Implementing Maturity Systems for Paving and Bridge Applications

Fall 2019 National Concrete Consortium
Kalispell, MT

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Table of Contents

Maturity Systems

- NDT tool
- Includes:
  - Sensors
  - Some way of collecting data from sensors
  - Software

Typical Applications

Temperature Monitoring

- Mass Placement
- Cold Weather Placement
- Hot Weather Placement
- Precast

Maturity - In Situ Strength Evaluation

- Form/Falsework Removal
- Post Tensioning/Precast
- Opening to traffic
- Loading structures

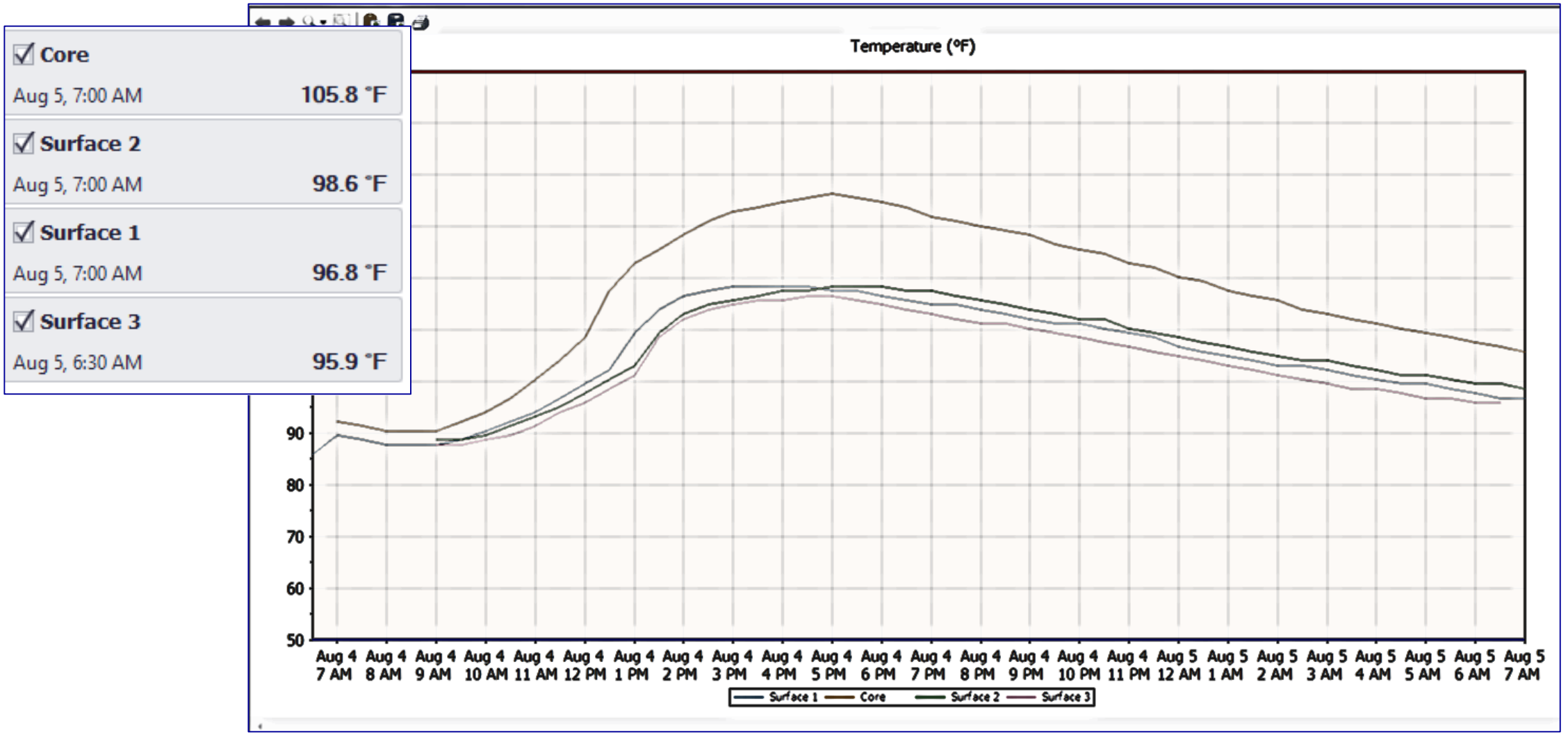
Maturity Systems for Temperature Monitoring

Specifications

Cold weather:

- Alabama: ...furnish two "continuous temperature reading" thermometers for the measurement of the concrete surface temperature. The measurements shall me made as directed by the Engineer.
- Nevada: Monitor temperatures with thermocouples at top and bottom surfaces
- New York: Place recording surface thermometers between the pavement surface and insulating material.

