

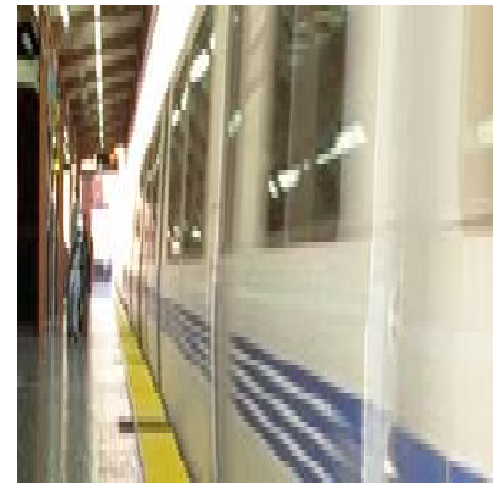


Earth Pressures and Deflections of Below-Grade U-Walls



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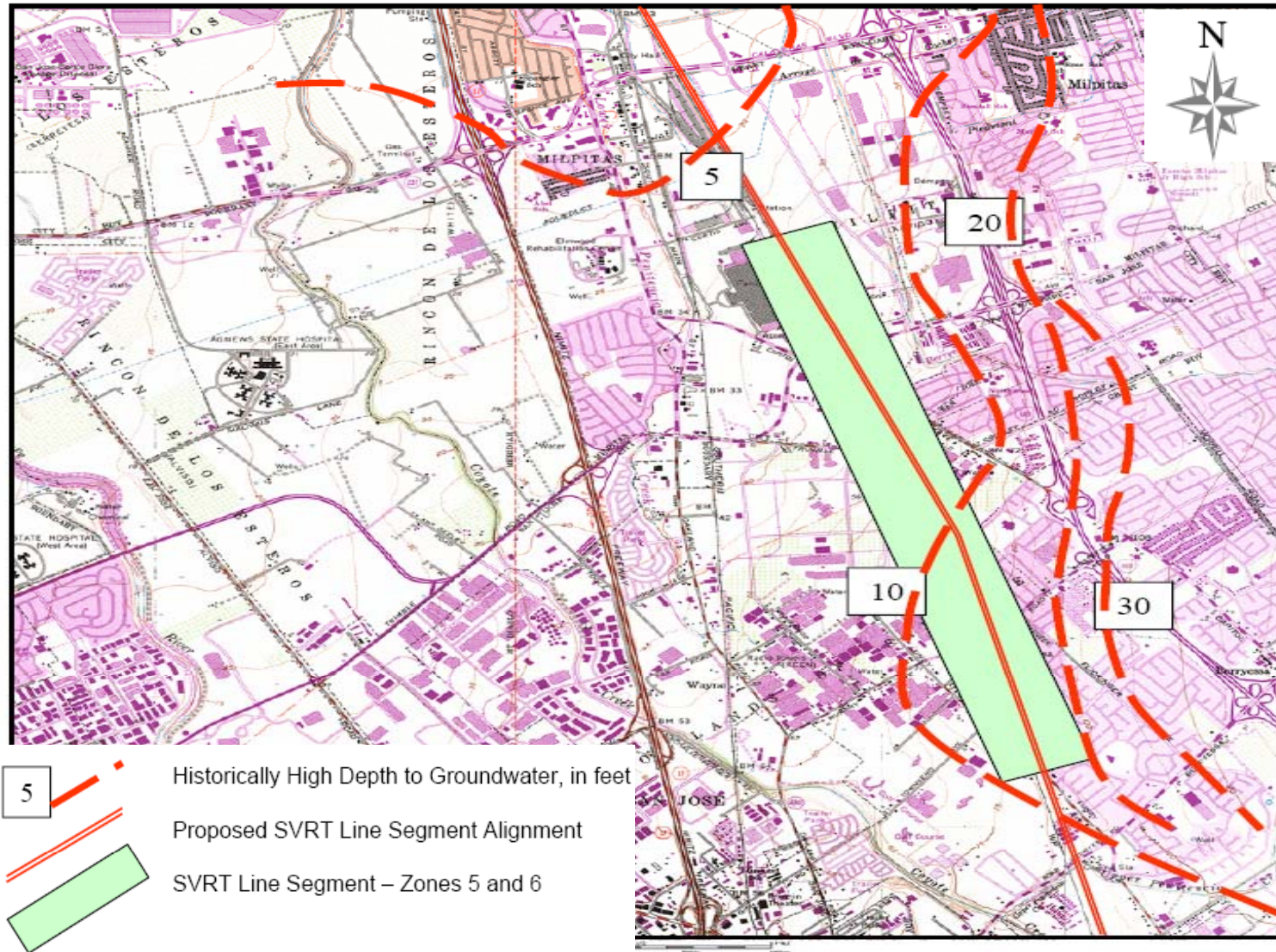
Brian O'Neill, PE, GE
Kleinfelder Oakland Office



Outlines

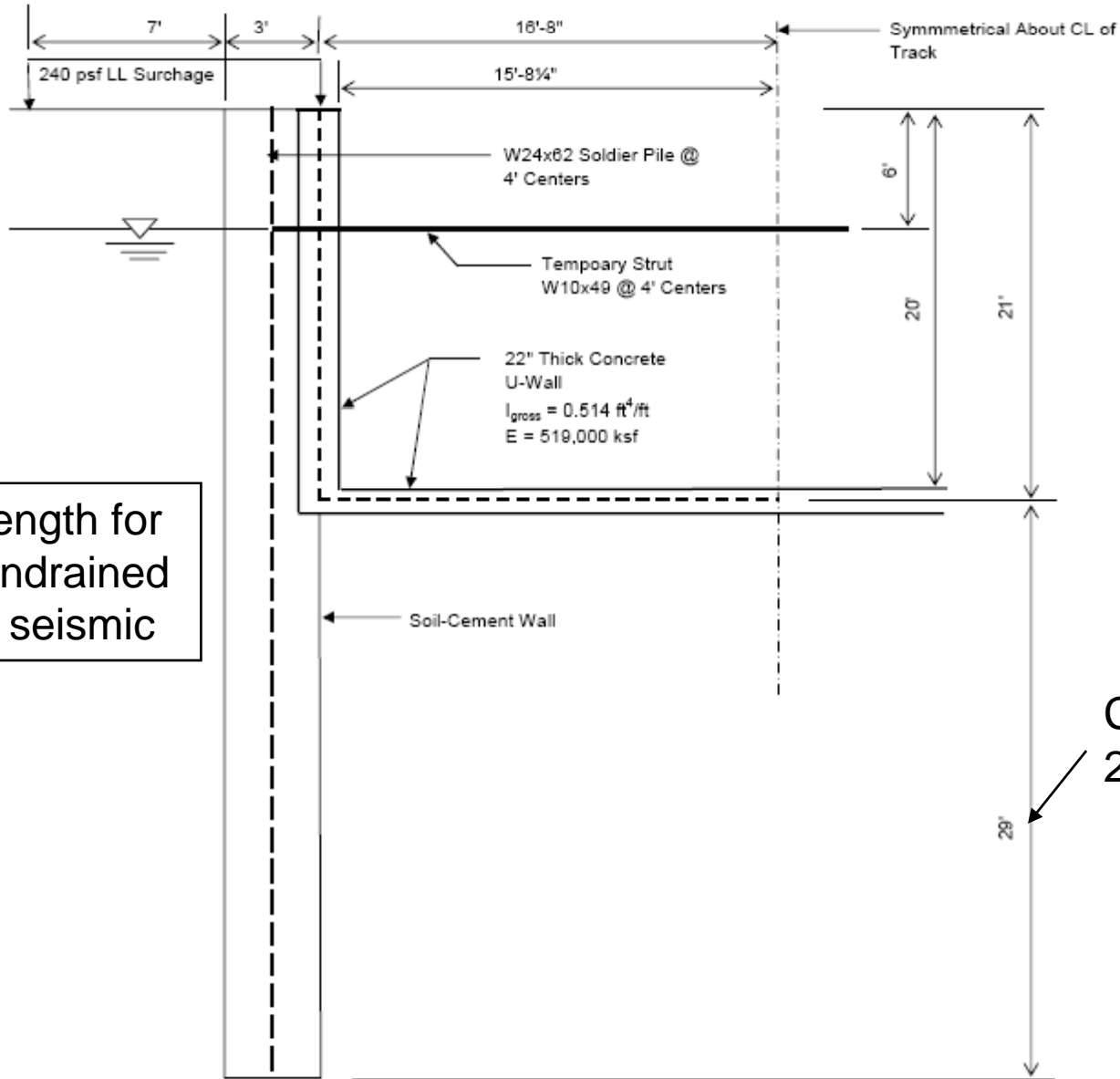
- Brief project description
- Design assumptions and criteria
- FLAC Modeling challenges
- SSI analysis steps
- SSI analysis results
- Conclusions

