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concrete facts • superior results

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Concrete maturity: Harnessing the “rate of strength change” of your concrete.

Wisconsin Concrete Pavement
Association
February 2010

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Constructive Intelligence

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How to take full advantage of “Time and Temperature” using ASTM-1074!

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Today's Agenda: Why Maturity?

- Review of maturity in concrete (ASTM-1074)
- Calibration and validation
 - Early and accurate strength data,
 - significant time savings,
 - carbon counting options,
 - cylinder reductions.
- Elimination of low strength risks?
- Review and questions





Maturity Is A Recognized Standard

Maturity Is Found In the Following Industry Standards:



- **ASTM C 1074** – Standard Practice for Estimating Concrete Strength by the Maturity Method
- **ASTM C 918** – Measuring Early Age Compressive Strength & Projecting Later Age Strength
- **ACI Committee 318**, Par 6.2 – Building Code Requirements for Structural Concrete
- **ACI Committee 228**, Par 2.7 – Nondestructive Committee
- **ACI Committee 306**, Par 6.4 – Cold Weather Committee
- **OSHA** Section 1926.752 & 1926.703
- **FHWA** SA-97-105





Implementing Maturity

intelliRock System The “New Age” Temperature and Maturity System



Logger - “Intelligent Sensor”:
Microprocessor
Memory
Temp. Sensor
Battery



Reader:
Communicates
with loggers



Wireless Monitoring





Why Does Maturity Work?

- Concrete is a chemical reaction – **EXOTHERMIC**
- Chemistry 101
 - Principle ingredients of Portland cement are Silica and Calcium
 - Curing (*drying*) is called “HYDRATION”
 - What is happening during hydration?
 - Ca plus H-O-H (water) → Ca OH plus H+ (released energy)
- The energy released generates **HEAT**
- **Heat = Energy** → More particles plus moving faster → More Likely to Collide (React) → ***Hydration Accelerates!!***
- Thanks to:
 - Svante August Arrhenius 1884 (Nobel Prize Winner)





What is Maturity?

- Maturity describes a relationship between time and temperature
- Measured in “celcius-degrees-hours” (C°H)
- **Represents a “rate of change”**
- “Simple” to calculate – area under the time & temperature curve (calculus)
- “Discovered” (described) by Nurse and Saul in 1950’s





What is Maturity?

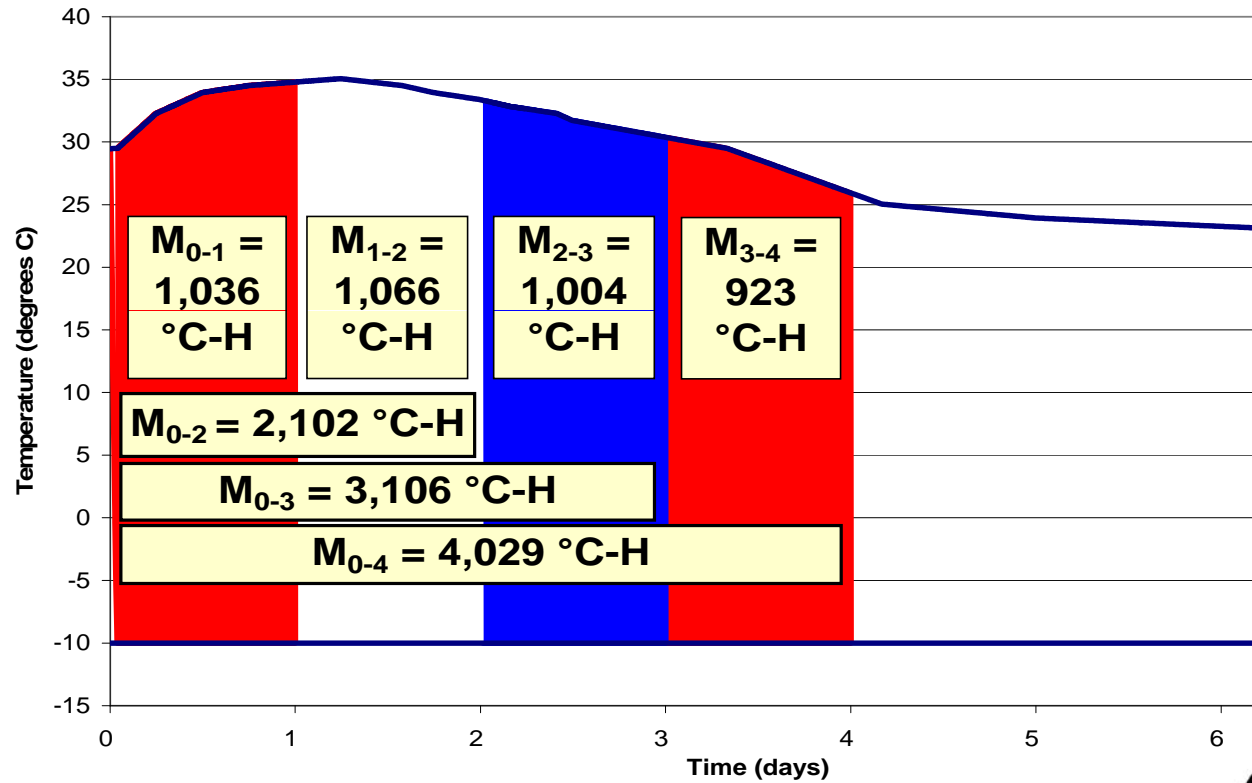
- What did Nurse & Saul “Discover” ?
- “Concrete of the same mix at the same maturity (reckoned in temperature-time) has approximately the same strength whatever combination of temperature and time go to make up that maturity” (Saul 1951)





What does Maturity Look Like?

