FINAL FOUNDATION REPORT

Retaining Wall 349
Orange County, California
12-ORA-5, PM 6.62
Caltrans Project No. 1200020279 (EA 12-0F96E4)
EMI Project No. 11-137
Date: October 5, 2012

EARTH MECHANICS, INC.

Geotechnical and Earthquake Engineering

Earth Mechanics, Inc.
Geotechnical & Earthquake Engineering

October 5, 2012

EMI Project No. 11-137

TRC Solutions, Inc.
123 Technology Drive West
Irvine, California 92618

Attention: Dr. Ayman Salama, P.E.

Subject: Final Foundation Report for Retaining Wall 349
Orange County, California
12-ORA-5, PM 6.62
Caltrans Project No. 1200020279 (EA 12-0F96E4)

Dear Dr. Salama:

Attached please find the Final Foundation Report for the subject retaining wall. This report contains the findings and conclusions of our field investigation and laboratory testing program. This report also contains our recommendations for the design and construction of the bridge foundations.

Earlier versions of this report dated August 13, 2012 and April 23, 2012 were submitted to Caltrans for review. Caltrans provided their comments in a memorandum dated September 5, 2012 and August 1, 2012. Caltrans review comments and EMI responses are included in Appendix D. Our responses to all the review comments have been incorporated into this report.

We appreciate the opportunity to provide geotechnical design services for this project. If you have any questions, please call us.

Sincerely,

EARTH MECHANICS, INC.

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FINAL FOUNDATION REPORT

RETAINING WALL 349
ORANGE COUNTY, CALIFORNIA
12-ORA-5, PM 6.62
CALTRANS PROJECT NO. 1200020279 (EA 12-0F96E4)

Prepared for:

TRC Solutions, Inc.
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EMI Project No. 11-137

October 5, 2012

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF STUDY

This Foundation Report presents the findings and conclusions of a geotechnical investigation conducted by Earth Mechanics, Inc. (EMI). It presents foundation design and construction recommendations for the proposed Retaining Wall 349 located in front and on both sides of Abutment 1 of the existing Via California Overcrossing (OC) (Bridge No. 55-0225). A site location map is presented in Figure 1-1.

EMI is a subconsultant to TRC Solutions, Inc. (TRC). The geotechnical services provided for this project included the following tasks:

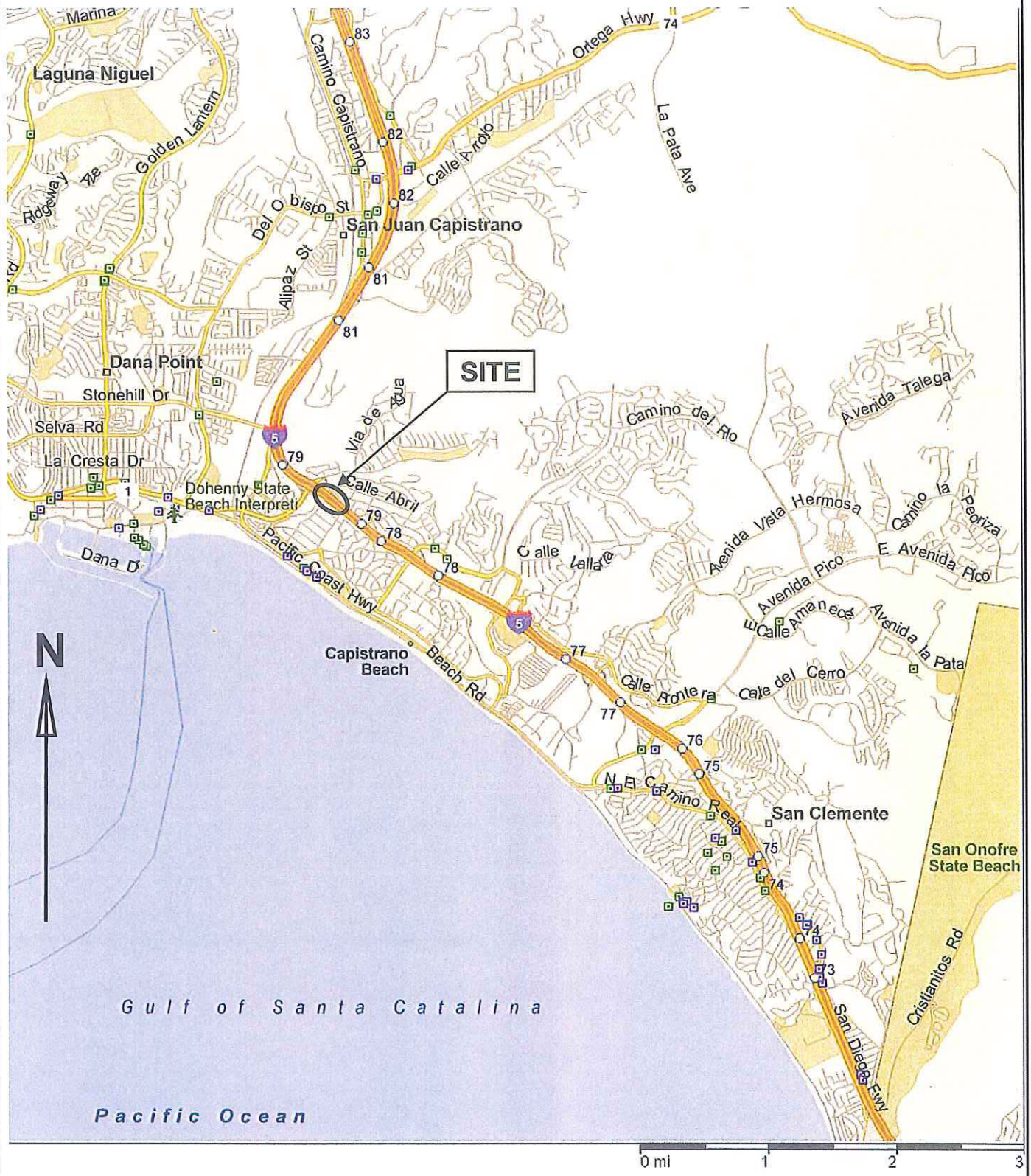
- Collection and review of existing geotechnical information;
- Field exploration consisting of drilling and logging exploratory borings;
- Laboratory testing of selected bulk and relatively undisturbed soil samples;
- Engineering calculations and analysis to develop foundation design and construction recommendations; and
- Preparation of this report presenting our findings, conclusions, and recommendations.

1.2 PROJECT DESCRIPTION

The California Department of Transportation (Caltrans), in cooperation with the Orange County Transportation Authority (OCTA) and the cities of Dana Point and San Juan Capistrano, proposes to improve the I-5 corridor. The project's southern terminus is approximately 0.6 mile south of the PCH/Camino Las Ramblas Interchange (I-5 Mainline Station 340+00) in the City of Dana Point. The northern terminus of the project is approximately 0.2 mile south of San Juan Creek Road (I-5 Mainline Station 465+00) in the City of San Juan Capistrano. The total project length along the I-5 corridor is approximately 2.5 miles. However, according to the Project Report prepared in October 2011, the proposed project improves the I-5 corridor from I-5 Mainline Stations 340+00 (southern project limit) to 407+50. From I-5 Mainline Stations 407+50 to 465+00 (northern project limit), the proposed project will consist primarily of restriping the existing pavements only.

The proposed Retaining Wall 349 is approximately 1315 feet long with a maximum wall height of 26 feet. The portion of the proposed wall within the limits of the Via California OC is a tieback wall. Soil nail walls are proposed outside the Via California OC limits.

The existing Via California OC was constructed in 1960 and consists of a six-span bridge. The abutments and bents are supported on spread footings. A tieback wall was installed at Abutment 7 in 1973. The bridge also received an earthquake retrofit in 1997. Soundwall No. 105 was constructed just south of the Via California OC along Via Lopez on top of the slope in 2001.



Retaining Wall 349

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SITE LOCATION MAP

Figure 1-1

Project No. 11-137 | Date: 03-20-12

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 FIELD INVESTIGATION

A geotechnical field investigation was conducted between September 27 and October 4, 2011. Three soil borings and two cone penetration test (CPT) soundings were performed under the supervision of EMI. Boring information, including surveyed locations and elevations, are summarized in Table 2-1. Locations of the borings and CPTs are shown on the LOTB sheets provided in Appendix A.

Table 2-1. Geotechnical Exploration Information

Boring/ CPT	Easting	Northing	Station (A-Line) (feet)	Offset (feet)	Top of Boring Ele. (feet)	Bottom of Boring Ele. (feet)	Ground Water Ele. (feet)	Drilling Method
CPT-11-309	6,129,956	2,115,431	352+05	77 Lt	+201.9	+189.3	NM	CPT
A-11-310	6,129,685	2,115,561	354+96	152 Lt	+225.9	+184.4	NE	HSA
CPT-11-311	6,129,491	2,115,811	358+05	86 Lt	+199.3	+189.3	NM	CPT
A-11-312	6,129,110	2,116,072	362+65	131 Lt	+184.9	+133.4	NE	HSA
A-11-313	6,129,322	2,115,848	359+58	166 Lt	+225.6	+174.1	NE	HSA

Notes:
(1) A-Line = I-5 Mainline; NE = Not Encountered; NM = Not Measured.
(2) CPT = Cone Penetration Test; HSA = Hollow-Stem Auger.

Borings were drilled using a truck-mounted drill rig equipped with 8-inch diameter hollow-stem augers. Sampling was performed by alternating the Modified California Drive (MCD) sampler and Standard Penetration Test (SPT) sampler. The soil sampling interval was generally 5 feet.

Relatively undisturbed soil samples were obtained using a 3.25-inch outer diameter MCD sampler lined with brass rings. Each of these brass rings is 1-inch long with a 2.5-inch outside diameter. The SPT sampler (1.4-inch inside diameter) was also used to obtain soil samples. The MCD and SPT samplers were driven 18 inches into the ground or until refusal was encountered using a 140-lb hammer free falling from a height of 30 inches. Automatic hammer were used to drive samplers in the truck-mounted drill rig. The numbers of blows to advance the sampler each 6 inches of penetration were recorded. The number of blows for the final 12 inches or shorter of driving was recorded on the boring logs and LOTB sheets. Charts published by Winterkorn and Fang (1975) can be used to determine a reduction factor used to convert blowcounts recorded using the modified California Drive sampler into SPT blowcounts. Using those charts, we obtained a reduction factor of 0.5 which was used for this project.

The CPT sounding was performed using an electronic cone penetrometer in general accordance with current ASTM Standards (ASTM D5778 and ASTM D3441). The CPT equipment consisted of a cone penetrometer assembly mounted at the end of a series of hollow sounding rods. The cone penetrometer assembly consisted of a conical tip with a 60° apex angle and a

projected cross sectional area of 1.55 in² (10 cm²) and a cylindrical friction sleeve with a surface area of 23.25 in² (150 cm²). The interior of the cone penetrometer is instrumented with strain gauges that allow simultaneous measurements of cone tip and friction sleeve resistance during penetration. The cone penetrometer assembly is continuously pushed into the soil by a set of hydraulic rams at a standard rate of 0.79 inch per second (20 mm per second) while the cone tip resistance and sleeve friction resistance are recorded every 1.967 inches (50 mm) and stored in digital form. A specially designed all-wheel drive 25-ton truck provides the required reaction weight for pushing the cone assembly and is also used to transport and house the testing equipment. The computer generated graphical logs include tip resistance, friction resistance, and friction ratio. Soil behavior type interpretations are based on guidelines by Robertson and Campanella (1989).

2.2 LABORATORY TESTING

Soil samples considered representative of the subsurface conditions were tested to obtain or derive relevant physical and engineering soil properties. The following laboratory tests were conducted to supplement the observations recorded during the field investigation:

- In-situ Moisture Content and Unit Weight
- Percent Passing No. 200 Sieve
- Direct Shear
- Unconsolidated Undrained Triaxial
- Consolidation
- Minimum Resistivity, pH, Sulfate Content and Chloride Content

The laboratory tests were conducted in general accordance with California Test Methods or American Society for Testing and Materials (ASTM) Standards. Laboratory test results are included in Appendix B.

3.0 GEOLOGY AND SEISMICITY

3.1 PHYSIOGRAPHY

The project area is in the northwestern part of the Peninsular Ranges physiographic province. The Peninsular Ranges comprise a northwest-southeast trending group of fault-bounded ranges between the Salton Trough and the Pacific Ocean. The Santa Ana Mountains, Puente Hills, and San Joaquin Hills are ranges within the Peninsular Ranges.

The site is located on the low lying rolling hills westerly of the Santa Ana Mountains at the southerly end of the San Joaquin Hills in an area referred to as the Capistrano Embayment.

3.2 GEOLOGIC STRUCTURE

The geological structure at the site consists of slightly to moderately folded bedrock of the Capistrano formation overlain by horizontally bedded Quaternary terrace deposits and alluvium without any notable geological structures such as faults, folds, or unconformities. The northerly portion of the project is underlain by deposits of the McCracken Hill landslide which is described in Section 3.3.

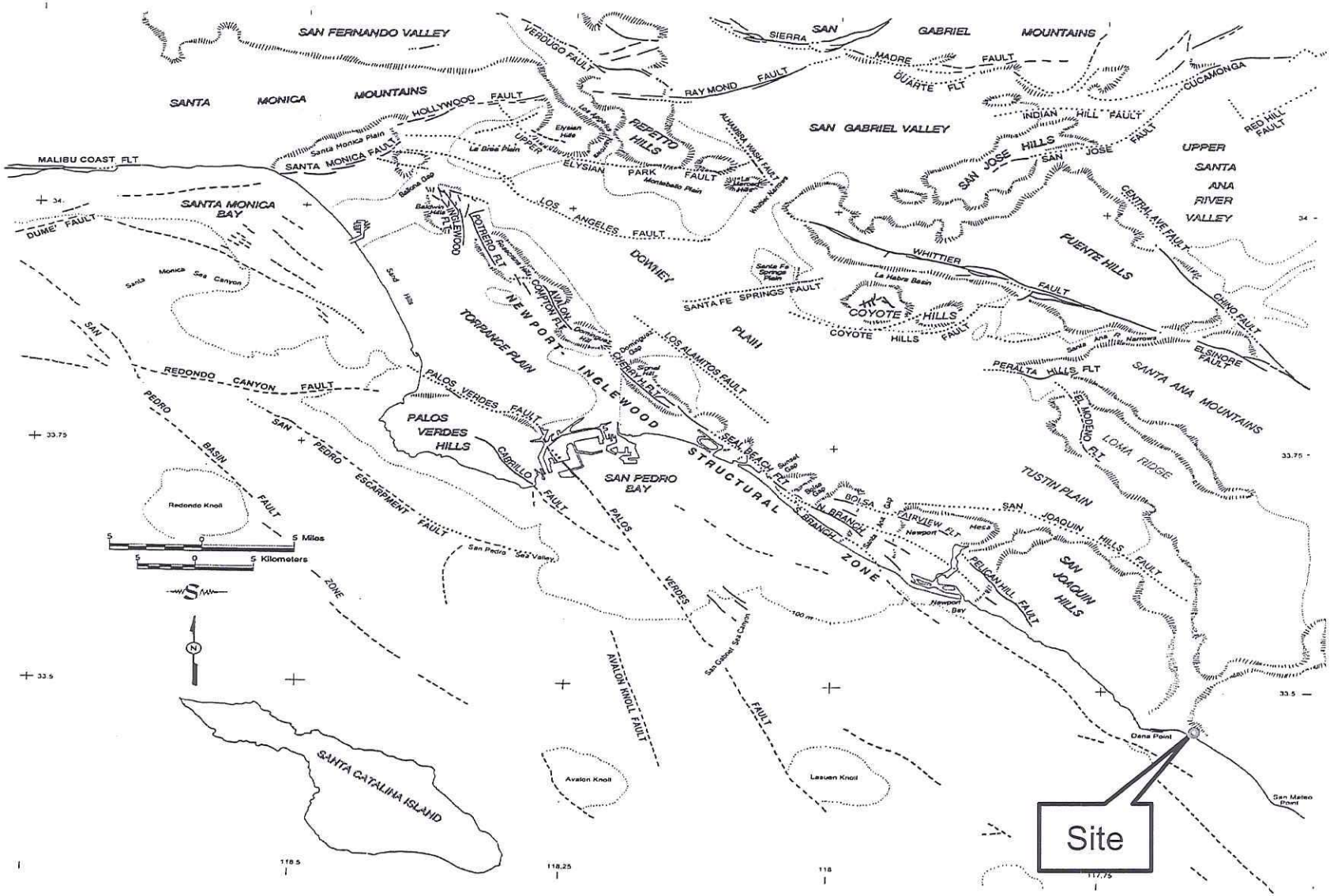
The Capistrano Formation is widespread throughout the southern part of Orange County, which is known geologically as the Capistrano Embayment. The Capistrano Embayment is the name given to the structural/stratigraphic block west of the Cristianitos Fault. Geologic faults in the region are shown on Figure 3-1. Geological structure in the Capistrano Embayment area consists primarily of a broad, gentle syncline of the Monterey and Capistrano Formations between the San Joaquin Hills and the Santa Ana Mountains. This structure originated as a deep submarine structural trough that has since been uplifted at least 3000 feet from the marine environment to its present position above sea level (Ehlig, 1989). Subsequent regional uplift during the late Pliocene and Pleistocene time resulted in folding of the bedrock units.

The bedrock of the Capistrano Formation underlying the site was found to be massive to poorly bedded. Where bedding was observed, the strikes were generally to the northeast with shallow dips less than about 10 degrees westerly. Throughout the project corridor, the dominant structural pattern is high-angle joints and fractures within the Capistrano bedrock.

Pleistocene Terrace Deposits unconformaly overlie the Capistrano Formation. The contact is generally undulatory, with a slight overall dip seaward averaging about 2 degrees. This erosional contact is marked by cobble and boulder rich beds of varying thicknesses.

3.3 GEOLOGIC HAZARD

The geological hazards present at the site include earthquake shaking and landsliding. The site lies outside identified tsunami inundation zones (CGS, 2009), and there are no large bodies of water within the site area that could generate a seiche. There are no volcanos in the region and there are no known active surface faults within the project area so ground rupture is not a factor. As shown in Figure 3-2, the California Geological Survey (CGS, 2001a) has indicated that the project alignment has a low susceptibility to liquefaction during a strong earthquake. The potential for liquefaction is discussed in detail in Section 5.2.



Retaining Wall 349

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REGIONAL MAP OF ACTIVE FAULTS AND PHYSIOGRAPHY

Figure 3-1

Project No. 11-137

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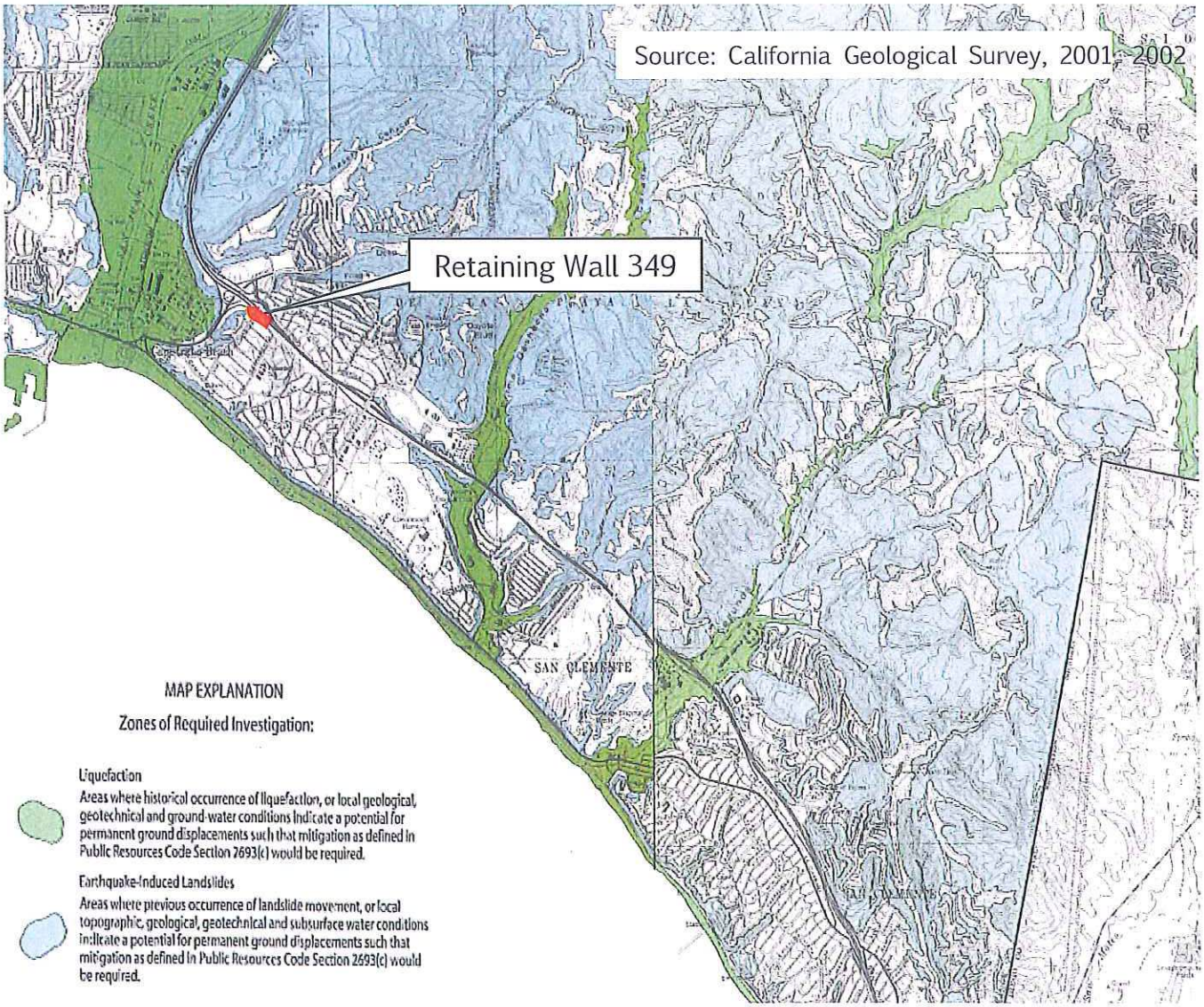


Retaining Wall 349	MAP OF LIQUEFACTION POTENTIAL
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 3-2
	Project No. 11-137 | Date: 03-01-12

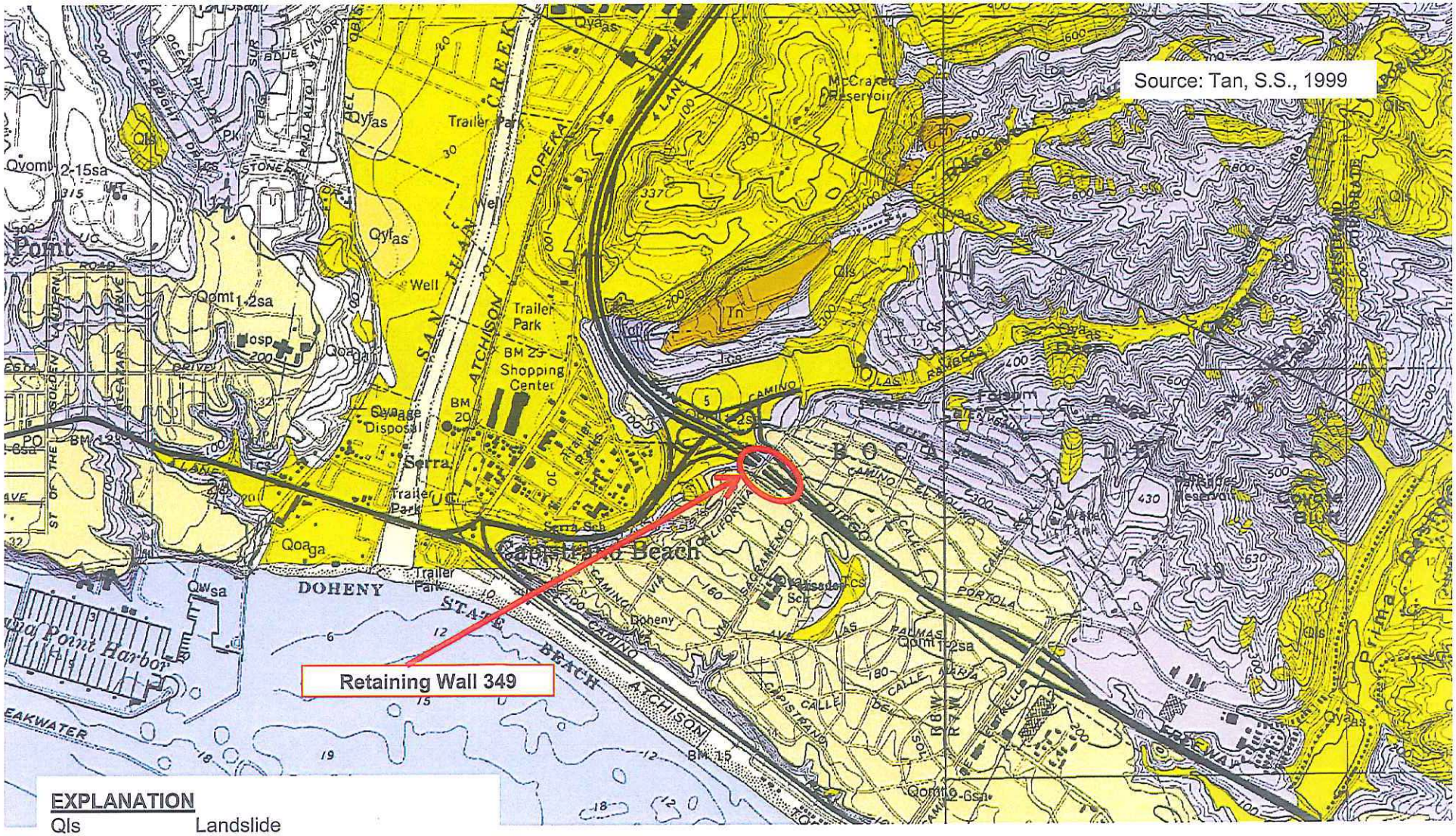
The Capistrano Formation bedrock underlying the majority of the site is notoriously susceptible to landsliding. The landslides are shown in Figure 3-3. At the north of PCH/Camino Las Ramblas Interchange, the I-5 alignment traverses the McCracken Hill Landslide. The remnant headscarp of this ancient landslide is defined by a west to northwest facing slope that extends for about 7000 feet on the eastern side of the I-5 Freeway (AMEC, 2006a and 2006b). It is believed that the landslide occurred between 11,000 to 30,000 years ago when the sea level was lower than present day and San Juan Creek carved a deep channel on its course to the Pacific Ocean. During the Pleistocene, the climate was considerably wetter than present day and this combined with the loss of support at the toe of the slope due to erosion by San Juan Creek are believed to have been causative factors in the landslide failure. Since the landslide failure, a considerable thickness of alluvium has infilled the ancestral San Juan Creek channel with deposits more than 130 feet thick forming a natural buttress for the landslide mass. Extensive investigations of the landslide performed by Leighton and Associates (Leighton, 2004) and AMEC (AMEC, 2006a, 2006b, and 2000a through 2000e) in conjunction with proposed residential developments in the area indicate that the landslide is stable.

In addition, a smaller landslide is present along the PCH NB on-ramp to I-5 SB. The slope ascending from the PCH NB on-ramp to I-5 SB is underlain by Quaternary Terrace Deposits overlying bedrock of the Capistrano Formation. A landslide measuring approximately 150 feet wide by 300 feet long was observed on this slope during field mapping. Research of files at the City of Dana Point did not reveal any geologic reports relating to the landslide or details of when it occurred. Based on the geomorphology of the slide it appears to have been a shallow failure involving the Terrace Deposits and possibly the weathered upper portion of the underlying bedrock. It is estimated the landslide is likely less than about 30 feet deep.

Bedrock exposures along Via Canon (southwesterly of the landslide, outside the limits of the geologic map) indicate that the bedding is variable but generally dips south to southeast at angles ranging from 5 to 22 degrees. This bedding orientation is generally considered favorable to the gross stability of the slope. Proposed grading performed in conjunction with the project is not considered to have an impact on this landslide.

3.4 SEISMICITY

The project is in seismically active Southern California. The present-day seismotectonic stress field in the Los Angeles region is one of north-northeasterly compression. This is indicated by the geologic structures, earthquake focal-mechanism solutions, and geodetic measurements. These data suggest crustal shortening of between 0.2 and 0.35 inch per year across the greater Los Angeles area (Argus et al., 1999).



Retaining Wall 349	**GEOLOGICAL MAP**
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Figure 3-3
Project No. 11-137	Date: 03-01-12

Historical earthquake epicenter maps show widespread seismicity throughout the region. Although historical earthquakes occur in proximity to known faults, they are difficult to directly associate with mapped faults. Part of this difficulty is due to the fact that the basin is underlain by several poorly known subsurface thrust faults, generally referred to as blind thrust faults. Ward (1994) estimated that about 40 percent of seismic moment cannot be associated with known faults. Earthquakes occur primarily as loose clusters along the Newport-Inglewood Structural Zone (NISZ), the southern margin of the Santa Monica Mountains, the margin between the Santa Susana-San Fernando Valley and the southern margin of the San Gabriel Mountains, and in the Coyote Hills-Puente Hills area. There is no clustering or alignment of earthquakes in proximity to the site. There are fewer earthquakes in the site region than anywhere else in the Los Angeles Basin area. This apparent lack of earthquake activity suggests that the site area is tectonically stable and suggests that there are no unrecognized active faults at the site.

The largest historical earthquake within the Los Angeles Basin was the 1933 Long Beach event which had a moment magnitude (M_W) of about 6.4 (M_L = 6.3). This earthquake did not rupture the surface but is believed to have been associated with the NISZ (Benioff, 1938). The association was based on abundant ground failures along the NISZ trend but no unequivocal surface rupture was identified. Reevaluation of the seismicity data by Hauksson and Gross (1991) relocated the 1933 earthquake hypocenter to a depth of about 6 miles below the Huntington Beach-Newport Beach city boundary.

Other major earthquakes in the region include the 1994 Northridge and the 1971 San Fernando earthquake both of which occurred in the San Fernando Valley region. The 1994 earthquake had a M_W of about 6.7 (M_S = 6.8, M_L = 6.4), and occurred on a southerly dipping subsurface fault which was unknown prior to the earthquake. The main shock occurred at a depth of about 12 miles. Earthquake aftershocks clearly defined the rupture surface dipping about 35 degrees southerly from a depth of about 1.2 or 1.9 miles to 14 miles (Hauksson et al, 1995). The causative fault was never identified with certainty. The event may have occurred on an eastern extension of the Oakridge fault (Yeats and Huftile, 1995), a southerly dipping feature fault bounding the Ventura Basin and the Santa Susana Mountains.

The 1971 San Fernando earthquake was of similar size (M_W = 6.7, M_S = 6.4, M_L = 6.4) to the 1994 event but did involve surface rupture. The 1971 event occurred on a northerly dipping thrust fault that dips from the northern side of the San Fernando Valley to a depth of about 9 miles under the San Gabriel Mountains. Several mapped surface faults were involved such as the Sylmar fault, Tujunga fault, and Lakeview fault. These faults are commonly considered to be part of the Sierra Madre fault system which extends easterly from the San Fernando Valley, along the base of the San Gabriel Mountains on the north side of the San Gabriel Valley, and to the Cucamonga fault in the San Bernardino area.

The 1987 Whittier earthquake (M_L = 5.9, M_W = 5.9) occurred on a subsurface fault dipping under the Puente Hills to about 10 miles beneath the San Gabriel Basin (Shaw and Shearer, 1999; Shaw et al., 2002). This event did not rupture the ground surface.

A magnitude 5.4 earthquake occurred at a depth of about 9 miles on 29 July 2008. The epicenter was in the Chino Hills area between the Chino fault and the Whittier fault. Preliminary data were inconclusive with regard to the causative fault. Detailed analysis by Shao and Hauksson (2009)

indicated a rupture plane striking N71°W, dipping 62 degrees northeast. They suggested a preference for the Whittier fault being the causative fault but were uncertain, primarily because the Whittier fault is supposed to dip at about 80 degrees. The aftershock pattern formed a subhorizontal alignment indicating the possibility that the event could have been associated with a subsurface thrust fault such as one of the blind faults of the Puente Hills Blind Thrust Fault System or with a blind fault under the Peralta Hills.

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

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

4.0 SUBSURFACE CONDITIONS

4.1 SOIL CONDITIONS

The existing freeway surface elevation is between +170 and +202 feet within the proposed wall limits and top of the slope elevations are between +220 and +230 feet along Via Lopez. Based on the recent field investigation, the site is underlain primarily by terrace deposits and bedrock of Capistrano Formation. Generally, the terrace deposits are encountered behind the wall and the bedrocks are encountered below the bottom of wall. The terrace deposit includes primarily lean clay and sandy lean clay, silt, sandy silt, silty sand and sand with silt. The bedrock of Capistrano Formation includes primarily claystone and siltstone. Based on the recent field investigation, the bedrock contact varies between elevations +170 feet and +189 feet within the wall limits.

The idealized soil profile and design strength parameters for the wall foundation design are presented in Table 4-1. The strength parameters are average of five direct shear tests performed within the terrace deposits.

Within the entire project limits, the undrained shear strength of the bedrock obtained from all the laboratory UU-tests ranges from 7,900 to 10,300 psf. Undrained shear strengths of the bedrock obtained from all the CPT correlations (Robertson and Campanella, 1989) vary from 2,000 to over 10,000 psf. Based on this, it appears the laboratory measured shear strength is close to the average shear strength obtained from the CPT correlation. A closer examination of the CPT interpreted logs show a majority of the undrained shear strength values immediately below the bedrock contact varies from 2,000 to 6,000 psf. Conservatively, an undrained shear strength value of 3,000 psf was selected for the bedrock.

Table 4-1. Idealized Soil Profile and Strength Parameters

Approximate Elevation (feet)	Predominant Soil Type	Equivalent SPT Blowcount* (blows/foot)	Total Unit Weight (pcf)	Friction Angle (degree)	Cohesion / Undrained Shear Strength (psf)
+226 to +185	Terrace Deposits – Lean Clay and Sandy lean Clay, Silt, Sandy Silt, Silty Sand and Sand with Silt	(6) to 50 Average = 22	115	27	350
+185 to +135	Bedrock – Elastic Silt, Lean and Fat Clay	(30) to >50 Average = 70	120	-	3000

* Values in ( ) are converted SPT blowcounts corrected for sampler size; correction factor from Modified California Drive sampler blowcounts to SPT blowcounts is 0.5.

4.2 GROUNDWATER CONDITIONS

Groundwater was not encountered down to elevation +133.4 feet during the recent field investigation. However, groundwater depth may be different during construction because groundwater level can fluctuate due to variations in seasonal precipitation, irrigation, groundwater injection or extraction, or numerous other man-made and natural influences.

Based on California Geological Survey, Division of Mines and Geology (CGS, 2001b), the highest historical groundwater at the project site is 5 to 10 feet below the ground surface. So, there is a major discrepancy between the CGS data and measured groundwater data described above. Based on our past experience, the CGS historical high groundwater data is often based on limited data and may or may not reflect actual site conditions. We believe the historical high groundwater data reported by CGS is likely to be either a perched water zone or the original ground surface is significantly lower than the current ground surface. In both cases, it does not appear to be representative of the site conditions. However, a conservative groundwater depth of 10 feet below the I-5 freeway is used for the liquefaction analyses.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 SEISMIC DESIGN CRITERIA

We have determined the design ARS curve based on the 2010 Seismic Design Criteria (SDC) (Caltrans, 2010a) and Geotechnical Services Design Manual (Caltrans, 2009a) procedures. The peak ground acceleration (PGA) is the zero-period spectral acceleration in the ARS curve. A PGA of 0.4g is obtained from the design ARS curve.

For analyzing global slope stability, Section 3.10 of the Caltrans Guidelines for Structures Foundation Reports (Caltrans, 2009b) recommends using a horizontal seismic coefficient equal to one-third of the peak acceleration but not exceeding 0.2. Therefore, a horizontal seismic coefficient of 0.133 was used in the slope stability analysis.

As presented in Section 11.8.6 of AASHTO (2007), the seismic earth pressures can be computed using a seismic coefficient equal to half of the peak acceleration. Therefore, a seismic coefficient of 0.2 can be used for the computation of seismic earth pressures.

5.2 LIQUEFACTION

Liquefaction analysis was performed using the available site-specific subsurface information from borings and CPTs. As discussed in Section 4.2, a conservative groundwater depth of 10 feet below the I-5 freeway is used for the liquefaction analyses.

The liquefaction potential of saturated, granular materials below the groundwater table was evaluated using the procedures outlined by Seed et al. (1983), Seed and Harder (1990), and updated by NCEER (1997). Results of the liquefaction analyses are included in Appendix C. Based on the analyses, granular materials susceptible to liquefaction were not encountered in any of the borings and CPTs. Therefore, the liquefaction potential is concluded to be low. Furthermore, as discussed in Section 3.3, the California Geological Survey (CGS, 2001a) has also indicated that the project alignment has a low susceptibility to liquefaction during a strong earthquake.

Since liquefiable potential is low, the seismically-induced settlement is not expected to adversely impact the retaining wall.

5.3 SOIL CORROSIVITY

Three soil samples were tested for pH, minimum resistivity, soluble chloride content and soluble sulfate content. The test results are summarized in Table 5-1. Minimum resistivities were between 220 and 1,000 ohm-cm. The pH values were between 6.0 and 8.4. The soluble sulfate measurements were between 240 and 560 parts per million (ppm), and the soluble chloride measurements were between 516 and 3,970 ppm.

Based on the Caltrans Corrosion Guidelines (2003b), soils are considered corrosive if the pH is 5.5 or less, or the sulfate concentration is 2,000 ppm or greater, or the chloride concentration is 500 ppm or greater. Based on the test results and the Caltrans criteria, the on-site soils are considered to be corrosive to tieback anchors and soil nails.

Table 5-1. Soil Corrosion Test Results

Boring	Location (A-Line Stations)		Sample Depth (feet)	Soil Type	Minimum Resistivity (ohm-cm)	pH	Soluble Sulfate Content (ppm)	Soluble Chloride Content (ppm)
	Station (feet)	Offset (feet)						
A-11-310	354+96	152 Lt	10.0	ML	220	7.2	240	3,970
A-11-312	362+65	131 Lt	5.0	CL	1,000	8.4	560	516
A-11-313	359+58	166 Lt	10.0	ML	380	6.0	400	881

To mitigate the corrosion for tieback anchors and soil nails, Caltrans Standard Specification Section 46-2.02D (Caltrans, 2010c), and Caltrans Standard Special Provision No. 46-3.02A (Caltrans, 2012) should be followed for tieback anchors and soil nails, respectively.