Project Vicinity Map



By: MHJ Date: 4/12/2007
 Checked: _____ Date: _____
 Backchecked: _____ Date: _____

Structural Parameters



Drained strength for static and undrained strength for seismic

Construction Sequences

- Install soil-cement wall and soldier piles
- Excavate to level of temporary strut
- Install temporary strut
- Excavate to bottom of invert slab
- Place concrete invert slab
- Remove temporary strut
- Place concrete walls

Design Assumptions and Design Criteria

Project Design Assumptions:

- No lateral resistance from the DSM/Soldier piles (shoring) for permanent U-wall design
- Soldier piles need to hold down U-Wall flotation

Project Design Criteria:

- Active condition if top deflection $\geq 0.004H$
- At-rest condition if top deflection $< 0.004H$

FLAC Modeling Challenges

- How to zero-out soldier piles lateral stiffness (i.e., allow soil pressure re-balance) but still remain axial stiffness and tension capacity after shoring and excavation equilibrium, but before dynamic shaking?

FLAC Analysis Steps for Shoring

- Step 1-1: in-situ equilibrium of soil mesh
- Step 1-2: install soldier piles of W24x62 @4' spacing & get equilibrium.
- Step 1-3: lower the water level within the trench to 21-ft depth, get equilibrium.
- Step 1-4: excavate to 6-ft depth, get equilibrium.
- Step 1-5: install temporary strut of W10x49@4' spacing, get equilibrium.
- Step 1-6: further excavate to 21' depth.
- Step 1-7: apply 240 psf Surcharge 10' from Excavation lines.

FLAC Analysis Steps for U-Walls

- Step 2-1: re-call Model-1 saved file.
- Step 2-2: Install the 22"(1.83') thick concrete bottom slab, get equilibrium
- Step 2-3: Install permanent side walls with water-proof interfaces, get equilibrium.
- Step 2-4: assume 15-ft of groundwater head back at bottom slab, get equilibrium.
- Step 2-5: remove strut, get equilibrium.
- Step 2-6: remove soldier piles and replace with equivalent hold-down stiffness elements.

JOB TITLE : Model-1 Analysis Step 1-2 Install soldier pile W24 x 62 C-C spacing=4 ft, get e

($\times 10^{-2}$)

FLAC (Version 5.00)

LEGEND

20-Jun-07 11:55
step 21587
-3.500E+01 <x< 3.500E+01
2.500E+01 <y< 1.000E+02

User-defined Groups

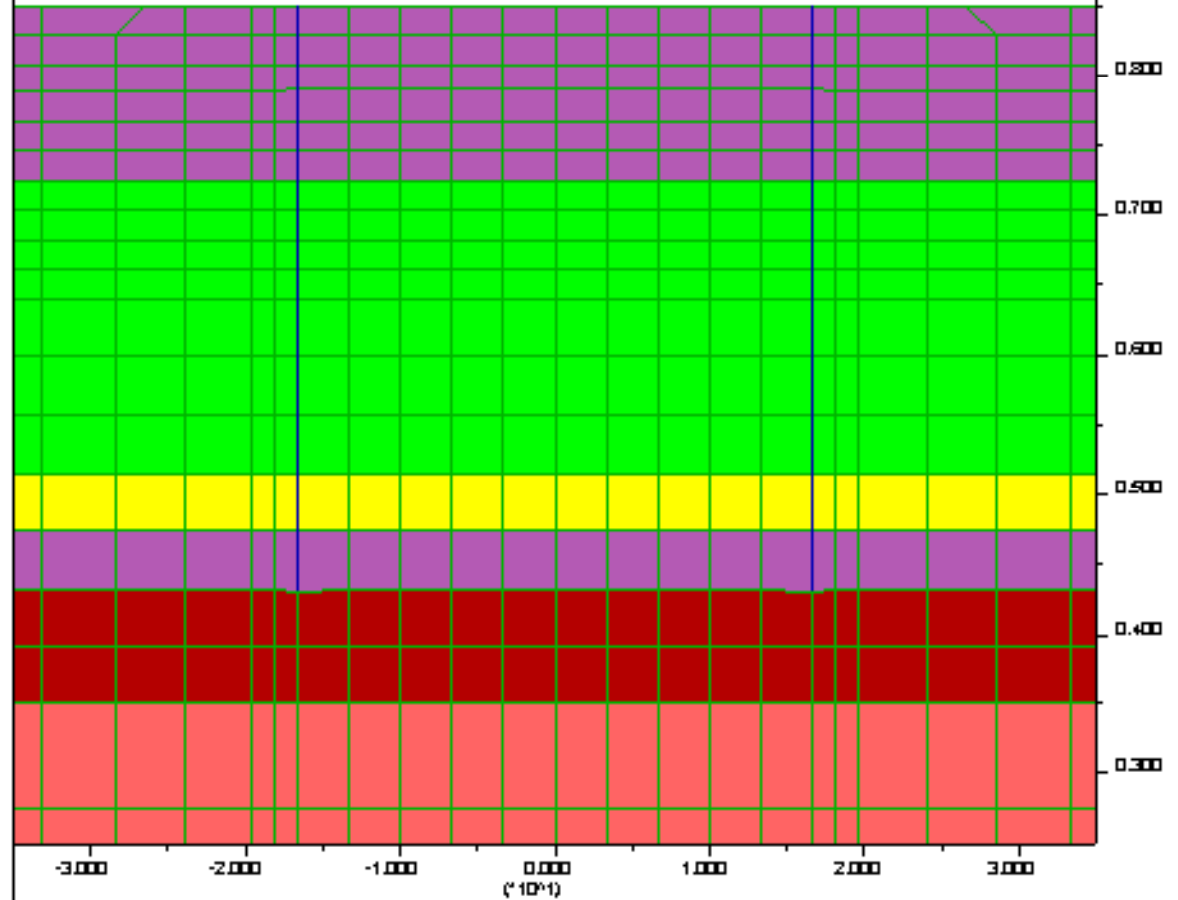
- 'Very Stiff Clay'
- 'Dense Clayey Sand'
- 'Stiff Clay'
- 'Dense Sand'
- 'Medium Stiff Clay'

Grid plot



Beam plot

Endi Zhai
Kleinfelder, Inc.



