CHAPTER 4

EXPERIMENTAL PROGRAMME

4.1 MEASUREMENTS OF WORKABILITY

Numerous attempts have been made by many research workers to quantitatively measure the workability property of concrete. But none of these methods is satisfactory for precisely measuring or expressing this property to bring out its full meaning. Some of the tests measure the workability closely and provide useful information. The following tests are commonly employed throughout the world to measure workability.

4.1.1 Slump test

The slump test is the oldest and still the most widely used workability test, having first appeared as an ASTM Standard in 1922. It employs a mould in the shape of a truncated cone, 300 mm high, 200 mm in diameter at the base and 100 mm in diameter at the top, into which the concrete is compacted by rod. The apparatus and experimental set up is shown in Figure 4.1. The difference in height of fresh concrete before and after removal of the mould is measured. It is called as the 'slump' of the concrete. The test is limited to ordinary fresh concrete, generally within the slump range of 20-180 mm, which covers low to high workability in terms of construction requirements. It is not suitable for non-cohesive mixes such as lean and no-fines mixes. The slump test is extensively used as a means of rapid and continual checking of uniformity of fresh concrete supply. It is not a
measure of workability as such. Its major disadvantages are that it has no basis in fundamental rheology and is operator sensitive. However, there is hardly a well-run construction site in the world where the slump test may not be seen in regular operation.

![Figure 4.1 Experimental setup for slump test](image)

**Figure 4.1 Experimental setup for slump test**

### 4.1.2 Compacting Factor Test

The test is meant to measure the degree of compaction achieved by applying a standard amount of work to a sample of fresh concrete, and is suitable for mixes of low to high workability (i.e., similar range to the slump test). A sample of concrete drops progressively through two upper conical hoppers into a steel cylinder, where after it is struck off, weighed, and the mass compared with that of a fully compacted sample of the same concrete in the cylinder. The test is seldom if at all in use now (indeed it has been deleted by ASTM), and suffers from the disadvantage that the energy used in compaction is very different from that applied in normal vibration compaction, thus not truly characterizing the practical compatibility of
modern mixes. Figure 4.2 explains the experimental procedure of compacting factor test carried in lab.

Figure 4.2  Experimental setup for Compacting Factor Test

4.1.3  Vebe Test

The test measures the compatibility of fresh concrete in terms of the time required to remould a sample of slumped concrete into standard cylinder. The apparatus is shown in Figure 4.3. It uses vibration and pressure to achieve this remoulding, making it more applicable to modern vibrated mixes. However, it is only suitable for low to very low workability, relatively dry and stiff mixes which have zero or very low slump. It is applied most widely in the production of precast concrete of low workability for which heavy
mechanical compaction is required. It is also sometimes used for fiber-reinforced concrete (FRC).

Figure 4.3  Experimental setup for Vebe Test

4.2  STRENGTH OF CONCRETE

Concrete structures must be sufficiently strong and stable to resist applied load. They must be stiff enough to provide load resistance without undue deformation. This section presents the effect of aggregate size in terms of compressive strength, flexural strength and split tensile strength of quarry rock dust concrete (QC) and reference concrete (RC) performed on Indian standard mix design approach. The parameters chosen as variables were the same, namely different mix numbers, W/C ratio, workability levels, and different size of aggregates (10 mm, 20 mm and 40 mm). The compressive strength, flexural strength and split tensile strength for three different mixes were determined at the age of 7 days, 28 days and 90 days.
4.2.1 Compressive strength

Compressive strength of concrete is one of its most important and useful properties and can be easily determined. In most of structural applications, concrete is employed primarily to resist compressive stresses. In those cases strength in tension or in shear is of primary importance. The compressive strength is used to measure overall quality of concrete and thus as an indication of other properties relating to the deformations or durability. Finally concrete making properties of the various gradients of the mix are usually measured in terms of compressive strength (Bai 2005).

150 mm cube was cast with the same concrete prepared for measuring slump test and compacting factor test. The cube was prepared and tested as per IS 516:1959. Figure 4.4 shows the experimental setup for compressive strength of concrete cube. The curing was done by immersion in water tanks kept in the laboratory.

Three cubes (minimum number) were tested at a given test age and the average compressive strength was obtained. The values were, however, rounded to the nearest 1 Mpa.
4.2.2 Flexural strength

Steel prisms (100 mm x 100 mm x 500 mm) were cast with the same concrete prepared for measuring flexural strength. The prisms were tested as per IS 516-1959. The testing arrangement for loading of flexure test specimen is explained in Figure 4.5.

The testing machine may be of any reliable type of sufficient capacity for the test and capable of applying the load at 1.80 KN/Minute for the specimen. The bed of the testing machine shall be provided two steel rollers with 38 mm diameter, on which the specimen is to be supported on these rollers, which will mount. The distance from center to center is 400 mm for specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span, that is spaced 133 mm, center to center. The load shall be divided equally between the two loading rollers.
4.2.3 Split tensile strength

Concrete is not usually expected to resist direct tensile forces because of its low tensile strength and brittle nature. However, tension is important with regard to cracking which is a tensile failure.

