Evaluating the Effect of Temporary Casing on Rock Socket Resistance

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Rock Socket Resistance

- Often designed as a function of the parent rock properties and characteristics:

  - Unconfined Compression Strength
  - Split Tensile Strength
  - Recovery
  - RQD

Ultimate Side Resistance

- O’Neill and Reese (1999) – AASHTO (2012)

$$fmax = 0.65pa\sqrt{\frac{q_u}{p_a}} \quad and\ qu\ \leq f'c$$

- Kulhawy et al. (2005) – Basis of FHWA (2010)

$$fmax = C * p_a\sqrt{\frac{q_u}{p_a}} \quad and\ qu\ \leq f'c$$

(C = 0.63 to 1.00)

- McVay et al. (1992) – Basis of FDOT (2015)

$$fmax = \frac{1}{2}\sqrt{q_u}\sqrt{q_t} \quad and\ qu\ \leq f'c$$

Construction Effects

not addressed by design

- Excavation Equipment
- Reinforcement Bar Size and Cage Spacing
- Concrete properties
- Cased or Slurry Supported
- Temporary or Permanent Casing
- Vibrated or Oscillated Casing
- Slurry Type
- Slurry Exposure

Problem Statements

- Construction methods affect drilled shaft side shear resistance which is not fully addressed by design.
- The effects from full length or partial length temporary casing can present the same concern.
- The effects of prolonged polymer slurry exposure are not clearly defined in literature.

Objectives

Quantify the effects of temporary casing on rock socket capacity

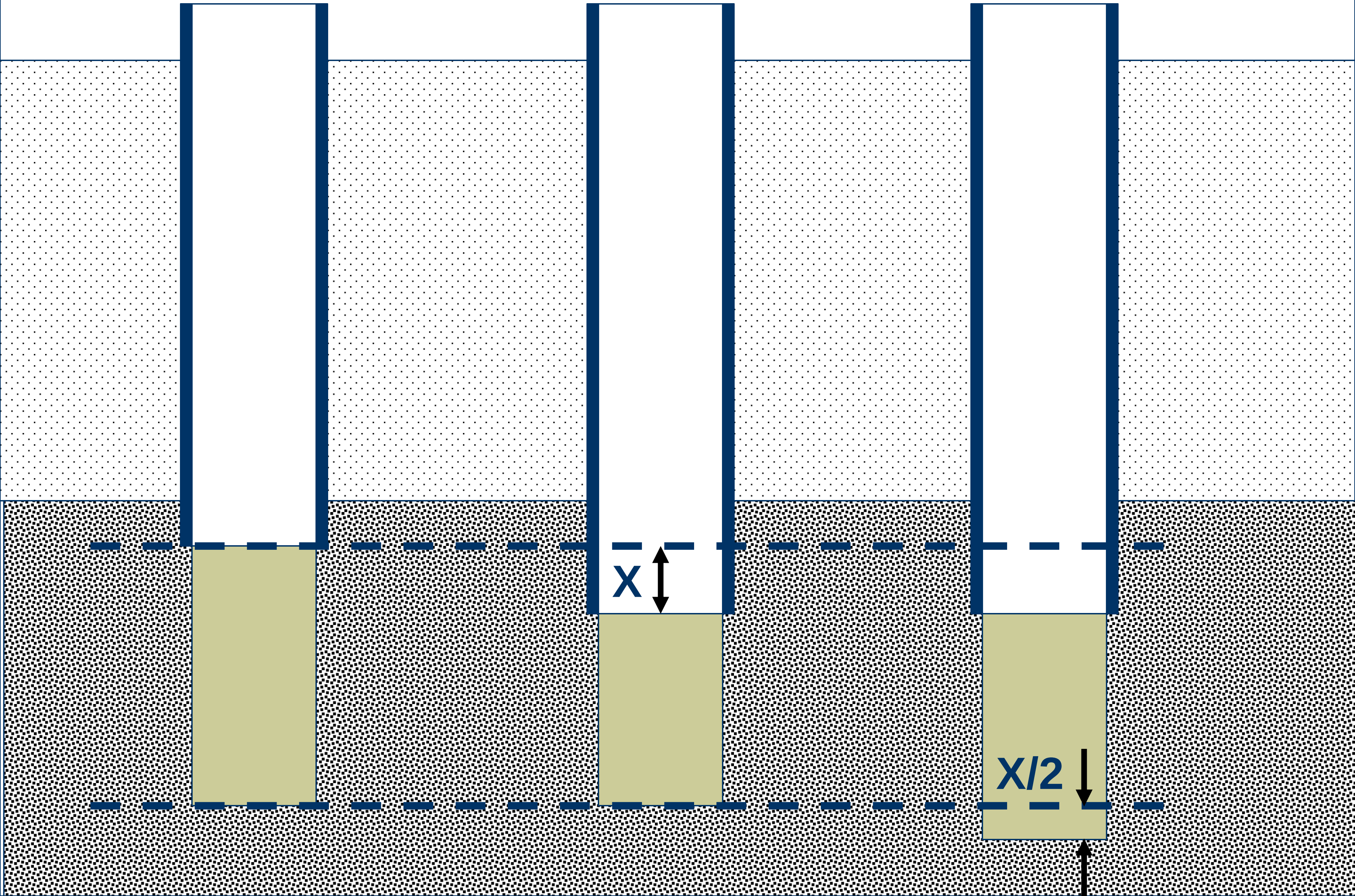
Quantify the effects of slurry exposure on side shear in wet construction