JOB TITLE : Model-1 Step 1-4 Excavate to 6-ft depth, get equilibrium

($\times 10^2$)

FLAC (Version 5.00)

LEGEND

20-Jun-07 11:56
step 28416
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2.500E+01 <y< 1.000E+02

User-defined Groups

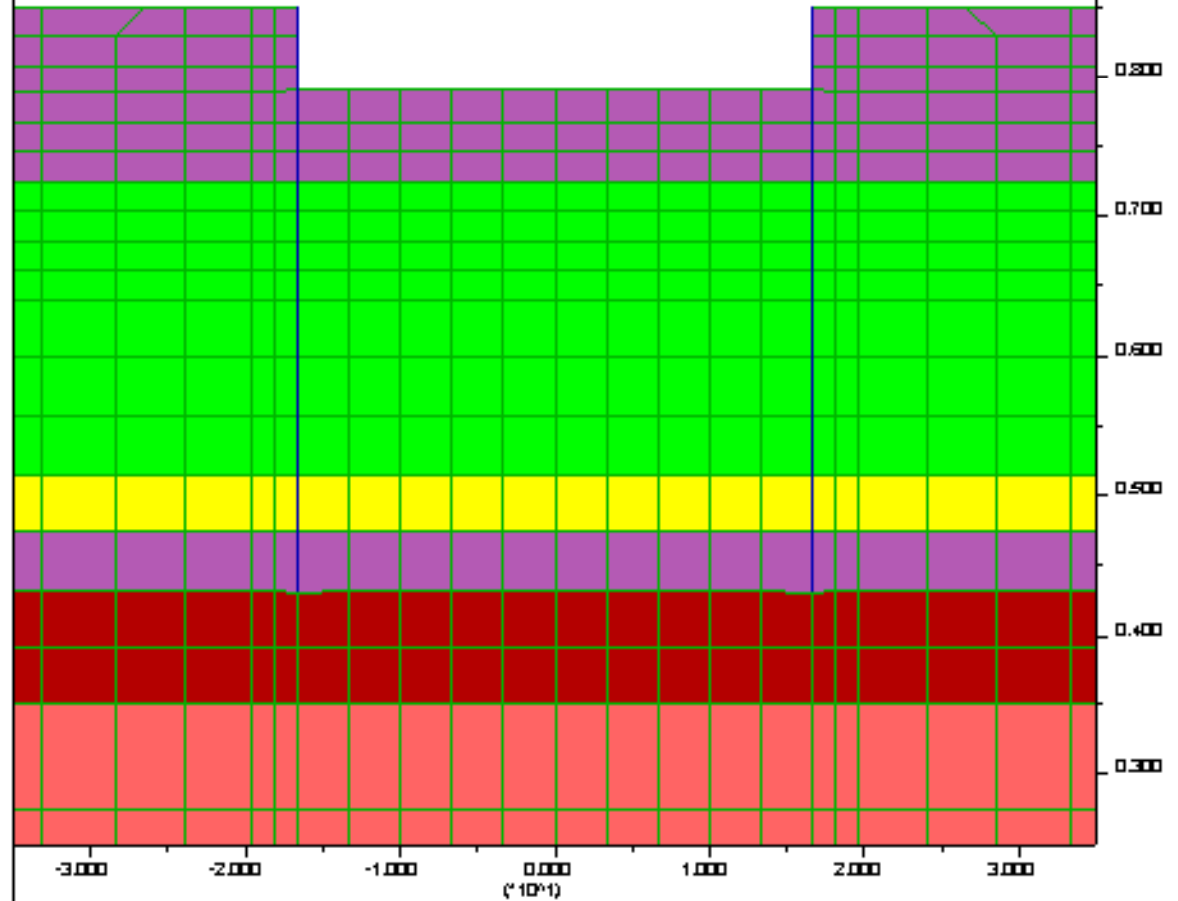
- 'Very Stiff Clay'
- 'Dense Clayey Sand'
- 'Stiff Clay'
- 'Dense Sand'
- 'Medium Stiff Clay'

Grid plot



Beam plot

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JOB TITLE : Model-1 Step 1-6 - Excavate to bottom @ 21-ft

($\times 10^2$)

FLAC (Version 5.00)

LEGEND

20-Jun-07 11:56
step 35301
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2.500E+01 <y< 1.000E+02

User-defined Groups

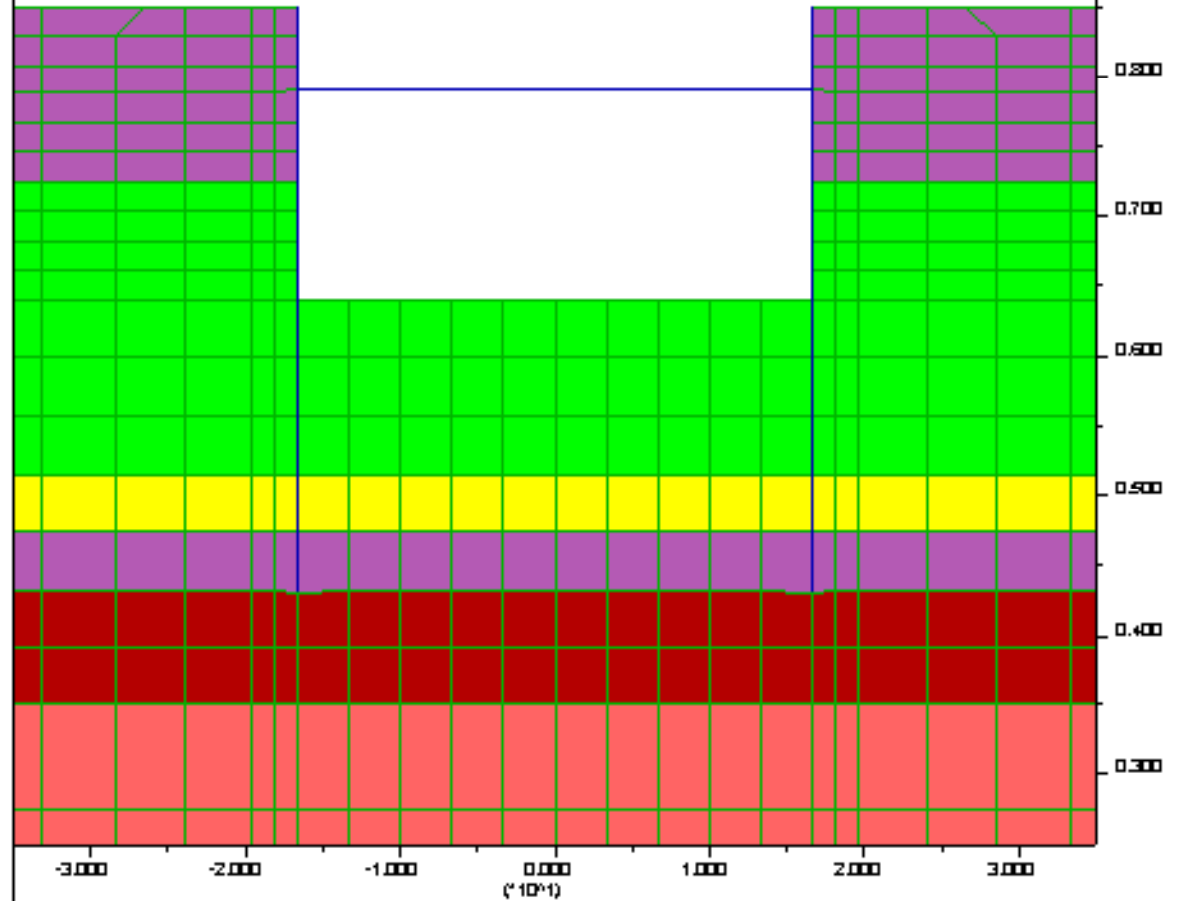
- 'Very Stiff Clay'
- 'Dense Clayey Sand'
- 'Stiff Clay'
- 'Dense Sand'
- 'Medium Stiff Clay'

Grid plot



Beam plot

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JOB TITLE : Model-1 Step Step 1-7 Apply 240 psf Surcharge 10' from Excavation lines

($\times 10^{-2}$)

FLAC (Version 5.00)

LEGEND

20-Jun-07 11:56
step 37473
-3.500E+01 <x< 3.500E+01
2.500E+01 <y< 1.000E+02

User-defined Groups

- 'Very Stiff Clay'
- 'Dense Clayey Sand'
- 'Stiff Clay'
- 'Dense Sand'
- 'Medium Stiff Clay'

