Reticulated Micropiles for the Preservation and Rehabilitation of Transportation Infrastructure

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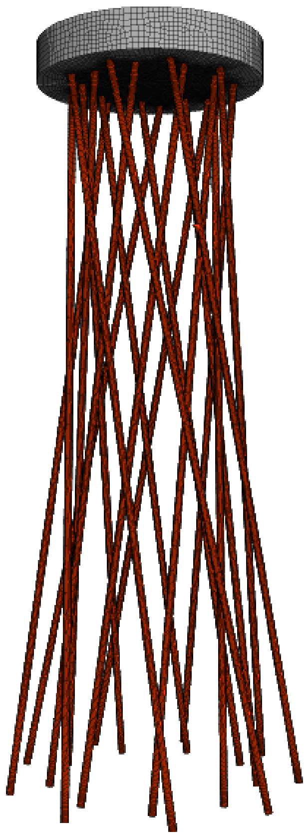
Acknowledgements

- Rhode Island Department of Transportation
  - David Fish, Christos Xenophontos

Agenda

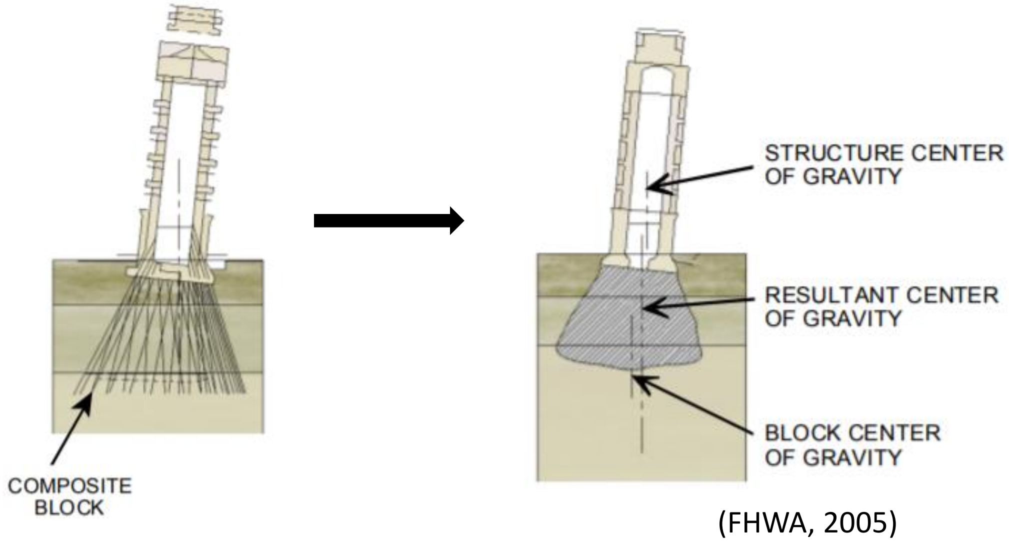
- Background of Reticulated Micropiles
- $FLAC^{3D}$ Modeling of Reticulated Micropiles
  - Constitutive Model
  - Numerical Model Generation
  - Numerical Results
- Questions

NUMERICAL STUDY OF THE ‘KNOT EFFECT’ IN MICROPILE GROUPS



Background

- A reticulated micropile structure is a three-dimensional lattice structure that involves the creation of a laterally confined soil/pile composite structure
- Developed by Fernando Lizzi in post-WWII Italy to rehabilitate Neapolitan seaport
- Lizzi assumed a “knot effect” caused the reticulated micropile system to act as a unit. Observed group efficiency greater than 2



(FHWA, 2005)

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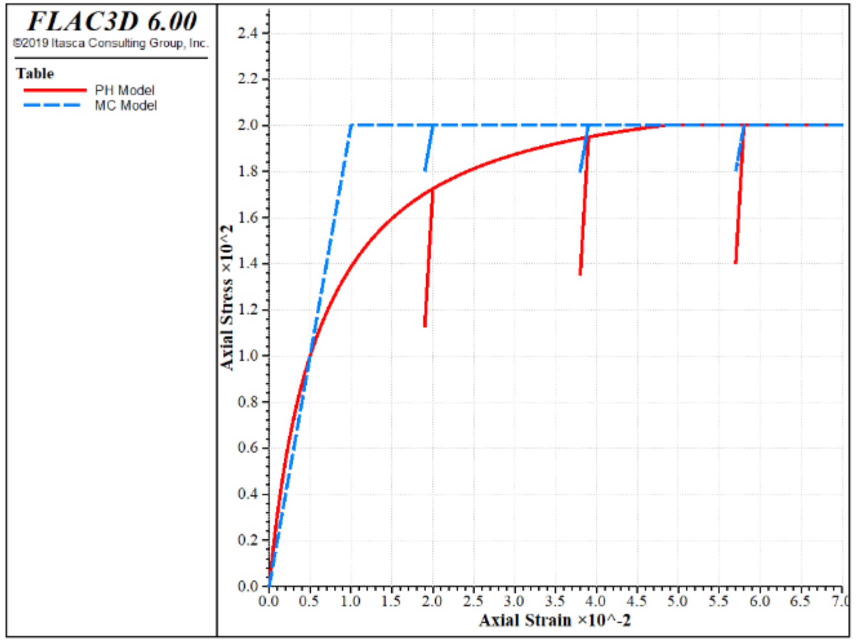
Overview

- Problem Statement
  - The ‘knot effect’ has been credited with increased group efficiency in a reticulated micropile system but the mechanics of the effect are not clearly understood

- Objectives
  - Investigate the potential causes of the ‘knot effect’ numerically

