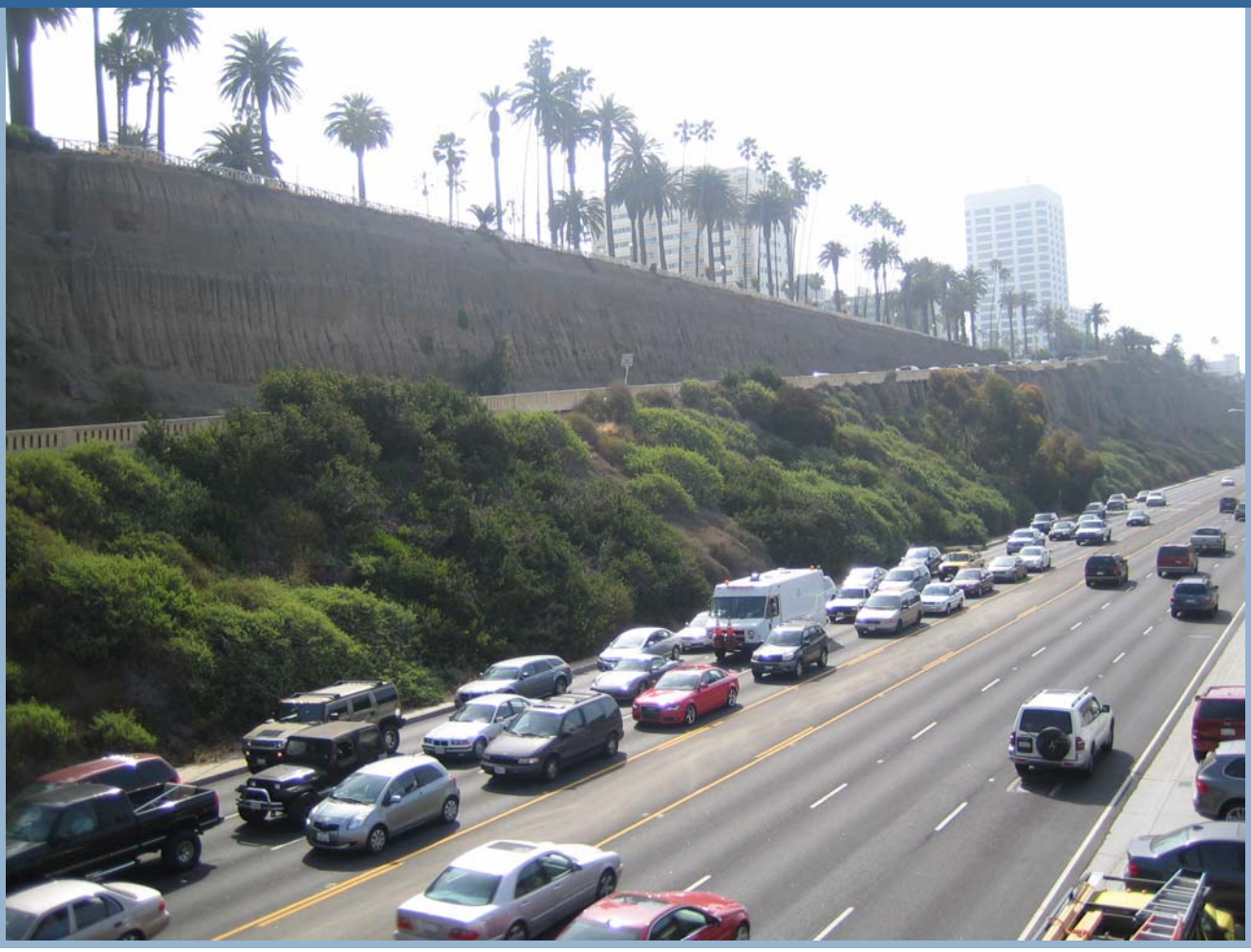
STRUCTURE TYPE SELECTION REPORT

CALIFORNIA INCLINE



Prepared for:

City of Santa Monica®

Caltrans

Prepared by:

T·Y·LIN INTERNATIONAL

January 29, 2010

ERRATA

This technical background report was drafted prior to the final definition of the current Build Alternative, with Design Options 1 and 2, presented in the draft environmental impact report/environmental assessment (DEIR/EA). Accordingly, several additional build alternatives and design options, other than those presented in the DEIR/EA, are still discussed in this report. They no longer apply and should be disregarded.

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I. Executive Summary

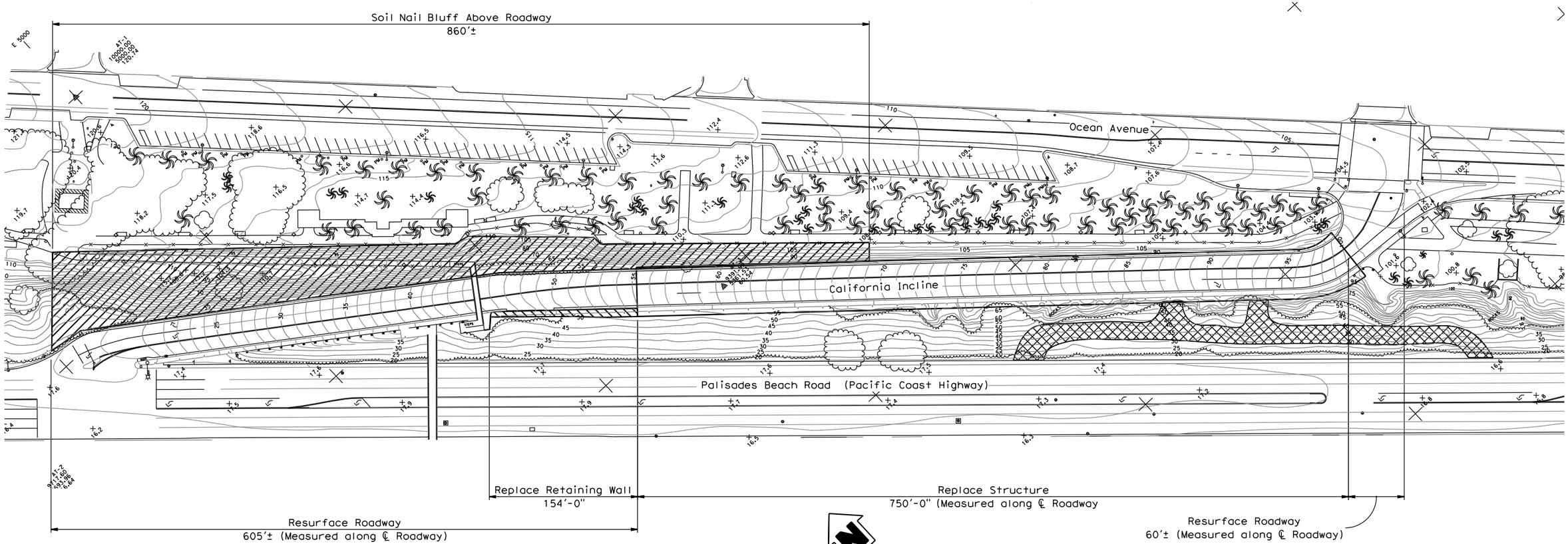
The California Incline is a roadway located in the City of Santa Monica that traverses the bluffs of Palisades Park connecting Ocean Avenue with Pacific Coast Highway. A portion of the roadway is supported with a sidehill viaduct structure (circa 1930) that is heavily deteriorated. A type selection analysis has been performed taking into account the needs of the City, the environment, and the Highway Bridge Program that has led to a recommendation to replace the structure.

A cast-in-place slab bridge supported on cast-in-drilled-hole piles is recommended as the replacement structure. The total estimated construction cost for this alternative is $10,780,000 which includes soil nail strengthening of the upper bluff slope and replacement of the approach roadway

This Structure Type Selection report discusses the constraints for this project and the options for replacing the existing structure. The City of Santa Monica will advertise, award, and administer the project.

II. Vicinity Map

III. Project Plan, General and Foundation Plans



PLAN

1'=100'-0"

LEGEND

- Temporary Construction Access Road
- Soil Nailing of Bluff
- Replace Retaining Wall

City of Santa Monica
Civil Engineering & Architecture
1918 Main Street, Suite 300 Santa Monica, CA 90405
tel. (310) 458-8721 fax. (310) 393-4425
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PROJECT DIRECTOR
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APPROVED BY :
DATE : _____ 20 __
ANTHONY ANTICH, P.E.
CITY ENGINEER & ARCHITECTURE MANAGER

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DESIGN PLANS
CALIFORNIA INCLINE

PROJECT PLAN

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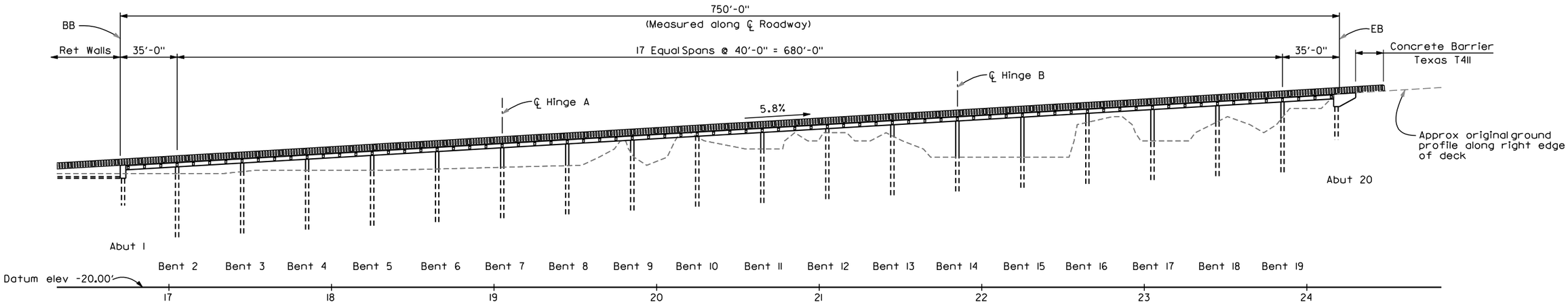

DEVELOPED ELEVATION

1" = 30'

CURVE DATA

No.	R	Δ	T	L
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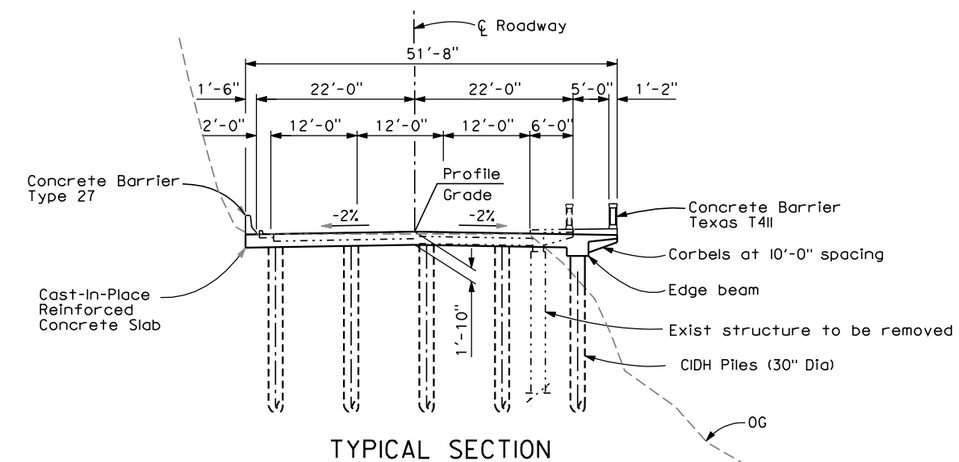
2	50.00	6°7'31"	44.27	72.47
3	122.50	18°06'44"	87.74	152.27



TYPICAL SECTION

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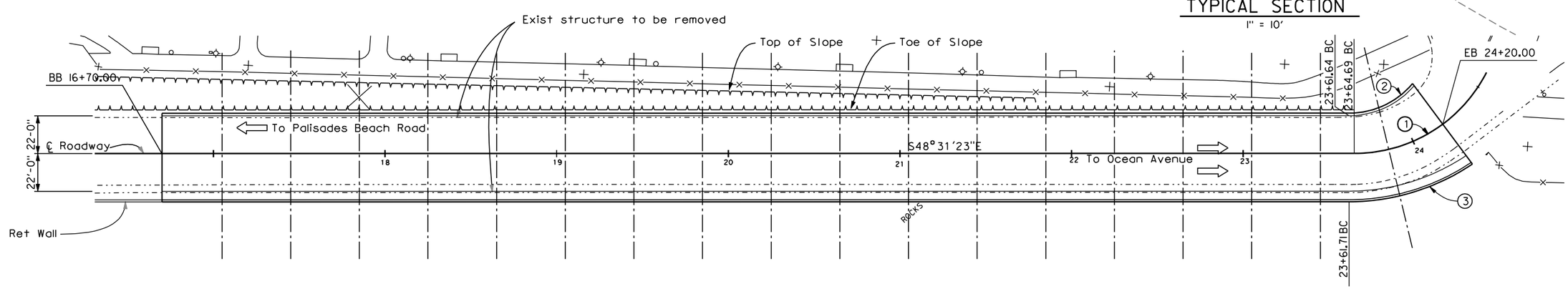

Legend:

-·-·-·- Indicates existing structure

——— Indicates new structure

PLAN

1" = 30'

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CALIFORNIA INCLINE

CAST-IN-PLACE SLAB OPTION
GENERAL PLAN

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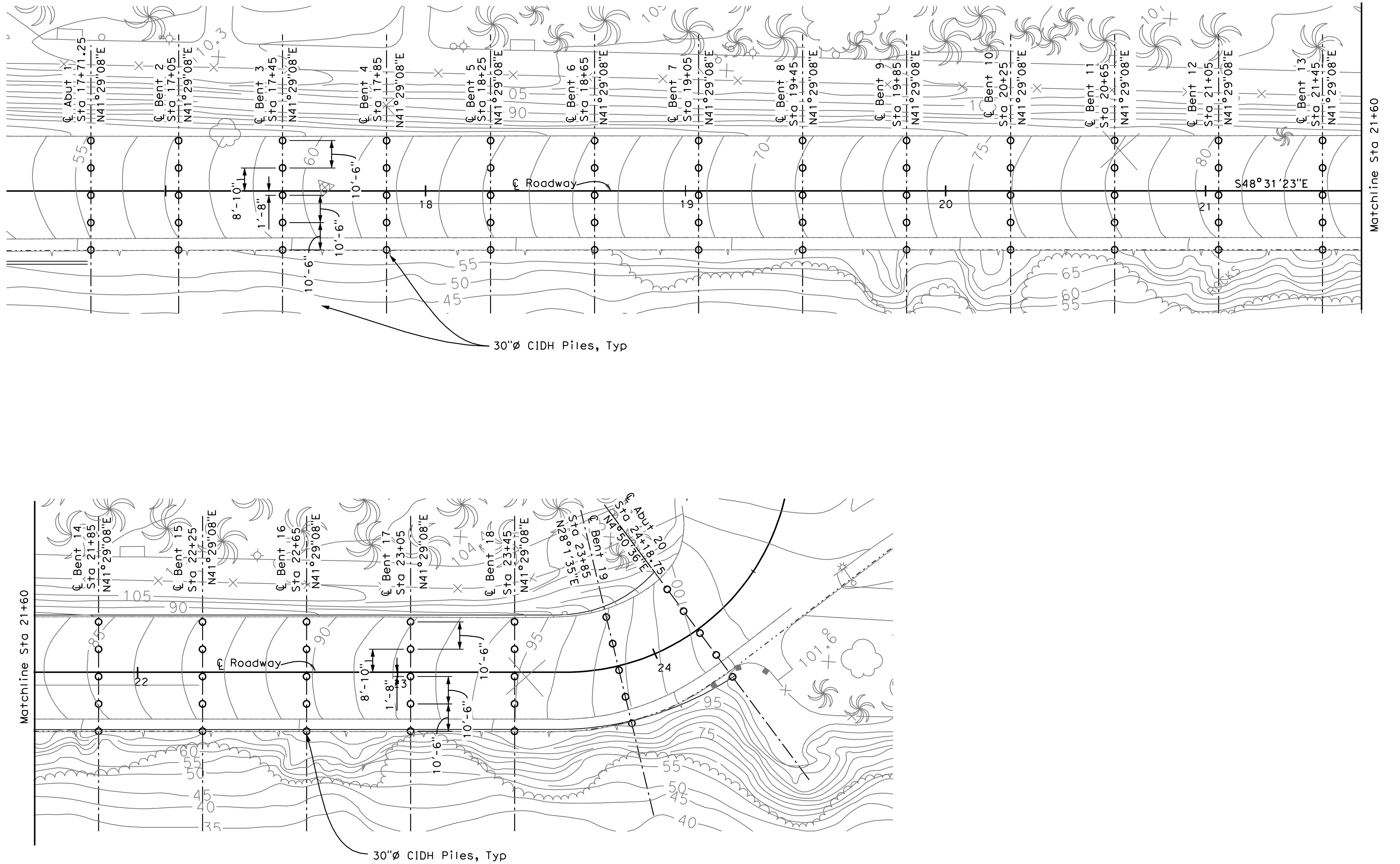

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1" = 20'-0"

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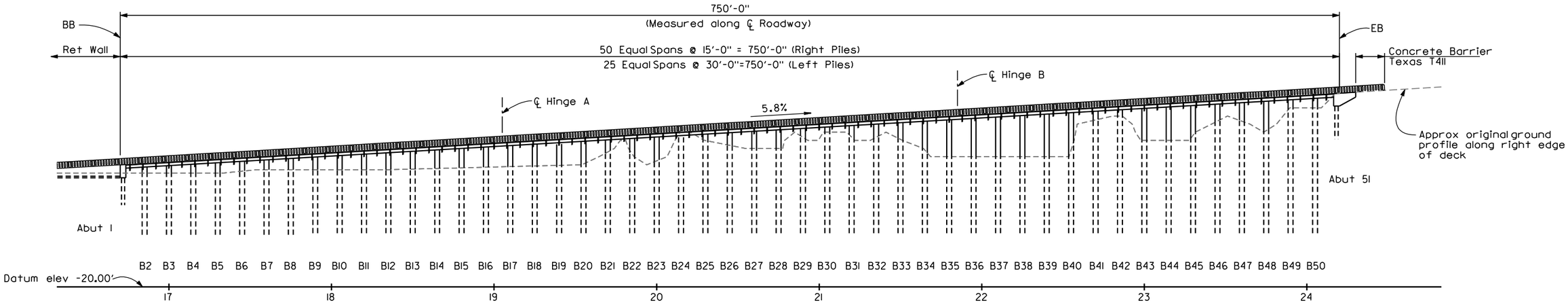

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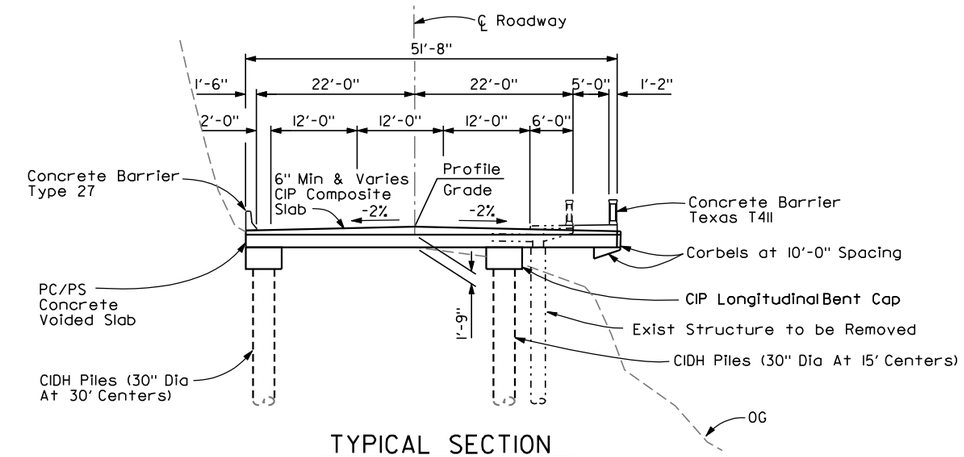

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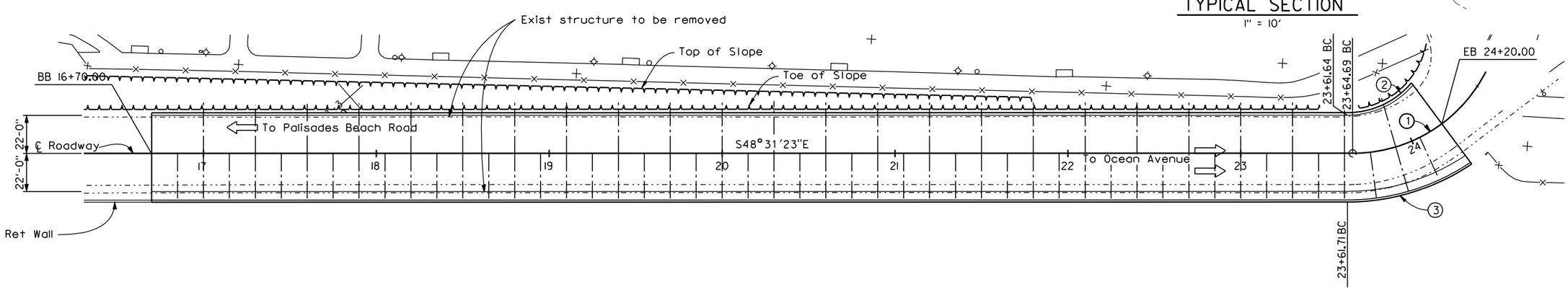

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DESIGN PLANS
CALIFORNIA INCLINE

TRANSVERSE PRECAST SLAB OPTION

GENERAL PLAN

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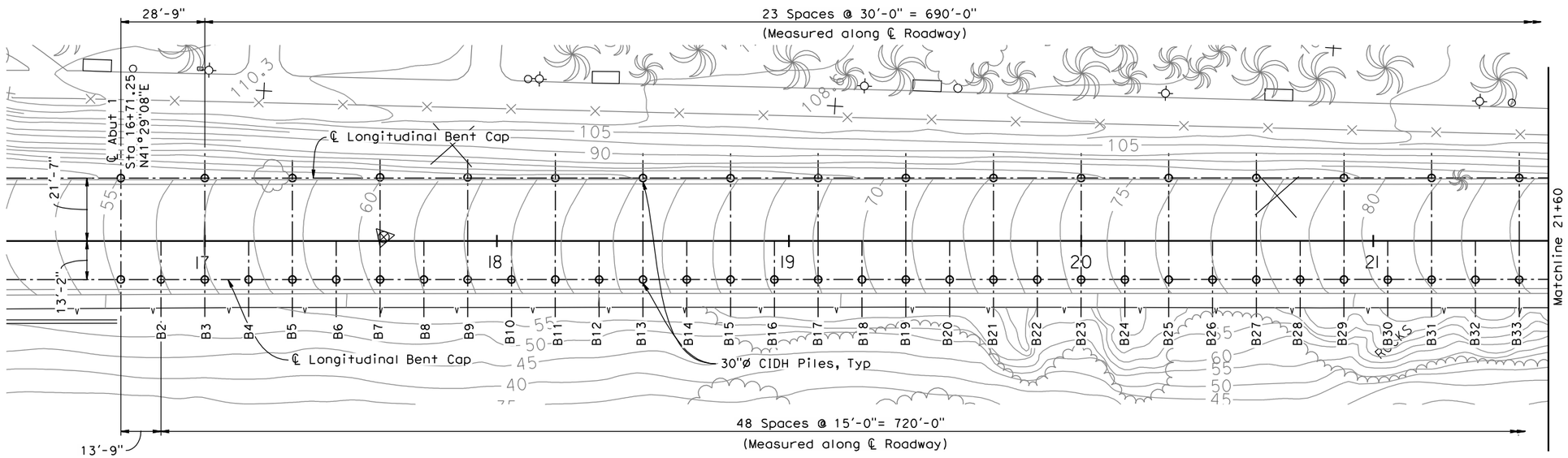

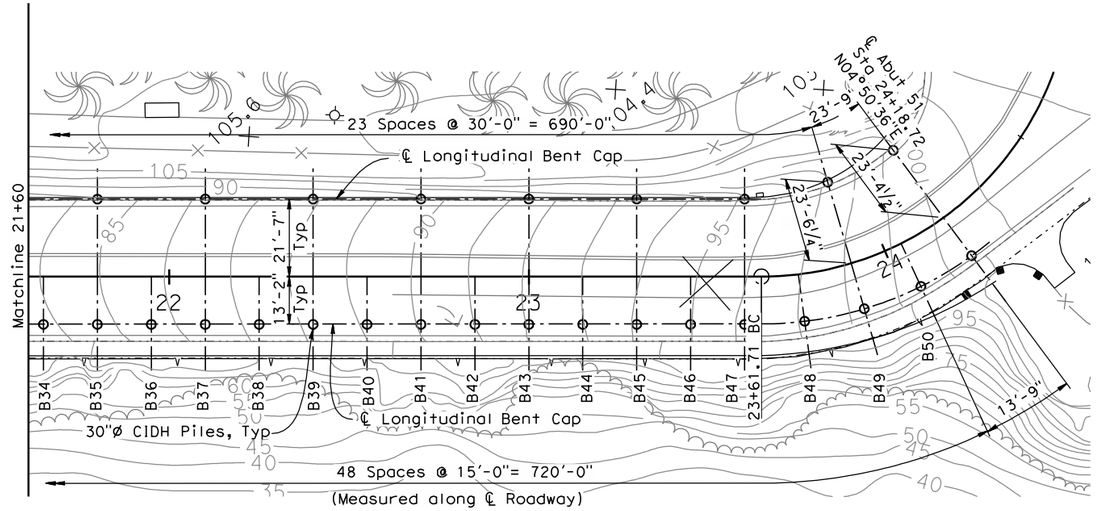

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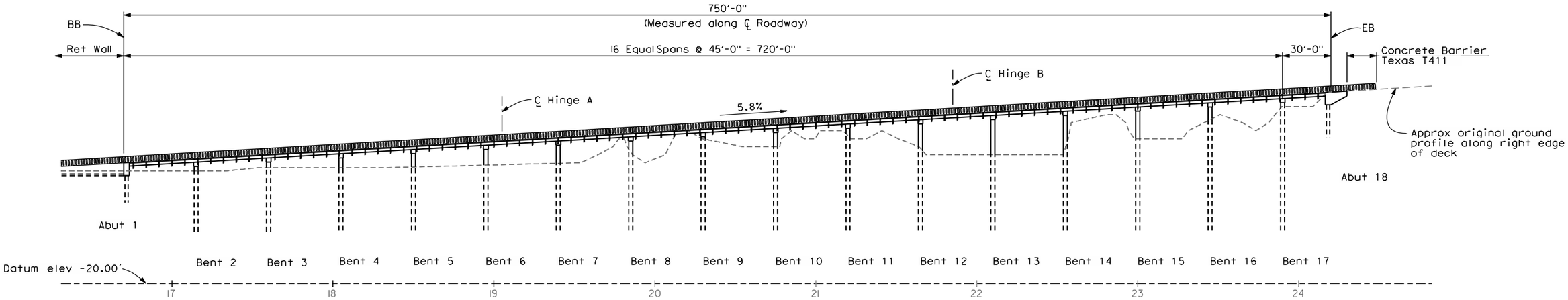

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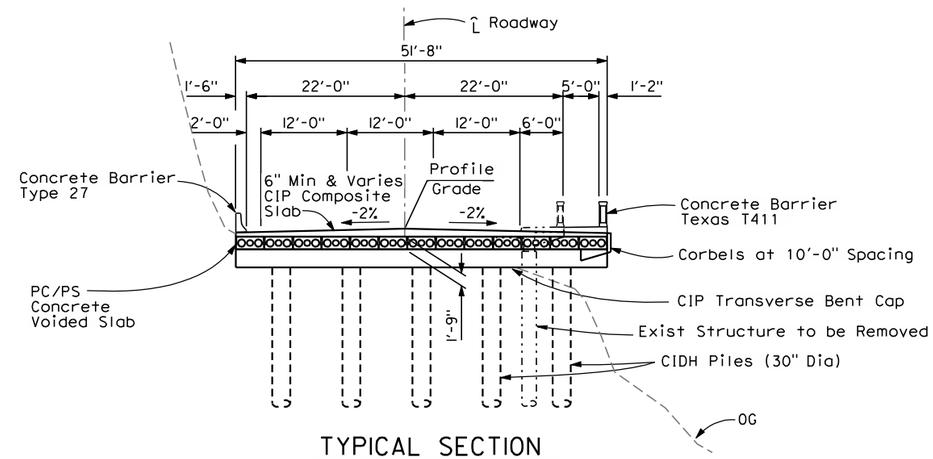

