Evaluation and Sealing Techniques for Epoxy Backing Materials for Quoin and Miter Blocks

ERDC
Engineer Research and Development Center

2014 Locks Maintenance Workshop

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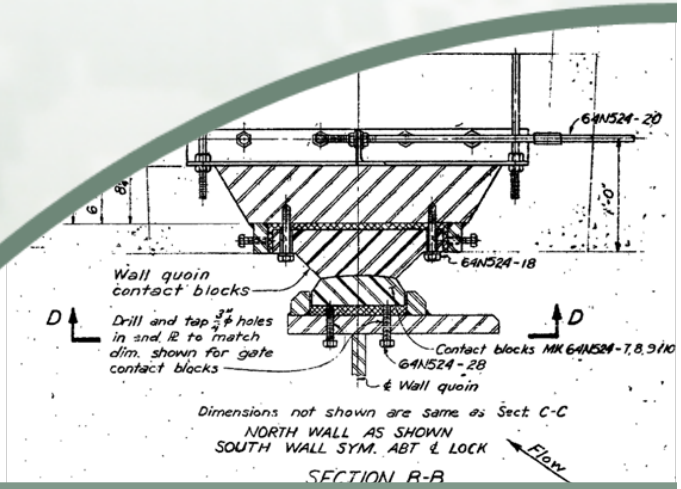
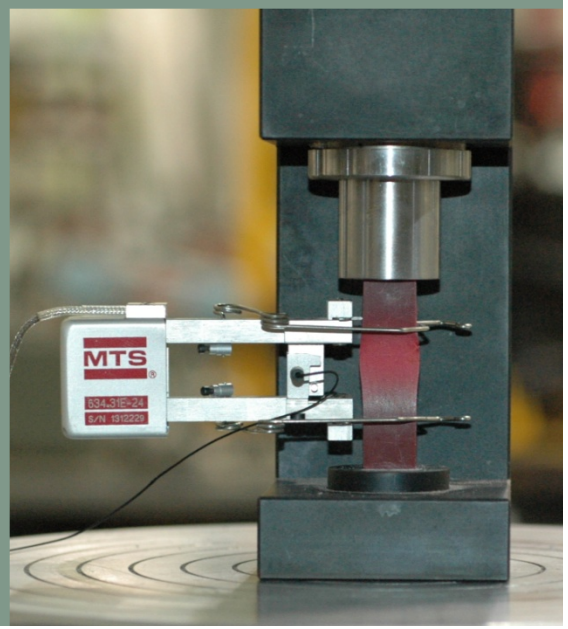
11FEB14





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Outline

- NAVSYS: “Evaluation of Emerging Filler Materials for Miter and Quoin Blocks”
  - Background
  - Problems/Objective/Approach
  - Mechanical Property Tests
    - Compression
    - Water Absorption
    - Hardness
    - Freeze-Thaw
    - Accelerated Aging
- Navigation Structures: “Sealing Techniques for Quoin Block Backing Materials”
  - Background
  - Problems/Objective/Approach
    - LD 27 Site Visit
    - Laboratory Mock-ups/Tests
    - Adhesion Testing

Background

- UFGS 35 20 16.33 “Miter Gates,” is out of date concerning miter and quoin block filler materials. UFGS addresses the use of zinc and epoxy as filler materials for setting miter and quoin contact blocks.
  - The epoxy filler specified in the guide specification refers to a particular product that is no longer available.
  - The UFGS allows for an equal product but lists performance specifications which are not adequate to ensure long term durability in this application.
- A statement of need for this project was submitted in 2009 by Richard Nichols of Louisville District. The Statement of Need titled, “Evaluation of Emerging Filler Materials for Miter and Quoin Blocks” was originated by an HQ request.

Problems

- Compressive Strength
  - What Definition? Can be arbitrary.
- Elasticity
  - May be too low for the application. Not provided by most manufacturers.
- Hardness?
- Water Absorption
  - Amount?
  - Affect on Properties?
- Temperature/Freeze-Thaw

Evaluation of Emerging Filler Materials for Miter and Quoin Blocks

- Mr. Jonathan Trovillion
- NAVSYS WU initiated FY12
- Objective: The objectives of this project are to identify, test, and evaluate emerging filler materials used in miter and quoin blocks such as epoxy products along with others types of fillers (grouts) for their performance characteristics, suitability for this application, and long term durability. A second objective is to determine what performance characteristics will best predict suitability and durability.
- Approach:
  - Identify filler materials that are currently being used or have been considered and problems that have been encountered.
  - Identify candidate epoxy fillers, testing methods, and performance characteristics.
  - Conduct material property testing related to in-service performance.