For the above measured sulfate concentration, cement type should be in accordance with Table 8.22.2 of the Caltrans BDS (Caltrans, 2003a) for "Sulfate Concentration from 0 to 1,499".

5.4 FOUNDATION DESIGN FOR TIEBACK WALL

The tieback wall is located underneath Abutment 1 of the Via California OC. The tieback wall pertinent data are presented in Table 5-2.

Table 5-2. Tieback Wall Pertinent Data

Location (A-Line Stations)		Length (feet)	Height (feet)	Bottom of Wall Elevation (feet)	Backfill Slope Condition	Ground Condition In Front Of Wall
Begin Wall	End Wall					
359+84.09 128.36 Lt	360+78.38 139.86 Lt	95.0	26	+188.62 to +191.21	2H:1V	Level

5.4.1 Lateral Pressures

Tieback anchors should be designed to resist all lateral pressures against the back of the tieback walls including earth pressures and surcharge pressures. The existing Abutment-1 foundation of the Via California OC will impact the proposed tieback wall. Abutment-1 of the existing Via California OC is supported on a rectangular spread footing at a horizontal clear distance of about 8 to 11.5 feet to the proposed tieback wall. The vertical pressure of the existing spread footing, which is shown on the as-built plans, is summarized in Table 5-3.

Table 5-3. Existing Via California OC, Abutment-1 Foundation Data

Support Location	Foundation Type	Footing Bottom Elevation (feet)	Footing Width (feet)	Footing Pressure (ksf)
Abutment 1	Spread Footing	+208.68 and +212.18	11.0	9.0

Lateral pressures that should be applied against the tieback wall are shown on Figure 5-1 include: (a) the static earth pressure; (b) abutment footing vertical load surcharge, (c) abutment footing horizontal load surcharge, and (d) incremental earthquake surcharge. The static earth pressure and the surcharge loads due to the vertical and horizontal loads of the existing OC footings were developed in accordance with Caltrans Memo to Designers 5-12 (2011).

For the tieback wall, lateral pressures (a), (b) and (c) should be used for service loading, and pressures (a), (b), (c) and (d) should be used for seismic design.

5.4.2 Unbonded Length

The unbonded length ("free length") of the anchor is that portion of the anchor which is not grouted. The unbonded length should fall outside the critical failure plane. In most cases, the critical failure plane usually coincides with the Rankine failure wedge. For this case, due to the bearing pressure exerted by the abutment footing, the critical failure plane extends beyond the Rankine failure wedge. Calculations in Appendix C show the critical failure plane extends from the bottom of the tieback wall clockwise at an angle of 49 degrees measured from the vertical. The unbonded length should be extended a minimum distance of H/5 (H is the wall height) or 5 feet, whichever is greater, behind the above critical failure surface.

For tiebacks located within a vertical distance of 11 feet below the bottom of the existing Abutment-1 footing, the unbonded length should be determined based on the above procedure, or extend beyond an imaginary vertical plane coinciding with the centerline of the existing Abutment-1 footing, whichever is larger. This requirement is necessary so that the unbonded length also extends outside the zone influenced by the soil bearing capacity failure wedges which could potentially develop immediately below the existing abutment footing.

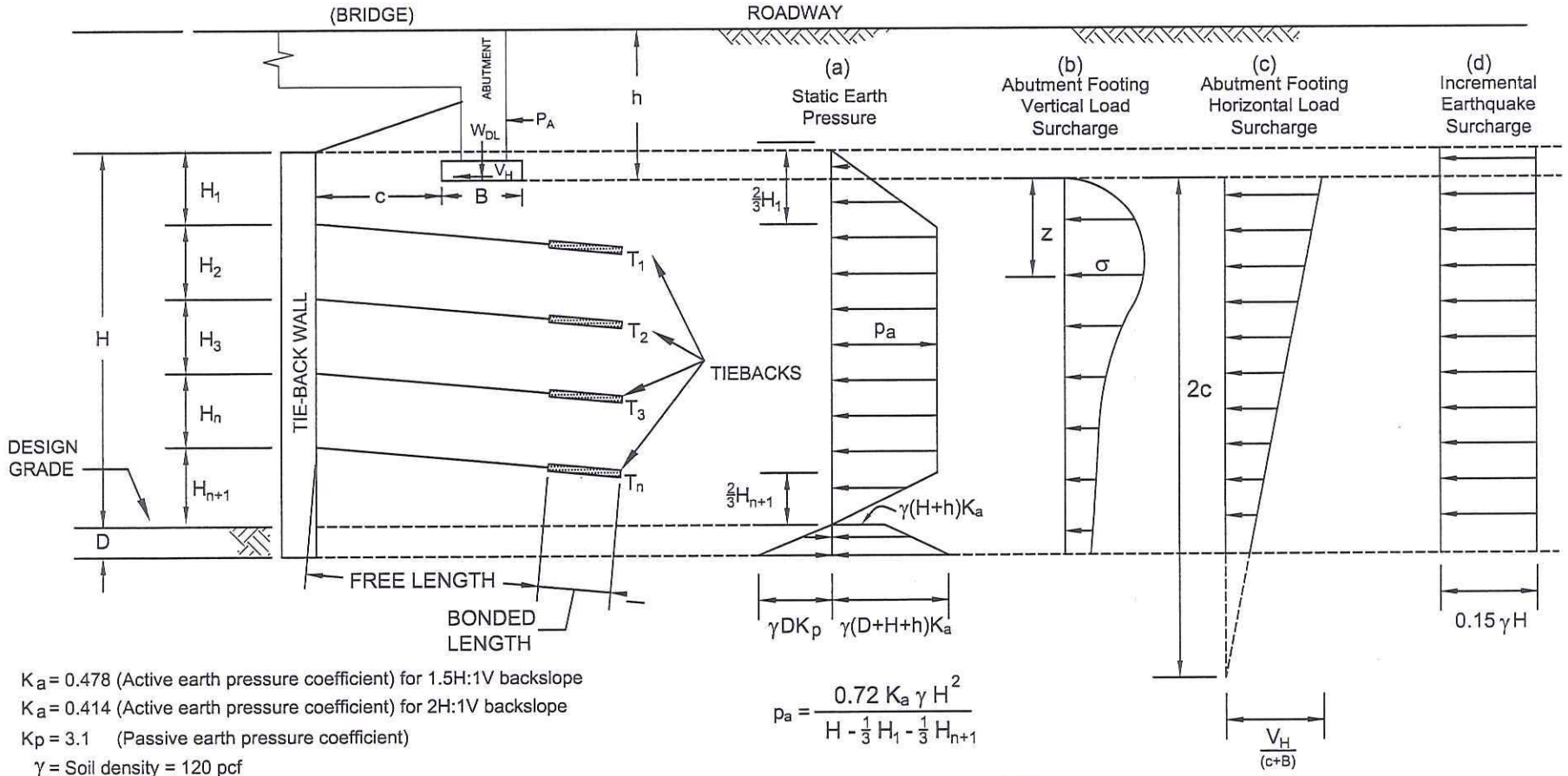
Additionally, the unbonded length for any tieback anchor should not be less than 15 feet. The angle of inclination of the anchors should be at least 10 degrees to facilitate tendon installation and grouting.

5.4.3 Bonded Length

The bonded length of tieback anchors is that portion which is grouted and provides the lateral resistance due to friction between the soil and concrete. Based on the approximate tieback anchor elevations and the subsurface profile of earth materials, the bonded length of the anchors is expected to be embedded in the layers of lean clay, silt and sandy silt.

The maximum allowable anchor design load is computed by multiplying the bonded length by the ultimate transfer load and dividing by a factor of safety. Based on information provided in ground anchor manuals by FHWA (1999) and the Post-Tensioning Institute, the ultimate transfer load of 3.6 kips/foot for an 8-inch diameter gravity or pressure grouted straight shaft is recommended.

A factor of safety of 2.5 (FHWA, 1999) can be applied to the ultimate transfer loads to obtain the allowable transfer loads. The contractor is responsible for determining the bonded length of the tieback anchors; however, the bonded length of the anchors should not be less than 15 feet.



K_a = 0.478 (Active earth pressure coefficient) for 1.5H:1V backslope

K_a = 0.414 (Active earth pressure coefficient) for 2H:1V backslope

K_p = 3.1 (Passive earth pressure coefficient)

γ = Soil density = 120 pcf

c = Distance between anchored wall and abutment footing (feet)

B = Width of existing spread footing (feet)

q = Abutment footing bearing pressure (psf)

P_A = $18h^2$ lbs/ft - Active lateral earth pressure resultant based on structure backfill

W_{DL} = Dead load reaction at base of footing

V_H = Static horizontal reaction at base of footing = $0.5W_{DL}$, but not less than P_A

$$p_a = \frac{0.72\, K_a\, \gamma\, H^2}{H - \frac{1}{3}H_1 - \frac{1}{3}H_{n+1}}$$

$$\sigma = \frac{1.5q}{\pi}[\beta - \sin\beta * \cos(\beta+2\alpha)]$$

where

β (radians) = $\arctan(\frac{B+c}{z}) - \arctan(\frac{c}{z})$

α (radians) = $\arctan(\frac{c}{z})$

z (feet) = Depth below abutment bottom of footing

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Retaining Wall 349 - Tieback Walls	Lateral Earth Pressures Against Tieback Wall
	Project No. 11-137 / Date: 03-20-2012	FIGURE 5-1

5.4.4 Spacing of Tieback Anchors

Tieback anchors should not be spaced closer than three diameters of the bonded (grouted) zone or 5 feet, whichever is greater. The tieback anchors should be located to maximize their distance from any existing foundation.

5.4.5 Bearing Capacity and Wall Friction

The bearing capacity for the footing (or leveling pad) at the bottom of the tieback walls was calculated using a minimum embedment depth of 2 feet and footing width of 1.5 feet following the LRFD guidelines. The calculated permissible net contact stress for the Service Limit State is 2 ksf, and factored gross nominal bearing resistance for Strength Limit State and Extreme Event Limit State are 6.75 ksf and 15 ksf, respectively.

A friction coefficient of 0.3 and 0.35 can be used between the vertical concrete wall and the soil behind the wall for the permanent and temporary (during construction) condition, respectively. It should be noted that the frictional coefficient is applicable only when the concrete wall is in full contact with the earth behind the wall.

5.4.6 Slope Stability

Global stability of the tieback wall was evaluated for static and pseudo-static loading conditions using the computer program, SLIDE (Rocscience, 2006). Results of this analysis are presented in Appendix C. The calculated factor of safety for a deep-seated failure is greater than the minimum required 1.5 under static condition with a 2-foot soil surcharge to represent traffic loading. Slope stability analysis under pseudo-static condition was performed using a seismic coefficient equal to 0.133 (which is the smaller of either one-third the horizontal peak ground acceleration or 0.2g) in accordance with guidelines provided in Section 3.10 of the Caltrans Guidelines for Structures Foundation Reports (Caltrans, 2009a). Analysis indicates that the calculated factor of safety is greater than the required minimum of 1.1 under pseudo-static condition.

5.5 FOUNDATION DESIGN FOR SOIL NAIL WALL

Soil nail walls are located on both sides of the Via California OC. The soil nail wall pertinent data are presented in Table 5-4.

Table 5-4. Retaining Wall Pertinent Data

Wall	Location (A-Line Stations)		Length (feet)	Height (feet)	Bottom of Wall Elevation (feet)	Backfill Slope Condition	Wall Face Slope Condition
	Begin Wall	End Wall					
South of Via California OC	349+99.69 99.81 Lt	359+84.09 128.36 Lt	985	8 to 26	+191.21 to +199.77	2H:1V	Level
North of Via California OC	360+78.38 139.86 Lt	363+10.73 182.20 Lt	235	10 to 26	+178.14 to +188.69	2H:1V	Level

Geotechnical aspects of soil nail design are based on the SNAILZ computer program developed by Caltrans Division of Materials and Foundations (Caltrans, 1999), Geotechnical Engineering Circular No. 7 (FHWA, 2003), and Manual for Design and Construction Monitoring of Soil Nail Walls (FHWA, 1998).

5.5.1 Soil Nails

Slope stability analyses were performed to determine the minimum soil nail length for each wall height. The analyses were performed using SNAILZ, a computer program which evaluates factors of safety against overall failure using two-dimensional limit equilibrium methods. The design data presented in Table 5-5 and the soil strength parameters presented in Table 4-1 were used for the analyses. As presented in the guidelines (FHWA, 2003), to ensure pullout failure controls the design of the soil nail, large facing punching shear is used for the analyses.

Table 5-5. SNAILZ Input Design Data

SNAILZ Input	Parameters
Soil Nail	Grade 60, 1-inch diameter (#8 bar)
Yield Stress of Reinforcement	60 kips
Nail Inclination from Horizontal	15 degrees
Horizontal Nail Spacing	5.0 feet
Vertical Nail Spacing	4.5 to 5.0 feet
Vertical Distance to Nail from Top of the Wall	2.0 to 3.0 feet
Pullout Resistance (Q_d) per Soil Nail (Grout-Soil)	1130 lbs per linear foot
Allowable Geotechnical Factor of Safety for Static	2.0
Allowable Geotechnical Factor of Safety for Seismic	1.5
Minimum Nail Bar Tensile Strength Factor of Safety for Static	1.8
Minimum Nail Bar Tensile Strength Factor of Safety for Seismic	1.35
Bond Stress Factor (BSF) for Static	0.75
Bond Stress Factor (BSF) for Seismic	0.73

The SNAILZ analytical results are presented in Appendix C for each wall height. The analyses include the number of soil nail levels and the minimum required nail lengths for each wall height.

5.5.2 Lateral Earth Pressure for Soil Nail Wall

A static active lateral earth pressure of 86 psf per foot of depth is recommended for a free draining, sloping backfill. For seismic incremental pressure, a uniform pressure distribution with

a horizontal pressure of 18H psf (H is the height of the wall) is recommended for a free draining, sloping backfill. The uniform seismic incremental pressure should be added to the static pressure to determine the total pressure for earthquake design. If applicable, a uniform lateral pressure of at least 72 psf due to vehicle loads, equivalent to a vertical pressure produced by at least 2 feet of earth, should be added to the above lateral earth pressure.

5.5.3 Sliding

Sliding stability analysis considers the ability of the soil nail wall to resist sliding along the base of the retained system in response to lateral earth pressure behind the soil-nail mass. The lateral load behind the soil nail can be calculated using an equivalent fluid pressure of 78 psf per foot of depth. For seismic incremental pressure, a uniform pressure distribution with a horizontal pressure of 18H (H is the height of the wall) is recommended. The uniform seismic incremental pressure should be added to the static pressure to determine the total pressure for earthquake design.

Friction along the base of the retained system will be developed to resist sliding of the soil-nail mass. A frictional coefficient of 0.5 is recommended.

6.0 CONSTRUCTION RECOMMENDATIONS

6.1 EARTHWORK

Earthwork should be performed in accordance with Caltrans Standard Specifications, Section 19 (Caltrans, 2010c). Appropriate measures should be taken to prevent damage to adjacent structures and utilities. Any design and construction of temporary sloping, sheeting, or shoring should be made the contractor's responsibility. It should be noted that it is the responsibility of the contractor to oversee the safety of the workers in the field during construction. The contractor shall conform to all applicable occupational and health standards, rules, regulations, and orders established by the State of California. In addition, other State, County, or Municipal regulations may supersede the recommendations presented in this section. If a trench shoring design and safety plan is required, the geotechnical consultant should review the plan to confirm that recommendations presented in this report have been applied to the design.

The subsurface materials to be excavated or drilled into are terrace deposits consisting generally of interbedded fine and granular materials. Therefore, the potential of caving should not be precluded during the installation of the tieback anchors and soil nails. Special provisions such as casing may be required for the installation of tieback anchors and soil nails. Casing within the bonded length of tieback and soil nail must be removed prior to placement of grout to allow mobilization of the estimated tieback or soil nail capacity.

During the recent field investigation, groundwater was not encountered in any of the borings down to elevation +133 feet. Groundwater is not anticipated to be encountered during the tieback and soil nail wall construction. However, groundwater level can fluctuate due to seasonal rainfall amount, local irrigation and groundwater recharge program and other man-made conditions. If groundwater is encountered during construction, contractor may need to evaluate alternative drilling equipment and procedure to minimize potential collapse of the drilled hole.

6.2 WALL ZONE

The wall zones described in Section 19-3.01A(3) of the Caltrans Standard Specifications (Caltrans, 2010c) are defined based on the soil subsurface conditions. Along the entire wall, predominantly terrace deposit is encountered. Therefore, only one wall zone is expected behind the entire wall.

6.3 TEMPORARY EXCAVATIONS

Temporary excavations must be properly sloped or shored in accordance with all applicable codes and regulations including OSHA standards. Qualified geotechnical personnel should inspect temporary slopes for erosion and sloughing, and should inspect temporary shoring for signs of instability and deformations, during construction on a daily basis. In order to minimize sloughing, the contractor may elect to make slot cuts or injection-grout the site soils where vertical excavations are required for tieback or soil nail installation.

To determine the excavation lift height and the exposure time during the excavation, stability test should be performed per Caltrans Standard Specification Section 19-3.01A(3) (Caltrans, 2010c).

To maintain stability of the existing Abutment-1 footing of Via California OC, the tieback walls should be constructed in segments (slot cuts), with each segment completed (i.e., vertical excavation followed by tieback construction and shotcrete facing) prior to excavating another segment. We recommend for each segment, the maximum length of any vertical excavation (lift) for anchor installation at any given time, should be limited to one-quarter of the length of the existing Abutment-1 footing.

The excavation for soil nail walls should be carried out in lifts using top-to-bottom construction with each lift completed to closure (i.e., with nail testing and temporary shotcrete facing completed) prior to excavating subsequent lifts. The depth of excavation lift is usually 5 feet and reaches slightly below the elevation where nails will be installed. The width of the excavated platform or bench must be sufficient enough to provide access to installation equipment.

We recommend the maximum length of each lift (vertical excavation) for soil nail installation at any given time, should not exceed 100 feet.

Soil or other construction materials should not be stockpiled adjacent to excavations. Stockpiles should be set back a minimum distance which is equal to the height of the excavation. Shoring should be designed for site specific conditions using input from qualified geotechnical personnel during construction.

6.4 TIEBACK INSTALLATION

Tieback anchors should be constructed in accordance with Caltrans procedures and specifications. The tieback anchors should be performance and proof tested in the field in accordance with Caltrans Standard Specification Section 46-2.01D(2) (Caltrans, 2010c). The contractor is responsible for determining the bonded length of tieback anchors. The minimum bonded length is 15 feet. The un-bonded length should not be less than 15 feet.

In addition, the unbonded length should be extended a minimum distance of H/5 or 5 feet, whichever is greater, behind the critical failure surface. The critical failure plane extends from the bottom of the tieback wall clockwise at an angle of 49 degrees measured from the vertical. For tiebacks located within a vertical distance of 11 feet below the bottom of the existing Abutment-1 footing, the unbonded length should be determined based on the above procedure, or extend beyond an imaginary vertical plane coinciding with the centerline of the existing Abutment-1 footing, whichever is larger.

The anchors should be inclined at least 10 degrees to facilitate tendon installation and grouting. Tieback anchors should not be spaced closer than three diameters of the bonded zone or 5 feet, whichever is greater.

The contractor should exercise care to minimize impact to the existing Abutment-1 footing of Via California OC during installation of tieback anchors and construction of the tieback wall. We recommend that a monitoring program be implemented during construction to monitor movements of Abutment-1. If the measured vertical or lateral movement is excessive, construction should be stopped immediately and measures to mitigate the movement should be implemented.

6.5 SOIL NAIL INSTALLATION

Drilling, nail installation and grouting are contractor's responsibility. Care should be taken to avoid caving of the drill hole. Soil that may have sloughed into the holes should be removed prior to installation of the nails. Nails that are driven or pushed beyond the drill hole length or cut off should not be allowed.

Soil nails should be load tested in the field in accordance with the criteria and test schedule outlined in Section 46-3 of Caltrans Standard Specifications (Caltrans, 2010c) to verify if the design loads can be carried without excessive movements, and the contractor's installation method and operations are adequate.

The load test should include verification and proof tests in accordance with Caltrans Standard Specification Section 46-3.01D(2) (Caltrans, 2010c). As a minimum, two verification tests in each wall zone should be performed on non-production nails installed at locations approved by the Engineer. Proof test should be conducted on sacrificial test nails no less than ten percent of total number of production nails. Among the proof test nails, eight percent of their test locations should be shown on plan, with the remaining two percent at locations specified by the Engineer during construction. If subsurface conditions differ and/or the contractor's installation procedures change during the installation, additional testing may be required to evaluate the influence on the soil nail performance.

6.6 SURFACE AND SUBSURFACE DRAINAGE

Surface and subsurface drainage is important to minimize the amount of water entering the earth materials behind the back of the walls. EMI recommends constructing a concrete gutter at the top and behind the walls and guiding surface water to approved drainage devices. In addition, a minimum 5-ft length of the slope face behind the walls, and measured from the outside edge of the v-ditch, should be paved with an impermeable material.

Prefabricated geocomposite vertical drains ("drainage board") connected to gravel galleries and weepholes should be placed behind the proposed tieback and soil nail walls. The geocomposite vertical drains should be at least 12-inch wide and installed at a maximum horizontal spacing of 5 feet. Weep holes should be installed to collect the drained water from the geocomposite vertical drains. The backdrainage pipes or weepholes should outlet to approved surface drainage collection devices.

6.7 REVIEW OF CONSTRUCTION PLANS

Recommendations contained in this report are based on draft plans. The geotechnical consultant should review the final construction plans and specifications in order to confirm that the general intent of the recommendations contained in this report have been incorporated into the final construction documents. Recommendations contained in this report may require modification or additional recommendations may be necessary based on the final design.

6.8 GEOTECHNICAL OBSERVATION AND TESTING

It is recommended that inspections and testing be performed by the geotechnical consultant during the following stages of construction:

- Grading operations, including excavations
- Shoring installation
- Tieback anchors and soil nail installation and testing
- Removal or installation of support of buried utilities or structures
- When any unusual subsurface conditions are encountered

7.0 LIMITATIONS

This report is intended for the use of OCTA, TRC and Caltrans for design and construction of the Retaining Wall 349. This report is based on the project as described and the information obtained from the exploratory borings at the approximate locations indicated on the attached LOTB sheets. The findings and recommendations contained in this report are based on the results of the field investigation, laboratory tests, and engineering analyses. In addition, soils and subsurface conditions encountered in the exploratory borings are presumed to be representative of the project site. However, subsurface conditions and characteristics of soils between exploratory borings can vary. The findings reflect an interpretation of the direct evidence obtained. The recommendations presented in this report are based on the assumption that an appropriate level of quality control and quality assurance (inspections and tests) will be provided during construction. EMI should be notified of any pertinent changes in the project plans or if subsurface conditions are found to vary from those described herein. Such changes or variations may require a re-evaluation of the recommendations contained in this report.

The data, opinions, and recommendations contained in this report are applicable to the specific design element(s) and location(s) which is (are) the subject of this report. They have no applicability to any other design elements or to any other locations and any and all subsequent users accept any and all liability resulting from any use or reuse of the data, opinions, and recommendations without the prior written consent of EMI.

EMI has no responsibility for construction means, methods, techniques, sequences, or procedures; for safety precautions or programs in connection with the construction; for the acts or omissions of the CONTRACTOR or any other person performing any of the construction; or for the failure of any worker to carry out the construction in accordance with the Final Construction Drawings and Specifications.

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

8.0 REFERENCES

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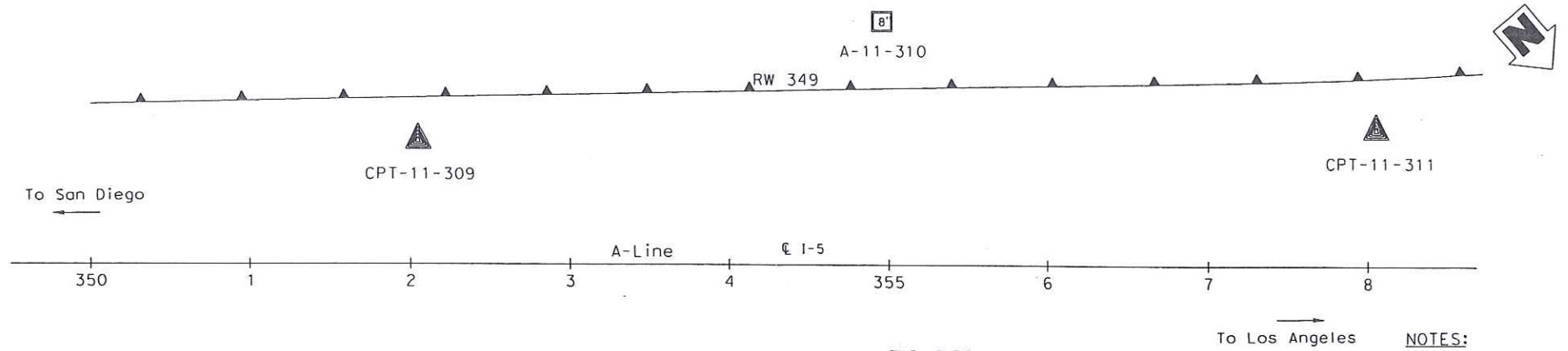
Appendix A

LOG OF TEST BORING SHEETS

BENCH MARK

Designation: F-785 Elev = 75.717 feet (NAVD 88); 73.413 feet (NGVD29) Described by OCS 2003 - Found 3¾" US Coast and Geodectic Survey Bronzed Disk Stamped "F 785 1946", Set in the Top of a Concrete Bridge Abutment. Monument is Located in the Southwesterly Corner of the Atchinso\Topeka and Santa Fe Railway Overcrossing of San Mateo Creek, 69 ft. Northerly Along the Railway from the Centerline of the Interstate 5 Freeway Southbound Onramp at Camino Capistrano Prolonged to the West and 150± Westerly from the Centerline of Camino Capistrano. Monument is Set 2.0 ft. below the Tracks.



PLAN

1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET NO	TOTAL SHEETS
12	ORA	5	6.2/8.7		

Q. Pirathiviraj
GEOTECHNICAL PROFESSIONAL DATE

REGISTERED PROFESSIONAL ENGINEER
S. PIRATHIVIRAJ
NO. GE 2963
EXP. 12-31-13
GEOTECHNICAL
STATE OF CALIFORNIA

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ORANGE COUNTY TRANSPORTATION AUTHORITY
550 S. MAIN STREET
ORANGE, CA 92863-1584

EARTH MECHANICS, INC.
17800 NEWHOPE STREET, SUITE B
FOUNTAIN VALLEY, CA 92708

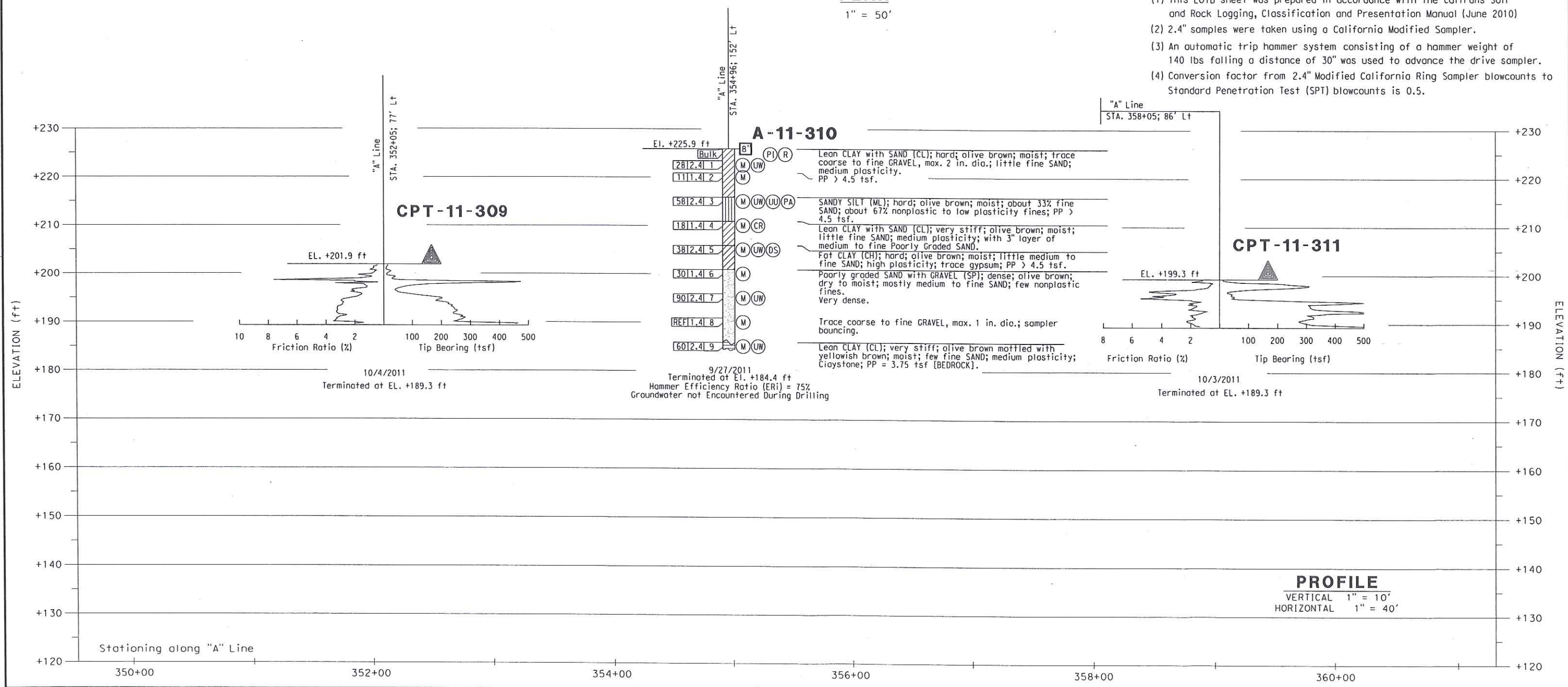
NOTES:

(1) This LOTB sheet was prepared in accordance with the Caltrans Soil and Rock Logging, Classification and Presentation Manual (June 2010)

(2) 2.4" samples were taken using a California Modified Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) Conversion factor from 2.4" Modified California Ring Sampler blowcounts to Standard Penetration Test (SPT) blowcounts is 0.5.



PROFILE

VERTICAL 1" = 10'
HORIZONTAL 1" = 40'

DESIGN OVERSIGHT	DRAWN BY	J. Fong	R. Jie		PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	S. PIRATHIVIRAJ PROJECT ENGINEER	BRIDGE NO. -
SIGN OFF DATE	CHECKED BY	S. PIRATHIVIRAJ	FIELD INVESTIGATION BY: DATE: 9/2011, 10/2011				POST MILES 6.62

RETAINING WALL NO. 349

LOG OF TEST BORINGS 1 OF 2

GS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 7/16/10)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

UNIT: 2998
PROJECT NUMBER & PHASE: 1200020279

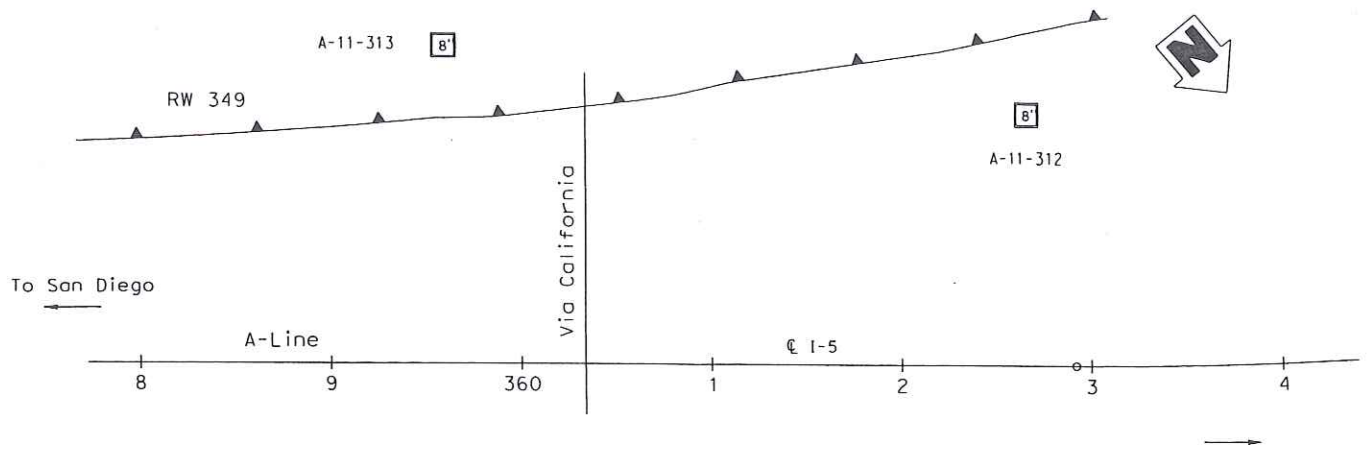
DISREGARD PRINTS BEARING EARLIER REVISION DATES

REVISION DATES | SHEET | OF

TIME PLOTTED => $TIME
DATE PLOTTED => $DATE
USERNAME => $USER

BENCH MARK

Designation: F-785 Elev = 75.717 feet (NAVD 88); 73.413 feet (NGVD29) Described by OCS 2003 - Found 3¼" US Coast and Geodectic Survey Bronzed Disk Stamped "F 785 1946", Set in the Top of a Concrete Bridge Abutment. Monument is Located in the Southwesterly Corner of the Atchinso\Topeka and Santa Fe Railway Overcrossing of San Mateo Creek, 69 ft. Northerly Along the Railway from the Centerline of the Interstate 5 Freeway Southbound Onramp at Camino Capistrano Prolonged to the West and 150± Westerly from the Centerline of Camino Capistrano. Monument is Set 2.0 ft. below the Tracks.



PLAN
1" = 50'

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No	TOTAL SHEETS
12	ORA	5	6.2/8.7		

GEOTECHNICAL PROFESSIONAL DATE

PLANS APPROVAL DATE

REGISTERED PROFESSIONAL ENGINEER — S. PIRATHIVIRAJ — NO. GE 2963 — EXP. 12-31-13 — GEOTECHNICAL — STATE OF CALIFORNIA

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.

ORANGE COUNTY TRANSPORTATION AUTHORITY
550 S. MAIN STREET
ORANGE, CA 92863-1584

EARTH MECHANICS, INC.
17800 NEWHOPE STREET, SUITE B
FOUNTAIN VALLEY, CA 92708

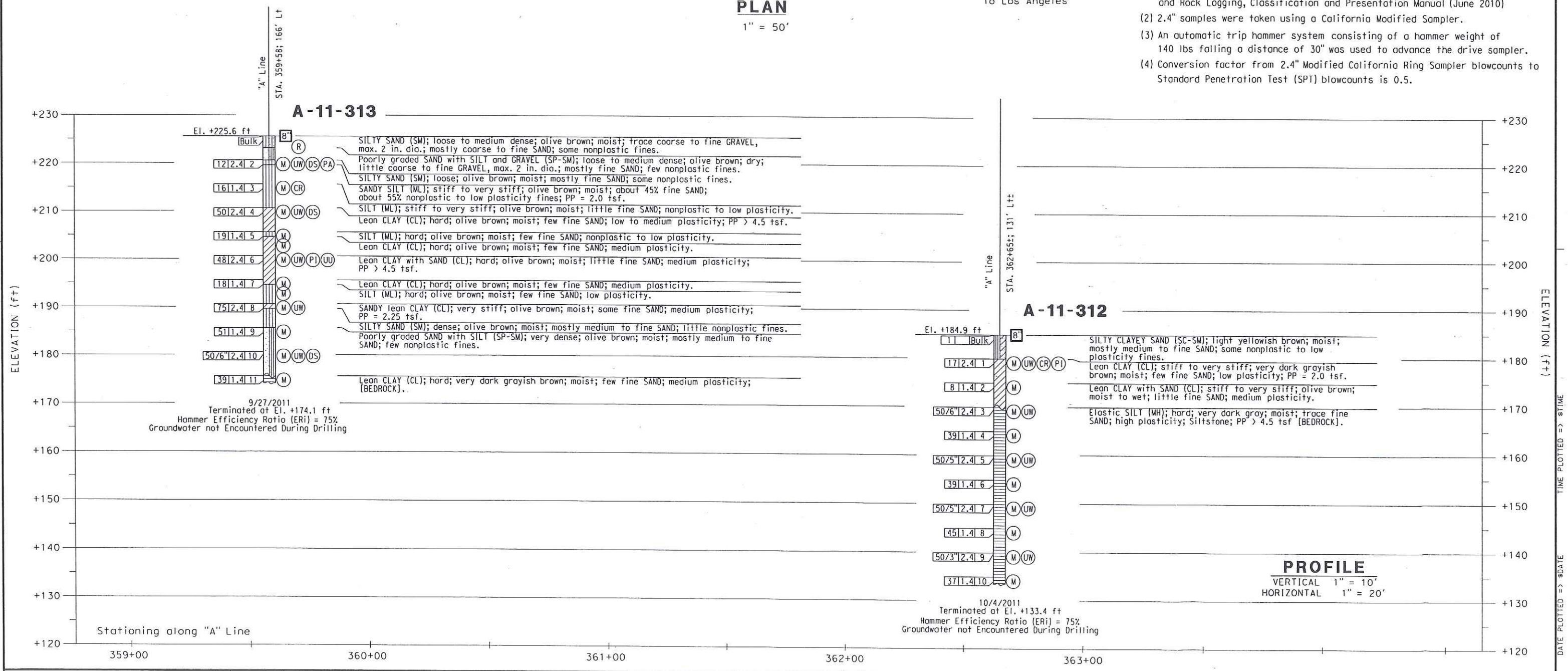
NOTES:

(1) This LOTB sheet was prepared in accordance with the Caltrans Soil and Rock Logging, Classification and Presentation Manual (June 2010)

(2) 2.4" samples were taken using a California Modified Sampler.

(3) An automatic trip hammer system consisting of a hammer weight of 140 lbs falling a distance of 30" was used to advance the drive sampler.

(4) Conversion factor from 2.4" Modified California Ring Sampler blowcounts to Standard Penetration Test (SPT) blowcounts is 0.5.



