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Behind the Ashes- Fire Damage Assessment of Concrete

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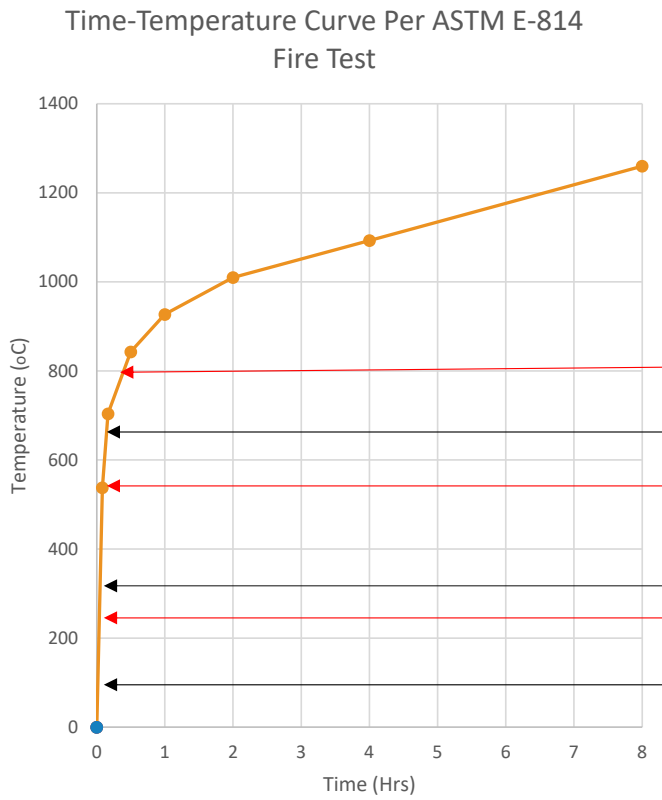
Restore | Repurpose | Renew

Learning Objectives

1. The assessment process
2. Site test methods
3. Lab test methods.

How is concrete affected by fire?



300°C (570°F) Isotherm: Assume concrete is damaged

375°C (700°F) Isotherm: Assume 50% strength reduction

800°C, Limestone aggregate will expand causing spalling

650°C, 80% loss of concrete strength

500°C-600°C, Color change to purple/gray and cement dehydration complete and is soft and cracked. Aggregate expands. Reinforcement undergoes microstructural changes.

320°C, High strength concrete starts to spall

250°C-290°C, Color change of aggregate begins pink/red and surface crazing begins

100°C, Concrete loses free water

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Where To Start?

- Gather information prior to site visit.
  - Drawings
  - Information about the event
  - What tools might be needed for the site assessment
    - Ladders/lifts
    - NDT equipment vs. visual only
  - Formulate an assessment plan with the understanding that it will likely change while onsite.

Visual Site Assessment

Visual Site Assessment

Complete an initial walk-thru.

- Locate a possible control area- what was the condition of the structure prior to the fire?
- Take A LOT of photos!

Visual Site Assessment

Identify and locate these indicators:

- Soot/Smoke
- Melted interior finishes
- Friable surfaces
- Discoloration
- Spalling/Cracking
- Differential movement

Soot and lack of soot

Condition of interior finishes and electrical/mechanical equipment

Melted Pipe

Intact Flooring and Paint

Discoloration

Painted surface with soot **vs** **Discolored surface from Fire**

Close up of the discolored CMU

Cracking

Spalling

Movement

Non-Destructive Field Testing

Non-Destructive Testing

- Generally Noninvasive
  - May mean different things depending on your point of view.
  - Are cores extracted from a structure noninvasive?
- ACI Definition – “Any test preformed that causes no structurally significant damage to the concrete”

Non-Destructive Testing

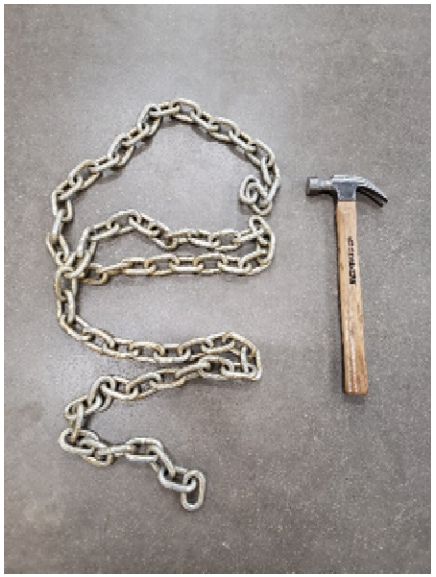
- Selection of Methods
  - Understanding the situation
  - Determine the **"GOALS"** of the investigation
  - Understanding advantages and limitations of different test methods
- Practical Considerations
  - Cost
  - Timeline
  - Physical Access
  - Reliability

