Quality Testing of Wisconsin Aggregate – WHRP 0092-20-05

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Outline

- Objective
- Background
- Aggregate Durability Testing Program
- Analyses
- Conclusions

Objective

- Investigate the feasibility of implementing statewide freeze-thaw testing.
- Recommend thresholds for Wisconsin aggregates used in base course, HMA pavement and PCC pavement regarding freeze-thaw durability.

Aggregate Breakage/Disintegration Mechanisms in Freezing Conditions

- Aggregate resistance to freeze-thaw (F-T) conditions is significantly affected by pore structure

- Mechanism of F-T damage in an aggregate's pore structure is either because:
  - Increase in volume of water during freezing
  - Pressure increase due to the growth of ice

Coarse Aggregate Sources

- Coarse aggregate (CA) sources: 34
- Aggregate samples were collected from:
  - Quarries
  - Pits
  - Aggregate piles in concrete mixing plants (crushed stone and gravel)
- Aggregate samples were collected by certified technicians via coordination with the POC

Aggregate F-T Research Program

- Aggregate Laboratory Testing:
  - SSS vs F-T
  - F-T → E vs M, F-T Systems, # of F-T Cycles, CLS vs DLS, Lab variability, Size Fraction
- PCC Laboratory Mixing and Testing
- PCC Field Sampling and Laboratory Testing
- PCC Field Coring and Laboratory Testing
- PCC Pavement Field Evaluation

Coarse Aggregate

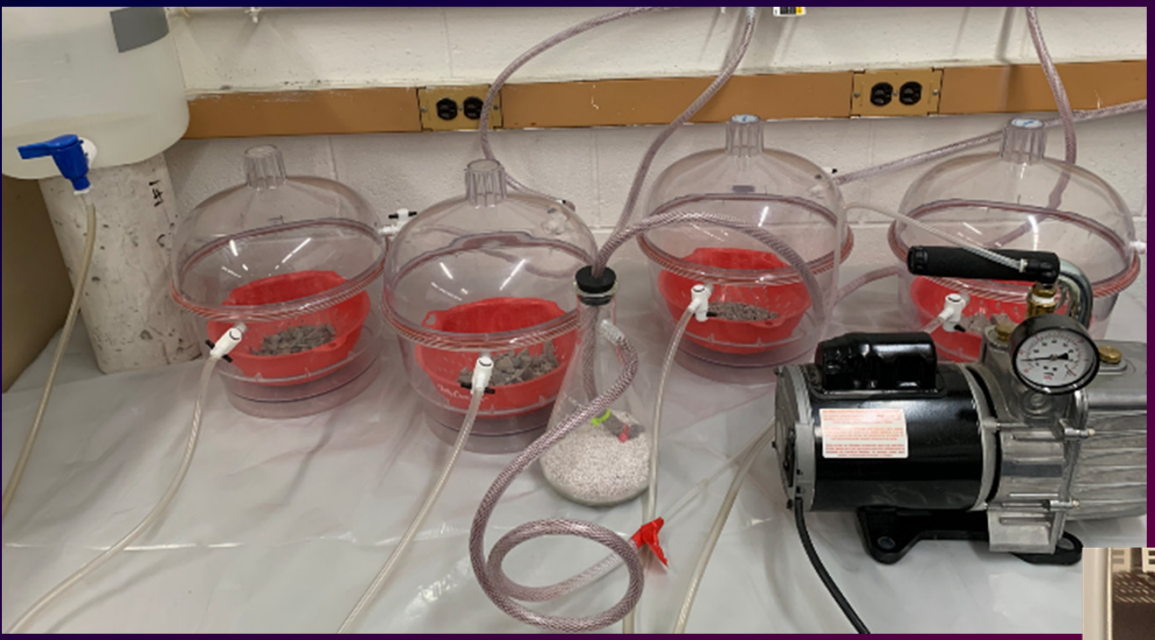
- CA collected included:
  - 1¼″ base course
  - ¾″ base course
  - Concrete #1
  - Concrete #2
  - 1″ clear stone
  - 1½″ bituminous aggregate

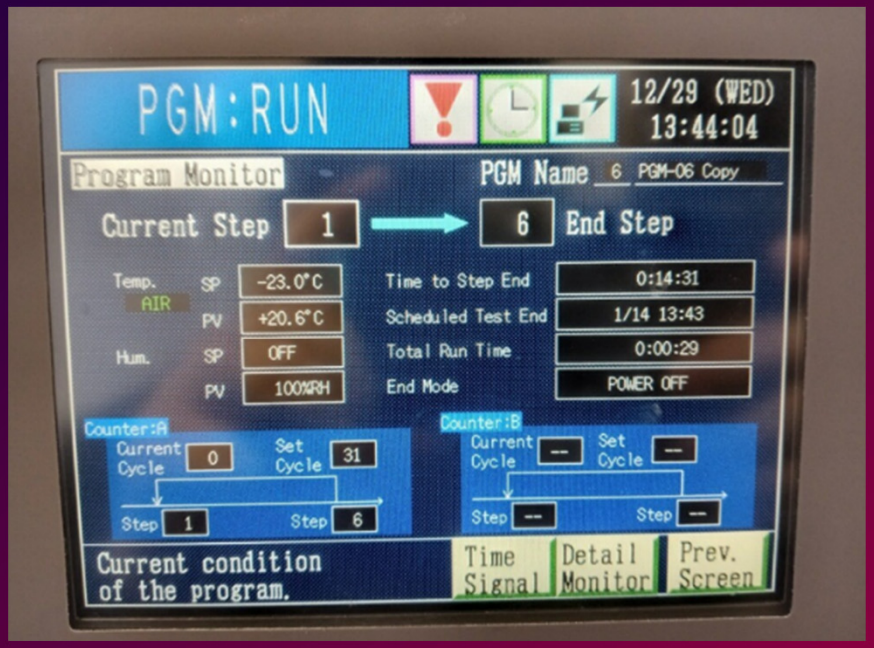
Aggregate Laboratory Testing

- Soundness of Aggregates by Freezing and Thawing Test (AASHTO T103)
- WisDOT Modified AASHTO T 103
- Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (AASHTO T 104 , Sodium Sulfate)
- Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate (AASHTO T 85
- CA Vacuum Absorption Test (MDOT MTM 113)

