Unit 2 module 2

Fresh concrete

Measurement of Workability

It is discussed earlier that workability of concrete is a complex property.

Slump Test

Compacting Factor Test

Flow Test

Vee Bee Consistometer Test.

Slump Test

- **Slump test is the most commonly used method of measuring consistency** of concrete which can be employed either in laboratory or at site of work.

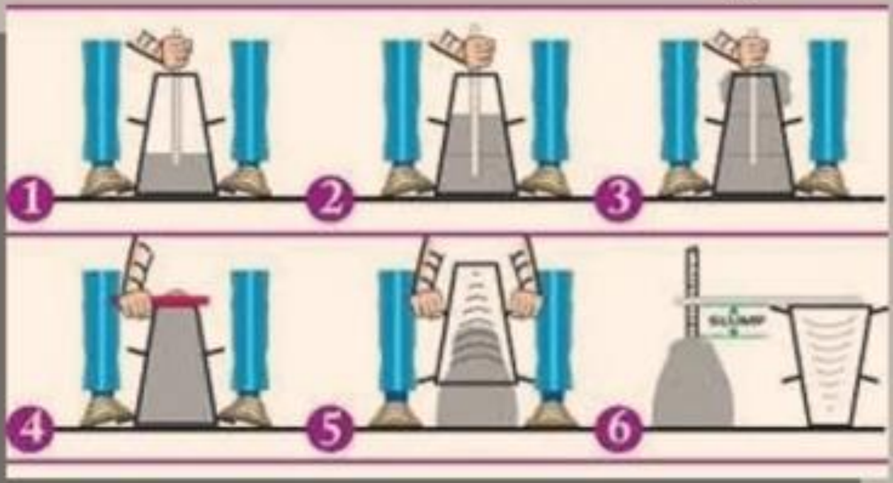
- It is not a suitable method for very wet or very dry concrete.

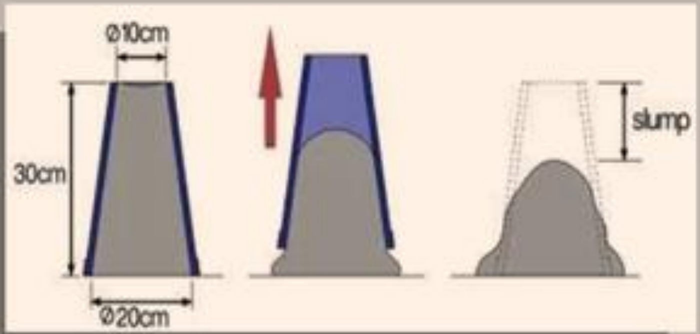
- **Additional information on workability and quality of concrete can be obtained** by observing the manner in which concrete slumps.

- **Quality of concrete can also be further assessed by giving a few tappings** or blows by tamping rod to the base plate.

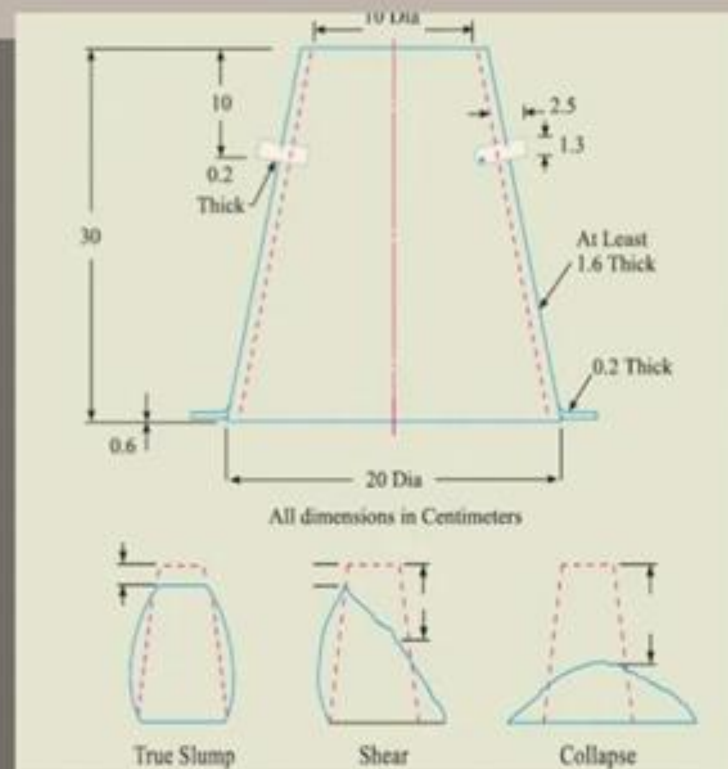
- **The deformation shows the characteristics** of concrete with respect to tendency for segregation.

