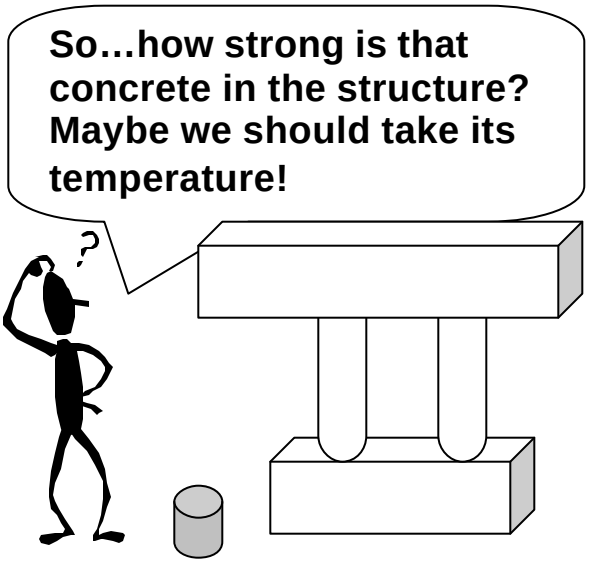
Tech Brief

Development of Maturity Protocol for Construction of NJDOT Concrete Structures

FHWA-NJ-2001-017-TB December 1999



HERE'S THE PROBLEM

Conventionally, cylinder tests have been employed to evaluate the quality of the concrete mixture used in structure, but not to estimate the strength of concrete during construction. Cylinder compression tests make do not make an allowance for differences in the mass, placing techniques, compaction, consolidation or curing between the cylinder and the structure. In addition, since standard-cured cylinders are tested at an age of 28 days, they cannot be used to estimate the strength at earlier ages for safe removal of formwork, shoring, post-tensioning, or opening to traffic. Non-destructive test methods have been developed to estimate the strength of the in-place concrete. One such technique for estimating the strength of the in-situ concrete is the maturity method (ASTM C 1074), which is based upon the measured temperature-time history of concrete during the curing period.

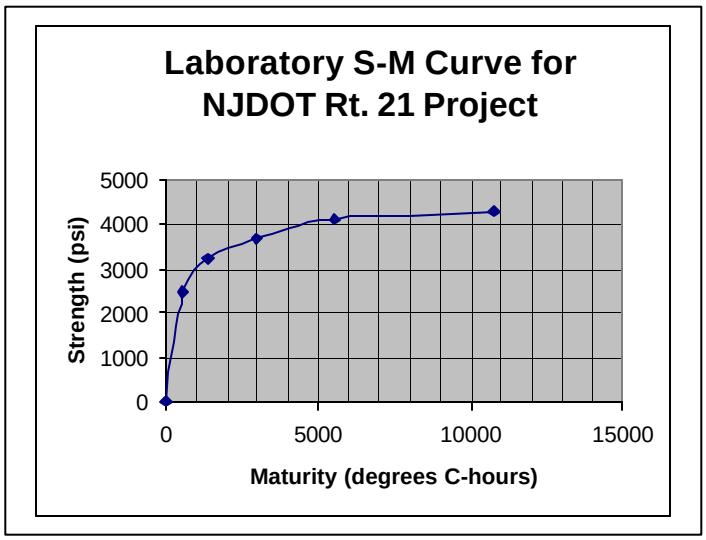
The Main principle is "Samples of the same concrete will have equal strength if they have equal maturity, irrespective of their actual time-temperature histories". The concrete in the test cylinder may take 28 days to reach the same level of maturity as the concrete in the structure at only 7 days, due to differences in mass and temperature or heat development.

THESE ARE OBJECTIVES OF THE PROJECT…

- To evaluate the use of the ASTM C 1074 Maturity Test Method to estimate in-situ concrete strengths.
- To develop laboratory and field testing protocols for the use of maturity concepts in NJDOT concretes.
- To develop guidelines for use on NJDOT construction projects.

