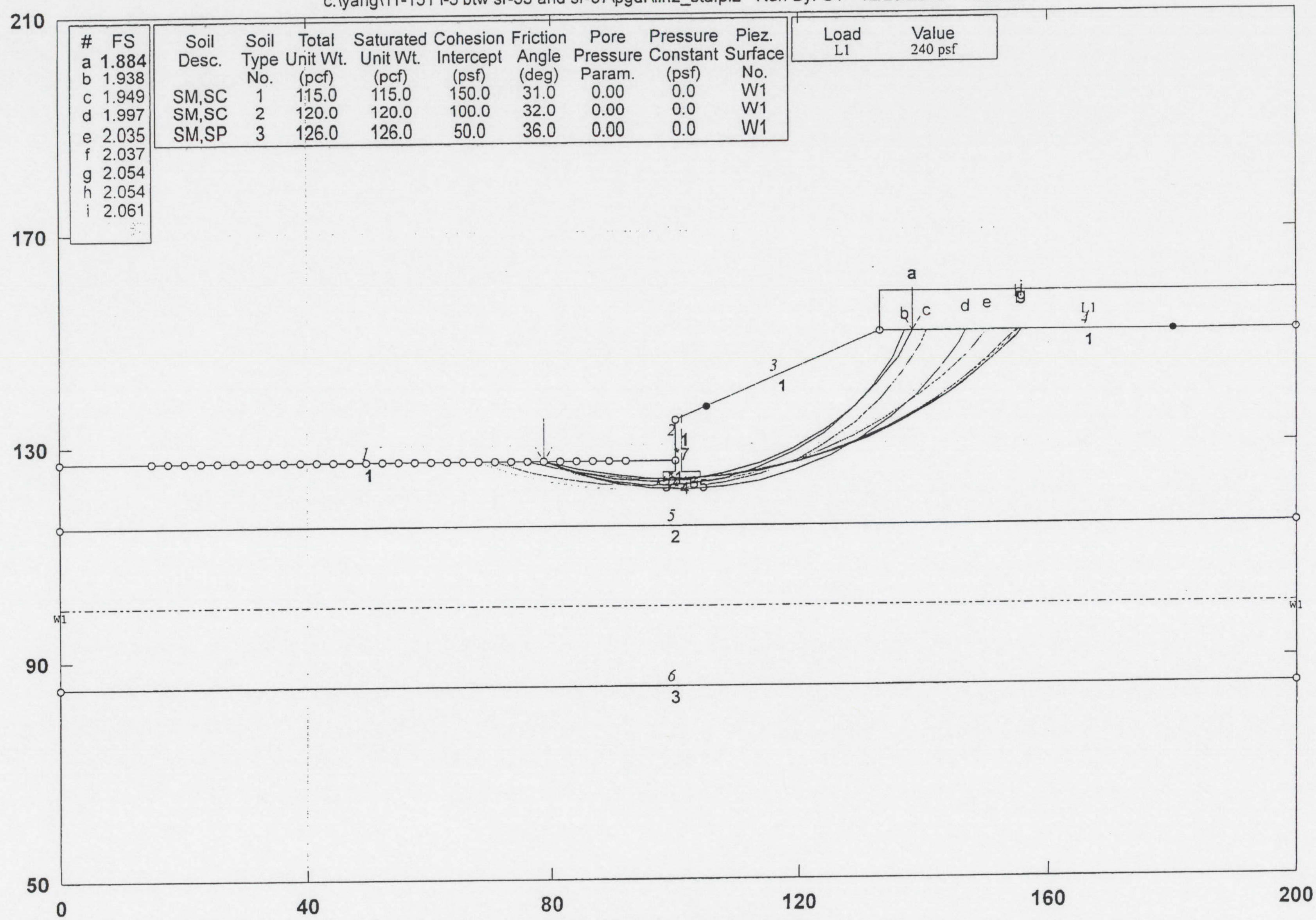
I-5 Between SR-55 and SR-57 Near Sta 933+00 NB -- Static

c:\yang\11-151 i-5 btw sr-55 and sr-57\pgdr\lin2_sta.pl2 Run By: CT 12/28/2012 11:54AM

#	FS
a	1.884
b	1.938
c	1.949
d	1.997
e	2.035
f	2.037
g	2.054
h	2.054
i	2.061

Soil Desc.	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.
SM,SC	1	115.0	115.0	150.0	31.0	0.00	0.0	W1
SM,SC	2	120.0	120.0	100.0	32.0	0.00	0.0	W1
SM,SP	3	126.0	126.0	50.0	36.0	0.00	0.0	W1

