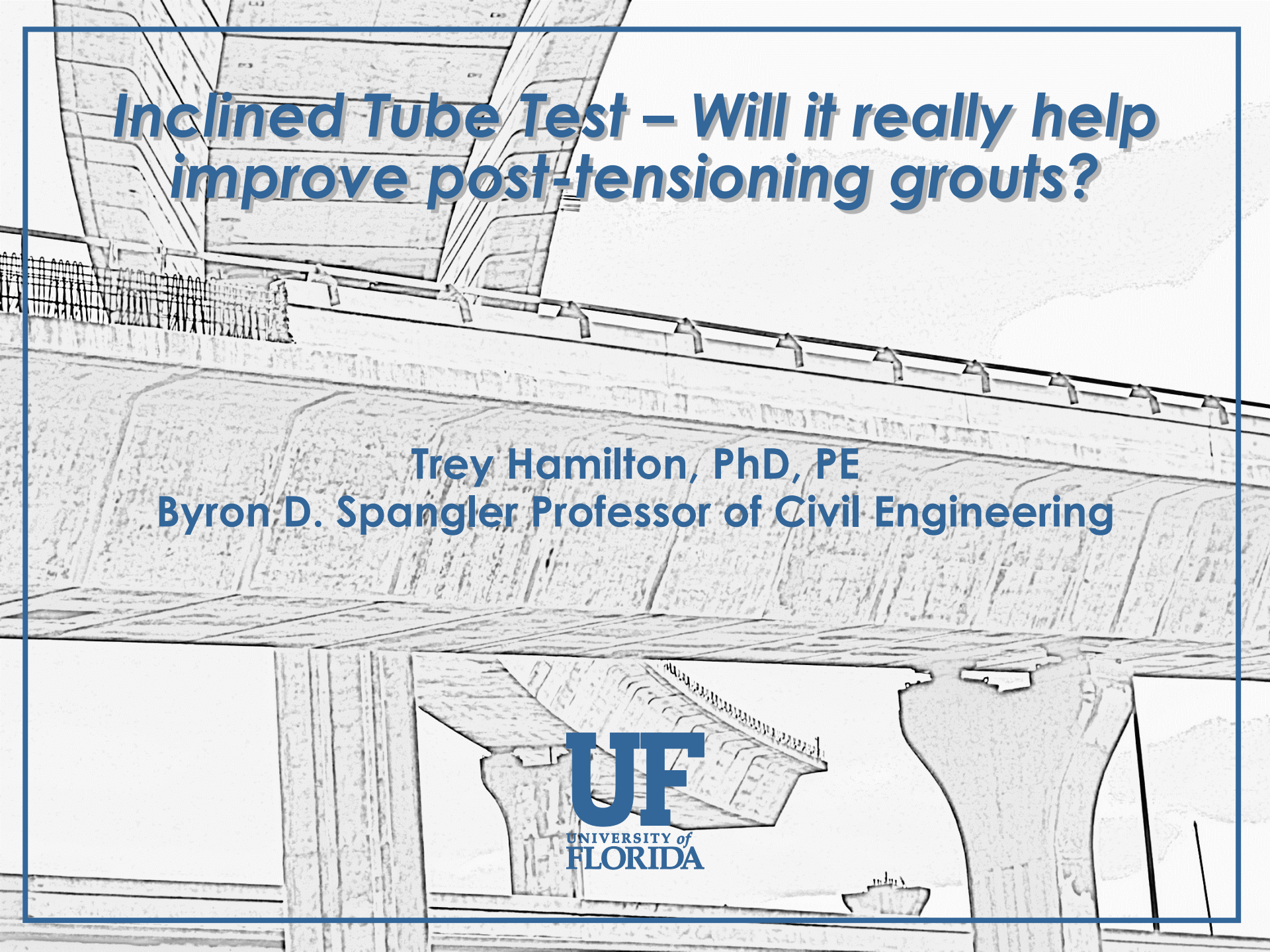
Inclined Tube Test – Will it really help improve post-tensioning grouts?



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Byron D. Spangler Professor of Civil Engineering

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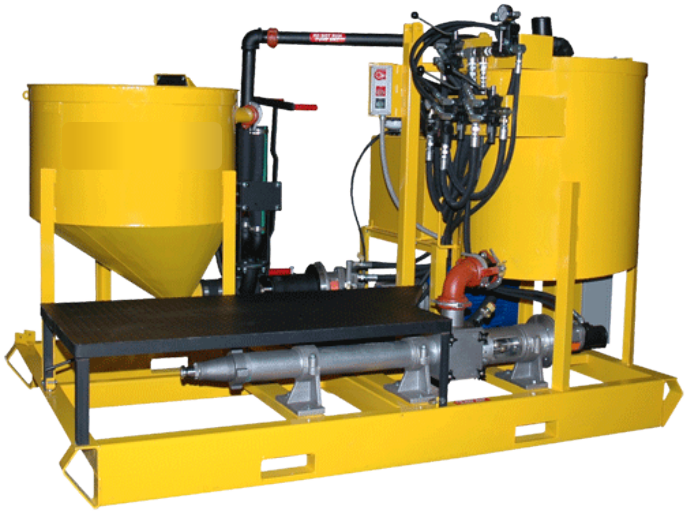
PT Grout

- Transfer post-tensioning force
- Strand protection



Grout Classification

- Class A-non-aggressive applications
- Class B-aggressive applications
- Class C-prepackaged grout for both
- Class D-specialized grouts

Prepackaged Grout Constituents

- Portland Cement (ASTM C150)
- Fly ash (ASTM C618, Class C and Class F)
- Slag cement (ASTM C989, Grade 120)
- Silica Fume (ASTM C1240)
- HRWR
- Other admixtures

Grout Performance Characteristics

Fresh

- Low viscosity to allow pumping and filling
- Bleed resistance
- Segregation resistance
- Minimum volume change

Hardened

- Duct filled solid with good grout
- Adequate compressive strength
- Low permeability
- High pH

Prepackaged Grout Laboratory Testing

- Chlorides (ASTM C1152) < 0.08% by weight of grout
- Set time (ASTM C953) 3 to 12 hours
- Compressive Strength (ASTM C942) 5000 psi at 28 days
- Permeability (ASTM C1202) <2500 coulombs (@ 30V)
- Volume change (ASTM C1090) 0.0% to +0.1% (at 24 hours)
- Pumpability and Fluidity (Modified flow cone ASTM C939)
- Bleed
  - ✓ Wick-induced (Modified C940 – 40 in. long x 3-in. diam.) 0.0%
  - ✓ Pressure Bleed Test (ASTM C1741) varies
- ACT Corrosion test (if required)
- Wet Density (mud balance)
- Inclined tube test (EN 445) 0.3% by volume allowed

*conducted at the min and max water dosage recommended

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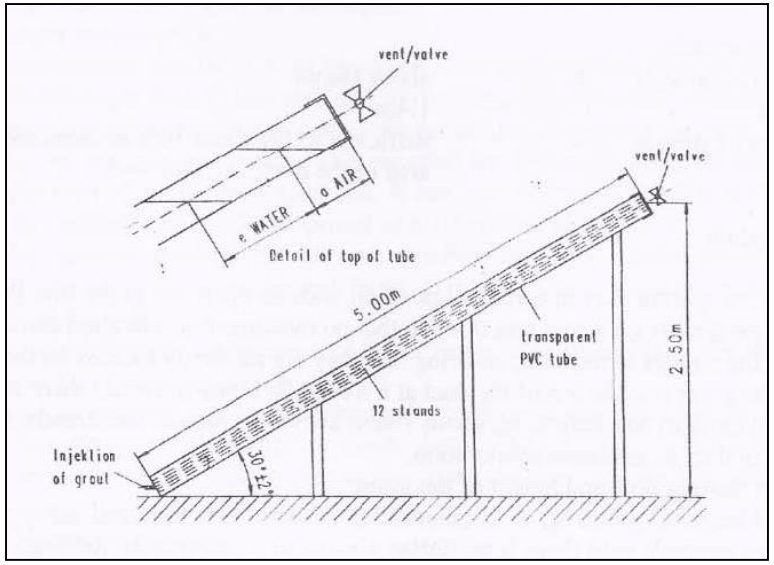
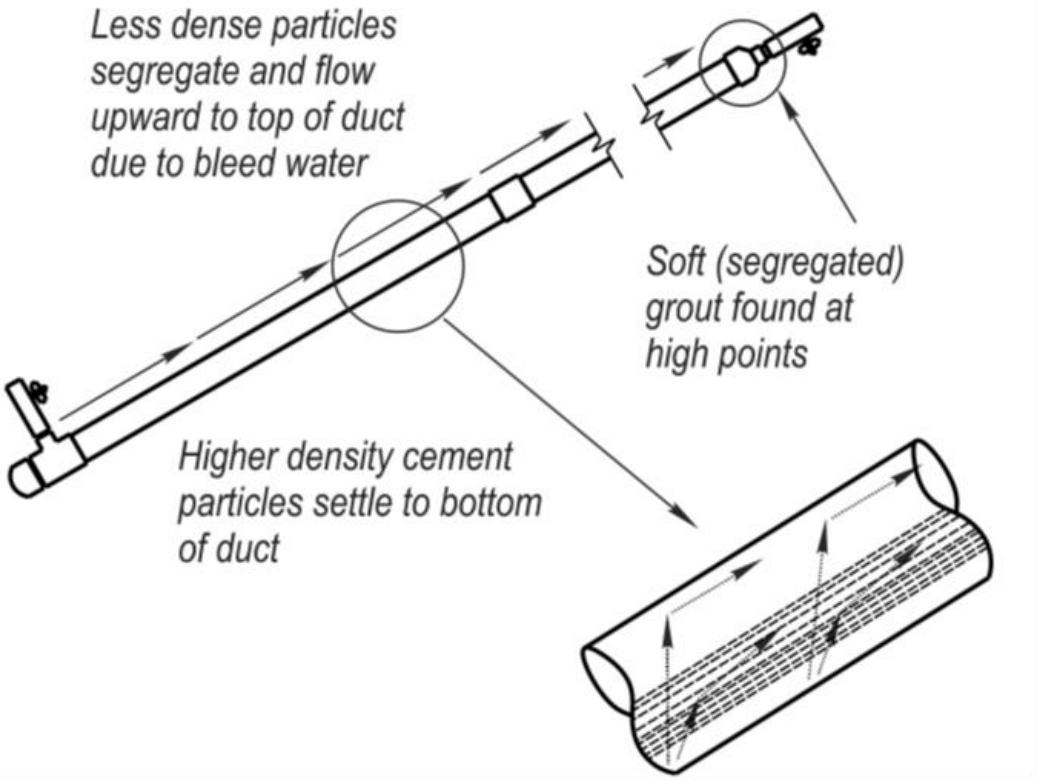
Inclined Tube Test