Grid plot

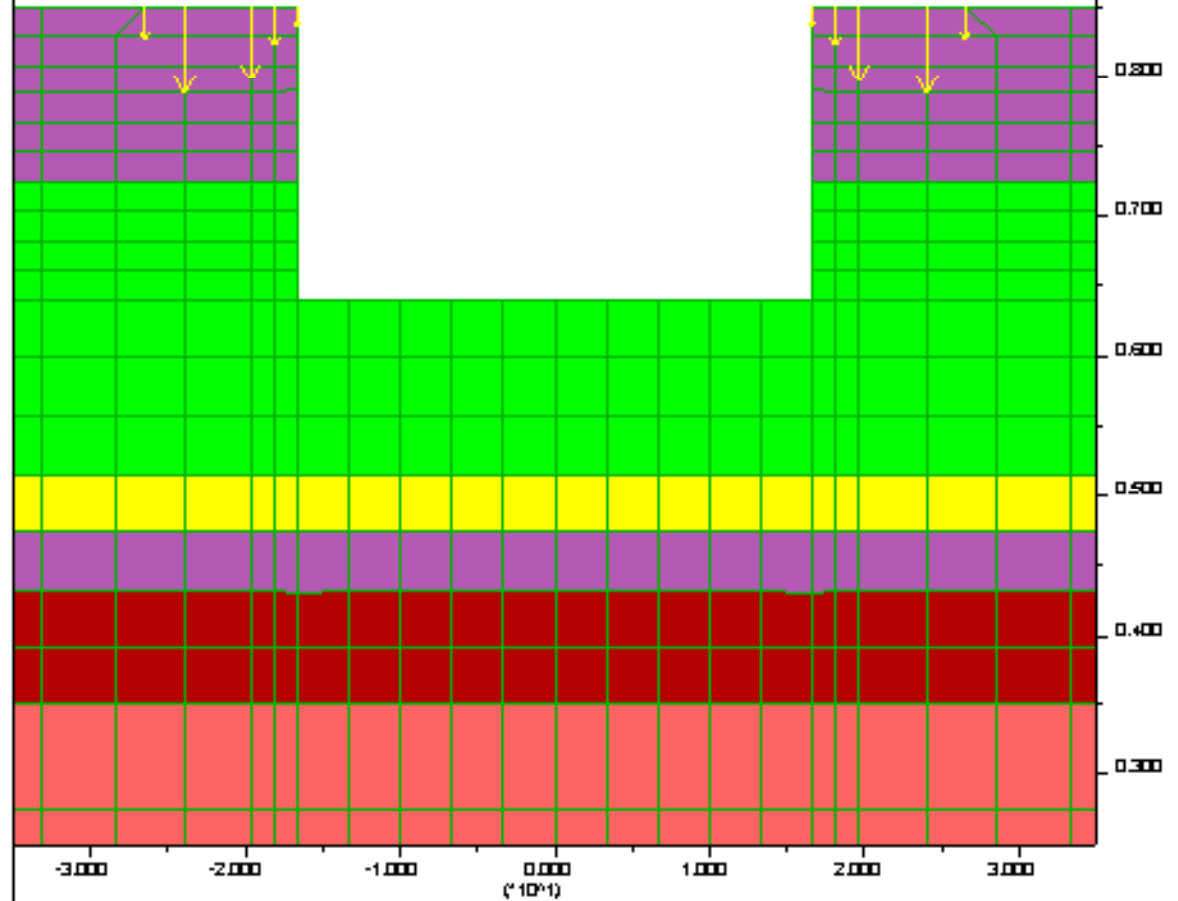


Net Applied Forces

max vector = 8.220E+02



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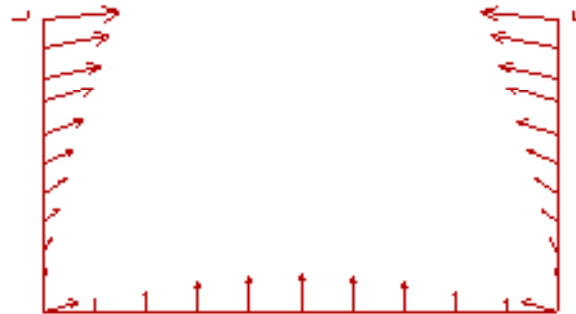


FLAC (Version 5.00)

LEGEND

21-Jun-07 9:40
step 54163
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Structural Displacement
Max Value = 1.775E-02



Max deflection = 0.2 inch, requires
at-rest pressures for static design.

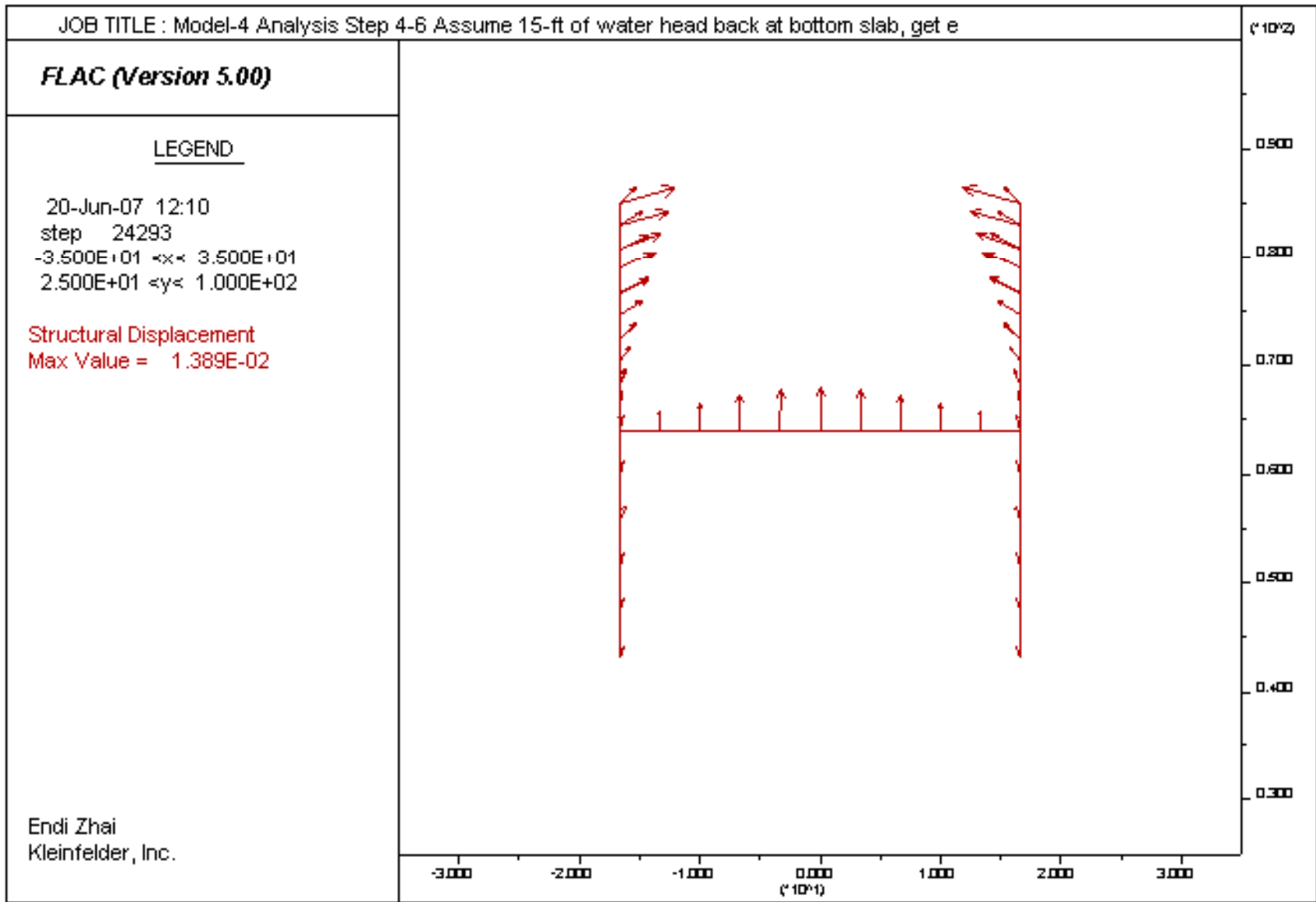
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-3.000 -2.000 -1.000 0.000 1.000 2.000 3.000
($\times 10^{-1}$)

