Tech Brief

Fast Track Concrete For Construction Repair

FHWA-NJ-2001-015-TB March

BACKGROUND

Under the sponsorship of the New Jersey Department of Transportation, a unique concrete mix was developed which could attain significant strength in a period of six to nine hours for use on pavement repair in high-traffic areas. This development of high strength is purely based on Portland cement, which is reliant on chemical admixtures and insulated coverings, to attain very high temperature levels quickly. This 'fast-track mix', through various full-scale laboratory and field demonstrations, has shown to be effective in reaching its target compressive and flexural strengths of 3,000 and 350 psi in as little as six hours.

HERE'S THE PROBLEM

Numerous functions have been developed that are useful in estimating the strength of concrete after it has been placed, however no effort has yet been made to predict the strength of concrete before it has been placed. If such a test measurement were developed, it would provide important information regarding thermal properties of heat transfer and heat generation, either as a function of time, or as a function of maturity.

AND, HERE'S THE SOLUTION

To determine these properties experimentally, and, based on the results, it is possible to examine the effect of various initial mix temperatures, insulation thickness and slab thickness on time required to reach the target strength.

BUT HOW CAN IT BE DONE?

By developing a computer simulation of the heat generation and transfer within the developed concrete slab, which could enable us to determine the temperature history of a hypothetical slab, based on its geometry, insulation, initial temperature and air temperature.

THESE ARE OBJECTIVES…

- To develop a computer simulation of the heat generation and transfer within a fast-track concrete slab.
- To predict the time required to reach a target strength, prior to commencing with the pour.

HERE IS WHAT WE DID…

The first step during this experiment was the establishment of a correlation between strength and maturity. In order to do this, we needed to experimentally determine the datum temperature for which ASTM standard was to be used. However, it was concluded that a single, temperature-independent datum temperature for very early ages could not be obtained using an ASTM standard, so it was decided to estimate using statistical means.

In the effort to establish a correlation between strength and maturity, it was concluded that factored maturity offers a correlation with strength that is only marginally better than temperature-time. Consequently, to obtain the best possible correlation, factored maturity was used in the subsequent development of the computer model.

Next, five experiments were carried out for the purpose of obtaining a heat-rate function for the concrete mix for which it was assumed that heat rate may be functionally related to either time or some measure of maturity. The factored maturity provided the most consistent relationship over the tested temperature ranges. This temperature rate exhibits four phases, characterized by distinct functional shapes. The temperature-rate curves were analyzed statistically to obtain four equations that described the heat of hydration of the fast-track mix.

By knowing the rate of heat generated, it became possible to develop a heat transfer computer simulation capable of predicting the temperature history of the slab. The computer model allowed the study the primary parameters, such as initial concrete temperature, outside temperature, insulated covering (R-value) and slab thickness. The simulation consisted of seven modules: Input, Element Properties, Initial Ground Temperature Profile, Heat Generation and Factored Maturity, Temperature-time, Summary Statistics and Graphical Output. The simulation used the experimental-obtained heat functions and the thermal properties of the soil, slab, and insulation, to calculate the change in temperature of a model slab over time.

Finally, the results of the parametric study enabled recommendations to be made regarding the use of the fast-track mix and the effects of different slab thickness, the useful temperature ranges of the mix, and the required insulated covering.

WHAT IS THE NEXT STEP?

Since the datum temperature derived in this study was through statistical means, future research can be conducted to examine whether a datum temperature can be derived through any other scientific means, which would also be statistically correct. The entire experiment could be conducted utilizing the datum temperature, still providing favorable results, and a comparison could then be made between this research and the future research for optimal conditions and results.

FOR MORE INFORMATION CONTACT:

NJDOT PROJECT MANAGER:	Mr. Nicholas Vitillo
PHONE NO.	(609) 530-5637
e-mail	**Nick.Vitillo@dot.state.nj.us**
UNIVERSITY PRINCIPAL INVESTIGATOR:	Dr. P. Balaguru, Dr. Ali Maher, Dr. Gary Consolazio
UNIVERSITY:	**Rutgers University -CAIT**
	(732) 445-3537, (732) 445-2569
e-mail	**balaguru@rci.rutgers.edu, mmaher@rci.rutgers.edu**

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

If you would like a copy of the full report, please FAX the NJDOT, Bureau of Research, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Bureau@dot.state.nj.us and ask for:

Report Title Fast Track Concrete For Construction Repair
NJDOT Research Report No: FHWA-NJ-2001-015