M E M O R A N D U M

To : SARAH RAMOS
Project Engineer
Traffic Operational Improvements Branch

Date : March 29, 2000

File : 11-SD-15
KP M31.4-M35.2
11-073401

From : **DEPARTMENT OF TRANSPORTATION**
Engineering Service Center - Office of Materials and Foundations
Roadway Geotechnical Engineering South (MS #63)

Subject : Geotechnical Recommendations for Proposed Type I Wall and Segmental Retaining Wall (SRW) near Carmel Mountain Rd. OC

In accordance with your letter request, dated January 31, 2000, we have performed a geotechnical investigation and prepared recommendations pertinent to geotechnical design of the proposed walls for the freeway widening project at the subject location. The purpose of our investigation is to advise the Project Engineer of geotechnical constraints with regards to wall design/construction and to provide geotechnical information for use in PS&E preparation. We have received from your office the proposed project layout sheets and cross sections (at 20 m intervals) for use in our study.

Scope of Work

The following tasks were completed in preparation of this report:

1. Office review of existing Materials Reports, as-built plans and geologic maps
2. Field subsurface investigation
3. Laboratory testing of soil samples
4. Analysis of laboratory test data and boring logs
5. Computer design of a segmental retaining wall (SRW)
6. Geotechnical recommendations
7. Review of SRW vendor information and specifications

Office Review

A review of existing in-house and published information was performed in advance of our field investigation to ascertain data pertaining to the geologic setting, prior geotechnical work performed in the general area and existence of underground utilities. This information assisted us in planning our subsurface investigation.

In-house information included the Materials Report for the original construction of I-15 (P.M. M18.5-M21.8, Poway Rd. to Carmel Valley Rd., 11208-105621, dated May 24, 1973) and the as-built plans for Contract 11-105624, dated July 28, 1982.

Geologic maps for the area (California Division of Mines and Geology, Bulletin 200, 1975) show the site to be underlain by alluvium and slopewash. Volcanic basement rock underlies the alluvium. Several borings and penetrometer tests were previously performed for the design of the Carmel Mtn. Rd. OC, slightly north of this site, by the Division of Structures.

Field Investigation

Our field investigation consisted of the following:

Southbound

- Four (4) hand auger holes with soil probes (SP-1 through SP-4) were drilled along the proposed Type I wall layout line. The maximum depth explored at these locations was approximately 3 m. Soils encountered (in the up-station direction), ranged from native sandy alluvium to weathered volcanic rock to relatively soft clayey fill. No ground water was encountered.

- Two (2) hand auger holes (HA-5 and HA-6), located on top of the sound berm to a maximum depth of 1.25 m. Fill soils were encountered and consisted of plastic sandy clay with gravel.

Northbound

- Two (2) mud-rotary borings (B-1 and B-3) on the shoulder of the northbound off-ramp (N-2A) to Carmel Mountain Rd. The locations of these boreholes are offset approximately 3.5 m left of the proposed wall layout line. The maximum depth explored at these locations was approximately 7 meters. Undisturbed sampling and Standard Penetration Testing (SPT) was perfomed at 1.5 m intervals.

  The stratigraphy encountered consisted of structural section overlying embankment fill (ranging in thickness from 1.25 m to 3.25 m) overlying native alluvium (ranging in thickness from 2.25 to 3.5 m) overlying weathered bedrock. Ground water was encountered near the top of the alluvium layer or approximately 4 m below ground surface.

- Two (2) hand auger holes (HA-2 and HA-4) were drilled on top of the sound berm adjacent to ramp N-2A. The location of these boreholes approximately correspond to the back-cut daylight of the proposed SRW. The maximum depth explored at these locations was approximately 2 m. Berm fill at these locations varied between sandy clay and silty sand.

Locations of all borings, hand auger holes and soil probes are shown on *Figures 1 and 2*. Boring logs are presented in Appendix A.1.

Laboratory Testing

Bulk and undisturbed samples were retrieved during our subsurface investigation and shipped to the Headquarters Materials Laboratory in Sacramento for testing. The following tests were performed:

- Unit weight and moisture content
- Specific gravity
- Sieve analysis with hydrometer
- Atterberg limits
- Direct shear

Laboratory test data are presented in Appendix A.2 and are also summarized on the boring logs.

Direct shear test results on samples from Boring B-3 were inconclusive due to inconsistent data. Lack of quality data, however, did not significantly impact design of the SRW.

Geotechnical Design

Southbound

The proposed Type I wall extends from Sta. 334+60 to Sta. 338+00 on the 'G' line. It ranges in height from approximately 0.8 to 2.1 m. The maximum height wall section occurs at Sta. 338+00. Geotechnical considerations vary considerably along the alignment and are described below:

SCALE 1:1000

FIGURE 1
SITE PLAN
SOUTHBOUND

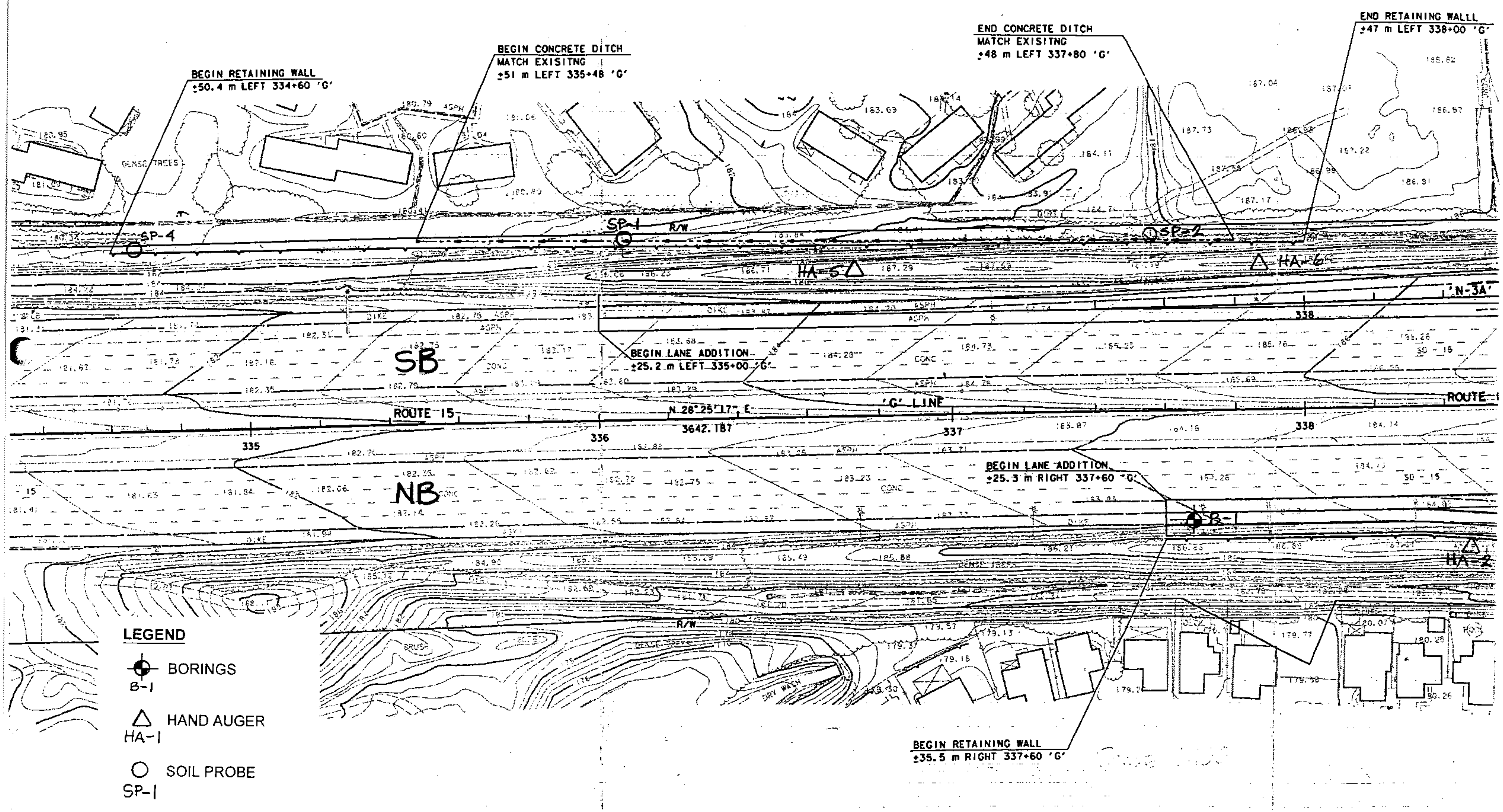
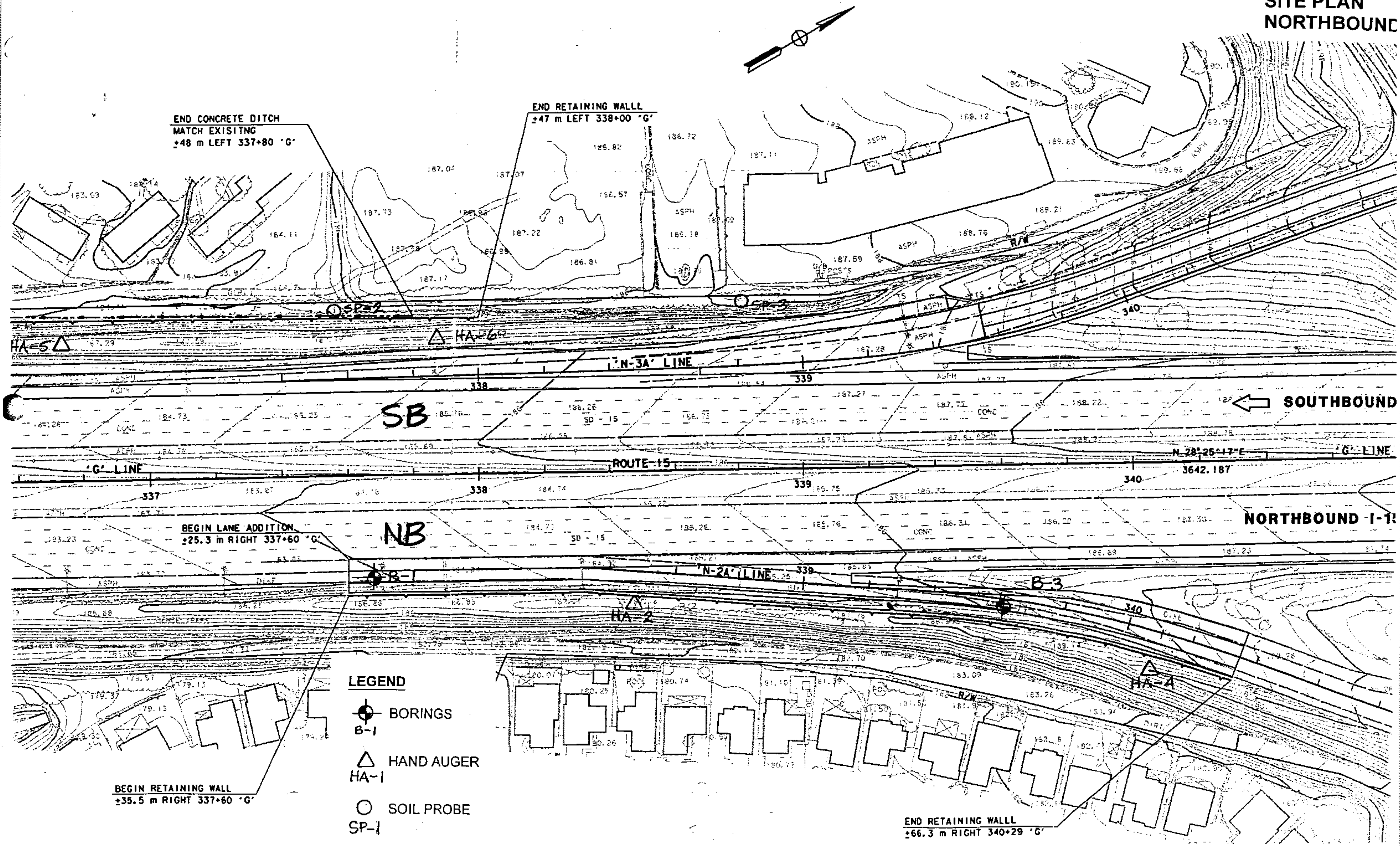


FIGURE 2
SITE PLAN
NORTHBOUND



Station 334+60 to 335+45

The maximum wall height in this interval is approximately 1.9 m. Soils encountered included medium dense sand (alluvium) with little silt and some gravel. Ground water was not encountered during exploration to a maximum depth of 2.5 m in Soil Probe 4 (SP-4). Per the 1999 Standard Plan B3-1 (Retaining Wall Type I), the design (applied) toe pressure for a 1.8 m-high wall and Case II Loading (1:2 slope) is 70 kPa.

