SUMMARY REPORT 70-3(S)

EFFECTS OF CHEMICAL ADMIXTURES IN CONCRETE AND MORTAR

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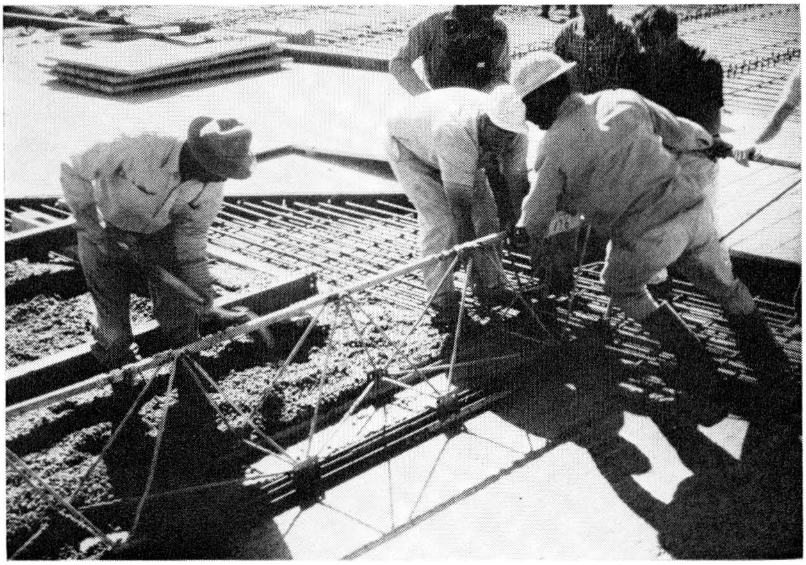

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Effects of Chemical Admixtures in Concrete and Mortar

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The controversy over the necessary performance specifications for chemical admixtures has been intense since the entrance of these admixtures in the field of concrete construction. Within the past ten years the major areas of controversy have been the requirements on limitation of concrete shrinkage, the effect of admixtures on durability, and the control of the uniformity of these admixtures.

In the area of shrinkage control, ASTM C494-63T, Chemical Admixtures for Concrete, required that admixture concrete be limited to a shrinkage of 100 micro-inches per inch over that of a control concrete without admixture. It was first shown by Tremper and Spellman (1)* and later by Torrans et al. (2), that this was a highly arbitrary specification depending to a large extent on the selection of the coarse and fine aggregate to be used in the test. The revisions to ASTM C494-63T now specify a maximum increase in shrinkage of 100 micro-inches per inch and not more than 135% of control for concretes with control shrinkage of over 300 micro-inches per inch. Since it is highly impractical to run physical acceptance tests on concretes made with every different aggregate that may be used on various jobs, the mortar tests that are reported in this paper represent an effort to standardize admixture performance tests. The effect of chemical admixtures on concrete durability has come under closer scrutiny as bridge deck deterioration has become a significant problem in some areas. Control of uniformity of chemical admixtures has been subject to considerable discussion within the profession, and a portion of the latest revision to ASTM C494-63T is devoted to this problem. The sample tests reported in this paper give indications of ways in which the uniformity may be verified.

In the use of cement mortars to determine product variations, a precedent was set by Walker and Bloem (3) in an extensive

*Refers to numbers in Selected References.

study of cement variations. It was not expected that the effect of chemical admixtures on a standard cement mortar could be extrapolated to accurately predict effects on various job concretes, but the relative performance of admixtures should be indicated, and performance variations in excess of predetermined testing variations should indicate variations in the admixture. The data presented in Research Report 70-3 (Final) provide a basis for utilizing a standard mortar for quality control tests of chemical admixtures.

Research Report 70-3 (Final) reports physical effects of chemical admixtures on concrete and cement mortars, compares the variability of mortar tests with the variations encountered in concrete tests, and shows the degree of correlation of these tests with tests on concrete. The data presented provide a basis for utilizing a standard mortar for quality control tests of chemical admixtures. Most of the work is concentrated on compressive strength, shrinkage, and time of set. Also included are the results of durability tests on admixture concrete and a section on the control of chemical admixture uniformity. A theoretical solution for restrained shrinkage crack spacing is developed and a comparison of this theory with limited test data is shown.

The admixtures tested were five lignosulfonates (AL*, DL_1, DL_2, DL_3, and DL_4), three organic acids (DO_1, DO_2, and DO_3), two polymers (AP and DP), and calcium chloride (CC). The materials under study reveal that:

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*The first letter of the admixture designation is the ASTM designation given in ASTM C 494-36T (A—Water reducing, C—Accelerating, D—Water reducing and retarding). The second letter refers to chemical type (L—Lignosulfonate, O—Organic Acid, P—Polymer, C—Calcium Chloride). The subscript which may occur differentiates between commercial products of the same ASTM designation and chemical type.