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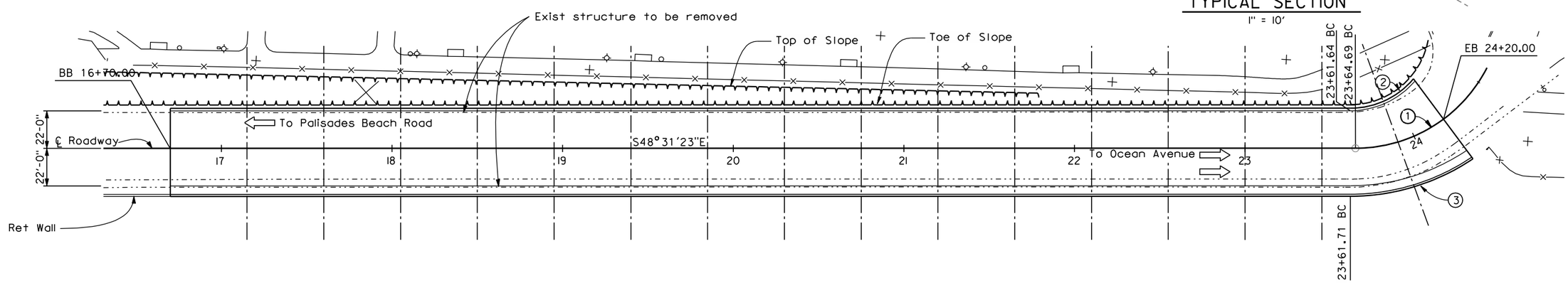

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APPROVED BY : DATE : 20 ANTHONY ANTICH, P.E. CITY ENGINEER & ARCHITECTURE MANAGER

REFERENCE ENGINEERING

DESIGN PLANS
CALIFORNIA INCLINE

LONGITUDINAL PRECAST SLAB OPTION
GENERAL PLAN

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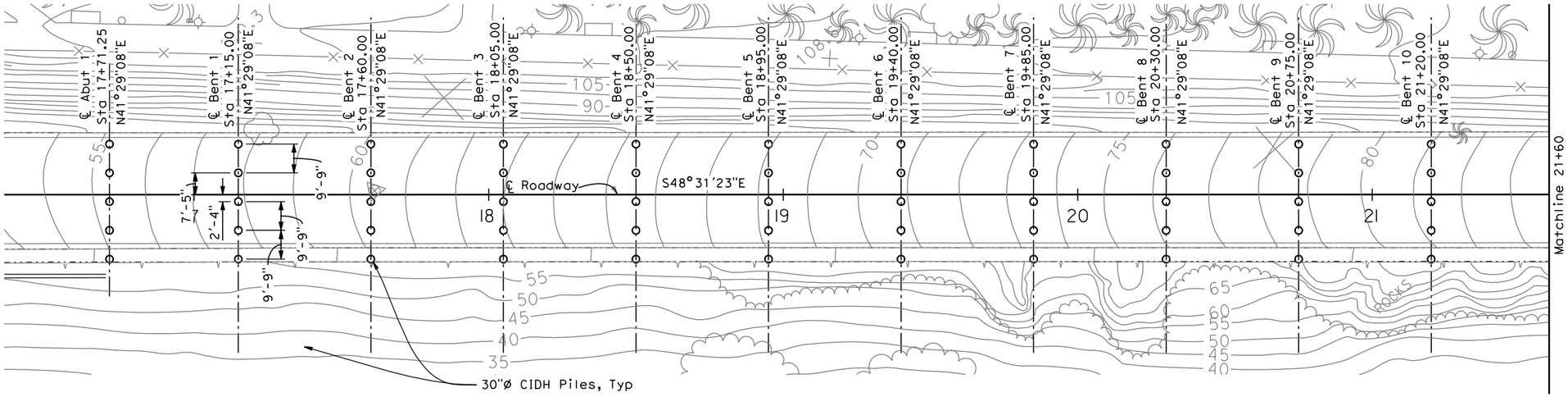

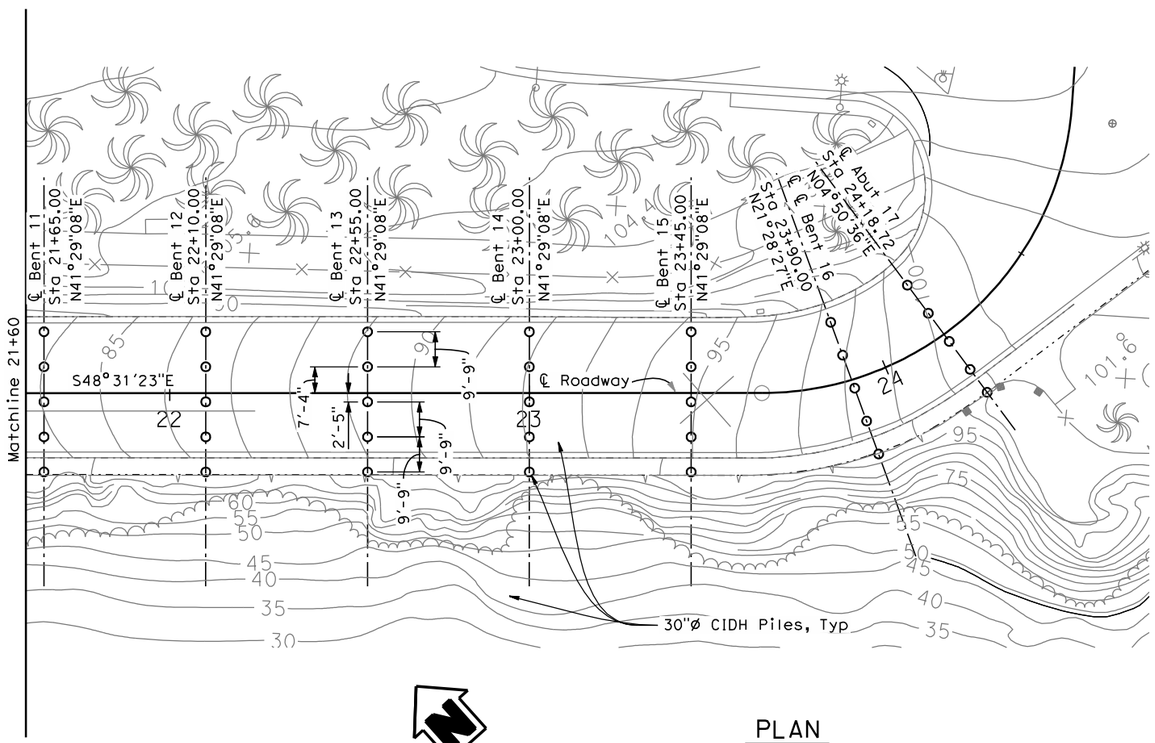

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IV. General Plan Estimates

STRUCTURE COST ESTIMATE

	Advance Planning Study Estimate
x	General Plan Estimate
	Engineer's Estimate

PROJECT: California Incline **ESTIMATE DATE:** 1/29/2010

BRIDGE: California Incline **CALTRANS DISTRICT:** 07

TYPE: Approach Roadway **BR. NO:** 53C-0543

LENGTH: 665.00 **WIDTH:** 45.11 **AREA (SF) =** 30,000 **RTE:**

NO. OF STRUCTURES IN PROJECT : 1 **EST. NO:** 1 **CO:** LA

QUANTITIES BY: Pete Smith **PM:**

PRICING BY: Pete Smith **COST INDEX DATE:** 10/1/2009 **COST INDEX:** 337

NO.	CODE	CONTRACT ITEMS	TYPE	UNIT	QUANTITY	PRICE	AMOUNT
1.		REMOVE A/C AND BASE		CY	1,204	$ 25.00	$ 30,100.00
2.		CLASS 2 BASE		CY	1,204	$ 60.00	$ 72,240.00
3.		PLACE HMA		TON	718	$ 90.00	$ 64,620.00

SUBTOTAL	$ 166,960.00
MOBILIZATION (@ 10 %)	$ 18,551.11
SUBTOTAL BRIDGE ITEMS	$ 185,511.11
CONTINGENCIES 25%	$ 46,377.78
BRIDGE TOTAL COST	$ 231,888.89
COST PER SQ. FT.	$ 7.73
BRIDGE REMOVAL (CONTINGENCIES INCL.)	
WORK BY RAILROAD OR UTILITY FORCES	$ -
SUPPLEMENTAL WORK	$ -
GRAND TOTAL	$ 231,888.89
FOR BUDGETING (CURRENT DOLLARS)	**$ 230,000.00**

COST ESCALATION FORECAST:

PROJECTED CONSTRUCTION START DATE	
TIME OF COMPLETION (WORKING DAYS)	
COMPUTED CONSTRUCTION FINISH DATE	
MIDPOINT OF CONSTRUCTION	
ANNUAL ESCALATION RATE	
ESTIMATED COST ESCALATION	
FOR BUDGETING (ESCALATED DOLLARS)	

COMMENTS:

1. This estimate represents the Engineer's professional opinion of probable cost only and no guarantee regarding its accuracy is expressed or implied. Actual bid prices will vary depending on market conditions at the time of bidding and are not within the Engineer's control.
2. This estimate does not include any forecast of cost escalation unless shown in the table above.
3. This estimate includes structure items only and does not include costs for utilities, landscaping, mitigation, right-of-way or engineering.

STRUCTURE COST ESTIMATE

	Advance Planning Study Estimate
x	General Plan Estimate
	Engineer's Estimate

PROJECT: California Incline **ESTIMATE DATE:** 1/29/2010

BRIDGE: California Incline **CALTRANS DISTRICT:** 07

TYPE: Cast-in-Place Slab Bridge **BR. NO:** 53C-0543

LENGTH: 750.00 **WIDTH:** 51.67 **AREA (SF) =** 38,753 **RTE:**

NO. OF STRUCTURES IN PROJECT : 1 **EST. NO:** 1 **CO:** LA

QUANTITIES BY: Pete Smith **PM:**

PRICING BY: Pete Smith/Wade Durant **COST INDEX DATE:** 10/1/2009 **COST INDEX:** 337

NO.	CODE	CONTRACT ITEMS	TYPE	UNIT	QUANTITY	PRICE	AMOUNT
1.		BRIDGE REMOVAL		LS	1	$ 280,000.00	$ 280,000.00
2.		STRUCTURE EXCAVATION (BRIDGE)		CY	1,442	$ 100.00	$ 144,200.00
3.		STRUCTURE BACKFILL (BRIDGE)		CY	20	$ 72.00	$ 1,440.00
4.		750 mm (30") CAST-IN-DRILLED-HOLE CONCRETE PILING		LF	8,160	$ 350.00	$ 2,856,000.00
5.							$ -
6.							$ -
7.		STRUCTURAL CONCRETE, BRIDGE		CY	2,400	$ 1,200.00	$ 2,880,000.00
8.		STRUCTURAL CONCRETE, BRIDGE FOOTING		EA	20	$ 460.00	$ 9,200.00
9.		CONCRETE BARRIER (TEXAS T411)		LF	907	$ 250.00	$ 226,750.00
10.		CONCRETE BARRIER (TYPE 27)		LF	770	$ 100.00	$ 77,000.00
11.		BAR REINFORCING STEEL (BRIDGE)		LB	323,713	$ 1.05	$ 339,898.65
12.		JOINT SEAL, TYPE B (MR = 50 MM)		LF	207	$ 92.00	$ 19,044.00
13.		BAR REINFORCING STEEL (RETAINING WALL)		LB	10,164	$ 1.15	$ 11,688.60
14.		STRUCTURAL CONCRETE, RETAINING WALL		CY	104	$ 460.00	$ 47,840.00
15.		STRUCTURE EXCAVATION (RETAINING WALL)		CY	455	$ 55.00	$ 25,025.00
16.		STRUCTURE BACKFILL (RETAINING WALL)		CY	110	$ 50.00	$ 5,500.00
17.		REMOVE RETAINING WALL		LS	1	$ 50,000.00	$ 50,000.00
18.		MINOR CONCRETE (SIDEWALK)		CY	24	$ 350.00	$ 8,400.00

SUBTOTAL	$ 6,981,986.25
MOBILIZATION (@ 10 %)	$ 775,776.25
SUBTOTAL BRIDGE ITEMS	$ 7,757,762.50
CONTINGENCIES 25%	$ 1,939,440.63
BRIDGE TOTAL COST	$ 9,697,203.13
COST PER SQ. FT.	$ 250.23
BRIDGE REMOVAL (CONTINGENCIES INCL.)	
WORK BY RAILROAD OR UTILITY FORCES	$ -
SUPPLEMENTAL WORK	$ -
GRAND TOTAL	$ 9,697,203.13
FOR BUDGETING (CURRENT DOLLARS)	**$ 9,700,000.00**

COST ESCALATION FORECAST:

PROJECTED CONSTRUCTION START DATE	
TIME OF COMPLETION (WORKING DAYS)	
COMPUTED CONSTRUCTION FINISH DATE	
MIDPOINT OF CONSTRUCTION	
ANNUAL ESCALATION RATE	
ESTIMATED COST ESCALATION	
FOR BUDGETING (ESCALATED DOLLARS)	

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	Engineer's Estimate

PROJECT: California Incline **ESTIMATE DATE:** 1/29/2010

BRIDGE: California Incline **CALTRANS DISTRICT:** 07

TYPE: Longitudinal Precast/Prestressed Voided Slab **BR. NO:** 53C-0543

LENGTH: 750.00 **WIDTH:** 51.67 **AREA (SF) =** 38,753 **RTE:**

NO. OF STRUCTURES IN PROJECT : 1 **EST. NO:** 1 **CO:** LA

QUANTITIES BY: Pete Smith **PM:**

PRICING BY: Pete Smith/Wade Durant **COST INDEX DATE:** 10/1/2009 **COST INDEX:** 337

NO.	CODE	CONTRACT ITEMS	TYPE	UNIT	QUANTITY	PRICE	AMOUNT
1.		BRIDGE REMOVAL		LS	1	$ 280,000.00	$ 280,000.00
2.		STRUCTURE EXCAVATION (BRIDGE)		CY	1,442	$ 100.00	$ 144,200.00
3.		STRUCTURE BACKFILL (BRIDGE)		CY	20	$ 72.00	$ 1,440.00
4.		750 mm (30") CAST-IN-DRILLED-HOLE CONCRETE PILING		LF	5,700	$ 350.00	$ 1,995,000.00
5.		FURNISH PC PS CONCRETE GIRDER (10 M-15 M)		EA	221	$ 12,000.00	$ 2,652,000.00
6.		ERECT PRECAST PRESTRESSED CONCRETE GIRDER		EA	221	$ 3,000.00	$ 663,000.00
7.		STRUCTURAL CONCRETE, BRIDGE		CY	1,739	$ 800.00	$ 1,391,200.00
8.		STRUCTURAL CONCRETE, BRIDGE FOOTING		EA	20	$ 460.00	$ 9,200.00
9.		CONCRETE BARRIER (TEXAS T411)		LF	907	$ 250.00	$ 226,750.00
10.		CONCRETE BARRIER (TYPE 27)		LF	770	$ 100.00	$ 77,000.00
11.		BAR REINFORCING STEEL (BRIDGE)		LB	195,358	$ 1.05	$ 205,125.90
12.		JOINT SEAL, TYPE B (MR = 50 MM)		LF	207	$ 92.00	$ 19,044.00
13.		BAR REINFORCING STEEL (RETAINING WALL)		LB	10,164	$ 1.15	$ 11,688.60
14.		STRUCTURAL CONCRETE, RETAINING WALL		CY	104	$ 460.00	$ 47,840.00
15.		STRUCTURE EXCAVATION (RETAINING WALL)		CY	455	$ 55.00	$ 25,025.00
16.		STRUCTURE BACKFILL (RETAINING WALL)		CY	110	$ 50.00	$ 5,500.00
17.		REMOVE RETAINING WALL		LS	1	$ 50,000.00	$ 50,000.00
18.		MINOR CONCRETE (SIDEWALK)		CY	24	$ 350.00	$ 8,400.00

SUBTOTAL	$ 7,812,413.50
MOBILIZATION (@ 10 %)	$ 868,045.94
SUBTOTAL BRIDGE ITEMS	$ 8,680,459.44
CONTINGENCIES 25%	$ 2,170,114.86
BRIDGE TOTAL COST	$ 10,850,574.31
COST PER SQ. FT.	$ 280.00
BRIDGE REMOVAL (CONTINGENCIES INCL.)	
WORK BY RAILROAD OR UTILITY FORCES	$ -
SUPPLEMENTAL WORK	$ -
GRAND TOTAL	$ 10,850,574.31
FOR BUDGETING (CURRENT DOLLARS)	**$ 10,850,000.00**

COST ESCALATION FORECAST:

PROJECTED CONSTRUCTION START DATE	
TIME OF COMPLETION (WORKING DAYS)	
COMPUTED CONSTRUCTION FINISH DATE	
MIDPOINT OF CONSTRUCTION	
ANNUAL ESCALATION RATE	
ESTIMATED COST ESCALATION	
FOR BUDGETING (ESCALATED DOLLARS)	

COMMENTS:

1. This estimate represents the Engineer's professional opinion of probable cost only and no guarantee regarding its accuracy is expressed or implied. Actual bid prices will vary depending on market conditions at the time of bidding and are not within the Engineer's control.
2. This estimate does not include any forecast of cost escalation unless shown in the table above.
3. This estimate includes structure items only and does not include costs for roadwork, utilities, landscaping, mitigation, right-of-way or engineering.

STRUCTURE COST ESTIMATE

	Advance Planning Study Estimate
x	General Plan Estimate
	Engineer's Estimate

PROJECT: California Incline **ESTIMATE DATE:** 1/29/2010

BRIDGE: California Incline **CALTRANS DISTRICT:** 07

TYPE: Transverse Precast/Prestressed Voided Slab **BR. NO:** 53C-0543

LENGTH: 750.00 **WIDTH:** 51.67 **AREA (SF) =** 38,753 **RTE:**

NO. OF STRUCTURES IN PROJECT : 1 **EST. NO:** 1 **CO:** LA

QUANTITIES BY: Pete Smith **PM:**

PRICING BY: Pete Smith/Wade Durant **COST INDEX DATE:** 10/1/2009 **COST INDEX:** 337

NO.	CODE	CONTRACT ITEMS	TYPE	UNIT	QUANTITY	PRICE	AMOUNT
1.		BRIDGE REMOVAL		LS	1	$ 280,000.00	$ 280,000.00
2.		STRUCTURE EXCAVATION (BRIDGE)		CY	1,442	$ 100.00	$ 144,200.00
3.		STRUCTURE BACKFILL (BRIDGE)		CY	20	$ 72.00	$ 1,440.00
4.		750 mm (30") CAST-IN-DRILLED-HOLE CONCRETE PILING		LF	5,100	$ 350.00	$ 1,785,000.00
5.		FURNISH PC PS CONCRETE GIRDER (15 M-20 M)		EA	188	$ 15,000.00	$ 2,820,000.00
6.		ERECT PRECAST PRESTRESSED CONCRETE GIRDER		EA	188	$ 3,000.00	$ 564,000.00
7.		STRUCTURAL CONCRETE, BRIDGE		CY	2,227	$ 800.00	$ 1,781,600.00
8.		STRUCTURAL CONCRETE, BRIDGE FOOTING		EA	20	$ 460.00	$ 9,200.00
9.		CONCRETE BARRIER (TEXAS T411)		LF	907	$ 250.00	$ 226,750.00
10.		CONCRETE BARRIER (TYPE 27)		LF	770	$ 100.00	$ 77,000.00
11.		BAR REINFORCING STEEL (BRIDGE)		LB	268,980	$ 1.05	$ 282,429.00
12.		JOINT SEAL, TYPE B (MR = 50 MM)		LF	207	$ 92.00	$ 19,044.00
13.		BAR REINFORCING STEEL (RETAINING WALL)		LB	10,164	$ 1.15	$ 11,688.60
14.		STRUCTURAL CONCRETE, RETAINING WALL		CY	104	$ 460.00	$ 47,840.00
15.		STRUCTURE EXCAVATION (RETAINING WALL)		CY	455	$ 55.00	$ 25,025.00
16.		STRUCTURE BACKFILL (RETAINING WALL)		CY	110	$ 50.00	$ 5,500.00
17.		REMOVE RETAINING WALL		LS	1	$ 50,000.00	$ 50,000.00
18.		MINOR CONCRETE (SIDEWALK)		CY	24	$ 350.00	$ 8,400.00

SUBTOTAL	$ 8,139,116.60
MOBILIZATION (@ 10 %)	$ 904,346.29
SUBTOTAL BRIDGE ITEMS	$ 9,043,462.89
CONTINGENCIES 25%	$ 2,260,865.72
BRIDGE TOTAL COST	$ 11,304,328.61
COST PER SQ. FT.	$ 291.71
BRIDGE REMOVAL (CONTINGENCIES INCL.)	
WORK BY RAILROAD OR UTILITY FORCES	$ -
SUPPLEMENTAL WORK	$ -
GRAND TOTAL	$ 11,304,328.61
FOR BUDGETING (CURRENT DOLLARS)	**$ 11,300,000.00**

COST ESCALATION FORECAST:

PROJECTED CONSTRUCTION START DATE	
TIME OF COMPLETION (WORKING DAYS)	
COMPUTED CONSTRUCTION FINISH DATE	
MIDPOINT OF CONSTRUCTION	
ANNUAL ESCALATION RATE	
ESTIMATED COST ESCALATION	
FOR BUDGETING (ESCALATED DOLLARS)	

COMMENTS:

1. This estimate represents the Engineer's professional opinion of probable cost only and no guarantee regarding its accuracy is expressed or implied. Actual bid prices will vary depending on market conditions at the time of bidding and are not within the Engineer's control.
2. This estimate does not include any forecast of cost escalation unless shown in the table above.
3. This estimate includes structure items only and does not include costs for roadwork, utilities, landscaping, mitigation, right-of-way or engineering.

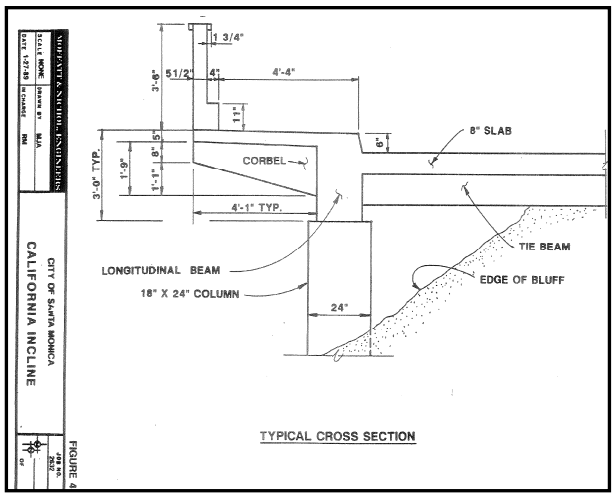
V. Structure Description

The California Incline extends in a north-south direction from Ocean Avenue to SR-1, Pacific Coast Highway (PCH), within the City of Santa Monica. The California Incline Bridge (Bridge No. 53C-0543), runs down the bluffs of Palisades Park and is estimated to have been constructed in 1930. The structure is considered historic with the most prominent feature being the balustrade ornamental railing. The existing roadway width is 40′ with a 5′ sidewalk for a total width of 45′.

California Incline and PCH

The east side of the existing roadway is supported at grade while the west side is supported intermittently on individual sidehill viaduct structures that span drainage gullies between eroded terrace deposits. In 1988 Moffat and Nichol performed a detailed site inspection of the structures and determined there are five separate sidehill viaduct structures. The sidehill viaducts consist of an 8″ concrete slab supported on transverse tie beams spaced at 8′ on center. The tie beams are supported at grade on the east side and frame into a continuous longitudinal beam that is supported on rectangular columns between the eroded terrace deposits on the west side. The continuous longitudinal beam connects the individual viaducts together and also supports the sidewalk and railing. The total length of the California Incline is approximately 1400′ with the railing, sidewalk, continuous beam, and viaduct structures extending for 750′ of that length. Where the north end of the continuous beam stops a retaining wall supports the sidewalk and railing that extends for approximately 150′ to a pedestrian overcrossing structure.

Existing Sidehill Viaduct



Typical Section – from Moffat and Nichol Report

VI. Purpose and Need

The California Incline Bridge is deteriorated beyond the capabilities of what routine maintenance can repair. Erosion of soil beneath the California Incline has caused localized settlement of the roadway and a patchwork of asphalt has been used to fill the erosion holes. The bridge is rated as Structurally Deficient and has a Sufficiency Rating of 35.8 making it eligible for replacement under the Highway Bridge Program (HBP). The bridge railing has concrete spalls and is rated as substandard as documented in the latest bridge inspection report. Rehabilitation of the structure is considered as a type selection alternative and is eliminated as discussed in the report.

AC Repair Patches in Roadway

The California Incline is closed to commercial traffic and is posted for a gross vehicle weight of 3 tons, based on the original design details of the structure. The City of Santa Monica desires replace the structure so that it can support legal loads and widen the roadway to increase the lane and shoulder widths.

Existing Deteriorated Railing

The bluff slopes above and below the California Incline roadway are highly erodible, which needs to be considered in the replacement design. The existing structure is supported on shallow foundations and there are no countermeasures to prevent erosion. There is evidence of damage to the structure caused by erosion as seen by the exposed and cracked footings.

Eroded and Exposed Footing

Cracked Concrete Footing

VII. Roadway Geometrics

According to Caltrans' Local Assistance Procedures Manual (LAPM), local federal-aid reconstruction projects off the National Highway System (NHS) are to follow statewide design criteria, unless certain locally developed design criteria are approved. This project will follow the statewide geometric standard which is AASHTO's Policy on Geometric Design of Highways and Streets (Green Book). The FHWA has designated twelve geometric controlling design criteria:

- Design Speed
- Lane Width
- Shoulder Width
- Bridge Width
- Horizontal Alignment
- Vertical Alignment
- Grades
- Stopping Sight Distance
- Cross Slopes
- Superelevation
- Horizontal Clearance
- Vertical Clearance

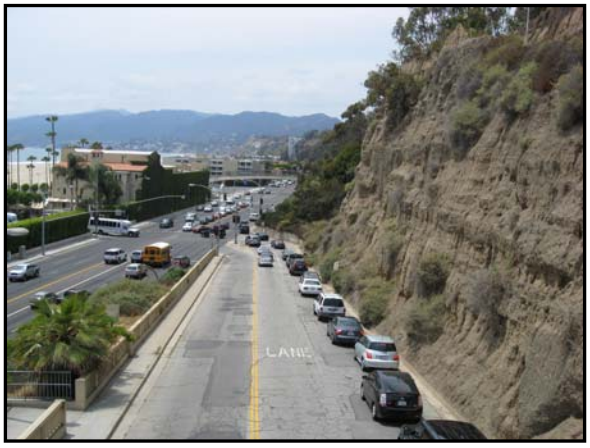
Applying the twelve criteria to the California Incline four have been identified as substandard that will need a design exception: shoulder width, horizontal alignment, vertical alignment and stopping sight distance.

A. Shoulder Width

The existing California Incline traveled way is 40′ wide curb to curb with northbound and southbound lanes and a middle left turn lane. The northbound and southbound lanes are 12′ wide, the left turn lane is 10′ wide, and the shoulders are 2′ and 4′ wide on the east and west sides of the roadway, respectively. According to the Green Book the California Incline is an urban collector since it connects a highway, Pacific Coast Highway, with a local street, Ocean Avenue. The traffic volume on the road is over 2000 vehicles per day therefore the recommended minimum traveled way width is 24′, for two 12′ lanes, with 8′ shoulders on both sides. The current roadway configuration provides the recommended 12′ lane width for primary lanes, but the shoulder widths are less than the minimum recommended.