Maturity is Measured in Degrees Celsius*Hours





Computing Maturity

Nurse-Saul – Linear Relationship

Simple, Easy to Use, Most Conservative, Safest and Most Widely Used

$$TTF = \sum_0^t (T_c - T_o) \cdot \Delta t$$

TTF = Temperature-Time Factor, °C-hrs or °F-hrs

Δt = time interval, hrs

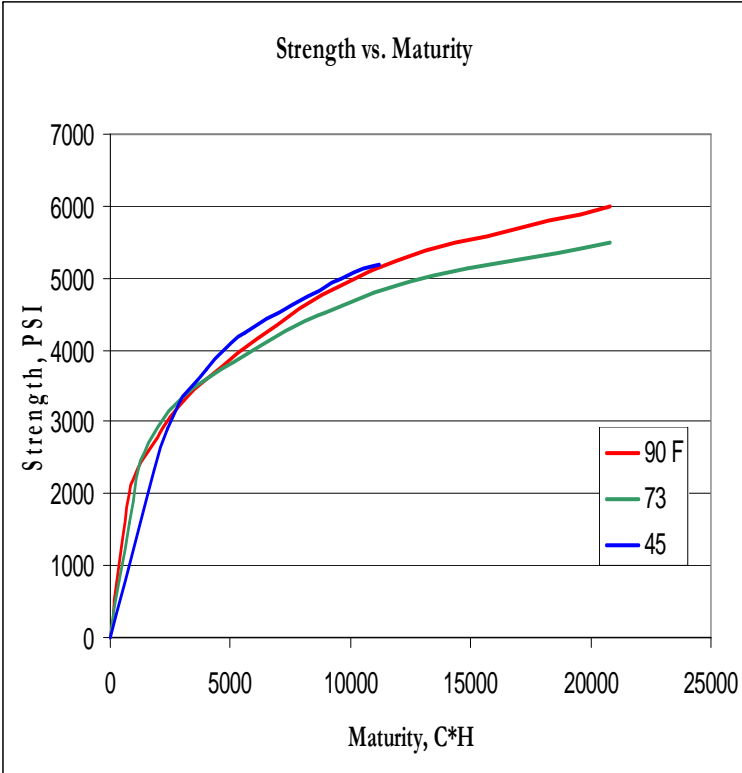
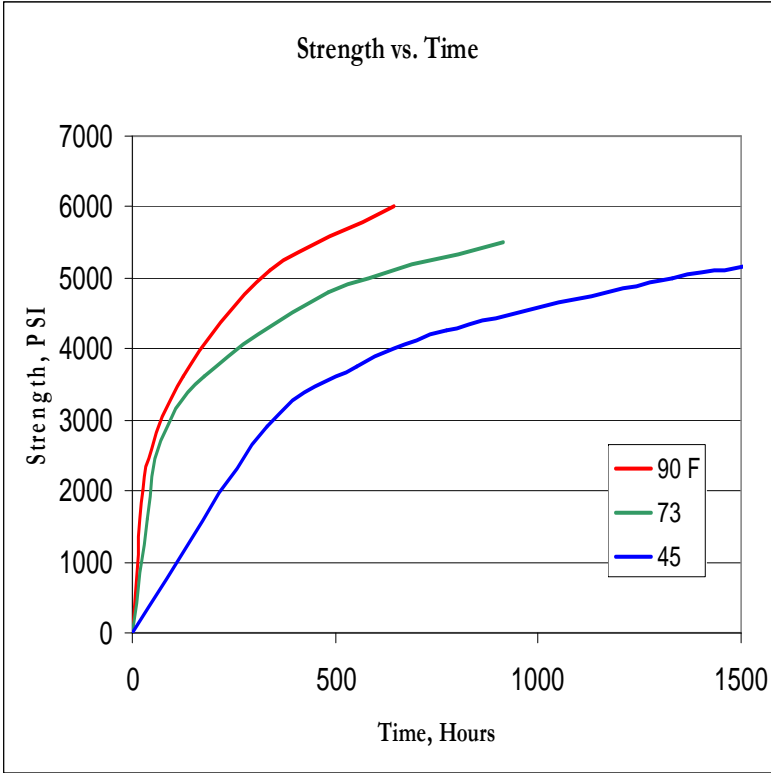
T_c = average concrete temperature during Δt , °C or °F

T_o = datum temperature, typically -10°C or 14°F





What does Maturity Look Like?

