NUCLEAR POWER GENERATION
CF3.ID4
ATTACHMENT 7.2

Index No. 402
Binder No.

TITLE: CALCULATION COVER SHEET

Unit(s): 1 & 2

File No.: 52.27

Responsible Group: Civil

Calculation No.: 52.27.100.739

No. of Pages 3 pages + Index (4 pages) + 1 Attachment (60 pages)

Design Calculation YES [x] NO [ ]

System No. 42C

Quality Classification Q (Safety-Related)

Structure, System or Component: Independent Spent Fuel Storage Facility

Subject: Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route (GEO.DCPP.01.29, Rev. 0)

Electronic calculation YES [ ] NO [x]

Computer Model	Computer ID	Program Location	Date of Last Change

Registered Engineer Stamp: Complete A or B

A. Insert PE Stamp or Seal Below	B. Insert stamp directing to the PE stamp or seal
Expiration Date:	***REGISTERED ENGINEERS' STAMPS AND EXPIRATION DATES ARE SHOWN ON DWG 063618***

NOTE 1: Update DCI promptly after approval.
NOTE 2: Forward electronic calculation file to CCTG for uploading to EDMS.

TITLE: CALCULATION COVER SHEET

CALC No. 52.27.100.739, R0

RECORD OF REVISIONS

Rev No.	Status	Reason for Revision	Prepared By:	LBIE Screen	LBIE	Check Method*	LBIE Approval		Checked	Supervisor	Registered Engineer
		Remarks	Initials/ LAN ID/ Date	Yes/ No/ NA	Yes/ No/ NA		PSRC Mtg. No.	PSRC Mtg. Date	Initials/ LAN ID/ Date	Initials/ LAN ID/ Date	Signature/ LAN ID/ Date
0	F	Acceptance of Geosciences Calc. No. GEO.DCPP.01.29, Rev. 0. Calc. supports current edition of 10CFR72 DCPP License Application to be reviewed by NRC prior to implementation. Prepared per CF3.ID17 requirements.	AFT2 AT 12/13/01	[ ] Yes [ ] No [x] NA	[ ] Yes [ ] No [x] NA	[ ] A [ ] B [x] C	N/A	N/A	N/A	[signature] 12/14/01 LJS2	[signature] 12/14/01 LJS2
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					

*Check Method: A: Detailed Check, B: Alternate Method (note added pages), C: Critical Point Check

Pacific Gas and Electric Company
Engineering - Calculation Sheet
Project: Diablo Canyon Unit ( )1 ( )2 (x) 1&2

SUBJECT Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

MADE BY A. Tafoya AT DATE 12/13/01 CHECKED BY N/A DATE

Table of Contents:

SUBJECT Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

MADE BY A. Tafoya DATE 12/13/01 CHECKED BY N/A DATE

1- This table cross references between Geosciences calculation numbers and DCPP (Civil Group's) calculation numbers. This section is For Information Only.

Cross-Index
(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
1	GEO.DCPP.01.01	Development of Young's Modulus and Poisson's Ratios for DCPP ISFSI Based on Field Data	52.27.100.711	
2	GEO.DCPP.01.02	Determination of Probabilistically Reduced Peak Bedrock Accelerations for DCPP ISFSI Transporter Analyses	52.27.100.712	
3	GEO.DCPP.01.03	Development of Allowable Bearing Capacity for DCPP ISFSI Pad and CTF Stability Analyses	52.27.100.713	
4	GEO.DCPP.01.04	Methodology for Determining Sliding Resistance Along Base of DCPP ISFSI Pads	52.27.100.714	
5	GEO.DCPP.01.05	Determination of Pseudostatic Acceleration Coefficient for Use in DCPP ISFSI Cutslope Stability Analyses	52.27.100.715	
6	GEO.DCPP.01.06	Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses	52.27.100.716	
7	GEO.DCPP.01.07	Development of Coefficient of Subgrade Reaction for DCPP ISFSI Pad Stability Checks	52.27.100.717	
8	GEO.DCPP.01.08	Determination of Rock Anchor Design Parameters for DCPP ISFSI Cutslope	52.27.100.718	
9	GEO.DCPP.01.09	Determination of Applicability of Rock Elastic Stress-Strain Values to Calculated Strains Under	52.27.100.719	Calculation to be replaced by letter

SUBJECT Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

MADE BY A. Tafoya DATE 12/13/01 CHECKED BY N/A DATE

Cross-Index
(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
		DCPP ISFSI Pad		
10	GEO.DCPP.01.10	Determination of SSER 34 Long Period Spectral Values	52.27.100.720	
11	GEO.DCPP.01.11	Development of ISFSI Spectra	52.27.100.721	
12	GEO.DCPP.01.12	Development of Fling Model for Diablo Canyon ISFSI	52.27.100.722	
13	GEO.DCPP.01.13	Development of Spectrum Compatible Time Histories	52.27.100.723	
14	GEO.DCPP.01.14	Development of Time Histories with Fling	52.27.100.724	
15	GEO.DCPP.01.15	Development of Young's Modulus and Poisson's Ratio Values for DCPP ISFSI Based on Laboratory Data	52.27.100.725	
16	GEO.DCPP.01.16	Development of Strength Envelopes for Non-jointed Rock at DCPP ISFSI Based on Laboratory Data	52.27.100.726	
17.	GEO.DCPP.01.17	Determination of Mean and Standard Deviation of Unconfined Compression Strengths for Hard Rock at DCPP ISFSI Based on Laboratory Tests	52.27.100.727	
18	GEO.DCPP.01.18	Determination of Basic Friction Angle Along Rock Discontinuities at DCPP ISFSI Based on Laboratory Tests	52.27.100.728	
19	GEO.DCPP.01.19	Development of Strength Envelopes for Jointed Rock Mass at DCPP ISFSI Using	52.27.100.729	

Cross-Index
(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
		Hoek-Brown Equations		
20	GEO.DCPP.01.20	Development of Strength Envelopes for Shallow Discontinuities at DCPP ISFSI Using Barton Equations	52.27.100.730	
21	GEO.DCPP.01.21	Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site	52.27.100.731	
22	GEO.DCPP.01.22	Kinematic Stability Analysis for Cutslopes at DCPP ISFSI Site	52.27.100.732	
23	GEO.DCPP.01.23	Pseudostatic Wedge Analyses of DCPP ISFSI Cutslopes (SWEDGE Analysis)	52.27.100.733	
24	GEO.DCPP.01.24	Stability and Yield Acceleration Analysis of Cross Section I-I'	52.27.100.734	
25	GEO.DCPP.01.25	Determination of Seismic Coefficient Time Histories for Potential Siding Masses Above Cut Slopes Behind ISFSI Pad	52.27.100.735	
26	GEO.DCPP.01.26	Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses on DCPP ISFSI Slope	52.27.100.736	
27	GEO.DCPP.01.27	Cold Machine Shop Retaining Wall Stability	52.27.100.737	
28	GEO.DCPP.01.28	Stability and Yield Acceleration Analysis of Potential Sliding Masses Along DCPP ISFSI Transport Route	52.27.100.738	

Cross-Index
(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
29	GEO.DCPP.01.29	Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route	52.27.100.739	
30	GEO.DCPP.01.30	Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route	52.27.100.740	
31	GEO.DCPP.01.31	Development of Strength Envelopes for Clay Beds at DCPP ISFSI	52.27.100.741	
32	GEO.DCPP.01.32	Verification of Computer Program SPCTLR.EXE	52.27.100.742	
33	GEO.DCPP.01.33	Verification of Program UTEXAS3	52.27.100.743	
34	GEO.DCPP.01.34	Verification of Computer Code - QUAD4M	52.27.100.744	
35	GEO.DCPP.01.35	Verification of Computer Code DEFORMP	52.27.100.745	
36	GEO.DCPP.01.36	Reserved	52.27.100.746	
37	GEO.DCPP.01.37	Development of Freefield Ground Motion Storage Cask Spectra and Time Histories for the Used Fuel Storage Project	52.27.100.747	

PG&E
Geosciences Department
Departmental Calculation Procedure

Number: GEO.001
Revision: 4 KI 12/13/01

Title: Design Calculation Cover Sheet

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.29
Revision 0
Date 11/26/2001
Calc Pages: 58
Verification Method: See Summary : A
Verification Pages: See Summary : 2 | NOT ATTACHED KI 12/15/01

TITLE: Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

PREPARED BY: Zhiliang Wang DATE 11/21/01
ZHILIANG WANG
Printed Name
GEOMATRIX
Organization

VERIFIED BY: [signature] DATE 11/26/01
[illegible]
Printed Name
Geomatrix Cons., Inc.
Organization

APPROVED BY: Lloyd Cluff DATE 11/27/01
Lloyd Cluff
Printed Name
Geosciences
Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG[illegible]
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Exp. 12/31/02

PG&E
Geosciences Department
Departmental Calculation Procedure

Number: GEO.001
Revision: 4 KT 12/13/01

Title: Design Calculation Cover Sheet

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.29
Revision 0
Date 11/26/2001
Calc Pages: 58
Verification Method: See Summary : A
Verification Pages: See Summary : 2 | NOT ATTACHED KT 12/13/01

TITLE: Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

PREPARED BY: Zhiliang Wang DATE 11/21/01
ZHILIANG WANG — Printed Name
GEOMATRIX — Organization

VERIFIED BY: [signature] DATE 11/26/01
Faiz Makdisi — Printed Name
Geomatrix Cons., Inc. — Organization

APPROVED BY: ______________ DATE ______________
Printed Name ______________
Organization ______________

Calculation Title: Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route

Calculation No.: GEO.DCPP.01.29

Revision No.: 0

Calculation Author: Zhi-Liang Wang

Calculation Date: 11/21/01

PURPOSE

The purpose of this calculation package is to provide the seismic responses and seismic coefficient time histories for potential sliding masses along DCPP ISFSI transport route. Representative locations along the transport route were identified in calculation package GEO.DCPP.01.21, Revision 1 (see Attachment 1). The calculations reported in this package were performed in accordance with the requirements of Geomatrix Consultants, Inc. Work Plan, Revision 2 (dated December 8, 2000), entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site." The analyses include two-dimensional finite element analyses of two representative sections along the transport route. The results of these analyses will be used in calculation package GEO.DCPP.01.30, Revision 0, to estimate earthquake-induced permanent displacements and seismic stability of potential sliding masses along the transport route. Results of estimated ground motions also will be used to evaluate the stability of the transporter to vibratory ground motions.

ASSUMPTION

Not applicable.

INPUT

1. Plan and three cross sections along the transport route (Sections D-D′, E-E′, and L-L′): Transmittal from PG&E Geosciences, dated November 12, 2001 (Attachment 1)
2. Five sets of rock motions originating on the Hosgri fault: Transmittal from PG&E Geosciences dated September 28, 2001, as confirmed in Attachment 3.

3. Azimuths of three cross-sections along transporter route: Transmittal from PG&E Geosciences, dated November 12, 2001 (Attachment 1).
4. Orientation (azimuth) of the strike of the Hosgri fault: Transmittal from William Lettis & Associates dated August 23, 2001, as confirmed in Attachment 7.
5. Direction of positive fault parallel component on Hosgri fault (Attachment 6).
6. Rotated motions from Sets 5 and 6, from calculation package GEO.DCPP.01.30, Revision 0.
7. Reduced peak bedrock acceleration of 0.15g (Transmittal of additional inputs for DCPP ISFSI Transport Route Analysis): Transmittal from PG&E Geosciences dated November 19, 2001 (Attachment 8)

Selection of Sections for Dynamic Finite Element Analyses

Three cross sections along the transport route (Sections D-D′, E-E′, and L-L′) were provided by PG&E Geosciences (see Attachment 1). These are the powerblock section (section L-L'), the warehouse section (section D-D'), and the parking lot section (section E-E'). The powerblock section L-L' represents the typical slope profile above power block unites 1 and 2. This section also has a thick colluvium deposit on the slope, and was selected for the dynamic analyses to estimate the seismic amplification effects along the colluvium slope. The parking lot section E-E', between elevation 180 feet and 220 feet, is generally similar to the profile in the vicinity of the transport route at section D-D' (the warehouse section). Section E-E' also has a thicker colluvium deposit than that at section D-D', and was selected for the dynamic analyses. It is estimated that seismic amplification effects at section E-E' could be higher than those at section D-D'.

Dynamic Properties for Finite Element Analyses

Properties required for the dynamic finite element analyses include the unit weight, shear modulus at low shear strain, G_{max}, and relationships describing the modulus reduction and damping ratio increase, with increasing shear strains.

Unit weights

Unit weights of rock mass were based on field investigations for the ISFSI site as reported in Attachment 6. The unit weights for the colluvium fan underlying the slope above Unit 2 (section L-L′), and the marine terrace deposit underlying the colluvium at sections D-D′

and E-E′, were reported in an assessment of slope stability near Diablo Canyon power plant (PG&E, 1997). These unit weights are presented in Table 1 (from PG&E, 1997).

Shear Wave Velocity and Shear Modulus at Low Strain

Shear modulus values at low strain (G_{max}) can either be measured in the laboratory using resonant column tests or obtained from field shear wave velocity measurements. When available, estimates of G_{max} based on field shear-wave velocity measurements are preferable to laboratory test data. The shear modulus at low strain is related to the shear wave velocity by the following relationship:

$$G_{max} = \frac{\gamma}{g}(V_s)^2$$

where: G_{max} = shear modulus at low strain

γ = unit weight of material

g = acceleration due to gravity

V_s = shear wave velocity

Results of shear wave velocity measurements performed at the power block area were presented in the Long Term Seismic Program report (PG&E, 1989). Additional shear-wave velocity measurements were made in the slope behind the ISFSI pad during the current investigation. The results of these field measurements are presented in calculation package GEO.DCPP.01.21, Revision 1. A copy of the variation of average shear wave velocity with depth in two borings on the slope above the ISFSI pad is shown in Attachment 6. Based on the results of these investigations, a shear-wave velocity distribution with depth was selected for use in the dynamic analyses, and is shown in Table 2 (reproduced from PG&E's 1997 study) and on the finite element representations for sections L-L′ and E-E′ in Figures 1 and 2, respectively. Shear wave velocities for the Pleistocene colluvium and the marine terrace deposit were estimated based on values reported in PG&E's 1997 study, and are presented in Table 2.

Modulus Reduction and Damping Relationships with Strain

In the iterative equivalent-linear procedure used in QUAD4M, relationships of the variation of modulus reduction factor and damping ratio with shear strain are used to select strain-compatible shear moduli and damping ratios for each element. The variation of shear modulus reduction factor and damping ratio with shear strain for rock in the vicinity of the power block area was estimated on the basis of cyclic triaxial and resonant column tests performed on rock cores in 1978. The data are presented on Figures 3 and 4, from Attachment 6, for the modulus reduction factor and damping ratio, respectively. The modulus reduction curve shown on Figure 3 (identified as rock curve from the manual of the program SHAKE) was selected for the current analysis, and roughly corresponds to the middle of the range obtained from tests on the DCPP rock cores shown on Figure 4 (reported in the LTSP 1989 report). For the variation of damping ratio with shear strain, the curve defining the lower bound of the shaded zone for the DCPP rock, was selected for use in the current analysis. Modulus and damping curves for the Pleistocene colluvium and marine terrace deposits were based on relationships for similar soils published in the literature and reported in PG&E's 1997 study. These relationships are also listed in Table 2.

METHODOLOGY

Earthquake-induced seismic coefficient time histories (and their peak values k_{max}) for potential sliding masses within the selected profiles were computed using the two-dimensional dynamic finite element analysis program QUAD4M (Hudson and others, 1994). This is a time-step analysis that incorporates a Rayleigh damping approach, and allows the use of different damping ratios in different elements. The program QUAD4M was verified in calculation package GEO.DCPP.01.34, Revision 1.

The program uses equivalent linear strain-dependent modulus and damping properties and an iterative procedure to estimate the non-linear strain-dependent soil and rock properties.

Selection of Input Motions

Geosciences department of PG&E developed five sets of possible earthquake rock motions for the ISFSI site (Attachment 2 as confirmed in Attachment 3) to be used as input to the analyses. These motions are estimated to originate on the Hosgri fault about 4.5 km west of the plant site. Both fault normal and fault parallel components were determined for each of the five sets of motions. The fault parallel component incorporated the fling effect and its positive direction was specified in the southeasterly fault direction (see Attachment 5, as confirmed in Attachment 6). The fault normal component has a direction normal to the fault, and its polarity can be either positive or negative depending on the assumed location of the initiation of the rupture. Based on Attachments 1 and 4 (as confirmed in Attachment 7), the direction of movement along cross section L-L′ (which as shown in Figure 5 has an azimuth of 67 degrees) is 91 degrees (counter-clock wise) from the direction of the strike of the Hosgri fault. The fault normal component can be at ± 90 degrees from fault parallel direction, that is 91+90 = 181 (or 91-90 = 1) degrees from the direction of section L-L′. From these relations, the ground motion component along section L-L′ can be determined from the specified components along the fault normal and fault parallel directions. Similar computations are made for section E-E′ that has an azimuth of 35 degrees, and thus is 123 degrees (counter clock wise) from the direction of the positive fault parallel component of the Hosgri fault. The computed motions along the directions of sections L-L′ and E-E′ will be referred to as the rotated components.

The rotated component along each of the specified section is the sum of the projections of the fault normal and fault parallel components along the direction of the section (Figure 5). The formulation is as follows:

$$Rot^{+} = F_P \cos(\phi) + F_N \sin(\phi)$$

and

$$Rot^{-} = F_P \cos(\phi) - F_N \sin(\phi)$$

in which the F_P and F_N are fault parallel and fault normal components of the acceleration time-histories, Rot^{+} is the component along the section when considering the positive fault normal component, and Rot^{-} is the component along the section when considering the negative fault normal component. ϕ is the angle between up-slope direction of the section analyzed and the fault parallel direction (to the southeast). The five sets of earthquake motions on the Hosgri fault are now rotated to earthquake motions along the up-slope direction of cross sections L-L′ and E-E′. For a given angle between the analyzed section and the fault direction, there are 10 rotated earthquake motions, because for each set, the positive and negative directions of the fault normal component are considered separately.

The response of the slopes were computed using, as input, control motions specified at the horizontal ground surface in the free field away from the toe of the slope. The originally developed five sets of earthquake motions all fit the ISFSI design spectrum. These motions were first rotated to the directions of the two cross sections analyzed as described above. Then, approximate earthquake-induced displacements were initially computed for each set using a rigid sliding block model based on the Newmark approach (see calculation package GEO.DCPP.01.30, Revision 0). The set of rotated motions that produced the highest deformation in the rigid sliding block analysis was selected as input motions for the two-dimensional dynamic response analyses. For an assumed yield acceleration of 0.5g (based on the results from calculation package GEO.DCPP.01.28, Revision 0), rotated motions from sets 5 and 6 (both with a negative fault normal component) provided the greatest deformation. Thus, two ground motion sets (5 and 6) were selected as the input motions and used for the dynamic analyses. The results of the dynamic response analysis as described in this calculation and the subsequent deformation analyses (described in calculation package GEO.DCPP.01.30, Revision 0) indicated that the input motion for set 5 produced the largest deformations of the two sets. Accordingly, the detailed results for ground motion set 5 are only presented in this calculation. However, because the direction of section L-L' is 91 degrees from the direction of the fault, the rotated component along this section is almost identical to the fault normal component (with a reversed polarity).

The rotated acceleration time histories (from set 5) along the directions of sections E-E′ and L-L′ are presented in Figures 6 and 7, respectively. The positive values indicate motions in the up-slope direction of the section. The acceleration response spectra of the two motions are presented on Figures 8 and 9, for sections L-L′ and E-E′, respectively. In these two figures, the response spectra of the original fault normal and fault parallel components of set 5 are also shown for comparison. The rotated motions along the sections show some variations from the originally developed fault normal and fault parallel components.

Because the base of the finite element mesh is at a depth of 300 feet, and because the QUAD4M program only allows the input motion to be applied at the base, the base motion was first computed by deconvolving the surface ground motion. The control motions specified at the ground surface (in the free field beyond the toe of the slope) were deconvolved using a one-dimensional wave propagation analysis, SHAKE (Schnabel, Lysmer, and Seed, 1972, Geomatrix version, 1995, see SOFTWARE section), to obtain input motions at the level of the base of the two-dimensional finite-element model. Calculation package GEO.DCPP.01.34 shows that, when using the base motion developed from SHAKE, the program QUAD4M can produce reasonably similar surface ground motions in the free field. This calculation package verified that the deconvolved motions could be specified as input (outcropping) motions at the base of the two-dimensional model. The rock below this depth was modeled as an elastic half-space that has the same shear wave velocity as the rock just above it.

Finite Element Model and Boundary Conditions

Finite element representations of the slope profiles along sections L-L′ and E-E′ are shown in Figures 1 and 2, respectively. The minimum thickness of the mesh layer (8 feet) was selected to allow propagation of shear waves having frequencies up to 25 Hz. The bedrock underlying the slope was modeled to a depth of about 300 feet below the horizontal free field near the toe of the slope. The base of the finite element mesh is treated as an elastic half space. For the nodes at the two lateral boundaries, the dynamic displacement is only allowed in the horizontal direction when the horizontal input motion is applied at the base. A better choice is to use transmitting boundaries on both sides to avoid wave reflections from the vertical boundary. However, the program QUAD4M does not have this option. In order to avoid unrealistic reflections from the lateral boundaries, the lateral boundaries were extended horizontally to a significant distance on both sides of the transport route. The finite element mesh was extended in the horizontal free field, a distance of about 600 to 700 feet from the toe of the slope. In the up-slope direction, the profiles were modeled for a distance of about 1000 to 1100 feet beyond the edge of the transport route (Reservoir Road). Beyond that point, the ground surface was leveled-off and extended horizontally an additional 550 feet (for section L-L′) and 800 feet (for section E-E′) where the lateral boundary was placed. Because the response is needed for potential sliding masses in the vicinity of the transport route, the laterally extended portion of the mesh does not accurately match the topography beyond a 1000 feet from the edge of Reservoir Road. The extended boundary was used only to improve the numerical accuracy of the response in the immediate vicinity of the transport route, and not to model the response of the entire hillside.

SOFTWARE

Computer program QUAD4M was verified in calculation package GEO.DCPP.01.34. Computer program SHAKE (Schnabel, Lysmer, and Seed, 1972, Geomatrix version, 1995) was used to compute base motions in this calculation package. Two modified versions of SHAKE, i.e., SHAKE91 (by I.M. Idriss and Joseph I. Sun, 1992), and SHAKE96S (by Tseng and Hamasaki, 1996) were also used to calculate the base motion from input motion set 5 for verification purpose. The results from the above three slightly modified versions of the program SHAKE were almost identical. The results of these verification runs are included in the enclosed compact disc.

ANALYSES RESULTS

Dynamic analyses were performed at sections E-E′ and L-L′ for three purposes: (a) to estimate earthquake-induced average accelerations within the profiles for evaluating the stability of typical slopes along the transport route at the full level of ISFSI design ground motions; (b) to estimate rock-to-soil amplification of ground motions at reduced levels of ground motion; and (c) to estimate the profile response at reduced levels of ground motions for evaluating the stability of the road fill wedges including the transport load. The reduced levels of ground motions were specified as ISFSI input rock motions scaled to a peak ground acceleration of 0.15g, based on the results of calculation package GEO.DCPP.01.02 (see Attachment 8).

Response at ISFSI Design Ground Motion Levels

The results of the dynamic analyses provide a distribution of the earthquake-induced accelerations at all nodal points of the modeled slope profile. The analyses also provide estimates of the time history of the average induced acceleration within a specified potential sliding mass. Using the rotated input motion developed from set 5, peak accelerations within the slope (in the vicinity of the transport route) were computed. The contours of peak accelerations in the soil deposit are presented in Figures 10 and 11 for sections L-L′ and E-E′, respectively. As expected, the input motion was significantly amplified in the colluvium deposit within the slope, with computed peak surface accelerations of about 1.7g and 2.0g for sections L-L' and E-E', respectively.

Acceleration time histories were also calculated for a number of locations within the specified potential sliding masses as shown in Figures 12 and 13, for the two sections analyzed. These sliding masses have the least computed yield accelerations as estimated from calculation package GEO.DCPP.01.28, Revision 0. Acceleration time histories were averaged for each potential sliding mass (using the acceleration time histories computed at locations inside the mass) at sections L-L′ and E-E′ and are presented in Figure 14. The computed peak accelerations are of the order of 1.1 g to 1.2 g. This shows an amplification of peak acceleration of about 32 percent compared to the input bedrock motions. The time histories shown in these figures will be used to estimate earthquake-induced deformations within these potential sliding masses as described in calculation package GEO.DCPP.01.30, Revision 0.

Response at Reduced Ground Motion Levels

Dynamic analyses similar to those described above were performed, but in this case the ISFSI design rock motions were scaled to a peak acceleration of 0.15g. The computed peak accelerations along the surface of the slope are presented in Figures 15 and 16 for sections L-L′ and E-E′ respectively. The input motions were amplified mainly in the colluvium zones along the slopes of both sections. The greatest computed surface accelerations are of the order of 0.26g and 0.31g at sections L-L′ and E-E′, respectively. For comparison, the computed peak surface accelerations for the response using the full design input motions are also shown in Figures 15 and 16.

Amplification factors for peak accelerations along the slope surface (normalized to the peak input bedrock acceleration in the free-field) were computed for the two slope surfaces and are presented in Figures 17 and 18 for section L-L′ and E-E′, respectively. For section L-L′, the maximum amplification factor is less than 2. For section E-E′, the maximum amplification factor is less than 2.2. For comparison, amplification factors were also computed for the response using the full design input motions and are shown by solid lines in Figures 17 and 18. The maximum amplification factors for the full ground motions are of the same order of magnitude as those computed using reduced input motion with peak acceleration of 0.15g.