The roadway width at the north end is constrained by the span of the pedestrian overcrossing (POC) and the width of the existing intersection at PCH, therefore the roadway can not be widened at this end without reconstructing the POC. The roadway can be widened south of the POC but is limited by the bluff slope on the east side and the geometry of the intersection at Ocean Avenue.

It is proposed to widen the roadway 4′ south of the POC to increase the left turn lane to 12′ and to increase the west shoulder to 6′. The west shoulder is widened since this is a climbing lane for bicyclists and the additional width will increase separation to vehicular traffic. The total roadway width will be 44′ with three 12′ wide lanes, a 6′ wide shoulder on the west and a 2′ wide shoulder on the east.



Roadway North of POC

Since the bluff slope is above the roadway on the east side, the widening will be toward the west side of the roadway. The alignment of the retaining wall north of the POC will be shifted west and the bridge structure will be cantilevered further over the edge of the lower slope.

B. Horizontal Alignment

The horizontal alignment of the roadway is straight for the majority of the length with a slight bend at the POC and sharp, small radius curves at the north and south ends at the intersections with PCH and Ocean Avenue. The design speed of the roadway is 45 MPH and with a -2.0% cross slope and according to the Greenbook the minimum curve radius recommended is 1039′. The existing curve radii at the intersections are less than 100′, therefore improving the roadway geometry to comply with the statewide standard can not be accomplished without significantly realigning the roadway. This can not be accomplished due to the alignment being constrained on the Palisades bluffs and the connections with the intersections at the north and south ends.

C. Vertical Alignment and Stopping Sight Distance

Traveling up the California Incline from PCH the roadway has a grade of approximately 2.4% and goes through an approximately 14′ long sag curve and then climbs at a grade that varies from 7.5% to 5.8%. At the top the roadway goes through a crest curve that is approximately 25′ long. For a 45 MPH design speed the Greenbook indicates the length of the vertical curves is too short for the grade changes and do not provide adequate stopping sight distance at the bottom or top of the roadway. Given the roadway is tying into existing intersections and any disturbance to the bluff slopes need to be minimized; it will not be possible to change the lengths of the vertical curves or change the slope of the roadway.

VIII. Structure Design Criteria

The replacement bridge will be designed in accordance with the following design standards:

- AASHTO LRFD Bridge Design Specifications, Fourth Edition, 2007 with California Department of Transportation (CALTRANS) Amendments, Version 4, December 2008.
- Live load: HL93 w/ Low-Boy and permit design live load.
- Project specific seismic design criteria. The criteria will be based Caltrans Seismic Design Criteria (SDC), Version 1.4, June 2006 with exceptions taken for complying with balanced frame and bent stiffness.

The California Incline structure is classified as an ordinary non-standard bridge. Since the structure traverses the side of a bluff slope that has erosion gullies and eroded terrace deposits the structure is likely to have adjacent columns with greatly varying lengths. It is anticipated this will cause noncompliance with the balanced stiffness requirements of the SDC. Therefore project specific seismic design criteria are needed to note exceptions to the SDC. The replacement structure will be designed to comply with the other requirements of the SDC.

IX. Geology

A Preliminary Foundation Report (PFR) has been prepared by Earth Mechanics, Inc. (EMI) dated January 26, 2010. The following is a summary of the report findings:

1. Based on the borings and proximity to the Pacific Ocean, groundwater is expected to be encountered for deep foundations.
2. Maximum Credible Event (MCE) of 7.5, type D soil, and a peak acceleration of 0.6g with increases due to near fault source effects.
3. Liquefaction and seismic settlement are not anticipated to occur for the MCE.
4. There is no scour potential however the bluff is susceptible to localized erosion from surface runoff.
5. A preliminary static and seismic global stability analysis for the slope above the California Incline roadway has been prepared by URS Corporation and strengthening of the slope with soil nails is recommended. EMI has performed a global stability analysis of the slope below the roadway and the lower slope has been determined to be stable under static and seismic loading.
6. The on-site soils are considered to be corrosive to bare steel and concrete.
7. Driven piles are not recommended due to difficult driving conditions and the potential for pile driving vibrations causing localized surface failures.
8. Cast-in-drilled-hole piles are recommended since they will be able to accommodate future surficial erosion. Shallow spread footings are not recommended due to the erosion potential of the bluffs.

X. Project Constraints

Replacement of the California Incline will need to take into consideration the site topography, the environmental sensitivity, the needs of the community, the historic significance of the structure, and the funding requirements of the HBP program.

A. Site Topography and Environmental Sensitivity

The California Incline is 45′ wide and traverses the Pacific Palisades bluffs at a slope of approximately 6.5%. The bluffs, which are above and below the roadway, have a history of surface erosion and stand nearly vertical. The California Incline is bordered by the Pacific Palisades Park on top and PCH at the bottom of the bluffs. North of the existing bridge structure a pedestrian bridge crosses over the roadway that will limit the vertical clearance for construction equipment access.

Even though the bluffs and eroded terrace deposits are continually eroding they are considered to be visually sensitive according to the environmental document and must be protected, as much as possible during the construction of this project. Addition of a concrete facing or geogrid to prevent future erosion has been determined to have an adverse environmental impact and is not an option for this project. Therefore the replacement solution for this project will need to accommodate the total estimated future erosion of the bluffs over the 75-year design life of the structure.

The stability of the bluffs above the California Incline has been evaluated by URS Corporation and the results of their analysis have been presented in a report dated June 23, 2009, see the appendix of this report. The factor of safety of slope failure has been calculated and strengthening of the slope above the Incline at the north end is recommended to prevent soil slip outs from falling onto the bridge deck. To minimize visual impacts the slope strengthening will consist of soil nails grouted into the bluff face but without the use of anchor nuts or a concrete facing. This will provide global stability to the slope but not protect it from erosion. As the slope continues to erode the ends of the soil nails will be exposed and will periodically be trimmed as needed. The final design of the upper slope strengthening will become part of this project.

Steep Bluffs

The stability of the lower bluff slopes has been evaluated by Earth Mechanics, Inc. and the results of their preliminary analysis are in the appendix of the PFR. The lower slopes have factors of safety for the static and seismic conditions that are greater than the Caltrans minimums, therefore the slopes are expected to be globally stable. No remediation for the lower slopes is anticipated however they will continue to be susceptible to localized surficial erosion.

The following photos of the California Incline show different aspects of the roadway, slopes, and structure:

California Incline Looking North

Erosion Gullies in Slope

Bluff Slope Looking South

Overhanging Slope at North End

Pedestrian Overcrossing

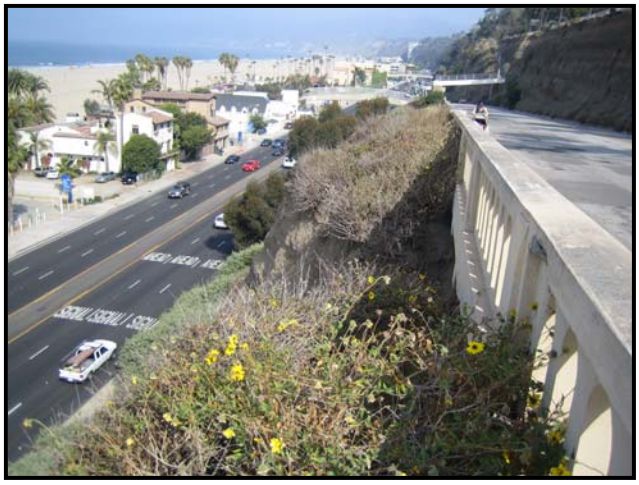
Eroded Terrace Deposits below CA Incline

B. Community

Pacific Palisades Park, Pacific Coast Highway, and Santa Monica beaches are heavily used by the community and disruptions to their use needs to be minimized during this project. There are several residents within the project area that will be affected by the project. The Pacific Palisades Park is a historic, well maintained green belt between Ocean Avenue and the California Incline that has walking paths, benches, and mature palm trees. The park is located at the top of the bluffs with an ornamental concrete railing to protect the public from the bluff edge. If the park were to be used for equipment staging and construction activities, some trees may need to be removed, landscaping and trails could be damaged, and some areas would need to be closed to the public. Considering the adverse impacts to the park, the replacement design will need to consider that Pacific Palisades Park cannot be used and must remain open during construction.

Pacific Palisades Park

The Pacific Coast Highway is a major 6 lane arterial road that connects the cities north of Santa Monica to the I-10 freeway. The highway has heavy rush hour traffic volumes with reduced, but steady flow of personal and commercial vehicles throughout the day. Santa Monica's beaches and local businesses are directly accessed by PCH and construction activities will need to consider times of peak traffic and allowable lane closures. PCH is on state right-of-way and is maintained by Caltrans District 7. The District has lane closure charts that dictate the number of lanes that can be closed during specific hours of the day and these closures change depending on the season of the year. The lane closure charts will be incorporated into the final construction documents.



PCH Below California Incline

Several residential homes on the west side of PCH will be affected by traffic disruptions and will be the primary recipient of the construction noise of the project. Hours of construction operations need to consider the impact to these residents. Construction night work can minimize traffic disruptions on PCH but can be a significant disturbance to the local residents. Allowing night work for this project will be coordinated through

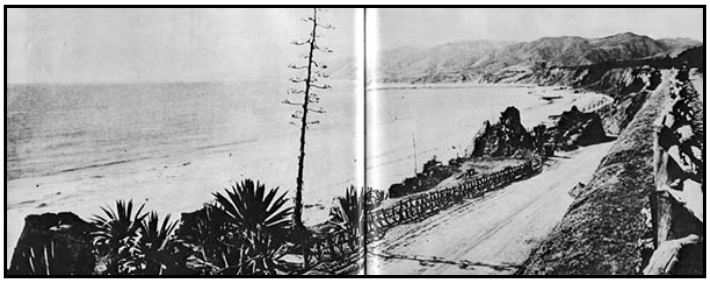
Homes West of PCH

the City of Santa Monica.

The California Incline links Ocean Avenue to PCH and is used by non-commercial traffic, pedestrians, and bicyclists. Closure of the California Incline would require traffic detours through local streets and may limit beach access. Consideration was given to keep a portion of the roadway open during construction; however, given the limited work space, for public safety, it is recommended the California Incline be closed during construction.

C. History

The California Incline was first engineered in the early 1900's as a roadway cut into the bluff. The current structure (circa 1930) was needed to fill in the gaps caused by erosion of the bluff slope. The historic features of the bridge structure are the balustrade type railing and concrete brackets under the overhang. Similar features will be incorporated on the replacement structure.



California Incline in 1900's

Another historic feature is the bluff slopes that have remained relatively unchanged since the 1940's. The replacement structure will maintain the same slope and alignment but the roadway will be widened as previously discussed. The bluffs will be protected as much as possible but some eroded terrace deposits will need to be reduced in height to accommodate the widening of the roadway.

D. HBP Requirements

The replacement bridge will need to satisfy the requirements of the Highway Bridge Program meeting the structural, environmental, and funding requirements. The requirements of the program include correcting the geometric deficiencies however, as previously discussed; some design exceptions will be required.

The preliminary slope stability analysis indicates a portion of the upper bluff slope will need to be strengthened with soil nails. Failure of the slope could damage the replacement structure therefore HBP reimbursement for the soil nail work will be requested.

XI. Bridge Structure Type Selection Alternatives

In determining the most suitable solution for the California Incline Bridge all of the project constraints need to be considered. For example if the replacement structure was a long span bridge with a deep superstructure depth, the bridge would effectively be buried below grade since the roadway profile can not be raised due to clearance of the POC and to be able to tie into the existing intersections.

Six options have been considered for replacing the existing structure that could accommodate the existing geometry of the project site. The replacement project will include removal and replacement of the existing retaining wall south of the POC. The replacement

structure will begin where the existing retaining wall ends and will extend for 750′ to the intersection at Ocean Avenue.

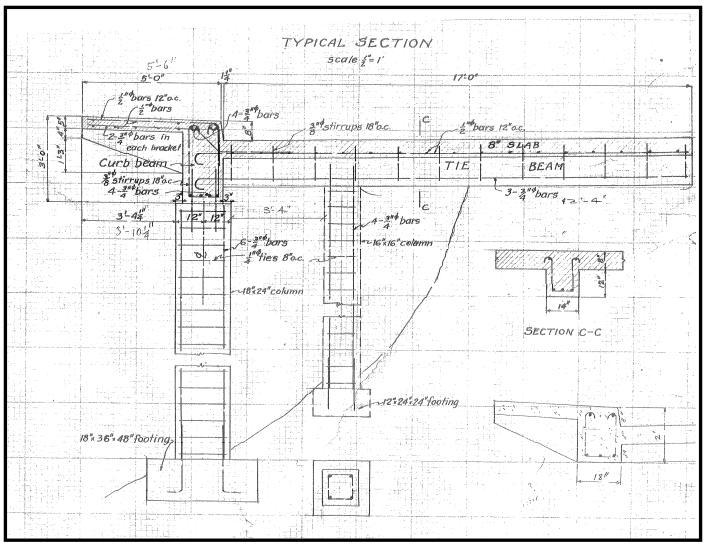
1. Rehabilitate and Widen Existing Structure

Rehabilitate

The bridge inspection report for the California Incline, dated April 15, 2008 and included in Appendix B, classifies the bridge as structurally deficient (SD) with a sufficiency rating of 35.8. Items that can cause an SD status are a condition rating of 4 or less for the deck, superstructure, or substructure or an appraisal rating of 2 or less for the structural condition. The California Incline has condition ratings of 6, 5, and 4 for the deck, superstructure, and substructure, respectively, and an appraisal rating of 3 for the structural condition. The SD status is triggered by the condition rating of 4 for the substructure. A condition rating of 4 indicates that advanced section loss, deterioration, or spalling was observed during inspection.

The bridge sufficiency rating is a percentage between 0% and 100% and is calculated using data from the bridge inspection report. The sufficiency rating is the sum of three components that are shown below with their respective percentage of contribution:

1. Structural Adequacy and Safety (55%)
2. Serviceability and Functional Obsolescence (30%)
3. Essentiality for Public Use (15%)



California Incline - Original Design Drawing

The Structural Adequacy and Safety component includes the inventory live load rating, which has a maximum value of 32.4 metric tons. The inventory rating for the California Incline is estimated to be 4.5 metric tons from calculations performed in the Moffat and Nichol report. This rating is based on the structural details of the deck slab. The deck slab is 8″ thick and is comprised of low strength concrete and steel and is reinforced with ½″ diameter rebar spaced at 12″ on center. A deck slab constructed to current standards will have higher strength materials and twice the amount of reinforcing steel. The low inventory rating for the California Incline causes the Structural Adequacy and Safety component to be 0% and it does not contribute to the sufficiency rating.

In 1989 a rehabilitation study was performed by Moffat and Nichol that describes previous repair work and areas of distress in the structure such as spalled concrete, corroded rebar, and visible deflections in transverse tie beams. Since part of the existing superstructure is supported on grade there could be other areas of distress that are not possible to inspect. Parts of the structure still retain the original formwork that may conceal degraded concrete. Rehabilitation would require limited excavation under the structure for inspection and

possibly installation of new formwork to re-cast slabs and beams. Additional beams, columns and footings will also be needed to shore up beams that have deflected and to strengthen the existing structure to carry legal loads to remove the structurally deficient status.

Widen

Widening the roadway will be challenging since the existing structure is not designed to carry construction loading. The widened structure will need to cantilever over the bluffs requiring new beams, columns, and footings. Given the weakened state of the existing structure, the widened structure would need to carry these loads independently. In addition, new structural members requiring extensive concrete forming will likely cause additional slope disturbance.

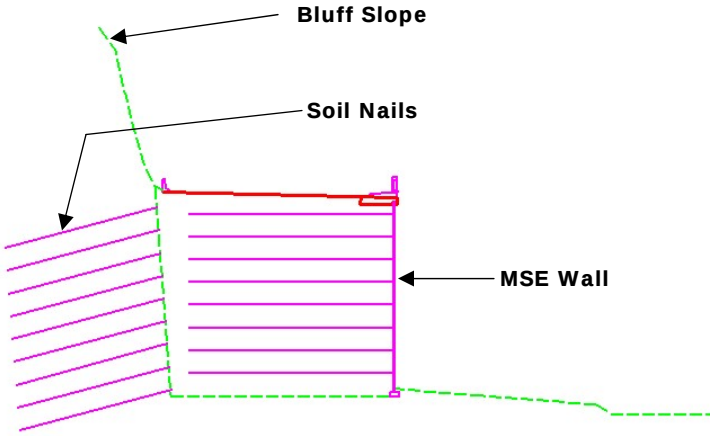
Columns between Eroded Deposits

Some of the distress of the existing structure has been caused by surficial erosion of the slope. Therefore rehabilitating and widening of the existing structure will require the addition of erosion countermeasures to protect the structure. This would most likely be accomplished with the addition soils nails and a concrete facing on the slope, however this will have a negative visual impact.

Rehabilitating and widening the existing structure is structurally inefficient, has a negative visual impact, and could cause a significant amount of slope disturbance. Given these reasons this option is not recommended for this project.

2. *Earth Retaining Structure*

Due to the alignment of the Incline along the bluff slope, the roadway and structure could be replaced by an earth retaining structure. A possible solution would be to reinforce the slope with soil nails and grade it down to competent bearing material, then build a mechanically stabilized earth (MSE) wall against the soil nail wall up to the roadway elevation. The MSE wall would allow visually appealing fascia panels and use the historic balustrade railing on top of the wall. This option would replace the bridge structure, strengthen the slope, and provide protection of the slope below the roadway from future erosion.



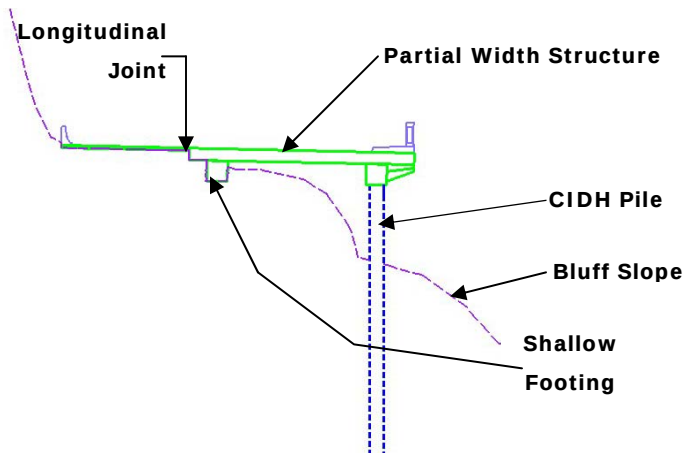
MSE Wall with Soil Nails

A significant drawback of this option is the MSE wall would drastically change the visual appearance of the slope and have an adverse environmental impact per the environmental document. Construction of the MSE wall would require mass grading of the slope and

importing select backfill. Due to these reasons this option is not recommended for this project.

3. Sidehill Viaduct Structure

Given the existing structure is a sidehill viaduct this same type of structure could be used for the replacement structure. The superstructure would extend across a portion of the roadway width to span the existing drainage channels in the slope. The substructure would be composed of a combination of footings and cast-in-drilled-hole (CIDH) piles. A shallow footing could be cast on the east side while CIDH piles would be used on the west side. The superstructure could be a cast-in-place or precast concrete structure. A benefit of this type of structure is that it minimizes the amount of superstructure and substructure work which in turn could be the most cost effective solution. A partial width sidehill viaduct would closely match the existing structure type.



Sidehill Viaduct

A significant problem with the existing structure is the erosion that has occurred underneath the superstructure causing sinkholes in the roadway. While no evidence of global instability of the structure has been observed, repair of the roadway surface is an ongoing maintenance problem. In order to support the new structure with a shallow footing it will need to be protected from erosion. The most effective solution for protecting the hillside from erosion is through the use of soil nails and a concrete facing but this will have a negative visual impact. It is possible to use a concrete ditch between the roadway and upper slope to capture any runoff, however over time drainage gullies could form behind the ditch and run below the roadway and structure footing.

Another option to protect the footing is to estimate the anticipated surficial erosion over the life of the structure and design the footing with a correspondingly appropriate embedment and set-back from the edge of the slope. A problem with this approach is there are no design standards or guidelines to determine the future erosion and a significant amount of engineering judgment will be required. The resulting factor of safety for footing stability could be conservative or unconservative depending on the actual erosion rates observed.

To ensure protection from erosion the shallow footing could be supported on a CIDH pile, then the only major design decision remaining is to determine the location of the longitudinal joint between the structure and the roadway. To protect the adjacent roadway from erosion an estimate of the surficial erosion, previously discussed, could be performed but this will have the same shortcomings.

Problems with a longitudinal structure joint include the possibility of it being aligned on a vehicle wheel line and roadway runoff and other debris collecting in the joint. This could result in maintenance problems and erosion underneath the structure.

From the discussion above, a partial width sidehill viaduct structure is not recommended as the replacement structure.

4. Cast-In-Place Slab Bridge

A standard reinforced concrete cast-in-place slab bridge supported on CIDH piles could be used as the replacement structure. This type bridge will be designed to carry legal loads, be visually similar to the existing structure, and require minimal maintenance. A pile supported structure would be stable and accommodate slope erosion throughout the structure's design life. This type of structure can be readily constructed on straight and curved alignments.

Falsework and Temporary Footings

A drawback for using this type of structure at this site is that a large amount of falsework will be used and portions may need to be supported on the bluff slope. A large portion of the slope underneath the roadway may also need to be graded to install the falsework and accommodate the falsework footings and bents. Some of the bluff features may need to be removed in order to bring in equipment for constructing and erecting the falsework. The California Incline is being widened and cantilevered over the bluff slope and temporary footings may be needed under the existing roadway and at the bottom of the bluffs on the lower slope. This could require additional grading of the lower slope. The vertical clearance under the bridge will be small in some locations and removal of falsework could be difficult. To minimize the number of temporary footings the falsework beams could be supported from the permanent CIDH pile extensions. Since the superstructure will be cast-in-place this type of structure will require a large number of concrete truck deliveries that will need to be scheduled to minimize traffic disruptions.

The benefits of a cast-in-place slab bridge outweigh the drawbacks and this is considered to be a viable option for replacement of the California Incline.

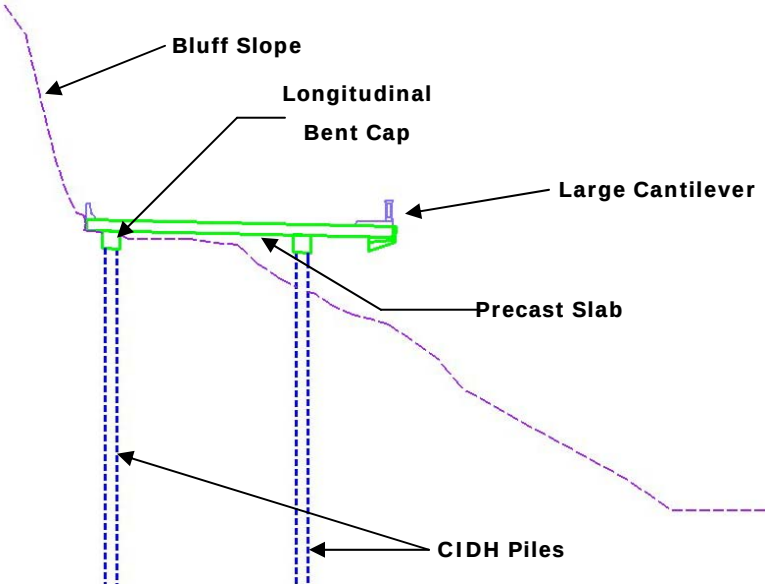
5. Precast Slab Bridge Spanning Transversely

A precast slab bridge supported on CIDH piles could be used to minimize the amount of falsework used at the site. One option is to orient the precast panels transversely to span between two longitudinal girders that are connected directly to the CIDH piles. The CIDH piles would be cast in two lines, one near the slope face and another along the bluff edge. The transverse panels could be designed with a large cantilever over the bluff edge in order to maximize the distance from the piles to the bluff. The longitudinal bent caps would be cast-in-place on the ground and on falsework. The falsework needed would be relatively small and the forms could be supported on the pile extensions to minimize ground disturbance.

The precast slabs would be designed to act compositely with a cast-in-place topping slab and no transverse post-tensioning of the slabs would be used. The use of a topping slab will

ensure structural continuity between the precast slabs to avoid differential deflections, will increase the strength of the superstructure for negative bending over the cantilever, and will vary in thickness to provide the roadway cross slope. A special design of the precast slabs will be needed since LRFD live load distribution factors are provided for slabs spanning longitudinally. A fascia panel will be used on the transverse edge to provide a smooth surface at the ends of the slabs and to replicate the existing concrete brackets. Precast panels spanning transversely will be efficient for casting and erecting since they will all the same length and carry the same loading. At the south end of the bridge special wedge shaped slab units would be needed to form the curve in the roadway.

A drawback of using transversely spanning precast slabs is that it forces a greater number of piles toward the bluff edge. The piles can be set back from the edge but the distance will be limited by the structural capacity of the slab cantilever and any potential deflection and vibration problems of the cantilever. The deflection and natural period of vibration of the slabs would need to be checked so as not to cause discomfort to pedestrians. Another drawback is the limited work space available at the site. The turning radius at the top and bottom of the roadway is small and a flatbed truck may not be able to negotiate the turn. Therefore lane closures or night work is anticipated when the precast units are delivered to the site and set in place.

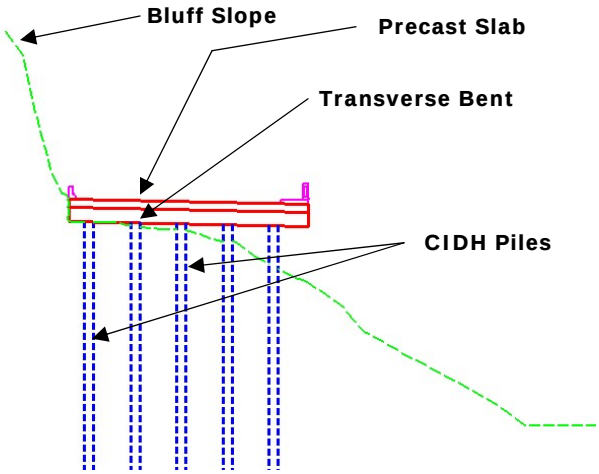


Transverse Precast Slab

The benefits of a transversely spanning precast structure outweigh the drawbacks and this is considered to be a viable option for replacement of the California Incline.

6. Precast Slab Bridge Spanning Longitudinally

A precast slab bridge spanning longitudinally could be used as the replacement option and it would have similar benefits as a transversely spanning structure. A CIP topping slab would be used to provide structural continuity and the desired roadway profile. This type of structure would be supported on CIDH piles that are aligned in transverse bents similar to the cast-in-place slab bridge option. A benefit of this orientation of piles is that it puts fewer piles near the bluff edge where there is a potential for disturbance to the slope. The span lengths can be adjusted to cross over deep erosion gullies in the slope, but standard precast units have a



Longitudinal Precast Slab

maximum span length of approximately 55′. At the south end of the bridge precast units with skewed ends would be needed and oriented to form the curve in the roadway.

A drawback of precast slabs spanning longitudinally is that the pile bents will be aligned transversely across the roadway which will require construction vehicles to maneuver over and around them during construction. This could be mitigated by sequencing the construction operations but may result in extending the project duration and increasing the construction cost. Also as discussed for the transversely spanning option, lane closures and night work are anticipated to deliver and place the precast units.

The benefits of a longitudinally spanning precast structure outweigh the drawbacks and this is considered to be a viable option for replacement of the California Incline.

XII. Constructability

Removing the existing structure and constructing the replacement bridge will be challenging whether the superstructure is cast-in-place or precast. This is due to the California Incline being constrained between steep erodible cliffs, heavy traffic volumes on adjacent city streets and highway, environmental sensitivity of the site, and the requirement to minimize disruptions to the local community. It is anticipated that a temporary access road will be constructed on the lower slope to remove the existing columns, construct new foundations, and to erect falsework beams. Construction of a temporary access road has been incorporated into the environmental document.