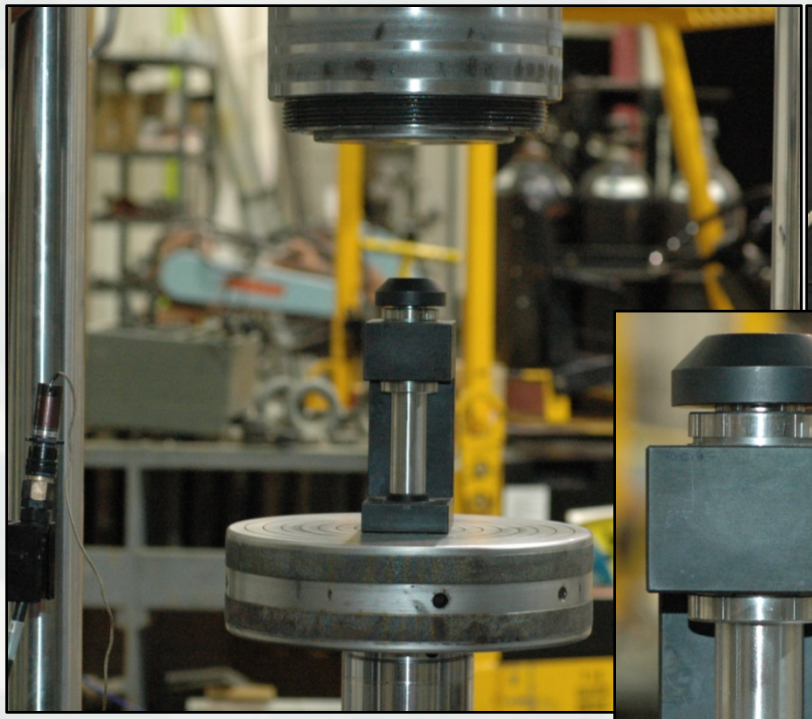
FY13 Activities

- Field Interviews and Site Visits:
  - Phone interviews with personnel from 12 Districts in 5 Divisions.
  - Site Visit to LD27. (Feb13).
- Conduct Mechanical Property Tests:
  - Compression
    - ASTM D 695 – Standard Test Method for Compressive Properties of Rigid Plastics
    - Baseline Dry sample Testing: Completed.
    - Saturated Samples Testing: Sample fabricated and submerged, awaiting saturation.
  - Water Absorption
    - ASTM D 570 – Standard Test Method for Water Absorption of Plastics
    - Testing in progress, waiting for saturation
  - Hardness
    - ASTM D 2240 – Standard Test Method for Rubber Property – Durometer Hardness
    - Baseline Dry sample Testing: Completed.
    - Saturated Samples Testing: Sample fabricated and submerged, awaiting saturation.

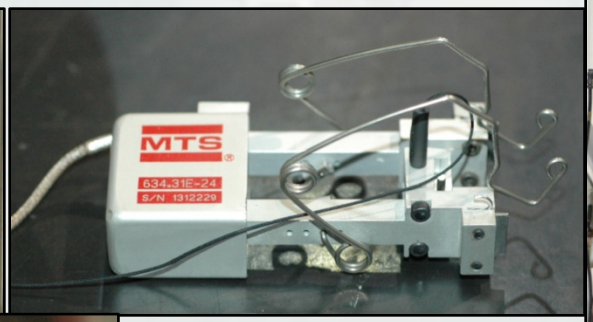
Compression Laboratory Equipment

MTS 50 Kip Load Frame

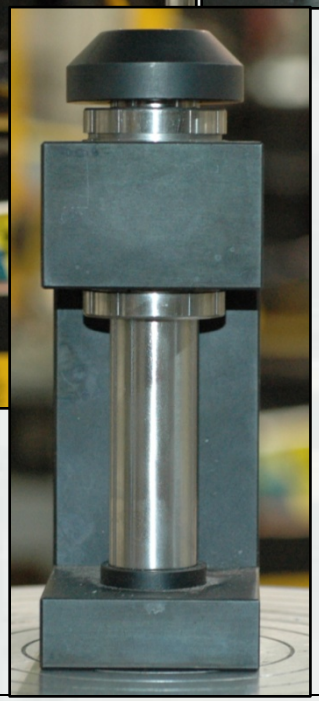
ASTM D 695 – Standard Test Method for Compressive Properties of Rigid Plastics