See Temperature History



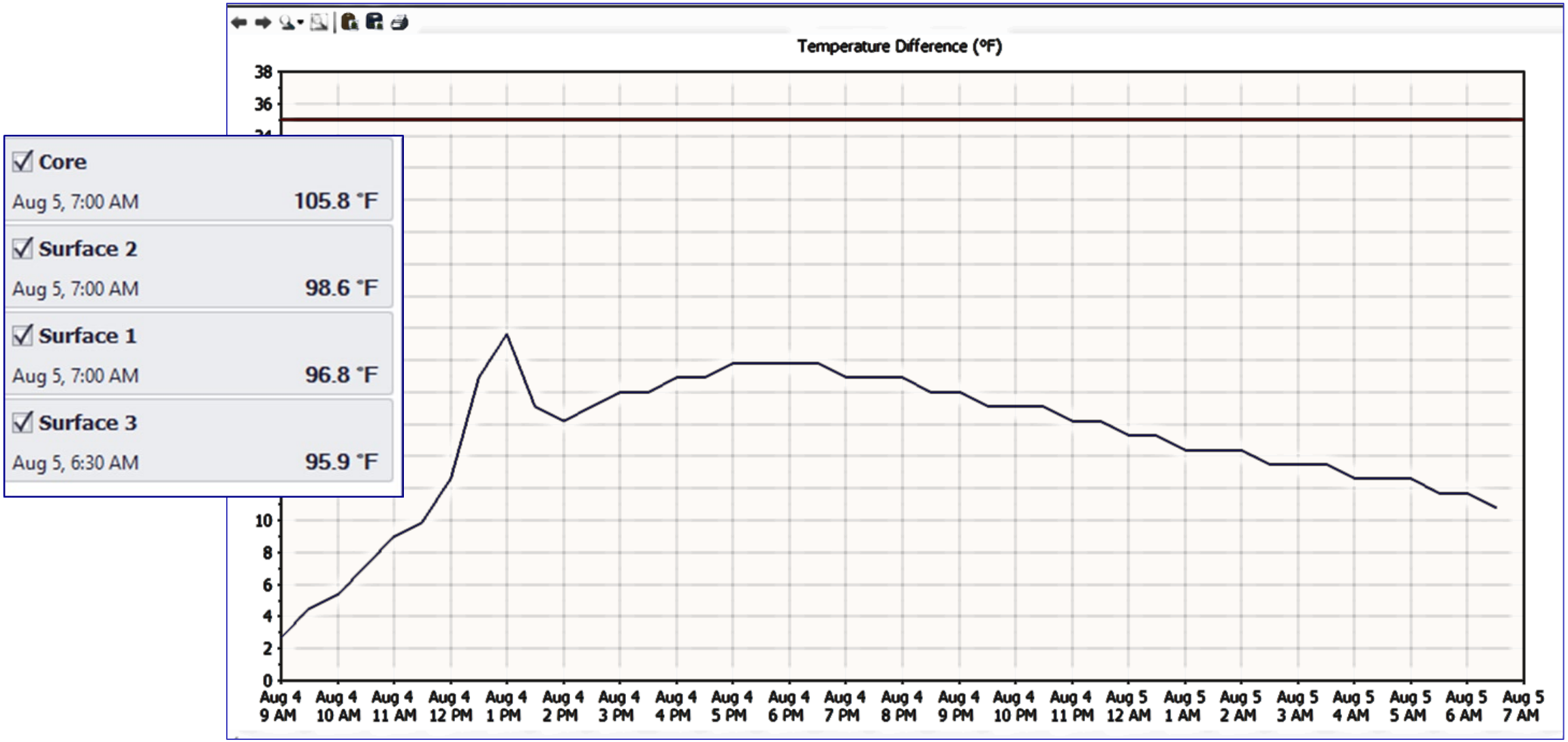
Specifications

Mass placement:

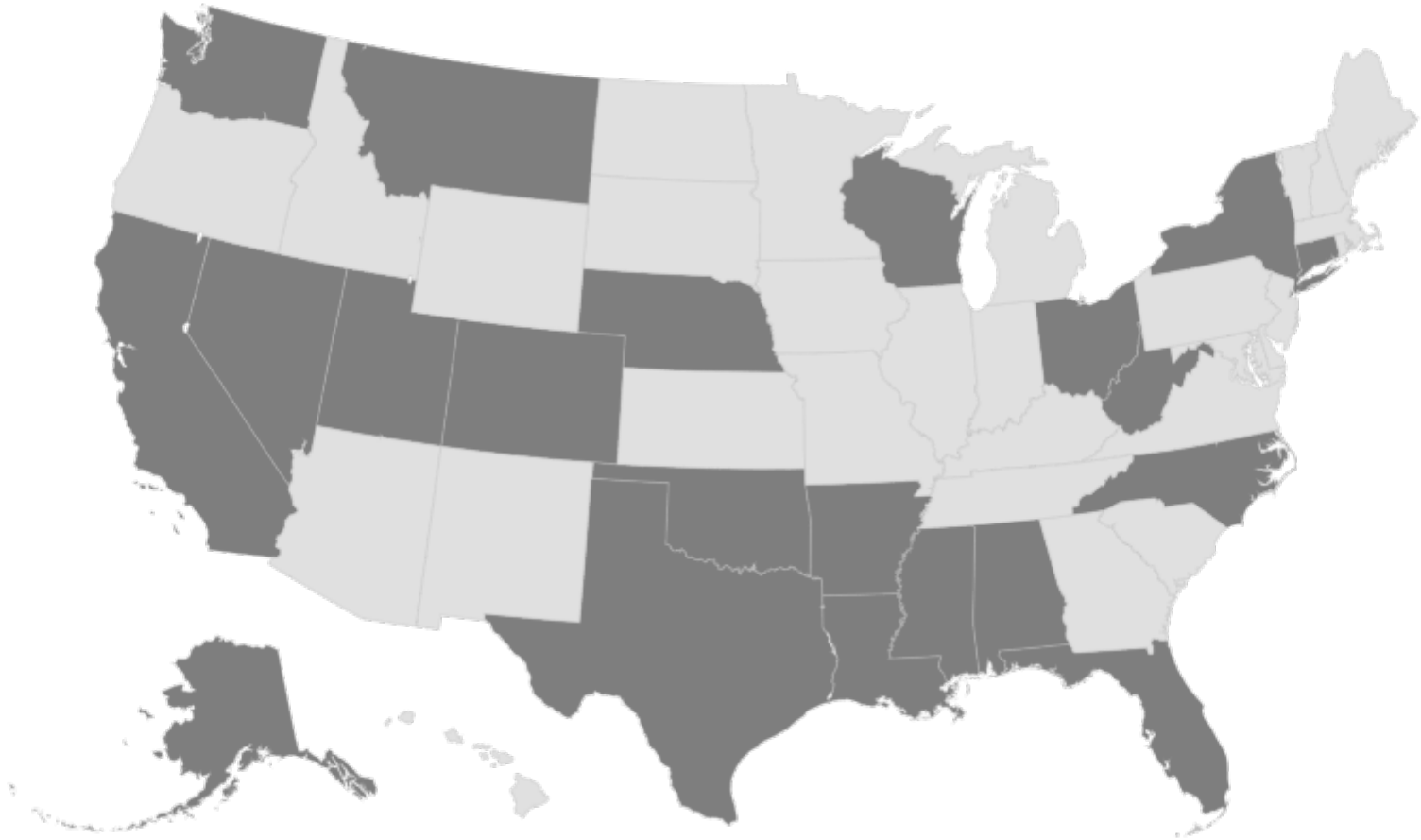
- Louisiana: A maximum temperature during curing of 160ºF and a maximum differential temperature of 35°F is allowed.