Non-Destructive Testing

Tests:

- Sounding
- Ground Penetrating Radar (GPR)
- Ultrasonic Pulse Velocity (UPV)
- Impact Echo (IE)
- Rebound Hammer in conjunction with Compressive Strength Testing

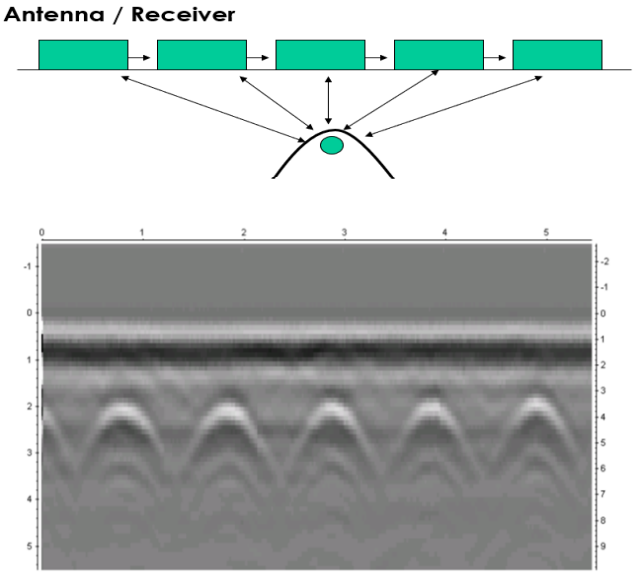
Sounding



- Running a chain along the surface of the concrete or tapping the surface on the concrete with a hammer.
- A distinctive hollow or “tin” sound is heard at locations of delaminations.

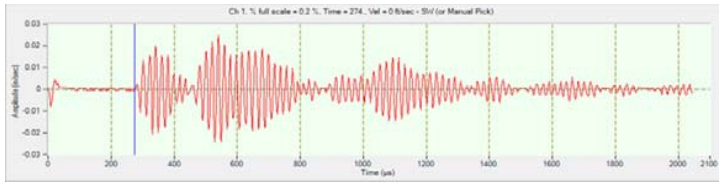
Ground Penetrating Radar (GPR)

- A GPR “event” is an electromagnetic pulse and the returning responses
- Responses are recorded over a set time window
- By compiling GPR events we create a time slice (depth) profile
- Detect possible voids and locate reinforcement



Ultrasonic Pulse Velocity

- Ultrasonic Stress Wave
- Pitch & Catch Method
- Pick initial arrival time
- Calculate wave “speed”



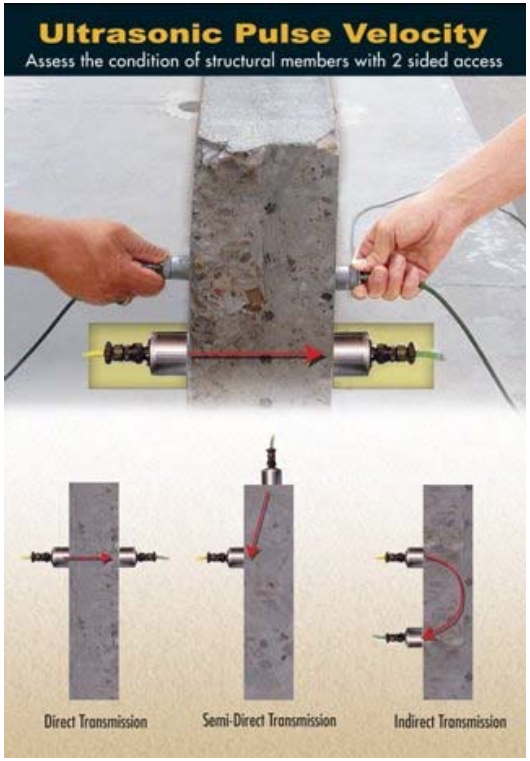


Figure Provided by Olson Instruments

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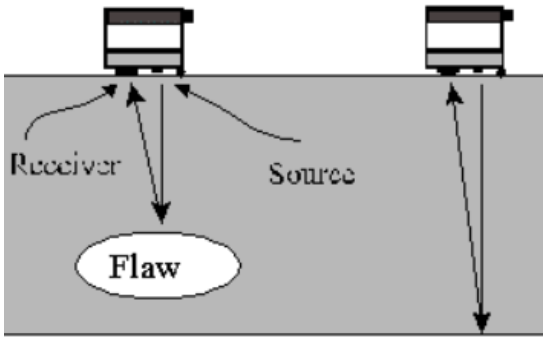
Impact Echo