A. Construction Equipment

The equipment envisioned to be used for demolition of the existing structure includes backhoes, concrete saws, and jackhammers. The equipment anticipated to be used for construction of the replacement structure includes backhoes, drill rigs, concrete pumps, and cranes for lifting material.

B. Construction Staging

The California Incline is bounded to the east and west by the Palisades Park and the Pacific Coast Highway, respectively. No equipment can enter the park per the environmental document therefore nothing can be lowered down on to the roadway. Pacific Coast Highway has heavy daytime traffic and limited lane closures are allowed per Caltrans District 7. Some lane closures are expected to be necessary to construct the temporary access road and to remove and deliver material but night time work is not expected to be allowed. Therefore construction equipment will be staged on the roadway approaches to the existing structure.

C. Construction Sequence

For typical bridge projects the sequence of operations would be to demolish the existing structure, construct the foundations, build the substructure, and then the superstructure. That sequence of operations may not be possible at this site given the limited access, deep erosion gullies under the existing structure, and the new structure will extend over the bluff edge. To demolish the existing structure and construct the new structure a staggered construction approach may be needed where a section of the existing roadway and structure

is demolished and a subsequent section of the new bridge is constructed. Construction equipment could be supported from the existing structure or new structure.

The California Incline is currently posted for a 3 ton weight limit, due to the design and condition of the existing structure, and drill rigs and cranes to be used on this project could weigh as much as 45 tons. Therefore it is unlikely the existing structure could be used as a platform to support construction equipment without further construction engineering and strengthening of the structure. The soil beneath the roadway and structure may need to be evaluated for its ability to support construction equipment. Crane rails or steel plates could be used to distribute the weight of construction equipment. The erosion gullies under the structure may need to be graded and filled with soil so that construction equipment can pass over them.

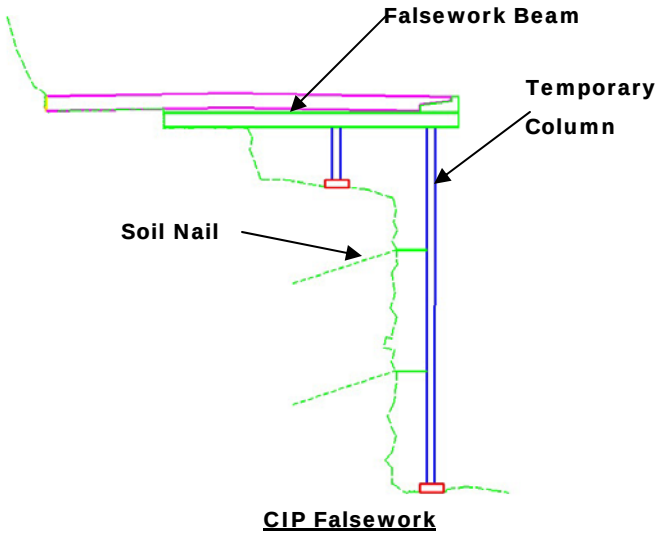
If the existing structure and roadway are not capable of supporting construction equipment construction could progress from the new structure. Given the new structure will be designed for permit loading it will most likely have sufficient capacity to carry construction vehicles. A drawback of staggered construction is that it is inefficient, requiring demolition and construction crews to interlace their work, increasing construction cost and schedule.

D. Pile Construction

The replacement structure is anticipated to employ CIDH piles to mitigate for future erosion of the slope. Due to the presence of groundwater a minimum of 30″ diameter piles are recommended to accommodate pile inspection tubes. The contractor will determine if the drill rig will be supported on the existing structure, new structure, or roadway. If the drill rig is support on the roadway this could be challenging due the looseness of the slope near the bluff edge. The contractor will need to set back equipment as far as possible from the bluff edge to prevent collapse of the eroded trace deposits. Preliminary geotechnical information recommends that piles be located 2 diameters from the bluff edge. This recommendation may dictate the final layout of the piles and require long cantilevered slabs or unique bent cap beams. Constructability of the piles will be taken into consideration during final design.

E. Cast-In-Place Slab Bridge Construction

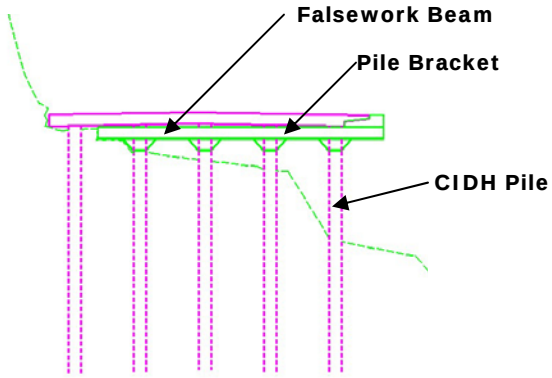
To construct a cast-in-place slab bridge, falsework beams will need to be erected to support concrete forms, reinforcing steel and wet concrete. The vertical clearance under the existing structure above the ground varies from 40′ to no clearance and consideration of the layout, installation, and removal of falsework beams is needed.



At the south end where the structure cantilevers over the bluff a temporary column may be constructed on the lower slope and extend up to the bridge deck elevation. To stabilize a tall falsework column temporary soil nails could be installed into the bluff and

bracing members could be attached to the column. From that column a falsework beam would be extended to the slope and supported on another shorter temporary column. The next segment of the beam could be founded on the slope where the ground approaches the deck level. Where the ground comes up to the underside of the slab some excavation will be needed to place the falsework beam at the correct elevation. Where the slab is on top of the slope no falsework beams or forms will be needed and the slab can be cast directly on the ground.

An option to avoid building tall falsework columns could be to support the falsework beams on brackets that are attached to the extended section of the piles above the ground. Custom brackets could be attached to the piles and the beams would span between the brackets. If the bridge spans are relatively short, around 40′, this should be a viable option.



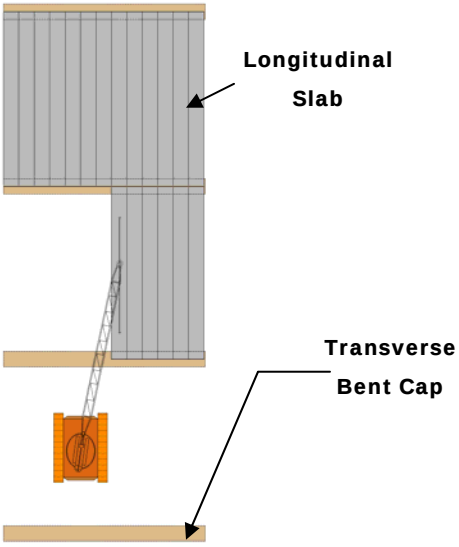
Falsework Supported on Piles

After the falsework and concrete forms are in place, reinforcing steel will be delivered to the site that could be stored on the roadway approaches to the bridge. Once the reinforcing is in place, concrete pumps will most likely be located on the roadway approaches where concrete trucks can off-load concrete while minimizing disruptions to traffic. After the concrete slab is cast, the falsework beams can be lowered with mechanical or sand jacks. Then they would be pulled out laterally from underneath the slab with a crane mounted on the bridge or on the lower slope.

F. Precast Slab Bridge Construction

After the piles are installed some falsework beams and forms will be needed to construct the concrete bent caps that support the precast slabs, but the falsework would be lighter and smaller than that used for slab bridge construction. The beams could be supported on temporary columns or from the pile extensions. After the bent cap beams are complete, the precast slab panels will be delivered to the site and lifted by cranes onto the bent caps. The cranes may need to be staged on a closed lane on PCH depending on the horizontal reach of the crane. Otherwise the crane could be staged on the California Incline roadway if it can fit under the vertical clearance of the pedestrian overcrossing. The precast slabs would be connected to the bent caps with dowel bars that are grouted in holes in the slabs.

Once the precast slabs are in place, a cast-in-place topping slab will be poured to join the precast units together that will also form the roadway cross slope. The topping slab will be designed act compositely with the precast units so that supplemental transverse post-tensioning or bolting of the units will not be required.

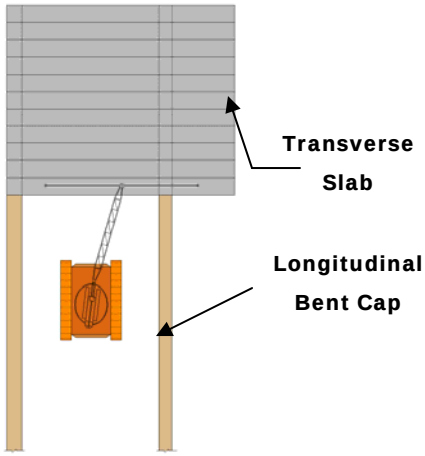


Longitudinal Slab Alignment

The orientation of the precast slabs could have an impact on the constructability of the replacement structure. If the precast slabs are oriented longitudinally the bent caps will be transverse to the roadway and extend from the slope on the east to the bluff edge on the west. This will require vehicles to drive over the cap beams as there will not be space to go around the beams. If there are deep gullies between the beams or if the top of the beams is more than a foot or two above the adjacent ground, soil will need to be graded so vehicles can traverse over the gullies and beams.

Another option is to have the crane located on the previously constructed span but this could cause other complications. Since the precast units will be designed to be composite with the topping slab there will be stirrup bars that extend out of the top of the slabs and the bars would be damaged by the construction vehicles. Therefore the topping slab will need to be cast on the slab prior to any construction vehicles driving on the span that will make the construction inefficient and extend the schedule.

If the precast slab units are oriented transversely the bent cap beams will be cast in two longitudinal lines that will provide space for construction vehicles to pass between them. Some filling of gullies with soil along the roadway may be needed but the placing of slab units transversely may proceed more quickly than the longitudinal orientation since the bent caps do not need to be traversed. A smaller crane may be used in lifting the slab units in this orientation since the crane does not have to reach as far to set them as in the longitudinal orientation. This orientation also allows for a large cantilever on the west side to maximize the distance of the piles from the bluff edge but it places more piles toward that edge.



Transverse Slab Alignment

XIII. Foundation Options

The topography along the length of the California Incline roadway is highly complex with long and deep erosion gullies at the south end to almost no erosion at the north end. The west side of the roadway is at the edge of a steep slope that is susceptible to erosion while the east side is at the base of a tall slope. Therefore deep piles could be used where there are erosion problems and shallow footings could be located where no erosion is anticipated.

The difficulty in changing the type of foundation along the structure is knowing where the change should occur. This would be based on a significant amount of engineering judgment that could result in a conservative or unconservative design. Switching from piles to shallow footings will cause a change in foundation stiffness of the substructure that could lead to differential settlement of the superstructure. There may not be a significant cost savings in switching from piles to shallow footings since the contractor has already mobilized equipment for the piles and a change in foundation type may require a different work crew. From a structural and construction standpoint it is most efficient to use one type of foundation along the entire length of the structure. The decision to change foundation types will be evaluated in final design.

XIV. Utilities

There are 2 utilities that will have to be accommodated with the replacement of the existing structure. Southern California Edison has an electrical line and the City of Santa Monica has a 12″ waterline that are both buried beneath the roadway. The loading imposed by construction equipment and demolition of the existing structure is likely to damage these utilities, therefore the utilities will be rerouted, shutdown, and removed during construction.

The replacement structure will create a permanent barrier to the utilities that are buried underneath. Therefore coordination with the utility owners will be needed to either plan for new alignments of the utilities along the California Incline or encase the utilities under the structure so they will be accessible for future maintenance.

XV. Aesthetics and Barriers

The aesthetics of the replacement bridge will mimic the look of the existing structure. The significant visual feature of the existing structure is the open balustrade railing. A Texas Department of Transportation T411 railing is proposed to be used on the west side of the new structure which has similar features to the existing railing. This railing is crash rated for the NCHRP TL-2 loading which translates to a 45 MPH vehicle impact. The speed limit on the Incline is 25 MPH therefore this railing is acceptable for this roadway. Under the overhang of the new structure concrete brackets will be cast that are visually similar to the brackets on the existing structure.

Existing Railing and Brackets

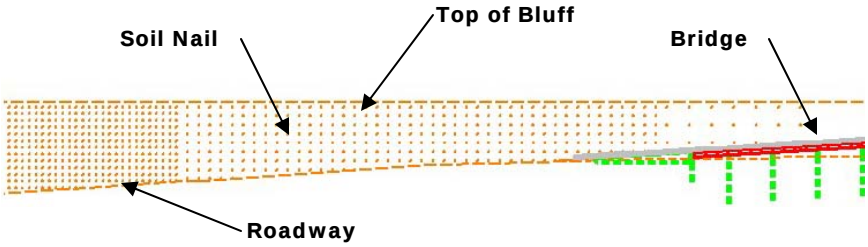
On the east side of the roadway a Type 27 concrete barrier will be used. This barrier type has a smooth vertical face on the outside that is not visible to the public and will be facing the bluff slope. This barrier will capture future erosion of the slope above that could be periodically removed by City maintenance forces.

XVI. Right-of-Way

The California Incline is located on City of Santa Monica right-of-way however an encroachment permit will be needed from Caltrans to allow partial or full lane closure of the Pacific Coast Highway.

XVII. Soil Nailing of Upper Slope

URS Corporation has performed a slope stability analysis of the Palisades Bluffs in the vicinity of the roadway and their report is attached in Appendix A. They provide preliminary recommendations for the extent of the soil nailing to strengthen the bluffs and a construction cost estimate. The extent of soil nailing is shown on the Project Plan sheet. The sketch below shows an elevation view of the bluffs and roughly shows the density of the soil nails as recommended in the URS report.



Extent of Soil Nailing

XVIII. Approach Road Work

Given the limited space for construction around the California Incline it is anticipated that the roadway approaching the bridge structure will be used by the contractor for staging. It is anticipated that using the roadway for staging will result in damage to the road surface requiring it to be replaced. The combined length of approach roadway on both sides of the structure is approximately 665′. Caltrans Local Assistance Program Guidelines specifies that 200′ of approach road work from both bridge abutments, for a total of length of 400′, is reimbursable for federal funding. Therefore additional HBP funding will be requested to replace the total length of roadway beyond the bridge structure.

XIX. Structure Cost

Structure quantities were estimated using the guidelines in Bridge Design Aids for general plan quantity takeoffs. Unit prices are taken from Caltrans Cost Statistics that are averaged over the years from 2003 through 2007 and that unit price is adjusted to the current cost index. The unit prices are further adjusted based on specific site conditions and quantity of the bid item.

Below is the estimated construction cost for each of the bridge alternatives:

- Cast-in-Place Slab Bridge: **$9,700,000**
- Transverse PC/PS Slab Bridge: **$11,300,000**
- Longitudinal PC/PS Slab Bridge: **$10,850,000**

Below is the estimated construction cost for the soil nailing and approach road work:

- Soil Nailing of Bluff Slope: **$850,000**
- Approach Roadway Work: **$230,000**

XX. Type Selection Recommendation

Each one of the three bridge replacement alternatives are viable solutions for this project. They all will be visually and structurally similar. Each option has similar challenges in constructing falsework on the bluff slope. The difference is in minimizing community disturbance and cost.

Taking into consideration to minimize disturbance to the community the precast options are likely to require more lane closures and night work than the cast-in-place option. The precast bridges have a lifting and placing operation then an additional operation to place the cast-in-place topping slab. The superstructure of the cast-in-place slab bridge can be completed as one construction operation and lane closures should not be required during placement of concrete. From the cost estimates the cast-in-place bridge is expected to cost significantly less than the precast options.

Based on issues of minimizing community disturbance and having the lowest construction cost, a cast-in-place slab bridge supported on CIDH piles is the recommended alternative. The estimated construction cost of the replacement structure, soil nailing, and associated roadway work is **$10,780,000**

XXI. Structure Summary

- Superstructure Type: Cast-in-place reinforced concrete slab
- Abutments: Short seat abutments on CIDH piles
- Bents: Cast-in-place bent cap with CIDH piles and pile extensions
- Skew: None
- Barriers: Texas T411 and Type 27
- Utilities: Water and Electrical
- Approach Slabs: None

XXII. Appendix A – URS Slope Stability Analysis

REPORT (REVISED)
ANALYSES OF SLOPE STABILITY
ABOVE CALIFORNIA INCLINE
SANTA MONICA PALISADES BLUFFS
SANTA MONICA, CALIFORNIA

Prepared for:

City of Santa Monica, California

Prepared by:

URS Corporation

915 Wilshire Blvd, Suite 700
Los Angeles, California 90017

June 23, 2009

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1.0 INTRODUCTION

This report presents additional slope stability analyses for a portion of the Santa Monica Palisades Bluffs above the California Avenue ramp connecting Pacific Coast Highway and Ocean Avenue, i.e. the California Incline. This work, which is based on the recommendations for stability enhancement discussed in our geotechnical study report (URS, 2007), involved the following tasks:

1. Selection of a critical section, based on slop geometry, geological strata and material properties developed in previous studies and field exploratory programs.

2. Review of slope-improvement methods previously proposed (URS, 2007), and developing additional alternative concepts.

3. Perform additional field borings and laboratory testing in April 2009 for soil properties and strength parameters pertinent to the California Incline area.

4. Performing slope stability analyses for improvement concepts.

5. Interpretation of analyses results and recommendation of a preferred bluff-stabilization alternative aimed at achieving a slope-stability factor of safety of 1.5.

Dames & Moore (1996) first evaluated the stability of the bluffs after the 1994 Northridge earthquake and the subsequent heavy winter and spring rains of 1995, which triggered a number of rockfalls and debris slides. The report recommended mitigation measures including increasing setbacks for walkways along the rim of the bluffs, and controlling surface runoff to reduce the likelihood of medium to large-scale failures. In April 1998, a localized bluff failure occurred northwest of the California Incline after a heavy storm. Emergency repair included removal of loose material from the bluff face and installation of 9 horizontal drains (hydraugers) at the failure location (Dames & Moore, 1998). In 2002, a comprehensive geotechnical investigation was conducted by URS (2007) for the entire bluffs, which included drilling vertical and horizontal exploratory borings; installation of observation wells and horizontal drains; laboratory and field testing of soils; and further development of slope-stability improvement alternatives for the bluffs. Various subsurface-drainage concepts with and without soil nailing and surface treatment with grout were recommended as improvement methods. All these methods were aimed at improving bluff stability with little or no visible changes to the bluffs which are considered an important part of Santa Monica's historic natural scenery. For the California Incline project, two additional borings were drilled for site-specific analysis in April 2009. The locations of borings are shown in Figure 1.

2.0 MODEL SETUP AND SOIL PROPERTIES

2.1 INTRODUCTION OF FINITE DIFFERENCE ANALYSIS METHOD

The stability of the bluffs was analyzed using the explicit finite difference program FLAC (Itasca, 2005) which uses a wide range of non-linear stress-strain models for soil and can handle soil-structural interaction, groundwater flow, consolidation, and dynamic earthquake loading. For slope stability analysis, FLAC's shear-strength-reduction scheme (Dawson et al, 1999) automatically identifies the critical potential slip surface. Soil shear strength is reduced in stages until failure occurs at the limit-equilibrium state. The factor of safety (FOS) is then defined as the ratio of the actual shear strength of the soil to the hypothetical strength triggering failure at the limit-equilibrium state. With this method, the most critical failure mode (slip surface or shear zone) is found automatically without any trials, and the computed FOS represents the absolute minimum for the entire slope configuration.

2.2 DATA PREPARATION

URS performed 12 borings in Santa Monica Palisades Bluffs during the 2002 field exploratory program, and the data are incorporated in our understanding of the soil strata. In April 2009, two new borings (BA-1 and BA-2) were drilled to about 110 feet deep by means of a large-diameter bucket-auger drill rig, directly above the California Incline to allow down-hole logging by a Certified Engineering Geologist, and to obtain soil properties and strength parameters pertinent to the slope above the Incline. Relatively undisturbed soil samples were retrieved from these two borings for laboratory testing. The boring logs are shown in Appendix A.

The borings have encountered relatively thick layers of gravels interbedded with sand, silt and clay, and high blow counts were recorded during soil sampling. Our geologist also took photographs of the typical gravel layers as part of the down-hole logging process, and a surface mapping was conducted to verify soil layer compositions from the slope surface above the roadway. The down-hole photographs are also included in Appendix A.

Based on the findings of the 2002 and 2009 borings and the surface mapping, three geological sections, A-A', B-B' and C-C' have been prepared, as shown in Figures 2 to 4, and the locations of these cross-sections are shown on Figure 1. It is noted that some portions of the slope have erosion gullies and over-hanging materials, and that slope-wash materials (Talus) have accumulated near the bottom of the slope below the Incline. For our analysis, the toes of the slope at Cross-section B-B' and C-C' have been artificially cut by 5 and 20 feet, respectively, i.e., most of the slope-wash materials at the bottom of the slope were excluded from our analytical model for conservatism. In reality, the slope-wash materials provide overburden and some strength against deep-seated slope failures. The surficial slope stability of the slope below the Incline is included in a separate report by the consultant for the Incline project. The loose and overhanging surficial materials are to be trimmed during construction for safety reasons.

The phreatic surface was estimated based on groundwater-table data obtained in the 2002 field investigation (URS, 2007) and the new borings. The phreatic surface is conservatively assumed at about mid-slope under the Palisades Park, although groundwater was encountered only at the bottom of the slope in our borings.

Soil strength parameters used for the stability analysis were derived from laboratory testing including moisture and density, particle-size distribution, unconfined-compression, and direct-shear tests, including new direct-shear test results from the most recent borings as shown in Appendix B. It should be noted that the soil at the site consists of interbedded thin layers of gravels, sands, silts and clays. Further, gravel layers within fine-grained soil matrix are recorded in our large-diameters borings and are also visible at the bluff face above the Incline. Therefore, our soil property model has incorporated the unique nature of soil layers.

The shear modulus of each soil unit was estimated based on soil properties using regression equations summarized by Lee (1992). Poisson's ratio was assumed to be 0.3 for all soil units. The bonding strength has been assumed per FHWA manual and other references. A summary of soil parameters used in the stability analyses is shown as Table 1.

Table 1: Soil Properties

Unit	Unit Weight (lbs/ft^3)	Cohesion (psf)		Friction Angle (deg)		Shear Modulus (ksf)
		Lab Test Results	Adopted For Analysis	Lab Test Results	Adopted for Analysis	
Top Soil (mixture of Sand and Clay)	120		400*		24*	1,900
Silty Sand to Sandy Gravel	120	0 to 1200	300	19 to 42	38	3,000
Silty Clay with Sand	120	50 to 1000	1200	26 to 37	25	1,900
Interbedded Gravel, Sand, and Clay	120	200 to 1000	500	42 to 44	42	4,100

* The thin top soil layer has little effect on the stability of the slope, and its strength is based on past experience with similar materials.

3.0 BLUFF STABILIZATION METHOD

3.1 VERIFICATION OF SOIL STRENTH PARAMETERS

At the outset, the factor of safety for the bluff slope without improvement was computed to establish existing conditions to verify the soil strength parameters adopted for analysis. It should be noted that the slope has been standing at its current conditions for the past century, and has gone through several strong earthquakes with little noticeable damage. Therefore, its current safety factor must be above the marginal value. Cross-section A-A' is located at the end of the Incline where the slope is the highest; therefore it is selected to verify the strength parameters adopted for analysis.

With the soil-strength parameters adopted in Table 1, the computed value of safety factor for Cross-section A-A' is 1.02 as shown in Figure 5. Considering the past history and performance of the slope, these strength parameters are considered to be very conservative, since the actual safety factor for Section A-A' is certainly above unity. With the conservative strength parameters back-calculated from Section A-A', the computed safety factors for Cross-sections B-B' and C-C' are 1.23 and 1.50, respectively, as shown in Figures 6 and 7.

3.2 BASIC STRUCTURAL ELEMENTS

Cross-section A-A' and B-B' are analyzed for mechanical improvement methods for the slope. To improve the slope stability, and at the same time, to minimize disturbance to the Palisades Park above the Incline, soil nails are considered as the feasible improvement method. Soil nails would consist of steel bars installed without washers and without shotcrete applied at the bluff face. This scheme would have minimal visual impact and, thus, would preserve the natural beauty of the Bluffs. Over the years, as the bluff face may gradually recede due to surface erosion, the soil nails without washers can be trimmed to match the bluff face.

For our analyses we have assumed that 1-inch diameter soil nails would be grouted into small diameter holes. The weak link in this system is the pull-out strength of the soil nails, which is governed by the bonding strength at the interface of the grout with the native soils of the bluff. The bonding strength parameters used in our analysis are 800 pounds per square foot (psf) for silty clayey soil, 2,500 psf for silty sandy soil with gravel, and 3,200 psf for gravelly soil.

3.3 RESULTS OF ANALSYIS

The number of soil nail rows (controlled by soil nail spacing), lengths, inclined angles, and hole diameter were parameters varied in the analyses, to reach a minimum FOS of 1.5 under static loading conditions, and 1.1 under seismic (pseudo-static) loading conditions. In our analysis of pseudostatic loading conditions, a horizontal acceleration factor of 0.2 was adopted, which is 1/3 of the peak ground acceleration of 0.6g under the design-level earthquake event.

Based on our analysis, 30-ft to 50-ft long soil nails should be installed in 6 inch diameter holes, with an inclination of 15 degrees from horizontal, in grid patterns of 6 feet by 6 feet to 10 feet by 10 feet. The soil-nail length and spacing requirements to achieve the minimum safety factors at Cross-section A-A' are shown in Figures 8 and 9, and the requirements for Cross-section B-B' are shown in Figures 10 and 11. Cross-section C-C' has a safety factor of 1.1 under the design seismic loading, as shown in Figure 12. The summary of our analysis with elevations of soil nails are shown in Figure 13. The soil nails improves both the surficial and deep-seated slope stability.

For distribution of soil nails, we have calculated the "density" of soil nails at each of the cross-section locations, i.e., length of soil nails required as shown in Figure 14, and the curve connecting "density" at each of the sections is used to calculate the "theoretical" minimum amount of soil nails needed, i.e., the area below the curve. Further, the transition from one "density" to the next level is assumed to be in a stepped-down manner during construction, as shown in Figure 14 and described as the following:

1) The soil-nail starts at Cross-section A-A' and continues to the mid-point between A-A' and B-B'.

2) Then the pattern from the above steps down to approximately the average of A-A' and B-B' requirements, and continues until it reaches B-B'.

3) The pattern then changes to the requirement of B-B' and continues to the mid-point between B-B' and C-C'.

4) The pattern further steps down to approximately ½ of B-B's requirement to about ¾ of the distance between B-B' and C-C'

5) The final distance before Cross-section C-C' (i.e., the last ¼ of distance between B-B' and C-C') is assumed to have no soil nails. Soil nails may be added during the final design stage.

The theoretical minimum amount of soil nails needed is about 26,000 feet, and the amount calculated using the above stepped-down distribution method is about 34,000 feet.

3.4 ROUGH ORDER-OF-MAGNITUDE COST ESTIMATES

We have discussed the mitigation alternatives with several specialty contractors who have experience in similar types of construction. The rough-order-of-magnitude (ROM) cost estimates for soil nails is about $25/foot of soil nail installed. With the total length of soil nails about 34,000 feet, the rough cost is estimated to be about $850k.

4.0 REFERENCES

Dames & Moore, 1996, DRAFT Report, Geotechnical Services, Santa Monica Palisades Park, For City of Santa Monica. November 6, 1996.

Dames & Moore, 1998, Report (Final Draft): Geotechnical Services, Landslide Repair, Palisades Bluffs, Dames & Moore Job No. 15657-009-015.

Dawson, E.M., Roth, W.H., and Drescher, A., 1999, Slope Stability Analysis by Strength Reduction, Geotechnique 49, No. 6, pages 835-840.

Itasca Consulting Group, 2005, FLAC, Fast Lagrangian Analysis of Continua, Version 5.0, Minneapolis, Minnesota, USA.

LEE, S. H., 1992, Analysis of The Multicollinearity of Regression Equations of Shear Wave Velocities, Soils and Foundations, Volume 32, No. 1, pages 205 - 214, March, 1992.

URS, 2007, Geotechnical Study Santa Monica Palisades Bluffs, Santa Monica, California, for City of Santa Monica, October 20th, 2007.