PROFILE
VERTICAL 1" = 10'
HORIZONTAL 1" = 20'

DESIGN OVERSIGHT	DRAWN BY	J. Fang	R. Jie		PREPARED FOR THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION	S. PIRATHIVIRAJ PROJECT ENGINEER	BRIDGE NO. - / POST MILES 6.62	RETAINING WALL NO. 349
SIGN OFF DATE	CHECKED BY	S. PIRATHIVIRAJ	FIELD INVESTIGATION BY: DATE: 9/2011, 10/2011					LOG OF TEST BORINGS 2 OF 2

GS GEOTECHNICAL LOG OF TEST BORINGS SHEET (ENGLISH) (REV. 7/16/10)

ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

UNIT: 2998
PROJECT NUMBER & PHASE: 12000202791

DISREGARD PRINTS BEARING EARLIER REVISION DATES →

REVISION DATES | SHEET | OF

USERNAME => $USER DATE PLOTTED => $DATE TIME PLOTTED => $TIME

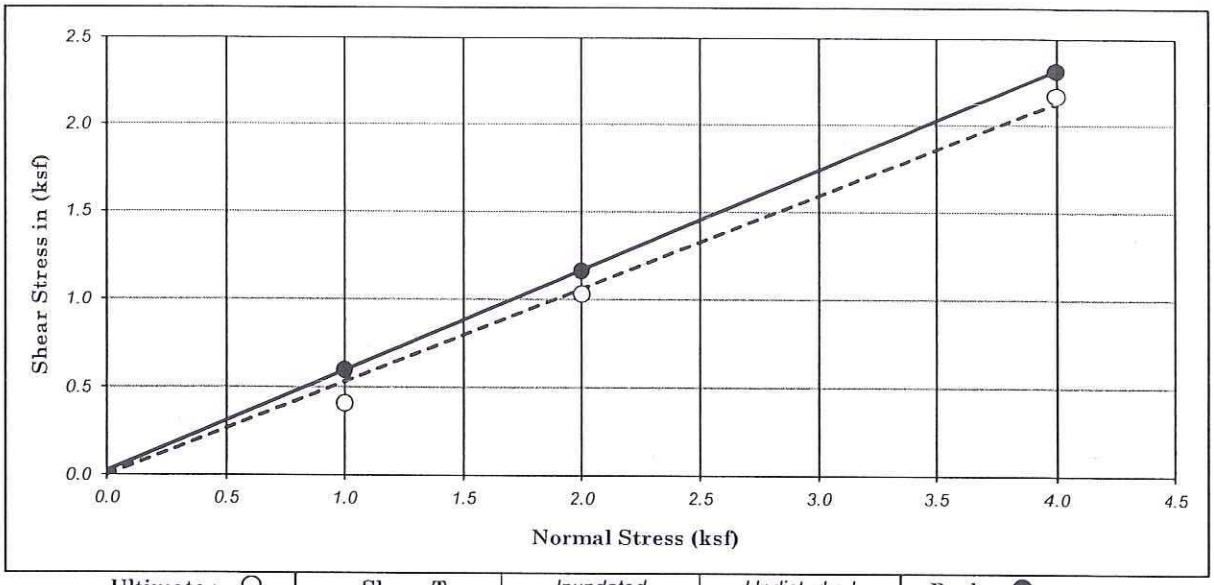
Appendix B

LABORATORY TEST RESULTS

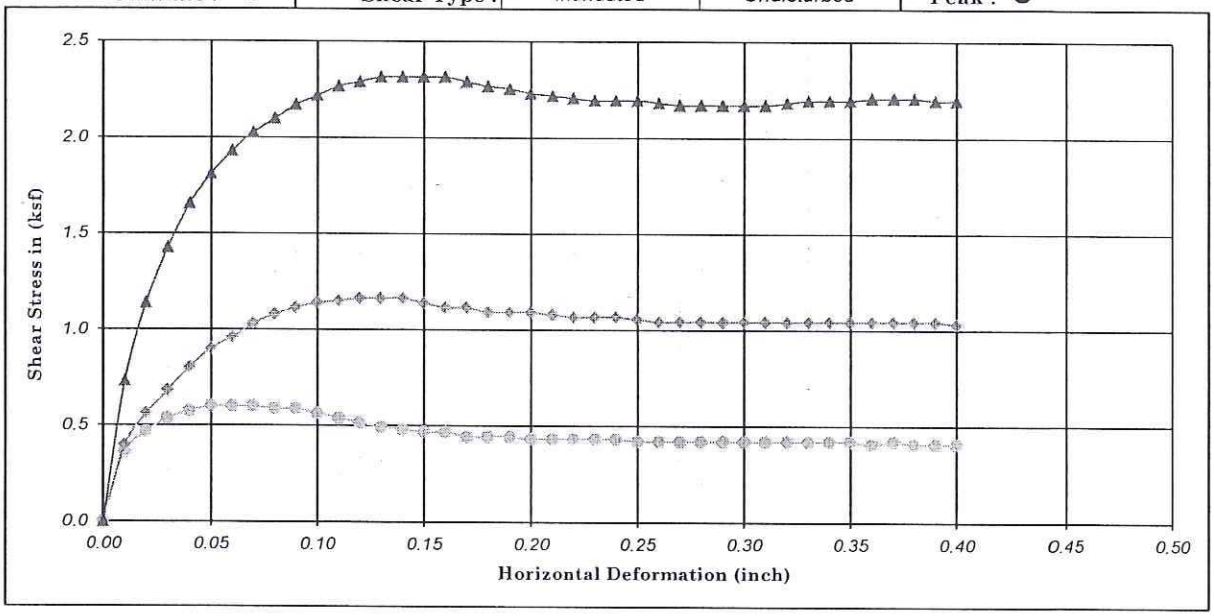
TABLE B-1 SUMMARY OF LABORATORY TEST RESULTS

Project No. : 11-137 Project Name : Retaining Wall 349

Boring No .	Sample No.	Sample Depth (ft)	Soil Identification (group symbol) ASTM D2488/D2487	Moisture Content ASTM D2216 (%)	Total Unit Weight ASTM D2937 (pcf)	Pocket Penetrometer (tsf)	Torvane Shear (tsf)	Grain Size Distribution GR:SA:FI (%)	Sand Equivalent (CT-217)	Atterberg Limits ASTM D4318 (LL/PL/PI)	Soil-Minimum Resisivity CT-532 (ohm-cm)	Soil-pH CT-532	Soil-Soluble Sulfate Content CT-417 (ppm)	Soil-Moisture Free Chloride Content CT-422 (ppm)
A-11-310	D-1	2.5	CL	11.4	119.2	>4.5								
A-11-310	S-2	5	CL	17.6										
A-11-310	D-3	10	ML	13.3	119.4	>4.5		0:33:67			220	7.2	240	3970
A-11-310	S-4	15	CL	20.1										
A-11-310	D-5	20	CH	31.0	116.5	>4.5								
A-11-310	S-6	25	SP-SM	2.1										
A-11-310	D-7	30	SP-SM	3.2	99.6									
A-11-310	S-8	35	SP-SM	3.6										
A-11-310	D-9	40	CL	20.7	154.4	3.75								
A-11-312	D-1	5	CL	19.6	121.8	2.0				34/16/18	1000	8.4	560	516
A-11-312	S-2	10	CL	21.9										
A-11-312	D-3	15	MH	28.7	115.4	>4.5								
A-11-312	S-4	20	MH	41.5										
A-11-312	D-5	25	MH	26.5	120.5	>4.5								
A-11-312	S-6	30	MH	28.3										
A-11-312	D-7	35	MH	29.2	119.4	>4.5								
A-11-312	S-8	40	MH	29.3										
A-11-312	D-9	45	MH	26.9	122.4	>4.5								
A-11-312	S-10	50	MH	25.0										
A-11-313	D-2	5	ML to SM	12.6	118.1	2.0		0:45:55						
A-11-313	S-3	10	ML	11.5							380	6.0	400	881
A-11-313	D-4	15	CL	12.0	126.5	>4.5								
A-11-313	S-5T	20	ML	16.4										
A-11-313	S-5B	21	CL	17.9										
A-11-313	D-6	25	CL	18.7	125.8	>4.5								
A-11-313	S-7T	30	CL	21.4										
A-11-313	S-7B	31	ML	16.4										
A-11-313	D-8	35	CL to SM	17.8	122.6	2.25								
A-11-313	S-9	40	SP-SM	2.5										
A-11-313	D-10	45	SP-SM	4.3	98.9									
A-11-313	S-11	50	CL	26.8										



Ultimate : ○	Shear Type :	Inundated	Undisturbed	Peak : ●



Boring No. : A-11-310		Strength Intercept (C) :	0.02	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-1			1.15	(kPa)		0.00	(kPa)	
Depth (ft/m) : 2.5	0.00	Friction Angle (ϕ) :	29.79	Degree		27.99	Degree	
Description : Olive-brown, Lean CLAY with SAND (CL)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	24.10	95.60	15.05	0.76	1.00	47.88	0.60	28.73	0.41	19.54
◆	21.36	93.70	14.75	0.80	2.00	95.76	1.16	55.73	1.03	49.41
▲	24.07	93.53	14.72	0.80	4.00	191.52	2.32	110.89	2.17	104.00

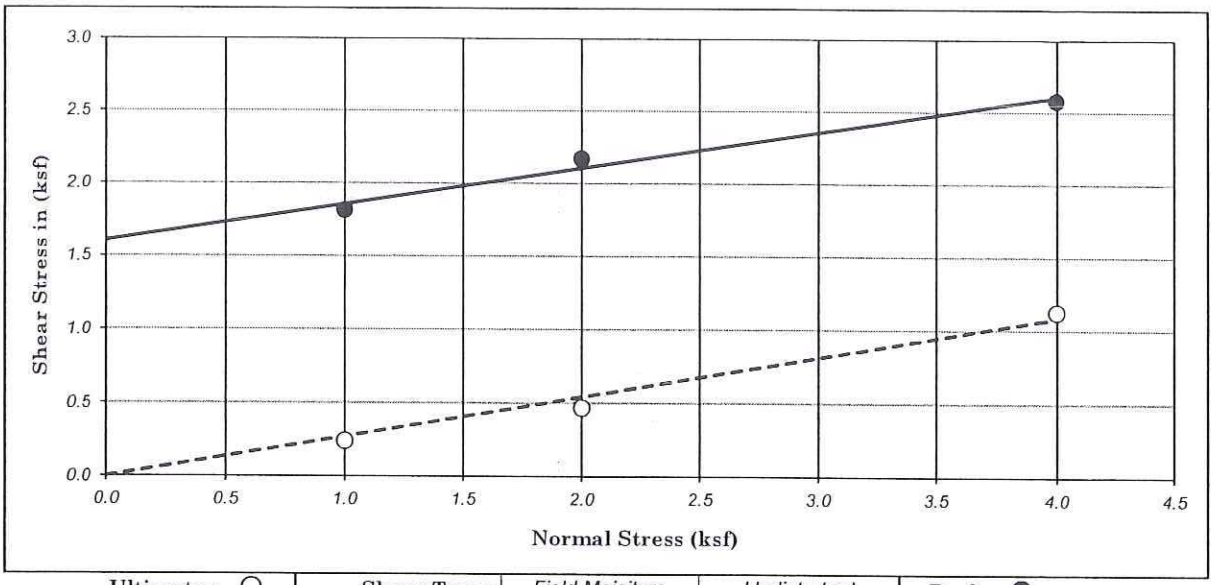
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

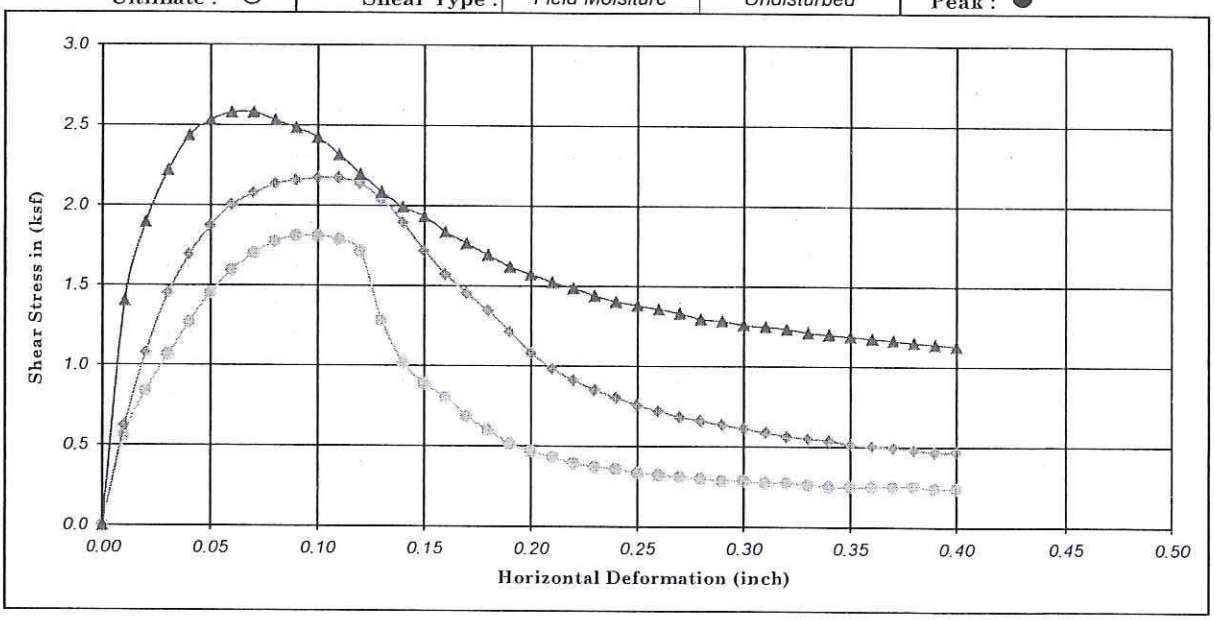
Retaining Wall 349

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 11-137 | Date : 01/18/12 | Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-310		Strength Intercept (C) :	1.61	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-5			76.99	(kPa)		0.00	(kPa)	
Depth (ft/m) : 20.0	0.00	Friction Angle (ϕ) :	13.96	Degree		15.16	Degree	
Description : Olive-brown, Lean CLAY (CL)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	27.81	96.39	15.17	0.75	1.00	47.88	1.81	86.76	0.24	11.49
◆	25.02	99.17	15.61	0.70	2.00	95.76	2.17	104.00	0.47	22.41
▲	27.33	98.38	15.49	0.71	4.00	191.52	2.58	123.53	1.13	54.01

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I-5 HOV Improvement Project
PCH to San Juan Creek Road

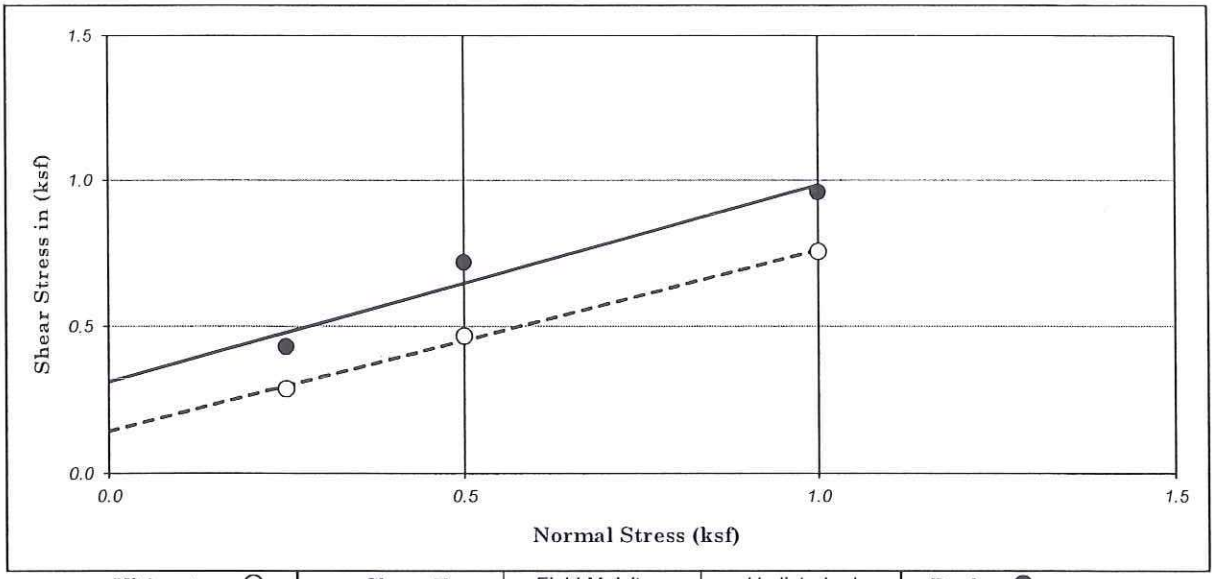
Retaining Wall 349

DIRECT SHEAR TEST (ASTM D-3080)

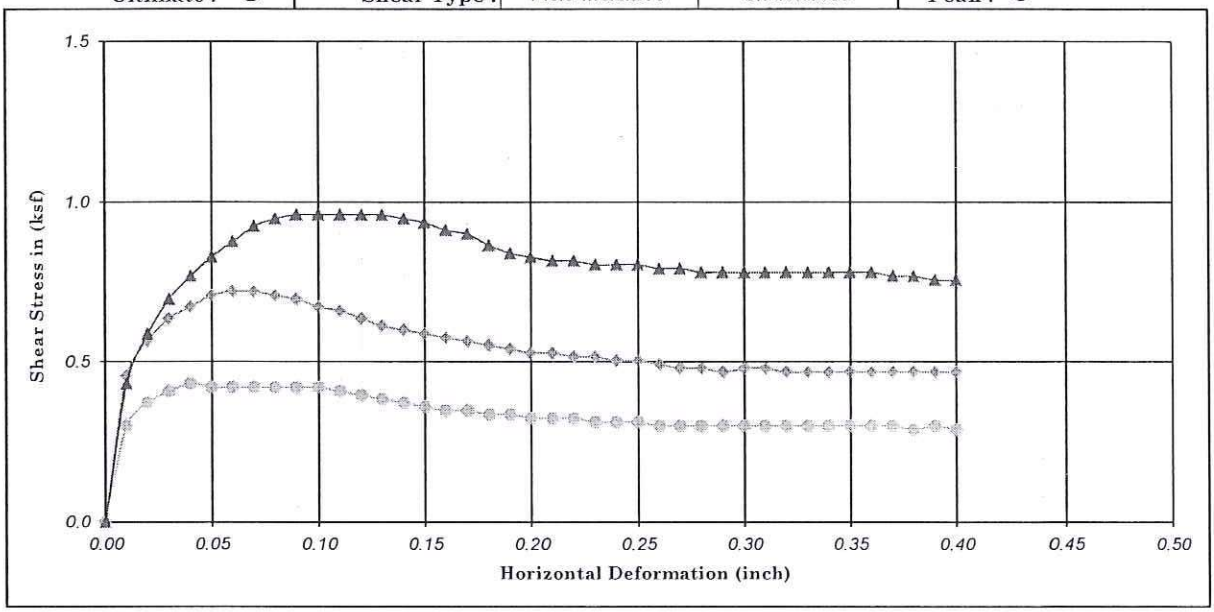
Project No. : 11-137

Date : 01/13/12

Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-313		Strength Intercept (C) :	0.31	(ksf)	Peak	0.14	(ksf)	Ultimate
Sample No. : D-2			14.94	(kPa)		6.89	(kPa)	
Depth (ft/m) : 5.0	0.00	Friction Angle (ϕ) :	33.90	Degree		31.68	Degree	

Description : Olive-brown, SILTY SAND (SM) — Shear Rate (inch/minute) : 0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	12.38	103.51	16.29	0.63	0.25	11.97	0.43	20.68	0.29	13.79
◆	14.33	103.65	16.32	0.63	0.50	23.94	0.72	34.47	0.47	22.41
▲	18.15	103.60	16.31	0.63	1.00	47.88	0.96	45.96	0.76	36.20

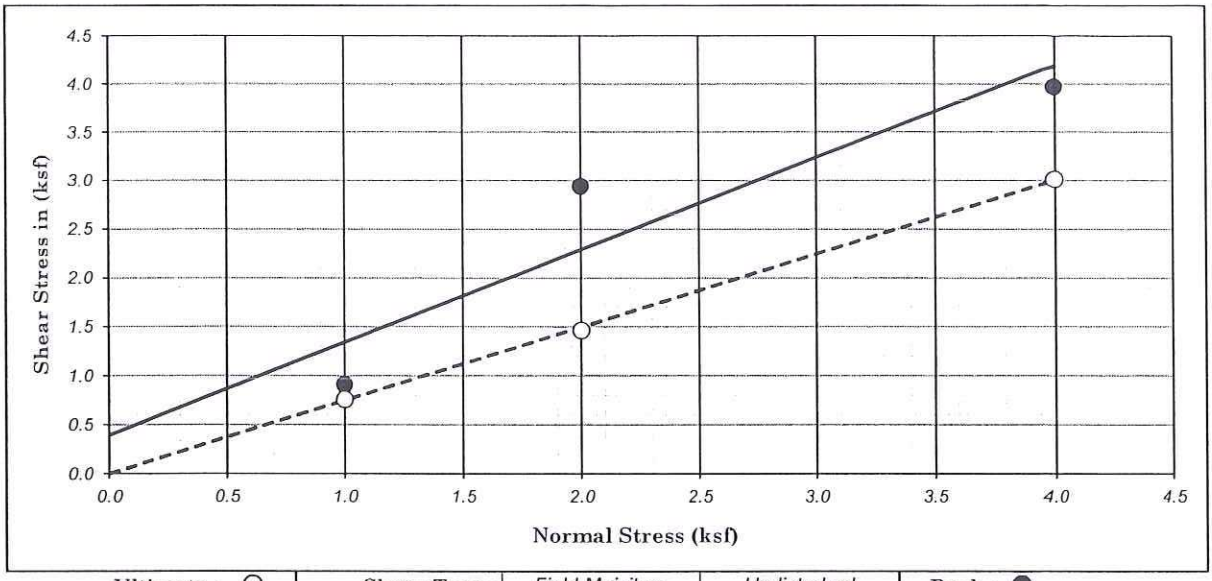
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

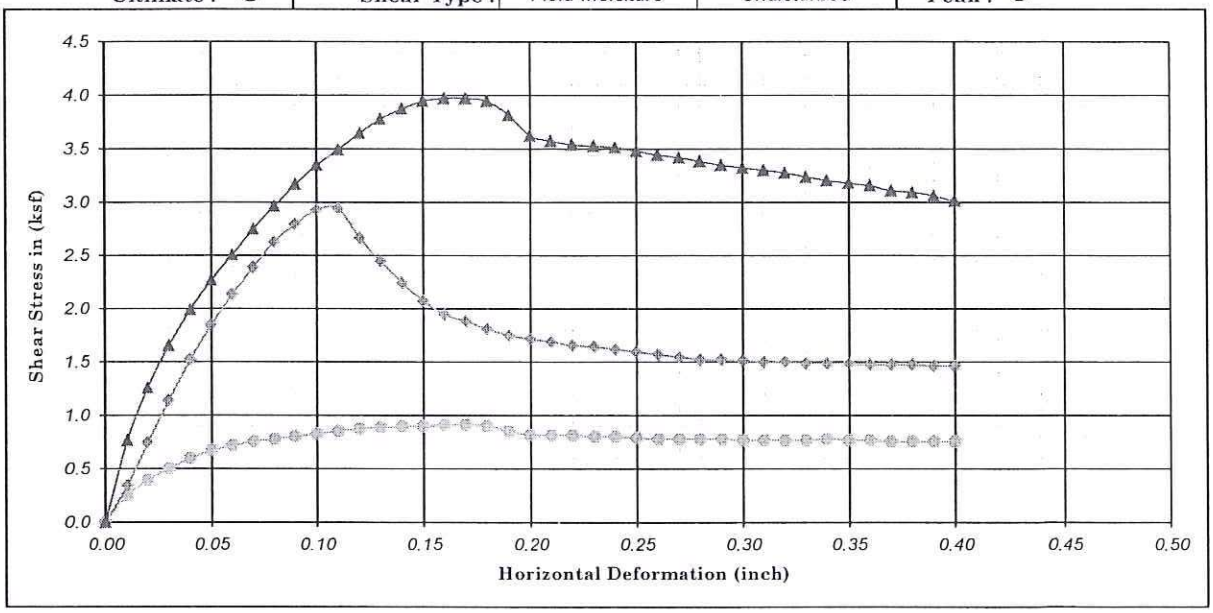
Retaining Wall 349

DIRECT SHEAR TEST (ASTM D-3080)

Project No. : 11-137 | Date : 11/05/11 | Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-313		Strength Intercept (C) :	0.40	(ksf)	Peak	0.00	(ksf)	Ultimate
Sample No. : D-4			18.96	(kPa)		0.00	(kPa)	
Depth (ft/m) : 15.0	0.00	Friction Angle (ϕ) :	43.47	Degree		36.84	Degree	
Description : Olive-brown, Lean CLAY with SAND (CL)					Shear Rate (inch/minute) :		0.02	

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	14.45	112.30	17.68	0.50	1.00	47.88	0.91	43.67	0.76	36.20
◆	15.10	113.51	17.87	0.49	2.00	95.76	2.94	140.77	1.46	70.10
▲	15.41	110.31	17.36	0.53	4.00	191.52	3.97	190.18	3.01	144.21

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

I-5 HOV Improvement Project
PCH to San Juan Creek Road

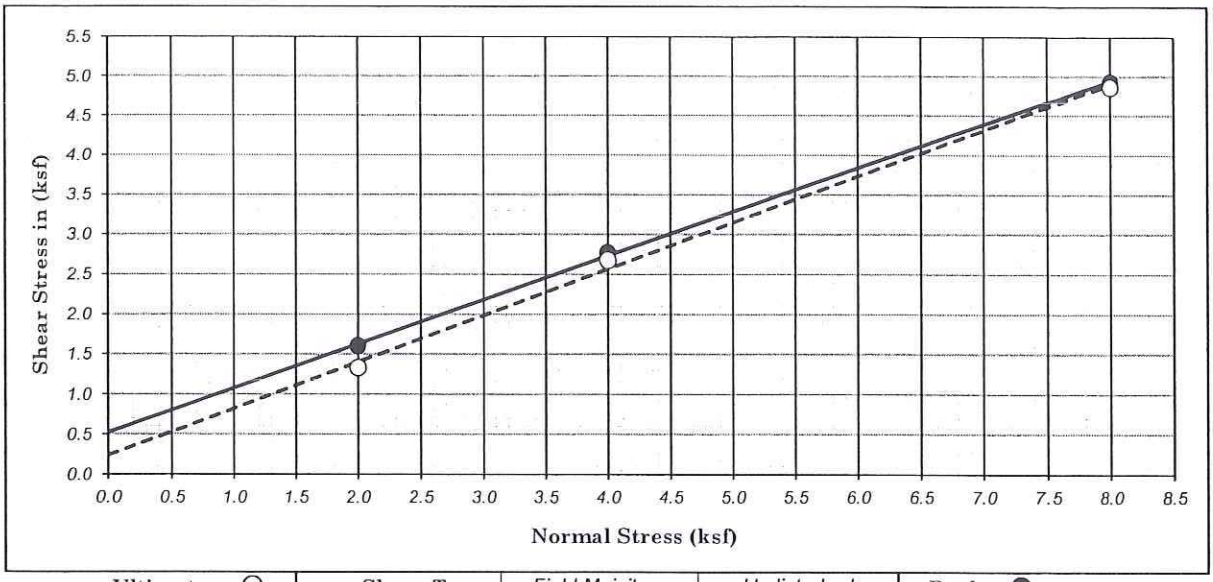
Retaining Wall 349

DIRECT SHEAR TEST (ASTM D-3080)

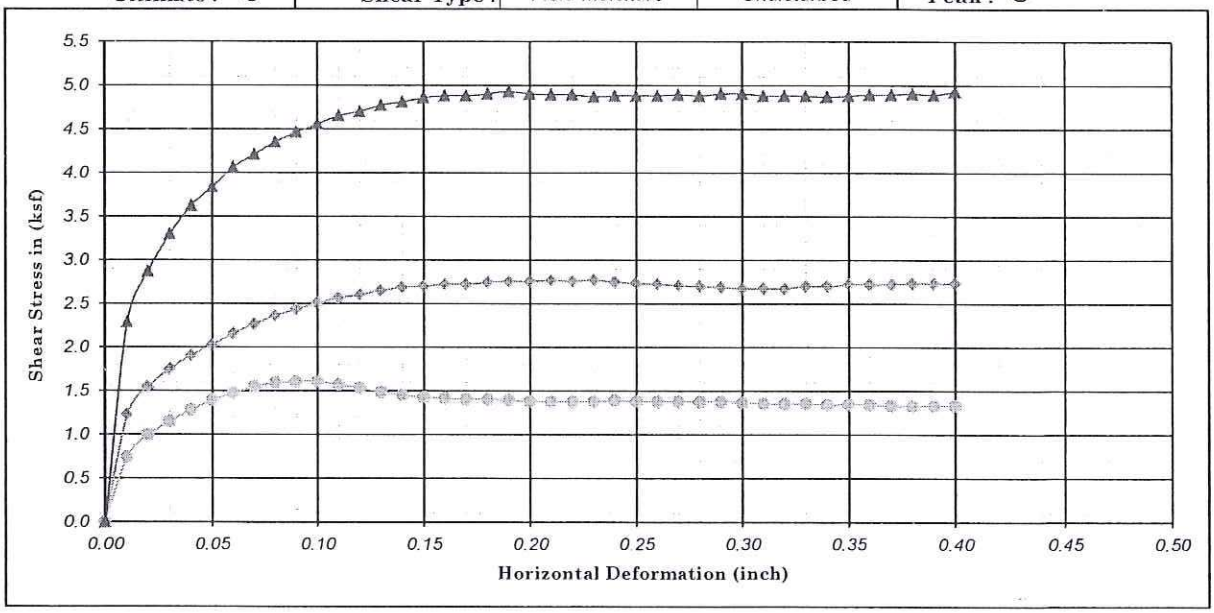
Project No. : 11-137

Date : 01/13/12

Figure No. :



Ultimate : ○	Shear Type :	Field Moisiture	Undisturbed	Peak : ●



Boring No. : A-11-313		Strength Intercept (C) :	0.53	(ksf)	Peak	0.24	(ksf)	Ultimate
Sample No. : D-10			25.28	(kPa)		11.49	(kPa)	
Depth (ft/m) : 45.0	0.00	Friction Angle (ϕ) :	28.90	Degree		30.20	Degree	
Description : Olive-brown, Poorly graded SAND with SILT (SP-SM)						Shear Rate (inch/minute) :		0.02

SYMBOL	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DRY DENSITY (kN/m^3)	VOID RATIO	NORMAL STRESS (ksf)	NORMAL STRESS (kPa)	PEAK STRESS (ksf)	PEAK STRESS (kPa)	ULTIMATE STRESS (ksf)	ULTIMATE STRESS (kPa)
●	3.93	94.81	14.92	0.78	2.00	95.76	1.61	76.99	1.33	63.78
◆	3.67	93.94	14.79	0.79	4.00	191.52	2.77	132.72	2.68	128.13
▲	3.19	95.97	15.11	0.76	8.00	383.04	4.93	236.14	4.86	232.70

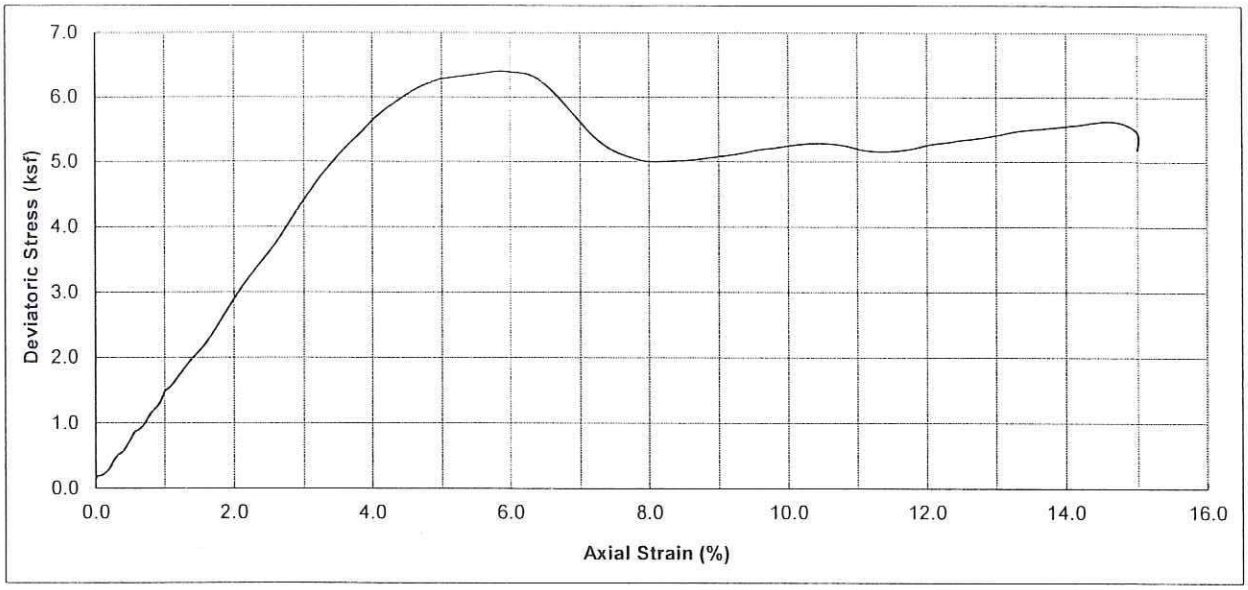
Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

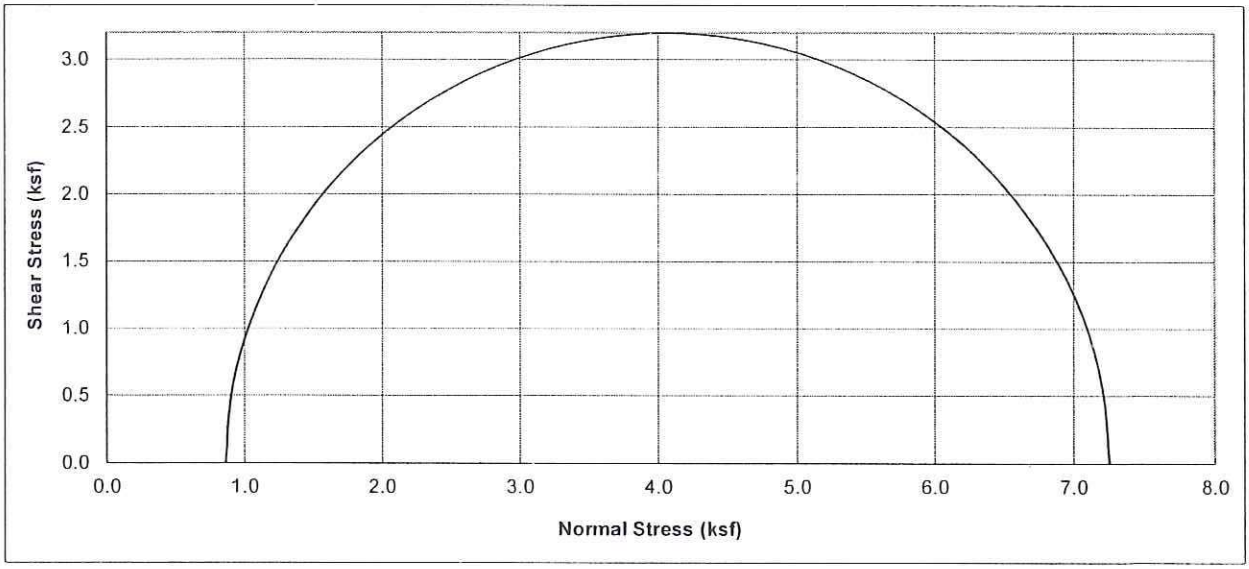
I-5 HOV Improvement Project
PCH to San Juan Creek Road

Retaining Wall 349

DIRECT SHEAR TEST (ASTM D-3080)

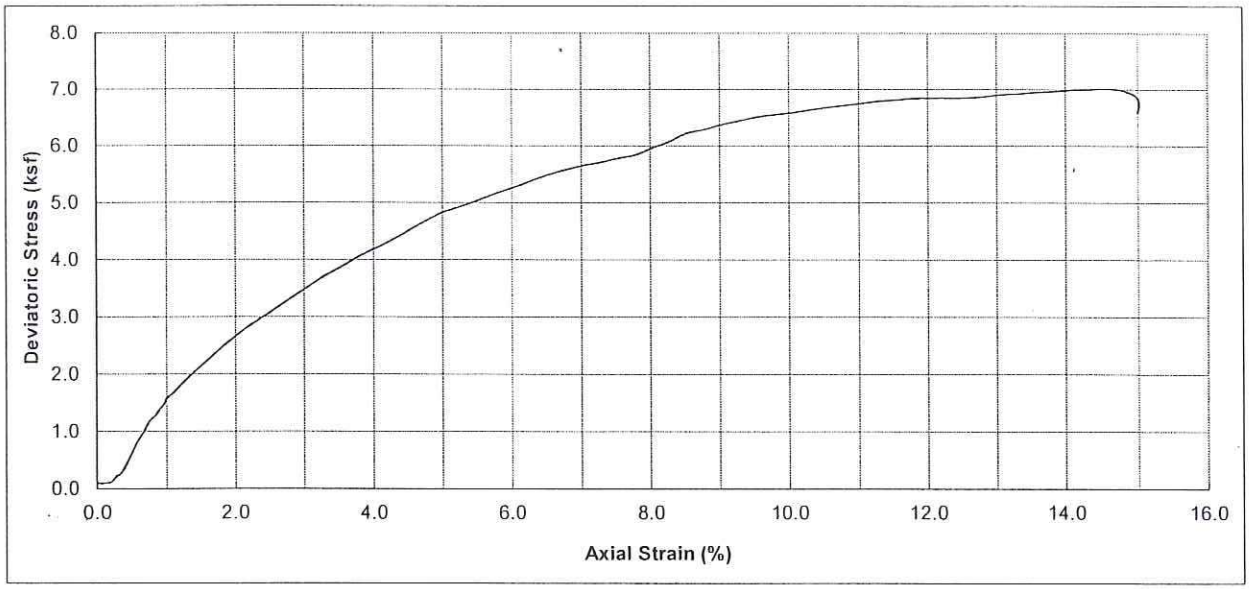
Project No. : 11-137 | Date : 11/05/11 | Figure No. :