Because the computed peak accelerations for the reduced input motions are lower than the estimated yield accelerations for the potential sliding surfaces (computed in calculation package GEO.DCPP.01.28, Revision 0), the expected earthquake-induced displacements will be negligible. Accordingly, there was no need to compute the corresponding acceleration time histories for potential sliding masses for this level of input motion.

REFERENCES

1. Geomatrix Consultants, Inc. Work Plan, Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site, Revision 2, dated December 8, 2000.
2. Geosciences Calculation Package GEO.DCPP.01.21, revision 1, Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site.
3. Geosciences Calculation Package GEO.DCPP.01.28, revision 0, Stability and Yield Acceleration Analysis of Potential Sliding Masses Along DCPP ISFSI Transport Route.
4. Geosciences Calculation Package GEO.DCPP.01.30, revision 0, Determination of Earthquake-Induced Displacements of Potential Slides Masses Along DCPP ISFSI Transport Route (Newmark Analysis).
5. Geosciences Calculation Package GEO.DCPP.01.34, revision 1, Verification of QUAD4M computer code.
6. Hamasaki, D., and Tseng, W.S., 1996, SHAKE96S, CEC.

7. Hudson, M., Idriss, I.M. and Beikae, M, 1994, QUAD4M (program and User's manual) Center for Geotechnical Modeling, Department of Civil & Environmental Engineering, University of California, Davis, California.
8. Idriss, I.M., and Sun, Joseph I., 1992, User's manual for SHAKE91, program modified based on the original SHAKE program published in December 1972 by Schnabel, Lysmer, and Seed, Center for Geotechnical Modeling, Department of Civil & Environmental Engineering, University of California, Davis, California. November 1992.
9. PG&E, 1989, Diablo Canyon Long Term Seismic Program, Response to NRC Question 19 dated December 19.
10. PG&E, 1997, Assessment of slope stability near the Diablo Canyon Power Plant, Response to NRC request of January 31, 1997.
11. Schnabel, P.B., Lysmer. J. and Seed, H.B., SHAKE, A computer program for earthquake response analysis of horizontally layered sites, EERC Report No. 72-12, University of California, Berkeley, December.

ATTACHMENTS

1. 11/12/01, PG&E Geosciences, Robert K. White, Re: Forwarding of approved plan and cross-sections D-D', E-E′, and L-L′ for DCPP ISFSI transport route stability analyses
2. 09/28/2001, PG&E Geosciences, Robert K. White, Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses.
3. 10/31/01, PG&E Geosciences, Robert K. White, Re: Confirmation of preliminary inputs to calculations for DCPP ISFSI site.
4. 08/23/2001, William Lettis & Associates, Inc., Jeff Bachhuber, Re: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project.
5. 10/18/2001, PG&E Geosciences, Joseph Sun, Re: Positive direction of the fault parallel component time history on the Hosgri fault.
6. 10/25/2001, PG&E Geosciences, Robert White, Re: Input parameters for calculations,
7. 11/1/2001, PG&E Geosciences, Robert White, Re: Confirmation of additional inputs to calculations for DCPP ISFSI site.

8. 11/19/01, PG&E Geosciences, Robert K. White, Re: Transmittal of additional inputs for DCPP ISFSI transport route analysis.

ENCLOSURE

CD, entitled, "Data Files for Calculation Package GEO.DCPP.01.29"

TABLE 1

SOIL PARAMETERS FOR STABILITY ANALYSIS
SLOPE SECTIONS A-A' AND C-C'
DIABLO CANYON POWER PLANT SITE
(From PG&E, 1997)

Geologic Unit	Description	Density In-Place (pcf)	Shear Strength Parameters
Topsoil	Organic CLAY, silty (CH) (section B-B' only)	115	S_u = 1200 psf
Qc	Young colluvium, soft to stiff CLAY, silty and sandy (CH-CL)	115	S_u = 1500 psf
Qpf	Pleistocene colluvial fan deposits, CLAY to SILT, gravelly and sandy	115	S_u = 3000 psf
Qptm	Pleistocene marine terrace deposits, poorly graded SAND to GRAVEL	130	c = 0; $\phi = 40°$
Tof_b	Miocene Obispo Formation, sandy siltstone and silty sandstone, local chert, blocky, Bedrock	140	C = 4000 psf; $\phi = 35°$

TABLE 2

MATERIAL PROPERTIES FOR DYNAMIC FINITE ELEMENT ANALYSIS,
CUT SLOPE EAST OF UNIT 2, PROFILE A-A',
DIABLO CANYON POWER PLANT
(From PG&E, 1997)

Material	Layer and Thikness[1] (h)	Unit Weight (pcf)	Shear Wave Velocity (fps)	Poisson's Ratio	Modulus and Damping Relationships
Qc - Recent Colluvium	Surface Layer	115	600	0.35	Clay (PI=15), Vucetic & Dobry,1991[2]
Qpf - Pleistocene Colluvium	below Qc	115	1200	0.35	Clay (PI=15), Vucetic & Dobry,1991
Qtm - Marine Terrace Deposit	between Qpf and Tofb	130	1500	0.45	Sand (Upper Bound Modulus and Lower Bound Damping), Seed & Idriss,1970[3]
Tofb - Obispo Formation Bedrock	below Qpf and Qtm, h=15 feet	140	2000	0.4	Rock, LTSP SSI analysis, PG&E, 1988
Obispo Formation Bedrock	h=20 feet	140	3300	0.4	Same
Obispo Formation Bedrock	h=125 feet	145	4000	0.37	Same
Obispo Formation Bedrock	h=100 feet	150	4800	0.35	Same
Obispo Formation Bedrock	h=200 feet	150	5900	0.22	Same
Elastic Half Space	below Elevation. - 300 feet	150	5900	-	linear

[1] Thickness below horizontal ground surface in free field
[2] Vucetic, M., and Dobry, R., 1991, Effect of soil plasticity on cyclic response: Journal of Geotechnical Engineering, American Society of Civil Engineers, v. 117, Paper No. 25418
[3] Seed, H. B., and Idriss, I. M., 1970, Soil moduli and damping factors for dynamic response analyses: Report No. EERC 70-10, Earthquake Engineering Research Center, University of California, Berkeley.
[4]Final report of the long term seismic program submitted by PG&E to the NRC. On July, 1988.

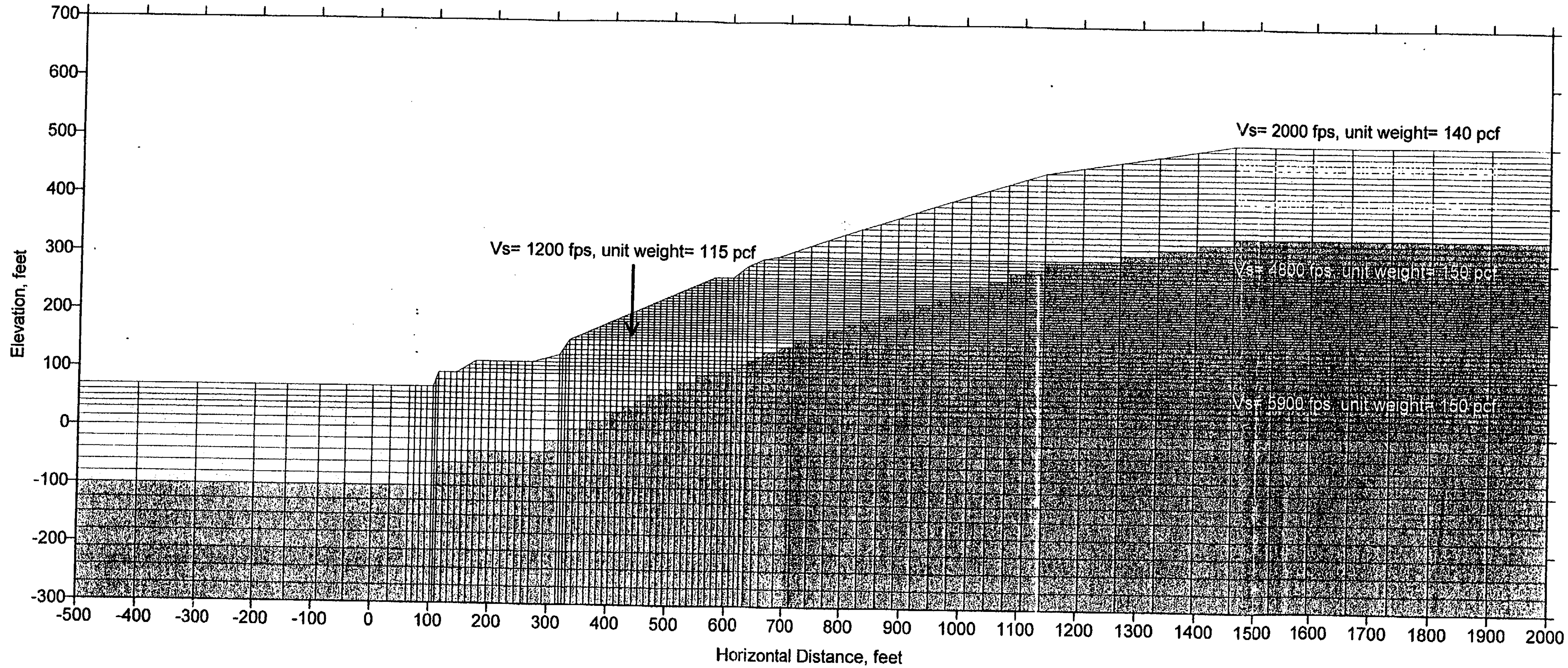


Figure 1. Finite Element Representation of Cross Section L-L'.

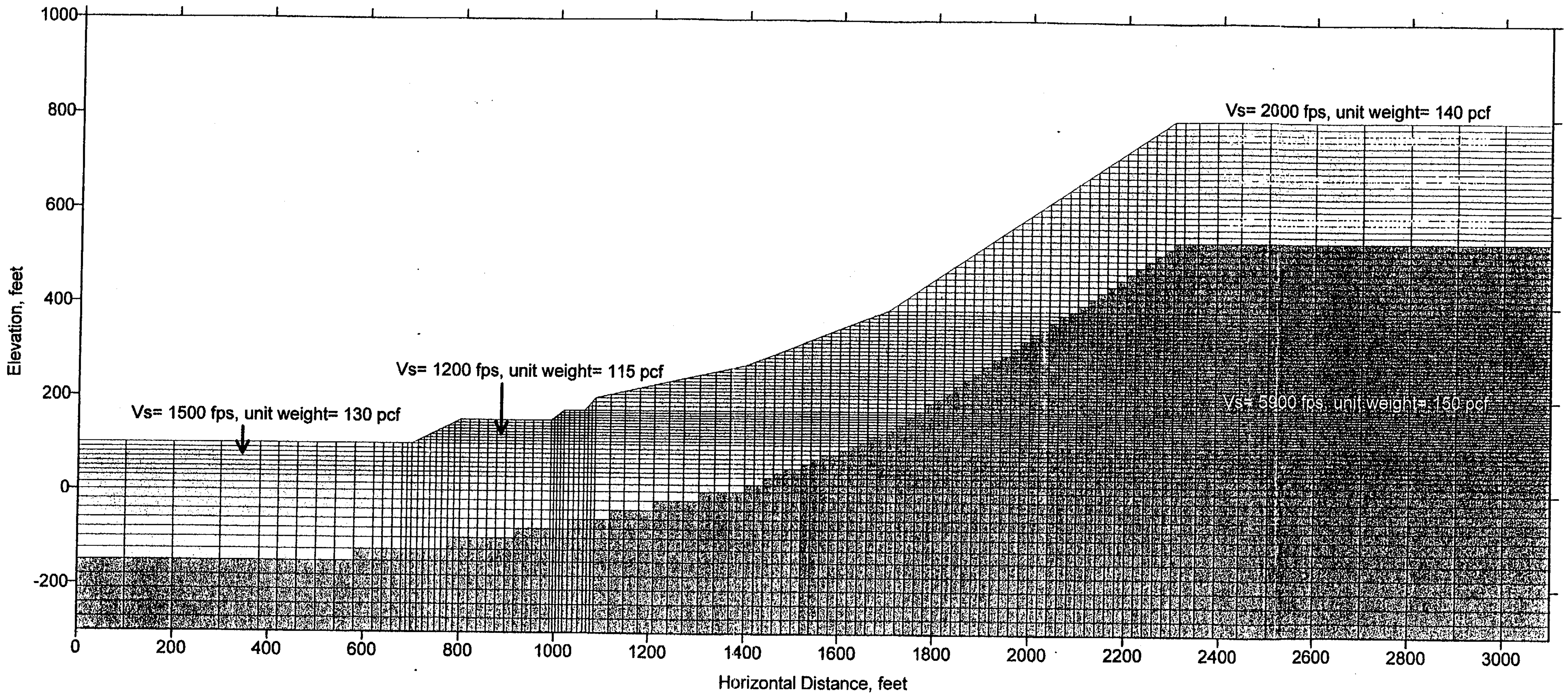


Figure 2. Finite Element Representation of Cross Section E-E'.

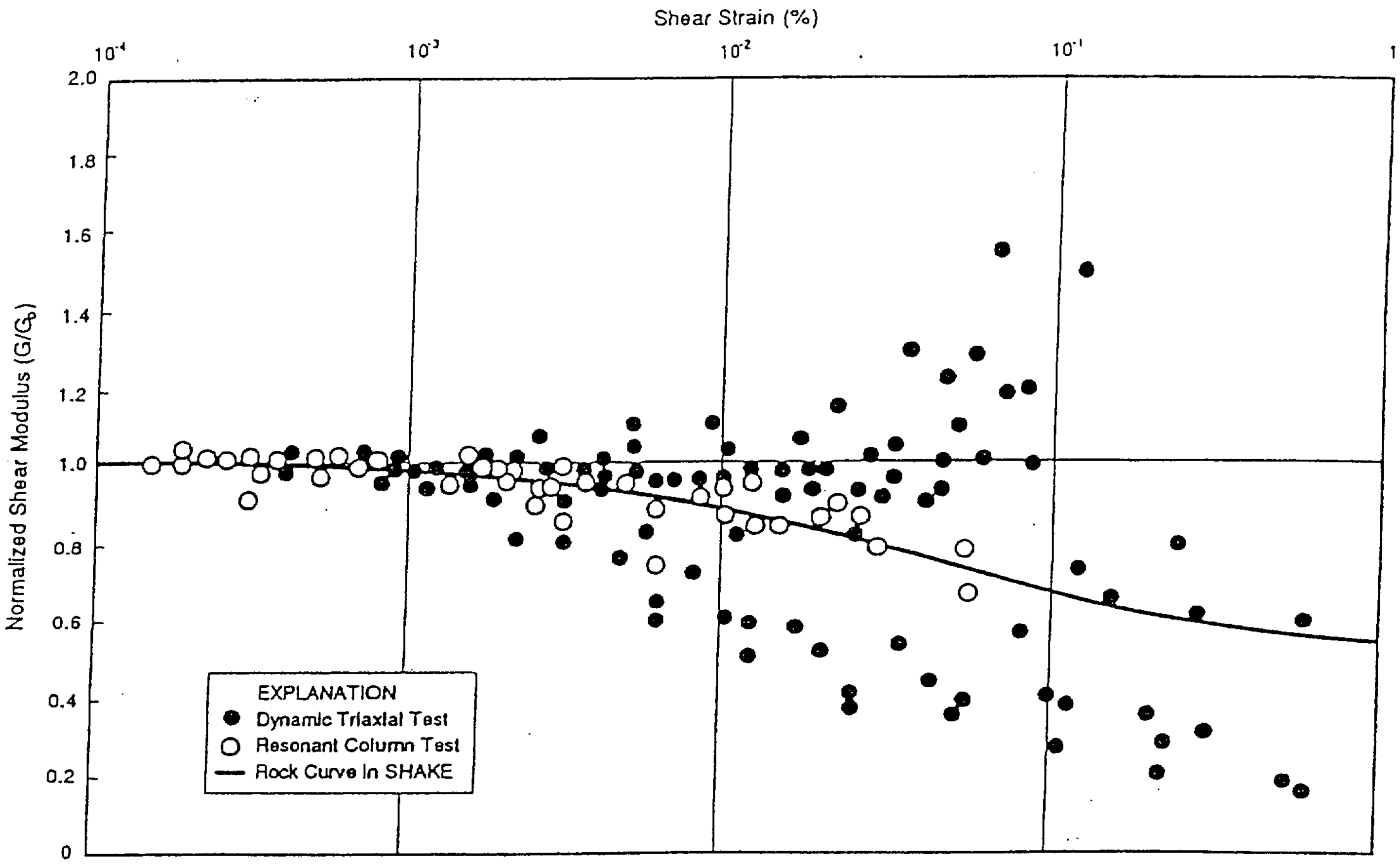


Figure 3

Variation of shear modulus with shear strain for the site rock based on 1978 laboratory test data.
(From Attachment 6)

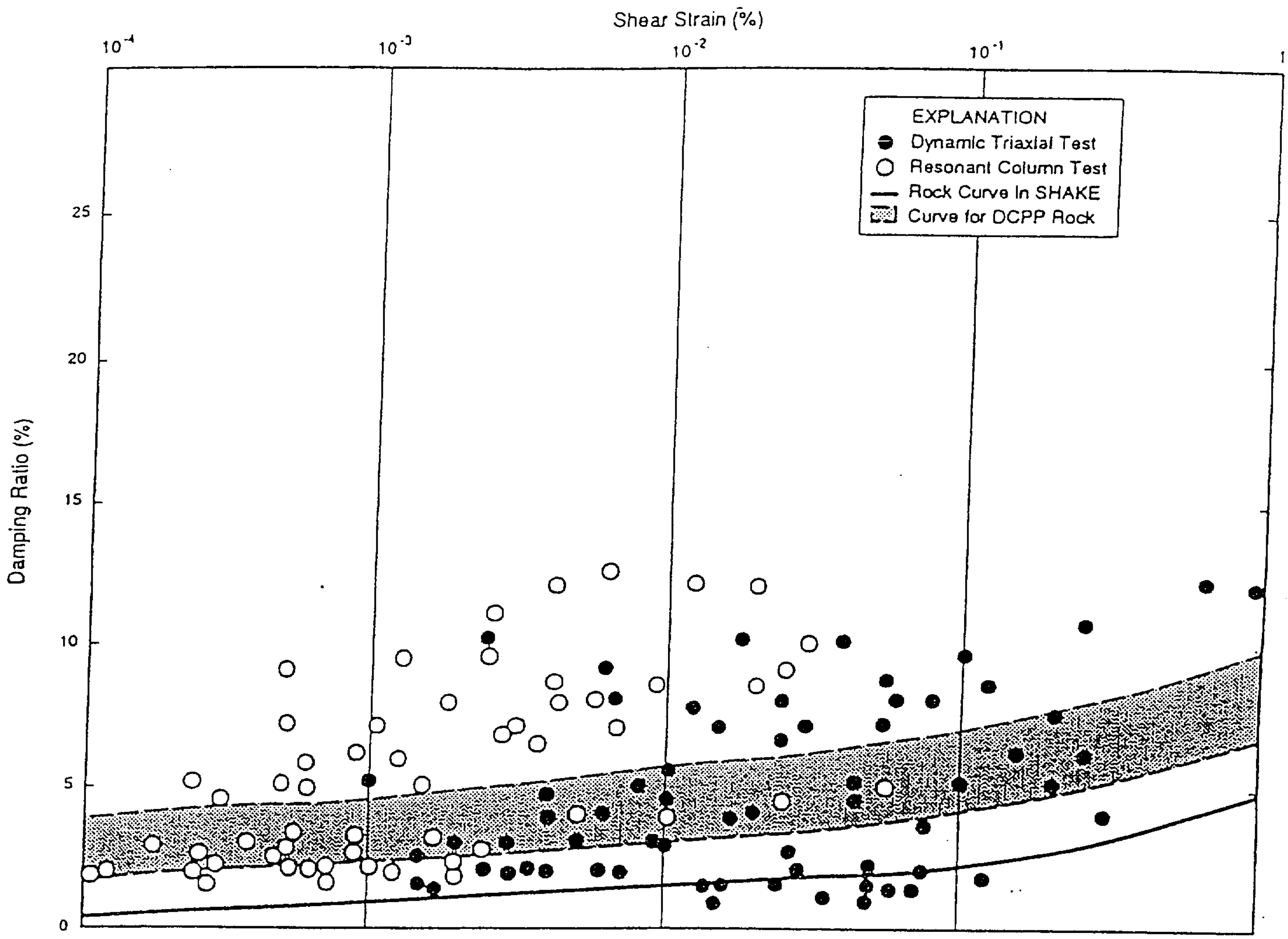


Figure 4.

Variation of damping ratio with shear strain for the site rock based on 1977 laboratory test data.

(From Attachment 6)

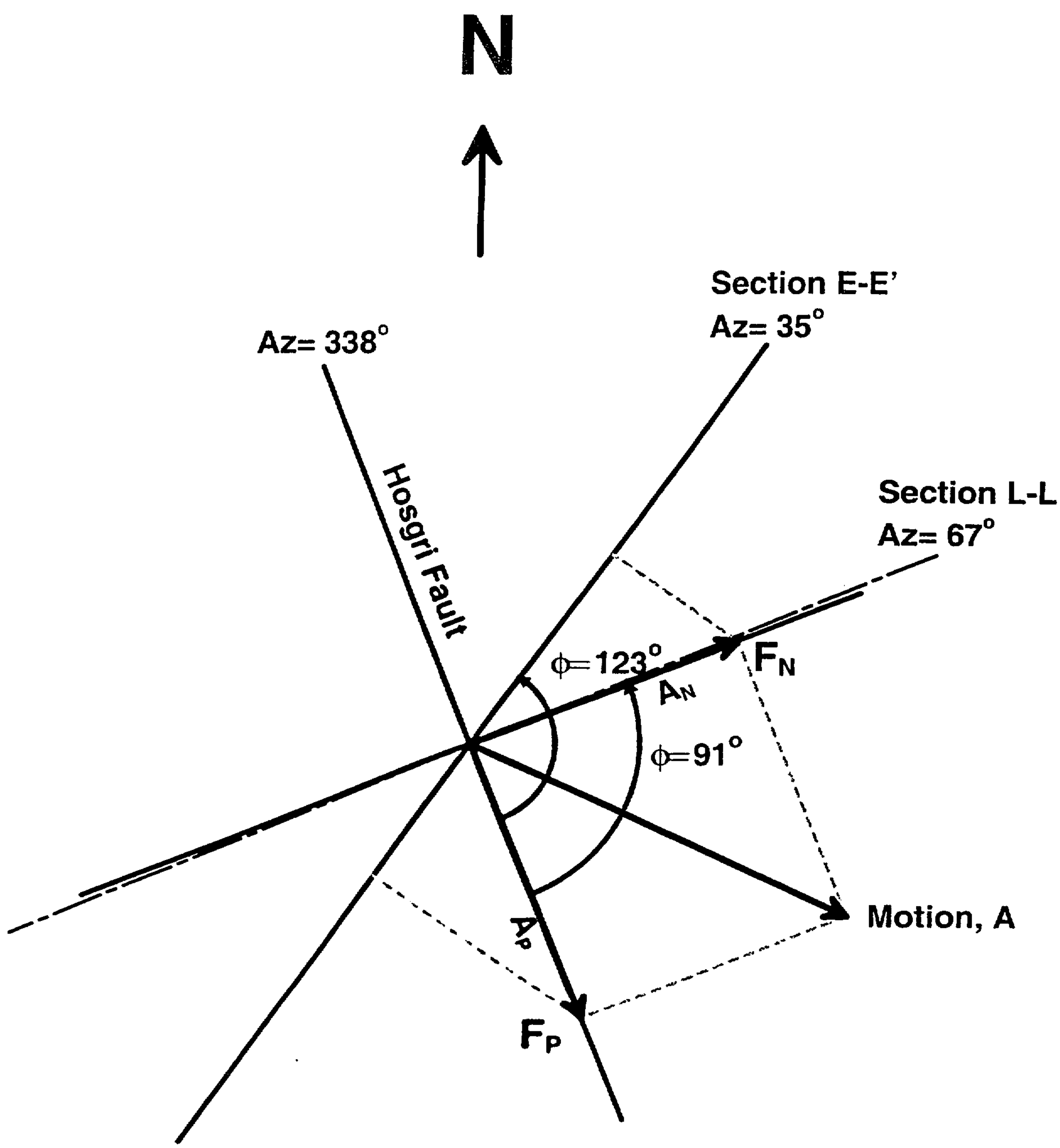


Figure 5. Orientations of Sections E-E', and L-L' , relative to the Hosgri Fault.