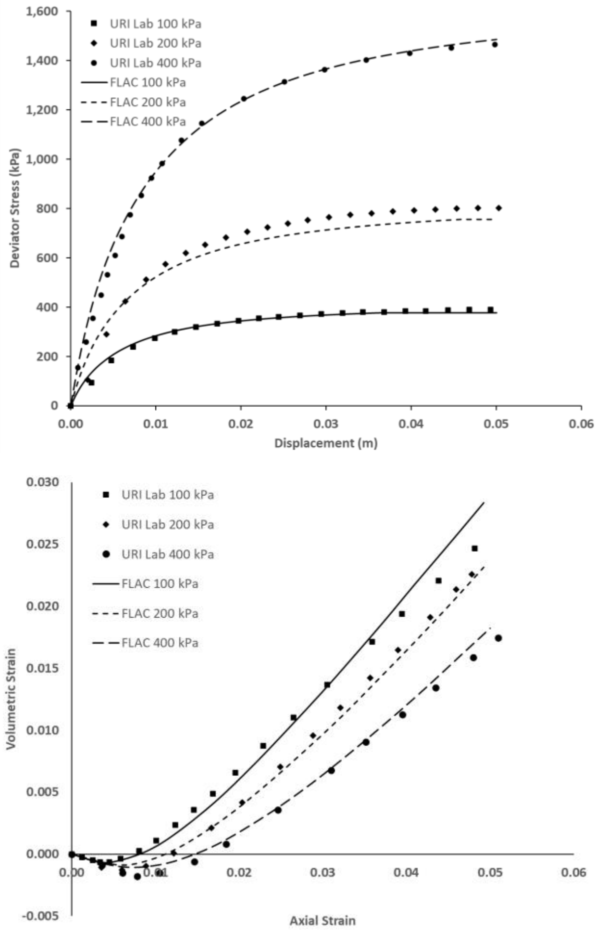
Constitutive Model: Background

- Plastic Hardening constitutive model
  - More realistic pre-failure stress-strain behavior
  - Yield surface is not fixed in principal stress space but can expand due to plastic straining
    - Shear Hardening
      - Irreversible strains due to primary deviatoric loading
    - Volumetric hardening
      - Irreversible strains due to primary compression in oedometer loading and isotropic loading

