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DRAFT

MEMORANDUM

DATE: January 17, 2002

TO: Mr. Jim Thomson, P.E., HNTB Corporation

FROM: Doug Lindquist, P.E., Reda Mikhail, P.E., Michael Bailey, P.E.

RE: **Third Runway FLAC Analysis of MSE Walls**
4978-40

CC: Mr. Robert Millar, P.E., HNTB Corporation
Mr. John Sankey, P.E., RECo

This memo presents results of Hart Crowser's analyses using the finite difference model, FLAC, for three proposed mechanically stabilized earth (MSE) retaining walls for the Third Runway project at Seattle-Tacoma International Airport.

SUMMARY

Results of the analyses presented herein provide an independent verification of acceptable performance for the Third Runway MSE walls that are designed in accordance with AASHTO.

Four wall sections were selected for analysis to represent various soil conditions, and the range of wall and slope heights for the three proposed MSE walls. The purpose of the FLAC analyses was to provide additional information to the design team on anticipated wall performance to supplement the AASHTO design analyses. Results of the FLAC analyses are not intended to replace design analyses accomplished in accordance with AASHTO code.

The FLAC analyses show generally similar wall performance (stresses and displacements) will occur regardless of when liquefaction occurs relative to the start and end of shaking. Dynamic response varies somewhat with stiffness of the modeled soil elements. This was of particular interest because soils at the site have: 1) varying resistance to liquefaction and 2) potential variability in the timing of the onset of liquefaction relative to the start of shaking. The analyses indicated that softening of the foundation soil due to liquefaction reduced the magnitude of shear stress transferred into the embankment soils. Generally, the magnitude

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of wall displacement and stress in the MSE reinforcing was reduced when liquefaction occurred at the beginning of shaking, compared to liquefaction that follows the end of shaking.

The wall sections analyzed show levels of seismic deformation generally less than 1 foot. Some of the liquefied soils beyond the limits of the runway embankment have predicted displacements of 2 to 3 feet.

Predicted stresses in the reinforcing elements did not exceed the yield strength of the reinforcement for any of the cases analyzed with FLAC. While in some cases the stress in some of the reinforcing strips exceeds the limiting value (0.55 times yield) allowed by AASHTO, the magnitude and extent of this is so limited that it falls within the performance criteria described below. In our opinion, the FLAC results should be used to focus further discussions with the design team, and not as the sole basis for final design.

In our opinion, the FLAC analyses demonstrates that the proposed MSE design satisfies the seismic performance objectives previously presented to the Corps of Engineers (Hart Crowser 2001b).

- The MSE walls and embankment fill will remain stable. Some deformation is acceptable (up to a few feet) provided stress in the retaining wall materials are typically below the value allowed by the AASHTO code;

- There will be no wetland or creek impacts due to seismic shaking of the embankment or MSE walls; and

- There will be no operational impacts to the new runway related to movement of the embankment slopes and walls during an earthquake.

INTRODUCTION TO FLAC ANALYSES

FLAC analyses were accomplished to provide information on wall performance at the end of construction, and during and after a design level earthquake. Results of the analyses that are presented include horizontal and vertical deformations of the walls and areas adjacent to the walls, and stresses in the reinforcing for various load conditions.

Seismic liquefaction due to the design level earthquake is anticipated to occur at or near three of the four sections analyzed. The effect of the development of liquefaction relative to the start and end of shaking is encompassed by the range of conditions presented herein.

Soil Properties

The soil profile, shear strength, and unit weight parameters for each of the FLAC cross sections were based on the parameters used in the limit equilibrium slope stability analyses. The soil moduli for glacial soils were based on the shear wave velocity measurements. The soil moduli for the embankment fill and non-glacial soils were based on empirical correlations and our experience. After comparing results of preliminary analyses, these FLAC analysis are based on our best estimate of shear moduli. We discussed the effect of variation of shear moduli on predicted deformations and reinforcement stresses in our memorandum dated December 20, 2001 (Hart Crowser 2001c). Table 1 summarizes the soil property values that were used.

Wall Sections

FLAC analyses were accomplished for four MSE wall sections selected to represent the variable range of wall and slope heights for the project as a whole, see Table 2.

Structural Properties

Components of the RECo wall design included in the FLAC analysis consist of the concrete facing panels and steel reinforcement strips extending from the back of the concrete panels some length into the soil mass. The concrete panels are typically 4.92 feet tall, 4.92 feet wide, and 5-1/2 to 7 inches thick (typically the 7-inch panels are used where wall stresses are greater or equal to 2.55 ksf.) Layers of reinforcement (one layer per facing panel) were modeled to extend from the facing panels into the soils mass. Hart Crowser assigned length, tensile, and pull-out capacity properties to each reinforcing layer to represent the actual length, cross section, and number of reinforcing strips for each panel in RECo's design for these sections. For three of the sections the reinforcing was modified to incorporate the changes recommended to meet target factor of safety criteria, as discussed in our memo dated January 9, 2002. The analysis for section 105+20 is based on RECo's original 50x4 mm reinforcing instead of the 50x6 mm strips recommended by Hart Crowser. The result of this is likely less deformation but somewhat higher stress in the reinforcing, but we do not consider this would change our recommendation. Also, dimensions of the steel reinforcement were reduced by 1.008 mm per side to account for corrosion during the 100-year design life span per AASHTO recommendations. This is a conservative assumption for

the end of construction case, but it allows for direct comparison of stresses between the cases. Table 3 presents the concrete facing properties and Table 4 presents the steel reinforcement properties used in the FLAC analyses.

Dynamic Parameters

The 10 percent probability of exceedence in 50 years (475-year return period) seismic event was selected as the seismic basis of design event. Hart Crowser developed a response spectrum for this level of event based on the results of a site-specific probabilistic seismic hazard analysis (see Hart Crowser 2001a). Professor Steven L. Kramer developed synthetic seismic time histories (earthquake record) for the FLAC analyses. After analysis of several alternatives, a time history referred to as Motion E was selected for final design. Motion E was input into the 2-D ground response analysis program QUAD4 as an outcrop motion at an equivalent bedrock depth of 250 feet. For each FLAC model cross section, a corresponding QUAD4 analysis was used. In each case, an acceleration time history was obtained from QUAD4 at an elevation corresponding to the base of the FLAC model for input into dynamic FLAC analyses.

With regard to timing of liquefaction, we considered two scenarios:

- Liquefaction would occur at the beginning of shaking; and
- Liquefaction would follow the end of shaking.

To assess the range in wall performance considering variation in potential timing of the liquefaction relative to shaking, Hart Crowser modeled a range in conditions as indicated on Figure 1.

Results

Displacement of the representative MSE sections and stresses in the reinforcing were determined for the following conditions:

1) At the end of staged construction;

2) During ground shaking without liquefaction;

3) At the end of ground shaking without liquefaction;

4) After liquefaction occurred at the end of ground shaking;

5) During ground shaking, when liquefaction occurred at the beginning of shaking; and

6) At the end of shaking, when liquefaction occurred at the beginning of shaking.

The analysis of permanent displacements and reinforcement stresses (i.e. cases 3 and 6 above) were determined after equilibrium occurred, after the actual end of shaking, to enable inclusion of creep effects that could occur due to lower residual soil strength and stiffness after an earthquake.

Results are presented in the tables and figures listed on Figure 1. Results for each wall section are presented separately (figures following tables for each section).

- Negative horizontal displacement contours indicate elongation or outward displacement (toward the "creek" away from the body of the fill); values of positive horizontal displacement contours indicate compression.

- Negative vertical displacement contours indicate settlement; values of positive vertical displacement contours indicate heave.

- Positive stress values indicate tension in the reinforcing, negative values refer to compression.

It should be noted the FLAC models were constructed as large as practically possible to reduce "edge effects" on the wall and the part of the embankment adjacent to the wall. The deformations in the immediate vicinity of the model boundaries, however, should be ignored.

Attachments:
References
Table 1 - Soil Properties Used in Analyses
Table 2 - Location and Geometry of the Wall Sections for FLAC Analyses
Table 3 - Concrete Facing Properties Used in FLAC Analyses
Table 4 - Steel Reinforcing Element Properties Used in FLAC Analyses
Table 5 - NSA Wall, Station 105+20, Reinforcement Stresses - End of Staged Construction

Attachments (Continued):

Table 6 - NSA Wall, Station 105+20, Cumulative Horizontal Displacements in Feet - End of Staged Construction

Table 7 - NSA Wall, Station 105+20, Cumulative Vertical Displacements in Feet - End of Staged Construction

Table 8 - NSA Wall, Station 105+20, Maximum Reinforcement Stresses - During Shaking Without Liquefaction

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Table 10 - NSA Wall, Station 105+20, Permanent Horizontal Displacements in Feet - End of Shaking Without Liquefaction

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Table 31 - NSA Wall, Station 110+47, Permanent Horizontal Displacements in Feet - End of Shaking With Concurrent Liquefaction

Table 32 - NSA Wall, Station 110+47, Permanent Vertical Displacements in Feet - End of Shaking With Concurrent Liquefaction

Table 33 - West Wall, Station 180+00, Reinforcement Stresses - End of Staged Construction

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Table 35 - West Wall, Station 180+00, Cumulative Vertical Displacements in Feet - End of Staged Construction

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Table 38 - West Wall, Station 180+00, Permanent Horizontal Displacements in Feet - End of Shaking Without Liquefaction

Table 39 - West Wall, Station 180+00, Permanent Vertical Displacements in Feet - End of Shaking Without Liquefaction

Table 40 - West Wall, Station 180+00, Permanent Reinforcement Stresses - End of Shaking Followed by Liquefaction

Table 41 - West Wall, Station 180+00, Permanent Horizontal Displacements in Feet - End of Shaking Followed by Liquefaction

Attachments (Continued):

Attachments (Continued):

Figure 7 - NSA Wall, Station 105+20, Permanent Vertical Displacements - End of Shaking Followed by Liquefaction

Figure 8 - NSA Wall, Station 105+20, Permanent Horizontal Displacements - End of Shaking with Concurrent Liquefaction

Figure 9 - NSA Wall, Station 105+20, Permanent Vertical Displacements - End of Shaking with Concurrent Liquefaction

Figure 10 - NSA Wall, Station 110+47, Cumulative Horizontal Displacements - End of Staged Construction

Figure 11 - NSA Wall, Station 110+47, Cumulative Vertical Displacements - End of Staged Construction

Figure 12 - NSA Wall, Station 110+47, Permanent Horizontal Displacements - End of Shaking Without Liquefaction

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Figure 14 - NSA Wall, Station 110+47, Permanent Horizontal Displacements - End of Shaking Followed by Liquefaction

Figure 15 - NSA Wall, Station 110+47, Permanent Vertical Displacements - End of Shaking Followed by Liquefaction

Figure 16 - NSA Wall, Station 110+47, Permanent Horizontal Displacements - End of Shaking with Concurrent Liquefaction

Figure 17 - NSA Wall, Station 110+47, Permanent Vertical Displacements - End of Shaking with Concurrent Liquefaction

Figure 18 - West Wall, Station 180+00, Cumulative Horizontal Displacements - End of Staged Construction

Figure 19 - West Wall, Station 180+00, Cumulative Vertical Displacements - End of Staged Construction

Figure 20 - West Wall, Station 180+00, Permanent Horizontal Displacements - End of Shaking Without Liquefaction

Figure 21 - West Wall, Station 180+00, Permanent Vertical Displacements - End of Shaking Without Liquefaction

Figure 22 - West Wall, Station 180+00, Permanent Horizontal Displacements - End of Shaking Followed by Liquefaction

Figure 23 - West Wall, Station 180+00, Permanent Vertical Displacements - End of Shaking Followed by Liquefaction

Figure 24 - West Wall, Station 180+00, Permanent Horizontal Displacements - End of Shaking with Concurrent Liquefaction

Attachments (Continued):

Figure 25 - West Wall, Station 180+00, Permanent Vertical Displacements - End of Shaking with Concurrent Liquefaction

Figure 26 - South Wall, Station 147+25, Cumulative Horizontal Displacements - End of Staged Construction

Figure 27 - South Wall, Station 147+25, Cumulative Vertical Displacements - End of Staged Construction

Figure 28 - South Wall, Station 147+25, Permanent Horizontal Displacements – End of Shaking

Figure 29 - South Wall, Station 147+25, Permanent Vertical Displacements – End of Shaking

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Hart Crowser 2000. Draft Memorandum: Use of Advanced Testing Data, Sea-Tac Third Runway Project, SeaTac, Washington, August 28, 2000.

Hart Crowser 2001a. Additional Information on the Seismic Design. January 25, 2001.

Hart Crowser 2001b. Geotechnical Summary Report, Third Runway Embankment and MSE Retaining Walls, Sea-Tac International Airport, November 2, 2001

Hart Crowser 2001c. Effect of Shear Modulus on Deformations and Reinforcing Stresses of MSE Walls, Third Runway Project. December 20, 2001.

Hart Crowser 2002. Stability Review of RECo 30% Design, Sea-Tac Third Runway Embankment Project, January 9, 2002.

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Table 1 - Soil Properties Used in Analyses

soil units	Unit wt (pcf)	ϕ'(degrees)	c' (psf) [1]	dilation angle	S_u or S_r psf	SECANT Shear Modulus (psf x 1e6) [based on Gmax/Gsecant=3.6] 0.0 ft	50 ft RM	100 ft RM	150 ft RM	υ
1 -Embankment Fill	*135*	35	10	5	-	G^3 is based on $K_{2,max}$=75 (min G_{secant}=0.6e6)[5]				0.35
2 -Reinforced fill	*140*	37	10	7	-					0.35
3- Drainage blanket	*140*	37	10	7.01	-					0.35
4- Ground Improvement	*140*	37	10	7.02	-					0.35
5- loose to medium dense silty sand					-					
static	*125*	32	10	2		G^3 is based on $K_{2,max}$=39 (min G_{secant}=0.15e6)[6]				0.35
seismic										
post earthquake - No liq										
post earthquake - liq.					S_r Based on Liq. Analysis [7]	G^4 is based on Sr and $(N_1)_{60}$				0.495
6- med. dense to dense sand	*130*	35	10	5.01	-	G^3 is based on $K_{2,max}$=51 (min. G_{secant}=0.35e6)[7]				0.35
7- dense to very dense silty sand	*135*	37	10	7.03	-					0.35
8- Till	*140*	40	250	10	-	1.4	2.8	3.9	4.4	0.35
9- Very stiff to Hard Silt										
static	*120*	32	10	0.02	-	0.7	1.4	1.95	2.2	0.35
seismic		-	-	-	4000					0.495
post earthquake		-	-	-	3200					0.495
10 - Normally to slightly consolidated silt & clay										
static	*115*	32	10	0.01						0.35
seismic		-	-	-	0.23 σ'$_v$ (min 1000 psf)	69 * σ$_v$' (min. G_{secant} = 0.1e6 psf)				0.495
post earthquake - No liq		-	-	-	0.8 * su (seismic case)					0.495
post earthquake - liq.		0	0	0	0.11 * σ$_v$'	22 * σ$_v$'				0.495
11- Peat										
static	*110*	15	10	0.03	-					0.4
seismic		0	0	0	0.23 σ'$_v$ (min. site specific)	39 * σ$_v$' (min = 0.05e6)				0.495
post earthquake		0	0	0	0.8 * su (seismic case)					0.495

Notes

1 c' =10 psf is only for FLAC model, zero cohesion was used in the limit equilibrium analyses.

2 Use drained strength if it is less than residual strength

3 G(secant)= Gur (pressuremeter)=1000*sigma_m'^0.5*$K_{2,max}$ /(3.6); where (3.6) accounts for reduction associated with shear strain- Reference: Kramer (1996), pp. 231-233

4 G(large strain)= Sr/γ_{hm} ; where γ_{hm} is based on $(N_1)_{60}$ Reference: Kramer (1996), p. 457

5 Based on min. Shear Wave Velocity=700 ft/sec & G_{max} /G_{secant}=3.6

6 Based on min. Shear Wave Velocity=400 ft/sec & Gmax/Gsecant=3.6

7 Based on min. Shear Wave Velocity = 550 ft/sec & Gmax/Gsecant=3.6

Bulk Modulus, K = 2 G / 3 * (1+m)/(1-2*m)

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AR 053261

Table 2 - Location and Geometry of the Wall Sections for FLAC Analyses

Station	Location	Height of Slope Above Wall in Feet	Height of MSE Wall in Feet	Height of Slope Below Wall in Feet
105+20	NSA Wall	6	31	61
110+47	NSA Wall	0	86	13
180+00	West Wall	20	134	11
147+25	South Wall	28	12.5	4

Table 3 - Concrete Facing Properties Used in FLAC Analyses

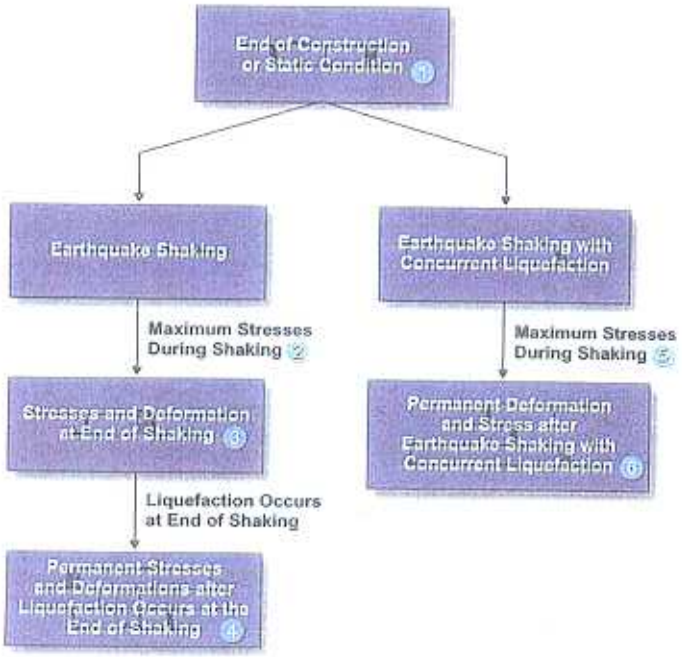
Properties (for 7-inch facing)	Physical Value	FLAC Input (for 7-inch facing)
Area	0.583 ft^2/ft	a = 0.583 ft^2/ft
Elastic Modulus (F'_c = 4000psi concrete)	3.6e6 psi	e = 5.18e8 psf
Bending (plastic) Moment	4.9 k-ft/ft	pmom = 996 lb-ft
Moment of Inertia	343 in^4/ft	I = 0.01654 ft^4
Density	150 pcf	dens = 4.66 $slugs/ft^3$

Table 4 - Steel Reinforcing Element Properties Used in FLAC Analyses

Properties	Physical Value	[1] Scaled FLAC Input per Strip
Area	2*50*(6-2*1.008) mm^2	a = 0.00206 ft^2
Perimeter	2*(50*2+(6-2*1.008)*2)/5 mm/ft	p = 0.0693 ft/ft
Elastic Modulus	29e9 psi	e = 8.49e8 psf
Yield Strength	65 ksi	yield = 3915 lb/ft
Compressive Strength	65 ksi	ycom = 2153 lb/ft
Soil/Reinforcement Adhesion	0 psf	sbond = 0 psf
Soil/Reinforcement Friction	37°	sfric = 37°
Soil/Reinforcement Stiffness	1e6 psf/ft	kbond = 1e6 psf/ft

[1] These values are per 50 by 6 mm strip and are scaled by the panel width (4.92 feet)

Comparison of FLAC Analysis Cases



	Station 105+20	Station 110+47	Station 180+00	Station 147+25
Case 1	Tables 5, 6, and 7 Figures 2 and 3	Tables 19, 20, and 21 Figures 10 and 11	Tables 33, 34, and 35 Figures 18 and 19	Tables 47, 48, and 49 Figures 26 and 27
Case 2	Table 8	Table 22	Table 36	Table 50
Case 3	Tables 9, 10, and 11 Figures 4 and 5	Tables 23, 24, and 25 Figures 12 and 13	Tables 37, 38, and 39 Figures 20 and 21	Tables 51, 52, and 53 Figures 28 and 29
Case 4	Tables 12, 13, and 14 Figures 6 and 7	Tables 26, 27, and 28 Figures 14 and 15	Tables 40, 41, and 42 Figures 22 and 232	(no liquefaction)
Case 5	Table 15	Table 29	Table 43	(no liquefaction)
Case 6	Tables 16, 17, and 18 Figures 8 and 9	Tables 30, 31, and 32 Figures 16 and 17	Tables 44, 45, and 46 Figures 24 and 25	(no liquefaction)

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Figure 1

Sta. 105+20

CASE 1

Table 5 - NSA Wall, Station 105+20
Reinforcement Stresses (as a percent of yield)
End of Staged Construction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		6	5	4	6	7	7	7	6
4	7.5		18	14	12	12	11	10	8	7
4	12.5		25	23	21	19	16	13	11	8
4	17.5	4 mm	29	31	28	24	19	16	13	9
5	22.5	Reinforcement	28	35	32	25	19	16	14	9
5	27.5		31	40	31	22	18	15	13	9
7	32.5		23	25	19	16	14	12	10	7
9	37.5		2	10	10	11	10	10	9	6

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.

Table 6 - NSA Wall, Station 105+20
Cumulative Horizontal Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.04	-0.04	-0.04
7.5	-0.05	-0.05	-0.05
12.5	-0.06	-0.06	-0.05
17.5	-0.06	-0.06	-0.06
22.5	-0.07	-0.06	-0.06
27.5	-0.07	-0.06	-0.06
32.5	-0.06	-0.06	-0.06
37.5	-0.06	-0.06	-0.06

Note Negative numbers indicate outward displacements.

Table 7 - NSA Wall, Station 105+20
Cumulative Vertical Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.01	-0.02	-0.02
7.5	-0.02	-0.04	-0.04
12.5	-0.03	-0.05	-0.05
17.5	-0.03	-0.06	-0.06
22.5	-0.04	-0.06	-0.06
27.5	-0.05	-0.06	-0.06
32.5	-0.05	-0.06	-0.07
37.5	-0.06	-0.07	-0.07

Note Negative numbers indicate downward displacements.