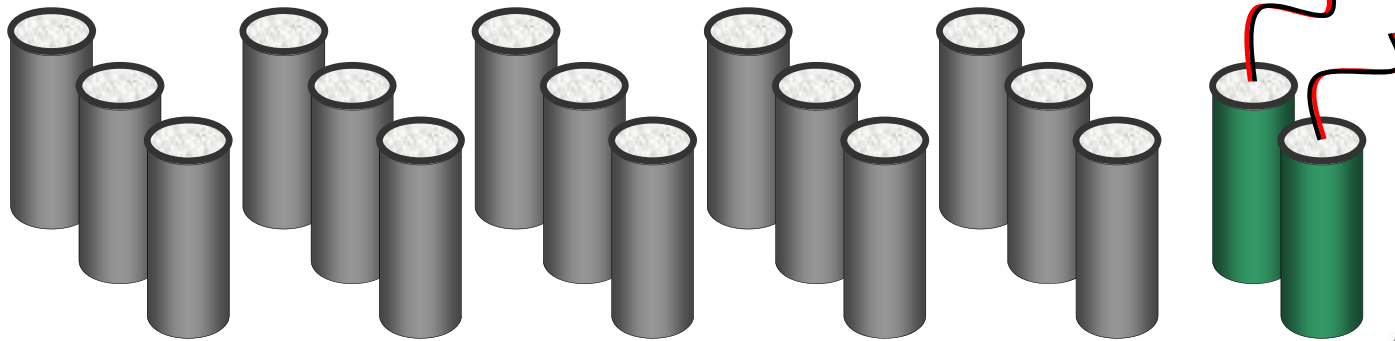




Calibration – Fingerprint of your mix design
using 17 Cylinders

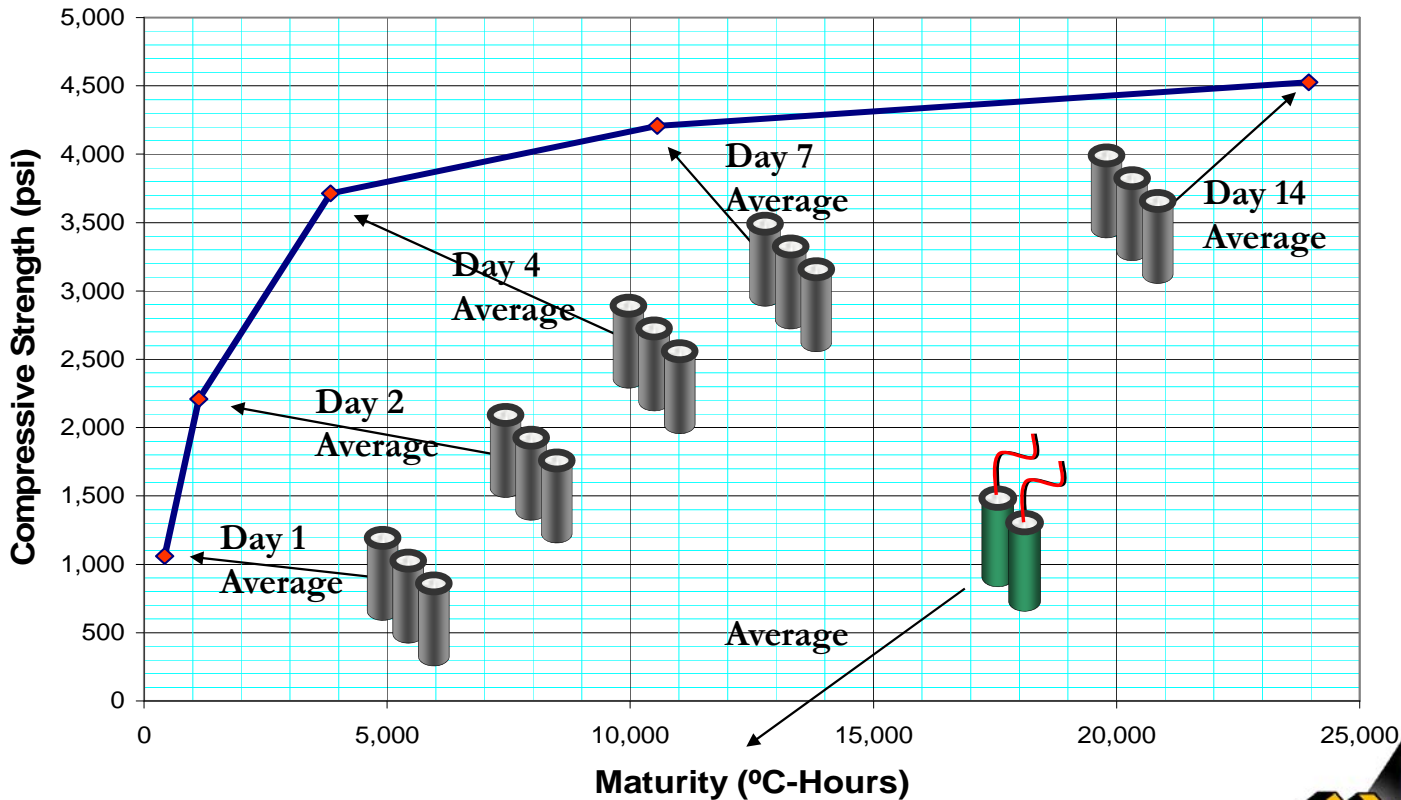
15 (5 sets of 3) for testing

2 for maturity
sensors





Generating a calibration curve



Temperature-Time Factor for each break





Calibration – Fingerprint of your mix design

ASTM-1074-A





Calibration – Fingerprint of your mix design

Maturity Level	Specimen #	Specimen Strength (psi)	Average Strength (psi)	Maturity Logger Serial Number	Maturity Elapsed Time (hh:mm)	Specimen Maturity (10 ³ C-Hrs)	Temperature (°C)	Average Maturity (10 ³ C-Hrs)	Average Temperature (°C)	Average Age (days)
1	1	1149.0	1048.3	14,383	24:00	1,222	23	1,212	23	1.00
1	1	1016.0		14,418	24:00	1,201	23			
1	1	980.0								
2	2	2246.0	2205.3	14,383	72:00	2,935	24	2,908	24	3.00
2	2	2253.0		14,418	72:00	2,881	23			
2	2	2117.0								
3	3	2882.0	2861.0	14,383	120:00	4,051	23	4,011	24	5.00
3	3	2742.0		14,418	120:00	3,971	24			
3	3	2959.0								
4	4	3289.0	3437.3	14,383	168:00	6,075	24	6,017	24	7.00
4	4	3553.0		14,418	168:00	5,959	24			
4	4	3470.0								
5	5	4339.0	4254.7	14,383	336:00	12,570	24	12,462	24	14.00
5	5	4255.0		14,418	336:00	12,354	23			
5	5	4170.0								