FIGURES

LEGEND

- City of Santa Monica Property Line
- C.B. Existing Catch Basin
- BA-2 URS Bucket Auger Boring (2009)
- B-8 URS Hollow Stem & Bucket Auger Boring (2002)
- EB-10 EMI Soil Boring (1997)
- C — C' Cross Section Location

0 150 300

SCALE, feet

CALIFORNIA INCLINE EVALUATION

SANTA MONICA PALISADES BLUFFS IMPROVEMENT PROJECT

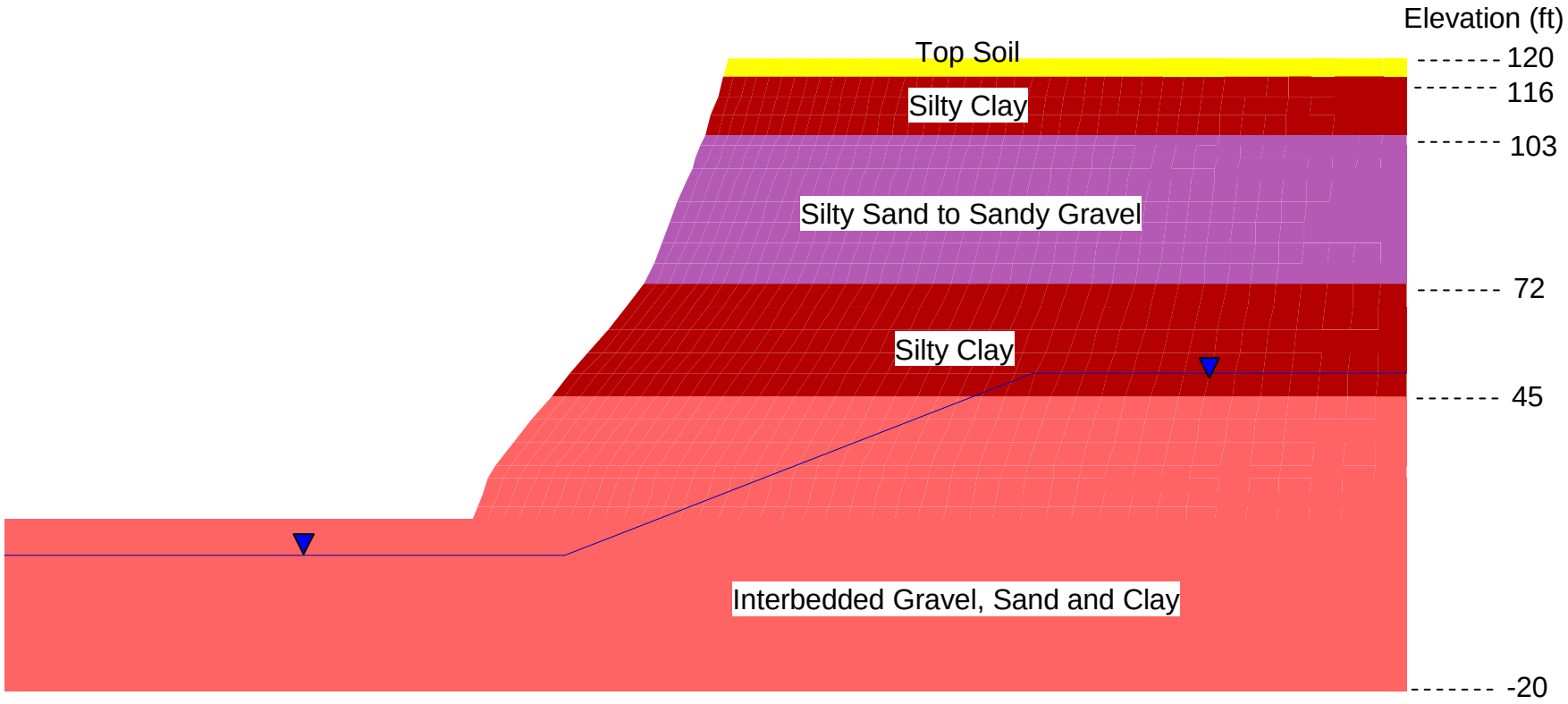
URS

915 WILSHIRE BOULEVARD
SUITE 700
LOS ANGELES, CA 90017
TEL: (213) 996-2200
FAX: (213) 996-2290

URS PROJECT NO. 29410/2057.40000

Figure 1

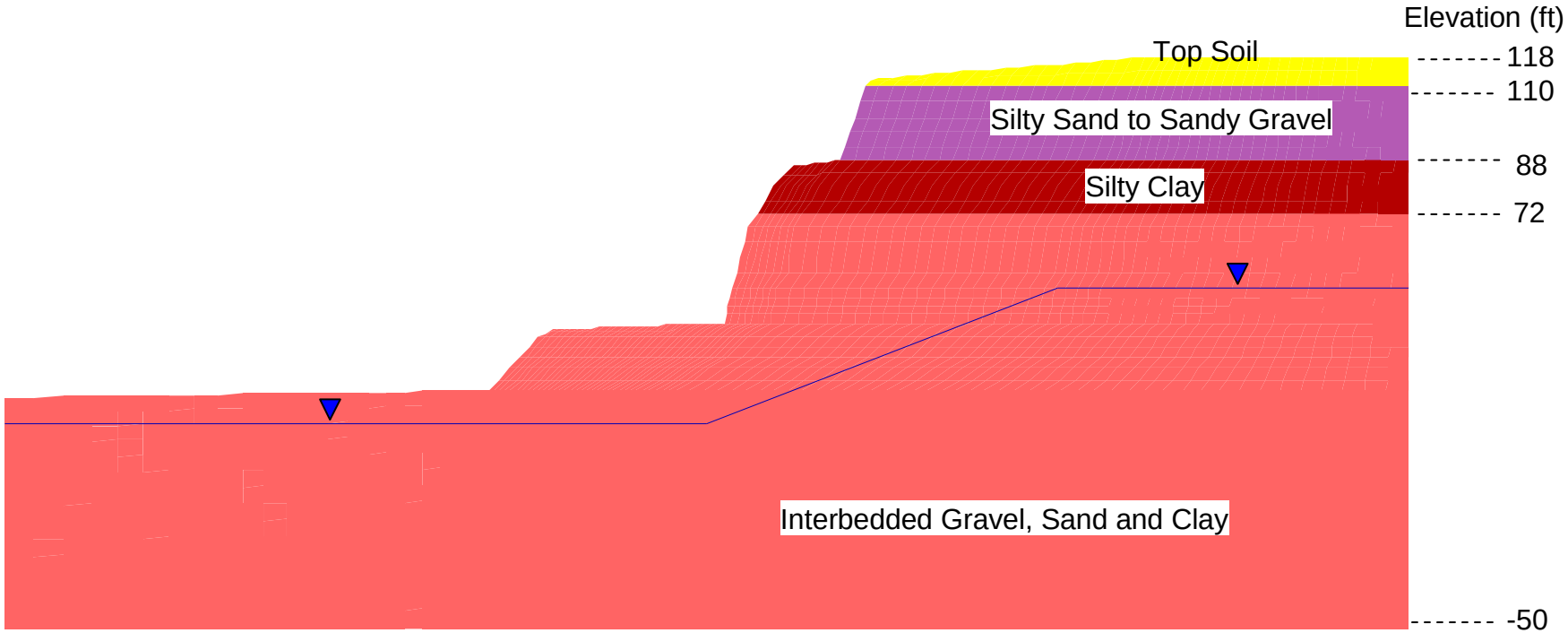
Model Setup (Section A-A')



Santa Monica Palisades Bluffs Stability, California Incline

Figure 2

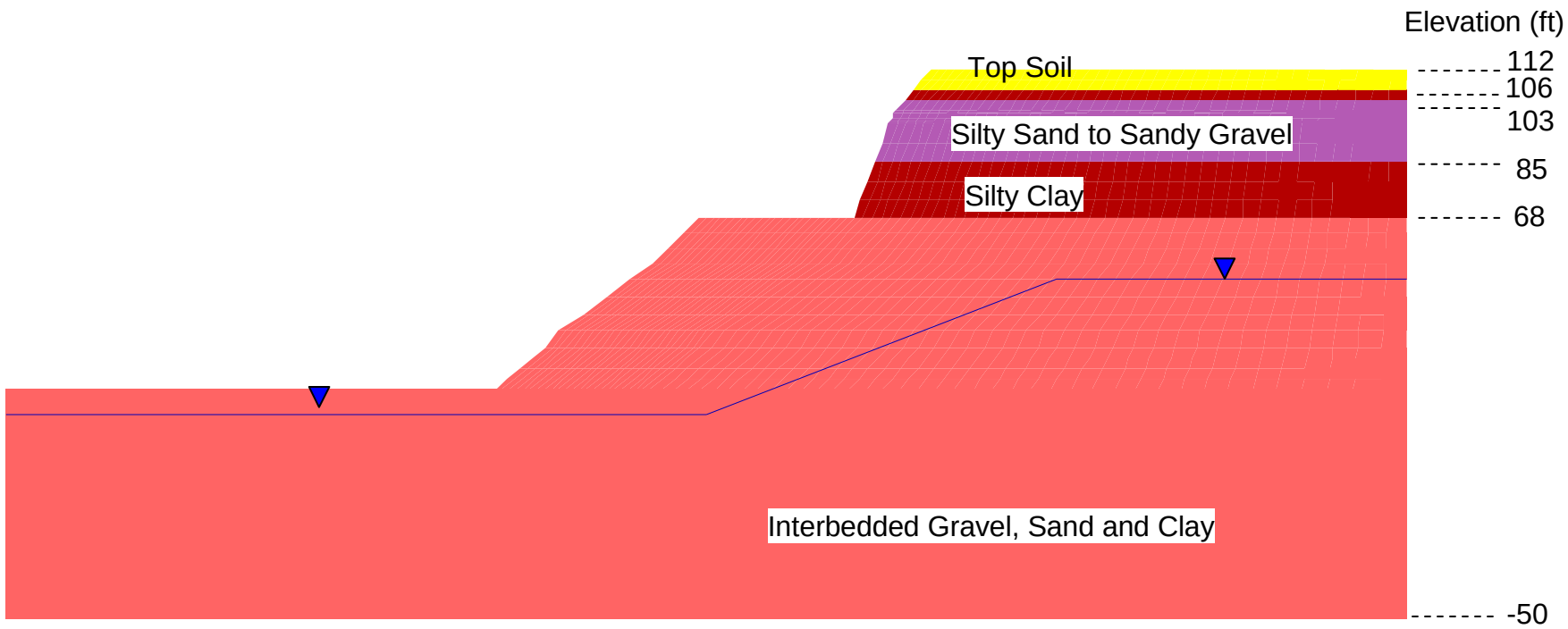
Model Setup (Section B-B')



Santa Monica Palisades Bluffs Stability, California Incline

Figure 3

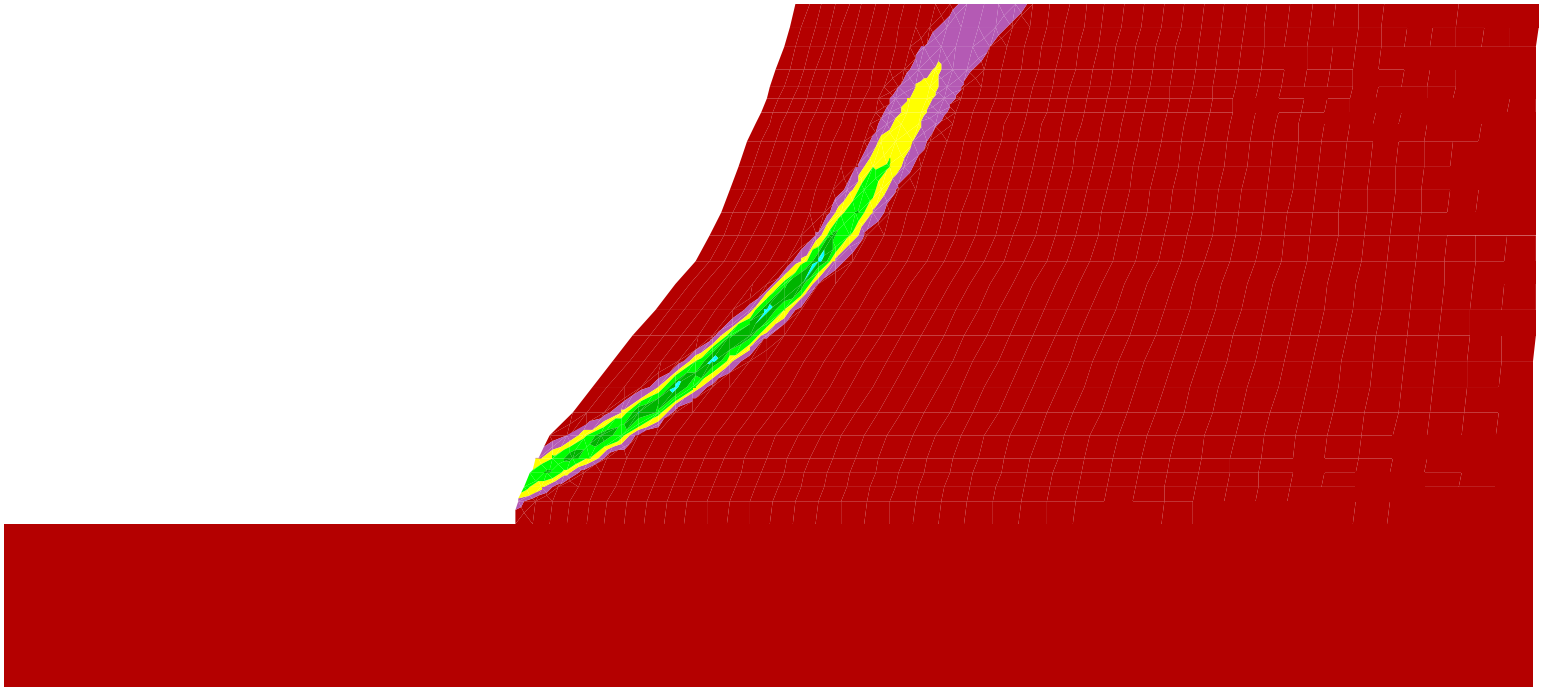
Model Setup (Section C-C')



Santa Monica Palisades Bluffs Stability, California Incline

Figure 4

Existing Condition (Section A-A')

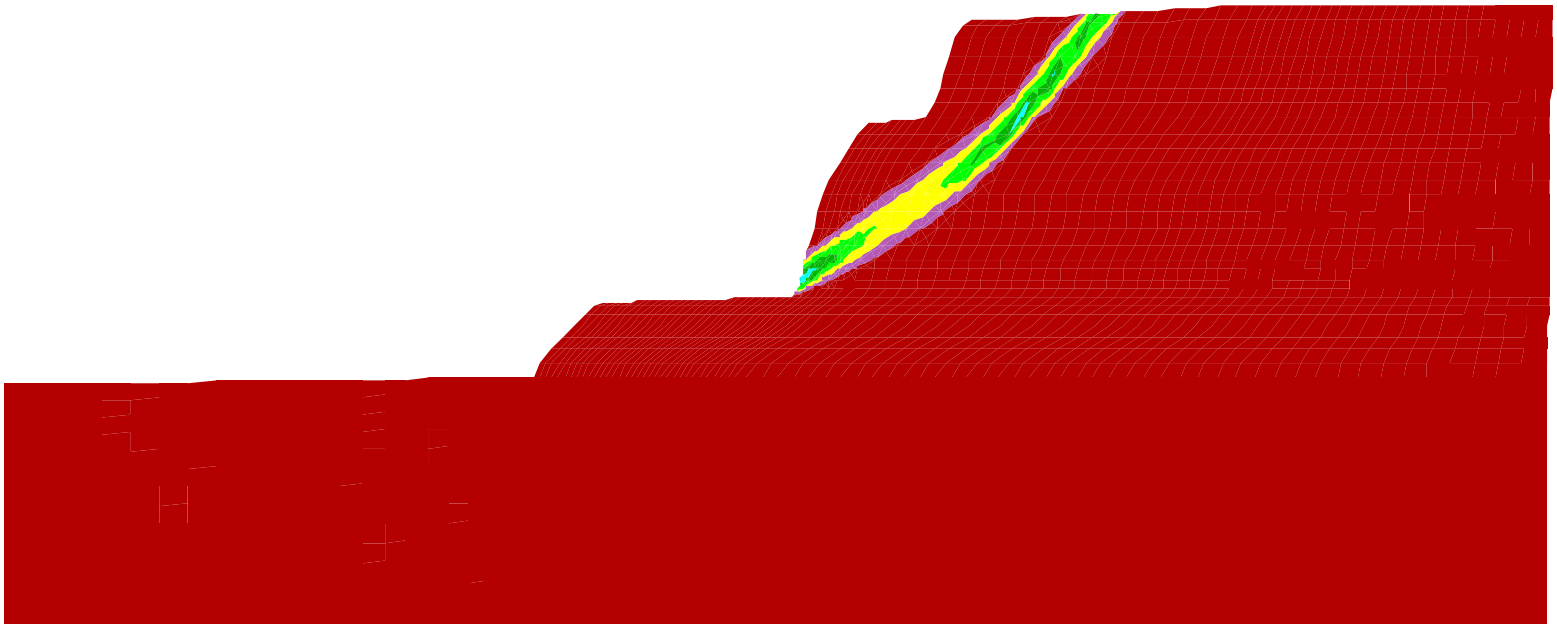


FOS=1.02

Santa Monica Palisades Bluffs Stability, California Incline

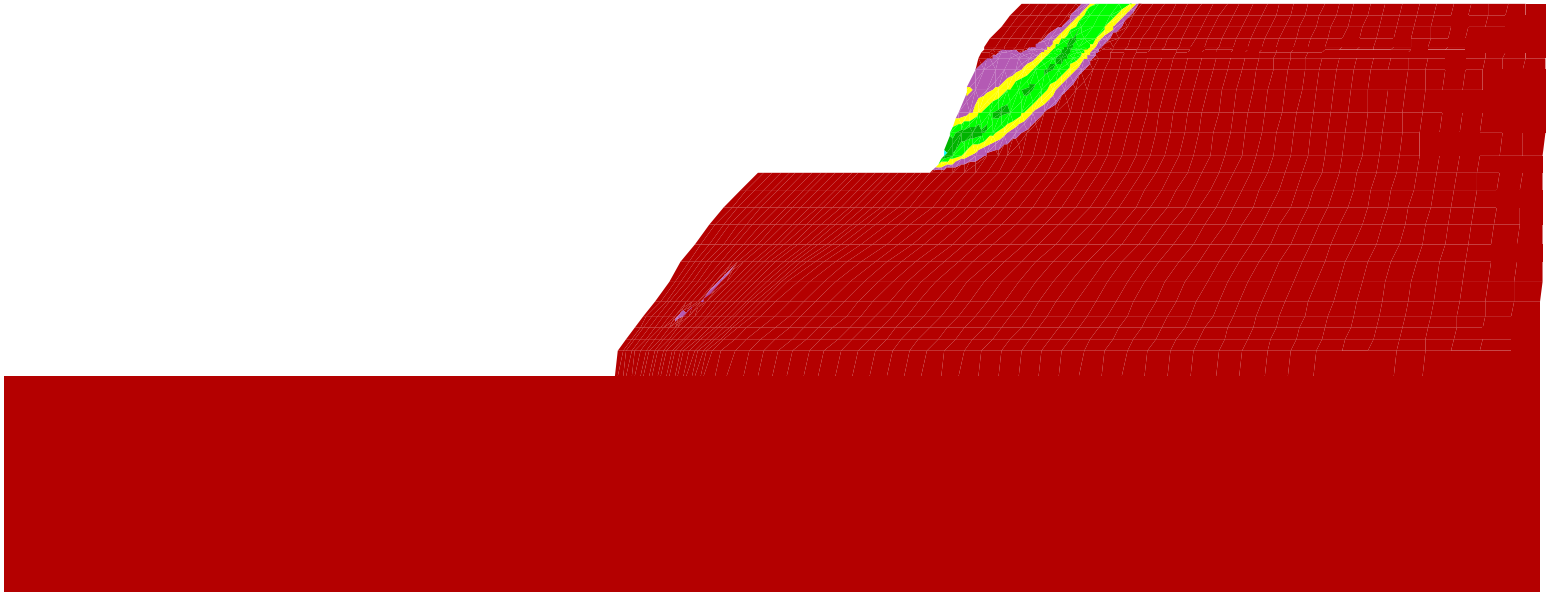
Figure 5

Existing Condition (Section B-B')



FOS=1.22

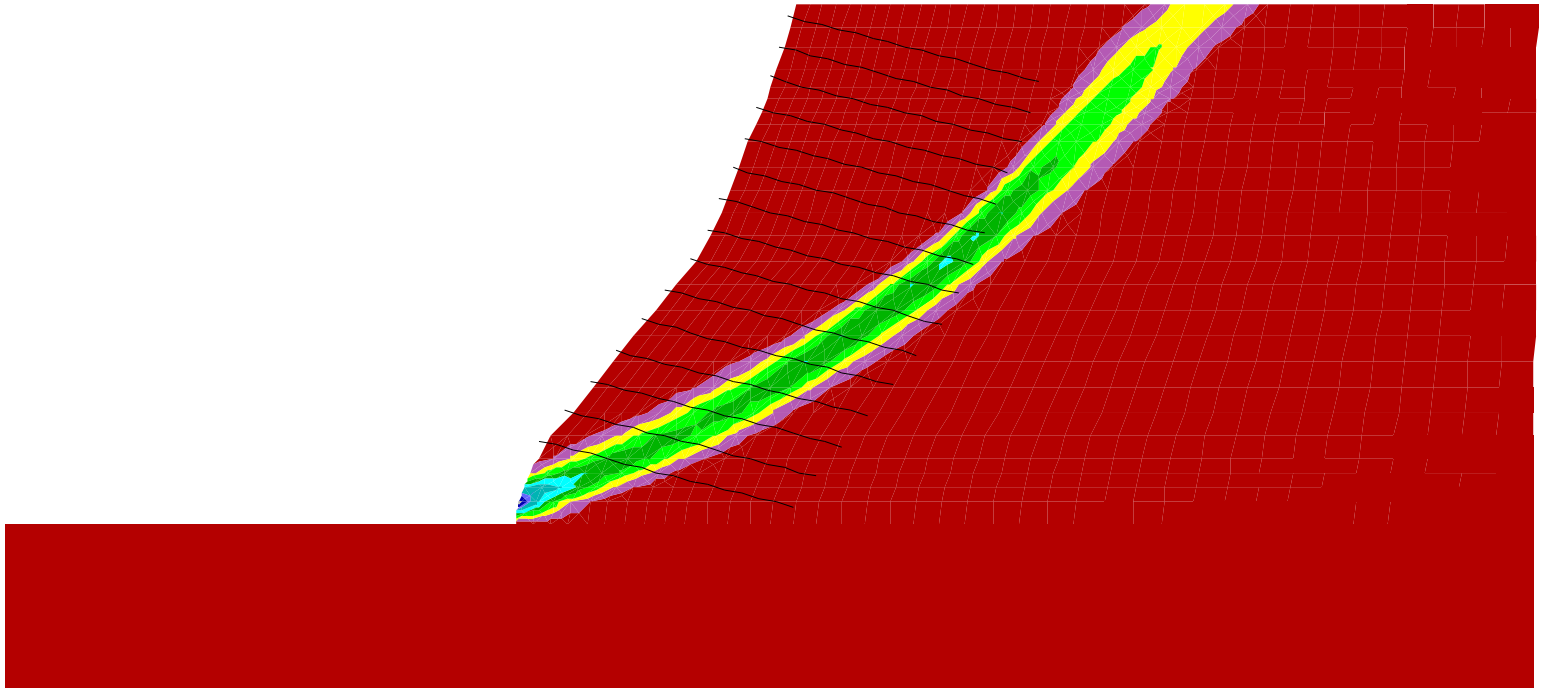
Existing Condition (Section C-C')



FOS=1.50

After Soil Nail Installation (Section A-A)

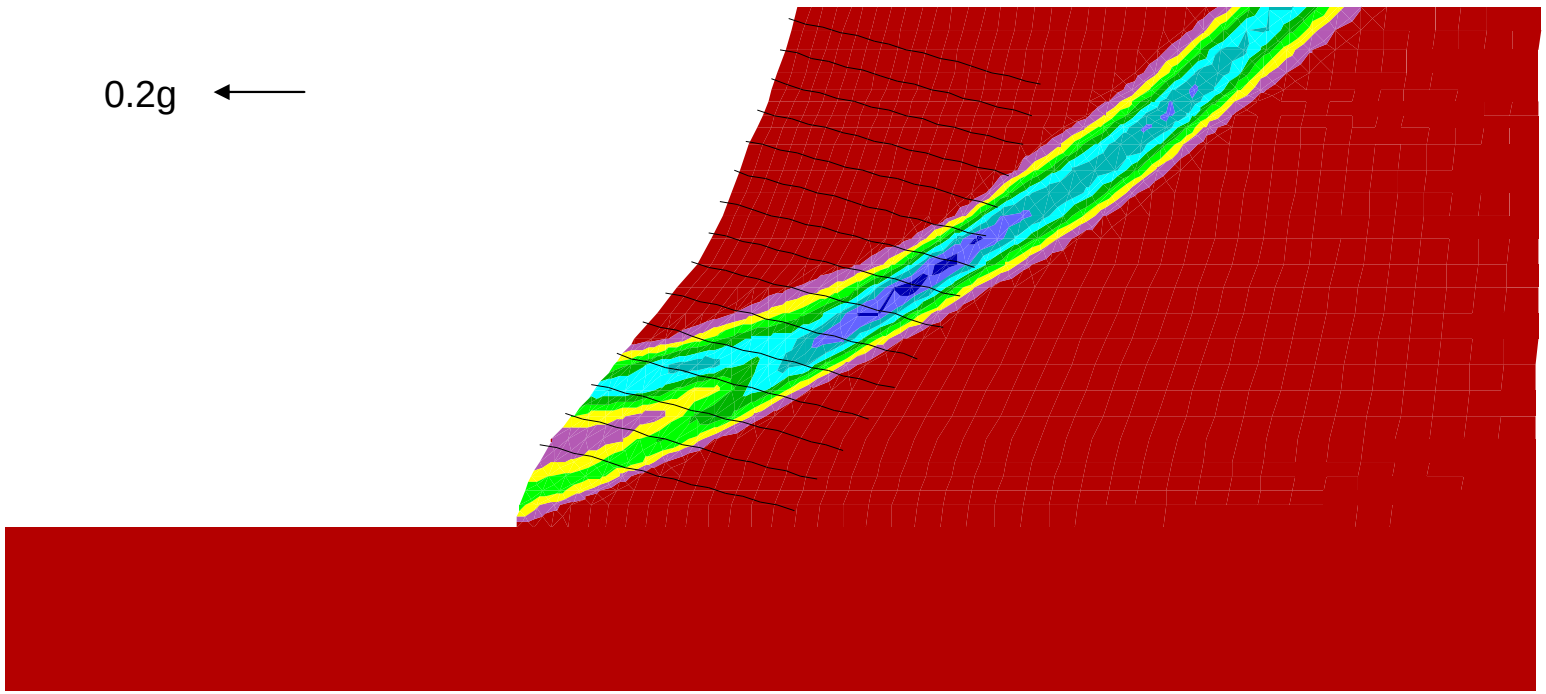
Soil Nails				
Rows #	Length (ft)	Angle (degree)	Horizontal Spacing (ft)	Vertical Spacing (ft)
15	50	15	6	6