- Ohio: As a minimum, concrete temperatures shall be monitored at the calculated hottest location, on at least 2 outer faces, 2 corners, and top surfaces.

See Temperature Differentials



Temperature Monitoring



Mass Placement Application

Gerald Desmond Bridge

Courtesy http://www.shimmick.com/projects/gerald-desmond-bridge-replacement

Courtesy https://www.facebook.com/newgdbridge

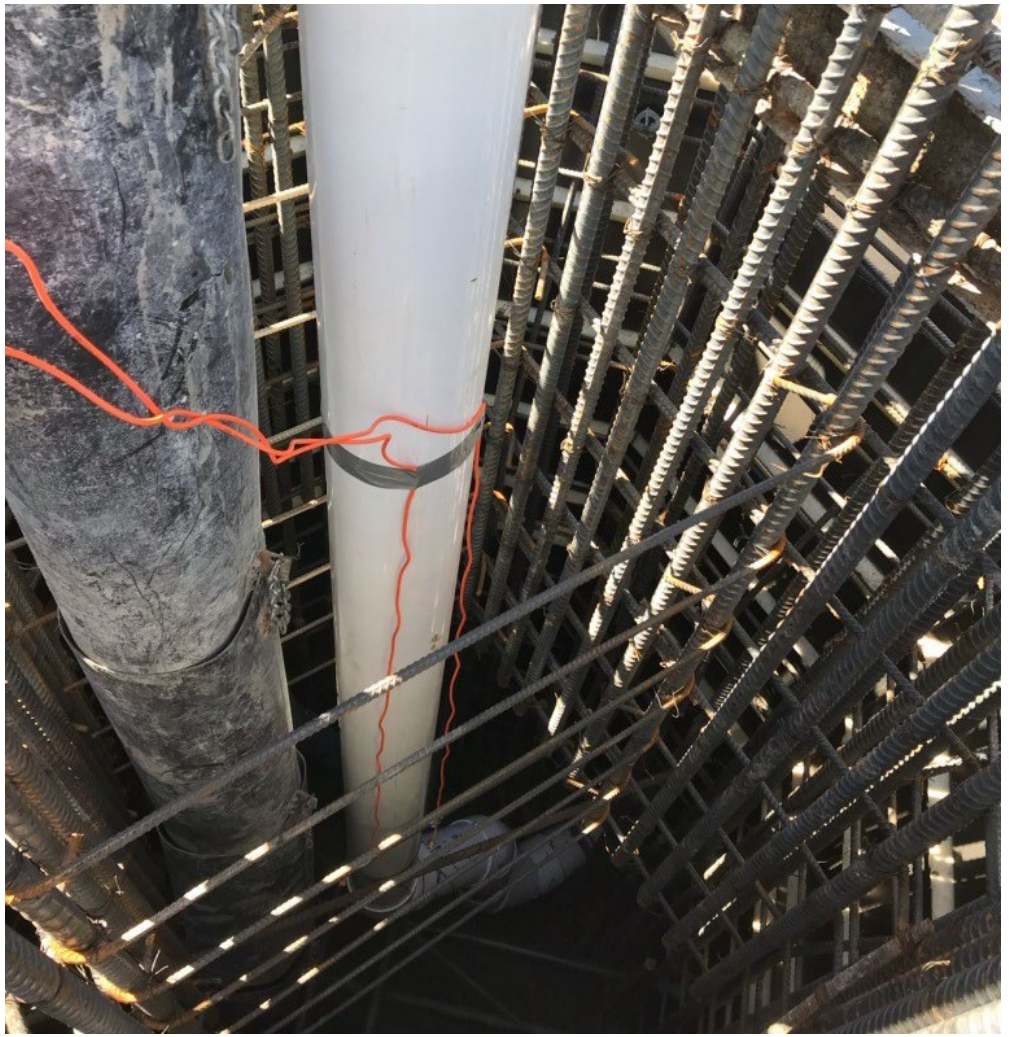
Mass Placement Application

DFW Connector

Courtesy http://www.dfwconnector.com/photosandvideos.php

Mass Placement Applications

I-35 and US 183



Maturity Systems for In Situ Strength Estimations

Maturity Highlights

- Benefits
  - Increased safety
  - Expedited construction schedules
  - Improved construction methods
- Advantages
  - Provides instant predictions of in-place strength
  - Not operator dependent
  - Not specimen dependent
  - Simple test method/Portable equipment
  - Efficient and consistent
  - Can improve quality control

Build safe.

Build faster.

Build better.

Save money.

Maturity Considerations

- Measures only time and temperature
- Does not account for humidity conditions during curing
- Mix specific
- May not fully characterize long-term strength