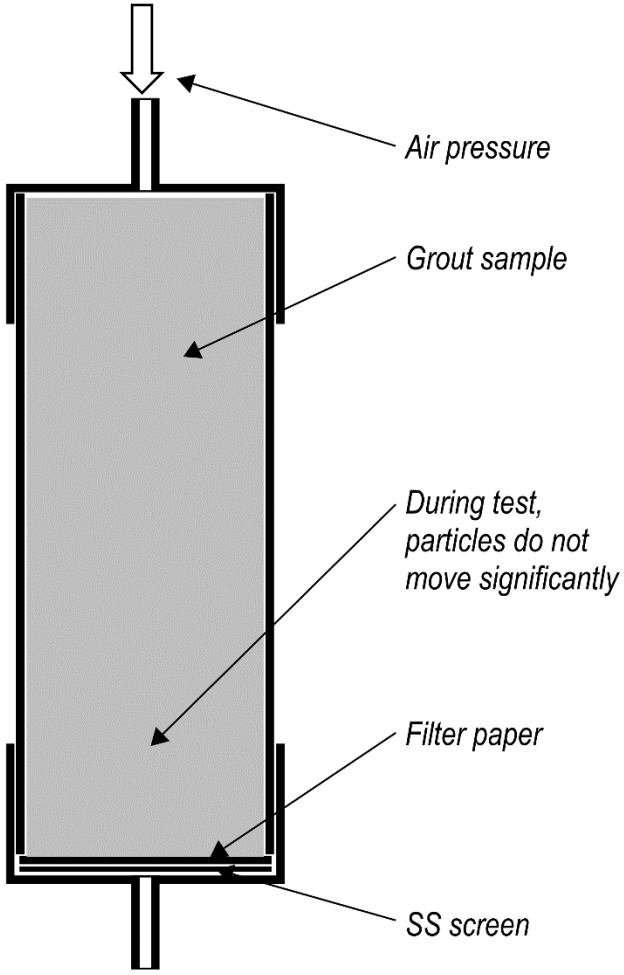


- Based on EN445
- Focus is "bleed and stability" of grout
- Two tubes are grouted to evaluate re-grouting
- Transparent tubes at ~80 mm dia. and 5 m long.
- 12 strands in each tube (15-16 mm)

"Bleed" test comparison



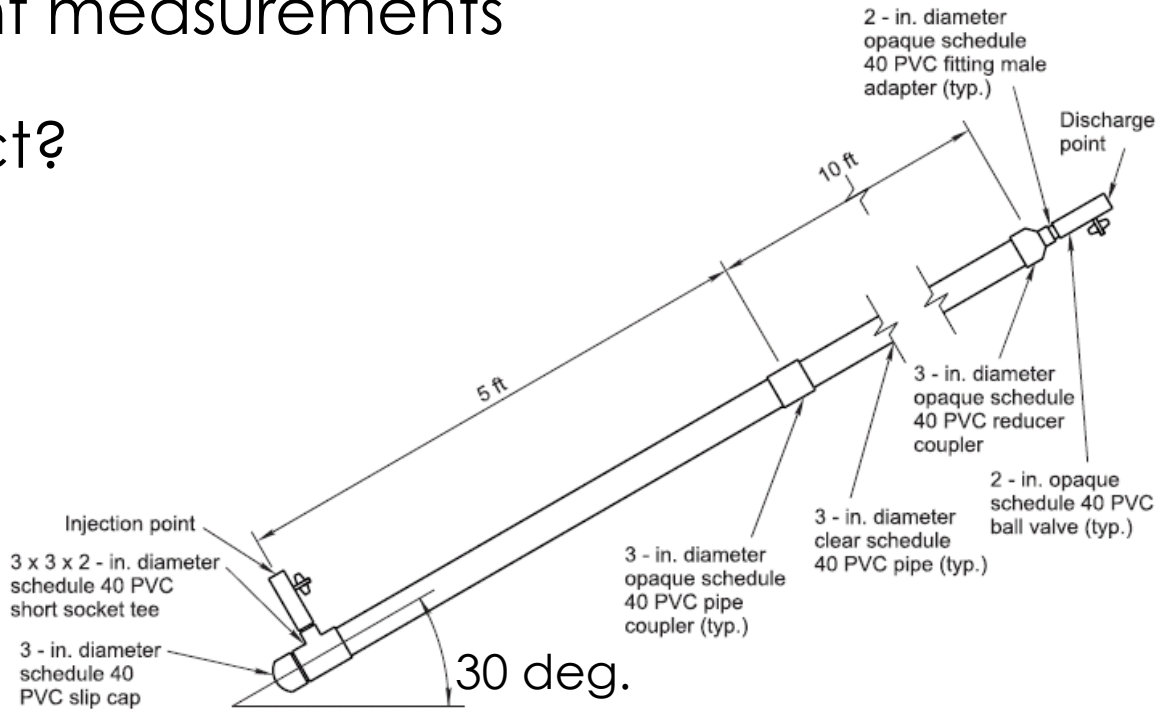
Inclined Test



Schupack Pressure Test

Modified Inclined Tube Test (MITT)

- Shortened strand bundle (ease grout sampling)
- Dissection of duct
- Moisture content measurements
- Transparent duct?