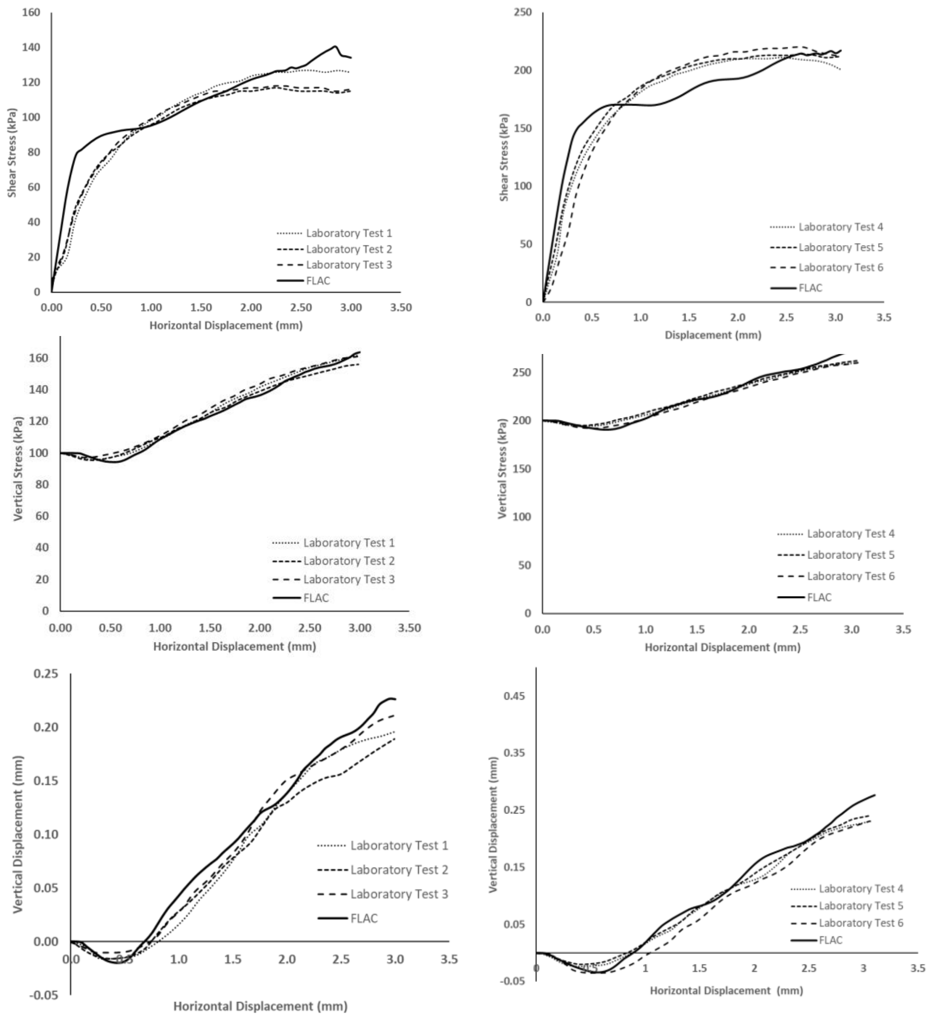


Soil Element Testing: PH Model

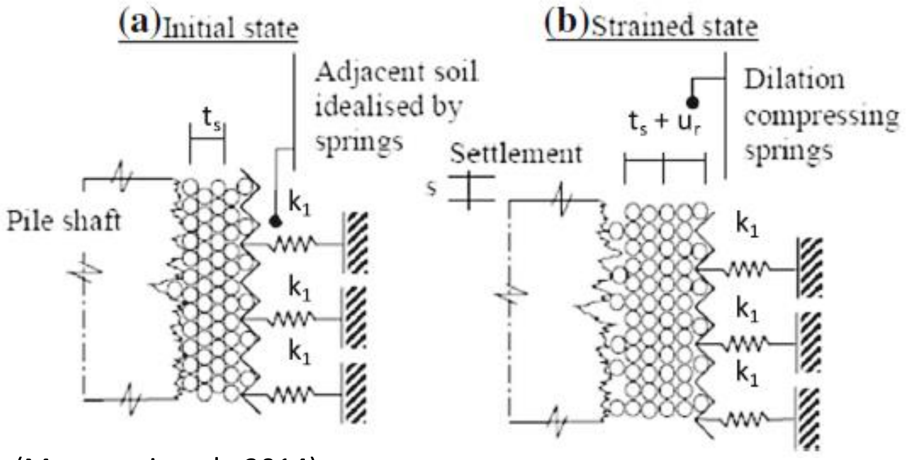
CD Triaxial Tests



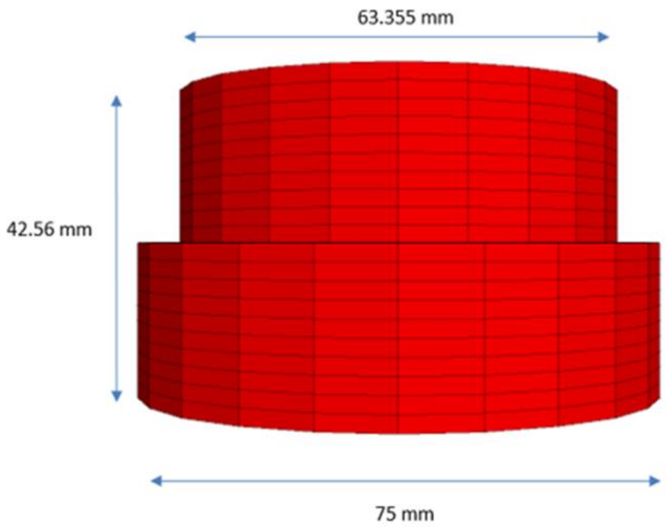
CNS Tests

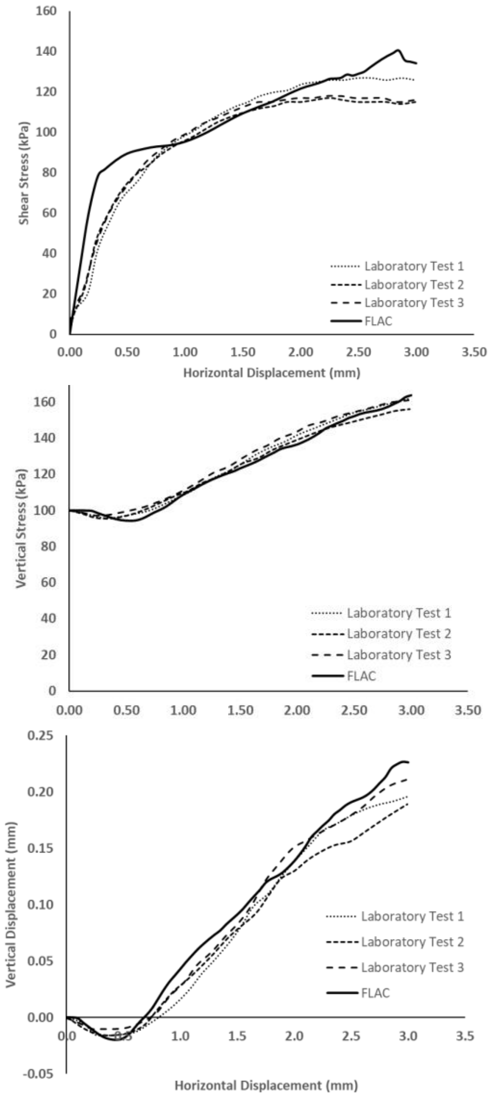


Constitutive Model: Background



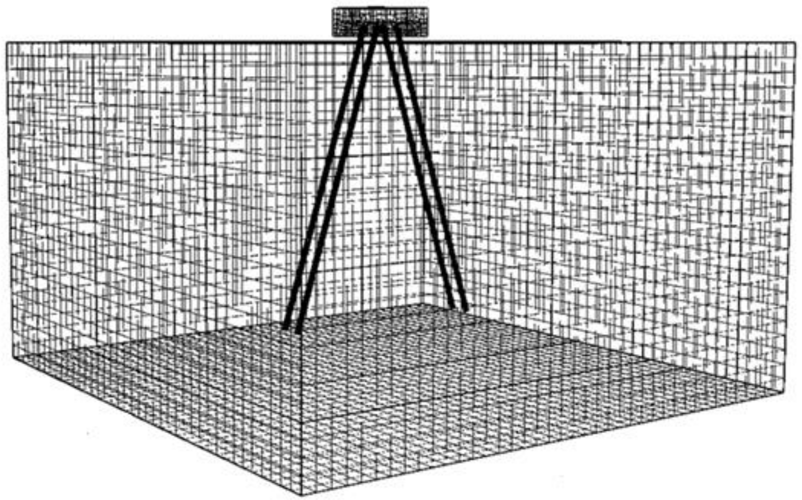
(Masarucci et al., 2014)

