makes a stronger concrete for a given workability and is preferred to angular particles. The particles should be compact and not flat and elongated.

PROPORTIONING CONCRETE.—The composition of concrete varies considerably, depending upon the specific requirements in respect to strength, durability, impermeability, workability and economy, in addition to the quality and characteristics of the materials. Thus, the proportions of materials for concrete required for a reinforced concrete beam will differ from those for a concrete non-load-bearing internal partition or for site concrete.

Great care should be taken to determine the correct proportions of the materials. That of cement should always be specified by weight. The former practice of specifying cement by volume has been discontinued, as the weight of a cubic foot of cement is not constant but varies according to its fineness and the manner in which it is filled, loosely or otherwise. The unit of weight of cement usually taken is that of a bag of cement as sold, *i.e.*, 1-cwt.

The fine and coarse aggregates may be expressed either by weight or by volume. Although the former may be more accurate, it is not often adopted in this country where it is the common practice to specify the aggregate in terms of volume (cubic feet). Hence a concrete mix is usually specified as consisting of 1-cwt. of cement to so many cubic feet of fine aggregate and so many cubic feet of coarse aggregate. Examples of this form appear in the Model Bye-laws (1939) and in the Code of Practice for the Use of Reinforced Concrete in Buildings (see p. 29). Thus, the Bye-laws stipulate that site concrete shall consist of not less than 112-lb. of cement to every $3\frac{1}{2}$-cub. ft. of fine aggregate and 7-cub. ft. of coarse aggregate. The Code gives tables in which the following four arbitrary mixes appear :—

Nominal Mix.	Cement.[1]	Fine Aggregate.	Coarse Aggregate.
	Cwt.	Cub. ft.	Cub. ft.
1 : 1 : 2	1	$1\frac{1}{4}$	$2\frac{1}{2}$
1 : 1·2 : 2·4	1	$1\frac{1}{2}$	3
1 : $1\frac{1}{2}$: 3	1	$1\frac{7}{8}$	$3\frac{3}{4}$
1 : 2 : 4	1	$2\frac{1}{2}$	5

Sometimes a mix is specified as consisting of 1-cwt. of cement to so many cubic feet of fine and coarse aggregates combined. Thus, the Model Bye-laws require that concrete for foundations shall be composed of not less than 112-lb. cement to every 15-cub. ft. of coarse and fine aggregates in combination.

The 1 : 2 : 4 mix given in the above table meets general requirements and is often adopted ; both it and the 1 : $1\frac{1}{2}$: 3 mix are usefully employed for reinforced concrete work. The 1 : 1 : 2 and 1 : 1·2 : 2·4 mixes, having a high cement content, are suitable for producing very strong and impermeable concretes. There are several variations to these mixes, depending upon the class of work required.

In practice, and during wet weather especially, it is difficult to obtain batches of concrete which are uniform when the fine aggregate is measured by volume. This is due to the increase in volume, known as *bulking*, of the sand which occurs when it is in a moist condition. Experiments show that 1-cub. ft. of dry sand will approximately increase to $1\frac{1}{5}$-cub. ft. if 3 per cent. of water is added to it, and therefore there is actually less aggregate in 1-cub. ft. of moist sand than in the same volume of dry sand. If the water content increases to 4 per cent., the volume will be increased by approximately $\frac{1}{4}$; as the moisture increases beyond this percentage, the bulking gradually decreases, and when the sand becomes submerged the volume of the inundated sand is the same as that when dry. The finer the sand, the greater the bulking. This bulking of moist sand should be allowed for ; it is customary to assume that the volume has increased by 20 per cent., and therefore this amount of sand is added to the proportion of fine aggregate when mixing.

It is obvious that this is only an approximate correction. In wet weather, sand which has been deposited on a site has a variable water content. When high-grade concrete is required, the actual bulking may be obtained in the following manner : The gauge box used for measuring the fine aggregate (see p. 34) is filled with the moist sand. This sand is dried, returned to the box, and after being levelled off at the top the reduced depth of the sand is measured. The percentage of bulking equals

$$\frac{\text{Depth of box} - \text{depth of dry aggregate}}{\text{Depth of dry aggregate}} \times 100.$$

This method is not readily applied in practice and is only resorted to when specially called for.

The bulking of sand does not present any practical difficulties when the mixes are proportioned by weight. Coarse aggregates are not normally subjected to the phenomenon of bulking.

WATER.—The water used for mixing concrete is required to produce a workable plastic mix, in addition to hydrating the cement. It must be clean and fresh. It is emphasized that the strength of concrete depends upon the quantity of water used in relation to the cement content, and *an excess of water, however slight*, reduces the strength of the concrete.

The following tests were carried out in the Building Laboratory of the Manchester College of Technology to demonstrate to students the marked effect that the water content has upon the compressive strength of concrete : Three different mixes of concrete were separately prepared. The materials in mix " A " were mixed dry in the proportion of 1 : 1 : 2. The cement used was normal Portland cement. The mix was divided and each half was separately mixed with water, one half having 30 per cent. more water added than the other. A 4-in. cube (see p. 32) was then made from each half of each batch and tested for compression strength at the end of twenty-eight days. Mixes " B " and " C " were dealt with in a similar manner, the excess water added to one-half of each mix being also 30 per cent. The following were the results :—

[1] The weight of cement varies from 80 to 90-lb. per cub. ft. (see p. 31). Therefore the volume of 1-cwt. of cement is approximately $1\frac{1}{4}$-cub. ft.