- Mechanically induce stress wave
- Record returning wave(s)
- Detect flaws based on returning waveforms



Compressive Strength/Rebound Hammer

Take cores and complete compressive strength Testing

Correlate rebound hammer values to the compressive strength values

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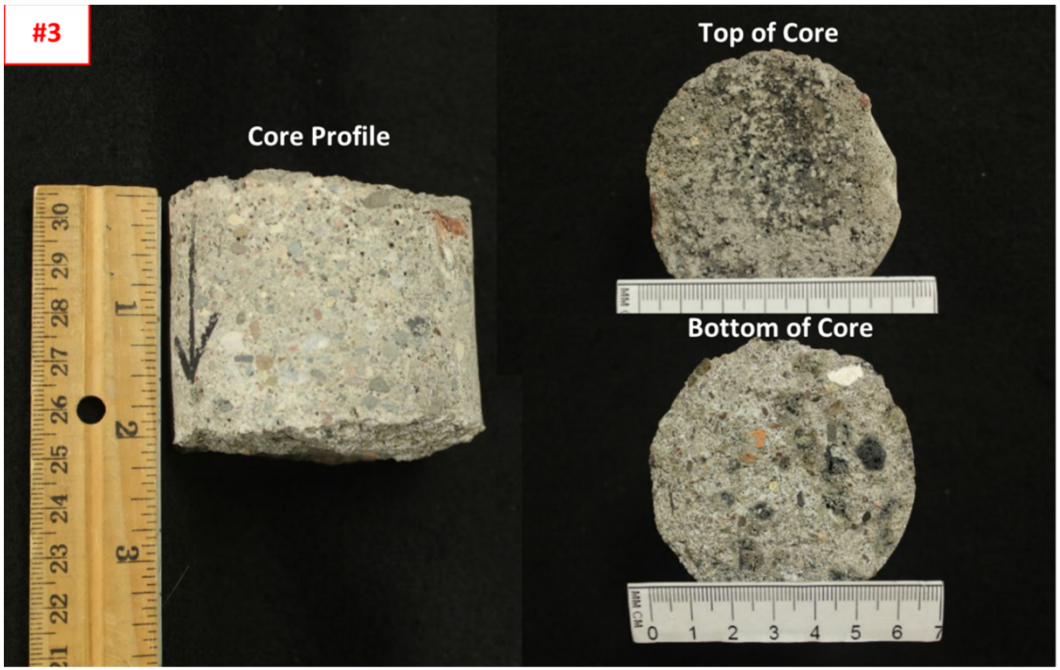
Petrographic Analysis

Petrographic Analysis

Tests:

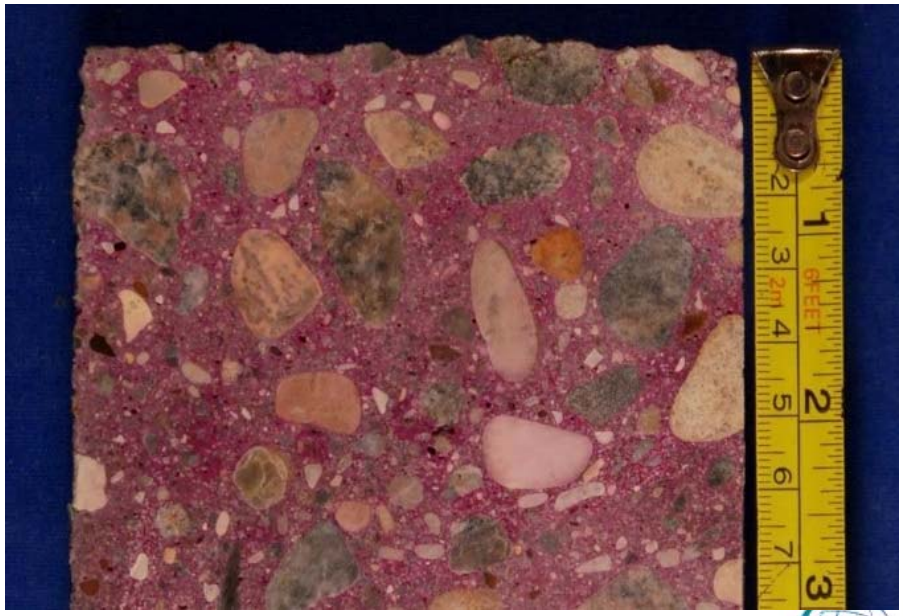
- Carbonation
- Discoloration
- Microcracks/Cracks
- Voids