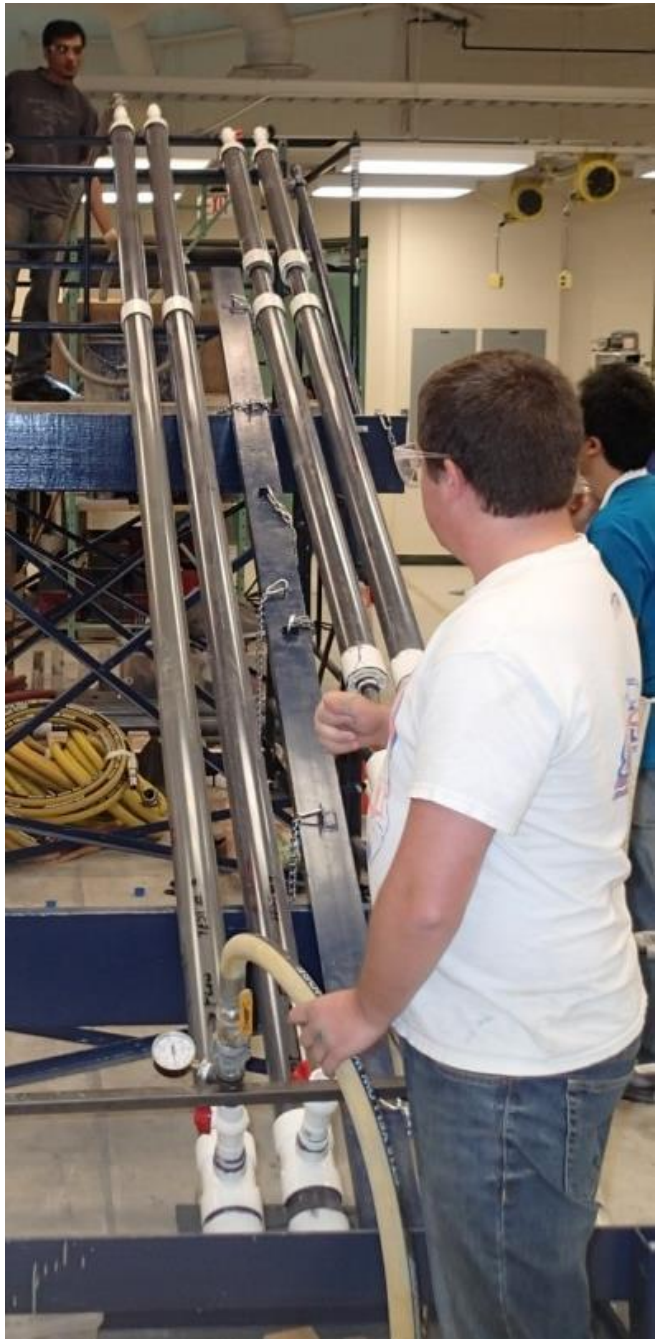


Grout Mixing

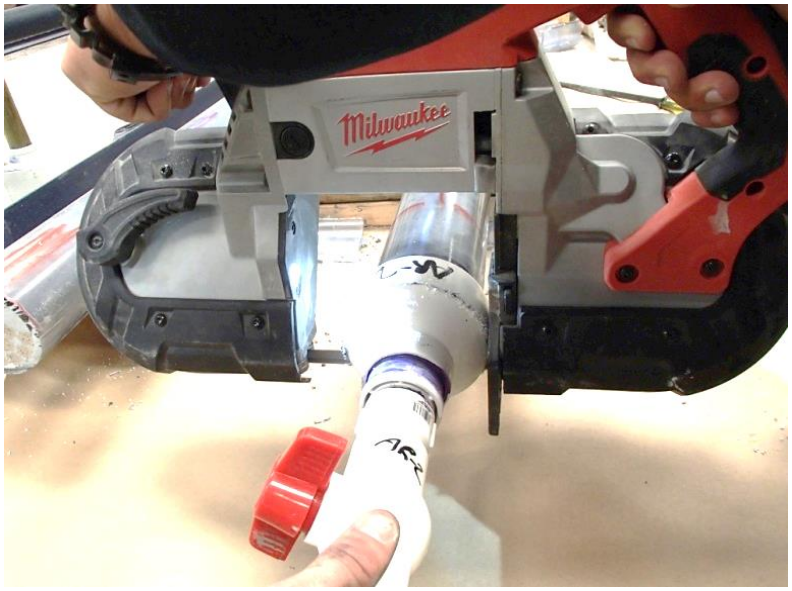
Used 4 bag mixes with colloidal plant

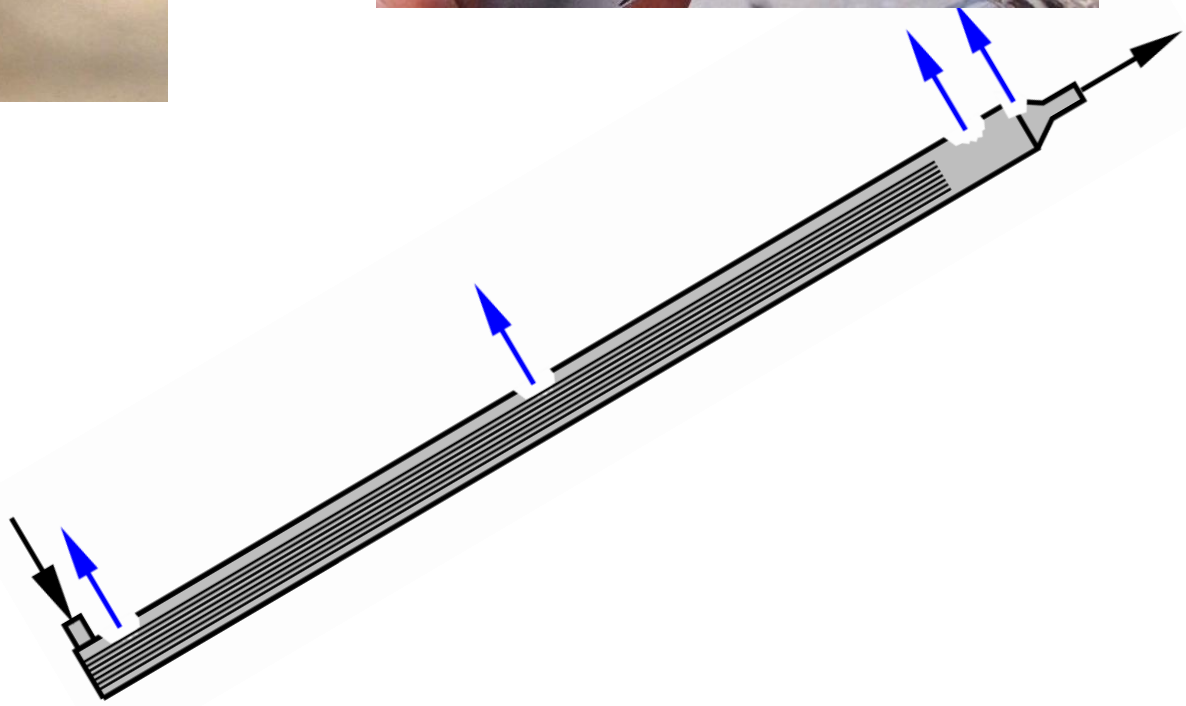
Fresh Properties

Grout Injection



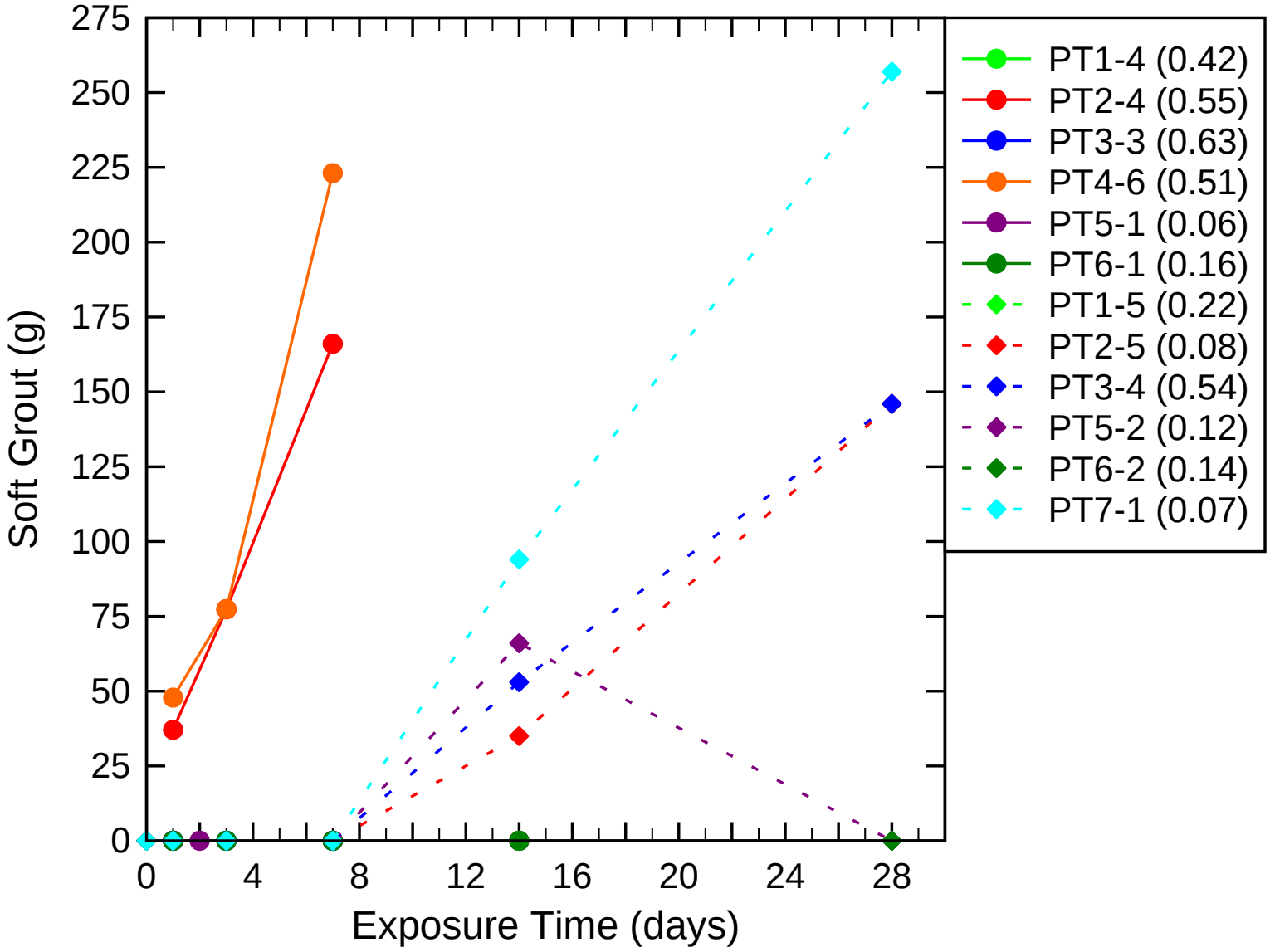
Sampling (24 Hours)