An allowable bearing capacity of 110 kPa was calculated based on a 0.85 m footing depth, 1 m footing width, internal friction angle of 29 degrees, unit weight of 18.1 kN/m^3 and a safety factor of 3.0. Bearing capacity calculations are included in Appendix A.3. The in-situ soils possess adequate bearing capacity for the proposed wall height. We do not anticipate significant total or differential settlement of the wall based on our findings. Foundation treatment will not be required in this interval.

Our office should be contacted if materials other than those stated above are encountered during excavation of the wall footing in this interval.

Station 335+45 to Station 336+60

Dense weathered volcanic rock outcrops are evident along the R/W boundary from approximately Sta. 335+45 (near terminus of concrete drainage ditch) to Sta. 336+60. Our subsurface investigation in this interval consisted of a hand auger/soil probe (SP-1). No ground water was encountered at this location.

The proposed wall footing would be founded in weathered rock. This material is very dense and competent foundation material. Allowable bearing capacity of this material easily exceeds the applied toe pressure for the wall height in this interval. Conventional excavating equipment should be able to excavate this material to footing depth.

Station 336+60 to Station 338+00

The maximum wall height in this interval is 2.1 m. Our investigation in this area consisted of a hand auger/soil probe (SP-2). Hand auger/soil probe SP-3 was performed slightly outside of this interval, but is representative of the subsurface conditions in the interval.

Relatively soft, plastic, clayey fill material was encountered in the upper 2.5 m in this interval. Ground water was not encountered. Due to low

Roadway et

blow counts and unsuitability of plastic clays for foundation material, we recommend this soil be excavated to a **depth of 1 m below the base of the footing** and replaced with a well-graded granular material such as Class 2 Aggregate Base. The replacement soil should be compacted to 95% of maximum density in accordance with the Standard Specifications.

Northbound (Station 337+60 to 340+29)

General

At the conclusion of a meeting held at the District Office on March 7, 2000, our office was asked to produce a geotechnical design of a segmental retaining wall (SRW) at this location. An SRW is typically comprised of dry-stacked (mortarless) modular concrete blocks that are stacked vertically and may be connected with shear pins, lips, or keys. Typically, for wall heights exceeding 1.5 m or for walls with surcharge slopes, planar reinforcement (geogrid) behind the wall is required to ensure adequate stability. This design option was selected based on ease and speed of construction/removal and aesthetic considerations.

This particular wall will have a design life of approximately 3-5 years, after which it will be removed for future widening. The mortarless block construction will facilitiate ease of removal. We encourage recycling these concrete blocks for other wall projects if they are undamaged following removal. This could amount to a significant cost savings. Another option is to sell the blocks back to the vendor for a minor (pennies on the dollar) rebate. Cost of this temporary wall is estimated to be approximately $330/m^2 of wall face.

The proposed wall height shown on the cross-sections varies between 1.8 and 2.1 m, including an embedment depth of approximately 0.3 m. The base of wall elevation increases upstation, from el. 183.6 to 185. The top of wall elevation similarly increases from el. 185.7 to 186.8. These differences in elevation along the wall alignment will require stepping the wall foundation.

Foundation Considerations

Borings B-1 and B-3 were drilled to characterize foundation conditions for the wall. The wall will be founded on previously compacted fill consisting of a mixture of sand, silt and clay. This fill was found to be medium dense/stiff and in a moist condition. The sand is typically fine-grained and the clays possess some plasticity. Ground water is at sufficient depth so as not to be problematic with regards to bearing capacity or settlement. The top of wall elevation typically coincides with the existing surface of the sound berm, so no significant amount of additional surcharge will be placed on foundation materials. Hence, no significant amount of settlement is anticipated. Due to its flexible nature, as compared to rigid walls, the SRW can accommodate some minor differential settlement without any apparent distress.

Computer Analysis

An analysis of the wall's external and internal stability was performed using Federal Highway Administration's MSEW (Mechanically Stabilized Earth Walls) computer program, version 1.0. The MSEW program is based on AASHTO Standards and is more robust and versatile than numerous vendor-supplied software programs that our office has utilized in the past. Additionally, it is well-documented. The maximum wall section occurs at Station 337+80 through 338+00. The geometry of the cross-section at this location was used for the computer run. Table 1 summarizes the design input to the program.

Table1 – Design Input

Wall Batter	3 degrees
Embedment (measured from adjacent pavement surface to top of leveling pad)	0.3 m
Design Height (measured from top of leveling pad to top of wall)	2.2 m
Slope ratio above wall	1:2
Slope height above wall	1.2 m
Foundation Soil: Internal Friction Angle Cohesion Unit Weight	 27 degrees 14.4 kPa 18.8 kN/m^3
Retained Soil: Internal Friction Angle Unit Weight	 27 degrees 18.8 kN/m^3
Reinforced Soil: Internal Friction Angle Unit Weight	 34 degrees 18.8 kN/m^3
Geogrid Long-Term Design Strength	20 kN/m
Block Height	0.2 m
Block Depth	0.3 m

MSEW calculates the length and vertical positioning of the reinforcement in order to meet design criteria for external and internal stability. External stability is evaluated in terms of bearing capacity, direct sliding and eccentricity (overturning). Internal stability is evaluated with respect to strength and pullout of the reinforcement, in addition to connection strength of the reinforcement to the concrete block. Table 2 summarizes the design criteria and the output values from the MSEW program. Computer output of the analysis is included in Appendix A.4.

Table 2
External and Internal Stability

	Parameter	Design Criteria	Minimum Computed Value[1]
External Stability:	Bearing Capacity	F.S.[2]=2.5 min.	6.23
	Direct Sliding	F.S.=1.5 min.	1.63
	Eccentricity (e/L)	0.167 max.	0.167
Internal Stability:	Reinforcement Strength	F.S.=1.5	1.71
	Pullout	F.S.=1.5	3.73
	Connection		
	Break	F.S.=1.5	2.56
	Pullout	F.S.=1.5	1.85

[1]Lowest value of foundation interface and two levels of reinforcement
[2]Factor of Safety

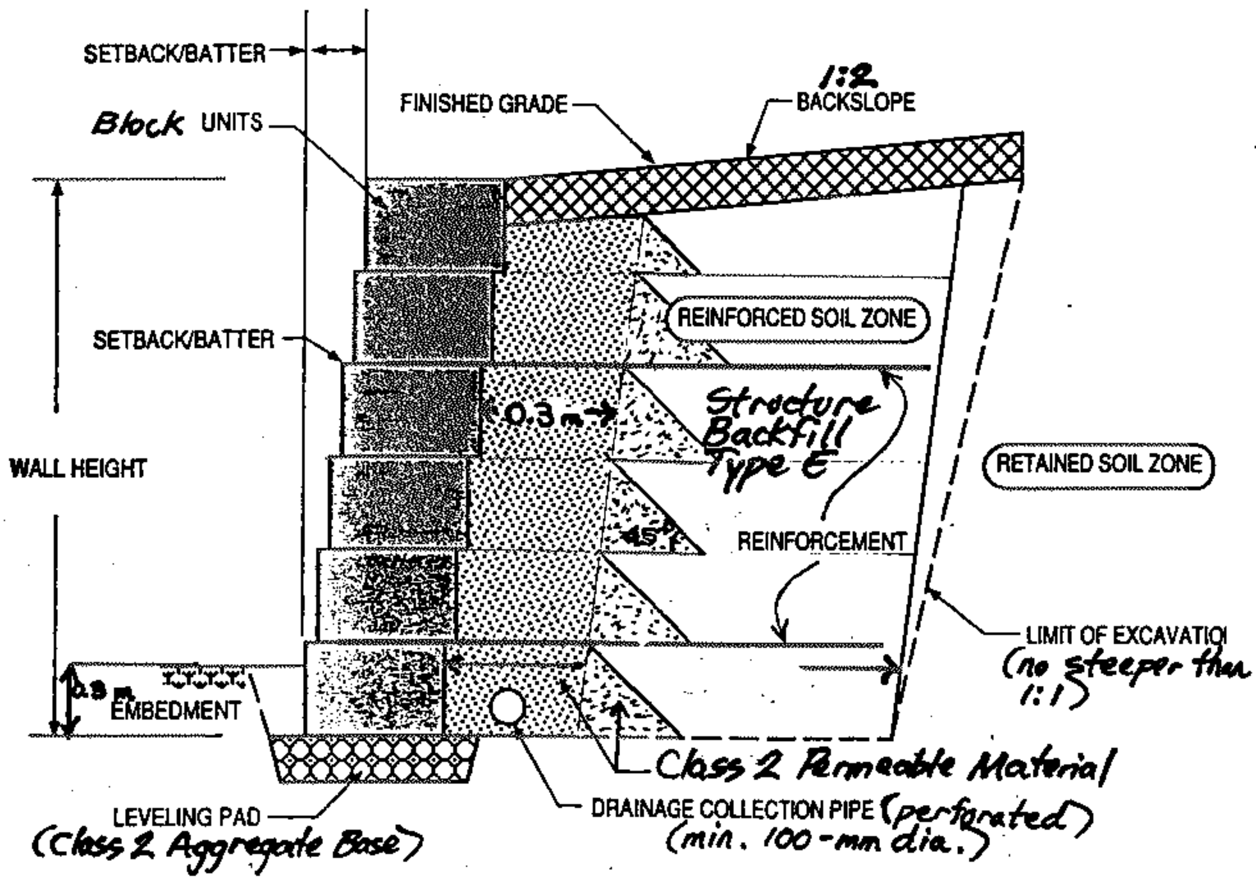
Table 2 shows that this design exceeds the minimum criteria.

The computed length and spacing of reinforcement is shown on Figure 3. The length for both layers is 1.7 m. The first and second layers of reinforcement are located 0.7 m and 1.45 m above the top of leveling pad, respectively. This configuration should be used for the entire length of wall. If wall height changes during the design process, our office should be consulted for revisions to the reinforcement type and spacing.

Seismicity was not specifically addressed in the design of this wall due to its relatively short design life and positive predicted performance during an earthquake. Due to their flexibility, mechanically reinforced walls have considerable resistance to forces developed during a seismic event, as confirmed by the excellent performance of some of these walls in several recent earthquakes.

Design/Construction Considerations

We recommend the use of a compacted gravel leveling pad beneath the first course of blocks. This gravel pad should have a minimum thickness of 150 mm and a minimum width of 300 mm. Class 2 Aggregate Base with 19-mm maximum particle size is recommended for the leveling pad. Pea gravel or other rounded aggregate is unacceptable. Construction personnel should ensure that the subgrade of the excavation for the base trench is well-compacted prior to placement of the gravel pad. A concrete leveling pad was deemed unnecessary due to the relatively short wall



N.T.S.