Load	Value
L1	240 psf

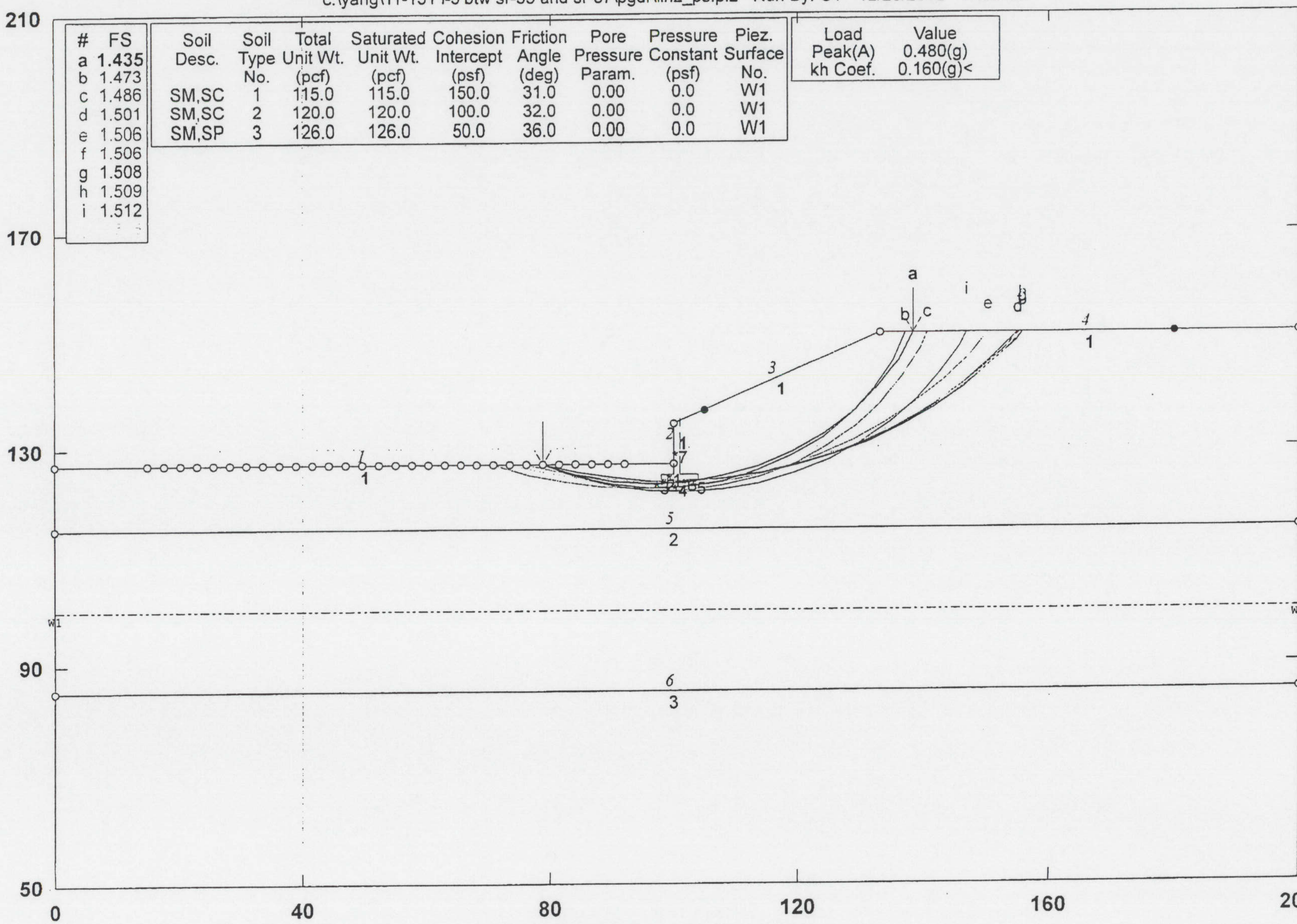


GSTABL7 v.2 FSmin=1.884

Safety Factors Are Calculated By The Modified Bishop Method

I-5 Between SR-55 and SR-57 Near Sta 933+00 NB -- Pseudostatic

c:\yang\11-151 i-5 btw sr-55 and sr-57\pgdr\lin2_ps.pl2 Run By: CT 12/28/2012 11:55AM



#	FS
a	**1.435**
b	1.473
c	1.486
d	1.501
e	1.506
f	1.506
g	1.508
h	1.509
i	1.512

Soil Desc.	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.
SM,SC	1	115.0	115.0	150.0	31.0	0.00	0.0	W1
SM,SC	2	120.0	120.0	100.0	32.0	0.00	0.0	W1
SM,SP	3	126.0	126.0	50.0	36.0	0.00	0.0	W1

Load	Value
Peak(A)	0.480(g)
kh Coef.	0.160(g)<

GSTABL7 v.2 FSmin=1.435

Safety Factors Are Calculated By The Modified Bishop Method

Earth Mechanics, Inc.
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Project: **I5 Between SR-55 and SR-57** Project No. **12-151**
By CTY Date 12/26/12 Check by Date Sheet

Caltrans Standard Wall - Spread Footing Design
Wall Height of 12 feet or less

Standard Caltrans Type 1 Wall - 2010 Caltrans RSP B3-1C

Max H= 12 ft Net pressure, $q_{o'}$= 1.8 ksf (for Load Case 3)
B'= 8.00 ft

Check Permissible Settlement Under Service Demand
Method: 2007 AASHTO LRFD Bridge Design Spec -Hough's Method

Layer	Elev. (ft)	(N')	c'	Soil	γ (pcf)	depth (ft)
	130.0					0.0
0					γ= 120 pcf	
	127.0			Over EX		3.0
I					γ= 115 pcf	
	126.0					4.0
II		(N')= 14	c'= 48	SM	γ= 115 pcf	
	122.0					8.0
III		(N')= 18	c'= 55	SM	γ= 120 pcf	
	115.0					15.0
IV		(N')= 18	c'= 55	SM	γ= 120 pcf	
	100.0					30.0
V		(N')= 55	c'= 129	SM	γ= 65.6 pcf	
	90.0					40.0

Note: 1. c'= bearing capacity index
2. N'= average corrected SPT blowcount
3. The overexcavation in Layer I is recommended to remove weak material. Since the back fill in the overexcavation zone will be well-compacted, the settlement in this zone is negligible.

Layer	Layer Thick. (ft)	Mid pt. depth (ft)	Mid pt. depth to FB (ft)	σ_{vo}' (ksf)	Z/B	$\Delta\sigma$ %	$\Delta\sigma_v'$ (ksf)	σ_{vt} (ksf)	C	ΔH w overex (in)	
0	3	1.5		0.18							
I	1	3.5	0.5	0.42	0.06	1.00	1.80	2.22	0		1ft OverEX
II	4	6	3	0.71	0.38	0.91	1.63	2.34	48	0.52	
III	7	11.5	8.5	1.37	1.06	0.55	0.99	2.36	55	0.36	
IV	15	22.5	19.5	2.69	2.44	0.26	0.47	3.16	55	0.23	
V	10	35	32	3.92	4.00	0.14	0.25	4.17	129	0.03	
									total=	***1.13***	

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By CTY Date 12/26/12 Check by Date Sheet

Caltrans Standard Wall - Spread Footing Design

Wall Height of 12 feet or less

Standard Caltrans Type 1 Wall - Check Bearing Capacity

Method: Terzaghi Ultimate Capacity from NAVFAC DM 7.2

Strength Limit

Base material propertires:	γ'=	0.115	ksf		=> Nq= 20.6
	ϕ=	31	° =	0.541 rad	Nr= 18.5
	c=	0.15	ksf		Nc= 32.6
Footing Information	D=	3	feet	Overburn	
	FBE=	127	ft	Footing Bottom Elevation	
	GWE=	100	ft	Ground Water Elevation	
	B'=	4.30	ft	Effective Dimensions from 2010 RSP B3-1A	
	qo=	3.8	ksf	Required gross bearing capacity from 2010 RSP B3-1A	

q_{ult} = cNc+ γ'DNq + 0.4γ'BNr = 0.15*32.6+0.115x3x20.6+0.4x0.115x4.3x18.5 = 15.66 ksf

q_{allow} = q_{ult} * 0.45 = 15.66 * 0.45 = 7 ksf > q_o = 3.8 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

Extreme I Limit

Base material propertires:	γ'=	0.115	ksf	
Footing Information	D=	3	feet	Overburn
	FBE=	127	ft	Footing Bottom Elevation
	GWE=	100	ft	Ground Water Elevation
	B'=	3.60	ft	Effective Dimensions from 2010 RSP B3-1A
	qo=	4.9	ksf	Required gross bearing capacity from 2010 RSP B3-1A

q_{ult} = cNc+ γ'DNq + 0.4γ'BNr = 0.15*32.6+0.115x3x20.6+0.4x0.115x3.6x18.5 = 15.06 ksf

q_{ult} = 15.1 ksf > q_o = 4.9 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

