Ministry of Higher Education
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Al-Mustaqble University
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Concrete Technology

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Testing

of

Fresh Concrete

Fresh Concrete

is the concrete that starts from the moment of adding water to the dry concrete components until the moment of the initial setting time. In this stage, concrete is characterized by the ability to mix, molding and transport.

-The most important characteristics of fresh concrete are:

1. Consistency
2. Workability

1. Consistency

The consistency of the fresh concrete expresses the degree of wetness of the concrete. For example, it said that the consistency of concrete is dry consistency or Stiff, Plastic, wet and Sloppy consistency.

-There are three main methods for determining the consistency of fresh concrete.

1. Slump Test.
2. Flow Test.
3. Kelly Ball Penetration Test.

2. Workability

It is the property of fresh concrete, which shows the ease that by which the concrete mixture can be casted and handled, as well as shows the degree of its homogenousity and resistance to granular separation.

-There are three main methods for determining the workability of fresh concrete.

1. Compacting Factor Test
2. Remoulding Test
3. Vebe Test

The Main Tests of Freshly Mixed Concrete

- Sampling of concrete.
- Slump Test.
- Density and yield Test.
- Temperature Test.
- Air content Test.

Slump Test

The Purpose of the Test:

Determine the consistency of the fresh concrete mixture by determining the extent of its fall after forming it as a minus cone.

The Standard Specification :

In this test, American standard specification is adopted (ASTM C143).

Equipment and Tools:

1. Slump cone, which is a minus cone made of durable metal with a thickness of (1.5 mm) open from the top and bottom, the diameter of its upper opening is (10 cm), the lower is (20 cm), and the height is (30 cm).
2. The standard compacting rod which is a steel skewer with a diameter of (16 mm) and a length of (60 cm).
3. Mixing tools (shovel and mixing bowl).
4. Measuring ruler.

Fig.1: The Used Tools.

Test Method:

- Place the base on a leveled surface.
- Cleaning the base and the internal surfaces of the minus cone, so that there are no suspended water or concrete traces.
- place the slump cone on its base.
- The cone fills with concrete on three layers of equal thickness, the height of each layer is equal to one third of the mold volume, then each layer shall be tamped with twenty-five strokes (25 strokes) by a tamped rod, distributed almost evenly over the surface and provided that the rod penetrates to the layer below it.
- After finished the tamped, the top layer of the mold is leveled with the edge of the mold.
- Removing and cleaning any mortar which may have leaked out between the mold and the base.
- The cone is raised vertically slowly and carefully to allow the concrete to fall freely.
- The amount of slump is measured by measuring the distance between the cone surface and the surface of the falling concrete. This distance expresses the slump the concrete.

Calculations:

The slump reading is taken to the nearest 5 mm.

Typical specification limits:

According to ASTM C94:

Specified Slump	Tolerance
≤ 2 in.	±½ in.
2-4	± 1 in.
> 4 in.	± 1½.

If Specified ″ Not to Exceed″

Max.Slump	Tolerance
≤ 3 in.	- 1½ in.
> 3 in.	- 2½ in.

Sampling Freshly Mixed Concrete

American standard specification (ASTM C172) illustrate procedures for obtaining representative samples of fresh concrete as delivered to the project site on which tests are to be performed to determine compliance with quality requirements of the specifications under which the concrete is furnished. The method of sampling concrete illustrated below:

- Collect two or more portions of concrete in less than 15 min. time during the discharge of the middle of the batch. Do not obtain portions from the very first or last portions.
- Composite the portions into one sample in a container. The sample shall be not less than 28 liter for strength test. Smaller samples may be obtained for slump and air content tests.
- Transport the samples to the place where the tests are to be performed. Combine the samples and remix them by shovel.
- Start slump test, or air content test, or both in 5 min. after taking last portion of the sample. Start molding specimens for strength tests within 15 min. after making the composite sample. - Keep the elapsed time between obtaining and using the samples as short as possible and protect the sample from the sun, wind and other sources of evaporation and contamination.

There are four types of concrete sampling sources:

- Sampling from stationary mixers, except paving mixers.
- Sampling from paving mixers.
- Sampling from revolving drum truck mixers or agitators.
- Sampling from continuous mixers.

Sampling from stationary mixers except paving mixers.

This sample consist of collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch during the specified time (15 min). Do not obtain portions from the very first or last portions.