0.500
0.800
0.700
0.600
0.500
0.400
0.300

Recommended FLAC Analysis Steps

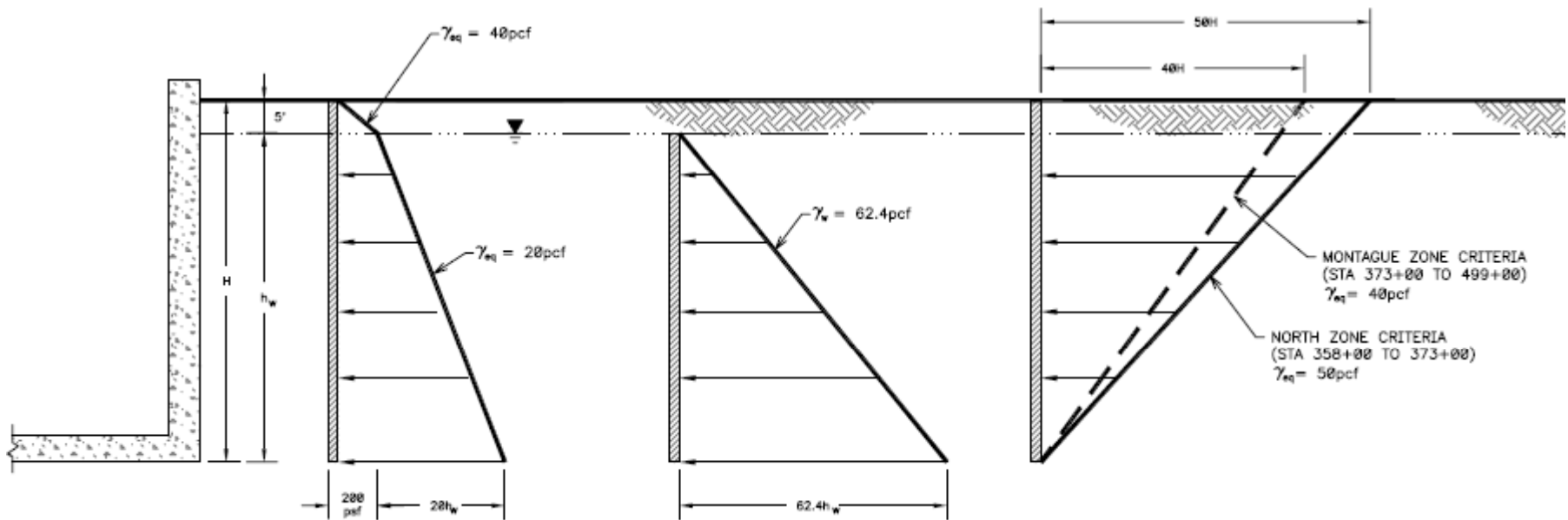
- Step R-1: in-situ equilibrium of soil mesh with actual drained soil strength.
- Step R-2: Install soldier pile W24 x 62 C-C spacing=4 ft with zero flexural stiffness, get equilibrium.
- Step R-3: lower groundwater to 21-ft depth within the trench, hold.
- Step R-4: excavation to the bottom @ 21-ft and hold.
- Step R-5: Instantly install the U-wall, slave top nodes, get equilibrium.
- Step R-6: assume 15-ft of groundwater head back at bottom slab, get equilibrium.



Structural deflections under final static condition

Standard Active Condition

ACTIVE PRESSURE CASE (STATIONS 358+00 TO 370+00, 400+00 TO 414+50, 448+00 TO 499+00)



TRENCH STRUCTURE

Fig. 1. STATIC SOIL PRESSURE

Fig. 2. HYDROSTATIC PRESSURE

Fig. 3. SEISMIC PRESSURE *

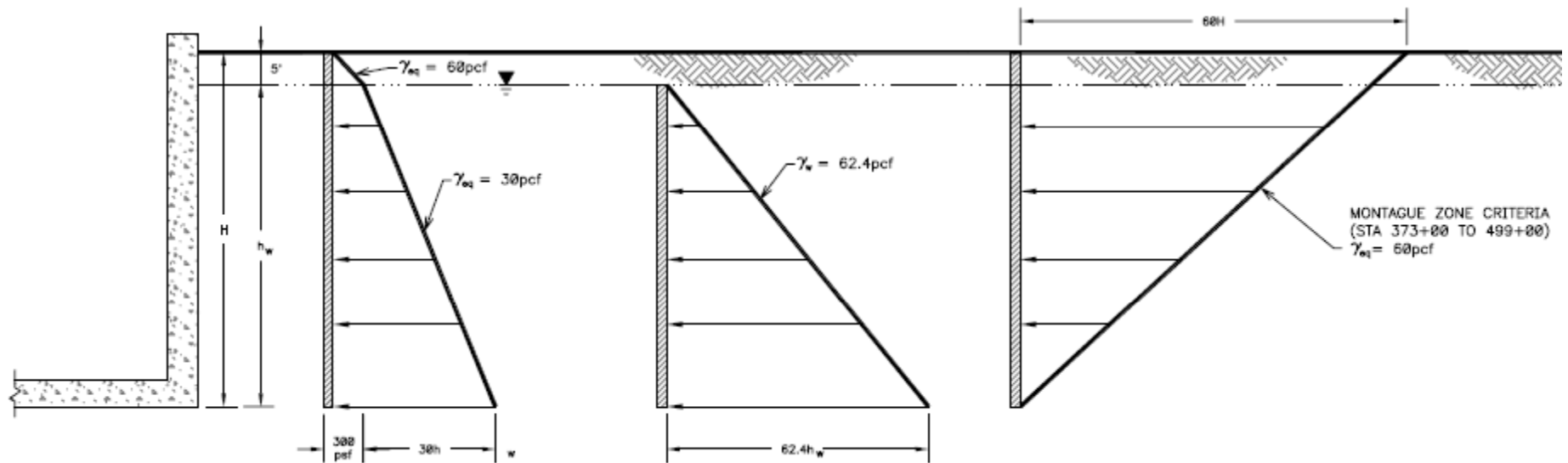
H = Wall height, feet

h_w = Height of water above base of wall, feet

* Liquefaction-induced earth pressure increase is recommended for Sierra/Lundy overcrossing structure from Sta. 487+50 to 492+50. See report Section 5.5.2 for earth pressure values for PE design.

