

DISCUSSION OF REPORT OF COMMITTEE ON CHARACTER AND USE OF ROAD MATERIALS

I CONCRETE MATERIALS

Opened by D A ABRAMS

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It is difficult to discuss the properties of concrete materials aside from the properties of the concrete itself, since the quality of the concrete depends on the proportions of materials, manipulation and curing, as well as on the characteristics of the constituent materials. I am inclined to believe that in general the proportions and manipulation are of much greater importance than the characteristics of the materials.

Concrete is uniform in its properties and behavior if it is consistently made. Poor concrete is not accidental, it is poor because we made it that way, in other words we get exactly *the kind of concrete that we make*.

WATER-CEMENT RATIO LAW OF CONCRETE MIXTURES

The importance of the water-cement ratio has been fully established by many independent series of tests carried out both in this country and in Europe. The strength and many other properties of concrete depends on the ratio of mixing water to cement so long as the concrete is plastic or workable. The water-cement ratio may be expressed in terms of gallons of water to each 94-lb sack of cement.

Too much mixing water is fatal to concrete, disregarding this fundamental relation is responsible for most of the difficulties which have been encountered so far as quality of concrete is concerned.

More recent researches have shown that the water-cement ratio controls not only the compressive strength but the tensile and cross-breaking strength, resistance to wear, resistance to weather, permeability, resistance to alkali attack and probably other properties of concrete.

WATER-CEMENT-RATIO SPECIFICATION FOR CONCRETE

A specification has been used on a number of important jobs which is based almost entirely on the adequate control of the quantity of mixing water. Under this specification the contractor is given considerable latitude so far as proportions of cement and relative quantities of fine and coarse aggregate are concerned, so long as the water-cement ratio does not exceed a fixed value (say 6 or 7 gallons per sack of cement). Where concrete of greater workability is re-

quired (as measured by the slump or flow test) it is produced by *reducing the quantity of aggregates*, rather than by increasing the quantity of mixing water as is ordinarily done under the older practice. Experience in using this specification shows that it offers no difficulties and that satisfactory control of concrete quality is readily secured.

Mr. Crum's report reviews a number of groups of tests of concrete made during construction and shows how this type of specification works out in practice.

HIGH EARLY STRENGTH CONCRETE

In a number of instances during the past year or two, concrete roads and streets have been opened to traffic within 3 to 7 days instead of excluding traffic for 14 to 30 days as had been the usual practice.

Concrete which will give a compressive strength of 2,500 lbs. or more at 3 days can be readily produced. Concrete of this strength can be relied upon to safely carry any ordinary traffic loads.

Under favorable weather conditions, this result is readily accomplished with ordinary Portland cement, by proper attention to the quantities of materials in the batch. The principal factor in the control consists of restricting the water-cement ratio to a minimum which will produce a plastic mix.

One of the most important streets in Duluth, Minn. (Michigan Ave.) was paved with concrete during the past summer. The pavement was opened to traffic 3 or 4 days after the concrete was placed.

AGGREGATES

Three tendencies have been notable during the past few years with reference to the requirements of aggregates for concrete roads:

- (1) Acceptance of aggregates of lower hardness or toughness
- (2) Specifying aggregate of larger size,
- (3) Insistence on uniformity of size and grading.

The question which frequently confronts the engineer is not whether a certain aggregate meets specification requirements, but, "How can I make acceptable concrete of this aggregate which falls short of the usual standards?"

Both experience and tests have shown that concrete of good quality can be made of aggregates which are distinctly inferior as judged by commonly accepted standards; on the other hand, it is not uncommon that extremely poor concrete is made from excellent aggregate due to faulty proportions or manipulation.

An effort is now being made to define more fully some of the general requirements of the aggregate specifications such as "hardness", "soundness" and "durability."

The sodium sulfate test commonly known as Brard's test has been applied to concrete aggregates by a number of different investigators. The evidence presented thus far seems to indicate that 5 repetitions of exposure to a saturated solution of sodium sulfate followed by drying is too severe a test for many aggregates which are known to be satisfactory. Further study should be given to this type of test and its relation to natural freezing and thawing.

In tests of aggregate or researches involving aggregate, extreme care must be used in securing proper samples. Unsatisfactory sampling has been responsible for a great deal of puzzling and contradictory test data.

CONCRETE EXPOSED TO ALKALI

Field investigations carried out under the speaker's direction during the past 5 years on concrete blocks exposed to highly concentrated sulfate soils and waters in Colorado and South Dakota have shown a remarkable correlation between the resistance of concrete to sulfate attack and its compressive strength at 28 days. Factors such as reduced water-cement ratio, increased quantity of cement, better grading of aggregates, more satisfactory curing, etc. which gave concrete of higher strength, also gave concrete of better resistance to sulfate action.

Our tests have confirmed Mr. Miller's findings with reference to admixtures and surface coatings. A surface treatment of 3 paint coats of boiled linseed oil gave excellent protection up to 5 years.

II BITUMINOUS MATERIALS

Opened by PREVOST HUBBARD

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That portion of the report of the Committee on Character and Use of Road Materials which the speaker has been scheduled to discuss, namely, bituminous materials, is a most excellent brief summary of progress made during the past year and statement of status quo of the more important investigations. There is nothing for him to criticize and but little to add to this report except perhaps to enlarge on a few of the points which have been covered and to suggest some additional factors involved in the practical application of the information already secured which are in need of careful and immediate study.

In introducing the subject of laboratory investigations of asphalt