

Behavior of Laterally Loaded Piles in A Mechanically Stabilized Earth (MSE) Wall

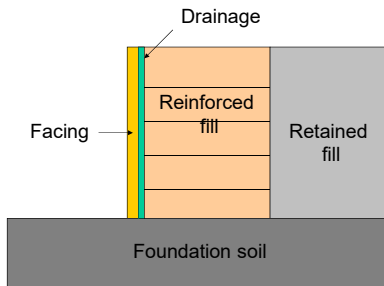
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 Geotechnical Engineering

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Outline of Presentation

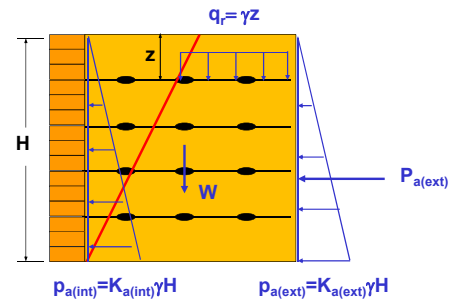
- Introduction
- Problem Statement
- Construction of Test Wall
- Instrumentation
- Lateral Load Testing and Results
- Numerical Analysis
- p-y Curves of Laterally Loaded Piles
- Cyclic Loading Effect
- Conclusions

Mechanically Stabilized Earth (MSE) Wall - Key Components



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Internal and External Stability Analysis of MSE Wall



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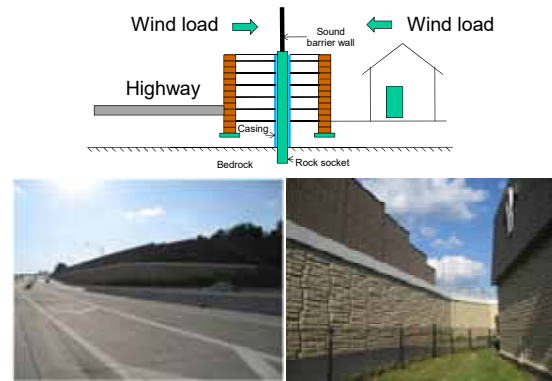
MSE Wall-Supported Bridge Abutment



Lateral load: traffic loading, thermal effect, earthquake

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MSE Wall-Supported Sound Barrier Walls



Basic Design Questions

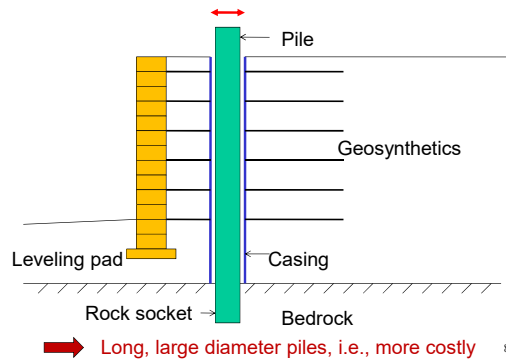
1. How to design laterally loaded piles behind an MSE wall?
2. How to design an MSE wall considering lateral loads from piles?
3. How to consider cyclic loading effect?

Answer:

no design method available for these conditions!

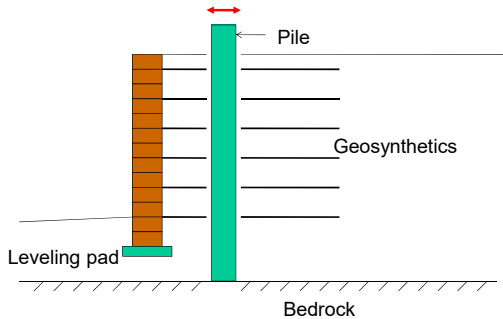
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Current Practice