Standard At-Rest Condition

AT-REST PRESSURE CASE (STATIONS 448+00 TO 499+00)



TRENCH STRUCTURE

Fig. 1. STATIC SOIL PRESSURE

Fig. 2. HYDROSTATIC PRESSURE

Fig. 3. SEISMIC PRESSURE

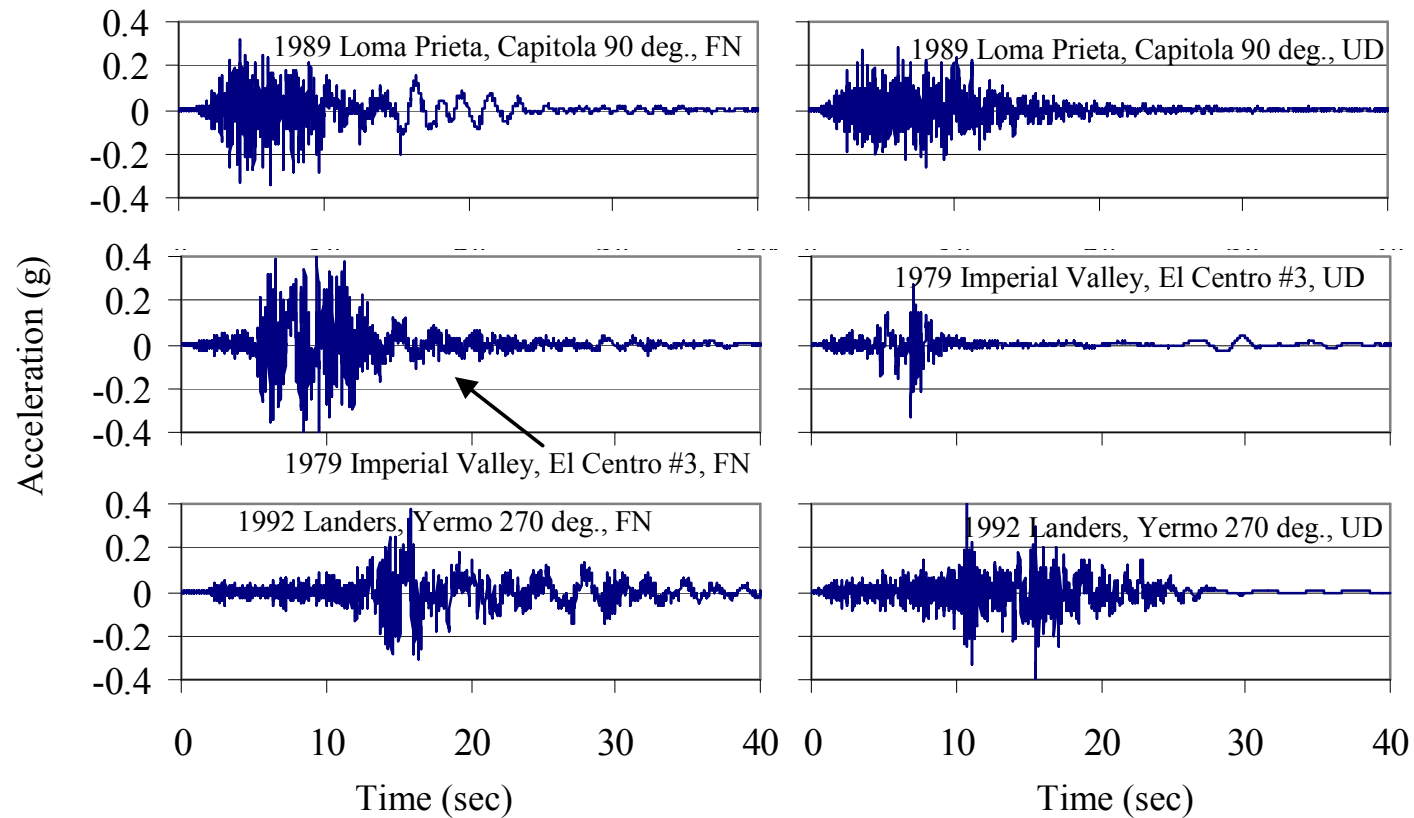
H = Wall height, feet

h_w = Height of water above base of wall, feet

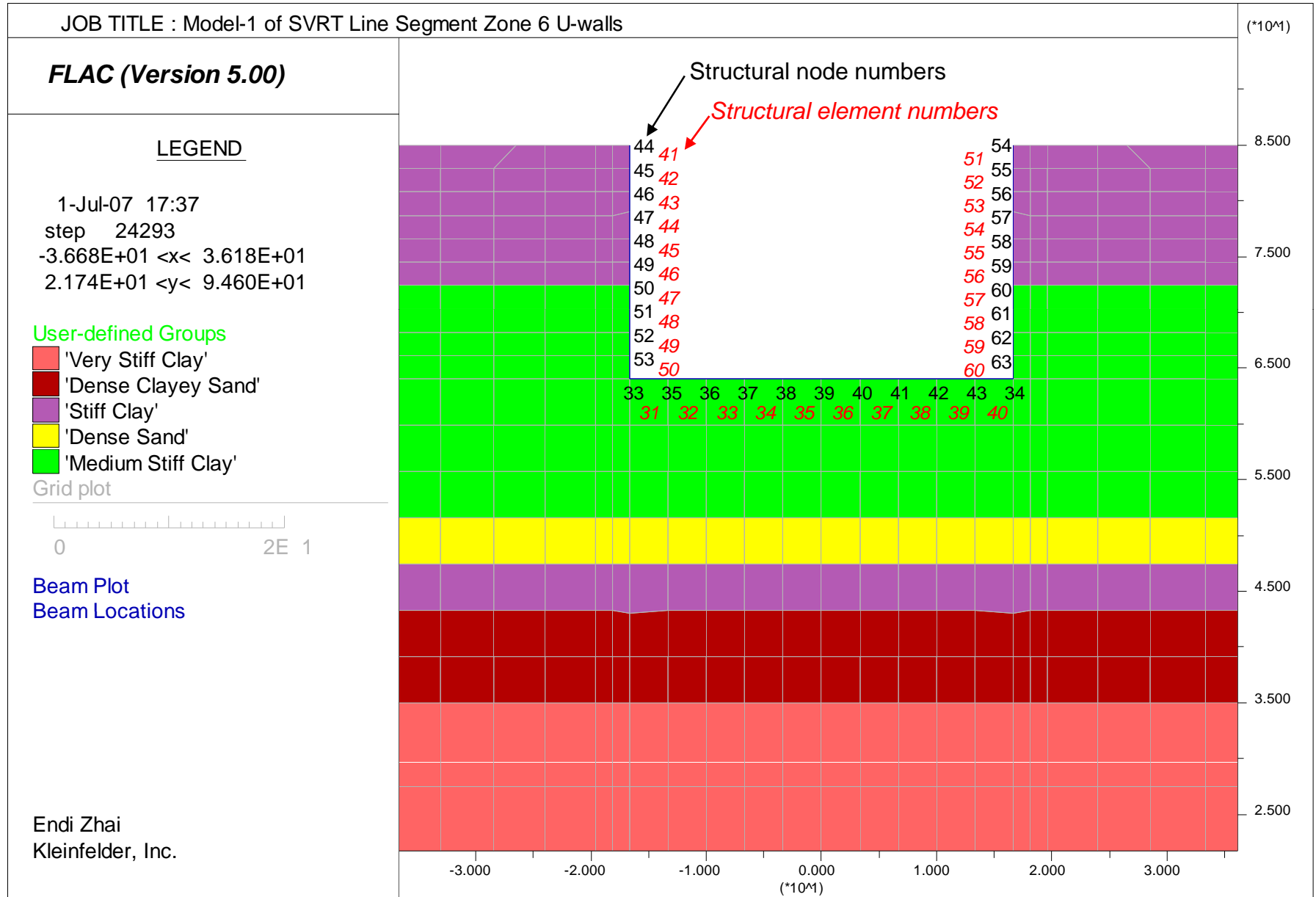
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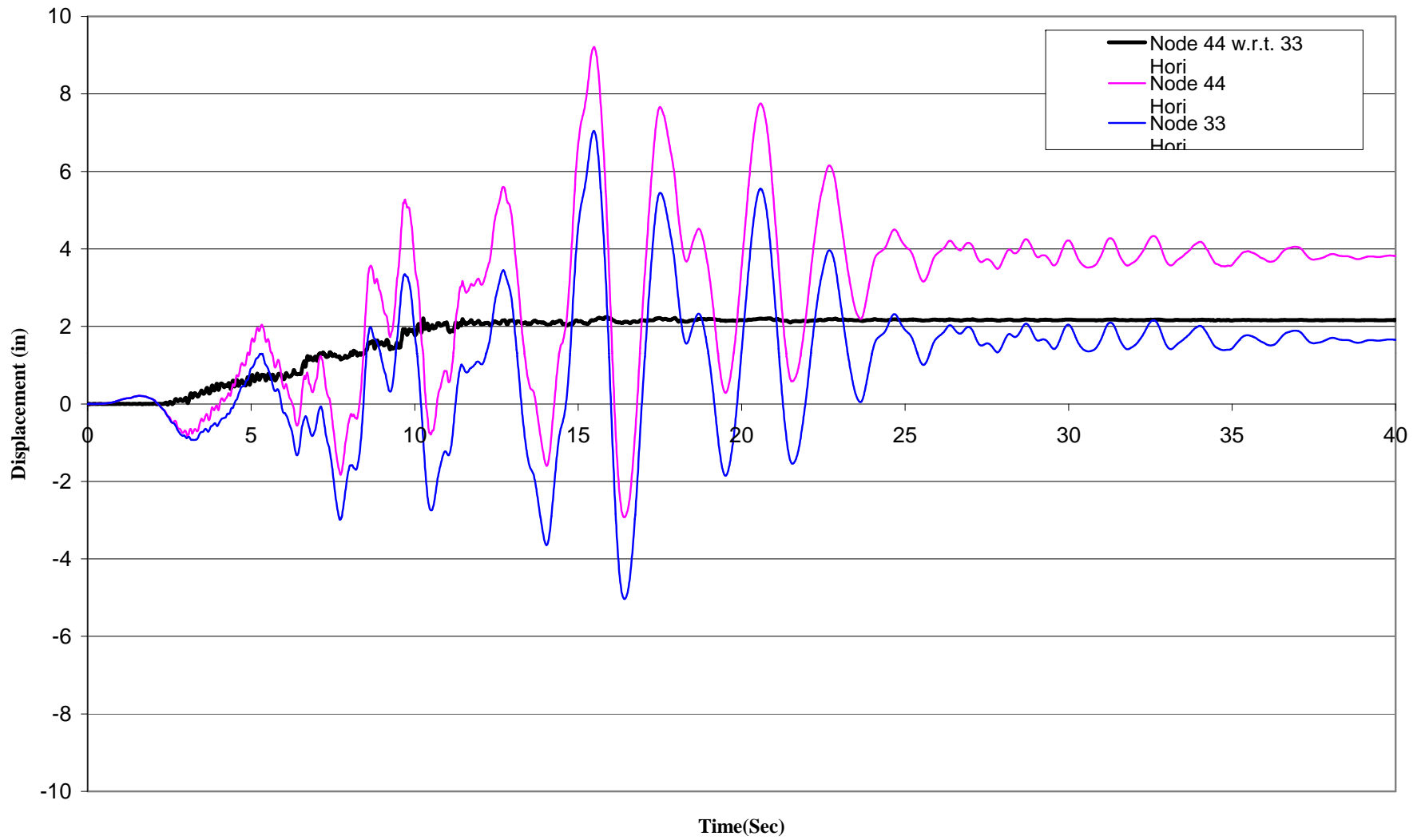