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Project: **I5 Between SR-55 and SR-57** Project No. **12-151**
By CTY Date 12/26/12 Check by Date Sheet ______

Caltrans Standard Wall - Spread Footing Design

Wall Height of 14 feet

Standard Caltrans Type 1 Wall - 2010 Caltrans RSP B3-1C

Max H= 14 ft Net pressure, $q_{o'}$= 2.1 ksf (for Load Case 3)
B'= 9.30 ft

Check Permissible Settlement Under Service Demand
Method: 2007 AASHTO LRFD Bridge Design Spec -Hough's Method

Layer	Elev. (ft)	(N')	c'	Soil	γ (pcf)	depth (ft)
	130.0					0.0
0 (Over EX)					120	
	127.0					3.0
I					115	
	125.0					5.0
II		14	48	SM	115	
	122.0					8.0
III		18	55	SM	120	
	115.0					15.0
IV		18	55	SM	120	
	100.0					30.0
V		55	129	SM	65.6	
	90.0					40.0

Note: 1. c'= bearing capacity index
2. N'= average corrected SPT blowcount
3. The overexcavation in Layer I is recommended to remove weak material. Since the back fill in the overexcavation zone will be well-compacted, the settlement in this zone is negligible.

Layer	Layer Thick. (ft)	Mid pt. depth (ft)	Mid pt. depth to FB (ft)	σ_{vo}' (ksf)	Z/B	$\Delta\sigma$ %	$\Delta\sigma_v'$ (ksf)	σ_{vt} (ksf)	C	ΔH w overex (in)	
0	3	1.5		0.18							
I	2	4	1	0.48	0.11	0.98	2.07	2.54	0		2ft OverEX
II	3	6.5	3.5	0.77	0.38	0.91	1.90	2.67	48	0.41	
III	7	11.5	8.5	1.37	0.91	0.62	1.30	2.66	55	0.44	
IV	15	22.5	19.5	2.69	2.10	0.30	0.63	3.32	55	0.30	
V	10	35	32	3.92	3.44	0.17	0.36	4.27	129	0.04	
									total=	***1.18***	

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Caltrans Standard Wall - Spread Footing Design

Wall Height of 14 feet

Standard Caltrans Type 1 Wall - Check Bearing Capacity

Method: Terzaghi Ultimate Capacity from NAVFAC DM 7.2

Strength Limit

Base material propertires:	γ'=	0.115	ksf		=>	Nq=	20.6
	φ=	31	° =	0.541 rad		Nr=	18.5
	c=	0.15	ksf			Nc=	32.6
Footing Information	D=	3	feet	Overburn			
	FBE=	127	ft	Footing Bottom Elevation			
	GWE=	100	ft	Ground Water Elevation			
	B'=	5.90	ft	Effective Dimensions from 2010 RSP B3-1A			
	qo=	3.8	ksf	Required gross bearing capacity from 2010 RSP B3-1A			

q_{ult} = cNc+ γ'DNq + 0.4γ'BNr = 0.15*32.6+0.115x3x20.6+0.4x0.115x5.9x18.5 = 17.02 ksf

q_{allow} = q_{ult} * 0.45 = 17.02 * 0.45 = 7.7 ksf > q_o = 3.8 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

Extreme I Limit

Base material propertires:	γ'=	0.115	ksf	
Footing Information	D=	3	feet	Overburn
	FBE=	127	ft	Footing Bottom Elevation
	GWE=	100	ft	Ground Water Elevation
	B'=	4.30	ft	Effective Dimensions from 2010 RSP B3-1A
	qo=	5.5	ksf	Required gross bearing capacity from 2010 RSP B3-1A

q_{ult} = cNc+ γ'DNq + 0.4γ'BNr = 0.15*32.6+0.115x3x20.6+0.4x0.115x4.3x18.5 = 15.66 ksf

q_{ult} = 15.7 ksf > q_o = 5.5 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

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Project: **I5 Between SR-55 and SR-57** Project No. **12-151**
By CTY Date 12/26/12 Check by Date Sheet

Caltrans Standard Wall - Spread Footing Design

Wall Height of 16 feet

Standard Caltrans Type 1 Wall - 2010 Caltrans RSP B3-1C

Max H= 16 ft Net pressure, $q_{o'}$= 10.6 ksf (for Load Case 3)

B'= 2.30 ft

Check Permissible Settlement Under Service Demand

Method: 2007 AASHTO LRFD Bridge Design Spec -Hough's Method

Layer	Elev. (ft)			depth (ft)
	130.0			0.0
0		Over EX	γ= 120 pcf	
	127.0			3.0
I			γ= 115 pcf	
	124.0			6.0
II		(N')= 14 c'= 48	**SM** γ= 115 pcf	
	122.0			8.0
III		(N')= 18 c'= 55	**SM** γ= 120 pcf	
	115.0			15.0
IV		(N')= 18 c'= 55	**SM** γ= 120 pcf	
	100.0			30.0
V		(N')= 55 c'= 129	**SM** γ= 65.6 pcf	
	90.0			40.0

Note: 1. c'= bearing capacity index
2. N'= average corrected SPT blowcount
3. The overexcavation in Layer I is recommended to remove weak material. Since the back fill in the overexcavation zone will be well-compacted, the settlement in this zone is negligible.

Layer	Layer Thick. (ft)	Mid pt. depth (ft)	Mid pt. depth to FB (ft)	σ_{vo}' (ksf)	Z/B	$\Delta\sigma$ %	$\Delta\sigma_v'$ (ksf)	σ_{vt} (ksf)	C	ΔH w overex (in)	
0	3	1.5		0.18							
I	3	4.5	1.5	0.53	0.65	0.76	8.09	8.62	0		3ft OverEX
II	2	7	4	0.83	1.74	0.37	3.96	4.78	48	0.38	
III	7	11.5	8.5	1.37	3.70	0.15	1.64	3.01	55	0.52	
IV	15	22.5	19.5	2.69	8.48	0.05	0.54	3.22	55	0.26	
V	10	35	32	3.92	13.91	0.02	0.21	4.13	129	0.02	
									total=	***1.18***	

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Caltrans Standard Wall - Spread Footing Design

Wall Height of 16 feet

Standard Caltrans Type 1 Wall - Check Bearing Capacity

Method: Terzaghi Ultimate Capacity from NAVFAC DM 7.2

Strength Limit

Base material propertires:	γ'=	0.115	ksf		=>	Nq= 20.6
	ϕ=	31	° =	0.541 rad		Nr= 18.5
	c=	0.15	ksf			Nc= 32.6
Footing Information	D=	3	feet	Overburn		
	FBE=	127	ft	Footing Bottom Elevation		
	GWE=	100	ft	Ground Water Elevation		
	B'=	7.90	ft	Effective Dimensions from 2010 RSP B3-1A		
	qo=	4.3	ksf	Required gross bearing capacity from 2010 RSP B3-1A		

