TABLE I

Mix.	Proportions.	Normal Mixes.			Mixes with 30 per Cent. Excess Water.			Per Cent. Reduction in Strength.
		$\frac{W}{C}$.	Slump.	Strength.	$\frac{W}{C}$.	Slump.	Strength.	
			In.	Lb. per sq. in.		In.	Lb. per sq. in.	
A	1 : 1 : 2	0·43	2½	5,060	0·56	9	3,400	33
B	1 : 2 : 4	0·62	3½	2,940	0·81	9	1,690	42½
C	1 : 3 : 6	0·85	2	1,550	1·10	7	860	44½

These figures illustrate the appreciable reduction in strength as a result of excess water content.

This relationship between the quantity of mixing water and amount of cement in a concrete mix is known as the *water-cement ratio*, expressed as "W" "C" $\left(\frac{\text{Water}}{\text{Cement}}\right)$ either by volume, or by weight, or by the number of gallons of water per hundredweight (weight of a bag) of cement. Thus, if expressed by volume, 1-cub. ft. of water per 1-cub. ft. of cement equals a ratio of $\frac{1}{1}=1$; if by weight, this ratio becomes

$$\frac{62\cdot5\text{-lb. (weight of 1-cub. ft. of water)}}{90\text{-lb. (weight of 1-cub. ft. of cement)}^{1}}=0\cdot69;$$

if 6-gals. of water are used per hundredweight of cement, the ratio is

$$\frac{6\times10\text{-lb. (weight of 1-gal. of water)}}{112}=0\cdot54.$$

Whilst in the laboratory the materials are usually taken by weight, it is more convenient for practical purposes to specify the number of gallons per hundredweight bag of cement. The $\frac{W}{C}$ ratios and the corresponding strengths shown in Table I clearly indicate that the strength of the concrete is lowered as a result of the additional water.

It is not possible to state definitely the amount of water which should be used in a concrete mix, as this depends upon the desired workability, amount of water in the fine aggregate and that absorbed by the coarse aggregate. An approximate rule for finding the amount of water for concrete consisting of dry and non-porous aggregate is to take 28 per cent. of the weight of the cement plus 4 per cent. of the weight of the aggregate. Thus, for a 1 : 2 : 4 mix requiring 1-cwt. cement, 2½-cub. ft. sand (weighing 100-lb. per cub. ft.) and 5-cub. ft. gravel (weighing 98-lb. per cub. ft.), the number of gallons of water equals :

(Cement) $\frac{28}{100}\times1\times112=31\cdot36$ lb. $\div10=3\cdot14$ gals.

(Sand) $\frac{4}{100}\times2\frac{1}{2}\times100=10\cdot00$ „ $\div10=1\cdot00$ „

(Gravel) $\frac{4}{100}\times5\times98=19\cdot60$ „ $\div10=1\cdot96$ „

6·10 gals.

SLUMP TEST.—The best practical test for determining the desired workability of concrete and the required amount of water is that known as the slump test. This is now universally adopted both on the site during the progress of the work and in the laboratory. The apparatus simply consists of a metal mould, frustum of a cone in shape, with both ends open and provided with two handles ; the dimensions are 12-in. high, 8-in. internal diameter at the bottom and 4-in. internal diameter at the top (see G, Fig. 9). A 2-ft. long metal rod, ⅝-in. in diameter and bullet nosed, is also required.

In carrying out the test, the mould is placed on a flat surface which *must be non-absorbent*. It is filled with the freshly mixed concrete to a height of about 3-in. ; this is puddled to expel the air by applying twenty-five strokes of the rod. The filling is completed in similar successive consolidated layers and the surface is struck off flush with the top by a trowel. The mould must be held firmly as it is being filled, and to prevent movement it may be provided with two flat footpieces, attached near the base, upon which the operator stands. Immediately it is full, the mould is carefully lifted *vertically* and placed on the mixing surface adjacent to the concrete specimen, which will have subsided or slumped. The amount of settlement, which varies according to the water content, is measured in inches by placing a rule across the top of the mould and measuring the height that its lower edge is above the top of the concrete. Thus, at H, Fig. 9, a 3-in. slump is indicated.

This is an excellent practical test, as it is simple and takes little time to carry out on the job. By its use it is possible to reasonably control and obtain a uniform consistency of the concrete. It is important to note that the slump will be affected if the cement and aggregates are changed, and therefore any such change of materials will necessitate preliminary trial tests to see if any alteration in the slump is necessary. A slump test is taken daily to check the consistency (or condition of wetness) of the concrete used for first-class work.

[1] The weight of 1-cub. ft. of cement depends upon its fineness ; thus, for normal Portland cement the weight is usually taken as 90-lb per cub. ft. ; the finer ground rapid-hardening Portland cement may only weigh 80-lb. per cub. ft.