Maturity Specifications

Pavements

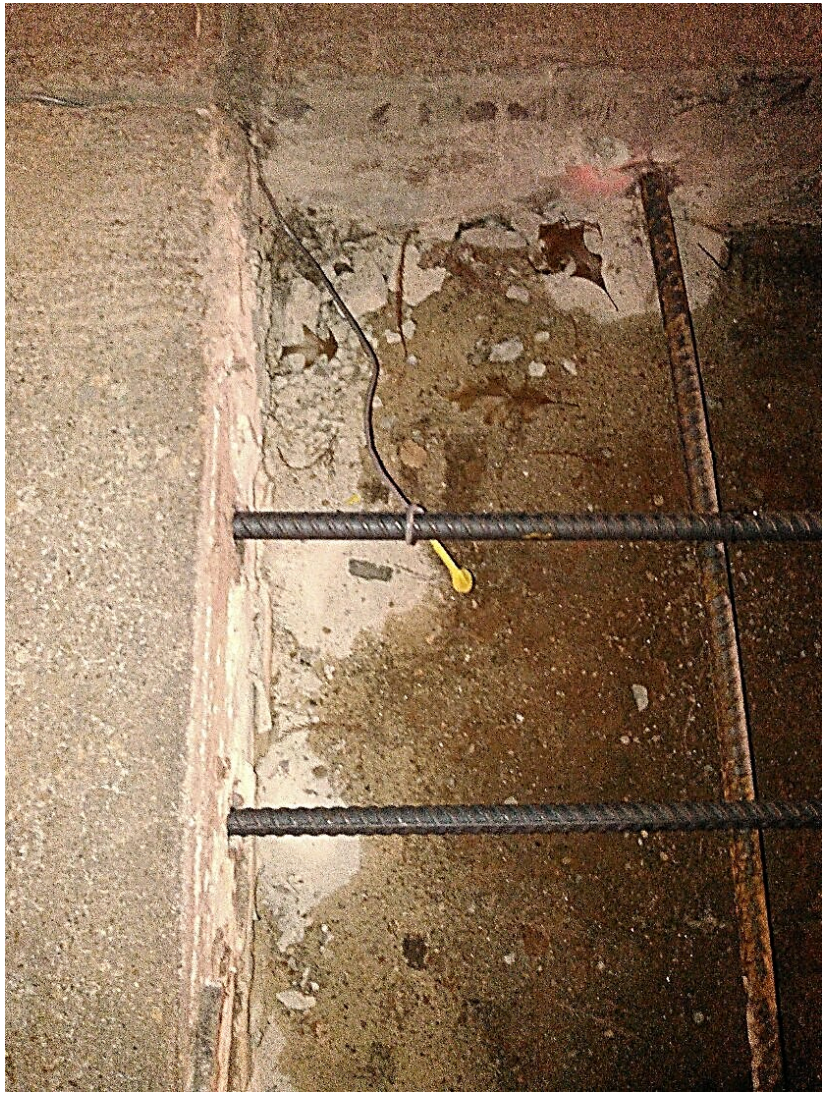
- Idaho: Do not allow traffic on the pavement until a 3,500 psi or greater compressive strength is attained determined by maturity testing in accordance with ASTM C1074.

- Kansas: The flexural strength of the pavement shall meet or exceed 450 psi. Determine the flexural strength of the pavement by testing flexural strength specimens utilizing the third point loading method, or by use of a calibrated maturity meter.

Maturity Application

Pavement Repair – TX, Utah

Courtesy Ryan Williams



Courtesy John Eitel and Scott Riegler

Maturity Specifications

Structures

- New Mexico: The Contractor shall not place the load of the Superstructure on the Substructure until the Substructure concrete has been in place for at least 14 Days or until in place strength measured by the Maturity Method indicates that the concrete has attained 75% of the design strength.

- Colorado: For formwork: Concrete compressive strength shall be determined by maturity meters in accordance with CP 69.