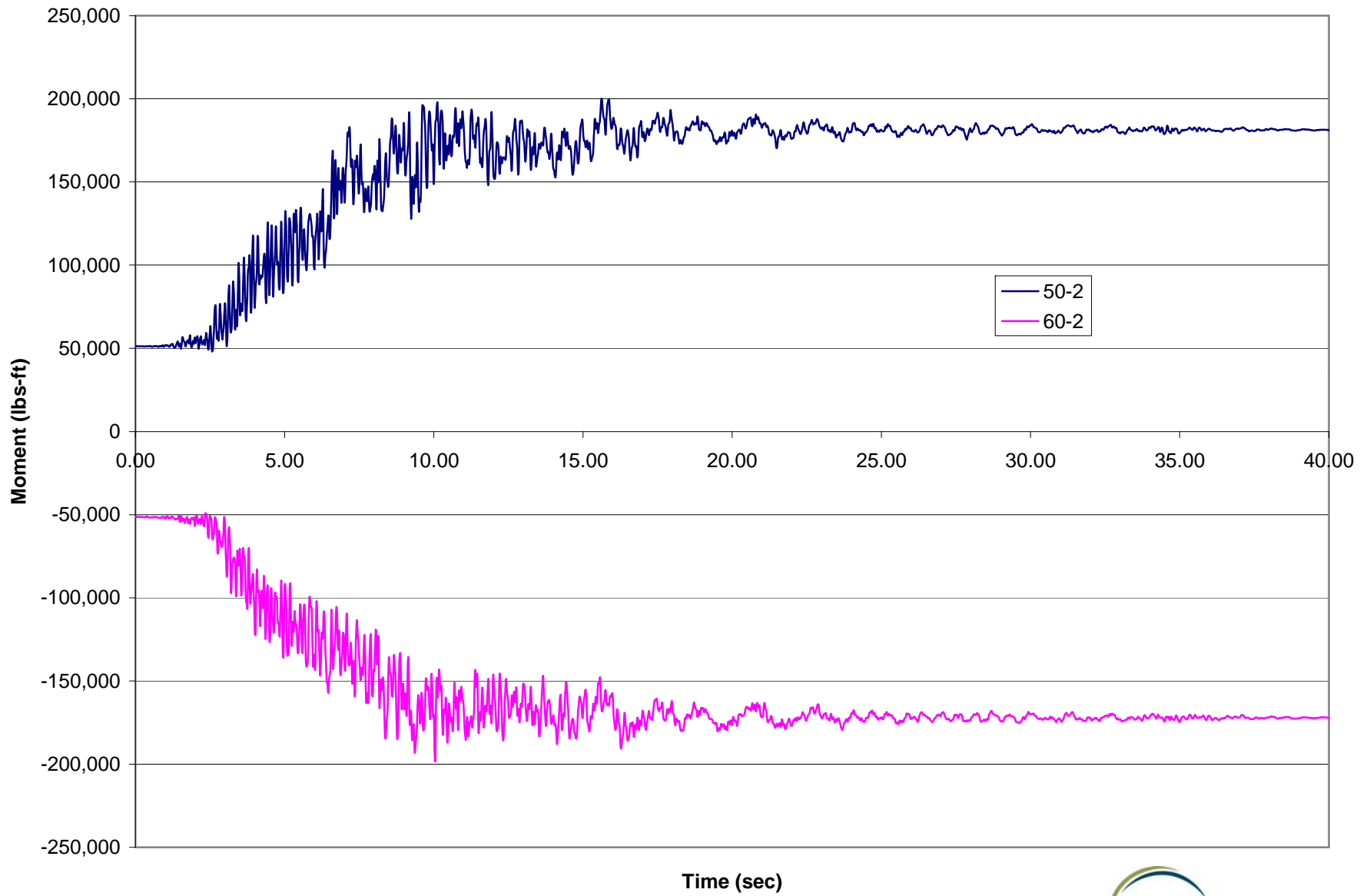
Dynamic Analysis - Input Time Histories

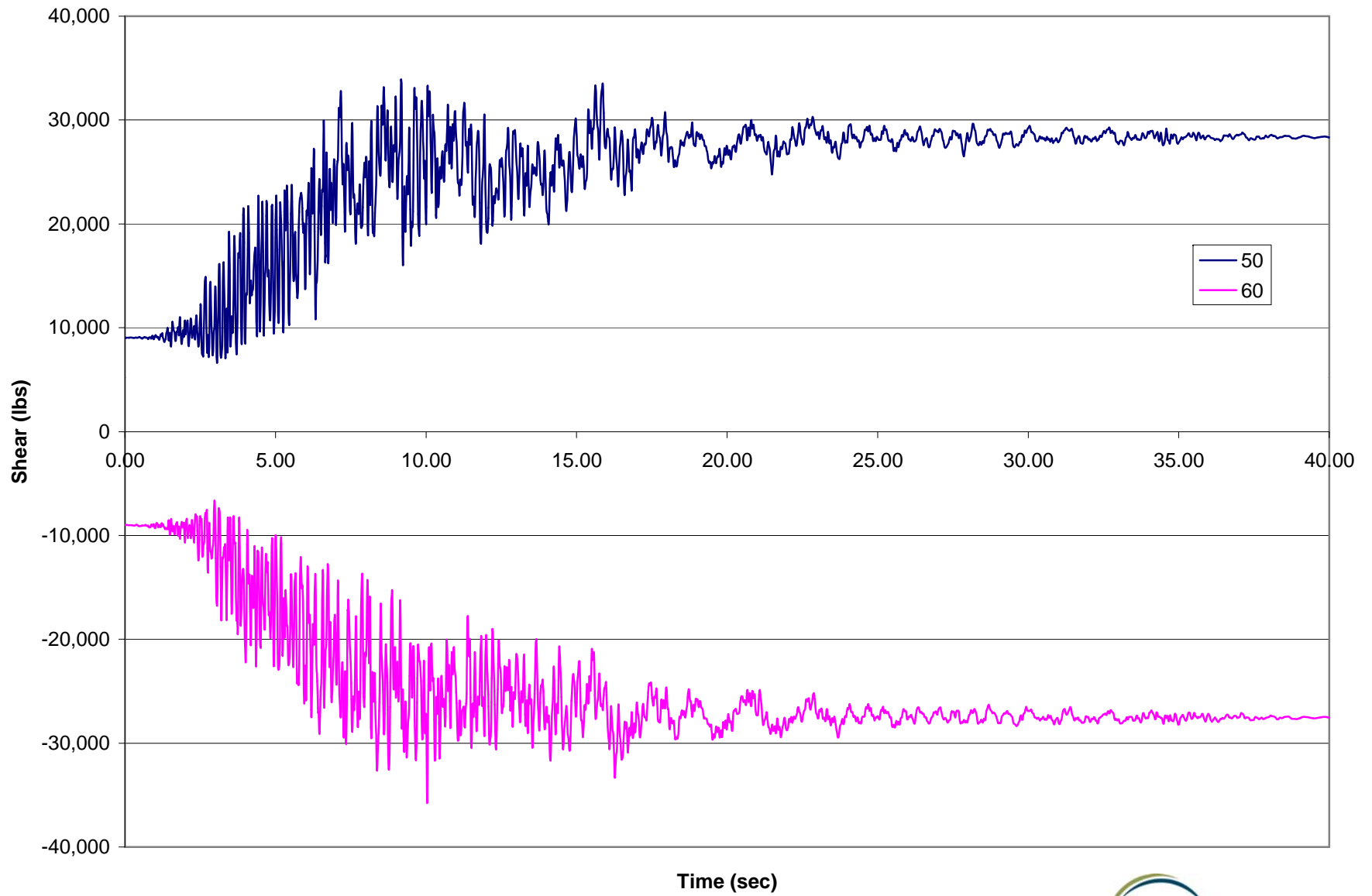


Structural Nodes and Elements

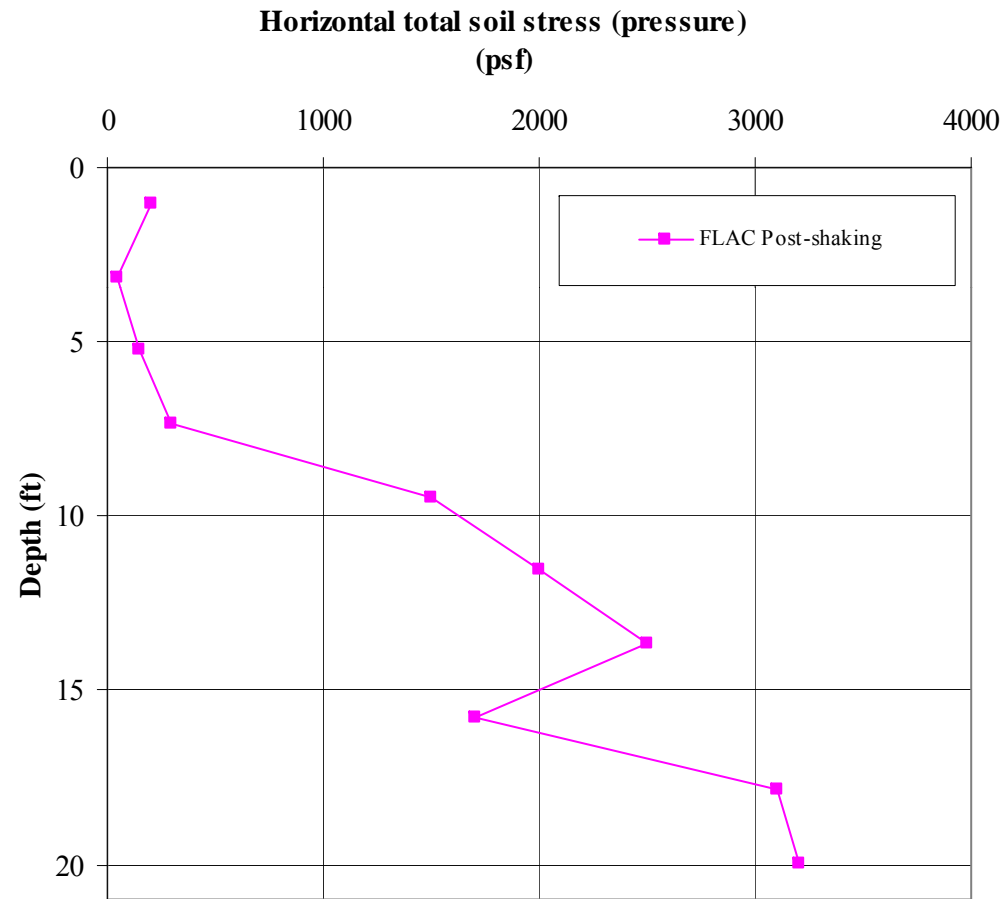








Soil horizontal stresses at the soil grids next to the wall structure (psf per foot of wall)

