SANDS AND CONSISTENCY OF CONCRETE

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(Continued from last week's issue.)

THE first batch of concrete used in the tests was mixed on March 30th, the last batch on July 25th. The range of temperature and humidity was therefore comparable with that usually found in northern latitudes in a working season extending from April 1st to October 20th. In this connection, however, it must be borne in mind that the actual mixing of the concrete was done between 7 and 8.30 a.m. The proportioning, mixing, and placing was doubtless more accurately, uniformly, and carefully done than is usual upon high-grade construction work. The conditions of seasoning were as nearly uniform as could be provided at a nominal expense. All testing of materials, cylinders, beams, etc., was done by experienced operators. It is therefore reasonable to assume that irregularities due to the methods of procedure are comparatively small, and that the results obtained are generally normal.

In actual concrete construction operations in the field, the object sought, in so far as the specifications for any particular structure are concerned, is, without exception, to produce a good, reliable material. Results frequently fall short, however, for due to a misleading popular opinion that "anyone can build in concrete," comparatively few field superintendents and foremen have developed a thorough knowledge of concrete materials and of high-class field methods. The hazardous policy of "save the labor and spoil the concrete" is too frequently found in a sort of inseparable combination with the above.

As a result of the conditions already described, it occasionally happens that the materials used are not always of good quality, neither are they always free from admixture with harmful ingredients in dangerous quantities. In the transitory stage the component materials are frequently used in improper proportions; they are insufficiently mixed; the cementing material is not fully developed; and the mass is subjected to more or less abuse, with the eventual result that the concrete produced contains myriads of voids and cavities, and frequently lacks strength, hardness, toughness, and the general durability requisite for good construction material of the class contemplated by modern practice in plain and reinforced-concrete design.

Strength Requirements

As a basis for comparisons assume the ultimate compressive strength of concrete in pounds per square inch, when tested on 6 by 12-in. cylinders, to be as follows:—

Age of 1 month, 1:2:4 mix, 2,200 lbs. per sq. in.; 1:2½:5 mix, 1,900 lbs. per sq. in.

Age of 3 months, 1:2:4 mix, 2,800 lbs. per sq. in.; 1:2½:5 mix, 2,300 lbs. per sq. in.

Assume also the conditions of mixing, placing, storage, etc., to be the same as existed in the tests already described.

By reference to Figs. 8 and 9, it appears that of the weaker sands Nos. 9, 10, 11 and 12, only sand No. 9 would be acceptable for a 1:2:4 mix, and sands Nos. 9 and 10 for a 1:2½:5 mix. The stronger sands, Nos. 2, 3, 6 and 7, would give an excess strength of from 25 to 51 per cent. for a 1:2:4 mix, and from 36 to 49 per cent. for a 1:2½:5 mix.

Using relative strengths, as shown in Fig. 13 for a third consistency of mix, all sands used in the tests would fail to fulfil the 1-month age requirements. At the age of 3 months, sands Nos. 2, 3 and 6 would give an excess strength of from 1.5 to 16 per cent. for a 1:2:4 mix; while sands Nos. 2, 3, 6 and 7 would give an excess strength of from 6 to 15 per cent. above that required for a 1:2½:5 mix. Similarly for a fifth consistency of mix, the weaker sands would give approximately 40 to 60 per cent. and the stronger sands 65 to 85 per cent. of the required strengths.

The results as given under "time of mixing" show that the conditions attending field mixing may be such as to very materially affect the final strength of the concrete produced. The detrimental influences of one or more of the factors investigated in this series of tests frequently exist in connection with actual field construction work. In addition, there are other harmful factors which to a greater or less degree affect the strength and durability of the concrete produced. To the contrary, the generally accepted requirements of modern practice in plain and reinforced-concrete design assumes the existence of good materials, and the use of efficient field methods and operations in their application. Economy of construction requires that the practice of design be upheld. Safety and permanence demand greater knowledge of concrete materials, and greater efficiency in construction methods and operations.

Sand Specifications

As early as 1855 Mr. T. Hughes, Civil Engineer, in a series of papers described his choice of sand for concrete work as follows:—

"To speak practically of the mixture of sand in making concrete we should say that none of the particles ought to exceed the size of a barley-corn, and that a great portion of the sand should not exceed half that size, while another portion of the sand, equal in quantity to the other two portions united, should consist of grains of sand not so large as a pin's head. The sand to be sharp and clean."

This quotation is interesting, in that it shows the valuable information gained by early artisans and engineers in concrete construction work, to have been ignored by the writers of sand specifications in comparatively recent years. It is only within the past decade that American concrete specifications have provided requirements other than that the sand aggregate shall be sharp and clean.

The author submits specifications for a sand to be used for general concrete purposes, which are as follows:—

Sand shall be of hard, preferably silicious, material, clean, rough, free from dust, soft particles, vegetable loam or other deleterious matter. It shall consist of particles graded from coarse to fine, of sizes that will pass, when dry, a sieve having 4 meshes per linear inch. The grading of particles shall otherwise conform to the following:—

Not more than 80 per cent. shall pass a sieve having 10 meshes per linear inch, not more than 55 per cent. shall pass a sieve having 20 meshes per linear inch, not more than 15 per cent. shall pass a sieve having 50 meshes per linear inch, and not more than 5 per cent. shall pass a sieve having 100 meshes per linear inch. Upon the 10, 20 and 50-mesh sieves an allowable variation of 5 per cent. will be permitted.

Sand, when combined with a normal Portland cement and 1-in. broken granite, limestone or trap of good quality in the proportions 10 lb. of cement, 21 lb. of dry sand, and 35 lb. of dry broken stone, thoroughly mixed with 4¼ lb. of water for not less than 1 minute and moulded into cylinders 6 in. in diameter by 12 in. long, shall develop a compressive strength of 1,300 lb. per sq. in. when tested at the age of 7 days and a strength of 2,200 lb. per sq. in. at the age of 30 days. Strength