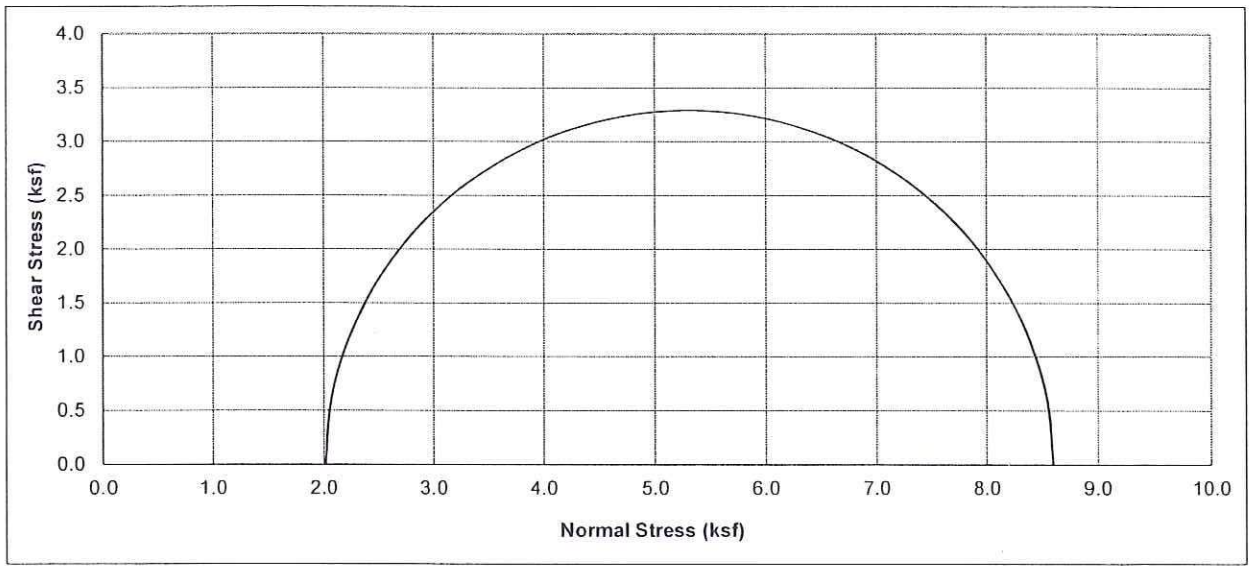




Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-310	D-3	10	Olive brown , SANDY SILT (ML)	106.6	13.33	0.86	6.39	62.1

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering		I-5 HOV Improvement Project PCH to San Juan Creek Road
		UNCONSOLIDATED UNDRAINED TEST
Project No. : 11-137	Date : 10/27/11	(ASTM D2850) Figure No. :





Boring No.	Sample No.	Depth (ft)	Soil Type	Dry Density (pcf)	Moisture Content (%)	Conf. Stress (ksf)	10% Axial Strain Dev. Stress (ksf)	Initial Saturation (%)
A-11-313	D-6	25	Olive brown , Lean CLAY with SAND (CL)	108.8	18.70	2.01	6.58	92.1

Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	I-5 HOV Improvement Project PCH to San Juan Creek Road
Project No. : 11-137 / Date : 10/27/11	UNCONSOLIDATED UNDRAINED TEST (ASTM D2850) Figure No. :

Appendix C

DESIGN CALCULATIONS

I-5 HOV Improvement Project, Segment 3 - Retaining Wall 349 SP 11-137
LIQUEFACTION ANALYSIS; ACC. = 0.4 g 17-Apr-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
^1C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

A-11-310

Emean (%)	75	Sur.=		psf	225.9	=top of ground el.		Borehole Diamete		8				192	=water table El.			acc. max =	0.40	g		Earthq. M=	7.5
C_E	1.25							C_B		1.15												Cm=	1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
223.4	2.5	0.14	0.14	2.50	2.00	0.75	1.00	0.50	115	2	2	28	0.99	0.26	31	51.0	43	1.00	high N	high N	LARGE	AboveWT
220.9	2.5	0.29	0.29	5.00	1.91	0.75	1.20	1.00	115	1	1	11	0.99	0.26	28	51.0	39	1.00	high N	high N	LARGE	AboveWT
215.9	5	0.58	0.58	10.00	1.35	0.75	1.00	0.50	115	2	2	58	0.98	0.25	43	67.0	57	1.00	high N	high N	LARGE	AboveWT
210.9	5	0.86	0.86	15.00	1.10	0.85	1.20	1.00	115	1	1	18	0.97	0.25	30	51.0	41	1.00	high N	high N	LARGE	AboveWT
205.9	5	1.15	1.15	20.00	0.95	0.85	1.00	0.50	115	2	2	38	0.95	0.25	23	51.0	33	0.98	high N	high N	LARGE	AboveWT
200.9	5	1.44	1.44	25.00	0.85	0.95	1.20	1.00	115	1	1	30	0.94	0.24	42	5.0	42	0.94	high N	high N	LARGE	AboveWT
195.9	5	1.73	1.73	30.00	0.78	0.95	1.00	0.50	115	2	2	90	0.93	0.24	48	5.0	48	0.90	high N	high N	LARGE	AboveWT
190.9	5	2.01	1.86	35.00	0.75	1.00	1.20	1.00	115	1	1	100	0.89	0.25	130	5.0	130	0.88	high N	high N	LARGE	high N
185.9	5	2.30	1.99	40.00	0.72	1.00	1.00	0.50	115	2	2	60	0.85	0.26	32	51.0	44	0.86	high N	high N	LARGE	high N/fines

I-5 HOV Improvement Project, Segment 3 - Retaining Wall 349 SP 11-137

LIQUEFACTION ANALYSIS: ACC. = 0.4 g 17-Apr-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
$^{1}C_N$ = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

A-11-312

Emean (%)	75	Sur.=	psf	184.9	=top of ground el.	Borehole Diamete	8							175	=water table El.			acc. max =	0.40	g	Earthq. M=	7.5
C_E	1.25					C_B	1.15														Cm=	1.00

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA.MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
179.9	5	0.29	0.29	5.00	1.91	0.75	1.00	0.50	115	2	2	17	0.99	0.26	18	51.0	27	1.00	0.34	0.34	1.32	AboveWT
174.9	5	0.58	0.42	10.00	1.58	0.75	1.20	1.00	115	1	1	8	0.98	0.35	17	51.0	26	1.00	0.31	0.31	0.90	fines
169.9	5	0.86	0.55	15.00	1.38	0.85	1.00	0.50	115	2	2	100	0.97	0.39	85	51.0	107	1.00	high N	high N	LARGE	high N/fines
164.9	5	1.15	0.68	20.00	1.24	0.85	1.20	1.00	115	1	1	39	0.95	0.42	71	51.0	91	1.00	high N	high N	LARGE	high N/fines
159.9	5	1.44	0.81	25.00	1.13	0.95	1.00	0.50	115	2	2	100	0.94	0.43	78	51.0	99	1.00	high N	high N	LARGE	high N/fines
154.9	5	1.73	0.95	30.00	1.05	0.95	1.20	1.00	115	1	1	39	0.93	0.44	68	51.0	87	1.00	high N	high N	LARGE	high N/fines
149.9	5	2.01	1.08	35.00	0.98	1.00	1.00	0.50	115	2	2	100	0.89	0.43	71	51.0	91	0.99	high N	high N	LARGE	high N/fines
144.9	5	2.30	1.21	40.00	0.93	1.00	1.20	1.00	115	1	1	45	0.85	0.42	73	51.0	93	0.97	high N	high N	LARGE	high N/fines
139.9	5	2.59	1.34	45.00	0.88	1.00	1.00	0.50	115	2	2	100	0.81	0.41	64	51.0	82	0.95	high N	high N	LARGE	high N/fines
134.9	5	2.88	1.47	50.00	0.84	1.00	1.20	1.00	115	1	1	37	0.77	0.39	54	51.0	70	0.93	high N	high N	LARGE	high N/fines

I-5 HOV Improvement Project, Segment 3 - Retaining Wall 349 SP 11-137

LIQUEFACTION ANALYSIS; ACC. = 0.4 g 17-Apr-12

Liquefaction analysis is performed following Seed's Procedure, outlined by Seed et al (1985), Seed and Harder (1990), updated NCEER (1997)

Emean/E60 = Energy Ratio to correct to standard 60% Energy
Surcharge = Any surcharge on top of the ground (psf)
acc. max = maximum peak acceleration at the ground surface (g's)
^1C_N = square root of (100 kPa or 1.04427 tsf/effective overburden)
The induced cyclic stress ratio (CSR i) by a given peak ground acceleration (acc. max) is:

CSR i = 0.65 x acc max. x total normal stress x rd / (effective normal stress x g)

where: rd = stress reduction factor (Robertson and Wride (1996), Marcuson (USArmy Eng), per NCEER (1997))
g = acceleration of gravity

The resisting cyclic stress ratio (CSR r) is equal to:

CSR r = CSR x Cm x K sigma

where: Cm = Earthquake Magnitude Correction Factor (Blake, NCEER Table 3, Eq.4)
K sigma = Normalized resistance factor (Fig. 14 from NCEER Liquefaction workshop, Harder Boulanger)
CSR = Resisting Cyclic Stress Ratio. It is a function of the content of fines
(Figure 2, NCEER Workshop, after Seed et al 1985))

Factor of Safety, F sub L is:

F sub L = CSR r / CSR i

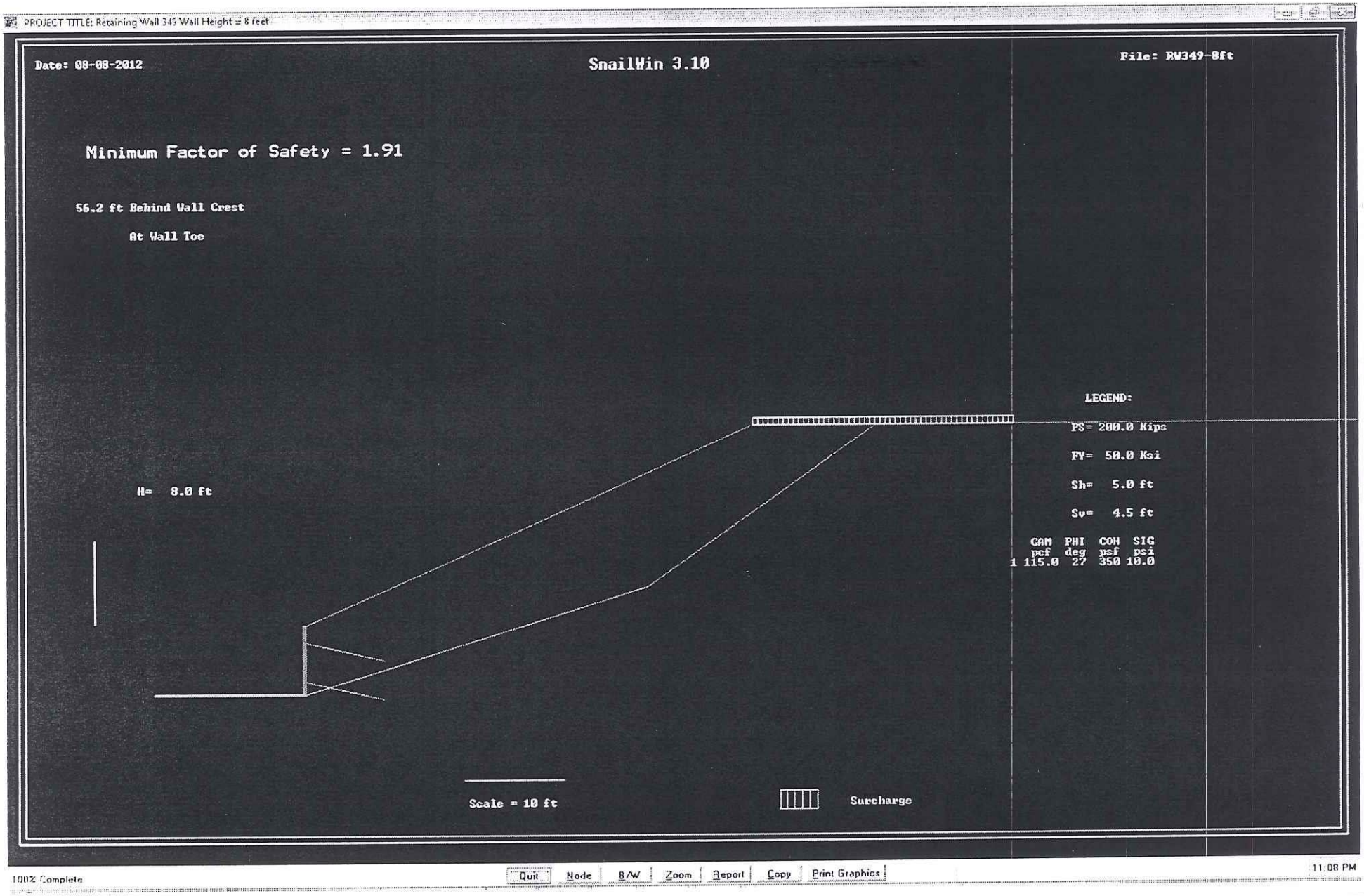
A-11-313

Emean (%)	75	Sur.=	psf	225.6	=top of ground el.	Borehole Diamete	8							192	=water table El.		acc. max =	0.40	g		Earthq. M=	7.5		
C_E	1.25					C_B	1.15														Cm=	1.00		

ELEVATION TOP OF LAYER (ft.)	LAYER THICKNESS L (ft.)	TOTAL OVERBUR. PRESS. (tsf)	EFFEC. OVERBUR. PRESS. (tsf)	DEPTH BELOW SURFACE (ft)	C_N	C_R	C_S	C_{ST}	TOTAL UNIT WEIGHT (pcf)	SAMPLER TYPE 1=SPT 2=CA,MOD.	SAMPLER LINED 1=UNLINED 2=LINED	FIELD BLOW COUNT N	STRESS REDUC. COEFF. rd	INDUCED CYCLIC STRESS RATIO	CORRECT BLOW COUNT Nc	EST. PERCENT OF FINES (%)	(N1)60cs	K sigma	RESIST. CYCLIC STRESS RATIO M=7.5	RESIST. CYCLIC STRESS RATIO Overburd Cor Mag Corr	FACTOR OF SAFETY (F sub L)	WILL IT LIQUEFY?
220.6	1	0.06	0.06	5.00	2.00	0.75	1.00	0.50	115	2	2	12	0.99	0.26	13	15.0	17	1.00	0.18	0.18	0.70	AboveWT
219.6	4	0.29	0.29	6.00	1.91	0.75	1.00	0.50	115	2	2	12	0.99	0.26	13	55.0	21	1.00	0.23	0.23	0.89	AboveWT
215.6	5	0.58	0.58	10.00	1.35	0.75	1.20	1.00	115	1	1	16	0.98	0.25	28	51.0	39	1.00	high N	high N	LARGE	AboveWT
210.6	5	0.86	0.86	15.00	1.10	0.85	1.00	0.50	115	2	2	50	0.97	0.25	34	51.0	46	1.00	high N	high N	LARGE	AboveWT
205.6	5	1.15	1.15	20.00	0.95	0.85	1.20	1.00	115	1	1	19	0.95	0.25	27	51.0	38	0.98	high N	high N	LARGE	AboveWT
200.6	5	1.44	1.44	25.00	0.85	0.95	1.00	0.50	115	2	2	48	0.94	0.24	28	51.0	39	0.94	high N	high N	LARGE	AboveWT
195.6	5	1.73	1.73	30.00	0.78	0.95	1.20	1.00	115	1	1	18	0.93	0.24	23	51.0	33	0.90	high N	high N	LARGE	AboveWT
190.6	5	2.01	1.86	35.00	0.75	1.00	1.00	0.50	115	2	2	75	0.89	0.25	41	5.0	41	0.88	high N	high N	LARGE	high N
185.6	5	2.30	1.99	40.00	0.72	1.00	1.20	1.00	115	1	1	51	0.85	0.26	64	5.0	64	0.86	high N	high N	LARGE	high N
180.6	5	2.59	2.12	45.00	0.70	1.00	1.00	0.50	115	2	2	100	0.81	0.26	51	51.0	67	0.87	high N	high N	LARGE	high N/fines
175.6	5	2.88	2.25	50.00	0.68	1.00	1.20	1.00	115	1	1	39	0.77	0.25	46	51.0	61	0.86	high N	high N	LARGE	high N/fines

Retaining Wall 349 Soil Nail Wall

Wall Height = 8 feet



Retaining Wall 349 – Soil Nail Wall

Soil Nail Wall Height = 8 feet
Static Condition

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project No. 11-137

Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*         ENGINEERING SERVICE CENTER             *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:08:25    *
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Project Identification - Retaining Wall 349 Wall Height = 8 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	8.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	27.9	49.8
Second Slope from 1st slope.	=	0.0	30.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	44.1 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	2
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	2.0	1.00	0.75
2	8.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.857	7.9	42.8	5.4	65.1	9.4

Reinf. Stress at Level 1 = 7.261 Ksi (Pullout controls...)
2 = 14.469 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.803	14.8	28.1	10.1	61.9	12.6

Reinf. Stress at Level 1 = 0.570 Ksi (Pullout controls...)
2 = 13.103 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.484	21.7	28.3	12.3	51.5	17.4

Reinf. Stress at Level 1 = 0.651 Ksi (Pullout controls...)
2 = 13.123 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.329	28.6	28.3	19.5	50.5	18.0

Reinf. Stress at Level 1 = 0.662 Ksi (Pullout controls...)
2 = 13.126 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	2.224	35.5	26.7	23.8	48.5	21.5

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.930 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	2.141	42.4	22.3	32.1	55.2	22.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.335 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.951	49.3	22.9	32.1	43.6	27.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.427 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.911	56.2	20.4	36.0	39.9	29.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.033 Ksi (Pullout controls...)

	MINIMUM	DISTANCE	LOWER FAILURE		UPPER FAILURE

	SAFETY FACTOR	BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.955	63.1	16.6	32.9	34.8	38.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.349 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	2.033	70.0	12.6	28.7	30.8	48.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.456 Ksi (Pullout controls...)

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**************************************************************************
*                  For Factor of Safety = 1.0                            *
*          Maximum Average Reinforcement Working Force:                  *
*                        0.000 Kips/level                                *
**************************************************************************
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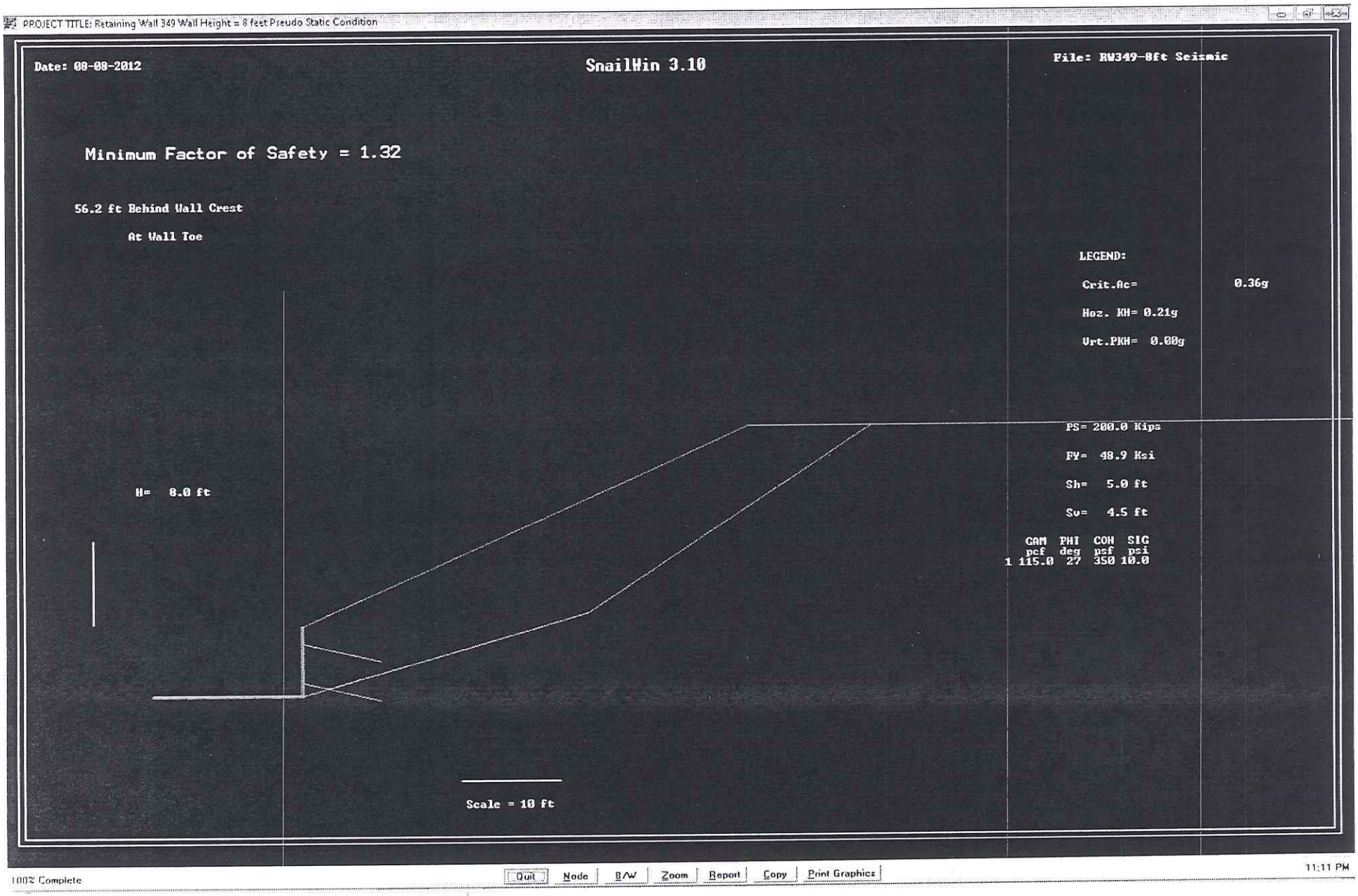

Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 8 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:11:44    *
**************************************************
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Project Identification - Retaining Wall 349 Wall Height = 8 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height = 8.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	49.8
Second Slope from 1st slope. =	0.0	30.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 2
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 48.9 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	2.0	1.00	0.73

2 8.0 15.0 4.5 1.00 0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.690	7.9	42.8	10.8	89.9	4.9

Reinf. Stress at Level 1 = 5.899 Ksi (Pullout controls...)
2 = 14.141 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.954	14.8	32.7	17.6	89.9	6.3

Reinf. Stress at Level 1 = 2.478 Ksi (Pullout controls...)
2 = 13.286 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.733	21.7	32.2	25.6	89.9	5.8

Reinf. Stress at Level 1 = 2.264 Ksi (Pullout controls...)
2 = 13.232 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.620	28.6	29.5	32.9	89.9	6.9

Reinf. Stress at Level 1 = 1.172 Ksi (Pullout controls...)
2 = 12.959 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.546	35.5	27.9	40.2	89.9	8.0

Reinf. Stress at Level 1 = 0.421 Ksi (Pullout controls...)
2 = 12.772 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.485	42.4	22.3	32.1	55.2	22.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.055 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.371	49.3	22.9	32.1	43.6	27.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.146 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.325	56.2	18.5	29.6	37.9	35.6

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.444 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.325	63.1	16.6	32.9	34.8	38.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.092 Ksi (Pullout controls...)

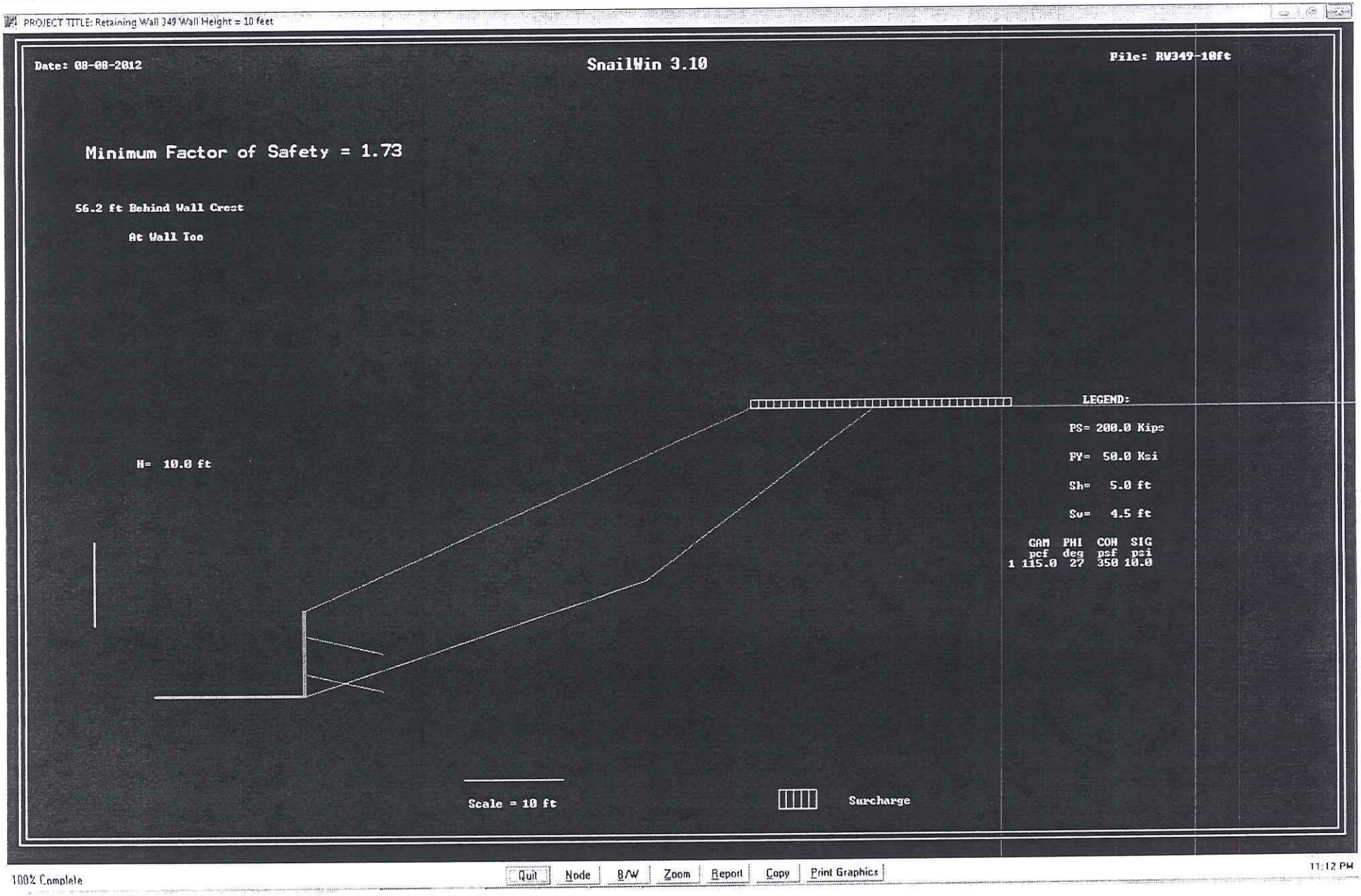
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.343	70.0	12.6	28.7	30.8	48.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.219 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 0.000 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 10 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 10 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
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*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:12:54    *
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Project Identification - Retaining Wall 349 Wall Height = 10 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	10.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	27.9	49.8
Second Slope from 1st slope.	=	0.0	30.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	44.1 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	2
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	3.0	1.00	0.75
2	8.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.516	7.9	51.5	12.7	89.9	4.3

Reinf. Stress at Level 1 = 7.013 Ksi (Pullout controls...)
2 = 13.613 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.096	14.8	40.2	19.4	89.9	5.4

Reinf. Stress at Level 1 = 3.198 Ksi (Pullout controls...)
2 = 12.251 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.965	21.7	33.4	15.6	56.1	15.5

Reinf. Stress at Level 1 = 0.415 Ksi (Pullout controls...)
2 = 11.257 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.906	28.6	32.1	23.6	55.7	15.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.040 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.876	35.5	30.1	28.7	53.5	17.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.682 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.852	42.4	28.7	33.8	51.9	20.6

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.417 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.742	49.3	25.8	38.3	48.4	22.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 9.831 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.734	56.2	21.6	36.3	41.6	30.1

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 8.848 Ksi (Pullout controls...)

MINIMUM	DISTANCE	LOWER FAILURE	UPPER FAILURE

	SAFETY FACTOR	BEHIND WALL TOE (ft)	PLANE ANGLE (deg)	PLANE LENGTH (ft)	PLANE ANGLE (deg)	PLANE LENGTH (ft)
NODE 9	1.782	63.1	21.6	27.1	31.6	44.5

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 8.858 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.861	70.0	19.6	29.7	29.0	48.0

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 8.332 Ksi (Pullout controls...)

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**************************************************************************
*                  For Factor of Safety = 1.0                            *
*          Maximum Average Reinforcement Working Force:                  *
*                       0.000 Kips/level                                 *
**************************************************************************
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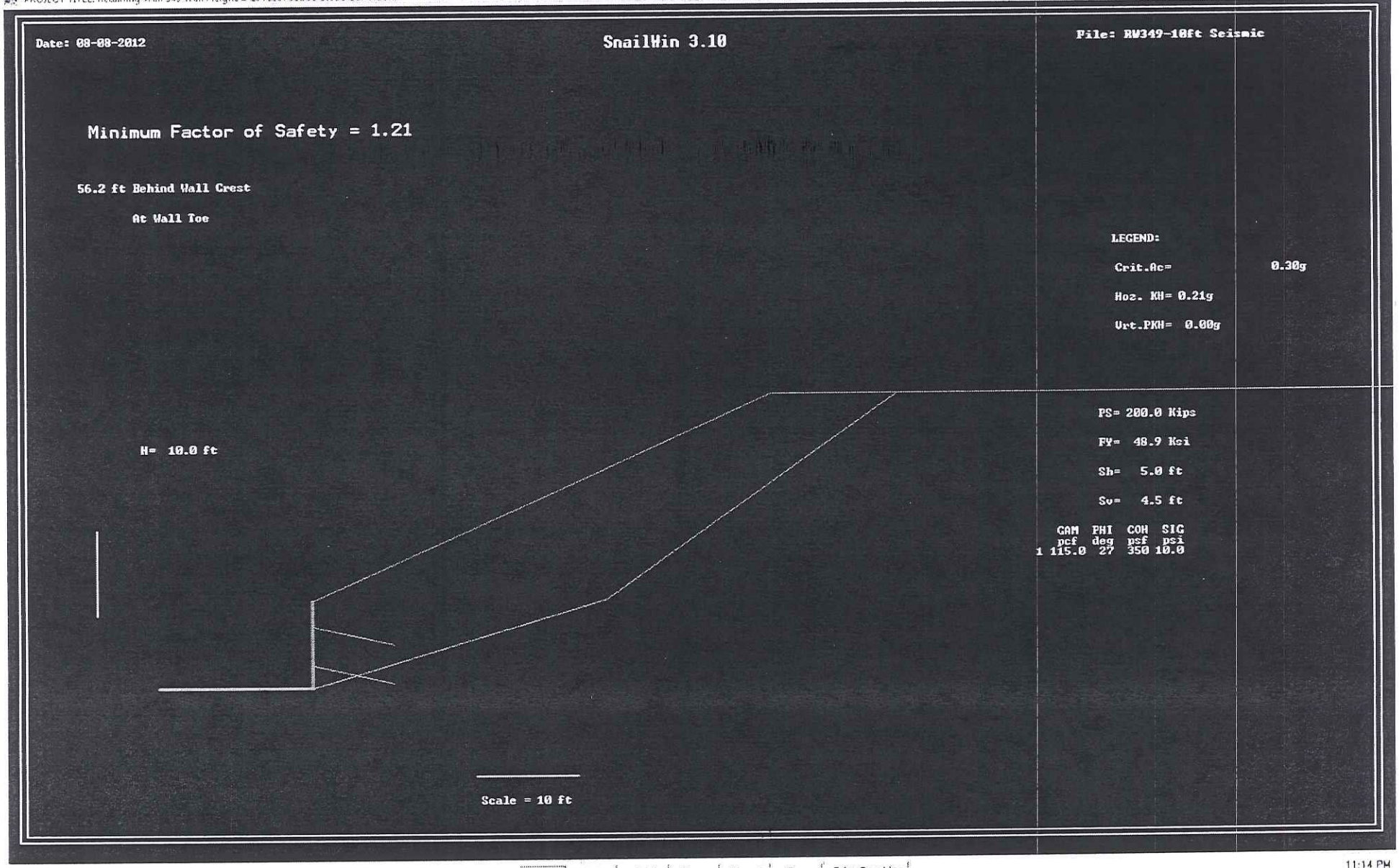
PROJECT TITLE: Retaining Wall 349 Wall Height = 10 feet Pseudo Static Condition



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 10 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
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*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:14:26    *
**************************************************
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Project Identification - Retaining Wall 349 Wall Height = 10 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

		Angle (Deg)	Length (Feet)
Vertical Wall Height	=	10.0 ft	
Wall Batter	=	0.0 degree	
First Slope from Wallcrest.	=	27.9	49.8
Second Slope from 1st slope.	=	0.0	30.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	2
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	48.9 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	3.0	1.00	0.73

2 8.0 15.0 4.5 1.00 0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.894	7.9	47.1	11.6	89.9	5.7

Reinf. Stress at Level 1 = 5.515 Ksi (Pullout controls...)
2 = 12.826 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.509	14.8	40.2	19.4	89.9	5.4

Reinf. Stress at Level 1 = 3.125 Ksi (Pullout controls...)
2 = 11.973 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.449	21.7	34.7	26.4	89.9	6.4

Reinf. Stress at Level 1 = 0.972 Ksi (Pullout controls...)
2 = 11.204 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.385	28.6	32.1	23.6	55.7	15.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.790 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.342	35.5	30.1	28.7	53.5	17.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.440 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.308	42.4	28.7	33.8	51.9	20.6

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.181 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.229	49.3	24.2	32.4	45.4	28.1

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 9.282 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.208	56.2	19.6	29.8	39.7	36.5

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 8.125 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.219	63.1	17.6	33.1	36.5	39.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 7.542 Ksi (Pullout controls...)

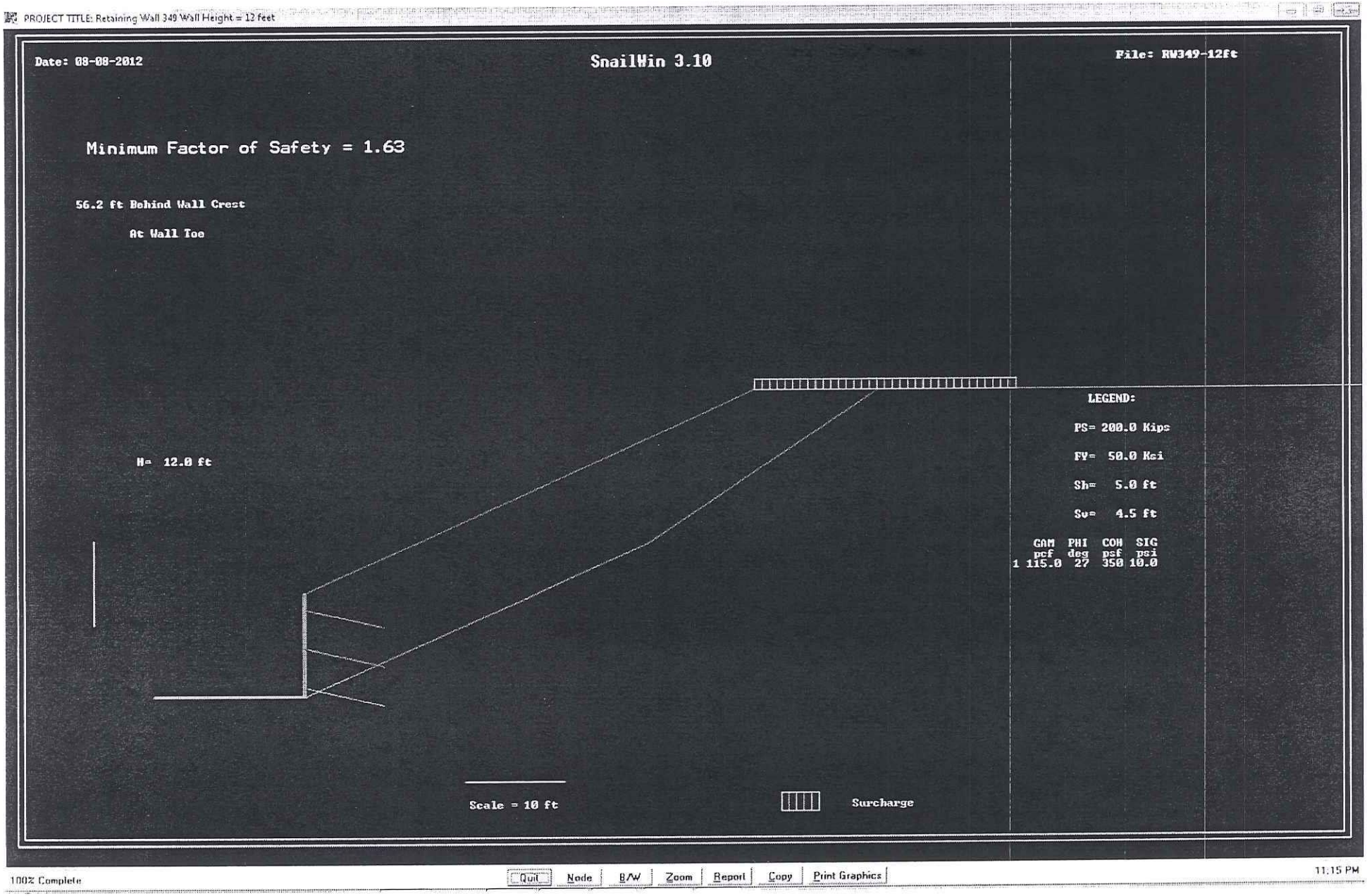
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.243	70.0	17.6	22.0	28.5	55.8

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 7.550 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 0.000 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 12 feet



Retaining Wall 349 – Soil Nail Wall

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Soil Nail Wall Height = 12 feet
Static Condition

Project No. 11-137

Date: 08-08-12

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*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:15:41    *
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Project Identification - Retaining Wall 349 Wall Height = 12 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height = 12.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	49.8
Second Slope from 1st slope. =	0.0	30.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe = 44.1 ft
End Surcharge - Distance from toe = 70.0 ft
Loading Intensity - Begin = 240.0 psf/ft
Loading Intensity - End = 240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 3
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 50.0 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	2.0	1.00	0.75
2	8.0	15.0	4.5	1.00	0.75

3 8.0 15.0 4.5 1.00 0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.364	7.9	55.1	13.8	89.9	4.9

Reinf. Stress at Level 1 = 4.140 Ksi (Pullout controls...)
2 = 10.053 Ksi (Pullout controls...)
3 = 15.966 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.894	14.8	47.0	21.7	89.9	4.0

Reinf. Stress at Level 1 = 0.594 Ksi (Pullout controls...)
2 = 8.103 Ksi (Pullout controls...)
3 = 15.611 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.805	21.7	40.9	28.7	89.9	4.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 6.434 Ksi (Pullout controls...)
3 = 15.308 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.782	28.6	37.2	35.9	89.9	5.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 5.306 Ksi (Pullout controls...)
3 = 15.103 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1 755	35.5	31.8	29.2	55.3	18.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 3.423 Ksi (Pullout controls...)
3 = 14.761 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.732	42.4	30.1	34.3	53.6	21.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 2.782 Ksi (Pullout controls...)
3 = 14.644 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.641	49.3	27.1	38.8	50.0	23.0

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 1.501 Ksi (Pullout controls...)
3 = 14.411 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

NODE 8

1.633	56.2	27.6	38.1	38.1	28.6

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 1.739 Ksi (Pullout controls...)
3 = 14.454 Ksi (Pullout controls...)