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Proposed Design



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Research Methodology

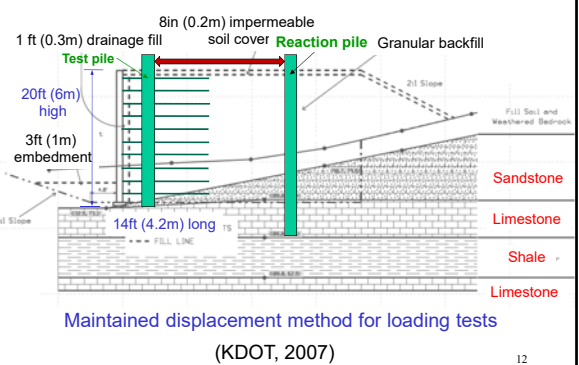
- Theoretical derivation
- Numerical analysis
- Laboratory model test
- Field test
 - KDOT research project investigated
 - ❖ Pile offset distance effect
 - ❖ Pile length effect
 - ❖ Group pile effect

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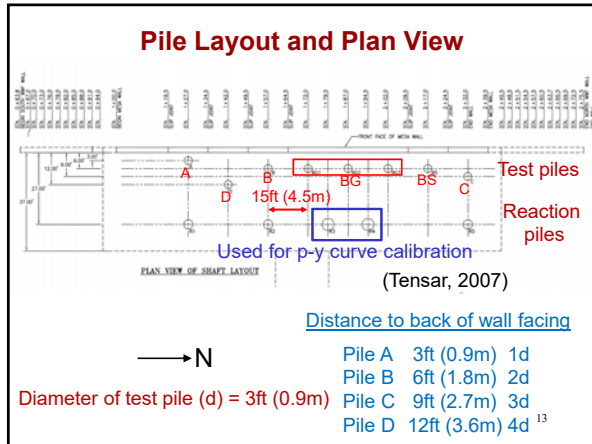
Site Location for Field Test Wall



Test Wall Cross-section



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Instrumentation

- Inclinator Casing
- Strain Gages on Geogrid
- Photo Targets Attached to Facing
- Earth Pressure Cells Behind Facing