FOS=1.54

After Soil Nail Installation (Section A-A), Pseudo Analysis

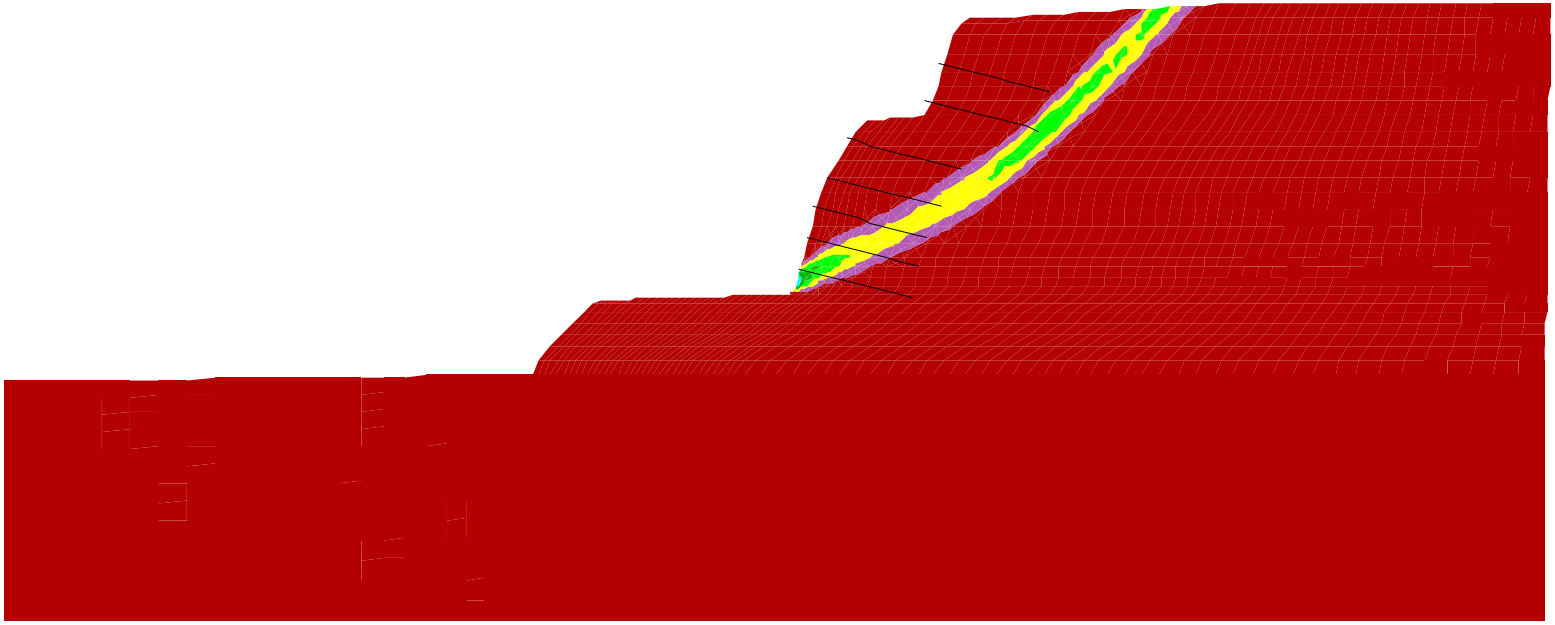
Soil Nails				
Rows #	Length (ft)	Angle (degree)	Horizontal Spacing (ft)	Vertical Spacing (ft)
15	50	15	6	6



FOS=1.10

After Soil Nail Installation (Section B-B)

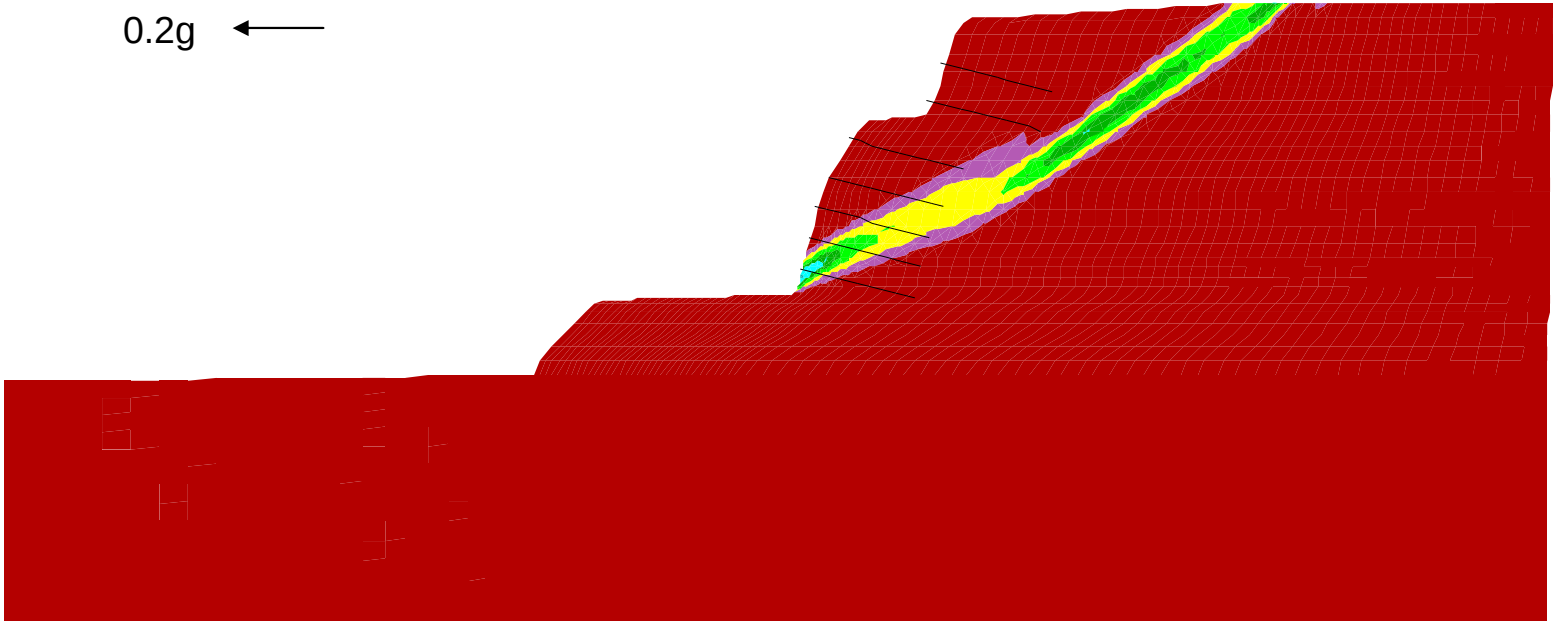
Soil Nails				
Rows #	Length (ft)	Angle (degree)	Horizontal Spacing (ft)	Vertical Spacing (ft)
3	30	15	10	10
4	30	15	8	8



FOS=1.54

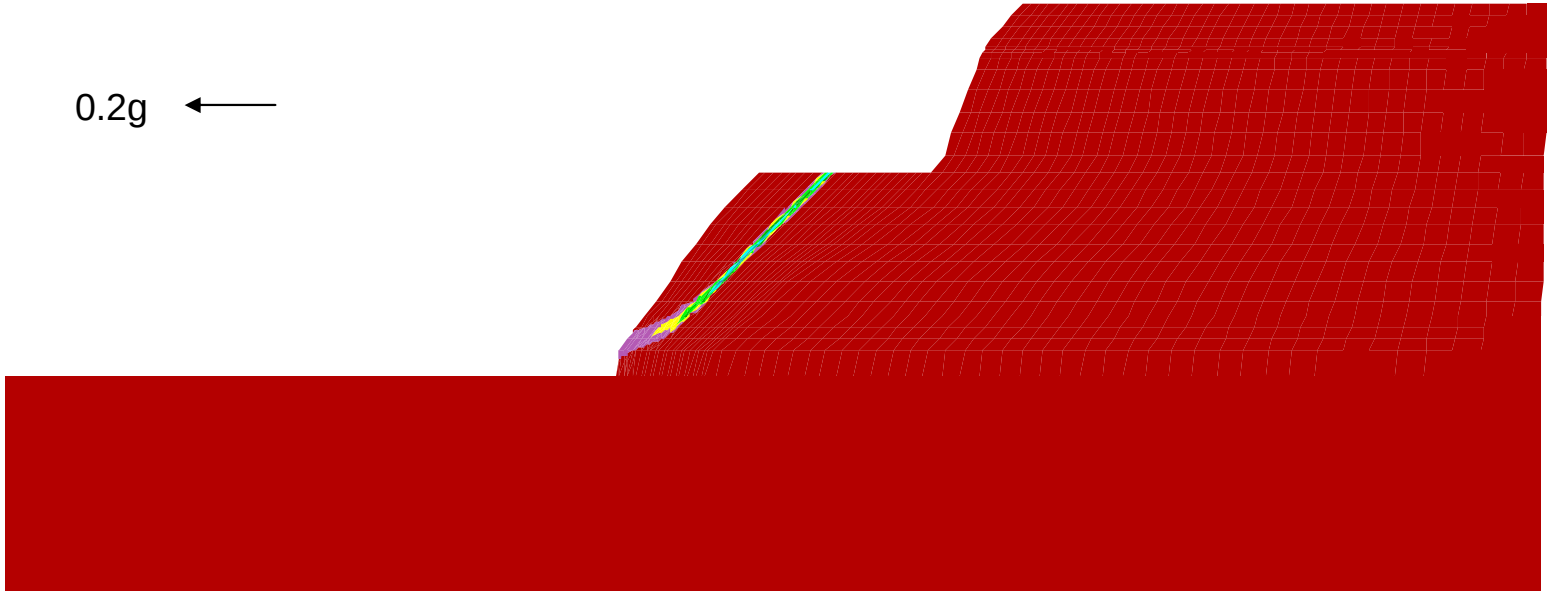
After Soil Nail Installation (Section B-B), Pseudo Analysis

Soil Nails				
Rows #	Length (ft)	Angle (degree)	Horizontal Spacing (ft)	Vertical Spacing (ft)
3	30	15	10	10
4	30	15	8	8



FOS=1.10

Existing Condition (Section C-C), Pseudo Analysis

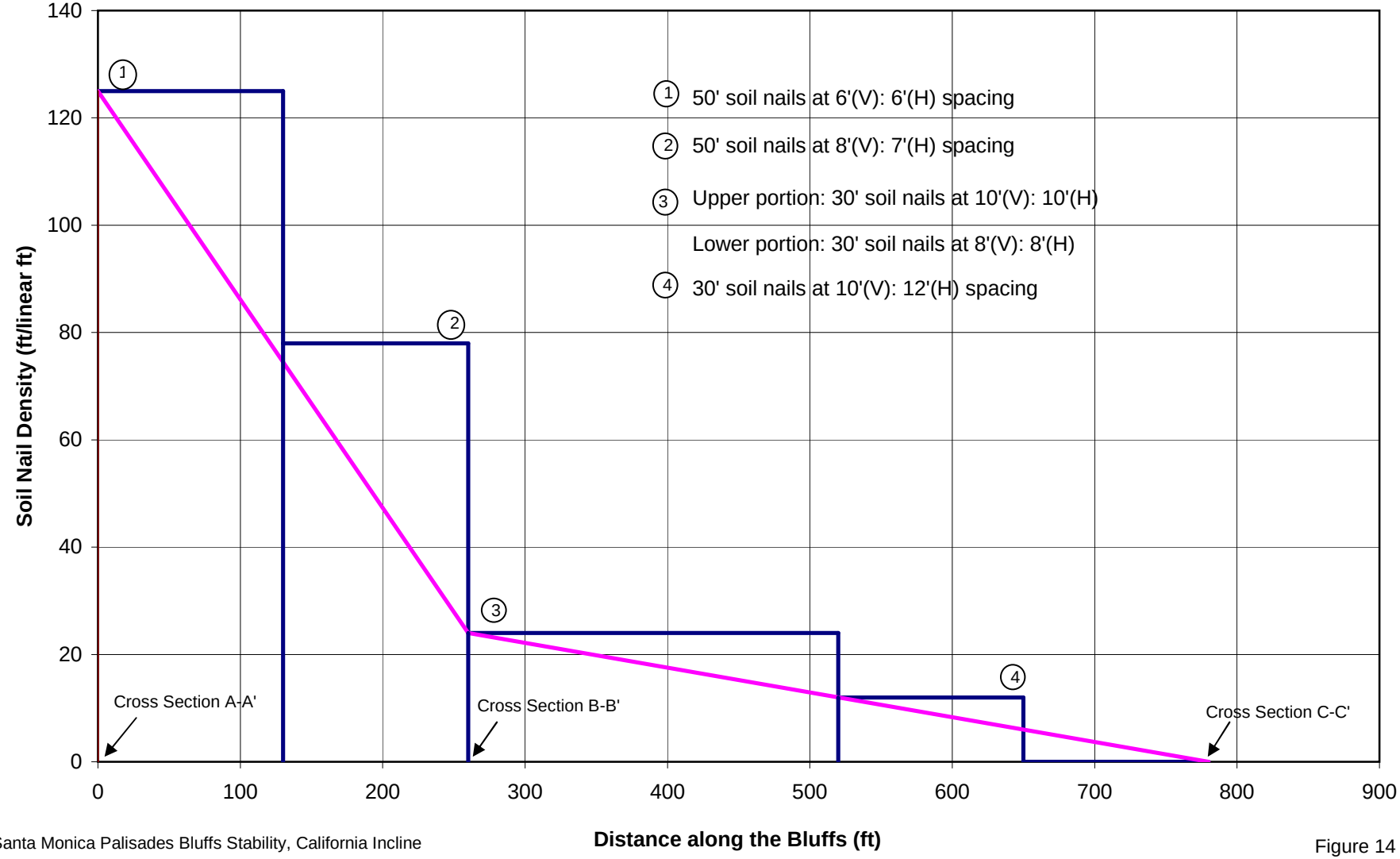


FOS=1.10

Summary of Slope Stability Analysis

Section	Existing FOS	After Improvement with Soil Nail	Pseudo Static (0.2g) FOS	Soil Nail Elevation (ft)
A-A’	1.02	1.54	1.10	@115.7, @109.7, @103.7, @97.7, @91.7, @85.7, @79.7, @73.7, @67.7, @61.7, @55.7, @49.7, @43.7, @37.7, @31.7
B-B’	1.22	1.54	1.10	@ 100, @ 90, @ 80, @ 70, @ 62, @ 54, @ 46
C-C’	1.50	-	1.10	-

Soil Nail Distribution



Santa Monica Palisades Bluffs Stability, California Incline

Figure 14

APPENDIX A – BORING LOGS AND DOWN-HOLE PHOTOGRAPHS OF BA-1 AND BA-2

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	*GRAVEL AND GRAVELLY SOILS* MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	*CLEAN GRAVELS* (LITTLE OR NO FINES)	**GW**	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	**GM**	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	*CLEAN SANDS* (LITTLE OR NO FINES)	**SW**	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	**SM**	SILTY SANDS, SAND - SILT MIXTURES
			SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	*SILTS AND CLAYS*	LIQUID LIMIT LESS THAN 50	**ML**	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	**MH**	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			**PT**	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Dual symbols are used to indicate gravels or sand with 5-12% fines and soils with fines classifying as CL-ML. Symbols separated by a slash indicate borderline soil classifications.

Rock Material Symbols (examples)

Modelo Formation Topanga Formation Santa Monica Slate

Sampler and Symbol Descriptions

- Dames & Moore Type-U sample
- Standard Penetration Test
- No Recovery
- Bk Bulk sample
- Disturbed Type-U Sample
- Pitcher Tube Sample
- Shelby Tube Sample
- Rock Core Sample
- Approximate depth of perched water or groundwater

Note: Number of blows required to advance driven sample 12" (or length noted) is recorded; blow count recorded for seating interval (initial 6" of drive) is indicated by an asterisk.

Laboratory and Field Test Abbreviations

CBR	California Bearing Ratio Test
COL	Collapse Potential test (test result in parentheses)
COMP	Compaction test
CON	Consolidation test
CORR	Corrosivity test
DSCD	Consolidated drained direct shear test (normal pressure and shear strength results shown)
EI	Expansion Index test (test result in parentheses)
LL=29	Liquid limit (Atterberg limits test)
PI=11	Plasticity Index (Atterberg limits test)
PP	Pocket Penetrometer test (test result in parentheses)
R-Value	Resistance Value test
SA	Sieve Analysis (-200 result in parentheses)
SE	Sand Equivalent test (test result in parentheses)
SWELL	Swell Load test (test result in parentheses)
TV	Torvane test (test result in parentheses)
-200	Percent passing #200 sieve (test result in parentheses)

KEY TO LOG OF BORING

Santa Monica Bluffs - California Incline
Santa Monica, CA
FOR: City of Santa Monica

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FIGURE A-1

Report: DMG4PALM; Project File: L:\SANTA-MONICA-BLUFFS\CALIFORNIA INCLINE\BUCKET AUGER DRILLING (2009)\BORING LOGS\GINT\SANTA MONICA BLUFFS - CALIFORNIA INCLINE (REV_051109).GPJ; Data Template:DMLA.GDT

Date(s) Drilled	04/07/09	Logged By	E.P
Drilling Method	Bucket-Auger	Drill Bit Size/Type	28-inch auger
Drill Rig Type	EZ-bore	Hammer Data	4800 lbs / 12" drop
Sampling Method(s)	Dames & Moore 'U' Sampler		
Approximate Groundwater Depth and Date Measured	No Groundwater		
Comments			

Boring BA-1

Sheet 1 of 3

Job Number	29402057
Total Depth Drilled (ft)	101.0
Approximate Ground Surface Elevation (ft)	111.0

Elevation (ft) (MLLW)	Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
110	0					SM	**[Older Alluvium / Terrace Deposits]** Silty SAND (SM) Medium dense, moist, brown, few fine gravel, root hairs and roots to 3/8"			
	5		1	10		CL	Silty Lean CLAY (CL) Hard, moist, brown, trace fine gravel	13	114	
						SP	Poorly Graded SAND (SP) with gravel Dense, moist, gray to grayish brown, fine grained sand, fine to coarse gravel, angular to subrounded			
100	10		2	12		SM-GM	Silty SAND (SM) and Well Graded Silty GRAVEL (GM) with sand Medium dense, moist, brown, medium to coarse grained sand, fine to coarse gravel, angular to subrounded			DSCD
	15		3	12		SM-GM		4	107	DSCD
90	20		4	14		SM-GM				
	25		5	12		SM-GM		4	120	
80	30		6	8		SC-CL	Interbedded layers of Silty Lean CLAY (CL) and Clayey SAND (SC) CL: Very stiff, moist, tan, low plasticity SC: Medium dense, moist, reddish brown, fine grained sand, trace fine gravel 8" bed - Well Graded GRAVEL (GW) with silt and sand			
	35		7	8		SC-CL	6" bed - Well Graded GRAVEL (GW) with silt and sand	14	112	
	40									

This log is part of the report prepared by URS for this project and should be read together with the report. This summary applies only at the location of the exploration and at the time of drilling or excavation. Subsurface conditions may differ at other locations and may change at this location with time. Data presented are a simplification of actual conditions encountered.

LOG OF BORING

Santa Monica Bluffs - California Incline
Santa Monica, CA
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Figure A-2

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Santa Monica, CA
FOR: City of Santa Monica

Boring BA-1

Elevation (ft) (MLLW)	Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
70	40	■	8	8		SC-CL				
							24" bed - Well Graded GRAVEL (GW) with silt and sand			
	45	■	9	8		SC-CL		17	105	
60	50	■	10	10			12" bed - Well Graded GRAVEL (GP) with silt and sand			
	55	■	11	8		SC-CL		20	105	
50	60	■	12	22		CL-GW	Interbedded layers of Silty Lean CLAY (CL) and Well Graded GRAVEL (GW) with silt and sand CL: Very stiff, moist, yellowish brown to brown, low plasticity GW: Very dense, moist, brown, fine to coarse gravel, angular to subangular, fine to coarse grained sand			
		☒	BK-1					10	126	
	65	■	13	30		CL-GW				
40	70	■	14	18		CL-GW		4	113	
	75	■	15	18		CL-GW				
30	80	■	16	12		CL-GW				
	85	■	17	34		CL-GW		4	125	
	90									

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Figure A-2

Report: DMG4PALM; Project File: L:\SANTA-MONICA-BLUFFS\CALIFORNIA INCLINE\BUCKET AUGER DRILLING (2009)\BORING LOGS\GINT\SANTA MONICA BLUFFS - CALIFORNIA INCLINE (REV_051109).GPJ; Data Template:DMLA.GDT

Santa Monica, CA

FOR: City of Santa Monica

Boring BA-1

Sheet 3 of 3

Elevation (ft) (MLLW) Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
90 (20)		18	30		CL-GW				
		BK-2							
95		19	64		CL-GW		5	130	
100 (10)		20	50		CL-GW				
						End of boring @ 101 feet Backfill with cement / bemtonite / soil cuttings mix (19 bags bentonite chips / 10 bags cement) No groundwater encountered No seepage encountered 9 drums (55-gallon) of soil cuttings shipped out			
105									
110 (0)									
115									
120 (-10)									
125									
130 (-20)									
135									
140									

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Figure A-2

Report: DMG4PALM; Project File: L:\SANTA-MONICA-BLUFFS\CALIFORNIA INCLINE\BUCKET AUGER DRILLING (2009)\BORING LOGS\GINT\SANTA MONICA BLUFFS - CALIFORNIA INCLINE (REV_051109).GPJ; Data Template:DMLA.GDT

Date(s) Drilled	04/08-09 to 04/09/09	Logged By	E.P
Drilling Method	Bucket-Auger	Drill Bit Size/Type	28-inch auger
Drill Rig Type	EZ-bore	Hammer Data	4800 lbs / 12" drop
Sampling Method(s)	Dames & Moore 'U' Sampler		
Approximate Groundwater Depth and Date Measured	Groundwater @ 108 feet		
Comments			

Boring BA-2

Sheet 1 of 3

Job Number	29402057
Total Depth Drilled (ft)	111.0
Approximate Ground Surface Elevation (ft)	117.0

Elevation (ft) (MLLW)	Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
	0					SP	**[Older Alluvium / Terrace Deposits]** Poorly Graded SAND (SP) with clay Medium dense, moist, brown, fine grained, trace fine gravel, minor porosity, some 1/8" to 1/4" rootlets			
	5		1	8		SP				
110										
	10		2	10		SP		16	110	DSCD
						SM-GM	Silty SAND (SM) and Well Graded Silty GRAVEL (GM) with sand Medium dense, moist, brown, fine to medium grained sand, fine to coarse gravel, trace cobbles up to 9" diameter, angular to subrounded			
	15		3	14		SM-GM				
100										
	20		4	12		SM-GM		4	121	
	25		5	10		SM-GM				
90										
	30		6	12				21	114	
						SC-CL	Silty Lean CLAY (CL) and Clayey SAND (SC) CL: Stiff, moist, brown, low plasticity SC: Medium dense, moist, gray to brown, fine grained sand, trace fine gravel			
	35		7	8		SC-CL				
80										
	40									

This log is part of the report prepared by URS for this project and should be read together with the report. This summary applies only at the location of the exploration and at the time of drilling or excavation. Subsurface conditions may differ at other locations and may change at this location with time. Data presented are a simplification of actual conditions encountered.

LOG OF BORING

Santa Monica Bluffs - California Incline
Santa Monica, CA
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Figure A-3

Report: DMG4PALM; Project File: L:\SANTA-MONICA-BLUFFS\CALIFORNIA INCLINE\BUCKET AUGER DRILLING (2009)\BORING LOGS\GINT\SANTA MONICA BLUFFS - CALIFORNIA INCLINE (REV_051109).GPJ; Data Template:DMLA.GDT

Santa Monica, CA
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Boring BA-2
Sheet 2 of 3

Elevation (ft) (MLLW)	Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
	40		8	10		SC-CL		15	114	
	45		9	12		CL-GW	Interbedded layers of Silty Lean CLAY (CL) and Well Graded GRAVEL (GW) with silt and sand CL: Stiff, moist, brown, low plasticity, trace gravel GW: Very dense, brown, fine to coarse gravel, angular to subangular, fine to coarse grained sand			DSCD
70										
	50		10	16		CL-GW		2	123	
	55		11	24		CL-GW				
60										
	60		12	12		CL-GW		20	106	
	65		13	18		CL-GW				
50										
	70		14	16		CL-GW		14	118	
	75		15	38		CL-GW				
40										
	80		16	28		CL-GW		6	126	
			BK-1							
	85		17	20		CL-GW				
30										
	90									

URS

Figure A-3

Report: DMG4PALM; Project File: L:\SANTA-MONICA-BLUFFS\CALIFORNIA INCLINE\BUCKET AUGER DRILLING (2009)\BORING LOGS\GINT\SANTA MONICA BLUFFS - CALIFORNIA INCLINE (REV_051109).GPJ; Data Template:DMLA.GDT

Santa Monica, CA
FOR: City of Santa Monica

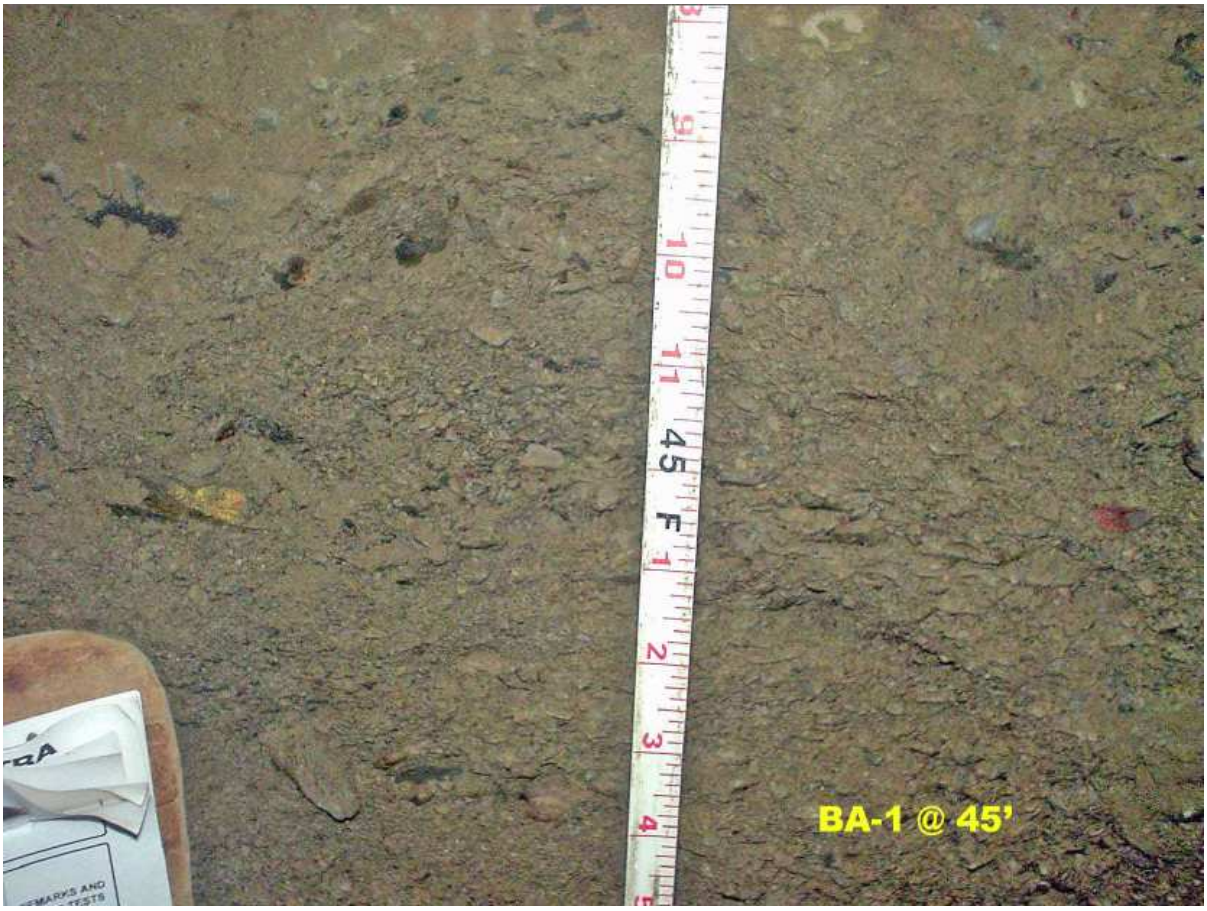
Boring BA-2
Sheet 3 of 3

Elevation (ft) (MLLW)	Depth (ft)	SAMPLES Type	Number	Blows per Foot	Graphic Log	USCS	MATERIAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	OTHER TESTS and REMARKS
	90		18	52		CL-GW		3	119	
	95		19	36		CL-GW				
20										
	100		20	82		CL-GW		5	124	
			BK-2							
	105		21	68		CL-GW				
10							Groundwater @ 108 feet, moderate to heavy seepage. 2 feet of standing water.			
	110		22	58		CL-GW		11	125	
							End of boring @ 111 feet Backfill with cement / bemtonite / soil cuttings mix (21 bags bentonite chips / 10 bags cement) Groundwater encountered @ 108 feet Seepage encountered @ 108 feet 13 drums (55-gallon) of soil cuttings shipped out			
	115									
0										
	120									
	125									
-10										
	130									
	135									
-20										
	140									