Sampling from paving mixers

Concrete samples take from at least five different portions of the pile and combine them into one composite sample for test purposes. Avoid contamination with subgrade material or prolonged contact with and absorptive subgrade. To preclude contamination or absorption by the subgrade, sample the concrete by placing three shallow containers on the subgrade and discharging the concrete across the container.

Sampling from revolving drum truck mixers or agitators.

Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the middle portion of the batch. Take the samples so obtained within the time limit specified (15 min).

Sampling from continuous mixers

Sample the concrete after the discharge of at least 140 L of concrete. Sample the concrete by collecting two or more portions taken at regularly spaced intervals during discharge of the concrete. Take the portions so obtained within the time limit specified (15 min.) and combine them into one composite sample for test purposes.

Note:

- In any case do not obtain samples until after all of the water and any admixtures have been added to the mixer.
- Do not obtain samples from the very first or last portions of the batch discharge.
- After obtaining the composite sample, wait a minimum of (2) minutes and a maximum of (5) minutes before beginning tests.

Sampling of large maximum size aggregate concrete

use the wet-sieving when the concrete sample contains aggregate larger than that appropriate for the size of the molds or equipment to be used.

Wet-sieving concrete:

The process of removing aggregate larger than a designated size from the fresh concrete by sieving it on a sieve of the designated size.

Used tools:

- A container of suitable size having a nonabsorbent surface.
- Sieve having the appropriate sized opening.
- Hand Tools—Shovels, hand scoops, plastering trowels, and rubber gloves as required.

Procedure:

- Damping the container.
- Position and support the sieve over the container.
- Place a layer of concrete onto the sieve.
- Shake or vibrate the sieve by hand or mechanical means, a horizontal back and forth motion is preferred. Shake the sieve until no undersized particles remain.
- Remove and discard any particles retained on the sieve.
- The material retained on the sieve should not be more than one particle thick again remove and discard any aggregate particles retained on the sieve.

- Scrap any mortar adhering to the sieve into the container.
- Using a shovel combined and remix the sieve material then immediately proceed with testing this material.

Density (Unit Weight), Yield Test

The Purpose of the Test:

To find density of concrete which is the mass of freshly mixed concrete required to fill the container of a unit volume.

The Standard Specification :

In this test, the American standard specification is adopted (ASTM Standard C138).

Equipment and Tools:

1. Balance.
2. Tamping rod.
3. Cylindrical measure.

Test Method:

- Measure the weight of the cylinder measure while it is empty.
- Place the measure on level, firm surface.
- The cylinder measure fill with freshly mixed concrete in three layers of approximately equal volume and each layer shall be tamped with 25 strokes by a tamped rod.
- Compaction us either done by tamping rod or by means of a suitable vibrating table until the specified condition is attained.
- After compaction 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.

- Clean all excess concrete from the exterior of the cylindrical measure. Then the filled cylindrical measure is weighed.

