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

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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
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

Less dense particles segregate and flow upward to top of duct due to bleed water

Higher density cement particles settle to bottom of duct

Soft (segregated) grout found at high points

Schupack Pressure Test

Air pressure

Grout sample

During test, particles do not move significantly

Filter paper

SS screen
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

![Graph showing the effect of aging on soft grout exposure time](attachment:graph.png)

- Soft Grout (g)
- Exposure Time (days)
- PT1-4 (0.42)
- PT2-4 (0.55)
- PT3-3 (0.63)
- PT4-6 (0.51)
- PT5-1 (0.06)
- PT6-1 (0.16)
- PT1-5 (0.22)
- PT2-5 (0.08)
- PT3-4 (0.54)
- PT5-2 (0.12)
- PT6-2 (0.14)
- PT7-1 (0.07)
Effect of aging-moisture content
Filler and soft grout

Graph showing the effect of water-to-cement (w/c) and water-to-sand (w/s) ratios on the soft grout (g) for different fill levels: 0%, 35%, and 45% fill.
Bleed

Bleed water to cement ratio

Schupack bleed (mL)
0.2 0.3 0.4 0.5 0.6 0.7 0.8

Bleed water (mL)
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400

0% fill
35% fill
45% fill

0% fill
35% fill
45% fill
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?

15 ft (5 m)

5 ft (1.6 m)
**Soft Grout-Scaling issues?**

- **15-ft (5 m) tube with strand:** 77 gm
- **5-ft. (1.6 m) tube with strand:** 8 gm
- **5-ft. (1.6 m) tube without strand:** 3 gm
Bleed water

- 15-ft (5 m) tube with strand: 175 ml
- 5-ft. (1.6 m) tube with strand: 0 ml
- 5-ft. (1.6 m) tube without strand: 0 ml
Is an incline necessary?

- Deviated Tendons
- Transverse tendons on superelevation
- Cantilever tendons
Is an incline necessary?

- Traces of soft grout
- 100 gm soft grout
- 4.6°
- 100 gm soft grout
- 30°
Is an incline necessary?
Is an incline necessary?
Is an incline necessary?

![Graph showing moisture content (%) along the length of a duct for different inclines: Horizontal tendon (0° inclination), Superelevated Tendon (4.6° inclination), Normal Inclined Tendon (30° inclination), Vertical Tendon (90° inclination).]
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
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