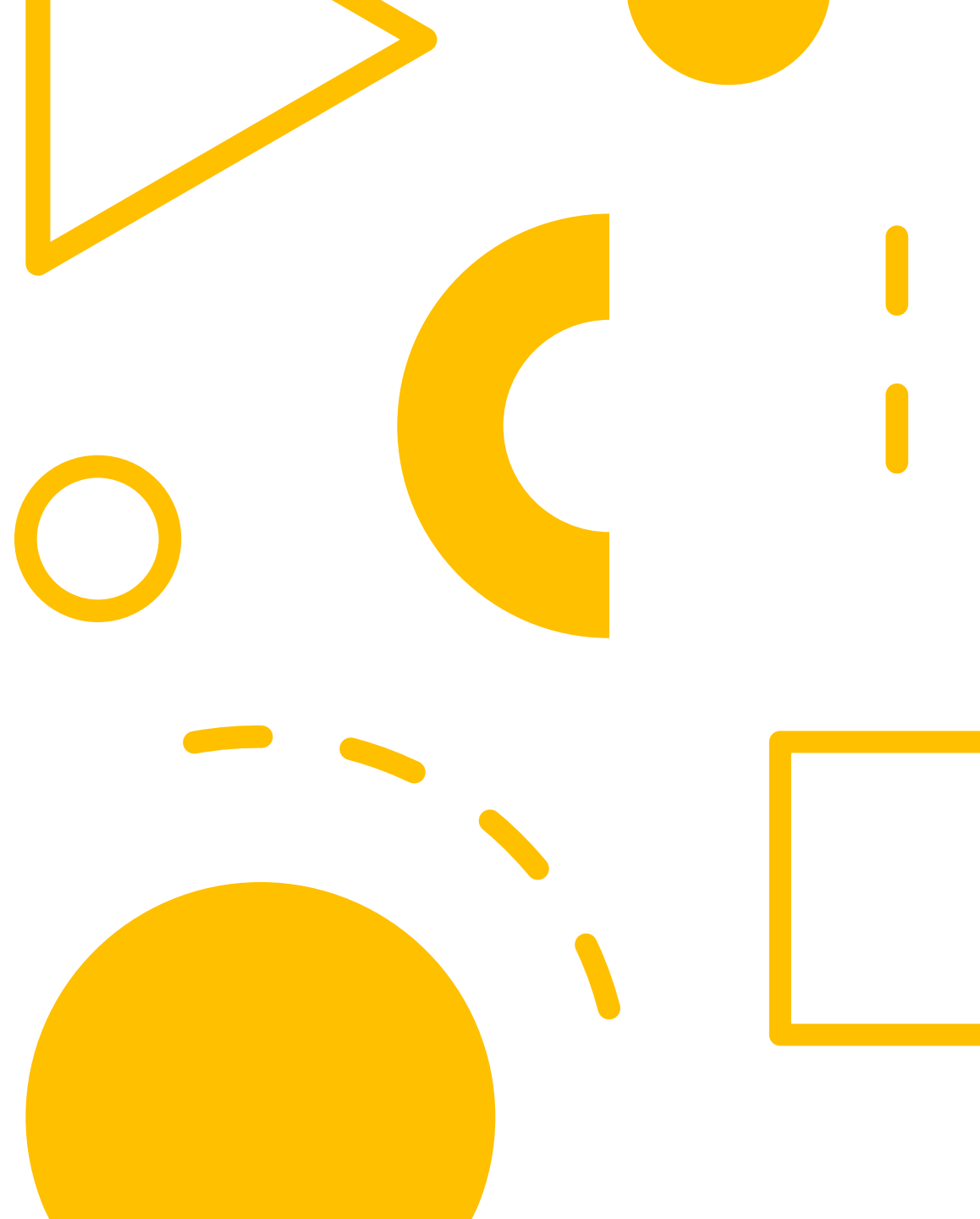


Estimating Relative Strength Loss from Environmental Degradation in Thin Dam Sections Using Portable NDT Methods

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What's the problem with aging infrastructure?