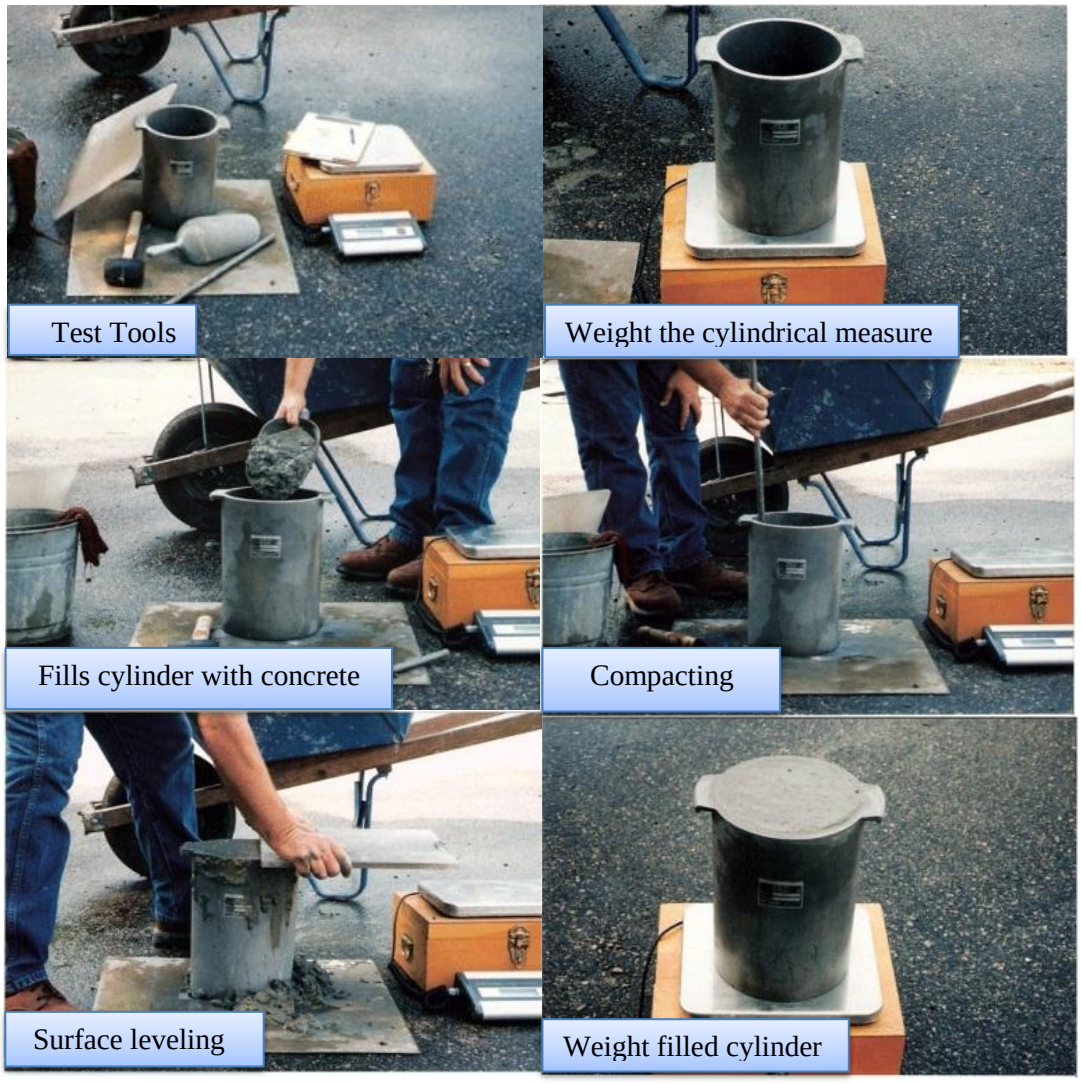

Fig.2: Show the Steps of test procedure.

Calculations:

- Calculate the net mass of the concrete in pounds or kilograms by subtracting the mass of the cylindrical measure, Mm, from the mass of the cylindrical measure filled with concrete, Mc.
- Calculate the density, D, kg/m^3 [lb/ft^3] , by dividing the net mass of concrete by the volume of the cylindrical measure, Vm as follows:

.Density = $\frac{Mass\ of\ concrete - mass\ of\ the\ cylinder\ filled\ with\ concrete}{Volume\ of\ the\ cylindrical\ measure}$

$$D = \frac{Mc - Mm}{Vm}$$

Temperature Test

The Purpose of the Test:

To measuring the temperature of freshly mixed concrete in order to make sure it is conforming to specifications

The Standard Specification :

In this test, the American standard specification is adopted (ASTM Standard C1064).

Equipment and Tools:

- Container.
- Thermometer.
- Scoop or shovel.

Fig.3: Thermometer used in temperature test.

Test Method:

- A sample of concrete mixture is prepared
- Mix concrete mixture thoroughly with scoop or shovel to get a temperature reading that is representative of the entire sample.
- Once the concrete is mixed, put the thermometer in the center of the sample at least (75mm).
- Leave the thermometer for 2 minutes in fresh concrete.
- Take reading with accuracy of 0.5 C°.

Fig.4: Temperature test of freshly concrete.

Calculations:

Take and record reading with accuracy of 0.5 C°.

Air Content Test of Freshly Mixed Concrete by the Volumetric Method

The Purpose of the Test:

To determine air content of freshly mixed concrete.

The Standard Specification :

In this test, the American standard specification is adopted (ASTM Standard C173).

Equipment and Tools:

- Volumetric air meter.
- Scoop.
- Strike off bar.
- Tamping rod.
- Isopropyl Alcohol.
- Measuring Vessel for Isopropyl.

Fig.5:Volumetric air meter.