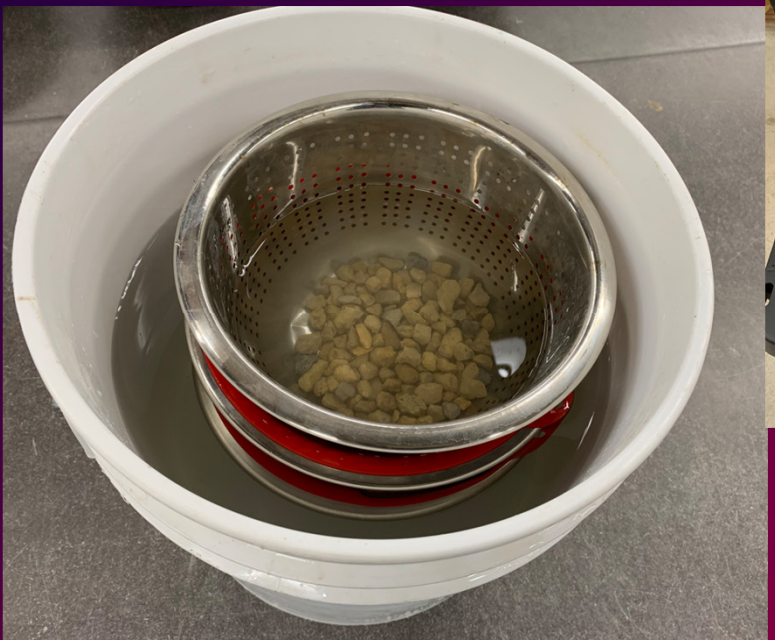
Aggregate Laboratory Testing

Coarse Aggregate F-T Testing





Coarse Aggregate SSS Testing



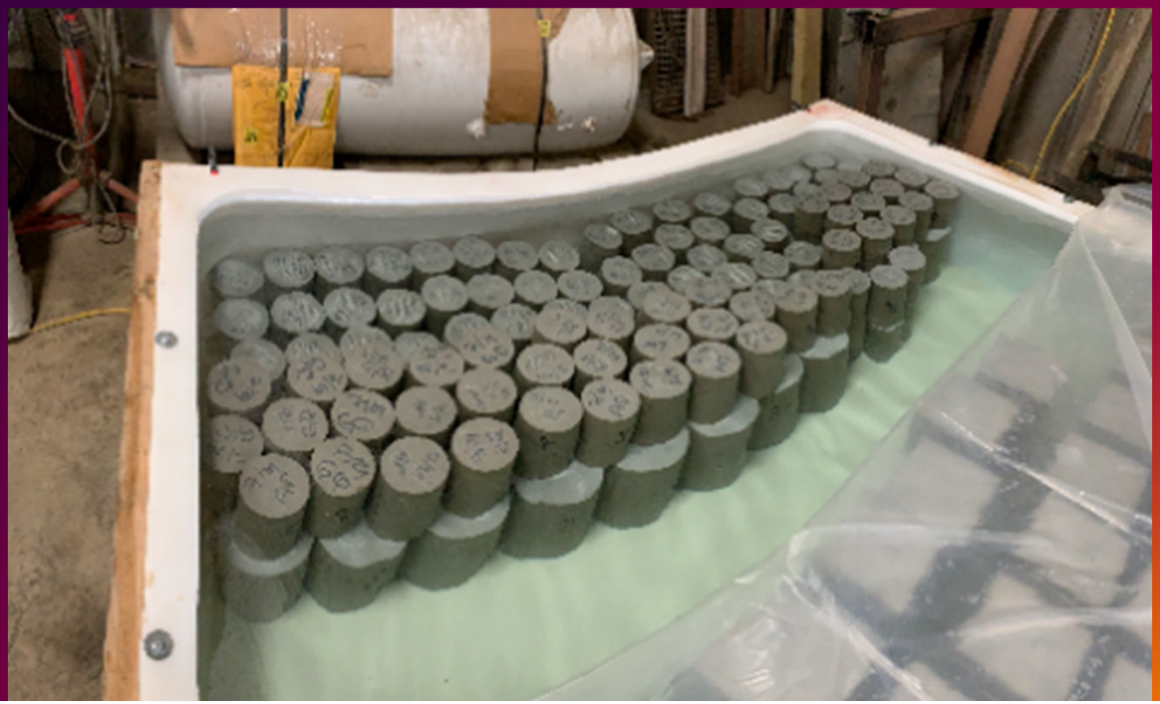
PCC Mixing and Samples Preparation - Lab

PCC Samples from Paving Projects

PCC Samples

PCC samples:

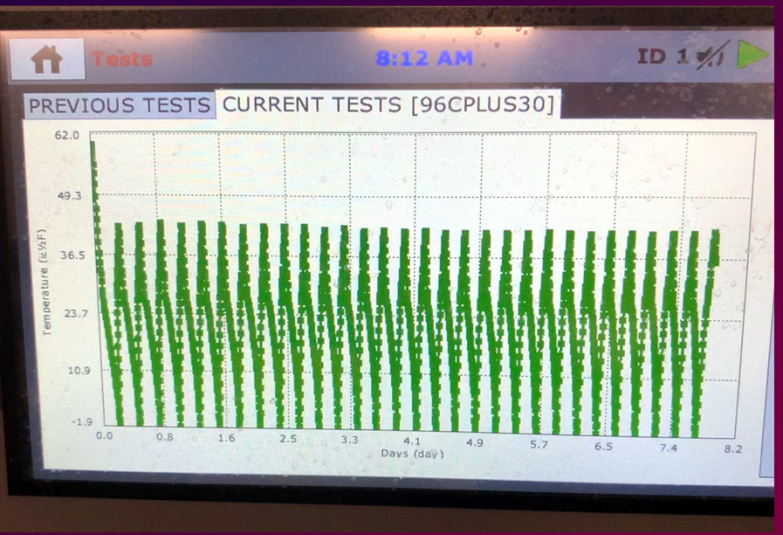
- **Short-term:**
  - **6” cylinders → 28-day curing**
  - **4” cylinders → 28-day curing**
- **Long-term:**
  - **4” cylinders → 28-day curing → 6 month storage**