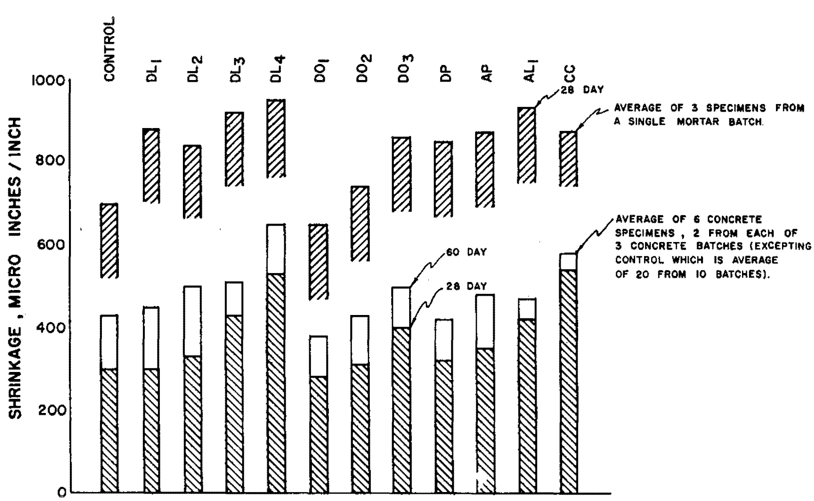

Figure 1. Concrete and mortar shrinkage.

1. **Quality Control.** The data and test procedures presented in this report provide a basis for the use of cement mortars as quality control tests for chemical admixtures.

2. **Compressive Strength.** All admixture concretes and mortars tested showed higher 7- and 28-day compressive strength than control concretes or mortars when they were allowed to utilize their characteristic water reductions.

3. **Shrinkage.** The results of shrinkage tests indicate some differences in the effect of different chemical types in both concrete and mortar. As a class, even though they have in general higher water reductions, the lignosulfonates show higher drying shrinkage than the organic acids and polymers tested (Figure 1).

4. **Setting Time.** The effect of retarders on setting time is significantly increased by using Ottawa sand mortars as opposed to mortar screened from concrete batches. Comparison of these mortars with mortar from the siliceous aggregate concrete batched in this program indicated an increase in setting time of approximately four to one.

Delayed addition of retarders to mortar batches increased set retardation by more than 100% over mortar batches with the admixture added with the gauge water.

5. **Air Entrainment.** High variations in the air entrainment characteristics of different admixtures were observed. Lignosulfonates entrain significant amounts of air while organic acids and polymers may contribute to the entrainment of small amounts of air.

6. **Concrete Durability.** The freeze-thaw testing of concrete according to ASTM C290 indicated significant differences in the durability of concrete using the various chemical types of admixtures (Figure 2).

7. **Extensibility.** The extensibility test used in this study has shown some correlation with a theoretical solution for restrained shrinkage crack spacing. It was noted that shrinkage increases of 41% decreased average crack spacing by 76%. This tends to indicate that allowing arbitrary percentage increases in shrinkage may have a marked effect on concrete cracking.

8. **Admixture Uniformity.** Infrared spectrographs of admixture samples obtained on a state-wide basis did not show significant variations, within a particular commercial admixture, in chemical constituents.

Hydrometer specific gravity tests can be used to determine admixture concentration in the field.

Continuing Research

Chemical admixtures are currently being studied in a program primarily concerned with air entrainment. An important aspect of this study is the variation in concrete properties due

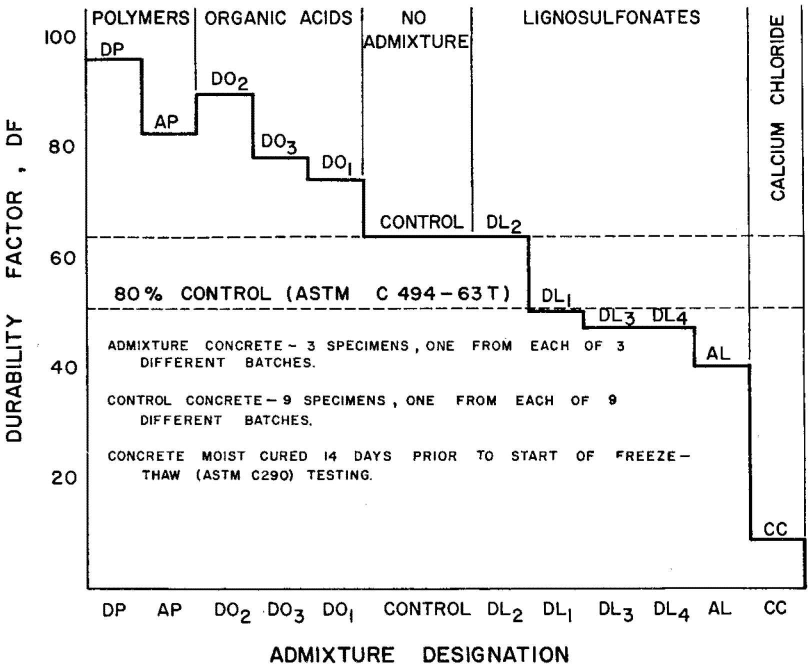

Figure 2. Relative durability of concrete using different admixtures (n = 300).

to interaction of retarders and air entraining agents under different batching conditions. Field studies of transit and central mix concrete will aid in the understanding of this problem.

Selected References

1. Tremper, Bailey, and Spellman, D. S., "Shrinkage of Concrete, Comparison of Laboratory and Field Performance," a report presented to the Forty-second Annual Meeting of the Highway Research Board, January, 1963.

2. Torrans, Patrick H., Ivey, Don L., and Hirsch, Teddy J., "The Effect of Chemical Admixtures on the Drying Shrinkage of Concrete and the Control of Chemical Uniformity of Admixtures," Research Report 70-1, Texas Transportation Institute, October, 1965.

3. Walker, Stanton and Bloem, Delmar L., "Variations in Portland Cement," ASTM Proceedings, Volume 58, 1958, P. 1009.