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Inclinometer Casing

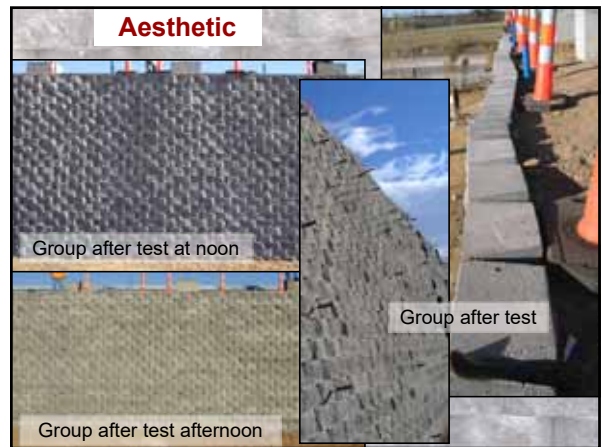
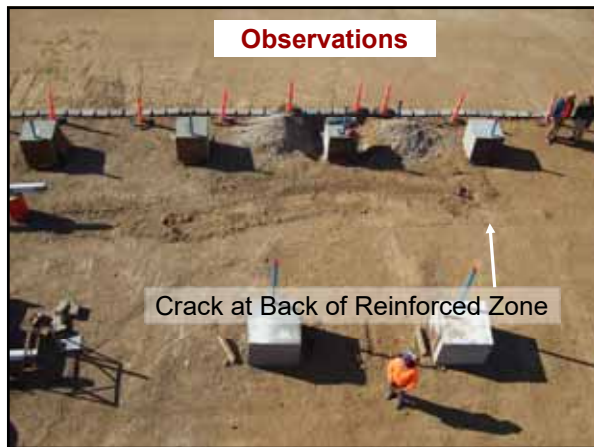
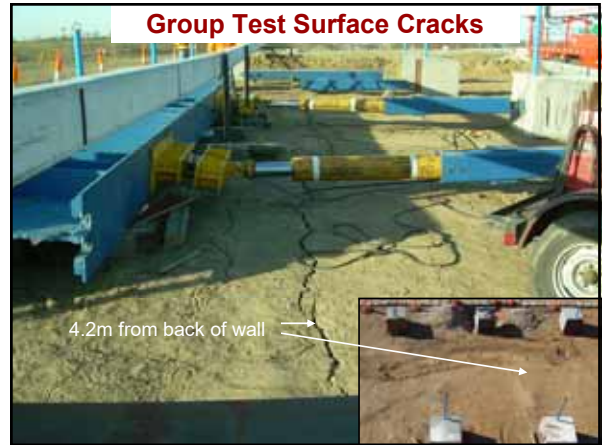
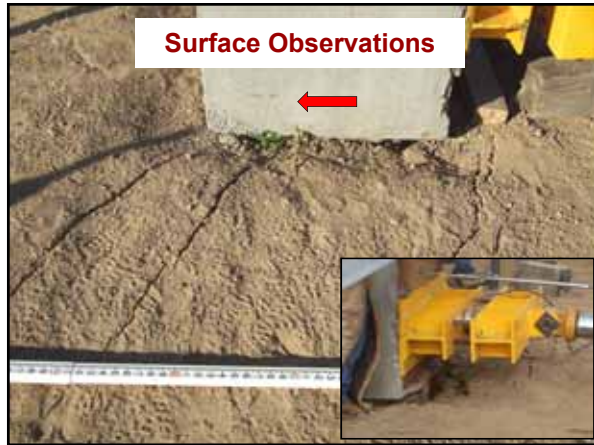
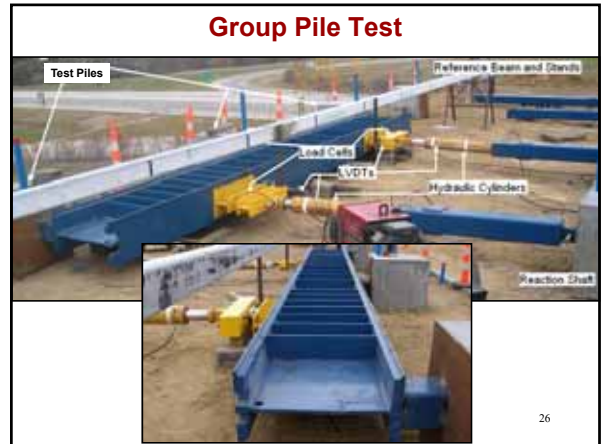
Strain Gages on Geogrid

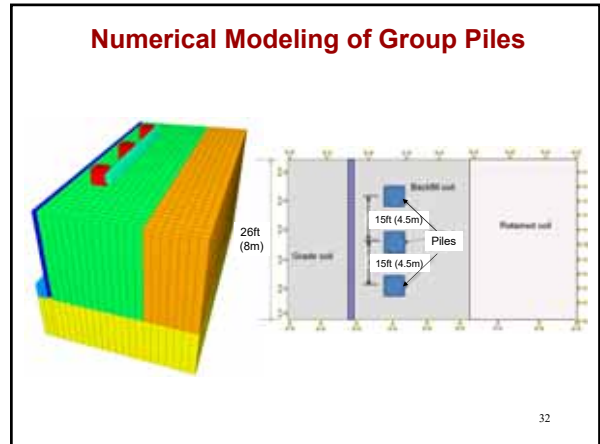
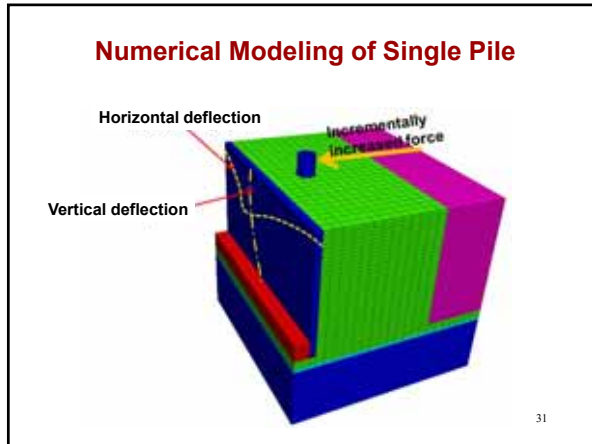
Photogrammetry