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

NODE 9

1.672	63.1	24.1	34.6	33.9	38.0

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.091 Ksi (Pullout controls...)
3 = 14.155 Ksi (Pullout controls...)

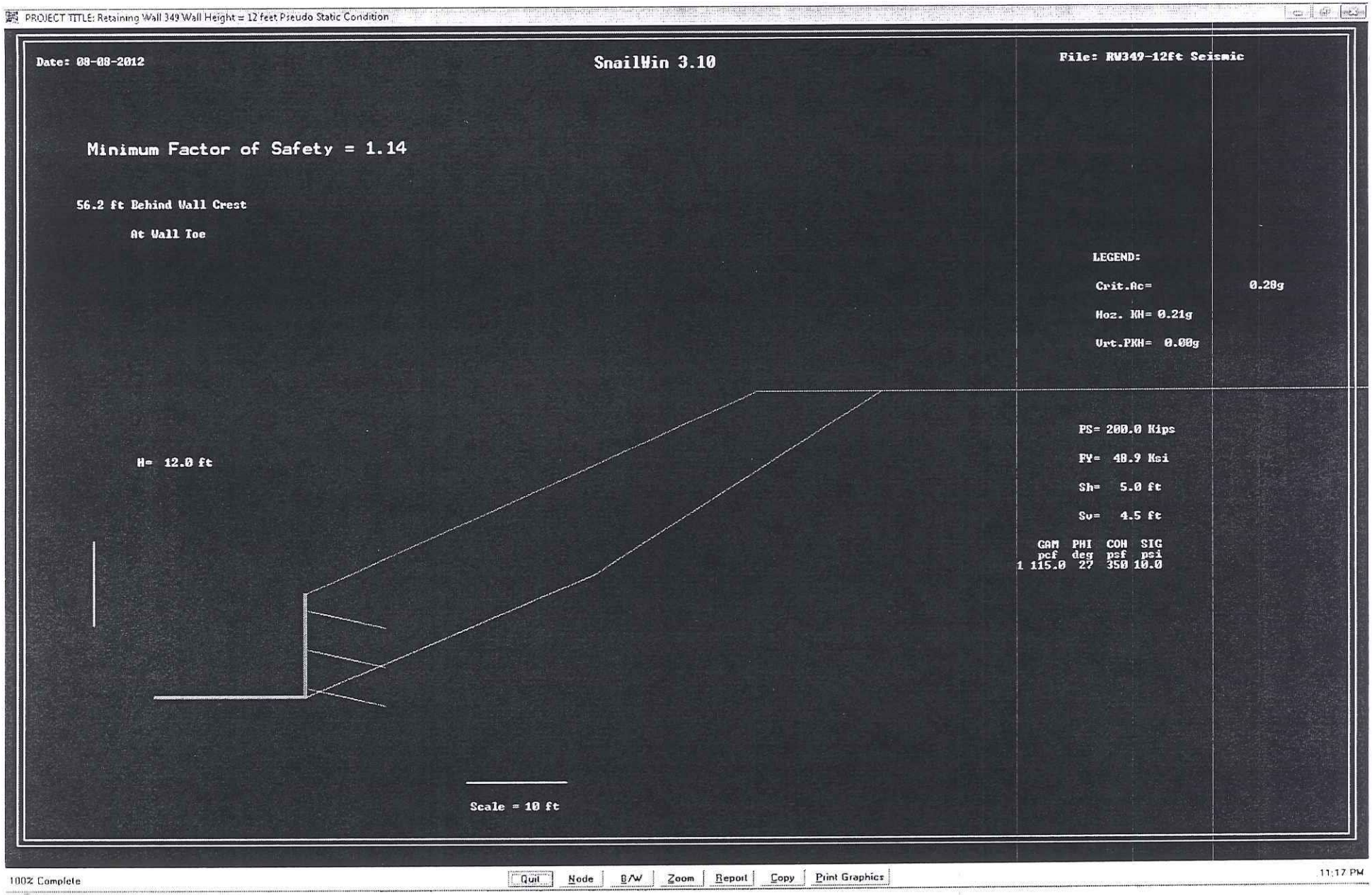
MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

NODE10

1.755	70.0	20.7	29.9	30.5	48.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.000 Ksi
3 = 13.819 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 0.000 Kips/level *
****



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 12 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*         ENGINEERING SERVICE CENTER             *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012        Time: 23:17:12      *
**************************************************
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Project Identification - Retaining Wall 349 Wall Height = 12 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height = 12.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	49.8
Second Slope from 1st slope. =	0.0	30.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 3
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 48.9 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ----------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	8.0	15.0	2.0	1.00	0.73

2	8.0	15.0	4.5	1.00	0.73
3	8.0	15.0	4.5	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	1.787	7.9	45.7	11.3	89.9	8.1

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 7.586 Ksi (Pullout controls...)
3 = 15.197 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.414	14.8	43.2	20.3	89.9	6.0

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 6.922 Ksi (Pullout controls...)
3 = 15.076 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.317	21.7	40.9	28.7	89.9	4.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 6.288 Ksi (Pullout controls...)
3 = 14.961 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.276	28.6	37.2	35.9	89.9	5.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 5.186 Ksi (Pullout controls...)
3 = 14.761 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.252	35.5	34.8	43.2	89.9	6.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 4.393 Ksi (Pullout controls...)
3 = 14.616 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.221	42.4	30.1	34.3	53.6	21.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 2.718 Ksi (Pullout controls...)
3 = 14.312 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.157	49.3	25.5	32.8	47.0	28.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.761 Ksi (Pullout controls...)
3 = 13.956 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE	LOWER FAILURE PLANE ANGLE	LOWER FAILURE PLANE LENGTH	UPPER FAILURE PLANE ANGLE	UPPER FAILURE PLANE LENGTH

		(ft)	(deg)	(ft)	(deg)	(ft)
NODE 8						
1.144	56.2	26.7	31.4	37.0	35.2	

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 1.287 Ksi (Pullout controls...)
3 = 14.052 Ksi (Pullout controls...)

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9					
1.150	63.1	24.1	34.6	33.9	38.0

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.089 Ksi (Pullout controls...)
3 = 13.834 Ksi (Pullout controls...)

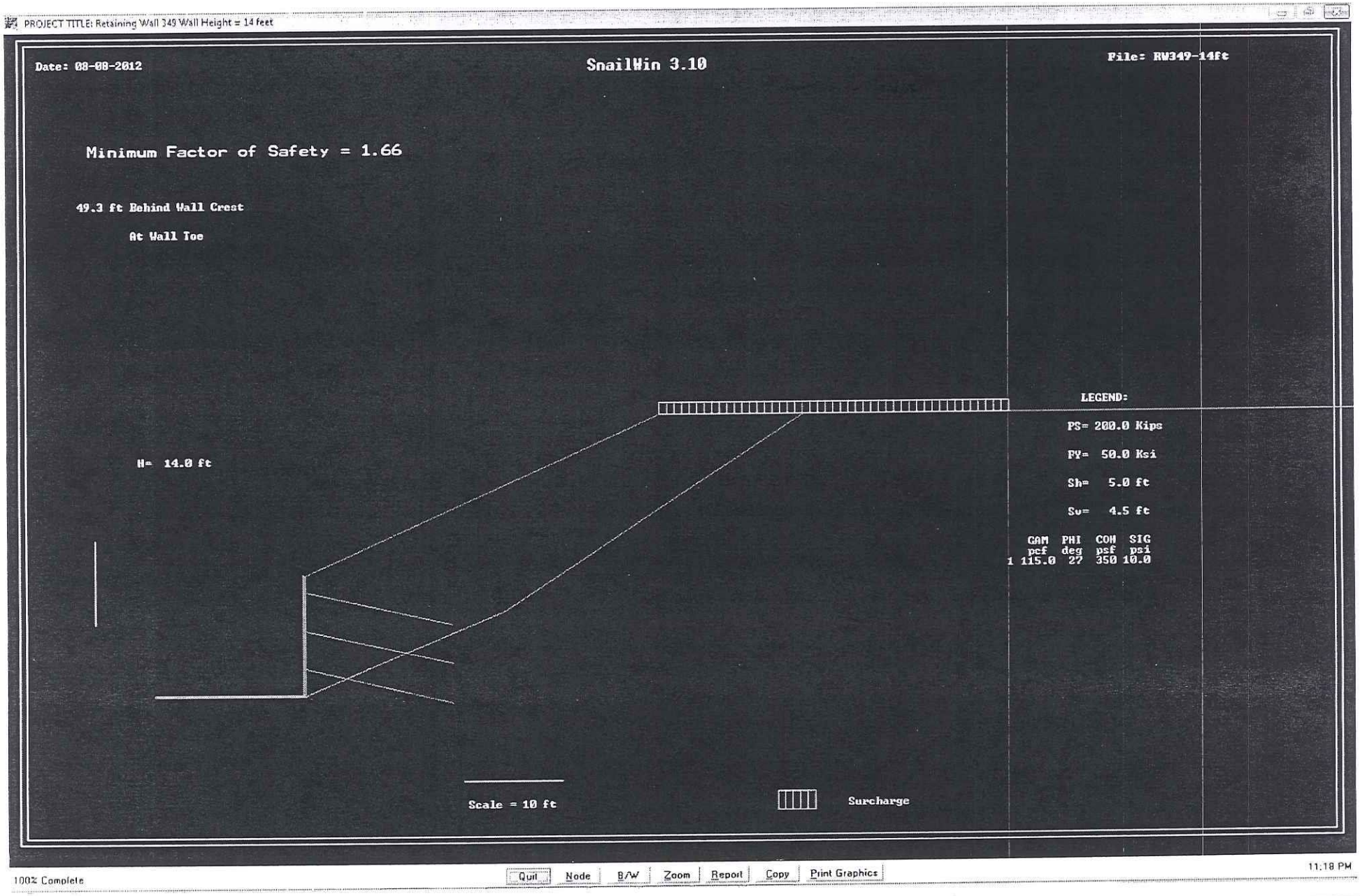
MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10					
1.176	70.0	20.7	29.9	30.5	48.7

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.000 Ksi
3 = 13.506 Ksi (Pullout controls...)

```
**************************************************************************
*                  For Factor of Safety = 1.0                            *
*          Maximum Average Reinforcement Working Force:                  *
*                       0.000 Kips/level                                 *
**************************************************************************
```

Retaining Wall 349 Soil Nail Wall

Wall Height = 14 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 14 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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*****************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION        *
*          ENGINEERING SERVICE CENTER               *
*     DIVISION OF MATERIALS AND FOUNDATIONS         *
*   Office of Roadway Geotechnical Engineering      *
*    Date: 08-08-2012          Time: 23:18:09       *
*****************************************************
```

Project Identification - Retaining Wall 349 Wall Height = 14 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	14.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	27.9	39.6
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	35.0 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	3
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ----------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	15.0	15.0	2.0	1.00	0.75
2	15.0	15.0	4.5	1.00	0.75

3	15.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.044	7.9	29.9	3.6	73.8	17.0

Reinf. Stress at Level 1 = 19.723 Ksi (Pullout controls...)
2 = 22.427 Ksi (Pullout controls...)
3 = 25.132 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.462	14.8	44.5	12.5	65.7	14.4

Reinf. Stress at Level 1 = 11.744 Ksi (Pullout controls...)
2 = 19.000 Ksi (Pullout controls...)
3 = 27.040 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.072	21.7	30.4	10.1	57.4	24.2

Reinf. Stress at Level 1 = 7.410 Ksi (Pullout controls...)
2 = 12.897 Ksi (Pullout controls...)
3 = 24.556 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.907	28.6	31.4	16.8	55.0	24.9

Reinf. Stress at Level 1 = 1.883 Ksi (Pullout controls...)
2 = 13.327 Ksi (Pullout controls...)
3 = 24.771 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.791	35.5	28.8	20.3	52.1	28.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.891 Ksi (Pullout controls...)
3 = 24.196 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.657	42.4	27.1	28.6	49.0	25.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.882 Ksi (Pullout controls...)
3 = 23.793 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.656	49.3	26.3	22.0	37.6	37.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.414 Ksi (Pullout controls...)
3 = 23.606 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

```
NODE 8
     1.715        56.2        21.1   18.1     33.5   47.2

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   6.749 Ksi (Pullout controls...)
                          3 =  22.140 Ksi (Pullout controls...)

           MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
           SAFETY       BEHIND          PLANE            PLANE
           FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                         (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
     1.796        63.1        19.0   20.0     30.5   51.3

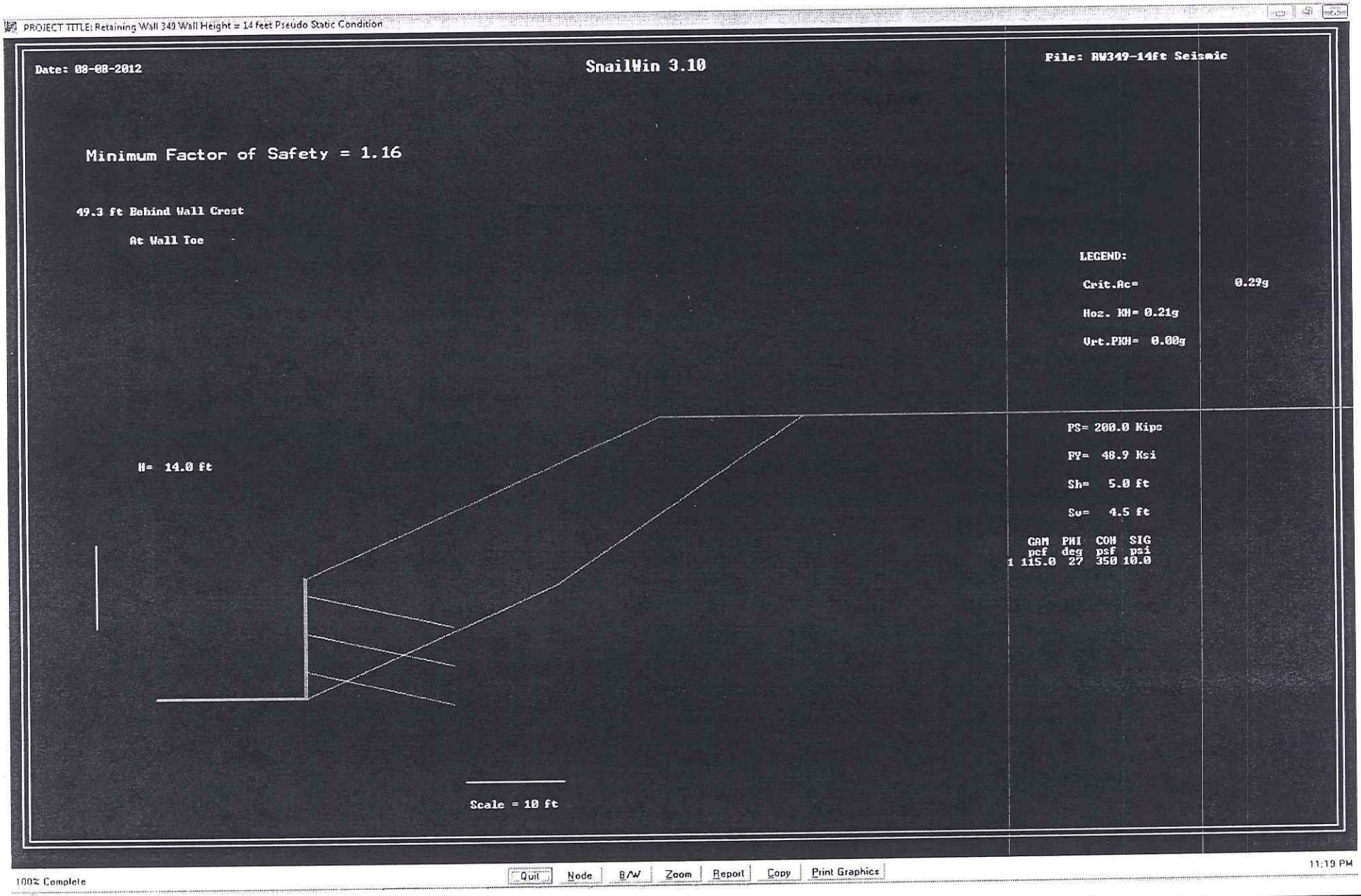
  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   4.979 Ksi (Pullout controls...)
                          3 =  21.432 Ksi (Pullout controls...)

           MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
           SAFETY       BEHIND          PLANE            PLANE
           FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                         (ft)       (deg)   (ft)     (deg)   (ft)

NODE10
     1.888        70.0        13.1   14.4     27.6   63.2

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   0.000 Ksi
                          3 =  18.991 Ksi (Pullout controls...)

      ************************************************************************
      *                  For Factor of Safety = 1.0                          *
      *          Maximum Average Reinforcement Working Force:                *
      *                       0.000 Kips/level                               *
      ************************************************************************
```



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 14 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
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*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:19:40    *
**************************************************
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Project Identification - Retaining Wall 349 Wall Height = 14 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height = 14.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	39.6
Second Slope from 1st slope. =	0.0	40.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 3
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 48.9 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	15.0	15.0	2.0	1.00	0.73

2	15.0	15.0	4.5	1.00	0.73
3	15.0	15.0	4.5	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.217	7.9	49.0	12.0	89.9	9.1

Reinf. Stress at Level 1 = 14.398 Ksi (Pullout controls...)
2 = 20.112 Ksi (Pullout controls...)
3 = 27.044 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	1.719	14.8	41.5	19.8	89.9	8.7

Reinf. Stress at Level 1 = 8.924 Ksi (Pullout controls...)
2 = 17.452 Ksi (Pullout controls...)
3 = 25.980 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.486	21.7	39.4	28.1	89.9	7.6

Reinf. Stress at Level 1 = 7.609 Ksi (Pullout controls...)
2 = 16.630 Ksi (Pullout controls...)
3 = 25.652 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.354	28.6	35.5	35.1	89.9	8.7

Reinf. Stress at Level 1 = 4.938 Ksi (Pullout controls...)
2 = 14.961 Ksi (Pullout controls...)
3 = 24.984 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.275	35.5	31.4	25.0	54.0	24.1

Reinf. Stress at Level 1 = 1.824 Ksi (Pullout controls...)
2 = 13.015 Ksi (Pullout controls...)
3 = 24.205 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.179	42.4	27.1	28.6	49.0	25.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 10.636 Ksi (Pullout controls...)
3 = 23.254 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.161	49.3	27.8	27.9	38.4	31.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 11.069 Ksi (Pullout controls...)
3 = 23.427 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE	LOWER FAILURE PLANE ANGLE	LOWER FAILURE PLANE LENGTH	UPPER FAILURE PLANE ANGLE	UPPER FAILURE PLANE LENGTH

	(ft)	(deg)	(ft)	(deg)	(ft)

NODE 8

1.174	56.2	21.1	18.1	33.5	47.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 6.596 Ksi (Pullout controls...)
3 = 21.638 Ksi (Pullout controls...)

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

NODE 9

1.201	63.1	19.0	20.0	30.5	51.3

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 4.866 Ksi (Pullout controls...)
3 = 20.946 Ksi (Pullout controls...)

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)

NODE10

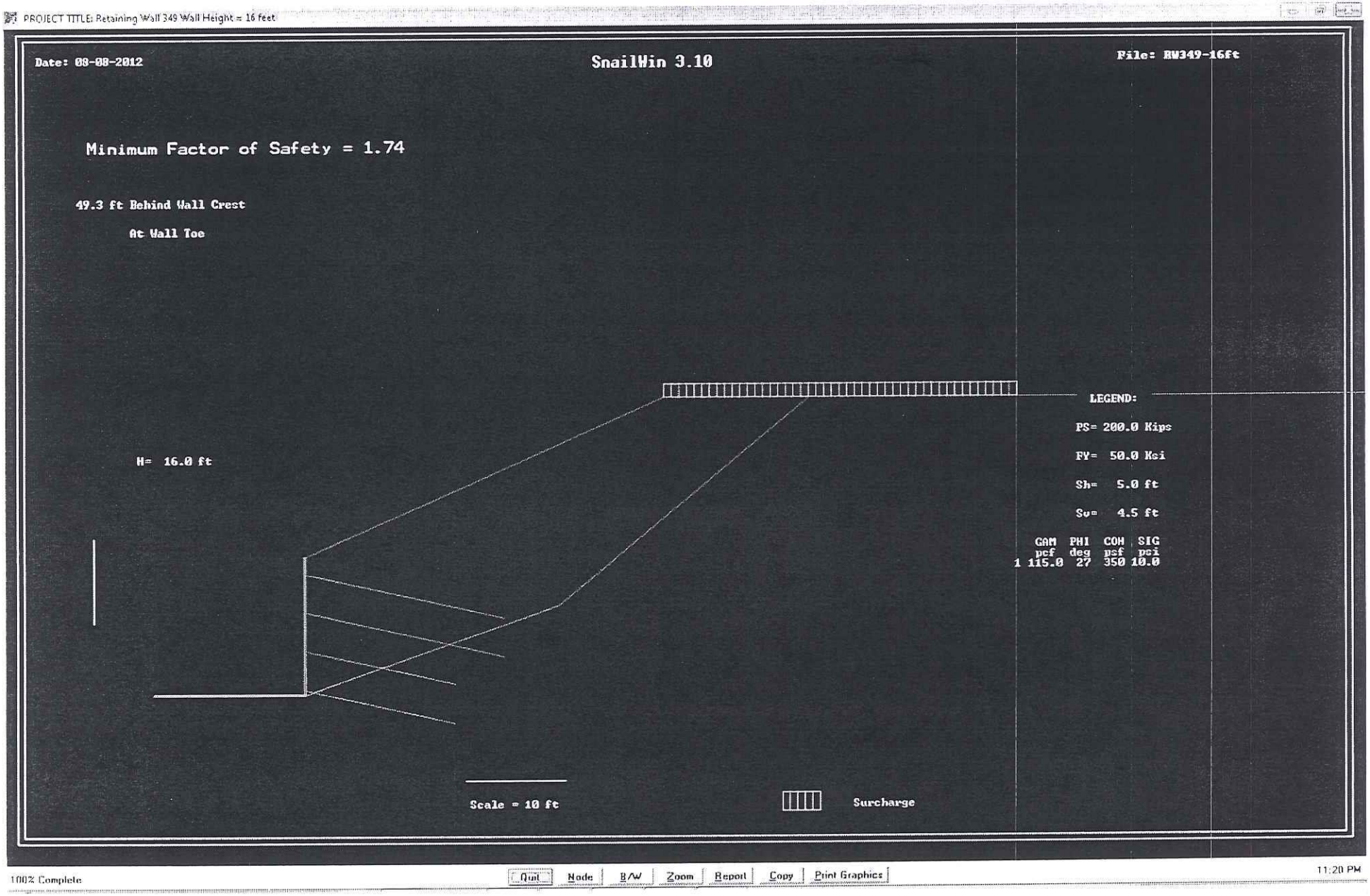
1.233	70.0	13.1	14.4	27.6	63.2

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 0.000 Ksi
3 = 18.561 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 0.435 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 16 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 16 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**********************************************************
*     CALIFORNIA DEPARTMENT OF TRANSPORTATION            *
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*    Office of Roadway Geotechnical Engineering          *
*     Date: 08-08-2012          Time: 23:20:35           *
**********************************************************
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Project Identification - Retaining Wall 349 Wall Height = 16 feet

--------- WALL GEOMETRY ---------

		Angle (Deg)	Length (Feet)
Vertical Wall Height	=	16.0 ft	
Wall Batter	=	0.0 degree	
First Slope from Wallcrest.	=	27.9	39.6
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	35.0 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	20.0	15.0	2.0	1.00	0.75
2	20.0	15.0	4.5	1.00	0.75

3	15.0	15.0	4.5	1.00	0.75
4	15.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.625	7.9	59.6	9.4	75.4	12.5

Reinf. Stress at Level 1 = 30.061 Ksi (Pullout controls...)
2 = 32.515 Ksi (Pullout controls...)
3 = 26.728 Ksi (Pullout controls...)
4 = 31.833 Ksi (Pullout controls...)

NODE 2

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
3.002	14.8	44.0	10.3	66.1	18.3

Reinf. Stress at Level 1 = 22.339 Ksi (Pullout controls...)
2 = 26.327 Ksi (Pullout controls...)
3 = 23.341 Ksi (Pullout controls...)
4 = 31.494 Ksi (Pullout controls...)

NODE 3

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
2.552	21.7	26.9	12.2	63.7	24.5

Reinf. Stress at Level 1 = 13.485 Ksi (Pullout controls...)
2 = 17.870 Ksi (Pullout controls...)
3 = 17.967 Ksi (Pullout controls...)
4 = 30.957 Ksi (Pullout controls...)

NODE 4

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
2.172	28.6	28.6	13.0	55.4	30.3

Reinf. Stress at Level 1 = 11.499 Ksi (Pullout controls...)
2 = 17.350 Ksi (Pullout controls...)
3 = 18.637 Ksi (Pullout controls...)
4 = 31.024 Ksi (Pullout controls...)

NODE 5

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
1.995	35.5	25.9	23.7	59.6	28.0

Reinf. Stress at Level 1 = 1.695 Ksi (Pullout controls...)
2 = 15.036 Ksi (Pullout controls...)
3 = 17.577 Ksi (Pullout controls...)
4 = 30.918 Ksi (Pullout controls...)

NODE 6

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
1.769	42.4	26.0	23.6	48.7	32.2

Reinf. Stress at Level 1 = 1.821 Ksi (Pullout controls...)
2 = 15.121 Ksi (Pullout controls...)
3 = 17.622 Ksi (Pullout controls...)
4 = 30.922 Ksi (Pullout controls...)

NODE 7

MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
1.737	49.3	22.8	26.7	44.4	34.5

Reinf. Stress at Level 1 = 0.000 Ksi

```
                        2 =  12.331 Ksi (Pullout controls...)
                        3 =  16.153 Ksi (Pullout controls...)
                        4 =  30.775 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 8
    1.762         56.2         22.3   18.2      35.1   48.1

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  11.846 Ksi (Pullout controls...)
                          3 =  15.898 Ksi (Pullout controls...)
                          4 =  30.750 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
    1.826         63.1         20.0   20.2      32.0   52.1

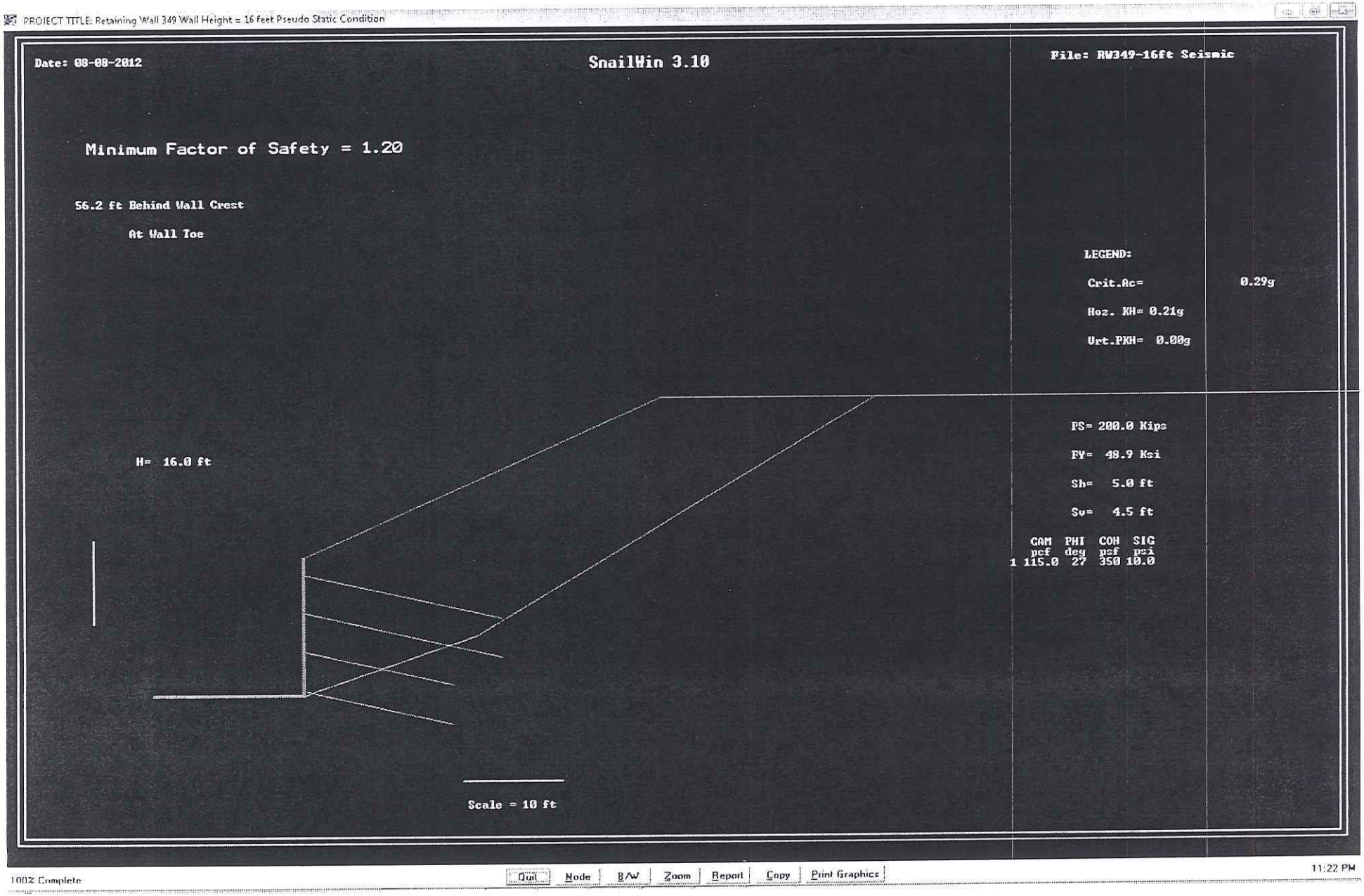
  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   9.627 Ksi (Pullout controls...)
                          3 =  14.730 Ksi (Pullout controls...)
                          4 =  30.633 Ksi (Pullout controls...)

          MINIMUM    DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY      BEHIND          PLANE            PLANE
          FACTOR     WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                       (ft)       (deg)   (ft)     (deg)   (ft)

NODE10
    1.912         70.0         13.9   14.4      29.0   64.0

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   5.655 Ksi (Pullout controls ..)
                          3 =  10.672 Ksi (Pullout controls...)
                          4 =  30.227 Ksi (Pullout controls...)

  ************************************************************************
  *                  For Factor of Safety = 1.0                          *
  *          Maximum Average Reinforcement Working Force:                *
  *                        0.000 Kips/level                              *
  ************************************************************************
```



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 16 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 | Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*         ENGINEERING SERVICE CENTER             *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:21:58    *
**************************************************
```

Project Identification - Retaining Wall 349 Wall Height = 16 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height = 16.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	39.6
Second Slope from 1st slope. =	0.0	40.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 4
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 48.9 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	20.0	15.0	2.0	1.00	0.73

2	20.0	15.0	4.5	1.00	0.73
3	15.0	15.0	4.5	1.00	0.73
4	15.0	15.0	4.5	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.978	7.9	59.6	9.4	75.4	12.5

Reinf. Stress at Level 1 = 29.379 Ksi (Pullout controls...)
2 = 31.778 Ksi (Pullout controls...)
3 = 26.122 Ksi (Pullout controls...)
4 = 31.111 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.193	14.8	44.0	10.3	66.1	18.3

Reinf. Stress at Level 1 = 21.832 Ksi (Pullout controls...)
2 = 25.731 Ksi (Pullout controls...)
3 = 22.812 Ksi (Pullout controls...)
4 = 30.780 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.705	21.7	41.6	29.0	89.9	8.2

Reinf. Stress at Level 1 = 15.723 Ksi (Pullout controls...)
2 = 24.240 Ksi (Pullout controls...)
3 = 22.202 Ksi (Pullout controls...)
4 = 30.719 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.522	28.6	41.1	37.9	89.9	6.2

Reinf. Stress at Level 1 = 15.360 Ksi (Pullout controls...)
2 = 23.994 Ksi (Pullout controls...)
3 = 22.072 Ksi (Pullout controls...)
4 = 30.706 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.393	35.5	34.2	42.9	89.9	10.4

Reinf. Stress at Level 1 = 9.973 Ksi (Pullout controls...)
2 = 20.339 Ksi (Pullout controls...)
3 = 20.149 Ksi (Pullout controls...)
4 = 30.514 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.245	42.4	26.0	23.6	48.7	32.2

Reinf. Stress at Level 1 = 1.780 Ksi (Pullout controls...)
2 = 14.778 Ksi (Pullout controls...)
3 = 17.222 Ksi (Pullout controls...)
4 = 30.221 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.206	49.3	22.8	26.7	44.4	34.5

```
  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  12.051 Ksi (Pullout controls...)
                          3 =  15.787 Ksi (Pullout controls...)
                          4 =  30.078 Ksi (Pullout controls...)

           MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
           SAFETY       BEHIND          PLANE            PLANE
           FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                         (ft)       (deg)   (ft)     (deg)   (ft)

NODE 8
     1.198        56.2        22.3   18.2      35.1   48.1

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  11.578 Ksi (Pullout controls...)
                          3 =  15.538 Ksi (Pullout controls...)
                          4 =  30.053 Ksi (Pullout controls...)

           MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
           SAFETY       BEHIND          PLANE            PLANE
           FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                         (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
     1.215        63.1        20.0   20.2      32.0   52.1

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   9.409 Ksi (Pullout controls...)
                          3 =  14.396 Ksi (Pullout controls...)
                          4 =  29.939 Ksi (Pullout controls...)

           MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
           SAFETY       BEHIND          PLANE            PLANE
           FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                         (ft)       (deg)   (ft)     (deg)   (ft)

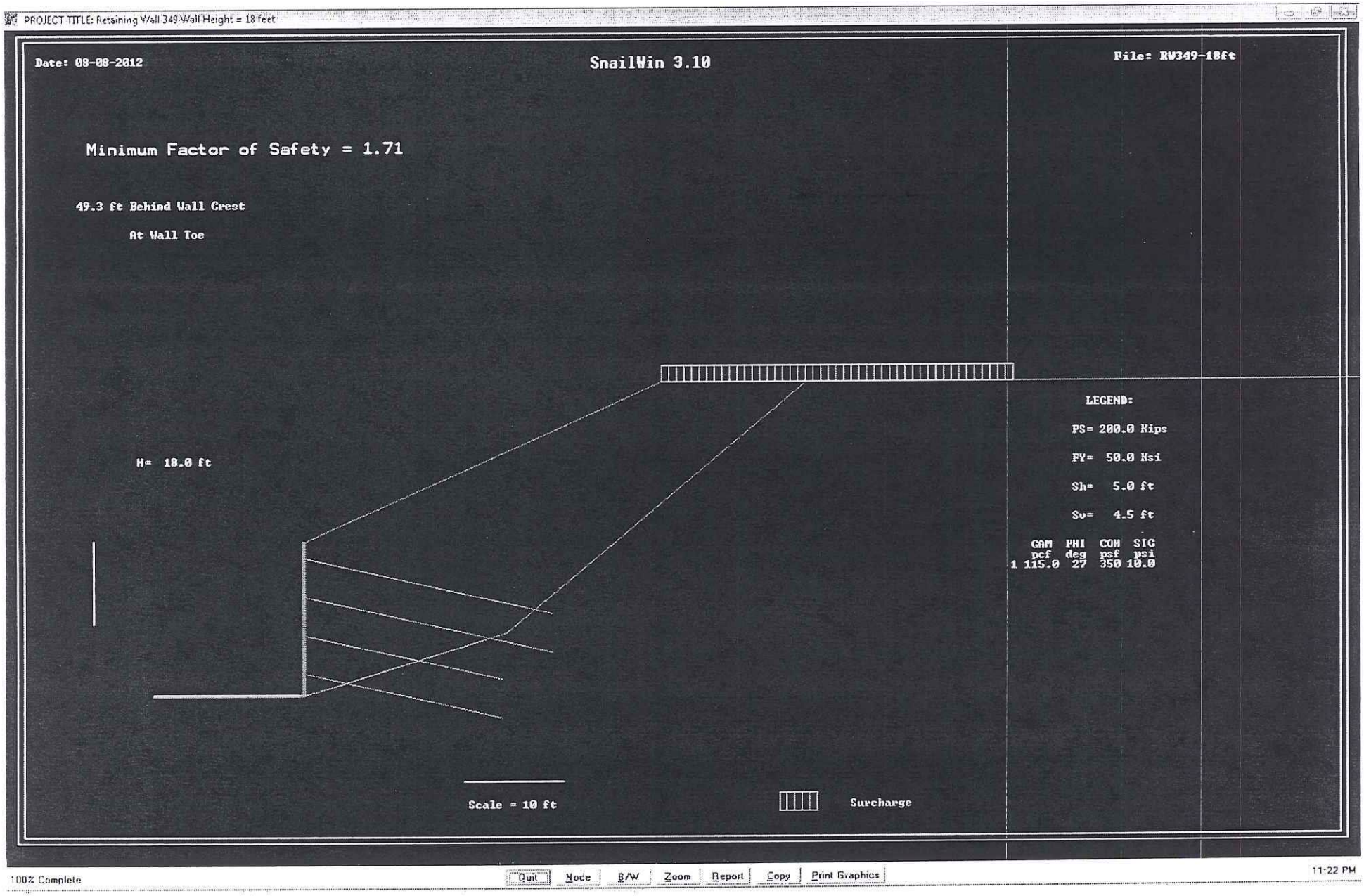
NODE10
     1.243        70.0        18.2   22.1      29.4   56.3

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =   7.432 Ksi (Pullout controls...)
                          3 =  13.356 Ksi (Pullout controls...)
                          4 =  29.835 Ksi (Pullout controls...)

      ************************************************************************
      *                  For Factor of Safety = 1.0                          *
      *          Maximum Average Reinforcement Working Force:                *
      *                       4.217 Kips/level                               *
      ************************************************************************
```

Retaining Wall 349 Soil Nail Wall

Wall Height = 18 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 18 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:22:45    *
**************************************************
```

Project Identification - Retaining Wall 349 Wall Height = 18 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height = 18.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	39.6
Second Slope from 1st slope. =	0.0	40.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe = 35.0 ft
End Surcharge - Distance from toe = 70.0 ft
Loading Intensity - Begin = 240.0 psf/ft
Loading Intensity - End = 240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 4
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 50.0 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	25.0	15.0	2.0	1.00	0.75
2	25.0	15.0	4.5	1.00	0.75

3	20.0	15.0	4.5	1.00	0.75
4	20.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.387	7.9	38.7	7.1	82.4	17.9

Reinf. Stress at Level 1 = 38.727 Ksi (Pullout controls...)
2 = 40.025 Ksi (Pullout controls...)
3 = 30.522 Ksi (Pullout controls...)
4 = 37.976 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.986	14.8	41.1	7.9	66.8	22.5

Reinf. Stress at Level 1 = 32.795 Ksi (Pullout controls...)
2 = 36.672 Ksi (Pullout controls...)
3 = 29.749 Ksi (Pullout controls...)
4 = 38.299 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.572	21.7	37.8	19.2	69.8	18.9

Reinf. Stress at Level 1 = 19.932 Ksi (Pullout controls...)
2 = 29.379 Ksi (Pullout controls...)
3 = 28.214 Ksi (Pullout controls...)
4 = 37.848 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.191	28.6	24.9	15.8	61.7	30.1

Reinf. Stress at Level 1 = 16.185 Ksi (Pullout controls...)
2 = 20.927 Ksi (Pullout controls...)
3 = 21.801 Ksi (Pullout controls...)
4 = 35.557 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.974	35.5	27.2	16.0	53.9	36.2

Reinf. Stress at Level 1 = 15.579 Ksi (Pullout controls...)
2 = 21.715 Ksi (Pullout controls...)
3 = 23.195 Ksi (Pullout controls...)
4 = 36.055 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.773	42.4	27.3	23.9	50.3	33.2

Reinf. Stress at Level 1 = 8.415 Ksi (Pullout controls...)
2 = 21.236 Ksi (Pullout controls...)
3 = 23.256 Ksi (Pullout controls...)
4 = 36.077 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.709	49.3	20.3	21.0	44.7	41.6

Reinf. Stress at Level 1 = 3.831 Ksi (Pullout controls...)