150 x 300 mm cylinders were cast with the same concrete, which was prepared for measuring slump test and compacting factor test. The cylinder was prepared and tested according to IS.516-1959. The testing arrangement for split tensile strength is given in Figure 4.6. A minimum of three cylinders was tested for each group of mix.
4.2.4 Test on RC beams with quarry rock dust concrete

Reinforcement details are indicated in Figure 4.7. The beams were 120 mm wide and 150 mm deep and 1350 mm long for an effective span of 1200 mm. The Longitudinal reinforcement comprised 3 nos. of 10 mm dia bars of Fe 500 grade at bottom and 2 nos of 10 mm dia bars at top. Two-Legged stirrups of 6mm mild steel bars were provided at 90 mm on centre. The beams were designed to sustain a bending movement of 6.20 kN m at the limit state of collapse in flexure (M20 grade concrete and Fe 500 grade steel) pertaining to a two-point load of 30 kN spaced at 400 mm as shown in Figure 4.7. The beams were under-reinforced, and the effect of compression steel was not considered in the design.

The beams cast with natural sand as fine aggregate were designated RC 1, RC 2 and RC 3 (Reference Concrete) The beam cast with quarry rock
dust as fine aggregate were designated QC1, QC2 and QC3 (Quarry Rock Concrete). The concrete was compacted using a 25 mm needle vibrator. Moulds were removed after 24 hours and beams cured for 28 days before testing.

The beam deflection was measured by means of three dial gauges set below the beam to provide mid span and one-third section. The dial gauges used had a least a count of 0.01 mm.

The beams were tested on a universal testing machine (2000 kN Capacity) under two - point loading at one-third points of the span as indicated in Figure 4.7. Dial gauge readings were recorded for every incremental load of 2.5 kN distributed equally over two points - deflection cracks were monitored during the tests and results on flexural behavior (deflection, and failure modes) were compared.

Figure 4.7 Beam Reinforcement and Loading Details
4.3 DRYING SHRINKAGE

This study presents the drying shrinkage measurement on conventional concrete as well as quarry rock dust concrete. Shrinkage measuring device (length comparator) conforming to the specification of IS: 4031-1988 was used. The prism test specimens of size 75x75x305 mm with the gauge length between the stainless steel gauge studs, as 250 mm were prepared.

The shrinkage strain has been calculated by dividing the change in length of the test specimen (250 mm). The change in length of the test specimens at the end of a particular time has been calculated by multiplying the difference in a dial gauge records between the first reading and the reading at the end of the chosen interval with the sensitivity of the dial gauge (0.002 mm).

4.4 DETERIORATION STUDIES

In order to evaluate the degree of deterioration of two concrete mixes against accelerated sulphate and acid attack, standard prism specimens were immersed in testing baths (one containing 7.5 percent MgSO$_4$ and 7.5 percent Na$_2$SO$_4$ by weight of water and other containing H$_2$SO$_4$ of pH value 2). After 28 days of water curing, the change in weight and direct emission of Ultrasonic Pulse Velocity (UPV) with age of different mixes were subjected to above solutions.

4.5 WATER ABSORPTION TEST

Water absorption test was carried out as per ASTM C 642-97 (1995). Six cubes of size 100 mm were cast for two different mixes. All specimens were removed after 24 hours for casting and subsequently water
cured for 28 days. Samples were removed from water and wiped out any traces of water wiped out with damp cloth and differences in weight were measured.

4.6 PERMEABILITY TEST

Testing concrete for permeability has not been generally standardized. The values of the coefficient of permeability quoted in different publications may not be compared. It is also possible to use the depth of penetration of water as a qualitative assessment of concrete: a depth of less than 50 mm classifies the concrete as permeable, a depth of less than 30 mm, as impermeable under aggressive conditions" (Neville A.M 1995).

It is observed that water permeability of plain and fiber reinforced concrete was measured with and without an applied compressive stress. For the measurement of permeability under stress, a novel test technique was developed. A special design of the permeability cell eliminates leakage and allows the specimen to achieve conditions of the flow of equilibrium in the early test. For the stressed specimens, two levels of the applied stresses, 0.3 \( f_u \) and 0.5\( f_u \), where \( f_u \) is the ultimate strength of concrete in compression, have been investigated. (Nemkumar Banthia 2007).

4.6.1 Test Setup

The permeability test was carried out as explained by Nemkumar Banthia et al (2007) and is shown in Figure 4.8. Standard concrete cube of specimen of size 150 mm x 150 mm x 150 mm was installed within the apparatus. At first the specimen was rubbed by sand paper to remove any oily layer on it. Water pressure of 0.1 MPa was applied for 48 hours, and then pressure of 0.30 MPa and 0.70 MPa, each for 24 hours, was applied. Immediately after this, the specimen was split vertically in the middle applying compressive forces on two laid mild steel bars on the top and bottom
surface of the cube specimen under compression testing machine. The greatest penetration depth of (average of greatest penetration depth of three similar samples) of six mixes was measured and plotted.

Figure 4.8  Test setup of water permeability test
(All dimensions are mm)