Slump Test





Slump Test



10 Dia
10
2.5
1.3
0.2
Thick
30
At Least
1.6 Thick
0.2 Thick
0.6
20 Dia
All dimensions in Centimeters
True Slump
Shear
Collapse

Slump Test

Degree of workability	Slump mm	Compacting factor		Use for which concrete is suitable
		Small appartus	Large appartus	
Very Low compacting factor is suitable	–	0.78	0.80	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated machines.
Low	25–75	0.85	0.87	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregate of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	50–100	0.92	0.935	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration
High	100–150	0.95	0.96	For sections with congested reinforcement. Not normally suitable for vibration. For pumping and tremie placing
Very High	–	–	–	Flow table test is more suitable.

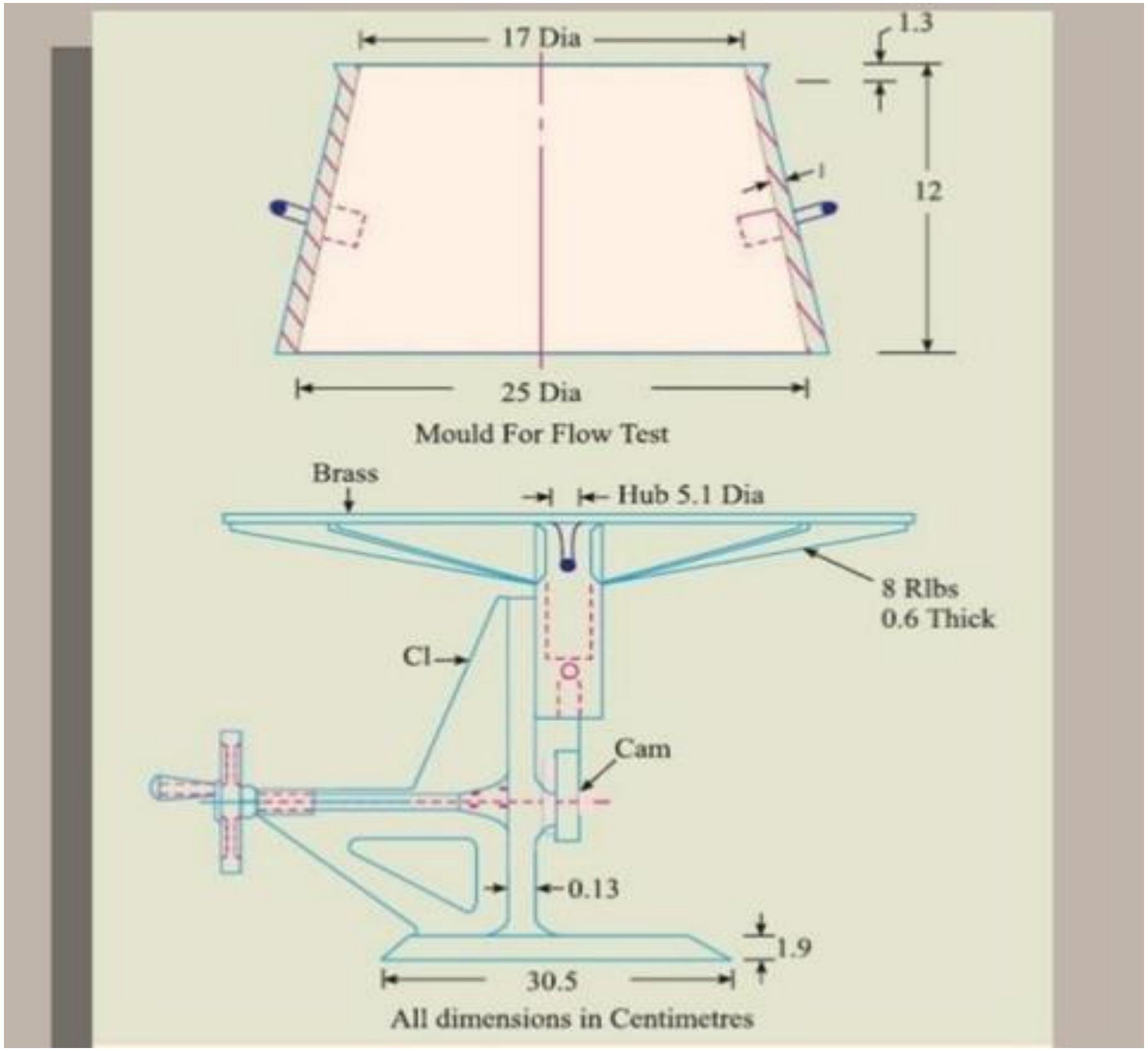
Flow Test

- This is a laboratory test, which gives an indication of the quality of concrete with respect to consistency, cohesiveness and the proneness to segregation. In this test, a standard mass of concrete is subjected to jolting. The spread or the flow of the concrete is measured and this flow is related to workability
- The apparatus consists of flow table, about 76 cm. in diameter over which concentric circles are marked. A mould made from smooth metal casting in the form of a frustum of a cone is used with the following internal dimensions.