Study Motivation

455-15.7 Casings. Ensure casings are metal . . .

*. . . . **<u>If temporary casing is advanced deeper than</u>** the minimum top of rock socket elevation shown in the **<u>Plans</u>** or actual top of rock elevation is deeper, withdraw the casing from the rock socket and overream the shaft. If the temporary casing cannot be withdrawn from the rock socket before final cleaning, **<u>extend the length of rock socket</u>** below the authorized tip elevation one-half of the distance between the minimum top of rock socket elevation or actual elevation if deeper, and the temporary casing tip elevation.*

Design/anticipated Field/actual FDOT Spec



Quantifying the Effects

- How does temporary casing affect the resulting side shear?
- Does concrete flow out and form intimate bond with surrounding rock?

or

- Do residual fragments of crushed rock remain and get squeezed/trapped between outward flowing concrete?

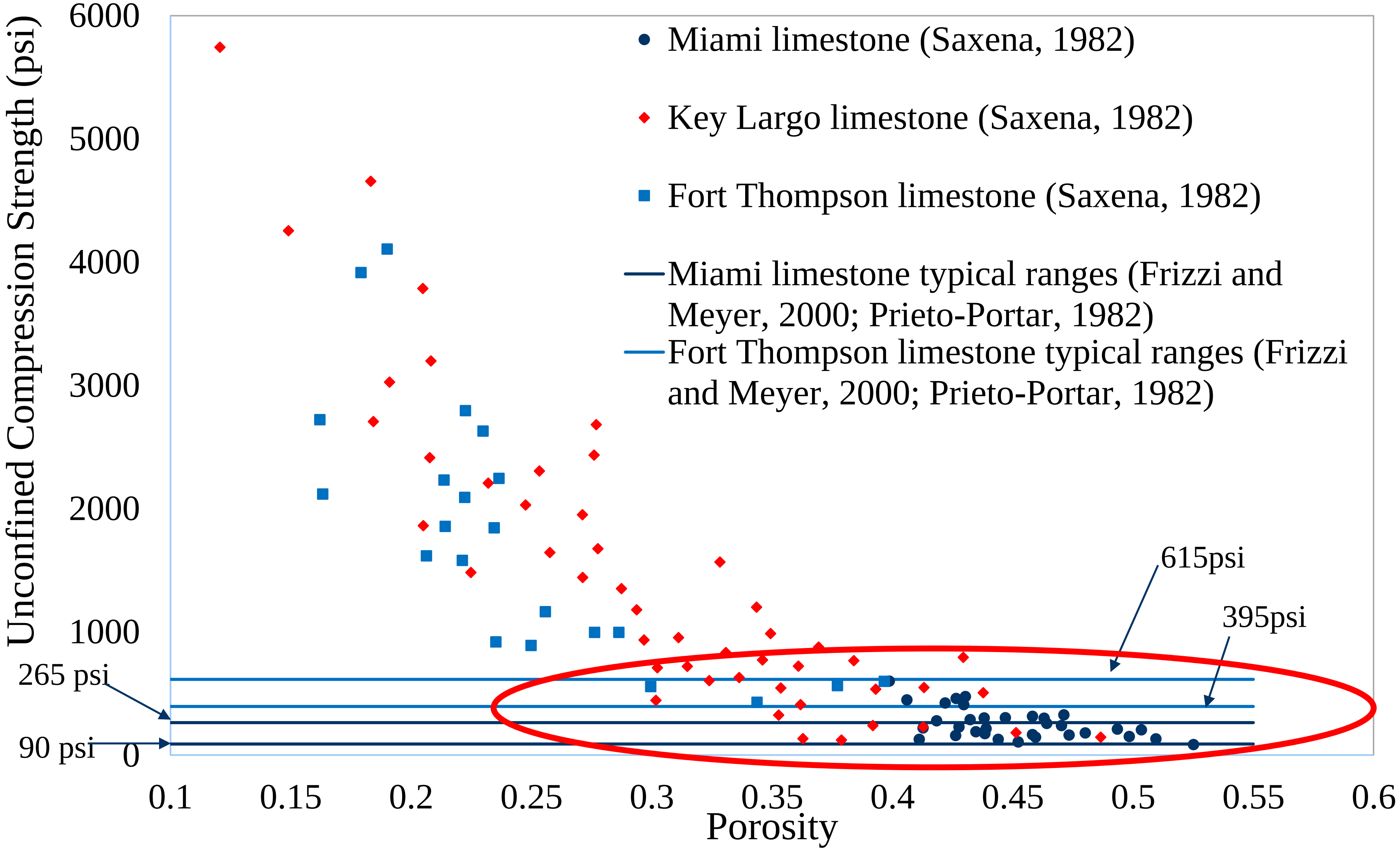
Research Approach

- Find / create simulated limestone parent material
- Construct rock socketed shafts
- Perform pull out tests
- Evaluate results

- Small scale and full scale test program

Target Limestone Strength

100psi – 600psi (SPT-N<60)



Develop Simulated Limestone (small-scale)

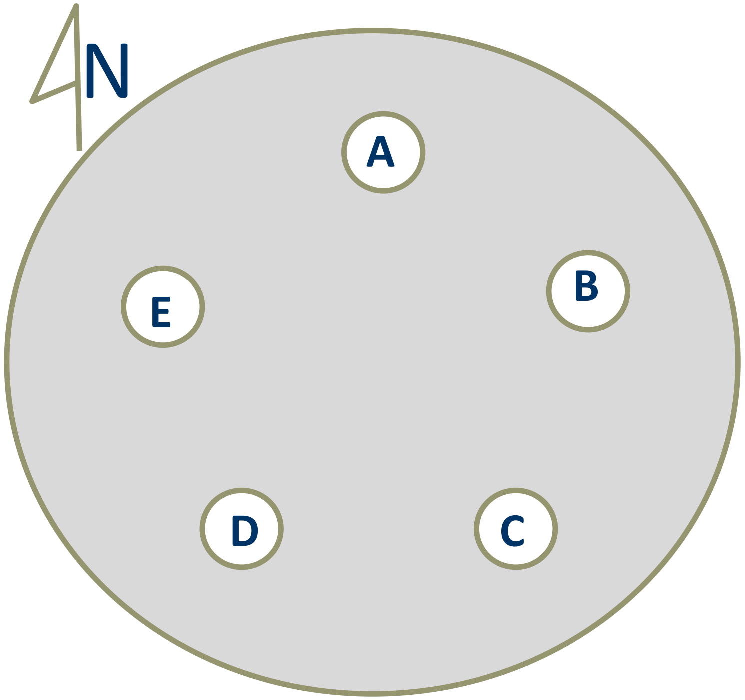
- Target UCS 60 psi – 800 psi
- Porous texture
- Mixing materials
  - Cement (0-800pcy)
  - Lime (100-500pcy)
  - Sand
  - Coquina and Oyster shells (increased porosity)
- Over 200 UCS tests

