4.4 TEST ON HARDENED CONCRETE

Many destructive and non-destructive tests are conducted on hardened concrete to measure their properties such as strength, permeability and durability;

Destructive testing

(Specimen is broken down)

1. Compressive strength test
2. Flexural Strength test
3. Splitting tensile test
4. Modulus of elasticity
5. Pull out test etc.

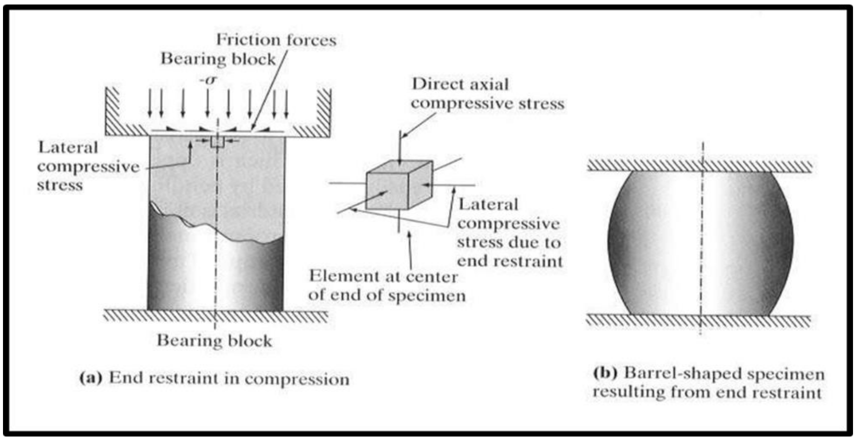
Non-Destructive testing

(Specimen is not broken down)

1. Ultrasonic pulse velocity test
2. Rebound hammer test
3. Electrical resistivity test
4. Other corrosion studies

4.4.1 COMPRESSIVE STRENGTH

The compressive strength of the concrete is considered the basic character of the concrete. Consequently, it is known as the characteristic compressive strength of concrete (f_{ck}) which is defined as that value below which not more than five percent of test results are expected to fall based on IS: 456-2000. In this definition the test results are based on 150 mm cube cured in water under temp. Of 27 + 2°C for 28 days.

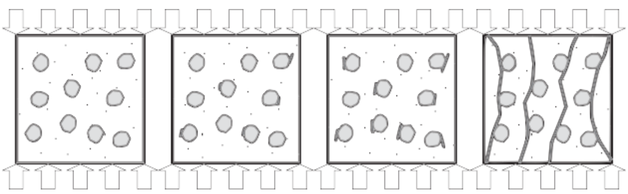


Testing procedure

- These cured specimens are taken from the curing tank and excess water is removed from the surface.
- The cleaned specimens are tested by compression testing machine after 7 days curing or 28 days curing as required.
- Load should be applied gradually till the Specimens fails.
- Load at the failure is noted and the compressive strength of concrete can be calculated by the *ratio of failure load to surface area of the specimen i.e. f= P/A*

As per Indian standard code, the compressive strength improvement percentages is presented in the table

Curing period in days	Strength improvement in percentage
1	16
3	40
7	65
14	90
28	99



(a) (b) (c) (d)

Failure process of a concrete under compression:

(a) shear-bond crack (load less than 40% ultimate value);

(b) load-initiated cracks (load between 40 and 80% ultimate value);

(c) Crack concentration (load greater than 80% ultimate value);

(d) Major cracks formed (failure indication)

4.4.2 TENSILE STRENGTH

Tensile strength is one of the basic and important properties of concrete. A knowledge of its value is required for the design of concrete structural elements. Its value is also used in the design of prestressed concrete structures, liquid retaining structures, roadways and runway slabs. Direct tensile strength of concrete is difficult to determine; recourse is often taken to the determination of flexural strength or the splitting tensile strength and computing the direct tensile.

4.4.2.1 SPLIT TENSILE STRENGTH TEST

A method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. It is an indirect method of testing tensile strength of concrete.

- In direct tensile strength test it is impossible to apply true axial load. There will be always some eccentricity present.
- Another problem is that stresses induced due to grips. Due to grips there is a tendency for specimen to break at its ends.

Test Specimens

Cylinder

- The length of the specimens shall not be less than the diameter and not more than twice the diameter. For routine testing and comparison of results, unless otherwise specified the specimens shall be cylinder 150 mm in diameter and 300 mm long.

Curing

- The procedure of making and curing tension test specimen in respect of sampling of materials, preparation of materials, proportioning, weighing, mixing, workability, moulds, compacting and curing shall comply in all respects with the requirements given in IS 516.

Sampling of Materials

- Representative samples of the materials of concrete for use in the particular concrete construction work shall be obtained by careful sampling.
- Test samples of cement shall be made up of a small portion taken from each of a number of bags on the site. Test samples of aggregate shall be taken from larger lots.

Preparation of Materials

- All materials shall be brought to room temperature, preferably 27°±3°C before commencing the tests.
- The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material, care being taken to avoid the intrusion of foreign matter. The cement shall then be stored in a dry place, preferably in air-tight metal containers.
- Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. In general, the aggregate shall be separated into fine and coarse fractions and recombined for each concrete batch in such a manner as to produce the desired grading.

Weighing

- The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

Mixing Concrete

- The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

Moulds

Cylinders

- The cylindrical mould shall be of 150mm diameter and 300mm height. Similarly the mould and base plate shall be coated with a thin film of mould oil before use, in order to prevent adhesion of the concrete.

Test for Split Tensile Strength

Aim:

To determine the splitting tensile strength for the concrete specimen.

Apparatus:

1. Weights and weighing device.
2. Tools, containers and pans for carrying materials & mixing.
3. A circular cross-sectional rod (φ16mm & 600mm length).
4. Testing machine.
5. Three cylinders (φ150mm & 300mm in height).
6. A jig for aligning concrete cylinder.

The jig for aligning concrete cylinder and bearing strips

Procedure:

1. Prepare three cylindrical concrete specimens.

2. After moulding and curing the specimens for seven days in water, they can be tested. The cylindrical specimen is placed in a manner that the longitudinal axis is perpendicular to the load.

3. Two strips of nominal thick plywood, free of imperfections, approximately (25mm) wide, and of length equal to or slightly longer than that of the specimen should be provided for each specimen.

4. The bearing strips are placed between the specimen and both upper and lower bearing blocks of the testing machine.

5. The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2 N/ (mm2/min) to 2.4 N/ (mm2/min).

6. Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

Computations: Calculate the splitting tensile strength of the specimen as follows:

$$T = \frac{2P}{\pi L d}$$

Where:

T: splitting tensile strength, kPa

P: maximum applied load indicated by testing machine, kN

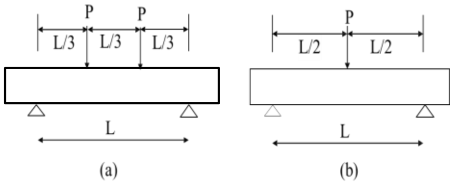
L: Length, m

d: diameter, m

Result

- It is found that the splitting test is closer to the true tensile strength of concrete it gives about 5 to 12% higher value than the direct tensile strength test.

4.4.2.2 FLEXURAL TENSILE STRENGTH TEST



Test procedure:

- Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 25 times using the tamping bar.
- The specimen is placed to the machine as shown in above figure.
- Hence the load is applied gradually to the specimen and failure of the specimen is carefully noted.
- After getting of failure loading, the flexural strength can be calculated by using following expression,

$$fb = PL/bd^2$$

Where, P-load, L-Length of the specimen, B and d- breadth and depth of specimen