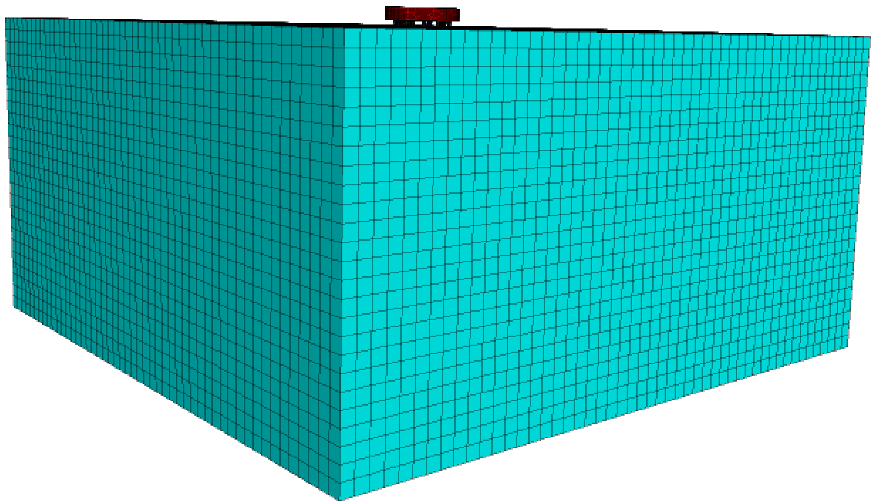




Rhino → FLAC

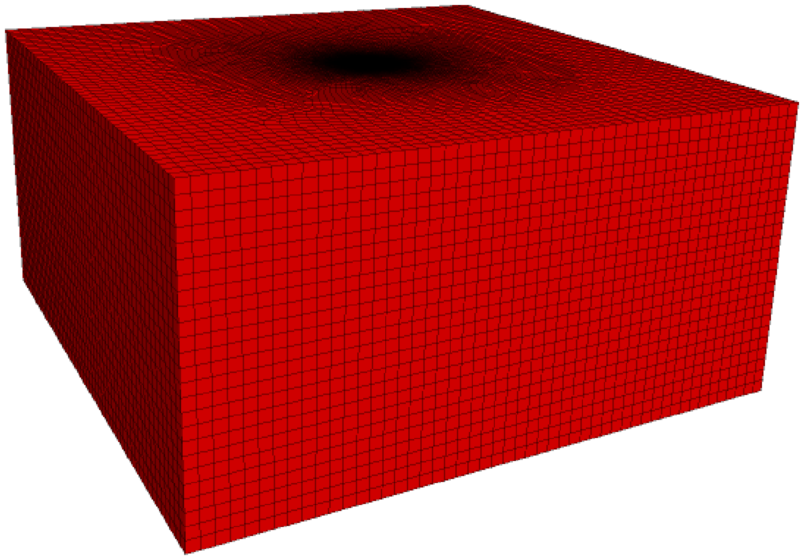
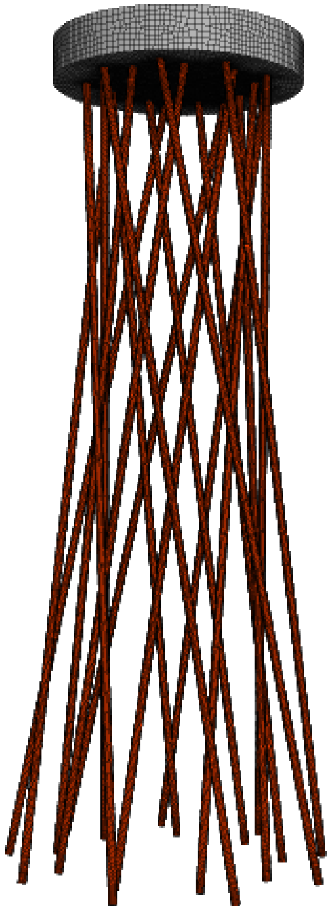
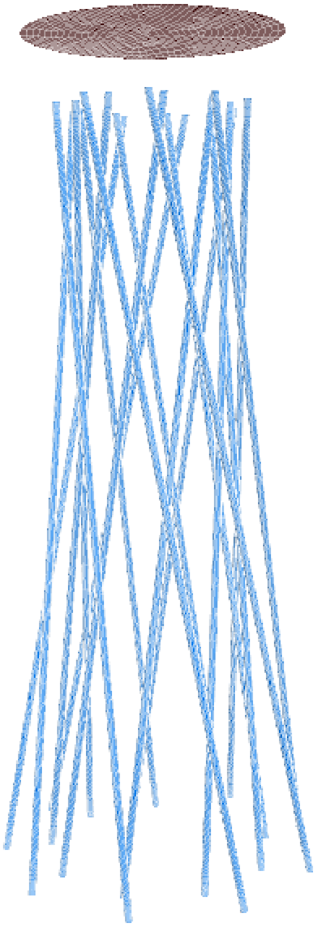
- Create the mesh in Rhino using the Griddle 2.0 plug-in and import into FLAC3D





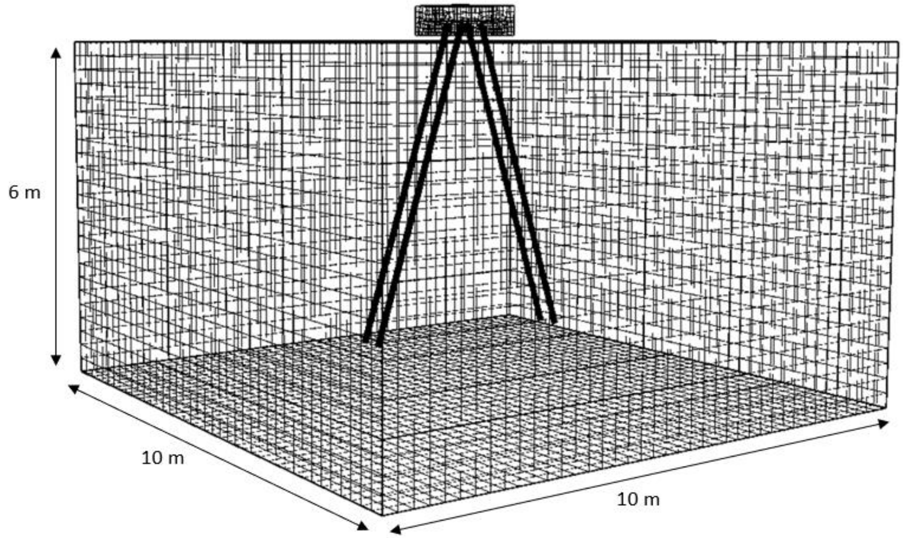
Rhino → FLAC

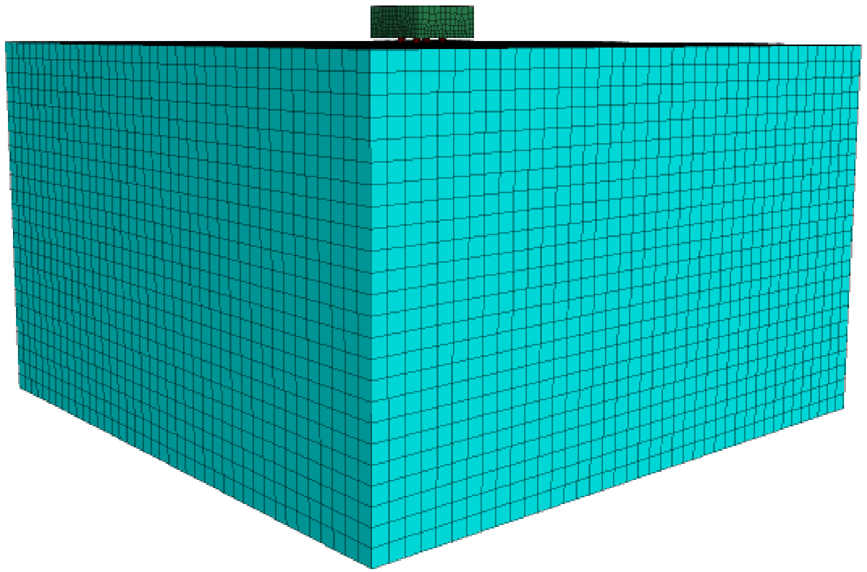
- Once in FLAC, define your zones and interfaces in the Model pane