Earth Pressure Cell

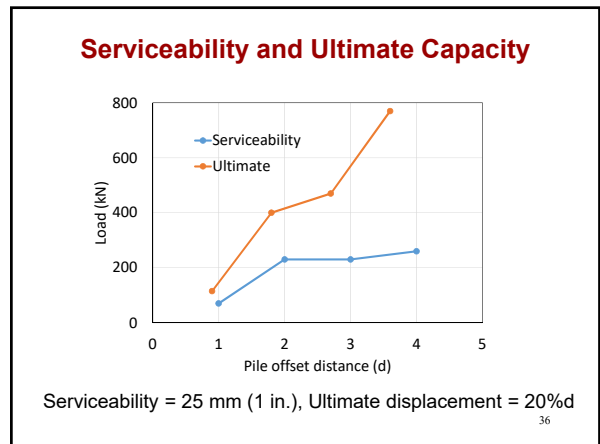
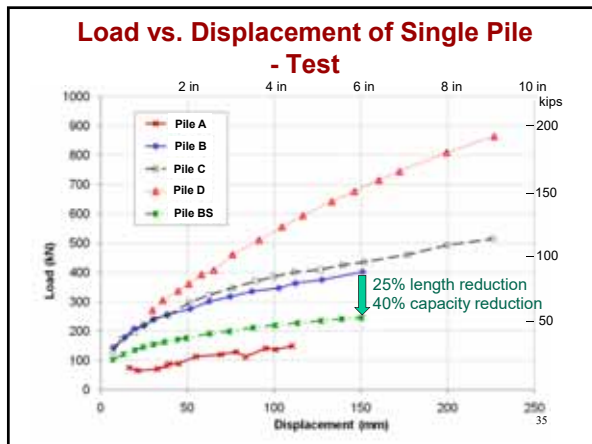
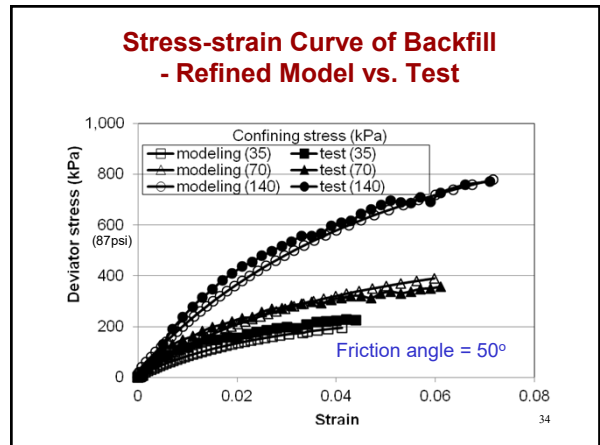
Black area = 0.15m scale