Petrographic Analysis

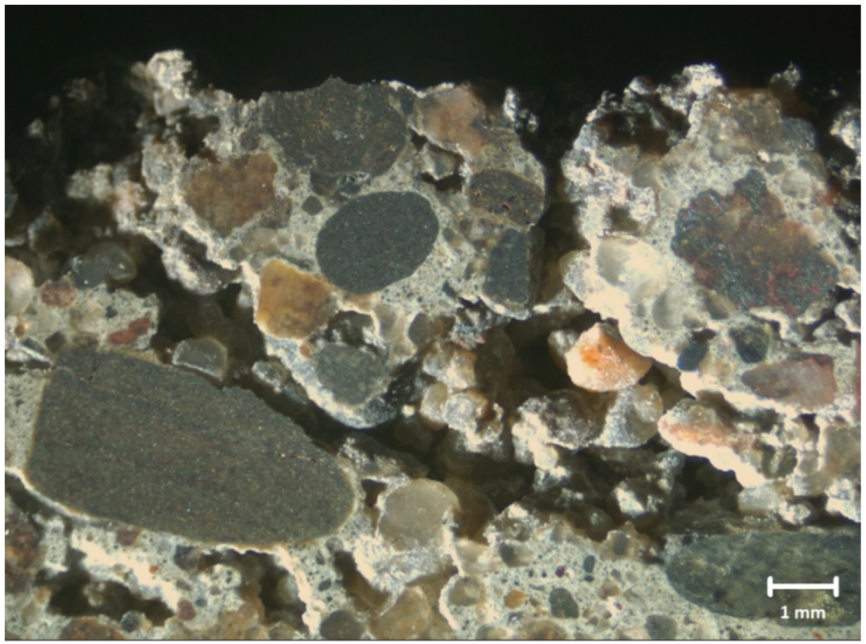
Discoloration

Carbonation

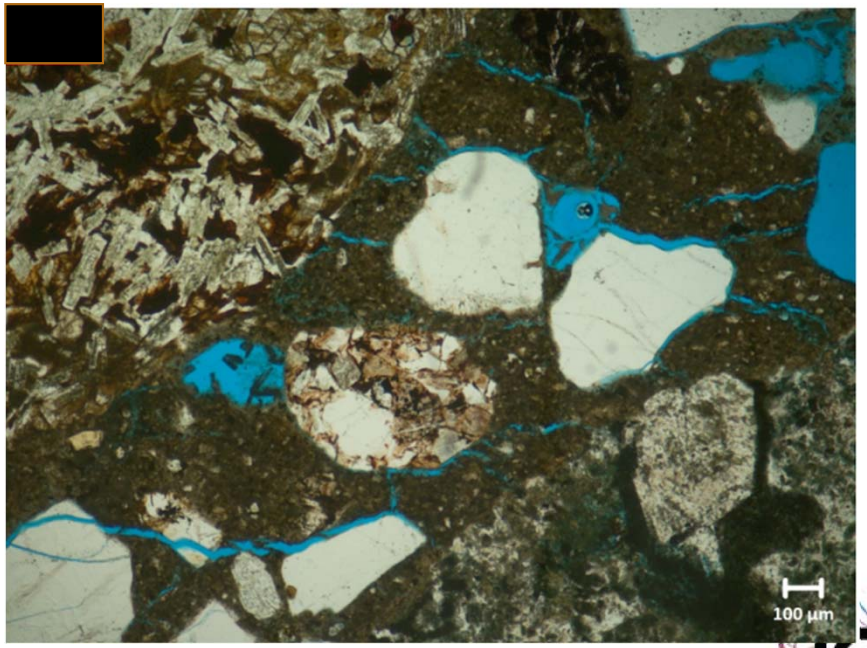


Petrographic Analysis

Friable surface, missing cement paste



Horizontal Cracking



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Next Steps

- Based on the performed site visit and testing:
  - Destructive Testing
    - Removal of a portion of the concrete to review interior condition- find the "good" concrete
  - Repair options
    - Patching
    - Reinforcement such as FRP/FRCM
    - Partial section replacement
  - Replacement
    - Remove and fully replace with new concrete

Special Thanks to:

- Alfred Gardiner, PE – Concrete Technical Leader, Braun Intertec
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Questions?

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