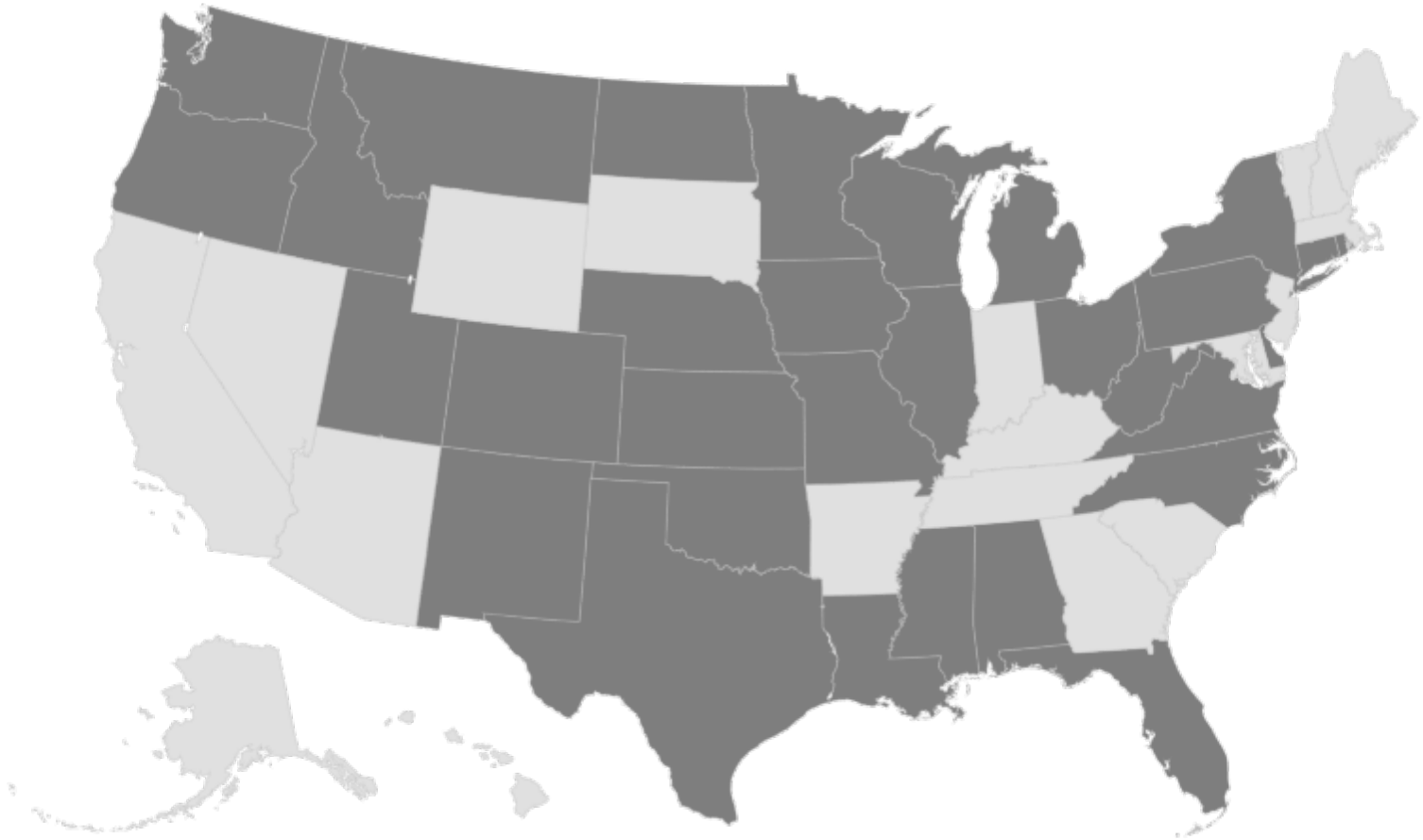
Maturity Application

US 6 - Colorado

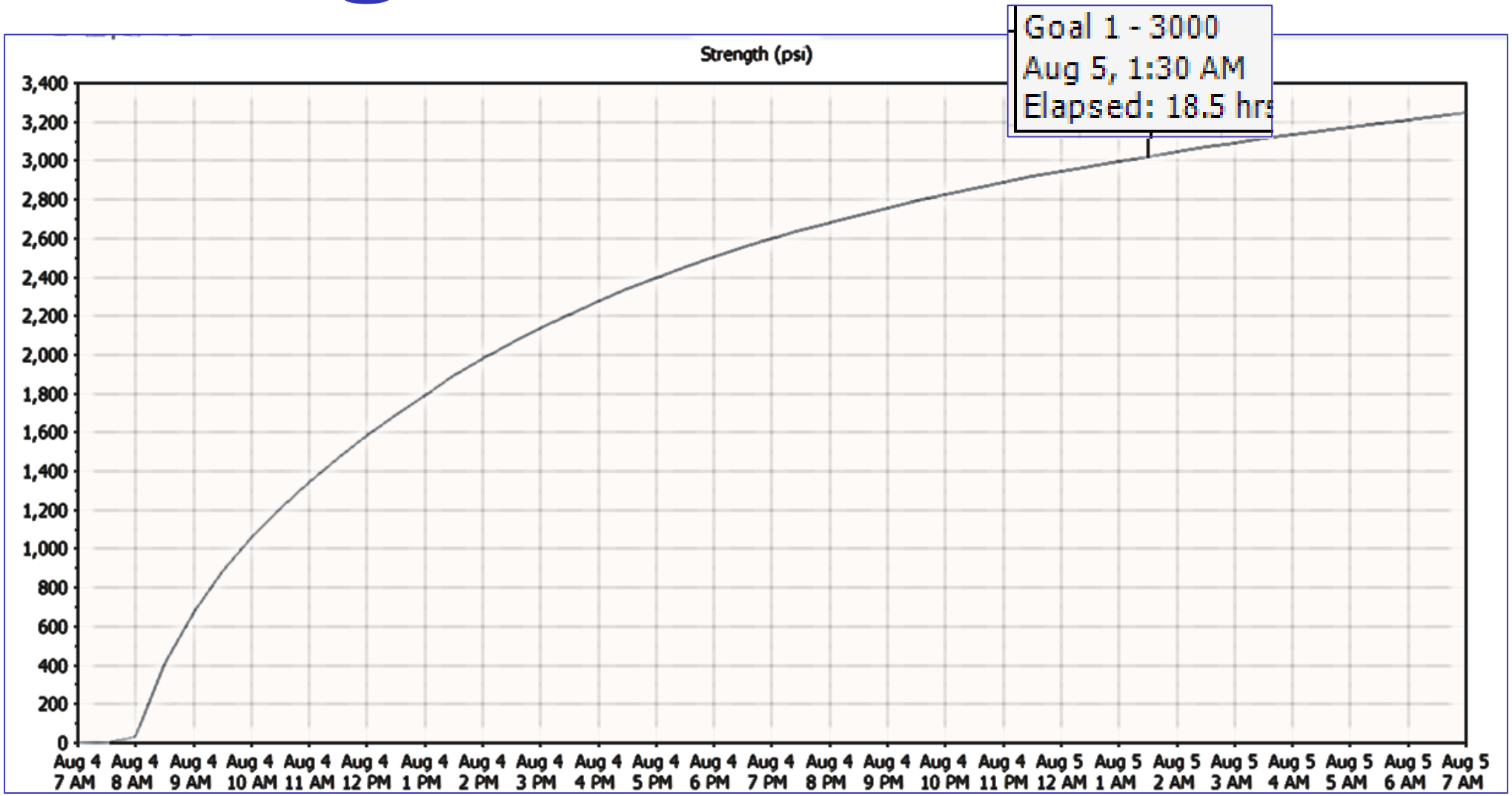
- Design Build
- $100 million project
- Used on structural components