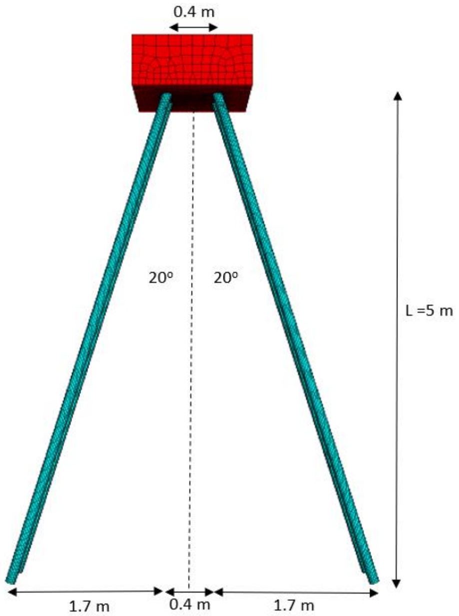
Model Validation: St.-Rémy-lès-Chevreuse

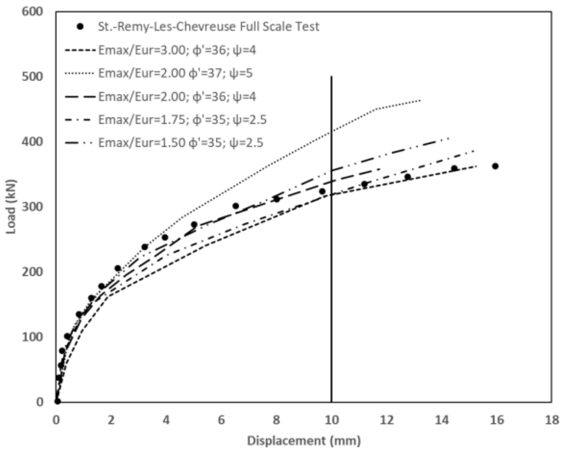
- Full-scale tests
  - D = 100 mm, L = 5 m
  - Fontainebleau sand; D_r 53% - 62%