Caltrans

FIGURE 3
Segmental Retaining Wall Schematic

height, the added expense of cast-in-place concrete, and the increase in demolition costs after the design life. The contractor should be given the option, however, of constructing a unreinforced concrete leveling pad at his expense if he believes it will assist with construction and alignment of the wall.

A back-drain consisting of a 0.3-m wide zone of clean, well-graded crushed gravel (Class 2 Permeable Material) with a perforated pipe at the base elevation of the wall should be placed in accordance with Figure 3. Construction personnel should be advised of the construction procedure for this back-drain so that a vertically continuous free-draining zone is achieved (see Figure 3). This zone of free-draining material will prevent hydrostatic build-up and minimize deterioration (sulfate attack/staining) of the concrete blocks as a consequence of seepage through the wall face. The perforated pipe should conform to Section 68-1.02K of the Standard Specifications. The perforated pipe should connect to solid wall pipe at discrete intervals (25 m), which in turn should exit the wall face and drain to an existing inlet. Class 2 Permeable Material should also be used as block infill if hollow-core blocks (e.g. Keystone™) are used.

The reinforced zone, which extends from the rear of the back-drain to the end of the reinforcement should be infilled with Structure Backfill Type E. Lift thickness should not exceed the height of the block unit. The material and placement requirements should conform to the Standard Specifications 19-3.06 and be compacted to 95% of maximum density.

Both layers of reinforcement should be uni-axial geogrid with a minimum long-term design strength (LTDS) of 20 kN/m in the primary reinforcement direction (perpendicular to wall alignment).

Specifications

Two sets of guide specifications for Segmental Retaining Walls are included in Appendix A.5. The first specification is from AASHTO and the second is from Reference 1. We should fashion our specifications to encourage competition among the wall vendors. A few major SRW vendors include Keystone™, Versa-Lok™, Allan Block™ and Anchor Wall Systems™. It is a good idea for your office to contact these vendors for product information. A comparison of three SRW vendors is presented in Appendix A.6 to assist with design.

A wall batter between 1.5 and 10 degrees is typical for most SRW vendors (see Appendix A.6). Some vendors offer a variable setback per block height, while this is a fixed quantity for others. We recommend specifying a narrow range of wall batter that will be buildable for several vendors. The range of wall batter should be selected by your office. Our geotechnical design is valid for a wall batter as low as 1.5 degrees. A larger wall batter will increase the conservatism of our design.

We recommend that the Office of Engineering consult with HQ to determine if Caltrans has an SSP for a 'Geogrid-Reinforced Segmental Retaining Wall). At this time we are unaware of such a specification, however, this should be verified. Caltrans has an SSP for 'Geosynthetic Reinforced Embankment', which is included in Appendix A.5. For this project, this existing specification could be modified to read 'Geogrid-Reinforced Segmental Retaining Wall' and encompass all aspects of the wall construction (modular blocks, geogrid reinforcement, backfill requirements, etc.)

References

1. Mechanically Stabilized Earth Walls and Reinforced Soil Slopes, Design and Construction Guidelines, FHWA Demonstration Project 82, Publication No. FHWA-SA-96-071, reprinted June 1999.

Please contact me at (858) 467-4061 for further assistance.

Martin Skyrman
Transportation Engineer

Attachments:
- Figures
- Appendix
  - A.1 Boring logs
  - A.2 Laboratory Test Data
  - A.3 Bearing Capacity Calculations
  - A.4 MSEW Computer Output
  - A.5 Guide Specifications
  - A.6 Comparison of SRW Vendors

cc: KJackura, RGES
JEgan, RGES
RGES 02

APPENDIX A.1
BORING LOGS

BORING LOG

Caltrans

Boring No.: B-1	Dist.-Co.-Rte.-P.M.:11-SD-15 KP 31.4
Sheet: 1 of 1	Location: 337+66, 32 m RT "G" line
Date Drilled: 2-7-00	EA: 073400
Project Name: Widening	Drilling Method: mud rotary
Logged By: M. Skyrman	Top of Hole Elev.: 184.3+/-

Depth (ft)	Depth (m)	Description	Number	Blow Counts per ~~6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–1		***AC***									
1–2.5		***BASE, sand and gravel***									
2.5–6.5	1–2	***FILL, sandy silt and clay*** (ML/CL), soft to firm, mottled olive green to brown, fine-grained sand, wet, medium plasticity	1								
6.5–18	2–5	***ALLUVIUM, clayey sand*** (SC), loose to medium dense, dark brown, wet	2	5-4-4	8						
			3			19.2					
		same, plastic clay lenses, up to 10 mm thick, brown									
		same, clayey sand to sandy clay	4	3-8-8	16						
		G.W. ▽?									
			5		no rec.						
			6	12-16-20	36						
18–22.5	5–7	***WEATHERED BEDROCK,*** olive/light brown									
		same, calcite deposits	7								
			8	25-35-50+	85+						
22.5	7	End of Borehole									

BORING LOG

Caltrans

Boring No.: B-3	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 339+60, 4 m RT "N-2A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** mud rotary
Logged By: M. Skyrman	**Top of Hole Elev.:** 186.2+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per ~~6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–1		*AC*										
1–2.5		*BASE, sand and gravel*										
2.5–13		***FILL, sandy silt (ML),*** stiff, olive to light brown, wet, fine-grained sand	1	G			23.4					60
		same, dark brown clay layers, up to 10 mm thick	2		3-6-7	13						
			3				29.1					
		? ? G.W. ▽?	4		3-3-3	6						
13–20.5		***NATIVE, ALLUVIUM,*** dark brown clay (CL/CH), stiff, moist, grades to gray silty clayey sand (SM/SC), fine-grained with gravel fragments grades to dark brown plastic clay (CH), moist	5				27.5		15.4			
			6		3-6-7	13						
20.5–23.5		***SILTY CLAY (CH),*** olive green, high plasticity, v. stiff to hard (intensely weathered bedrock?)	7				32.3		14.9			
			8		9-13-18	31						
24		End of Borehole										

Depth scale: feet 1–24; meters 1–7.

BORING LOG

Caltrans

Boring No.: HA-2	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 338+52, 9 m RT "N-2A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** hand auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 187.2+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts ~~per 6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–5 ft (0–1.5 m)		***FILL, sandy clay and silt*** (ML/CL), light brown, moist, fine-grained sand, calcite deposits more clay with small gravel and few cobbles up to 100 mm diameter, brown, plastic, wet	1	G G G			20.9			45	24	63
		End of Borehole										

Depth scale: 1–24 (ft); 1–7 (m)

Auger hole located on top of sound berm

BORING LOG

Boring No.: HA-4	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 340+10, 12 m RT "N-2A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** hand auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 190.0+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per ~~6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–2 m (0–7 ft)		***FILL, silty sand*** (SM) with some small cobbles, dense, light brown, moist, fine-grained sand, calcite deposits same, moist	1	G G G G			9.1					
		End of Borehole										

Depth scale: 1–24 (ft); 1–7 (m)

Auger hole located on top of sound berm

BORING LOG

Boring No.: HA-5	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 336+75, 42 m LT "G" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** hand auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 187.2+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per ~~6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–4 ft (0–1 m)		***FILL, sandy fat clay (CH)*** with little gravel, stiff, gray/brown/red, moist, blocky structure	1	G / G			17.6			73	41	39
		End of Borehole										

Depth scale: 1–24 ft; 1–7 m

Auger hole located on top of sound berm

BORING LOG

Caltrans

Boring No.: HA-6	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 337+87, 12 m LT "N-3A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** hand auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 187.5+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per ~~6 inches~~ 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
1–4		***FILL, well-graded sand*** with plastic clay and gravel (SW-SC), few rounded cobbles, light brown to olive green, moist, calcite deposits	1	G G			11.5			50	23	56
		End of Borehole										

Depth scale: 1–24 (with 1–7 on secondary scale)

Auger hole located on top of sound berm

BORING LOG

Caltrans

Boring No.: SP-1	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 336+06, 50 m LT "G" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** soil probe/auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 182.5+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–1		*FILL, sandy silt/silty sand* (ML/SM), medium brown										
1–3.5		*NATIVE, sandy silt and clay,* red/brown, dry	1		88/28 cm							
			2		200/20 cm							
3.5–6		*WEATHERED BEDROCK* changed to orange, extremely weathered, dry	3		200/8 cm							
		End of Borehole										

Depth scale: 1–24 (ft); 1–7 (m)

BORING LOG

Caltrans

Boring No.: SP-2	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 337+54, 20 m LT "N-3A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** soil probe/auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 184.5+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–2 m (ft 0–2)		***FILL, sandy silt and clay*** with gravel fragments and cobbles (metavolcanic) and few cobbles, light brown/red/grey/olive green, moist	1		46/20 cm							
		FILL(?) ~~NATIVE~~, ***Fat clay with*** gravel (CH), olive green/brown (Friars Fm?), moist, some plasticity, some metavolcanic rock fragments, blocky structure	2		38							
			3		68							
			4		87		15.7			60	31	56
			5		80							
			6		46							
			7		45							
		WEATHERED ROCK (?)	8		180/20 cm							
		End of Borehole										

Depth scale: 1–24 (ft); 1–7 (m)

BORING LOG

Caltrans

Boring No.: SP-3	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 338+80, 18 m LT "N-3A" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** soil probe/auger
Logged By: M. Skyman	**Top of Hole Elev.:** 186.0+/-

SUBSURFACE PROFILE		SAMPLE									
Depth (ft / m)	Description	Number	Type	Blow Counts per 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–1.5	*FILL, silty sand (SM)* with debris, brown, dry										
1.5–8	*FILL (?), Fat clay with sand* and gravel (CH), olive green/gray/light brown, moist,	1		30							
		2		53							
		3		41		21.2			57	32	63
		4		44							
		5		36							
		6		38							
		7		89							
8–10	*WEATHERED BEDROCK (?)*	8		125							
		9		155							
10	End of Borehole										

No ground water encountered

BORING LOG

Caltrans

Boring No.: SP-4	**Dist.-Co.-Rte.-P.M.:** 11-SD-15 KP 31.4
Sheet: 1 of 1	**Location:** 334+70, 50 m LT "G" line
Date Drilled: 2-7-00	**EA:** 073400
Project Name: Widening	**Drilling Method:** soil probe/auger
Logged By: M. Skyrman	**Top of Hole Elev.:** 180.0+/-

SUBSURFACE PROFILE			SAMPLE									
Depth	Symbol	Description	Number	Type	Blow Counts per 0.3 m	Blows/ft (N)	Moisture Content (%)	Degree Saturation (%)	Dry Unit Weight (KN/M)	Liquid Limit (%)	Plasticity Index (%)	Percent Fines
0–2.4 m (0–8 ft)		***ALLUVIUM*** sand (SP) with 10% silt, medium dense to dense, fine to medium grained; large gravel @1.0 m; sandy silt and clay (CL) with gravel @ 1.4 m	1		32							
			2		117							
			3		85							
			4		115							
			5		117							
			6		62							
			7		33							
			8		60							
		End of Borehole										

Depth scale: 1–24 (ft); 1–7 (m)