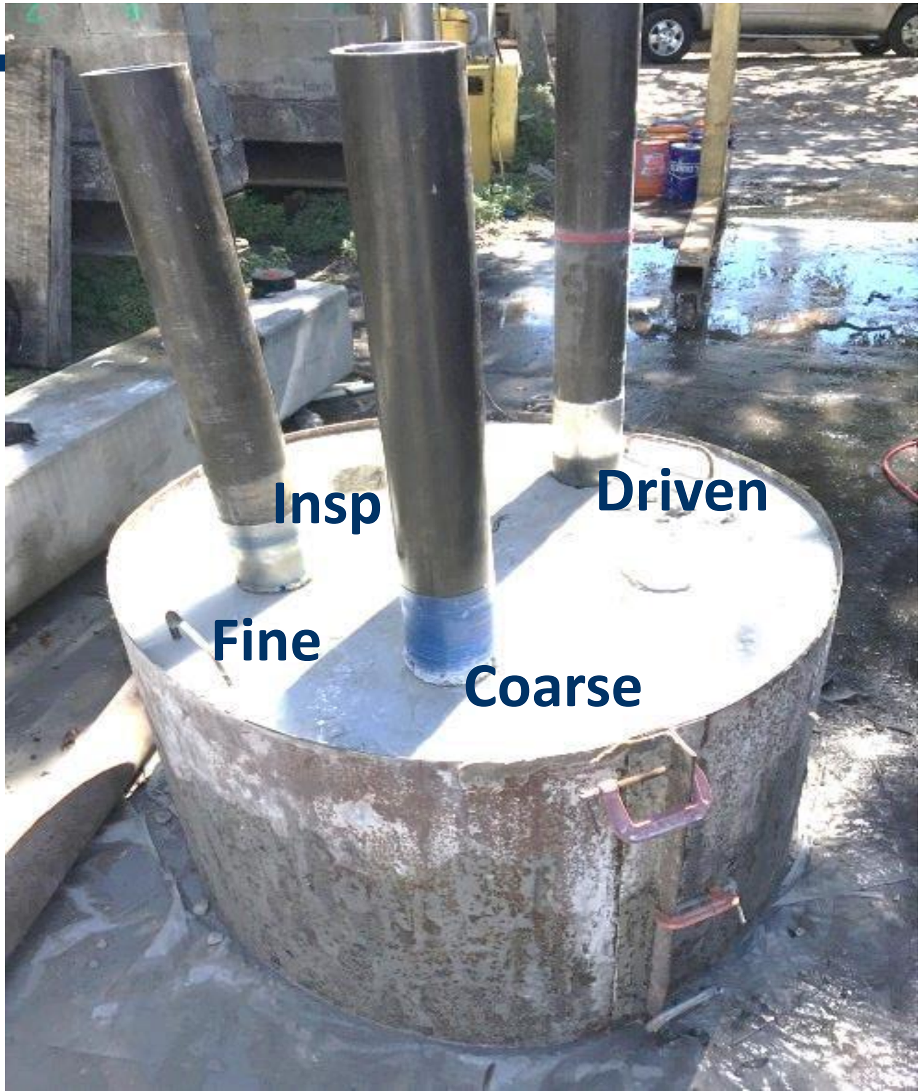
Cast Test Beds

- 6 simulated limestone beds cast
- 42 in. diameter, 23 in. tall.
- UCS 60-850psi
- Cement Content 170 – 680 pcy (1 – 4bags)
- Cement / Lime =1
- w/c 1.6 - 3