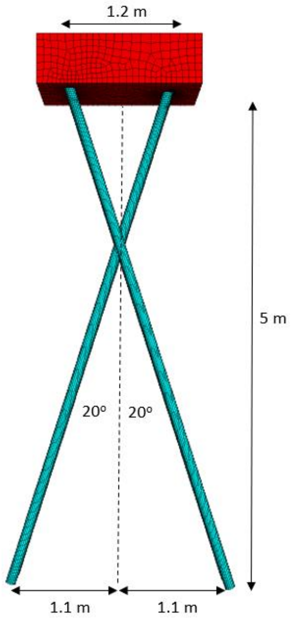


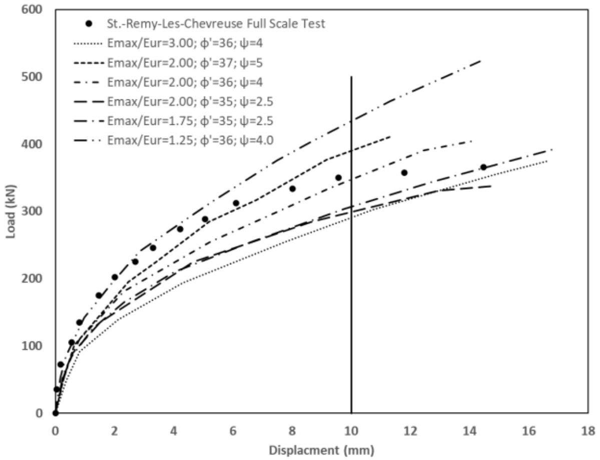


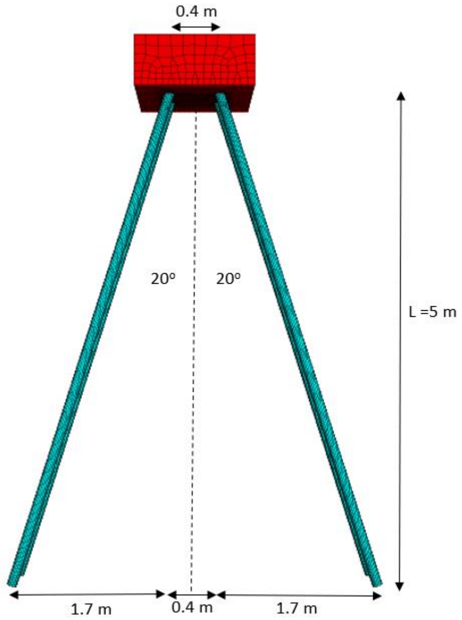
Model Validation: Load Test Simulations

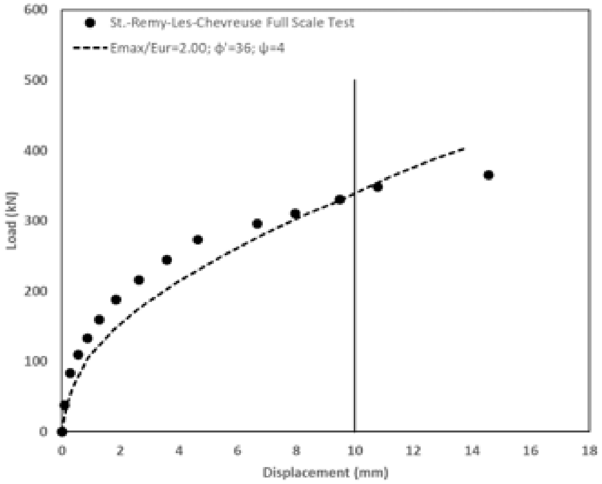






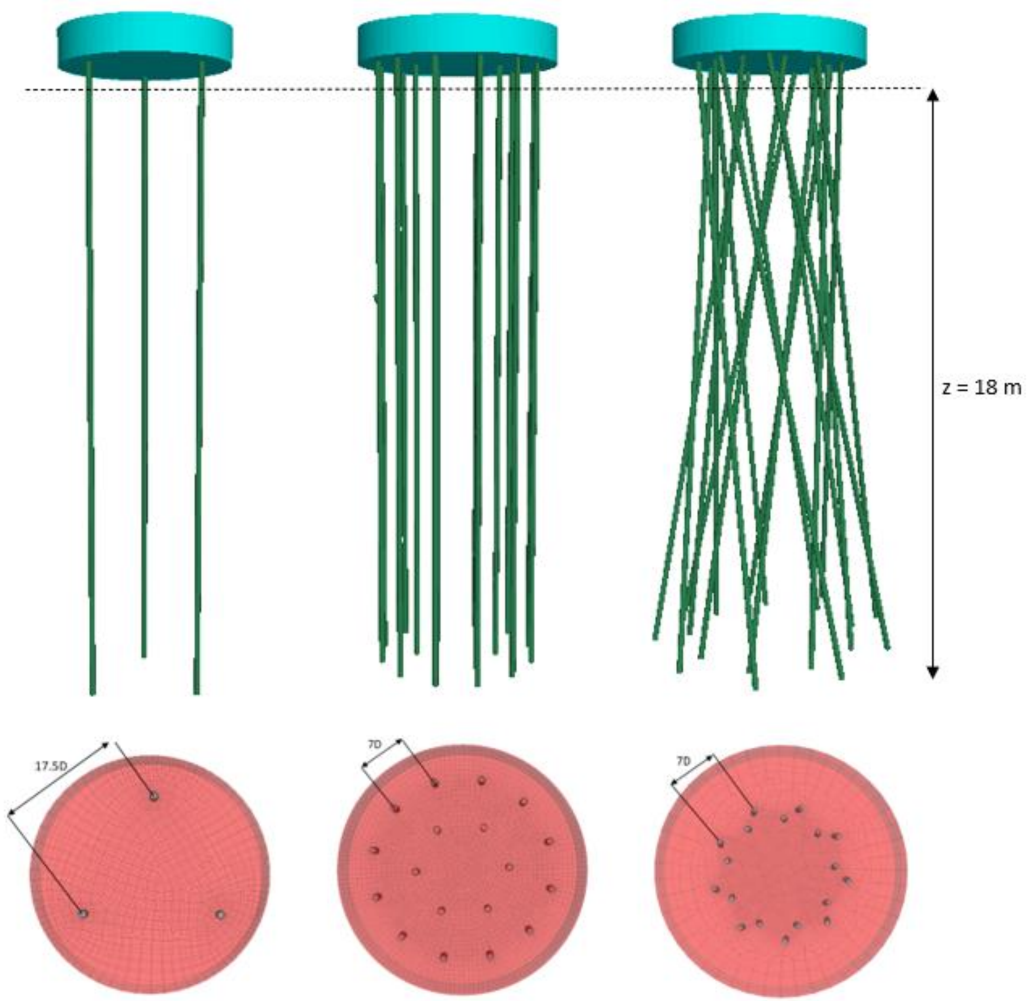


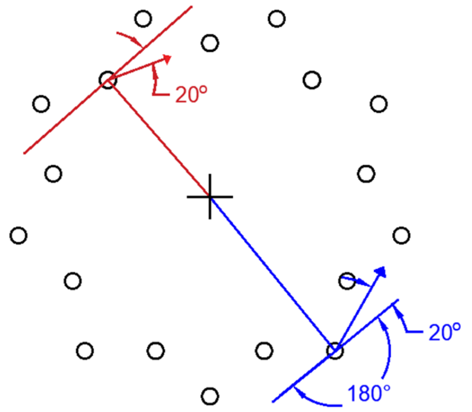




(Durot and Plumelle, 1996; Gagneux and Plumelle, 1997)