Courtesy Stefan Hennig

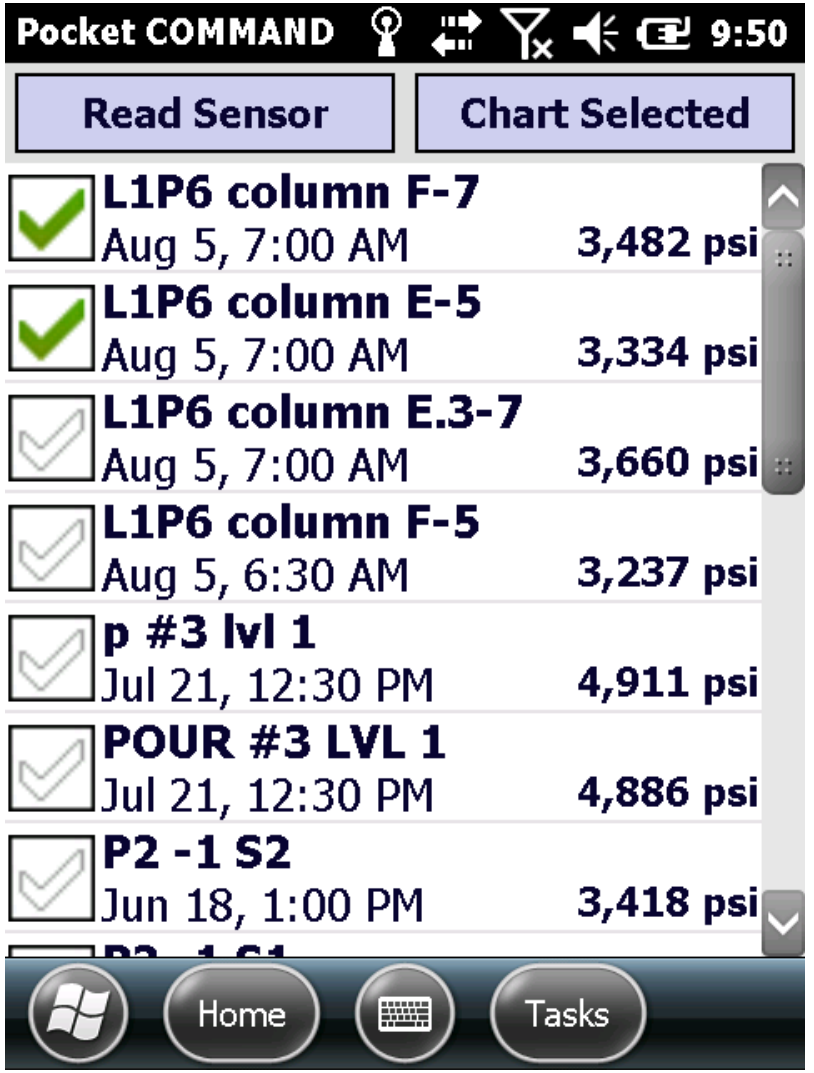
Maturity Specifications



See Strength Gain



See/Report Strength



Maturity Systems for Quality Control

- HIPERPAV
- Consistency

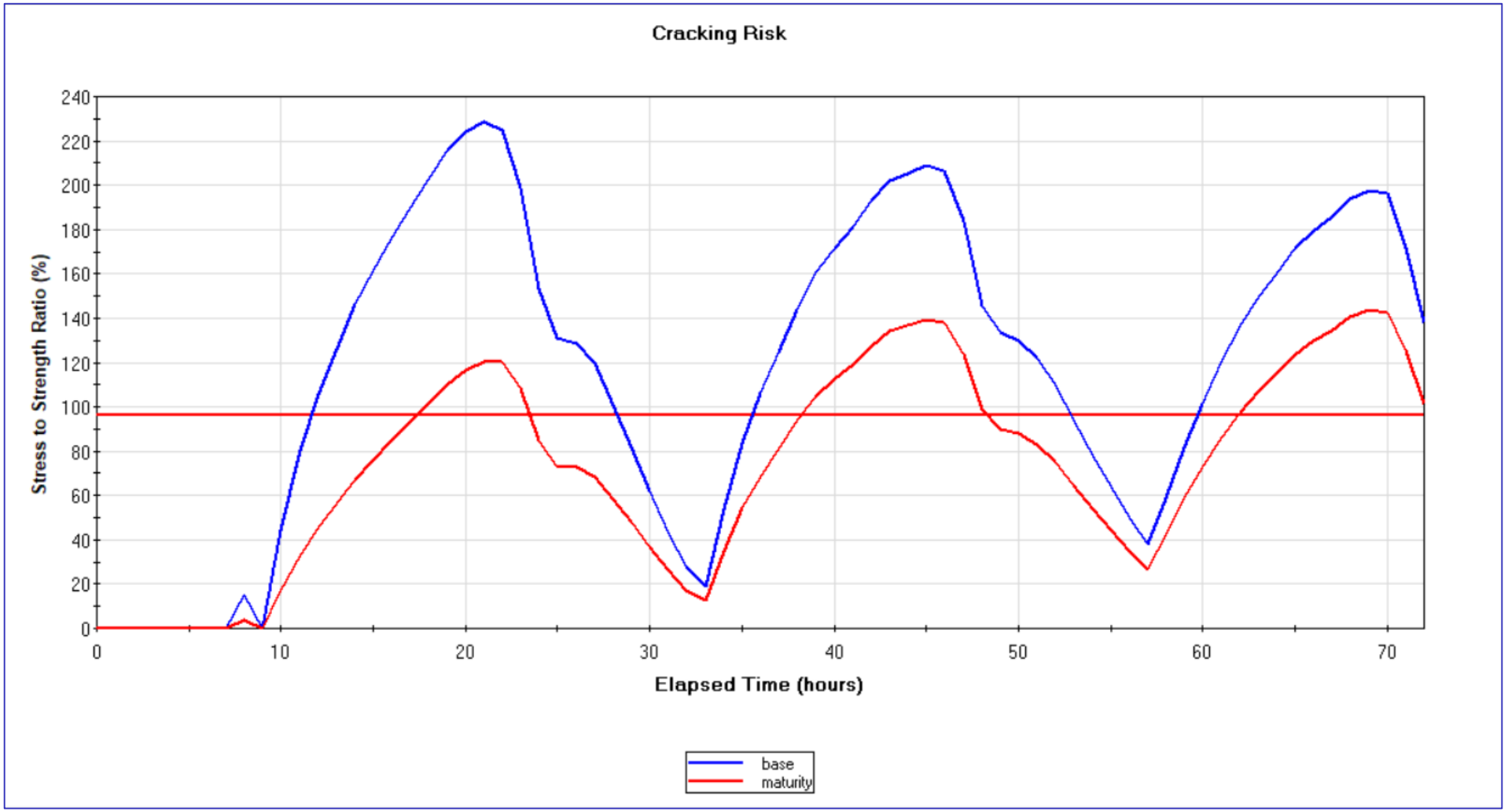
Maturity Application

- Caltrans **40-4.01C Submittals** JPCP:

  At least 24 hours before each paving shift, submit the following information as an informational submittals:

  - 1. Early age stress and strength predictions
  - 2. Schedule of sawing and curing activities
  - 3. Contingency plan if cracking occurs

HIPERPAV


Cracking Risk
Stress to Strength Ratio (%)
240
220
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
Elapsed Time (hours)
base
maturity

Steps for Implementation to Evaluate Strength

1. Create the Maturity Curve.
2. Place sensors in the field.
3. Use the maturity curve to determine strength in the field.
4. Validate the maturity curve.