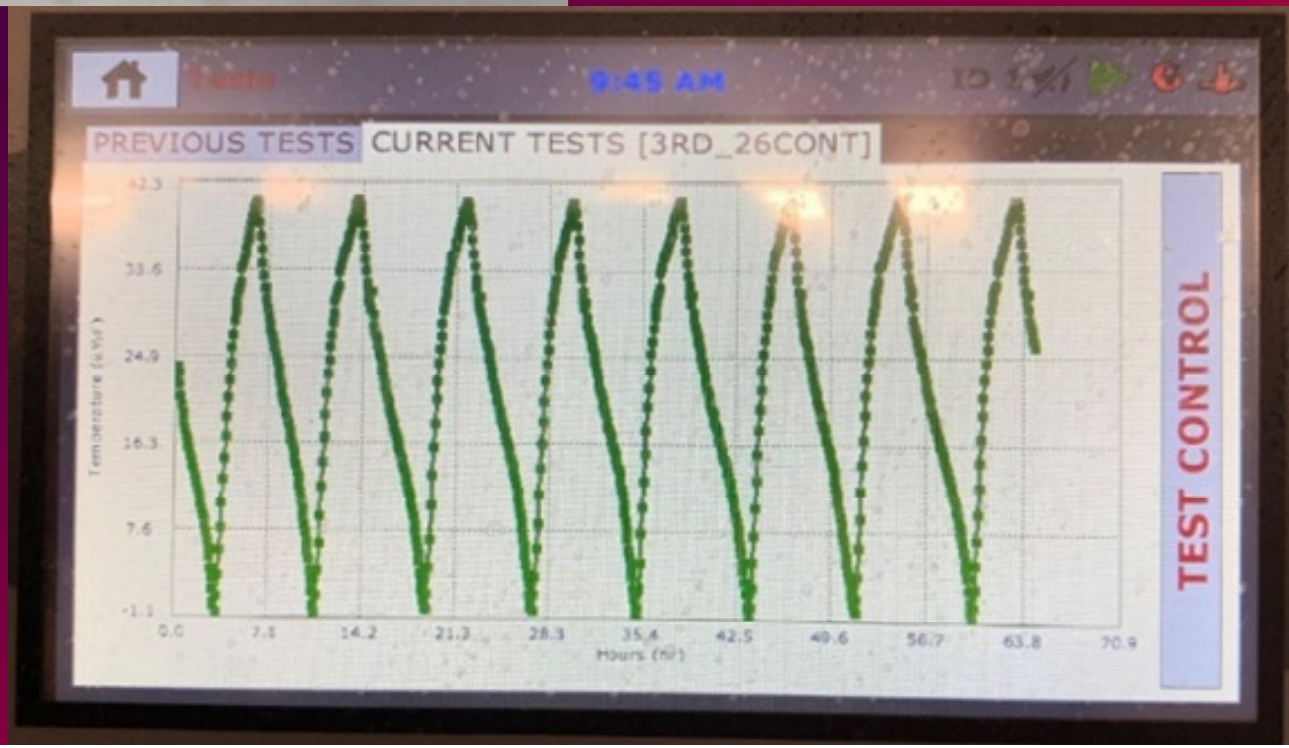


PCC Durability Testing Program

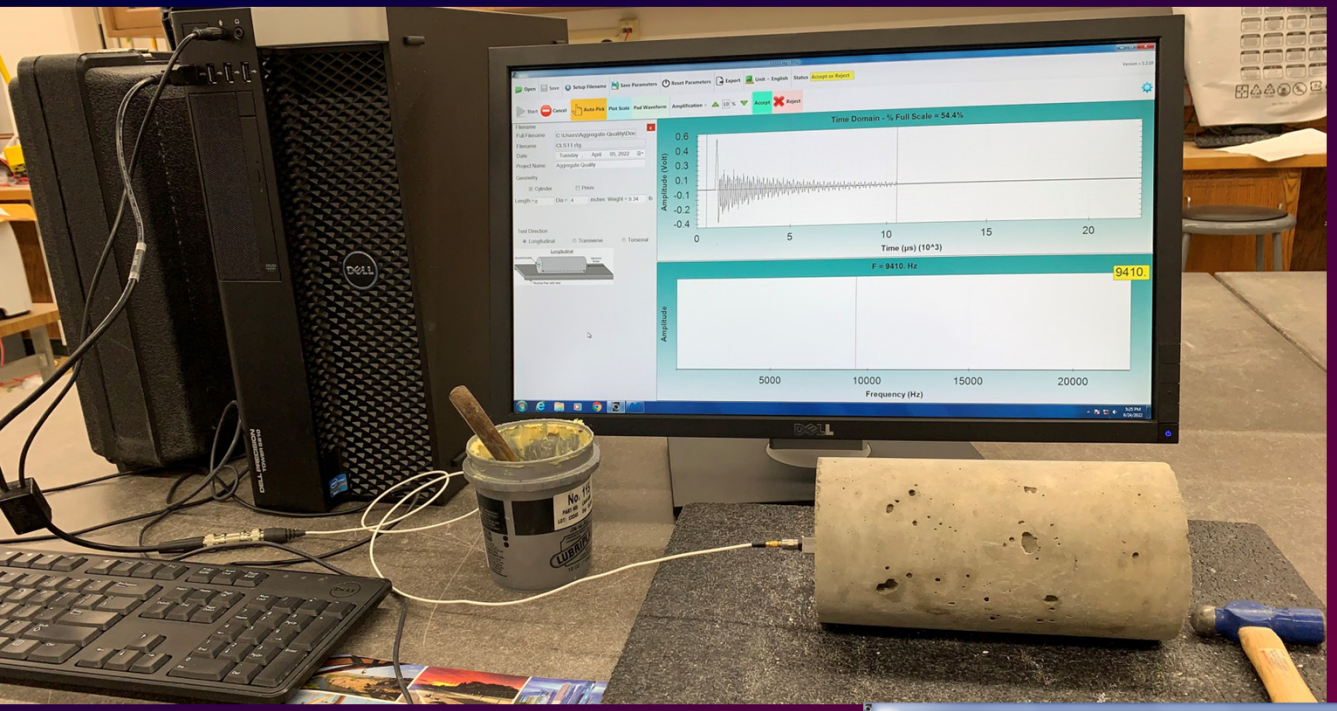
- ASTM C666: Resistance of Concrete to Rapid Freezing & Thawing
- ASTM C215: Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens
- ASTM C597: Pulse Velocity Through Concrete-Ultrasound Testing
- ASTM C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
- ASTM C469: Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
- ASTM C856: Standard Practice for Petrographic Examination of Hardened Concrete