Test Method:

- Sample the concrete according to ASTM C 172.
- Wet the inside of the measuring bowl and dry it.
- Using the scoop, fill the measuring bowl with freshly mixed concrete in two layers of approximately equal volume.
- Rod each layer 25 times uniformly over the cross section with the rounded end of the rod. After each layer is rodded, tap the sides of the measuring bowl 10 to 15 times with the mallet.
- Strike off the excess concrete with the strike-off bar until the surface is flush with the top of the measuring bowl. Wipe the flange of the measuring bowl clean.
- Attach the top section to the measuring bowl and insert the funnel and add at least 0.5 L of water followed by the selected amount isopropyl alcohol. (Use 70 % by volume isopropyl alcohol). Then Remove the funnel and adjust the liquid level until the bottom of the meniscus is level with the zero mark on the graduated neck.
- To displacing the volume of air in the concrete specimen, free the Concrete from the measuring bowl quickly invert the meter, shake the measuring bowl horizontally, and return the meter to the upright position. To do not keep it inverted for more than 5 s at a time. Repeat the inversion and shaking process for a minimum of 45 s.
- Place one hand on the neck of the meter and the other on the flange then rolling the air meter approximately 1 min.
- If at any time the liquid leaked the test is availed.
- Loosen the cap and allow the liquid level to stabilize, the liquid level is stable when it does not change for more than 0.25 percent within two minute period if the liquid level is not stabilize within 6

minute the test availed and return the test with a new sample using additional alcohol.

- If there is more than 2% foam in the neck the test is availed.
- When the liquid level is stable read bottom of the meniscus to the nearest 0.25 % and record the initial meter reading.
- Retighten the cup and repeat the rolling procedure vigorously roll the meter a quarter to a half turn or and back several times and repeat the rolling procedure for approximately one minute, set the meter upright loosen the cap and allow the liquid level to stable.
- If the liquid level has stabilized and the results are within a quarter percent of the initial reading then record the second reading as a final reading..
- If the second reading differs from the initial reading by more than 0.25%, record the second reading and repeat the rolling procedure if the third reading of the liquid level has not changed more than 0.25% from the second meter reading, record the third reading as a final reading.

Calculations:

- If more than 1.25 L [2.5] of alcohol is used, correction to the final meter reading is required.

Table(1):Correction for the Effect of Isopropyl Alcohol on C173/C173M Air Meter Reading.

70% Isopropyl Alcohol			
Pints	Fluid ounces	litres	Correction, %
2.0	32	1.0	0.0
3.0	48	1.5	0.25
4.0	64	2.0	0.5
5.0	80	2.5	0.75

Calculate the air content of the concrete in the measuring bowl as follows:

$A = Ar - C + W$

Where:

A: Air content %

Ar: Final meter reading %

C: Correction factor from table1

W: Number of calibrated cups of water added to the meter.

Flow Test

The Purpose of The Test:

Determine the percentage of concrete flow (Knowing the consistency of the concrete mixture and its tendency to segregation).

The Standard Specification:

In this test, the American standard specification is adopted (ASTM Standard C 124-77).

Equipment and Tools:

1. Mold test (slump cone).
2. Flow table.
3. Standard tamped rod.
4. Tape measure.
5. Mixing tools (shovel and mixing bowl).

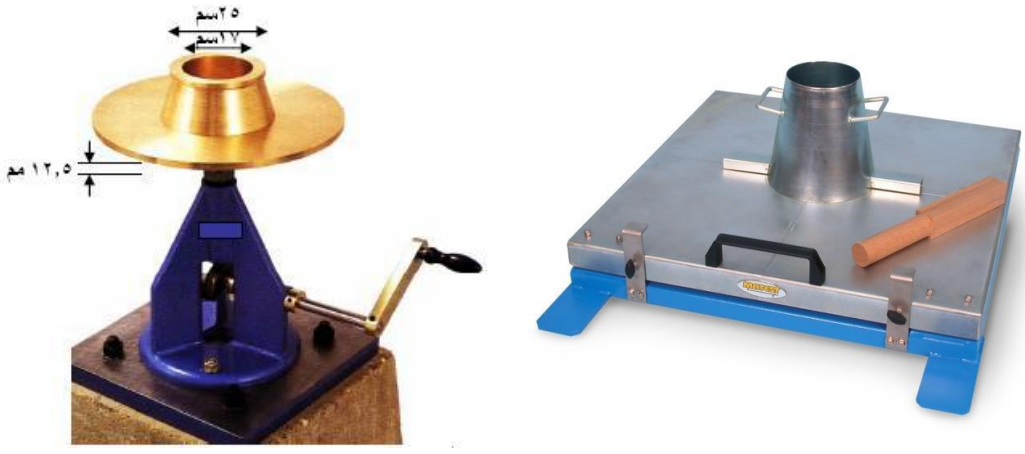

Fig.6: Flow Test Device.