Load Test Simulations: Full-Scale Groups





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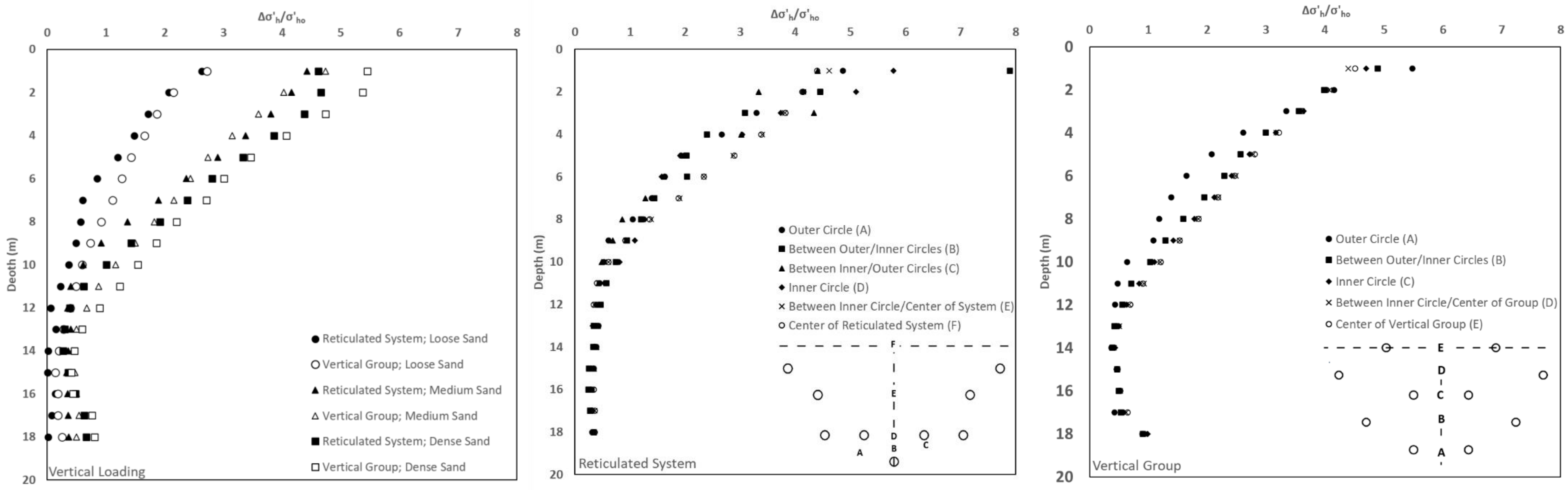
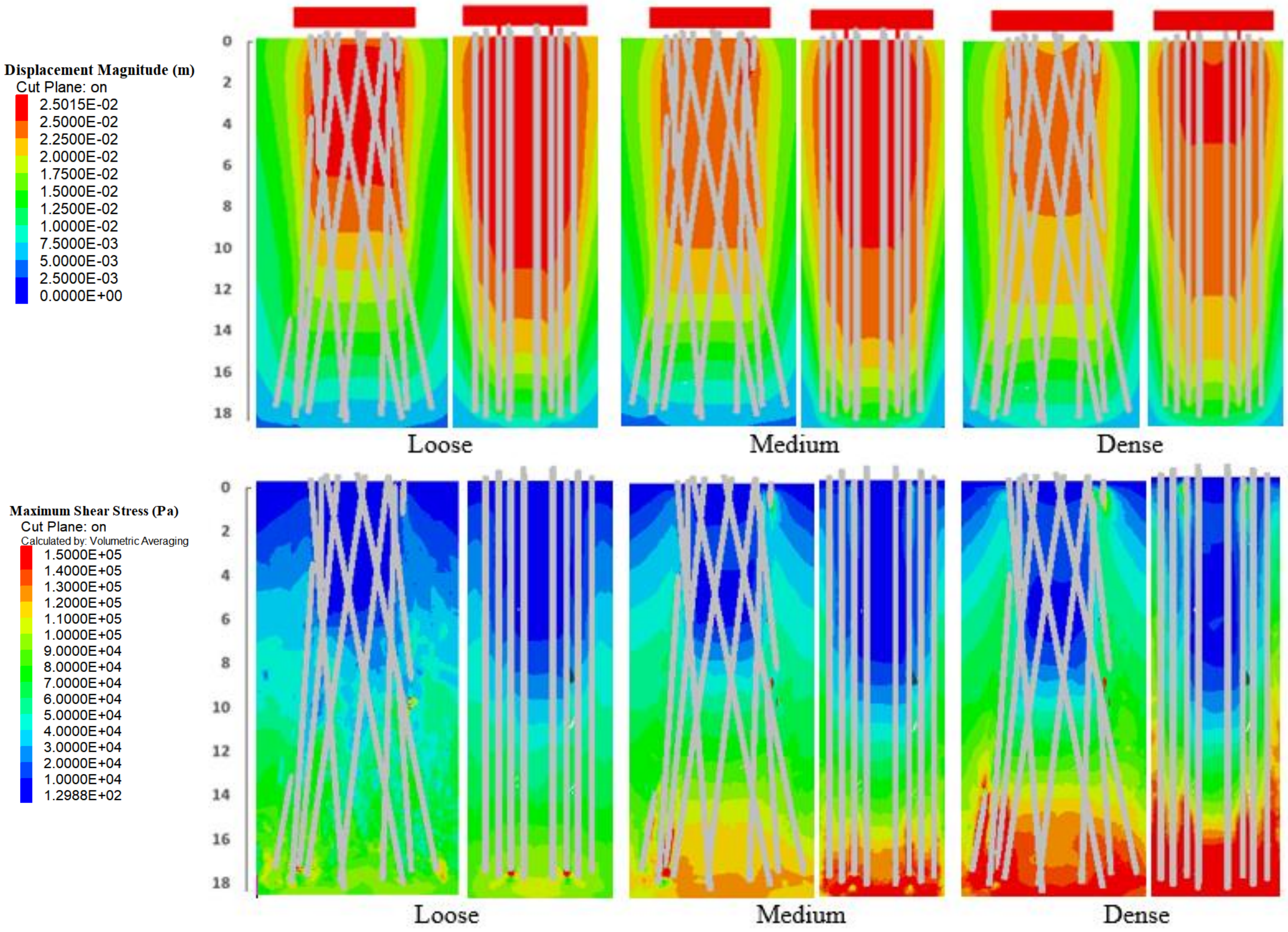
Load Test Simulations: Vertical Loading

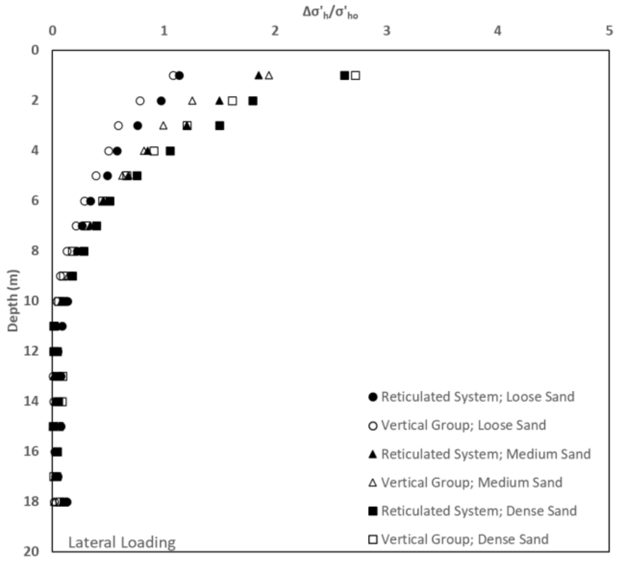


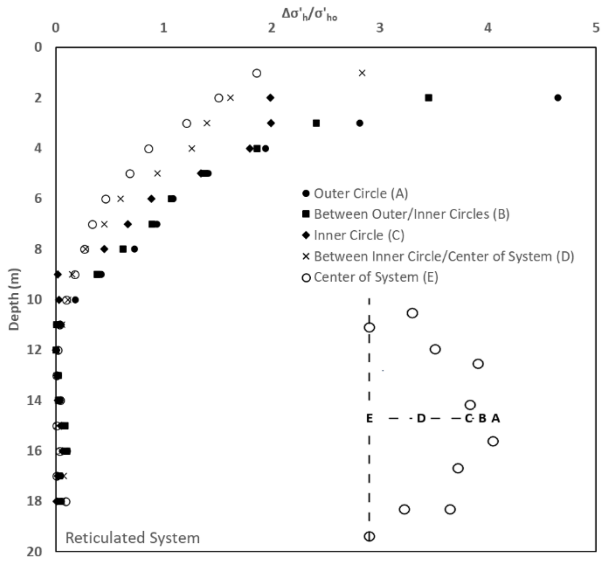
	η_g, Vertical Loading		
Group	**Loose**	**Medium**	**Dense**
18-Pile Vertical Group	0.75	0.66	0.65
18-Pile Reticulated System	0.74	0.74	0.63