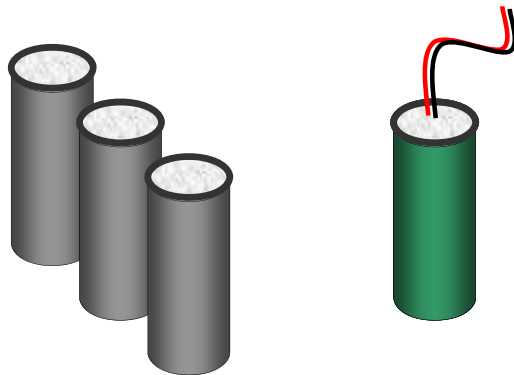




Quality Control Using Maturity

ASTM 1074-B

- **Validation** – To verify that your mix design has not changed
- **Cast 4 verification cylinders**
- **Embed *intelliRock* sensor** in one; test remaining three compressively
- **Verify** that the concrete is within 10% of the calibration curve

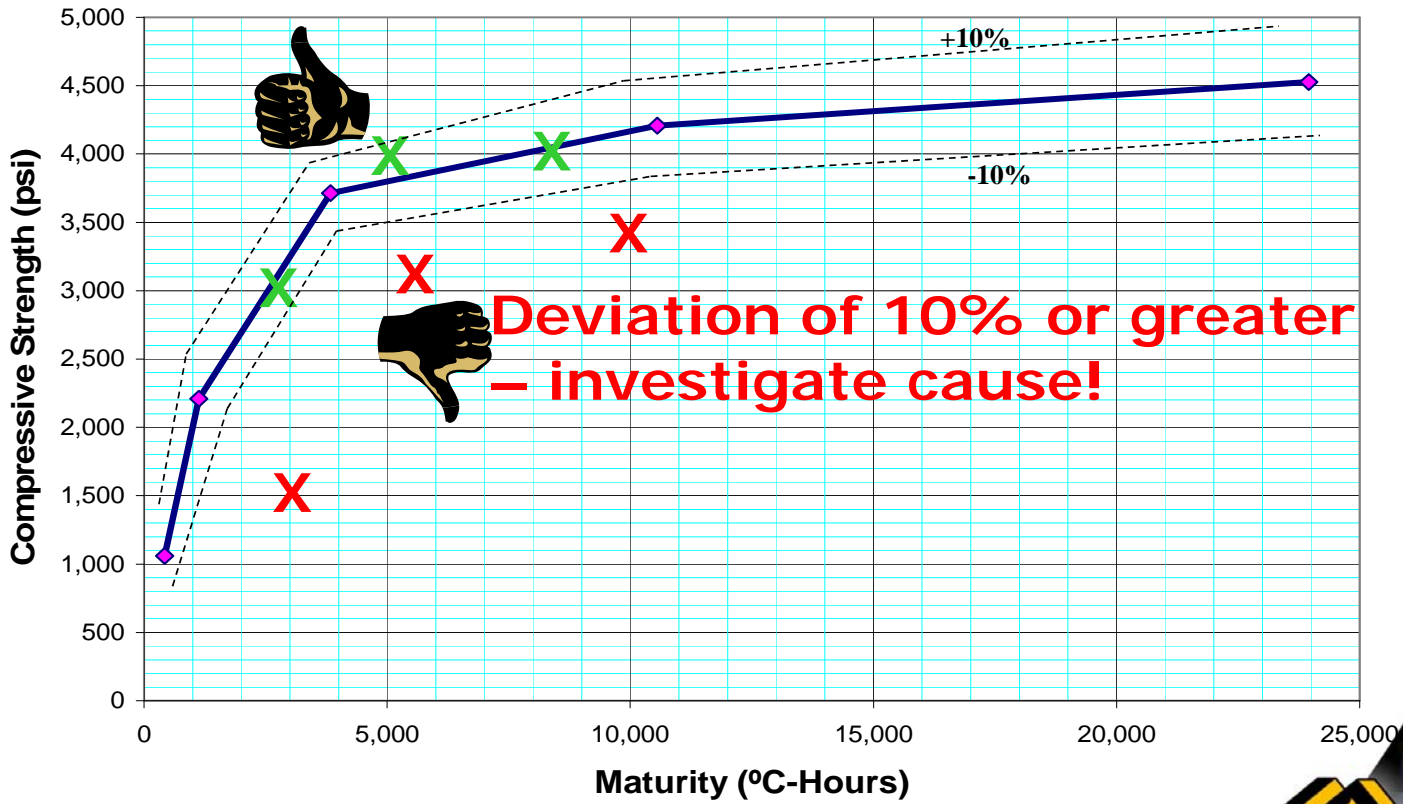




QA/QC Example

ASTM 1074-B

- **Validation** – Does the batch fit the curve?



