

SUMMARY REPORT — TASK 1

HPR Project No. 94 — Performance Related Specifications
for Hydraulic Cement Concrete Used in Construction and
Rehabilitation of Ground Transportation

by

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Research Consultant

(The opinions, findings, and conclusions expressed in this report
are those of the author and not necessarily those of the sponsoring
agencies.)

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INTRODUCTION

Task 1 of the study approved as HPR Project No. 94 — Performance Related Specifications for Hydraulic Cement Concrete Used in Construction and Rehabilitation of Ground Transportation consisted of a review of the state of the art for using statistical concepts for quality assurance of hydraulic cement concrete. In particular, the specifications employing statistical concepts in use by other states and the general experience of those states were reviewed. A detailed review was made of such specifications in use, or being proposed for use, in Georgia, Louisiana, Maryland, New Jersey, Ohio, West Virginia, and the direct construction units of the FHWA, and the special provisions to the FHWA specifications FP 79 in use by Region 15. With the exception of Colorado, these agencies include all those reported by the FHWA as using statistical probabilities in portland cement concrete specifications. Colorado did not respond to either a letter request for information or a telephone inquiry.

In addition to the review of these specifications and the telephone conversation with the principals in most of the states using them, the recommended practices of the American Concrete Institute were reviewed. In particular, the principles given in ACI 214 were carefully considered.

FINDINGS

The reviews collectively serve as a guide to improving portland cement concrete specifications in Virginia or in any state transportation department with similar situations. They showed that the tests used and the characteristics of concrete measured as a basis for quality control and acceptance are essentially the same in all agencies. The characteristics measured are a minimum cement content, a maximum water/cement ratio, a consistency requirement (slump), entrained air content, and strength (usually measured at 28 days).

Generally, very similar requirements concerning type of equipment and mixing procedures, including high and low temperature limitations, will be included in the overall specification. The contractor or concrete producer is made responsible for mix design and control procedures. These similarities exist from state to state, regardless of whether or not statistical probabilities are being applied to acceptance procedures.

From this study and in consideration of ACI recommendations, it is concluded that the development of a performance related specification does not constitute the development of new test methods, but rather should entail the definition of ranges of presently measured characteristics that adequately provide the expected service for expected environmental and loading conditions. The first step must be the development of procedures whereby, to the extent possible, the as-built characteristics of the concrete are quantitatively indicated by the acceptance tests. This can be accomplished only by the introduction of statistical evaluations and the application of probability concepts in the specifications.

The required statistical evaluation requires the use of averages and standard deviations of a set of test results. The sampling must be done by prearranged random sampling plans. Statisticians indicate that at least 30 tests are needed in order to establish a high level of confidence that correct estimates of the characteristics of the total material on the basis of the tests are being made. For tests on portland cement concrete, the costs and time required for this amount of testing for each lot or project are prohibitive. Thus, a major problem that must be dealt with is how to establish an acceptable level of risks that an incorrect decision is not being made without making the number of tests needed prohibitively high.

The recent history involving contracts for furnishing portland cement concrete to the Virginia Department of Highways and Transportation (VDHT) shows that most contracts are relatively small and that if the present frequency of testing were to be continued, the resulting numbers of test results for most projects would be insufficient to establish good statistical estimates.

After consideration of the effect of various statistical techniques, the use of a continuous sampling plan essentially like the one now employed in the special provisions used by FHWA Region 15 appears best suited to the Virginia situation.

RECOMMENDATIONS

The following recommendations are made concerning continuation of the study.

1. Prepare a detailed interim report of the study essentially as outlined in the approved working plan. This report will include a summary of the statistical techniques employed by the agencies reviewed; a summary of ACI 214, the recommended practice on evaluation of strength data; an evaluation of the problems associated with determining the quality of hydraulic cement concrete in highway facilities; discussion of the problem of risks associated with the use of statistical probabilities based on limited numbers of test results; and, finally, specific recommendations for changes in the VDHT specifications for structural concrete.
2. After completion and approval of the interim report, it is recommended that a reevaluation be made of the further work planned for Task 4 of the study. It is also recommended that a meeting be held at which representatives of the FHWA Division Office, the Materials Division of VDHT, and the Research Council, the Project Leader (or his representative) of the Project 6G of the Federally Coordinated Program, would discuss needs for a field evaluation of the recommended changes in the specifications. This meeting would also address the problem of how data should be collected and preserved in order to best provide a basis for determining the relation of quality assurance data to the ultimate performance of the concrete.

Considerable guidance for this ongoing effort should be obtained from the FHWA study mentioned by Dr. Mitchell in his initial review of the working plan for this study is nearing completion. In any event, maximum coordination with Project 6G of the FCP would be sought.