Validation

- What does validating the curve mean?

  Test that the maturity curve developed for the mix still represents the concrete being delivered and placed.

- Why is validation important?

  You have to make sure that the curve you are relying on represents the mix that is being delivered in the field.

  Changes in water content (among other things) can affect the accuracy of the curve.

- What test methods can I use?
  - ASTM C 31/C31M
  - ASTM C 873/C873M
  - ASTM C803/C803M
  - ASTM C900AXTM C918/C918M
  - ASTM C684

Cast companion cylinders and embed a sensor in one

- Cast test specimens when the concrete is being poured for the element in the field.
- Embed a sensor in (at least) one of the specimens.
- Be sure that the specimens have enough moisture during curing for complete hydration.
- Be sure all specimens, including the one with the sensor, all cure TOGETHER.

Compare Results – Requires Consistency!

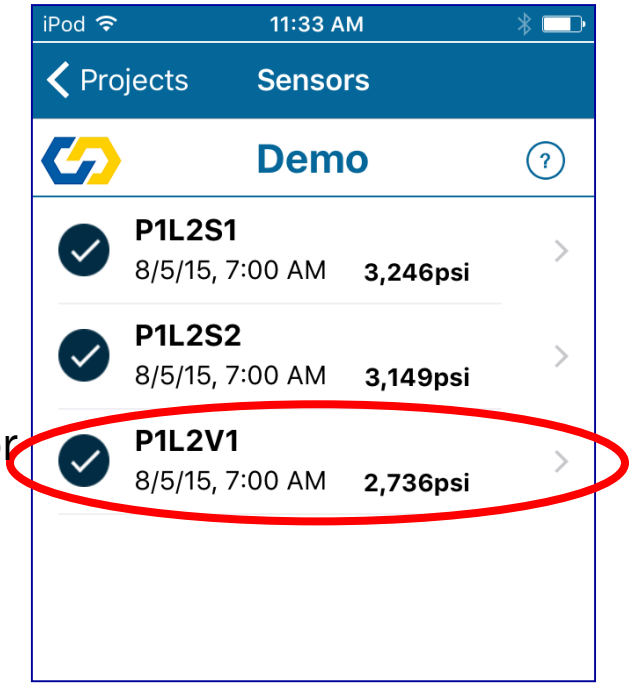
- Compare estimated strength to actual strength <u>of specimens</u>.

Estimated = 2736 psi **VS** Actual = 2850 psi ≤ 10%

Field sensor

Field sensor

Validation sensor



If the estimated strength is within 10% of the Average break strength, you can feel more confident that field estimations are good.

Maturity Systems Options

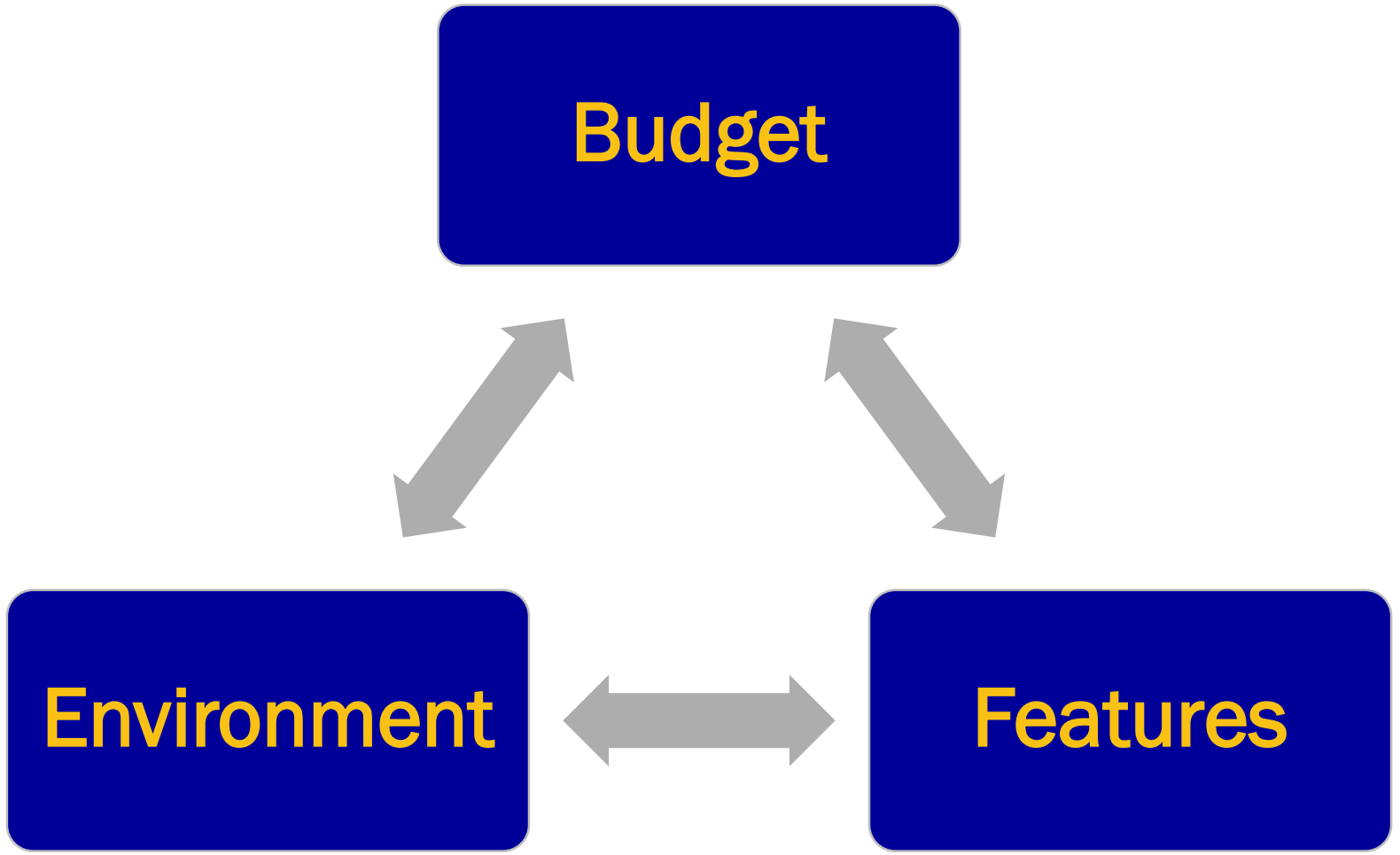
What are the technologies?