Deviation of 10% or greater – investigate cause!





•Application – Step 2: Start the Logger

1. Project
2. Location
3. Datum

GO!!!!!!



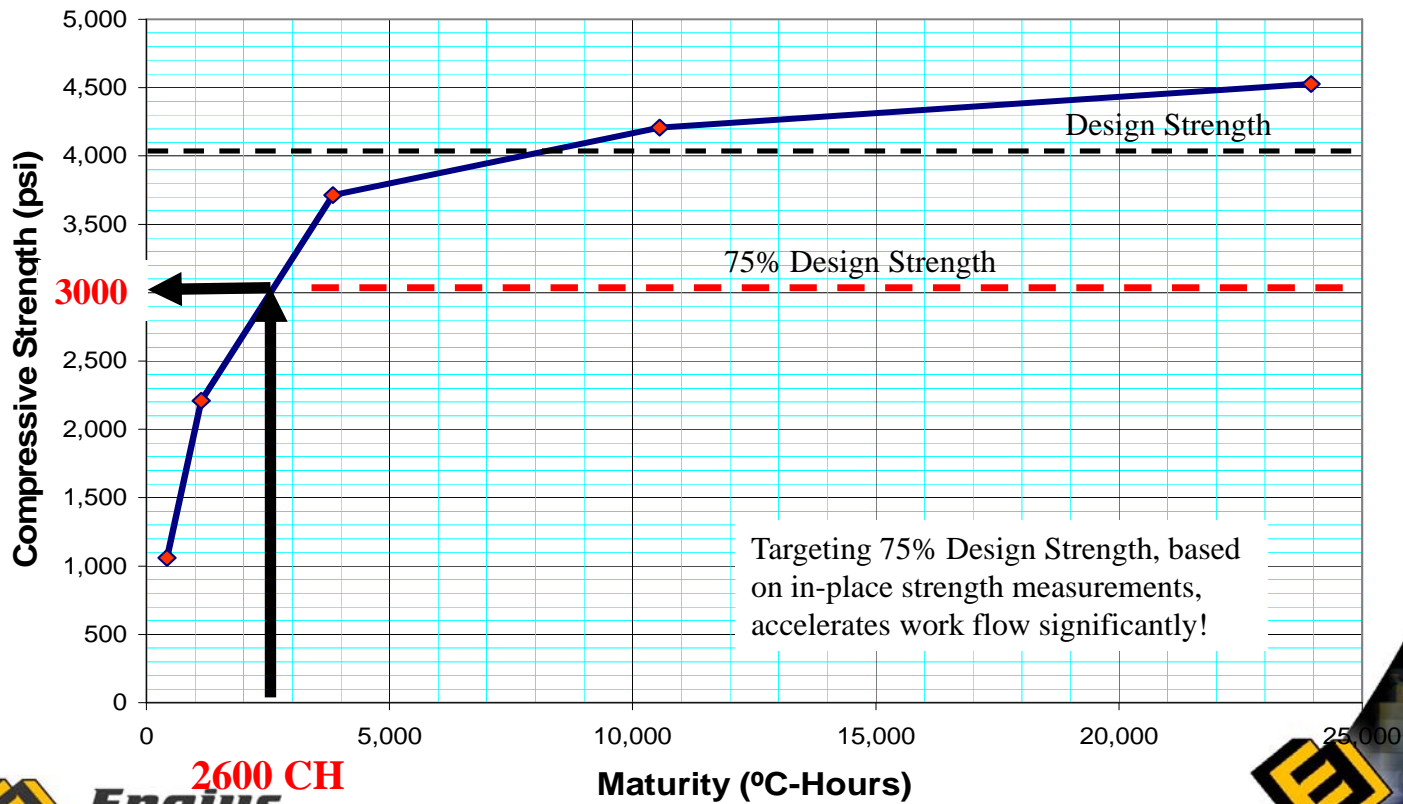
•Application – Step 3: Read Sensors

- After some curing time use IntelliRock to read maturity



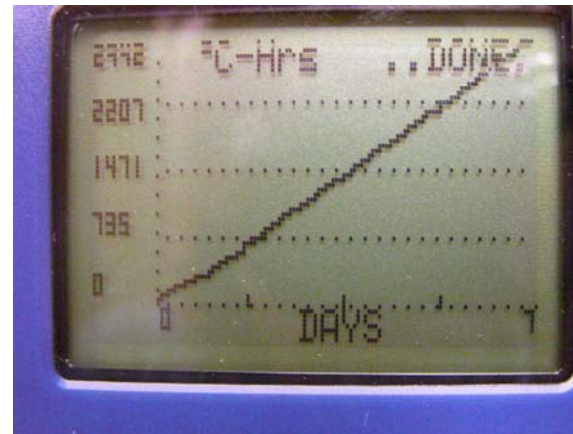
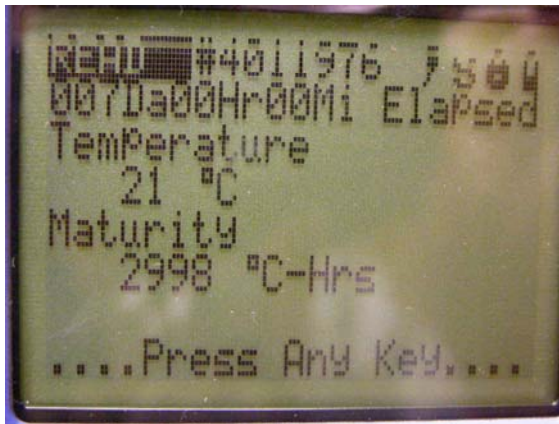