Test Resources Compression Fixture for ASTM D695



MTS Extensometer



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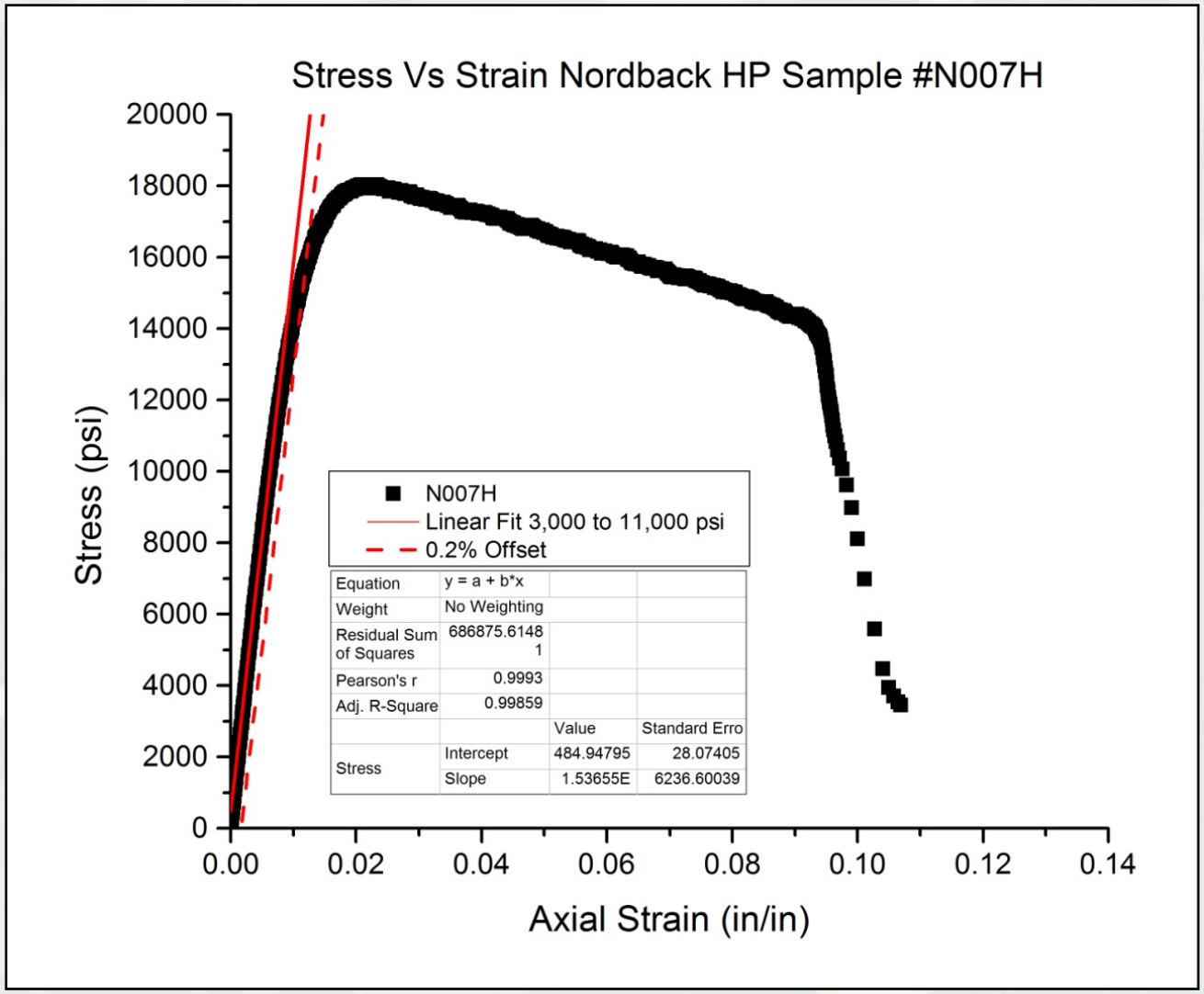
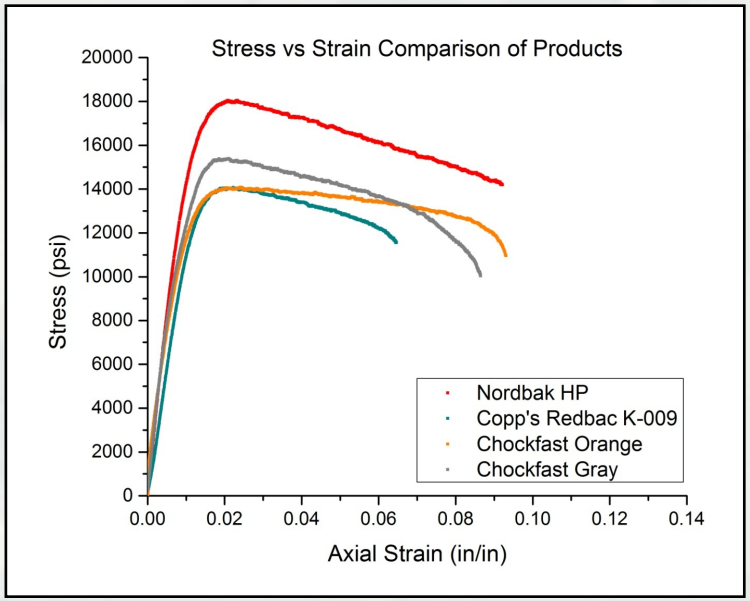
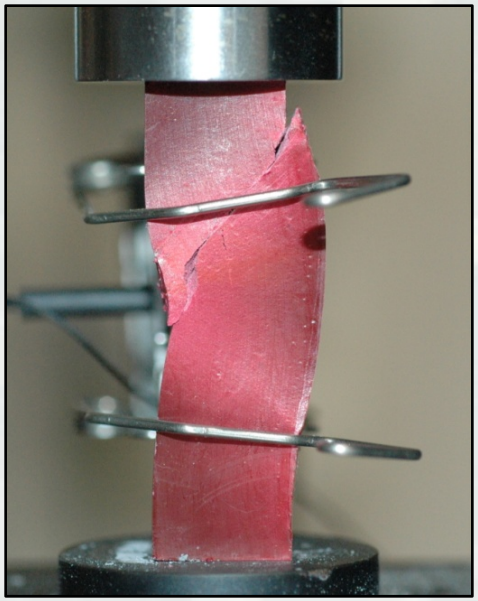
Compression Data Analysis