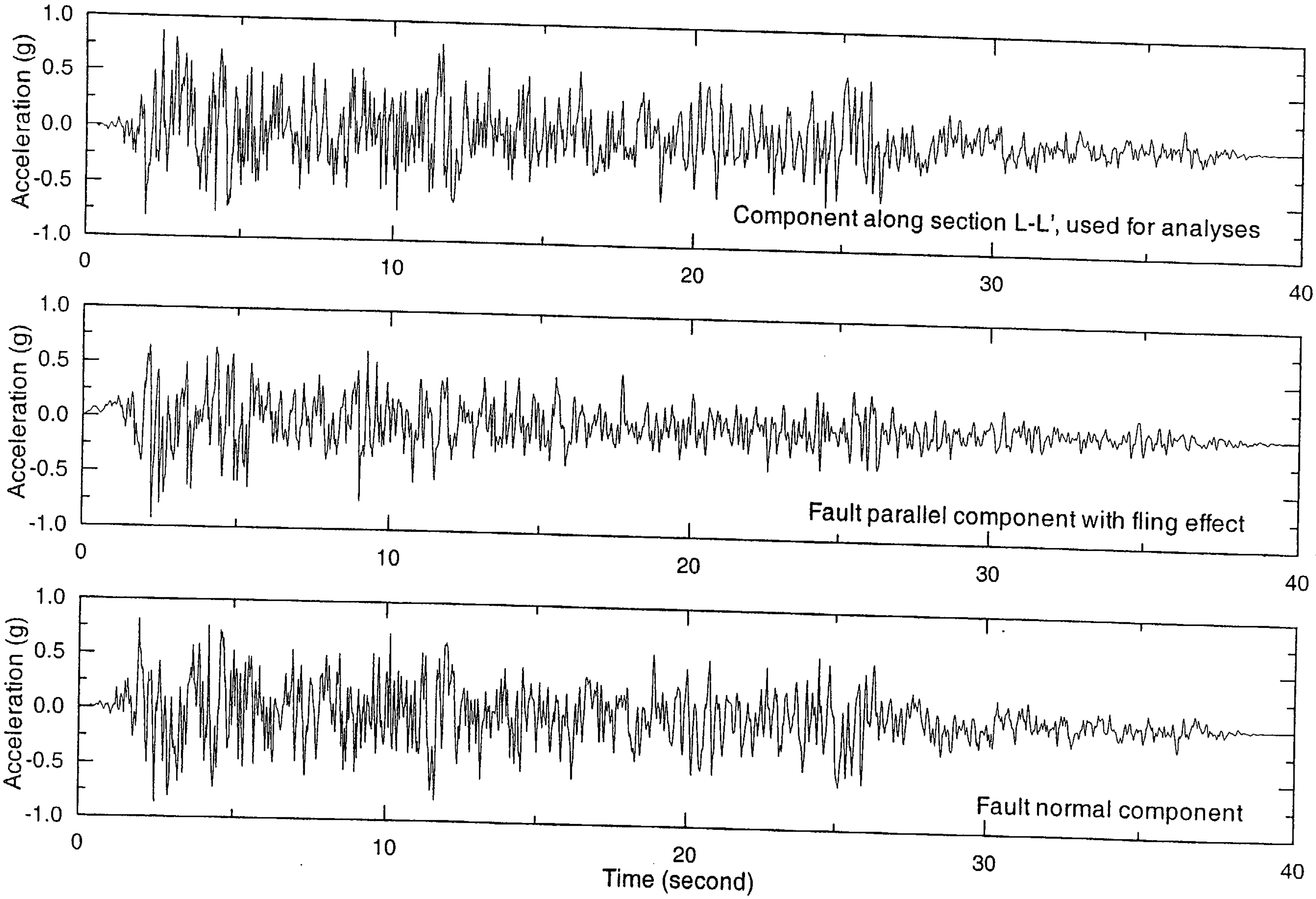


Figure 6. Acceleration time histories of fault normal, fault parallel, and rotated L-L' componenets of Set 5.

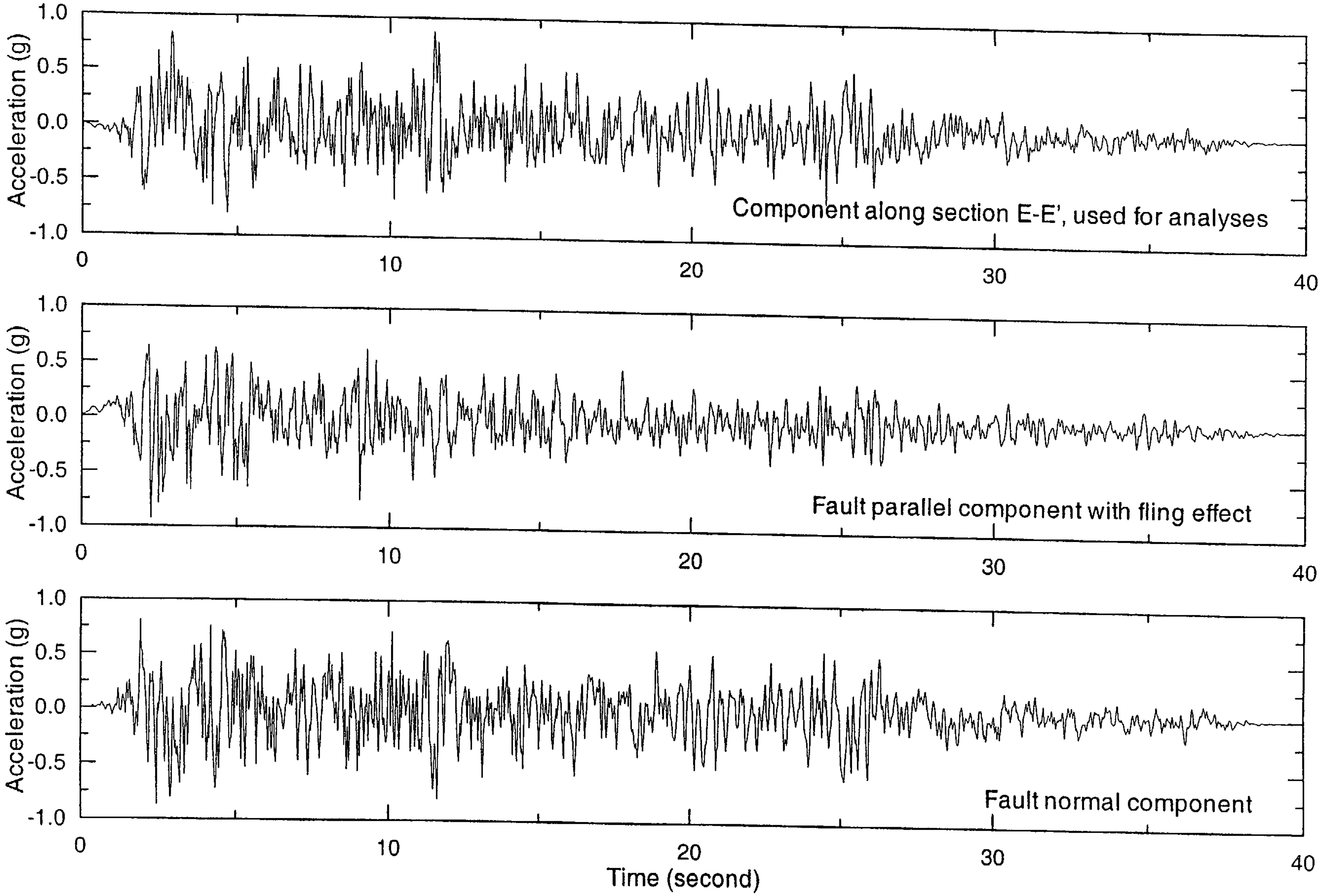


Figure 7. Acceleration time histories of fault normal, fault parallel, and rotated E-E' componenets of Set 5.

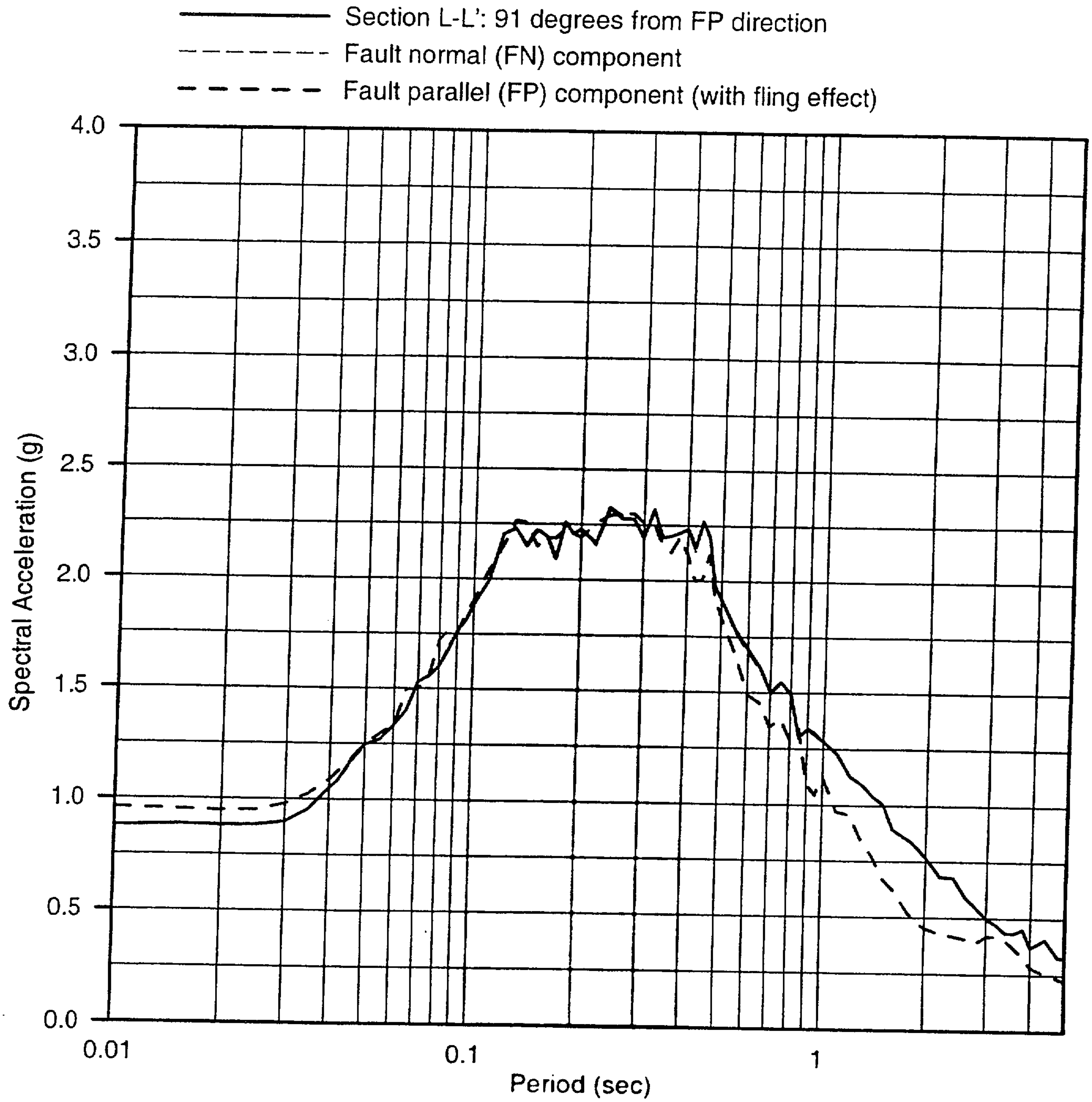


Figure 8. Acceleration response spectra of input motion set 5 for cross section L-L'.

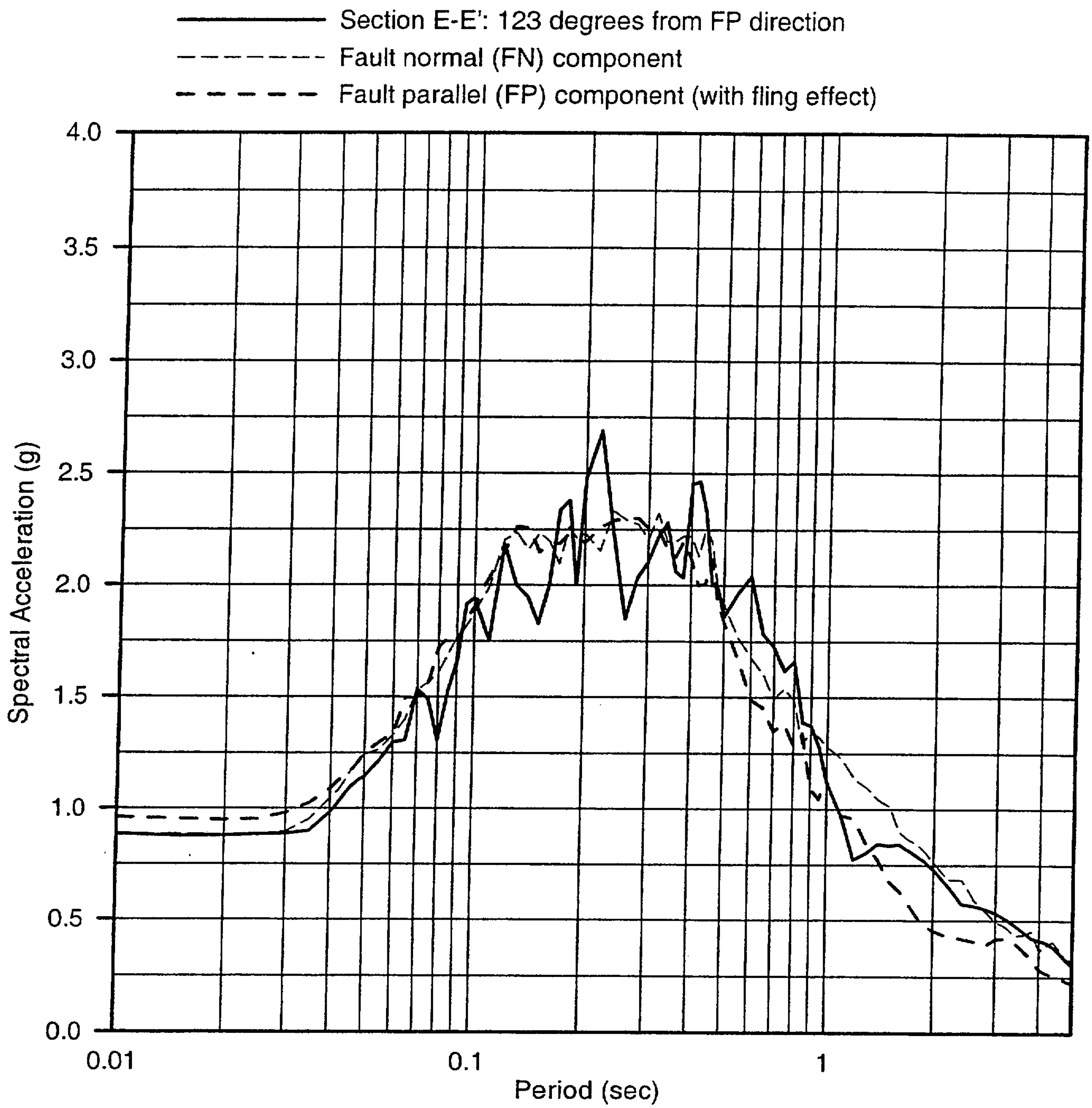


Figure 9. Acceleration response spectra of input motion set 5 for cross section E-E'.

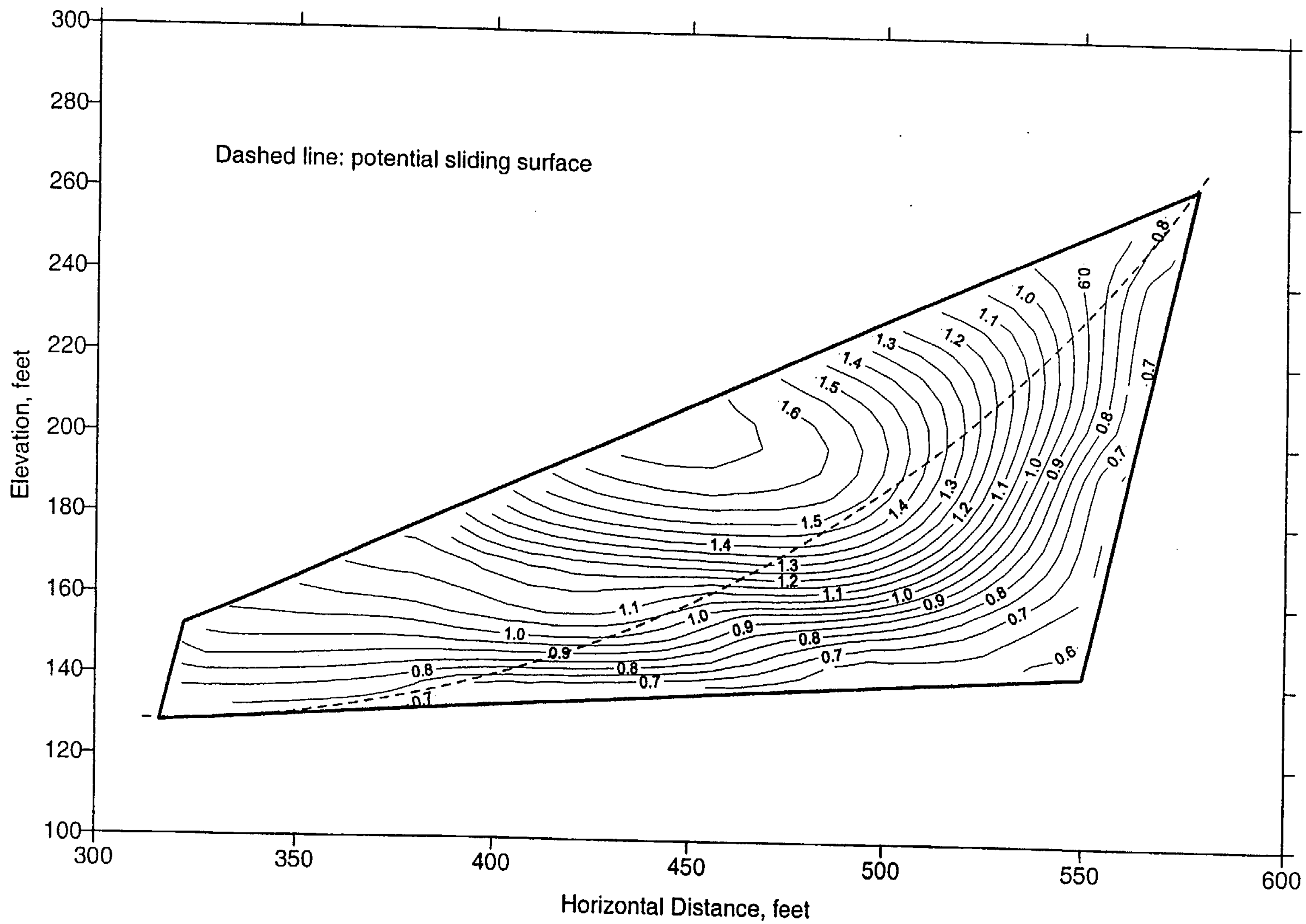


Figure 10. Contours of peak accelerations in coluvium zone, cross section L-L'

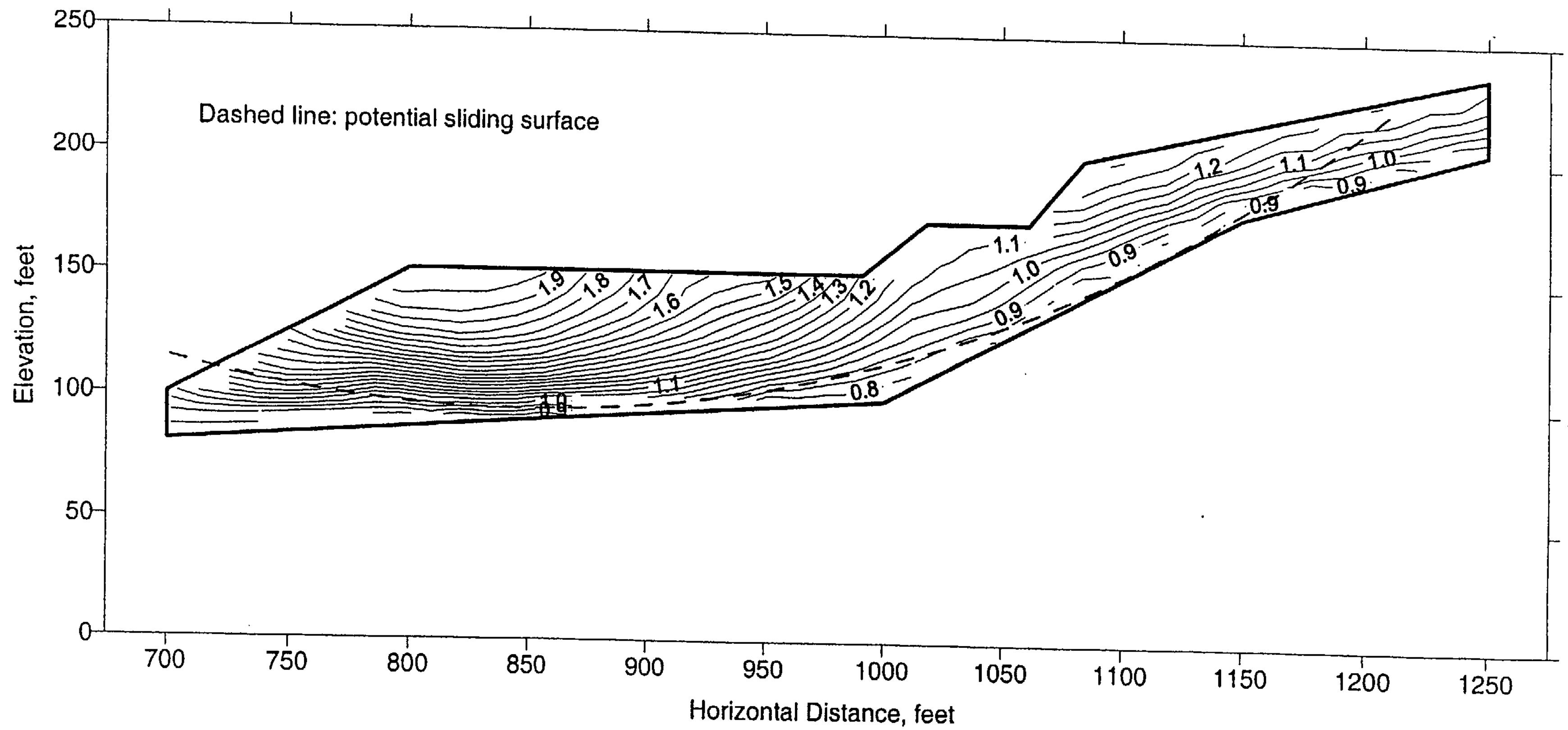


Figure 11. Contours of peak accelerations in coluvium zone, cross section E-E'

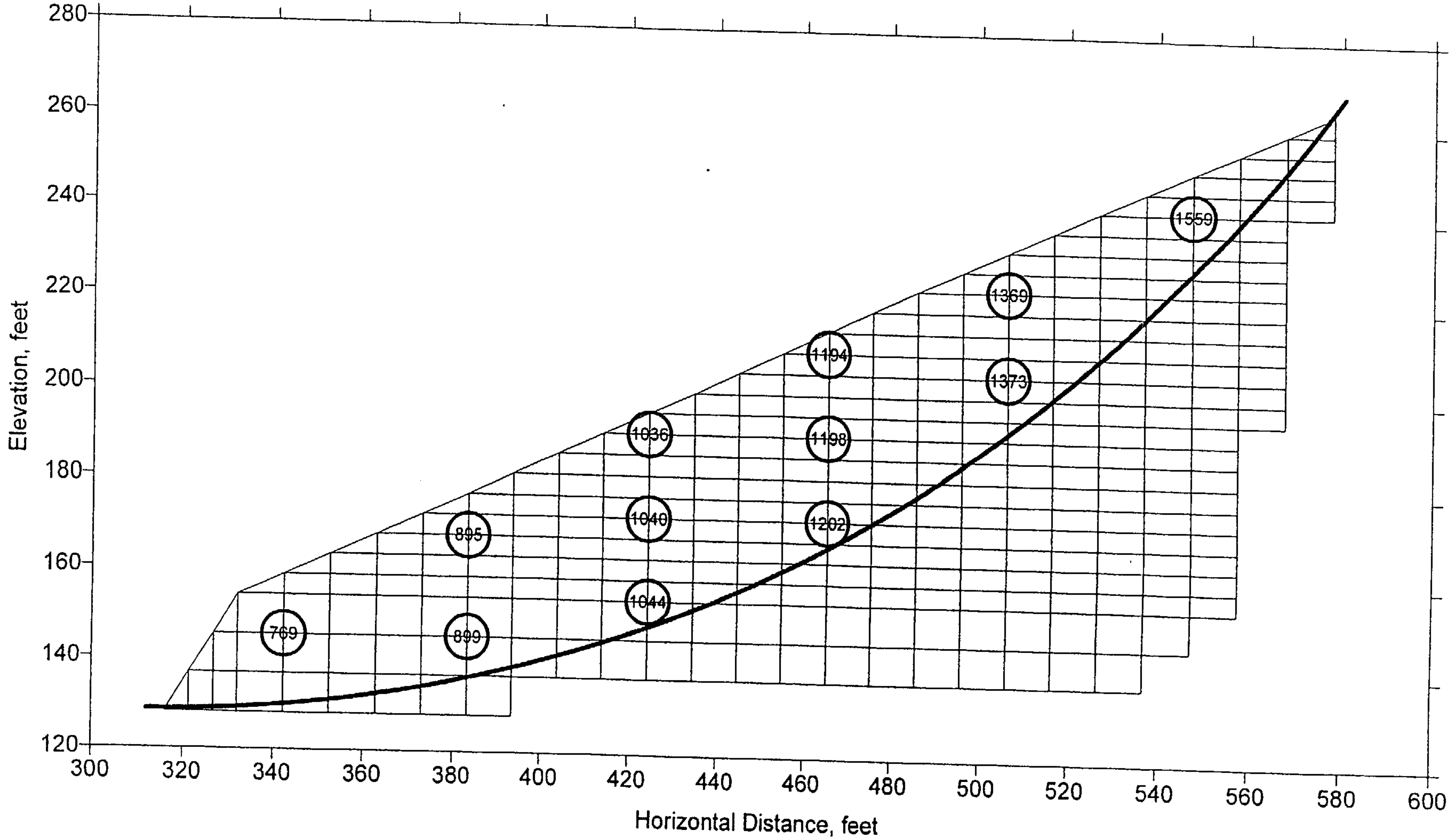


Figure 12. Potential Sliding Mass and Node Points of Computed Acceleration Time Histories for Cross Section L-L'.

