MATERIALS OF CONSTRUCTION LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
M.E.T.U.

TESTS ON CONCRETE

- Scope
- Concrete Mixing
- Tests on Fresh Concrete : Slump Test , Air Content , Yield
- Tests on Hardened Concrete : Compressive Strength , Flexural Strength , Split Tension Test
- Related Standards
- Glossary

I. SCOPE

These test methods cover procedures for the concrete mixing and preparation of specimens and testing of physical and mechanical properties of fresh and hardened concrete.

II- TESTS ON FRESH CONCRETE

1. Slump Test

TS EN 12350-2 Testing Fresh Concrete: Part:2 Slump Test,
TS EN 206-1 Concrete- Part:1 Specification, performance, production and conformity,
ASTM C 143 Standard Test Method for Slump of Hydraulic-Cement Concrete.

1.1 General

Slump test is performed to check the workability and consistency of the fresh concrete. The results of mix design calculations are used to prepare the concrete to be tested.

1.2 Apparatus

The test specimen shall be formed in a mould made of metal not readily attached by the cement paste and in the form of the lateral surface of the frustum of a cone with the base 8 in (20cm in TS) in diameter, the top 4 in (10cm in TS) in diameter, and the height 12 in (30cm in TS). The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mould shall be provided with foot pieces and handles.

A tamping rod of round, straight steel 5/8 in. In diameter and approximately 24 in. in length is also needed.

1.3 Procedure

The mould is dampened and placed on a flat, moist, non absorbent (rigid) surface. It shall be held firmly in place during filling by the operator standing on the two foot pieces, and filled by the fresh concrete in three layers, each approximately one third the volume of the mould. 25 strokes of the tamping rod is applied to each layer, uniformly distributing the strokes over the cross-section, and just penetrating into the underlaying layer. After the top layer has been rodded, the surface of the concrete is striken off by means of a screeding and rolling motion of the tamping rod. The mould is removed immediately from the concrete by raising it carefully in a vertical direction.

The slump is measured immediately by determining the difference between the height of the mould and the height over the original centre of the base of the specimen.

1.4 Standard' s Limitations

TS EN 206-1 defines concrete in 5 classes according to slump test results.

Class	Slump, mm
S1	10-40
S2	50-90
S3	100-150
S4	160-210
S5	>=220

2. Air Content

2.1 General

Air content of concrete may be either due to the inevitably entrapped air or due to air intentionally introduced by admixtures for a better freezing and thawing resistance. In both cases the air content of concrete should be determined and checked if it is in between the specified ranges. There are three methods of determining the air content of concrete;

1) Pressure Method (TS EN 12350-7 : Testing fresh concrete - Part 7: Air content - Pressure methods, ASTM C 231 Standart Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method)

2) Gravimetric Method (ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete)

3) Volumetric Method (ASTM C Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method)

This first one will be discussed in detail.

2.2 Apparatus

The measuring bowl shall be a flanged cylindrical bowl, preferably of steel or other hard metal not readily attached by the cement paste. There will be a conical cover assembly of similar material and other accessories.

2.3 Procedure

The bowl is filled by fresh concrete in three equal portions, rodding each layer 25 times with the tamping rod. The cover assembly is fixed and pressure is applied on to the surface of the concrete in the bowl, causing a change in the volume. This change is attributed to the air in the concrete since other constituents in the bowl are incompressible. The air content of concrete is then read on a scale on the cover assembly.

2.4 Standard's Limitations

The usual ranges of percent air content for normal concrete, and air entrained concrete are 1-3% and 3-8% respectively.

3. Yield

ASTM C 138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
TS EN 12350-6 Testing fresh concrete - Part 6: Density

3.1 General

Yield is defined as the calculated unit weight of concrete per actual unit eight of concrete . The test is made using the amounts of cement, aggregate and water dictated by the mix design calculations and the actual volume and weight are determined.

3.2 Apparatus

Besides a balance and a tamping rod, a cylindrical metal measure is needed. The measure shall be water tight, preferably provided with handles and machined to accurate dimensions on the inside having one half or one cu ft capacity.

3.3 Procedure

The measure is filled in three equal portions rodding each 25 times and tapping the exterior surface until no large bubbles of air appear on the surface of the rodded layer. After consolidation of the concrete, the top surface shall be struck off and finished smoothly with a flat cover plate using great care to leave the measure just level full. All excess concrete shall then be cleaned from the exterior and the filled measure weighed.

3.4 Calculations

Calculate the net weight of the concrete by subtracting the weight of the measure from the gross weight. Calculate the weight per cubic meter by multiplying the net weight by the factor for the measure, using 1m3=35ft3.