Compression Testing

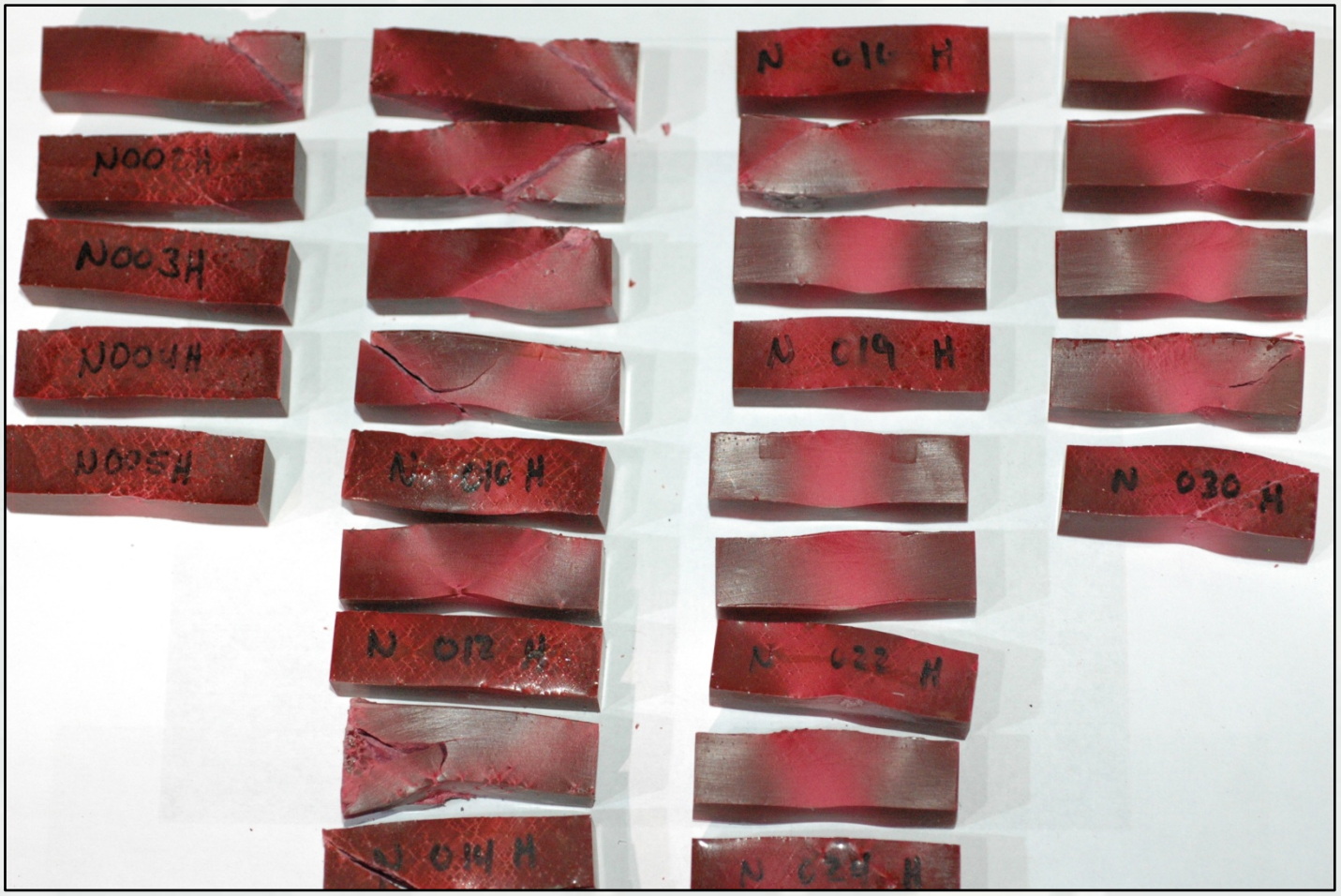




Sample	Average Compressive Strength (psi)	Literature Value Compressive Strength (psi)	Average Compressive Yield Strength (psi)	Average 0.2% Offset Yield Strength (psi)	Average Modulus of Elasticity (psi)	Literature Value Modulus of Elasticity (psi)
Nordbak High Performance	17,800	18,000	15,400	15,400	1,510,000	****
Copp's Redbac K-009	14,200	19,000	12,800	13,200	1,160,000	****
Chockfast Orange	14,200	19,000	12,200	12,900	1,100,000	533,000
Chockfast Gray	15,800	16,000	13,500	14,000	1,570,000	520,000