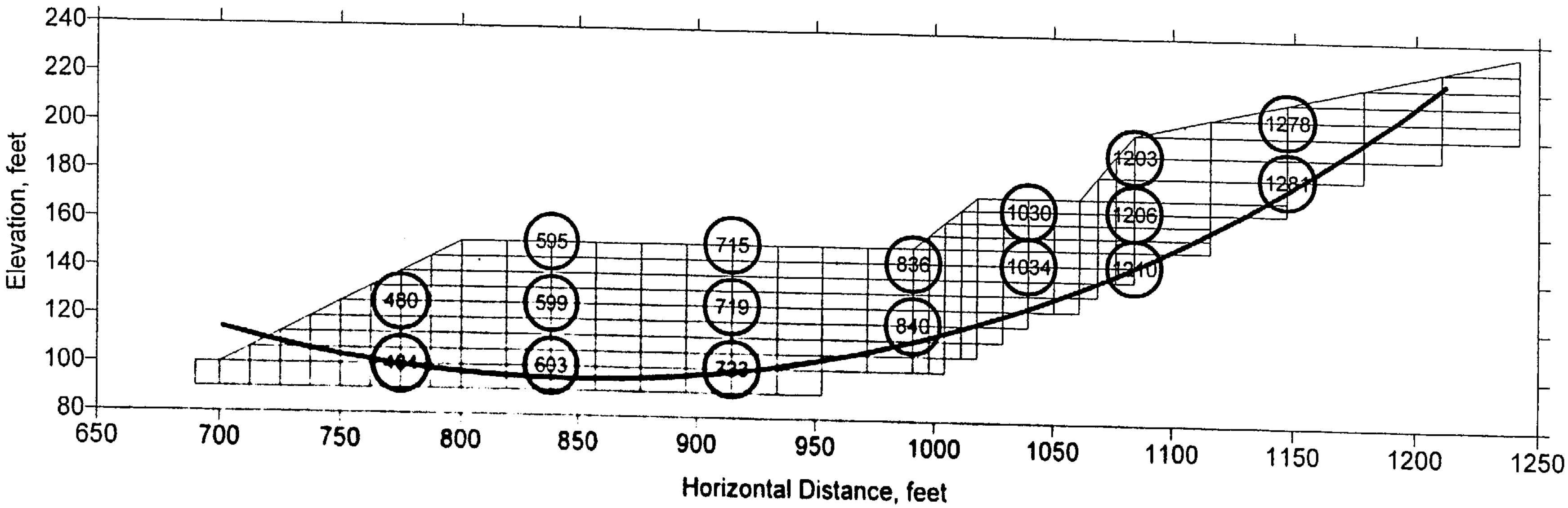


Figure 13. Potential Sliding Mass and Node Points of Computed Acceleration Time Histories for Cross Section E-E'.

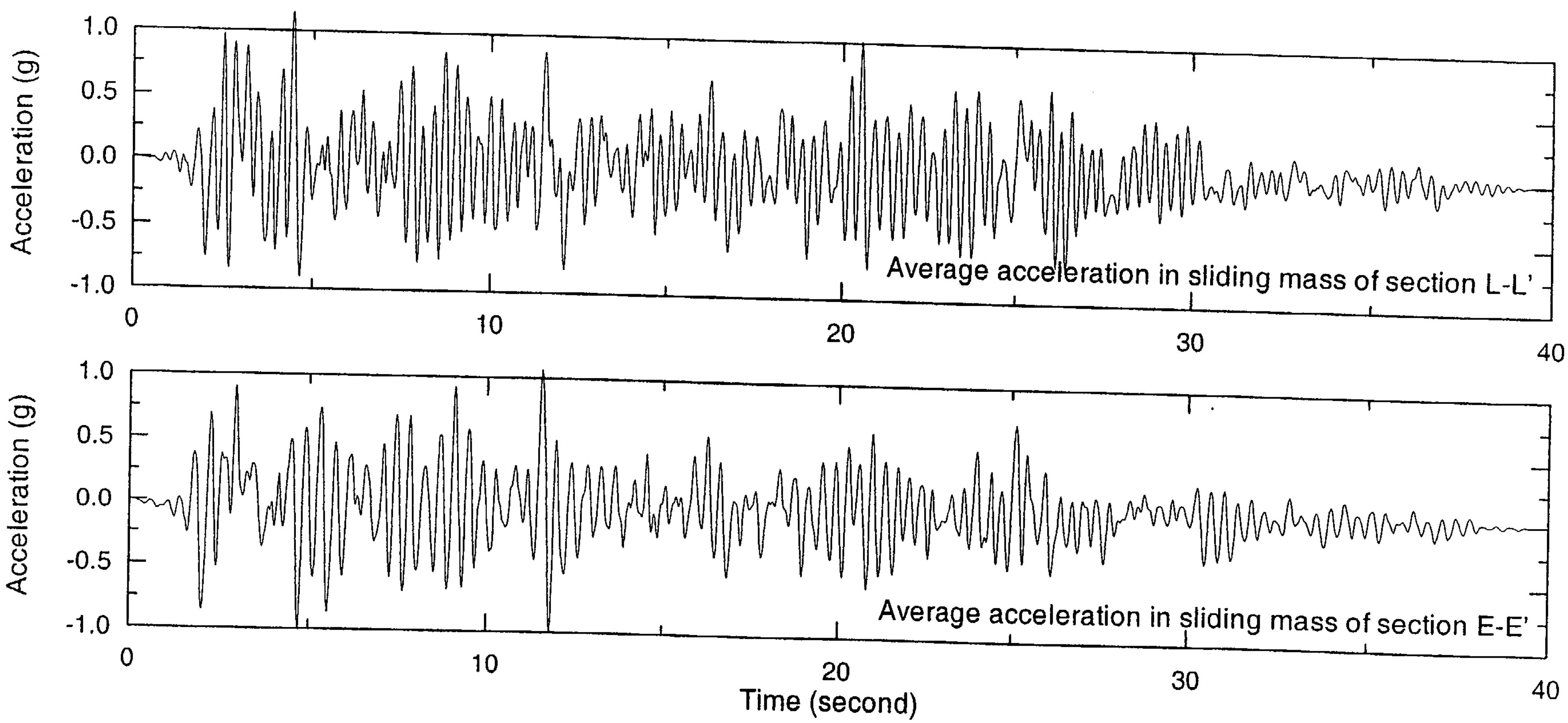


Figure 14. Average acceleration time histories of potential sliding masses using input motion set 5

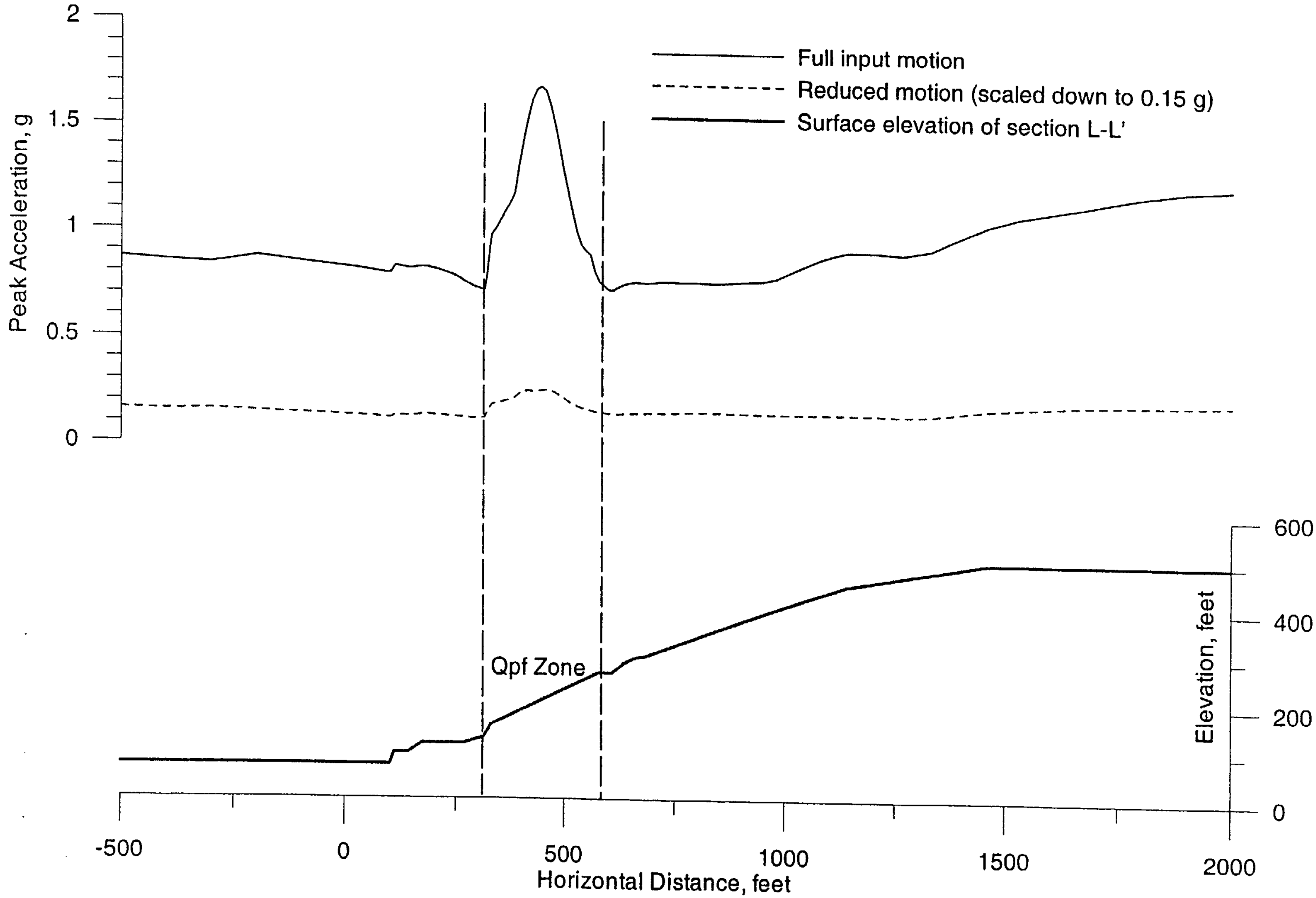


Figure 15. Variations of computed peak accelerations along slope surface of section L-L'.

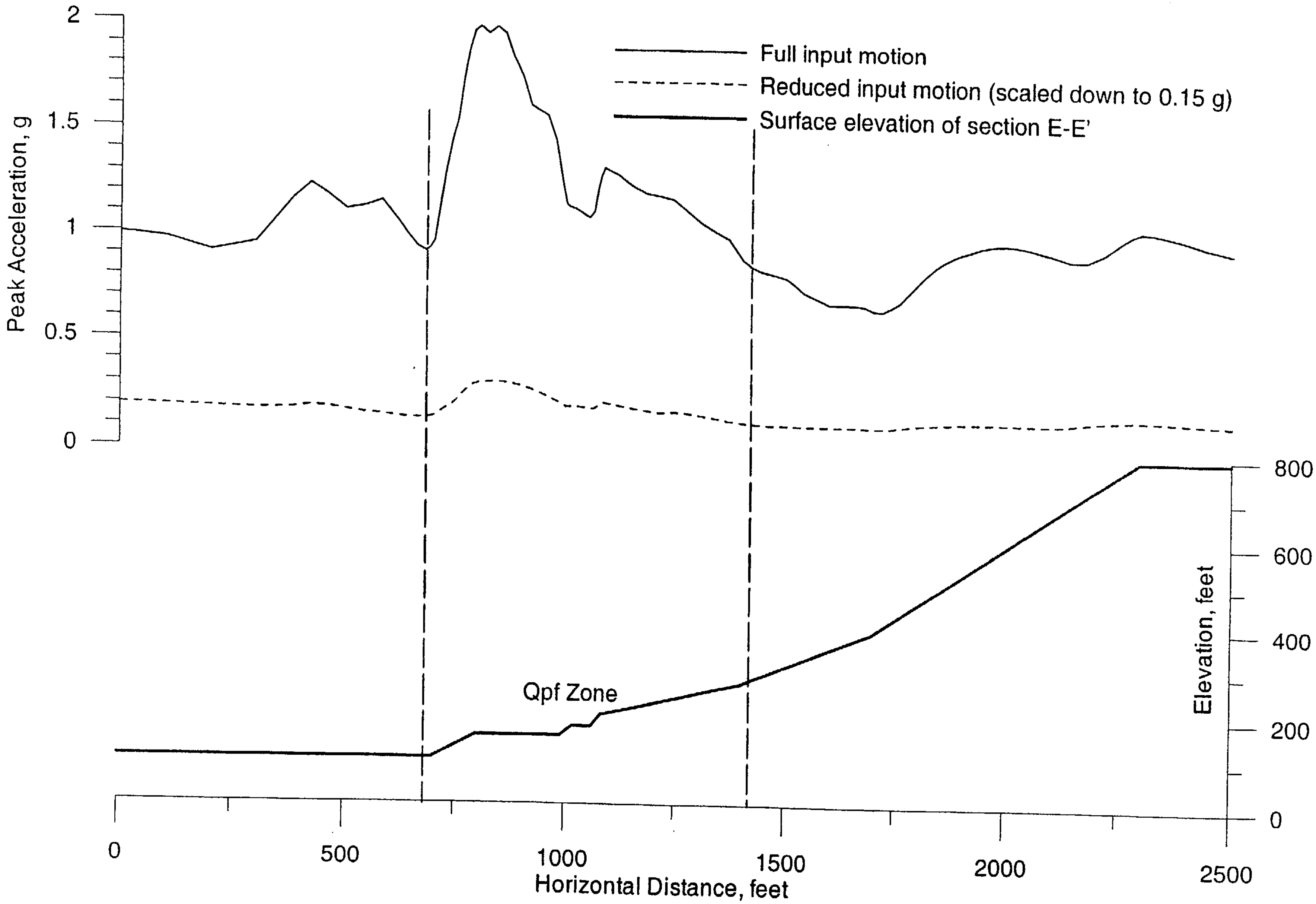


Figure 16. Variations of computed peak accelerations along slope surface of section E-E'.

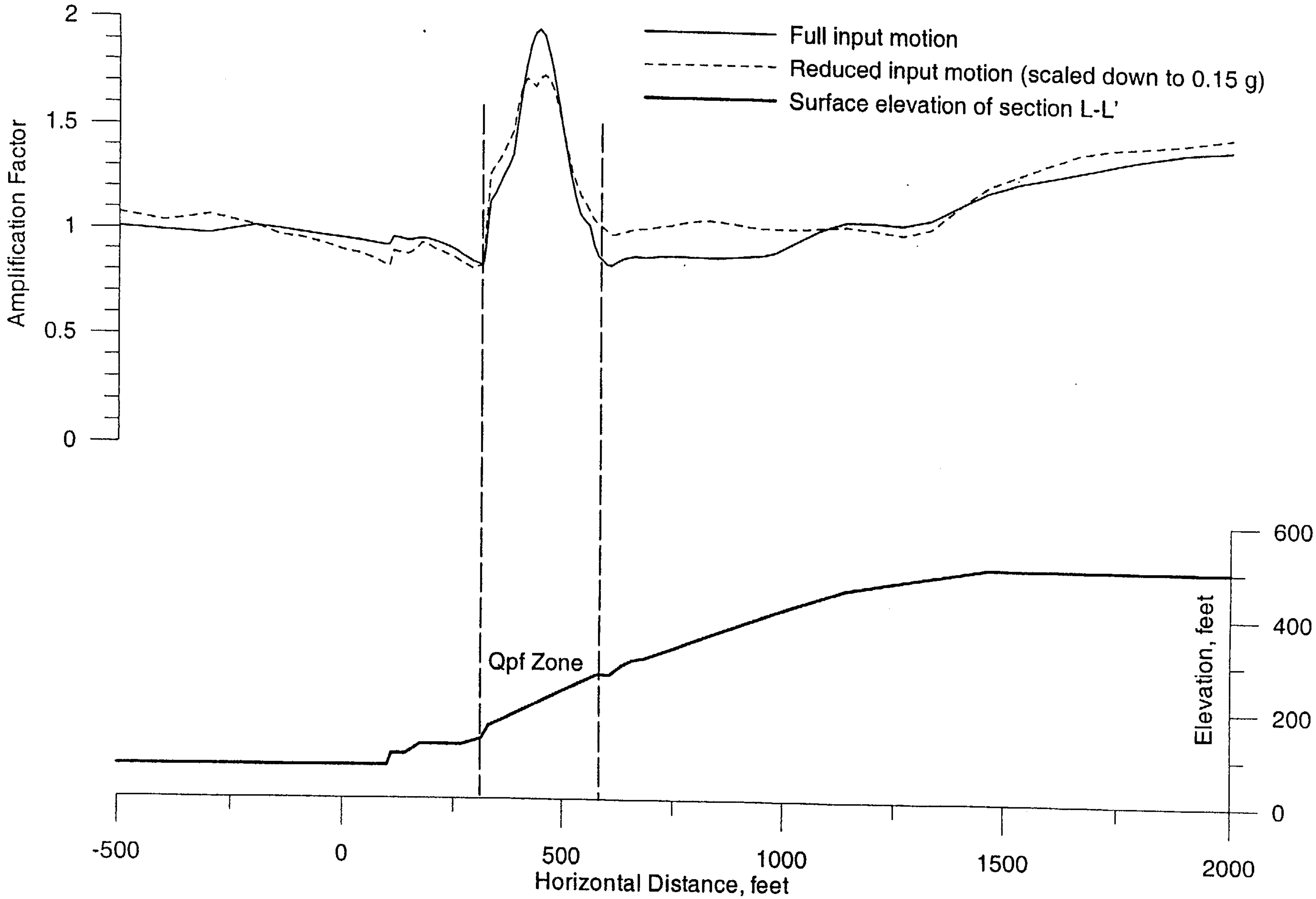


Figure 17. Variations of computed amplification factors of peak accelerations along slope surface of section L-L'.

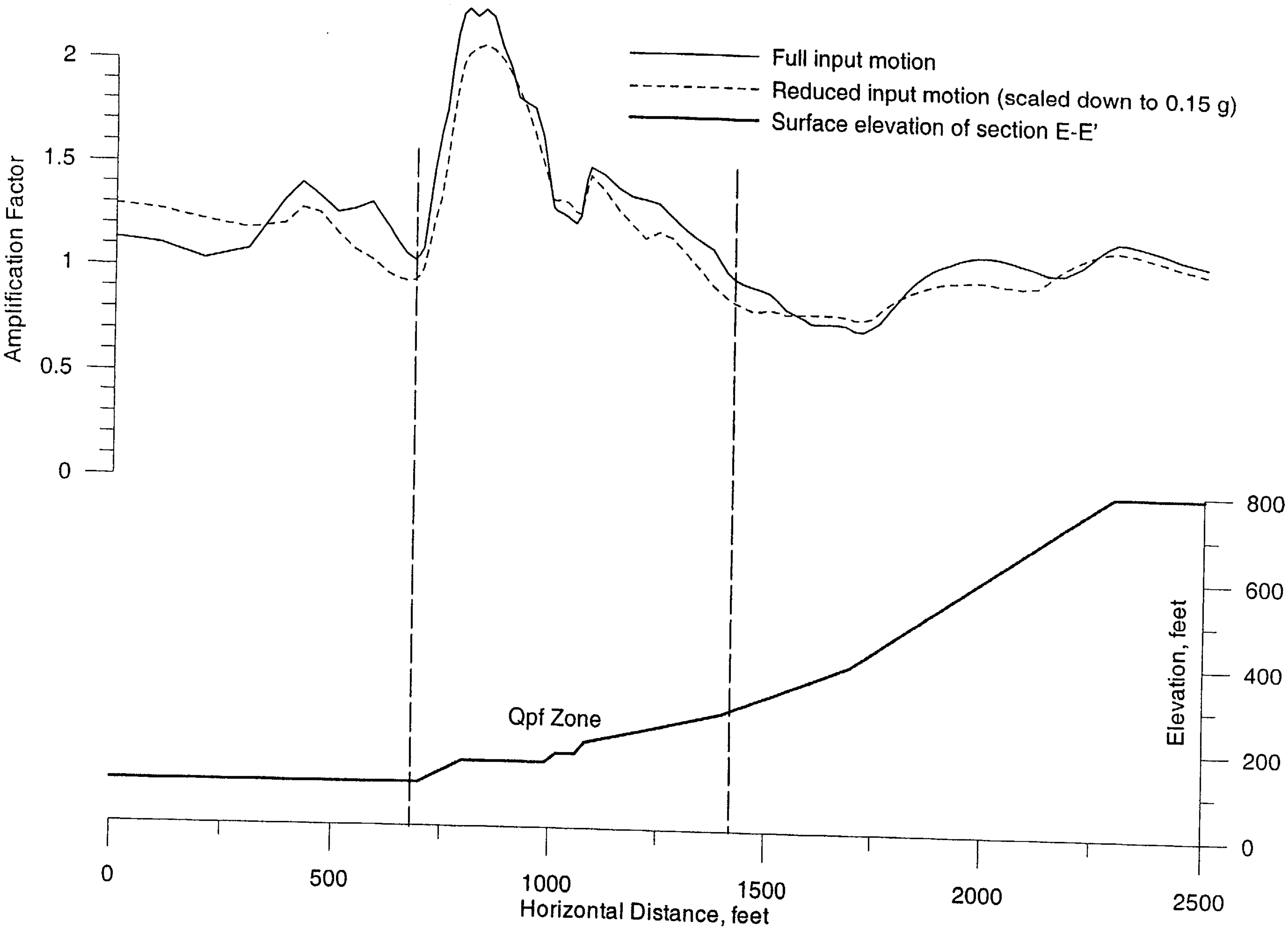


Figure 18. Variations of computed amplification factors of peak accelerations along slope surface of section E-E'.

ATTACHMENT 1

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

PG&E

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 12, 2001

Re: Forwarding of Approved Plan and Cross Sections D-D', E-E', and L-L' for DCPP ISFSI Transport Route Stability Analyses

DR. MAKDISI:

Please find enclosed the following approved plan and cross sections from Geosciences Calculation GEO.DCPP.01.21, rev. 1:

Figure 21-3, Geologic Map of the ISFSI Site and Transport Route Vicinity
Figure 21-17a, Cross Section D-D' through Patton Cove Landslide
Figure 21-18a, Cross Section E-E'
Figure 21-25, Cross Section L-L'

for your use in DCPP ISFSI transport route stability analyses. These figures supersede those transmitted to you in draft form by Rich Koehler of William Lettis Associates on October 25, 2001.

Also for your use, we have determined the azimuth of each section from Figure 21-3, as follows:

Section D-D': 38 degrees
Section E-E': 34 degrees
Section L-L': 67 degrees

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

Enclosures

ltr2fm6.doc:rkw:11/12/01

Security-Related Information – Withhold Under 10 CFR 2.390.

ATTACHMENT 2

Pacific Gas and Electric Company
Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

Dr. Faiz Makdisi
Geomatrix Consultants
2101 Webster Street
Oakland, CA 94612

September 28, 2001

Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses

DR. MAKDISI:

This is to confirm transmittal of inputs related to slope stability analyses you are scheduled to perform for the Diablo Canyon Power Plant (DCPP) Independent Spent Fuel Storage Installation (ISFSI) under the Geomatrix Work Plan entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for the Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site."

Inputs transmitted include:

Drawing entitled "Figure 21-19, Cross Section I-I'," dated 9/27/01, labeled "Draft," and transmitted to you via overnight mail under cover letter from Jeff Bachhuber of WLA and dated 9/27/01.

Time histories in Excel file entitled "time_histories_3comp_rev1.xls," dated 8/17/2001, file size 3,624 KB, which I transmitted to you via email on 8/17/2001.

Please confirm receipt of these items and forward confirmation to me in writing.

Please note that both these inputs are preliminary until the calculations they are part of have been fully approved. At that time, I will inform you in writing of their status. These confirmation and transmittal letters are the vehicles for referencing input sources in your calculations.

Although the Work Plan does not so state, as you are aware all calculations are required to be performed as per Geosciences Calculation Procedure GEO.001, entitled "Development and Independent Verification of Calculations for Nuclear Facilities," revision 3. All of your staff assigned to this project have been previously trained under this procedure.

I am also attaching a copy of the Work Plan. Please make additional copies for members of your staff assigned to this project, review the Work Plan with them, and have them sign Attachment 1. Please then make copies of the signed attachment and forward to me.

If you have any questions, feel free to call.

Thanks.

Rob White

ROBERT K. WHITE

Attachment

cc: Chris Hartz

ATTACHMENT 3

Pacific Gas and Electric Company
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

October 31, 2001

Re: Confirmation of preliminary inputs to calculations for DCPP ISFSI site

DR. MAKDISI:

A number of inputs to calculations for the DCPP ISFSI slope stability analyses have been provided to you in a preliminary fashion. This letter provides confirmation of those inputs in a formal transmittal. A description of the preliminary inputs and their formal confirmation follow.

Letter to Faiz Makdisi from Rob White dated June 24, 2001. Subject: Recommended rock strength design parameters for DCPP ISFSI site slope stability analyses.