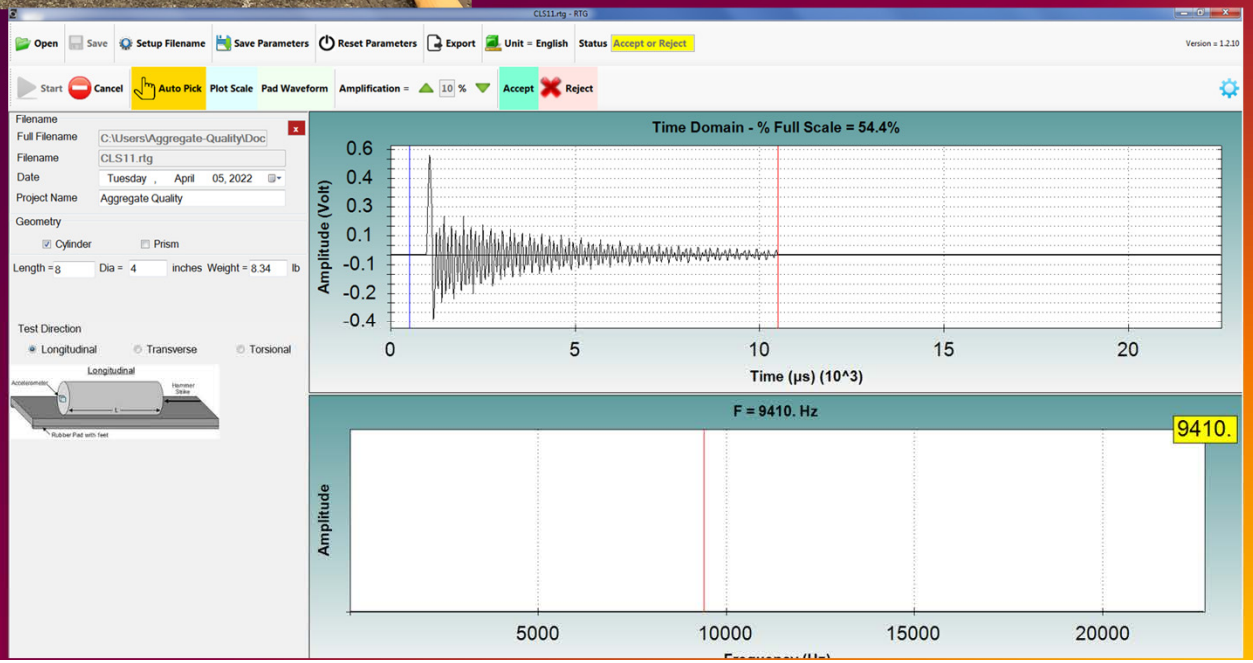
PCC Durability Testing Program



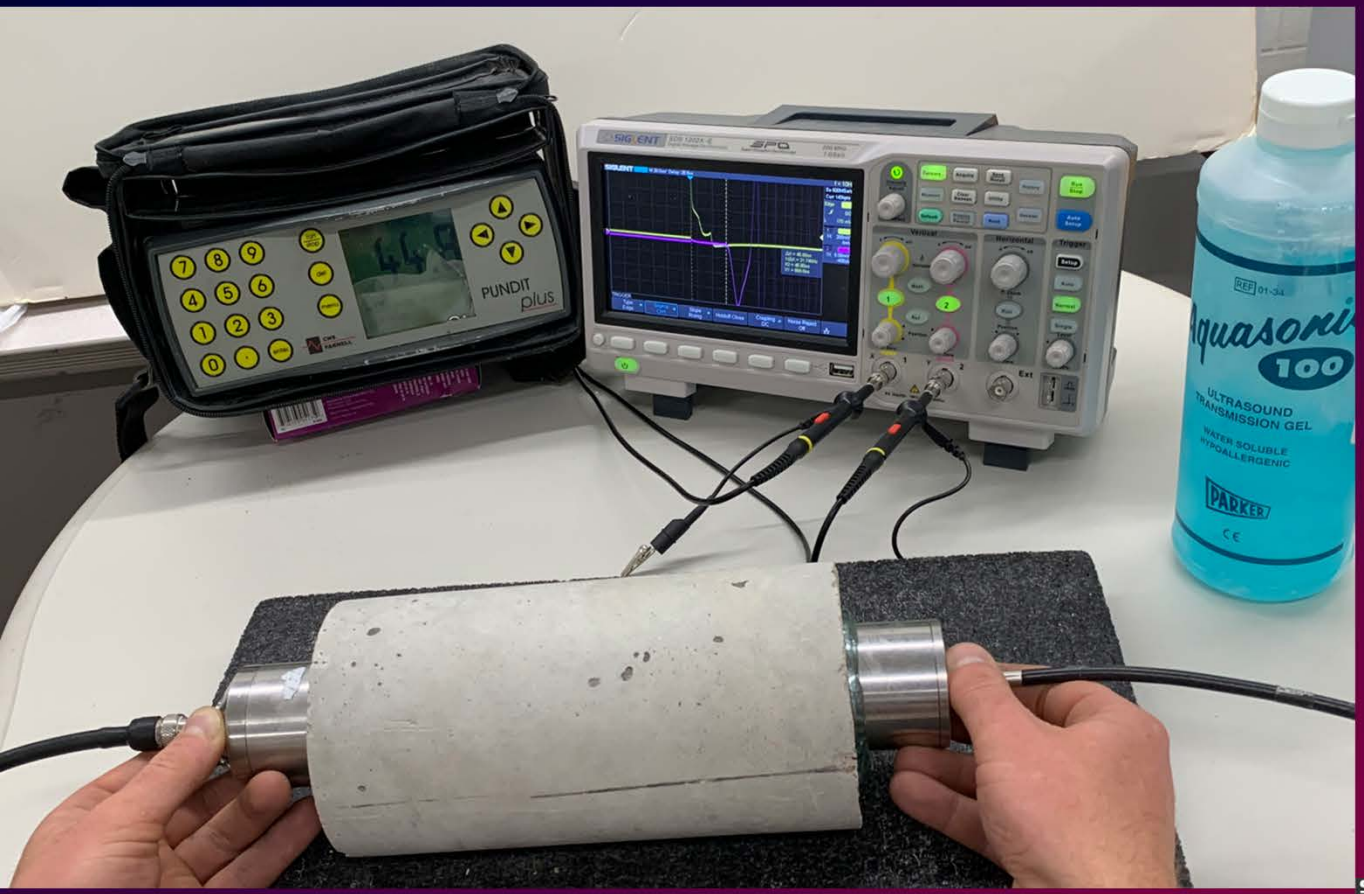


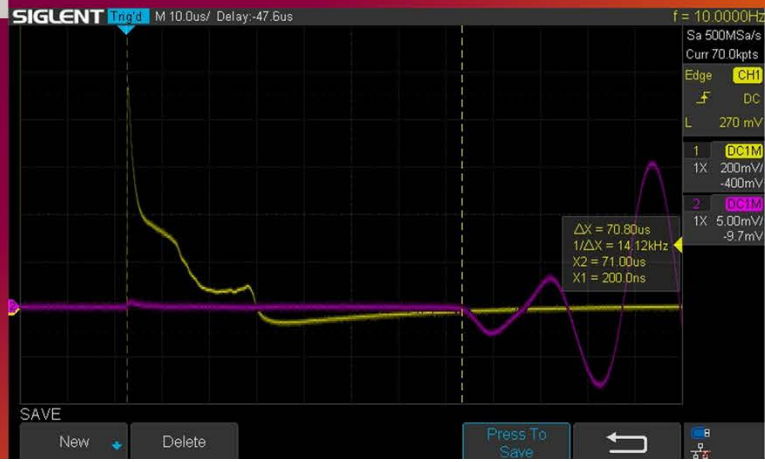
PCC Durability Testing Program





