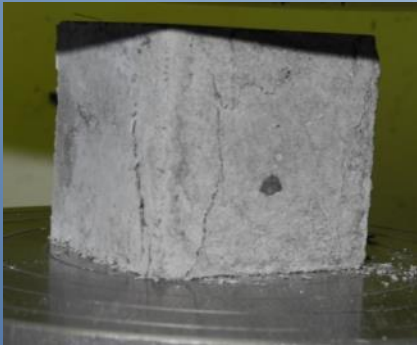




Grout Compression Test Project

Cubes vs. Cylinders



Engineering Branch

Jacqueline Pigeon
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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 (50dia x 100mm high), 9 cubes (50.8 x 50.8 x 50.8mm)
 - 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:



Mixing.mp4



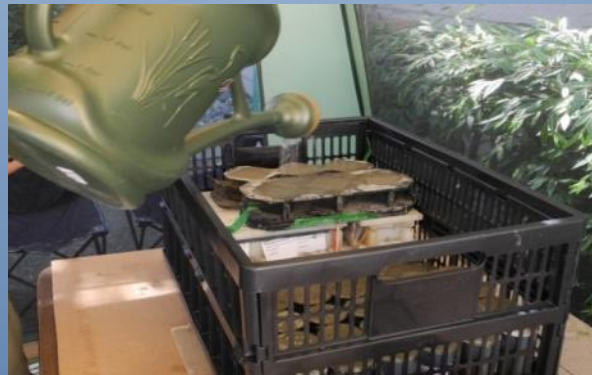
Methodology: Casting

- 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



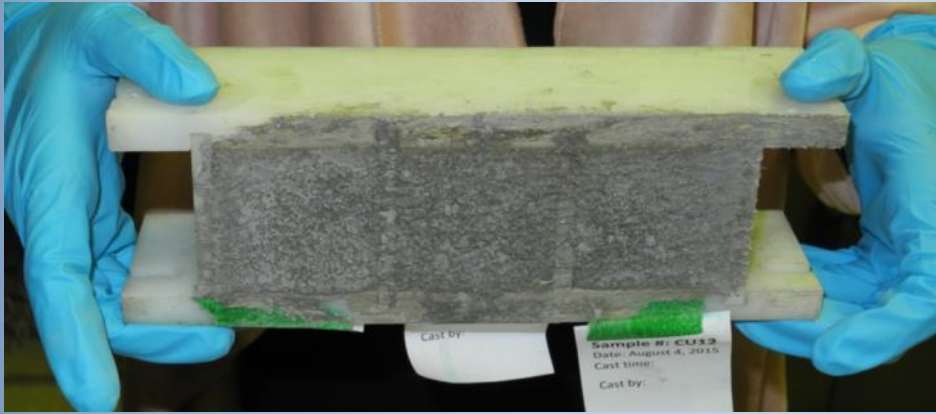
Methodology: Setting

- 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**



**Cylinders failed
in Shear**

To watch a video:

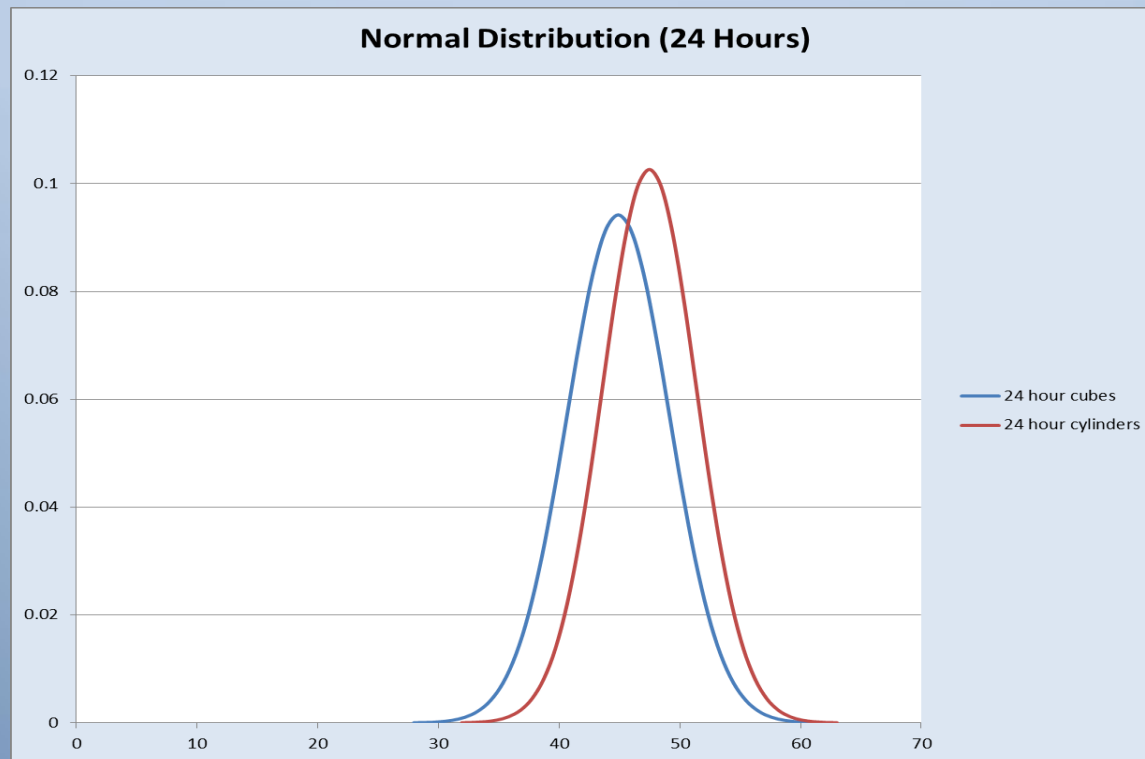


shearbreak1.mp4

Results: Data

Compressive Strength (Mpa)							Average Compressive Strength of Grouping (Mpa)					
Batch Number	Test Age						Test Age					
	Sample ID	24 hours	Sample ID	72 hours	Sample ID	7 days	24 hour	Delta	72 hour	Delta	7 day	
Batch 1	CU1	42.0	CU4	46.8	CU7	46.2	40.4	3.0	43.3	4.0	47.3	
	CU2	40.1	CU5	41.4	CU8	49.3						
	CU3	38.9	CU6	41.7	CU9	46.5						
						Delta	4.4		7.9		4.6	
	CY1	45.9	CY4	53.1	CY7	52.7	44.7	6.5	51.2	0.8	52.0	** updated to only include CY7 and CY9
	CY2	45.4	CY5	49.4	CY8	43.2						
	CY3	42.8	CY6	51.1	CY9	51.3						
Batch 2	CU10	45.3	CU13	46.3	CU16	50.8	44.5	3.0	47.5	2.2	49.6	
	CU11	44.8	CU14	51.2	CU17	46.5						
	CU12	43.4	CU15	44.9	CU18	51.5						
						Delta	4.6		5.4		8.7	
	CY10	46.4	CY13	50.9	CY16	57.9	49.0	3.8	52.9	5.4	58.3	
	CY11	50.1	CY14	53.1	CY17	58.4						
	CY12	50.6	CY15	54.6	CY18	58.7						
Batch 3 Brass Molds for Cubes	CU19	50.4	CU22	49.3	CU25	51.2	49.8	0.7	50.5	2.4	52.9	
	CU20	49.8	CU23	49.4	CU26	53.8						
	CU21	49.3	CU24	52.9	CU27	53.7						
						Delta	3.4		9.5		5.7	
	CY19	54.7	CY22	61.9	CY25	57.4	53.3	6.8	60.1	-1.4	58.6	
	CY20	52.3	CY23	58.3	CY26	60.2						
	CY21	52.7	CY24	60.0	CY27	58.2						
					Averages	CU	44.9	2.2	47.1	2.8	49.9	
						Delta	4.1		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 51.3MPa

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 
consistency.mp4
- 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?