This letter recommended using $\phi = 50$ degrees for the preliminary rock strength envelope in your stability analyses, and indicated that this value would be confirmed once calculations had been finalized and approved. Calculations GEO.DCPP.01.16, rev. 0, and GEO.DCPP.01.19, rev. 0, are approved and this recommended value is confirmed.

Letter to Faiz Makdisi from Rob White dated September 28, 2001. Subject: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses.

This letter provided confirmation of transmittal of cross section I-I' and time histories, and indicated that these preliminary inputs would be confirmed once calculations had been approved. Calculation GEO.DCPP.01.21, rev. 0, is approved and section I-I' as described in the September 28 letter is confirmed. A copy of the figure from the approved calculation is attached. Calculations GEO.DCPP.01.13, rev. 1, and GEO.DCPP.01.14, rev. 1, are both approved and time histories as described in the September 28 letter are confirmed. A CD of the time histories from the approved calculations is attached.

ltr2fm3.doc:rkw:10/31/01

Email to Faiz Makdisi from Joseph Sun dated October 24, 2001. Subject: Ground motion parameters for back calculations.

This email provided input for a back calculation to assess conservatism in clay bed properties in the slope. Inputs included maximum displacement per event of 4 inches and a factor of 1.6 with which to multiply ground motions for use in the back calculation analysis. This letter confirms those input values, with the following limitation: these values have not been developed under an approved calculation, therefore should not be used to directly determine clay bed properties for use in forward analyses, but may be used for comparative purposes only, to assess the level of conservatism in those clay bed properties determined in approved calculations

Letter to Faiz Makdisi from Jeff Bachhuber dated October 10, 2001. Subject: Transmittal of Revised Rock Mass Failure Models – DCPP ISFSI Project.

This letter provided you with figures indicating potential rock mass failure models as superimposed on section I-I'. This letter confirms PG&E approval to use these models in your analyses. These figures are labeled drafts and are currently being finalized in a revision to Calculation GEO.DCPP.01.21. Once this revision and the included figures have been approved, I will inform you in writing of their status.

Rob White

ROBERT K. WHITE

Attachments

ATTACHMENT 4

WLA

William Lettis & Associates, Inc.

1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
Voice: (925) 256-6070 FAX: (925) 256-6076

MEMORANDUM

TO: Dr. Faiz Makdisi - Geomatrix Consultants, Inc.
FROM: Jeff L. Bachhuber - William Lettis & Associates, Inc.
DATE: August 23, 2001

RE: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project

FAIZ:

This memorandum provides a revised strike azimuth of 338° for the Hosgri fault for evaluation of ground motion directional components for slope stability analyses at the PG&E DCPP ISFSI site. The revised azimuth presented in this memorandum supercedes the previous estimated azimuths (328° to 335°) presented in our memorandum dated August 8, 2001, and is based on a re-evaluation of fault maps in the PG&E LTSP (1988), and ISFSI project Calculation Package GEO.01.21.

The revised estimated average strike for the Hosgri fault nearest the ISFSI site (between Morro Bay and San Luis Bay) is 338°. Figure 21-23 of Calculation Package GEO.01.21, which previously showed an azimuth of 340° for the Hosgri fault, will be revised to correspond to this re-interpreted average strike. Discrete faults and local reaches of the fault zone exhibit variations in strike azimuth between about 328° and 338°, but the average overall strike of 338° is believed to be the best approximation for the ground motion modeling.

Please call me if you have any questions or require further input for this issue.

Jeff Bachhuber

Cc: Rob White/Bill Page - PG&E Geosciences

ATTACHMENT 5

PG&E
Pacific Gas & Electric Company
Geosciences Department

P.O. Box 770000, Mail Code N4C
San Francisco, CA 94177
Fax: (415) 973-5778

TELEFAX COVER SHEET

Date: Oct 13 '01

Number of pages including cover sheet: 3

To: Faiz Makdisi
Company: Geomatrix

Phone: (510) 663-4100
Fax: (510) 663-4141
cc:

From: Joseph Sun
Company: PG&E

Phone: (415) 973-2460
Fax: (415) 973-5778

REMARKS: ☐ Per request ☐ For review ☐ Reply ASAP ☐ Please comment

Faiz,

The fault parallel with fling ground motions positive is to the southeast. We will follow up with a formal transmittal of the calc package to you

Joseph

c:\osia\forms\fax cover.doc

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.14
Revision 1
Date October 15, 2001
Calc Pages: 26
Verification Method: A
Verification Pages: 17 & 8 Attachments

TITLE: Development of time histories with Fling

PREPARED BY: ______________ DATE October 15, 2001

Norman Abrahamson — Printed Name

Geosciences — Organization

VERIFIED BY: ______________ DATE October 15, 2001

Joseph Sun — Printed Name

Geosciences — Organization

APPROVED BY: ______________ DATE 10/15/01

Lloyd Cluff — Printed Name

Geosciences — Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. 1725
STATE OF CALIFORNIA

Expires: 12/31/02

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG567
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Expires: 12/31/02

6. BODY OF CALCULATIONS

Step 1: S-wave arrival times
The approximate arrival times of the S-waves is estimated by visual inspection of the velocity time histories (Figures 1, 2, 3, 4, and 5). The selected arrival times are listed in Table 6-1.

Table 6- 1. Time of Fling

Set	Reference Time History	Approximate Arrival time of S-waves	Arrival Time of fling (t_1) (sec)	Polarity*
1	Lucerne	8.0	7.1	-1
2a	Yarimca	9.0	8.5	-1
3	LGPC	4.0	3.4	-1
5	El Centro (1940)	1.5	0.0	1
6	Saratoga	4.5	3.7	-1

* The polarity is applied to the fault parallel time history from calculations GEO.DCPP.01.13 (rev 1) to cause constructive interference between the S-wave and the fling (eq. 5-2).

A fling arrival time is selected by visual inspection of the interference of the velocity of the transient motion and the fling (Figures 1, 2, 3, 4, and 5). The selected fling arrival time are listed in Table 6-1.

Since DCPP is on the east side of the Hosgri fault and the fault has right-lateral slip, the permanent tectonic deformation at the site will be to the southeast. In the time histories the fling has a positive polarity. Since the tectonic deformation will be to the southeast, the positive direction of the fault parallel time history is defined to the southeast.

Step 2: Fling Time History
Using the values of A, ω, and T_{fling} given in input 4-1, and the values of t_1 given in Table 6-1, the fling time history is determined using eq. (5-1). The computed fling time histories for the 5 sets are shown in Figures 1, 2, 3, 4, and 5.

ATTACHMENT 6

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

October 25, 2001

Re: Input parameters for calculations

DR. MAKDISI:

As required by Geosciences Calculation Procedure GEO.001, entitled "Development and Independent Verification of Calculations for Nuclear Facilities," rev. 4, I am providing you with the following input items for your use in preparing calculations.

1. The shear wave velocity profiles obtained in borings BA98-1 and BA98-3 in 1998 are presented in Figure 21-42, attached, of Calculation GEO.DCPP.01.21, entitled "Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site," rev. 0, and can be so referenced. These profiles were previously presented in Figure 10 of the WLA report entitled "Geologic and Geophysical Investigation, Dry Cask Storage Facility, Borrow and Water Tank Sites," dated January 5, 1999.

2. The average unit weight of rock obtained from the hillside has been determined to be 140 pounds per cubic foot, as documented in a data report entitled "Rock Engineering Laboratory Testing - GeoTest Unlimited."

3. Regarding the time histories provided to you on 8/17/01, since the tectonic deformation will be to the southeast, the positive direction of the fault parallel time history is defined as to the southeast, as described in Geosciences Calculation GEO.DCPP.01.14, entitled "Development of Time Histories with Fling," rev. 1, page 4.

4. The source of the shear modulus and damping curves are Figures Q19-22 and Q19-23, attached, from PG&E, 1989, Response to NRC Question 19 dated December 13, 1988, and can be so referenced.

Regarding format of calculations, please observe the following:

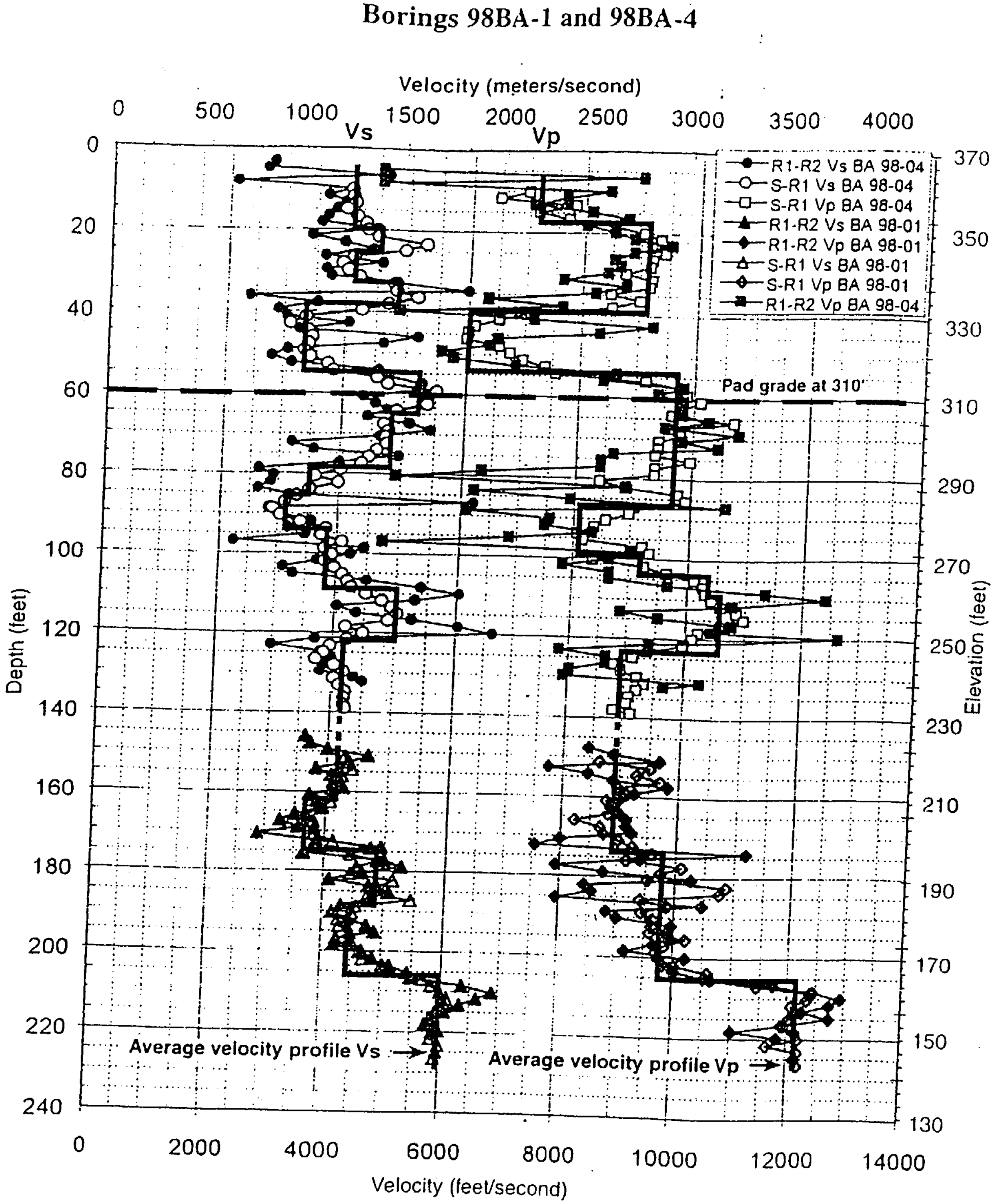
Contents of CD-ROMs attached to calculations should be listed in the calculation, including title, size, and date saved associated with each file on the CD-ROM. If the number of files is considerable, a simple screen dump of the CD-ROM contents is sufficient.

If you have any questions regarding the above, please call me.

Robert K White

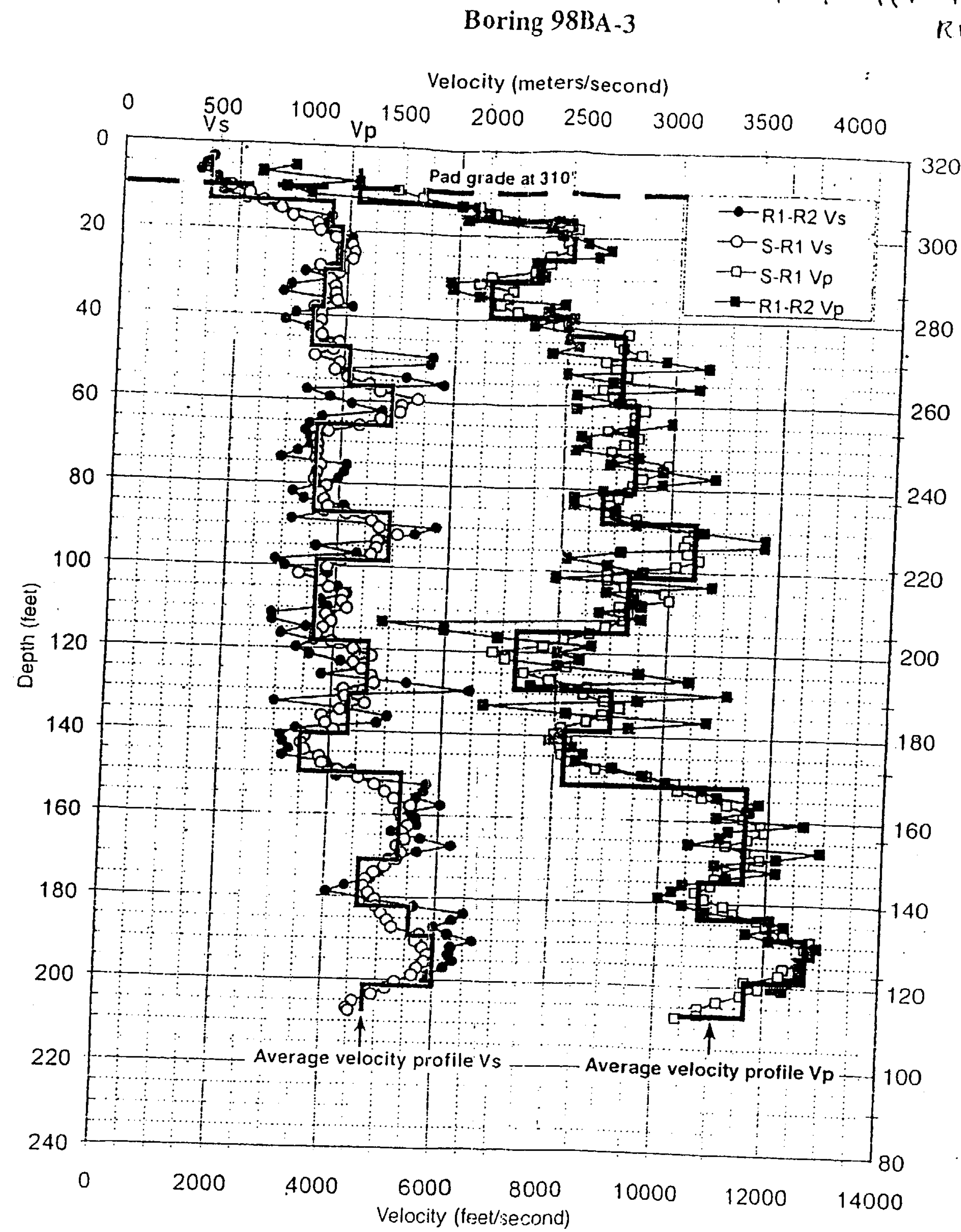
ROBERT K. WHITE

Attachments



Note: Average velocity profiles interpreted from data.

R1 - R2 = Receiver-to-receiver velocity (3.3-foot spacing)
S-R1 = Source-to-receiver velocity (10.3-foot spacing)



Modified from GeoVision (1998), DCPP ISFSI SAR Section 2.6 Topical Report Appendix C

DIABLO CANYON ISFSI

FIGURE 21-42
ISFSI SITE SUSPENSION LOGS AND INTERPRETED AVERAGE SEISMIC VELOCITIES

GEO.DCPP.01.21 REV 0

October 15, 2001

ATTACHMENT 7

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 19, 2001

Re: Transmittal of additional inputs for DCPP ISFSI Transport Route Analysis

DR. MAKDISI:

As part of the scope of your analysis of the stability of the transport route for the DCPP ISFSI, you are assessing stability of the route at various sections using both unreduced ground motions previously transmitted to you (reference my October 31 2001 letter to you) and reduced ground motions based on incorporating results of a probabilistic seismic hazard analysis and the estimated exposure interval of the transporter on the route. A probabilistically reduced peak bedrock ground acceleration of 0.15g has been derived in calculation GEO.DCPP.01.02, and this value has been approved for further analyses. Accordingly, please scale the peak acceleration of the unreduced ground motions to this level for your transport route analyses.

In addition, you are assessing the stability of transport route road fill wedges at reduced ground motion levels and with the transporter load previously transmitted to you (reference my November 5 2001 letter to you). The exact subsurface configuration of any fill wedges along the access road is currently unknown, and is shown in only a general way on sections provided to you (reference my November 12 2001 letter to you) based on general descriptions provided in the road construction specification. However, given that the density of any compacted fill derived from the native material is likely to be at or above the density of underlying native material, fill strength is likely to be comparable to the native material, and the exact configuration of the fill is therefore not of consequence. Please proceed with near-surface stability analyses with this assumption.

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

ATTACH NO. 7

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 1, 2001

Re: Confirmation of additional inputs to calculations for DCPP ISFSI site

DR. MAKDISI:

Additional inputs to calculations for the DCPP ISFSI slope stability analyses have been provided to you by Jeff Bachhuber of William Lettis Associates. This letter provides confirmation of our acceptance of those inputs in a formal transmittal. A description of those additional inputs and their formal acceptance follow.

Letter to Faiz Makdisi from Jeff Bachhuber dated August 3, 2001. Subject: Ground Motion Directional Components.

This letter recommended using an azimuth of 302 degrees plus or minus 10 degrees for the orientation of the most likely failure surfaces, coinciding with Section I-I'. We concur with this recommendation based on the discussion on page 53 of the approved Calculation GEO.DCPP.01.21, rev. 0, and verification of the orientation of Section I-I' on Calculation Figure 21-4, attached.

Letter to Faiz Makdisi from Jeff Bachhuber dated August 23, 2001. Subject: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project.

This letter recommended using an azimuth of 338 degrees for the orientation of the average strike of the Hosgri fault. We concur with this recommendation, based on verification of the orientation as presented in the LTSP plates and as shown on Figure 21-36, attached, of Calculation GEO.DCPP.01.21, rev. 0.

Rob White

ROBERT K. WHITE

Attachments

Security-Related Information – Withhold Under 10 CFR 2.390.

ATTACHMENT 8

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 19, 2001

Re: Transmittal of additional inputs for DCPP ISFSI Transport Route Analysis

DR. MAKDISI:

As part of the scope of your analysis of the stability of the transport route for the DCPP ISFSI, you are assessing stability of the route at various sections using both unreduced ground motions previously transmitted to you (reference my October 31 2001 letter to you) and reduced ground motions based on incorporating results of a probabilistic seismic hazard analysis and the estimated exposure interval of the transporter on the route. A probabilistically reduced peak bedrock ground acceleration of 0.15g has been derived in calculation GEO.DCPP.01.02, and this value has been approved for further analyses. Accordingly, please scale the peak acceleration of the unreduced ground motions to this level for your transport route analyses.

In addition, you are assessing the stability of transport route road fill wedges at reduced ground motion levels and with the transporter load previously transmitted to you (reference my November 5 2001 letter to you). The exact subsurface configuration of any fill wedges along the access road is currently unknown, and is shown in only a general way on sections provided to you (reference my November 12 2001 letter to you) based on general descriptions provided in the road construction specification. However, given that the density of any compacted fill derived from the native material is likely to be at or above the density of underlying native material, fill strength is likely to be comparable to the native material, and the exact configuration of the fill is therefore not of consequence. Please proceed with near-surface stability analyses with this assumption.

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

lu2fm10.doc:rkw:11/19/01

NUCLEAR POWER GENERATION
CF3.ID4
ATTACHMENT 7.2

Index No. 402
Binder No.

TITLE: CALCULATION COVER SHEET

Unit(s): 1 & 2

File No.: 52.27

Responsible Group: Civil

Calculation No.: 52.27.100.740

No. of Pages 3 pages + Index (4 pages) + 1 Attachment (48 pages)

Design Calculation YES [x] NO [ ]

System No. 42C

Quality Classification Q (Safety-Related)

Structure, System or Component: Independent Spent Fuel Storage Facility

Subject: Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route (GEO.DCPP.01.30, Rev. 0)

Electronic calculation YES [ ] NO [x]

Computer Model	Computer ID	Program Location	Date of Last Change

Registered Engineer Stamp: Complete A or B

A. Insert PE Stamp or Seal Below	B. Insert stamp directing to the PE stamp or seal
Expiration Date:	***REGISTERED ENGINEERS' STAMPS AND EXPIRATION DATES ARE SHOWN ON DWG 063618***

NOTE 1: Update DCI promptly after approval.
NOTE 2: Forward electronic calculation file to CCTG for uploading to EDMS.

TITLE: CALCULATION COVER SHEET

CALC No. 52.27.100.740, R0

RECORD OF REVISIONS

Rev No.	Status	Reason for Revision / Remarks	Prepared By: Initials/ LAN ID/ Date	LBIE Screen Yes/ No/ NA	LBIE Yes/ No/ NA	Check Method*	LBIE Approval PSRC Mtg. No.	LBIE Approval PSRC Mtg. Date	Checked Initials/ LAN ID/ Date	Supervisor Initials/ LAN ID/ Date	Registered Engineer Signature/ LAN ID/ Date
0	F	Acceptance of Geosciences Calc. No. GEO.DCPP.01.30, Rev. 0. Calc. supports current edition of 10CFR72 DCPP License Application to be reviewed by NRC prior to implementation. Prepared per CF3.ID17 requirements.	AFT2 AT 12/13/01	[ ] Yes [ ] No [x] NA	[ ] Yes [ ] No [x] NA	[ ] A [ ] B [x] C	N/A	N/A	N/A	[signature] LJS2 12/14/01	[signature] LJS2 12/14/01
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					
				[ ] Yes [ ] No [ ] NA	[ ] Yes [ ] No [ ] NA	[ ] A [ ] B [ ] C					

*Check Method: A: Detailed Check, B: Alternate Method (note added pages), C: Critical Point Check

SUBJECT Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route

MADE BY A. Tafoya KI DATE 12/13/01 CHECKED BY N/A DATE

Table of Contents:

SUBJECT Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route

MADE BY A. Tafoya DATE 12/13/01 CHECKED BY N/A DATE

1- This table cross references between Geosciences calculation numbers and DCPP (Civil Group's) calculation numbers. This section is For Information Only.