$q_{ult} = cNc + \gamma'DNq + 0.4\gamma'BNr$ = 0.15*32.6+0.115x3x20.6+0.4x0.115x7.9x18.5 = 18.72 ksf

$q_{allow} = q_{ult}$ * 0.45 = 18.72 * 0.45 = 8.4 ksf > q_o = 4.3 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

Extreme I Limit

Base material propertires:	γ'=	0.115	ksf	
Footing Information	D=	3	feet	Overburn
	FBE=	127	ft	Footing Bottom Elevation
	GWE=	100	ft	Ground Water Elevation
	B'=	4.60	ft	Effective Dimensions from 2010 RSP B3-1A
	qo=	6.3	ksf	Required gross bearing capacity from 2010 RSP B3-1A

$q_{ult} = cNc + \gamma'DNq + 0.4\gamma'BNr$ = 0.15*32.6+0.115x3x20.6+0.4x0.115x4.6x18.5 = 15.91 ksf

q_{ult} = 15.9 ksf > q_o = 6.3 kPa

Note: since (depth to GW) > (footing width), no reduction for soil effective weight is required.

C:\Yang\11-151 I-5 btw SR-55 and SR-57\PGDR\AltXa.cpt

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AXIALLY LOADING PILE ANALYSIS PROGRAM - APILEplus
VERSION 5.0 - (C) COPYRIGHT ENSOFT,INC.,1987-2008.

I-5 Btw SR-55 and SR-57 (Alt-X pile design)

DESIGNER : CTY

DATE :

PILE PROPERTIES :

PERIMETER OF PILE WITH NONCIRCULAR SECTION	=	48.00 IN.
TIP AREA OF PILE WITH NONCIRCULAR SECTION	=	1.00 SQF
OUTSIDE DIAMETER OF CIRCULAR PILE	=	0.00 IN.
INTERNAL DIAMETER OF CIRCULAR PILE	=	0.00 IN.
PILE LENGTH	=	50.00 FT.
MODULUS OF ELASTICITY	=	0.360E+07 PSI

LENGTH OF SURFACE SECTION WITH ZERO SKIN FRICTION	=	2.00 FT.
INCREMENT OF PILE LENGTH USED IN COMPUTATION	=	1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.00	115.00	31.00	0.00
12.00	SAND	0.00	115.00	31.00	0.00
12.00	SAND	0.00	120.00	32.00	0.00
27.00	SAND	0.00	120.00	32.00	0.00
27.00	SAND	0.00	57.60	32.00	0.00
42.00	SAND	0.00	57.60	32.00	0.00
42.00	SAND	0.00	63.60	36.00	0.00
60.00	SAND	0.00	63.60	36.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
9999.00	99999.00	0.00	0.00	14.00	0.00	0.00
9999.00	99999.00	0.00	0.00	14.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	35.00	0.00	0.00
9999.00	99999.00	0.00	0.00	35.00	0.00	0.00

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****
* COMPUTATION RESULT *
****

	* FED. HWY. METHOD *			* ARMY CORPS METHOD *			* LAMBDA 2 METHOD *			
PILE PENETR-ATION FT.	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	
0.0	0.0	3.1	3.1	0.0	3.9	3.9	0.0	0.0	0.0	
1.0	0.0	5.5	5.5	0.0	6.9	6.9	0.0	0.0	0.0	
2.0	0.2	8.0	8.2	0.0	10.0	10.0	0.0	0.0	0.0	
3.0	0.8	10.4	11.3	0.0	13.0	13.0	0.0	0.0	0.0	
4.0	1.7	12.9	14.5	0.0	16.1	16.1	0.0	0.0	0.0	
5.0	2.8	15.3	18.1	0.0	19.1	19.1	0.0	0.0	0.0	
6.0	4.1	17.7	21.8	0.0	22.2	22.2	0.0	0.0	0.0	
7.0	5.6	19.5	25.2	0.0	25.2	25.2	0.0	0.0	0.0	
8.0	7.4	20.4	27.9	0.0	28.3	28.3	0.0	0.0	0.0	
9.0	9.5	20.7	30.2	0.0	31.3	31.3	0.0	0.0	0.0	
10.0	11.8	23.3	35.1	0.0	35.4	35.4	0.0	0.0	0.0	
11.0	14.3	28.2	42.4	0.0	40.6	40.6	0.0	0.0	0.0	
12.0	17.1	33.0	50.1	0.0	44.8	44.8	0.0	0.0	0.0	
13.0	20.3	33.0	53.3	0.0	45.1	45.1	0.0	0.0	0.0	
14.0	23.9	33.0	56.9	0.0	43.9	43.9	0.0	0.0	0.0	
15.0	27.9	33.0	60.9	0.0	43.9	43.9	0.0	0.0	0.0	
16.0	32.1	33.0	65.1	0.0	43.9	43.9	0.0	0.0	0.0	
17.0	36.6	33.0	69.6	0.0	43.9	43.9	0.0	0.0	0.0	
18.0	41.4	33.0	74.4	0.0	43.9	43.9	0.0	0.0	0.0	
19.0	46.4	33.0	79.4	0.0	43.9	43.9	0.0	0.0	0.0	
20.0	51.8	33.0	84.8	0.0	43.9	43.9	0.0	0.0	0.0	
21.0	57.4	33.0	90.4	0.0	43.9	43.9	0.0	0.0	0.0	
22.0	63.3	33.0	96.3	0.0	43.9	43.9	0.0	0.0	0.0	
23.0	69.5	33.0	102.5	0.0	43.9	43.9	0.0	0.0	0.0	
24.0	76.0	33.0	109.0	0.0	43.9	43.9	0.0	0.0	0.0	
25.0	82.7	33.0	115.7	0.0	43.9	43.9	0.0	0.0	0.0	
26.0	89.8	33.0	122.8	0.0	43.9	43.9	0.0	0.0	0.0	
27.0	97.1	33.0	130.1	0.0	43.9	43.9	0.0	0.0	0.0	
28.0	104.6	33.0	137.6	0.0	43.9	43.9	0.0	0.0	0.0	
29.0	112.3	33.0	145.3	0.0	43.9	43.9	0.0	0.0	0.0	
30.0	120.0	33.0	153.0	0.0	43.9	43.9	0.0	0.0	0.0	
31.0	128.0	33.0	161.0	0.0	43.9	43.9	0.0	0.0	0.0	
32.0	136.0	33.0	169.0	0.0	43.9	43.9	0.0	0.0	0.0	
33.0	144.2	33.0	177.2	0.0	43.9	43.9	0.0	0.0	0.0	180 kips use L=36'
34.0	152.6	33.0	185.6	0.0	43.9	43.9	0.0	0.0	0.0	
35.0	161.0	33.0	194.0	0.0	43.9	43.9	0.0	0.0	0.0	
36.0	169.7	33.0	202.7	0.0	43.9	43.9	0.0	0.0	0.0	
37.0	178.4	33.0	211.4	0.0	43.9	43.9	0.0	0.0	0.0	
38.0	187.3	33.0	220.3	0.0	43.9	43.9	0.0	0.0	0.0	
39.0	196.3	33.0	229.3	0.0	43.9	43.9	0.0	0.0	0.0	
40.0	205.4	58.5	263.9	0.0	70.5	70.5	0.0	0.0	0.0	280 kips use L=44'
41.0	214.7	105.0	319.7	0.0	119.1	119.1	0.0	0.0	0.0	
42.0	224.1	151.6	375.7	0.0	167.8	167.8	0.0	0.0	0.0	
43.0	236.5	151.6	388.1	0.0	167.8	167.8	0.0	0.0	0.0	
44.0	251.8	151.6	403.4	0.0	167.8	167.8	0.0	0.0	0.0	
45.0	267.3	151.6	418.9	0.0	167.8	167.8	0.0	0.0	0.0	
46.0	283.1	151.6	434.7	0.0	167.8	167.8	0.0	0.0	0.0	
47.0	299.1	151.6	450.7	0.0	167.8	167.8	0.0	0.0	0.0	
48.0	315.3	151.6	466.9	0.0	167.8	167.8	0.0	0.0	0.0	
49.0	331.8	151.6	483.4	0.0	167.8	167.8	0.0	0.0	0.0	
50.0	348.5	151.6	500.1	0.0	167.8	167.8	0.0	0.0	0.0	