NSA Wall, Station 105+20

Cumulative Horizontal Displacements - End of Staged Construction

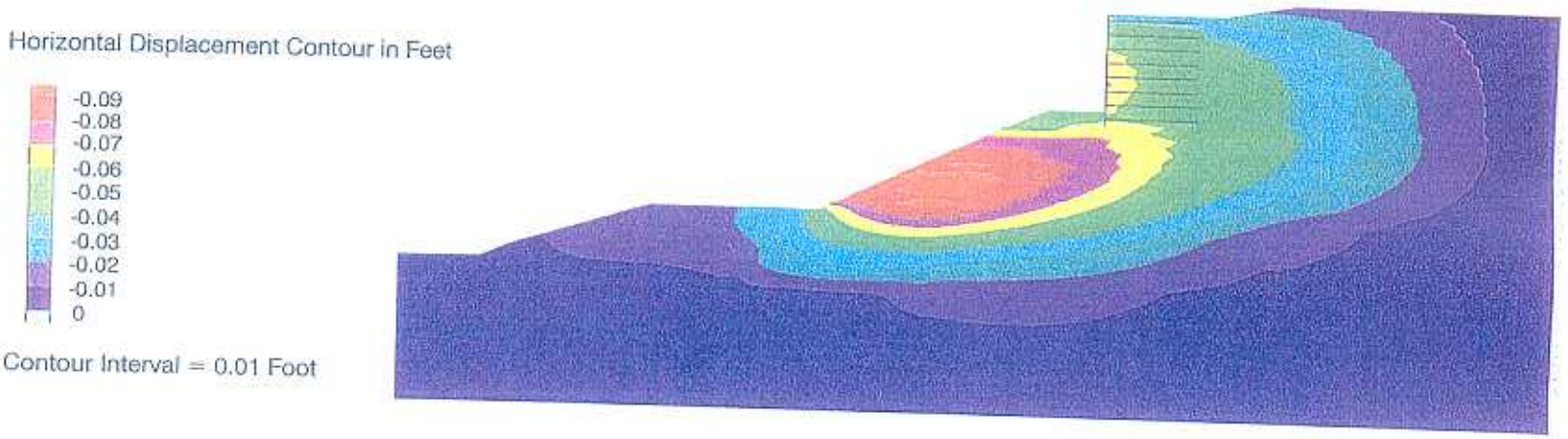

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Figure 2

AR 053270

NSA Wall, Station 105+20

Cumulative Vertical Displacements - End of Staged Construction

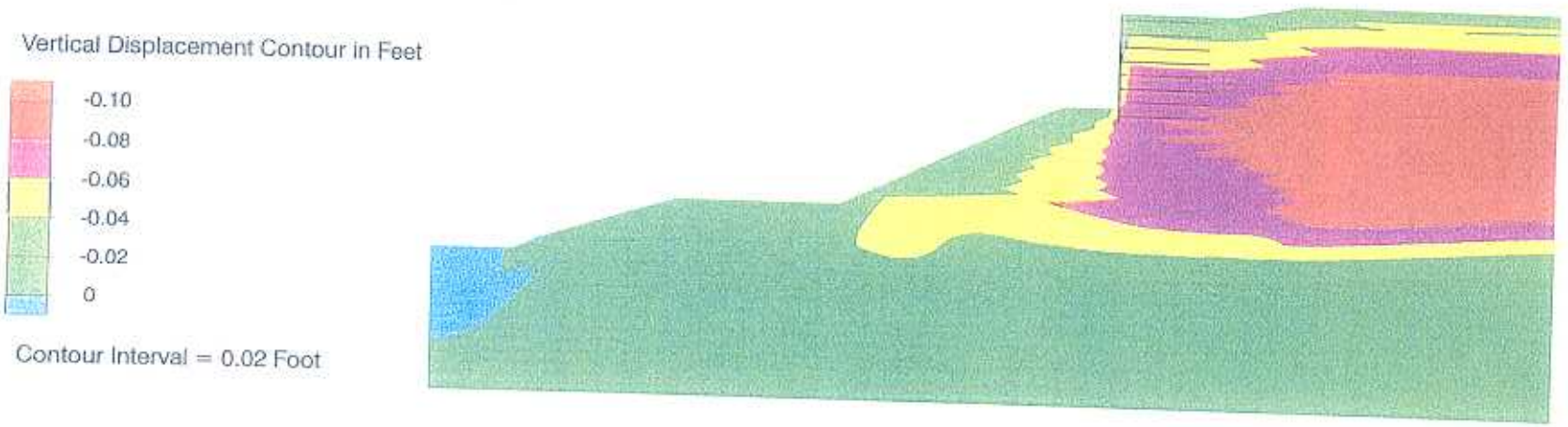

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Figure 3

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Due to a clerical error this number has been omitted.

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CASE 2

Table 8 - NSA Wall, Station 105+20
Maximum Reinforcement Stresses (as a percent of yield)
During Shaking Without Liquefaction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		19	22	26	29	27	21	16	6
4	7.5		27	35	39	43	42	38	28	9
4	12.5		33	42	52	52	48	43	36	10
4	17.5	4 mm	37	54	60	58	53	46	30	10
5	22.5	Reinforcement	35	58	64	60	54	44	28	12
5	27.5		41	76	69	59	53	45	29	15
7	32.5		35	65	55	49	46	41	30	17
9	37.5		38	64	56	55	51	48	38	18

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 3

Table 9 - NSA Wall, Station 105+20
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking Without Liquefaction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		17	20	23	21	18	13	5	3
4	7.5		25	35	38	41	40	36	24	7
4	12.5		27	37	50	50	46	41	27	9
4	17.5	*4 mm*	25	41	56	55	50	43	24	8
5	22.5	*Reinforcement*	17	39	61	58	51	36	23	7
5	27.5		27	63	69	58	52	42	26	8
7	32.5		27	63	54	48	44	38	28	10
9	37.5		34	47	49	48	48	42	28	7

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 10 - NSA Wall, Station 105+20
Permanent Horizontal Displacements in Feet
End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.43	-0.43	-0.42
7.5	-0.39	-0.39	-0.39
12.5	-0.35	-0.35	-0.35
17.5	-0.31	-0.31	-0.31
22.5	-0.27	-0.27	-0.27
27.5	-0.23	-0.24	-0.23
32.5	-0.20	-0.20	-0.19
37.5	-0.17	-0.17	-0.16

Note Negative numbers indicate outward displacements.

Table 11 - NSA Wall, Station 105+20
Permanent Vertical Displacements in Feet
End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.17	-0.21	-0.17
7.5	-0.17	-0.21	-0.17
12.5	-0.16	-0.20	-0.17
17.5	-0.16	-0.20	-0.16
22.5	-0.16	-0.18	-0.15
27.5	-0.16	-0.17	-0.15
32.5	-0.16	-0.16	-0.14
37.5	-0.16	-0.15	-0.14

Note Negative numbers indicate downward displacements.

NSA Wall, Station 105+20

Permanent Horizontal Displacements - End of Shaking Without Liquefaction

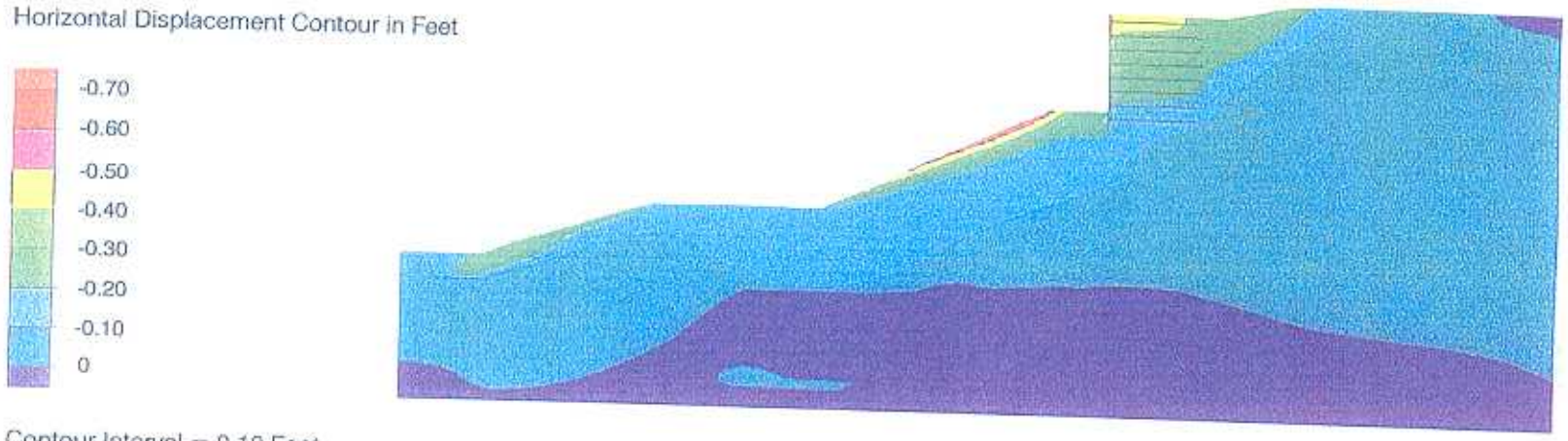

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Figure 4

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NSA Wall, Station 105+20

Permanent Vertical Displacements - End of Shaking Without Liquefaction

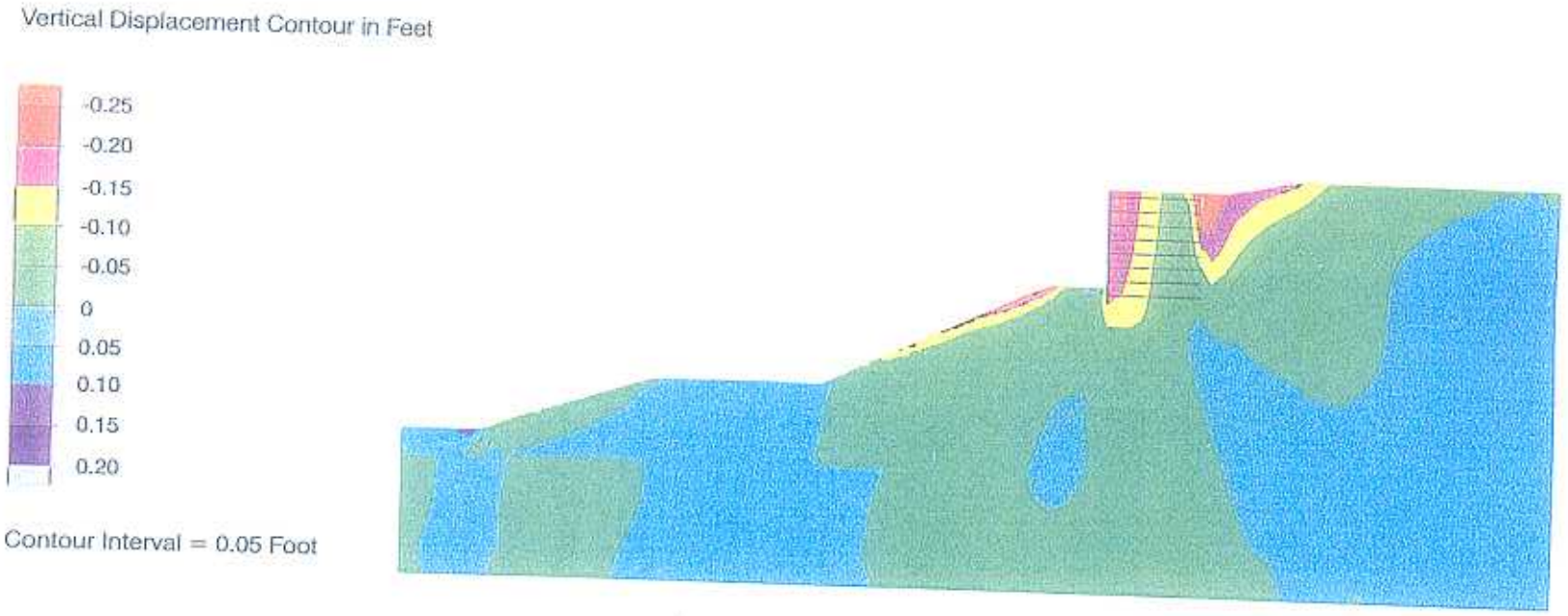

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Figure 5
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CASE 4

Table 12 - NSA Wall, Station 105+20
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking Followed by Liquefaction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		19	22	25	26	22	14	6	2
4	7.5		27	38	42	45	42	36	21	6
4	12.5		30	44	53	52	48	43	27	9
4	17.5	4 mm	27	44	57	55	51	40	23	7
5	22.5	Reinforcement	19	42	63	59	52	38	24	8
5	27.5		26	62	69	59	53	44	27	10
7	32.5		26	63	55	49	46	40	31	12
9	37.5		37	49	50	50	49	45	33	11

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 13 - NSA Wall, Station 105+20
Permanent Horizontal Displacements in Feet
End of Shaking Followed by Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.42	-0.42	-0.41
7.5	-0.38	-0.38	-0.38
12.5	-0.34	-0.34	-0.34
17.5	-0.30	-0.31	-0.30
22.5	-0.26	-0.27	-0.27
27.5	-0.23	-0.24	-0.23
32.5	-0.20	-0.20	-0.19
37.5	-0.17	-0.17	-0.16

Note Negative numbers indicate outward displacements.

Table 14 - NSA Wall, Station 105+20
Permanent Vertical Displacements in Feet
End of Shaking Followed by Liquefaction

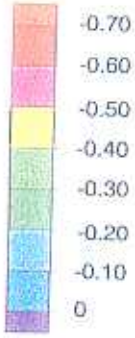
Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.16	-0.21	-0.17
7.5	-0.16	-0.20	-0.17
12.5	-0.16	-0.20	-0.16
17.5	-0.16	-0.19	-0.16
22.5	-0.15	-0.18	-0.15
27.5	-0.15	-0.17	-0.14
32.5	-0.15	-0.16	-0.14
37.5	-0.15	-0.15	-0.13

Note Negative numbers indicate downward displacements

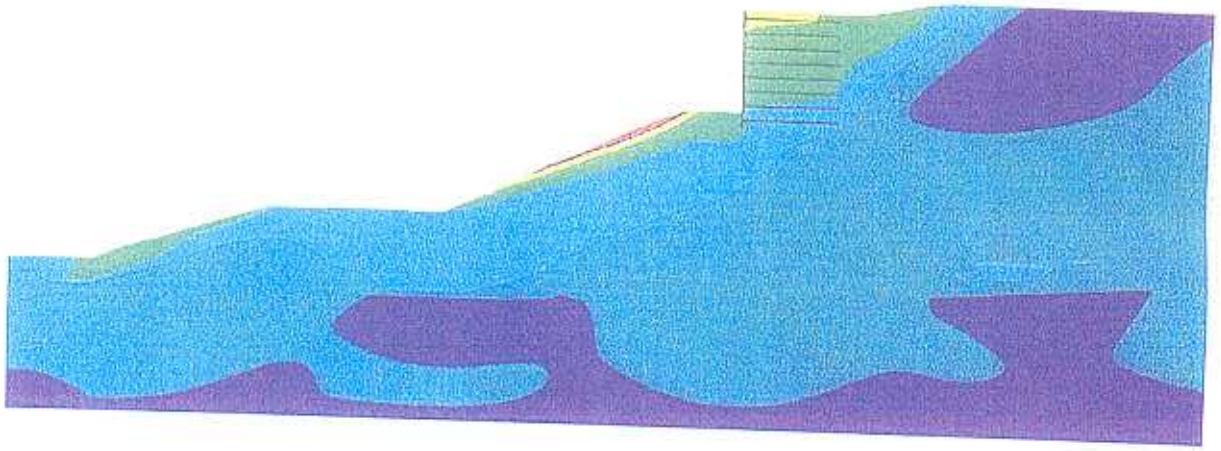
NSA Wall, Station 105+20

Permanent Horizontal Displacements - End of Shaking Followed by Liquefaction

Horizontal Displacement Contour in Feet



Contour Interval = 0.10 Foot



0 30 60

Scale in Feet

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Figure 6

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NSA Wall, Station 105+20

Permanent Vertical Displacements - End of Shaking Followed by Liquefaction

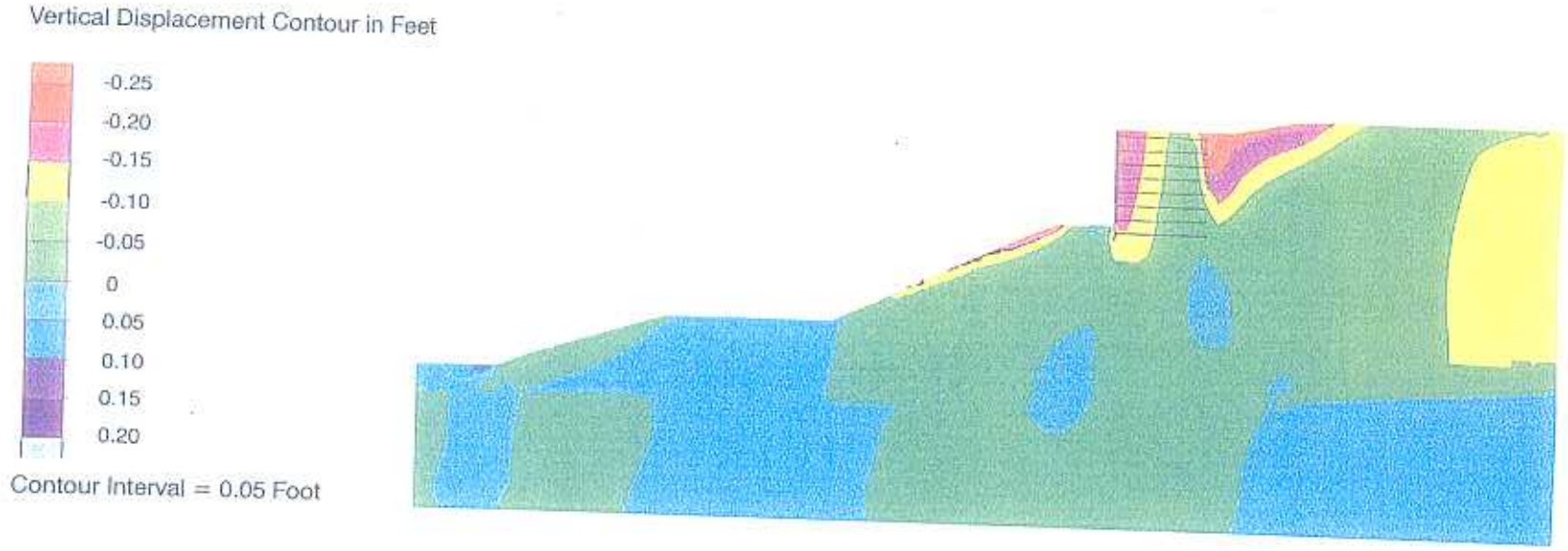

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Figure 7

AR 053286

CASE 5

Table 15 - NSA Wall, Station 105+20
Maximum Reinforcement Stresses (as a percent of yield)
During Shaking With Concurrent Liquefaction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		16	20	23	24	24	17	8	6
4	7.5		27	33	34	34	35	40	24	10
4	12.5		31	40	41	41	41	46	31	12
4	17.5	*4 mm*	39	46	48	46	44	45	32	11
5	22.5	*Reinforcement*	41	48	54	50	46	44	38	13
5	27.5		47	62	60	52	47	43	40	16
7	32.5		38	54	53	50	47	41	34	20
9	37.5		39	47	57	61	61	58	48	23

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 6

Table 16 - NSA Wall, Station 105+20
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking with Concurrent Liquefaction

Strip Density/ panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8
4	2.5		15	18	20	18	15	5	2	-1
4	7.5		25	30	31	31	32	29	18	5
4	12.5		28	35	37	37	36	37	17	5
4	17.5	*4 mm*	37	41	45	42	38	35	15	5
5	22.5	*Reinforcement*	38	46	51	46	42	35	15	4
5	27.5		44	60	58	48	43	35	18	5
7	32.5		37	52	51	46	42	35	27	7
9	37.5		31	41	50	52	52	47	34	9

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 31 to 35 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 17 - NSA Wall, Station 105+20
Permanent Horizontal Displacements in Feet
End of Shaking with Concurrent Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.30	-0.30	-0.30
7.5	-0.28	-0.28	-0.28
12.5	-0.27	-0.27	-0.27
17.5	-0.25	-0.25	-0.25
22.5	-0.23	-0.23	-0.23
27.5	-0.21	-0.21	-0.21
32.5	-0.19	-0.19	-0.19
37.5	-0.18	-0.18	-0.17

Note Negative numbers indicate outward displacements.