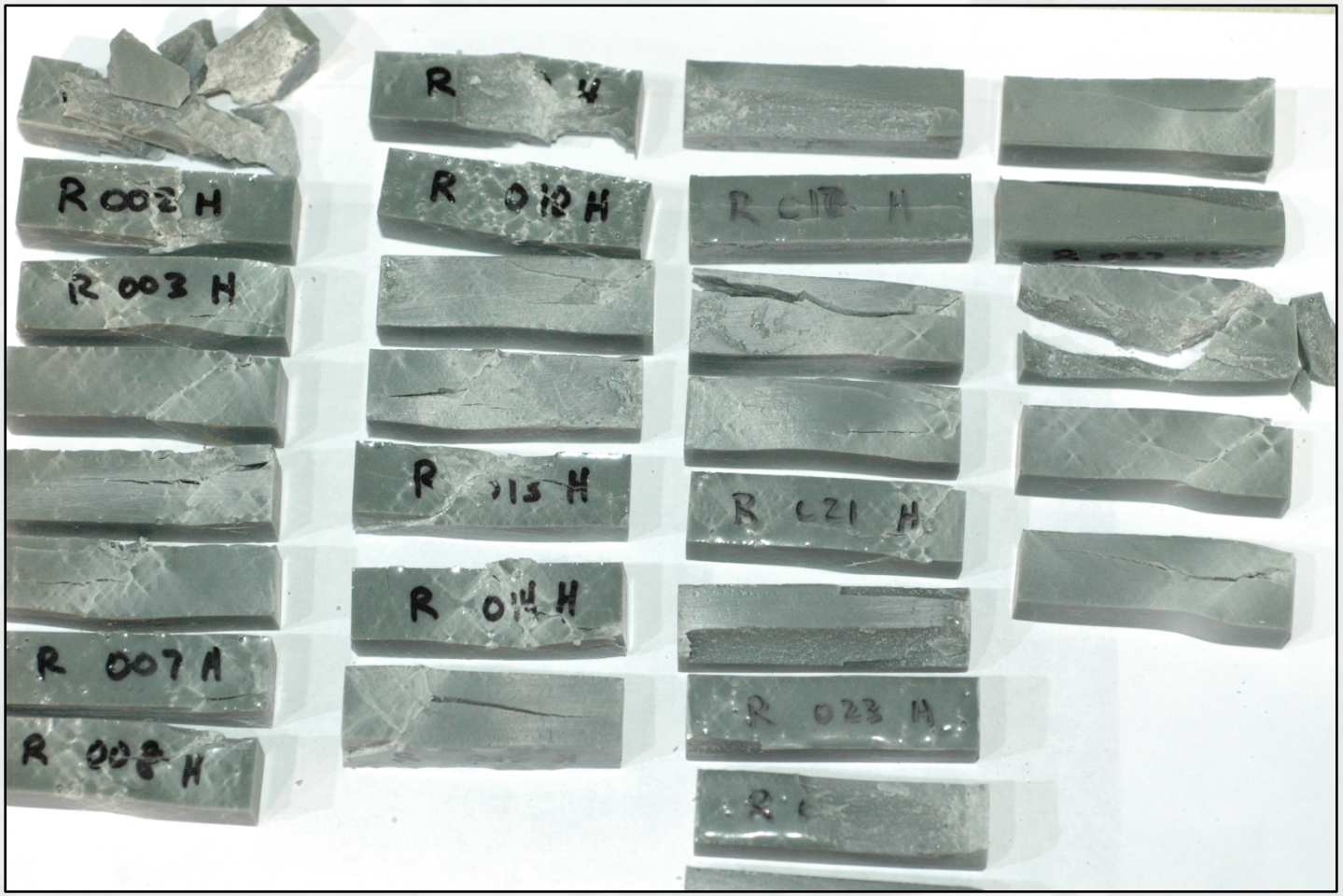
Compression Testing

Fractured Samples – Nordbak High Performance

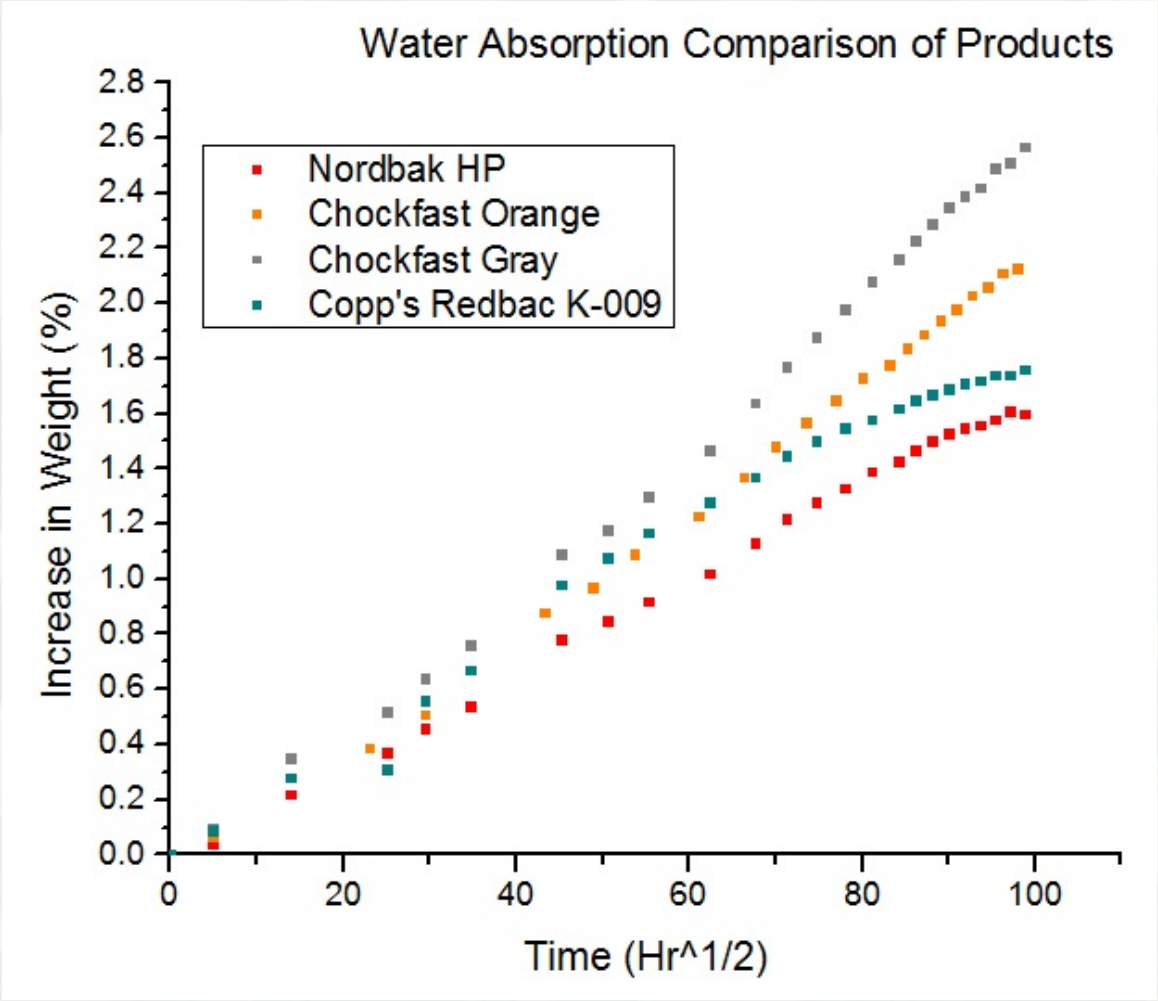


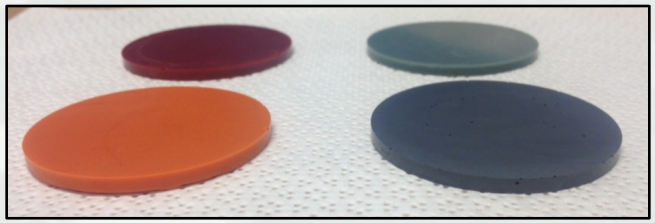
Compression Testing

Fractured Samples – Copp's Redbac K-009

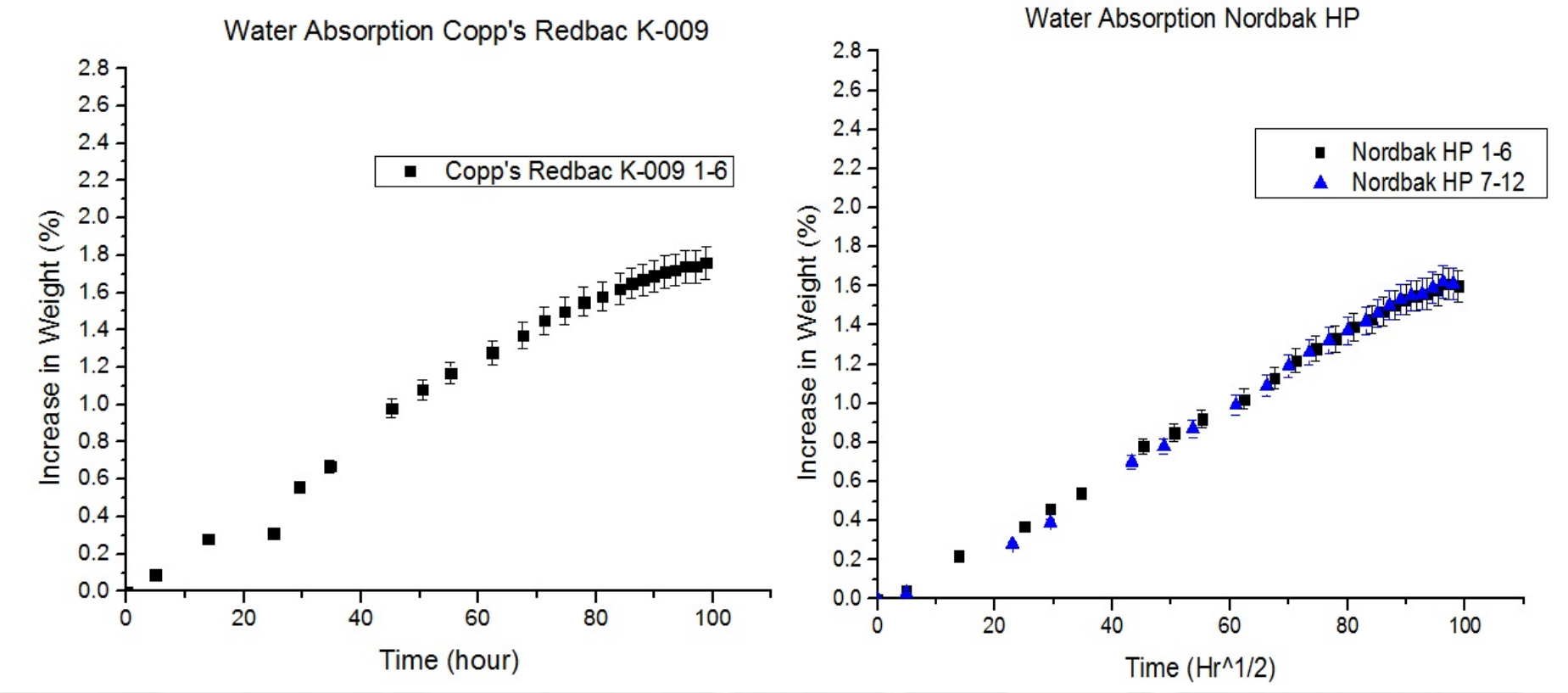


Water Absorption

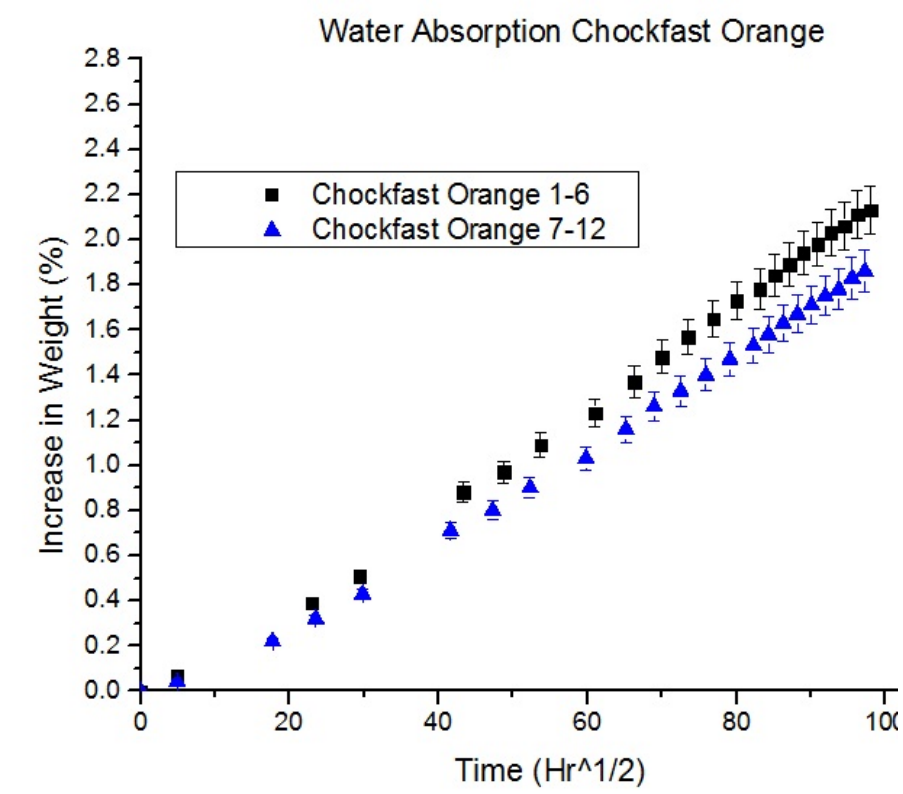


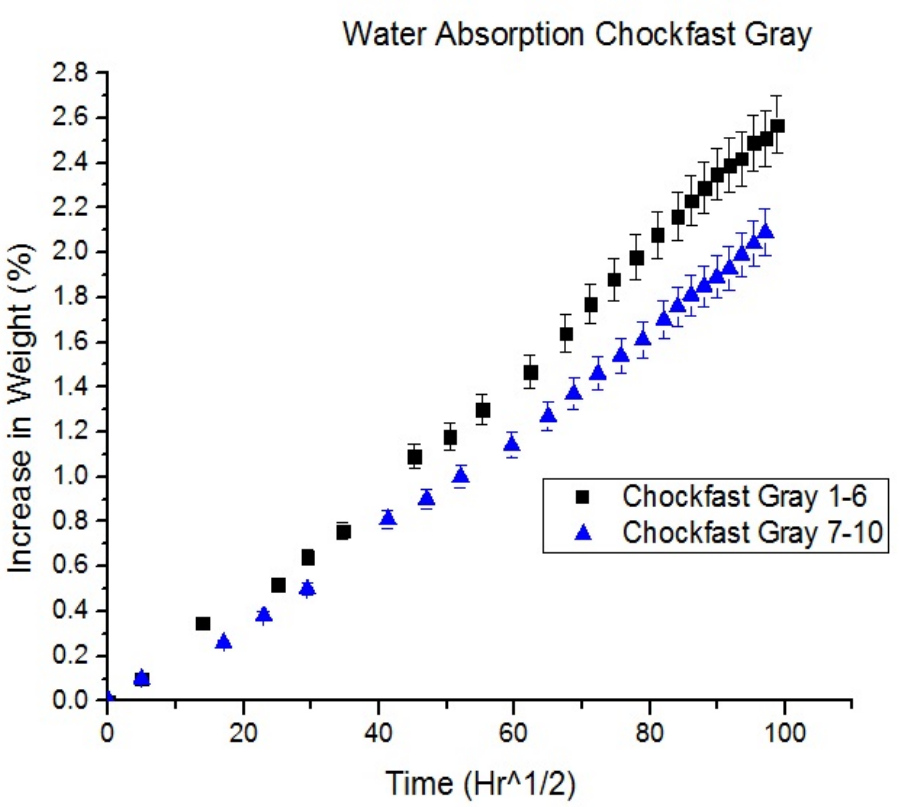


Water Absorption



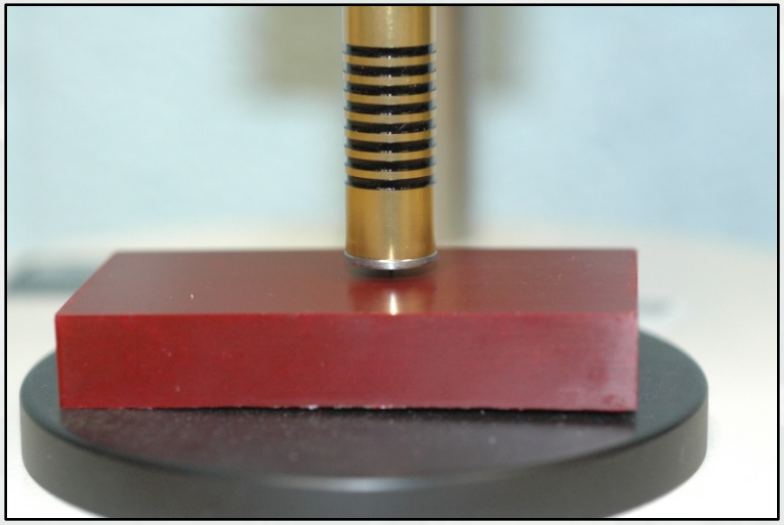
Water Absorption





Hardness Testing

Sample	Average Hardness Value	Standard Deviation	Literature Hardness Value	Cure Time (days)
Nordback High Performance Backing Material	87.6	2.46	90	7
Chockfast Gray Chocking Material	88.9	1.07	****	7
