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The Maturity Method in Prestressed Concrete Applications

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SUMMARY

This study finds that the maturity method can make accurate, precise measurements of the strength of the concrete used for precast/prestressed box beams. The method is applied to measuring adequate concrete strength for the transfer of the prestressing force. Analysis of the temperature distribution within steam curing specimens and structural considerations identify the critical area for strength assessment to be the lower portion of the beam where the prestressing strands leave the forms for the anchorages. Surprisingly, the normal companion test cylinders predict the strength in this critical area very well.

INTRODUCTION/BACKGROUND

A previous report, *Implementation of Maturity Meters*, FHWA/NJ 2003-003, failed to provide guidance for using the maturity method for precast/prestressed steam cured specimens. It had been thought that the maturity method might be used to decrease the need for cylinder testing especially with regard to evaluation of the concrete for sufficient strength to allow transfer of the prestressing force. Based on the recommendations of the previous report a study of precast/prestressed elements was undertaken.

In order to test the maturity method's prediction of concrete strength a modification of ASTM C 873 is used, cured in-place lift-out cylinders, CIPLOC. Standard ASTM C 31 cylinders of the same concrete as the structure are placed into cylindrical heat wells precast into the structure. Since they are made of the same concrete as the structure and undergo the same temperature history, they are reasonably assumed to represent the strength of the structure

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RESEARCH APPROACH

Maturity measurements of the concrete strength in precast/prestressed concrete box beams are compared to both the industry standard ASTM C31 companion concrete cylinders, steam cured along with the specimen, and CIPLOC cylinders installed at the top of the test beam. A verification principal is applied which requires the strength-maturity relationship to accurately predict the strength of the companion test cylinders before it can be used to predict the strength of the structure. A procedure is demonstrated that refines the strength-maturity relationship by iteratively recomputing constants of the equation after the addition of successful tests to the strength-maturity database until at least 30 tests are included.

FINDINGS

1. The maturity method can make accurate, precise measurements of the strength of precast/prestressed heat accelerated concrete elements.

2. Using a datum temperature of 50° F in the computation of the temperature-time factor produced accurate predictions of the concrete strength of heat accelerated elements.

3. The bottom ends, where the prestressing strands leave the forms for the anchorages, are the critical areas for assessing the concrete strength of precast/prestressed beams.

4. Companion cylinders are shown to be an good representation of the structure's strength in the critical area for the precast/prestressed steam accelerated items tested.

5. The 28-day required strength of the prestressed/precast concrete elements was reached within 2 days for all observations.

6. The cured in-place lift out cylinders were shown to be a practical alternative for measuring in-place concrete strength.

CONCLUSIONS

1. The maturity method can be used for determining adequate concrete strength in an element to allow release of the prestressing force.

2. The verification principal for the maturity method is validated by the experiments.

3. A good strength-maturity relationship can be derived for precast heat-accelerated concrete mixes in a few good field trials.

4. The iterative refinement process, based on Excel's logarithmic Trendline function for the curve fitting, is able to produce an accurate and precise predictive equation.

5. The ability of maturity method, in conjunction with one-sided tolerance factor analysis, to express the required average strength is demonstrated.

6. Some consideration should be given to temperature conditions other than the late summer ones of this study. In these conditions the specimens were able to reach their 28-day strengths within the minimum acceptance time of 3 days. This might not be the case in winter conditions.

RECOMMENDATIONS

1. A datum temperature of 50° F is assigned for use in steam accelerated applications.

2. Maturity measurements are to be made in the critical areas of the beams adjacent to the anchorages at both ends of the prestressing bed. The maturity measurements in the section cast last are expected to be lower and will probably control the release strength. However, the lowest strength prediction will always control.

3. The strength-maturity relation must be validated by predicting accurately the strength of companion cylinders cured with the structure. After the required curing time the maturity method is used to predict adequate strength for the prestressing release. A strength test of companion cylinders is simultaneously conducted to check that the strength-maturity relationship is able to predict this concrete's strength. If the strength of the companion cylinder is predicted within the standard deviation, from at least 30 previous tests, then the prediction can be applied to the structure.

4. If the strength maturity relationship is not validated it will be necessary to determine the release strength by conventional means. This would constitute a reversion to the acceptance of the release strength in companion cylinders as indicative of that strength in the structure. If the validation has failed the causes must be investigated. It might be necessary to recompute the strength-maturity relationship.

5. The iterative refinement process shall continue until at least 30 tests are included in the strength-maturity data base for that concrete.

6. A verification test shall be conducted for each particular mix at least once each week of production. The verified strength-maturity relationship may be used for all production using this concrete at this plant.