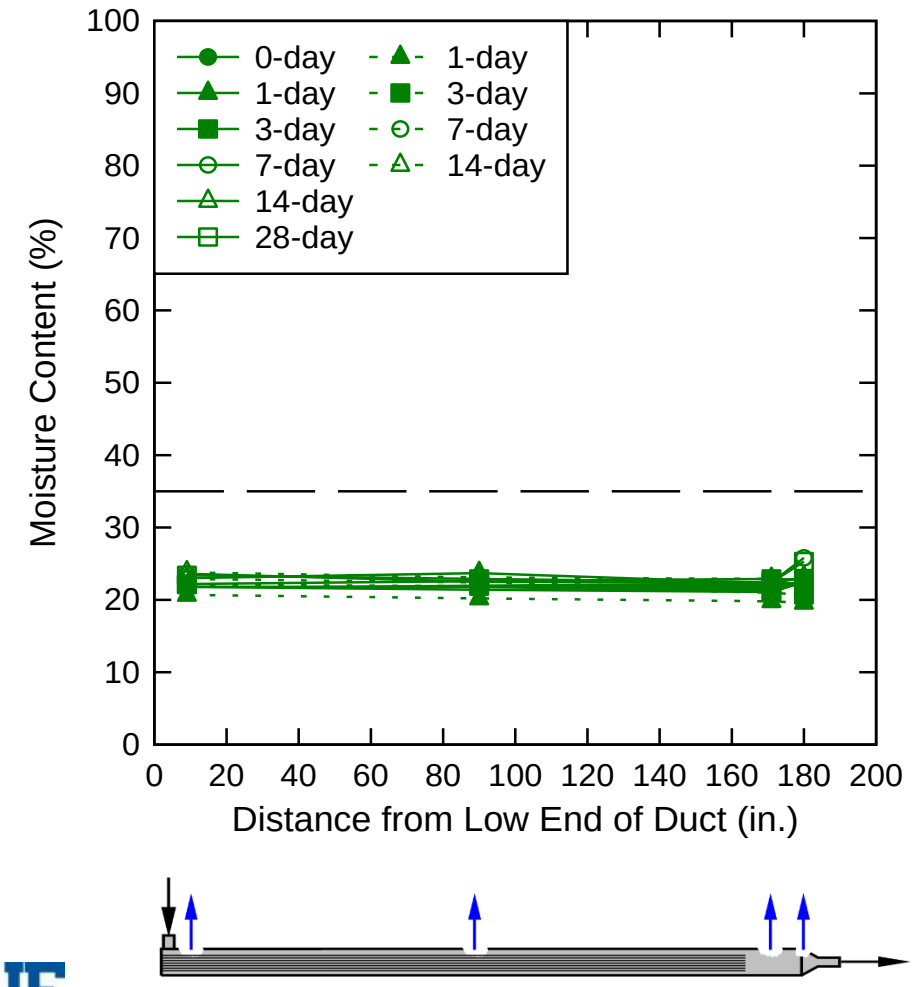


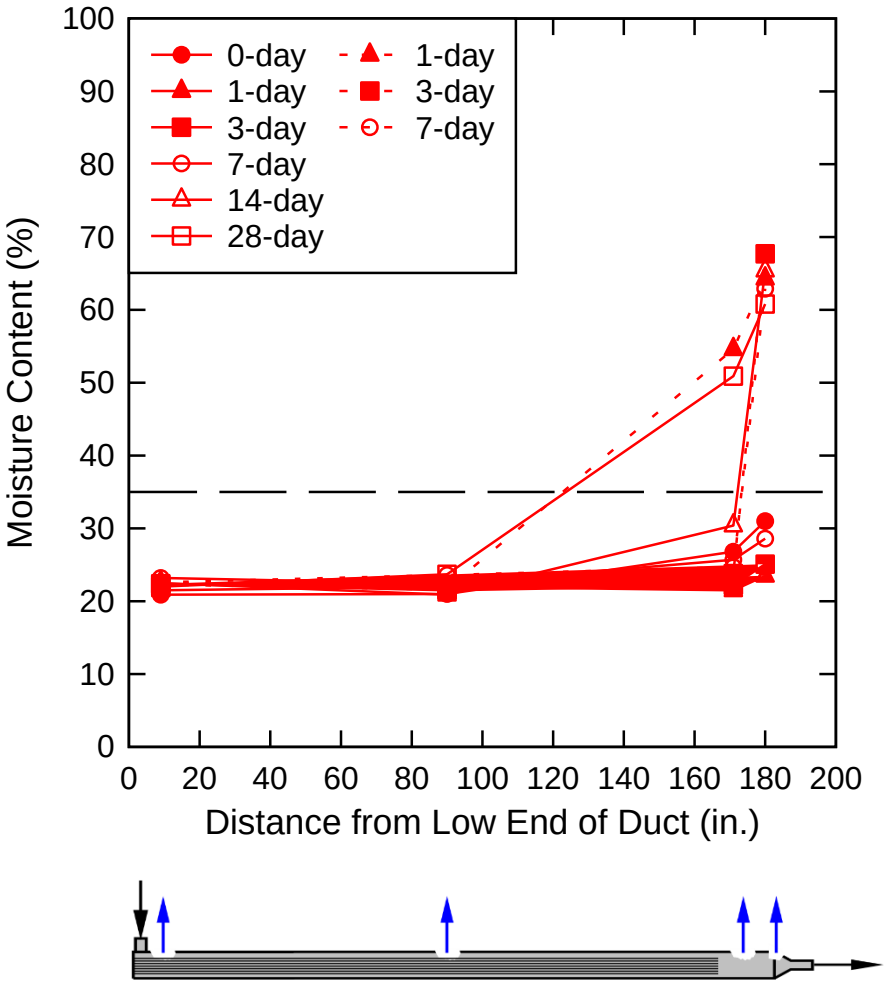
Moisture Content

Effect of aging-soft grout

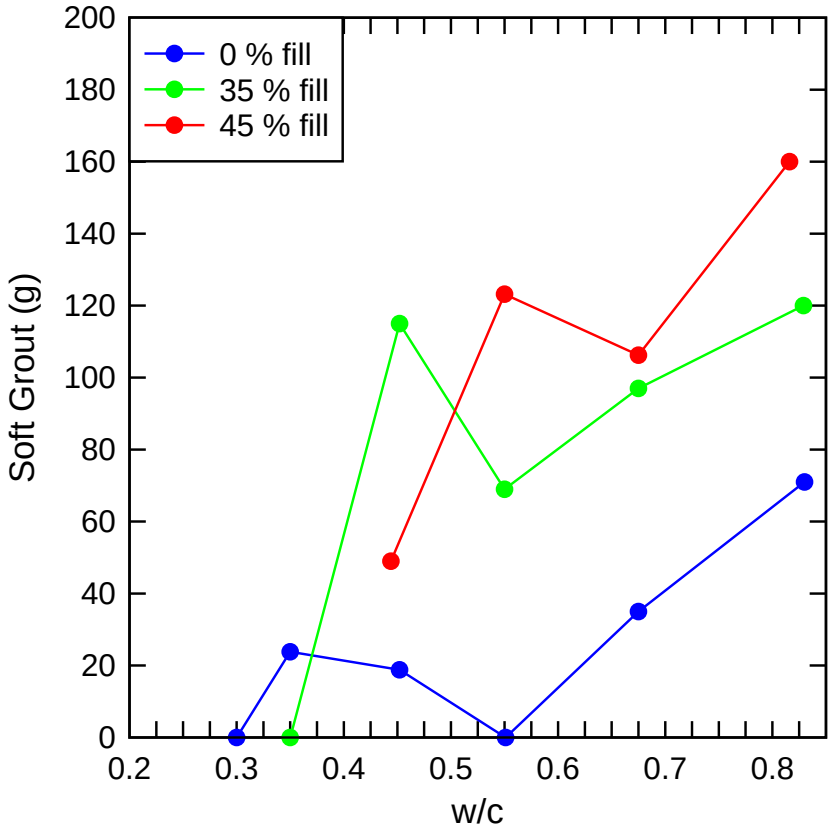


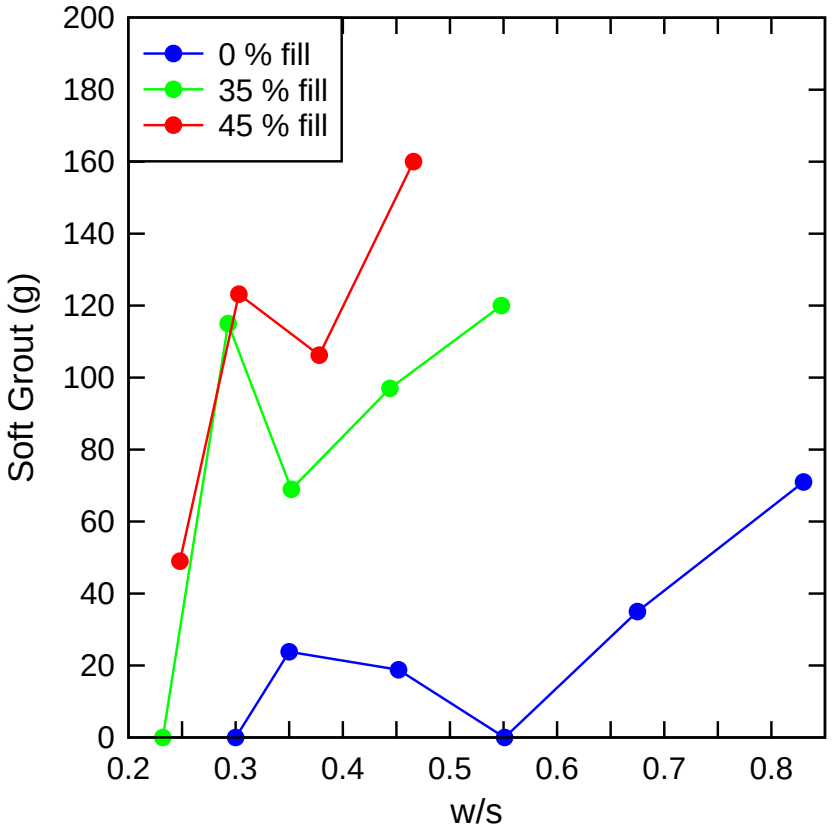
Effect of aging-moisture content



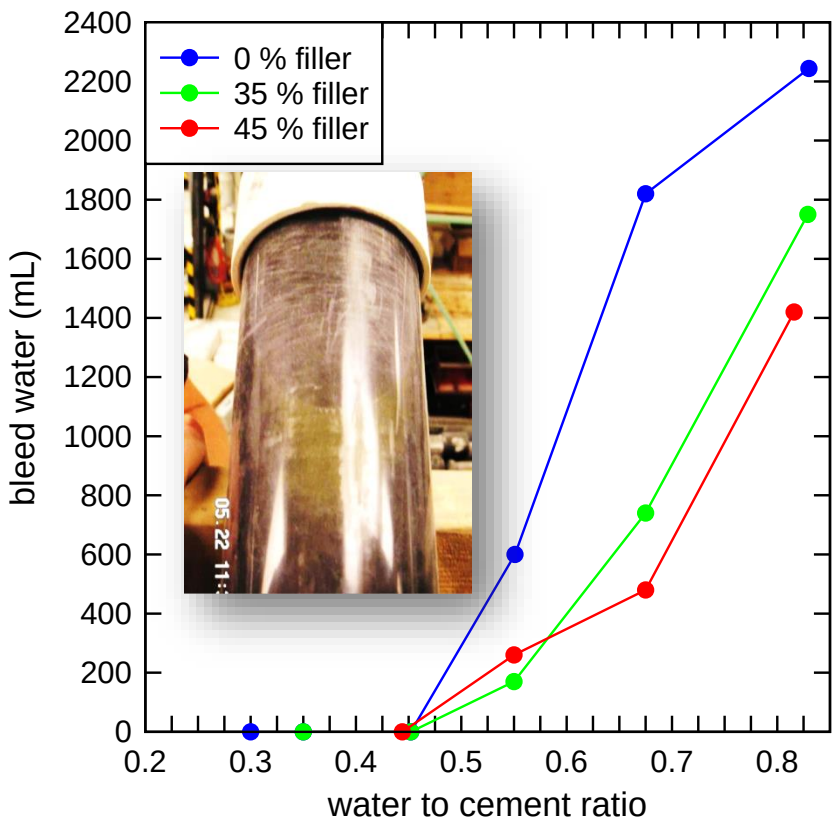