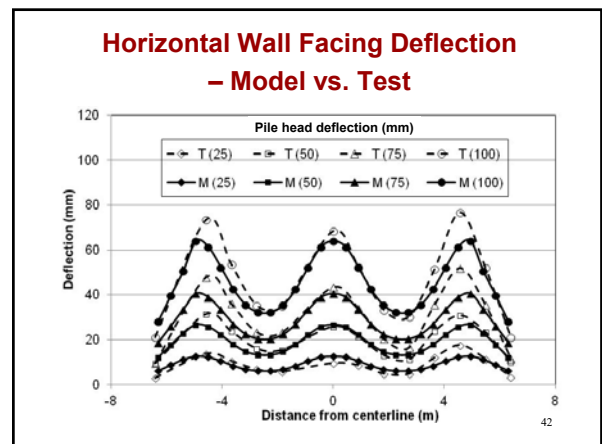
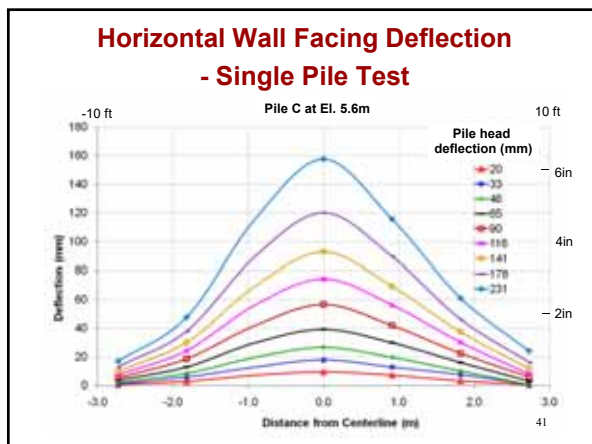
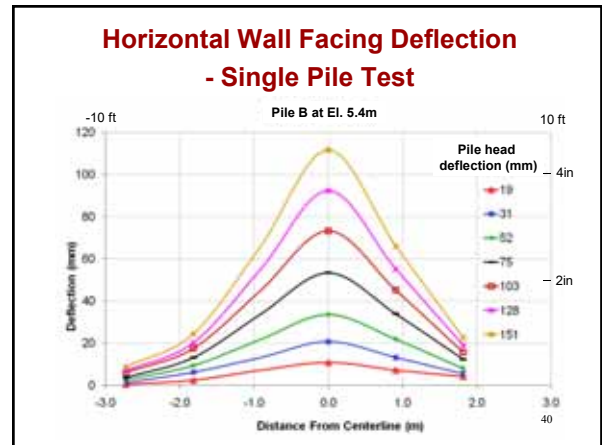
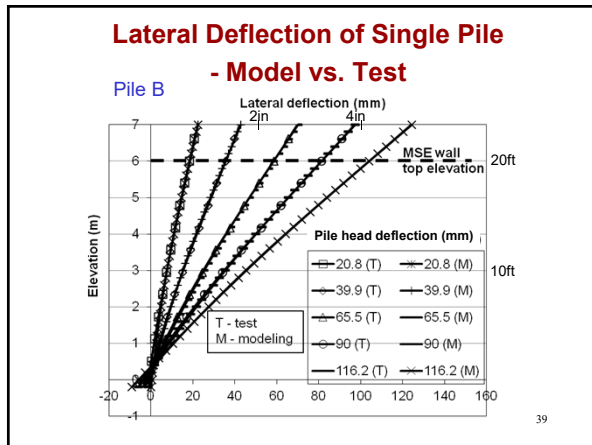
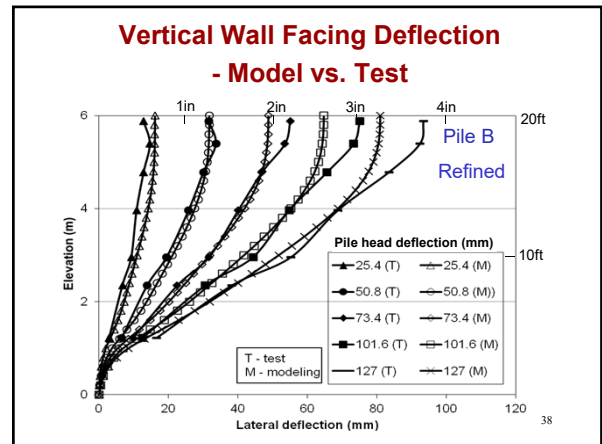
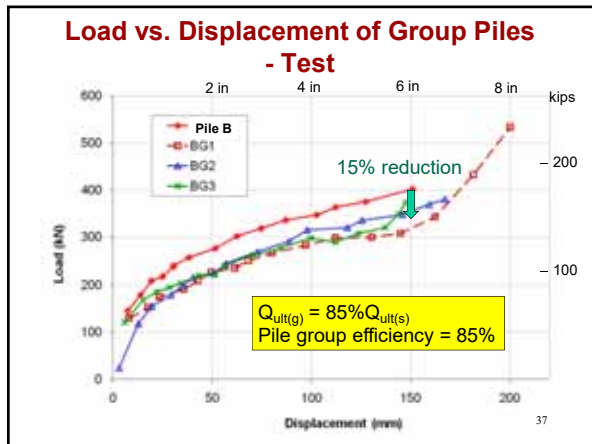
Earth Pressure Cell

