PROPORTIONING OF CONCRETE.

In correctly made concrete the amount of sand should be just sufficient to fill the voids in the coarse material, and the amount of cement just sufficient to fill the voids in the mixture of sand and coarse material and to coat all the particles with very thin jointing layers. It is a rational assumption that such concrete will give a maximum of strength with the minimum of cost, and if such assumption be justified by experimental results it follows at once that the proportioning of concrete-forming materials is of the utmost importance. Greater strengths can be obtained by the use of excess of cement, as in the case of the ordinary mix of 1:2:4, but the increase in strength is less than the increase of cost of materials and is, therefore, only justified in particular cases.

The strength of any concrete will depend not only upon the materials and their proportions, but also upon the method of using those materials. Any void in a mass of ¾-in. coarse material may be filled in many ways. Firstly, it may be filled with cement and sand mortar, as in the 1:2:4 concrete; secondly, it may be filled with a piece of stone which practically fills the whole space; and thirdly, it may be filled with a number of stones which vary in size with a minimum amount of cement and sand mortar. The first filling is composed almost wholly of joints, and on that account is weak; the second filling is strong, owing to the absence of joints, but it is impracticable; but the third is a compromise which is not only practicable but also strong. It will be seen that the amount of the variations in size or the grading will depend upon the nature and quality of the work required. On the one hand there will be good but costly filling and on the other a cheap but still good filling, and whether the gradiation be large or small the filling will be better than one of cement and sand mortar only.

With a view to testing the effect of "proportioning" upon the strength and other properties, and also the cost of concrete, John A. Davenport and Prof. S. W. Perrott, of the civil engineering department of Liverpool University, drew up a series of experiments, the intention being to test compressive strength, modulus of rupture, specific gravity, water resistance, and fire resistance. Various difficulties arose in the course of the work which prevented the inclusion of specific gravity, water resistance and fire resistance tests. The results were contained in a paper recently presented by them at a meeting of The Concrete Institute, and entitled "Sand and Coarse Material and Proportioning Concrete."

The series involve 216 test pieces, to which must be added others prepared for water and fire resistance and specific gravity tests, but which could not be tested in the time available. The voids were measured in a patent apparatus designed by Mr. Davenport, which gives results to 1/5 of 1%; and which was found to be independent of the observer. The preliminary data comprised tests on Portland cement, size of granite chips, volume of chips per batch, percentage volume of voids in chips, sizes of river-sand used, volume of sand used per batch, percentage volume of voids in sand, and the volume of cement used per batch. Regarding the latter item it must be noted that no allowance was made for the excess cement required for jointing, only the amount required to fill the voids being used. Had time permitted it, the correct allowance in each case would have been ascertained and additional tests made therewith. The limited time made it impossible to test the cement before using it for the concrete testpieces, the brand only suggesting its probable good qualities.

The batches were hand-mixed by engineering students and as no special means of testing the thoroughness of the mix were adopted, the resulting concrete will probably not compare favorably with machine-mixed concrete so far as uniformity of results go. Every care was exercised, however, in mixing to get all the materials thoroughly intermixed and apparently uniform. This proved to be the case when the specimens were tested. The moulds were made of planed boards, bolted together with gangs, damped before using, and lined with paper on the under side to facilitate removal. In spite of this, several pieces were damaged in removal, due more particularly to the relatively small sections used.

Immediately after mixing, the moulds were filled and left in a tool shed till required for testing. They were wetted regularly every three or four days.

It was found that the ratio of compressive to tensile strength varied more in the one-month than in the three-month tests, and is not sufficiently uniform to base any conclusions upon, beyond the fact that such ratio is not constant. It is considered by the authors, however, that this ratio should be more or less constant as the failure, whether compressive or tensile, depends upon the adhesive strength of the cement.

The ratios of strength at three months to strength at one month were more or less uniform, more particularly in the case of comparative strengths. In the case of 1:2:4 concrete the modulus of rupture appears to increase more rapidly than the compressive strength, while in the other series with cement accurately proportioned, the compressive strength increases more rapidly than the modulus of rupture, as out of six series only one runs the other way, probably due to rather dry mixing of those three-month test pieces.

Although the cement tests are unsatisfactory, it will be possible to compare the strengths and costs of the concrete in the different series, as they will probably all be affected to the same extent. The most important point brought out by such comparison is the fact that for accurate proportions, the ratio of cost of cement to total cost is practically constant for all gradings taken in the tests, so that when the graded coarse material is used the total cost need only be further considered. Of course, the total cost is always the final criterion as regards economy, and it may be suggested that the ratio cost of cement to total cost need not be considered. But the relative values of total cost obtained may be altered when additional tests are made at other ages, and it is difficult to say whether they will be affected by the ratio, so that if it can be shown conclusively that this ratio is constant or nearly so, the total cost, age and proportions need only be dealt with.

The authors did not feel justified in attempting to generalize from the results which they obtained, as they considered such results did no more than open up the subject of proportioning and grading in relation to cost. They had no hesitation, however, in saying that the figures given by them show conclusively that the subject is well worth being made the object of special research.

It is announced at Ghent, Belgium, that the third section of the railway line of the Great Lakes will, it is estimated, be completed as far as the shore of Lake Tanganyika, during the second half of the current year as only 50 kilometers of rails remain to be placed and several bridges to be completed.