  - *The base is 25 cm. in diameter, upper surface 17 cm. in*
  - *diameter, and height of the cone is 12 cm. The table top is cleaned of all gritty material and is wetted. The mould is kept on the centre of the table, firmly held and is filled in two layers. Each layer is rodded 25 times with a tamping rod 1.6 cm in diameter and 61 cm long rounded at the lower tamping end.*

- After the top layer is rodded evenly, the excess of concrete which has overflowed the mould is removed.
- The mould is lifted vertically upward and the concrete stands on its own without support. The table is then raised and dropped 12.5 mm 15 times in about 15 seconds.
- The diameter of the spread concrete is measured in about 6 directions to the nearest 5 mm and the average spread is noted.
- The flow of concrete is the percentage increase in the average diameter of the spread concrete over the base diameter of the mould.

$$\text{Flow, per cent} = \frac{\text{Spread diameter in cm} - 25}{25} \times 100$$

- The value could range anything from 0 to 150 per cent. A close look at the pattern of spread of concrete can also give a good indication of the characteristics of concrete such as tendency for segregation.



https://www.youtube.com/watch?v=KN-nKeSqDPU

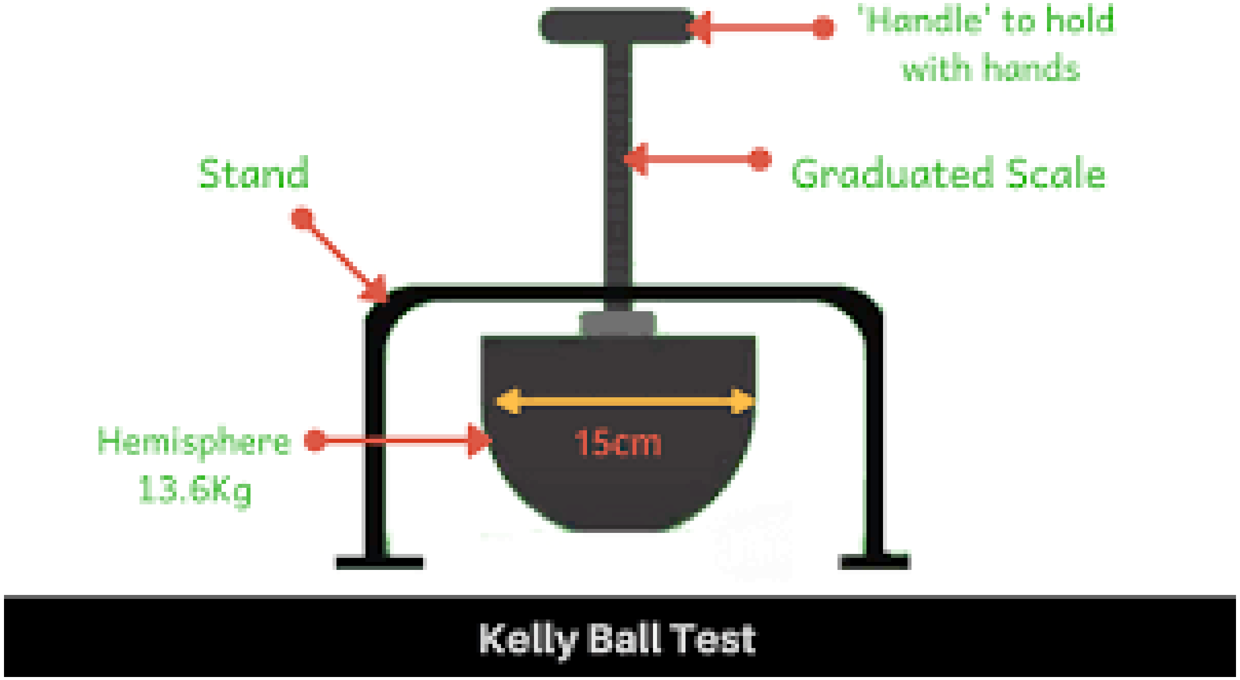
Kelly Ball Test:

- The test has been devised by Kelly and hence known as Kelly Ball Test.
- The advantages of this test is that it can be performed on the concrete placed in site and it is claimed that this test can be performed faster with a greater precision than slump test.

- The disadvantages are that it requires a large sample of concrete and it cannot be used when the concrete is placed in thin section.

- The minimum depth of concrete must be at least 20 cm and the minimum distance from the center of the ball to nearest edge of the concrete 23 cm.

- The surface of the concrete is struck off level and the ball is lowered gradually on the surface of the concrete. The depth of penetration is read immediately on the stem to the nearest 6 mm. The test can be performed in about 15 seconds.



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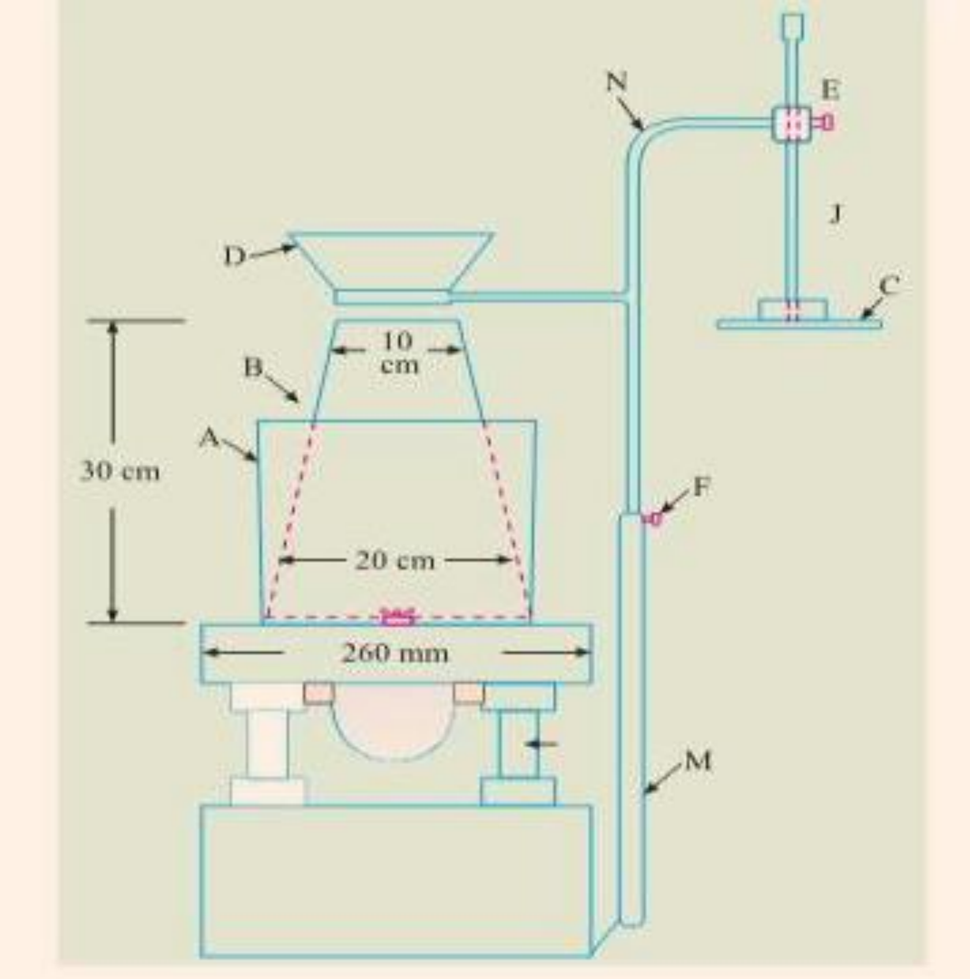
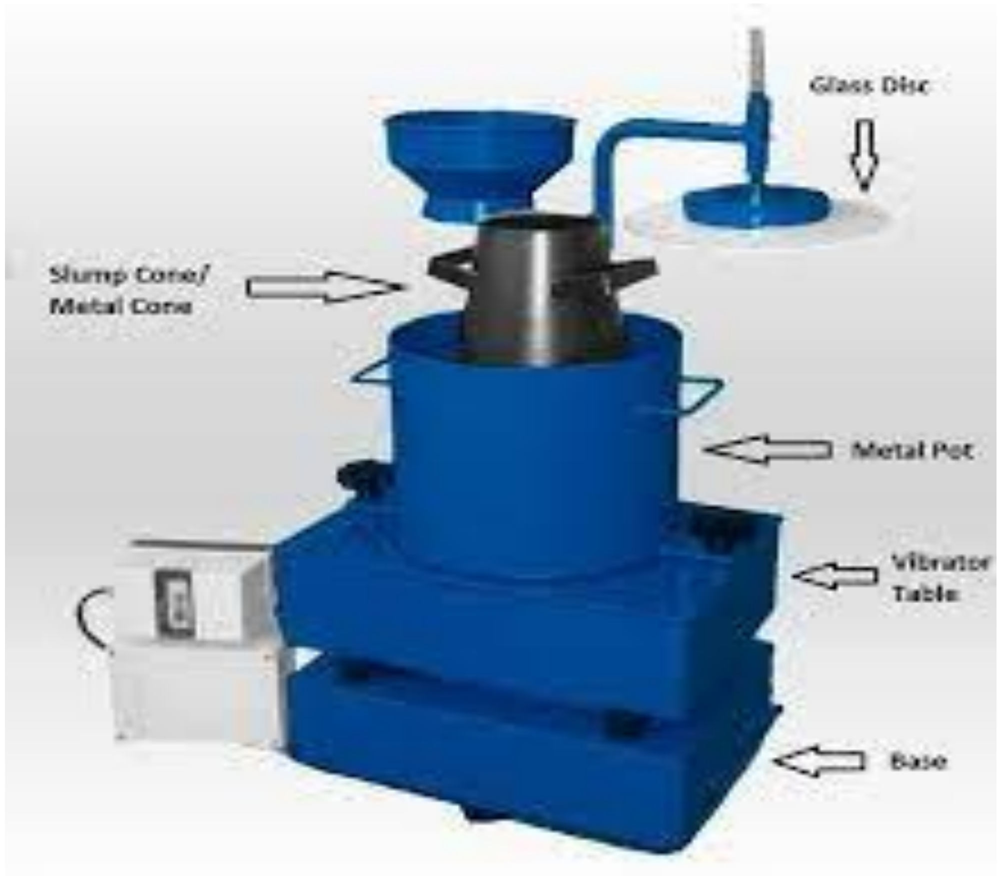
Vee Bee Consistometer Test:

- This is a good laboratory test to measure indirectly the workability of concrete. This test consists of a vibrating table, a metal pot, a sheet metal cone, a standard iron rod.
- Slump test is performed by placing the slump cone inside the sheet metal cylindrical pot of the consistometer.
- The glass disc attached to the swivel arm is turned and placed on the top of the concrete in the pot.
- The electrical vibrator is then switched on and simultaneously a stop watch started. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes a cylindrical shape.
- This can be judged by observing the glass disc from the top for disappearance of transparency. Immediately when the concrete fully assumes a cylindrical shape, the stop watch is switched off.
- The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as Vee Bee Degree.
- This method is suitable for very dry concrete whose slump value cannot be measured by Slump Test.