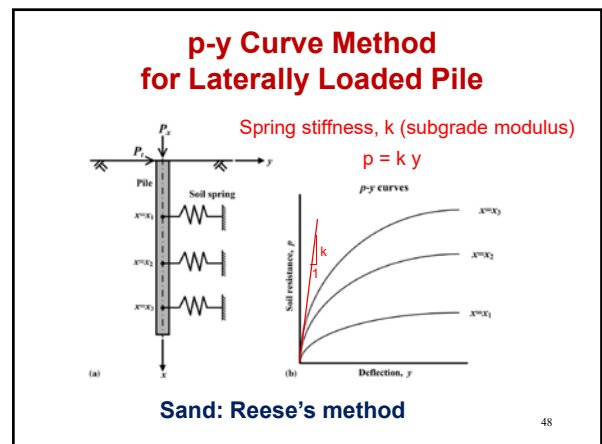
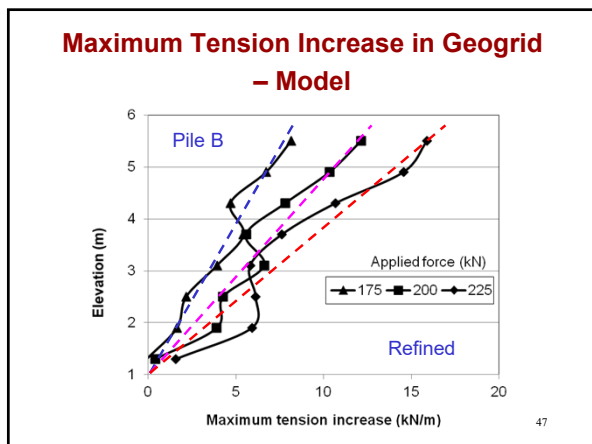
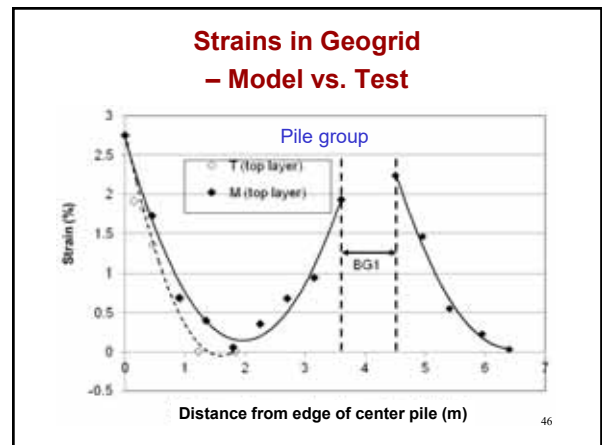
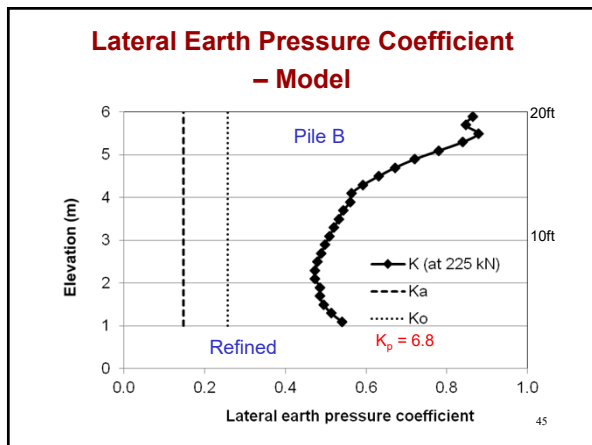
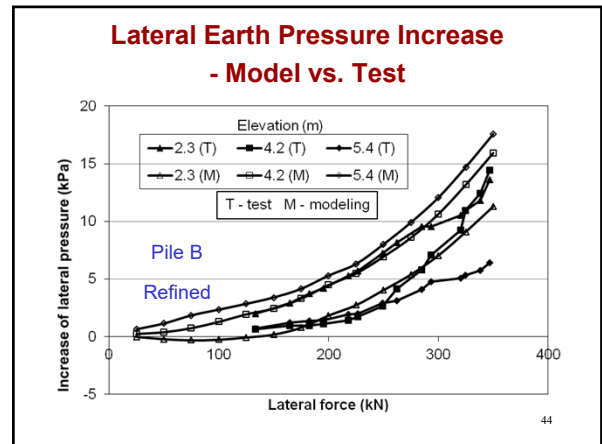
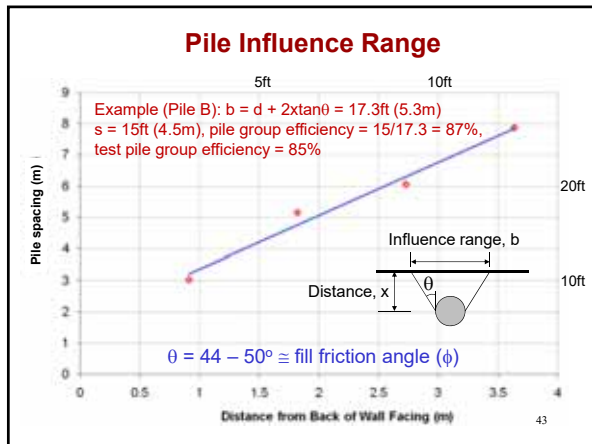