PCC Durability Testing Program

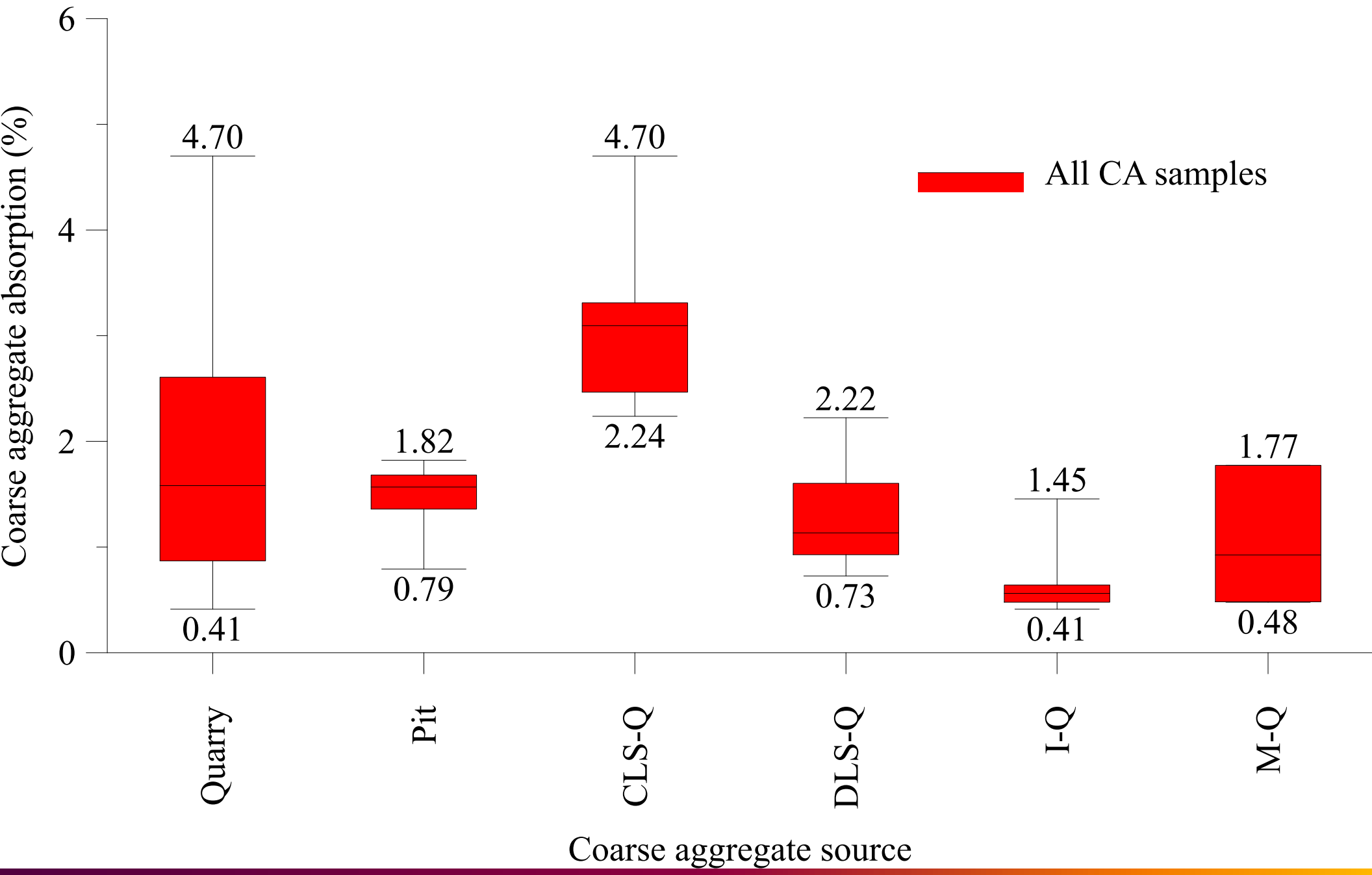




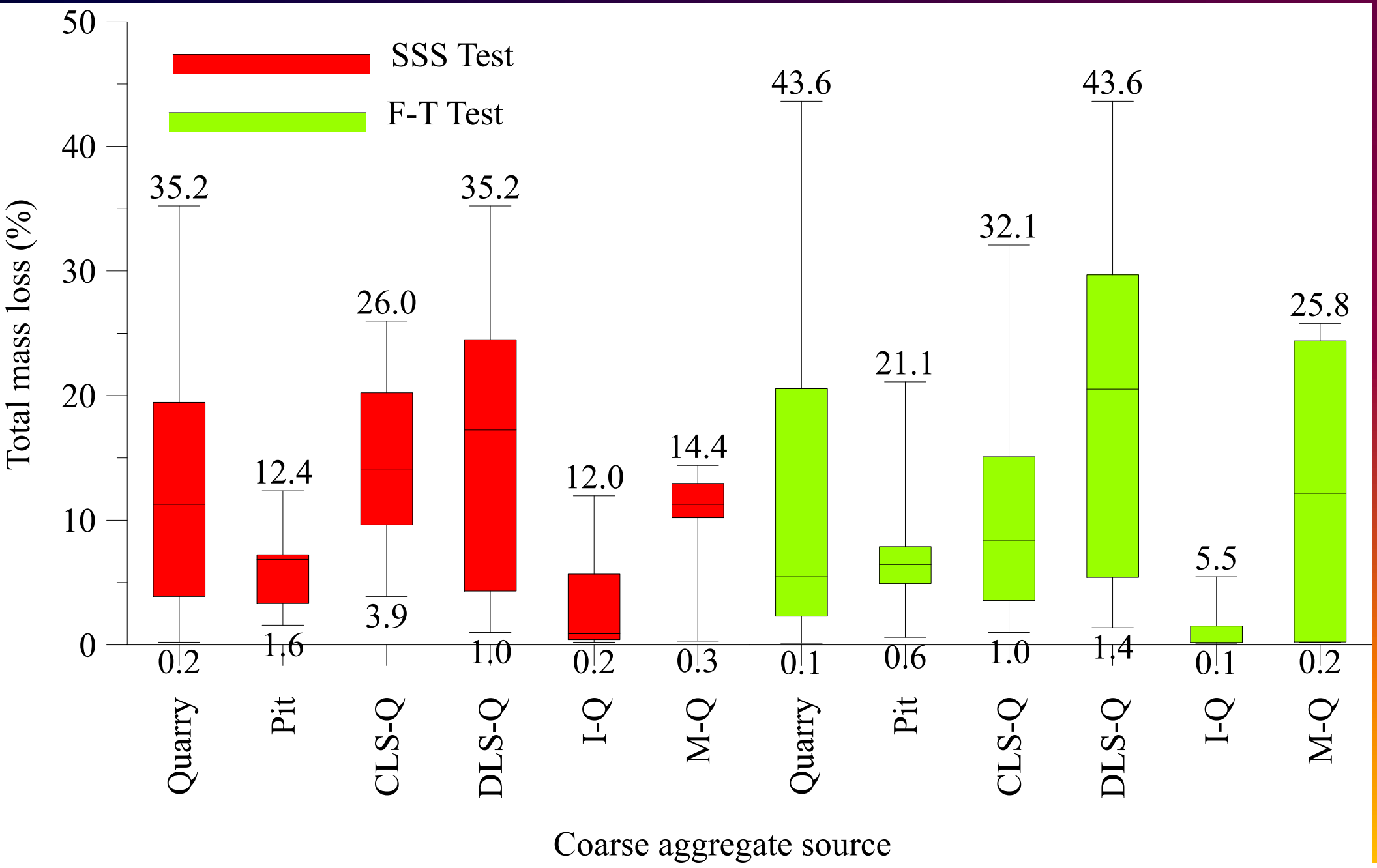
PCC Durability Testing Program

Field Investigation-Coring

CA – Absorption



CA Source – SSS & FT