Table 18 - NSA Wall, Station 105+20
Permanent Vertical Displacements in Feet
End of Shaking with Concurrent Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.12	-0.14	-0.13
7.5	-0.12	-0.14	-0.12
12.5	-0.12	-0.14	-0.12
17.5	-0.12	-0.14	-0.12
22.5	-0.12	-0.13	-0.12
27.5	-0.12	-0.13	-0.11
32.5	-0.12	-0.12	-0.11
37.5	-0.12	-0.11	-0.10

Note Negative numbers indicate downward displacements

NSA Wall, Station 105+20

Permanent Horizontal Displacements - End of Shaking With Concurrent Liquefaction

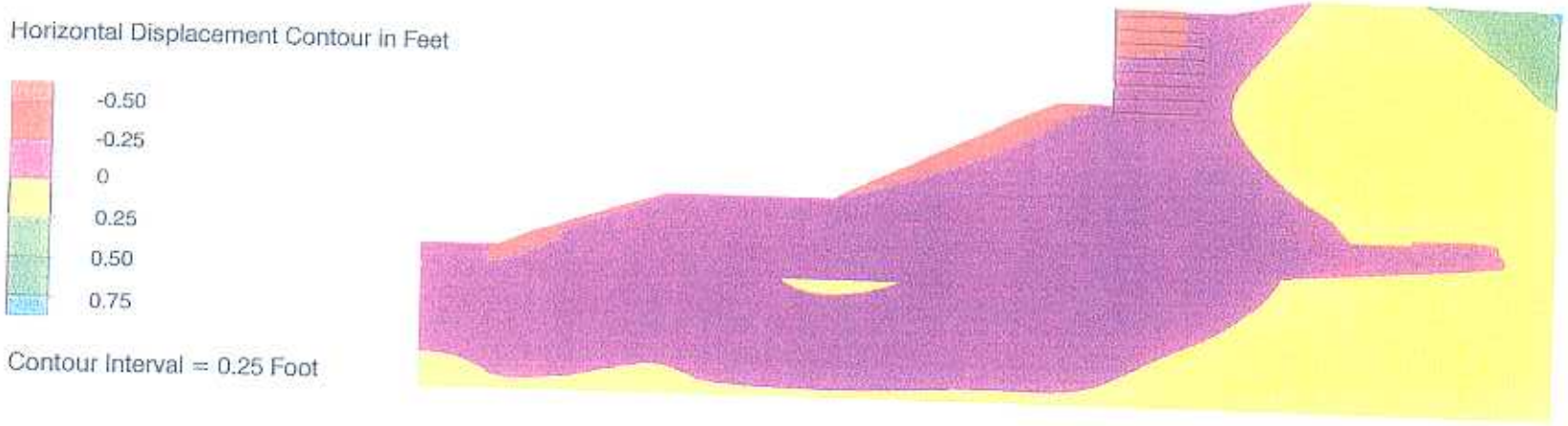

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Figure 8

AR 053292.01

NSA Wall, Station 105+20

Permanent Vertical Displacements - End of Shaking With Concurrent Liquefaction

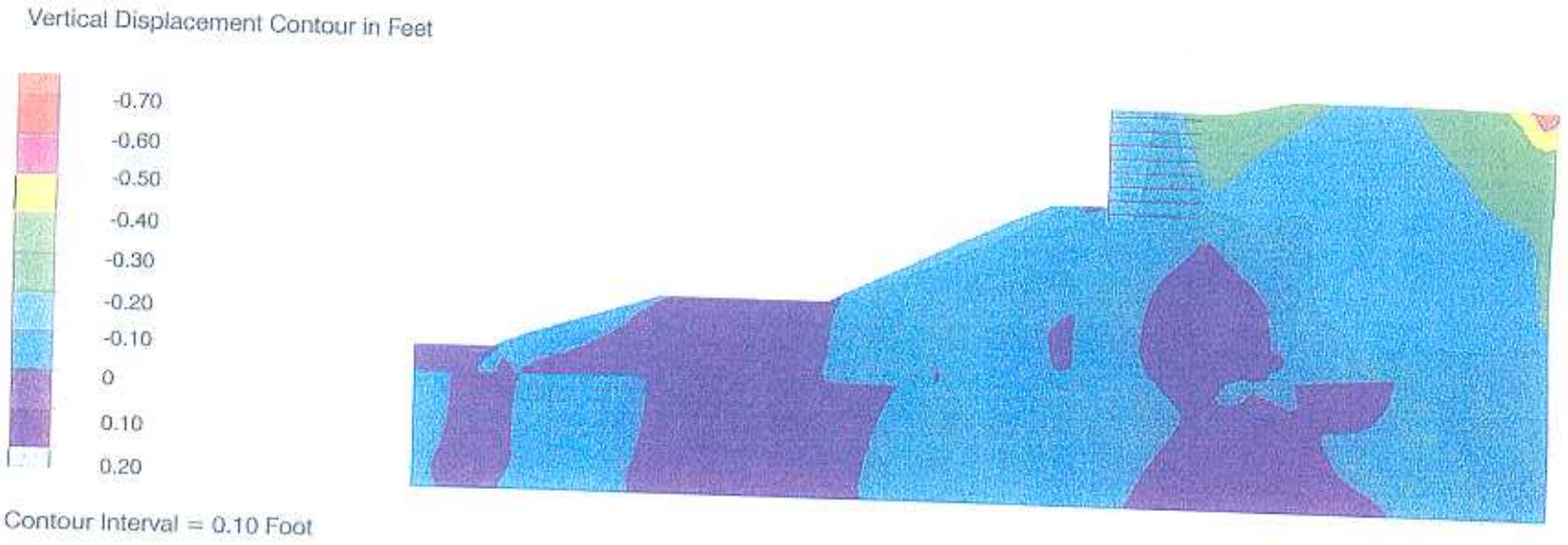

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Figure 9

AR 053292.02

Sta. 110+47

CASE 1

Table 19 - NSA Wall, Station 110+47
Reinforcement Stresses (as a percent of yield)
End of Staged Construction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				9	6	3	3	5	5	6	6	6	6	5	5	4	4	3
4	7.5				18	12	10	11	12	12	13	13	13	12	11	10	9	8	6
5	12.5				22	19	18	18	17	17	17	16	15	14	14	13	12	11	8
5	17.5				25	25	24	24	23	22	21	19	18	17	16	16	15	14	10
7	22.5	Tier 1			21	26	27	28	27	26	24	22	21	20	19	18	17	15	11
7	27.5	(4 mm Reinforcement)			23	30	32	32	31	29	26	24	23	22	21	20	19	17	12
7	32.5				25	35	38	37	34	31	28	26	25	23	22	22	21	19	13
7	37.5				28	40	43	40	35	31	28	27	26	24	23	23	22	20	14
9	42.5				27	42	42	37	33	30	28	27	26	25	24	23	22	19	13
11	47.5				22	33	31	30	29	28	27	26	25	24	23	22	20	18	12
5	50		8	9	18	22	24	24	24	24	23	22	21	21	20	19	18	16	11
6	55		25	28	36	29	27	27	26	25	25	24	23	22	21	20	19	17	11
7	60		22	26	38	38	35	34	32	31	30	29	28	27	25	24	23	20	12
7	65		22	27	38	39	37	34	33	31	30	29	27	26	25	24	23	20	12
9	70		19	25	34	36	35	34	32	30	29	28	27	25	24	23	21	18	11
9	75	Tier 2	20	27	35	35	34	32	31	29	28	26	25	24	23	22	21	18	11
11	80	(6 mm)	19	27	33	33	31	30	28	27	26	25	24	23	22	21	20	17	10
12	85		18	29	31	30	28	27	25	24	23	22	21	21	20	19	18	16	9
14	90		12	20	22	23	22	22	21	20	19	19	18	17	17	16	15	13	8
7	92.5		10	22	23	23	22	22	21	20	19	18	17	16	16	16	17	17	11

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged.

Table 20 - NSA Wall, Station 110+47
Cumulative Horizontal Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in Feet				
		0	4	8	12	16
2.5				-0.02	-0.02	-0.02
7.5				-0.04	-0.03	-0.03
12.5				-0.05	-0.05	-0.05
17.5				-0.06	-0.06	-0.06
22.5			Tier 1	-0.07	-0.07	-0.07
27.5				-0.08	-0.08	-0.08
32.5				-0.09	-0.09	-0.08
37.5				-0.09	-0.09	-0.09
42.5				-0.10	-0.09	-0.09
47.5		-0.08	-0.09	-0.10	-0.10	-0.09
50		-0.10	-0.10	-0.10	-0.09	-0.09
55		-0.10	-0.11	-0.10	-0.10	-0.09
60		-0.10	-0.11	-0.10	-0.10	-0.09
65	Tier 2	-0.10	-0.11	-0.10	-0.10	-0.09
70		-0.10	-0.10	-0.10	-0.09	-0.09
75		-0.10	-0.10	-0.09	-0.09	-0.08
80		-0.09	-0.09	-0.09	-0.08	-0.08
85		-0.08	-0.08	-0.08	-0.07	-0.07
90		-0.07	-0.07	-0.07	-0.07	-0.06
92.5		-0.07	-0.07	-0.06	-0.06	-0.06

Note Negative numbers indicate outward displacements.

Table 21 - NSA Wall, Station 110+47
Cumulative Vertical Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in 0	4	8	12	16
2.5				-0.01	-0.02	-0.02
7.5				-0.03	-0.04	-0.04
12.5				-0.04	-0.06	-0.06
17.5				-0.05	-0.07	-0.07
22.5			Tier 1	-0.06	-0.09	-0.09
27.5				-0.08	-0.10	-0.09
32.5				-0.09	-0.10	-0.10
37.5				-0.10	-0.11	-0.11
42.5				-0.11	-0.11	-0.11
47.5		-0.04	-0.08	-0.13	-0.12	-0.12
50		-0.04	-0.09	-0.13	-0.11	-0.11
55		-0.05	-0.11	-0.12	-0.12	-0.11
60		-0.05	-0.11	-0.11	-0.12	-0.11
65	Tier 2	-0.06	-0.11	-0.11	-0.11	-0.11
70		-0.06	-0.11	-0.11	-0.11	-0.11
75		-0.06	-0.11	-0.10	-0.10	-0.10
80		-0.07	-0.10	-0.10	-0.10	-0.10
85		-0.07	-0.09	-0.09	-0.09	-0.09
90		-0.08	-0.08	-0.09	-0.09	-0.09
92.5		-0.08	-0.08	-0.08	-0.08	-0.08

Note Negative numbers indicate downward displacements.

NSA Wall, Station 110+47

Cumulative Horizontal Displacements - End of Staged Construction

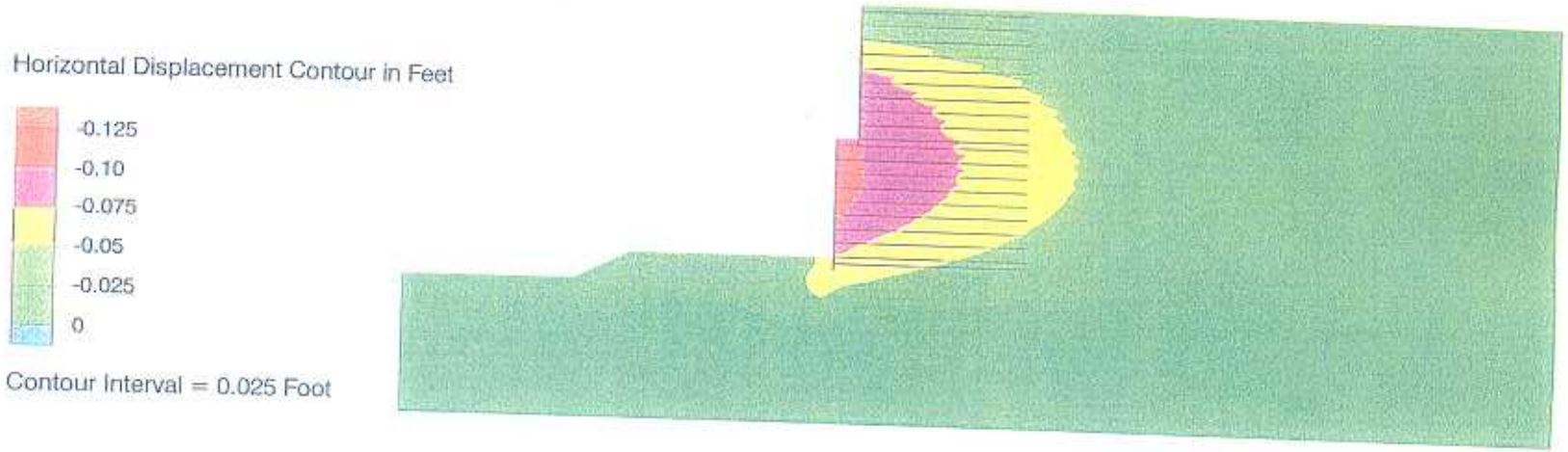

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Figure 10

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NSA Wall, Station 110+47

Cumulative Vertical Displacements - End of Staged Construction

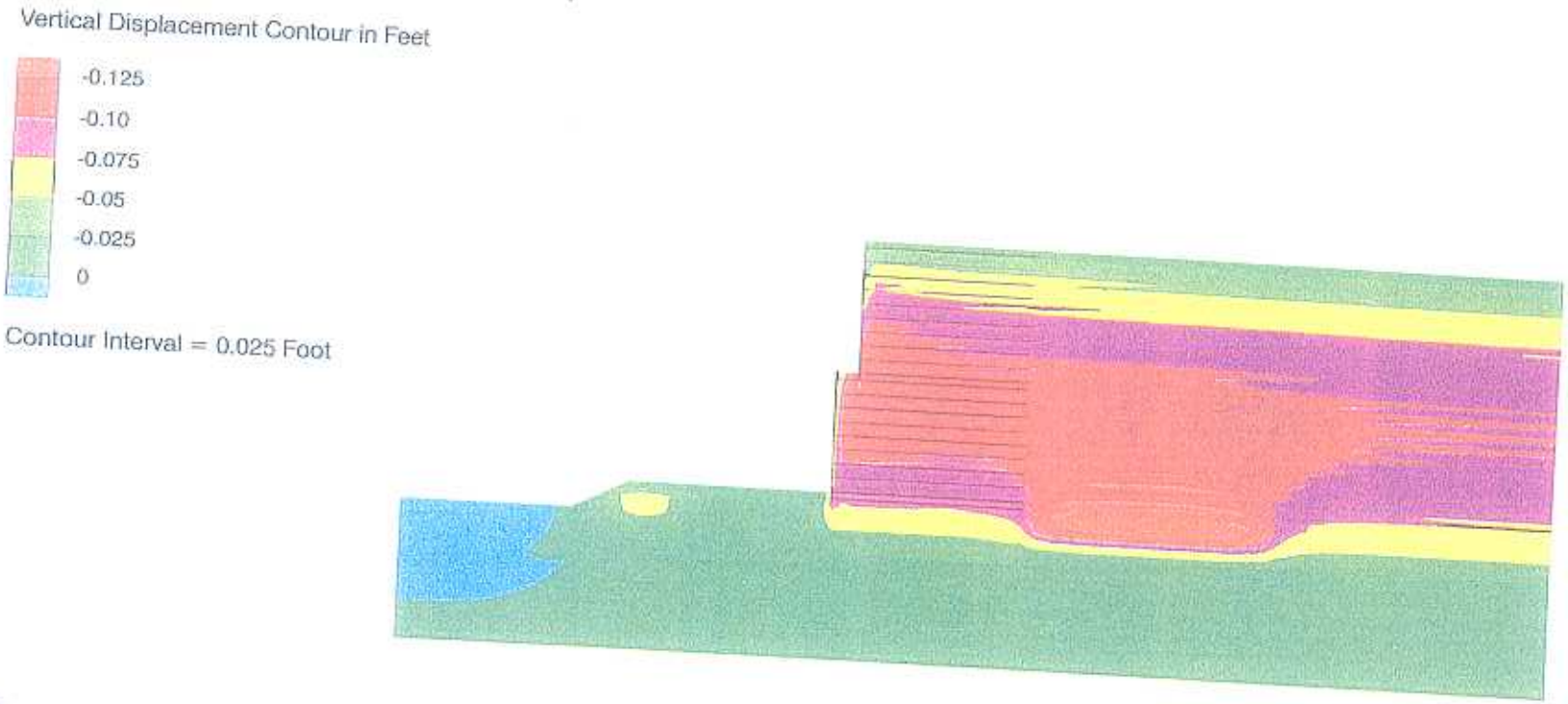

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Figure 11
1/02

AR 053299

CASE 2

Table 22 - NSA Wall, Station 110+47
Maximum Reinforcement Stresses (as a percent of yield)
During Shaking Without Liquefaction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				63	64	68	68	65	61	52	43	39	36	32	22	11	6	3
4	7.5				49	66	72	74	73	68	62	54	46	39	34	31	34	25	6
5	12.5				57	68	66	69	59	56	50	45	40	33	27	23	24	24	8
5	17.5				49	66	62	51	47	46	44	40	36	31	27	24	23	22	10
7	22.5	Tier 1			25	38	45	44	44	44	43	40	36	31	27	23	21	20	11
7	27.5	(4 mm Reinforcement)			29	45	50	48	47	45	43	39	36	31	27	24	21	21	16
7	32.5				35	53	59	56	51	47	44	40	35	31	27	25	24	24	19
7	37.5				42	60	67	62	53	47	43	41	35	32	28	26	26	25	21
9	42.5				44	61	66	58	50	45	42	37	34	31	28	26	25	23	17
11	47.5				33	52	50	48	44	40	37	35	32	29	25	24	23	21	15
5	50		18	18	27	33	42	44	43	41	39	36	34	30	27	25	24	20	13
6	55		27	34	42	48	50	47	45	42	39	37	34	31	27	26	24	21	13
7	60		25	37	50	56	53	50	46	43	40	38	35	32	29	26	24	21	13
7	65		24	35	53	60	55	50	47	44	41	38	35	33	29	26	24	21	13
9	70		20	32	49	55	53	49	45	43	40	38	35	32	29	25	24	20	12
9	75	Tier 2	22	35	49	52	50	47	44	42	40	38	35	33	30	26	23	20	12
11	80	(6 mm)	22	36	47	47	45	44	42	41	40	38	35	33	29	25	22	19	11
12	85		24	40	44	43	43	43	43	42	40	37	34	31	27	23	21	18	10
14	90		20	35	39	43	46	46	45	42	38	33	29	25	20	19	18	15	8
7	92.5		37	58	56	59	58	58	50	44	37	30	24	19	18	18	18	17	11

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 3

Table 23 - NSA Wall, Station 110+47
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking Without Liquefaction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				63	64	64	65	61	58	49	39	36	32	28	18	8	1	-1
4	7.5				48	65	68	70	69	64	58	50	42	35	30	27	28	14	2
5	12.5				57	64	62	55	55	52	47	42	37	30	25	20	20	16	4
5	17.5				48	64	59	48	44	44	42	38	33	29	24	22	20	18	4
7	22.5	Tier 1			9	35	43	40	39	39	38	36	33	28	25	21	18	17	8
7	27.5	(4 mm Reinforcement)			8	40	49	45	42	40	38	35	32	28	24	20	17	15	8
7	32.5				33	41	54	53	48	44	39	37	32	28	24	21	19	16	7
7	37.5				41	55	64	59	51	44	40	36	32	28	25	22	20	17	8
9	42.5				40	57	63	56	48	42	38	35	32	28	25	21	18	15	8
11	47.5				27	49	48	46	41	38	36	33	30	27	23	19	17	14	9
5	50		14	14	16	24	39	42	41	39	36	34	32	28	24	20	17	13	3
6	55		22	26	31	46	48	46	42	40	37	35	32	29	25	21	18	14	4
7	60		18	26	36	53	51	48	44	41	39	36	33	30	27	22	18	14	6
7	65		17	25	41	54	52	48	45	42	39	36	34	31	28	23	19	14	6
9	70		14	24	43	51	50	47	44	41	38	36	34	31	28	23	19	14	5
9	75	Tier 2	17	28	45	49	47	45	42	40	38	36	34	31	28	24	20	14	5
11	80	(6 mm)	18	30	42	43	43	42	41	40	38	36	34	31	28	24	19	14	6
12	85		21	37	41	40	41	42	42	40	38	36	32	29	25	21	17	13	6
14	90		17	33	38	41	44	45	43	40	36	31	27	22	18	15	12	9	5
7	92.5		35	56	55	57	56	54	48	41	34	28	22	17	13	11	10	9	5

Notes. Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 24 - NSA Wall, Station 110+47
Permanent Horizontal Displacements in Feet
End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in Feet				
		0	*4*	*8*	*12*	*16*
2.5				-0.34	-0.34	-0.33
7.5				-0.30	-0.31	-0.30
12.5				-0.28	-0.28	-0.27
17.5				-0.25	-0.26	-0.25
22.5			*Tier 1*	-0.22	-0.24	-0.23
27.5				-0.21	-0.21	-0.21
32.5				-0.19	-0.20	-0.19
37.5				-0.18	-0.18	-0.18
42.5				-0.17	-0.17	-0.17
47.5		-0.16	-0.19	-0.15	-0.15	-0.15
50		-0.14	-0.17	-0.16	-0.15	-0.14
55		-0.13	-0.14	-0.14	-0.13	-0.13
60		-0.12	-0.13	-0.13	-0.12	-0.12
65	*Tier 2*	-0.11	-0.11	-0.11	-0.11	-0.10
70		-0.09	-0.10	-0.10	-0.09	-0.09
75		-0.08	-0.09	-0.08	-0.08	-0.08
80		-0.07	-0.08	-0.07	-0.07	-0.07
85		-0.06	-0.06	-0.06	-0.06	-0.06
90		-0.06	-0.06	-0.05	-0.05	-0.05
92.5		-0.06	-0.06	-0.05	-0.05	-0.05

Note Negative numbers indicate outward displacements.

Table 25 - NSA Wall, Station 110+47
Permanent Vertical Displacements in Feet
End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in				
		0	*4*	*8*	*12*	*16*
2.5				-0.20	-0.17	-0.11
7.5				-0.20	-0.16	-0.11
12.5				-0.19	-0.15	-0.10
17.5				-0.19	-0.13	-0.09
22.5			*Tier 1*	-0.19	-0.11	-0.08
27.5				-0.08	-0.09	-0.08
32.5				-0.08	-0.08	-0.07
37.5				-0.08	-0.08	-0.07
42.5				-0.08	-0.07	-0.06
47.5		-0.05	0.00	-0.08	-0.07	-0.06
50		-0.05	-0.07	-0.08	-0.06	-0.06
55		-0.05	-0.07	-0.07	-0.06	-0.05
60		-0.04	-0.08	-0.06	-0.06	-0.05
65	*Tier 2*	-0.04	-0.07	-0.06	-0.05	-0.05
70		-0.04	-0.07	-0.06	-0.05	-0.04
75		-0.04	-0.06	-0.05	-0.05	-0.04
80		-0.04	-0.06	-0.05	-0.04	-0.04
85		-0.04	-0.05	-0.05	-0.04	-0.04
90		-0.04	-0.05	-0.05	-0.04	-0.03
92.5		-0.04	-0.05	-0.04	-0.04	-0.03

Note Negative numbers indicate downward displacements.