Application – Step 3: Convert Maturity to Strength
(apply the calibration curve)





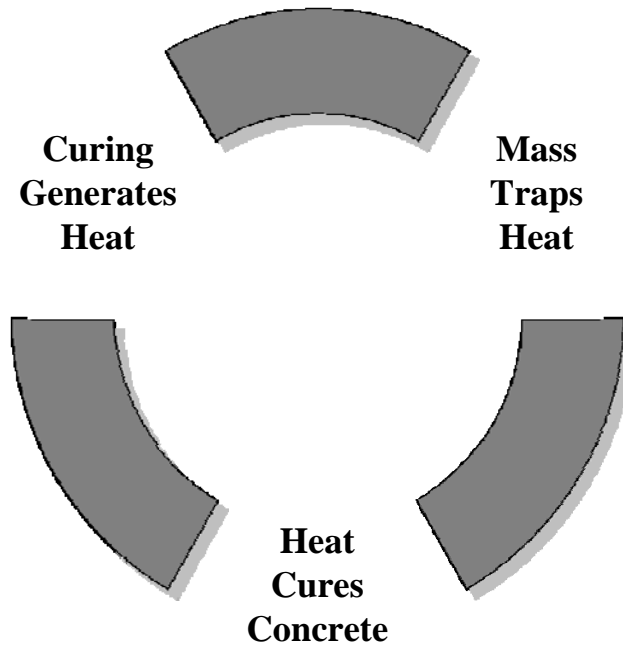
Application #4: Read Loggers!





Optimize Construction Schedules

Concrete Curing Cycle



Cylinder VS Placement

Cylinders or beams

- Less Heat Retention
- Lower Curing Temperature
- Lower Early Strength

Placement

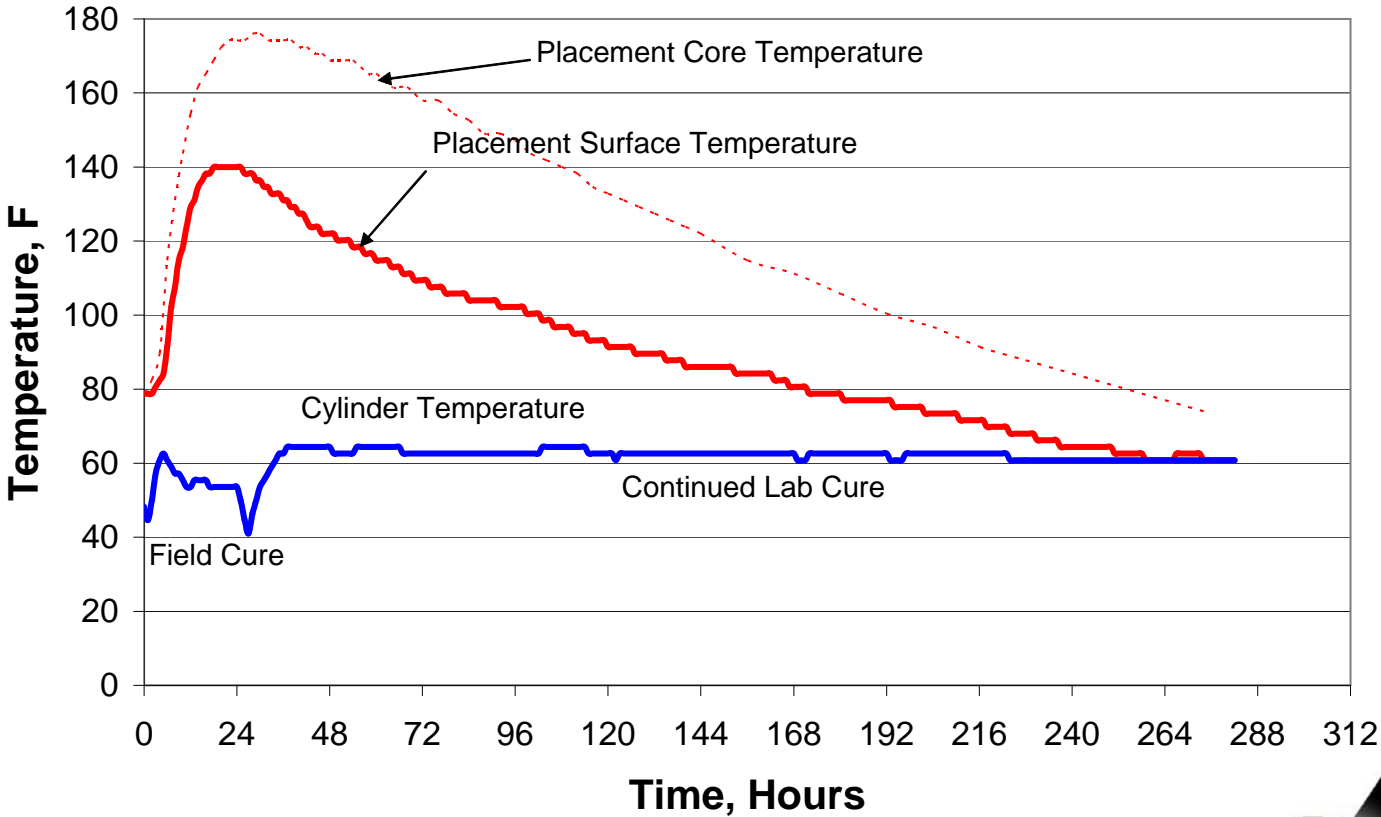
- Higher Mass
- More Heat Retention
- Higher Curing Temperature
- Higher Early Strength





