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Autor: Bresler, B.

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Control of Shrinkage by Laboratory Tests

B. BRESLER
USA

There is general agreement that shrinkage, creep and temperature changes can no longer be neglected in design of reinforced concrete structures. Consideration of strength alone is not sufficient as a measure of serviceability. Various methods for taking into account time-dependent volume changes in concrete have been proposed and availability of large digital computers greatly simplifies use of these methods by the designer.

Reliance on such design calculations requires a prescription of shrinkage and creep characteristics as part of the general specification for the structure and a subsequent verification of compliance with this prescription. The prescription and verification must be based on standard laboratory tests, just as prescription and verification of compressive strength is based on such tests.

The Structural Engineers Association of California in 1963 appointed a special committee to study the problems of shrinkage in concrete structures and to recommend methods of control from a practical point of view. A report of this committee was issued in 1965[1]. One part of this report deals with control of shrinkage of concrete by proper specifications and laboratory tests. It is based on the idea that shrinkage of a small laboratory specimen observed at a reasonably early age is an index of potential shrinkage of concrete used on the job. Troxell[2], based on test results, concluded that actual long-time shrinkage may be predicted from short-time shrinkage provided a proper conversion factor for the special test conditions has been determined.

The SEAOC report proposes to use a 4 x 4 x 11 in. prism as a standard specimen, moist cured for 7 days, and then dried under 50 percent relative humidity and 73.4° F (23°C). Measurements of shrinkage shall be made on a 10 inch gage length at 7, 14, 21 and 28 days of drying. From experimental studies it was found that shrinkage of such a specimen approaches its ultimate value in about 64 weeks, that at 28 days the observed shrinkage is about 0.4 and at 21 days the observed shrinkage is about 0.33

of ultimate value. It was then assumed that due to variation in humidity, temperature, size of members, etc. the "effective" shrinkage of concrete member in the structure is about 0.5 that of a 4 x 4 in. laboratory specimen. Effective shrinkage is defined as that observed in unreinforced member. Thus, should the design of the structural element be based on effective ultimate shrinkage S, the laboratory specimen after 28 days of drying should exhibit a shrinkage of S_{28} = (S/0.5) (0.4) = 0.8S, or after 21 days of drying it should exhibit a shrinkage of S_{21} = (S/0.5) (0.33) = 0.66S.

Three classes of concrete are proposed, as shown below:

Class	A	B	C
Value of S, millionths	400	600	800

Due to variability in test results and conditions on which these relationships are based, a variation of 15 percent in the observed values can be allowed. It is also recognized that laboratory tests on small specimens cannot predict the shrinkage of concrete members of all sizes under widely varying conditions. Future tests on correlation between laboratory and field shrinkage may show that the above values should be increased or decreased.

The general specifications can be written to require control tests in order to verify shrinkage characteristics of the particular concrete. Two types of test should be required:

1. For the concrete mix proposed for the project, a "trial batch" mix shall be prepared and at least three shrinkage specimens and six compression test specimens should be tested to verify shrinkage and strength characteristics <u>prior</u> to placing any concrete.

2. <u>During construction</u> shrinkage specimens for each class of concrete should be taken at the same time as compression strength test specimens. At least one set of three specimens should be taken for each 150 cubic yards of concrete placed, and in no case less than one set of specimens should be taken for each day's concreting.

Above remarks focused attention on shrinkage characteristics of concrete. Other properties, such as creep and thermal coefficient of expansion, also require attention. Appropriate short term tests to predict these characteristics have not yet been developed, and it is hoped that this discussion will stimulate efforts in this direction.

References

1. Control of Shrinkage of Concrete, Report of Committee on Shrinkage of Concrete, Structural Engineers Association of California, 1965.

2. Troxell, G. E., "Short-Time Tests for the Effect of Type of Cement on Concrete Shrinkage," Proc. ACI, Vol. 35, 1939.