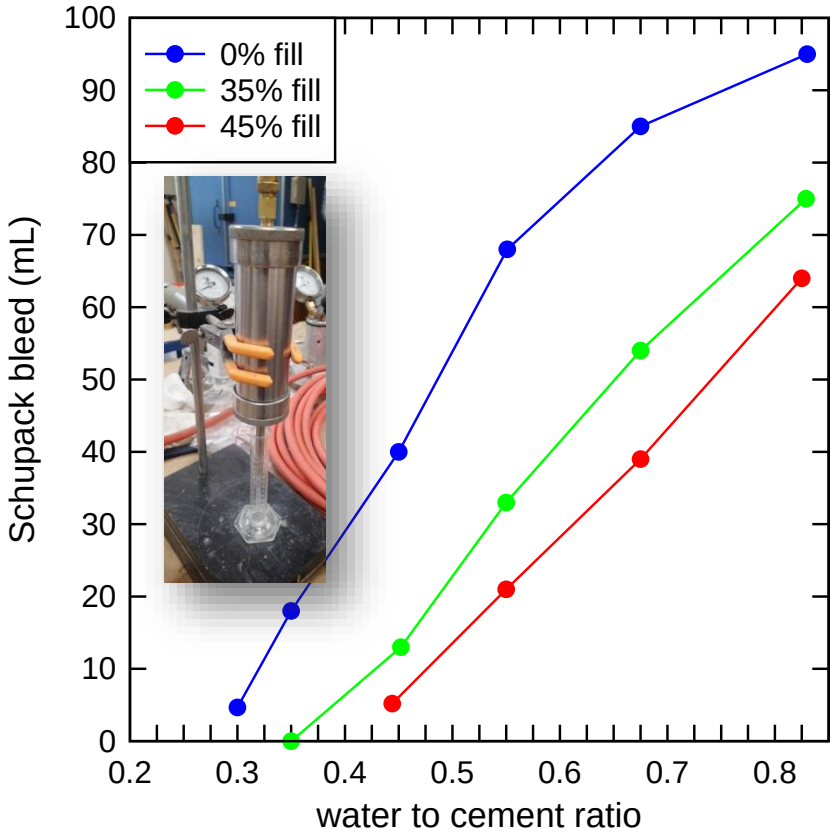
Filler and soft grout





Bleed

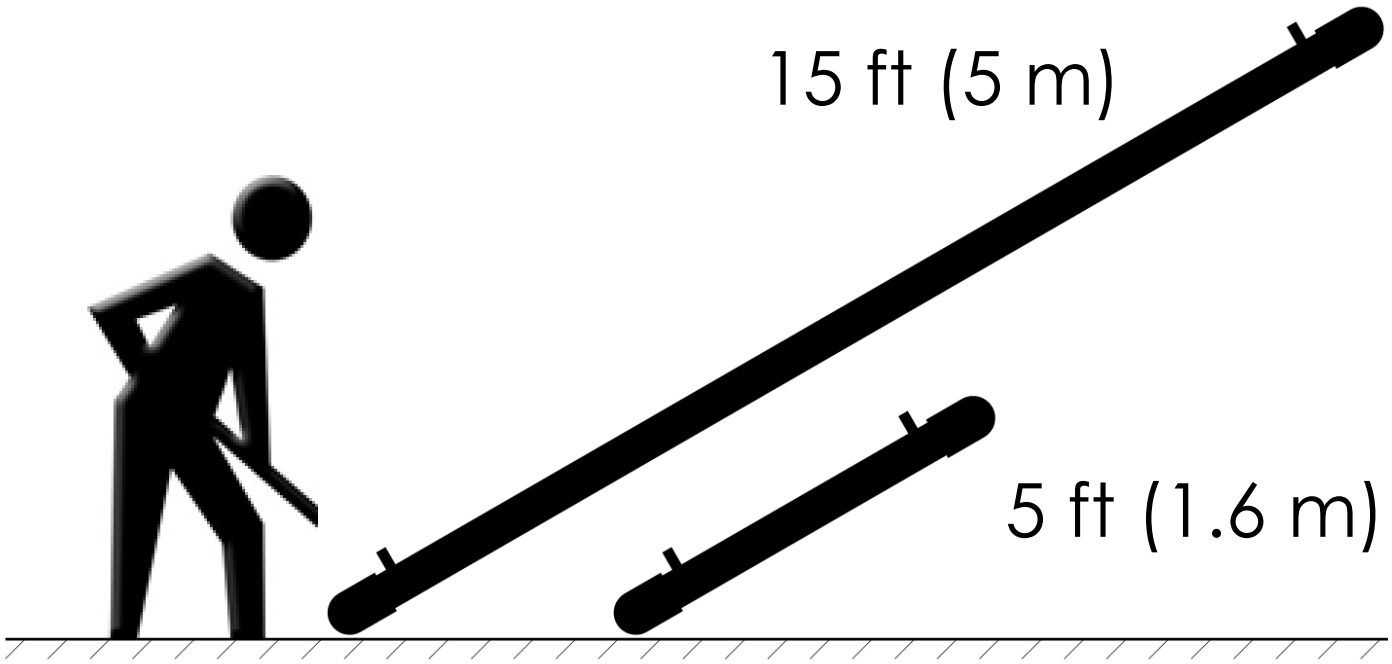

0 % filler
35 % filler
45 % filler
bleed water (mL)
water to cement ratio
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0.2
0.3
0.4
0.5
0.6
0.7
0.8