```
                        2 =  13.720 Ksi (Pullout controls...)
                        3 =  18.682 Ksi (Pullout controls...)
                        4 =  34.443 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

NODE 8
     1.717        56.2        18.0   23.6      40.9   44.6

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  10.630 Ksi (Pullout controls...)
                          3 =  16.801 Ksi (Pullout controls...)
                          4 =  33.772 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
     1.770        63.1        21.1   20.3      33.5   53.0

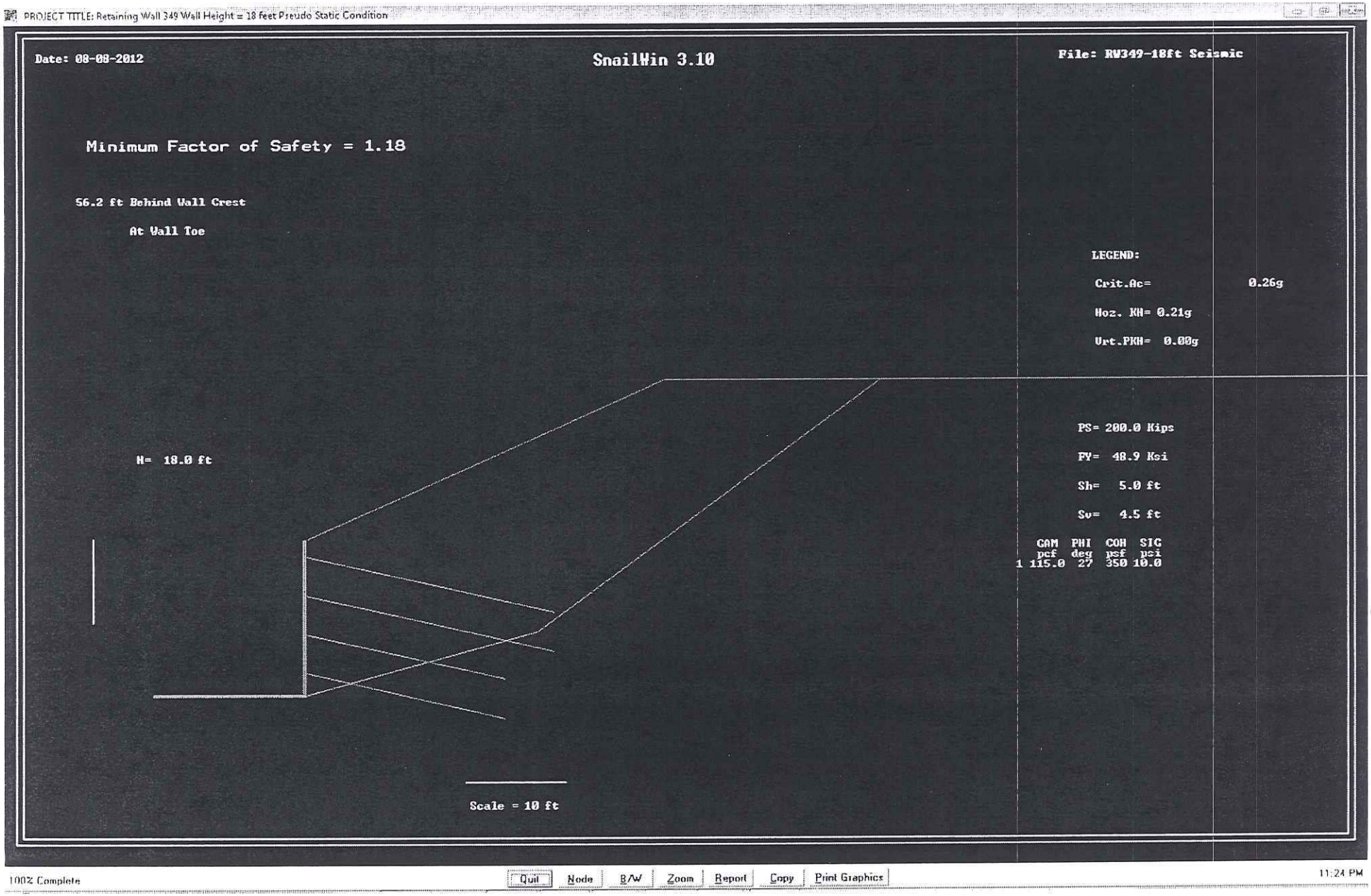
  Reinf. Stress at Level  1 =   2.956 Ksi (Pullout controls...)
                          2 =  14.672 Ksi (Pullout controls...)
                          3 =  19.261 Ksi (Pullout controls...)
                          4 =  34.651 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

NODE10
     1.828        70.0        19.2   22.2      30.8   57.1

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  12.243 Ksi (Pullout controls...)
                          3 =  17.783 Ksi (Pullout controls...)
                          4 =  34.122 Ksi (Pullout controls...)

      ************************************************************************
      *                  For Factor of Safety = 1.0                          *
      *          Maximum Average Reinforcement Working Force:                *
      *                        0.000 Kips/level                              *
      ************************************************************************
```



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 18 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 | Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:24:00    *
**************************************************
```

Project Identification - Retaining Wall 349 Wall Height = 18 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	18.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	27.9	39.6
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	4
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	48.9 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	25.0	15.0	2.0	1.00	0.73

2	25.0	15.0	4.5	1.00	0.73
3	20.0	15.0	4.5	1.00	0.73
4	20.0	15.0	4.5	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.781	7.9	59.3	15.5	89.9	8.9

Reinf. Stress at Level 1 = 35.509 Ksi (Pullout controls...)
2 = 39.905 Ksi (Pullout controls...)
3 = 34.386 Ksi (Pullout controls...)
4 = 39.423 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.189	14.8	36.8	12.9	76.2	18.6

Reinf. Stress at Level 1 = 27.379 Ksi (Pullout controls...)
2 = 29.644 Ksi (Pullout controls...)
3 = 27.165 Ksi (Pullout controls...)
4 = 36.844 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.768	21.7	43.6	30.0	89.9	8.8

Reinf. Stress at Level 1 = 24.095 Ksi (Pullout controls...)
2 = 32.162 Ksi (Pullout controls...)
3 = 29.673 Ksi (Pullout controls...)
4 = 37.739 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.506	28.6	39.0	36.8	89.9	9.9

Reinf. Stress at Level 1 = 20.372 Ksi (Pullout controls...)
2 = 29.486 Ksi (Pullout controls...)
3 = 28.044 Ksi (Pullout controls...)
4 = 37.158 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.393	35.5	35.8	43.8	89.9	11.0

Reinf. Stress at Level 1 = 17.392 Ksi (Pullout controls...)
2 = 27.344 Ksi (Pullout controls...)
3 = 26.740 Ksi (Pullout controls...)
4 = 36.692 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.246	42.4	27.3	23.9	50.3	33.2

Reinf. Stress at Level 1 = 8.224 Ksi (Pullout controls...)
2 = 20.754 Ksi (Pullout controls...)
3 = 22.729 Ksi (Pullout controls...)
4 = 35.260 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.188	49.3	24.0	27.0	46.1	35.5

```
  Reinf. Stress at Level  1 =   3.700 Ksi (Pullout controls...)
                          2 =  17.503 Ksi (Pullout controls...)
                          3 =  20.750 Ksi (Pullout controls...)
                          4 =  34.553 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

NODE 8
     1.175        56.2        18.0   23.6     40.9   44.6

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  10.389 Ksi (Pullout controls...)
                          3 =  16.420 Ksi (Pullout controls...)
                          4 =  33.006 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

NODE 9
     1.181        63.1        21.1   20.3     33.5   53.0

  Reinf. Stress at Level  1 =   2.889 Ksi (Pullout controls...)
                          2 =  14.340 Ksi (Pullout controls...)
                          3 =  18.825 Ksi (Pullout controls...)
                          4 =  33.865 Ksi (Pullout controls...)

          MINIMUM     DISTANCE     LOWER FAILURE    UPPER FAILURE
          SAFETY       BEHIND          PLANE            PLANE
          FACTOR      WALL TOE     ANGLE  LENGTH    ANGLE  LENGTH
                        (ft)       (deg)   (ft)     (deg)   (ft)

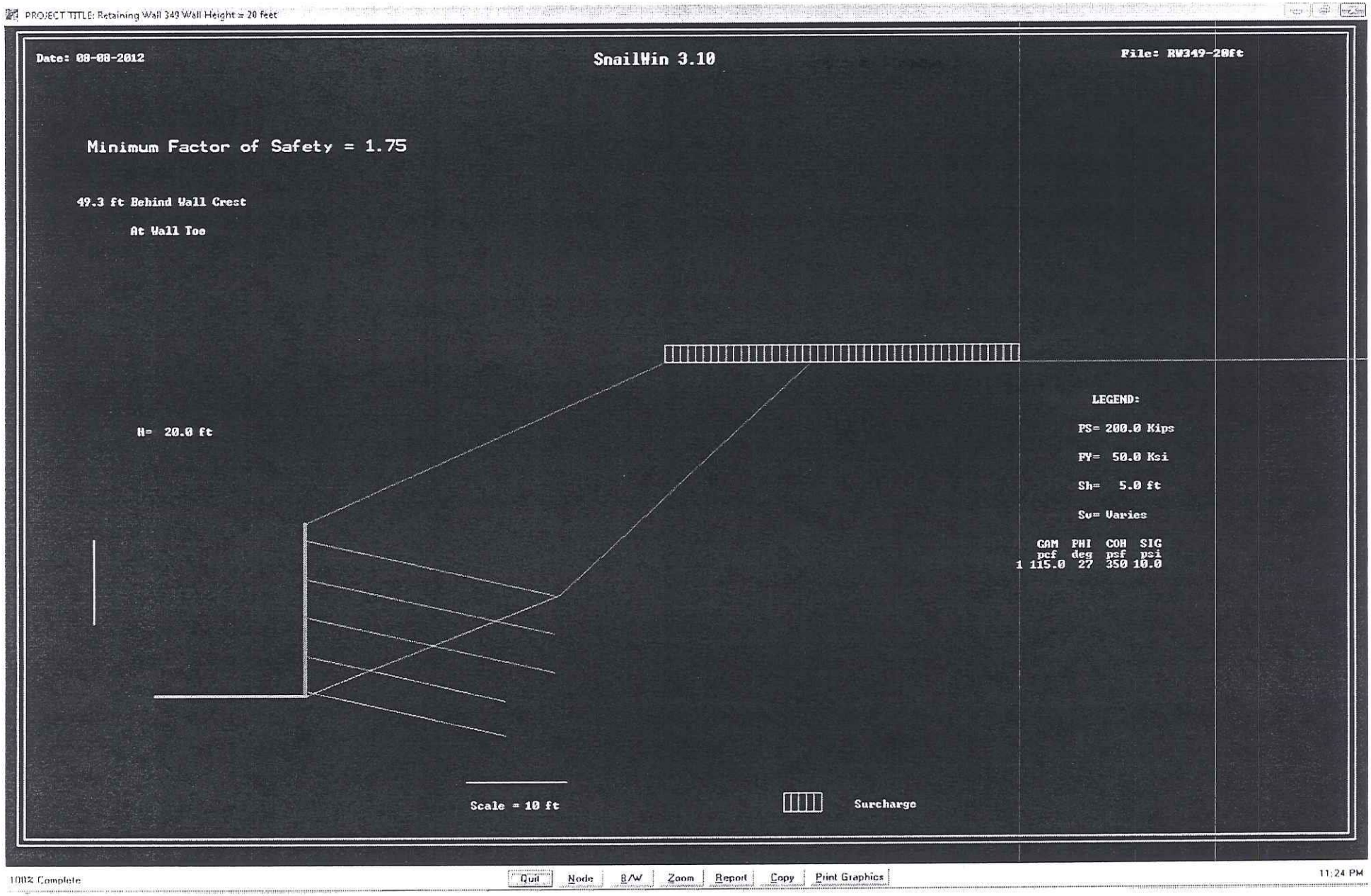
NODE10
     1.197        70.0        19.2   22.2     30.8   57.1

  Reinf. Stress at Level  1 =   0.000 Ksi
                          2 =  11.965 Ksi (Pullout controls...)
                          3 =  17.380 Ksi (Pullout controls...)
                          4 =  33.349 Ksi (Pullout controls...)

      ************************************************************************
      *                                                                      *
      *                  For Factor of Safety = 1.0                          *
      *          Maximum Average Reinforcement Working Force:                *
      *                        8.429 Kips/level                              *
      *                                                                      *
      ************************************************************************
```