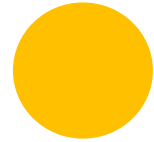
The Assets:

100-year-old concrete structures

The Data Gap: Unknown mix designs, lost records, no baselines

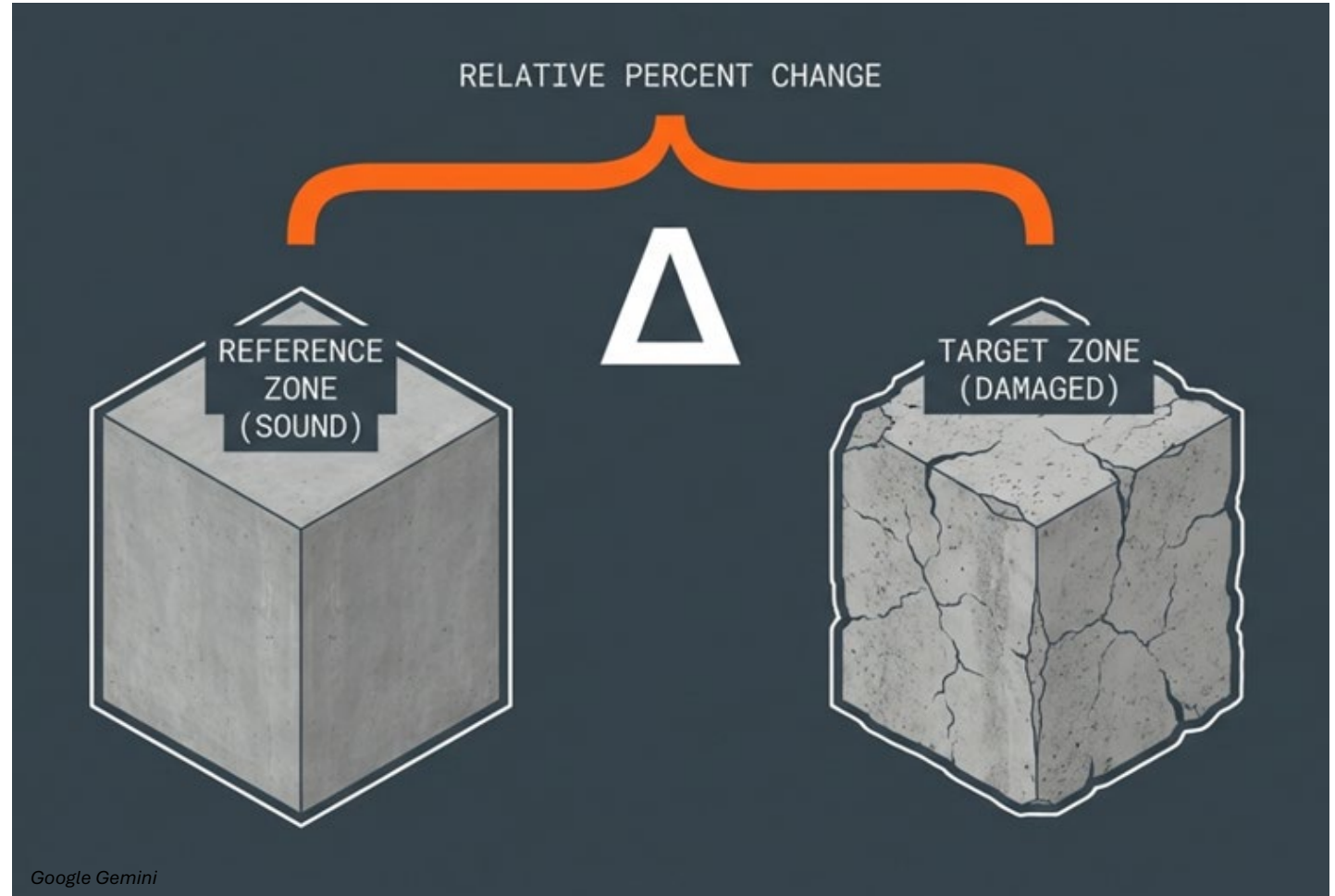
The Material: High water-cement ratios, no air entrainment

The Challenge: Evaluating what we cannot historically verify



The Conceptual Solution

- Need a workaround for the lack of a baseline
- Measure against “healthy” concrete in-situ
- Predict the % strength loss of damaged concrete based on NDT results