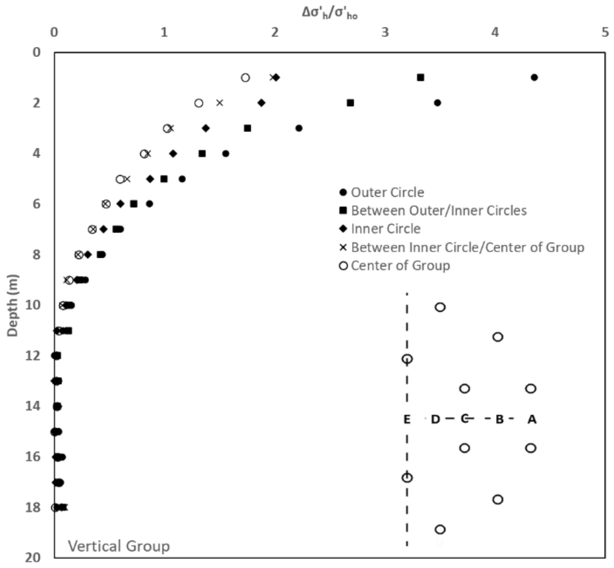
Load Test Simulations: Vertical Loading



Load Test Simulations: Lateral Loading

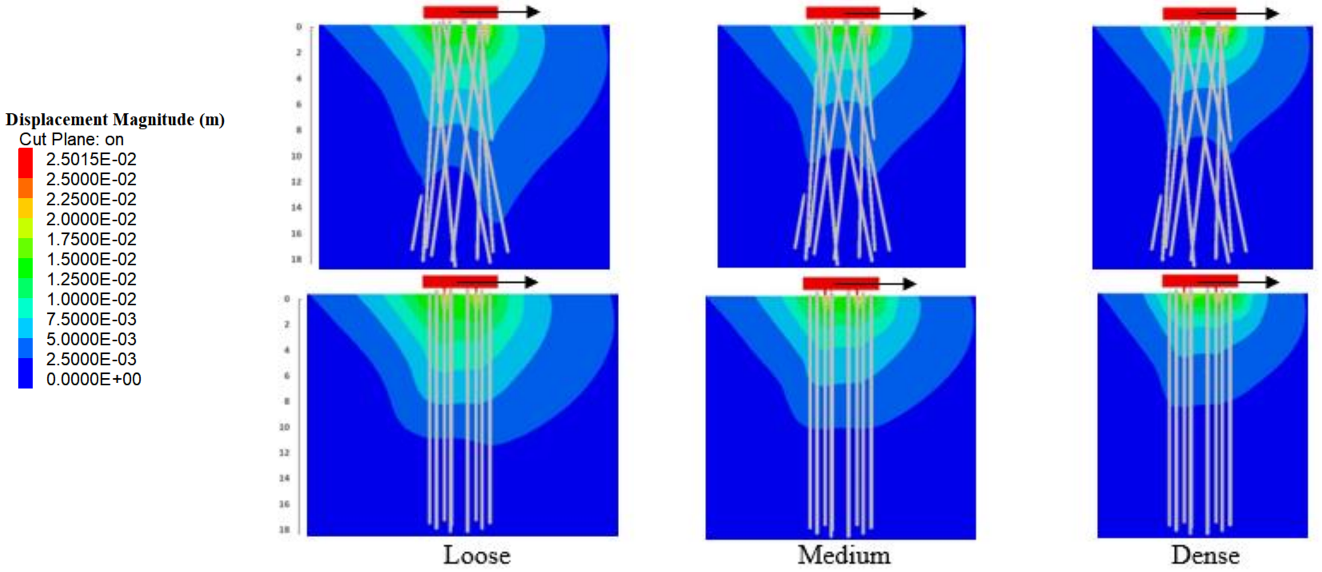


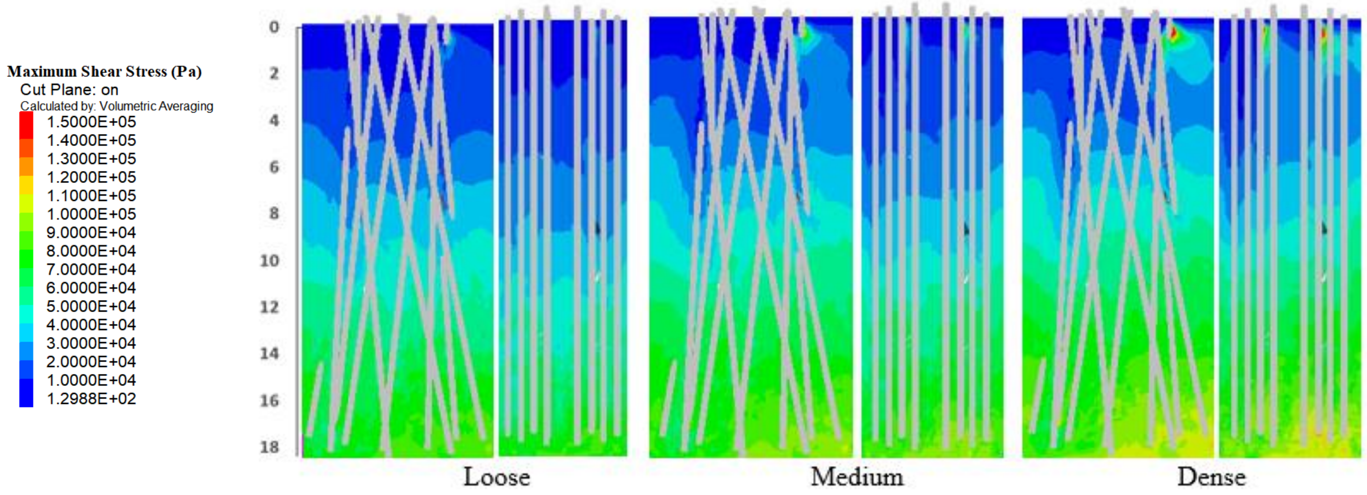




	η_g, Lateral Loading		
Group	**Loose**	**Medium**	**Dense**
18-Pile Vertical Group	2.00	1.55	1.70
18-Pile Reticulated System	2.16	1.79	1.70

Load Test Simulations: Lateral Loading





Conclusions of Pile Group Study

- The formation of a soil block was observed under conditions of vertical loading
  - Group efficiencies for all cases less than unity
- Soil block was not observed for lateral loading conditions
  - Group efficiencies for all cases greater than unity
- We believe the knot effect is due to the shear and dilation of the soil surrounding the micropiles, but an improved numerical model will be needed to verify

Questions

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