Simulated Limestone Beds

Small Scale Tests





Casing Types

Coarse-tooth

Large annulus

Fine-tooth

Small annulus

Driving Shoe

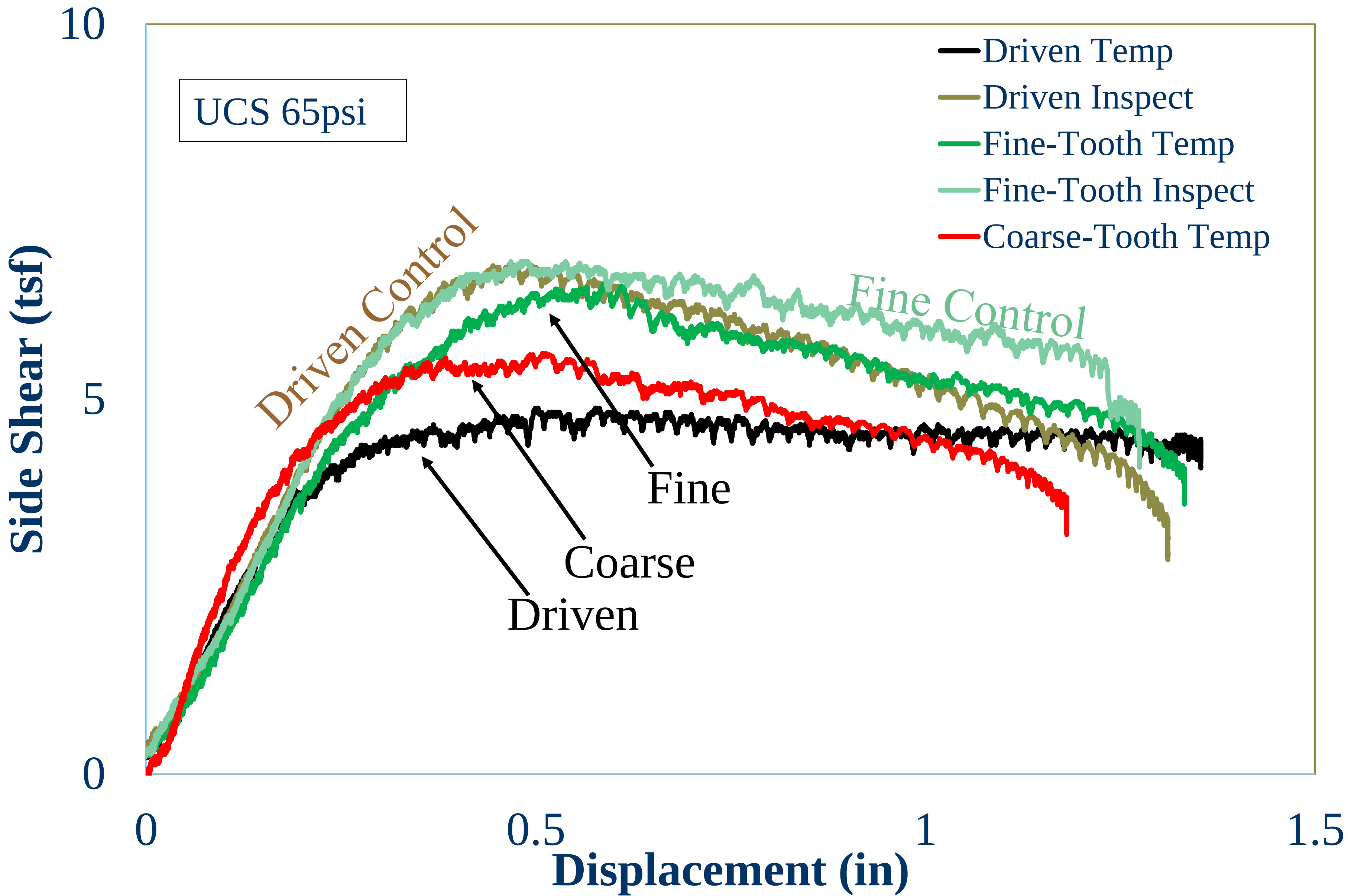
No annulus

Small Scale Test Matrix

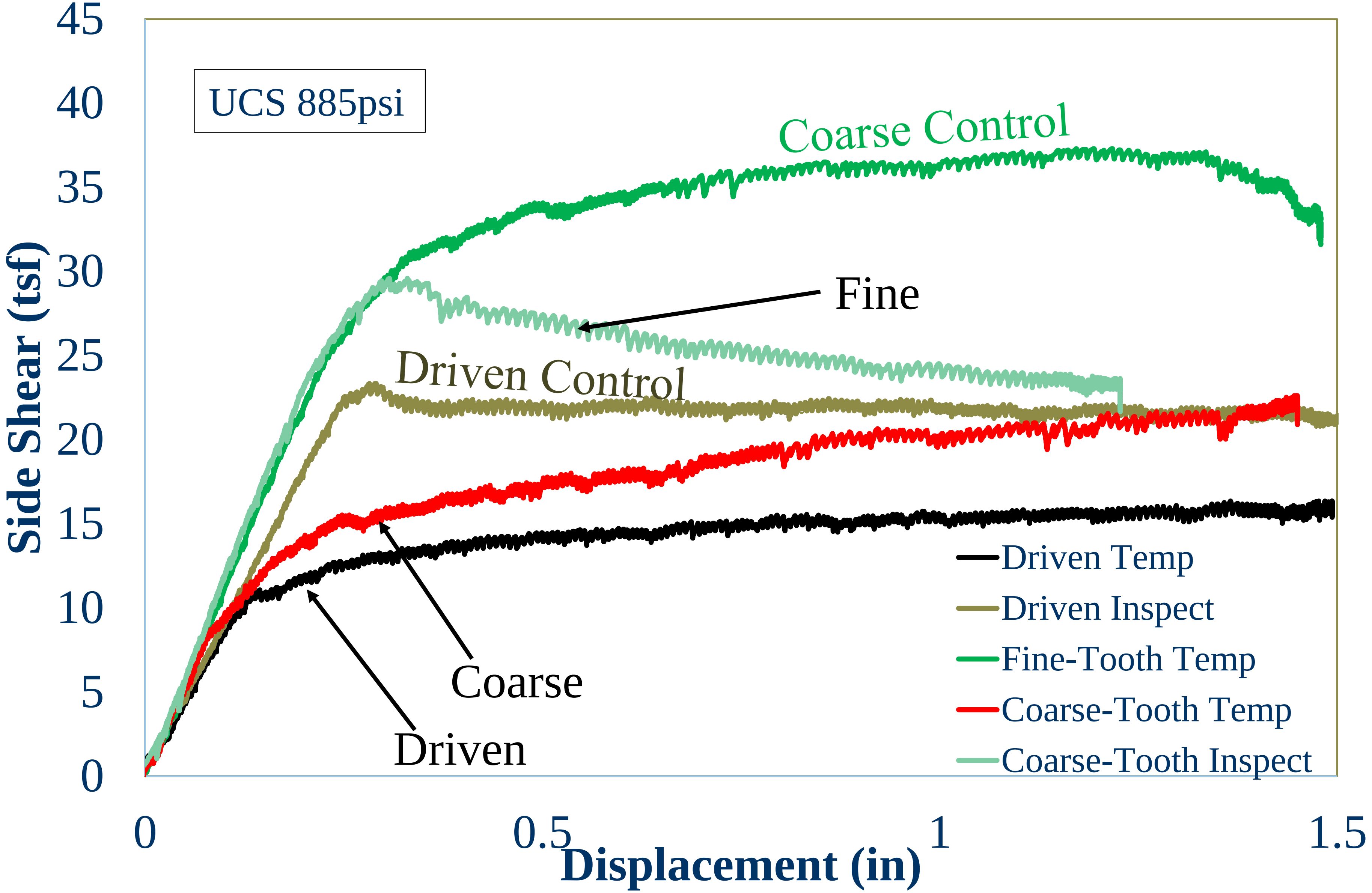
Bed I.D.	Specimen Position I.D.				
	A	B	C	D	E
1 (502.78 psi)	Coarse	Fine	**Fine (insp)**	Driven	**Driven (insp)**
2 (885.02 psi)	Coarse	Fine	Driven	**Driven (insp)**	**Coarse (insp)**
3 (487.42 psi)	Coarse	Fine	Abandoned	Driven	**Driven (insp)**
4 (64.78 psi)	Coarse	Fine	**Fine (insp)**	Driven	**Driven (insp)**
5 (163.40 psi)	Coarse	Fine	Driven	**Driven (insp)**	**Coarse (insp)**
6 (685.6 psi)	Coarse	Fine	**Fine (insp)**	Driven	**Driven (insp)**