No ground water encountered

APPENDIX A.2
LABORATORY TEST DATA

STATE OF CALIFORNIA
DEPT OF TRANSPORTATION
SOILS LAB

E.A. 11-073400

Br. #

CLASSIFICATION TEST SUMMARY

LOCATION	% FINER THAN															ATT. LIMITS		Gs	IN-SITU		LAB. COMP	
Sample I.D.	1 1/2	1	3/4	1/2	3/8	4	8	16	30	50	100	200	5μ	2μ	1μ	LL	PI		γ_d	%m	γ_d	%m
B-1-1																				19.2		
B-3-1							100	97	90	80	70	60	24	•	2					23.4		
B-3-2-III																		2.74		29.1		
B-3-3-III																				27.5		
B-3-4-II																				32.3		
B-3-5					100	99	98	97	91	82	69	57	21	-	4					27.2		
HA-2-1						100	99	98	95	83	71	63	30	-	26	45	24			20.9		
HA-4-1						100	99	98	95	64	44	36	19	-	11					9.1		
HA-5-1			100	99	99	93	92	90	85	77	71	66	39	-	16	73	41			17.6		
HA-6-1		100	95	89	87	82	81	79	76	69	61	56	30	-	16	50	23			11.5		
SP-2-1	100	95	89	86	84	73.	71	69	67	64	60	56	30	-	0	60	31			15.7		
SP-3-1				100	98	81	79	78	77	74	69	63	37	-	1	57	32			21.2		

* Sample received fractured -- Not suitable for testing

** Sample disintegrated while preparing for testing -- Not suitable for testing

*** Sample received desiccated -- Test results may not represent the true soil conditions

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION
OFFICE OF GEOTECHNICAL SUPPORT - GEOTECHNICAL LABORATORY

DENSITY - WATER CONTENT

JOB NUMBER 11-073400 * DATE 22-Feb-00 * TEST BY LP CHECKED BY KW 2/24

SAMPLE NO.	WET WT. +TARE (g)	DRY WT. +TARE (g)	WT. OF WATER (g)	TARE WT. (g)	WT. OF DRY SOIL (g)	% WATER	DIAM. SAMPLE (mm)	LENGTH SAMPLE (mm)	VOLUME (cm^3)	WET WT. + TARE (g)	TARE WT. (g)	WT. OF WET SOIL (g)	WET DENS (g/cm^3)	DRY DENS (g/cm^3)
B-3-3-III (15')	184.8 *	158.4 *	26.4	62.5 *	95.9	27.5	48.9 *	100.0 *	187.8			368.9 *	1.96	1.54
B-3-4-II (21')	188.5 *	157.6 *	30.9	62.0 *	95.6	32.3	48.0 *	95.4 *	172.6			341.4	1.98	1.49

* Received fractured
** Disintegrated while preparing for testing
*** Received dessicated - results may not represent true soil conditions

EA #	**11-073400**
Direct Shear #	**DS00025 A,B,C**
Sample #	**B-3-2-III**

All Values in Grams

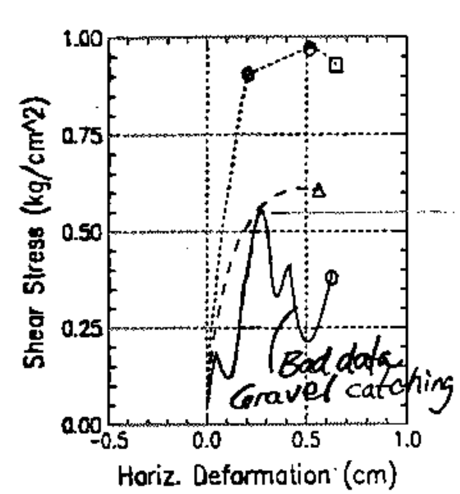
Moisture Content
Before Test

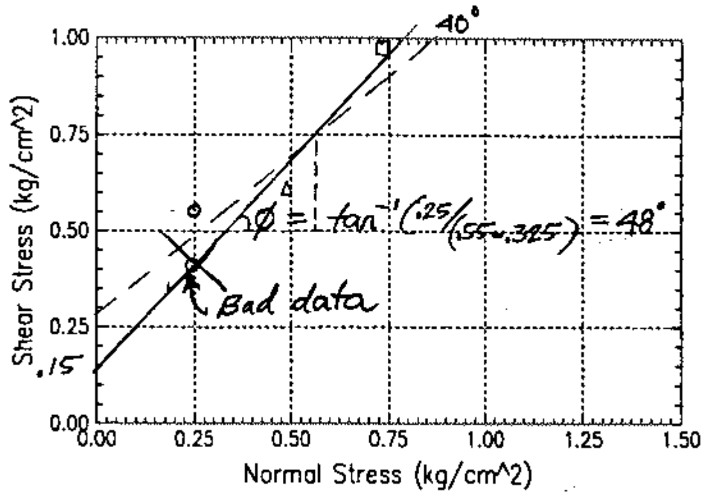
	A	B	C
Gross Wet wt.	119.3	118.9	120.5
Ring Tare wt.	23.8	24.2	24.6
Net Wet wt.	95.5	94.7	95.9
Grams of Moisture	21.4	20.9	21.0
Moisture %	28.9	28.3	28.0
Wet Trimmings + Can Tare	157.5	157.2	160.7

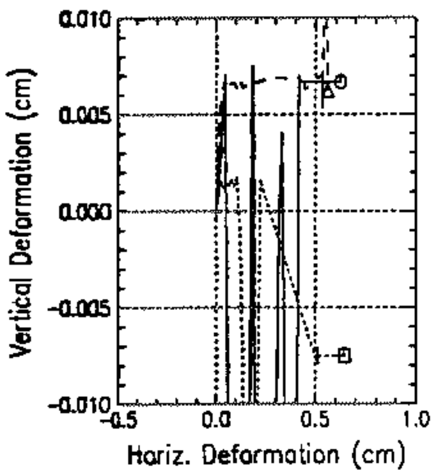
Moisture Content
After Test

	A	B	C
Gross Wet wt.	156.8	156.5	159.7
Gross Dry wt.	136.1	136.3	139.7
Can Tare	62.0	62.5	64.8
Grams of Moisture	20.7	20.2	20.0
Net Dry wt.	74.1	73.8	74.9
Moisture %	27.9	27.4	26.7

	A	B	C
Wet trimmings + Can tare	157.5	157.2	160.7
Dry Trimmings + Can Tare	136.1	136.3	139.7
Can Tare wt.	62.0	62.5	64.8
Wet Specimen + Tare Before Test	157.5	157.2	160.7
Wet Specimen + Tare After Test	156.8	156.5	159.7
Dry Specimen + Tare After Test	136.1	136.3	139.7







Strength Parameters

Graph Symbol			O	Δ	□	
Test No.			DS00025A	DS00025B	DS00025C	
Initial	Water content (%)	w_o	28.88	28.32	28.04	
Initial	Void ratio	e_o	0.00	0.00	0.00	
Initial	Saturation (%)	S_o	44.00	42.97	43.18	
Initial	Dry density (gm/cm^3)	γ_d	1.52	1.52	1.54	
Void ratio after consolidation		e_c	0.00	0.00	0.00	
Time for 50 percent consolidation		t_{50}				
Final	Water content (%)	w_f	27.94	27.37	26.70	
Final	Void Ratio	e_f	0.00	0.00	0.00	
Final	Saturation (%)	S_f	42.67	41.63	41.00	
Normal stress (kg/cm^2)		σ	0.24	0.49	0.73	
Maximum shear stress (kg/cm^2)		τ_{max}	0.41	0.61	0.98	
Actual time to failure (min)		t_f	40	43	49	
Rate of strain .004 in/min.						
Ultimate shear stress (kg/cm^2)		τ_{ult}	0.38	0.61	0.93	

Type of Specimen	1.944						
Description	MOIST FIRM GREEN GRAY CLAY WITH SAND & GRAVEL						
LL	0.0	PL	0.0	PI	0.0	G_s	0

Remarks	Project	WIDENING		
	Area	19.15 (cm^2	Boring No.	B-3
	Depth	10' ---	Sample No.	B-3-2-III
	Elevation	---	Date	03/03/00

DIRECT SHEAR TEST REPORT

APPENDIX A.3
BEARING CAPACITY CALCULATIONS

/ /

Type I Wall
Sta. 334+60 – 335+49
Bearing Capacity

11-SD-15

M. SKYRMAN

3-27-0

BEARING CAPACITY CALCULATION

SP-4: medium dense fine to medium grained sand w/ a little silt (alluvium)

Assign $\phi = 29°$, moist unit weight = 115 pcf (18.84 kN/m³)

For a 1.8m wall, embedment = 0.85 m
width of ftg. (B) = 1.0m

$$q_{ult} = \cancel{cN_c}^{\,0} + qN_q + 0.5B\gamma N_\gamma$$

$N_q = 15$ (Reissner)

$N_\gamma = 11$ (Meyerhof)

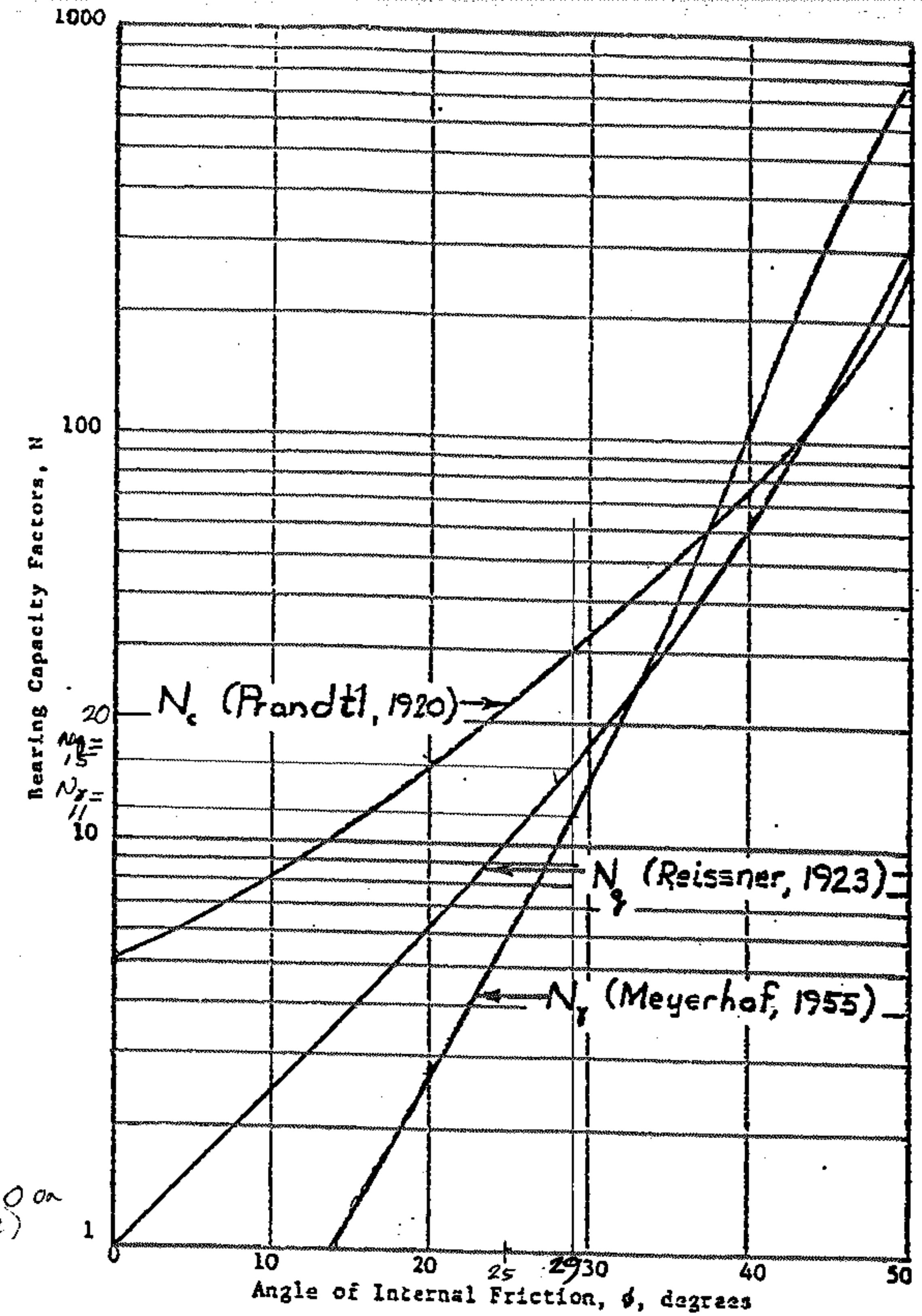
$$q_{ult} = (18.1\ kN/m^3)(.85)(15) + 0.5(1)(18.1)(11)$$
$$= 231 + 100$$
$$= 331$$

$$q_{all} = \frac{331 kPa}{3.0} = 110\ KPa$$

Toe Pressure of 70 KPa ≤ qall

⟶ Meets Bearing Capacity Criteria

116-7157



Check this chart for
ϕ = 0 :
$N_c = 5.14$
$N_q = 1$
$N_\gamma = 0$ (can't plot 0 on log scale)

Fig. 5 Bearing Capacity Factors for Use in the Bearing Capacity Equation

APPENDIX A.4
MSEW DESIGN CALCULATIONS

I-15 NB KP 34.1-Widening at Carmel Mtn

PROJECT IDENTIFICATION

Title:	I-15 NB KP 34.1-Widening at Carmel Mtn
Project Number:	EA 073400 30600
Client:	Caltrans D11 Design
Designer:	M. Skyrman
Station Number:	

Description:

Segmental retaining wall from Sta. 337+60 to 340+29 "N-2A" line

Company's information:

Name: Caltrans
Street: 7177 Opportunity Rd.

