

HIGH STRENGTH CONCRETE

Concrete is generally classified as Normal Strength Concrete (NSC), High Strength Concrete (HSC) and Ultra High Strength Concrete (UHSC). There are no clear cut boundary for the above classification. Indian Standard Recommended Methods of Mix Design denotes the boundary at 35 MPa between NSC and HSC. They did not talk about UHSC. But elsewhere in the international forum, about thirty years ago, the high strength label was applied to concrete having strength above 40 MPa. More recently, the threshold rose to 50 to 60 MPa. In the world scenario, however, in the last 15 years, concrete of very high strength entered the field of construction, in particular construction of high-rise buildings and long span bridges. Concrete strengths of 90 to 120 MPa are occasionally used. Table 7.8 shows the kind of high strength produced in RMC plant.

High strength concrete has taken its due place in Indian construction scenario.

Of late concrete of strength varying from 45 MPa to 60 MPa has been used in high rise buildings at Mumbai, Delhi and other Metropolitan cities. Similarly high strength concrete was employed in bridges and flyovers. Presently (year 2000) in India, concrete of strength 75 MPa is being used for the first time in one of the flyovers at Mumbai. Other notable example of using high strength concrete in India is in the construction of containment Dome at Kaiga Power Project. They have used High performance concrete of strength 60 MPa with silica fume as one of the constituents.

Ready Mixed Concrete has taken its roots in India now. The manufacture of high strength concrete will grow to find its due place in concrete construction for all the obvious benefits. In the modern batching plants high strength concrete is produced in a mechanical manner. Of course, one has to take care about mix proportioning, shape of aggregates, use of supplementary cementitious materials, silica fume and superplasticizers. With the modern equipments, understanding of the role of the constituent materials, production of high strength concrete has become a routine matter.

There are special methods of making high strength concrete. They are given below.

- (a) Seeding (b) Revibration (c) High speed slurry mixing;
- (d) Use of admixtures (e) Inhibition of cracks (f) Sulphur impregnation, (g) Use of cementitious aggregates.

Seeding: This involves adding a small percentage of finely ground, fully hydrated Portland cement to the fresh concrete mix. The mechanism by which this is supposed to aid strength development is difficult to explain. This method may not hold much promise.

Revibration: Concrete undergoes plastic shrinkage. Mixing water creates continuous capillary channels, bleeding, and water accumulates at some selected places. All these reduce the strength of concrete. Controlled revibration removes all these defects and increases the strength of concrete.

High Speed slurry mixing: This process involves the advance preparation of cement-water mixture which is then blended with aggregate to produce concrete. Higher compressive strength obtained is attributed to more efficient hydration of cement particles and water achieved in the vigorous blending of cement paste.

Use of Admixtures: Use of water reducing agents are known to produce increased compressive strengths.

Inhibition of cracks: Concrete fails by the formation and propagation of cracks. If the propagation of cracks is inhibited, the strength will be higher. Replacement of 2– 3% of fine aggregate by polythene or polystyrene “lenticules” 0.025 mm thick and 3 to 4 mm in diameter results in higher strength. They appear to act as crack arresters without necessitating extra water for workability. Concrete cubes made in this way have yielded strength upto 105 MPa.

Sulphur Impregnation: Satisfactory high strength concrete have been produced by impregnating low strength porous concrete by sulphur. The process consists of moist curing the fresh concrete specimens for 24 hours, drying them at 120°C for 24 hours, immersing the specimen in molten sulphur under vacuum for 2 hours and then releasing the vacuum and soaking them for an additional ½ hour for further infiltration of sulphur. The sulphur-infiltrated concrete has given strength upto 58 MPa.

Use of Cementitious aggregates: It has been found that use of cementitious aggregates has yielded high strength. Cement fondu is kind of clinker. This glassy clinker when finely ground results in a kind of cement. When coarsely crushed, it makes a kind of aggregate known as ALAG. Using Alag as aggregate, strength upto 125 MPa has been obtained with water/cement ratio 0.32.

Ultra High Strength Concrete

As technology advances, it is but natural that concrete technologists are directing their attention beyond high strength concrete to ultra high strength concrete. The following techniques are used for producing ultra high strength concrete.

- (a) Compaction by pressure (b) Helical binding;
- (c) Polymerisation in concrete (d) Reactive powder concrete.

Compaction by Pressure: It has been pointed out earlier that cement paste derives strength due to the combined effect of friction and bond. In ceramic material, grain size and porosity would be the most important parameters affecting friction and bond and hence the strength. It has been attempted to reduce grain size and porosity by the application of tremendous pressure at room temperature and also at higher temperature.

Unusually high strength have been generated in materials by employing “hot pressing” techniques and intermediate ranges of strengths have been achieved by applying high pressure at room temperature to Portland cement pastes. Strengths as high as 680 MPa (compressive), 66 MPa (indirect tensile) have been obtained by subjecting cement pastes to 357 MPa pressure under a temperature of 250°C. The water/cement ratio used was 0.093. It was also seen that hot pressed materials are volume stable. The micro structure of such materials is very compact, consisting of intergrowth of dense hydrated cement gel surrounding residual un hydrated cement grain cores. The lowest porosity of the materials measured was approximately 1.8%.

Helical Binding: This is an indirect method of achieving ultra high strength in concrete. High tensile steel wire binding externally over the concrete cylinder results in good strength.

Polymer Concrete: Impregnation of monomer into the pores of hardened concrete and then getting it polymerised by irradiation or thermal catalytic process, results in the development of very high strength. This method of making ultra high strength concrete holds much promise. This aspect has been discussed in detail in Chapter 12 under special concrete.

Reactive Powder Concrete: High strength Concrete with strength of 100 – 120 MPa have been used for the construction of structural members. Concrete with 250 to 300 MPa are also used for non-structural applications such as flooring, safes and storage of nuclear wastes.

For structural uses, high ductility is required along with high-strength. Reactive powder concrete (RPC) has been developed to have a strength from 200 to 800 MPa with required ductility.

Concrete is a heterogeneous material and strength obtained by cement paste is not fully retained when sand and aggregates are added. The Reactive Power concrete is made by replacing the convential sand and aggregate by ground quartz less than 300 micron size, silica fume, synthesized precipitated silica, steel fibres about 1 cm in length and 180 micron in diameter.