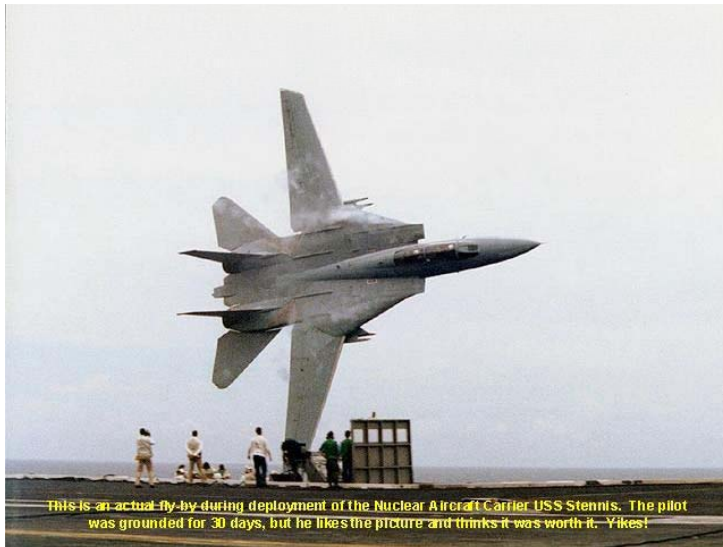


Design Recommendations

- Using At-Rest condition for Static Analysis
- Using Active condition for seismic analysis
- Using Standard earth pressure diagrams for the U-wall design, but should check against the results from FLAC SSI analyses.

Thank You

生活充满挑战



只有安全，才能安心