Calculate the volume of concrete produced per batch as follows:

Then the “Yield” is calculated by:

$$Y = \frac{\text{Calculated unit weight of concrete}}{\text{Actual unit weight of concrete}}$$

III. TESTS ON HARDENED CONCRETE

3.1 Compressive Strength

ASTM C 39 Standart Test for Compressive Strength of Cylindrical Concrete Specimen,
TS EN 12390-3 Testing hardened concrete - Part 3 : Compressive strength of test specimens
TS EN 12390-4 Testing hardened concrete- Part 4: Compressive strength- Specification for testing machines

3.1.1 General

The most important property of concrete is the compressive strength which is determined by loading the properly moulded and cured specimens as dictated by the standards.

3.1.2 Apparatus

The testing machine may be of any type of sufficient capacity which will provide the required rate of loading. It shall be equipped with two steel bearing blocks with hardened faces.

3.1.3 Preparation of Specimens

Fresh concrete is made by mixing the proper amounts of cement, water and aggregate as indicated by the mix design calculations, which is then placed in moulds. TS 500 and DIN designate 20x20x20 cm cubic moulds whereas ASTM specifies cylindrical moulds 6 in (15cm) in diameter and 12 in (30cm) in height. Three specimens should be prepared for each different mix or intended age. Cubes are filled in two equal portions whereas cylinders are filled in three. All possible measures should be taken during placing so that the specimen is prepared in a similar way to the actual placing condition in the site.

The specimens are left in moulds for two days and then cured in a moist environment such as curing room, water or a wet blanked. At the end of 7, 28 or 90 days, the cubic specimens are ready for the compression test. The cylindrical specimens should capped with cement, gypsum or sulfur before testing and leaving enough time for hardening. This step is necessary because the two surfaces of the specimen coming in contact with the plates of the testing machine must be smooth and parallel to each other. Cubes provide this with us capping, which is an advantage over the cylinders.

3.1.4 Loading

The specimens are placed between the bearing blocks on the machine and loaded at a uniform rate of 2 $kg/cm^2/sec$ until failure. The maximum load carried by the specimen is recorded from the machine.

3.1.5 Calculations

The compressive strength of each individual specimen is calculated by dividing the maximum load at failure by the cross-sectional area of the specimen. The average of the three individual compressive strengths is accepted as the compressive strength of that batch of concrete.

3.1.6 Interpretation and Interrelation of Results

Compressive strength of the same batch of concrete obtained from cubic specimens is usually greater than the value obtained from cylindrical specimens and value obtained at earlier ages are always smaller than the ones obtained at later ages. This is due to the fact that among many factors affecting the compressive strength of concrete two of them are the shape and age of the specimens. The following equation relate compressive strength of cubic and cylindrical specimens tested at 3, 7, 28, 90 and 365 days:

*cu28 = (1.15-1.30) *cy28

*cy28 = (0.80-0.85) *cu28

*cu3 = (0.40) *cu28

*cu7 = (0.65) *cu28

*cu90 = (1.20) *cu28

*cu365 = (1.40) *cu28

*cu28 = compressive strength of 15x15x15 cm cubic specimen at the end of 28 days
*cy28 = compressive strength of cylindrical specimen (d=15 cm, h=30 cm) at the end of 28 days

*cu7 , *cu7 ,*cu90 and *cu365 are the compressive strengths of cubic specimens at the end of 3, 7, 90 and 365 days. Same relations hold for cylindrical specimens when *cu is replaced by *cy.

3.2 Flexural Strength

ASTM C 78 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading),
ASTM C 293 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam With Center-Point Loading),
TS EN 12390-5 Testing hardened concrete - Part 5: Flexural strength of test specimens.

3.2.1 General

Flexural strength of concrete may be determined by using simple beam with centre-point loading or third-point loading. In the centre-point loading the maximum tensile force is concentrated at a single point, whereas in third-point loading it is distributed to the length between the two loading points. The specimens and procedures of the two methods are very similar, therefore only the centre-point loading method will be discussed.

3.2.3 Apparatus

A loading machine with sufficient capacity and bearing blocks (designed to insure that forces applied to the beam will be vertical only without eccentricity) are the necessary equipment to perform the test.

3.2.4 Preparation of Specimens

15x15x75 cm moulds are filled horizontally in two equal portions. Then they are cured as the cubic or cylindrical specimens.

3.2.5 Loading

The test specimen shall be centred on the supporting bearing blocks. The load-applying block shall be brought in contact with the upper surface at the centre line between the supports. If full contact is not obtained capping is recommended. Span length shall be 60 cm, and the specimen shall be loaded in the direction of filling at a rate of 1000 kgf/min.