AND, HERE'S WHAT WE DID…

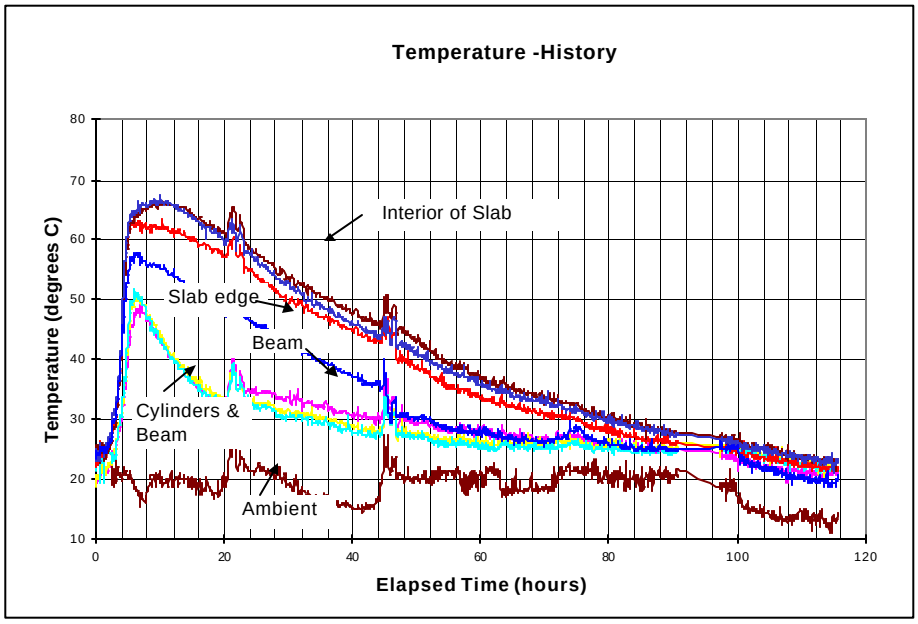
We chose to evaluate the concrete maturity method on a highway bridge located near Newark Airport, at the intersection of Interstate 78 and NJ Routes 1, 9 and 21. The experimental program utilized a concrete mix from the project and followed the ASTM testing method to conduct the laboratory and fieldwork. The laboratory procedures required curing test specimens at three different temperatures to develop test parameters called datum temperature and activation energy. We prepared concrete cylinders of the concrete mix and measured the temperature of the mixture from the time it was placed, until the cylinders were broken, to measure it's temperature-time history and develop a strength-maturity relationship. The maturity method worked just as well with cylinders for compressive strength or beams for flexural strength.



