CONCRETE

Concrete consists of a (1) matrix, (2) fine aggregate and (3) coarse aggregate thoroughly mixed with water. In general, a good concrete is required to be hard, strong, durable, dense, non-porous, fire-resisting and economical, although for certain structures, such as internal partitions, strength and impermeability are not necessary requirements where a porous concrete may be desirable on account of its lightness and sound-insulating properties. The characteristics of concrete are influenced by the quality of the materials, grading of the aggregates, proportioning, amount of water used, and workmanship. Ideally, the variation in the size of the aggregates (known as *grading*) should be such that the fine aggregate will fit into the spaces between the coarse aggregate to leave a minimum percentage of voids to be filled by the matrix in cementing the whole mass together. Adequate grading is economical, as less cement is needed when the aggregates are well graded. A mixture which is too rich in cement may shrink excessively. It is most important to appreciate that the strength of mortar depends very largely upon the amount of water used in relation to the cement; *an excess of water results in a considerable reduction in strength* (see p. 30). Just sufficient water should be added to make the mix reasonably plastic and workable.

The expression "workable mixture" is applied to concrete of such consistency that it can be readily deposited in position in a uniform condition and rendered dense after a reasonable amount of punning (see p. 35).

Concrete when used by itself is known as *mass concrete* (used for foundations, certain floors, retaining walls, etc.); concrete reinforced with steel is called *reinforced concrete*.

1. MATRIX.—The binding material used for most concretes is ordinary Portland cement (pp. 21 to 24). Rapid-hardening cement (p. 24) is suitable as a matrix for concrete structures which have to be speedily constructed. The fire-resisting and durable qualities of blast-furnace cement (p. 25) render this a satisfactory matrix for reinforced concrete and marine work. High alumina cement (p. 25), because of its high strength and rapid-hardening characteristics, is especially suited as a binding material for concrete used in structures which are to withstand high stresses and be speedily erected. Hydraulic lime is now very rarely employed as a concrete matrix, it having been displaced by cement for this purpose.

2. FINE AGGREGATE.—According to the Recommendations for a Code of Practice for the Use of Reinforced Concrete in Buildings,[1] a fine aggregate is classified as one which will pass through a sieve having a $\frac{3}{16}$-in. square mesh. Sand (p. 25) is the chief material employed as a fine aggregate, and both quarry and river sands are extensively used for this purpose. Sea sand is also used locally as an aggregate, chiefly because of its low cost; if such sand is required for concrete which is to be exposed to view, it is advisable to eliminate as much as possible of the salt content by washing with *fresh* water, otherwise efflorescence may be objectionable. Cleanliness and suitable grading, already referred to, are essential requirements.

3. COARSE AGGREGATE.—This is classified as material which is retained on a $\frac{3}{16}$-in. square meshed sieve. The maximum size varies; thus, for reinforced concrete work it is usually $\frac{3}{4}$-in., and for mass concrete, as for foundations, it is generally $1\frac{1}{2}$-in. and may be $2\frac{1}{2}$-in. The materials must be clean (to ensure the thorough adhesion of the cement and the development of the setting properties of the concrete), strong (to resist stresses), durable (to withstand alternate weather conditions of wetness and dryness, frost and thaw, etc.), suitably graded (for economy and the development of the strength and workability of the concrete), free from combustible material (to ensure adequate fire-resistance) and inert in the presence of water (otherwise disruption of the concrete may result by expansion and contraction movement). In addition, aggregate for concrete floors and roads should be effective in resisting abrasion. Flaky and laminated material should be avoided.

The following materials are used for coarse aggregate: (*a*) Broken brick, (*b*) broken stone, (*c*) gravel, (*d*) slag, (*e*) pumice, (*f*) breeze and clinker, (*g*) foamed slag and (*h*) expanded slate. See also *sawdust concrete* and *fibrous wood cement* (p. 47, Vol. III).

(a) *Broken Brick.*—Old bricks from demolished buildings, etc., are broken for use as aggregate. This is a good aggregate, provided the bricks are not porous and are thoroughly cleaned, *i.e.*, any lime and plaster must be removed. Soft and porous brick aggregate is particularly unsuited for reinforced concrete work, as such admits air and moisture to cause corrosion of the steel; broken well-burnt brick aggregate makes a valuable concrete because of its strong, durable and fire-resisting qualities. Adherent lime and plaster are very objectionable, as any calcium sulphate may cause expansion and disintegration of the concrete. Bricks having a high sulphur content are also unsuitable. Broken brick aggregate should be well watered before being mixed to prevent excessive absorption of the water used in mixing which may cause the concrete to crack.

(b) *Broken Stone* is an excellent aggregate provided the stone is free from any undesirable mineral constituents and is not soft, porous, friable or laminated. Granites, sandstones and close-grained limestones are all suitable. The stone is crushed and then screened.

There are several forms of crushers, such as the jaw, hammer, disc, gyratory and roll types, which break up large blocks of the rock into small pieces. There are also several types of screens, most of which have a vibrating action. In screening, the material is passed from the crusher by a belt conveyor to the primary screen, which has a large (3-in.) mesh. The screened material is then passed successively through a series of screens of various sized meshes, *i.e.*, $1\frac{1}{2}$-in., $\frac{3}{4}$-in. and $\frac{3}{16}$-in. Thus, the 3-$1\frac{1}{2}$-in. grade is retained on the $1\frac{1}{2}$-in. sieve and passed to the stock bin, that which passes through it is discharged on to the $\frac{3}{4}$-in. sieve which separates the $1\frac{1}{2}$-$\frac{3}{4}$-in. grade (discharged to a second stock hopper) and allows the finer material to pass through on to the $\frac{3}{16}$-in. sieve to be separated into $\frac{3}{4}$-$\frac{3}{16}$-in. and finer grades, each of which is conveyed to a stock bin.

[1] See footnote to p. 29.