* API RP-2A (1994) *

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.0	0.0	0.0
7.00	0.0	0.0	0.0
8.00	0.0	0.0	0.0
9.00	0.0	0.0	0.0

10.00	0.0	0.0	0.0
11.00	0.0	0.0	0.0
12.00	0.0	0.0	0.0
13.00	0.0	0.0	0.0
14.00	0.0	0.0	0.0
15.00	0.0	0.0	0.0
16.00	0.0	0.0	0.0
17.00	0.0	0.0	0.0
18.00	0.0	0.0	0.0
19.00	0.0	0.0	0.0
20.00	0.0	0.0	0.0
21.00	0.0	0.0	0.0
22.00	0.0	0.0	0.0
23.00	0.0	0.0	0.0
24.00	0.0	0.0	0.0
25.00	0.0	0.0	0.0
26.00	0.0	0.0	0.0
27.00	0.0	0.0	0.0
28.00	0.0	0.0	0.0
29.00	0.0	0.0	0.0
30.00	0.0	0.0	0.0
31.00	0.0	0.0	0.0
32.00	0.0	0.0	0.0
33.00	0.0	0.0	0.0
34.00	0.0	0.0	0.0
35.00	0.0	0.0	0.0
36.00	0.0	0.0	0.0
37.00	0.0	0.0	0.0
38.00	0.0	0.0	0.0
39.00	0.0	0.0	0.0
40.00	0.0	0.0	0.0
41.00	0.0	0.0	0.0
42.00	0.0	0.0	0.0
43.00	0.0	0.0	0.0
44.00	0.0	0.0	0.0
45.00	0.0	0.0	0.0
46.00	0.0	0.0	0.0
47.00	0.0	0.0	0.0
48.00	0.0	0.0	0.0
49.00	0.0	0.0	0.0
50.00	0.0	0.0	0.0

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN
IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
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T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.1528E-01
			0.0000E+00	0.3056E-01
			0.0000E+00	0.6112E-01
			0.0000E+00	0.9167E-01
			0.0000E+00	0.1222E+00
			0.0000E+00	0.1375E+00
			0.0000E+00	0.1528E+00
			0.0000E+00	0.7639E+00
			0.0000E+00	0.1528E+01
2	10	0.6025E+01		
			0.0000E+00	0.0000E+00
			0.2710E+00	0.1528E-01
			0.5421E+00	0.3056E-01
			0.1084E+01	0.6112E-01
			0.1626E+01	0.9167E-01
			0.2168E+01	0.1222E+00
			0.2439E+01	0.1375E+00
			0.2710E+01	0.1528E+00
			0.2710E+01	0.7639E+00

			0.2710E+01	0.1528E+01
3	10	0.1196E+02		
			0.0000E+00	0.0000E+00
			0.4795E+00	0.1528E-01
			0.9591E+00	0.3056E-01
			0.1918E+01	0.6112E-01
			0.2877E+01	0.9167E-01
			0.3836E+01	0.1222E+00
			0.4316E+01	0.1375E+00
			0.4795E+01	0.1528E+00
			0.4795E+01	0.7639E+00
			0.4795E+01	0.1528E+01
4	10	0.1200E+02		
			0.0000E+00	0.0000E+00
			0.5555E+00	0.1528E-01
			0.1111E+01	0.3056E-01
			0.2222E+01	0.6112E-01
			0.3333E+01	0.9167E-01
			0.4444E+01	0.1222E+00
			0.5000E+01	0.1375E+00
			0.5555E+01	0.1528E+00
			0.5555E+01	0.7639E+00
			0.5555E+01	0.1528E+01
5	10	0.1952E+02		
			0.0000E+00	0.0000E+00
			0.9282E+00	0.1528E-01
			0.1856E+01	0.3056E-01
			0.3713E+01	0.6112E-01
			0.5569E+01	0.9167E-01
			0.7426E+01	0.1222E+00
			0.8354E+01	0.1375E+00
			0.9282E+01	0.1528E+00
			0.9282E+01	0.7639E+00
			0.9282E+01	0.1528E+01
6	10	0.2696E+02		
			0.0000E+00	0.0000E+00
			0.1270E+01	0.1528E-01
			0.2540E+01	0.3056E-01
			0.5081E+01	0.6112E-01
			0.7621E+01	0.9167E-01
			0.1016E+02	0.1222E+00
			0.1143E+02	0.1375E+00
			0.1270E+02	0.1528E+00
			0.1270E+02	0.7639E+00
			0.1270E+02	0.1528E+01
7	10	0.2700E+02		
			0.0000E+00	0.0000E+00
			0.1306E+01	0.1528E-01
			0.2613E+01	0.3056E-01
			0.5225E+01	0.6112E-01
			0.7838E+01	0.9167E-01
			0.1045E+02	0.1222E+00
			0.1176E+02	0.1375E+00
			0.1306E+02	0.1528E+00
			0.1306E+02	0.7639E+00
			0.1306E+02	0.1528E+01
8	10	0.3452E+02		
			0.0000E+00	0.0000E+00
			0.1470E+01	0.1528E-01
			0.2941E+01	0.3056E-01
			0.5882E+01	0.6112E-01
			0.8823E+01	0.9167E-01
			0.1176E+02	0.1222E+00
			0.1323E+02	0.1375E+00
			0.1470E+02	0.1528E+00
			0.1470E+02	0.7639E+00
			0.1470E+02	0.1528E+01
9	10	0.4196E+02		
			0.0000E+00	0.0000E+00
			0.1635E+01	0.1528E-01
			0.3269E+01	0.3056E-01
			0.6538E+01	0.6112E-01
			0.9808E+01	0.9167E-01
			0.1308E+02	0.1222E+00
			0.1471E+02	0.1375E+00
			0.1635E+02	0.1528E+00
			0.1635E+02	0.7639E+00
			0.1635E+02	0.1528E+01
10	10	0.4200E+02		