0% fill
35% fill
45% fill
Schupack bleed (mL)
water to cement ratio
100
90
80
70
60
50
40
30
20
10
0
0.2
0.3
0.4
0.5
0.6
0.7
0.8

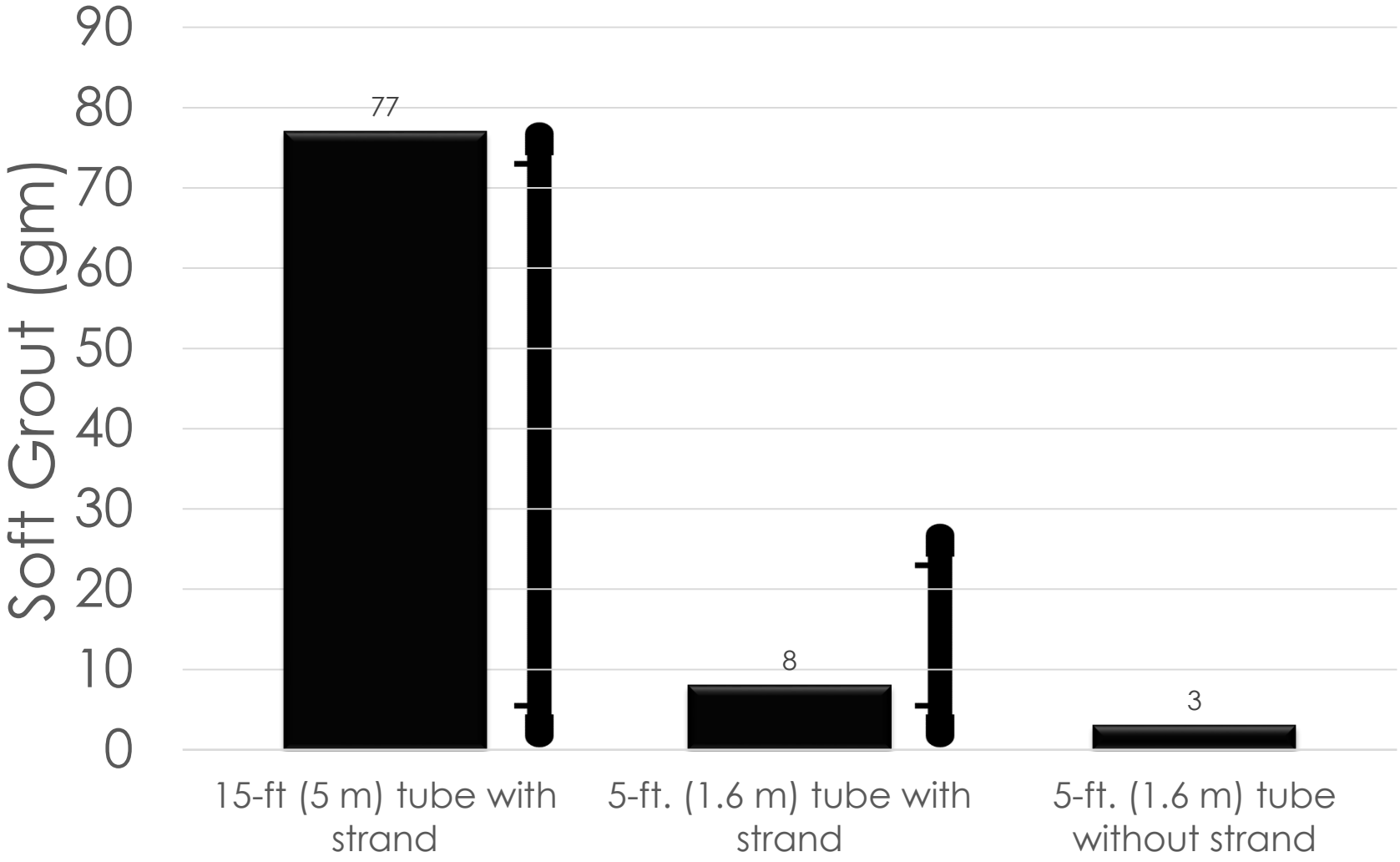
Modified Inclined Tube Test

- Test for bleed and segregation
- Effect of fillers/admixtures on segregation (benefit/risk)
- Effects of age on segregation (shelf life)
- Effect of excess water on segregation (robustness)

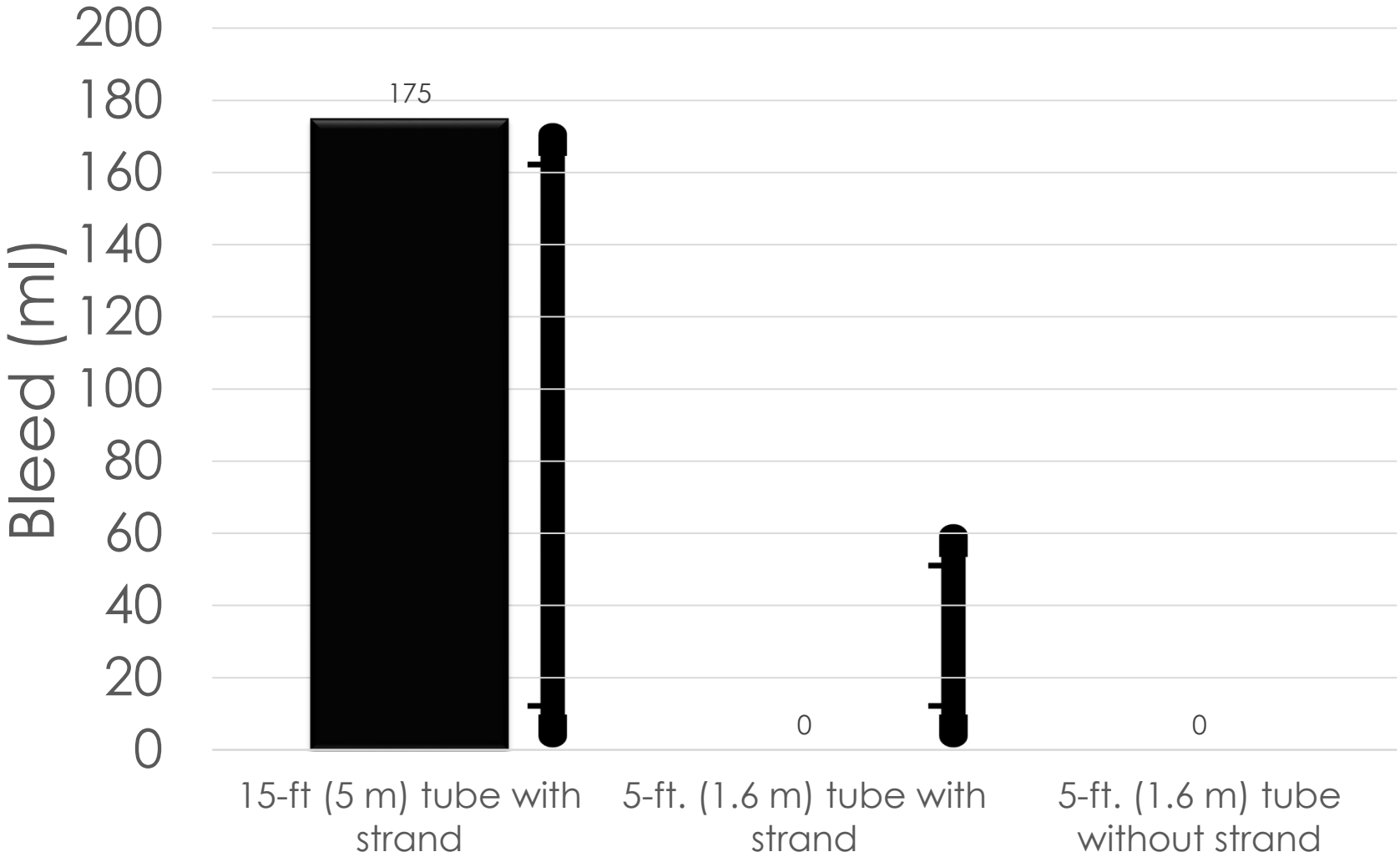
Can we get by with a shorter tube?