NSA Wall, Station 110+47

Permanent Horizontal Displacements - End of Shaking Without Liquefaction

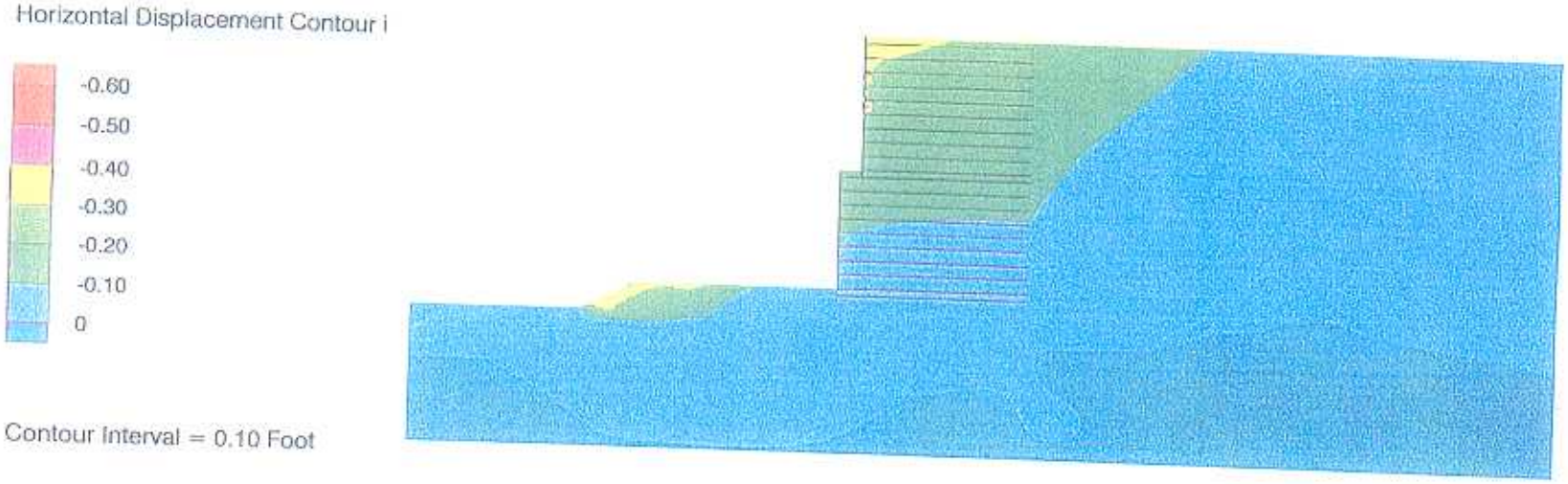

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Figure 12

AR 053306

NSA Wall, Station 110+47

Permanent Vertical Displacements - End of Shaking Without Liquefaction

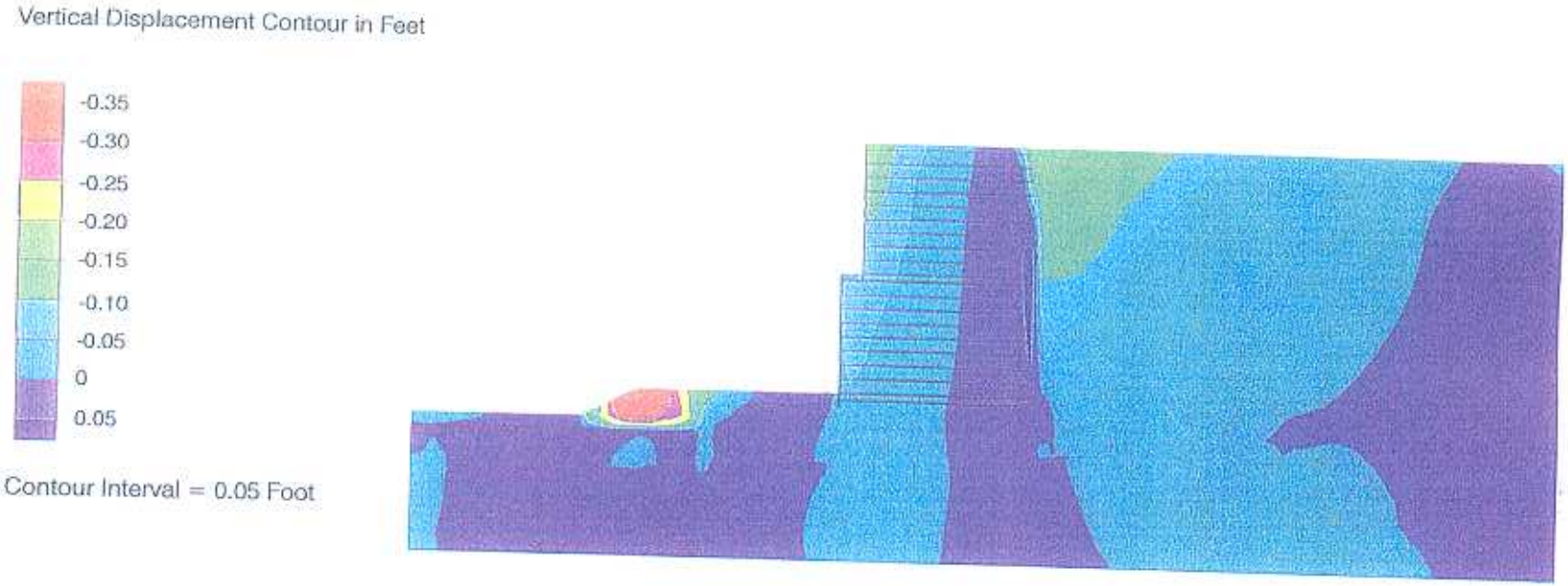

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Figure 13

AR 053307

CASE 4

Table 26 - NSA Wall, Station 110+47
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking Followed by Liquefaction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				63	64	65	65	61	58	49	39	36	33	28	18	8	1	-1
4	7.5				48	65	66	70	69	64	58	51	42	36	31	27	28	15	2
5	12.5				57	65	63	55	55	52	47	43	37	31	25	20	20	16	4
5	17.5				49	64	59	48	45	44	42	38	34	29	25	22	20	19	4
7	22.5	Tier 1			9	35	43	40	39	39	39	36	33	29	25	22	18	17	8
7	27.5	(4 mm Reinforcement)			8	40	49	45	42	40	39	36	32	28	24	20	17	16	8
7	32.5				31	43	55	53	48	43	40	37	32	29	25	21	19	17	8
7	37.5				41	55	64	59	51	45	40	36	33	29	25	23	20	17	8
9	42.5				40	57	63	56	48	43	39	35	32	29	25	22	19	16	8
11	47.5				28	49	48	46	42	39	36	33	31	27	24	20	17	15	9
5	50		14	15	17	24	39	42	41	39	37	35	32	29	25	21	17	14	3
6	55		22	26	30	46	48	46	43	40	38	36	33	30	26	22	18	15	5
7	60		18	26	36	53	51	48	45	42	39	36	34	31	27	23	19	15	7
7	65		17	25	41	54	52	48	45	42	39	37	34	32	28	24	20	15	7
9	70		14	24	43	51	50	47	44	41	39	36	34	31	28	24	20	15	6
9	75	Tier 2	17	27	45	48	47	45	42	40	38	36	34	32	29	25	21	15	6
11	80	(6 mm)	18	30	42	43	42	41	40	39	38	36	33	31	28	24	20	15	7
12	85		21	37	41	40	40	41	41	40	38	35	32	29	25	22	18	14	7
14	90		17	32	37	40	43	44	42	39	35	30	26	21	17	14	12	10	5
7	92.5		35	56	54	56	55	52	47	40	33	26	20	15	11	10	9	9	5

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 27 - NSA Wall, Station 110+47
Permanent Horizontal Displacements in Feet
End of Shaking Followed by Liquefaction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in Feet				
		0	*4*	*8*	*12*	*16*
2.5				-0.34	-0.34	-0.33
7.5				-0.31	-0.31	-0.30
12.5				-0.28	-0.28	-0.27
17.5				-0.25	-0.26	-0.25
22.5			*Tier 1*	-0.22	-0.24	-0.23
27.5				-0.21	-0.22	-0.21
32.5				-0.20	-0.20	-0.20
37.5				-0.18	-0.18	-0.18
42.5				-0.17	-0.17	-0.17
47.5		-0.16	-0.19	-0.15	-0.15	-0.15
50		-0.14	-0.17	-0.16	-0.15	-0.15
55		-0.13	-0.15	-0.14	-0.14	-0.13
60		-0.12	-0.13	-0.13	-0.12	-0.12
65	*Tier 2*	-0.11	-0.12	-0.11	-0.11	-0.11
70		-0.10	-0.10	-0.10	-0.10	-0.09
75		-0.08	-0.09	-0.09	-0.08	-0.08
80		-0.07	-0.08	-0.07	-0.07	-0.07
85		-0.07	-0.07	-0.06	-0.06	-0.06
90		-0.06	-0.06	-0.06	-0.06	-0.05
92.5		-0.06	-0.06	-0.06	-0.05	-0.05

Note Negative numbers indicate outward displacements.

Table 28 - NSA Wall, Station 110+47
Permanent Vertical Displacements in Feet
End of Shaking Followed by Liquefaction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in				
		0	*4*	*8*	*12*	*16*
2.5				-0.20	-0.17	-0.11
7.5				-0.19	-0.16	-0.11
12.5				-0.19	-0.15	-0.10
17.5				-0.19	-0.13	-0.09
22.5			*Tier 1*	-0.18	-0.11	-0.08
27.5				-0.08	-0.09	-0.08
32.5				-0.08	-0.08	-0.07
37.5				-0.08	-0.08	-0.07
42.5				-0.08	-0.07	-0.06
47.5		-0.05	0.00	-0.08	-0.07	-0.06
50		-0.05	-0.05	-0.08	-0.07	-0.06
55		-0.05	-0.07	-0.07	-0.06	-0.05
60		-0.04	-0.07	-0.06	-0.06	-0.05
65	*Tier 2*	-0.04	-0.07	-0.06	-0.05	-0.05
70		-0.04	-0.07	-0.06	-0.05	-0.04
75		-0.04	-0.06	-0.05	-0.05	-0.04
80		-0.04	-0.06	-0.05	-0.04	-0.04
85		-0.04	-0.05	-0.05	-0.04	-0.03
90		-0.04	-0.05	-0.04	-0.04	-0.03
92.5		-0.04	-0.04	-0.04	-0.04	-0.03

Note Negative numbers indicate downward displacements.

NSA Wall, Station 110+47

Permanent Horizontal Displacements - End of Shaking Followed by Liquefaction

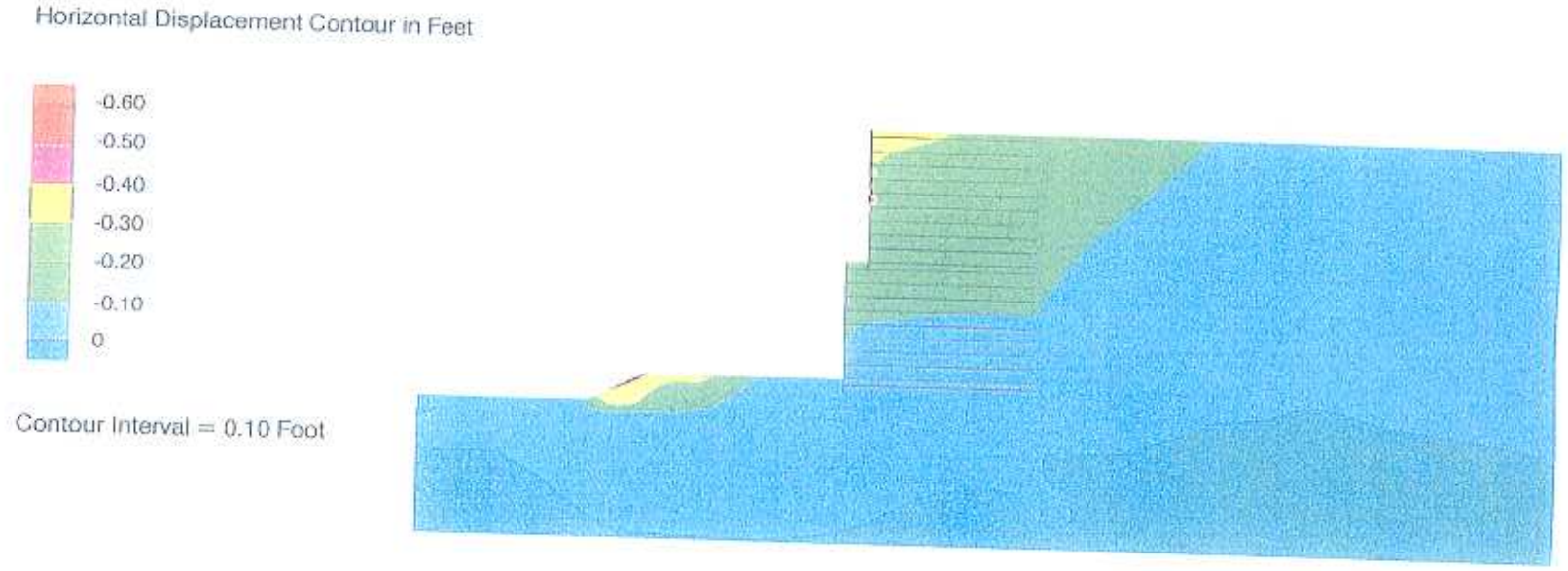

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Figure 14

AR 053312

NSA Wall, Station 110+47

Permanent Vertical Displacements - End of Shaking Followed by Liquefaction

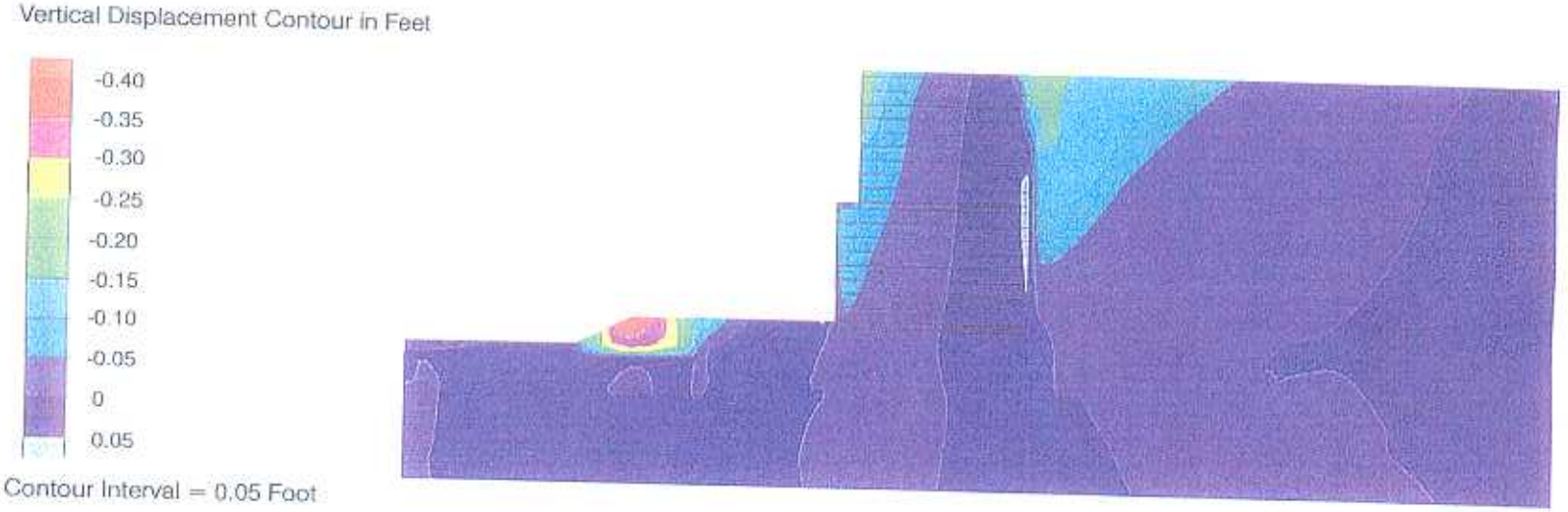

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Figure 15

AR 053313

CASE 5

Table 29 - NSA Wall, Station 110+47
Maximum Reinforcement Stresses (as a percent of yield)
During Shaking With Concurrent Liquefaction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				25	28	32	34	35	35	33	30	26	23	18	13	14	6	3
4	7.5				29	35	39	44	45	45	42	39	36	33	30	31	34	29	7
5	12.5				28	39	41	43	44	43	41	38	34	29	25	23	26	32	8
5	17.5				31	42	43	42	43	43	41	38	33	28	24	22	22	25	10
7	22.5	Tier 1			25	39	41	43	43	43	41	38	33	29	26	24	21	22	11
7	27.5	(4 mm Reinforcement)			30	43	47	47	46	44	41	38	34	30	27	24	22	21	16
7	32.5				35	49	55	53	49	45	42	39	35	31	28	26	24	24	18
7	37.5				42	56	63	58	51	46	42	39	34	32	28	27	26	26	21
9	42.5				42	58	63	55	48	43	40	37	34	31	28	26	26	24	17
11	47.5				33	50	47	45	41	39	37	34	32	29	26	25	24	22	16
5	50		22	22	32	42	51	53	52	49	47	45	42	38	34	33	31	28	17
6	55		32	40	58	59	59	55	52	50	47	45	42	38	34	32	30	27	16
7	60		24	35	49	53	50	48	45	42	40	37	35	32	29	26	25	22	13
7	65		24	35	53	58	53	49	46	43	40	38	35	33	30	26	25	22	14
9	70		20	32	49	54	52	48	45	42	40	37	35	32	29	26	23	20	12
9	75	Tier 2	22	35	49	52	49	46	43	41	39	37	35	32	29	26	23	20	12
11	80	(6 mm)	21	37	46	46	45	43	42	41	39	36	34	31	28	25	23	19	11
12	85		24	40	44	42	42	42	42	40	38	35	31	28	26	25	23	19	11
14	90		20	34	39	41	44	44	43	39	34	29	26	24	23	21	20	17	9
7	92.5		35	56	54	57	55	53	47	40	32	25	23	22	21	21	20	19	12

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 30 - NSA Wall, Station 110+47
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking with Concurrent Liquefaction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2	2.5				6	5	3	3	4	5	5	6	6	6	5	5	4	4	2
4	7.5				18	13	11	11	12	12	13	13	12	12	11	10	9	8	6
5	12.5				21	19	18	18	18	17	17	16	15	14	14	13	12	11	8
5	17.5				24	25	24	24	23	22	21	19	18	17	16	16	15	14	10
7	22.5		Tier 1		21	26	27	28	27	26	24	22	21	20	19	18	17	15	11
7	27.5		(4 mm Reinforcement)		23	30	32	32	31	29	26	24	23	22	21	20	19	17	12
7	32.5				25	35	38	37	34	30	28	26	24	23	22	21	20	19	13
7	37.5				28	40	43	39	35	31	28	27	25	24	23	23	22	20	14
9	42.5				27	42	42	36	32	30	28	27	25	24	23	22	21	19	13
11	47.5				22	32	30	29	28	27	26	25	24	23	22	21	20	18	12
5	50		10	12	25	31	34	36	36	36	35	34	32	31	30	29	27	24	16
6	55		30	34	46	39	37	37	36	35	34	33	32	31	30	28	27	24	15
7	60		21	26	38	37	35	33	32	31	29	28	27	26	25	24	22	19	12
7	65		22	27	38	39	36	34	32	31	29	28	27	26	25	24	23	20	12
9	70		19	25	34	36	35	33	32	30	29	28	26	25	24	23	21	18	11
9	75	Tier 2	20	27	35	35	34	32	30	29	28	26	25	24	23	22	21	18	11
11	80	(6 mm)	19	27	33	33	31	30	28	27	26	25	24	23	22	21	20	17	10
12	85		18	29	31	30	28	27	25	24	23	22	21	21	20	19	18	16	9
14	90		12	20	22	23	23	22	21	20	20	19	18	17	17	16	15	13	8
7	92.5		10	22	23	23	22	22	21	20	19	18	17	17	16	16	17	17	11

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height was slightly increased from 86 to 90 feet in FLAC to accommodate mesh size; total wall height remains unchanged.

Table 31 - NSA Wall, Station 110+47
Permanent Horizontal Displacements in Feet
End of Shaking with Concurrent Liquefaction

Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in Feet				
		0	*4*	*8*	*12*	*16*
2.5				-0.32	-0.32	-0.32
7.5				-0.30	-0.30	-0.30
12.5				-0.28	-0.28	-0.28
17.5				-0.26	-0.27	-0.26
22.5			*Tier 1*	-0.24	-0.25	-0.24
27.5				-0.23	-0.23	-0.23
32.5				-0.21	-0.22	-0.21
37.5				-0.20	-0.20	-0.20
42.5				-0.19	-0.19	-0.18
47.5		-0.17	-0.20	-0.17	-0.17	-0.17
50		-0.16	-0.18	-0.18	-0.16	-0.16
55		-0.15	-0.16	-0.15	-0.15	-0.15
60		-0.13	-0.14	-0.14	-0.13	-0.13
65	*Tier 2*	-0.12	-0.13	-0.12	-0.12	-0.12
70		-0.11	-0.11	-0.11	-0.11	-0.11
75		-0.10	-0.10	-0.10	-0.10	-0.09
80		-0.08	-0.09	-0.08	-0.08	-0.08
85		-0.07	-0.08	-0.07	-0.07	-0.07
90		-0.07	-0.07	-0.07	-0.06	-0.06
92.5		-0.07	-0.07	-0.06	-0.06	-0.06

Note Negative numbers indicate outward displacements.

Table 32 - NSA Wall, Station 110+47
Permanent Vertical Displacements in Feet
End of Shaking with Concurrent Liquefaction

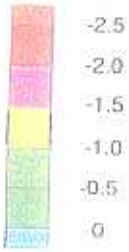
Depth Below Top of Wall in Feet		Horizontal Distance Measured from Wall Face in				
		0	*4*	*8*	*12*	*16*
2.5				-0.09	-0.10	-0.08
7.5				-0.09	-0.10	-0.08
12.5				-0.09	-0.10	-0.08
17.5				-0.08	-0.09	-0.07
22.5			*Tier 1*	-0.08	-0.09	-0.07
27.5				-0.08	-0.08	-0.07
32.5				-0.08	-0.08	-0.07
37.5				-0.08	-0.07	-0.06
42.5				-0.08	-0.07	-0.06
47.5		-0.05	-0.01	-0.08	-0.07	-0.06
50		-0.05	-0.06	-0.08	-0.06	-0.06
55		-0.05	-0.07	-0.07	-0.06	-0.05
60		-0.05	-0.08	-0.07	-0.06	-0.05
65	*Tier 2*	-0.05	-0.07	-0.06	-0.05	-0.05
70		-0.05	-0.07	-0.06	-0.05	-0.04
75		-0.05	-0.07	-0.06	-0.05	-0.04
80		-0.05	-0.06	-0.05	-0.04	-0.04
85		-0.05	-0.05	-0.05	-0.04	-0.03
90		-0.05	-0.05	-0.05	-0.04	-0.03
92.5		-0.05	-0.05	-0.04	-0.04	-0.03

Note Negative numbers indicate downward displacements.

