Journey through a Project
(Large-Scale Geotechnical Testing)

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Outline

➢ About Laminar Soil Container
➢ How to Plan Geotechnical Testing
   1. Model Construction
   2. Timeline
   3. Filling / Excavation
   4. Instrumentation
➢ Case Studies
   1. Shallow Tunnel
   2. U-Shaped Retaining Wall
   3. Retaining Wall with dense $c$-$\phi$ soil
➢ Lessons Learned from Case Studies
## Laminar Soil Container

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminar Weight to Soil Weight Ratio (target)</td>
<td>8 — 15%</td>
</tr>
<tr>
<td>Length to Height Ratio</td>
<td>L/H &lt; 2.0</td>
</tr>
<tr>
<td>Width to Height Ratio</td>
<td>W/H &lt; 1.0</td>
</tr>
<tr>
<td>Deflection Due to Soil-Water (2000 kg/m³)</td>
<td>L/1000</td>
</tr>
<tr>
<td>Ratio of Frequency of Lateral Support (f_{lat}) to Interested Maximum Frequency (f_{max})</td>
<td>f_{lat}/f_{max} &gt; 2.5</td>
</tr>
<tr>
<td>Ratio of Out-of-Plan Acceleration to Maximum Horizontal Acceleration</td>
<td>0.1 — 0.25</td>
</tr>
<tr>
<td>Ratio of Maximum Vertical Acceleration to Maximum Horizontal Acceleration</td>
<td>0.5 — 0.67</td>
</tr>
<tr>
<td>Laminar Frame to Soil Weight Ratio / Lateral Support to Soil Weight Ratio</td>
<td>&lt; 0.1</td>
</tr>
</tbody>
</table>
Test Model Construction

Transportation of container base

Assemblage of frames

Plastic liner

Backfill

Compaction

Instrumentation

Field-test

Tunnel

Backfill / Compaction

Excavation
Test Model Construction
Timeline of Geotechnical Testing

- Transporting laminar soil container and frames
- Stacking laminar frames
- Placing a plastic liner
- Pre-installation of instrumentation
- Filling the container / Compaction
- Instrumentation
- Placing a structural model
- Filling the container / Compaction
- Instrumentation
- Placing a structural model
- Finishing backfill
- Securing the top
- Instrumentation
- Excavation (5 ft depth)
- Replacement of the test model
- Instrumentation
- 1st Test
- 2nd Test
- Diassemblage/Demolition
- Storing the container
- Payment for damaged sensors
- Accomplishment

Weeks:
1 2 3 4 5 6 7 8 9 10
Filling The Box / Excavation

- Dry Sand (Carroll Canyon Type II)

- Saturated Sand (Ottawa Sand)
Instrumentation

- Accelerometers
- String potentiometers (SP)
- Linear potentiometers (LP)
- Strain gauges
- Pressure sensors
Case Study 1: Shallow Tunnel Testing

➢ Objectives

1. To evaluate seismic response of a shallow tunnel under different ground conditions:
   1) Backfill soil material properties
   2) Thickness of overburden soil (burial depth)

2. To provide recommendations for the current Caltrans seismic design criteria for shallow tunnels
Test Model Configurations

$R = 99\%$

$R = 85\%$

$R = 99\%$
Instrumentation

➢ Over 200 Channels

Strain gauges (S) / Inclinometers (Inc) / Linear potentiometers (LP) / Tactilus pressure sensors (TP) / Tekscan sensor

String potentiometers (SP)

West

Linear potentiometers (LP)

Accelerometers (A)

East
Dynamic Response of Tunnel

![Graphs showing dynamic response of a tunnel]

- At ground surface (Model 1)
- Racking (Model 1)
- At base (Model 1)

Nor100PT0, Nor100PT1, Nor100PT2, Nor200PT1, Tak100PT0, Tak100PT1, Tak100PT2
Case Study 2: U-Shaped Retaining Wall Testing

**Motivation:**

- Spillway walls are abutted on highly compacted soil.
- Stiffness and strength of the retained backfill might be different on one side of the spillway versus the other.
- This issue is conceptually addressed by employing soil compacted at different levels on either side of the spillway model in the tests.

Wall length = 111 inches (9.25 ft)  
Wall thickness = 0.75 inches  
Wall height = 33.5 inches (2.8 ft)  
Base height = 6.5 inches (0.54 ft)  
Base width = 71.5 inches (6 ft)
Test Model Configurations

Model 1: D120 soil ($R = 99\%, \gamma = 19 \text{ kN/m}^3$)
Model 2: D120 soil ($R = 99\%, \gamma = 19 \text{ kN/m}^3$)
Model 3: D104 soil ($R = 85\%, \gamma = 16.5 \text{ kN/m}^3$)
Model 1: D104 soil ($R = 85\%, \gamma = 16.5 \text{ kN/m}^3$)
Model 2: D94 soil ($R = 85\%, \gamma = 15 \text{ kN/m}^3$)
Model 3: D94 soil ($R = 85\%, \gamma = 15 \text{ kN/m}^3$)
Instrumentation

- Strain gauges (S)
- Inclinometer (I)
- String potentiometers (SP)
- Accelerometers (A)
- Tactile pressure sensors (TP)
Instrumentation of Retaining Wall
Lateral Wall Deflection During Shakings

West soil (Model 1)

West wall (Model 1)

East soil (Model 1)

East wall (Model 1)
Case Study 3: Lateral Earth Pressure Testing

Test Model Configuration

➢ Objectives:

To evaluate:
1) Influence of soil cohesion
2) Effect of small wall movements on the magnitude and distribution of earth pressure.

Lessons Learned

➢ Plan and Manufacture ahead before you arrive on site
  - Instrumentation: sensor types, calibration,…
  - Plastic liner / plywood
  - Shake table input motions (OLI)

➢ Think about staffing
  - Construction: site staff, local engineering company
  - Backfill/Removal: different approaches depending on soil types and conditions (dry and saturated)

➢ Achieve the target soil properties
  - Plan for secondary tests for shear wave velocity, relative density, and water table
  - CPT / Water table measuring device / Sand cone / Nuclear gauge

➢ System identification
  - High-resolution acceleration (sampling rate at 25,000 Hz, compared to 240 Hz for the main DAQ system)
  - White noise / Hammer test
Thank You