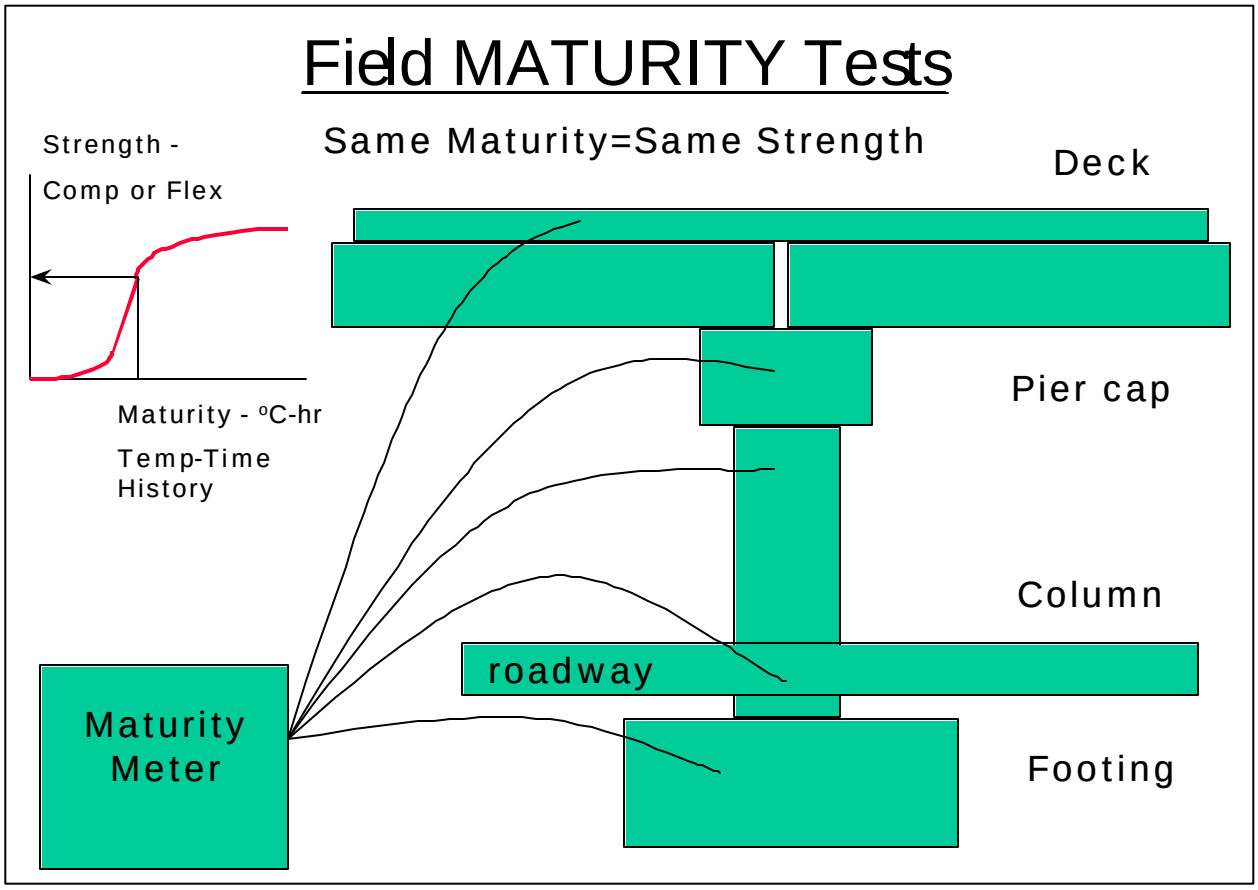
Next, field and laboratory maturity computations and data acquisition processes were automated to facilitate establishment of real-time temperature-age data, and strength-maturity correlation relationships. Field maturity test operation protocols were established for use by field personnel.

Field data was collected and analyzed to develop comparisons between cylinder maturity and strength, and also to measure the maturity of the concrete in the structure.

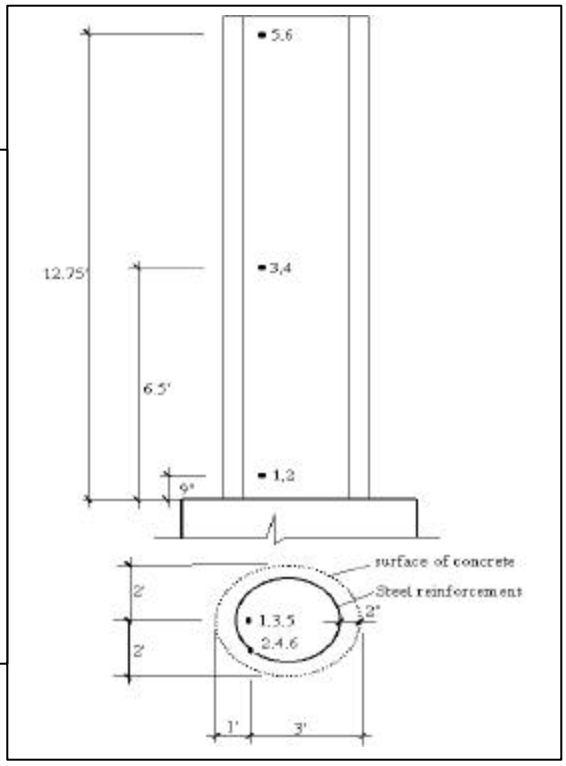
Temperature data was collected from several locations within the