Thermocouple wire systems

Wired Systems

Wireless Systems

How do I pick?



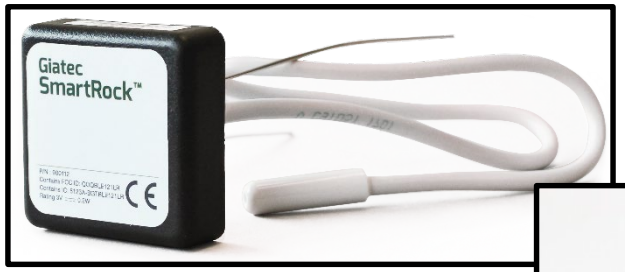
Thermocouple Systems

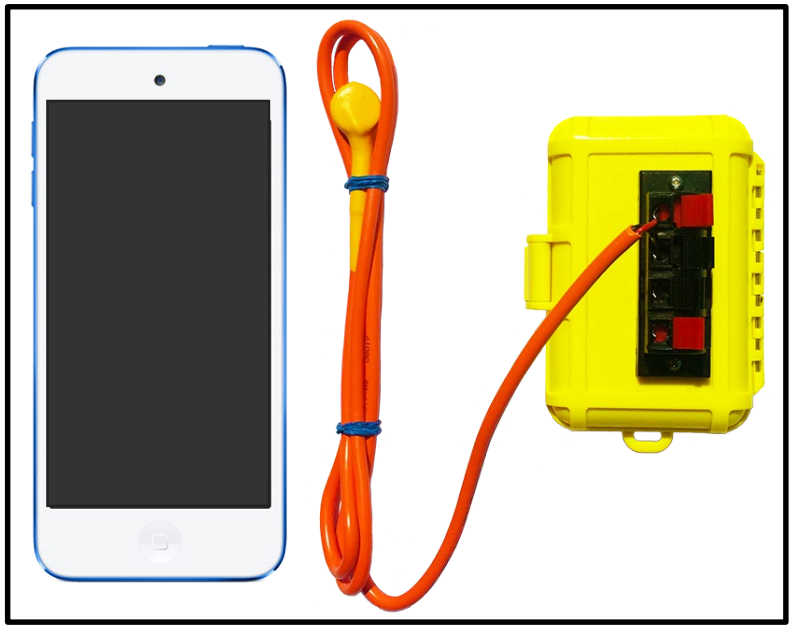
Wired Systems

Wired systems

Wireless Systems

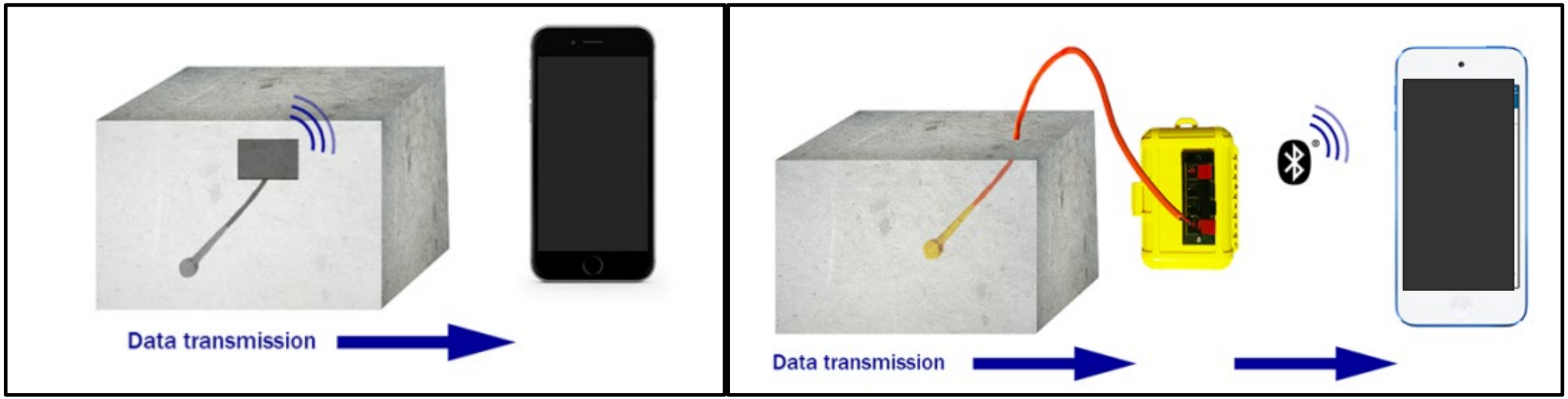
Wireless Systems: Bluetooth –embedded and nonembedded transmitters





Wireless Systems

Wireless Systems: Bluetooth –embedded and nonembedded transmitters



Wireless Systems

Wireless Systems: Cellular

Wireless Systems

Wireless Systems: Combination

Conclusions

- Maturity systems are used for monitoring concrete temperatures and estimating in situ strength.
- Many states have a temperature monitoring specification that suggest the use of a maturity system.
- Many states allow for the use of maturity to estimate in situ strength for opening pavements to traffic.
- Some states allow for the removal of formwork/falsework and opening/loading of structures.
- Select states require maturity for acceptance.
- There are a number of options for a system; be an informed consumer.