URS

Figure A-3

Figure A-4-1



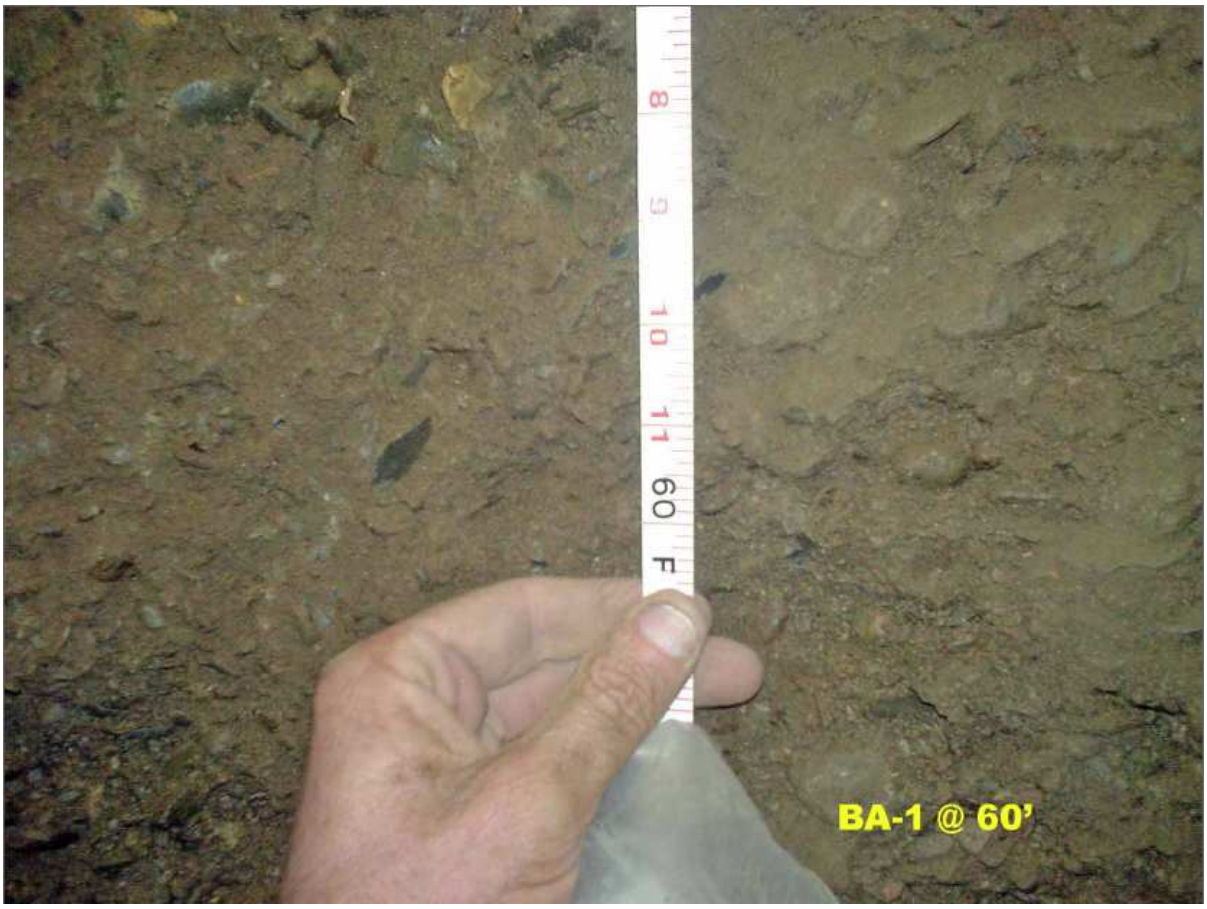


Figure A-4-2

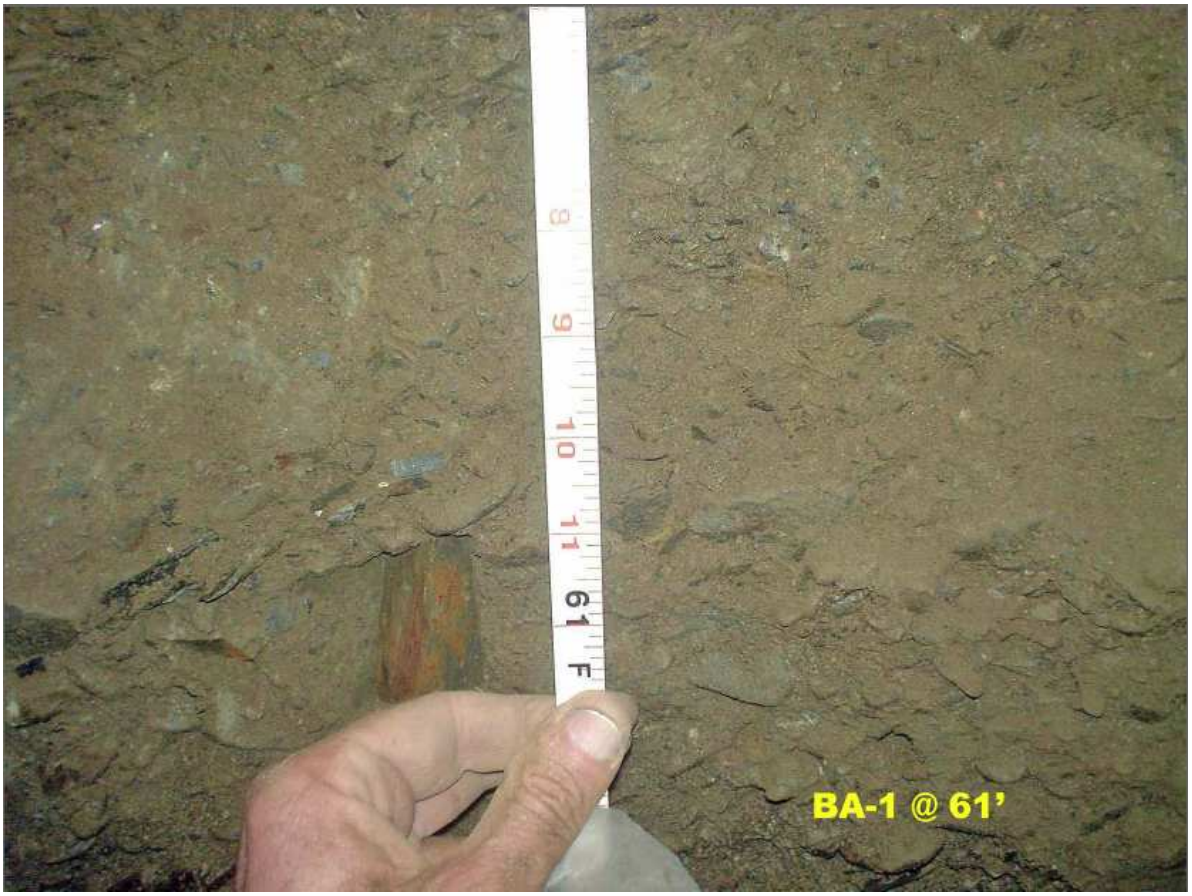
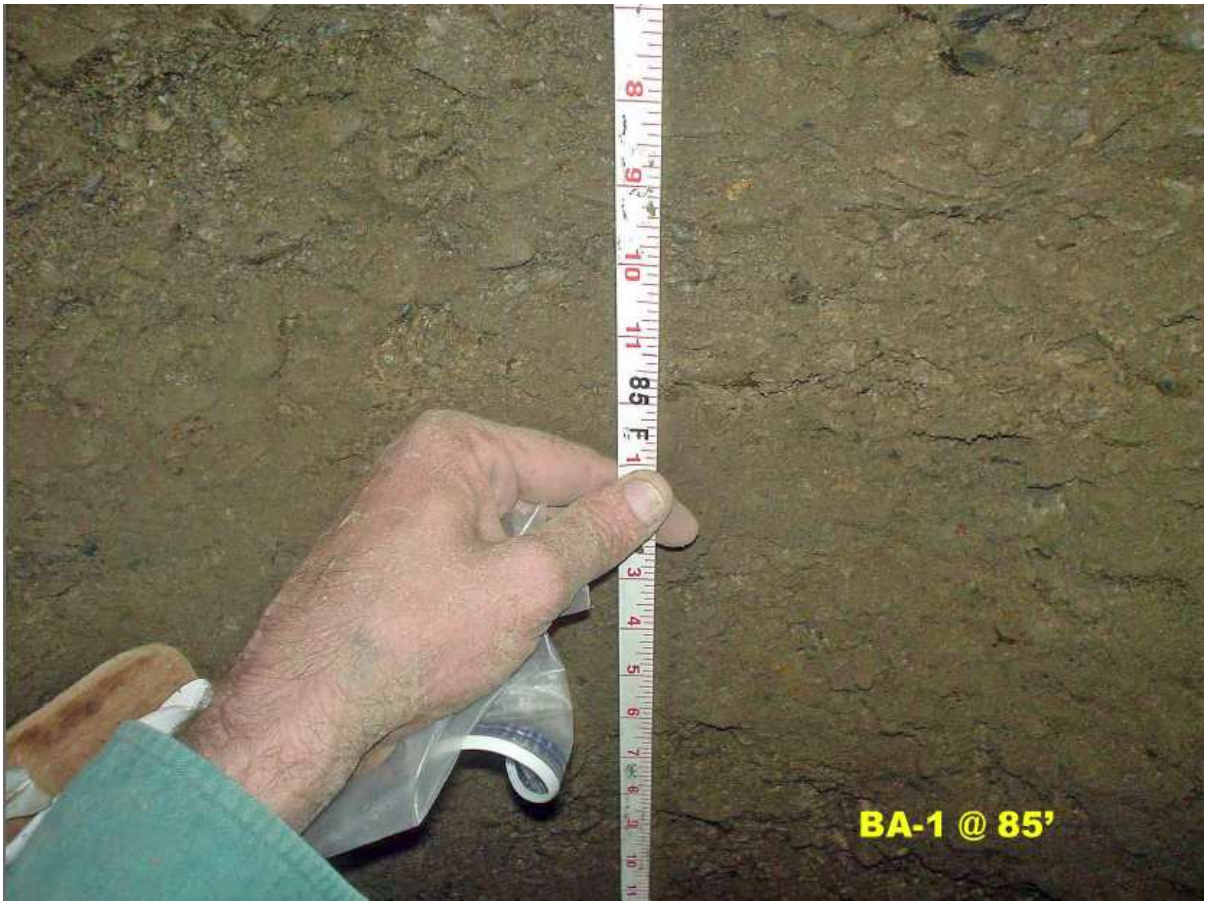


Figure A-4-3



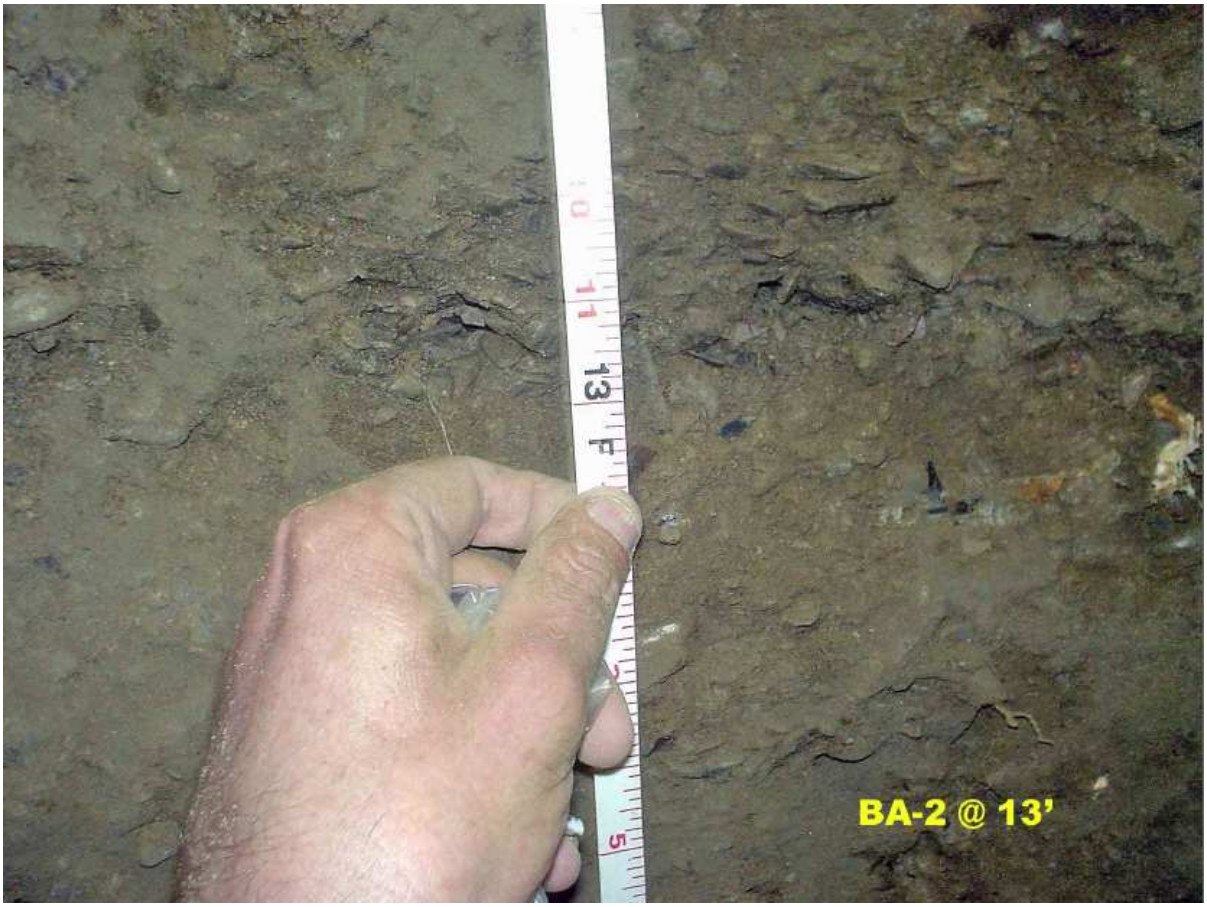


Figure A-4-4

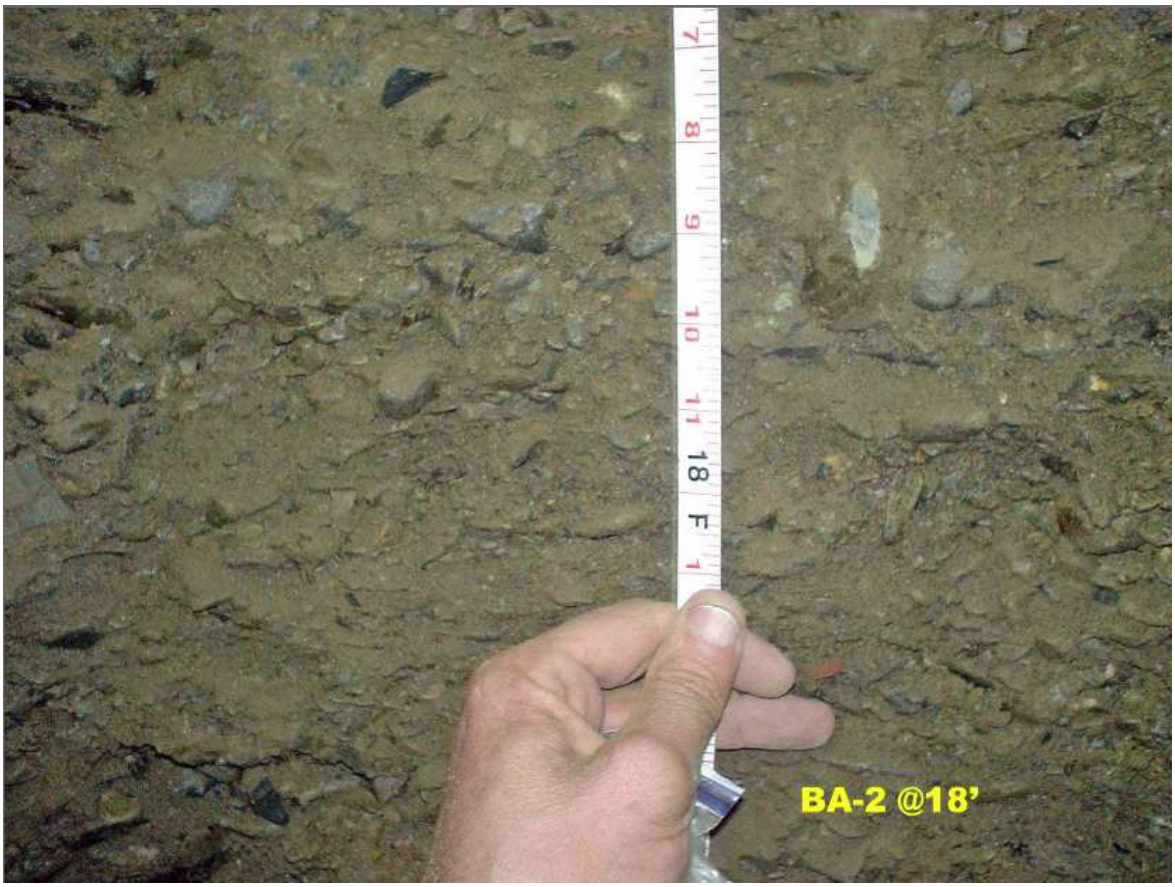


Figure A-4-6

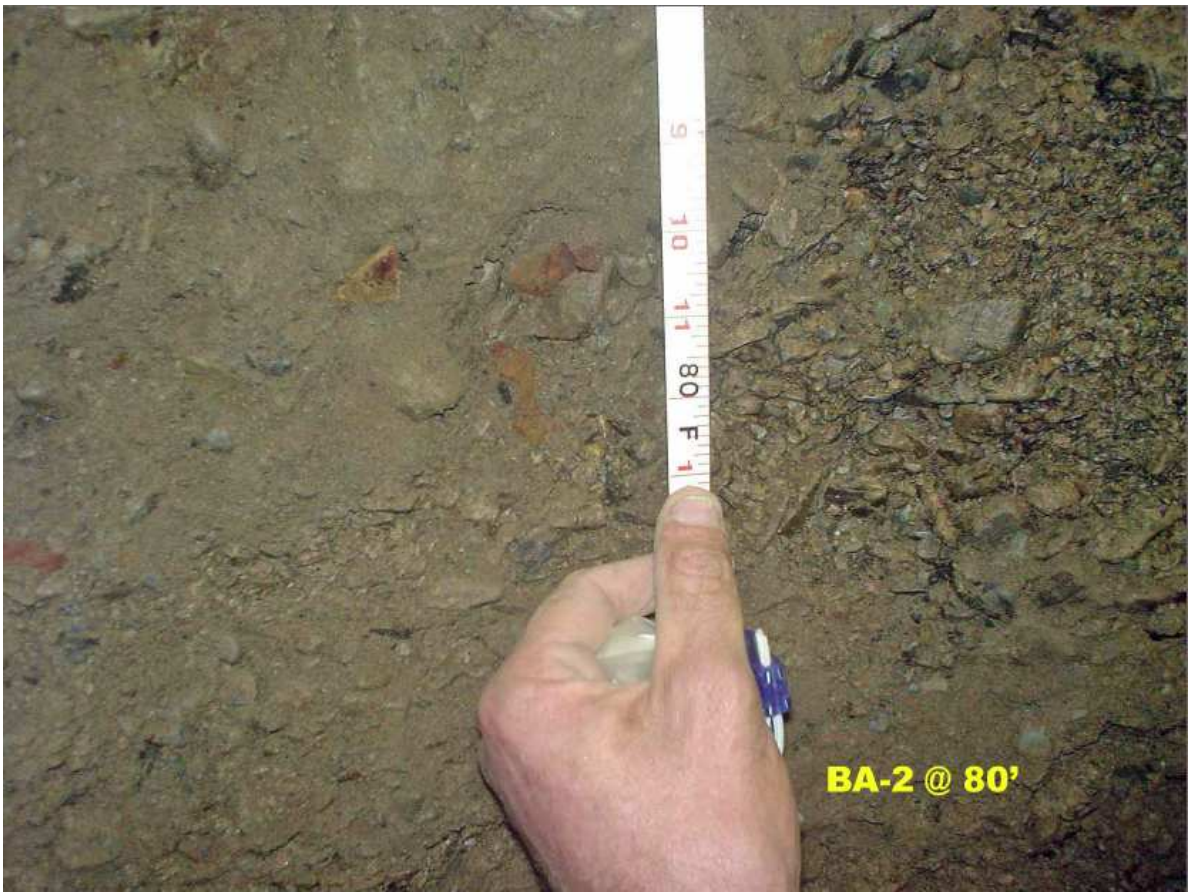
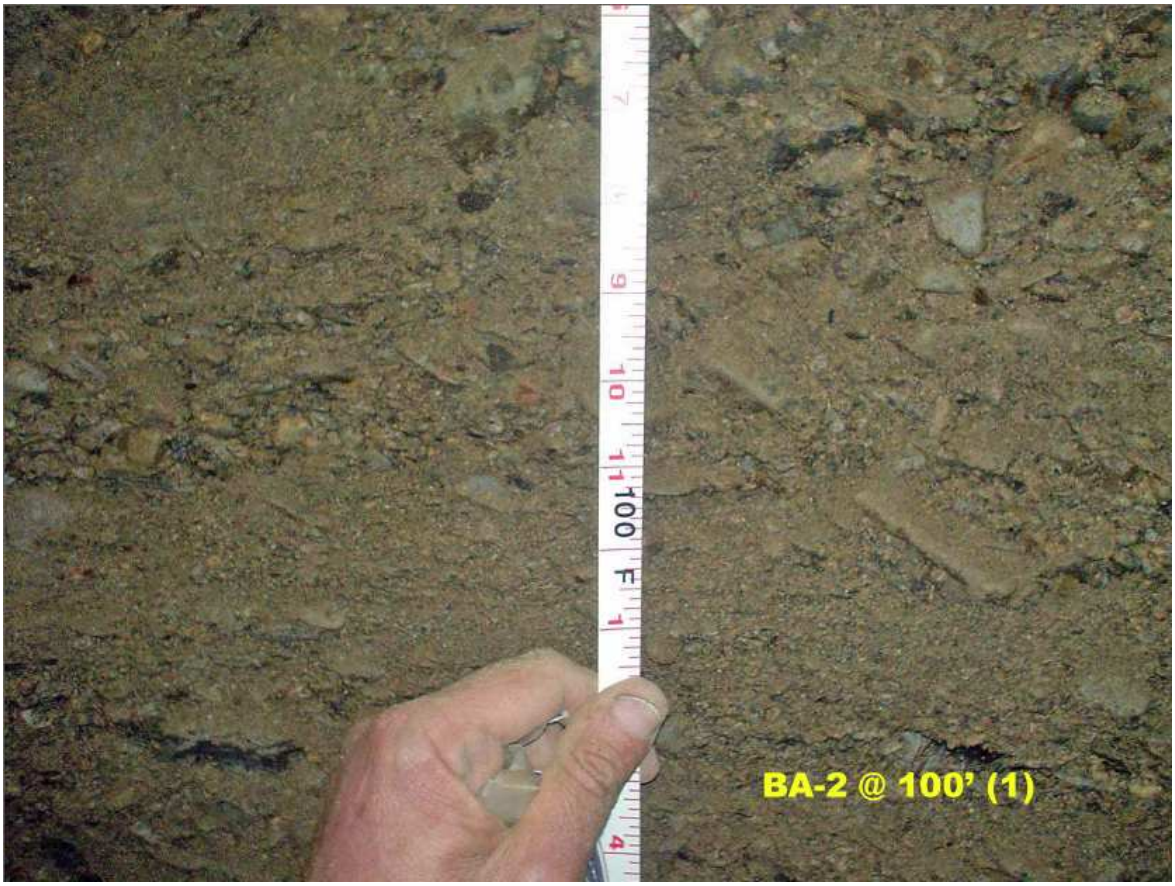


Figure A-4-7



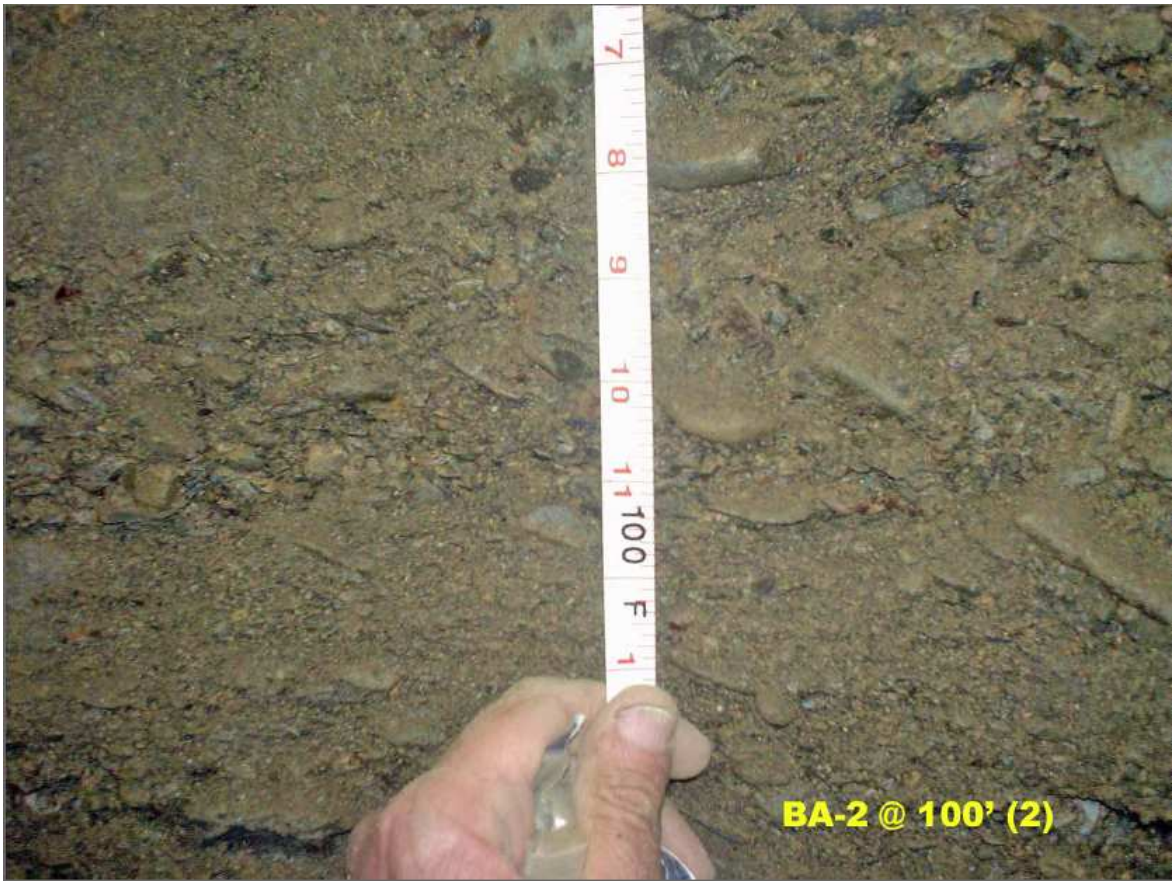
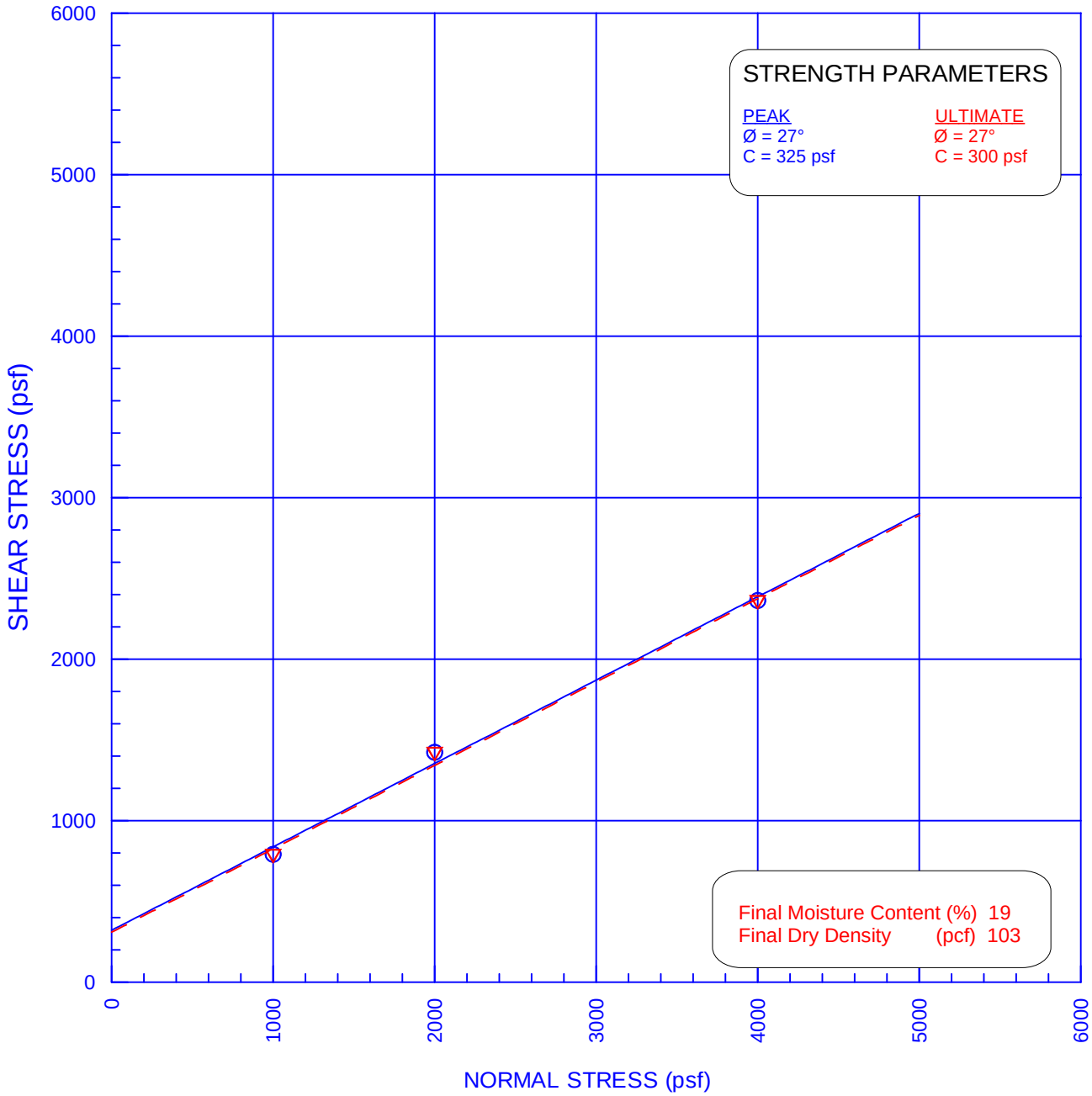