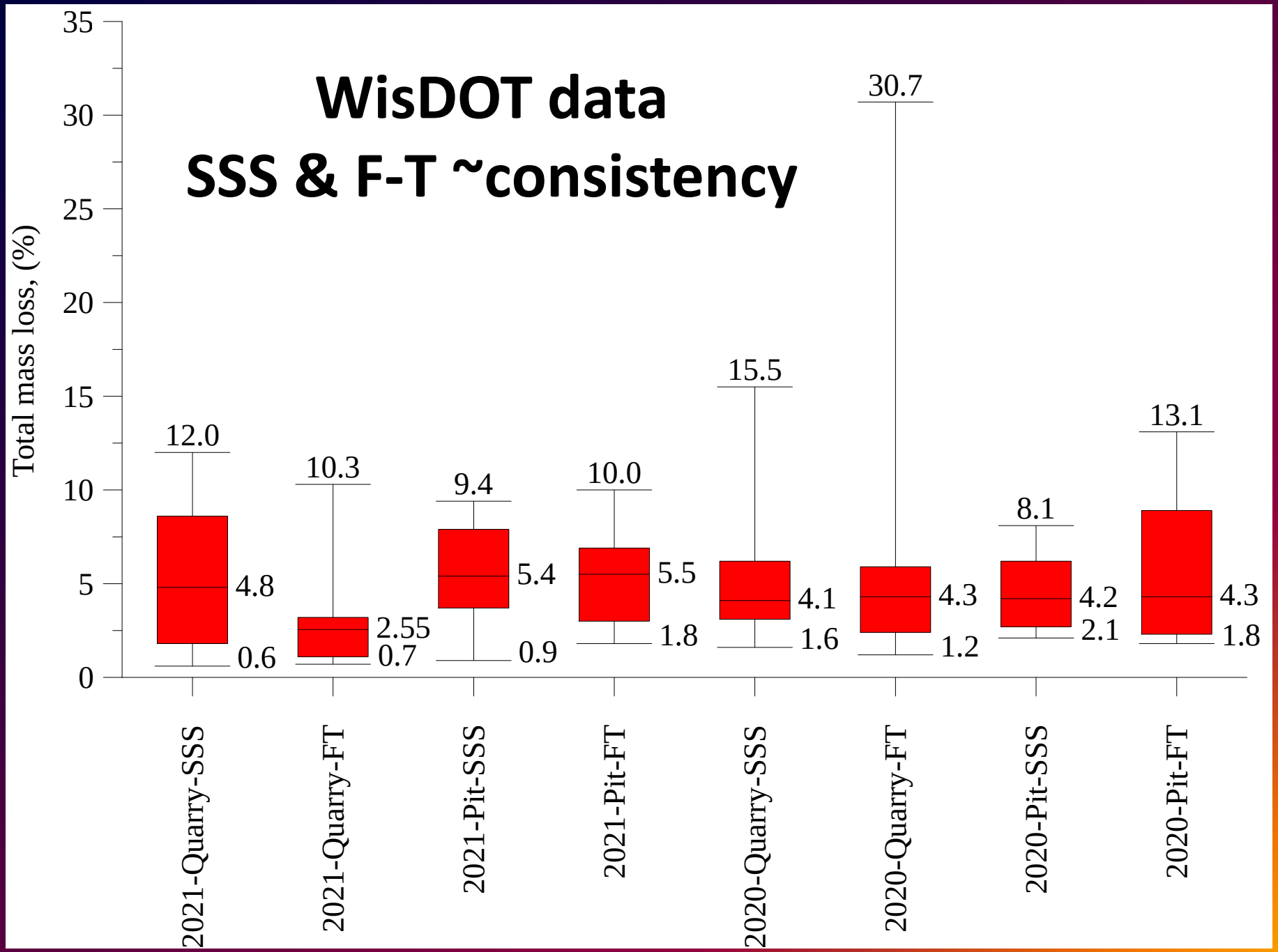


Freeze Thaw Sample Degradation

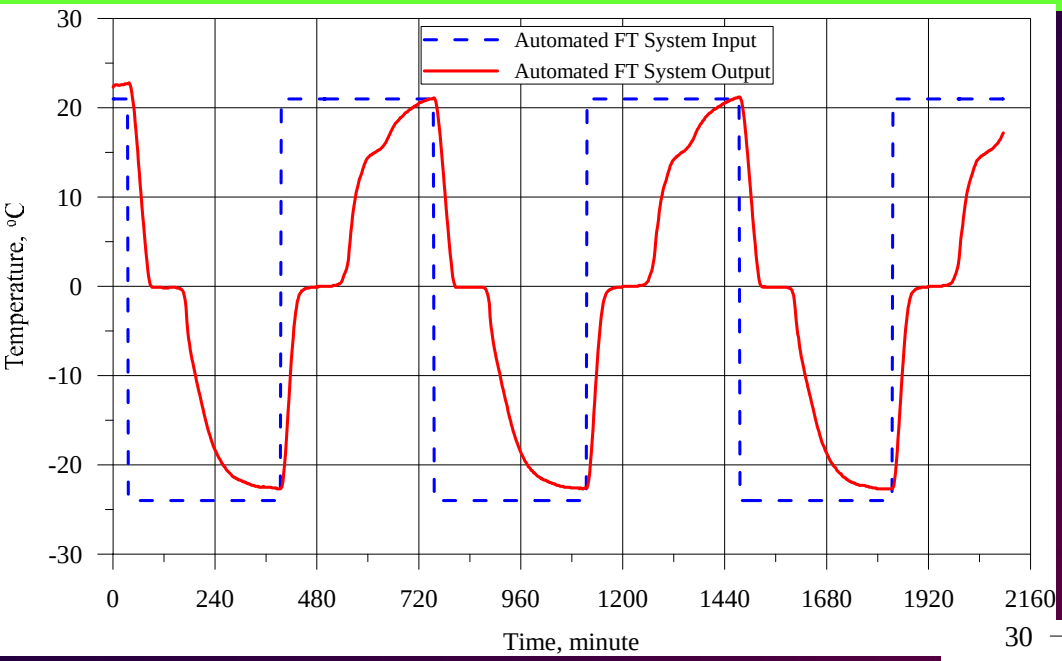
Freeze Thaw Sample Degradation

Freeze Thaw Sample Degradation

CA – SSS vs FT (Recent Data)