Test Method:

- Place the flow table on a leveled surface.
- Cleaning the surface of flow table and the internal surfaces of the slump cone.
- The mold shall be placed in the center of the flow table.
- The cone fills with concrete on two layers of equal thickness, then each layer shall be tamped with twenty-five strokes (25 strokes) by a tamped rod, distributed almost evenly over the surface and provided that the rod penetrates to the layer below it.
- After finished the tamped, the top layer of the mold is leveled with the edge of the mold.
- Removing and cleaning any mortar which may have leaked out between the mold and the flow table.
- The slump cone is raised vertically and slowly.
- The flow table raises and decreases at a regular rate of 12.5 mm, for 13 times over a period of 15 seconds.
- Measure the diameter of spread concrete, the measure of diameter base will be in 6 different direction then the average of these readings will be taken to represent flow diameter of base cone of concrete after concrete flow.

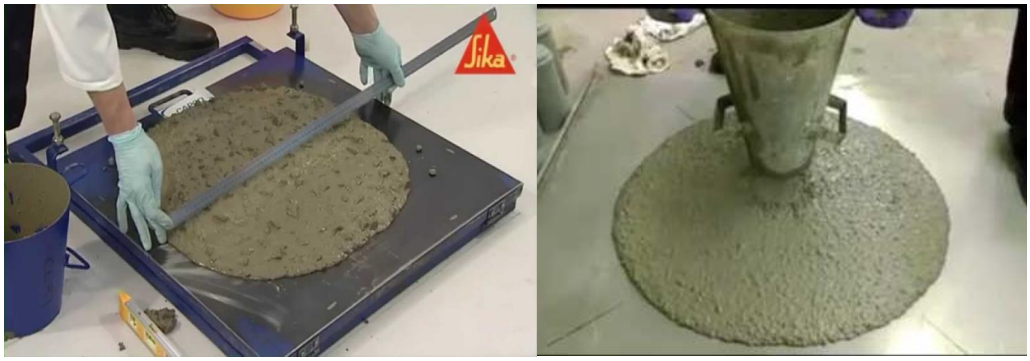

Fig.7: Flow test of fresh concrete.

Calculations:

The flow of concrete is determined by calculating the percentage for increase in the average diameter of the spread concrete on the flow disc (D1) divided by the original diameter of the concrete base (D):

The percentage of concrete flow %= $\frac{D1-D}{D} * 100$

Which:

D1: Diameter of the spread concrete.

D: The original diameter of the concrete base (D=25mm).

Standard Specifications for Comparing Results:

American specifications specifies limits for concrete flow for various consistency as shown in the table below.

Consistency of Concrete	The percentage of concrete flow
Dry	0-20
Stiff	15-60
Plastic	50-100
Wet	90-120
Sloppy	110-150

Kelly Ball Penetration Test

The Purpose of the Test:

This test used to determine the penetration of hemispherical metal weight of freshly mixed concrete with is related to workability of concrete.

The Standard Specification :

For kelly ball penetration test, American standard specification (ASTM Standard C 360) is adopted.

Equipment and Tools:

- Apparatus consist of a cylindrical with one end having hemispherical shape and having the other end fit with a graduated handle. The weight assembly is lowered through a frame into the concrete and penetration measured. Figure below show kelly ball test apparatus.

Fig.8: Kelly ball test apparatus.

Test Method:

- A large amount of freshly mixed concrete is taken and is poured into a container. The container should be more than wide enough to place the Kelly ball apparatus in it.
- The depth of poured concrete should be at least 20 cm.
- Level the concrete surface using suitable equipment.
- Place the Kelly ball apparatus on the leveled concrete surface using handle provided.
- The apparatus should be placed in such a way that the frame should rest on the concrete surface and also the center of the metal ball should be at least 23 cm away from any edge of the container.
- Now release the handle and allow the ball to penetrate through concrete and note down the penetration value by observing the reading on the graduated stem. The observation should be taken to the nearest 0.6 cm.
- Repeat the above procedure for 4 more times by placing the apparatus at different points on the same test sample.
- The workability of concrete is the average value of all the readings obtained.

