Tech Brief

Rapid Hardening Concrete

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HERE'S THE PROBLEM

To avoid interference with heavy traffic in metropolitan areas, there is a critical need for a concrete that can attain reasonable compressive and flexural strengths in approximately 3 hours.

AND, HERE'S THE SOLUTION

To develop a rapid set concrete mix that can attain the desired strength in the desired amount of time.

BUT, HOW CAN IT BE DONE?

By conducting laboratory testing to establish a concrete mixture capable of attaining a compressive strength of 2000 Ibf/in2 and a target modulus of rupture of 350 Ibf/in2, which is the typical load of bridge decks.

THESE ARE OBJECTIVES…

- The main objective of this project is to develop a concrete mix proportion that can attain a compressive strength of 2000 Ibf/in2 and a target modulus of rupture of 350 Ibf/in2 within 3 hours of placement.
- To develop such a concrete mix that can be prepared within reasonable working time, achieve strength gain at different temperatures, and have plastic and drying shrinkage cracking under restrained conditions and heat of hydration.

HERE IS WHAT WE DID…

This research plan consisted of five steps. Initially, identification of commercially available cements was necessary. Second, preliminary testing for strength gain and workability duration was conducted. The next step was systematic evaluation of compressive and flexural strength gain. The fourth step was the evaluation of plastic and drying shrinkage under restraints. The last process was establishing the influence of vibration and continuous mixing on the workability and castability of large slabs.

Six cements were evaluated for strength gain with the primary focus on the first four hours and workable duration. Compressive strengths and modulus of rupture were measured at 2, 3, 4, and 24 hours, 7 and 28 days. Modulus of rupture was measured at 3 and 6 hours and at 7 days.

Workability was then measured using slump tests and a modified flow test. Then, temperature influences were evaluated by using water baths. The water baths were conducted by using insulated drums filled with water maintained at various temperatures.

Plastic shrinkage characteristics were determined by using restrained shrinkage tests, commonly used for fiber concrete. After 24 hours, the crack areas were obtained by measuring crack lengths and widths at a number of locations along the crack.

The drying shrinkage characteristics of rapid set concrete was evaluated using ring tests, commonly used for evaluating fiber reinforced concrete. Rapid chloride permeability testing was then analyzed to evaluate the permeability of concrete.

Finally, large slabs were used in a field trial to demonstrate the feasibility for making thicker slabs without excessive heat of hydration. The slab for the field trial was placed on the bridge over Interstate 287 on River Road in Piscataway, NJ.

CONCLUSIONS…

From the results of this research, it can be concluded that it is possible to formulate a workable concrete that can provide 2000 Ibf/in2 compressive strength and a modulus rupture of 350 Ibf/in2 in 3 hours. The strength gain under flexure mode was found to be more rapid than the strength gain under compression loading. Retarding of the admixtures could be done to increase the workable duration to 25 minutes. The concrete was found to flow well under vibrations, and it retained its flowable characteristics better if the mix was kept under constant movement.

WHAT IS THE NEXT STEP?

Future research to improve field applications should be conducted. The primary challenges for the field applications are (1) placement and finishing in 25 minutes, (2) curing for the first 3 hours, and (3) reduction of shrinkage to minimize or eliminate shrinkage induced cracking. Additional research is proposed in the areas of (1) self compacting concrete, (2) curing blankets, and (3) reduction of shrinkage.

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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:

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