Cross-Index

(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
1	GEO.DCPP.01.01	Development of Young's Modulus and Poisson's Ratios for DCPP ISFSI Based on Field Data	52.27.100.711	
2	GEO.DCPP.01.02	Determination of Probabilistically Reduced Peak Bedrock Accelerations for DCPP ISFSI Transporter Analyses	52.27.100.712	
3	GEO.DCPP.01.03	Development of Allowable Bearing Capacity for DCPP ISFSI Pad and CTF Stability Analyses	52.27.100.713	
4	GEO.DCPP.01.04	Methodology for Determining Sliding Resistance Along Base of DCPP ISFSI Pads	52.27.100.714	
5	GEO.DCPP.01.05	Determination of Pseudostatic Acceleration Coefficient for Use in DCPP ISFSI Cutslope Stability Analyses	52.27.100.715	
6	GEO.DCPP.01.06	Development of Lateral Bearing Capacity for DCPP CTF Stability Analyses	52.27.100.716	
7	GEO.DCPP.01.07	Development of Coefficient of Subgrade Reaction for DCPP ISFSI Pad Stability Checks	52.27.100.717	
8	GEO.DCPP.01.08	Determination of Rock Anchor Design Parameters for DCPP ISFSI Cutslope	52.27.100.718	
9	GEO.DCPP.01.09	Determination of Applicability of Rock Elastic Stress-Strain Values to	52.27.100.719	Calculation to be replaced by letter

SUBJECT Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route

MADE BY A. Tafoya DATE 12/13/01 CHECKED BY N/A DATE

Cross-Index

(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
		Stress-Strain Values to Calculated Strains Under DCPP ISFSI Pad		
10	GEO.DCPP.01.10	Determination of SSER 34 Long Period Spectral Values	52.27.100.720	
11	GEO.DCPP.01.11	Development of ISFSI Spectra	52.27.100.721	
12	GEO.DCPP.01.12	Development of Fling Model for Diablo Canyon ISFSI	52.27.100.722	
13	GEO.DCPP.01.13	Development of Spectrum Compatible Time Histories	52.27.100.723	
14	GEO.DCPP.01.14	Development of Time Histories with Fling	52.27.100.724	
15	GEO.DCPP.01.15	Development of Young's Modulus and Poisson's Ratio Values for DCPP ISFSI Based on Laboratory Data	52.27.100.725	
16	GEO.DCPP.01.16	Development of Strength Envelopes for Non-jointed Rock at DCPP ISFSI Based on Laboratory Data	52.27.100.726	
17	GEO.DCPP.01.17	Determination of Mean and Standard Deviation of Unconfined Compression Strengths for Hard Rock at DCPP ISFSI Based on Laboratory Tests	52.27.100.727	
18	GEO.DCPP.01.18	Determination of Basic Friction Angle Along Rock Discontinuities at DCPP ISFSI Based on Laboratory Tests	52.27.100.728	

Cross-Index

(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
19	GEO.DCPP.01.19	Development of Strength Envelopes for Jointed Rock Mass at DCPP ISFSI Using Hoek-Brown Equations	52.27.100.729	
20	GEO.DCPP.01.20	Development of Strength Envelopes for Shallow Discontinuities at DCPP ISFSI Using Barton Equations	52.27.100.730	
21	GEO.DCPP.01.21	Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site	52.27.100.731	
22	GEO.DCPP.01.22	Kinematic Stability Analysis for Cutslopes at DCPP ISFSI Site	52.27.100.732	
23	GEO.DCPP.01.23	Pseudostatic Wedge Analyses of DCPP ISFSI Cutslopes (SWEDGE Analysis)	52.27.100.733	
24	GEO.DCPP.01.24	Stability and Yield Acceleration Analysis of Cross Section I-I'	52.27.100.734	
25	GEO.DCPP.01.25	Determination of Seismic Coefficient Time Histories for Potential Siding Masses Above Cut Slopes Behind ISFSI Pad	52.27.100.735	
26	GEO.DCPP.01.26	Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses on DCPP ISFSI Slope	52.27.100.736	
27	GEO.DCPP.01.27	Cold Machine Shop Retaining Wall Stability	52.27.100.737	
28	GEO.DCPP.01.28	Stability and Yield Acceleration Analysis of	52.27.100.738	

Cross-Index

(For Information Only)

Item No.	Geoscience Calc. No.	Title	PG&E Calc. No.	Comments
		Acceleration Analysis of Potential Sliding Masses Along DCPP ISFSI Transport Route		
29	GEO.DCPP.01.29	Determination of Seismic Coefficient Time Histories for Potential Sliding Masses on DCPP ISFSI Transport Route	52.27.100.739	
30	GEO.DCPP.01.30	Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses Along DCPP ISFSI Transport Route	52.27.100.740	
31	GEO.DCPP.01.31	Development of Strength Envelopes for Clay Beds at DCPP ISFSI	52.27.100.741	
32	GEO.DCPP.01.32	Verification of Computer Program SPCTLR.EXE	52.27.100.742	
33	GEO.DCPP.01.33	Verification of Program UTEXAS3	52.27.100.743	
34	GEO.DCPP.01.34	Verification of Computer Code - QUAD4M	52.27.100.744	
35	GEO.DCPP.01.35	Verification of Computer Code DEFORMP	52.27.100.745	
36	GEO.DCPP.01.36	Reserved	52.27.100.746	
37	GEO.DCPP.01.37	Development of Freefield Ground Motion Storage Cask Spectra and Time Histories for the Used Fuel Storage Project	52.27.100.747	

FILE No. 079 11/27 '01 17:08 ID:PG&E GEOSCIENCES DEPT 415 973 5778 PAGE 1
NOV. 27. 2001 6:28PM P 1
OM : Cluff - San Francisco PHONE NO. : 415 564 6697
FILE No. 077 11/27 '01 16:52 ID:PG&E GEOSCIENCES DEPT 415 973 5778 PAGE 4

PG&E
Geosciences Department
Departmental Calculation Procedure

Number: GEO.001
Revision: 4

Title: Design Calculation Cover Sheet

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.30
Revision 0
Date 11/2?/2001
Calc Pages:
Verification Method: See Summary : A
Verification Pages: See Summary : 2

TITLE: Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses along DCPP ISFSI Transport Route

PREPARED BY: [signature] DATE 11/21/01
ZHILIANG WANG — Printed Name
GEOMATRIX — Organization

VERIFIED BY: [signature] DATE 11/26/01
Faiz Makdisi — Printed Name
Geomatrix Cons., Inc — Organization

APPROVED BY: [signature] DATE 11/27/01
Lloyd Cluff — Printed Name
Geosciences — Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG567
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Exp. 12/31/02

Title: Design Calculation Cover Sheet

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.30
Revision 0
Date 11/21/2001
Calc Pages:
Verification Method: See Summary : A
Verification Pages: See Summary : 2

TITLE: Determination of Potential Earthquake-Induced Displacements of Potential Sliding Masses along DCPP ISFSI Transport Route

---

PREPARED BY: Zhiliang Wang DATE 11/21/01

ZHILIANG WANG — Printed Name

GEOMATRIX — Organization

VERIFIED BY: [signature] DATE 11/26/01

Faiz Makdisi — Printed Name

Geomatrix Cons., Inc — Organization

APPROVED BY: ______________________ DATE ______________________

______________________ Printed Name

______________________ Organization

Calculation Title: Determination of Earthquake-Induced Displacements of Potential Sliding Masses along DCPP ISFSI Transport Route (Newmark Analysis)
Calculation No.: GEO.DCPP.01.30
Revision No.: 0
Calculation Author: Zhi-Liang Wang
Calculation Date: 11/21/01

PURPOSE

The purpose of this calculation package is to estimate earthquake-induced permanent displacements of potential sliding masses along DCPP ISFSI transport route using Newmark-type analyses. The calculations reported in this package were performed in accordance with the requirements of Geomatrix Consultants, Inc. Work Plan Revision 2 (dated December 8, 2000), entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site."

ASSUMPTIONS

Not applicable.

INPUT

1. Five sets of rock motions originating on the Hosgri fault: Transmittal from PG&E Geosciences dated September 28, 2001 (Attachment 1 as confirmed in Attachment 7).
2. Plan and three cross sections along the transport route (Sections D-D′, E-E′, and L-L′): Transmittal from PG&E Geosciences, dated November 12, 2001 (Attachment 2).
3. Azimuths of three cross-sections along transport route (Attachment 1)
4. Orientation (azimuth) of the strike of the Hosgri fault: Transmittal from William Lettis & Associates dated August 23, 2001 (Attachment 4 as confirmed in Attachment 8).
5. Direction of positive fault parallel component on Hosgri fault: Transmittal from PG&E Geosciences dated October 18, 2001 (Attachment 5as confirmed in Attachment 6).
6. Yield accelerations and locations for potential sliding masses from calculation package GEO.DCPP.01.28, revision 0.
7. Average acceleration time histories in potential sliding masses from calculation package GEO.DCPP.01.29, revision 0.

METHODOLOGY

Development of Rotated Motions along Sections L-L′ and E-E′

Geosciences department of PG&E developed five sets of possible earthquake rock motions for the ISFSI site (see Attachment 1, as confirmed in Attachment 7) to be used as input to the analyses. These motions are estimated to originate on the Hosgri fault about 4.5 km west of the plant site. Both fault normal and fault parallel components were determined for each of the five sets of motions. The fault parallel component incorporated the fling effect and its positive direction was specified in the southeasterly fault direction (see Attachment 5, as confirmed in Attachment 6). The fault normal component has a direction normal to the fault, and its polarity can be either positive or negative depending on the assumed location of the initiation of the rupture. Based on Attachments 3 and 4 as confirmed in Attachment 7, the direction of movement along cross section L-L′ (which as shown in Figure 1 has an azimuth of 67 degrees) is 91 degrees (counter-clock wise) from the direction of the strike of the Hosgri fault. (i.e., to the southeast, see Attachment 2). The fault normal component can be at ± 90 degrees from fault parallel direction, that is 91+90 = 181 (or 91-90 = 1) degrees from the direction of section L-L′. From these relations, the ground motion component along section L-L′ can be determined from the specified components along the fault normal and fault parallel directions. Similar computations are made for section E-E′ that has an azimuth of 35 degrees as shown in Figure 1, and thus is 123 degrees (counter clock wise) from the direction of the positive fault parallel component of the Hosgri fault. The computed motions along the directions of sections L-L′ and E-E′ will be referred to as the rotated components.

The rotated component along each of the specified section is the sum of the projections of the fault normal and fault parallel components along the direction of the section. The formulation is as follows:

$$Rot^{+} = F_P \cos(\phi) + F_N \sin(\phi)$$

and

$$Rot^{-} = F_P \cos(\phi) - F_N \sin(\phi)$$

in which the F_P and F_N are fault parallel and fault normal components of the acceleration time-histories, Rot^+ is the component along the section (for a positive fault normal component) and Rot^- is the component along the section (for a negative fault normal component). ϕ is the angle between up-slope direction of the section analyzed and the fault parallel direction (southeast). The five sets of earthquake motions on the Hosgri fault, are now rotated to earthquake motions along the up-slope direction of cross sections L-L′ and E-E′. For a given angle between the analyzed section and the fault direction, there are 10 rotated earthquake motions, because for each set the positive and negative directions of the fault normal component are considered separately.

Procedures for Permanent Displacement Calculation

The procedure used to estimate permanent displacements is based on the concept of yield acceleration proposed by Newmark (1965) and modified by Makdisi and Seed (1978). It involves the following steps:

1. A yield acceleration, k_y, at which a potential sliding surface would develop a factor of safety of unity, is estimated using limit equilibrium, pseudo-static slope stability methods. The yield acceleration depends on the slope geometry, the ground water conditions, the undrained shear strength of the slope material, and the location of the potential sliding surface. The analyses are presented in calculation package GEO.DCPP.01.28, revision 0.
2. The seismic coefficient time history (and the maximum seismic coefficient, k_{max}) induced within a potential sliding mass is estimated using two-dimensional dynamic finite element methods. The seismic coefficient is the ratio of the force induced by an earthquake in a sliding block to the total mass of that block. Alternatively, the seismic coefficient time history can be obtained directly by averaging acceleration values from several different nodal points within the sliding block at each time interval. These analyses are presented in calculation package GEO.DCPP.01.29, revision 0.
3. For a specified potential sliding mass, the seismic coefficient time history for that mass is compared with the yield acceleration k_y. When the seismic coefficient exceeds the yield acceleration, down-slope movement will occur along the direction of the assumed failure plane. The movement will decelerate and will stop after the level of the induced acceleration drops below the yield acceleration, and the relative velocity of the sliding

mass drops to zero. The accumulated down-slope permanent displacement is calculated by double-integrating the increments of the seismic coefficient time history that exceed the yield acceleration. The program DEFORMP (see software section below) was used to compute the permanent displacements. The results of these computations are presented below.

SOFTWARE

The program DEFORMP was validated in GEO.DCPP.01.35, revision 1 and used in this package for the displacement computation.

ANALYSIS

The earthquake-induced deformation was initially estimated (in an approximate manner) using a Newmark type (Newmark, 1965) analysis for a sliding block on a rigid plane. An estimated yield acceleration of 0.5g (based on estimates from calculation package GEO.DCPP.01.28) was used to calculate the deformation of the potential sliding masses. The displacement was computed for the negative direction (representing down-slope movement) only. The down-slope permanent displacement of the sliding mass was integrated by using the input rock motions in the positive direction (representing up-slope direction) only. These preliminary displacement estimates were used to help in selecting the ground motion time histories that provided the largest permanent displacement, for subsequent use as input to the dynamic response analyses.

Table 1 shows the calculated down-slope permanent displacements (for the five sets of rotated rock motions) using the program DEFORMP, following the Newmark rigid block approach described above. Details of the DEFORMP calculations including the input and output files are included in the enclosed compact disc. The results indicate that, on average, ground motion sets 1, 5, 6, provided the largest displacements (0.30 feet to 0.51 feet) for yield acceleration of 0.5g. Set 1 motion, when combined with the negative fault normal component, produced 0.30 feet of displacement at section E-E′, however when combined with the positive fault normal component, produced much smaller displacement than that from sets 5 and 6.

Accordingly rock motion sets 5 and 6 were selected as the input motions for the dynamic finite element analyses that are described in calculation package GEO.DCPP.01.29. Both motions are rotated relative to the orientations of sections L-L′ and E-E′ using the fault parallel and the negative fault normal components.

TABLE 1.
DOWN SLOPE DISPLACEMENT CALCULATED BASED ON ROTATED INPUT MOTIONS ALONG SECTIONS L-L′ AND E-E′
(DISPLACEMENT UNIT: FEET, YIELD ACCELERATION: 0.5g)

Set No.	Description	Polarity of FN	ky=0.50g	
			$E\text{-}E_{123}$	$L\text{-}L_{91}$
Set 1	Lucerne	FN-	0.05	0.11
		FN+	0.30	0.16
Set 2a	Yarimca	FN-	0.10	0.23
		FN+	0.08	0.03
Set 3	LGPC	FN-	0.09	0.09
		FN+	0.08	0.06
Set 5	El Centro	FN-	0.24	0.18
		FN+	0.13	0.15
Set 6	Saratoga	FN-	0.51	0.38
		FN+	0.07	0.05

RESULTS

Earthquake-induced Displacements at full ground motions

The results of stability analyses were reported in calculation package GEO.DCPP.01.28. Using the yield accelerations for potential sliding masses having the lowest factor of safety obtained for section L-L′ and E-E′ in calculation package GEO.DCPP.01.28, the potential for permanent displacements was evaluated using the concept of yield acceleration and procedure described above.

The potential sliding masses and the node points where the computed acceleration time histories were used to develop average-acceleration time histories for each sliding mass, are presented in Figures 2 and 3, for sections L-L′ and E-E′, respectively. The computed average acceleration time histories for the potential sliding masses are presented in Figures 4 and 5 for sections L-L′ and E-E′, respectively. The computed peak seismic coefficient, k_{max}, for the potential sliding masses at sections L-L′ and E-E′ are listed in Table 2.

The seismic coefficient time histories shown in Figures 4 and 5 were then double integrated, using the program DEFORMP, to obtain earthquake-induced displacements for any specified yield acceleration. Details of these calculations including the input and out files are included in the enclosed compact disc labeled GEO.DCPP.01.30. Note that the positive direction (shown in Figure 1) of the rock motions is consistent with the coordinate system selected for the dynamic analysis, i.e. the horizontal coordinate increases in the up-slope direction. As mentioned before, the integration was made for the ground motion amplitudes exceeding the yield acceleration in the positive direction only, and the resulting displacement in the down-slope direction was computed for each potential sliding mass.

The relationships between calculated displacement and yield acceleration, k_y, for each of the two potential sliding masses considered, are presented on Figures 6 and 7 for sections L-L′ and E-E′, respectively. The normalized relationships between calculated displacement and yield acceleration ratio, k_y/k_{max}, for the potential sliding masses considered, are presented on Figures 8 and 9 for sections L-L′ and E-E′, respectively.

The yield accelerations estimated for potential sliding masses at sections L-L', E-E', and D-D' are also presented in Table 2. These results were presented in calculation package GEO.DCPP.01.28, revision 0. For the yield acceleration values listed in Table 2, the earthquake-induced down-slope displacements for the potential sliding masses at sections L-L' and E-E' were estimated from Figures 6 and 7, and are summarized in the same table. For the potential sliding mass at section D-D', the average acceleration time histories for potential sliding mass at section E-E' were used to calculate earthquake induced deformation (i.e. Figure 7). This is because that the seismic response of section D-D' was not analyzed, and it is estimated that it could be similar to those at section E-E'.

Computed permanent displacements using set 5 motion as input, range from about 0.5 foot, for the potential sliding mass at section E-E′ to about 1.3 feet for the potential sliding mass at section L-L′. Computed displacements using ground motion set 6 as input, are lower and range from 0.3 foot for the sliding mass at section E-E′, to about 0.9 foot at section L-L′.

Earthquake-induced displacements at reduced ground motion levels

Peak accelerations computed along the slope surface at sections L-L′ and E-E′, using reduced input bedrock motions (scaled to 0.15g), were reported in calculation package GEO.DCPP.01.29, Revision 0. The computed peak accelerations in the vicinity of the potential sliding masses at the two sections analyzed were of the order of 0.3g. The estimated peaks (k_{max}) of the average acceleration time histories within the specified potential sliding masses are expected to be less than 0.3g. The computed yield accelerations shown in Table 2 for the corresponding sliding masses are of the order of 0.5 g. Therefore, because the earthquake-induced peak accelerations are less than the yield acceleration, the potential for downslope displacements are expected to be negligible.

TABLE 2
COMPUTED DOWN-SLOPE DISPLACEMENTS
USING SET 1 AND SET 5 INPUT MOTIONS

Sliding Mass Location	Input Motion	Factor of Safety	Yield Acceleration, k_y, (g)	Peak Seismic Coefficient, k_{max}, (g)	Down-slope Displacement, feet
L-L′	Set 5	1.60	0.46	1.15	1.3
E-E′	Set 5	3.38	0.57	1.07	0.50
D-D′	Set 5	2.21	0.45	1.07	1.1
L-L′	Set 6	1.60	0.46	0.97	0.90
E-E′	Set 6	3.38	0.57	0.91	0.32
D-D'	Set 6	2.21	0.45	0.91	0.85

REFERENCES

1. Geomatrix Consultants, Inc. Work Plan, Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site, Revision 2, dated December 8, 2000.
2. Geosciences Calculation Package GEO.DCPP.01.28, Revision 0, Stability and yield acceleration analysis of potential sliding masses along DCPP ISFSI transport route.
3. Geosciences Calculation Package GEO.DCPP.01.29, Revision 0, Determination of seismic coefficient time histories for potential sliding masses on DCPP ISFSI transport route.

4. Geosciences Calculation Package GEO.DCPP.01.35, Revision 1, Verification of computer code – DEFORMP.

5. Makdisi, F.I., and Seed, H.B., 1978, Simplified procedure for estimating dam and embankment earthquake-induced deformations: Journal of the Geotechnical Engineering Division, American Society of Civil Engineers, v. 104, no. GT7, July, pp. 849-867.

6. Newmark, N.M., 1965, Effects of earthquakes on dams and embankments: Geotechnique, v. 15, no. 2, p. 139-160.

ATTACHMENTS

1. 09/28/2001, PG&E Geosciences, Robert K. White, Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses.
2. 11/12/01, PG&E Geosciences, Robert K. White, Re: Forwarding of approved plan and cross-sections D-D', E-E′, and L-L′ for DCPP ISFSI transport route stability analyses
3. 11/9/01, William Lettis & Associates, Inc., Jeff Bachhuber, Re: Azimuths for Analytical Cross-sections – ISFSI, e-mail transmittal to F. Makdisi.
4. 08/23/2001, William Lettis & Associates, Inc., Jeff Bachhuber, Re: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project.
5. 10/18/2001, PG&E Geosciences, Joseph Sun, Re: Positive direction of the fault parallel component time history on the Hosgri fault.
6. 10/25/2001, PG&E Geosciences, Robert White, Re: Input parameters for calculations,
7. 10/31/2001, PG&E Geosciences, Robert White, Re: Confirmation of preliminary inputs to calculations for DCPPISFSI site.
8. 11/1/2001, PG&E Geosciences, Robert White, Re: Confirmation of additional inputs to calculations for DCPP ISFSI site.
9. 11/19/01, PG&E Geosciences, Robert K. White, Re: Transmittal of additional inputs for DCPP ISFSI transport route analysis.

ENCLOSURE

Compact Disc (CD), labeled, "Data Files for Calculation Package GEO.DCPP.01.30" with input and output files for computed earthquake-induced displacements of potential sliding masses.

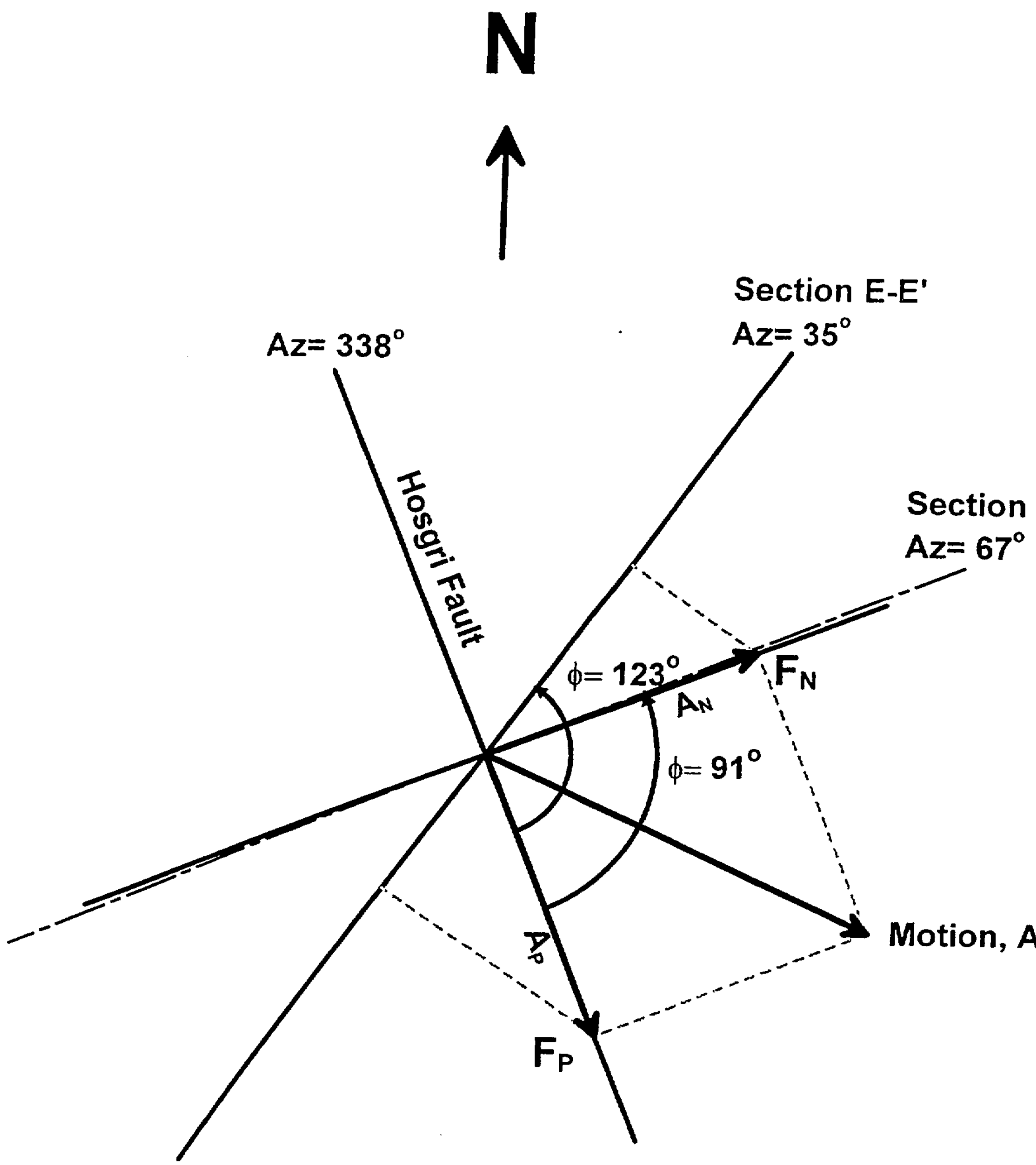


Figure 1. Orientations of Section E-E', Section L-L' and Hosgri Fault.

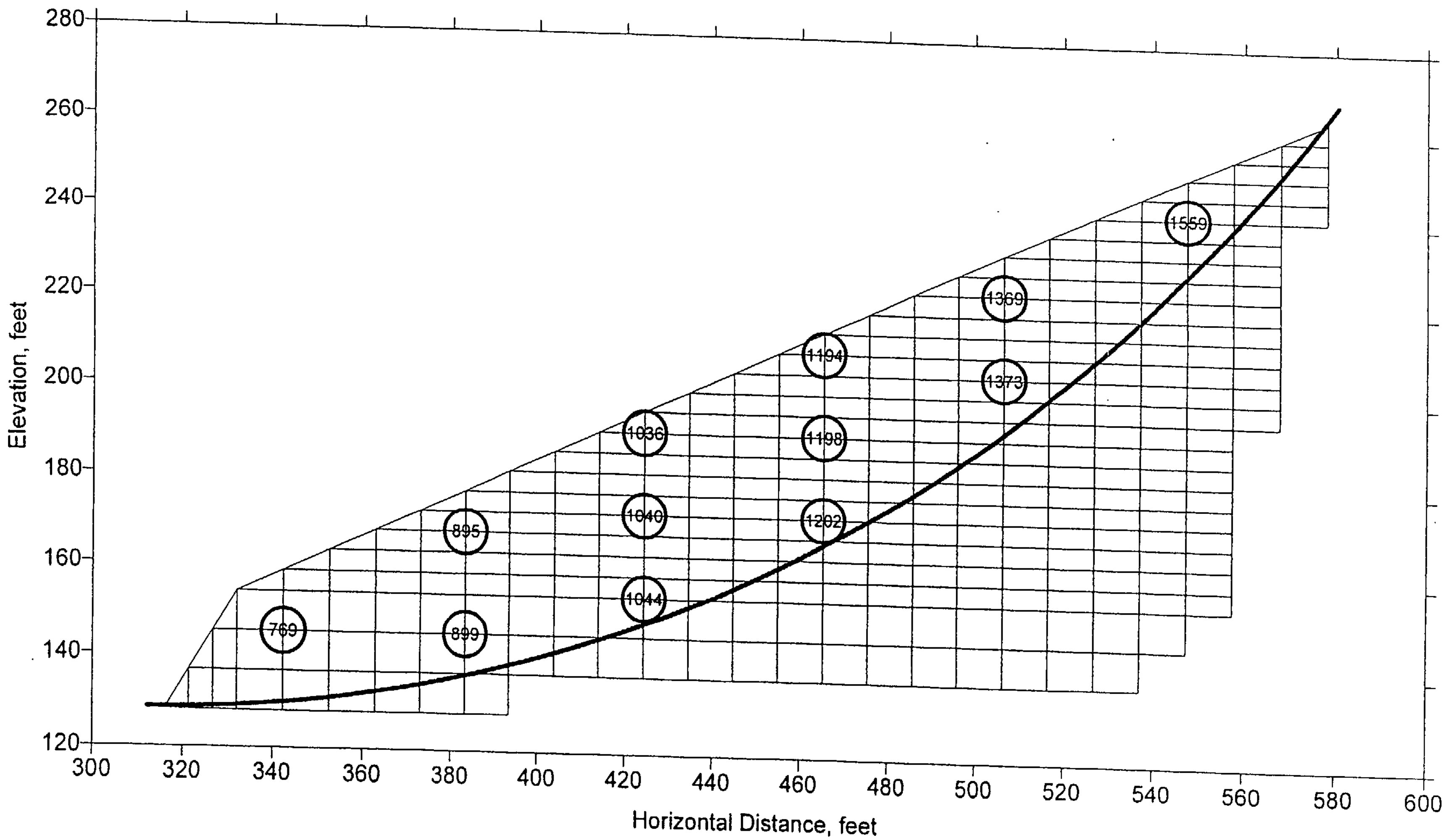


Figure 2. Potential Sliding Mass and Node Points of Computed Acceleration Time Histories for Cross Section L-L'.