Retaining Wall 349 Soil Nail Wall

Wall Height = 20 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 20 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**********************************************************
*     CALIFORNIA DEPARTMENT OF TRANSPORTATION            *
*          ENGINEERING SERVICE CENTER                    *
*       DIVISION OF MATERIALS AND FOUNDATIONS            *
*    Office of Roadway Geotechnical Engineering          *
*     Date: 08-08-2012          Time: 23:24:57           *
**********************************************************
```

Project Identification - Retaining Wall 349 Wall Height = 20 feet

--------- WALL GEOMETRY ---------

		Angle (Deg)	Length (Feet)
Vertical Wall Height	=	20.0 ft	
Wall Batter	=	0.0 degree	
First Slope from Wallcrest.	=	27.9	39.6
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	35.0 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	25.0	15.0	2.0	1.00	0.75
2	25.0	15.0	4.5	1.00	0.75

3	25.0	15.0	4.5	1.00	0.75
4	20.0	15.0	4.5	1.00	0.75
5	20.0	15.0	4.0	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.515	7.9	56.8	8.7	79.4	17.2

Reinf. Stress at Level
1 = 39.634 Ksi (Pullout controls...)
2 = 41.423 Ksi (Pullout controls...)
3 = 43.212 Ksi (Pullout controls...)
4 = 37.605 Ksi (Pullout controls...)
5 = 42.578 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	3.572	14.8	37.0	9.3	71.6	23.5

Reinf. Stress at Level
1 = 30.322 Ksi (Pullout controls...)
2 = 33.392 Ksi (Pullout controls...)
3 = 36.463 Ksi (Pullout controls...)
4 = 33.337 Ksi (Pullout controls...)
5 = 42.104 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.804	21.7	36.0	10.7	62.7	28.4

Reinf. Stress at Level
1 = 25.071 Ksi (Pullout controls...)
2 = 29.640 Ksi (Pullout controls...)
3 = 34.208 Ksi (Pullout controls...)
4 = 33.071 Ksi (Pullout controls...)
5 = 42.075 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.475	28.6	44.5	40.1	89.9	7.0

Reinf. Stress at Level
1 = 21.824 Ksi (Pullout controls...)
2 = 29.868 Ksi (Pullout controls...)
3 = 37.912 Ksi (Pullout controls...)
4 = 35.156 Ksi (Pullout controls...)
5 = 42.306 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	2.152	35.5	23.5	19.4	60.1	35.6

Reinf. Stress at Level
1 = 8.130 Ksi (Pullout controls...)
2 = 13.150 Ksi (Pullout controls...)
3 = 25.335 Ksi (Pullout controls...)
4 = 28.867 Ksi (Pullout controls...)
5 = 41.607 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.839	42.4	28.6	24.1	51.8	34.3

Reinf. Stress at Level
1 = 5.488 Ksi (Pullout controls...)
2 = 16.876 Ksi (Pullout controls...)
3 = 29.251 Ksi (Pullout controls...)
4 = 30.825 Ksi (Pullout controls...)
5 = 41.825 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.754	49.3	25.1	27.2	47.6	36.5

Reinf. Stress at Level
1 = 0.000 Ksi
2 = 13.031 Ksi (Pullout controls...)
3 = 26.688 Ksi (Pullout controls...)
4 = 29.544 Ksi (Pullout controls...)
5 = 41.683 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.762	56.2	18.9	23.8	42.4	45.7

Reinf. Stress at Level
1 = 0.000 Ksi
2 = 4.571 Ksi (Pullout controls...)
3 = 21.047 Ksi (Pullout controls...)
4 = 26.724 Ksi (Pullout controls...)
5 = 41.369 Ksi (Pullout controls...)

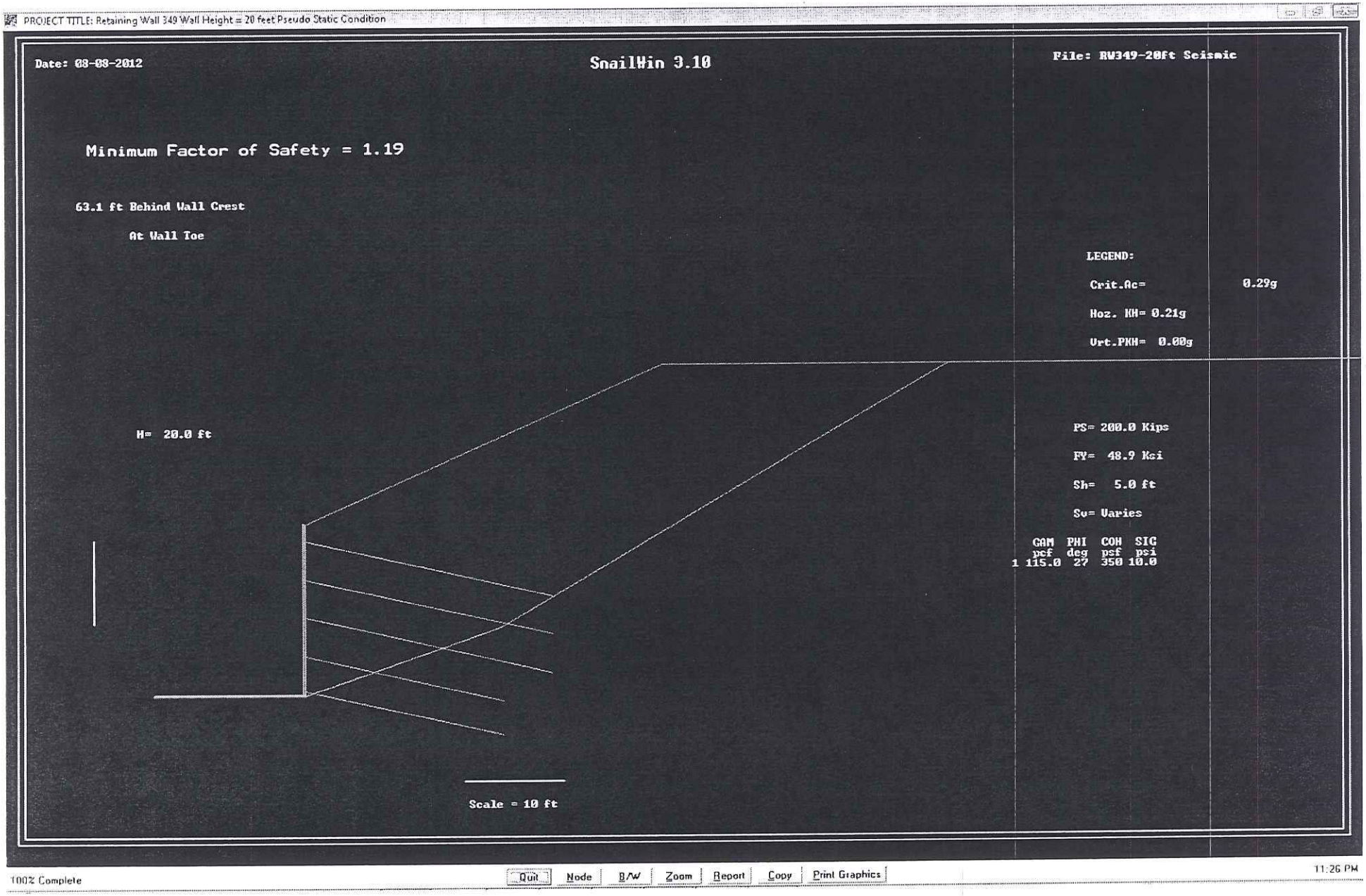
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.789	63.1	22.2	20.4	34.9	53.9

Reinf. Stress at Level
1 = 0.000 Ksi
2 = 9.998 Ksi (Pullout controls...)
3 = 24.185 Ksi (Pullout controls...)
4 = 28.293 Ksi (Pullout controls...)
5 = 41.544 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.856	70.0	20.2	22.4	32.2	57.9

Reinf. Stress at Level
1 = 0.000 Ksi
2 = 6.623 Ksi (Pullout controls...)
3 = 22.301 Ksi (Pullout controls...)
4 = 27.350 Ksi (Pullout controls...)
5 = 41.439 Ksi (Pullout controls...)

For Factor of Safety = 1.0
Maximum Average Reinforcement Working Force:
0.000 Kips/level



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 20 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*         ENGINEERING SERVICE CENTER             *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-08-2012          Time: 23:26:18    *
**************************************************
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Project Identification - Retaining Wall 349 Wall Height = 20 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height = 20.0 ft
Wall Batter = 0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	39.6
Second Slope from 1st slope. =	0.0	40.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 70.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels = 5
Horizontal Spacing = 5.0 ft
Yield Stress of Reinforcement = 48.9 ksi
Diameter of Grouted Hole = 6.0 in
Punching Shear = 200.0 kips

---------- (Varying Reinforcement Parameters) ----------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	25.0	15.0	2.0	1.00	0.73

2	25.0	15.0	4.5	1.00	0.73
3	25.0	15.0	4.5	1.00	0.73
4	20.0	15.0	4.5	1.00	0.73
5	20.0	15.0	4.0	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.987	7.9	56.8	8.7	79.4	17.2

Reinf. Stress at Level
1 = 38.735 Ksi (Pullout controls...)
2 = 40.484 Ksi (Pullout controls...)
3 = 42.232 Ksi (Pullout controls...)
4 = 36.752 Ksi (Pullout controls...)
5 = 41.613 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.405	14.8	43.2	20.3	89.9	13.9

Reinf. Stress at Level
1 = 20.430 Ksi (Pullout controls...)
2 = 28.359 Ksi (Pullout controls...)
3 = 36.498 Ksi (Pullout controls...)
4 = 34.082 Ksi (Pullout controls...)
5 = 41.316 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.915	21.7	45.4	30.9	89.9	9.4

Reinf. Stress at Level
1 = 22.132 Ksi (Pullout controls...)
2 = 29.793 Ksi (Pullout controls...)
3 = 37.454 Ksi (Pullout controls...)
4 = 34.560 Ksi (Pullout controls...)
5 = 41.370 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.589	28.6	40.7	37.7	89.9	10.5

Reinf. Stress at Level
1 = 17.904 Ksi (Pullout controls...)
2 = 26.622 Ksi (Pullout controls...)
3 = 35.340 Ksi (Pullout controls...)
4 = 33.503 Ksi (Pullout controls...)
5 = 41.252 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.443	35.5	37.2	44.6	89.9	11.6

Reinf. Stress at Level
1 = 14.497 Ksi (Pullout controls...)
2 = 24.067 Ksi (Pullout controls...)
3 = 33.637 Ksi (Pullout controls...)
4 = 32.651 Ksi (Pullout controls...)
5 = 41.157 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.284	42.4	28.6	24.1	51.8	34.3

Reinf. Stress at Level
1 = 5.364 Ksi (Pullout controls...)
2 = 16.494 Ksi (Pullout controls...)
3 = 28.588 Ksi (Pullout controls...)
4 = 30.127 Ksi (Pullout controls...)
5 = 40.877 Ksi (Pullout controls...)

♀
File: RW349-20ft Seismic Page - 5

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.214	49.3	25.1	27.2	47.6	36.5

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 12.736 Ksi (Pullout controls...)
3 = 26.083 Ksi (Pullout controls...)
4 = 28.874 Ksi (Pullout controls...)
5 = 40.738 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.198	56.2	27.2	25.3	38.7	43.2

Reinf. Stress at Level 1 = 2.791 Ksi (Pullout controls...)
2 = 15.053 Ksi (Pullout controls...)
3 = 27.628 Ksi (Pullout controls...)
4 = 29.647 Ksi (Pullout controls...)
5 = 40.824 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.191	63.1	22.2	20.4	34.9	53.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 9.771 Ksi (Pullout controls...)
3 = 23.637 Ksi (Pullout controls...)
4 = 27.651 Ksi (Pullout controls...)
5 = 40.602 Ksi (Pullout controls...)

♀
File: RW349-20ft Seismic Page - 6

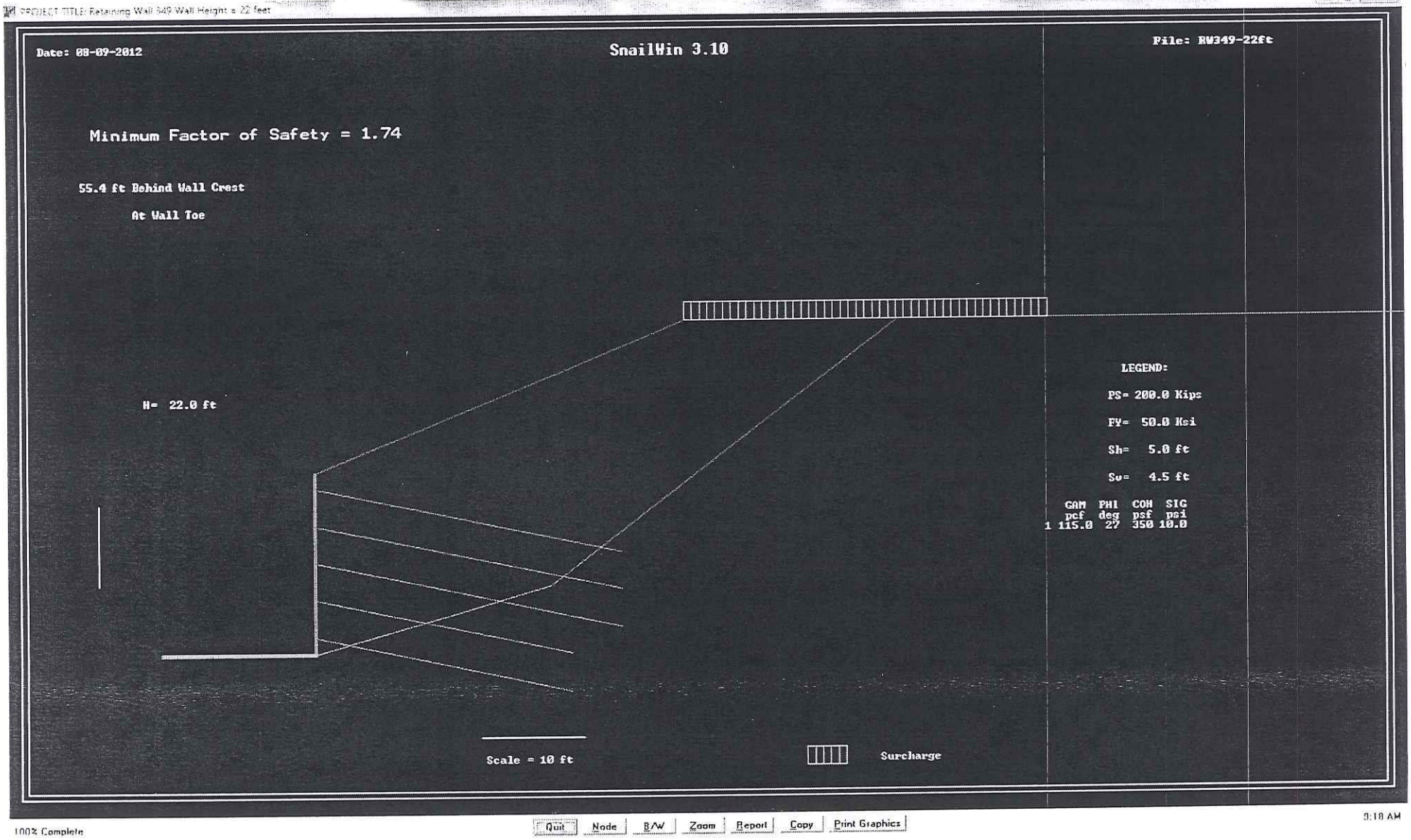
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.207	70.0	20.2	22.4	32.2	57.9

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 6.473 Ksi (Pullout controls...)
3 = 21.795 Ksi (Pullout controls...)
4 = 26.731 Ksi (Pullout controls...)
5 = 40.500 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 10.384 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 22 feet



Retaining Wall 349 – Soil Nail Wall

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Soil Nail Wall Height = 22 feet
Static Condition

Project No. 11-137

Date: 08-08-12

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*****************************************************
*     CALIFORNIA DEPARTMENT OF TRANSPORTATION       *
*          ENGINEERING SERVICE CENTER               *
*      DIVISION OF MATERIALS AND FOUNDATIONS        *
*    Office of Roadway Geotechnical Engineering     *
*     Date: 08-09-2012          Time: 09:18:15      *
*****************************************************
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Project Identification - Retaining Wall 349 Wall Height = 22 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	22.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	27.9	39.6
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	35.0 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ----------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	30.0	15.0	2.0	1.00	0.75
2	30.0	15.0	4.5	1.00	0.75

3	30.0	15.0	4.5	1.00	0.75
4	25.0	15.0	4.5	1.00	0.75
5	25.0	15.0	4.5	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	3.097	7.8	48.2	7.0	81.5	21.1

Reinf. Stress at Level 1 = 49.996 Ksi (Pullout controls...)
2 = 50.000 Ksi (Yield Stress controls.)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 43.528 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	3.218	14.6	50.7	11.5	70.7	22.1

Reinf. Stress at Level 1 = 41.933 Ksi (Pullout controls...)
2 = 45.160 Ksi (Pullout controls...)
3 = 48.386 Ksi (Pullout controls...)
4 = 44.243 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.868	21.4	31.9	12.6	68.1	28.7

Reinf. Stress at Level 1 = 32.392 Ksi (Pullout controls...)
2 = 36.038 Ksi (Pullout controls...)
3 = 39.684 Ksi (Pullout controls...)
4 = 37.686 Ksi (Pullout controls...)
5 = 48.980 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.416	28.2	33.2	13.5	60.2	34.0

Reinf. Stress at Level 1 = 28.927 Ksi (Pullout controls...)
2 = 33.923 Ksi (Pullout controls...)
3 = 38.919 Ksi (Pullout controls...)
4 = 38.248 Ksi (Pullout controls...)
5 = 49.153 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	2.258	35.0	24.9	19.3	61.6	36.8

Reinf. Stress at Level 1 = 18.069 Ksi (Pullout controls...)
2 = 22.814 Ksi (Pullout controls...)
3 = 31.157 Ksi (Pullout controls...)
4 = 34.120 Ksi (Pullout controls...)
5 = 47.883 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.886	41.8	30.2	24.2	53.6	35.2

Reinf. Stress at Level 1 = 14.981 Ksi (Pullout controls...)
2 = 24.009 Ksi (Pullout controls...)
3 = 35.851 Ksi (Pullout controls...)
4 = 36.894 Ksi (Pullout controls...)
5 = 48.737 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.776	48.6	26.6	27.2	49.4	37.4

Reinf. Stress at Level 1 = 8.389 Ksi (Pullout controls...)
2 = 19.687 Ksi (Pullout controls...)
3 = 32.784 Ksi (Pullout controls...)
4 = 35.082 Ksi (Pullout controls...)
5 = 48.179 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.743	55.4	20.1	23.6	44.3	46.4

Reinf. Stress at Level 1 = 4.534 Ksi (Pullout controls...)
2 = 12.627 Ksi (Pullout controls...)
3 = 25.986 Ksi (Pullout controls...)
4 = 31.064 Ksi (Pullout controls...)
5 = 46.943 Ksi (Pullout controls...)

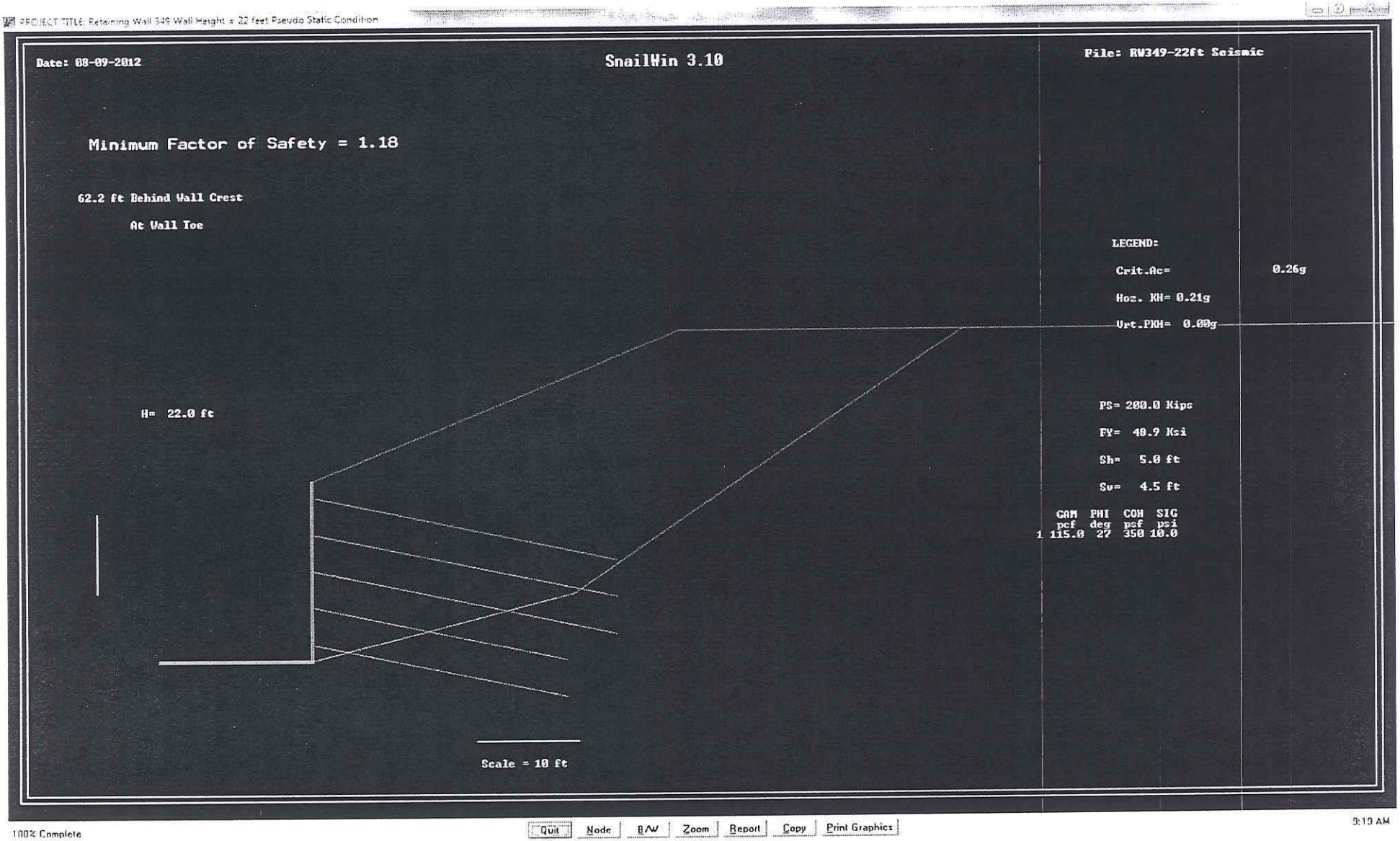
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.757	62.2	18.0	26.2	41.0	49.4

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 7.732 Ksi (Pullout controls...)
3 = 23.372 Ksi (Pullout controls...)
4 = 29.520 Ksi (Pullout controls...)
5 = 46.468 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.808	69.0	11.1	21.1	37.1	60.5

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 5.615 Ksi (Pullout controls...)
3 = 15.450 Ksi (Pullout controls...)
4 = 22.657 Ksi (Pullout controls...)
5 = 44.356 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 1.855 Kips/level *
****



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 22 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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*     CALIFORNIA DEPARTMENT OF TRANSPORTATION    *
*          ENGINEERING SERVICE CENTER            *
*      DIVISION OF MATERIALS AND FOUNDATIONS     *
*   Office of Roadway Geotechnical Engineering   *
*     Date: 08-09-2012          Time: 09:19:40   *
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Project Identification - Retaining Wall 349 Wall Height = 22 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	22.0 ft
Wall Batter	=	0.0 degree

	Angle (Deg)	Length (Feet)
First Slope from Wallcrest. =	27.9	39.6
Second Slope from 1st slope. =	0.0	40.0
Third Slope from 2nd slope. =	0.0	0.0
Fourth Slope from 3rd slope. =	0.0	0.0
Fifth Slope from 3rd slope. =	0.0	0.0
Sixth Slope from 3rd slope. =	0.0	0.0
Seventh Slope Angle. =	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	= 5
Horizontal Spacing	= 5.0 ft
Yield Stress of Reinforcement	= 48.9 ksi
Diameter of Grouted Hole	= 6.0 in
Punching Shear	= 200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	30.0	15.0	2.0	1.00	0.73

2	30.0	15.0	4.5	1.00	0.73
3	30.0	15.0	4.5	1.00	0.73
4	25.0	15.0	4.5	1.00	0.73
5	25.0	15.0	4.5	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.694	7.8	48.2	7.0	81.5	21.1

Reinf. Stress at Level 1 = 48.862 Ksi (Pullout controls...)
2 = 48.900 Ksi (Yield Stress controls.)
3 = 48.900 Ksi (Yield Stress controls.)
4 = 42.542 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.432	14.6	45.5	16.7	80.7	18.1

Reinf. Stress at Level 1 = 36.098 Ksi (Pullout controls...)
2 = 37.641 Ksi (Pullout controls...)
3 = 44.639 Ksi (Pullout controls...)
4 = 41.730 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.982	21.4	31.9	12.6	68.1	28.7

Reinf. Stress at Level 1 = 31.658 Ksi (Pullout controls...)
2 = 35.221 Ksi (Pullout controls...)
3 = 38.785 Ksi (Pullout controls...)
4 = 36.831 Ksi (Pullout controls...)
5 = 47.870 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.654	28.2	42.5	38.3	89.9	11.1

Reinf. Stress at Level 1 = 26.435 Ksi (Pullout controls...)
2 = 34.737 Ksi (Pullout controls...)
3 = 43.038 Ksi (Pullout controls...)
4 = 40.785 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.483	35.0	39.0	45.1	89.9	12.2

Reinf. Stress at Level 1 = 22.804 Ksi (Pullout controls...)
2 = 31.923 Ksi (Pullout controls...)
3 = 41.041 Ksi (Pullout controls...)
4 = 39.605 Ksi (Pullout controls...)
5 = 48.723 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.316	41.8	30.2	24.2	53.6	35.2

Reinf. Stress at Level 1 = 14.641 Ksi (Pullout controls...)
2 = 23.465 Ksi (Pullout controls...)
3 = 35.039 Ksi (Pullout controls...)
4 = 36.058 Ksi (Pullout controls...)
5 = 47.632 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.227	48.6	26.6	27.2	49.4	37.4

Reinf. Stress at Level
1 = 8.199 Ksi (Pullout controls...)
2 = 19.241 Ksi (Pullout controls...)
3 = 32.041 Ksi (Pullout controls...)
4 = 34.287 Ksi (Pullout controls...)
5 = 47.087 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.193	55.4	20.1	23.6	44.3	46.4

Reinf. Stress at Level
1 = 4.431 Ksi (Pullout controls...)
2 = 12.341 Ksi (Pullout controls...)
3 = 25.397 Ksi (Pullout controls...)
4 = 30.360 Ksi (Pullout controls...)
5 = 45.879 Ksi (Pullout controls...)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.182	62.2	18.0	26.2	41.0	49.4

Reinf. Stress at Level
1 = 0.000 Ksi
2 = 7.557 Ksi (Pullout controls...)
3 = 22.842 Ksi (Pullout controls...)
4 = 28.851 Ksi (Pullout controls...)
5 = 45.414 Ksi (Pullout controls...)

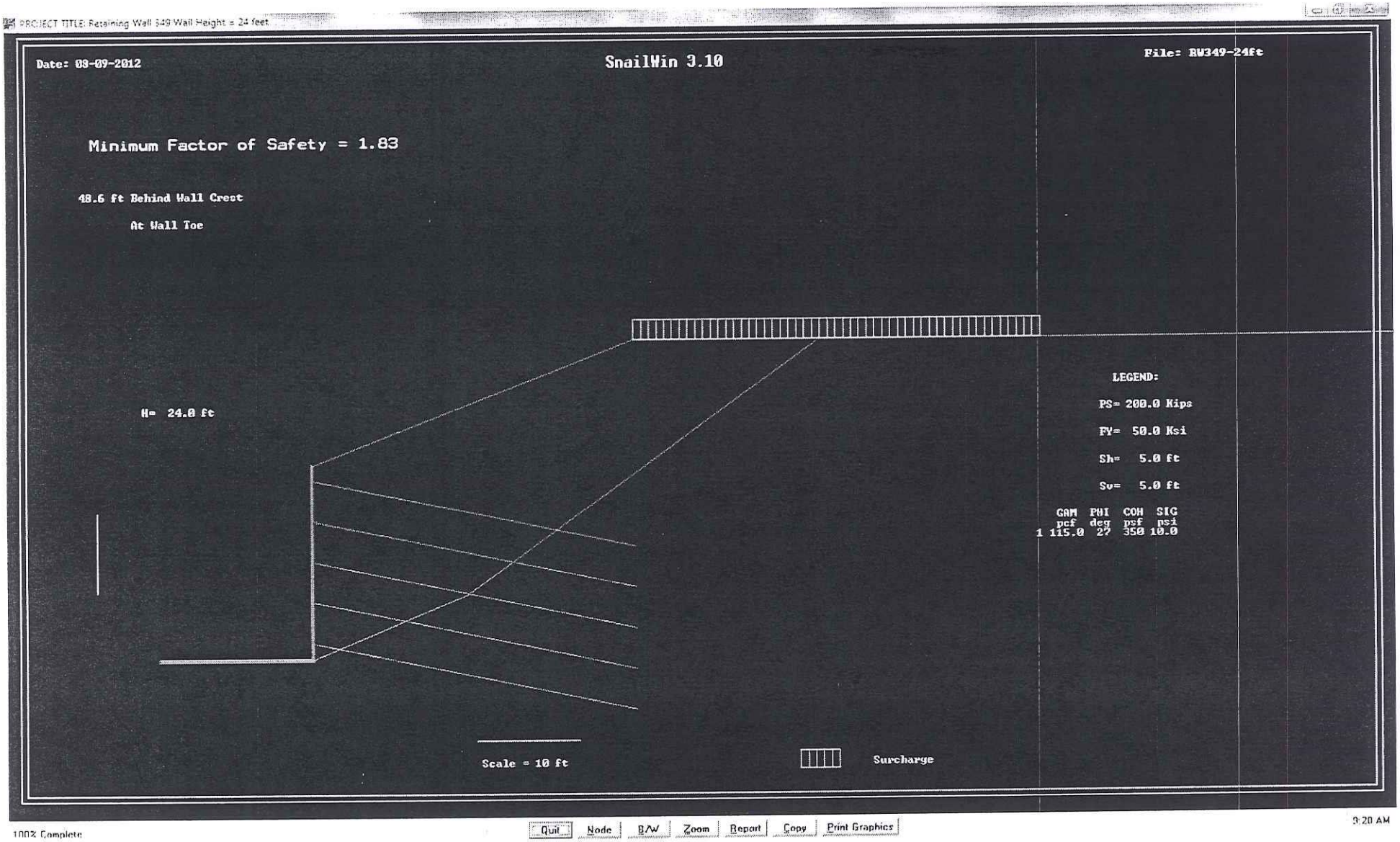
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.187	69.0	21.4	22.2	33.9	58.2

Reinf. Stress at Level
1 = 3.322 Ksi (Pullout controls...)
2 = 13.792 Ksi (Pullout controls...)
3 = 26.881 Ksi (Pullout controls...)
4 = 31.237 Ksi (Pullout controls...)
5 = 46.149 Ksi (Pullout controls...)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 14.346 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 24 feet



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 24 feet Static Condition
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 / Date: 08-08-12

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*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-09-2012          Time: 09:20:29    *
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Project Identification - Retaining Wall 349 Wall Height = 24 feet

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	24.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	26.6	34.2
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	30.6 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	32.0	15.0	2.0	1.00	0.75
2	32.0	15.0	5.0	1.00	0.75

3	32.0	15.0	5.0	1.00	0.75
4	32.0	15.0	5.0	1.00	0.75
5	32.0	15.0	5.0	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.856	7.8	55.1	6.8	80.1	22.7

Reinf. Stress at Level 1 = 50.000 Ksi (Yield Stress controls.)
2 = 50.000 Ksi (Yield Stress controls.)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.829	14.6	47.0	12.8	75.1	22.7

Reinf. Stress at Level 1 = 43.825 Ksi (Pullout controls...)
2 = 46.606 Ksi (Pullout controls...)
3 = 49.387 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.668	21.4	52.4	17.5	62.8	23.4

Reinf. Stress at Level 1 = 39.895 Ksi (Pullout controls...)
2 = 44.944 Ksi (Pullout controls...)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.367	28.2	34.1	13.6	61.0	34.9

Reinf. Stress at Level 1 = 31.633 Ksi (Pullout controls...)
2 = 37.034 Ksi (Pullout controls...)
3 = 42.434 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	2.004	35.0	34.0	21.1	57.5	32.6

Reinf. Stress at Level 1 = 23.284 Ksi (Pullout controls...)
2 = 29.359 Ksi (Pullout controls...)
3 = 40.630 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.875	41.8	35.2	20.5	47.7	37.2

Reinf. Stress at Level 1 = 22.352 Ksi (Pullout controls...)
2 = 30.542 Ksi (Pullout controls...)
3 = 41.550 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.829	48.6	28.3	16.6	42.8	46.3

Reinf. Stress at Level 1 = 17.330 Ksi (Pullout controls...)
2 = 26.707 Ksi (Pullout controls...)
3 = 36.084 Ksi (Pullout controls...)
4 = 49.728 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.836	55.4	19.5	23.5	43.4	45.8

Reinf. Stress at Level 1 = 4.464 Ksi (Pullout controls...)
2 = 13.673 Ksi (Pullout controls...)
3 = 26.031 Ksi (Pullout controls...)
4 = 43.985 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

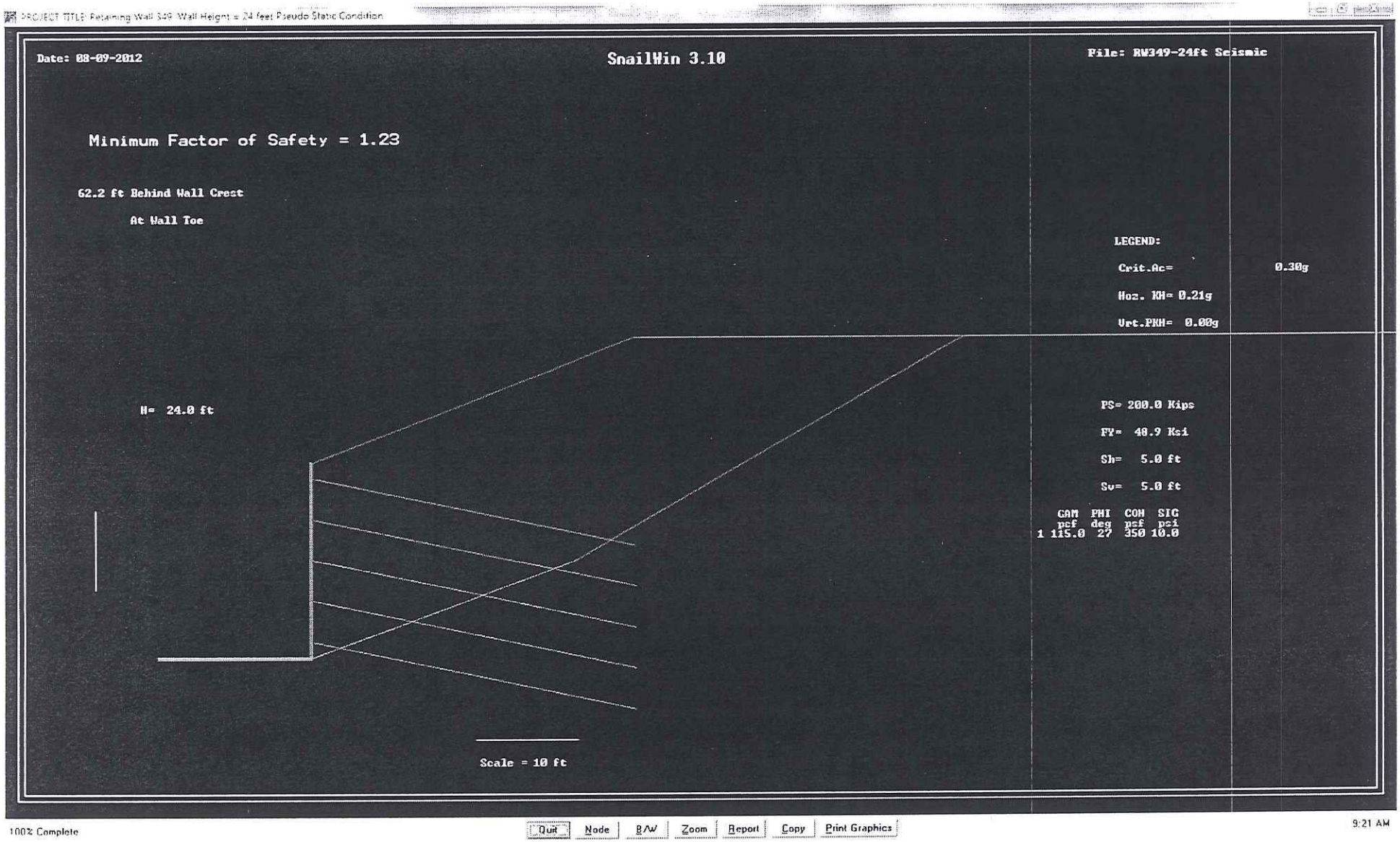
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.868	62.2	17.5	26.1	40.1	48.8

Reinf. Stress at Level 1 = 0.000 Ksi
2 = 8.509 Ksi (Pullout controls...)
3 = 23.169 Ksi (Pullout controls...)
4 = 42.315 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.915	69.0	20.8	22.1	33.1	57.6

Reinf. Stress at Level 1 = 1.929 Ksi (Pullout controls...)
2 = 14.094 Ksi (Pullout controls...)
3 = 27.695 Ksi (Pullout controls...)
4 = 44.956 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 3.834 Kips/level *
****



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 24 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 | Date: 08-08-12

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*****************************************************
*     CALIFORNIA DEPARTMENT OF TRANSPORTATION       *
*          ENGINEERING SERVICE CENTER               *
*      DIVISION OF MATERIALS AND FOUNDATIONS        *
*    Office of Roadway Geotechnical Engineering     *
*     Date: 08-09-2012          Time: 09:21:29      *
*****************************************************
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Project Identification - Retaining Wall 349 Wall Height = 24 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

		Angle (Deg)	Length (Feet)
Vertical Wall Height	=	24.0 ft	
Wall Batter	=	0.0 degree	
First Slope from Wallcrest.	=	26.6	34.2
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	48.9 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	32.0	15.0	2.0	1.00	0.73

2	32.0	15.0	5.0	1.00	0.73
3	32.0	15.0	5.0	1.00	0.73
4	32.0	15.0	5.0	1.00	0.73
5	32.0	15.0	5.0	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.427	7.8	68.2	21.0	89.9	8.4

Reinf. Stress at Level 1 = 48.900 Ksi (Yield Stress controls.)
2 = 48.900 Ksi (Yield Stress controls.)
3 = 48.900 Ksi (Yield Stress controls.)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.175	14.6	47.0	12.8	75.1	22.7

Reinf. Stress at Level 1 = 42.832 Ksi (Pullout controls...)
2 = 45.550 Ksi (Pullout controls...)
3 = 48.267 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.875	21.4	48.6	32.4	89.9	10.4

Reinf. Stress at Level 1 = 33.296 Ksi (Pullout controls...)
2 = 41.082 Ksi (Pullout controls...)
3 = 48.867 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.571	28.2	43.4	38.8	89.9	11.4

Reinf. Stress at Level 1 = 27.955 Ksi (Pullout controls...)
2 = 36.955 Ksi (Pullout controls...)
3 = 45.954 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.410	35.0	41.9	47.1	89.9	7.9

Reinf. Stress at Level 1 = 26.336 Ksi (Pullout controls...)
2 = 35.704 Ksi (Pullout controls...)
3 = 45.071 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.308	41.8	35.2	20.5	47.7	37.2

Reinf. Stress at Level 1 = 21.845 Ksi (Pullout controls...)
2 = 29.850 Ksi (Pullout controls...)
3 = 40.609 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.253	48.6	28.3	16.6	42.8	46.3

Reinf. Stress at Level 1 = 16.938 Ksi (Pullout controls...)
2 = 26.102 Ksi (Pullout controls...)
3 = 35.266 Ksi (Pullout controls...)
4 = 48.601 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.234	55.4	28.0	25.1	39.6	43.2

Reinf. Stress at Level 1 = 10.610 Ksi (Pullout controls...)
2 = 21.121 Ksi (Pullout controls...)
3 = 34.778 Ksi (Pullout controls...)
4 = 48.434 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.228	62.2	25.4	27.5	36.4	46.4

Reinf. Stress at Level 1 = 5.483 Ksi (Pullout controls...)
2 = 17.480 Ksi (Pullout controls...)
3 = 32.207 Ksi (Pullout controls...)
4 = 46.935 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.235	69.0	20.8	22.1	33.1	57.6

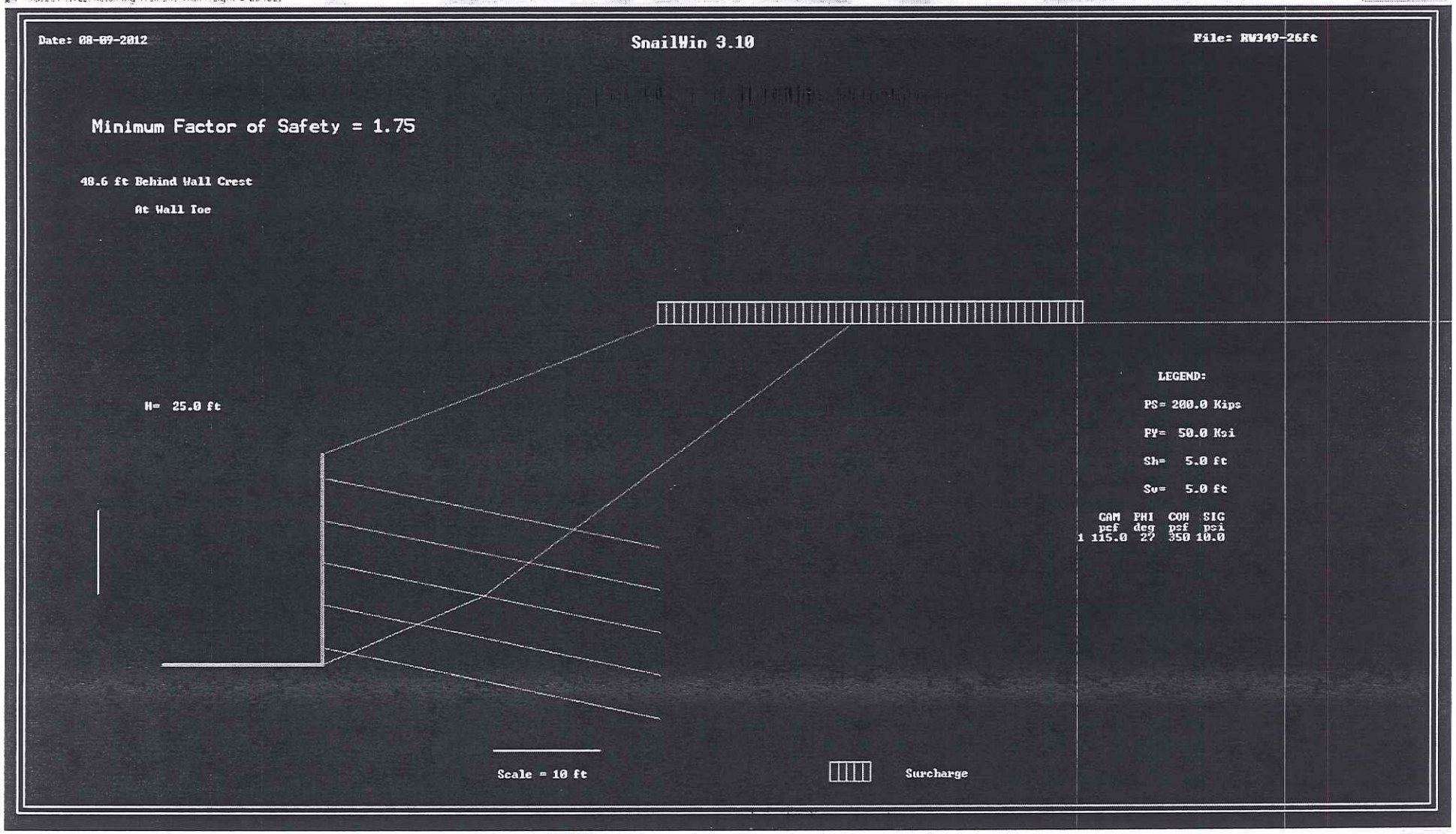
Reinf. Stress at Level 1 = 1.885 Ksi (Pullout controls...)
2 = 13.775 Ksi (Pullout controls...)
3 = 27.068 Ksi (Pullout controls...)
4 = 43.937 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 17.108 Kips/level *
****

Retaining Wall 349 Soil Nail Wall

Wall Height = 26 feet

PROJECT TITLE: Retaining Wall 349 Wall Height = 26 feet



100% Complete

Quit | Node | B/W | Zoom | Report | Copy | Print Graphics

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Retaining Wall 349 – Soil Nail Wall

Soil Nail Wall Height = 26 feet
Static Condition

Earth Mechanics, Inc.
Geotechnical and Earthquake Engineering

Project No. 11-137

Date: 08-08-12

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*****************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION        *
*          ENGINEERING SERVICE CENTER               *
*     DIVISION OF MATERIALS AND FOUNDATIONS         *
*   Office of Roadway Geotechnical Engineering      *
*    Date: 08-09-2012          Time: 09:23:04       *
*****************************************************
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Project Identification - Retaining Wall 349 Wall Height = 26 feet

--------- WALL GEOMETRY ---------

		Angle (Deg)	Length (Feet)
Vertical Wall Height	=	25.0 ft	
Wall Batter	=	0.0 degree	
First Slope from Wallcrest.	=	26.6	34.2
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

THE SURCHARGES IMPOSED ON THE SYSTEM ARE:

Begin Surcharge - Distance from toe	=	30.6 ft
End Surcharge - Distance from toe	=	70.0 ft
Loading Intensity - Begin	=	240.0 psf/ft
Loading Intensity - End	=	240.0 psf/ft

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	50.0 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ---------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	32.0	15.0	3.0	1.00	0.75
2	32.0	15.0	5.0	1.00	0.75

3	32.0	15.0	5.0	1.00	0.75
4	32.0	15.0	5.0	1.00	0.75
5	32.0	15.0	5.0	1.00	0.75

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.790	7.8	69.3	15.4	80.8	14.6

Reinf. Stress at Level 1 = 50.000 Ksi (Yield Stress controls.)
2 = 50.000 Ksi (Yield Stress controls.)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.648	14.6	53.0	12.1	72.1	23.8

Reinf. Stress at Level 1 = 45.920 Ksi (Pullout controls...)
2 = 49.241 Ksi (Pullout controls...)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	2.449	21.4	50.0	23.3	70.2	19.0

Reinf. Stress at Level 1 = 35.528 Ksi (Pullout controls...)
2 = 43.084 Ksi (Pullout controls...)
3 = 50.000 Ksi (Yield Stress controls.)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	2.197	28.2	48.0	42.1	89.9	7.8

Reinf. Stress at Level 1 = 33.413 Ksi (Pullout controls...)
2 = 41.528 Ksi (Pullout controls...)
3 = 49.643 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.896	35.0	34.6	21.3	58.2	33.2

Reinf. Stress at Level 1 = 23.783 Ksi (Pullout controls...)
2 = 29.729 Ksi (Pullout controls...)
3 = 41.139 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.778	41.8	35.9	20.6	48.4	37.8

Reinf. Stress at Level 1 = 23.021 Ksi (Pullout controls...)
2 = 31.047 Ksi (Pullout controls...)
3 = 42.049 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.747	48.6	28.9	16.7	43.5	46.9

Reinf. Stress at Level 1 = 18.069 Ksi (Pullout controls...)
2 = 27.265 Ksi (Pullout controls...)
3 = 36.460 Ksi (Pullout controls...)
4 = 50.000 Ksi (Yield Stress controls.)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.767	55.4	28.6	25.2	40.3	43.6

Reinf. Stress at Level 1 = 11.621 Ksi (Pullout controls...)
2 = 22.401 Ksi (Pullout controls...)
3 = 36.142 Ksi (Pullout controls...)
4 = 49.883 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

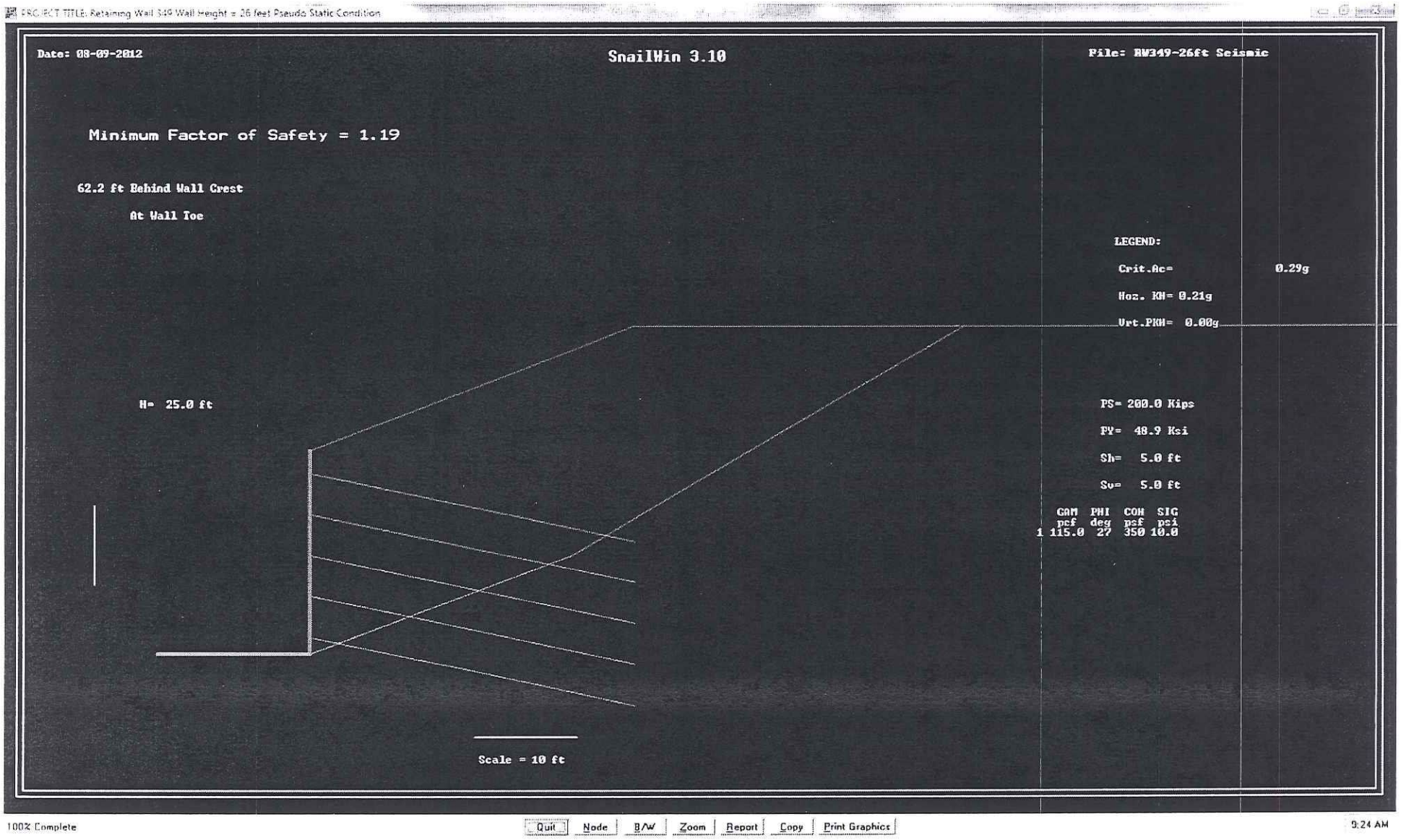
	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.800	62.2	25.9	27.7	37.1	46.8

Reinf. Stress at Level 1 = 6.410 Ksi (Pullout controls...)
2 = 18.705 Ksi (Pullout controls...)
3 = 33.533 Ksi (Pullout controls...)
4 = 48.361 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.847	69.0	21.3	22.2	33.7	58.1

Reinf. Stress at Level 1 = 2.777 Ksi (Pullout controls...)
2 = 14.727 Ksi (Pullout controls...)
3 = 28.304 Ksi (Pullout controls...)
4 = 45.311 Ksi (Pullout controls...)
5 = 50.000 Ksi (Yield Stress controls.)

****
* For Factor of Safety = 1.0 *
* Maximum Average Reinforcement Working Force: *
* 5.116 Kips/level *