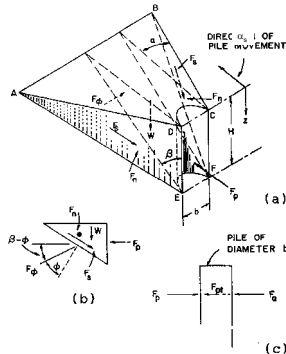
- ### Numerical Modeling
- Pre-test modeling
 - Elastic-plastic (M-C) model
 - Typical fill parameters
 - Immediate post-test modeling
 - Elastic-plastic (M-C) model
 - Measured fill parameters
 - Refined modeling
 - Cap-yield model – stress dependent
 - Individual blocks
 - Compaction stresses
 - Measured fill parameters
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Passive Wedge-type Failure of Pile in Sand (Reese et al., 1974)



This method is included in LPILE software.

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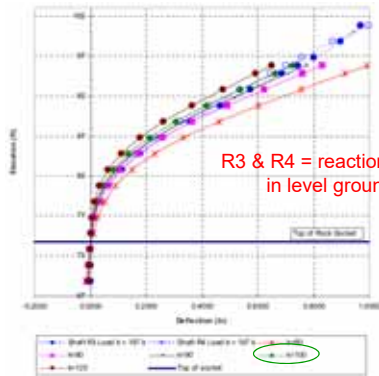
Key Parameters in Reese's Method

| | |
|-------------------------------------|------------|
| Backfill Friction Angle | 50 degrees |
| Backfill Unit Weight | 110 pcf |
| Subgrade modulus, k | 100 pci |
| Concrete Compressive Strength | 6200 psi |
| Yield Strength of Reinforcing Steel | 60 ksi |

Back-calculated using tests of piles with level ground

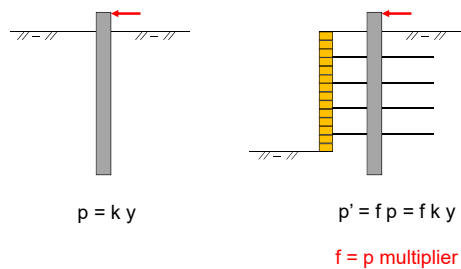
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Calibration of k Coefficient for p-y Curve