San Diego, CA 92111
Telephone #: 858-467-4061
Fax #: 858-467-4063
E-Mail:

Original date and time of creating this file: Wed Mar 22 16:30:42 2000

PROGRAM MODE: DESIGN
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

DESIGN DATA

DESIGN OBJECTIVES

Minimum factor of safety against pullout, Fs-po	1.50
Minimum factor of safety against direct sliding, Fs-sliding	1.50
Maximum allowable eccentricity ratio at each reinforcement level, e/L	0.1667
Minimum factor of safety against compound and overall failure, Fs-comp	1.30

Prescribed minimum resistive length to prevent pullout, Le = 1.00 m.
Prescribed minimum normalized length of each layer is: L/Hd = 0.70 --> L = 1.54 m.
Prescribed minimum absolute total length of each layer is: L = 1.70 m.

BEARING CAPACITY

Bearing capacity is controlled by general shear.

Maximum permissible eccentricity ratio (soil), e/L	0.1667
Minimum factor of safety with respect to ultimate bearing capacity (Meyerhof approach)	2.50

Bearing capacity coefficients: Nc = 23.94 $N_\gamma = 14.47$

SOIL DATA

REINFORCED SOIL

Unit weight, γ	18.8 kN/m³
Design value of internal angle of friction, ϕ	34.0 °

RETAINED SOIL

Unit weight, γ	18.8 kN/m³
Design value of internal angle of friction, ϕ	27.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	18.8 kN/m³
Equivalent internal angle of friction, $\phi_{equiv.}$	27.0 °
Equivalent cohesion, $c_{equiv.}$	14.4 kPa

Water table does not affect bearing capacity

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.4299 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2827 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)
Inclination of internal slip plane, $\psi = 62.00°$ (see Fig. 28 in DEMO 82).

SEISMICITY

Not Applicable

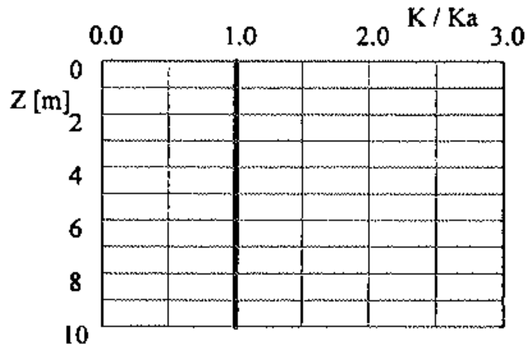
INPUT DATA: Geogrids
(Equally spaced single type reinforcement)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tavailable [kN/m]	20.0	N/A	N/A	N/A	N/A
Durability reduction factor, RFd	N/A	N/A	N/A	N/A	N/A
Installation-damage reduction factor, RFid	N/A	N/A	N/A	N/A	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A
Fs-overall for strength	1.50	N/A	N/A	N/A	N/A
Coverage ratio, Rc	1.000	N/A	N/A	N/A	N/A

Friction angle along geogrid-soil interface, ρ	28.35
Pullout resistance factor, F*	0.8·tan ϕ
Scale-effect correction factor, α	0.8

Variation of Lateral Earth Pressure Coefficient With Depth

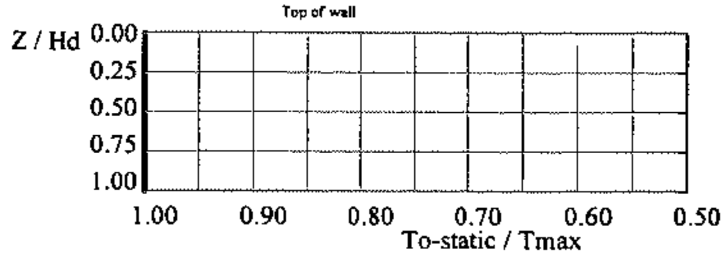
Z	K / Ka
0 m	1.00
1 m	1.00
2 m	1.00
3 m	1.00
4 m	1.00
5 m	1.00
6 m	1.00



INPUT DATA: Facia and Connection (Design)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 0.3/0.2 m. Horizontal distance to Center of Gravity of block is 0.1 m.
Average unit weight of block is $\gamma_f = 24.0$ kN/m³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



To-static, To-seismic = connection force, static and superimposed dynamic component, respectively.

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ [1]	Tc-break [2]	σ	Tc-break	σ	Tc-break	σ	Tc-break	σ	Tc-break
50.0	30.00								
100.0	30.00	N/A		N/A		N/A		N/A	

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	Tc-pullout [3]	σ	Tc-pullout	σ	Tc-pullout	σ	Tc-pullout	σ	Tc-pullout
0.0	0.00								
50.0	30.00	N/A		N/A		N/A		N/A	

[1] σ = Confining stress in between stacked blocks [kPa]
[2] Available connection strength, Tc-break criterion [kN/m]
[3] Available connection strength, Tc-pullout criterion [kN/m]

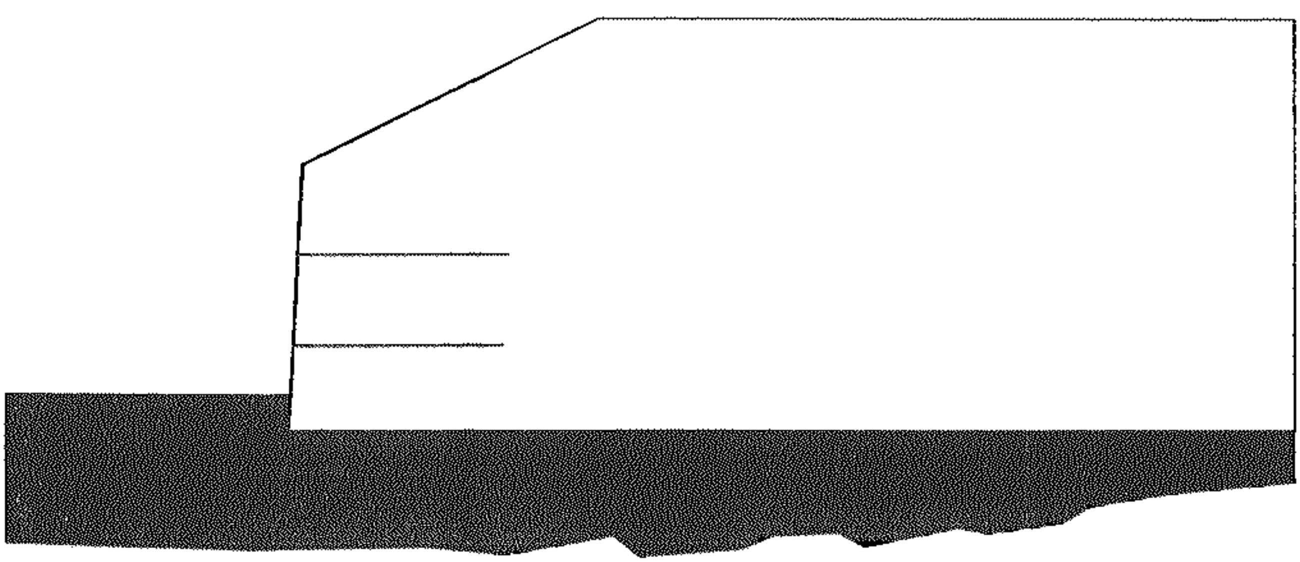
D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Long-term connection strength, Tc-available	23.00	N/A	N/A	N/A	N/A
Overall factor of safety: connection break, Fs	1.50	N/A	N/A	N/A	N/A
Overall factor of safety: connection pullout, Fs	1.50	N/A	N/A	N/A	N/A

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

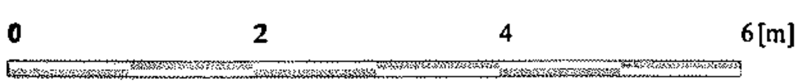
Design height, Hd	2.20	[m]	{ Embedded depth is E = 0.30 m, and height above top of finished bottom grade is H = 1.90 m }
Batter, ω	3.0	[deg]	
Backslope, β	26.6	[deg]	
Backslope rise	1.2	[m]	Broken back equivalent angle, I = 15.26° (see Fig. 25 in DEMO 82)

UNIFORM SURCHARGE
Uniformly distributed dead load is 0.0 [kPa]

DESIGNED REINFORCEMENT LAYOUT:



SCALE:



REINFORCEMENT LAYOUT AND DESIGN CRITERIA

LEGEND: **(1) Connection strength**
(2) Geogrid strength
(3) Pullout resistance
(4) Direct sliding
(5) Eccentricity