Fig.9: Performing kelly Ball Test.

Calculations:

Workability of concrete = Ball penetration value = Average of all the readings obtained

Compacting Factor Test

The Purpose of the Test:

Determine the degree of workability of fresh concrete.

The Standard Specification:

In this test, British standard specification is adopted (B.S.1881: Part 2:1970).

Equipment and Tools:

1. Device of compacting factor.
2. Standard tamped rod.
3. Mixing tools (shovel and mixing bowl).
4. Blance.

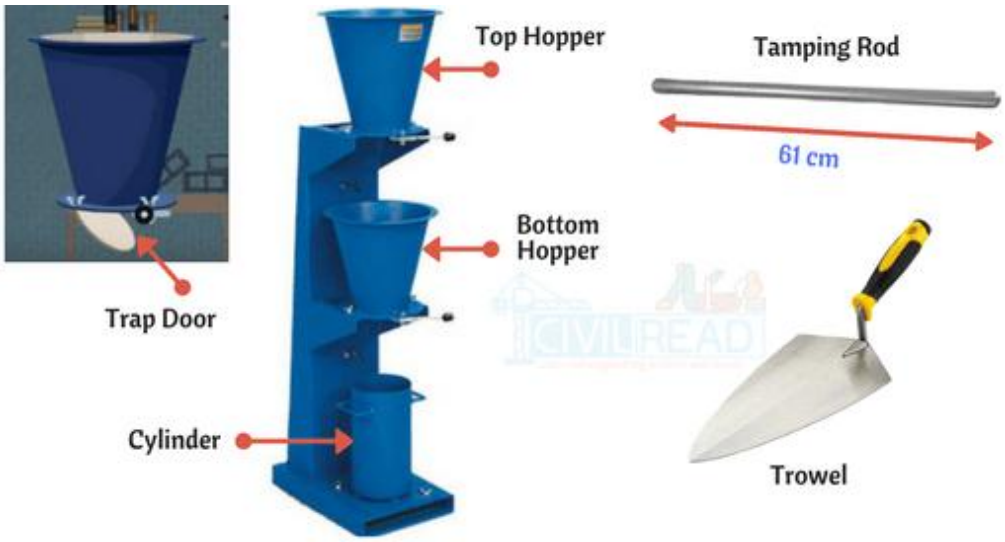

Fig.10: Compact factor testing device and tools used in the test..

Test Method:

- Clean the inner surfaces of the cones and the cylinder.
- Close the trap door of the upper cone.
- Filling the upper cone with concrete mixture by shovel and its surface is leveled with the edge of the cone.
- Open the trap door of the upper cone so that the concrete under the influence of its weight is allowed only to descend to the lower cone.
- Open the trap door of the lower cone and allows the concrete to drop to the cylinder.
- After completing the filling of the cylinder with concrete, its surface is smoothed and its sides and outer edges are cleaned, then weighs and set the weight of the concrete filling of the cylinder, which is the weight of the partly compacted concrete.
- The cylinder is re-filled from the same concrete mixture on 6 layers provided that each layer is manually or mechanically compacted until it is completely filled with concrete and then weighed and the weight of the concrete filling of the cylinder is determined and it is the weight of the fully compacted concrete.

Calculations:

The compacting factor is calculated by dividing weight of partially compacted concrete to the weight of fully compacted concrete.

$$\text{Compacting factor} = \frac{Weight\ of\ partially\ compacted\ concrete}{Weight\ of\ fully\ compacted\ concrete}$$

Vebe Test

The Purpose of the Test:

To determine the workability of the fresh concrete.

The Standard Specification:

In this test, British standard specification is adopted (B.S.1881: Part 2:1970).

Equipment and Tools:

- Vebe consistometer.
- Sampling tray.
- Scoop and Trowel.
- Tamping rod.
- Stopwatch.

Fig.11: Vebe test apparatus.