Figure A-4-8

Figure A-4-9

APPENDIX B – SHEAR STRENGTH TEST RESULTS



BORING NO.	SAMPLE NO.	DEPTH (ft)	STRAIN RATE (in/min)	NORMAL STRESS (psf)	PEAK STRESS (psf)	ULTIMATE STRESS (psf)
BA-1	2	10	0.005	1000	○ 792	▽ 780
				2000	○ 1424	▽ 1412
				4000	○ 2364	▽ 2352

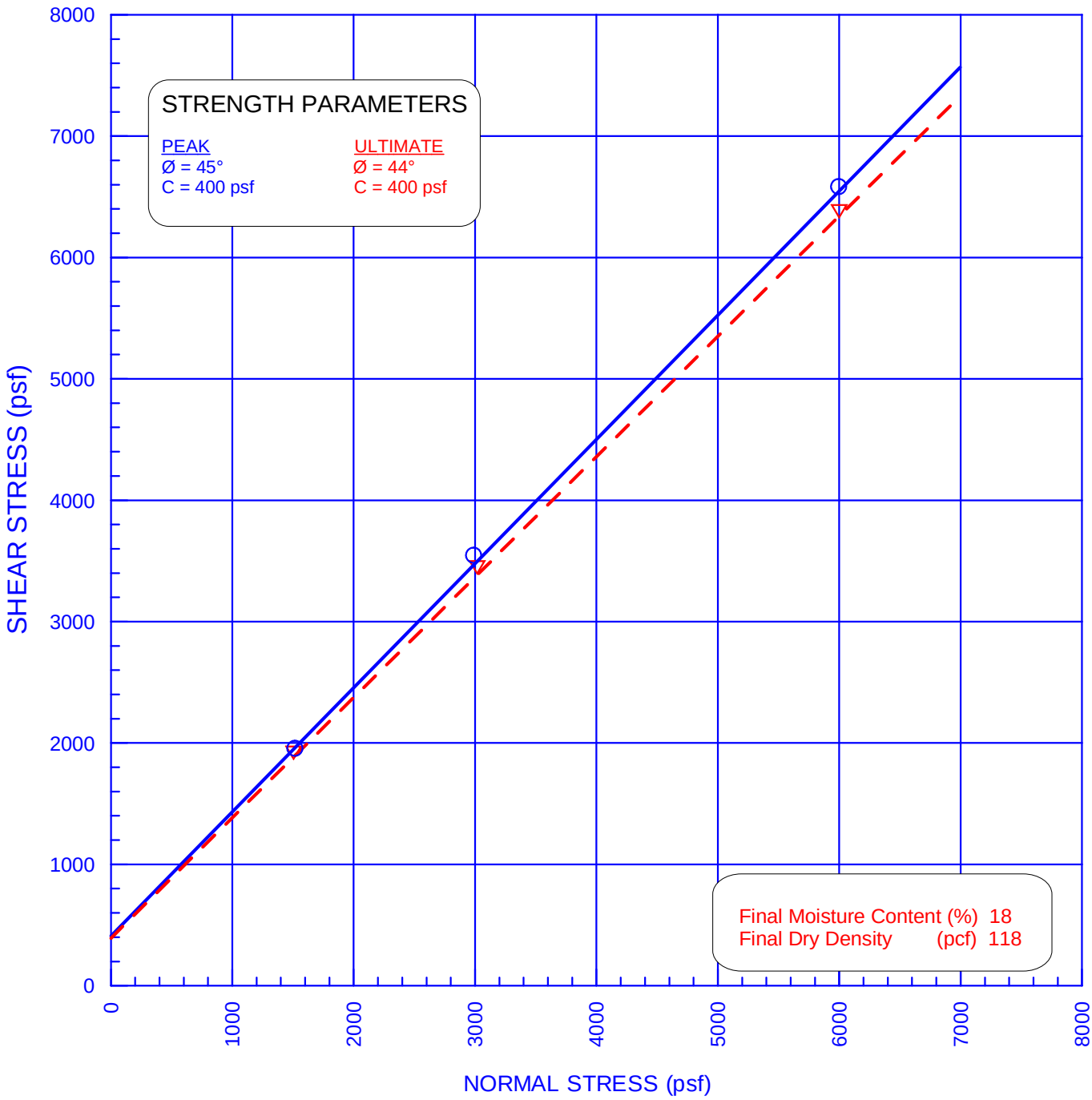
Sample Description: Silty SAND (SM)

DIRECT SHEAR TEST RESULTS
CONSOLIDATED DRAINED
ASTM D 3080

CALIFORNIA INCLINE
SANTA MONICA, CALIFORNIA
FOR: CITY OF SANTA MONICA

URS

FIGURE B-1



BORING NO.	SAMPLE NO.	DEPTH (ft)	STRAIN RATE (in/min)	NORMAL STRESS (psf)	PEAK STRESS (psf)	ULTIMATE STRESS (psf)
BA-1	3	15	0.005	1500	○ 1948	▽ 1907
				3000	○ 3557	▽ 3426
				6000	○ 6581	▽ 6398

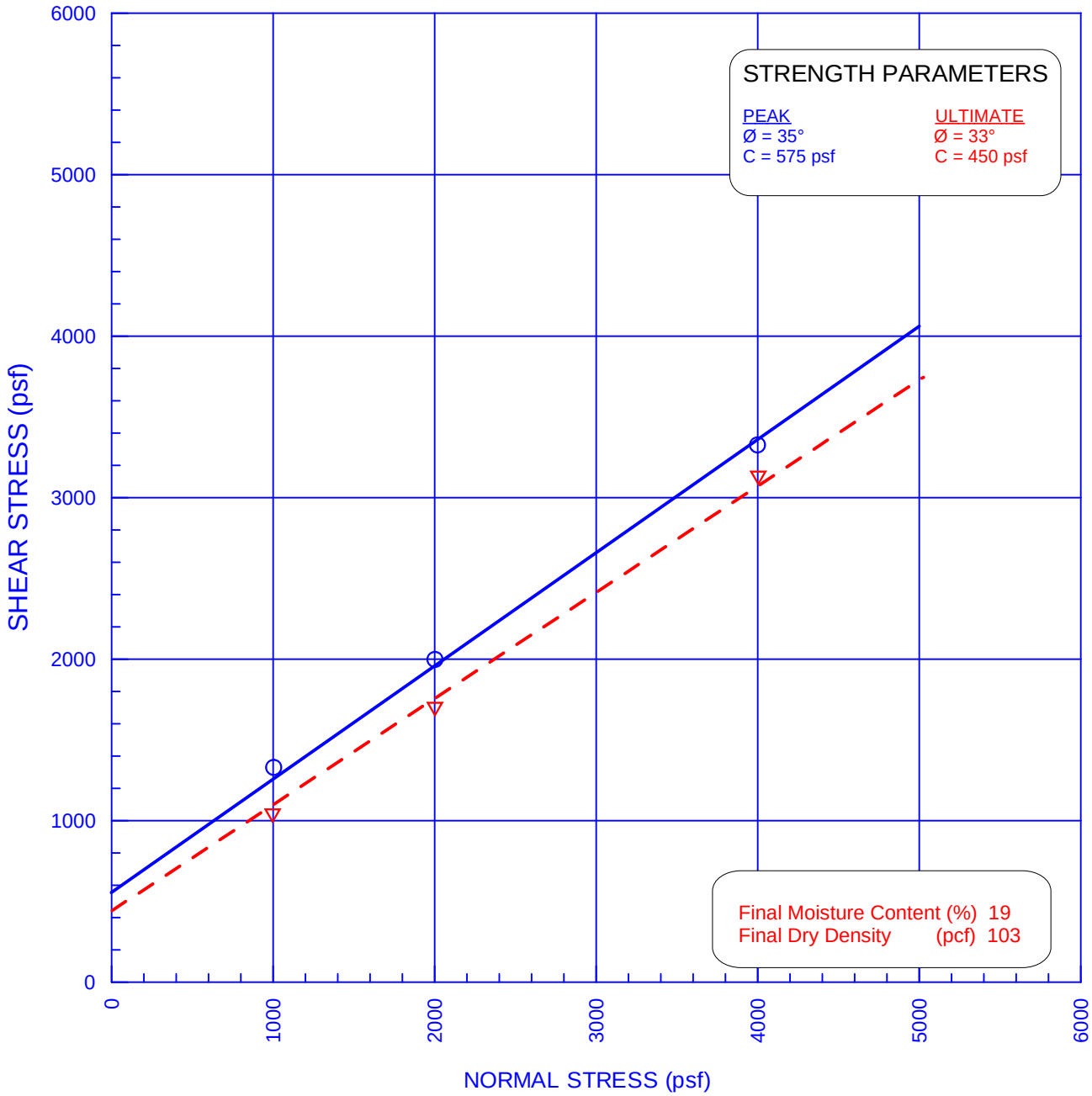
Sample Description: Silty SAND (SM) with gravel

DIRECT SHEAR TEST RESULTS
CONSOLIDATED DRAINED
ASTM D 3080

CALIFORNIA INCLINE
SANTA MONICA, CALIFORNIA
FOR: CITY OF SANTA MONICA

URS

FIGURE B-2



BORING NO.	SAMPLE NO.	DEPTH (ft)	STRAIN RATE (in/min)	NORMAL STRESS (psf)	PEAK STRESS (psf)	ULTIMATE STRESS (psf)
BA-2	2	10	0.005	1000	○ 1308	▽ 1019
				2000	○ 2001	▽ 1703
				4000	○ 3353	▽ 3121

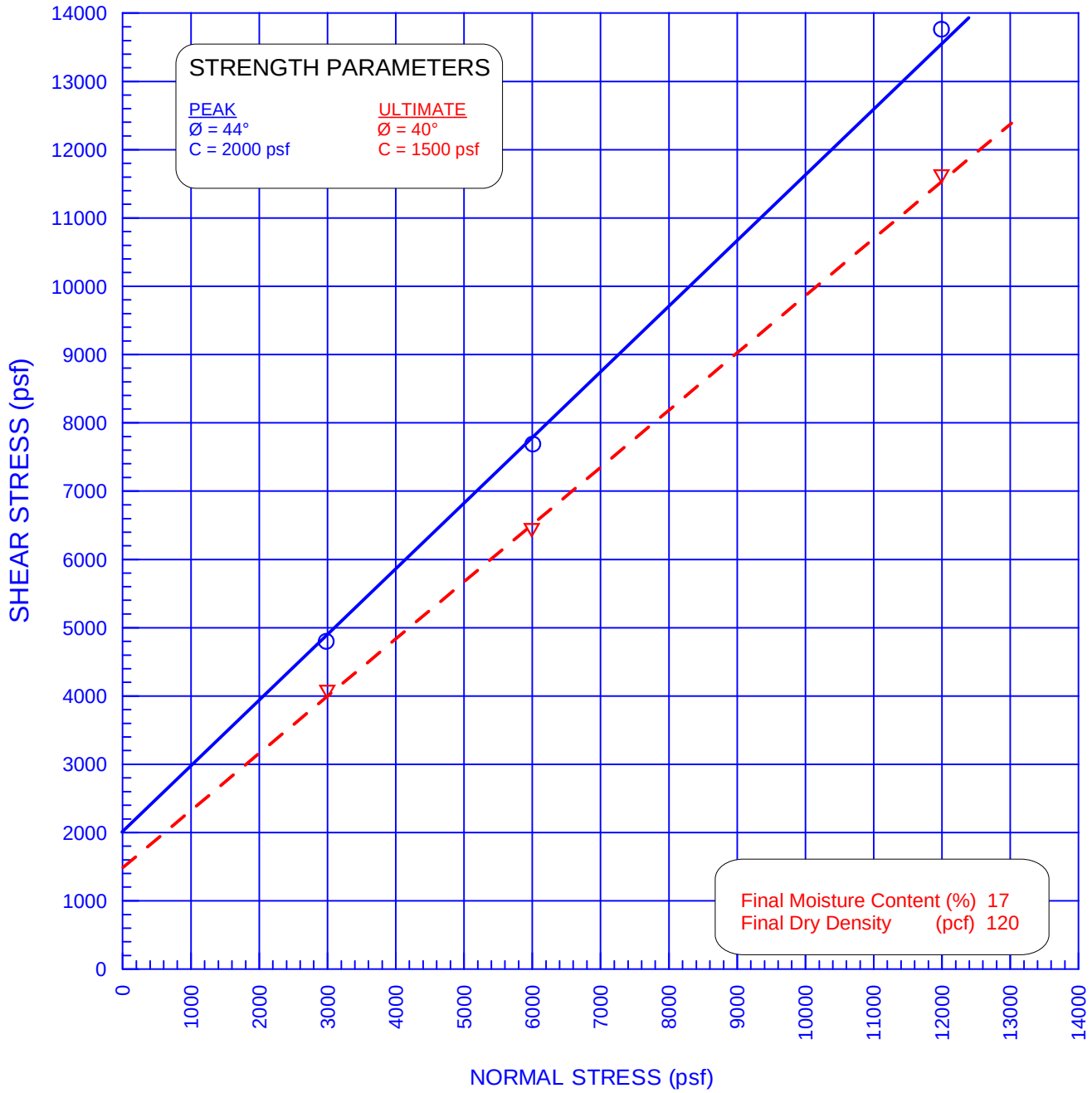
Sample Description: Silty SAND (SM)

DIRECT SHEAR TEST RESULTS
CONSOLIDATED DRAINED
ASTM D 3080

CALIFORNIA INCLINE
SANTA MONICA, CALIFORNIA
FOR:
CITY OF SANTA MONICA

URS

FIGURE B-3



BORING NO.	SAMPLE NO.	DEPTH (ft)	STRAIN RATE (in/min)	NORMAL STRESS (psf)	PEAK STRESS (psf)	ULTIMATE STRESS (psf)
BA-2	11	45	0.005	3000	○ 4802	▽ 4095
				6000	○ 7656	▽ 6479
				12000	○ 13795	▽ 11601

Sample Description: Well Graded GRAVEL with Silt & Sand (GW)

DIRECT SHEAR TEST RESULTS
CONSOLIDATED DRAINED
ASTM D 3080

SANTA MONICA BLUFFS CALIFORNIA INCLINE
SANTA MONICA, CALIFORNIA
FOR: CITY OF SANTA MONICA

URS

FIGURE B-4

XXIII. Appendix B – Bridge Inspection Report

CAL. INCLINE

Bridge Inspection Report

Bridge Key: 53C0543 Agency ID: 53C0543 Sufficiency Rating: 35.8

IDENTIFICATION

State 1: 06 California Struc Num 8: 53C0543
Facility Carried 7: CALIFORNIA INCLINE Location 9: 0.1 MI S PACIFIC COAST H
Rte.(On/Under)5A: Route On Structure Rte. Signing Prefix 5B: 5 City Street
Level of Service 5C: 0 None of the below Rte. Number 5D: 0Q110
Directional Suffix 5E: 0 N/A (NBI) % Responsibility : 0
SHD District 2: District 7 County Code 3: (53) Los Angeles
Place Code 4: 70000 Kilometer Post 11: 00.0 km
Feature Intersected 6: PACIFIC COAST HWY(BLUFF)
Latitude 16: 34d 01' 06" Longitude 17: 118d 30' 12"
Border Bridge Code 98: Not Applicable (P)
Border Bridge Number 99:

INSPECTION

Frequency 91: 24 months Inspection Date 90: 04/15/2008 Next Inspection: 04/15/2010
FC Frequency 92A: NA FC Inspection Date 93A: NA Next FC Inspection: NA
UW Frequency 92B: NA UW Inspection Date 93B: NA Next UW Inspection: NA
SI Frequency 92C: NA SI Date 93C: NA Next SI: NA
Element Frequency: 24 months Element Inspection Date: 04/15/2008 Next Elem. Insp. Due: 04/15/2010

CLASSIFICATION

Defense Highway 100: 0 Not a STRAHNET hwy Parallel Structure 101: No || bridge exists
Direction of Traffic 102: 2 2-way traffic Temporary Structure 103: Not Applicable (P)
Highway System 104: 0 Not on NHS NBIS Length 112: Long Enough
Toll Facility 20: 3 On free road Functional Class 26: 14 Urban Other Princ
Historical Significance 37: 5 Not eligible for NRHP
Owner 22: 4 City/Municipal Hwy Agenc
Custodian 21: 4 City/Municipal Hwy Agenc

STRUCTURE TYPE AND MATERIALS

Number of Approach Spans 46: 0 Number of Spans Main Unit 45: 8
Main Span Material/Design 43A/B:
2 Concrete Continuous 01 Slab
Deck Type 107: 1 Concrete-Cast-in-Place
Wearing Surface 108A: 6 Bituminous
Membrane 108B: 0 None
Deck Protection 108C: 0 None

CONDITION

Deck 58: 6 Satisfactory Super 59: 5 Fair Sub 60: 4 Poor
Culvert 62: N N/A (NBI) Channel/Channel Protection 61: N N/A (NBI)

LOAD RATING AND POSTING

Inventory Rating Method 65: 1 LF Load Factor Operating Rating Method 63:1 LF Load Factor
Inventory Rating 66: MS2.5 Operating Rating 64: MS4.1
Design Load 31: 0 Other or Unknown Posting 70: 0 >39.9% below
Posting status 41: P Posted for load

AGE AND SERVICE

Year Built 27: 1930 Year Reconstructed 106: 0
Type of Service on 42A: 5 Highway-pedestrian
Type of Service under 42B: 0 Other
Lanes on 28A: 2 Lanes Under 28B: 0 Detour Length 19: 03 km
ADT 29: 9,920 Truck ADT 109: 2 % Year of ADT 30: 2004

APPRAISAL

Bridge Rail 36A: 0 Substandard Approach Rail 36C: 0 Substandard
Transition 36B: 0 Substandard Approach Rail Ends 36D: 0 Substandard
Str. Evaluation 67: 3 Intolerable - Correct Deck Geometry 68: 5 Above Tolerable
Underclearance, Vertical and Horizontal 69: N Not applicable (NBI)
Waterway Adequacy 71: N Not applicable Approach Alignment 72: 5 Above Tolerable
Scour Critical 113: N Not Over Waterway

GEOMETRIC DATA

Length Max Span 48: 14.90 m Structure Length 49: 62.80 m
Curb/Sdwlk Wdth L 50A: 1.30 m Curb/Sidewalk Width R 50B: 0.20 m
Width Curb to Curb 51: 12.10 m Width Out to Out 52: 14.30 m
Approach Roadway Width 32: (w/ shoulders) 12.20 m Median 33: 0 No median
Deck Area: 895.00 m²
Skew 34: 0.00 ° Structure Flared 35: 0 No flare
Minimum Vertical Clearance Over Bridge 53: 99.99 m
Minimum Vertical Underclearance Reference 54A: N Feature not hwy or RR
Minimum Vertical Underclearance 54B: 00.00 m
Minimum Lateral Underclearance Reference R 55A: N Feature not hwy or RR
Minimum Lateral Undrclearance R 55: 00.00 m
Minimum Lateral Undrclearance L 56: 99.99 m

PROPOSED IMPROVEMENTS

Bridge Cost 94: Unknown Type of Work 75: Unknown (P)
Roadway Cost 95: Unknown Length of Improvment 76:
Total Cost 96: Unknown Future ADT 114: 11,900
Year of Cost Estimate 97: Unknown Year of Future ADT 115: 2024

NAVIGATION DATA

Navigation Control 38: 0 Permit Not Required
Vertical Clearance 39: 0.00 m Horizontal Clearance 40: 0.00 m
Pier Protection 111: Not Applicable (P) Lift Bridge Vertical Clearance 116: 0.00 m

ELEMENT CONDITION STATE DATA

Str Unit	Elm/Env	Description	Units	Total Qty	% in 1	Qty. St. 1	% in 2	Qty. St. 2	% in 3	Qty. St. 3	% in 4	Qty. St. 4	% in 5	Qty. St. 5
2	13/2	Unp Conc Deck/AC Ovl	sq.m.	1	0 %	0	100 %	1	0 %	0	0 %	0	0 %	0
2	110/2	R/Conc Open Girder	m.	63	57 %	36	40 %	25	3 %	2	0 %	0	0 %	0
2	155/2	R/Conc Floor Beam	m.	47	50 %	24	50 %	24	0 %	0	0 %	0	0 %	0
2	205/2	R/Conc Column	ea.	15	40 %	6	33 %	5	27 %	4	0 %	0	0 %	0
2	331/2	Conc Bridge Railing	m.	61	66 %	40	0 %	0	34 %	21	0 %	0	0 %	0

Bridge Inspection Report

Str Unit	Elem/Env	Description	Element Notes
2	13/2	Concrete Deck - Unprotected w/ AC	
2	110/2	Reinforced Conc Open Girder/Beam	
2	155/2	Reinforced Conc Floor Beam	
2	205/2	Reinforced Conc Column or Pile Ex	
2	331/2	Reinforced Conc Bridge Railing	

BRIDGE NOTES

The bridge is assumed to run from south to north. The bridge was photographed for the file 04/06/06.
A cursory inspection with the aid of binoculars was performed. (4/15/08)
Bridge jurisdiction is 100% City of Santa Monica.
LA County Bridge #2634.

PAST INSPECTION

Inspection Date: 04/15/2008 Type: 1 Regular NBI

Inspector: AGRAJEDA Pontis User Key: AGRAJEDA - Antc

Scope:

NBI: ☑ Other: ☐ Element: ☑

Underwater: ☐ Fracture Critical: ☐

INSPECTION NOTES

AGRAJEDA inspection comments -
Structure 53C0543 -
Date 2008-04-15 -

SEE ADDENDUM TO BRIDGE INSPECTION REPORT.

INSPECTOR WORK CANDIDATES

REGISTERED PROFESSIONAL ENGINEER
RODOLFO RIVERA
C 69995
EXP. 09-30-08
CIVIL
STATE OF CALIFORNIA

Rodolfo Rivera

ADDENDUM TO BRIDGE INSPECTION REPORT:

St. Br. No.: 53C-0543
LA County Br. No. #2634

Date Of Inspection: 04/15/08

CONDITION OF STRUCTURE:

The California Incline is a roadway that cuts into the steep bluffs above Pacific Coast Highway. The east side of the bridge is supported by the bluff while the westside is supported by a longitudinal girder that intermittently spans the recesses in the bluffs. The girders span more than several feet at the five locations. At these locations, the westside of the roadway was constructed as follows:

Continuous reinforced concrete slab and sidewalk on cantilevered reinforced concrete transverse floorbeams supported by reinforced concrete columns. The reinforced concrete columns vary from one to twenty feet in height and are supported by 14' spread footings. (4/87)

Load ratings are from Moffat & Nichol, Engineers report, Job No. 2632, December 1989.

The bridge was inspected according to the 1994 edition of the AASHTO Manual for Condition Evaluation of Bridges and related FHWA reports. Items observed during the visual inspection that appear to affect the condition of the bridge are listed below.

The bridge is in poor condition.

Deck

Potholes up to 0.4m in dia. exist in the asphalt overlay of southbound traffic. (Lane 1-2 each; lane 2-5 each)

Superstructure

The bottom of the cantilevered beam near the longitudinal beam has cracks and spalls exposing rusted rebar. Also, the dirt under the longitudinal beam at area 15 has eroded. (06/12/90)

Substructure

A 13mm gap exists between the top of column one and the bottom of the longitudinal beam. (6/12/90) (For record only)

Columns one thru five have minor rock pockets along the west face. (4/14/87) (For record only)

The fourth column under the longitudinal beam has a crack up to 13mm wide. (6/14/94)

There is a minor area of delamination in the west face of column 9. (04/06/06)

St. Br. No.: 53C-0543
LA County Br. No. #2634 **Date Of Inspection: 04/15/08**

CONDITION OF STRUCTURE (CON'T):

Miscellaneous

Clean the rebar and patch the spalls in the ornamental concrete handrail.

There are cracks up to 6mm wide and spalls with exposed rebar up to 1.8m long and 75mm wide in the ornamental handrail. The condition is more prominent in the south and north sections of rail. (04/15/08)

SIGNS:

Silhouette type signs indicating the weight limits under **"EXISTING POSTING"** are in place at the intersection of both approaches.

EXISTING POSTING:

VEHICLES IN EXCESS OF 6000 LBS. PROHIBITED.

RECOMMENDED LOAD POSTING:

Maintain existing posting.

WORK NOT DONE:

Superstructure

Clean the rebar and patch the spalls and rock pockets exposing rebar.

Clean the rebar and patch the spalls exposing rebar on the bottom of the cantilever beam next to the longitudinal beam at location 15.

Substructure

Epoxy inject the crack at the top of the fourth column.

Miscellaneous

Clean the rebar and patch the spalls in the ornamental concrete handrail.

WORK RECOMMENDED:

Do the work listed under **"WORK NOT DONE."**