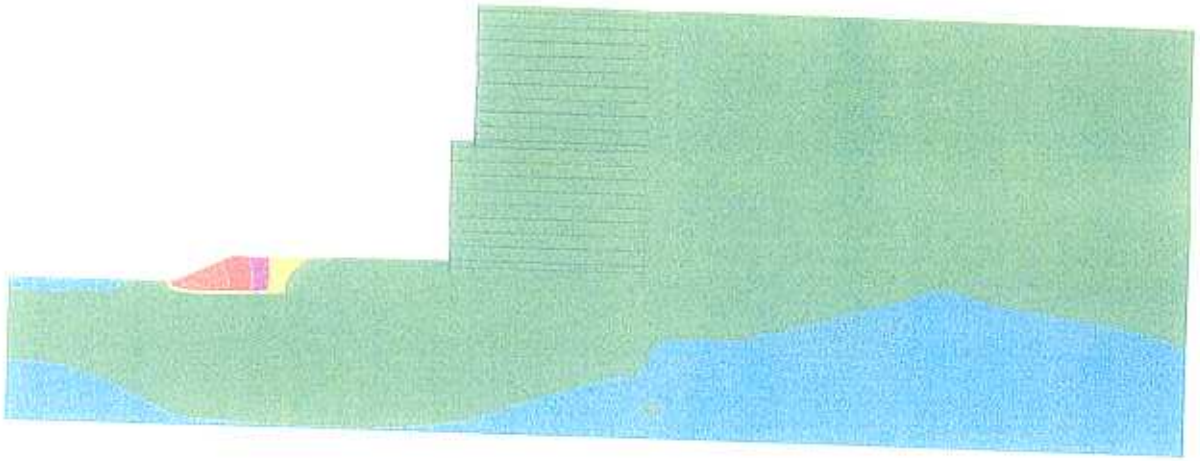
NSA Wall, Station 110+47

Permanent Horizontal Displacements - End of Shaking With Concurrent Liquefaction

Horizontal Displacement Contour in Feet



Contour Interval = 0.5 Foot



Scale in Feet

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Figure 16

AR 053320

DIN 1/14/02 4978401.cdr

NSA Wall, Station 110+47

Permanent Vertical Displacements - End of Shaking With Concurrent Liquefaction

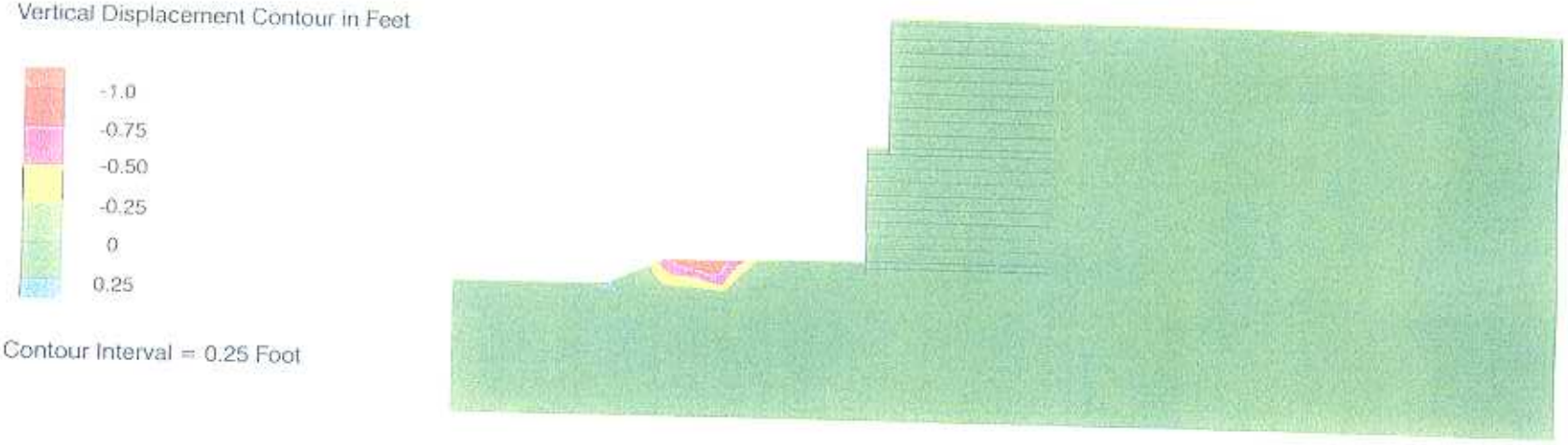

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Figure 17

AR 053321

Sta. 180+00

Table 33 - West Wall, Station 180+00
Reinforcement Stresses (as a Percent of Yield)
End of Staged Construction

Strip Density / Panel	Depth Below Top of Wall in Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							1	1	2	3	4	5	6	7	7	8	9	9	10	10	11	11	11	12	13	14	6
4	7.5							5	5	5	6	8	9	9	10	10	11	11	11	12	12	12	12	13	13	13	14	8
4	12.5	6 mm					Tier 1	10	9	9	10	11	11	11	12	12	12	12	12	12	13	13	13	13	14	14	15	10
5	17.5	Reinforcement						11	13	13	13	12	12	12	13	13	13	13	13	13	13	13	13	14	14	15	16	12
5	22.5	Throughout						13	17	15	14	13	13	13	13	13	13	13	13	13	14	14	14	14	15	17	18	13
6	27.5							8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	13	13	14	16	17	15
4	30					3	11	16	20	24	25	27	27	27	28	28	28	28	28	28	28	28	28	29	30	32	30	15
5	35					17	26	30	28	28	29	29	29	29	29	29	29	29	29	29	29	29	29	30	31	33	33	16
5	40					18	28	33	34	33	33	32	31	31	31	31	31	30	30	30	30	30	30	31	33	34	34	18
5	45				Tier 2	19	30	35	37	36	34	33	33	32	32	32	32	31	31	31	31	31	32	33	34	36	35	20
6	50					18	31	35	37	36	35	34	34	33	33	33	32	32	32	32	32	32	33	34	35	36	35	22
6	55					20	34	37	37	36	35	35	34	34	33	33	33	33	33	32	33	33	34	35	36	37	36	24
7	60					22	36	38	36	35	35	35	34	34	34	34	33	33	33	33	33	33	34	35	36	37	35	25
8	65					21	32	32	32	33	33	33	33	33	33	32	32	32	32	32	32	32	33	33	34	34	32	22
7	67.5			6	7	17	26	30	33	34	35	35	35	35	35	35	35	34	34	34	35	35	35	36	36	36	34	24
7	72.5			22	26	39	36	36	37	37	37	37	37	36	36	36	35	35	35	35	35	35	36	37	38	39	37	26
7	77.5			23	29	43	43	41	40	39	39	38	38	37	37	37	36	36	36	36	36	36	37	38	39	40	38	27
8	82.5		Tier 3	22	29	42	44	43	41	40	39	39	38	38	37	37	36	36	36	36	36	36	37	38	39	39	37	25
9	87.5			22	30	41	43	42	41	40	39	39	38	37	37	36	36	35	35	35	35	35	36	37	38	38	35	24
10	92.5			21	32	39	41	41	40	39	38	38	37	36	36	35	35	34	34	34	34	34	34	35	36	36	33	22
11	97.5			21	36	40	39	39	38	38	37	36	36	35	34	34	33	33	32	32	32	32	32	32	33	32	30	18
12	102.5			22	33	33	34	35	35	35	34	34	33	33	32	31	31	30	30	29	28	28	28	28	27	27	24	15
14	105	3	4	14	23	29	32	33	34	35	35	35	34	34	33	32	32	31	30	30	29	29	28	28	27	26	23	14
14	110	12	15	29	30	32	34	34	35	35	34	34	33	33	32	31	30	30	29	28	28	27	27	27	26	26	23	15
15	115	15	19	32	35	36	36	35	35	35	34	34	33	32	31	30	29	28	28	27	26	26	26	25	25	25	23	14
17	120	14	20	31	35	36	35	35	35	34	33	33	32	31	30	29	28	27	26	26	25	24	24	24	24	24	22	13
19	125	Tier 4 13	20	30	33	34	34	34	33	33	32	31	31	30	29	28	27	26	25	24	23	23	23	23	23	23	20	12
21	130	13	22	29	31	32	32	32	32	31	31	30	29	28	27	26	25	24	23	22	22	21	21	21	21	21	18	11
23	135	11	22	26	28	29	30	30	30	30	29	29	27	26	25	24	23	21	20	20	19	19	19	19	19	18	16	9
25	140	9	18	24	27	29	30	31	31	31	30	28	27	25	23	22	20	19	18	17	16	15	15	15	14	14	12	7
25	145	16	26	30	34	36	37	37	36	34	31	28	26	24	21	19	17	16	14	13	12	11	10	9	8	7	5	2

Notes: Reinforcement stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed Wall Height is 135 feet.

Table 34 - West Wall, Station 180+00

Cumulative Horizontal Displacements in Feet

End of Staged Construction

Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.10	-0.10	-0.10
5							-0.12	-0.12	-0.12
10						*Tier 1*	-0.15	-0.14	-0.14
15							-0.17	-0.16	-0.16
20							-0.18	-0.18	-0.18
25					-0.20	-0.20	-0.20	-0.20	-0.20
30					-0.22	-0.22	-0.22	-0.22	-0.21
35					-0.24	-0.23	-0.23	-0.23	-0.23
40					-0.26	-0.25	-0.24	-0.24	-0.24
45				*Tier 2*	-0.27	-0.25	-0.25	-0.25	-0.24
50					-0.27	-0.26	-0.26	-0.25	-0.25
55					-0.28	-0.27	-0.26	-0.26	-0.26
60					-0.27	-0.27	-0.26	-0.26	-0.25
65			-0.27	-0.28	-0.27	-0.27	-0.27	-0.26	-0.26
70			-0.28	-0.28	-0.28	-0.27	-0.27	-0.27	-0.26
75			-0.29	-0.29	-0.28	-0.28	-0.27	-0.27	-0.27
80		*Tier 3*	-0.29	-0.29	-0.29	-0.28	-0.28	-0.27	-0.27
85			-0.29	-0.29	-0.28	-0.28	-0.28	-0.27	-0.27
90			-0.29	-0.29	-0.28	-0.28	-0.27	-0.27	-0.27
95			-0.28	-0.28	-0.28	-0.27	-0.27	-0.27	-0.26
100		-0.26	-0.26	-0.28	-0.28	-0.28	-0.27	-0.27	-0.27	-0.26
105		-0.30	-0.29	-0.28	-0.27	-0.27	-0.27	-0.26	-0.26	-0.26
110		-0.30	-0.28	-0.27	-0.27	-0.27	-0.26	-0.26	-0.26	-0.25
115		-0.30	-0.27	-0.27	-0.26	-0.26	-0.25	-0.25	-0.25	-0.25
120		-0.29	-0.26	-0.26	-0.25	-0.25	-0.25	-0.24	-0.24	-0.24
125	*Tier 4*	-0.28	-0.25	-0.25	-0.24	-0.24	-0.24	-0.23	-0.23	-0.23
130		-0.26	-0.24	-0.23	-0.23	-0.23	-0.22	-0.22	-0.22	-0.22
135		-0.24	-0.23	-0.22	-0.22	-0.21	-0.21	-0.21	-0.21	-0.20
140		-0.21	-0.21	-0.21	-0.21	-0.20	-0.20	-0.20	-0.19	-0.19
145		-0.20	-0.20	-0.20	-0.19	-0.19	-0.19	-0.18	-0.18	-0.17

Note: Negative numbers indicate outward displacements

Table 35 - West Wall, Station 180+00

Cumulative Vertical Displacements in Feet

End of Staged Construction

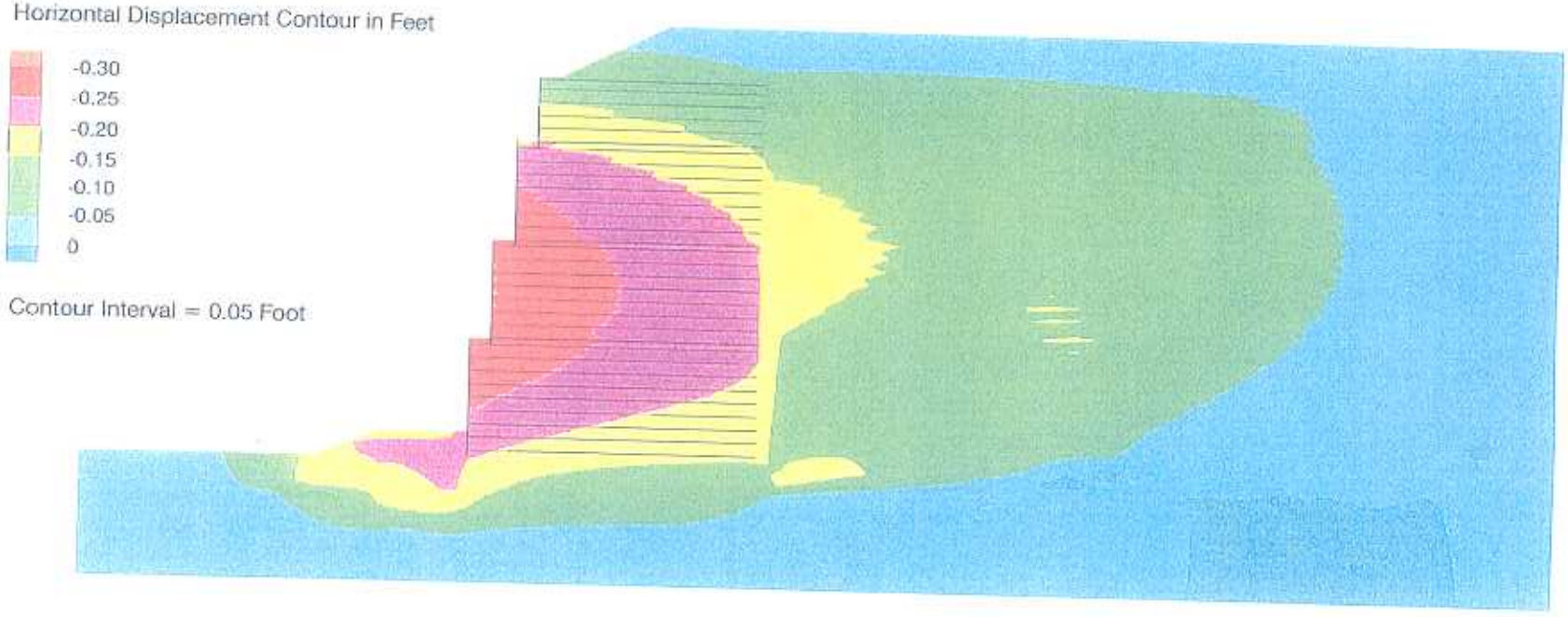
Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.05	-0.06	-0.06
5							-0.07	-0.08	-0.08
10						*Tier 1*	-0.09	-0.11	-0.11
15							-0.11	-0.12	-0.12
20							-0.13	-0.14	-0.14
25					-0.12	-0.15	-0.16	-0.16	-0.17
30					-0.14	-0.17	-0.18	-0.18	-0.18
35					-0.16	-0.19	-0.19	-0.19	-0.19
40					-0.17	-0.20	-0.20	-0.20	-0.20
45				*Tier 2*	-0.19	-0.21	-0.21	-0.21	-0.21
50					-0.20	-0.22	-0.22	-0.22	-0.22
55					-0.22	-0.23	-0.23	-0.23	-0.22
60					-0.22	-0.22	-0.22	-0.22	-0.22
65			-0.17	-0.21	-0.24	-0.23	-0.23	-0.23	-0.23
70			-0.18	-0.23	-0.24	-0.24	-0.23	-0.23	-0.23
75			-0.19	-0.24	-0.24	-0.24	-0.24	-0.24	-0.23
80		*Tier 3*	-0.20	-0.24	-0.24	-0.24	-0.24	-0.24	-0.23
85			-0.21	-0.25	-0.24	-0.24	-0.24	-0.24	-0.24
90			-0.23	-0.25	-0.24	-0.24	-0.24	-0.24	-0.23
95			-0.24	-0.24	-0.24	-0.24	-0.24	-0.23	-0.23
100		-0.15	-0.19	-0.26	-0.25	-0.25	-0.25	-0.24	-0.24	-0.24
105		-0.15	-0.22	-0.26	-0.25	-0.25	-0.24	-0.24	-0.24	-0.23
110		-0.16	-0.24	-0.25	-0.25	-0.24	-0.24	-0.24	-0.23	-0.23
115		-0.17	-0.24	-0.24	-0.24	-0.24	-0.23	-0.23	-0.23	-0.23
120		-0.17	-0.24	-0.24	-0.23	-0.23	-0.23	-0.23	-0.22	-0.22
125	*Tier 4*	-0.18	-0.23	-0.23	-0.23	-0.22	-0.22	-0.22	-0.22	-0.21
130		-0.18	-0.22	-0.22	-0.22	-0.22	-0.21	-0.21	-0.21	-0.21
135		-0.19	-0.21	-0.21	-0.21	-0.21	-0.21	-0.20	-0.20	-0.20
140		-0.20	-0.21	-0.21	-0.21	-0.20	-0.20	-0.20	-0.19	-0.19
145		-0.20	-0.19	-0.19	-0.19	-0.18	-0.18	-0.18	-0.17	-0.17

Note: Negative numbers indicate downward displacements

CASE 1

West Wall, Station 180+00

Cumulative Horizontal Displacements - End of Staged Construction



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4978-40 1/02
Figure 18

AR 053327

West Wall, Station 180+00

Cumulative Vertical Displacements - End of Staged Construction

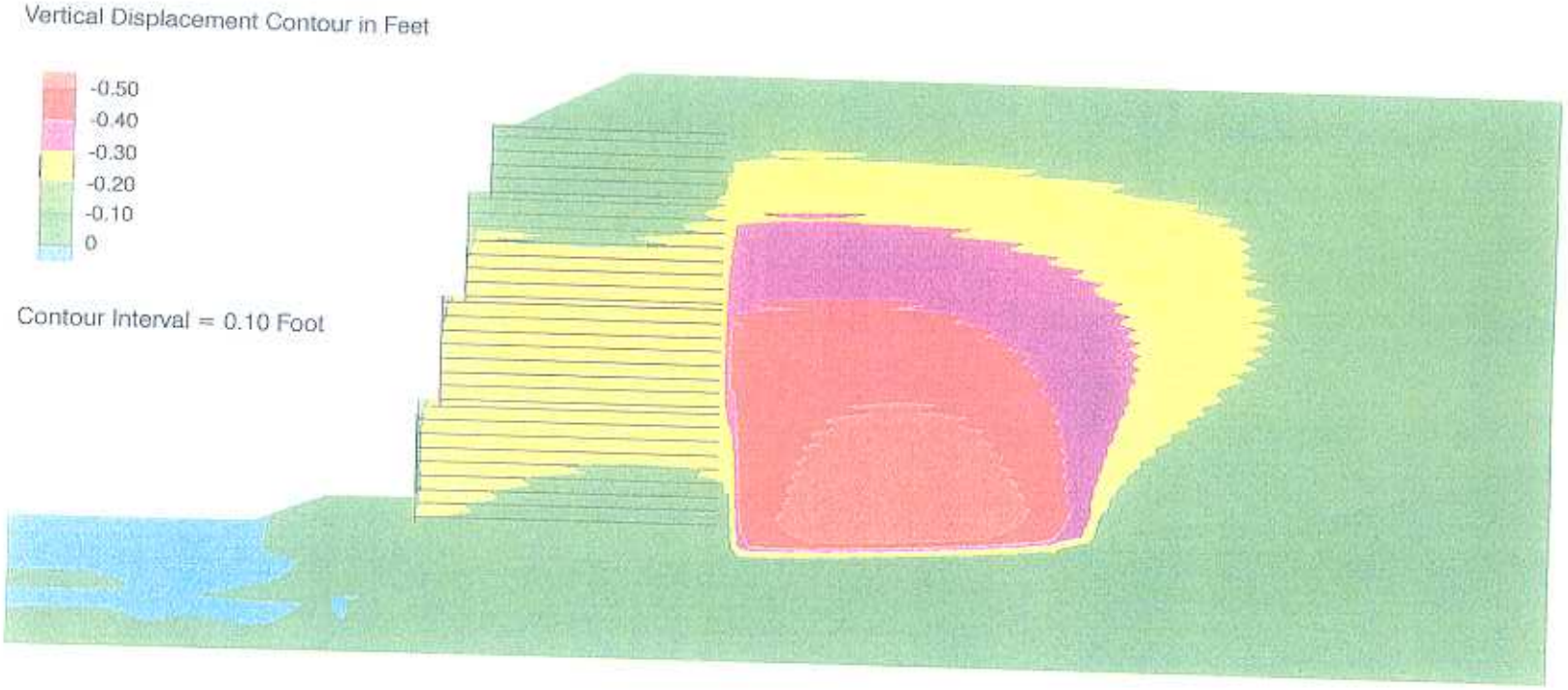

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Figure 19

AR 053328

CASE 2

Table 36 - West Wall, Station 180+00
Maximum Reinforcement Stresses (as a Percent of Yield)
During Shaking Without Liquefaction