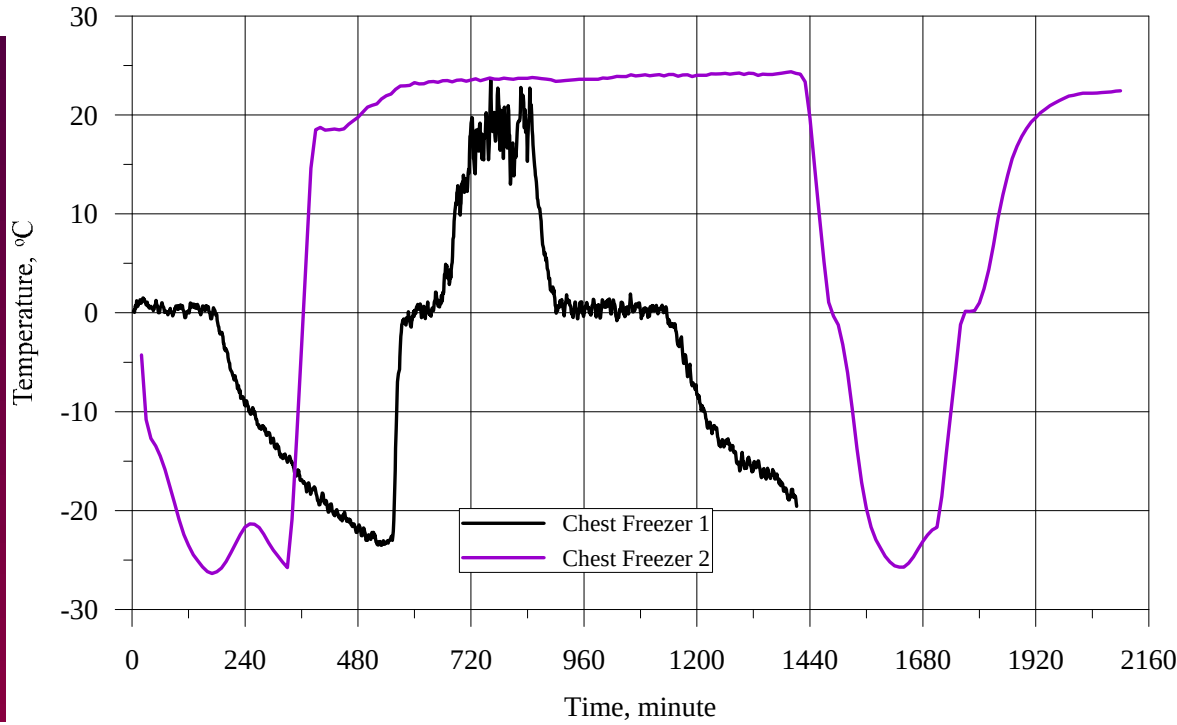


Freeze-Thaw System – CA Performance

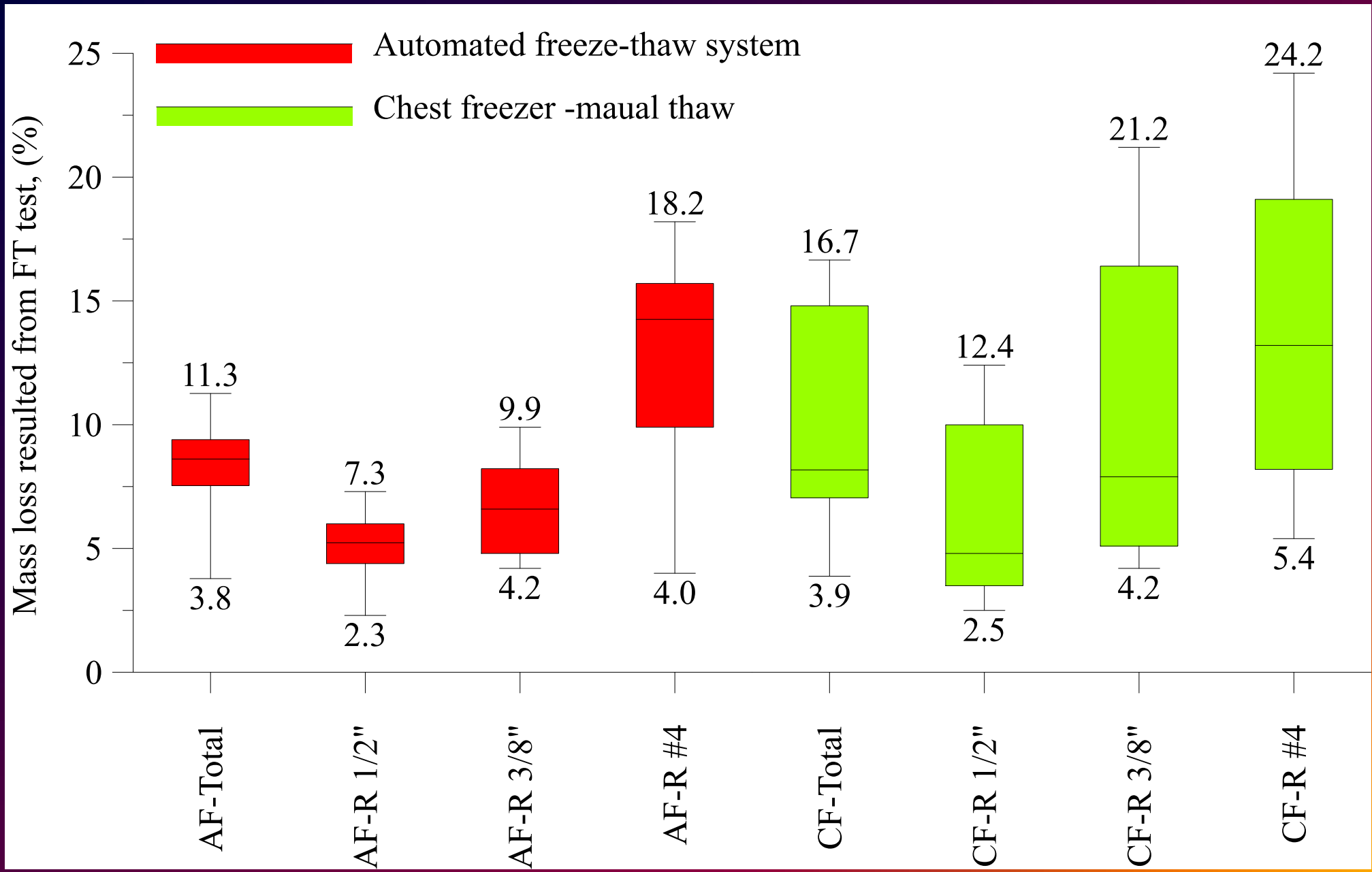


←Automated/programmable F-T System

Chest freezer →

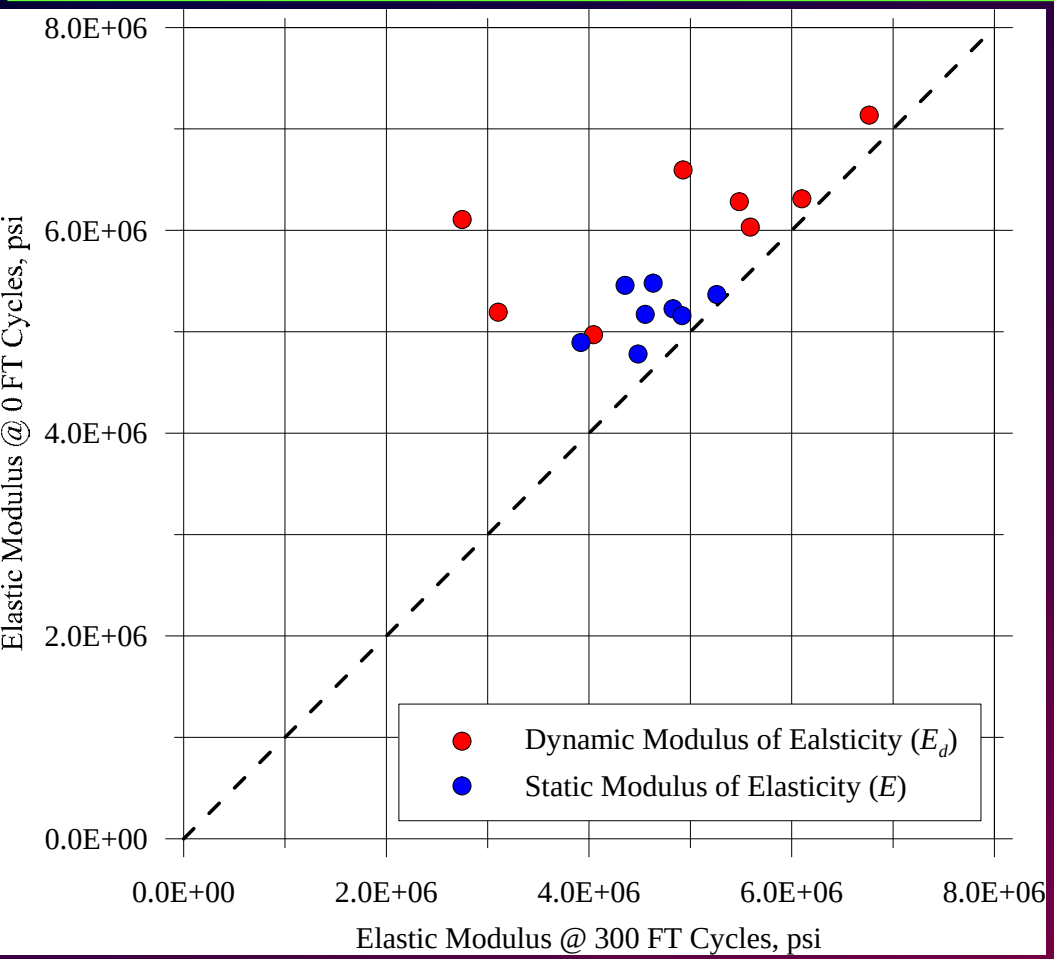


Freeze-Thaw System – CA Performance



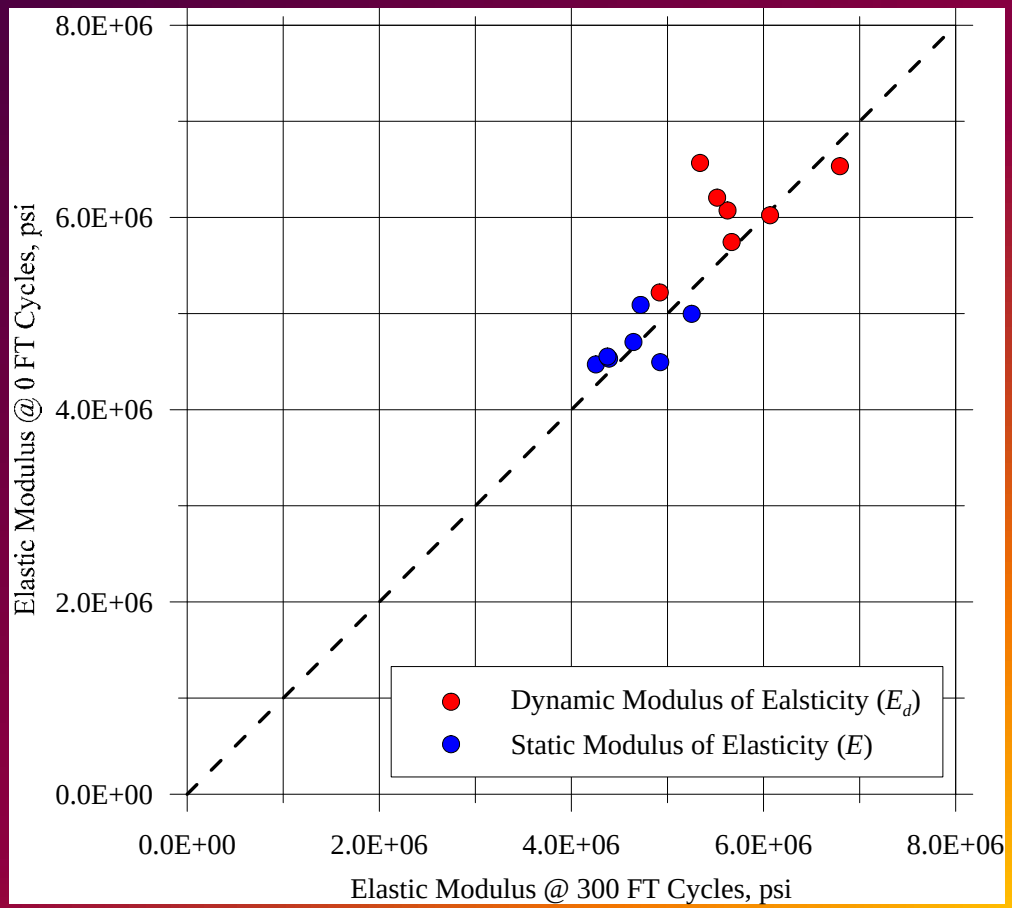
Resistance of PCC to Rapid F-T

PCC – Dynamic Modulus of Elasticity



Short-term

Long-term



Field - Visual Distress Survey

Conclusions

- CLS and DLS (carbonates) coarse aggregates exhibited durability issues compared with coarse aggregates from igneous and metamorphic formations

- Deleterious materials and structures in aggerate (i.e. shale, chalk, bedding planes) may have significantly increased the freeze-thaw loss of certain coarse aggregates from certain quarries.

Conclusions – F-T System

- Temperature-time of the automated F-T test system are consistent and repeatable compared with the chest freezers

- No clear relationship between the chest freezer and automated F-T system test results

Conclusions – PCC F-T (Short-Term)

- The PCC with limestone gravel from pits deteriorated the most at 300-FT cycles

- PCC with CLS and DLS aggregates had mixed F-T performance, but the PCC cylinders with CLS aggregates exhibited significant deterioration

Conclusions – PCC F-T (Long-Term)

- PCC with DLS deteriorated the most due to 300-FT cycles

- Performance of PCC with late-age F-T exposure did not show significant deterioration when compared with the PCC with early-age F-T exposure

Proposed Draft Specifications

- WisDOT modified AASTHO T 103
- Concrete #1 and #2 total mass loss ≤ 12%
- Base ≤ 18% (mean + 2 stdev)

Acknowledgement

- WisDOT POC
  - Erik Lyngdal
  - Dan Reid
  - Bob Downing
  - Josh Seaman
- Russell Frank
- Mathy
  - Erik Olson
- Trierweiler
  - Michael Hammitt
- Payne and Dolan
  - Stacy Glidden
- Kevin McMullen
- Dante Fratta
- Behnke Materials Eng.
- WHRP Geo TOC
- UWM CEE