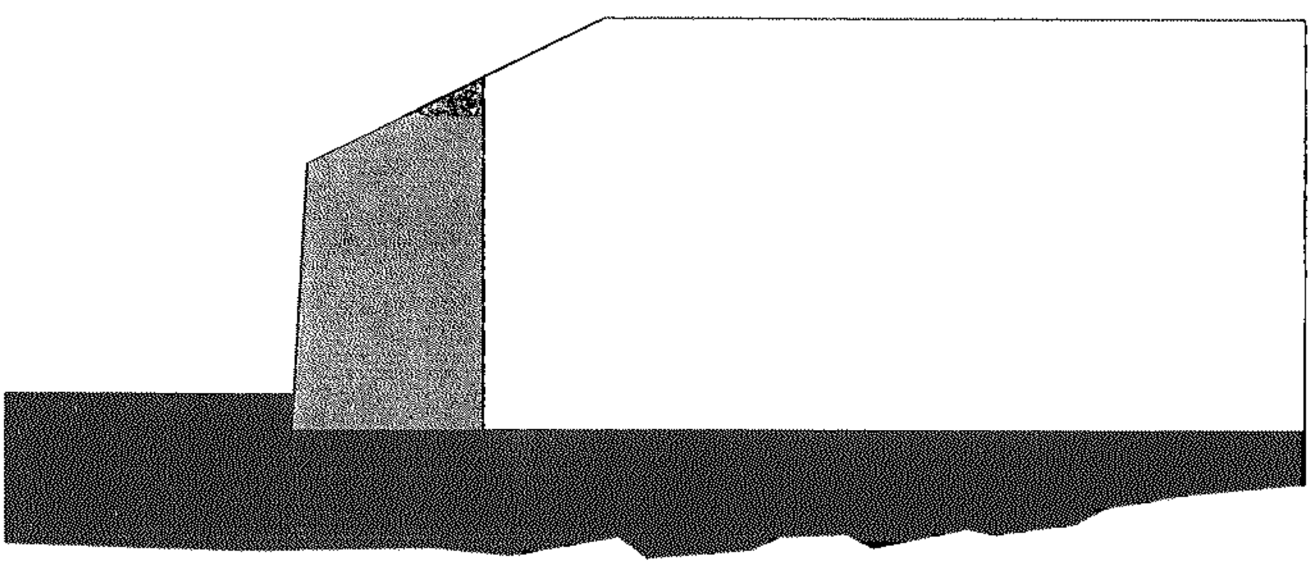
√ Satisfactory
⊗ Unsatisfactory

Bearing capacity: ⊗
Foudation Interface: Direct sliding ⊗ ; Eccentricity ⊗

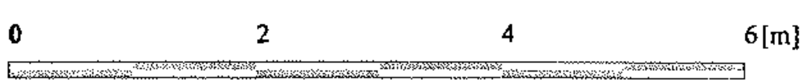
#	Geogrid Elevation [m]	Geogrid Length [m]	Geogrid Type #	(1)	(2)	(3)	(4)	(5)
1	0.70	1.70	N/A	√	√	√	√	√
2	1.45	1.70	N/A	√	√	√	√	√

BEARING CAPACITY for DESIGNED LAYOUT

	STATIC	SEISMIC	UNITS
Ultimate bearing capacity, q-ult	485.0	N/A	[kPa]
Meyerhof stress, σ_v	77.81	N/A	[kPa]
Eccentricity, e	0.26	N/A	[m]
Eccentricity, e/L	0.167	N/A	
Fs calculated	6.23	N/A	
Base length	1.55	N/A	[m]



SCALE:



DIRECT SLIDING for DESIGNED LAYOUT
(for GEOGRID reinforcements)

Specified Fs-static = 1.500

Along reinforced and foundation soils interface: Fs-static = 1.632

#	Geogrid Elevation [m]	Geogrid Length [m]	Fs Static	Fs Seismic	Geogrid Type #
1	0.70	1.70	1.680	N/A	N/A
2	1.45	1.70	2.176	N/A	N/A

ECCENTRICITY for DESIGNED LAYOUT

Along reinforced and foundation soils interface: e/L static = 0.1665

#	Geogrid Elevation [m]	Geogrid Length [m]	e / L Static	e / L Seismic	Geogrid Type #
1	0.70	1.70	0.0588	N/A	N/A
2	1.45	1.70	-0.0179	N/A	N/A

RESULTS for STRENGTH

#	Geogrid Elevation [m]	Tavailable [kN/m]	Tmax [kN/m]	Tmd [kN/m]	Specified minimum Fs-overall static	Actual calculated Fs-overall static	Specified minimum Fs-overall seismic	Actual calculated Fs-overall seismic
1	0.70	20.0	11.7	N/A	1.500	1.709	N/A	N/A
2	1.45	20.0	5.7	N/A	1.500	3.528	N/A	N/A

RESULTS for PULLOUT

#	Geogrid Elevation [m]	Coverage Ratio	Tmax [kN/m]	Tmd [kN/m]	Le [m]	La [m]	Avail.Static Pullout, Pr [kN/m]	Specified Static Fs	Actual Static Fs	Avail.Seism. Pullout, Pr [kN/m]	Specified Seismic Fs	Actual Seismic Fs
1	0.70	1.000	11.7	N/A	1.36	0.34	43.6	1.500	3.727	N/A	N/A	N/A
2	1.45	1.000	5.7	N/A	1.01	0.69	21.7	1.500	3.824	N/A	N/A	N/A

RESULTS for CONNECTION (static conditions)

#	Geogrid Elevation [m]	Connection force, To [kN/m]	Reduction factor for connection break, CRu	Reduction factor for connection pullout, CRs	Available connection strength, Tc-break criterion [kN/m]	Available connection strength, Tc-pullout criterion [kN/m]	Available Geogrid strength, Tavailable [kN/m]	Fs-overall connection break		Fs-overall connection pullout		Fs-overall Geogrid strength	
								Specified	Actual	Specified	Actual	Specified	Actual
1	0.70	11.7	N/A	N/A	30.0	21.6	20.0	1.50	2.56	1.50	1.85	1.50	1.71
2	1.45	5.7	N/A	N/A	30.0	10.8	20.0	1.50	5.29	1.50	1.91	1.50	3.53

APPENDIX A.5
SRW GUIDE SPECIFICATIONS

Designation: C 1372 – 97

Standard Specification for Segmental Retaining Wall Units[1]

This standard is issued under the fixed designation C 1372; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers segmental retaining wall units of concrete, machine-made from portland cement, water, and suitable mineral aggregates with or without the inclusion of other materials. The units are intended for use in the construction of mortarless segmental retaining walls.

NOTE 1—When particular features are desired, such as weight classification, higher compressive strength, surface texture, finish, color, or other special feature, such properties should be specified separately by the purchaser. Local suppliers should be consulted as to availability of units having the desired features.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

C 33 Specification for Concrete Aggregates[2]

C 140 Test Methods of Sampling and Testing Concrete Masonry Units[3]

C 150 Specification for Portland Cement[4]

C 331 Specification for Lightweight Aggregates for Concrete Masonry Units[2]

C 595M Specification for Blended Hydraulic Cements[4]

C 618 Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete[2]

C 989 Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars[2]

C 1157/C 1157M Performance Specification for Blended Hydraulic Cement[4]

C 1262 Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units[3]

3. Materials

3.1 *Cementitious Materials*—Materials shall conform to the following applicable specifications:

3.1.1 *Portland Cements*—Specification C 150.

3.1.2 *Modified Portland Cement*—Portland cement conforming to Specification C 150, modified as follows:

3.1.2.1 *Limestone*—Limestone, with a minimum 85 % Calcium Carbonate ($CaCO_3$) content, shall be permitted to be added to the cement, provided these requirements of Specification C 150 as modified are met:

(1) Limitation on Insoluble Residue—1.5 %.

(2) Limitation on Air Content of Mortar—Volume percent, 22 % max.

(3) Limitation on Loss of Ignition—7 %.

3.1.3 *Blended Cements*—Specification C 595M or C 1157/C 1157M.

3.1.4 *Pozzolans*—Specification C 618.

3.1.5 *Blast Furnace Slag Cement*—Specification C 989.

3.2 *Aggregates*—Aggregates shall conform to the following specifications, except that grading requirements shall not necessarily apply:

3.2.1 *Normal Weight Aggregates*—Specification C 33.

3.2.2 *Lightweight Aggregates*—Specification C 331.

3.3 *Other Constituents*—Air-entraining agents, coloring pigments, integral water repellents, finely ground silica, and other constituents shall be previously established as suitable for use in segmental retaining wall units and shall conform to applicable ASTM standards or shall be shown by test or experience to be not detrimental to the durability of the segmental retaining wall units or any material customarily used in segmental retaining wall construction.

4. Physical Requirements

4.1 At the time of delivery to the work site, the units shall conform to the physical requirements of Table 1 when tested in accordance with 7.2.

4.2 *Freeze-Thaw Durability*—In areas where repeated freezing and thawing under saturated conditions occur, freeze-thaw durability shall be demonstrated by test or by proven field performance that the segmental retaining wall units have adequate durability for the intended use. When testing is required by the specifier to demonstrate freeze-thaw durability, the units shall be tested in accordance with 7.3

4.2.1 Specimens shall comply with either of the following: 1) the weight loss of each of five test specimens at the conclusion of 100 cycles shall not exceed 1 % of its initial weight; or 2) the weight loss of each of four of the five test specimens at the conclusion of 150 cycles shall not exceed 1.5 % of its initial weight.

---

[1] This specification is under the jurisdiction of ASTM Committee C-15 on Manufactured Masonry Units and is the direct responsibility of C15.03 on Concrete Masonry Units and Related Units.

Current edition approved Aug. 10, 1997. Published October 1997.

[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.05.

[4] *Annual Book of ASTM Standards*, Vol 04.01.

TABLE 1 Strength and Absorption Requirements

Minimum Required Net Average Compressive Strength psi (MPa)		Maximum Water Absorption Requirements lb/ft³ (kg/m³)		
		Weight Classification Oven-Dry Density of Concrete lb/ft³(kg/m³)		
Average of 3 Units	Individual Unit	Lightweight Less than 105 (1682)	Medium Weight 105 (1682) to less than 125 (2002)	Normal Weight 125 (2002) or more
3000 (20.7)	2500 (17.2)	18 (288)	15 (240)	13 (208)

5. Permissible Variations in Dimensions

5.1 Overall dimensions for width, height, and length shall differ by not more than ± ⅛ in. (3.2 mm) from the specified standard dimensions.

NOTE 2—The term "width" refers to the horizontal dimension of the unit measured perpendicular to the face of the wall from the exposed surface of the unit to the back of the unit. The term "height" refers to the vertical dimension of the unit as placed in the wall. The term "length" refers to the horizontal dimension of the unit measured parallel to the running length of the wall.

5.1.1 Dimensional tolerance requirements for width shall be waived for architectural split faced surfaces.

6. Finish and Appearance

6.1 All units shall be sound and free of cracks or other defects that would interfere with the proper placement of the unit or would significantly impair the strength or permanence of the construction. Minor cracks incidental to the usual method of manufacture or minor chipping resulting from customary methods of handling in shipment and delivery, are not grounds for rejection.

6.2 Where units are to be used in exposed wall construction, the face or faces that are to be exposed shall not show chips or cracks, not otherwise permitted, or other imperfections when viewed from a distance of not less than 20 ft (6.1 m) under diffused lighting.

6.3 Five percent of a shipment containing chips not larger than 1 in (25.4 mm) in any dimension, or cracks not wider than 0.02 in. (0.5 mm) and not longer than 25 % of the nominal height of the unit is permitted.

7. Sampling and Testing

7.1 The purchaser or authorized representative shall be accorded proper facilities to inspect and sample units at place of manufacture from the lots ready for delivery.

7.2 Sample and test units for compressive strength, absorption, and dimensional tolerances in accordance with T Methods C 140.

7.3 When required, sample and test five specimens freeze-thaw durability in water in accordance with Test Meth C 1262. Freeze-thaw durability shall be based on tests of un made with the same materials, concrete mix design, manuf turing process, and curing method, conducted not more than months prior to delivery.

8. Rejection

8.1 If the samples tested from a shipment fail to conform the specified requirements, the manufacturer shall be permit to remove units from the shipment, and a new sample sh selected by the purchaser from the retained lot and testec expense of the manufacturer. If the second sample fai conform to the specified requirements, the entire lot shall rejected.

NOTE 3—Unless otherwise specified in the purchase order, the cos tests is typically borne as follows: (1) if the results of the tests show the units do not conform to the requirements of this specification, the is typically borne by the seller; (2) if the results of the tests show that units conform to the specification requirements, the cost is typically bo by the purchaser.

9. Keywords

9.1 absorption; aggregates; cementitious materials; co pressive strength; concrete masonry units; dimensions; du bility; weight classification

Reference 1

Payment

The quantities, determined as described above, will be paid for at the contract price per unit of measurement, respectively, for each pay item listed below and shown in the bid schedule, which prices and payment will be full compensation for the work prescribed in this section, except as provided below:

Excavation of unsuitable foundation materials will be measured and paid for as provided in AASHTO Division II, Section 1. Select backfill for replacement of unsuitable foundation materials will be paid for under item (4).