Test Method:

- Dampen the cone mold and place it in the container. Swing the funnel into position over the cone mold and lower onto the mold. Fix the cone mold so that it cannot rise from the bottom of the container by tightening the screws.
- Fill the cone mold in three layers by using the same procedure of slump test. Measure the slump and record its shape, i.e. shear, collapse, or true.
- allow the clear or transparent disc to slide down into the container to rest on the concrete.
- Start the vibration of the table and the timer simultaneously.
- record the time required to change the concrete from a conical shape to cylindrical shape. You need carefully to observe the plastic disk on top of concrete. once the concrete transferred to the cylindrical shape and covered the plastic disk completely record the time from stopwatch.
- Record the time taken to the nearest second.

Calculations:

Vebe time calculated by record the time required to change the concrete from a conical shape to cylindrical shape.

Testing of Hardened Concrete

Hardened Concrete

It begins with hardening of concrete until the end of its useful life, and this stage is characterized as the beginning of the increase in the main resistance and its ability to resist a loads over time.

-To ensure the design strength of concrete and quality of concrete construction, various tests on hardened concrete is done.

The test conducted on hardened concrete can be classified into two main categories:

- Destructive Tests on Hardened Concrete.
- Non-destructive Tests on Hardened Concrete.

Destructive Tests on Hardened Concrete

The main destructive tests on hardened concrete are as follows.

- Compressive Strength Test.
- Tensile Strength Test.

Concrete compressive Strength Test

Compressive strength test is carried out either on cube or cylinder according to the used standard specification.

Cube Test method for compressive Strength Test

The Purpose of the Test:

To determine compressive strength of hardened concrete.

The Standard Specification:

In this test, British standard specification is adopted (B.S.1881: Part 116 :1989).

Equipment and Tools:

- Mixing tools and standard tamped rod.
- Cubes (150*150*150 mm).
- Water basin.
- compressive strength test device.

Test Method

- Mix the concrete.
- Clean the molds and apply oil.
- Cubes fills with concrete in layers approximately (4) layer and each layer compacted by a tamping rod with 25 strokes.
- Level the top surface and smoothen it with a trowel.

- The test specimens are stored in moist air for 24 hours and after this period the specimens are removed from the molds and kept submerged in clear fresh water until taken out prior to test.
- After 28 days of curing, the specimens removed from basin water and prepared to test.
- Place the specimen in the machine, then the load applied gradually without shock and continuously till the specimen fails.
- Record the maximum load (failure load).

Fig.12: Casting cubes and Testing of Compressive strength of concrete.

Calculations:

The compressive strength for each specimen is determined by dividing failure load to the cross-sectional area. Then takes the average of compressive strength of the specimens, which represent the compressive strength of hardened concrete at 28 days.

$$\text{Cube compressive Strength} = \frac{Load}{Cross\text{-}sectional\ Area}$$

Average compressive strength of the concrete cube =……. N/mm^2 (at 28 days).

Cylinder Test method for compressive Strength Test

The Purpose of the Test:

To determine compressive strength of hardened concrete.

The Standard Specification:

In this test, American standard specification is adopted (B.S.1881: Part 116 :1989).

Equipment and Tools:

- Mixing tools and standard tamped rod.
- Cylinders (150*300 mm).
- Water basin.
- Test machine.

Test Method

- Mix the concrete.
- Clean the molds and apply oil.
- Cubes fills with concrete in layers approximately (4) layer and each layer compacted by a tamping rod with 25 strokes.
- Level the top surface and smoothen it with a trowel.
- The test specimens are stored in moist air for 24 hours and after this period the specimens are removed from the molds and kept submerged in clear fresh water until taken out prior to test.
- After 28 days of curing, the specimens removed from basin water and prepared to test.
- Place the specimen in the machine, then the load applied gradually without shock and continuously till the specimen fails.

- Record the maximum load (failure load).

Fig.13: Casting Clyinder and Testing of Compressive strength of concrete.

Calculations:

The compressive strength for each specimen is determined by dividing failure load to the cross-sectional area. Then takes the average of compressive strength of the specimens, which represent the compressive strength of hardened concrete at 28 days.

Cube compressive Strength = $\frac{Load}{Cross-sectional\ Area}$

Average compressive strength of the concrete cylinder =…….
N/mm^2 (at 28 days).

Tensile Strength Test

The tensile strength of concrete structures is determined by two way:

- Split Cylinder Test.
- Flexure Test.

-Split Cylinder Test.

The Purpose of the Test:

Determine the tensile strength of the hardened concrete.

