Proportions of Mix

The proportions of mix of cement and aggregate are usually designed for a particular condition, the general method for farm work being arbitrary selection based on experience and common practice, such as 1 part by volume of cement, 2 parts of sand, and 4 parts of stone (referred to as a 1:2:4 mix). Though this method is uneconomical and does not give the best results with a given aggregate, it is quite satisfactory for all normal farm concrete work.

Nature of Aggregates

Because the nature of aggregates affects the strength of concrete considerably, the particles of all materials must be sound and strong with no flakiness. As the fine materials, including the cement, enter more or less into the voids of the coarse aggregate, materials must be suitably graded to occupy these voids and be clean and absolutely free from organic impurities.

The strength of concrete depends on the bonding together of the particles and the solidarity or density of the mixture. The strength increases with the quantity of cement in a unit volume, with the decrease in the quantity of mixing water, with the density of the concrete, and with the size of the coarsest aggregate.

Unless voids in the aggregate can be completely filled by particles of less size, density is reduced and the concrete is weaker in proportion to the reduction in density.

Angular aggregates such as broken stone produce stronger concrete than rounded gravel. Specially-graded mixtures of aggregates produce concrete of higher strength. Strength is decreased by an excess of sand over that required to fill the voids in the stone and give sufficient workability.

These points can be applied to the choice of aggregate; for example, if beach sand is available, it is preferable to obtain it from below high-water mark, as any wind-blown sand available from, say, sand dunes has not the same angular particles as freshly-deposited sand.

Water-cement Ratio

The importance of the water-cement ratio depends on the principle that the strength of the concrete with given aggregates and cement bears a direct relation to the ratio of the volume of water to the volume of cement.

The smaller the ratio of the volume of water to the volume of cement, as long as the mix is workable, the higher is the strength of the resulting concrete. Therefore, the reduction of the mix to a plastic condition by the addition of water should be carried only as far as necessary to produce reasonable workability.

The consistency to be used will depend on the character of the structure. Medium or quaking concrete is adapted for ordinary mass concrete such as foundations, heavy walls, large arches, piers, and abutments. Mushy concrete is suitable for rubble concrete and reinforced concrete such as that used for thin building walls, columns, floors, conduits, water troughs, and tanks. Dry concrete may be used in dry locations for mass foundations which must withstand severe compressive strain within a month after placing, provided it is carefully spread in layers not more than 6in. thick and is well rammed.

A medium or quaking mixture is of a tenacious, jellylike consistency which shakes on ramming. A "mushy" mixture will settle when dumped in a pile, and will flow very sluggishly into the form or round the reinforcing bars. A dry mixture has the consistency of damp earth.

The proportion of water in the mix is of vital importance, a very wet mix being much weaker than a dry or mushy one.

For farm concreting operations mixing is usually carried out in small batches, and uniformity of mix is difficult to obtain. An easy method of testing each batch for uniformity is known as the "slump test," which will be described fully in a later article in this series.

Types of Cement

The type of cement used does not affect the quality as much as the characteristics of the concrete. Normal cement used for practically all purposes is known as Portland cement. Other cements obtainable are:—

Waterproofed cement, for use where a waterproof or water-repellent concrete or mortar is particularly desirable.

High-early-strength cement for use where high-strength concrete is required in 1 or 2 days.

Plastic cement, for use where a particularly workable and fat mortar or concrete is desired, such as for masonry work.

White cement, for use in architectural or ornamental work.

Natural cement, for use as a common mortar for brick or stone work.

A knowledge of Portland cement will help in the understanding of its behaviour in the making of concrete.

Chemical Action of Cement

Portland cement is made from a mixture of about 80 per cent. of carbonate of lime (limestone, chalk, or marl) with about 20 per cent. of clay in the form of clay, shale, or slag. After being intimately mixed the materials are finely ground by a wet or dry process and then calcined in kilns to a clinker. When cool the clinker is ground to a fine powder. This powder, which is the finished product, contains silica, alumina, certain metallic oxides, and some alkalis in varying proportions, depending on the raw materials used.

When the cement powder is mixed with aggregates and water chemical action takes place between the cement and water. The aggregate, which occupies most of the volume of the hardened concrete, is inert and the chemical action which results in the hardening of the cement paste binds all into a homogeneous mass.

This chemical process, called hydration, causes the generation of large quantities of heat, rapidly at first and gradually decreasing as the curing of the concrete takes place.

As cement depends on water to bring about its chemical change, normal atmospheric moisture will cause the change to take place with stored cement. For this reason it is essential to keep cement dry up to the time of use. Cement which has partially set in the bags has lost a considerable part of its cementing properties and concrete made with recrushed, lumpy, or hardened cement will be a failure.

Similarly the remixing of mortar or concrete after the setting action has started is extremely detrimental to the final soundness; by breaking up and retarding the consolidation of the elements pockets are produced where moisture cannot reach entirely, preventing completion of chemical action, that is, completion of hardening.

Properties of Concrete

The properties of any material used for construction are the deciding factor in the choice of application of that material to construction.

The properties of concrete for consideration as a construction material are:—

1. Strength—compressive, tensile, and shear.
2. Watertightness.
3. Immunity against fire.
4. Workability.

Strength

The compressive strength of concrete is very high and, being dependent on the type of aggregates used and the proportion of mix of aggregates and cement, can be regulated to suit the requirements of the particular construction.

Table 1 gives the compressive strength of different mixtures of concrete in pounds per square inch 28 days after use. From this table it is apparent that with a weak mixture of 1 part of cement to 9 parts of aggregate of sand and soft cinders a strength of 400lb. is obtained, as compared with a strength of 3300lb. when 1 part of cement to 3 parts of aggregate of sand and hard granite rock are used.

The tensile strength of concrete is of less importance than the crushing or compressive strength, as the former is seldom relied on and any members with tensile stressing are built with steel reinforcing placed in the tensile

TABLE 1—COMPRESSIVE STRENGTH IN LB. PER SQ. IN. OF DIFFERENT MIXTURES OF CONCRETE 28 DAYS AFTER LAYING

Aggregate	Proportions by parts				
	1:1:2	1:1½:3	1:2:4	1:2½:5	1:3:6
Granite or trap rock	3,300	2,800	2,200	1,800	1,400
Gravel, hard limestone, and hard sandstone	3,000	2,500	2,000	1,600	1,300
Soft limestone and sandstone	2,200	1,800	1,500	1,200	1,000
Cinders	800	700	600	500	400