3.2.6 Calculations

The modulus of rupture is calculated by:

$$R = \frac{3\,P\,L}{2bd^2} = \frac{90\,P}{bd^2} = \frac{2\,P}{75}$$

where ;
R = modulus of rupture, kgf/cm2
P = maximum applied load indicated by the testing machine, kgf
L = span length = 60 cm
b = average width of specimen = 15 cm
d = average depth of specimen = 15 cm

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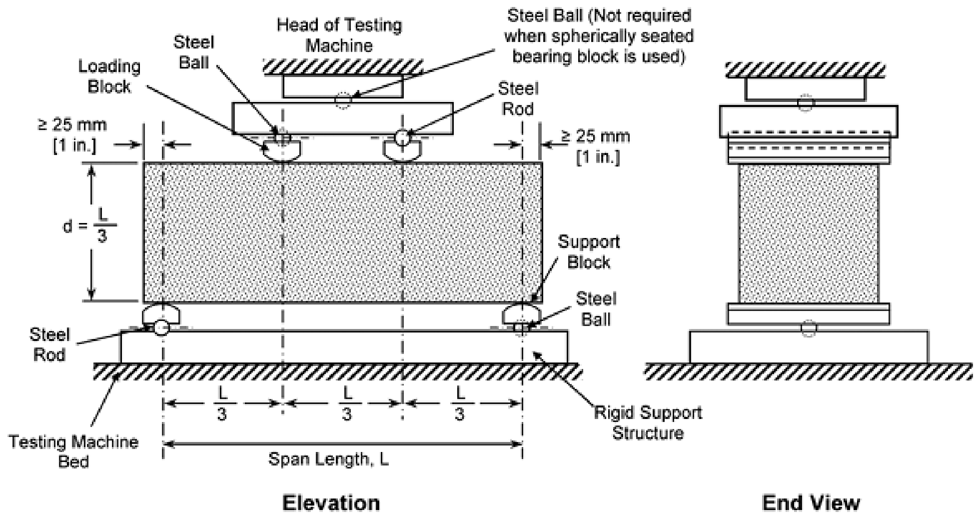
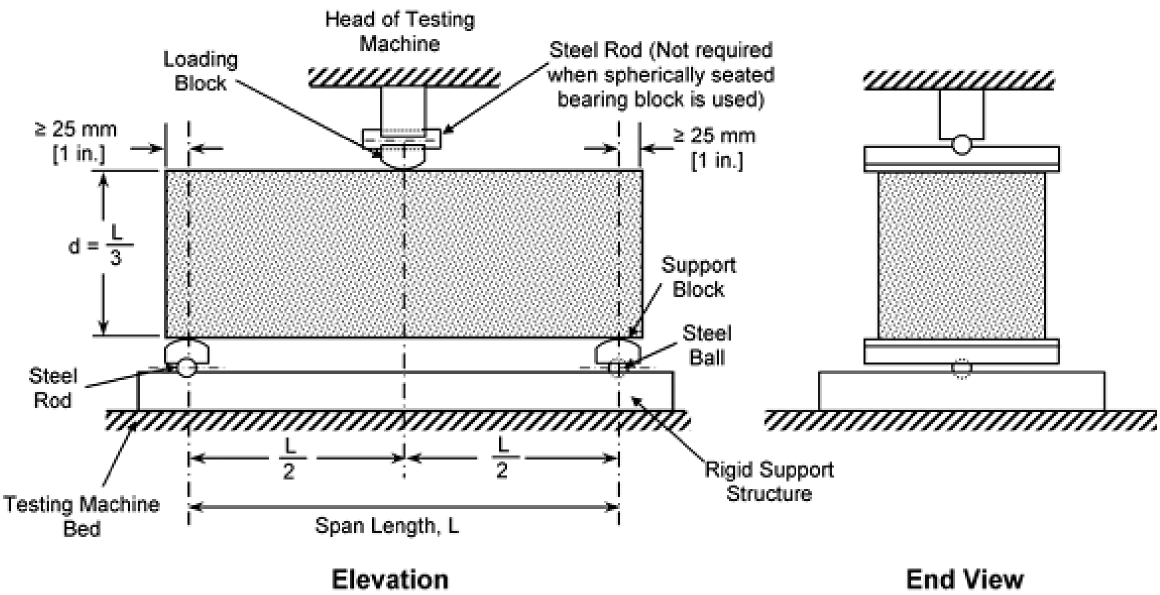


NOTE 1—This apparatus may be used inverted. If the testing machine applies force through a spherically seated head, the center pivot may be omitted, provided one load-applying block pivots on a rod and the other on a ball.

FIG. 1 Schematic of a Suitable Apparatus for Flexure Test of Concrete by Third-Point Loading Method



NOTE 1—Apparatus may be used inverted.