The Standard Specification:

In this test, American standard specification is adopted ()

Equipment and Tools:

- Mixing tools and standard tamped rod.
- Standard cylinders (150*300 mm).
- Water basin.
- Test machine.

Test Method:

- Mix the concrete.
- Clean the molds and apply oil.
- Cubes fills with concrete in layers approximately (4) layer and each layer compacted by a tamping rod with 25 strokes.
- Level the top surface and smoothen it with a trowel.
- The test specimens are stored in moist air for 24 hours and after this period the specimens are removed from the molds

and kept submerged in clear fresh water until taken out prior to test.

- After 28 days of curing, the specimens removed from basin water and prepared to test.
- Place the specimen in the machine, then the load applied gradually without shock and continuously till the specimen fails.
- Record the maximum load (failure load).

Calculations:

The tensile stress for each specimen is determined by dividing failure load to the cross-sectional area. Then takes the average of compressive strength of the specimens, which represent the compressive strength of hardened concrete at 28 days.

$$F_{ct} = \frac{2PL}{\pi DL}$$

Which:

f_{ct}: Tensile stress

P: Compressive load at the failure.

L: Length of cylinder.

D: Diameter of the cylinder being.

Average compressive strength of the concrete cylinder =…….

N/mm^2 (at 28 days).

Flexure Test

The Purpose of the Test:

Determine the tensile strength of the hardened concrete.

The Standard Specification:

In this test, British standard specification is adopted (BS 1881: Part 118 : 1983.)

Test Method

In this test, the tensile strength of the concrete is determined by testing concrete beam specimen of dimension (150x150x750 mm). The clear span of (600mm) divided into three equal part. The beam specimen loaded under two point of loading as shown in figure below. The specimen loaded gradually till failure occurred, then the maximum tensile stress at the bottom face at failure is calculated.

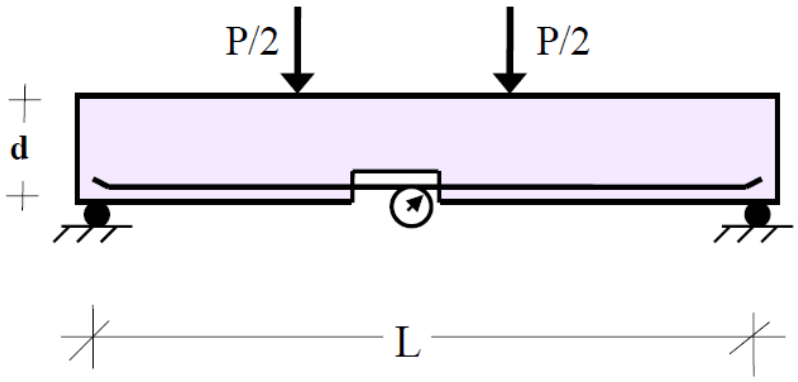

Fig.14: Experimental Arrangement for Flexural Strength Test.

Calculations:

After finding the load at which the beam failed, the tensile stress is calculated.

$$F_r = \frac{Pl}{bd2}$$

Which:

F_r: Tensile stress (modulus of rupture).

P: Compressive load at the failure.

L: Span length (from support to support).

b: Width of specimen.

d: Depth of specimen.

Non-destructive Tests on Hardened Concrete.

The main non-destructive tests for strength on hardened concrete are as follows:

1. Rebound Hammer (Hardness Test).
2. Ultrasonic Pulse Velocity Test.
3. Pull Out Test.

Rebound Hammer (Hardness Test)

The Schmidt hammer is used in the rebound hardness test in which a metal hammer held against the concrete is struck by another spring-driven metal mass and rebounds. The amount of rebound is recorded on a scale and this gives an indication of the concrete strength. The larger the rebound number is, the higher is the concrete strength.

Ultrasonic Pulse Velocity Test

In the ultrasonic pulse velocity test the velocity of ultrasonic pulses that pass through a concrete section from a transmitter to a receiver is measured. The pulse velocity is correlated against strength. The higher the velocity is, the stronger is the concrete.

Pull Out Test.

The pull out test will determine the force that is required to pull out a steel rod specially shaped from hardened concrete to which the steel was cast. Pulling out of steel is done with a cone of concrete that have a slope of 45 degrees. The force required to pull the concrete out is related with the compressive strength of the concrete.