Chockfast Orange Chocking Material	87.1	0.74	****	7
Copp's Redbac High Perfomance Grout K-009	86.8	0.59	90	7



FY14 Activities

- **Continue Mechanical Property Tests**
  - Water Absorption: Continue to saturation. Determine diffusion constants.
  - Compression: Compression tests on saturated specimens.
  - Hardness: Hardness tests on saturated specimens.
  - Viscosity: Merlin Viscometer
- **Initiate Freeze Thaw and Accelerated aging Tests**
  - Freeze Thaw: Determine protocol and initiate.
  - Accelerated Aging. Based on previous composite durability work.
- **Identify design loads and performance requirements for quoin and miter block backing materials.**

Sealing Techniques for Quoin Block Backing Materials

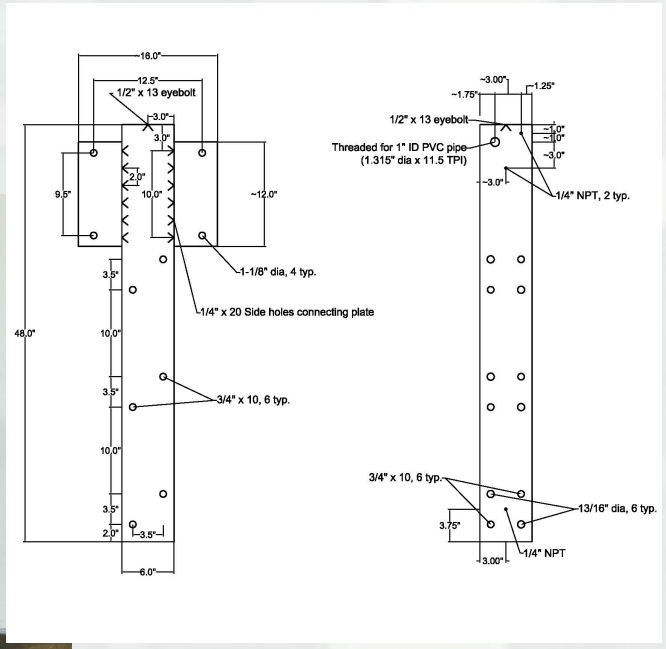
- Mr. Jonathan Trovillion/Stuart Foltz
- Nav Structures FY12 (Mid-Year)
- Background/Problem:
  - The epoxy backing materials are typically sealed with Bondo body filler material.
  - The sealing materials can fail as the pressure head of the epoxy material increases.
- Objective: The objective of this work unit is to develop improved sealing techniques and materials selection between the quoin or miter blocks and their respective channels.
- Approach:
  - Laboratory mock-ups simulating quoin and miter blocks. Allows control of surface preparation, gap size, and head pressure.
  - Adhesion tests between the sealing materials and steel substrates.