Payment will be made under:

	Pay Item	Pay Unit
1.	Wall materials	Square meter
2.	Wall erection	Square meter
3.	Concrete leveling pad	Linear meter
4.	Select granular backfill	Cubic meter
5.	Coping barrier	Linear meter
6.	Traffic barriers	Linear meter

MSE walls have been contracted on a lump sum or per wall basis to include compensation for all excavation, temporary support as required, materials, labor and incidental construction. For equitable bidding this method requires accurate quantity determinations and a method of compensation for changed conditions and or overruns/underruns of quantities.

8.9 GUIDE SPECIFICATIONS FOR CONCRETE MODULAR BLOCK (MBW) FACING AND UNIT FILL

Where MBW units are specified for a project, the primary specification detailed in Section 8.8, requires a deletion of *Reinforced Concrete Facing Panels* and the insertion of a new section detailed below. *Wall erection* requires the deletion of the first two sentences from the second paragraph. A specification for unit fill placed within the MBW units must be added.

It is presently recommended that the format of National Concrete Masonry Association (NCMA) TEK 2-4 (1994) specifications be used, except that the compressive strength for units should be increased to 28 MPa to increase durability, maximum water absorption be limited to 5 percent, requirements added for freeze-thaw testing, and tolerance limits expanded.

The full amended specification is included as follows:

Scope

This specification covers hollow and solid concrete structural retaining wall units, machine made from portland cement, water, and mineral aggregates with or without the inclusion of other materials. The units are intended for use in the construction of mortarless, modular block (MBW) retaining walls.

Referenced ASTM Documents

C-33	Specifications for Concrete Aggregates
C-90	Specification for Load Bearing Masonry Units
C-140	Methods of Sampling and Testing Concrete Masonry Units
C-150	Specification for Portland Cement
C-331	Specification for Lightweight Aggregates for Concrete Masonry Units
C-595	Specification for Blended Hydraulic Cements
C-618	Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
C-989	Specification for Ground Granulated Blast Furnace Slag Cement
C-666	Standard Method of Evaluating the Freeze-Thaw Durability Resistance of Concrete to Rapid Freezing and Thawing.

Materials

1.0 **Cementious Materials** - Materials shall conform to the following applicable specifications.

1.1 **Portland Cement** - Specification C-150.

1.2 Modified Portland Cement - Portland Cement conforming to Specification C-150, modified as follows:

1.2.1 **Limestone** - Calcium carbonate, with a minimum 85% ($CaCO_3$) content, may be added to the cement, provided the requirements of Specification C 150 as modified are met:

1) Limitation on Insoluble Residue - 1.5%
2) Limitation on Air Content of Mortar - Volume percent, 22% max.
3) Limitation on Loss of Ignition - 7%

1.3 **Blended Cements** - Specification C-595.

1.4 **Pozzolans** - Specification C-618.

1.5 **Blast Furnace Slag Cement** - Specification C-989.

NOTE: *Sulphate resistant cement should be used in the manufacture of units to be used in areas where the soil has high sulphate content such as arid regions of the western United States.*

2.0 **Aggregates** - Aggregates shall conform to the following specifications, except that grading requirements shall not necessarily apply:

2.1 **Normal Weight Aggregates** - Specification C-33.

2.2 **Lightweight Aggregates** - Specification C-331.

3.0 **Other Constituents** - Air-entraining agents, coloring pigments, integral water repellents, finely ground silica, and other constituents shall be previously established as suitable for use in concrete MBW units shall conform to applicable ASTM Standards or, shall be shown by test or experience to be not detrimental to the durability of the MBW units or any material customarily used in masonry construction.

Physical Requirements

1.0 At the time of delivery to the work site, the units shall conform to the following physical requirements:

Table 1. Physical Requirements

Minimum required compressive strength (Average 3 coupons) MPa	=	28 MPa
Minimum required compressive strength (Individual coupon) MPa	=	24.5 MPa
Maximum water absorption (freeze/thaw requirement)	=	5%
Maximum number of blocks per lot	=	2,000

Note: *Freeze thaw requirements may be omitted in areas of insignificant freeze thaw. Blocks may be sealed with a water resistant coating in lieu of meeting the freeze thaw requirements of C-666.*

2.0 **Tolerances.** Blocks shall be manufactured within the following tolerances:

2.1 The length and width of each individual block shall be within ± 3.2 mm of the specified dimension. Hollow units shall have a minimum wall thickness of 32 mm.

2.2 The height of each individual block shall be within ± 1.6 mm of the specified dimension. Important! w/regards to frictional connection

2.3 When a broken face finish is required, the dimension of the front face shall be within ± 25 mm of the theoretical dimension of the unit.

2.4 **Finish and Appearance.** All units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction. Minor cracks (e.g. no greater than 0.5 mm in width and no longer than 25% of the unit height) incidental to the usual method of manufacture or minor chipping resulting from shipment and delivery, are not grounds for rejection.

The face or faces of units that are to be exposed shall be free of chips, cracks or other imperfections when viewed from a distance of 10 m under diffused lighting. Up to five percent of a shipment may contain slight cracks or small chips not larger than 25 mm.

Color and finish shall be as shown on the plans and shall be erected with a running bond configuration.

2.5 If pins are required to align MBW units, they shall consist of a nondegrading polymer or galvanized steel and be made for the express use with the MBW units supplied.

2.6 Cap units shall be cast to or attached to the top MBW units in strict accordance with the manufacturer's requirements and the adhesive manufacturer's recommended procedures. Contractor shall provide a written 10 year warranty, acceptable to the Owner, that the integrity of the materials used to attach the cap blocks will preclude separation and displacement of the cap blocks for the warranty period.

3.0 Sampling and Testing. Acceptance of the concrete block with respect to compressive strength, will be determined on a lot basis. The lot will be randomly sampled in accordance with ASTM C-140. Compressive strength tests shall be performed by the manufacturer and submitted to the Owner. Compressive strength test specimens shall be cored or shall conform to the saw-cut coupon provisions of section 5.2.4 of ASTM C-140. Blocks represented by test coupons that do not reach an average compressive strength of 28 MPa will be rejected.

3.1 Rejection. Blocks shall be rejected because of failure to meet any of the requirements specified above. In addition, any or all of the following defects shall be sufficient cause for rejection.

- Defects that indicate imperfect molding.
- Defects indicating honeycomb or open texture concrete.
- Cracked or severely chipped blocks.
- Color variation on front face of block due to excess form oil or other reasons.

Unit Fill

The unit fill and drainage aggregate shall be a well graded crushed stone or granular fill meeting the following gradation:

U.S. Sieve Size	Percent Passing
25 mm	100-75
19 mm	50-75
No. 4	0-60
No. 40	0-50
No.200	0-5

10-1.__ GEOSYNTHETIC REINFORCED EMBANKMENT.--Geosynthetic reinforced embankment shall consist of placing geosynthetic reinforcement material between layers of compacted soil in accordance with the details shown on the plans, as specified in Section 19 "Earthwork," of the Standard Specifications, these special provisions, and as directed by the Engineer. Only one type of geosynthetic reinforcement material shall be used for an entire embankment.

If shown on the plans, a drainage system shall be constructed with the geosynthetic reinforced embankment. Specifications for the drainage system will be found elsewhere in these special provisions.

If shown on the plans, filter fabric shall be used within the geosynthetic reinforced embankment; specifications for the filter fabric will be found elsewhere in these special provisions or in the Standard Specifications.

MATERIAL CONFIGURATION SPECIFICATIONS.--The geosynthetic reinforcement material shall be configured as a geosynthetic and shall meet the requirements described under "Material Specifications" found elsewhere in this section. The Engineer shall be furnished a Certificate of compliance according to the provisions found in Section 6-1.07, "Certificate of Compliance," of the Standard Specifications for the geosynthetic reinforcement material a minimum of one week prior to beginning placement of geosynthetic reinforcement material. The Certificate of Compliance shall be prepared and signed by a representative of the manufacturer who is a California-registered Civil Engineer.

Geosynthetic reinforcement material shall consist of material designed for use in subsurface geotechnical slope reinforcement applications. Geosynthetic reinforcement material shall be configured as either a geogrid or geotextile material. Geogrid shall have in addition to the requirements for geosynthetic reinforcement, a regular and defined open area. Geogrid shall obtain pullout resistance from the soil by a combination of soils shearing friction on the plane surfaces parallel to the direction of shearing and soils bearing on transverse grid surfaces normal to the direction of grid movement. The percentage of the open area for geogrids shall range from 50 to 90 percent of the total projection of a section of the material. Geotextiles shall have in addition to the requirements for geosynthetic reinforcement material, an irregular or regular open area with the spacing of open areas being less than 6.3 millimeters in any direction.

Geosynthetic reinforcement material shall consist of material designed for use in subsurface geotechnical slope reinforcement applications. Geosynthetic reinforcement material shall be configured as a geogrid material. Geogrid shall have in addition to the requirements for geosynthetic reinforcement, a regular and defined open area. Geogrid shall obtain pullout resistance from the soil by a combination of soils shearing friction on the plane surfaces parallel to the direction of shearing and soils bearing on transverse grid surfaces normal to the direction of grid movement. The percentage of the open area for geogrids shall range from 50 to 90 percent of the total projection of a section of the material.

Geosynthetic reinforcement material shall consist of material designed for use in subsurface geotechnical slope reinforcement applications. Geosynthetic reinforcement material shall be configured as geotextile material. Geotextiles shall have in addition to the requirements for geosynthetic reinforcement material, an irregular or regular open area with the spacing of open areas being less than 6.3 millimeters in any direction.

Geosynthetic reinforcement material shall meet the following requirements in addition to the requirements described under "Materials Specifications" elsewhere in this section:

1. Long Term Design Strength (LTDS) for geosynthetic reinforcement material shall be equal to or greater than values shown on the plans or elsewhere in these specifications as determined by Geosynthetic Research Institute (GRI) Test Methods. LTDS for geogrid reinforcement and geotextile reinforcement shall be determined by Standard Practice GRI G4 (a) and (b) and GRI GT7, respectively. These values are minimum average roll values.

Long Term Design Strength is the strength of the geogrid or the geotextile calculated by applying all partial factors of safety in accordance with GRI Standard Practice GG4 (a) and (b) or GT7. The factor of safety for creep deformation shall be determined for a 75-year design life as determined by GRI G4 (a) and (b) for geogrids or GRI GT7 for geotextiles. The 75-year design life strength is determined from the creep curve which becomes asymptotic to a constant strain line of 10 percent or less.

In the absence of specific test data, the partial factor of safety default values (installation damage, creep deformation, chemical degradation, biological degradation, and joint) as indicated in the Standard Practice GRI G4 (a) and (b) and GRI GT7 shall be applied to the calculations of the LTDS.

2. Geosynthetic reinforcement material shall be resistant to naturally occurring alkaline and acidic soil conditions, and to attack by bacteria.

All test results which contributed to the calculations of the LTDS shall be submitted to the Engineer no less than one week prior to beginning placement of the geosynthetic reinforced embankment. All test results which contribute to the calculations of the LTDS shall be prepared and signed by a California-registered Civil Engineer.

MATERIAL.--Geosynthetic reinforcement material shall consist of high density polyethylene, polypropylene, high density polypropylene sheets, high tenacity polyester yarn, or polyaramide and shall meet the applicable material requirements found below. Geosynthetic reinforcement material shall consist of main and secondary reinforcement layers.

High Density Polyethylene.--Geosynthetic reinforcement material consisting of high density polyethylene shall meet or exceed the following material requirements:

1) Be manufactured from high density polyethylene (HDPE) which conforms to ASTM Method D 1248.
2) Shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter. Secondary geosynthetic reinforcement material shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter.