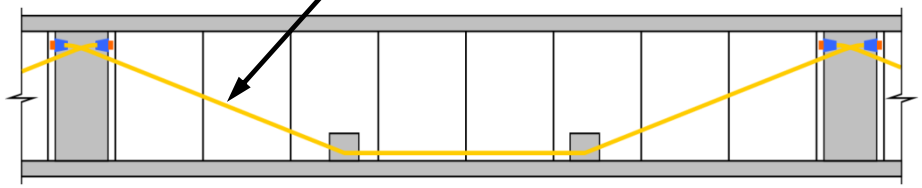
Soft Grout-Scaling issues?

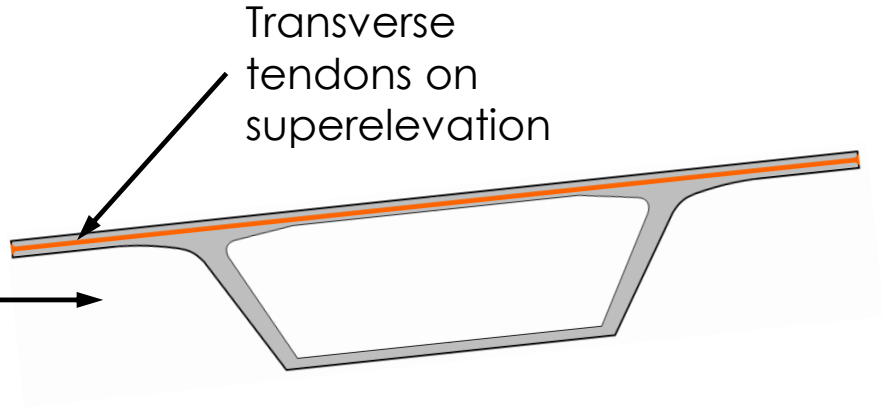


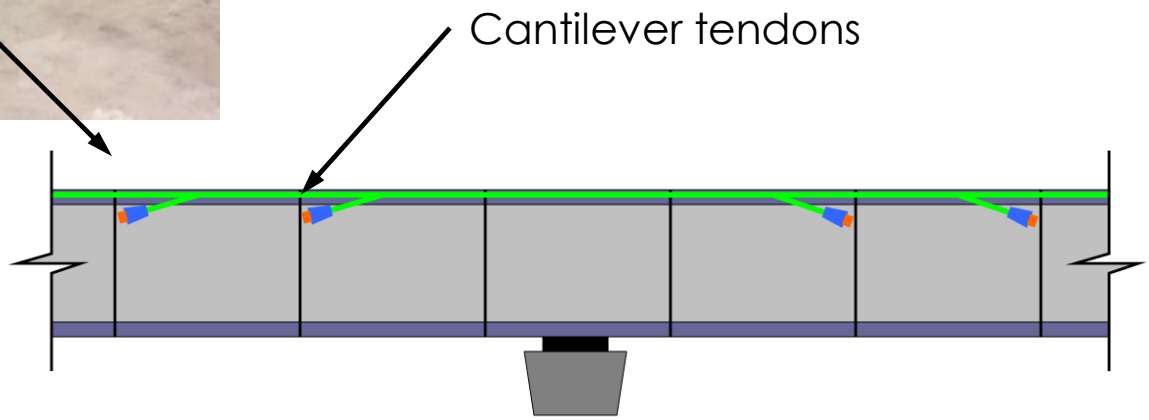
Bleed water


Bleed (ml)
200
180
160
140
120
100
80
60
40
20
0
175
0
0
15-ft (5 m) tube with strand
5-ft. (1.6 m) tube with strand
5-ft. (1.6 m) tube without strand

Is an incline necessary?







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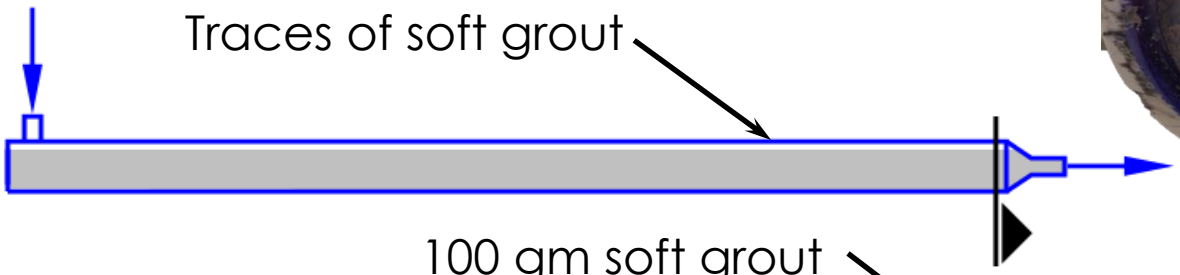