LD 27 Site Visit

- Visited in FEB13
- The main lock chamber dewatered, replacement of the lower miter gates.
- The outdoor temperatures were 25-35 degrees F with periodic rain and snow.
- Problems occurred with the sealant used to contain the epoxy backing material.
- Three Sealants were used:
  - Polyurethane had about 2 days to cure (performed OK with small leaks).
  - Liquid nails (failed rather badly).
  - Hilti anchor grout did well.

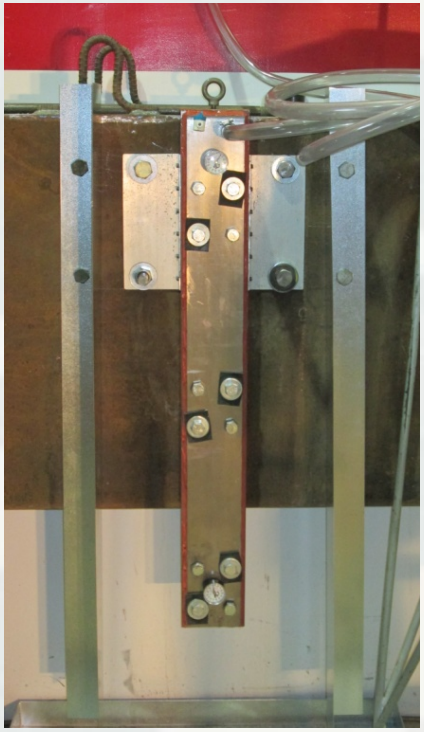
Laboratory Mock-ups

First test setup with **plexiglass** to enhance visibility.
Does not have same adhesion characteristics.



Actual **miter block**.
More difficult to use because of size and weight.

Steel plates.
Like the plexiglass, the gap width is adjustable. This setup works very well for testing the perimeter sealant.



Sealant Pressure Test Results

Sealant	Type	Results
Hilti HIT RE500	epoxy	80F, 94F, **Excellent** (twice)
3M™ Factory-Match Seam Sealer, 200 mL, 08323	polyurethane	(1) 76F, **Excellent** (2) 94F, **Failed**
Loctite 5607 Silicone Adhesive	silicone	84F, **Good** but with concerns.
Loctite Fixmaster® Anchor Bolt Grout HP	epoxy	90F, **Good** but with concerns. Viscosity was marginal (low)
Liquid Roc 3000 Twin Tube	polyester	75F, **Excellent**
Hilti HIT-HY 200R	urethane methacrylate	80F, **Poor**. Likely due to temperature
WR Meadows POLY-GRIP	polyester	81F. **Excellent** but short working life at this temperature
Redhead A7	acrylic	78F. **Excellent** but short working life at this temperature
Hilti HIT-HY 10 Plus	urethane methacrylate	80F. **Excellent** but short working life at this temperature
Hilti HIT ICE	epoxy acrylate	80F, **Marginal** due to short working life at this temperature
Redhead G5	epoxy	84F. **Good** but not usable below 70F
Five Star HP Anchor grout	epoxy acrylate	87F, **Poor** due to weak adhesion
Hilti Foam CF-ASCJP	polyurethane	80F, **Poor** (twice)
Touch ‘nSeal All Season Polyurethane Foam	polyurethane	80F, **Poor**
one part silicone caulk	silicone	80F, **Poor** (twice)
one part polyurethane caulk	polyurethane	80F, **Poor** (twice)
3M™ Scotch-Weld™ Epoxy Adhesive DP420	acrylic	**80F, Unusable**. Viscosity too low.

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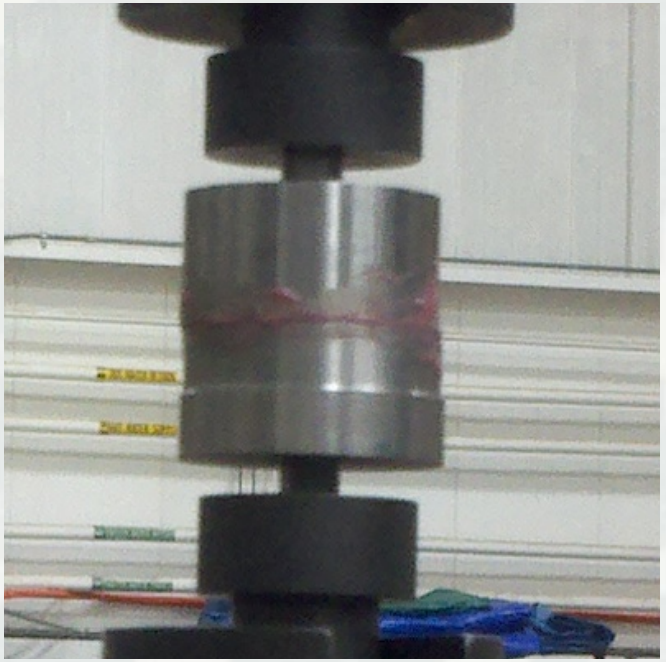
Adhesion Testing

- Both Mild Steel and Stainless pucks.
- Vary Surface Preparation.
- Vary Curing Temperature.



Questions ???