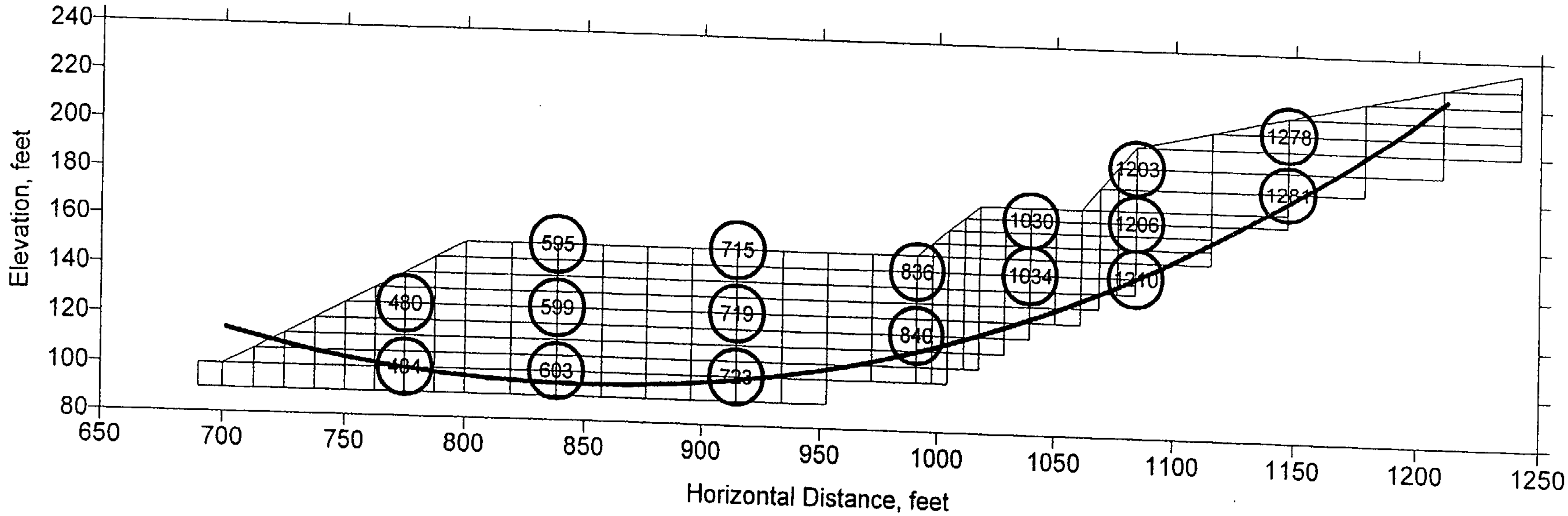


Figure 3. Potential Sliding Mass and Node Points of Computed Acceleration Time Histories for Cross Section E-E'.

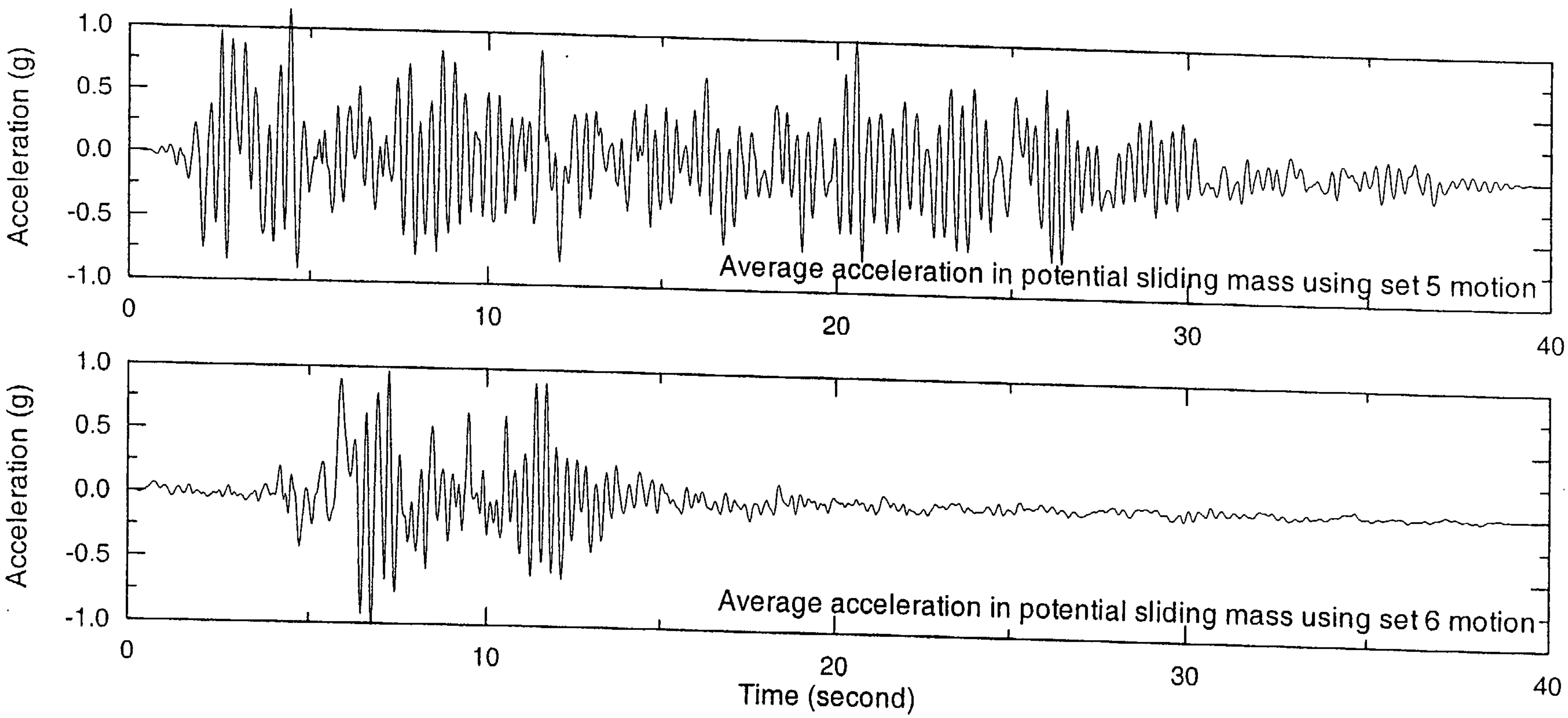


Figure 4. Average acceleration time histories of potential sliding masses at section L-L'.

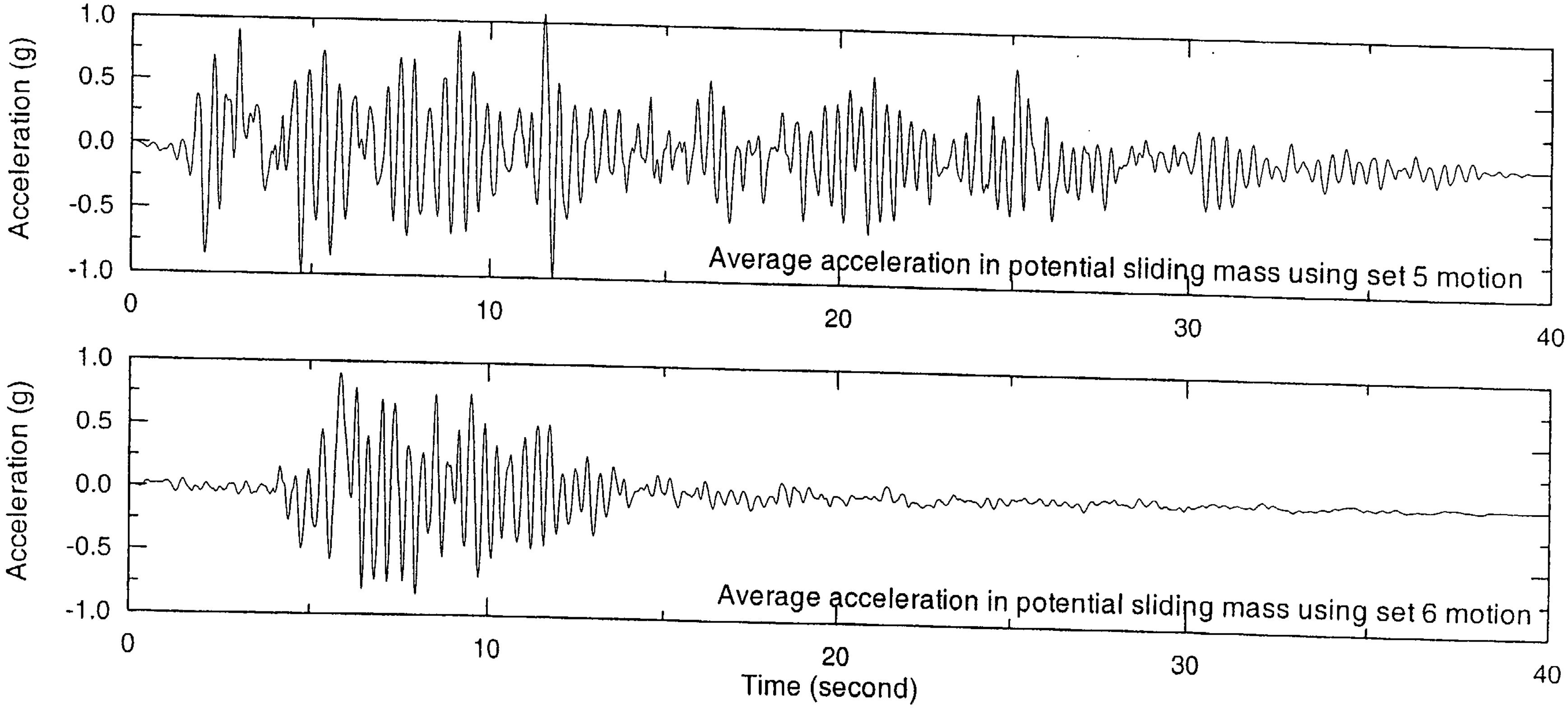


Figure 5. Average acceleration time histories of potential sliding masses at section E-E'.

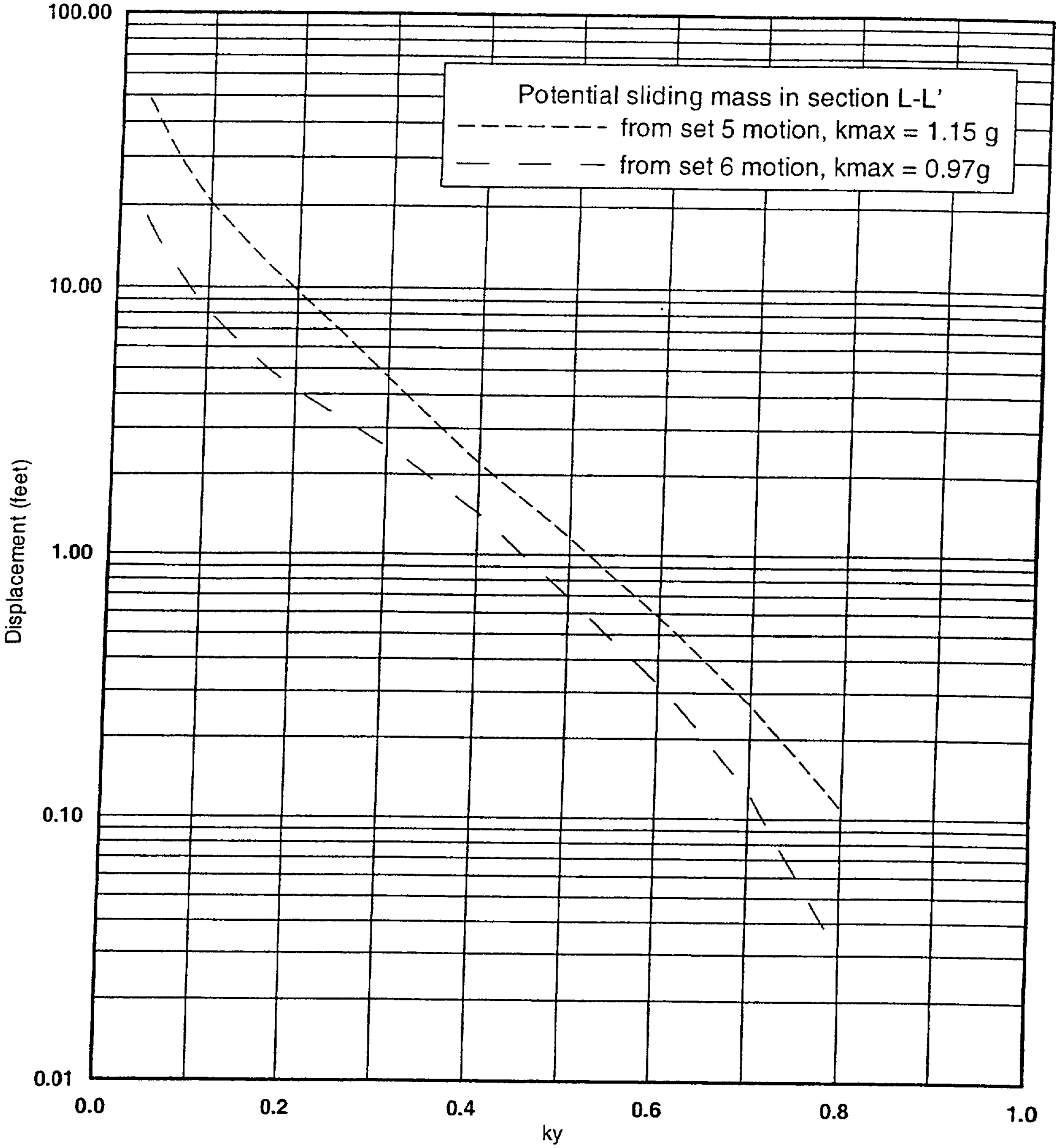


Figure 6. Permanent displacement versus yield acceleration from average acceleration time histories, section L-L'.

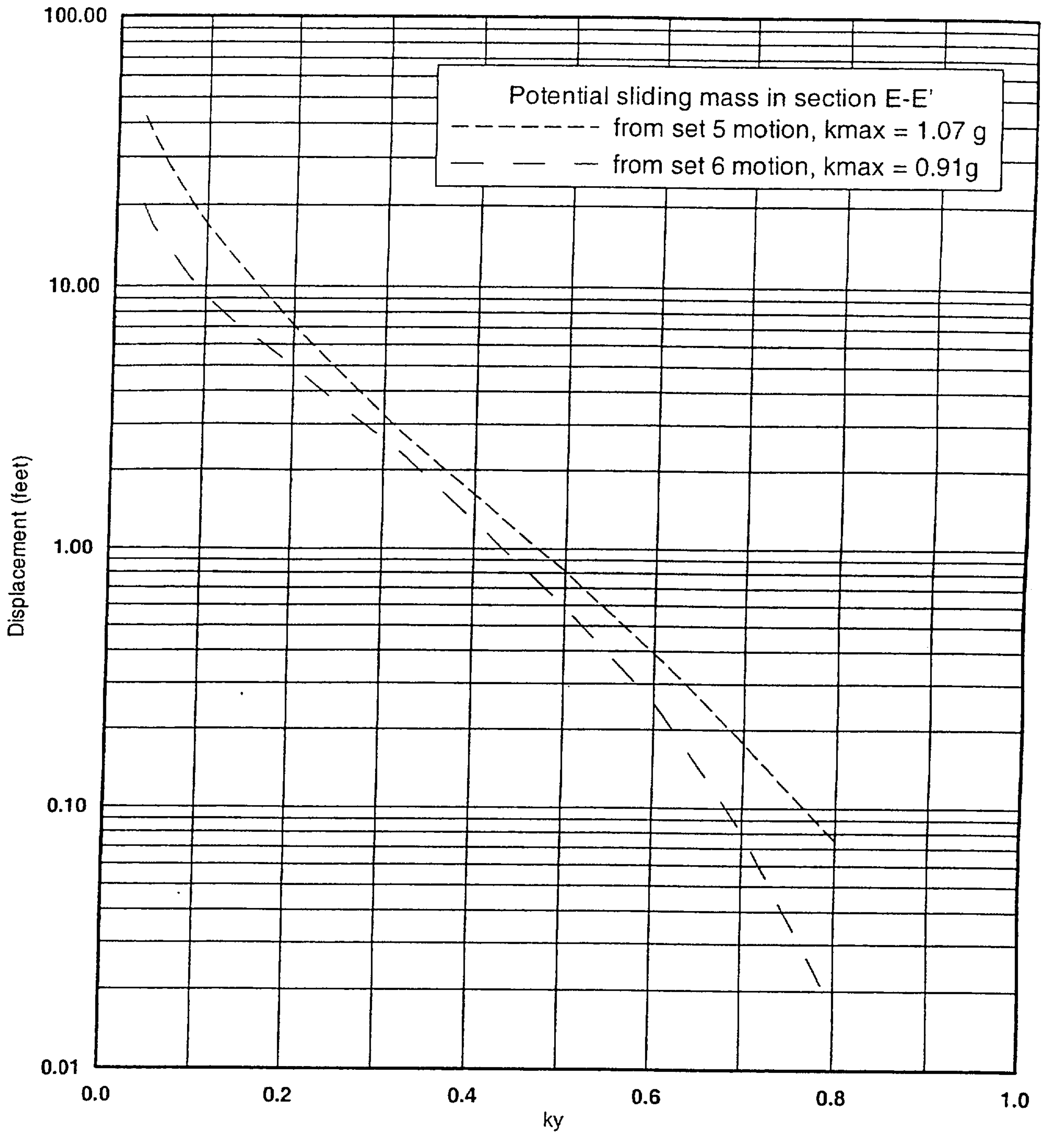


Figure 7. Permanent displacement versus yield acceleration from average acceleration time histories, section E-E'.

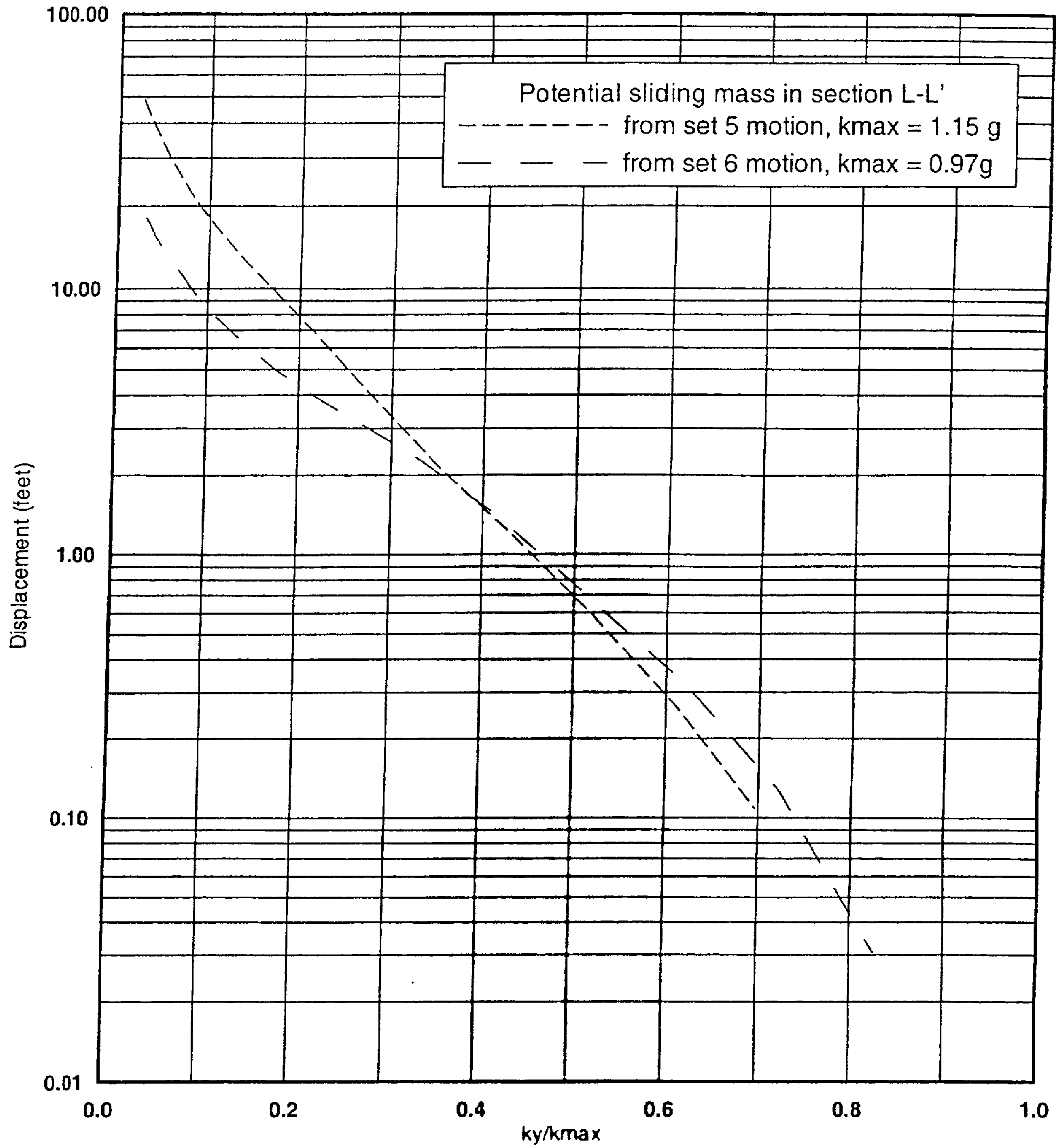


Figure 8. Permanent displacement versus yield acceleration ratio from average acceleration time histories, section L-L'.

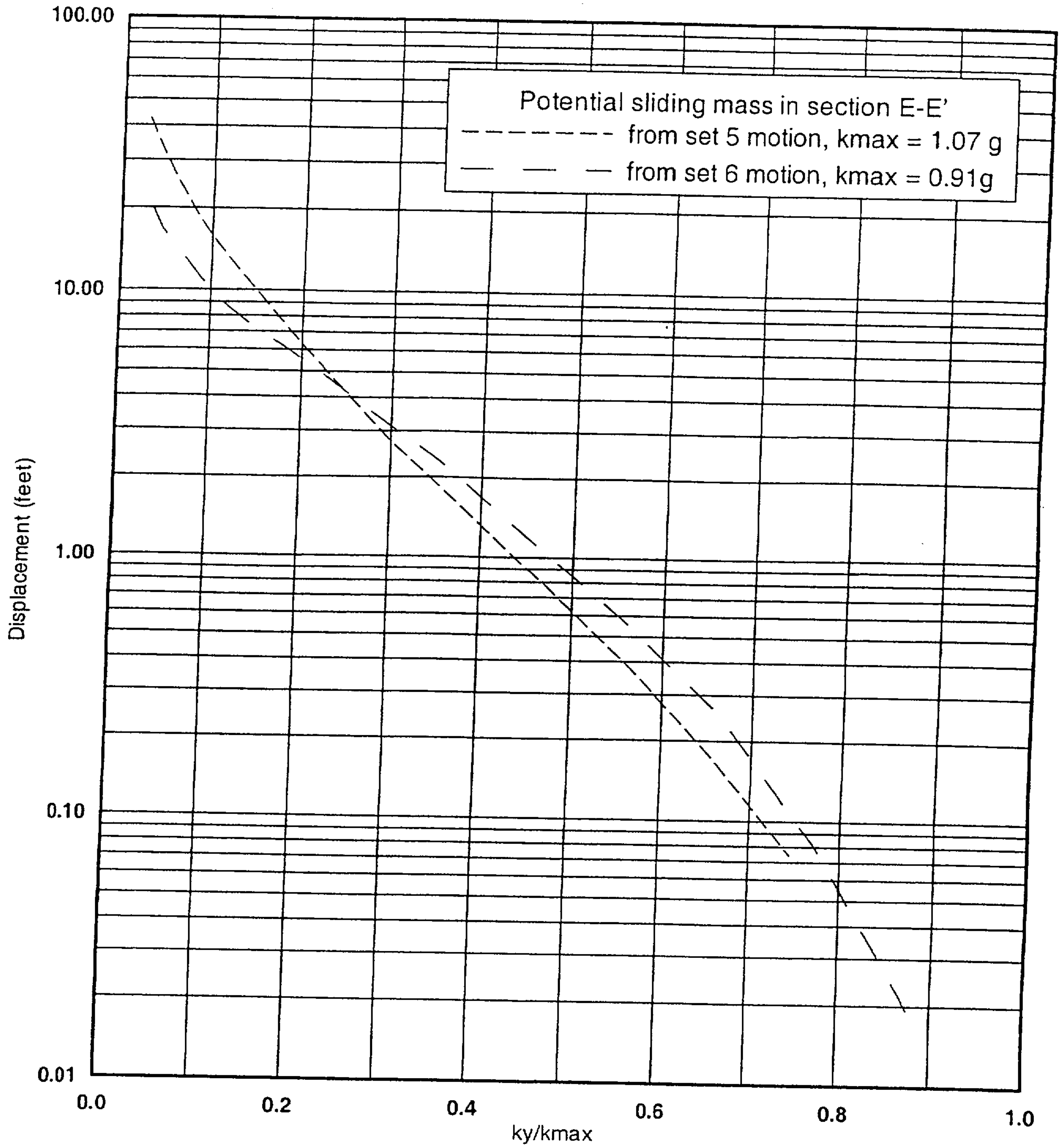


Figure 9. Permanent displacement versus yield acceleration ratio from average acceleration time histories, section E-E'.