Pullout Tests

Results (low strength limestone)



Results (higher strength limestone)



Temporary / Control Ratio

Bed ID	Casing Type	Ultimate Stress Ratio	Residual Stress Ratio
Bed 1	Driven Casing	0.67	0.49
	Fine-Tooth Casing	0.69	0.54
Bed 2	Driven Casing	0.65	0.55
	Coarse-Tooth Casing	0.56	0.53
Bed 3	Driven Casing	0.70	0.59
Bed 4	Driven Casing	0.69	0.66
	Fine-Tooth Casing	0.95	0.72
Bed 5	Driven Casing	0.75	0.64
	Coarse-Tooth Casing	0.75	0.61
Bed 6	Driven Casing	0.86	0.82
	Fine-Tooth Casing	0.81	0.37

Small-Scale Average Stress Ratios

Casing Type	Ultimate Stress Ratio	Avg Stress Ratio
Driven	0.67	0.72
	0.70	
	0.65	
	0.69	
	0.75	
	0.86	
Fine	0.69	0.82
	0.95	
	0.81	
Coarse	0.75	0.65
	0.56	

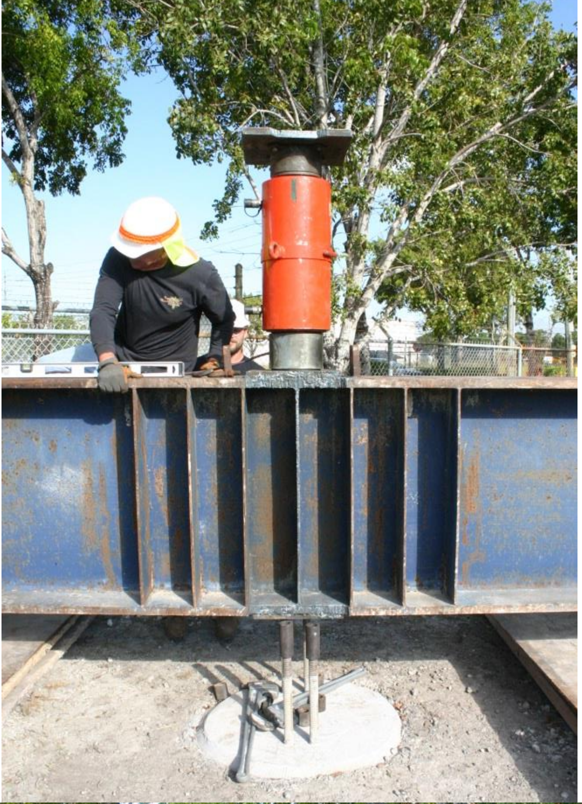
Full-scale Tests

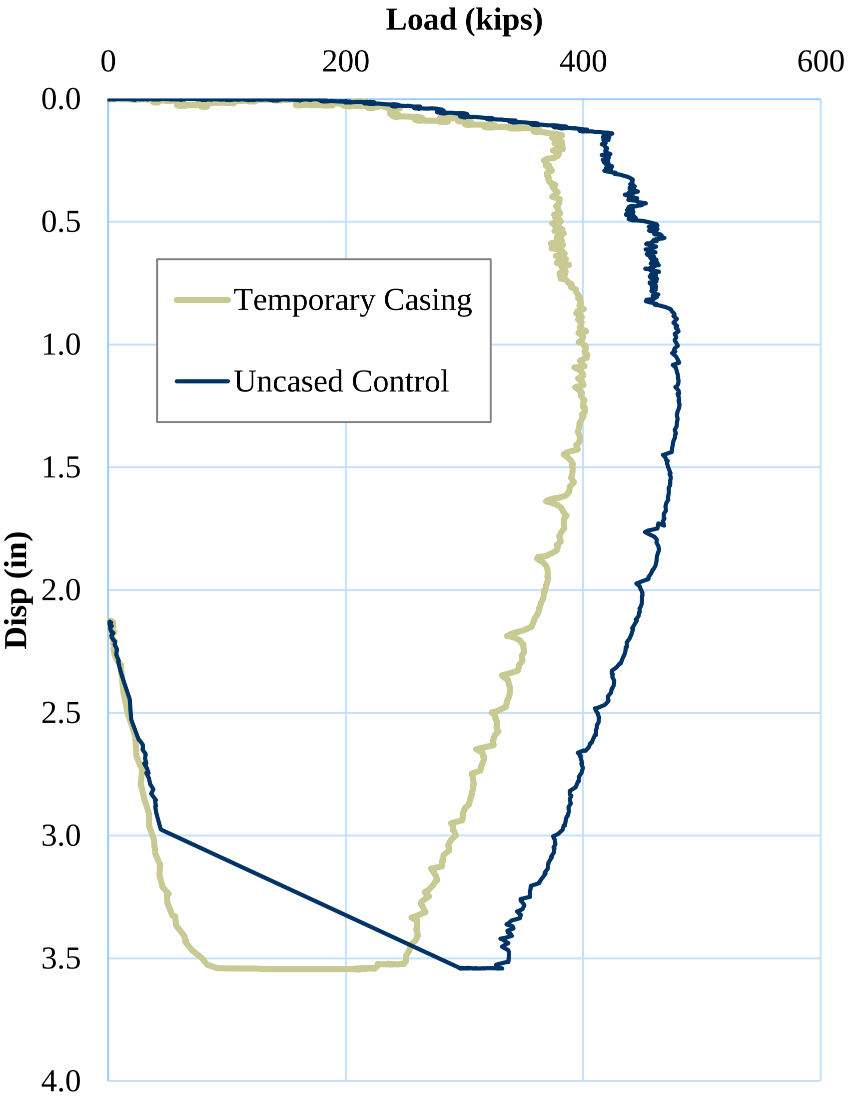
24in diameter
10ft long rock socket
Cast in Miami
Weathered limestone at surface

Control
(no casing)

Temporary
casing

Full Scale
Cased/uncased stress ratio = 0.83





Conclusions

- Temporary casing can affect side shear in rock sockets
- Small annulus rotated casing had least effect
- Driven casing with no annulus caused damage making it more affected
- Large annulus casing was most affected.
- Present specification reducing side shear to 50% is reasonable, no specimen fell below that level.