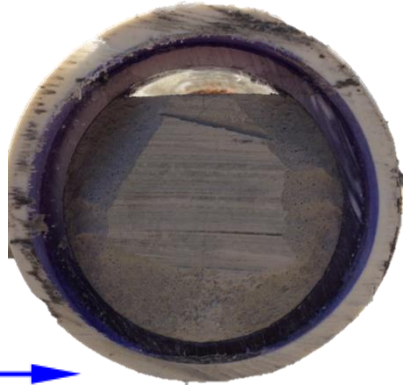

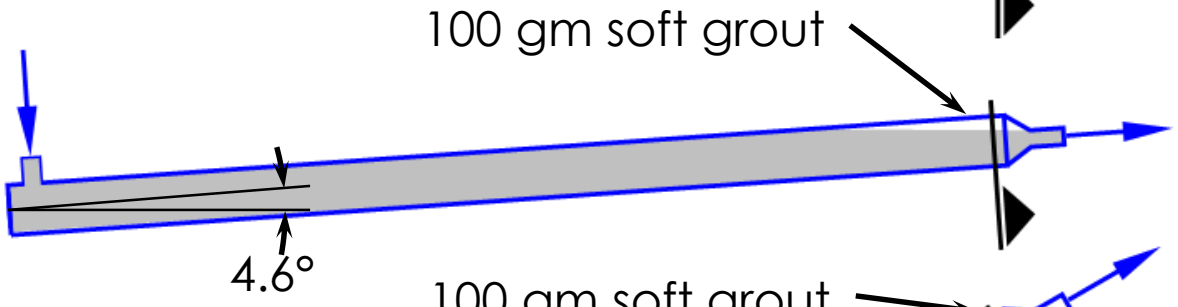

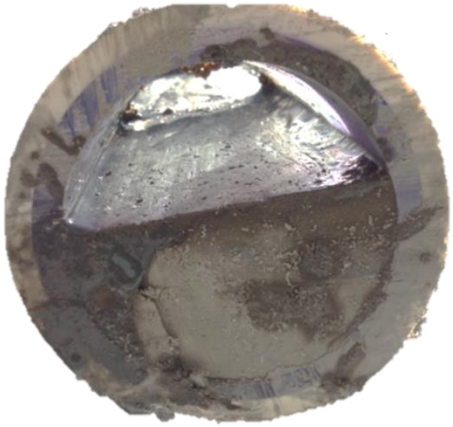

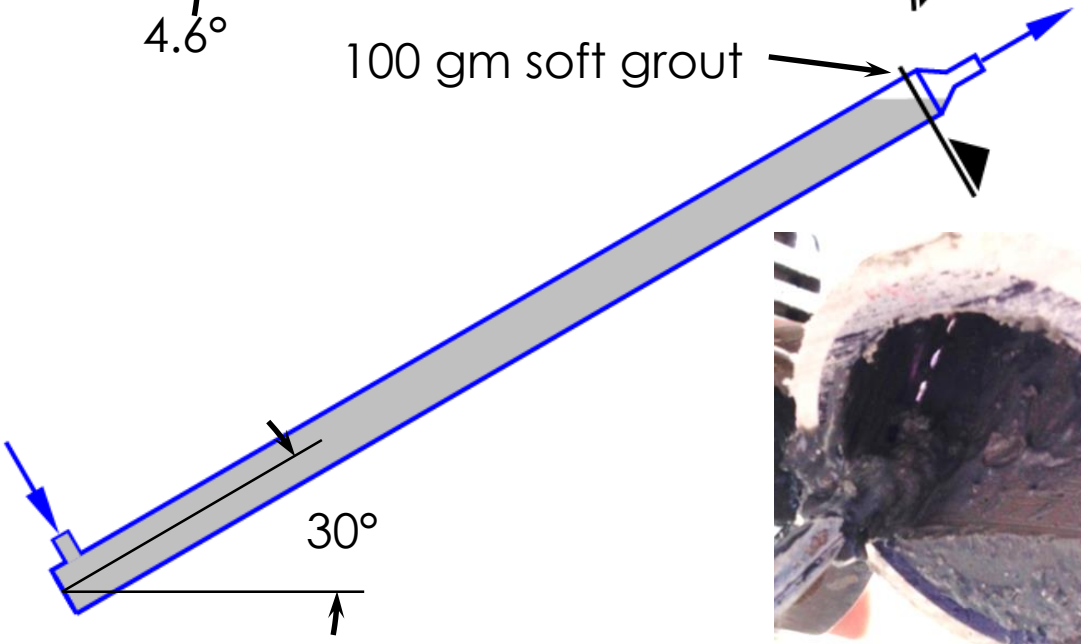

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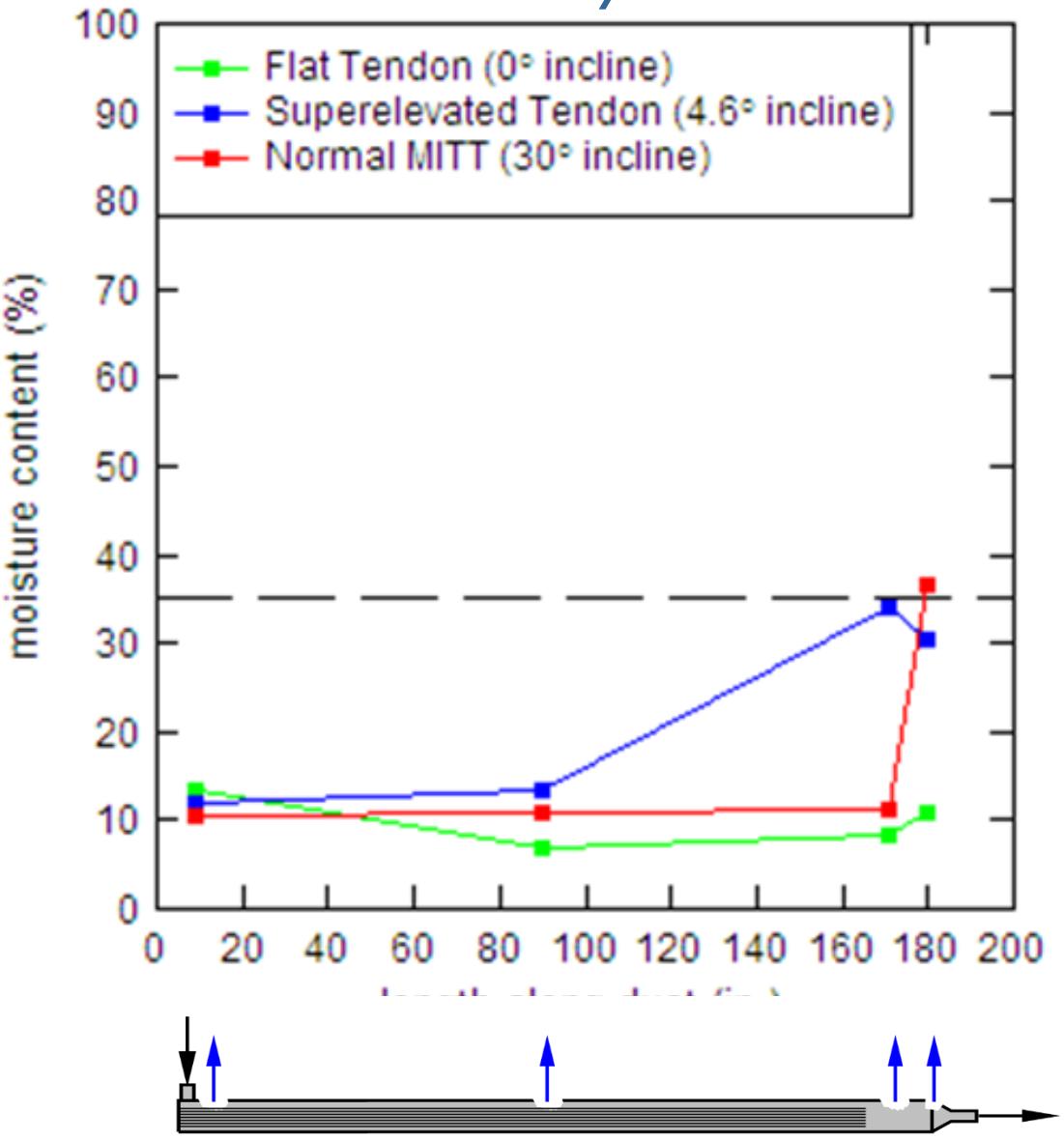

Is an incline necessary?

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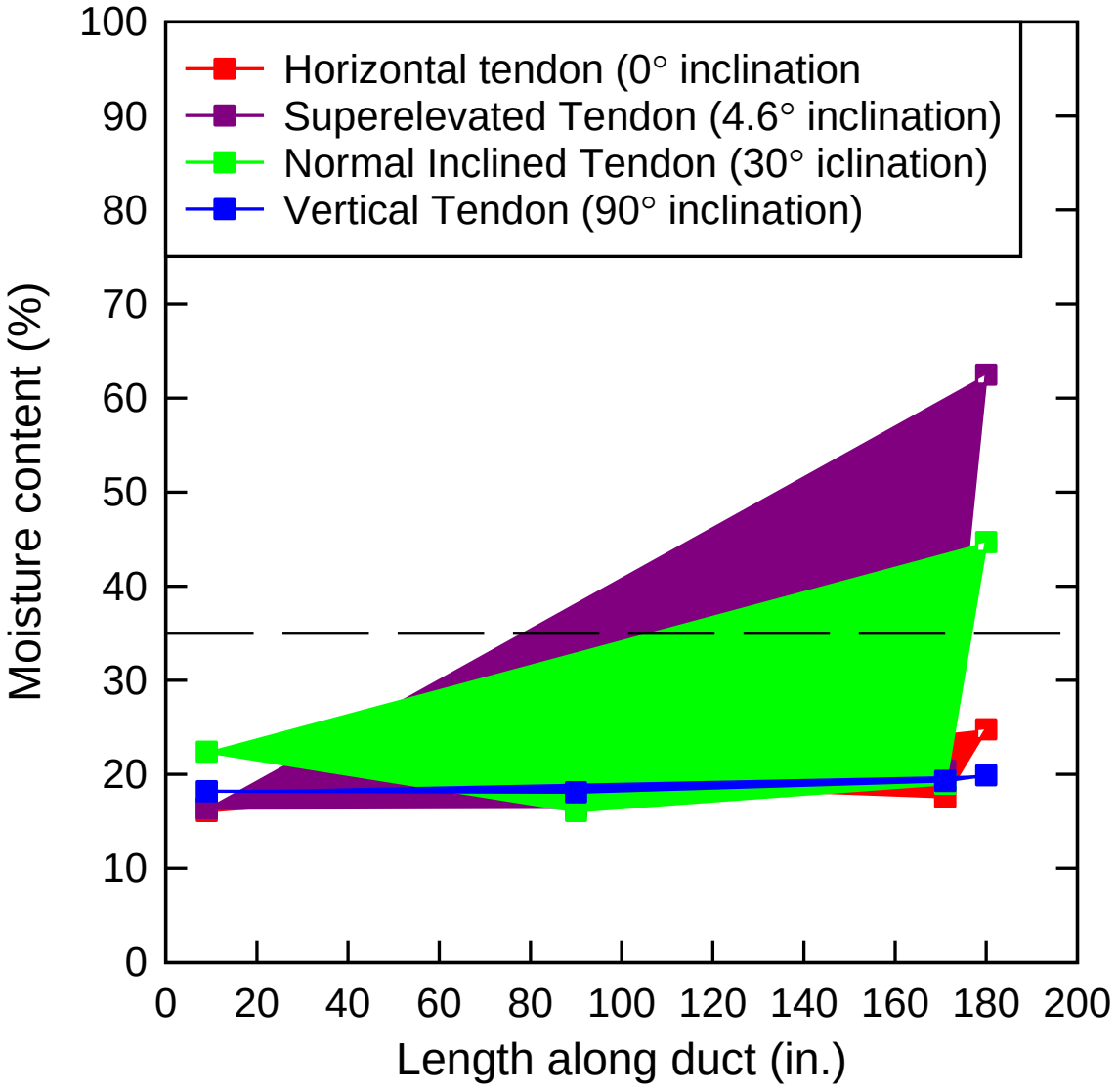

Closing comments

- Test for bleed and segregation
- Effect of fillers/admixtures on segregation (benefit/risk)
- Effects of age on segregation (shelf life)
- Effect of excess water on segregation (robustness)
- Current configuration and geometry is on target
- Incorporate modifications into PTI specifications

MITT Mockup?

- Require that (at least one) inclined test be conducted prior to construction
- Conduct test on site using equipment and personnel that will be used during construction
- Temperature during mockup sets the limit for the duration of the construction project
- Grout suppliers could use this to help ensure proper procedures are being used and to resolve initial technical issues

Special Thanks to "The Grout Team"

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Devon Minich

Rodrigo Antunes

Mark Lisek

FDOT