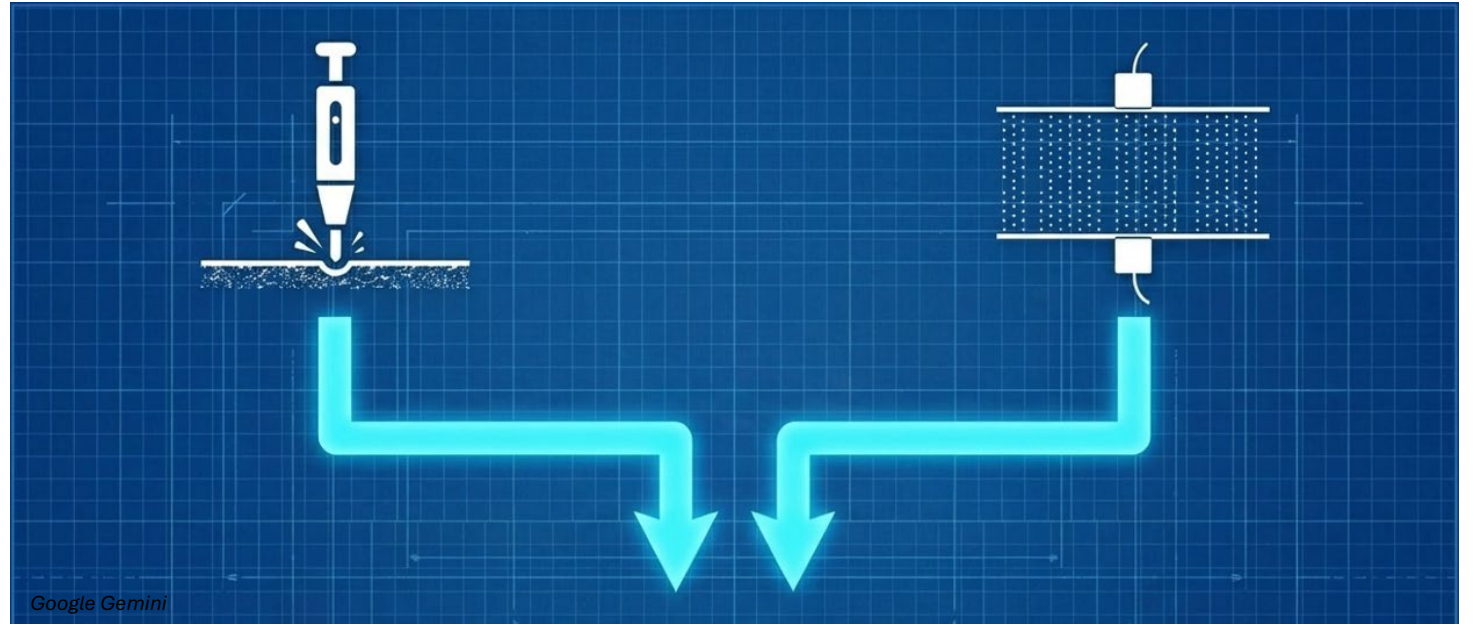


The Toolkit

- Rebound Hammer & Ultrasonic Pulse Velocity



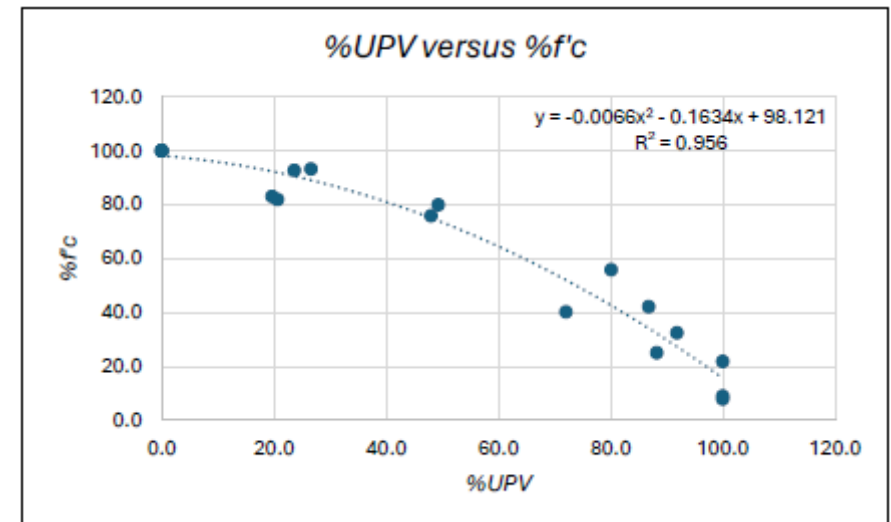
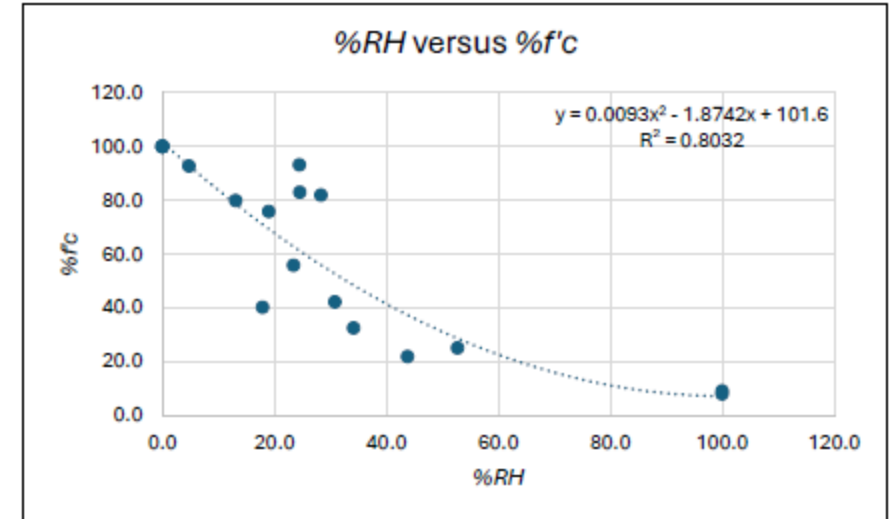
The Purpose: Concrete Degradation Prediction



- 2-factor regression model
 - Predicts % concrete strength loss
 - Based on % change in NDT results

The Basis: Fire Damage

- **Laboratory Testing**
 - 18 4" x 8" concrete cylinder samples
 - Burn durations 30 to 60 minutes
 - Burn temperatures 400° C to 1000° C
- **Regression Analysis (Two-Factor Model)**
 - $\%f'c = 104.73 - 0.332\%RH - 0.631\%UPV$
 - Adjusted $R^2 = 0.95$



The Application to Dams

- **Two Damage Modes**
 - Freeze-Thaw Cycling
 - Alkali Aggregate Reaction
- **Specific Geometry**
 - Thin Sections up to 15m (~49ft)
 - ASTM C597
 - Spillway Piers
 - Corbels
 - Internal Supports