Strip Density / Panel	Depth Below Top of Wall in Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							6	6	7	9	11	13	15	16	17	18	18	18	17	17	16	16	16	21	33	21	6
4	7.5							10	11	13	16	18	19	20	20	20	19	19	18	18	17	17	16	16	17	23	23	8
4	12.5	6 mm					Tier 1	14	16	17	20	22	22	22	21	21	20	19	18	17	16	15	15	15	18	25	25	10
5	17.5	Reinforcement						15	19	21	22	23	23	22	21	21	19	18	17	16	15	14	15	16	18	22	24	12
5	22.5	Throughout						18	24	24	22	22	22	22	21	20	19	18	16	15	15	15	15	16	17	20	22	13
6	27.5							14	21	19	19	20	20	20	20	19	18	16	15	13	13	13	13	14	15	17	20	15
4	30					11	14	29	35	36	40	42	43	43	42	40	38	35	32	30	29	30	30	31	33	34	33	15
5	35					21	34	42	40	42	43	44	44	44	43	41	39	36	33	32	31	31	31	32	33	35	35	16
5	40					20	38	48	49	47	47	46	46	45	44	42	40	37	34	33	32	32	32	33	34	36	36	18
5	45				Tier 2	21	41	50	52	50	49	47	46	45	44	42	40	38	36	34	33	33	33	34	36	37	36	20
6	50					20	41	48	51	50	48	47	46	45	44	42	40	38	36	35	34	34	34	34	35	36	35	22
6	55					24	45	50	50	49	47	46	45	44	43	42	41	39	37	35	35	35	35	35	36	37	36	24
7	60					27	47	50	48	46	45	45	44	44	43	42	41	40	38	35	35	35	34	35	36	37	35	25
8	65					29	44	42	42	42	42	42	42	42	42	41	40	38	37	35	33	33	33	33	34	34	32	22
7	67.5			10	12	20	32	38	41	43	44	44	44	44	44	43	42	41	40	37	36	35	35	36	36	36	34	24
7	72.5			25	29	43	44	45	46	46	46	46	46	46	45	45	44	42	41	38	36	36	36	37	38	39	37	26
7	77.5			27	32	53	55	52	51	50	49	48	48	47	46	45	45	43	41	39	36	36	37	38	39	40	38	27
8	82.5		Tier 3	25	32	53	57	55	53	51	50	49	48	47	46	46	45	43	42	40	37	36	37	38	39	39	37	25
9	87.5			26	35	51	56	56	53	51	49	48	47	46	46	45	44	43	42	40	37	36	36	37	38	38	35	24
10	92.5			26	39	51	54	54	51	49	47	46	46	45	44	44	43	43	41	40	38	36	35	35	36	36	33	22
11	97.5			28	44	52	52	50	48	46	45	44	44	43	43	43	42	41	41	39	38	35	35	34	34	33	30	19
12	102.5			29	42	43	43	43	43	42	42	41	41	41	41	41	40	40	39	38	36	34	32	31	30	29	25	15
14	105	4	7	17	27	34	38	40	41	42	42	42	42	42	42	42	41	41	40	39	38	36	34	32	30	28	24	14
14	110	13	17	31	35	38	40	41	41	42	42	42	41	41	41	41	41	41	40	39	38	36	34	31	29	27	24	15
15	115	16	20	37	42	42	42	42	42	42	41	41	41	41	40	40	40	40	39	38	37	35	33	30	29	27	23	14
17	120	15	21	36	41	41	41	41	41	41	41	40	40	40	39	39	39	38	38	37	35	33	31	29	28	26	22	13
19	125	Tier 4 14	22	34	39	40	40	39	39	39	39	39	39	38	38	37	37	36	35	34	33	31	29	28	27	25	21	12
21	130	14	24	33	36	37	38	38	38	38	38	38	37	37	36	35	34	33	32	31	30	29	28	27	26	24	20	12
23	135	12	24	30	34	35	37	37	38	38	38	37	36	35	34	32	31	30	29	28	27	27	26	25	24	22	19	10
25	140	14	24	31	35	38	40	41	41	41	40	39	37	35	32	29	27	26	25	23	23	22	21	21	20	19	16	9
25	145	21	35	42	46	49	50	51	51	49	46	43	38	33	27	23	20	19	17	16	15	14	13	13	12	11	9	5

Notes: Maximum reinforcement stress (as a percent of yield) shown for each 4 foot long segment.
Exposed Wall Height is 135 feet.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 3

Table 37 - West Wall, Station 180+00
Permanent Reinforcement Stresses (as a Percent of Yield)
End of Shaking Without Liquefaction

Strip Density / Panel	Depth Below Top of Wall in Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							5	5	6	7	9	11	13	14	15	15	15	15	14	14	13	13	13	19	31	18	1
4	7.5							10	10	12	15	17	18	18	18	18	17	16	16	15	14	13	12	12	14	21	18	1
4	12.5	6 mm					Tier 1	14	15	16	19	21	21	20	20	19	18	17	16	15	13	12	11	12	15	22	22	3
5	17.5	Reinforcement						15	18	20	21	22	22	21	20	19	18	16	15	14	13	12	12	13	16	19	22	6
5	22.5	Throughout						18	23	23	21	21	21	21	20	19	18	16	15	13	12	12	12	13	14	16	19	8
6	27.5							14	21	19	19	19	19	19	19	18	16	15	13	12	11	11	11	11	12	14	17	9
4	30					9	12	28	34	37	39	40	41	41	40	38	36	33	30	27	26	25	25	25	26	27	27	7
5	35					15	26	39	38	40	42	42	43	42	41	39	37	34	31	28	27	26	26	26	27	29	30	9
5	40					15	32	44	46	45	45	45	44	43	42	40	38	35	32	30	28	27	27	27	29	31	30	10
5	45				Tier 2	16	38	47	49	48	46	45	44	43	42	40	38	36	34	31	29	28	28	29	30	31	30	12
6	50					18	39	45	48	48	46	45	44	43	42	41	39	37	35	32	30	29	29	29	30	30	28	15
6	55					22	43	47	48	47	46	44	43	43	42	41	39	38	35	33	31	30	29	30	30	30	28	17
7	60					26	45	48	46	45	44	43	43	42	42	41	40	38	36	34	32	30	30	29	29	29	27	19
8	65					28	42	41	41	41	41	41	41	41	40	40	38	37	35	33	31	29	28	27	27	26	24	17
7	67.5			7	9	14	32	38	40	42	43	43	43	43	43	42	41	40	38	36	33	31	30	30	29	28	26	19
7	72.5			21	25	37	43	44	45	45	45	45	45	45	44	43	42	41	39	37	34	32	30	30	30	30	29	21
7	77.5			25	30	49	53	51	49	48	47	47	46	46	45	44	43	42	40	38	35	32	31	30	30	30	29	21
8	82.5		Tier 3	23	30	50	55	53	51	49	48	47	47	46	45	45	44	42	41	38	36	33	31	30	30	29	28	19
9	87.5			24	32	48	53	53	51	49	48	47	46	45	45	44	43	42	40	39	36	33	31	30	29	28	26	18
10	92.5			25	36	48	51	51	49	47	46	45	45	44	44	43	42	41	40	39	36	34	31	30	29	28	26	18
11	97.5			26	41	49	49	48	46	45	44	43	43	42	42	42	41	41	39	38	36	34	31	29	28	27	25	16
12	102.5			26	39	40	41	41	41	41	40	40	40	40	40	40	39	39	38	37	35	33	31	28	27	25	22	14
14	105	3	5	10	26	33	37	39	40	41	41	41	41	41	41	41	41	40	39	38	37	35	32	30	28	25	21	13
14	110	8	11	24	33	36	38	40	40	40	40	40	40	40	40	40	40	40	39	38	36	35	32	29	27	24	20	12
15	115	11	14	33	39	40	41	41	41	41	40	40	40	40	39	39	39	39	38	37	35	33	31	28	25	22	18	10
17	120	10	14	32	38	39	40	40	40	40	40	39	39	38	38	38	37	37	36	35	33	31	29	26	23	20	16	8
19	125	Tier 4 10	16	31	36	37	38	38	38	38	38	38	38	37	36	36	35	34	33	32	30	28	26	23	20	17	13	7
21	130	12	19	30	33	35	36	37	37	37	37	37	36	35	34	33	32	31	30	29	27	25	23	20	17	14	10	5
23	135	10	22	28	32	34	35	36	37	37	36	36	35	34	32	31	29	27	26	24	22	20	17	15	13	10	7	4
25	140	12	23	29	34	37	38	39	40	39	39	37	35	33	30	27	24	22	19	17	14	12	10	8	6	4	2	1
25	145	18	34	41	45	48	49	50	49	48	45	41	36	31	25	20	16	12	9	6	3	0	-2	-5	-7	-8	-7	-4

Notes: Reinforcement stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed Wall Height is 135 feet.

Table 38 - West Wall, Station 180+00

Permanent Horizontal Displacements in Feet

End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.31	-0.31	-0.31
5							-0.30	-0.30	-0.30
10						*Tier 1*	-0.29	-0.29	-0.29
15							-0.28	-0.28	-0.28
20							-0.27	-0.27	-0.26
25					-0.25	-0.26	-0.25	-0.25	-0.25
30					-0.26	-0.25	-0.24	-0.24	-0.24
35					-0.25	-0.24	-0.23	-0.23	-0.23
40					-0.23	-0.23	-0.22	-0.22	-0.22
45				*Tier 2*	-0.22	-0.21	-0.21	-0.21	-0.21
50					-0.21	-0.20	-0.20	-0.20	-0.20
55					-0.20	-0.20	-0.19	-0.19	-0.19
60					-0.19	-0.19	-0.18	-0.18	-0.18
65			-0.18	-0.18	-0.18	-0.18	-0.17	-0.17	-0.17
70			-0.17	-0.17	-0.17	-0.17	-0.17	-0.17	-0.17
75			-0.16	-0.16	-0.16	-0.16	-0.16	-0.16	-0.16
80		*Tier 3*	-0.15	-0.16	-0.15	-0.15	-0.15	-0.15	-0.15
85			-0.15	-0.15	-0.15	-0.14	-0.14	-0.14	-0.14
90			-0.14	-0.14	-0.14	-0.14	-0.14	-0.13	-0.13
95			-0.13	-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
100	-0.13	-0.13	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12
105	-0.15	-0.13	-0.13	-0.12	-0.12	-0.12	-0.12	-0.11	-0.11
110	-0.14	-0.12	-0.12	-0.11	-0.11	-0.11	-0.11	-0.11	-0.11
115	-0.13	-0.11	-0.11	-0.11	-0.11	-0.10	-0.10	-0.10	-0.10
120	-0.12	-0.11	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10
125	-0.11	-0.10	-0.10	-0.10	-0.10	-0.10	-0.09	-0.09	-0.09
130	-0.11	-0.10	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
135	-0.10	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09	-0.09
140	-0.09	-0.09	-0.09	-0.09	-0.09	-0.08	-0.08	-0.08	-0.08
145	-0.11	-0.09	-0.09	-0.08	-0.08	-0.08	-0.08	-0.08	-0.08

Tier 4

Note: Negative numbers indicate outward displacements

Table 39 - West Wall, Station 180+00

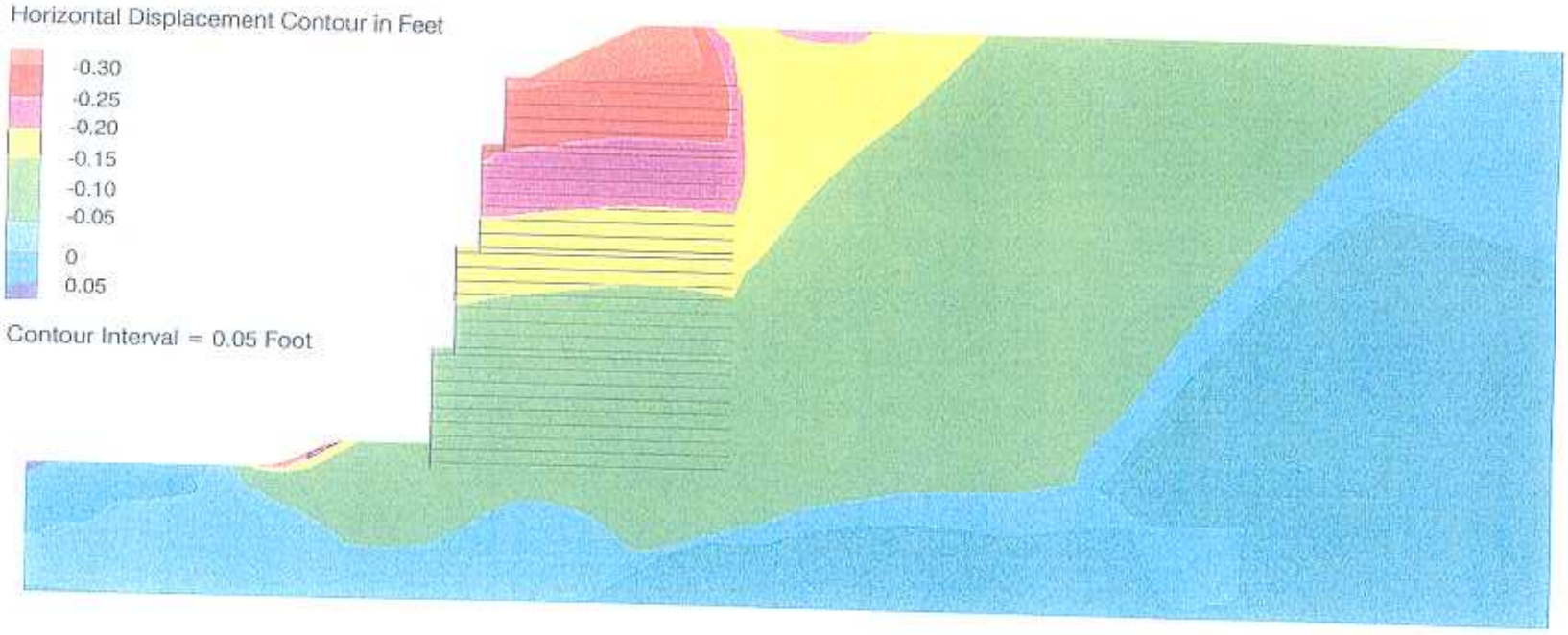
Permanent Vertical Displacements in Feet
End of Shaking Without Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet								
	0	4	8	12	16	20	24	28	32
0							-0.08	-0.08	-0.07
5							-0.08	-0.08	-0.07
10						Tier 1	-0.08	-0.08	-0.07
15							-0.08	-0.07	-0.07
20							-0.08	-0.07	-0.06
25					-0.07	-0.07	-0.08	-0.07	-0.06
30					-0.07	-0.08	-0.08	-0.07	-0.06
35					-0.07	-0.08	-0.07	-0.06	-0.06
40					-0.07	-0.08	-0.07	-0.06	-0.06
45				Tier 2	-0.07	-0.08	-0.07	-0.06	-0.05
50					-0.07	-0.07	-0.07	-0.06	-0.05
55					-0.07	-0.07	-0.06	-0.06	-0.05
60					-0.07	-0.07	-0.06	-0.05	-0.05
65			-0.07	-0.06	-0.07	-0.06	-0.06	-0.05	-0.05
70			-0.07	-0.07	-0.07	-0.06	-0.06	-0.05	-0.05
75			-0.07	-0.07	-0.06	-0.06	-0.05	-0.05	-0.04
80		Tier 3	-0.07	-0.07	-0.06	-0.06	-0.05	-0.05	-0.04
85			-0.07	-0.07	-0.06	-0.06	-0.05	-0.05	-0.04
90			-0.07	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04
95			-0.07	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04
100		-0.05	-0.04	-0.07	-0.06	-0.05	-0.05	-0.04	-0.04
105		-0.05	-0.06	-0.07	-0.06	-0.05	-0.05	-0.04	-0.04	-0.03
110		-0.05	-0.06	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.03
115		-0.05	-0.06	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.03
120		-0.05	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.04	-0.03
125	Tier 4	-0.05	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03
130		-0.05	-0.06	-0.06	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03
135		-0.05	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03
140		-0.05	-0.06	-0.05	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03
145		-0.05	-0.05	-0.05	-0.05	-0.04	-0.04	-0.03	-0.03	-0.02

Note: Negative numbers indicate downward displacements

West Wall, Station 180+00

Permanent Horizontal Displacements - End of Shaking Without Liquefaction



0 60 120

Scale in Feet

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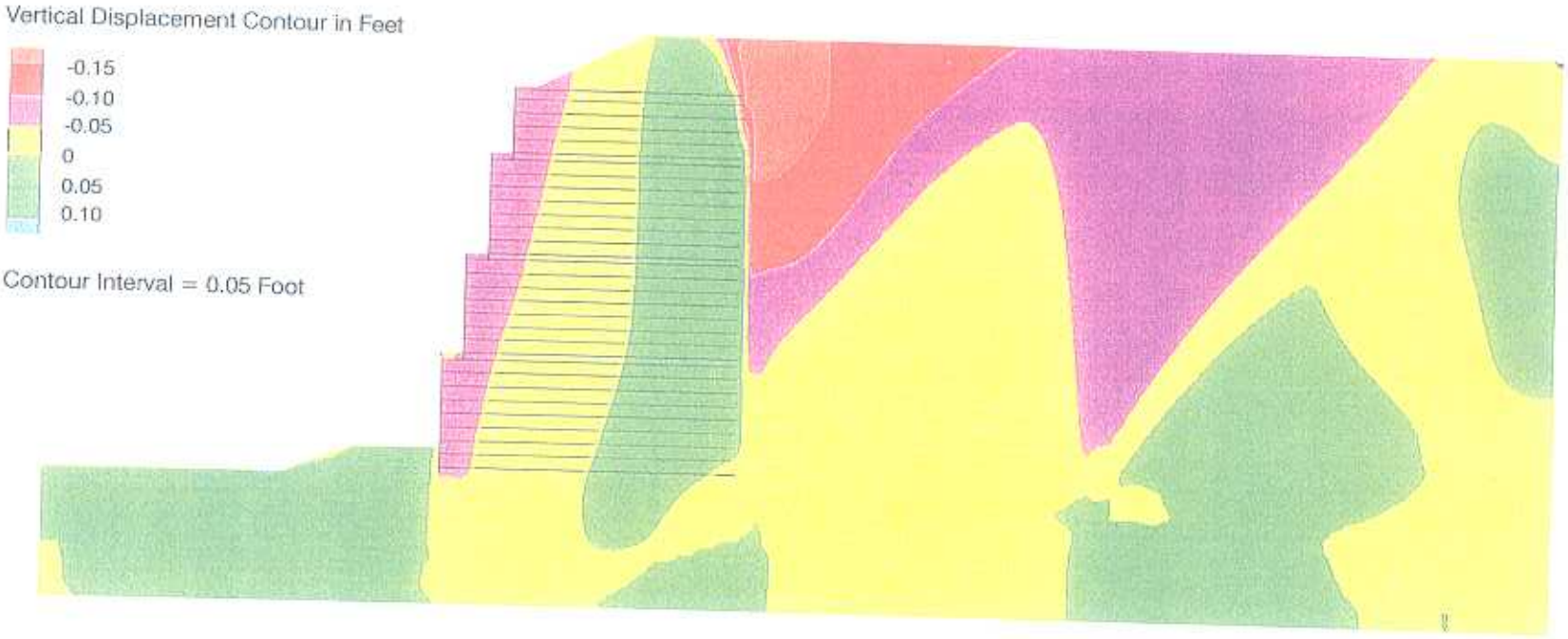
4978-40 1/02

Figure 20

AR 053335

West Wall, Station 180+00

Permanent Vertical Displacements - End of Shaking Without Liquefaction



0 60 120
Scale in Feet

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Figure 21

AR 053336

CASE 4

Table 40 - West Wall, Station 180+00
Permanent Reinforcement Stresses (as a Percent of Yield)
End of Shaking Followed by Liquefaction

Strip Density / Panel	Depth Below Top of Wall in Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							7	7	7	8	11	13	16	18	19	21	23	25	26	26	25	25	26	22	17	13	5
4	7.5							13	13	15	17	19	20	20	20	20	21	21	22	22	22	22	22	23	23	24	15	6
4	12.5	6 mm					Tier 1	15	17	18	21	22	22	22	21	20	19	19	18	18	19	19	19	19	23	19	7	
5	17.5	Reinforcement						15	18	20	22	22	22	21	20	19	18	16	15	15	16	16	17	17	18	20	23	7
5	22.5	Throughout						18	23	23	21	21	21	20	19	18	17	15	14	13	13	14	15	16	16	17	20	7
6	27.5							15	21	19	18	19	19	18	18	16	15	13	12	10	10	10	10	11	12	13	16	8
4	30					9	13	25	29	36	38	39	39	39	37	35	32	29	26	23	22	21	21	22	22	24	25	5
5	35					17	27	38	40	41	41	41	41	40	38	35	33	30	26	24	22	20	20	19	20	24	26	7
5	40					15	29	41	45	44	44	43	42	40	38	36	33	30	27	24	22	20	20	20	21	24	26	8
5	45				Tier 2	15	31	44	48	46	45	43	42	40	38	36	33	30	27	25	22	21	20	21	23	25	26	10
6	50					14	33	44	47	46	45	43	41	39	37	35	33	31	28	25	23	21	21	22	23	24	23	13
6	55					18	40	47	48	47	44	42	40	38	37	35	33	31	28	26	23	22	22	22	23	24	24	15
7	60					23	44	48	47	45	43	41	39	38	36	35	33	31	29	26	24	22	22	22	23	24	23	17
8	65					25	42	42	41	40	39	38	37	36	35	33	32	30	27	25	23	21	20	20	20	21	20	14
7	67.5			7	9	15	27	37	40	41	41	40	39	38	37	36	34	32	30	28	25	23	22	22	22	23	21	16
7	72.5			23	26	39	49	49	46	44	43	42	41	40	38	37	35	33	31	28	25	23	22	21	22	23	23	18
7	77.5			24	30	48	57	55	51	48	46	44	42	41	39	37	36	34	31	28	25	22	21	21	21	22	22	17
8	82.5		Tier 3	22	29	51	57	56	53	50	47	45	43	41	39	37	35	33	31	28	25	22	20	20	20	20	20	15
9	87.5			24	33	51	56	56	53	50	47	45	42	40	38	36	34	32	30	28	25	22	19	18	18	18	18	13
10	92.5			26	38	51	55	55	52	48	45	43	41	39	37	35	33	31	29	27	25	22	19	17	17	17	16	12
11	97.5			29	45	54	54	52	49	45	43	41	39	37	35	33	32	30	28	26	24	21	18	17	16	16	15	11
12	102.5			29	41	43	43	43	41	40	38	37	35	34	33	31	30	28	26	24	22	20	17	15	14	13	12	8
14	105	3	4	11	29	35	38	40	40	39	38	37	36	35	34	32	31	29	27	26	24	22	19	17	15	14	12	8
14	110	10	13	26	37	39	39	40	40	39	37	36	35	34	33	31	30	29	27	25	23	21	18	16	14	13	11	7
15	115	14	18	36	44	44	42	41	40	38	37	35	34	33	32	31	30	28	26	24	22	20	17	14	12	11	9	6
17	120	13	18	38	44	44	42	40	39	37	36	35	33	32	31	30	28	26	24	22	20	17	15	12	10	8	7	4
19	125	Tier 4 13	20	37	41	41	40	38	37	36	35	33	32	31	30	28	26	24	22	20	17	15	12	9	7	5	3	2
21	130	14	24	35	37	38	37	36	35	34	33	32	31	29	28	26	24	22	19	17	14	11	8	5	3	1	0	0
23	135	12	26	32	34	35	36	35	35	34	33	31	30	28	26	24	21	19	16	13	9	6	2	1	3	5	5	3
25	140	11	23	30	34	37	38	39	38	37	35	33	31	28	25	22	18	14	10	6	2	-2	-6	9	12	14	12	7
25	145	18	35	42	46	48	50	51	49	47	43	39	34	29	24	18	13	7	1	-4	-10	-15	-20	-24	-28	-30	-28	-16

Notes: Reinforcement stress (as a percent of yield) shown for each 4 foot-long segment.
Exposed Wall Height is 135 feet.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 41 - West Wall, Station 180+00