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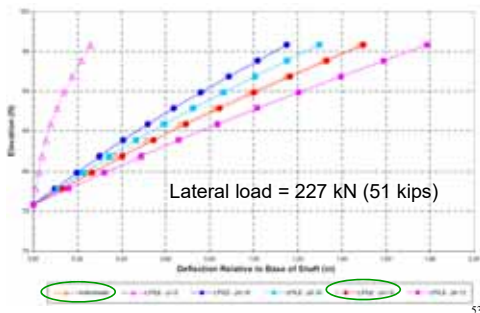
Piles in Level Ground vs. behind Wall



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Back-calculation of p Multiplier

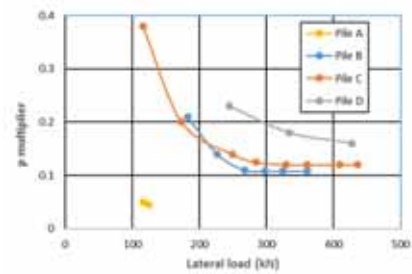
$$p' = f p$$



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p Multiplier for Resistance Reduction

$$p' = f p$$



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Physical Test Wall in Lab – Single Pile

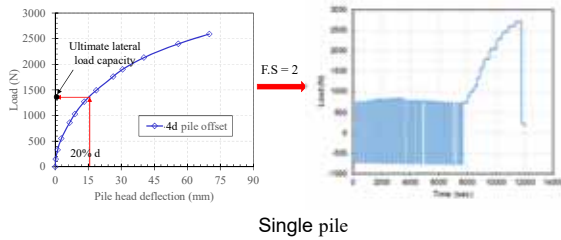


Physical Test Wall in Lab – Group Piles



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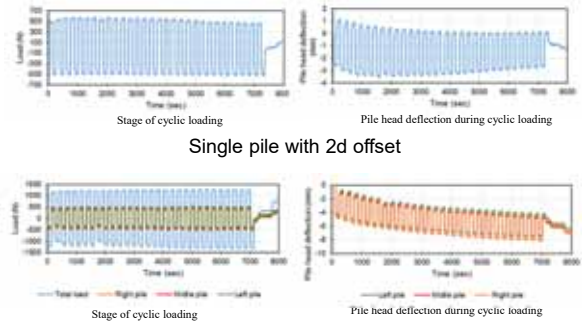
Static to Cyclic Lateral Load Test



Single pile

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Cyclic Lateral Load Test

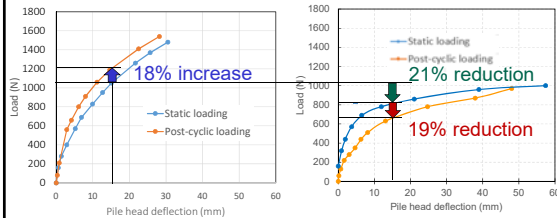


Group piles with 2d offset

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Load-Deflection of Pile Head

Pile offset = 2d



Single pile

Middle pile in group

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Summary

- Piles in the MSE wall can carry reasonable lateral loads without socketed into bedrock.
- Piles had rigid rotation while wall facing had flexible deflections.
- The MSE wall can tolerate a large local deformation (up to 4 inches or 100mm).
- Modular blocks can “hide” the local deformation well.
- Lateral pile capacity in the MSE wall depends on the distance to the wall facing.
- Pile group effect depends on pile spacing and the distance to wall facing.

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Summary

- Numerical method can reasonably simulate the laterally loaded pile in the MSE wall, especially after considering strain hardening, confining and compaction effect, and discrete blocks.
- Response of laterally loaded piles can be modeled by p-y curves with p-multipliers (<1.0), which depend on the distance to the wall facing and the lateral load.
- Cyclic loading increases single pile load capacity, but reduces group pile load capacity.

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Acknowledgements



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Questions?