N
E
J
D
C
10
cm
B
A
30 cm
F
20 cm
260 mm
M


Glass Disc
Slump Cone/
Metal Cone
Metal Pot
Vibrator
Table
Base

Segregation:

- Segregation can be defined as the separation of the constituent materials of concrete.
- A good concrete is one in which all the ingredients are properly distributed to make a homogeneous mixture.
- If a sample of concrete exhibits a tendency for separation of say, coarse aggregate from the rest of the ingredients, then, that sample is said to be showing the tendency for segregation.
- Such concrete is not only going to be weak; lack of homogeneity is also going to induce all undesirable properties in the hardened concrete.
- *Segregation may be of three types: firstly, the coarse aggregate separating out or settling down from the rest of the matrix,*
- *secondly, the paste or matrix separating away from coarse aggregate and*
- *thirdly, water separating out from the rest of the material being a material of lowest specific gravity.*

Segregation

- The conditions favorable for segregation are the badly proportioned mix where sufficient matrix is not there to bind and contain the aggregates. Insufficiently mixed concrete with excess water content shows a higher tendency for segregation.
- Dropping of concrete from heights as in the case of placing concrete in column concreting will result in segregation.
- Vibration of concrete is one of the important methods of compaction. Only comparatively dry mix should be vibrated. If too wet a mix is excessively vibrated, it is likely that the concrete gets segregated. It should also be remembered that vibration is continued just for required time for optimum results.
- If the vibration is continued for a long time, particularly, in too wet a mix, it is likely to result in segregation of concrete due to settlement of coarse aggregate in matrix.
- Tendency for segregation can be remedied by correctly proportioning the mix, by proper handling, transporting, placing, compacting and finishing.

- At any stage, if segregation is observed, remixing for a short time would make the concrete again homogeneous.
- Use of certain workability agents and pozzolanic materials greatly help in reducing segregation.
- The use of air entraining agent appreciably reduces segregation.
- The pattern of subsidence of concrete in slump test or the pattern of spread in the flow test gives a fair idea of the quality of concrete with respect to segregation

Bleeding:

- It is a particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete, being of the lowest specific gravity among all the ingredients of concrete.
- Bleeding is predominantly observed in a highly wet mix, badly proportioned and insufficiently mixed concrete. In thin members like roof slab or road slabs and when concrete is placed in sunny weather show excessive bleeding.
- Due to bleeding, water comes up and accumulates at the surface. Sometimes, along with this water, certain quantity of cement also comes to the surface. When the surface is worked up with the trowel and floats, the aggregate goes down and the cement and water come up to the top surface. This formation of cement paste at the surface is known as "Laitance"

Bleeding

Bleeding in Concrete

- In such a case, the top surface of slabs and pavements will not have good wearing quality. This laitance formed on roads produces dust in summer and mud in rainy season.
- If laitance is formed on a particular lift, a plane of weakness would form and the bond with the next lift would be poor. This could be avoided by removing the laitance fully before the next lift is poured.
- Bleeding can be reduced by proper proportioning and complete mixing. Use of finely divided pozzolanic materials reduces bleeding by creating a longer path for the water to traverse.
- Use of air-entraining agent is very effective in reducing the bleeding. It is also reported that the bleeding can be reduced by the use of finer cement or cement with low alkali content. Rich mixes are less susceptible to bleeding than lean mixes.