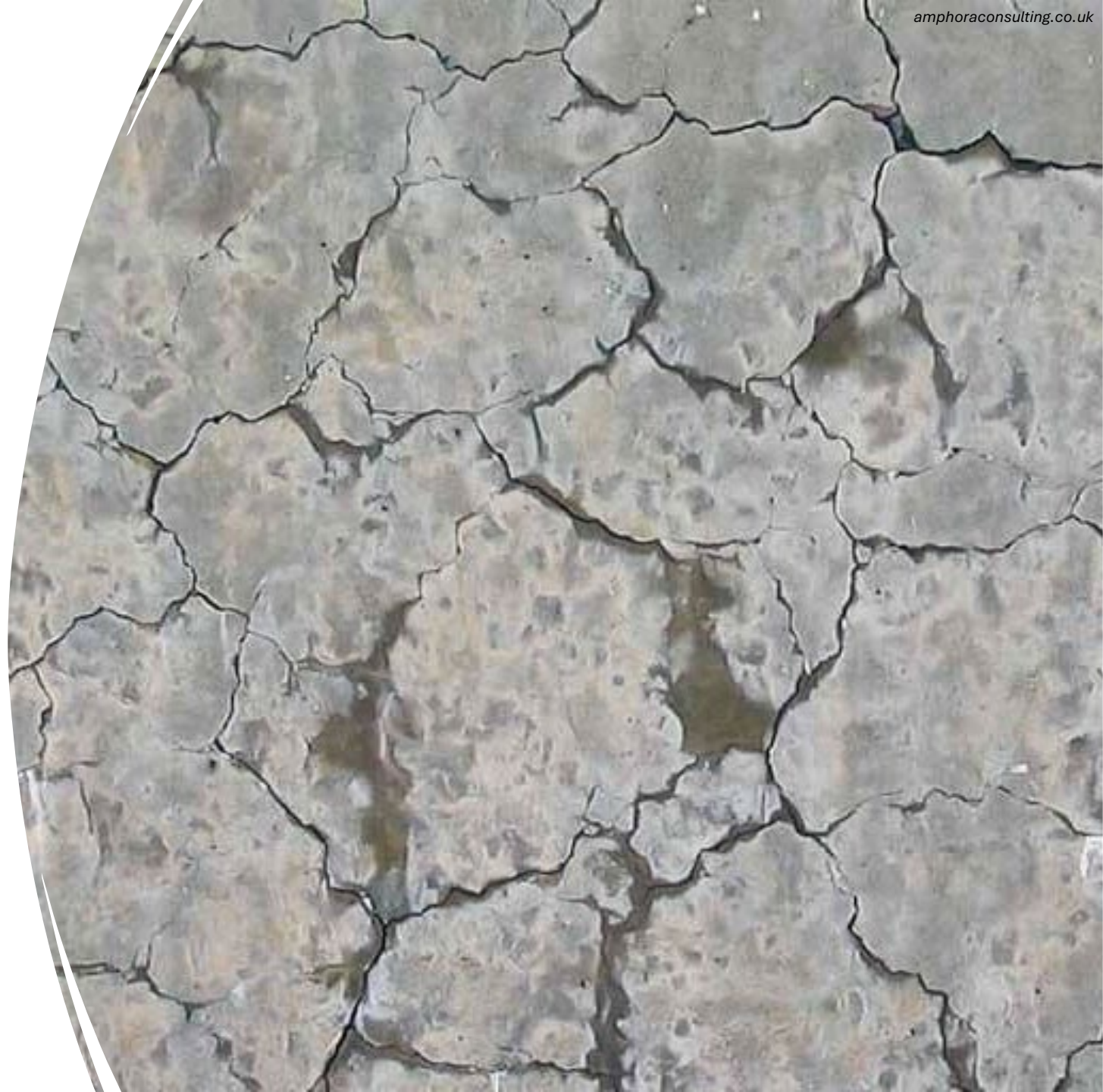
Damage Mode 1: Freeze-Thaw Cycling

- Surface degradation
- Symptom: Weathering, surface softening
- Detection: Reduced rebound number



Damage Mode 2: Alkali-Aggregate Reaction

- Internal Expansion
- Symptom: Swelling gel, internal microcracking, map cracking
- Detection: Slowed Ultrasonic Pulse





Literature

Concrete Degradation in Dams

- USBR DSO-03-05: Effects of Concrete Deterioration on Safety of Dams
- USBR DSO-05-05: Materials Properties Model of Aging Concrete

NDT Methods

- *SonReb Method for Evaluation of Compressive Strength of Concrete*, Chandak et. al. (2020)
- *Advancing non-destructive concrete compressive strength estimation: Large-Scale datasets and machine learning framework*, Matthews et. al. (2026)

ASTMs

- Samples: C192, C470
- Testing: C597, C805
- AAR: C1293, C1567



Project Progress

- 36 4" x 8" concrete cylinder samples
 - 18 standard concrete mix
 - 18 "spiked" with NaOH to accelerate AAR
 - 1.25% by mass of cement, adapted from ASTM C1293



Project Progress

- 6 Batches
 - Controls
 - Freeze-Thaw Cycling:
 - 10, 20, 40, 60, 80, 100
- Suspended Curing
 - Maintain Moisture
 - Prevent Leaching
- Testing
 - Rebound Hammer
 - UPV
 - Compressive Strength



Summary

- Aging concrete structures do not adhere to modern standards
 - Design specs and documents are difficult or impossible to obtain
- Need a way to assess aging structures for strength loss
- Apply NDT methods against “healthy” in-situ concrete
- Verified testing fire damage to bridges
- Apply the same concepts to dams
 - AAR and freeze-thaw
 - Critical thin sections



Questions?