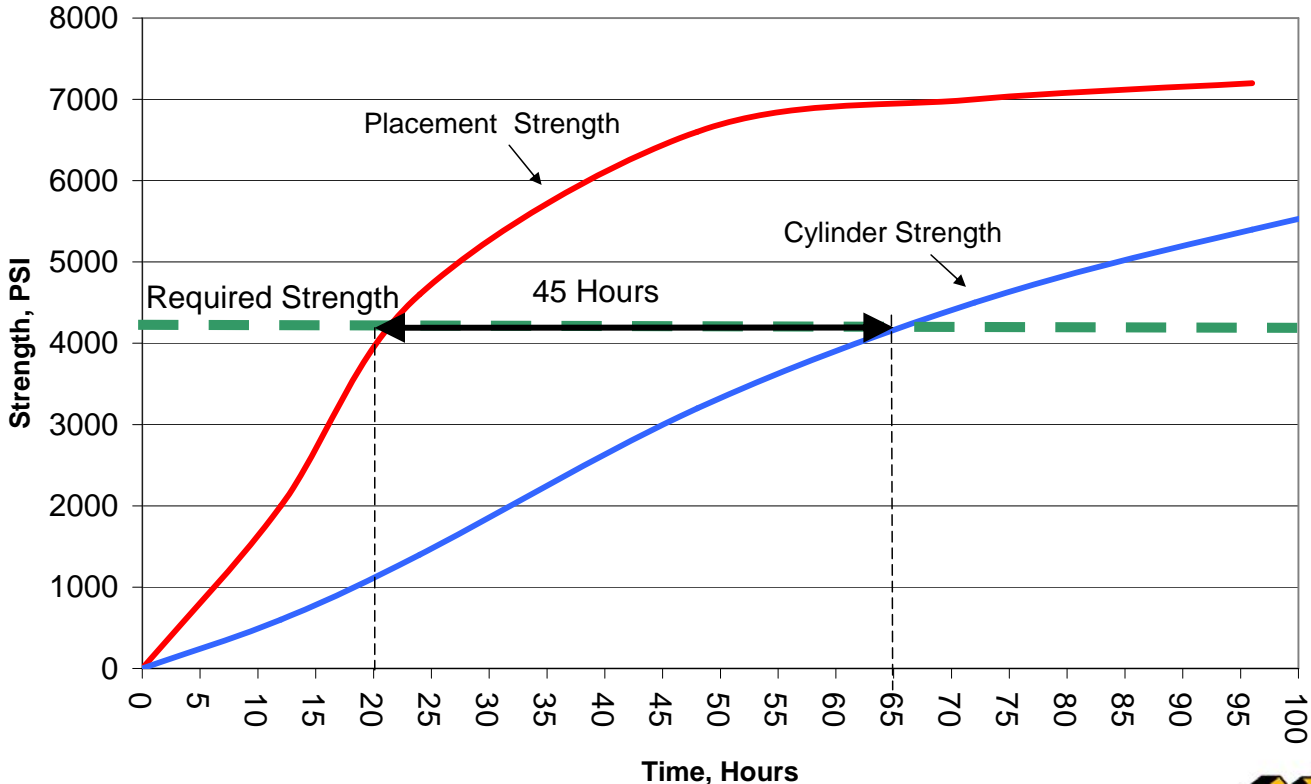
Optimize Construction Schedules

OU Health Sciences Center, Temperature Data
7' Thick Wall





OU Health Sciences Center - Strength Data





Accuracy and Variability ??

How Does Maturity Compare to:

- Compression Cylinders
- Flexural Beams
- Penetration Resistance
- Rebound Hammer
- Pullout
- Ultrasonic Pulse Velocity
- Drilled Cores





Accuracy and Variability ??

The Center For Transportation Research

University of Texas, Austin

CTR-1198-1F (1991)

“Of all the test methods studied, the maturity method exhibited the lowest variability and most consistent agreement with the generally accepted standards for concrete testing, including compression cylinder and flexural beams”





Case Study: I-40 Bridge - Gilbert Central

- Project scope: 6-month reconstruction projected when barge collision collapsed multiple spans. \$10.9 million project.
- Project issues: \$475,000/day user costs to reroute 22,000 vehicles. Rapid reconstruction was paramount.
- intelliRock results: *intelliRock* strength estimates allowed stripping of forms in record time. Bridge was reopened in just 47 days.
- intelliRock benefit: Contractor received **\$1.5 million** early completion bonus.





Case Study: Street Patching-Utility Improvements

- Project scope: 16 in-traffic patches
- Project issues: Cold spring weather
- Intellirock results: Opened all patches in 8 hours using I-M4 mix without significant user delay.
- Public Delay was minimized
- intelliRock benefit: Contractor saved
 - Signs and traffic control
 - Testing and cylinders
 - Much less winter protection





Case Study: 45TH Street Fargo, North Dakota

- **Project scope:** \$64.1 m, completed in 2005 including underground improvements.
- **intelliRock results:** Project was completed ahead of schedule and providing business access without interruption through out the project.
- **intelliRock benefit:** 7 day maturity strength assurance. Open for construction traffic in 18 hours.