Polypropylene.--Geosynthetic reinforcement material consisting of polypropylene or high-density polypropylene sheets shall meet or exceed the following material requirements:

1) Shall meet the requirements of ASTM Designation: D 4101, Group 1/Class1/Grade 2.
2) Shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter. Secondary geosynthetic reinforcement material shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter.

High Tenacity Polyester Encapsulated.--Geosynthetic reinforcement material consisting of high tenacity polyester yarn shall meet or exceed the following material requirements:

1) Be manufactured from high tenacity polyester yarn as determined by ASTM Designation: D 629. In addition to meeting the requirements for geosynthetic, geogrid shall be encapsulated in an acrylic latex coating or similar.
2) Shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter. Secondary geosynthetic

reinforcement material shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter.

Polyaramides.--Geosynthetic reinforcement material consisting of polyaramide shall meet or exceed the following material requirements:

1) Be manufactured from high tenacity polyester yarn as determined by ASTM Designation: D 629.
2) Shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter. Secondary geosynthetic reinforcement material shall have a LTDS in the primary strength direction greater than or equal to values shown on the plans/___ kilo-Newtons per meter.

IMPORTED BORROW (GEOSYNTHETIC REINFORCED EMBANKMENT).-All imported borrow used in the geosynthetic reinforced embankment shall be reasonably free from organic or other deleterious materials and shall conform to the following:

PROPERTY	VALUE	CA TEST NO.
Percent passing	Gradation	202
Sieve Size		
75-millimeters	100	
19-millimeters	70 - 100	
4.75-millimeters	20 – 70	
420-µm	0 - 60	
75-µm	0 – 45	
Sand Equivalent	10 minimum	217
Plasticity Index	20 maximum	204
pH	between 3 and 9	643

NATIVE BACKFILL MATERIAL.--All backfill material used in the geosynthetic reinforced embankment shall be developed from on-site material and shall be reasonably free from organic or other deleterious materials and shall conform to the following:

PROPERTY	VALUE	CA TEST NO.
Percent passing	Gradation	202
Sieve Size		
75-millimeters	100	
19-millimeters	70 - 100	
4.75-millimeters	20 - 70	
75-µm	0 – 55	
Sand Equivalent	10 minimum	217
Plasticity Index	20 maximum	204
pH	between 3 and 9	643

EMBANKMENT BACKFILL.--The backfill material used in the geosynthetic reinforced shall consist of imported material and/or material developed on site. The backfill shall be reasonably free from organic or other deleterious materials and shall conform to the following:

PROPERTY	VALUE	CA TEST NO.
Percent passing	Gradation	202
Sieve Size		
75-millimeters	100	

19-millimeters	70 - 100	
4.75-millimeters	20 – 80	
420-µm	0 - 70	
75-µm	0 – 55	
Sand Equivalent	10 minimum	217
Plasticity Index	20 maximum	204
pH	between 3 and 9	643

EMBANKMENT MATERIAL.—Specifications for embankment material shall conform to the requirement found elsewhere in these special provisions.

BACKFILL FOR EMBANKMENT FACING.--The backfill material used at the facing of the geosynthetic reinforced embankment shall consist of imported material and/or material developed on site. The backfill shall be reasonably free from organic or other deleterious materials and shall conform to the following:

PROPERTY	VALUE	CA TEST NO.
Percent passing	Gradation	202
Sieve Size		
75-millimeters	100	
19-millimeters	70 – 100	
420-µm	35 - 70	
75-µm	35 minimum	
Plasticity Index	10 minimum	204

HANDLING AND STORAGE.--Geosynthetic reinforcement material shall be handled and stored in accordance with the manufacturer's recommendations and these special provisions. Geosynthetic reinforcement material shall be furnished in an appropriate protective cover which shall protect it from ultraviolet radiation and from abrasion during shipping and handling. Only as much geosynthetic reinforcement material shall be placed as can be placed and covered with backfill in the same work shift.

CONSTRUCTION.--The Contractor shall prepare the grade that is to receive the layers of geosynthetic reinforcement material to the compaction and elevation tolerances described in the Standard Specifications under Section 19-2.05, "Slopes," and these special provisions. The grade shall be free of loose or extraneous material and objects that may damage the geosynthetic reinforcement material during installation. Relative compaction of not less than 95 percent shall be obtained in the embankment foundation under the lowest layer of geosynthetic reinforcement material for a minimum depth of 0.15 meter.

The maximum loose thickness of each light of embankment material shall not exceed 0.3 m and shall be compacted to 90% Relative Compaction.

Geosynthetic reinforcement material shall be handled and placed in accordance with the manufacturer's recommendations and these special provisions. The geosynthetic reinforcement material shall be laid horizontally at the elevation specified on the plans, on compacted backfill from within 150 millimeters of the face of the embankment to the required embedment length. The geosynthetic reinforcement material shall be placed in a wrinkle free manner, pulled taut, aligned, and anchored before backfill placement. Slack in geosynthetic reinforcement material shall be removed in a manner, and to such a degree, as approved by the Engineer. Geosynthetic reinforcement material shall be installed in a horizontal plane at the intervals, elevations, and for the minimum embedment length shown on the plans. Each layer of geosynthetic reinforcement material shall not vary more than 0.15 meter from the theoretical horizontal plane established for that layer for the entire width and length of the reinforced reinforcement.

Geosynthetic reinforcement material shall be placed as shown on the plans and shall extend the full width of the reinforced embankment. Where the full embedment length of geosynthetic reinforcement material as shown on the plans cannot be achieved along the sides or for other limited areas of the reinforcement zone, the geosynthetic reinforcement material shall be trimmed as necessary to avoid the obstruction and to achieve the maximum embedment possible.

Geosynthetic reinforcement material shall be secured in place with staples, pins, sand bags, or backfill as required by construction conditions, weather conditions, or as directed by the Engineer to prevent the displacement of the geosynthetic reinforcement material during compaction and placement of the reinforcement material.

Geosynthetic reinforcement material shall not extend into the pavement structural section.

Secondary geosynthetic reinforcement material shall have an embedment length as shown on the plans. Secondary geosynthetic reinforcement material shall not extend into the pavement structural section. Secondary geosynthetic reinforcement material shall be installed in a horizontal plane at intervals as shown on the plans and shall not vary more than 0.15 meter from the theoretical horizontal plane established for that layer for the entire width and length of the reinforced embankment..

Each layer of geosynthetic reinforcement materialshall be placed (unrolled) into the grade to form a continuous mat. Overlapping and splicing geosynthetic embankment material shall conform to the following:

> Uniaxial geogrid and geotextile geotechnical fabric does not need to be overlapped along edges parallel to the direction of working tensile strength. Uniaxial geogrid and woven geotechnical fabric shall not be overlapped or spliced along edges perpendicular to the direction of working tensile strength, or as directed by the Engineer.
>
> Biaxial geogrid shall be overlapped a minimum of 150 millimeters along edges parallel to the direction of working tensile strength, or as directed by the Engineer. Biaxial geogrid shall be overlapped a minimum of 1 meter along edges perpendicular to the direction of working tensile strength of reinforcement, or as directed by the Engineer.
>
> A layer of soil a minimum of 100 millimeters in thickness shall be spread between uniaxial geogrid layers or woven geotechnical fabric layers in the area to be overlapped, or as directed by the Engineer.

If a drainage feature or other feature is shown on the plans within or adjacent to the geosynthetic reinforced embankment, the construction of that feature shall be done in a time sequence relative to the geosynthetic reinforced embankment as best meets the project requirements.

The geosynthetic reinforcement material shall be placed in such a manner that the direction of maximum strength is oriented perpendicular to the project centerline. The Contractor shall verify correct orientation of the geosynthetic reinforcement material . Each layer of geosynthetic reinforcement material shall be placed onto the embankment material to form a continuous mat. Adjacent strips of geosynthetic reinforcement material placed in this manner need not be overlapped.

During spreading and compacting of the backfill, at least 150 millimeters, measured vertically, of backfill shall be maintained between the geosynthetic reinforcement material and the Contractor's equipment. Equipment or vehicles shall not be operated or driven directly on the geosynthetic reinforcement material .

At locations where guard rail posts will later be placed at the top of the geosynthetic reinforced embankment and the geosynthetic reinforcement material would interfere with placement of such posts, prior to backfilling the Contractor shall be allowed to cleanly the reinforcement material of the affected layers into a cross-shaped pattern to aid the later placement of the guard rail posts. The dimensions of the precutting shall not exceed the post dimensions by greater than 750 millimeters.

Splicing of geosynthetic reinforcement material shall not be allowed. For geotextiles, no splicing joints parallel to project centerline shall be allowed for with primary or secondary geotextile reinforcement. Geogrid reinforcement may be joined with mechanical connections. Joints shall not be placed vertically within 2 meters of the slope face, within 2 meters of the slope top, nor horizontally or vertically adjacent (within 1.2 meters) to another joint. Only one joint per length of geogrid shall be allowed. The joint shall be made for the full width of the strip by using a similar material with similar strength, and using a connection devise supplied or recommended by the manufacturer. Joints in geogrid shall be pulled and held taut during backfill placement.

If the geosynthetic reinforcement material is damaged during construction operations, the damaged sections shall be repaired, at the Contractor's expense, by placing sufficient additional geosynthetic reinforcement material to cover the damaged area and to meet the following overlap requirements:

1) Edges of geogrid perpendicular to centerline shall be overlapped for entire lengths by the small of: three aperture openings or 100 millimeters. Edges of geogrid parallel to centerline shall be joined using a mechanical connection described elsewhere in these special provisions.
2) Edges of geotextiles shall be overlapped a minimum of 150 millimeters on all sides.

MEASUREMENT AND PAYMENT.--Geosynthetic will be measured and paid for by the square meter for the total area shown on the plans and for any additional area as directed by the Engineer. Payment shall not include additional reinforcement required for overlaps.

MEASUREMENT AND PAYMENT.--Geosynthetic will be measured and paid for by the square meter for the total area shown on the plans and for any additional area as directed by the Engineer. Payment shall not include additional reinforcement required for overlaps nor for secondary geosynthetic reinforcement.

Imported Borrow (Geosynthetic Reinforced Embankment) shall be measured and paid for by the cubic meter. The contract price paid per cubic meter for Imported Borrow (Geosynthetic Reinforced Embankment) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in obtaining and placing the imported borrow, complete in place, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

The contract price paid per square meter of geosynthetic reinforced embankment shall include full compensation for furnishing all labor and materials, including tools and equipment, and incidentals, for developing, placing and compacting native and/or imported embankment backfill, and for doing all the work involved in placing the geosynthetic reinforcement layers complete and in place, including splicing, overlapping and anchoring as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

Full compensation for revisions to drainage systems or other facilities made necessary by the use of an alternative geosynthetic reinforcement material embankment material shall be considered as included in the contract price paid per square foot for geosynthetic reinforced embankment and no adjustment in compensation will be made therefor.

APPENDIX A.6
COMPARISON OF SRW VENDORS

COMPARISON OF SRW VENDORS

	Keystone ™	Versa-lok™	Anchor Wall Systems™	Allan Block™
Core type (hollow vs. solid)	Hollow	Solid	Solid	Hollow
Batter (Setback) (degrees)	Can vary 1.4 or 5.6	7.1	10.6 (Diamond unit)	Varies between blocks: 3,6 or 12
Block Height (mm)	203 (Std. Unit)	152	150	200
Block Depth (mm)	533 (Std. Unit)	305	300	305
Block Length (mm)	457 (Std. Unit)	406	438	460
Block Interlock Type	Shear pins	Shear pins	Rear lip	Front lip
Different colors ?	yes	no	yes	yes