			0.0000E+00	0.0000E+00
			0.2141E+01	0.1528E-01
			0.4283E+01	0.3056E-01
			0.8566E+01	0.6112E-01
			0.1285E+02	0.9167E-01
			0.1713E+02	0.1222E+00
			0.1927E+02	0.1375E+00
			0.2141E+02	0.1528E+00
			0.2141E+02	0.7639E+00
			0.2141E+02	0.1528E+01
11	10	0.5102E+02		
			0.0000E+00	0.0000E+00
			0.2902E+01	0.1528E-01
			0.5804E+01	0.3056E-01
			0.1161E+02	0.6112E-01
			0.1741E+02	0.9167E-01
			0.2322E+02	0.1222E+00
			0.2612E+02	0.1375E+00
			0.2902E+02	0.1528E+00
			0.2902E+02	0.7639E+00
			0.2902E+02	0.1528E+01
12	10	0.5996E+02		
			0.0000E+00	0.0000E+00
			0.2902E+01	0.1528E-01
			0.5804E+01	0.3056E-01
			0.1161E+02	0.6112E-01
			0.1741E+02	0.9167E-01
			0.2322E+02	0.1222E+00
			0.2612E+02	0.1375E+00
			0.2902E+02	0.1528E+00
			0.2902E+02	0.7639E+00
			0.2902E+02	0.1528E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.9475E+01	0.7639E-02
0.1895E+02	0.1528E-01
0.3790E+02	0.3056E-01
0.7580E+02	0.1986E+00
0.1137E+03	0.6417E+00
0.1364E+03	0.1115E+01
0.1516E+03	0.1528E+01
0.1516E+03	0.2292E+01
0.1516E+03	0.3056E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5422E+00	0.5188E-03	0.1240E+00	0.1000E-03
0.5422E+01	0.5188E-02	0.1240E+01	0.1000E-02
0.2748E+02	0.2616E-01	0.6201E+01	0.5000E-02
0.5511E+02	0.5244E-01	0.1240E+02	0.1000E-01
0.2323E+03	0.2280E+00	0.4228E+02	0.5000E-01
0.3474E+03	0.3811E+00	0.5356E+02	0.1000E+00
0.4396E+03	0.8824E+00	0.1016E+03	0.5000E+00
0.4689E+03	0.1416E+01	0.1309E+03	0.1000E+01
0.4896E+03	0.2440E+01	0.1516E+03	0.2000E+01

Steel HP Pile Design

By CTY 12/26/12

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AXIALLY LOADING PILE ANALYSIS PROGRAM - APILEplus
VERSION 5.0 - (C) COPYRIGHT ENSOFT,INC.,1987-2008.

I-5 Btw SR-55 and SR-57 (HP pile design)

DESIGNER : CTY

DATE :

PILE PROPERTIES :

PERIMETER OF PILE WITH NONCIRCULAR SECTION	=	40.00 IN.
TIP AREA OF PILE WITH NONCIRCULAR SECTION	=	0.21 SQF
OUTSIDE DIAMETER OF CIRCULAR PILE	=	0.00 IN.
INTERNAL DIAMETER OF CIRCULAR PILE	=	0.00 IN.
PILE LENGTH	=	60.00 FT.
MODULUS OF ELASTICITY	=	0.290E+08 PSI

LENGTH OF SURFACE SECTION WITH ZERO SKIN FRICTION	=	2.00 FT.
INCREMENT OF PILE LENGTH USED IN COMPUTATION	=	1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/CF	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.00	115.00	0.00	0.00
12.00	SAND	0.00	115.00	0.00	0.00
12.00	SAND	0.00	120.00	0.00	0.00
27.00	SAND	0.00	120.00	0.00	0.00
27.00	SAND	0.00	57.60	0.00	0.00
42.00	SAND	0.00	57.60	0.00	0.00
42.00	SAND	0.00	63.60	0.00	0.00
70.00	SAND	0.00	63.60	0.00	0.00

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
9999.00	99999.00	0.00	0.00	14.00	0.00	0.00
9999.00	99999.00	0.00	0.00	14.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	18.00	0.00	0.00
9999.00	99999.00	0.00	0.00	36.00	0.00	0.00
9999.00	99999.00	0.00	0.00	36.00	0.00	0.00