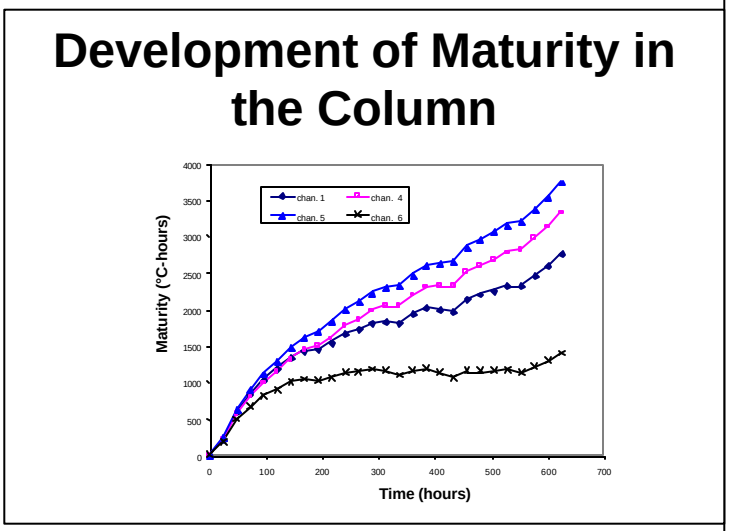


elements of the structure, i.e. pier caps, footings, and columns, and their maturities were compared.



In the column, the thermocouples were placed on the spiral steel near the center of the column

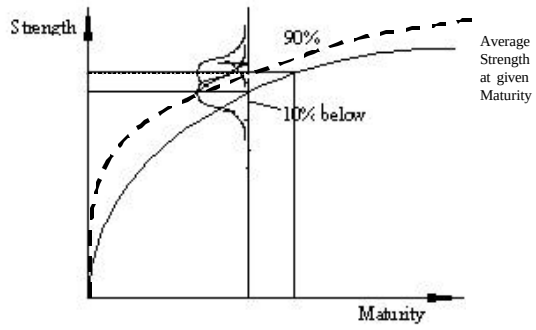




and at the top, middle, and bottom of the column. This placement painted a dramatic

variation in strength development. The concrete at the bottom or center of the column gained strength faster and was stronger than the remainder of the column.

In order to develop an understanding as to the basics of the maturity principle, NJDOT personnel were trained during a workshop at NJDOT. This workshop was intended to provide personnel with basic computation skills, in order to establish correlation relationships between the maturity and the in-place compressive strength in structures.

Here is what we found…	Here is what we recommend…
• Placing thermocouples at different locations (bottom, middle, top, center, at the edge, etc.) provide a 3-D representation of the strength of the structural element • Concrete that cooled faster gained strength more slowly that concrete that was deeper within the structure. • Concrete Maturity provides a good estimate of in-situ concrete strength for stripping of forms or opening to traffic.	Since average maturity would suggest that only 50 percent of the concrete has reached the desired strength, we recommend adjusting the required maturity level so that 90-95 percent of the concrete has reached the required strength. **Statistical Interpretation of the Characteristic Strength** 

WHAT IS THE NEXT STEP?

A follow up to this preliminary project will focus on the usage of developed maturity protocols in the construction of NJDOT concrete structures. In addition, the results of in-place concretes shall be evaluated against other in-place test methods, such as pull-out inserts, etc., in order to assure safe construction procedures. Furthermore, companion cylinder tests would accompany the maturity test data for comparison, as well as serve as an aid for making decisive actions regarding the construction sequence.

To gain additional confidence in the concrete maturity method, the next project will incorporate additional test methods, such as pull-out testing and matched temperature cylinders to verify results of maturity test method.

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A final report is available online at http://www.state.nj.us/transportation/research/research.html

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