ATTACHMENT 1

Pacific Gas and Electric Company

CALCULATION PACKAGE GEO.DCPP.01.30
REVISION 0
Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

Dr. Faiz Makdisi
Geomatrix Consultants
2101 Webster Street
Oakland, CA 94612

September 28, 2001

Re: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses

DR. MAKDISI:

This is to confirm transmittal of inputs related to slope stability analyses you are scheduled to perform for the Diablo Canyon Power Plant (DCPP) Independent Spent Fuel Storage Installation (ISFSI) under the Geomatrix Work Plan entitled "Laboratory Testing of Soil and Rock Samples, Slope Stability Analyses, and Excavation Design for the Diablo Canyon Power Plant Independent Spent Fuel Storage Installation Site."

Inputs transmitted include:

Drawing entitled "Figure 21-19, Cross Section I-I'," dated 9/27/01, labeled "Draft," and transmitted to you via overnight mail under cover letter from Jeff Bachhuber of WLA and dated 9/27/01.

Time histories in Excel file entitled "time_histories_3comp_rev1.xls," dated 8/17/2001, file size 3,624 KB, which I transmitted to you via email on 8/17/2001.

Please confirm receipt of these items and forward confirmation to me in writing.

Please note that both these inputs are preliminary until the calculations they are part of have been fully approved. At that time, I will inform you in writing of their status. These confirmation and transmittal letters are the vehicles for referencing input sources in your calculations.

Although the Work Plan does not so state, as you are aware all calculations are required to be performed as per Geosciences Calculation Procedure GEO.001, entitled "Development and Independent Verification of Calculations for Nuclear Facilities," revision 3. All of your staff assigned to this project have been previously trained under this procedure.

I am also attaching a copy of the Work Plan. Please make additional copies for members of your staff assigned to this project, review the Work Plan with them, and have them sign Attachment 1. Please then make copies of the signed attachment and forward to me.

If you have any questions, feel free to call.

Thanks.

Rob White

ROBERT K. WHITE

Attachment

cc: Chris Hartz

ATTACHMENT 2

Pacific Gas and Electric Company
Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

PG&E

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 12, 2001

Re: Forwarding of Approved Plan and Cross Sections D-D', E-E', and L-L' for DCPP ISFSI Transport Route Stability Analyses

DR. MAKDISI:

Please find enclosed the following approved plan and cross sections from Geosciences Calculation GEO.DCPP.01.21, rev. 1:

Figure 21-3, Geologic Map of the ISFSI Site and Transport Route Vicinity
Figure 21-17a, Cross Section D-D' through Patton Cove Landslide
Figure 21-18a, Cross Section E-E'
Figure 21-25, Cross Section L-L'

for your use in DCPP ISFSI transport route stability analyses. These figures supersede those transmitted to you in draft form by Rich Koehler of William Lettis Associates on October 25, 2001.

Also for your use, we have determined the azimuth of each section from Figure 21-3, as follows:

Section D-D': 38 degrees
Section E-E': 34 degrees
Section L-L': 67 degrees

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

Enclosures

Security-Related Information – Withhold Under 10 CFR 2.390.

Security-Related Information – Withhold Under 10 CFR 2.390.

ATTACHMENT 3

Faiz Makdisi

From: Jeff Bachhuber [bachhuber@lettis.com]
Sent: Friday, November 09, 2001 9:42 AM
To: Page, William
Cc: FMakdisi@geomatrix.com
Subject: AZIMUTHS FOR ANALYTICAL CROSS SECTIONS - ISFSI

Nov. 9, 2001

Bill:

Per your request, we have calculated azimuths for cross sections used for stability analyses for the DCPP ISFSI project. The azimuths were determined using a protractor and the WLA (2001) Geologic Map of the ISFSI Site and Transport Route Vicnity (Figure 21-3 from Calculation Package 21). The following azimuths were determined:

Section D-D': above transport route - 029°
below transport route - 038°
average total section above and below transport route - 032°

Section E-E': below elevation 600' - 035°
above elevation 600' - 019°

Section I-I': 300°

Section L-L': 067°

Please call me if you have any questions regarding these azimuths, or require additional information.

WILLIAM LETTIS & ASSOCIATES, INC.

Jeff Bachhuber
Jeff Bachhuber
William Lettis & Associates, Inc.
1777 Botelho Dr., STE 262
Walnut Creek, CA 94596
bachhuber@lettis.com
(925) 256-6070 TEL
(925) 256-6076 FAX

ATTACHMENT 4

WLA
William Lettis & Associates, Inc.
1777 Botelho Drive, Suite 262, Walnut Creek, California 94596
Voice: (925) 256-6070 FAX: (925) 256-6076

MEMORANDUM

TO: Dr. Faiz Makdisi - Geomatrix Consultants, Inc.
FROM: Jeff L. Bachhuber - William Lettis & Associates, Inc.
DATE: August 23, 2001

RE: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project

FAIZ:

This memorandum provides a revised strike azimuth of 338° for the Hosgri fault for evaluation of ground motion directional components for slope stability analyses at the PG&E DCPP ISFSI site. The revised azimuth presented in this memorandum supercedes the previous estimated azimuths (328° to 335°) presented in our memorandum dated August 8, 2001, and is based on a re-evaluation of fault maps in the PG&E LTSP (1988), and ISFSI project Calculation Package GEO.01.21.

The revised estimated average strike for the Hosgri fault nearest the ISFSI site (between Morro Bay and San Luis Bay) is 338°. Figure 21-23 of Calculation Package GEO.01.21, which previously showed an azimuth of 340° for the Hosgri fault, will be revised to correspond to this re-interpreted average strike. Discrete faults and local reaches of the fault zone exhibit variations in strike azimuth between about 328° and 338°, but the average overall strike of 338° is believed to be the best approximation for the ground motion modeling.

Please call me if you have any questions or require further input for this issue.

Jeff Bachhuber

Cc: Rob White/Bill Page - PG&E Geosciences

ATTACHMENT 5

PG&E

Pacific Gas & Electric Company
Geosciences Department

P.O. Box 770000, Mail Code ...
San Francisco, CA 94177
Fax: (415) 973-5778

TELEFAX COVER SHEET

Date: Oct 18 '01

Number of pages including cover sheet: 3

To: Faiz Makdisi
Company: Geomatrix

Phone: (510) 663-4100
Fax: (510) 663-4141
cc:

From: Joseph Sun
Company: PG&E

Phone: (415) 973-2460
Fax: (415) 973-5778

REMARKS: ☐ Per request ☐ For review ☐ Reply ASAP ☐ Please comment

Faiz,

The fault parallel with fling ground motions positive is to the south east. We will follow up with a formal transmittal of the calc package to you

Joseph

c:\data\forms\fax cover.doc

PACIFIC GAS AND ELECTRIC COMPANY
GEOSCIENCES DEPARTMENT
CALCULATION DOCUMENT

Calc Number GEO.DCPP.01.14
Revision 1
Date October 15, 2001
Calc Pages: 26
Verification Method: A
Verification Pages: 17 & 8 Attachments

TITLE: Development of time histories with Fling

PREPARED BY: [signature] DATE October 15, 2001

Norman Abrahamson — Printed Name
Geosciences — Organization

VERIFIED BY: [signature] DATE October 15, 2001

Joseph Sun — Printed Name
Geosciences. — Organization

APPROVED BY: [signature] DATE 10/15/01

Lloyd Cluff — Printed Name
Geosciences — Organization

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. 1725
STATE OF CALIFORNIA

Expires: 12/31/02

REGISTERED GEOLOGIST
LLOYD S. CLUFF
No. EG567
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Expires: 12/31/02

6. BODY OF CALCULATIONS

Step 1: S-wave arrival times

The approximate arrival times of the S-waves is estimated by visual inspection of the velocity time histories (Figures 1, 2, 3, 4, and 5). The selected arrival times are listed in Table 6-1.

Table 6- 1. Time of Fling

Set	Reference Time History	Approximate Arrival time of S-waves	Arrival Time of fling (t_1) (sec)	Polarity*
1	Lucerne	8.0	7.1	-1
2a	Yarimca	9.0	8.5	-1
3	LGPC	4.0	3.4	-1
5	El Centro (1940)	1.5	0.0	1
6	Saratoga	4.5	3.7	-1

* The polarity is applied to the fault parallel time history from calculations GEO.DCPP.01.13 (rev 1) to cause constructive interference between the S-wave and the fling (eq. 5-2).

A fling arrival time is selected by visual inspection of the interference of the velocity of the transient motion and the fling (Figures 1, 2, 3, 4, and 5). The selected fling arrival time are listed in Table 6-1.

Since DCPP is on the east side of the Hosgri fault and the fault has right-lateral slip, the permanent tectonic deformation at the site will be to the southeast. In the time histories the fling has a positive polarity. Since the tectonic deformation will be to the southeast, the positive direction of the fault parallel time history is defined to the southeast.

Step 2: Fling Time History

Using the values of A, ω, and T_{fling} given in input 4-1, and the values of t_1 given in Table 6-1, the fling time history is determined using eq. (5-1). The computed fling time histories for the 5 sets are shown in Figures 1, 2, 3, 4, and 5.

ATTACHMENT 6

CALCULATION PACKAGE GEO.DCPP.01.30
REVISION 0

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

PG&E

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

October 25, 2001

Re: Input parameters for calculations

DR. MAKDISI:

As required by Geosciences Calculation Procedure GEO.001, entitled "Development and Independent Verification of Calculations for Nuclear Facilities," rev. 4, I am providing you with the following input items for your use in preparing calculations.

1. The shear wave velocity profiles obtained in borings BA98-1 and BA98-3 in 1998 are presented in Figure 21-42, attached, of Calculation GEO.DCPP.01.21, entitled "Analysis of Bedrock Stratigraphy and Geologic Structure at the DCPP ISFSI Site," rev. 0, and can be so referenced. These profiles were previously presented in Figure 10 of the WLA report entitled "Geologic and Geophysical Investigation, Dry Cask Storage Facility, Borrow and Water Tank Sites," dated January 5, 1999.

2. The average unit weight of rock obtained from the hillside has been determined to be 140 pounds per cubic foot, as documented in a data report entitled "Rock Engineering Laboratory Testing - GeoTest Unlimited."

3. Regarding the time histories provided to you on 8/17/01, since the tectonic deformation will be to the southeast, the positive direction of the fault parallel time history is defined as to the southeast, as described in Geosciences Calculation GEO.DCPP.01.14, entitled "Development of Time Histories with Fling," rev. 1, page 4.

4. The source of the shear modulus and damping curves are Figures Q19-22 and Q19-23, attached, from PG&E, 1989, Response to NRC Question 19 dated December 13, 1988, and can be so referenced.

Regarding format of calculations, please observe the following:

Contents of CD-ROMs attached to calculations should be listed in the calculation, including title, size, and date saved associated with each file on the CD-ROM. If the number of files is considerable, a simple screen dump of the CD-ROM contents is sufficient.

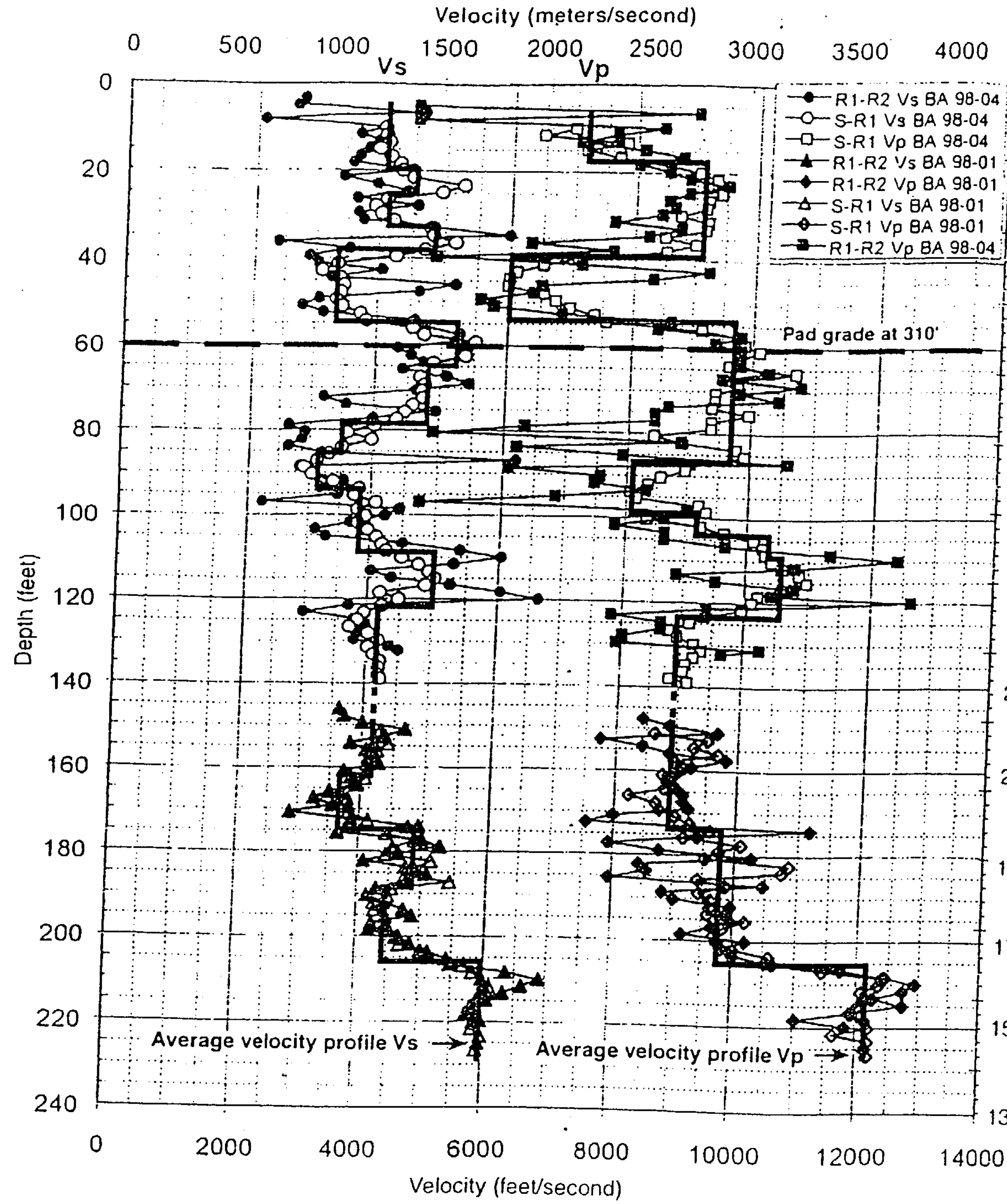
If you have any questions regarding the above, please call me.

Robert K White

ROBERT K. WHITE

Attachments

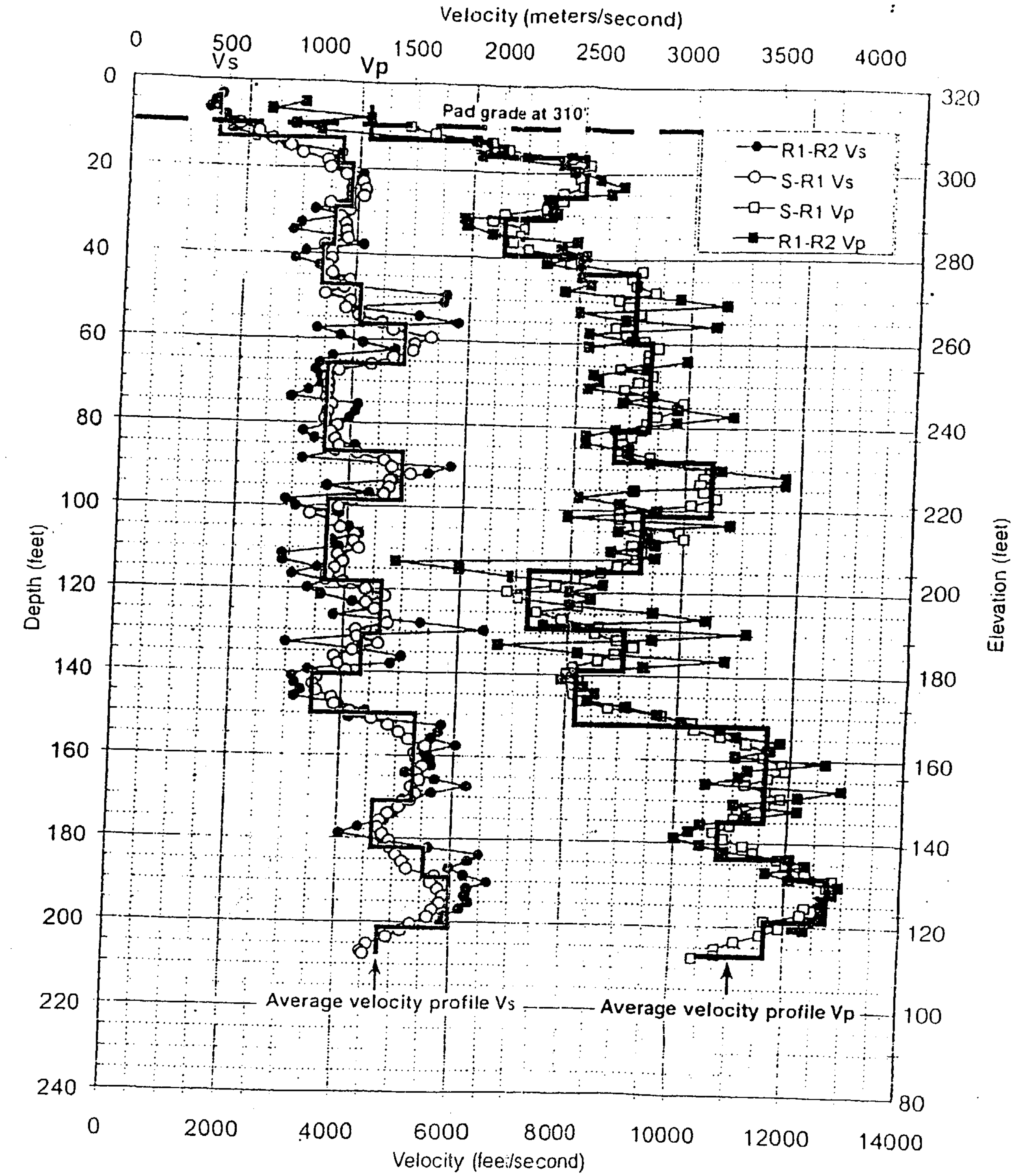
Borings 98BA-1 and 98BA-4



Note: Average velocity profiles interpreted from data.

R1 - R2 = Receiver-to-receiver velocity (3.3-foot spacing)
S-R1 = Source-to-receiver velocity (10.3-foot spacing)

Boring 98BA-3



Modified from GeoVision (1998), DCPP ISFSI SAR Section 2.6 Topical Report Appendix C

DIABLO CANYON ISFSI

FIGURE 21-42
ISFSI SITE SUSPENSION LOGS AND INTERPRETED AVERAGE SEISMIC VELOCITIES

GEO.DCPP.01.21 REV 0

October 15, 2001

ATTACHMENT 7

Pacific Gas and Electric Company

Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

PG&E

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

October 31, 2001

Re: Confirmation of preliminary inputs to calculations for DCPP ISFSI site

DR. MAKDISI:

A number of inputs to calculations for the DCPP ISFSI slope stability analyses have been provided to you in a preliminary fashion. This letter provides confirmation of those inputs in a formal transmittal. A description of the preliminary inputs and their formal confirmation follow.

Letter to Faiz Makdisi from Rob White dated June 24, 2001. Subject: Recommended rock strength design parameters for DCPP ISFSI site slope stability analyses.

This letter recommended using $\phi = 50$ degrees for the preliminary rock strength envelope in your stability analyses, and indicated that this value would be confirmed once calculations had been finalized and approved. Calculations GEO.DCPP.01.16, rev. 0, and GEO.DCPP.01.19, rev. 0, are approved and this recommended value is confirmed.

Letter to Faiz Makdisi from Rob White dated September 28, 2001. Subject: Confirmation of transmittal of inputs for DCPP ISFSI slope stability analyses.

This letter provided confirmation of transmittal of cross section I-I' and time histories, and indicated that these preliminary inputs would be confirmed once calculations had been approved. Calculation GEO.DCPP.01.21, rev. 0, is approved and section I-I' as described in the September 28 letter is confirmed. A copy of the figure from the approved calculation is attached. Calculations GEO.DCPP.01.13, rev. 1, and GEO.DCPP.01.14, rev. 1, are both approved and time histories as described in the September 28 letter are confirmed. A CD of the time histories from the approved calculations is attached.

Email to Faiz Makdisi from Joseph Sun dated October 24, 2001. Subject: Ground motion parameters for back calculations.

This email provided input for a back calculation to assess conservatism in clay bed properties in the slope. Inputs included maximum displacement per event of 4 inches and a factor of 1.6 with which to multiply ground motions for use in the back calculation analysis. This letter confirms those input values, with the following limitation: these values have not been developed under an approved calculation, therefore should not be used to directly determine clay bed properties for use in forward analyses, but may be used for comparative purposes only, to assess the level of conservatism in those clay bed properties determined in approved calculations

Letter to Faiz Makdisi from Jeff Bachhuber dated October 10, 2001. Subject: Transmittal of Revised Rock Mass Failure Models – DCPP ISFSI Project.

This letter provided you with figures indicating potential rock mass failure models as superimposed on section I-I'. This letter confirms PG&E approval to use these models in your analyses. These figures are labeled drafts and are currently being finalized in a revision to Calculation GEO.DCPP.01.21. Once this revision and the included figures have been approved, I will inform you in writing of their status.

Rob White

ROBERT K. WHITE

Attachments

ATTACHMENT 8

Pacific Gas and Electric Company
Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 1, 2001

Re: Confirmation of additional inputs to calculations for DCPP ISFSI site

DR. MAKDISI:

Additional inputs to calculations for the DCPP ISFSI slope stability analyses have been provided to you by Jeff Bachhuber of William Lettis Associates. This letter provides confirmation of our acceptance of those inputs in a formal transmittal. A description of those additional inputs and their formal acceptance follow.

Letter to Faiz Makdisi from Jeff Bachhuber dated August 3, 2001. Subject: Ground Motion Directional Components.

This letter recommended using an azimuth of 302 degrees plus or minus 10 degrees for the orientation of the most likely failure surfaces, coinciding with Section I-I'. We concur with this recommendation based on the discussion on page 53 of the approved Calculation GEO.DCPP.01.21, rev. 0, and verification of the orientation of Section I-I' on Calculation Figure 21-4, attached.

Letter to Faiz Makdisi from Jeff Bachhuber dated August 23, 2001. Subject: Revised Estimates for Hosgri Fault Azimuth, DCPP ISFSI Project.

This letter recommended using an azimuth of 338 degrees for the orientation of the average strike of the Hosgri fault. We concur with this recommendation, based on verification of the orientation as presented in the LTSP plates and as shown on Figure 21-36, attached, of Calculation GEO.DCPP.01.21, rev. 0.

Rob White

ROBERT K. WHITE

Attachments

Security-Related Information – Withhold Under 10 CFR 2.390.

ATTACHMENT 9

Pacific Gas and Electric Company
Geosciences
245 Market Street, Room 418B
Mail Code N4C
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

DR. FAIZ MAKDISI
GEOMATRIX CONSULTANTS
2101 WEBSTER STREET
OAKLAND, CA 94612

November 19, 2001

Re: Transmittal of additional inputs for DCPP ISFSI Transport Route Analysis

DR. MAKDISI:

As part of the scope of your analysis of the stability of the transport route for the DCPP ISFSI, you are assessing stability of the route at various sections using both unreduced ground motions previously transmitted to you (reference my October 31 2001 letter to you) and reduced ground motions based on incorporating results of a probabilistic seismic hazard analysis and the estimated exposure interval of the transporter on the route. A probabilistically reduced peak bedrock ground acceleration of 0.15g has been derived in calculation GEO.DCPP.01.02, and this value has been approved for further analyses. Accordingly, please scale the peak acceleration of the unreduced ground motions to this level for your transport route analyses.

In addition, you are assessing the stability of transport route road fill wedges at reduced ground motion levels and with the transporter load previously transmitted to you (reference my November 5 2001 letter to you). The exact subsurface configuration of any fill wedges along the access road is currently unknown, and is shown in only a general way on sections provided to you (reference my November 12 2001 letter to you) based on general descriptions provided in the road construction specification. However, given that the density of any compacted fill derived from the native material is likely to be at or above the density of underlying native material, fill strength is likely to be comparable to the native material, and the exact configuration of the fill is therefore not of consequence. Please proceed with near-surface stability analyses with this assumption.

If you have any questions regarding this information, please call.

Rob White

ROBERT K. WHITE

ltr2fm10.doc:rkw:11/19/01