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* COMPUTATION RESULT *
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	* FED. HWY. METHOD *			* ARMY CORPS METHOD *			* LAMBDA 2 METHOD *			
PILE PENETR-ATION FT.	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	TOTAL SKIN FRIC KIP	END BEARING KIP	ULTIM CAPAC-ITY KIP	
0.0	0.0	3.6	3.6	0.0	2.6	2.6	0.0	0.0	0.0	
1.0	0.0	6.5	6.5	0.0	4.8	4.8	0.0	0.0	0.0	
2.0	0.3	9.0	9.3	0.0	6.6	6.6	0.0	0.0	0.0	
3.0	0.9	11.2	12.1	0.0	8.4	8.4	0.0	0.0	0.0	
4.0	1.8	13.3	15.1	0.0	10.1	10.1	0.0	0.0	0.0	
5.0	3.0	15.0	17.9	0.0	11.7	11.7	0.0	0.0	0.0	
6.0	4.3	16.4	20.8	0.0	13.1	13.1	0.0	0.0	0.0	
7.0	5.9	17.6	23.5	0.0	14.4	14.4	0.0	0.0	0.0	
8.0	7.7	18.5	26.2	0.0	15.4	15.4	0.0	0.0	0.0	
9.0	9.6	19.1	28.7	0.0	16.4	16.4	0.0	0.0	0.0	
10.0	11.8	20.1	31.9	0.0	17.8	17.8	0.0	0.0	0.0	
11.0	14.1	26.0	40.1	0.0	21.5	21.5	0.0	0.0	0.0	
12.0	16.5	31.9	48.4	0.0	25.1	25.1	0.0	0.0	0.0	
13.0	19.4	32.0	51.4	0.0	25.8	25.8	0.0	0.0	0.0	
14.0	22.7	31.8	54.4	0.0	26.3	26.3	0.0	0.0	0.0	
15.0	26.1	31.2	57.3	0.0	26.6	26.6	0.0	0.0	0.0	
16.0	29.7	30.4	60.1	0.0	25.9	25.9	0.0	0.0	0.0	
17.0	33.3	29.9	63.2	0.0	24.6	24.6	0.0	0.0	0.0	
18.0	37.1	29.7	66.8	0.0	23.8	23.8	0.0	0.0	0.0	
19.0	41.0	29.4	70.4	0.0	23.0	23.0	0.0	0.0	0.0	
20.0	45.0	28.9	73.9	0.0	22.1	22.1	0.0	0.0	0.0	
21.0	49.0	28.3	77.3	0.0	21.3	21.3	0.0	0.0	0.0	
22.0	53.1	26.8	79.9	0.0	20.4	20.4	0.0	0.0	0.0	
23.0	57.2	24.8	82.0	0.0	19.7	19.7	0.0	0.0	0.0	
24.0	61.3	23.4	84.8	0.0	19.4	19.4	0.0	0.0	0.0	
25.0	65.5	22.7	88.2	0.0	19.1	19.1	0.0	0.0	0.0	
26.0	69.8	22.2	92.0	0.0	19.0	19.0	0.0	0.0	0.0	
27.0	74.2	21.9	96.2	0.0	18.9	18.9	0.0	0.0	0.0	
28.0	78.8	21.6	100.4	0.0	18.8	18.8	0.0	0.0	0.0	
29.0	83.4	21.3	104.7	0.0	18.7	18.7	0.0	0.0	0.0	
30.0	88.0	21.1	109.1	0.0	18.6	18.6	0.0	0.0	0.0	
31.0	92.7	20.8	113.5	0.0	18.5	18.5	0.0	0.0	0.0	
32.0	97.5	20.5	118.0	0.0	18.4	18.4	0.0	0.0	0.0	
33.0	102.4	20.2	122.6	0.0	18.3	18.3	0.0	0.0	0.0	
34.0	107.3	19.9	127.2	0.0	18.2	18.2	0.0	0.0	0.0	
35.0	112.3	19.6	132.0	0.0	18.1	18.1	0.0	0.0	0.0	
36.0	117.4	19.4	136.7	0.0	18.0	18.0	0.0	0.0	0.0	
37.0	122.5	19.1	141.6	0.0	17.9	17.9	0.0	0.0	0.0	
38.0	127.7	18.8	146.5	0.0	17.8	17.8	0.0	0.0	0.0	
39.0	132.9	18.5	151.4	0.0	17.7	17.7	0.0	0.0	0.0	
40.0	138.2	20.8	159.1	0.0	18.8	18.8	0.0	0.0	0.0	
41.0	143.6	41.7	185.3	0.0	28.4	28.4	0.0	0.0	0.0	180 kps use L=43'
42.0	149.1	62.2	211.2	0.0	37.8	37.8	0.0	0.0	0.0	
43.0	155.9	60.9	216.8	0.0	37.2	37.2	0.0	0.0	0.0	
44.0	164.1	59.7	223.8	0.0	36.7	36.7	0.0	0.0	0.0	
45.0	172.4	58.5	230.8	0.0	36.2	36.2	0.0	0.0	0.0	
46.0	180.7	57.2	237.9	0.0	35.7	35.7	0.0	0.0	0.0	
47.0	189.1	56.0	245.1	0.0	35.3	35.3	0.0	0.0	0.0	
48.0	197.6	54.7	252.3	0.0	35.0	35.0	0.0	0.0	0.0	
49.0	206.1	53.5	259.6	0.0	34.7	34.7	0.0	0.0	0.0	
50.0	214.6	52.3	266.9	0.0	34.4	34.4	0.0	0.0	0.0	
51.0	223.3	51.0	274.3	0.0	34.1	34.1	0.0	0.0	0.0	
52.0	231.9	49.8	281.7	0.0	33.9	33.9	0.0	0.0	0.0	280 kps use L=53'
53.0	240.6	48.6	289.3	0.0	33.6	33.6	0.0	0.0	0.0	
54.0	249.4	47.5	297.0	0.0	33.3	33.3	0.0	0.0	0.0	
55.0	258.2	46.5	304.7	0.0	33.0	33.0	0.0	0.0	0.0	
56.0	267.1	45.4	312.5	0.0	32.8	32.8	0.0	0.0	0.0	
57.0	276.0	44.4	320.3	0.0	32.5	32.5	0.0	0.0	0.0	
58.0	284.9	43.3	328.2	0.0	32.2	32.2	0.0	0.0	0.0	
59.0	293.8	42.2	336.1	0.0	31.9	31.9	0.0	0.0	0.0	
60.0	302.9	41.2	344.0	0.0	31.7	31.7	0.0	0.0	0.0	

*** API RP-2A (1994) ***

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0

1.00	0.0	0.0	0.0
2.00	0.0	0.0	0.0
3.00	0.0	0.0	0.0
4.00	0.0	0.0	0.0
5.00	0.0	0.0	0.0
6.00	0.0	0.0	0.0
7.00	0.0	0.0	0.0
8.00	0.0	0.0	0.0
9.00	0.0	0.0	0.0
10.00	0.0	0.0	0.0
11.00	0.0	0.0	0.0
12.00	0.0	0.0	0.0
13.00	0.0	0.0	0.0
14.00	0.0	0.0	0.0
15.00	0.0	0.0	0.0
16.00	0.0	0.0	0.0
17.00	0.0	0.0	0.0
18.00	0.0	0.0	0.0
19.00	0.0	0.0	0.0
20.00	0.0	0.0	0.0
21.00	0.0	0.0	0.0
22.00	0.0	0.0	0.0
23.00	0.0	0.0	0.0
24.00	0.0	0.0	0.0
25.00	0.0	0.0	0.0
26.00	0.0	0.0	0.0
27.00	0.0	0.0	0.0
28.00	0.0	0.0	0.0
29.00	0.0	0.0	0.0
30.00	0.0	0.0	0.0
31.00	0.0	0.0	0.0
32.00	0.0	0.0	0.0
33.00	0.0	0.0	0.0
34.00	0.0	0.0	0.0
35.00	0.0	0.0	0.0
36.00	0.0	0.0	0.0
37.00	0.0	0.0	0.0
38.00	0.0	0.0	0.0
39.00	0.0	0.0	0.0
40.00	0.0	0.0	0.0
41.00	0.0	0.0	0.0
42.00	0.0	0.0	0.0
43.00	0.0	0.0	0.0
44.00	0.0	0.0	0.0
45.00	0.0	0.0	0.0
46.00	0.0	0.0	0.0
47.00	0.0	0.0	0.0
48.00	0.0	0.0	0.0
49.00	0.0	0.0	0.0
50.00	0.0	0.0	0.0
51.00	0.0	0.0	0.0
52.00	0.0	0.0	0.0
53.00	0.0	0.0	0.0
54.00	0.0	0.0	0.0
55.00	0.0	0.0	0.0
56.00	0.0	0.0	0.0
57.00	0.0	0.0	0.0
58.00	0.0	0.0	0.0
59.00	0.0	0.0	0.0
60.00	0.0	0.0	0.0