Permanent Horizontal Displacements in Feet

End of Shaking Followed by Liquefaction

Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.67	-0.67	-0.67
5							-0.66	-0.66	-0.66
10						*Tier 1*	-0.64	-0.64	-0.63
15							-0.62	-0.62	-0.61
20							-0.60	-0.60	-0.59
25					-0.57	-0.58	-0.58	-0.57	-0.57
30					-0.59	-0.57	-0.56	-0.55	-0.55
35					-0.57	-0.54	-0.54	-0.53	-0.53
40					-0.55	-0.52	-0.52	-0.51	-0.51
45				*Tier 2*	-0.52	-0.50	-0.50	-0.49	-0.49
50					-0.49	-0.48	-0.48	-0.48	-0.47
55					-0.47	-0.46	-0.46	-0.46	-0.45
60					-0.44	-0.44	-0.44	-0.44	-0.44
65			-0.42	-0.43	-0.43	-0.42	-0.42	-0.42	-0.42
70			-0.40	-0.41	-0.41	-0.40	-0.40	-0.40	-0.40
75			-0.38	-0.39	-0.39	-0.38	-0.38	-0.38	-0.38
80		*Tier 3*	-0.37	-0.37	-0.37	-0.36	-0.36	-0.36	-0.36
85			-0.35	-0.35	-0.35	-0.35	-0.34	-0.34	-0.34
90			-0.33	-0.33	-0.33	-0.33	-0.33	-0.32	-0.32
95			-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
100		-0.30	-0.30	-0.29	-0.29	-0.29	-0.29	-0.29	-0.29
105		-0.32	-0.30	-0.29	-0.28	-0.27	-0.27	-0.27	-0.27
110		-0.30	-0.27	-0.26	-0.26	-0.26	-0.25	-0.25	-0.25
115		-0.28	-0.25	-0.24	-0.24	-0.24	-0.24	-0.24	-0.24
120		-0.26	-0.23	-0.23	-0.22	-0.22	-0.22	-0.22	-0.22
125	*Tier 4*	-0.24	-0.22	-0.21	-0.21	-0.21	-0.21	-0.21	-0.21
130		-0.22	-0.20	-0.20	-0.19	-0.19	-0.19	-0.19	-0.19
135		-0.19	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18
140		-0.18	-0.17	-0.17	-0.17	-0.17	-0.16	-0.16	-0.16
145		-0.18	-0.17	-0.16	-0.15	-0.15	-0.15	-0.15	-0.15

Note: Negative numbers indicate outward displacements

Table 42 - West Wall, Station 180+00

Permanent Vertical Displacements in Feet

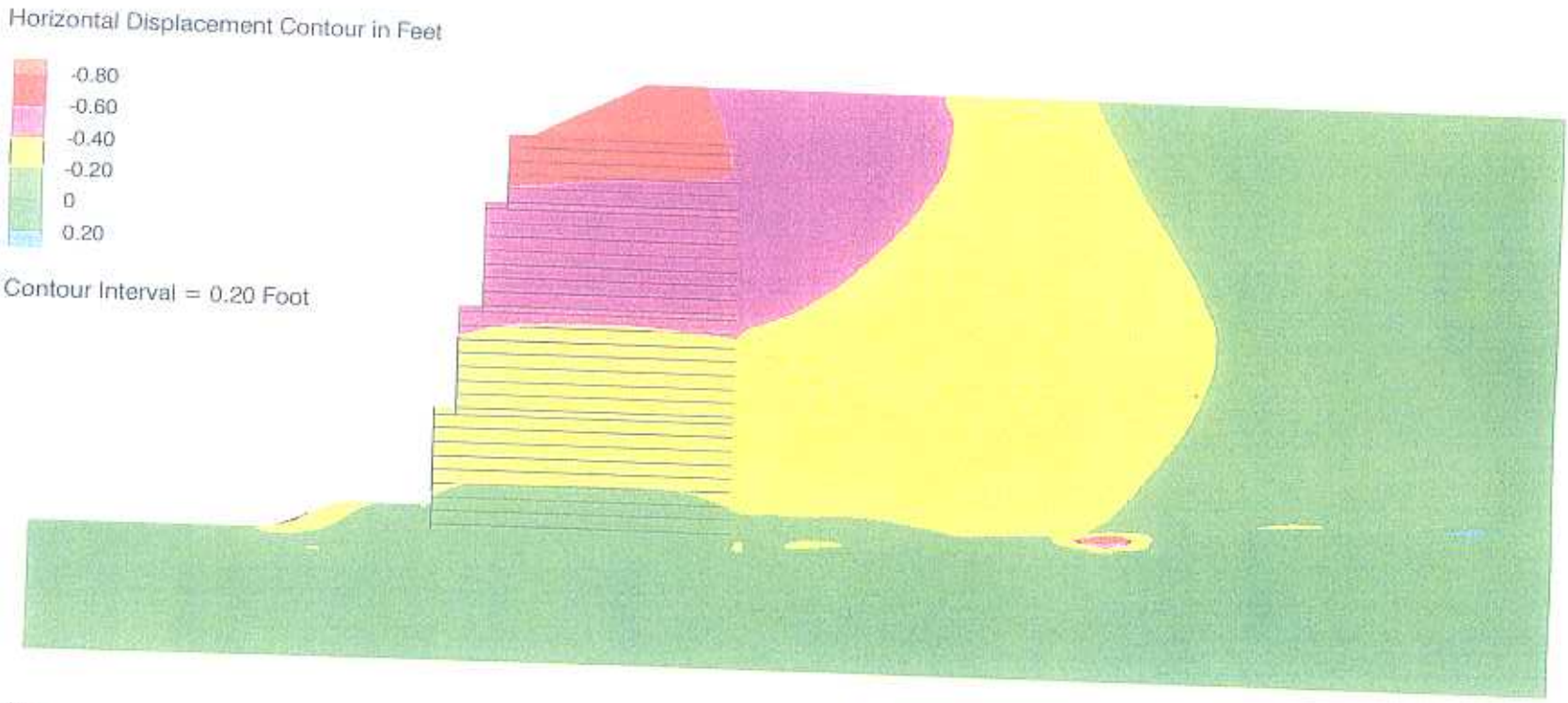
End of Shaking Followed by Liquefaction

Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.12	-0.11	-0.09
5							-0.12	-0.11	-0.09
10						*Tier 1*	-0.12	-0.11	-0.09
15							-0.12	-0.11	-0.09
20							-0.12	-0.10	-0.09
25					-0.13	-0.11	-0.12	-0.10	-0.08
30					-0.13	-0.13	-0.11	-0.10	-0.08
35					-0.13	-0.13	-0.11	-0.10	-0.08
40					-0.13	-0.13	-0.11	-0.09	-0.08
45				*Tier 2*	-0.13	-0.12	-0.11	-0.09	-0.08
50					-0.13	-0.12	-0.10	-0.09	-0.07
55					-0.13	-0.12	-0.10	-0.09	-0.07
60					-0.13	-0.11	-0.10	-0.08	-0.07
65			-0.13	-0.11	-0.13	-0.11	-0.10	-0.08	-0.07
70			-0.13	-0.13	-0.12	-0.10	-0.09	-0.08	-0.07
75			-0.13	-0.13	-0.11	-0.10	-0.09	-0.08	-0.06
80		*Tier 3*	-0.13	-0.12	-0.11	-0.10	-0.09	-0.07	-0.06
85			-0.13	-0.12	-0.11	-0.09	-0.08	-0.07	-0.06
90			-0.13	-0.12	-0.10	-0.09	-0.08	-0.07	-0.06
95			-0.13	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06
100	-0.09	-0.07	-0.13	-0.11	-0.10	-0.09	-0.07	-0.06	-0.05
105	-0.09	-0.11	-0.12	-0.11	-0.09	-0.08	-0.07	-0.06	-0.05
110	-0.09	-0.12	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06	-0.05
115	-0.09	-0.12	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06	-0.05
120	-0.09	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06	-0.06	-0.05
125 *Tier 4*	-0.09	-0.11	-0.10	-0.09	-0.08	-0.07	-0.06	-0.05	-0.04
130	-0.09	-0.10	-0.09	-0.09	-0.08	-0.07	-0.06	-0.05	-0.04
135	-0.09	-0.10	-0.09	-0.08	-0.07	-0.07	-0.06	-0.05	-0.04
140	-0.09	-0.09	-0.09	-0.08	-0.07	-0.06	-0.05	-0.05	-0.04
145	-0.09	-0.09	-0.08	-0.08	-0.07	-0.06	-0.05	-0.04	-0.04

Note: Negative numbers indicate downward displacements

West Wall, Station 180+00

Permanent Horizontal Displacements - End of Shaking Followed by Liquefaction



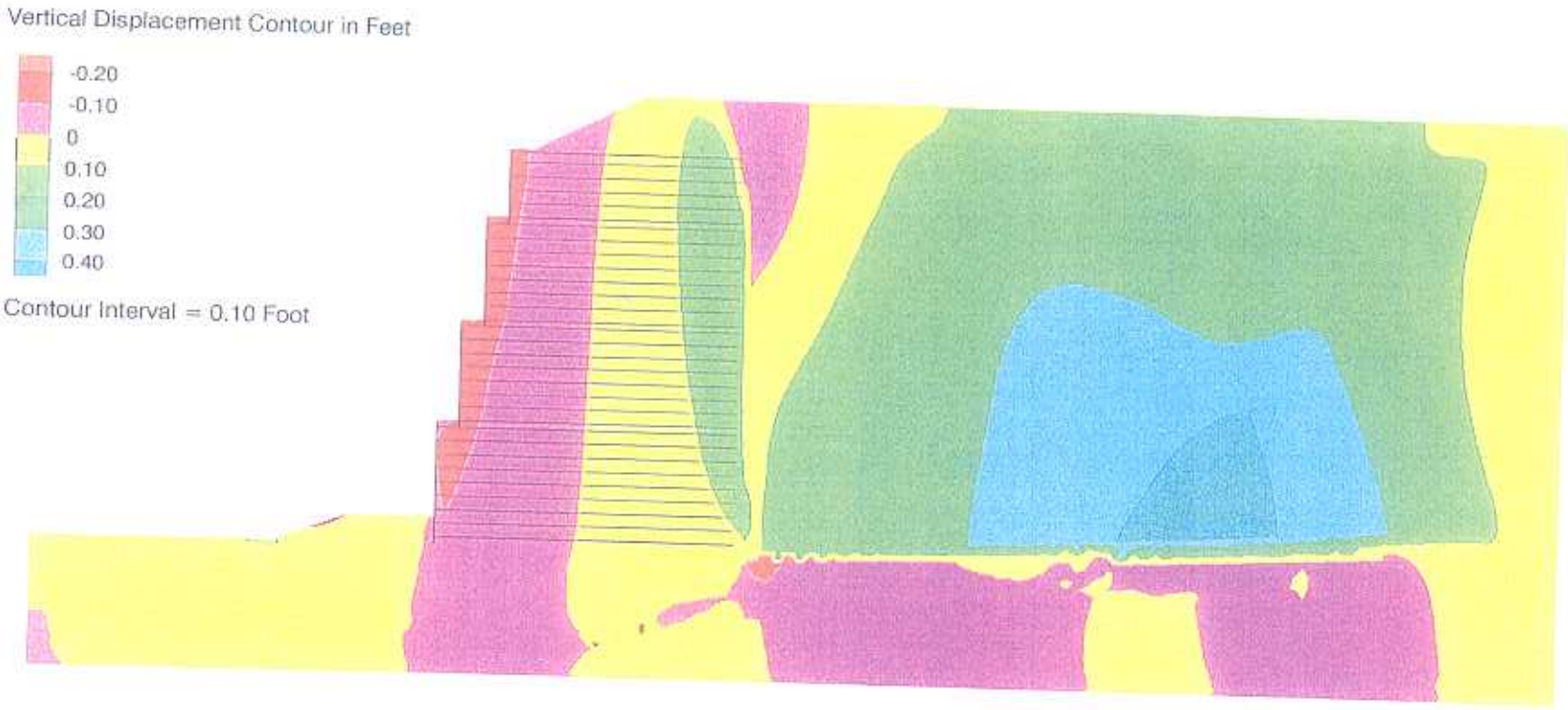
HARTCROWSER
4978-40 1/02
Figure 22

AR 053341

DTN 1/07/02 4978406.cdr

West Wall, Station 180+00

Permanent Vertical Displacements - End of Shaking Followed by Liquefaction



HARTCROWSER
4978-40
Figure 23
1/02

DTN 1/07/02 497840H.cdr

AR 053342

CASE 5

Table 43 - West Wall, Station 180+00
Maximum Reinforcement Stresses (as a Percent of Yield)
During Shaking With Concurrent Liquefaction

Strip Density / Panel	Depth Below Top of Wall In Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							6	6	7	8	10	14	17	19	20	22	24	25	26	25	24	24	25	23	21	18	6
4	7.5							11	11	13	16	17	18	19	20	21	21	22	23	24	24	24	23	23	23	23	23	8
4	12.5	6 mm					Tier 1	15	17	17	19	20	20	20	21	21	21	21	20	20	20	20	20	21	22	22	22	10
5	17.5	Reinforcement						15	18	20	20	21	21	21	20	20	20	19	18	18	17	18	19	20	20	19	19	12
5	22.5	Throughout						17	22	21	20	20	20	20	20	19	19	18	17	16	15	16	17	19	19	19	20	14
6	27.5							14	20	17	16	17	18	18	18	17	17	16	15	14	13	14	14	15	15	16	18	15
4	30					10	14	25	26	30	32	35	37	38	37	37	35	34	32	30	30	30	30	31	31	32	30	15
5	35					22	34	41	40	42	40	38	38	38	38	36	35	33	31	30	30	29	29	30	31	33	33	16
5	40					20	34	43	47	46	45	43	41	39	38	36	34	33	31	31	30	30	30	31	33	34	34	18
5	45				Tier 2	20	37	46	49	47	46	45	43	40	38	36	34	33	32	31	31	31	32	33	34	36	35	20
6	50					19	36	44	46	47	46	45	43	41	38	36	34	33	32	32	32	32	33	34	35	36	35	22
6	55					21	40	45	46	46	46	45	43	40	38	36	34	33	33	32	33	33	34	35	36	37	36	24
7	60					24	42	46	45	45	45	43	41	39	37	35	34	33	33	33	33	33	34	35	36	37	35	25
8	65					27	43	42	42	42	41	40	38	36	35	34	33	32	32	32	32	32	33	33	34	34	32	22
7	67.5			9	12	17	26	36	40	42	42	41	40	38	37	36	35	34	34	34	35	35	35	36	36	36	34	24
7	72.5			24	28	43	46	48	47	46	44	42	40	39	38	37	36	35	35	35	35	35	36	37	38	39	37	26
7	77.5			26	32	51	55	53	51	48	46	43	41	40	39	38	37	36	36	36	36	36	37	38	39	40	38	27
8	82.5		Tier 3	25	32	52	56	54	51	48	46	44	42	41	39	38	36	36	36	36	36	36	37	38	39	39	37	25
9	87.5			26	34	50	54	52	50	47	45	43	42	40	38	37	36	35	35	35	35	35	36	37	38	38	35	24
10	92.5			26	38	50	51	50	48	45	43	42	40	39	37	36	35	34	34	34	34	34	35	36	36	33	31	22
11	97.5			27	44	50	49	47	45	43	41	40	39	37	36	35	34	33	32	32	32	32	33	33	31	19		
12	102.5			29	43	42	41	40	39	38	38	37	36	35	34	33	32	31	30	30	29	28	28	28	28	25	16	
14	105	5	7	15	27	33	36	37	38	38	38	38	37	36	36	35	34	33	32	31	30	29	29	28	28	27	24	15
14	110	12	15	31	35	37	38	38	38	38	38	37	37	36	35	35	34	33	31	30	29	28	27	27	27	26	24	15
15	115	17	22	39	42	42	41	39	39	38	38	37	36	36	35	35	34	33	31	30	28	27	26	25	25	25	23	14
17	120	17	24	40	43	42	41	39	38	37	37	36	36	35	35	34	34	33	31	30	28	26	25	24	24	24	22	13
19	125	Tier 4 17	25	39	42	41	40	38	37	35	35	35	35	34	34	34	33	32	31	29	28	26	25	23	23	23	20	12
21	130	17	27	37	39	39	37	36	35	34	34	34	34	34	33	33	32	31	30	29	27	26	24	22	21	21	18	11
23	135	14	29	34	36	36	36	36	35	35	35	35	34	34	33	32	31	30	29	27	26	24	22	20	19	18	16	9
25	140	14	26	31	35	37	38	39	39	39	39	39	38	36	34	32	30	28	25	23	21	19	17	15	14	14	12	7
25	145	22	36	43	47	50	51	52	52	51	50	47	44	40	36	31	27	22	18	14	12	11	10	9	8	7	5	2

Notes: Maximum reinforcement stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed Wall Height is 135 feet.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 6

Table 44 - West Wall, Station 180+00
Permanent Reinforcement Stresses (as a Percent of Yield)
End of Shaking With Concurrent Liquefaction

Strip Density / Panel	Depth Below Top of Wall in Feet	Segment Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
3	2.5							5	5	5	6	9	12	15	17	18	20	22	23	23	23	22	22	22	20	19	16	2
4	7.5							11	11	12	15	16	17	17	18	19	19	20	21	21	21	21	21	21	21	21	21	3
4	12.5	6 mm					Tier 1	15	16	17	18	19	19	19	19	19	19	19	19	18	18	18	18	19	20	20	21	6
5	17.5	Reinforcement						15	18	19	20	20	20	19	19	19	18	17	17	16	15	16	17	17	18	17	18	8
5	22.5	Throughout						17	21	21	19	19	19	19	19	18	18	17	16	14	14	15	16	17	17	18	19	10
6	27.5							13	19	16	16	16	17	17	17	16	16	15	14	13	12	12	13	14	14	15	16	13
4	30					8	13	24	24	29	31	34	35	36	36	35	33	32	30	28	28	28	28	29	29	29	26	12
5	35					18	30	39	38	40	39	37	37	37	36	35	33	32	30	29	28	28	27	27	27	28	27	13
5	40					17	32	42	45	45	44	42	40	38	37	35	33	31	30	29	29	28	27	27	27	29	28	14
5	45				Tier 2	18	35	44	47	46	45	44	42	39	37	35	33	32	31	30	29	28	28	28	29	30	29	16
6	50					17	35	42	45	45	45	44	42	40	37	35	33	32	31	30	29	29	29	29	30	30	29	18
6	55					19	38	43	45	45	45	44	42	40	37	35	33	32	31	31	30	30	30	30	31	31	30	20
7	60					22	41	45	44	44	44	43	41	38	36	35	33	32	32	31	30	30	30	30	31	31	30	22
8	65					24	41	41	41	41	41	39	38	36	34	33	32	31	30	30	29	29	28	28	29	29	26	18
7	67.5			6	8	13	24	36	40	42	42	41	39	38	37	35	34	34	33	32	31	31	31	31	31	31	29	21
7	72.5			21	25	36	44	47	47	45	44	42	40	38	37	36	35	34	33	32	32	31	31	32	32	33	31	22
7	77.5			23	28	44	52	52	50	48	45	43	41	40	38	37	35	34	33	33	32	32	32	32	33	33	32	22
8	82.5		Tier 3	21	27	48	54	53	50	48	45	43	42	40	38	37	35	34	33	32	31	31	31	31	32	32	30	21
9	87.5			23	30	47	51	51	49	47	45	43	41	39	37	36	34	33	32	31	30	30	30	30	30	31	29	20
10	92.5			24	34	46	49	49	47	45	43	41	40	38	36	35	33	32	30	29	29	28	28	28	29	29	27	18
11	97.5			26	39	47	47	46	44	42	40	39	38	36	34	33	31	30	29	27	26	25	25	25	25	25	24	15
12	102.5			25	37	39	39	39	38	37	37	36	35	34	32	31	29	27	26	24	23	21	20	20	20	19	18	12
14	105	2	4	8	25	32	35	37	37	37	37	36	35	34	33	32	30	28	27	25	23	22	20	19	19	18	16	10
14	110	8	11	21	32	36	37	38	38	37	37	36	35	33	32	31	29	27	25	23	21	19	17	16	16	16	15	10
15	115	10	13	30	37	39	39	39	38	37	36	35	34	33	31	30	28	26	23	21	18	16	15	13	13	13	13	9
17	120	9	13	32	38	39	39	38	37	36	35	34	33	31	30	29	27	25	22	19	17	14	12	11	10	10	10	7
19	125	Tier 4 11	16	32	37	37	37	36	35	34	34	32	31	30	28	27	25	23	20	18	15	13	10	9	8	7	7	5
21	130	12	19	31	34	34	34	34	33	33	32	31	30	28	27	25	23	21	19	16	14	11	8	6	5	4	4	3
23	135	11	22	29	31	32	33	33	33	32	31	31	29	28	26	24	22	19	17	14	11	8	5	2	0	-1	-1	0
25	140	11	23	28	32	34	36	36	37	36	35	34	32	30	27	24	21	17	13	10	6	2	-2	-5	-8	-9	-8	-4
25	145	19	34	41	45	47	49	49	49	48	46	43	39	35	30	24	18	12	5	-1	-7	-13	-18	-23	-25	-25	-22	-12

Notes: Reinforcement stress (as a percent of yield) shown for each 4 foot long segment.
Exposed Wall Height is 135 feet.