****



Retaining Wall 349 – Soil Nail Wall	Soil Nail Wall Height = 26 feet Pseudo Static Condition (k_h = 0.21)
Earth Mechanics, Inc. Geotechnical and Earthquake Engineering	Project No. 11-137 | Date: 08-08-12

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**************************************************
*    CALIFORNIA DEPARTMENT OF TRANSPORTATION     *
*          ENGINEERING SERVICE CENTER            *
*     DIVISION OF MATERIALS AND FOUNDATIONS      *
*   Office of Roadway Geotechnical Engineering   *
*    Date: 08-09-2012          Time: 09:23:58    *
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Project Identification - Retaining Wall 349 Wall Height = 26 feet Pseudo Static Condition

--------- WALL GEOMETRY ---------

Vertical Wall Height	=	25.0 ft	
Wall Batter	=	0.0 degree	
		Angle (Deg)	Length (Feet)
First Slope from Wallcrest.	=	26.6	34.2
Second Slope from 1st slope.	=	0.0	40.0
Third Slope from 2nd slope.	=	0.0	0.0
Fourth Slope from 3rd slope.	=	0.0	0.0
Fifth Slope from 3rd slope.	=	0.0	0.0
Sixth Slope from 3rd slope.	=	0.0	0.0
Seventh Slope Angle.	=	0.0	

--------- SLOPE BELOW THE WALL ---------

There is NO SLOPE BELOW THE TOE of the wall

--------- SURCHARGE ---------

There is NO SURCHARGE imposed on the system.

--------- OPTION #1 ---------

Factored Punching shear, Bond & Yield Stress are used.

--------- SOIL PARAMETERS ---------

Soil Layer	Unit Weight (Pcf)	Friction Angle (Degree)	Cohesion Intercept (Psf)	Bond* Stress (Psi)	Coordinates of Boundary XS1 (ft)	YS1 (ft)	XS2 (ft)	YS2 (ft)
1	115.0	27.0	350.0	10.0	0.0	0.0	0.0	0.0

* Bond Stress also depends on BSF Factor in Option #5 when enabled.

--------- EARTHQUAKE ACCELERATION ---------

Horizontal Earthquake Coefficient = 0.21 (a/g)
Vertical Earthquake Coefficient = 0.00

--------- WATER SURFACE ---------

NO Water Table defined for this problem.

--------- SEARCH LIMIT ---------

The Search Limit is from 1.0 to 69.0 ft

You have chosen NOT TO LIMIT the search of failure planes to specific nodes.

--------- REINFORCEMENT PARAMETERS ---------

Number of Reinforcement Levels	=	5
Horizontal Spacing	=	5.0 ft
Yield Stress of Reinforcement	=	48.9 ksi
Diameter of Grouted Hole	=	6.0 in
Punching Shear	=	200.0 kips

---------- (Varying Reinforcement Parameters) ----------

Level	Length (ft)	Inclination (degrees)	Vertical Spacing (ft)	Bar Diameter (in)	Bond Stress Factor
1	32.0	15.0	3.0	1.00	0.73

2	32.0	15.0	5.0	1.00	0.73
3	32.0	15.0	5.0	1.00	0.73
4	32.0	15.0	5.0	1.00	0.73
5	32.0	15.0	5.0	1.00	0.73

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
Toe	2.245	7.8	61.6	16.4	89.9	14.5

Reinf. Stress at Level 1 = 48.900 Ksi (Yield Stress controls.)
2 = 48.900 Ksi (Yield Stress controls.)
3 = 48.900 Ksi (Yield Stress controls.)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 2	2.078	14.6	53.0	12.1	72.1	23.8

Reinf. Stress at Level 1 = 44.879 Ksi (Pullout controls...)
2 = 48.125 Ksi (Pullout controls...)
3 = 48.900 Ksi (Yield Stress controls.)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 3	1.741	21.4	49.4	32.9	89.9	10.7

Reinf. Stress at Level 1 = 34.076 Ksi (Pullout controls...)
2 = 41.685 Ksi (Pullout controls...)
3 = 48.900 Ksi (Yield Stress controls.)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 4	1.501	28.2	48.0	42.1	89.9	7.8

Reinf. Stress at Level 1 = 32.656 Ksi (Pullout controls...)
2 = 40.587 Ksi (Pullout controls...)
3 = 48.518 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 5	1.334	35.0	42.7	47.6	89.9	8.1

Reinf. Stress at Level 1 = 27.128 Ksi (Pullout controls...)
2 = 36.316 Ksi (Pullout controls...)
3 = 45.503 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 6	1.250	41.8	35.9	20.6	48.4	37.8

Reinf. Stress at Level 1 = 22.500 Ksi (Pullout controls...)
2 = 30.343 Ksi (Pullout controls...)
3 = 41.096 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 7	1.206	48.6	28.9	16.7	43.5	46.9

Reinf. Stress at Level 1 = 17.660 Ksi (Pullout controls...)
2 = 26.647 Ksi (Pullout controls...)
3 = 35.634 Ksi (Pullout controls...)
4 = 48.900 Ksi (Yield Stress controls.)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 8	1.191	55.4	28.6	25.2	40.3	43.6

Reinf. Stress at Level 1 = 11.358 Ksi (Pullout controls...)
2 = 21.894 Ksi (Pullout controls...)
3 = 35.323 Ksi (Pullout controls...)
4 = 48.752 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE 9	1.189	62.2	25.9	27.7	37.1	46.8

Reinf. Stress at Level 1 = 6.265 Ksi (Pullout controls...)
2 = 18.281 Ksi (Pullout controls...)
3 = 32.773 Ksi (Pullout controls...)
4 = 47.265 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

	MINIMUM SAFETY FACTOR	DISTANCE BEHIND WALL TOE (ft)	LOWER FAILURE PLANE ANGLE (deg)	LOWER FAILURE PLANE LENGTH (ft)	UPPER FAILURE PLANE ANGLE (deg)	UPPER FAILURE PLANE LENGTH (ft)
NODE10	1.199	69.0	21.3	22.2	33.7	58.1

Reinf. Stress at Level 1 = 2.714 Ksi (Pullout controls...)
2 = 14.393 Ksi (Pullout controls...)
3 = 27.663 Ksi (Pullout controls...)
4 = 44.284 Ksi (Pullout controls...)
5 = 48.900 Ksi (Yield Stress controls.)

For Factor of Safety = 1.0
Maximum Average Reinforcement Working Force:
19.280 Kips/level

Earth Mechanics, Inc.
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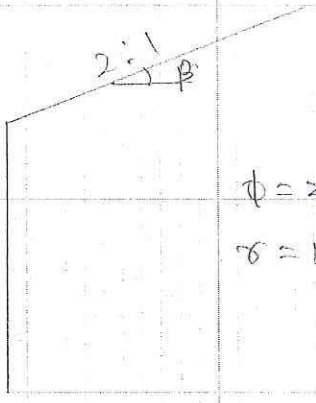
Project I-5 HOV Implementation Segment 5 - RW349 **Project No.** 11-137

By SP **Date** 08/09/12 **Checked By** LCC **Date** 8/19/12 **Sheet** ____ **of** ____

Lateral Earth pressure for soil nail wall



$\phi = 27^\circ$

$\gamma = 115$ pcf

for 2:1 backfill slope

$\beta = \tan^{-1}(\frac{1}{2}) = 26.6^\circ$

$$K_a = \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}$$

$$= \frac{\cos 26.6 - \sqrt{\cos^2 26.6 - \cos^2 27}}{\cos 26.6 + \sqrt{\cos^2 26.6 - \cos^2 27}}$$

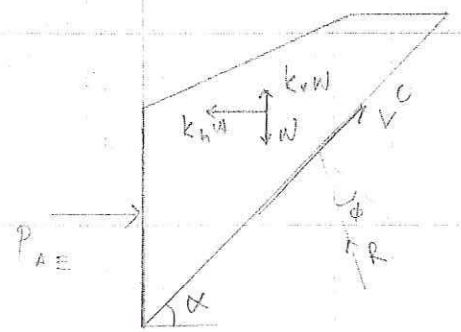
$= 0.75$

Equivalent fluid pressure $= 0.75 \times 115 = 86$ psf/ft

for seismic earth pressure

consider $\phi = 27^\circ$, $c = 350$ psf, $\gamma = 115$ pcf

using trial wedge method



for static

$$P_A = (W - Lc\sin\alpha)\tan(\alpha - \phi) - Lc\cos\alpha$$

for seismic

$$P_{AE} = ((1 - k_v)W - Lc\sin\alpha)\tan(\alpha - \phi) - Lc\cos\alpha + k_h W$$

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Project I-5 HOV Improvement segment 3 - RW 3.19 **Project No.** 11-137

By SP **Date** 08/09/12 **Checked By** LCC **Date** 8/10/12 **Sheet** ____ **of** ____

from trial wedge analysis (for wall height of 24 feet)

for static $\alpha = 53.3^\circ$

$L = 42.5$ ft

$W = 38000$ lbs/ft

$P_A = (38000 - 42.5 \times 350 \sin 53.3) \tan(53.3 - 27) - 42.5 \times 350 \cos 53.3$

$= 3997$ lbs

for seismic $k_h = 0.21$, $k_v = 0$

$\alpha = 45.1^\circ$

$L = 47$ ft

$W = 54750$ lbs/ft

$P_{AE} = (54750 - 47 \cdot 350 \sin 45.1) \tan(45.1 - 27) + 47 \times 350 \times \cos 45.1 \tan 0.21 \times 54750$

$= 13980$ lbs/ft

$\Delta P_{AE} = 13980 - 3997 = 9983$ lbs

for 24 ft wall height

ΔE_{AE} for uniform distribution $= \frac{9983}{24^2} = 17.3$

considered 18H as incremental uniform seismic lateral earth pressure

Seismic Earth Pressure, Trial wedge method, (c, ϕ) material

c/γh= 0.127

T_c (ft) 9.933

$$T_c = \frac{2c}{\gamma\sqrt{\tan^2\left(\frac{\pi}{4}-\frac{\phi}{2}\right)}}$$

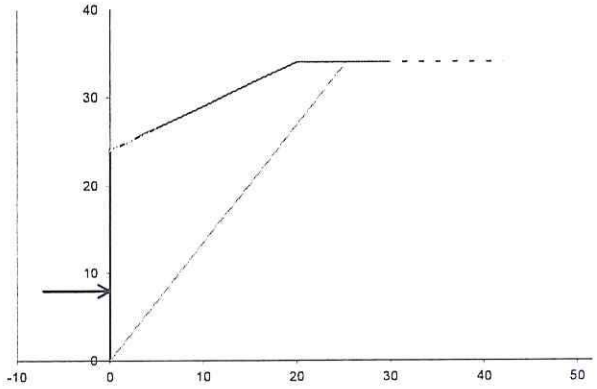
ϕ =	27	deg =	0.47124	radians	adhesion (c_a):	0	psf
c =	350	psf			loading, start:	5	ft
k_h =					loading, end:	30	ft
k_v =	0				loading, magnitude:	0	psf
β =	0	deg =	0	radians	slope length, L_s =	20.0	ft
i =	26.565	deg =	0.46365	radians	tension crack depth =	0.00	ft
H =	24	ft			water-filled tension crack?	no	
γ =	115	pcf			unit weight of water:	62.4	psf
δ =	0	deg =	0	radians	note: distances for loading and slope measured horizontally from top of wall.		

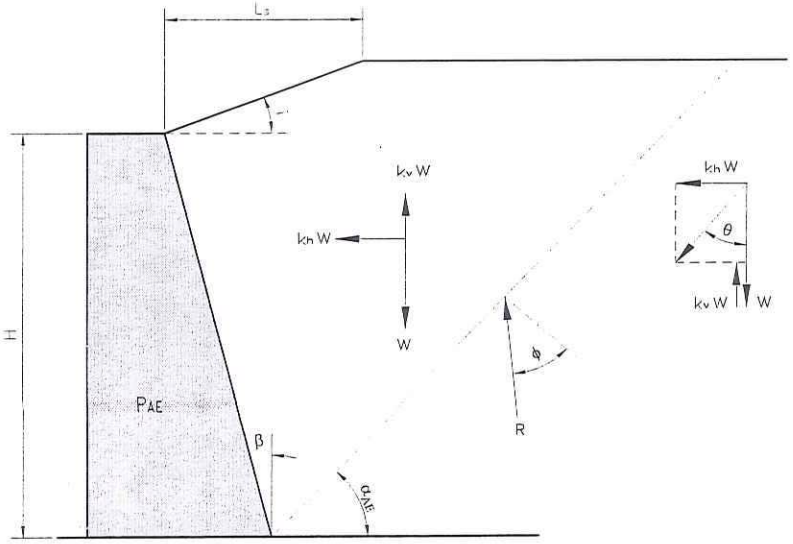
α_{AE} =	53.2804	deg	0.92992	radians
ΔW_{load} =	0	lbs/ft		
ΔW_{Tc} =	0	lbs/ft		
W =	38,081	lbs/ft		
θ =	0.000	deg =	0	radians
L =	42.417	ft		
criteria:	0.64			

Solution: Update!

P_{AEH} =	4,052	lbs (horizontal active force)
K_{AEH} =	0.122	horizontal active force coefficient
P_{AE} =	4,052	lbs (total active force)
K_{AE} =	0.122	total active force coefficient

Note: $P_{AE} = \frac{1}{2} K_{AE} \lambda H^2 (1 - k_v)$





Seismic Earth Pressure, Trial wedge method, (c, ϕ) material

c/γh= 0.127

T_c (ft) 9.933

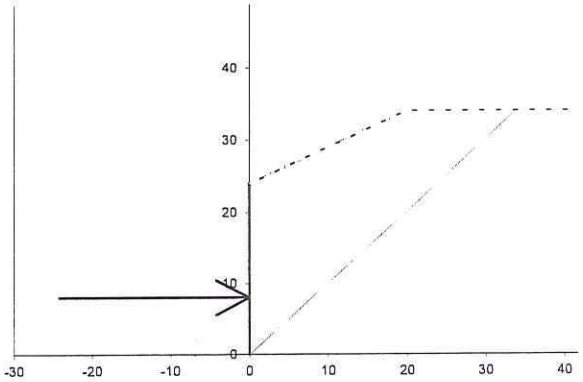
$$T_c = \frac{2c}{\gamma\sqrt{\tan^2\left(\frac{\pi}{4}-\frac{\phi}{2}\right)}}$$

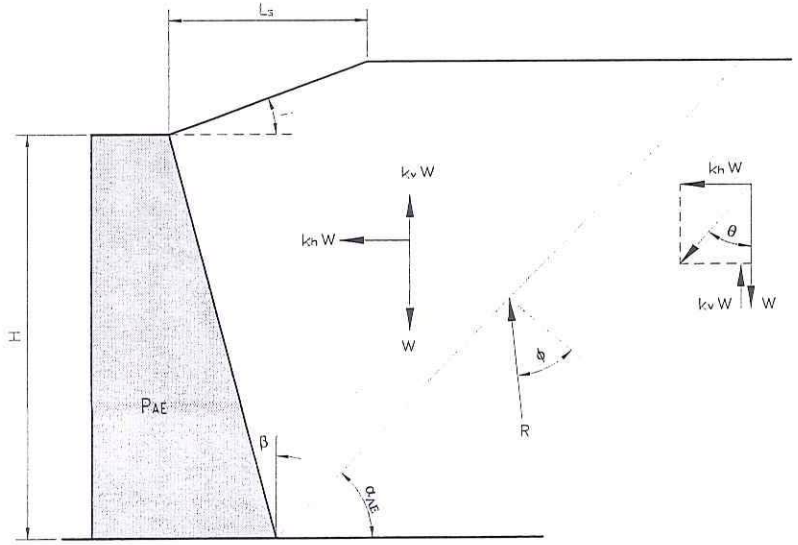
ϕ =	27	deg =	0.47124	radians	adhesion (c_a):	0	psf
c =	350	psf			loading, start:	0	ft
k_h =	0.21				loading, end:	0	ft
k_v =	0				loading, magnitude:	0	psf
β =	0	deg =	0	radians	slope length, L_s =	20.0	ft
i =	26.565	deg =	0.46365	radians	tension crack depth =	0.00	ft
H =	24	ft			water-filled tension crack?	no	
γ =	115	pcf			unit weight of water:	62.4	psf
δ =	0	deg =	0	radians	note: distances for loading and slope measured horizontally from top of wall.		
α_{AE} =	45.1039	deg	0.78721	radians			
ΔW_{load} =	0	lbs/ft					
ΔW_{Tc} =	0	lbs/ft					
W =	54,729	lbs/ft					
θ =	11.860	deg =	0.20699	radians			
L =	47.996	ft					
criteria:	0.43						

Solution: Update!

P_{AEH} =	13,638	lbs (horizontal active force)
K_{AEH} =	0.412	horizontal active force coefficient
P_{AE} =	13,638	lbs (total active force)
K_{AE} =	0.412	total active force coefficient

Note: $P_{AE} = \frac{1}{2} K_{AE} \lambda H^2 (1 - k_v)$





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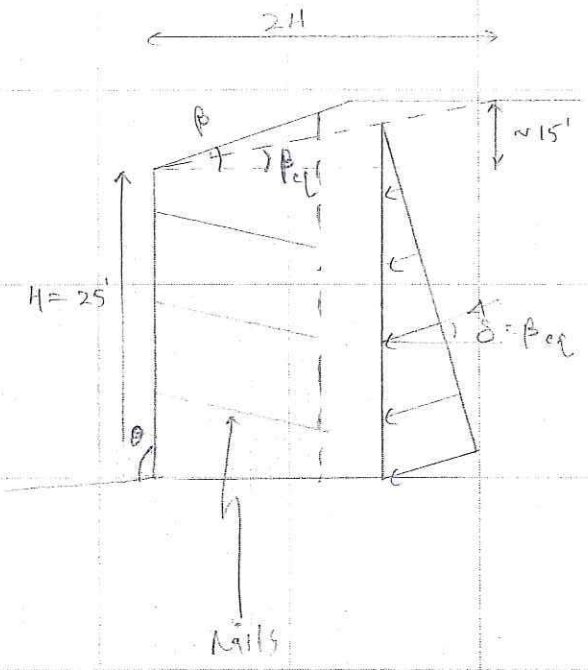
Project Ron Bay Soil nail wall **Project No.** 11-191

By SP **Date** 09/11/12 **Checked By** LCC **Date** 10/12/12 **Sheet** ____ **of** ____

Sliding



$\beta_{eq} = \tan^{-1}\left(\frac{15}{54}\right)$

$\beta_{eq} = \sim 17^\circ$

$\beta = 26.6$

$\phi = 27^\circ$

to calculate earth pressure behind soil nails

$$K_a = \frac{\sin^2(\theta+\phi)}{\sin^2\theta \sin(\theta-\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\sin(\theta-\delta)\sin(\theta+\beta)}}\right]^2}$$

$= 0.65$ for friction angle of 27°

ϕ'_b = effective angle of internal friction of the base (remolded or residual values may be needed if significant movement takes place);

ϕ' = effective friction angle of soil behind soil nail block;

δ = wall-soil interface friction angle [for a broken slope, $\delta = \beta_{eq}$, for infinite slope, $\delta = \beta$];

γ = total unit weight of soil mass;

H_1 = effective height over which the earth pressure acts [$H_1 = H + (B + \tan \alpha) \tan \beta_{eq}$]; and

K_A = active earth pressure coefficient for soil behind the soil nail wall system.

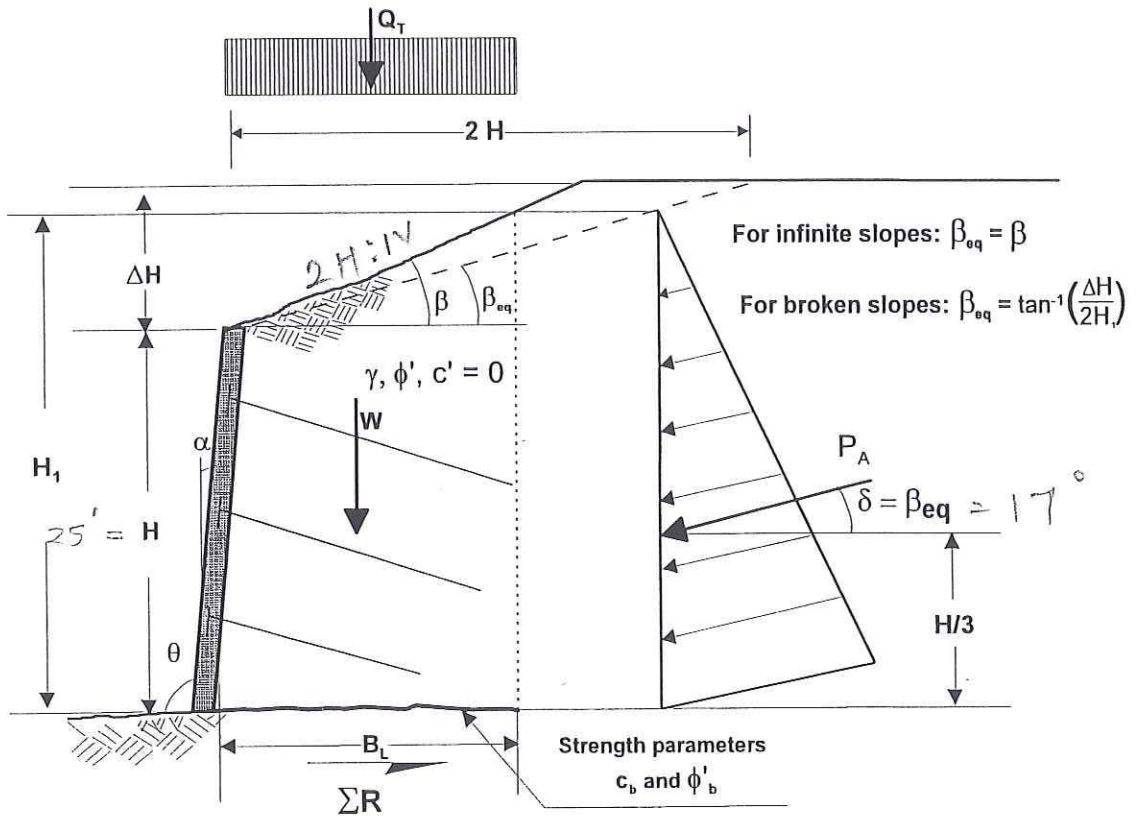


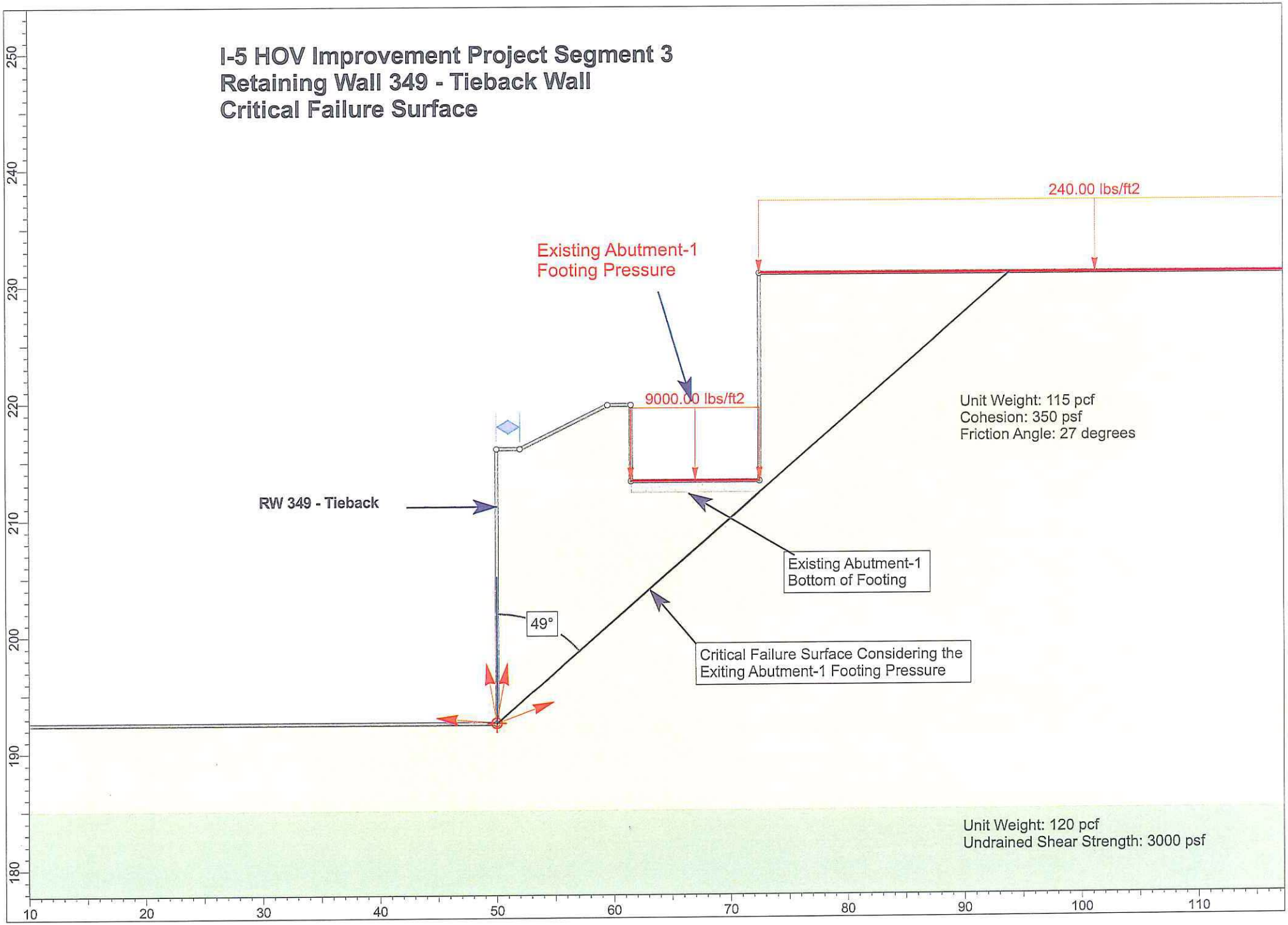
Figure 5.5: Sliding Stability of a Soil Nail Wall.

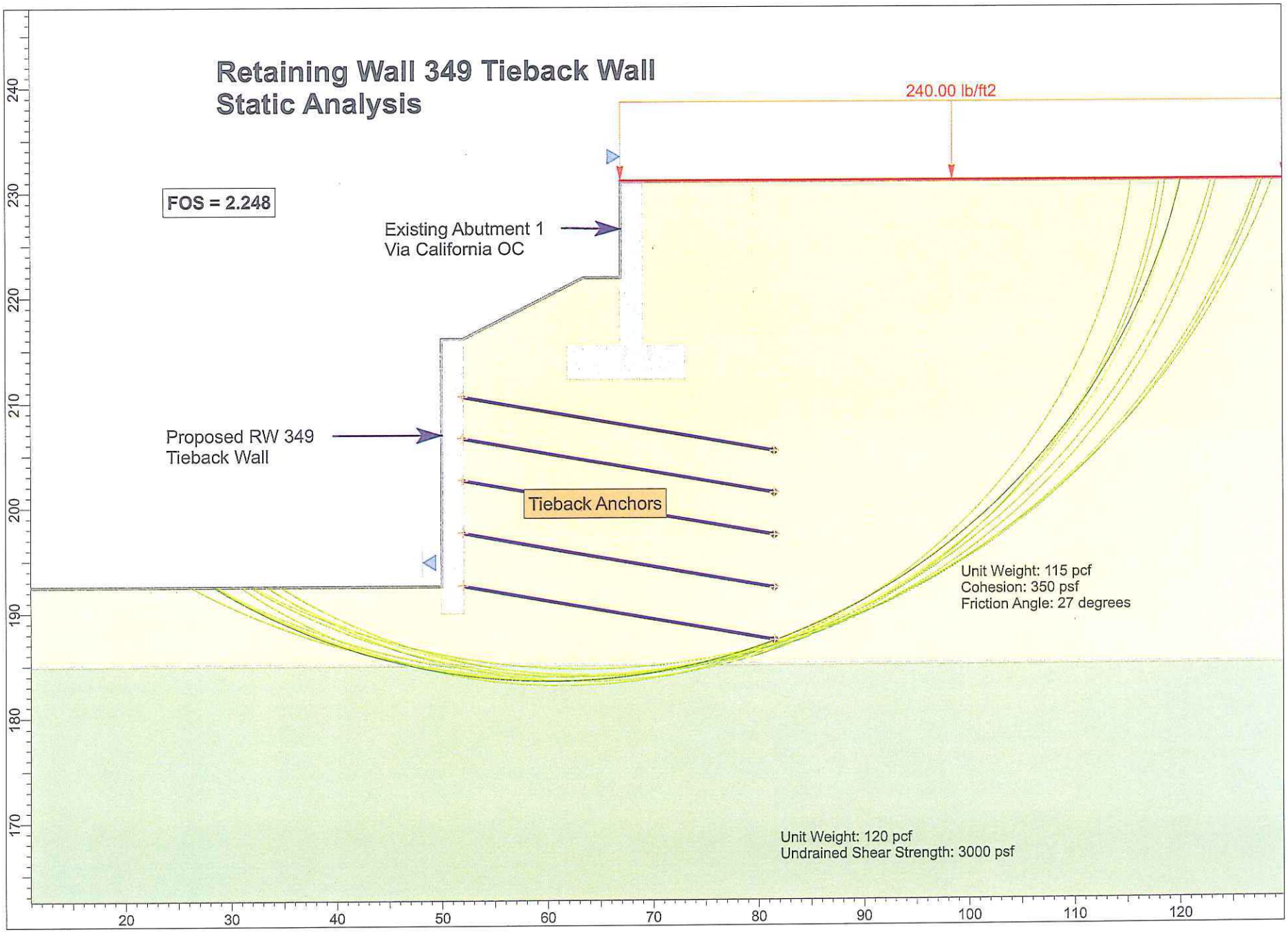
The active earth pressure coefficient, K_A, can be obtained using the formulation derived from the general Coulomb theory or the Rankine theory for cohesionless soil (assuming that the soil behind the soil nail wall behaves in accordance with $c' = 0$ in the long-term loading condition).

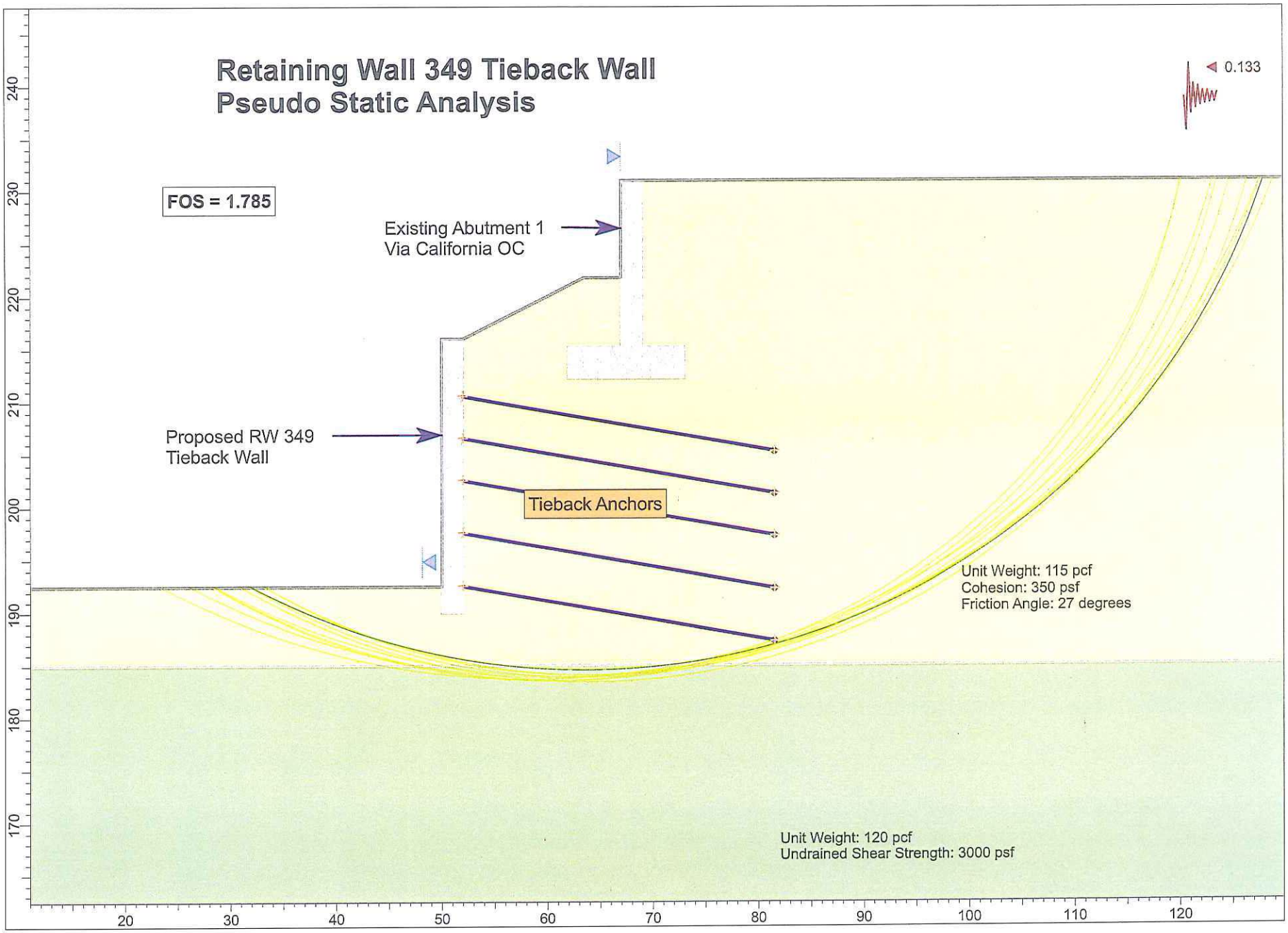
According to the Coulomb theory:

$$K_A = \frac{\sin^2(\theta + \phi')}{\sin^2\theta \sin(\theta - \delta)\left[1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi' - \beta)}{\sin(\theta - \delta)\sin(\theta + \beta)}}\right]^2} = 0.65 \quad \text{(Equation 5.11)}$$

where the parameters have been defined previously.


I-5 HOV Improvement Project Segment 3
Retaining Wall 349 - Tieback Wall
Critical Failure Surface
240.00 lbs/ft2
Existing Abutment-1
Footing Pressure
9000.00 lbs/ft2
Unit Weight: 115 pcf
Cohesion: 350 psf
Friction Angle: 27 degrees
RW 349 - Tieback
Existing Abutment-1
Bottom of Footing
49°
Critical Failure Surface Considering the
Exiting Abutment-1 Footing Pressure
Unit Weight: 120 pcf
Undrained Shear Strength: 3000 psf
250
240
230
220
210
200
190
180
10
20
30
40
50
60
70
80
90
100
110


Retaining Wall 349 Tieback Wall
Static Analysis
240.00 lb/ft2
FOS = 2.248
Existing Abutment 1
Via California OC
Proposed RW 349
Tieback Wall
Tieback Anchors
Unit Weight: 115 pcf
Cohesion: 350 psf
Friction Angle: 27 degrees
Unit Weight: 120 pcf
Undrained Shear Strength: 3000 psf
240
230
220
210
200
190
180
170
20
30
40
50
60
70
80
90
100
110
120


Retaining Wall 349 Tieback Wall
Pseudo Static Analysis
0.133
FOS = 1.785
Existing Abutment 1
Via California OC
Proposed RW 349
Tieback Wall
Tieback Anchors
Unit Weight: 115 pcf
Cohesion: 350 psf
Friction Angle: 27 degrees
Unit Weight: 120 pcf
Undrained Shear Strength: 3000 psf
240
230
220
210
200
190
180
170
20
30
40
50
60
70
80
90
100
110
120

Appendix D

CALTRANS REVIEW COMMENTS AND EMI RESPONSES

EXTERNAL SUBMITTAL REVIEW

PROJECT: INTERSTATE 5 HOV IMPROVEMENT
PROJECT No. 1200020279

EA No.: 12-0F96E	
Agency: CalTrans	
Submittal No.	Title: FR for RW 349 (I-5 HOV, Segment 3) by EMI, 8/13/2012

Lead:	Date: 9/5/2012
Technical Discipline: Geotechnical	

ACTION (30, 60, 85%): RL = Revise in Later Submittal RI = Revise Immediately & OTS Review

30, 60, 85% SUBMITTAL DISPOSITION (check one): ( )Approved, ( ) Approved as Noted for Correction, ( ) Rejected, Revise & Resubmit, ( ) Record Only

CODE: A - Accept/will comply, B - Agency Action, C - Clarify/Discuss, D - Delete Comment, E - Different Submittal

FINAL SUBMITTAL (100%) DISPOSITION (check one): ( ) Approved, (X) Approved as Noted for Correction, ( ) Rejected, Revise & Resubmit, ( ) Record Only

FILLED OUT BY REVIEWER						FILLED OUT BY RESPONDER		FILLED OUT AT RESOLUTION MEETING		
No.	Plan/SSP/ Page No.	Reviewer	Reviewer Comment No.	Comments	Action	Initial Code	Response	Final Code	Verify (1)	Verify (2)
1	Page 15, Section 5.3	H.Liu	1	Section 46-3.02 A of Caltrans Standard Specifications (2010) only provides material requirements for nails in non-corrosive soils. For soil nails within corrosive ground, please follow the requirement outlined in corresponding section in Caltrans' SSP (July, 2012)	RI	A	We will comply. We will add the Caltrans SSP Section 46-3.02A (July, 2012) in the report.			
2	Page 16, Section 5.4.2, and Section 6.3	H.Liu	2	The suggested 45-degree failure plane at ground anchor location may cut through the existing abutment footing, which is unlikely given the high strength of RC footing. Failure surface may start from the heel of the existing footing (right edge), creating a larger failure wedge than proposed in the report. Please revaluate the unbonded length based on such consideration.	RI	A	We will extend the failure surface to heel of the existing footing (right edge). The unbonded length will be larger of all criteria stated in Section 5.4.2.			
3	Page 17, Figure 5-1	H.Liu	3	The incremental earthquake surcharge should be distributed as inverted triangle, instead of rectangular (uniformly ditributed).	RI	C	AASHTO/CA State Amendments Section A11.1.1.1 uses a triangular distribuition for seismic earth pressure. The Structural Engineers have completed the wall design using our uniform pressure distribution. We request no change to the seismic pressure.			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.

EA No.: 12-0F96E	
Agency: CalTrans	
Submittal No.	Title: FR for RW 349 (I-5 HOV, Segment 3) by EMI, 8/13/2012

Lead:	Date: 9/5/2012
Technical Discipline: Geotechnical	

ACTION (30, 60, 85%): RL = Revise in Later Submittal RI = Revise Immediately & OTS Review

30, 60, 85% SUBMITTAL DISPOSITION (check one): ( )Approved, ( ) Approved as Noted for Correction, ( ) Rejected, Revise & Resubmit, ( ) Record Only

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FILLED OUT BY REVIEWER						FILLED OUT BY RESPONDER		FILLED OUT AT RESOLUTION MEETING		
No.	Plan/SSP/ Page No.	Reviewer	Reviewer Comment No.	Comments	Action	Initial Code	Response	Final Code	Verify (1)	Verify (2)
4	Section 6.4, Page 23, first paragraph.	H.Liu	4	Please revise the statement to: Soil nails should be load tested.... with the criteria ***and test schedule outlined in Section 46-3 of Caltrans Standard Specifications (2010)*** to verify if the design loads can be....	RI	A	We will comply.			
5	Section 6.4, Page 23, second paragraph.	H.Liu	5	Please replace "In addition, minimum of ....must be proof tested" with ***Proof test should be conducted on sacraficial test nails no iess than 10% of total number of production nails.***	RI	A	We will comply.			
6	Section 6.0 Construction Recommend ations	H.Liu	6	Please define wall zone explicitly in THIS SECTION of the report.	RI	A	We will add a subsection for Wall Zone under Section 6.0.			
7	Appendix C Calculations. Lateral earth pressure for ground anchor	H.Liu	7	Please present calculations for determining failure wedge of the cut slope at ground anchor location.	RI	A	We will comply.			

(1) Responder's Initials - concur with response.

(2) Reviewer's Initials - concur with response.

EXTERNAL SUBMITTAL REVIEW

PROJECT: INTERSTATE 5 HOV IMPROVEMENT
PROJECT No. 1200020279

EA No.: 12-0F96E	
Agency: CalTrans	
Submittal No.	Title: FR for RW 349 (I-5 HOV, Segment 3) by EMI, 4/23/2012

Lead:	Date: 8/1/2012
Technical Discipline: Geotechnical	

ACTION (30, 60, 85%): RL = Revise in Later Submittal RI = Revise Immediately & OTS Review

30, 60, 85% SUBMITTAL DISPOSITION (check one): ( )Approved. ( ) Approved as Noted for Correction. ( ) Rejected. Revise & Resubmit. ( ) Record Only
CODE: A - Accept/will comply. B - Agency Action. C - Clarify/Discuss. D - Delete Comment. E - Different Submittal

FINAL SUBMITTAL (100%) DISPOSITION (check one): ( ) Approved. (X) Approved as Noted for Correction. ( ) Rejected. Revise & Resubmit. ( ) Record Only

FILLED OUT BY REVIEWER						FILLED OUT BY RESPONDER		FILLED OUT AT RESOLUTION MEETING		
No.	Plan/SSP/ Page No.	Reviewer	Reviewer Comment No.	Comments	Action	Initial Code	Response	Final Code	Verify (1)	Verify (2)
1	Page 12, Table 4-1	H.Liu	1	Based on this report (including all soil borings), bedrock contact varies from Elev. +170' to +189' along the wall alighment. Please revise Table 4-1 by dividing the wall into different segments, using different idealized soil profile (ISP) for each wall segment. Or more conservatively, using Terrace deposit in ISP for the entire wall.	RI	C	The bedrock contact varies between elevations +189 feet near the beginning of the wall and +170 feet near the end of the wall. Bottom of wall elevations vary between +198 feet near the beginning of the wall and +178 feet near the end of the wall. Based on these elevations along the wall alignment, bedrock contact is about 8 to 10 feet below the bottom soil nail and tieback walls. Therefore, the influence of the bedrock is minimal in soil nail and tieback wall design. Conservatively, Terrace Deposit with a friction angle of 27 degrees and a cohesion of 350 psf was considered in the design of soil nails and tieback.			
2	Page 15, Section 5.4.1, Table 5-3	H.Liu	2	Please specify the existing footing width and its horizontal distance to the proposed wall in the table, or Section 5.4.1 of the report	RI	A	We will comply.			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.

EA No.: 12-0F96E	
Agency: CalTrans	
Submittal No.	Title: FR for RW 349 (I-5 HOV, Segment 3) by EMI, 4/23/2012

Lead:	Date: 8/1/2012
Technical Discipline: Geotechnical	

ACTION (30, 60, 85%): RL = Revise in Later Submittal RI = Revise Immediately & OTS Review

30, 60, 85% SUBMITTAL DISPOSITION (check one): ( )Approved. ( ) Approved as Noted for Correction. ( ) Rejected. Revise & Resubmit. ( ) Record Only

CODE: A - Accept/will comply. B - Agency Action, C - Clarify/Discuss, D - Delete Comment, E - Different Submittal

FINAL SUBMITTAL (100%) DISPOSITION (check one): ( ) Approved. (X) Approved as Noted for Correction. ( ) Rejected, Revise & Resubmit. ( ) Record Only

FILLED OUT BY REVIEWER						FILLED OUT BY RESPONDER		FILLED OUT AT RESOLUTION MEETING		
No.	Plan/SSP/ Page No.	Reviewer	Reviewer Comment No.	Comments	Action	Initial Code	Response	Final Code	Verify (1)	Verify (2)
3	Page 16, Sections 5.4.2 and 6.3	H.Liu	3	Due to the existance of abutment footing, the critical failure plane may not follow the Rankine wedge that is 30 degrees from vertical. Please re-evaluate the critical failure surface considering additional driving force from existing foundation in dertermining the un-bonded length of ground anchor.	RI	A	We reevaluated the critical failure surface considering additional driving force from the existing foundation. The critical failure surface is 45 degrees from vertical.			
4	Page 16, Section 5.4.2. Section 5.4.4	H.Liu	4	Un-bonded length of the ground anchor should also be developed to certain distance beyond the potential shear plane (left wedge) for general bearing capacity failure of the existing footing. It can be specified in terms of horizontal distance from the edge of anchor zone to the existing footing, and presented in either Section 5.4.2 or Section 5.4.4 of the report.	RI	A	As presented in NAVFAC design manual, the assumed general bearing capacity failure extend to an approximate vertical distance equal to width of the footing. Therefore, for tiebacks located within this vertical distance equal to width of the Abutment-1 footing (11 feet), the unbonded length should extend beyond an imaginary vertical plane coinciding with the centerline of the existing Abutment-1 footing. This will extend the unbonded length beyond the left wedge			
5	Page 16, Sections 5.4.4, and 6.3	H.Liu	5	The minimum spacing between ground anchor should be 5 feet based on Section 5.8.6.3 of Caltrans' BDS and MTD 5-12 (2012).	RI	A	We will comply.			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.

EA No.: 12-0F96E	
Agency: CalTrans	
Submittal No.	Title: FR for RW 349 (I-5 HOV, Segment 3) by EMI, 4/23/2012

Lead:	Date: 8/1/2012
Technical Discipline: Geotechnical	

ACTION (30, 60, 85%): RL = Revise in Later Submittal RI = Revise Immediately & OTS Review

30, 60, 85% SUBMITTAL DISPOSITION (check one): ( )Approved, ( ) Approved as Noted for Correction, ( ) Rejected, Revise & Resubmit, ( ) Record Only
CODE: A - Accept/will comply, B - Agency Action, C - Clarify/Discuss, D - Delete Comment, E - Different Submittal

FINAL SUBMITTAL (100%) DISPOSITION (check one): ( ) Approved, (X) Approved as Noted for Correction, ( ) Rejected, Revise & Resubmit, ( ) Record Only

FILLED OUT BY REVIEWER						FILLED OUT BY RESPONDER		FILLED OUT AT RESOLUTION MEETING		
No.	Plan/SSP/ Page No.	Reviewer	Reviewer Comment No.	Comments	Action	Initial Code	Response	Final Code	Verify (1)	Verify (2)
6	Page 19 Table 5-5 Section 5.5.2. Appendix C (SNAILZ)	H.Liu	6	Should factor of safety (FOS) for nail pull-out under internal stability be applied to SNAILZ for global stability run, simular factor (for internal stability) should also be used for nail bar tensile strength, so that the controlling failure mode (bar snap or nail pull-out) can be correctly reflected in data output. Please add reduction factor to the bar strength in the calcs as well.	RI	A	For nail tensile strength, we will apply minimum factor of safety of 1.8 and 1.35 for static and seismic analyses, respectively. The reduction factors of 1.5/1.8 for static and 1.1/1.35 for seismic are used in the calculation for nail tensile strength.			
7	Page 19 Table 5-5 Section 5.5.2 Appendix C (SNAILZ)	H.Liu	7	Should FOS of 1.5 (Static) and 1.1 (pseudo static) be selected as acceptable minimum in global stability analysis, bond stress factor in SNAILZ, if used, should be taken as 1.5/2.0 for static, and 1.1/1.5 for seismic to avoid double factoring of strength parameter. Same concept should also be applied to the bar strength of the soil nail.	RI	A	We will comply.			
8	Page 19, Section 5.5.3	H.Liu	8	Please present calculations for static active earth pressure and seismic incremental pressure for soil nail wall in the next submittal	RI	A	We will comply.			
9	Page 21, Section 6.4, Paragraph 3	H.Liu	9	Based on Caltrans' SSP for soil nail, 10% of production nails should be proof-tested, with 8% shown on Plan, and 2% randomly picked by Engineer. Please either revise or eliminate the applicable statement.	RI	A	We will revise the testing requirement in the report.			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.

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10	PP 21 & 22, Section 6.4	H.Liu	10	Please used "Engineer" instead of "Resident Engineer".	RI	A	We will comply.			
11	PP 21 & 22, Section 6.4	H. Liu	11	Please define the wall zone for RW349 as required by Caltrans' GDR Guidelines. This is fundamental for planning stability tests (Std Specs 19-3.01A(3)) for excavation, and nail verification tests (Std Specs 46-3.01D(2)) upon wall construction.	RI	A	The wall zones are defined based on the soil subsurface conditions. Along the entire wall, predominantly terrace deposit is encountered. Therefore, only one wall zone is expected. The stability tests and verification tests are recommended in Sections 6.2 and 6.4, respectively.			
12	Appendix A LOTBS	H. Liu	12	Please add route number for A-Line on boring location plan.	RI	A	We will comply.			
13	Appendix A LOTBS	H.Liu	13	For CL materials at depths of 20' from Boring # A-11-313 and 10' from Boring# A-11-312, plasticity should be "medium" to be defined as CL, per Caltrans' Soil and Rock Logging Manual (2010), and ASTM D2488.	RI	A	We will comply.			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.

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14	Appendix C Calculations	H.Liu	14	Although minimum nail length was not explicitly defined in design guidelines, performance of short nail will be more sensitive to sometimes inevitable construction defect during nail installation, which is the reason that 10 feet of minimum nail length was generally required for the test nails (verification test). Please extend the nail length from 5 feet to at least 8 feet for such a consideration (for design wall heights from 8 feet to 12 feet).	RI	A	We will extend the minimum nail length to 8 feet.			
15	General Comment	H.Liu	15	Please include structure/roadway plans (elevations and sections, showing bridge foundation) associated with the wall design in future submittal to assist our review.	RI	A	JACOBS/TRC will send the plans to the reviewer			

(1) Responder's Initials - concur with response.
(2) Reviewer's Initials - concur with response.