Grout Compression Test Project
Cubes vs. Cylinders

Engineering Branch

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  – Not rigorously scientific
  – Scope
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Introduction & Purpose

- Currently FLNRO specifies using disposable plastic cylinders for sampling and testing of structural field grout
- This experiment evaluates compression test results of cylinders as compared to cubes
- Sampling and testing is done for quality assurance testing & objectively informing suitability for placing structures in-service
- Results support continued use of cylinder samples for FLNRO purposes
Methodology: Scope

- Test batch mixed and cast using spare Traffic Patch Coarse (TPC) to test procedure & water to dry grout ratio – appropriate range = 0.11 to 0.14
- Ratio of 0.12 was selected for testing
- 52 samples cast using Traffic Patch Fine (TPF):
  - 3 batches mixed from 1 bag of TPF
  - Each batch:
    - 9 cylinders (50diax100mm high), 9 cubes (50.8x50.8x50.8mm)
    - Broken at: 24hrs, 72hrs and 7 days
- Note - target strength of 34.5 MPa at 24 hrs
Methodology: Materials

• 27 - cube (50.8x50.8x50.8mm) samples:
  – Three metal molds (3 cubes per mold)
  – Six plastic molds (3 cubes per mold)
• 27 – cylinder (50x100mm: diameter x height) samples:
  – Plastic disposable molds
• Electric mixer – drill and paddle
• Traffic Patch Fine – 1 bag, 26kgs
• Water
• Buckets, weight scales, timer, thermometers, burlap, hand tools
• Protective gear
Methodology: Preliminary Test

- Preliminary test of procedure with spare TPC used a water: dry grout ratio of 0.14
  - Too wet, water puddled on top surface
  - Therefore, chose 0.12 for actual test
Methodology: Prep Work

1. Labeled cubes and cylinders & sorted into batches
   - Cylinders: CY1 to CY27
   - Cubes: CU1 to CU27
2. Pre-cooled cube molds, dry grout and water in refrigerator in order to prolong working time
3. Temperatures of materials recorded just prior to mixing and subsequent to mixing

Labelled cylinders

Brass cube molds, pre-lubed with WD40
Methodology: Mixing

4. Divided one 25.9kg bag TPF into three approx. equal parts: 8.626kg, 8.626kg and 8.426kg

5. Water volume used based on 0.12 ratio by weight
   - Batch 1 & 2: water/dry grout = 0.12
   - Batch 3: water/dry grout = 0.11

6. Water gradually added to dry mix
Grout mixed in 5 gallon pail with electric mixer and paddle

To watch a video:

[Video: Mixing.mp4]
Methodology: Casting

- 3 separate batches:
  - 9 cylinders and 9 cubes were cast for each batch
- Molds filled approx. half way with grout
- Molds rodded with blunt rod approx. 15 times
- Second layer added and rodded again
- Tops of samples struck-off with a flat edge
Methodology: Setting

• Samples placed on a flat surface after casting
• Approx. 1 hr after casting, water was sprinkled and wet burlap was placed over the samples
• Cubes in plastic molds were capped therefore not directly exposed to water or burlap
• Plastic sheet placed over samples to help retain moisture
Methodology: Setting

- Samples left outside overnight (field cure)
- Min. and max. temperatures recorded overnight
Methodology: Breaking

• Samples transported to lab for compression testing just under 24 hrs after casting
• All samples removed from their molds
• Cylindrical samples capped with Sulphur Mortar
• Cube samples rough edges filed off
• 72hr and 7 day samples stored in outdoor field cure cabinet
• Samples broken at 24hr, 72hr and 7 days
• Samples broken closely to casting times
Cubes failed in Columnar

To watch a video:

shearbreak1.mp4

Cylinders failed in Shear
## Results: Data

<table>
<thead>
<tr>
<th>Batch Number</th>
<th>Test Age</th>
<th>Average Compressive Strength of Grouping (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>24 hour</td>
</tr>
<tr>
<td>Batch 1</td>
<td></td>
<td><strong>40.4</strong></td>
</tr>
<tr>
<td>Batch 2</td>
<td></td>
<td><strong>44.5</strong></td>
</tr>
<tr>
<td>Batch 3</td>
<td></td>
<td><strong>49.8</strong></td>
</tr>
</tbody>
</table>

**Brass Molds for Cubes**

|          |          | **53.3** | **6.8** | **60.1** | **-1.4** | **58.6** |                   |

**Averages**

|          | **44.9** | **2.2** | **47.1** | **2.8** | **49.9** |
|          | **41**   | **7.6** | **6.3**  |         |         |
| CY        | **49.0** | **5.7** | **54.7** | **1.6** | **56.3** |
24hr Results: Normal Distribution

**Cubes:** Approximately 95% of the data is within 36.4 to 53.4 MPa

**Cylinders:** Approximately 95% of the data is within 41.0 to 57.0 MPa

Using cubes as a “base line”: Approx 95% of the data is within 36.9 to 51.3 MPa

95% of samples greater than 36.4 MPa >34.5 MPa for Target Traffic Patch.
Results

• Cylinders failed in shear; cubes in columnar
• Grout cast in the cylindrical molds tested ~10% higher than from the cubes
• All 54 specimens yielded compressive strengths well above 35 MPa
• Compressive strengths increases over time (7 day > 72 hr > 24hr)
• Results support continued use of disposable plastic cylinders for collecting & testing structural field grout samples
Other Observations

• There is a point when gradually adding water that the dry mix suddenly transforms to a more fluid consistency.

• Limiting amount of water to that prescribed in the product specifications results in a workable mix.

• Work time subsequent to mixing is limited to about 20 minutes.

• Water has to be close to 0 degrees C in order to prolong set time.
QUESTIONS?