Table 45 - West Wall, Station 180+00

Permanent Horizontal Displacements in Feet

End of Shaking With Concurrent Liquefaction

Depth Below Top of Wall in Feet	*Horizontal Distance Measured from Wall Face in Feet*								
	0	*4*	*8*	*12*	*16*	*20*	*24*	*28*	*32*
0							-0.82	-0.82	-0.82
5							-0.81	-0.81	-0.80
10						*Tier 1*	-0.79	-0.79	-0.79
15							-0.78	-0.78	-0.78
20							-0.76	-0.76	-0.76
25					-0.74	-0.75	-0.75	-0.75	-0.75
30					-0.76	-0.74	-0.74	-0.73	-0.73
35					-0.74	-0.72	-0.72	-0.72	-0.72
40					-0.73	-0.71	-0.71	-0.71	-0.71
45				*Tier 2*	-0.71	-0.70	-0.69	-0.69	-0.69
50					-0.70	-0.68	-0.68	-0.68	-0.68
55					-0.68	-0.67	-0.67	-0.67	-0.67
60					-0.66	-0.66	-0.65	-0.65	-0.65
65			-0.64	-0.65	-0.65	-0.64	-0.64	-0.64	-0.64
70			-0.63	-0.64	-0.64	-0.63	-0.63	-0.63	-0.63
75			-0.62	-0.62	-0.62	-0.62	-0.62	-0.62	-0.62
80		*Tier 3*	-0.61	-0.61	-0.61	-0.61	-0.60	-0.60	-0.60
85			-0.59	-0.60	-0.59	-0.59	-0.59	-0.59	-0.59
90			-0.58	-0.58	-0.58	-0.58	-0.58	-0.58	-0.58
95			-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57
100	-0.57	-0.57	-0.56	-0.56	-0.56	-0.55	-0.55	-0.55	-0.55
105	-0.58	-0.56	-0.55	-0.55	-0.54	-0.54	-0.54	-0.54	-0.54
110	-0.56	-0.54	-0.54	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53
115	-0.55	-0.53	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52
120	-0.53	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51	-0.51
125	-0.52	-0.50	-0.50	-0.50	-0.49	-0.49	-0.49	-0.49	-0.49
130	-0.50	-0.49	-0.48	-0.48	-0.48	-0.48	-0.48	-0.48	-0.48
135	-0.48	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47
140	-0.47	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46
145	-0.46	-0.45	-0.45	-0.45	-0.44	-0.44	-0.44	-0.44	-0.44

Tier 4

Note: Negative numbers indicate outward displacements

Table 46 - West Wall, Station 180+00

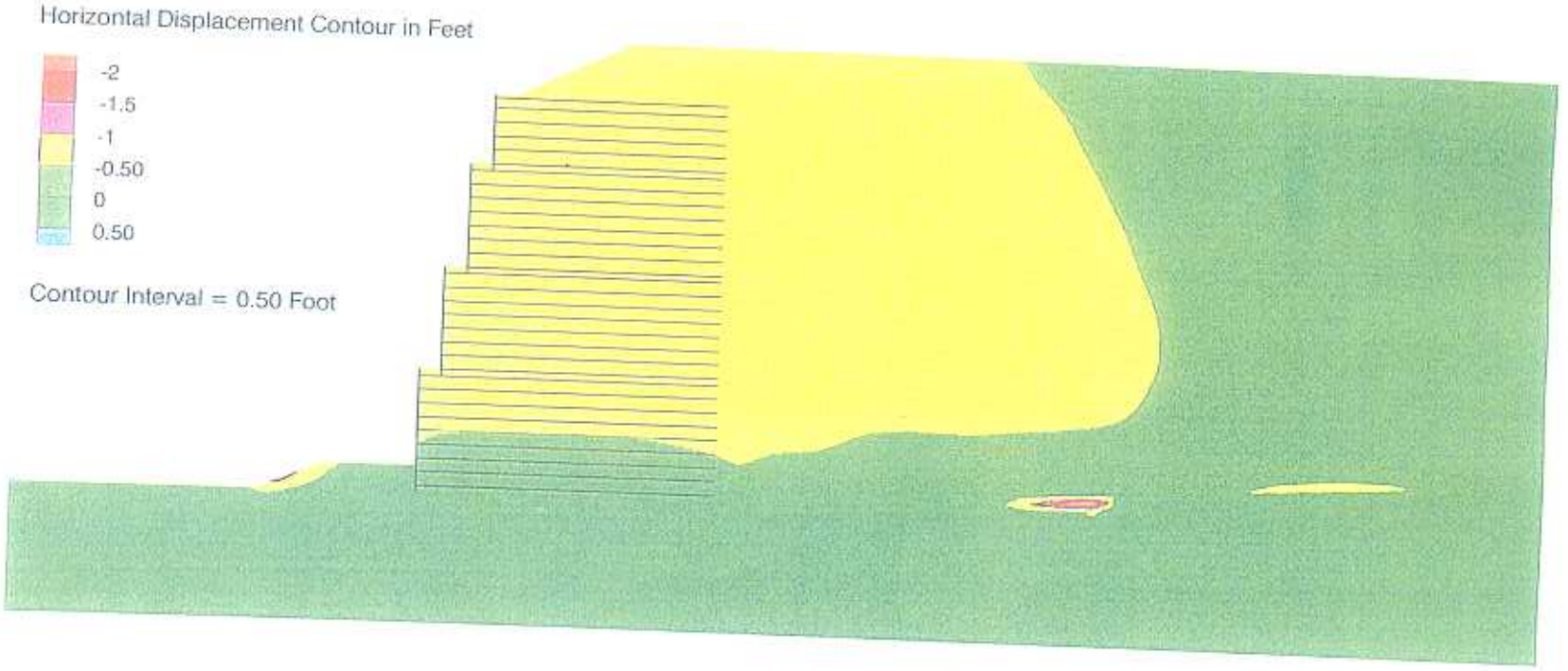
Permanent Vertical Displacements in Feet
End of Shaking With Concurrent Liquefaction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet								
	0	4	8	12	16	20	24	28	32
0							-0.14	-0.13	-0.12
5							-0.14	-0.13	-0.12
10						Tier 1	-0.14	-0.13	-0.12
15							-0.14	-0.13	-0.12
20							-0.14	-0.13	-0.12
25					-0.14	-0.12	-0.14	-0.12	-0.11
30					-0.14	-0.14	-0.13	-0.12	-0.11
35					-0.14	-0.15	-0.13	-0.12	-0.11
40					-0.14	-0.15	-0.13	-0.12	-0.11
45				Tier 2	-0.14	-0.14	-0.13	-0.12	-0.11
50					-0.14	-0.14	-0.13	-0.12	-0.11
55					-0.14	-0.14	-0.12	-0.11	-0.10
60					-0.14	-0.13	-0.12	-0.11	-0.10
65			-0.15	-0.13	-0.14	-0.13	-0.12	-0.11	-0.10
70			-0.15	-0.14	-0.14	-0.13	-0.12	-0.11	-0.10
75			-0.15	-0.15	-0.14	-0.13	-0.12	-0.11	-0.10
80		Tier 3	-0.15	-0.14	-0.13	-0.12	-0.11	-0.11	-0.10
85			-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09
90			-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09
95			-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09
100	-0.13	-0.12	-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09
105	-0.13	-0.14	-0.15	-0.13	-0.13	-0.12	-0.11	-0.10	-0.09
110	-0.13	-0.15	-0.14	-0.13	-0.12	-0.11	-0.11	-0.10	-0.09
115	-0.13	-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.10	-0.09
120	-0.14	-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09	-0.09
125 Tier 4	-0.14	-0.15	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09	-0.09
130	-0.14	-0.14	-0.14	-0.13	-0.12	-0.11	-0.10	-0.09	-0.08
135	-0.14	-0.14	-0.13	-0.13	-0.12	-0.11	-0.10	-0.09	-0.08
140	-0.14	-0.14	-0.13	-0.12	-0.12	-0.11	-0.10	-0.09	-0.08
145	-0.14	-0.13	-0.13	-0.12	-0.11	-0.10	-0.10	-0.09	-0.08

Note: Negative numbers indicate downward displacements

West Wall, Station 180+00

Permanent Horizontal Displacements - End of Shaking With Concurrent Liquefaction



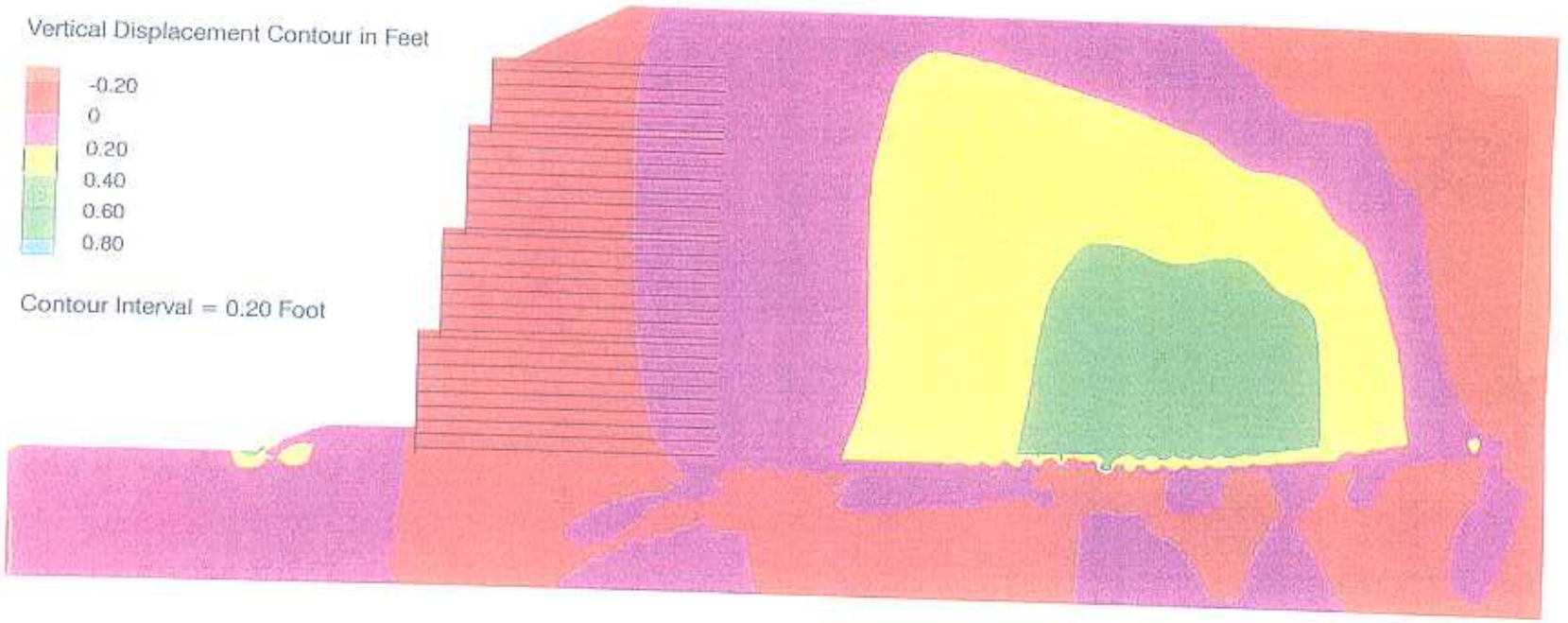
HARTCROWSER
4978-40
Figure 24
1/02

AR 053349

DTN 1/07/02 497840l.cdr

West Wall, Station 180+00

Permanent Vertical Displacements - End of Shaking With Concurrent Liquefaction



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4978-40
Figure 25
1/02

AR 053350

DTN 1/07/02 497840J.cdr

Sta. 147+25

CASE 1

Table 47 - South Wall, Station 147+25
Reinforcement Stresses (as a percent of yield)
End of Staged Construction

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4
2	2.5	6 mm	8	9	5	3
4	7.5	Reinforcement	14	15	11	6
4	12.5		5	5	6	4

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height is 12.5 feet.

Table 48 - South Wall, Station 147+25
Cumulative Horizontal Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.02	-0.02	-0.02
7.5	-0.02	-0.02	-0.02
12.5	-0.01	-0.01	-0.01

Note Negative numbers indicate outward displacements.

Table 49 - South Wall, Station 147+25
Cumulative Vertical Displacements in Feet
End of Staged Construction

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.01	-0.02	-0.01
7.5	-0.01	-0.02	-0.01
12.5	-0.01	-0.01	-0.01

Note Negative numbers indicate downward displacements.

South Wall, Station 147+25

Cumulative Horizontal Displacements - End of Staged Construction

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4978-40 1/02

Figure 26

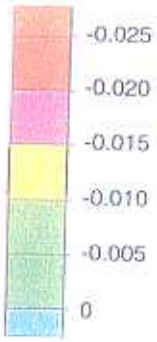
AR 053356

DTN 1/07/02 497840SS.cdr

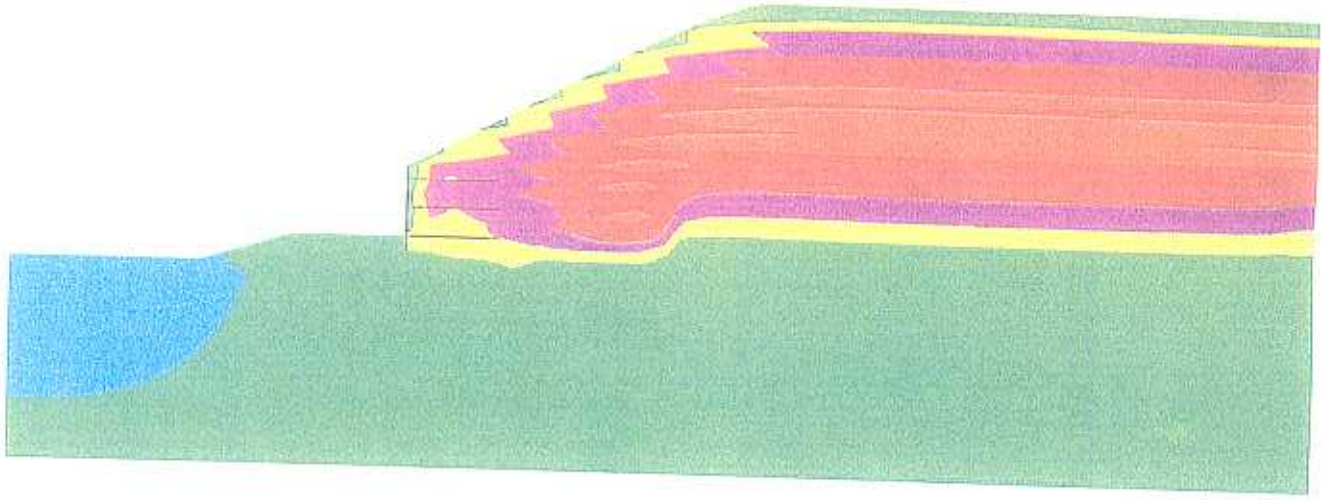
South Wall, Station 147+25

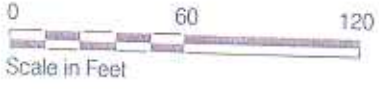
Cumulative Vertical Displacements - End of Staged Construction

Vertical Displacement Contour in Feet



Contour Interval = 0.005 Foot





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4978-40
Figure 27
1/02

DIN 1/14/02 4978407T.cdr

AR 053357

CASE 2

Table 50 - South Wall, Station 147+25
Maximum Reinforcement Stresses (as a percent of yield)
During Shaking

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4
2	2.5	6 mm	77	67	42	17
4	7.5	Reinforcement	32	38	29	12
4	12.5		12	16	13	5

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height is 12.5 feet.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

CASE 3

Table 51 - South Wall, Station 147+25
Permanent Reinforcement Stresses (as a percent of yield)
End of Shaking

Strip Density/ Panel	Depth Below Top of Wall in Feet		Segment Number 1	2	3	4
2	2.5	6 mm	71	56	31	11
4	7.5	Reinforcement	30	33	24	9
4	12.5		10	10	7	2

Notes: Reinforcement Stress (as a percent of yield) shown for each 4-foot-long segment.
Exposed wall height is 12.5 feet.
Shaded numbers indicate that the reinforcement stress exceeded 55% of the yield stress.

Table 52 - South Wall, Station 147+25
Permanent Horizontal Displacements in Feet
End of Shaking

Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.43	-0.43	-0.42
7.5	-0.33	-0.33	-0.30
12.5	-0.05	-0.04	-0.04

Note Negative numbers indicate outward displacements.

Table 53 - South Wall, Station 147+25
Permanent Vertical Displacements in Feet
End of Shaking

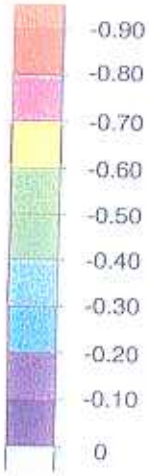
Depth Below Top of Wall in Feet	Horizontal Distance Measured from Wall Face in Feet		
	0	*4*	*8*
2.5	-0.03	-0.05	-0.02
7.5	-0.03	-0.05	0.00
12.5	-0.01	0.00	0.00

Note Negative numbers indicate downward displacements.

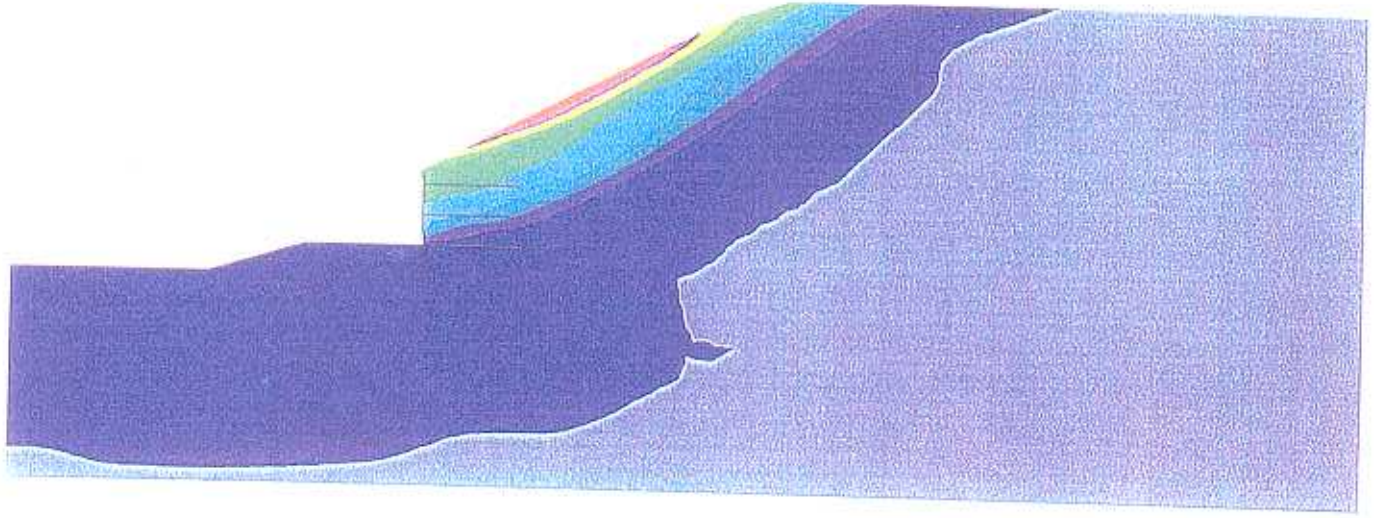
South Wall, Station 147+25

Permanent Horizontal Displacements - End of Shaking

Horizontal Displacement Contour in Feet



Contour Interval = 0.10 Foot



AR 053364

HARTCROWSER

4978-40 1/02

Figure 28

South Wall, Station 147+25

Permanent Vertical Displacements - End of Shaking

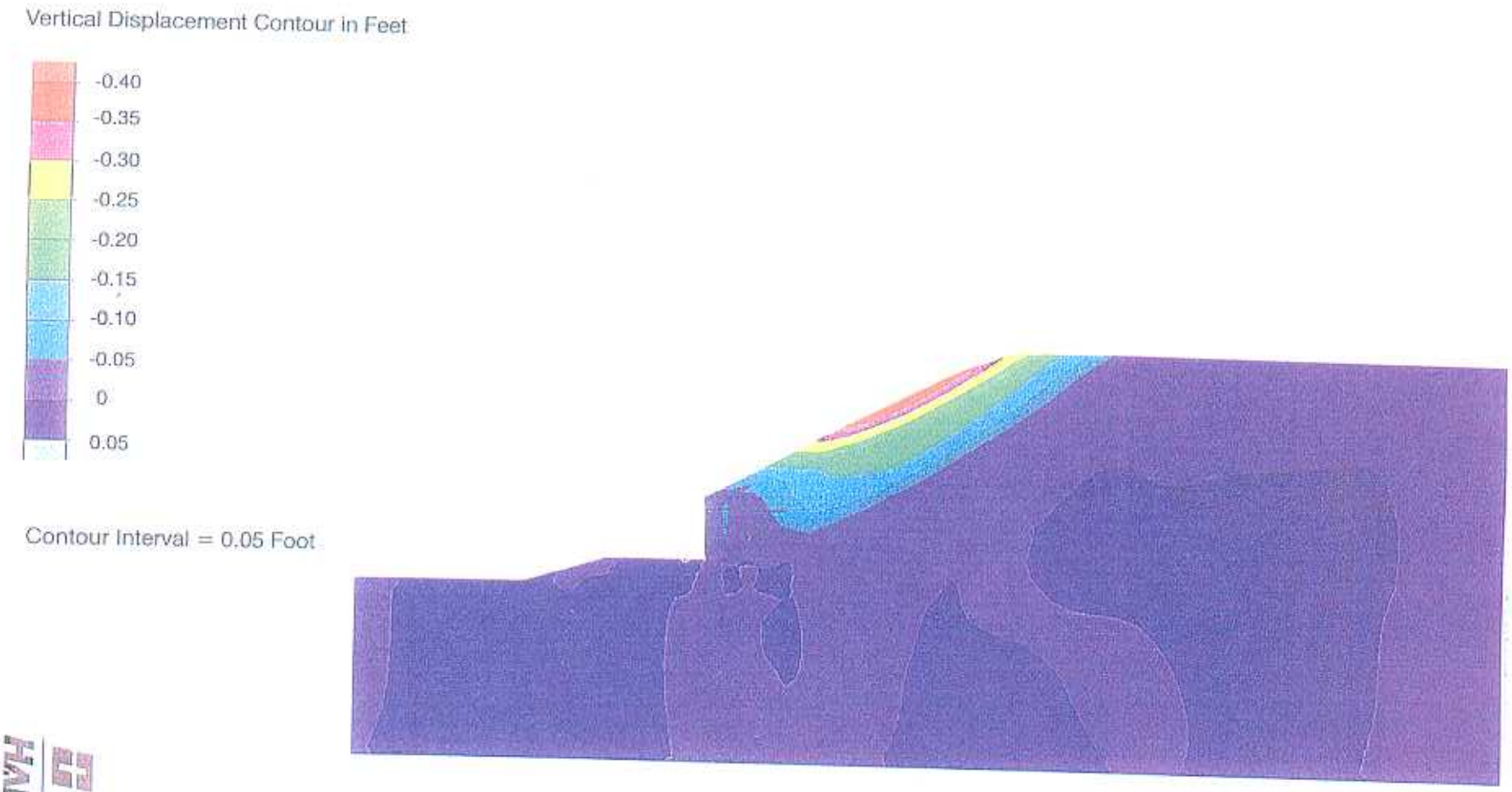


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Figure 29