Setting time of concrete:

- Setting time of concrete differs widely from setting time of cement.
- Setting time of concrete does not coincide with the setting time of cement with which the concrete is made.
- The setting time of concrete depends upon the w/c ratio, temperature conditions, type of cement, use of mineral admixture, use of plasticizers– in particular retarding plasticizer.
- The setting parameter of concrete is more of practical significance for site engineers than setting time of cement.
- When retarding plasticizers are used, the increase in setting time, the duration upto which concrete remains in plastic condition is of special interest

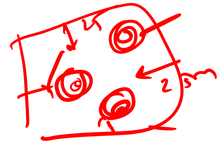
- The setting time of concrete is found by penetrometer test. This method of test is covered by IS8142 of 1976 and ASTM C – 403.
- The procedure given below may also be applied to prepared mortar and grouts.
- The apparatus consist of a container which should have minimum lateral dimension of 150 mm and minimum depth of 150 mm
- There are six penetration needles with bearing areas of 645, 323, 161, 65, 32 and 16 mm2. Each needle stem is scribed circumferentially at a distance of 25 mm from the bearing area.
- A device is provided to measure the force required to cause penetration of the needle.

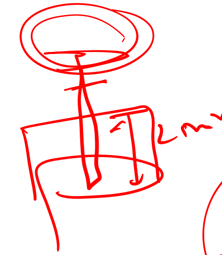
Sample

- The test procedure involves collection of representative sample of concrete in sufficient quantity and sieves it through 4.75 mm sieve and the resulting mortar is filled in the container.
- Compact the mortar by rodding, tapping, rocking or by vibrating. Level the surface and keep it covered to prevent the loss of moisture.

6 - needles

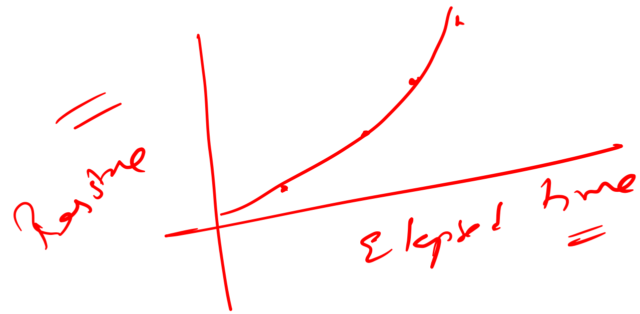
- Remove bleeding water, if any, by means of pipette.
- Insert a needle of appropriate size, depending upon the degree of setting of the mortar in the following manner. Bring the bearing surface of needle in contact with the mortar surface.