AN ASTERISK WILL BE PLACED IN THE END-BEARING COLUMN
IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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**************************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
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T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00

			0.0000E+00	0.1273E-01
			0.0000E+00	0.2546E-01
			0.0000E+00	0.5093E-01
			0.0000E+00	0.7639E-01
			0.0000E+00	0.1019E+00
			0.0000E+00	0.1146E+00
			0.0000E+00	0.1273E+00
			0.0000E+00	0.6366E+00
			0.0000E+00	0.1273E+01
2	10	0.6025E+01		
			0.0000E+00	0.0000E+00
			0.3286E+00	0.1273E-01
			0.6572E+00	0.2546E-01
			0.1314E+01	0.5093E-01
			0.1972E+01	0.7639E-01
			0.2629E+01	0.1019E+00
			0.2957E+01	0.1146E+00
			0.3286E+01	0.1273E+00
			0.3286E+01	0.6366E+00
			0.3286E+01	0.1273E+01
3	10	0.1196E+02		
			0.0000E+00	0.0000E+00
			0.5120E+00	0.1273E-01
			0.1024E+01	0.2546E-01
			0.2048E+01	0.5093E-01
			0.3072E+01	0.7639E-01
			0.4096E+01	0.1019E+00
			0.4608E+01	0.1146E+00
			0.5120E+01	0.1273E+00
			0.5120E+01	0.6366E+00
			0.5120E+01	0.1273E+01
4	10	0.1200E+02		
			0.0000E+00	0.0000E+00
			0.5960E+00	0.1273E-01
			0.1192E+01	0.2546E-01
			0.2384E+01	0.5093E-01
			0.3576E+01	0.7639E-01
			0.4768E+01	0.1019E+00
			0.5364E+01	0.1146E+00
			0.5960E+01	0.1273E+00
			0.5960E+01	0.6366E+00
			0.5960E+01	0.1273E+01
5	10	0.1952E+02		
			0.0000E+00	0.0000E+00
			0.8253E+00	0.1273E-01
			0.1651E+01	0.2546E-01
			0.3301E+01	0.5093E-01
			0.4952E+01	0.7639E-01
			0.6603E+01	0.1019E+00
			0.7428E+01	0.1146E+00
			0.8253E+01	0.1273E+00
			0.8253E+01	0.6366E+00
			0.8253E+01	0.1273E+01
6	10	0.2696E+02		
			0.0000E+00	0.0000E+00
			0.9215E+00	0.1273E-01
			0.1843E+01	0.2546E-01
			0.3686E+01	0.5093E-01
			0.5529E+01	0.7639E-01
			0.7372E+01	0.1019E+00
			0.8294E+01	0.1146E+00
			0.9215E+01	0.1273E+00
			0.9215E+01	0.6366E+00
			0.9215E+01	0.1273E+01
7	10	0.2700E+02		
			0.0000E+00	0.0000E+00
			0.9422E+00	0.1273E-01
			0.1884E+01	0.2546E-01
			0.3769E+01	0.5093E-01
			0.5653E+01	0.7639E-01
			0.7538E+01	0.1019E+00
			0.8480E+01	0.1146E+00
			0.9422E+01	0.1273E+00
			0.9422E+01	0.6366E+00
			0.9422E+01	0.1273E+01
8	10	0.3452E+02		
			0.0000E+00	0.0000E+00
			0.1040E+01	0.1273E-01
			0.2080E+01	0.2546E-01

			0.4160E+01	0.5093E-01
			0.6240E+01	0.7639E-01
			0.8319E+01	0.1019E+00
			0.9359E+01	0.1146E+00
			0.1040E+02	0.1273E+00
			0.1040E+02	0.6366E+00
			0.1040E+02	0.1273E+01
9	10	0.4196E+02		
			0.0000E+00	0.0000E+00
			0.1133E+01	0.1273E-01
			0.2266E+01	0.2546E-01
			0.4532E+01	0.5093E-01
			0.6799E+01	0.7639E-01
			0.9065E+01	0.1019E+00
			0.1020E+02	0.1146E+00
			0.1133E+02	0.1273E+00
			0.1133E+02	0.6366E+00
			0.1133E+02	0.1273E+01
10	10	0.4200E+02		
			0.0000E+00	0.0000E+00
			0.1421E+01	0.1273E-01
			0.2843E+01	0.2546E-01
			0.5686E+01	0.5093E-01
			0.8528E+01	0.7639E-01
			0.1137E+02	0.1019E+00
			0.1279E+02	0.1146E+00
			0.1421E+02	0.1273E+00
			0.1421E+02	0.6366E+00
			0.1421E+02	0.1273E+01
11	10	0.5602E+02		
			0.0000E+00	0.0000E+00
			0.1852E+01	0.1273E-01
			0.3705E+01	0.2546E-01
			0.7409E+01	0.5093E-01
			0.1111E+02	0.7639E-01
			0.1482E+02	0.1019E+00
			0.1667E+02	0.1146E+00
			0.1852E+02	0.1273E+00
			0.1852E+02	0.6366E+00
			0.1852E+02	0.1273E+01
12	10	0.6996E+02		
			0.0000E+00	0.0000E+00
			0.1876E+01	0.1273E-01
			0.3752E+01	0.2546E-01
			0.7503E+01	0.5093E-01
			0.1125E+02	0.7639E-01
			0.1501E+02	0.1019E+00
			0.1688E+02	0.1146E+00
			0.1876E+02	0.1273E+00
			0.1876E+02	0.6366E+00
			0.1876E+02	0.1273E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.2572E+01	0.6366E-02
0.5144E+01	0.1273E-01
0.1029E+02	0.2546E-01
0.2058E+02	0.1655E+00
0.3087E+02	0.5348E+00
0.3704E+02	0.9295E+00
0.4115E+02	0.1273E+01
0.4115E+02	0.1910E+01
0.4115E+02	0.2546E+01

LOAD VERSUS SETTLEMENT CURVE
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TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5381E+00	0.6815E-03	0.4040E-01	0.1000E-03
0.5381E+01	0.6815E-02	0.4040E+00	0.1000E-02

0.2736E+02	0.3444E-01	0.2020E+01	0.5000E-02
0.5491E+02	0.6910E-01	0.4040E+01	0.1000E-01
0.2131E+03	0.2990E+00	0.1209E+02	0.5000E-01
0.2946E+03	0.4821E+00	0.1576E+02	0.1000E+00
0.3238E+03	0.9384E+00	0.2990E+02	0.5000E+00
0.3318E+03	0.1454E+01	0.3788E+02	0.1000E+01
0.3351E+03	0.2461E+01	0.4115E+02	0.2000E+01