FIG. 1 Schematic of a Suitable Apparatus for Flexure Test of Concrete by Center-Point Loading Method.

3.3 Split Tension Test

TS EN 12390-6 Testing hardened concrete - Part 6: Tensile splitting strength of test specimens
ASTM C 496 - Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens

3.3.1 General

In determining the modulus of rupture by a beam specimen the upper, part of the specimen is in compression while the lower part is under tension. In the split tension test all the specimen is under tension, therefore it gives a better idea about the tensile strength of concrete.

3.3.2 Apparatus

Besides the conventual testing machine, supplementary bearing bar or plate and bearing strips made of plywood are necessary to perform the test.

3.3.3 Specimens

The specimens are exactly the same as the cylindrical ones used in compression tests.

3.3.4 Procedure

Diametrical lines shall be drawn on each of the specimen and the dimeter shall be measured accurately. One of the plywood strips shall be centred along the centre of the lower bearing block. The specimen shall be placed on the plywood strip. A second plywood strip is placed lengthwise on the cylinder, centred on the lines marked on the ends of the cylinder.

The load is applied continuously and without shock, at a constant rate within the range 100 to 200 psi/min splitting tensile stress until failure of the specimen. The maximum applied load indicated by the machine at failure is recorded together with the type of failure and appearance of the concrete.

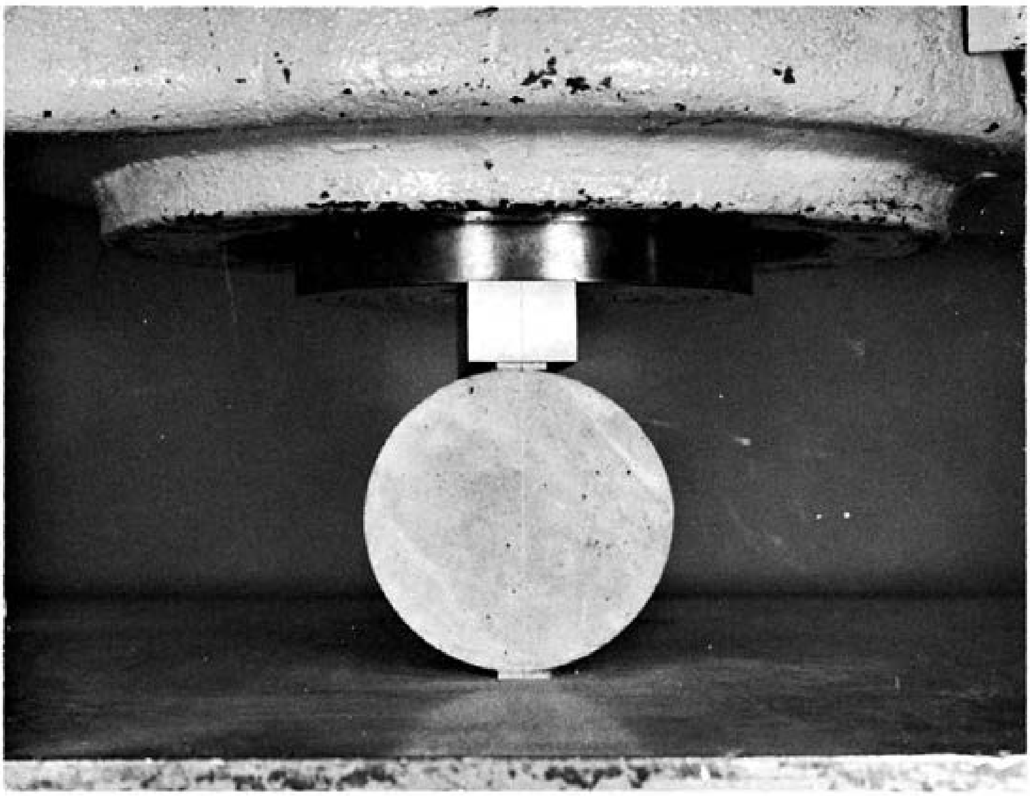


FIG. 5 Specimen Positioned in a Testing Machine for Determination of Splitting Tensile Strength

3.3.5 Calculation

The splitting tensile strength shall be calculated as follows:

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

where;

T = splitting tensile strength, psi
P = maximum applied load, lb
l = length, in
d = diameter, in

IV. GLOSSARY

Slump Test: Çökme deneyi
Workability: İşlenebilirlilik
Consistency: Kıvamlılık
Frustum: Kesik koni
Yield: Verimlilik
Modulus of Rupture: Eðilme-çekme dayanýmý
Fresh Concrete: Taze beton
Curing: Bakım
Split Test: Yarma deneyi
Hardened Concrete: Sertleşmiş beton