NORTHERN  IMPROVEMENT CO.





intelliRock LIVE - Login

Internet Access to intelliRock Loggers 24-7-365!

intelliRock LIVE

Log In

Email:

Password:

Remember me next time.

[Create New User](#)

MEASURE

Monitor concrete placements using intelliRock- the industry's leading temperature and strength sensors.

- Accurate!
- Rugged!
- Proven!

COMMUNICATE

Monitor readings from anywhere in the world, in real time

- At the sensor using a handheld reader!
- At the jobsite using wireless modules!
- World wide via the internet!

ALERT (Coming Soon!)

Receive automatic alarms or status updates from anywhere, anytime

- Email Alerts!
- Text-Message Alerts!
- Days, Nights, Weekends, Holidays!

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intelliRock LIVE - QuickView

BRIDGE PILE9:-6FT CENTER2

LastUpload
12/17/2009 7:11:00 PM
3 Day(s) ago

Temp
11C / 52F



intelliRock LIVE

Your Time Zone: Central Standard Time
Your Time: 12/21/2009 11:34:08 AM
UTC Time: 12/21/2009 5:34:08 PM

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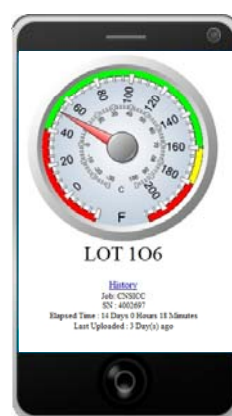
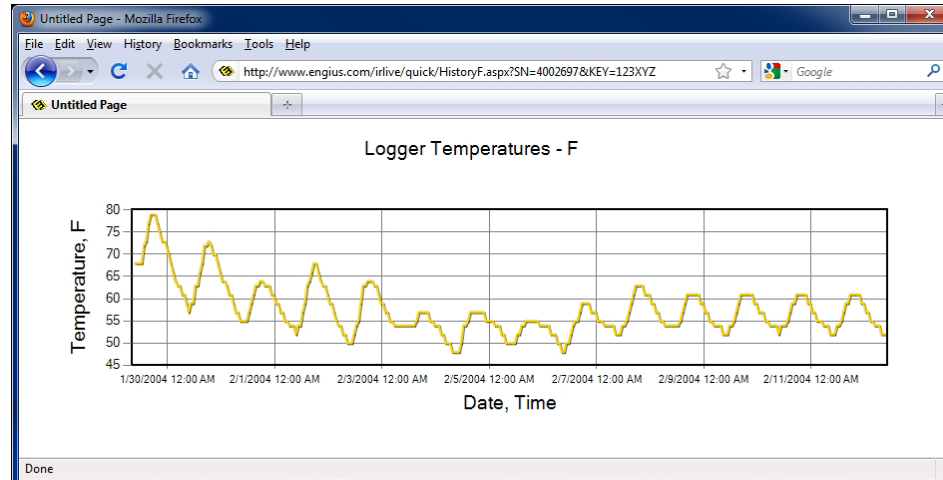
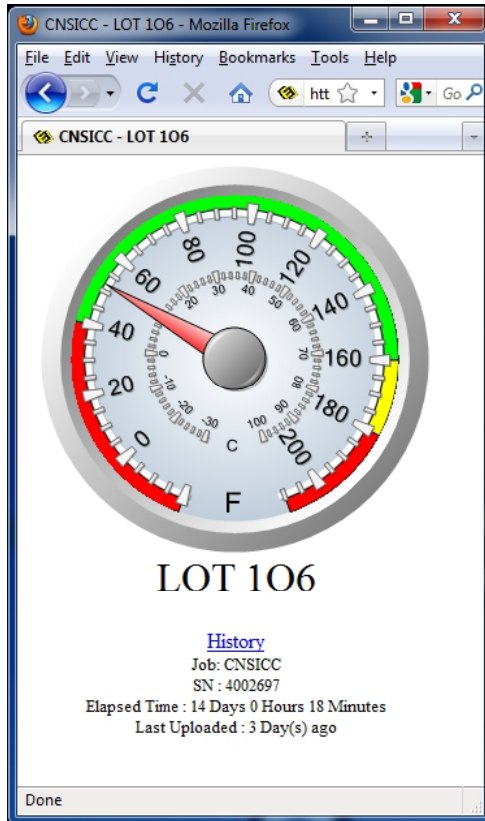
Maturity (CH)
4800

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Live Links – “One Click” on Phones



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intelliRock Advantages

- **Rugged, simple solution for measuring real-time, in-situ:**
 - Concrete strength
 - Temperature
- **Benefits:**
 - Provides in-situ record keeping-(Unalterable and Uninterruptible) .
 - Compliments traditional testing.
 - Accelerates work flow/minimizes traffic delays
 - Enhances QC and QA with validation.
 - Minimizes mix drift and admix overdosing.
 - Lessens the dependence on “ only” cylinder/beam tests.
 - Allows for accurate and early pavement openings.
 - Provides **LEED** opportunities.





Thanks for your mature attention!

Rock and Roll with Intellirock!

Jim Mikulanec,

Vice President of Sales and Market Development

Senior Intellirock Field Specialist

Western Regional Manager

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