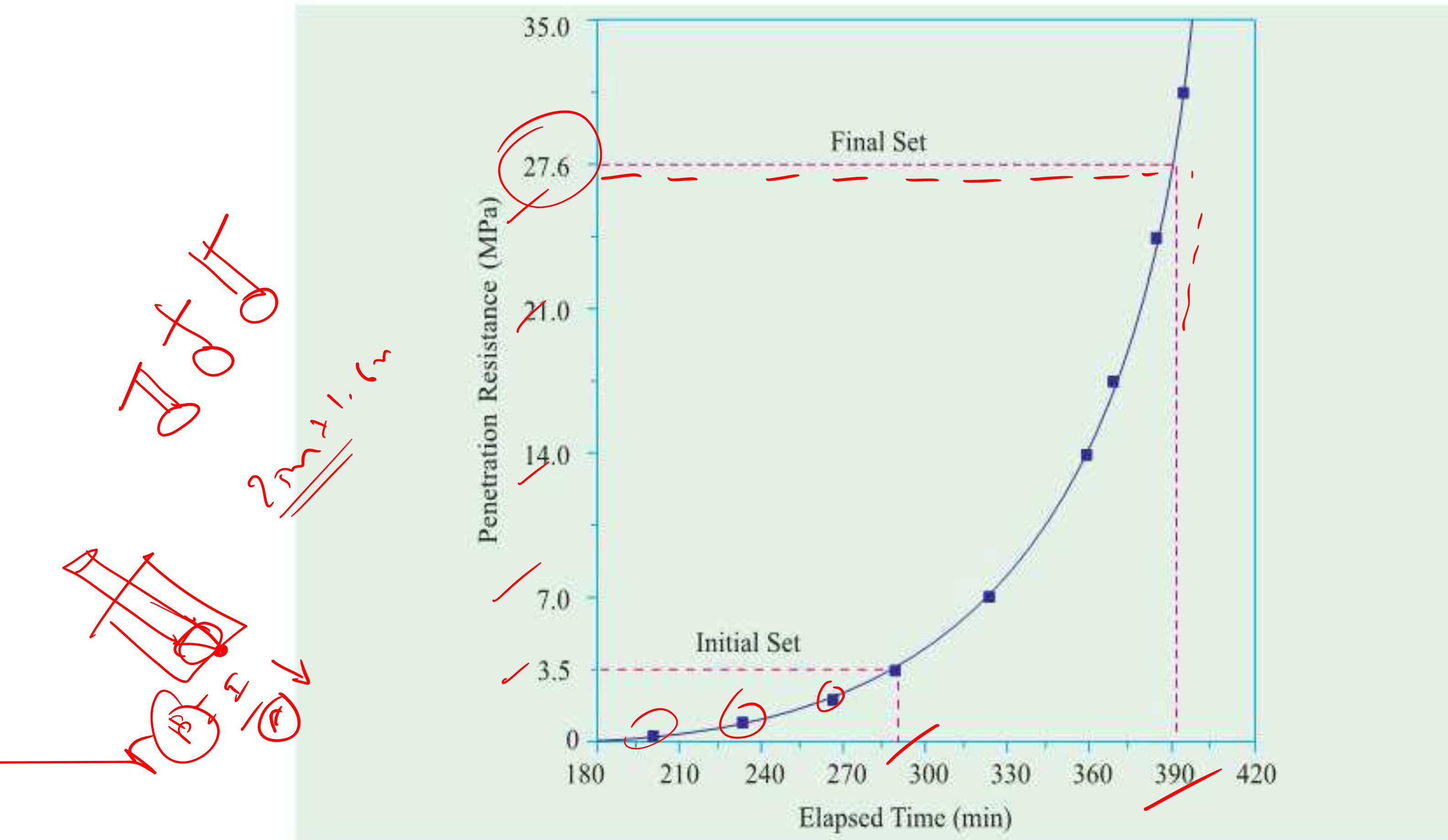


$\frac{F}{A} = \sigma$

- Gradually and uniformly apply a vertical force downwards on the apparatus until the needle penetrates to a depth of 25 ± 1.5 mm, as indicated by the scribe mark.
- The time taken to penetrate 25 mm depth could be about 10 seconds. Record the force required to produce 25 mm penetration and the time of inserting from the time water is added to cement.
- Calculate the penetration resistance by dividing the recorded force by the bearing area of the needle. This is the penetration resistance.
- For the subsequent penetration avoid the area where the mortar has been disturbed. The clear distance should be two times the diameter of the bearing area. Needle is inserted at least 25 mm away from the wall of container.



- Plot a graph of penetration resistance as ordinate and elapsed time as abscissa.
- Not less than six penetration resistance determination is made. Continue the tests until one penetration resistance of at least 27.6 MPa is reached. Connect various points by a smooth curve.
- From penetration resistance equal to 3.5 MPa, draw a horizontal line. The point of intersection of this with the smooth curve, is read on the x-axis which gives the initial setting time.
- Similarly a horizontal line is drawn from the penetration resistance of 27.6 MPa and point it cuts the smooth curve is read on the x-axis which gives the final set.


Final Set
Initial Set
Penetration Resistance (MPa)
Elapsed Time (min)
35.0
27.6
21.0
14.0
7.0
3.5
0
180
210
240
270
300
330
360
390
420

Everything in flows

Rheology of concrete

Concrete behaving like a fluid

Definitions of Rheology:

F.C is considered as fluid

Rheology is the science of the flow and deformation of the materials. It is concerned with the relationship between stress-strain, rate of strain and time. The term Rheology deals with the materials whose flow properties are more complicated than those of simple fluids as liquids and gases. The Rheological principles and techniques applied to concrete include the deformation of hardened concrete, handling and placing of freshly mixed concrete and the behavior of its constituents parts, namely cement paste and slurries.

The Rheology of fresh concrete like workability includes the parameters of stability, mobility and compatibility, which are necessary to determine the suitability of any concrete mix. For defining the Rheological properties of fresh concrete, the above parameters are defined in terms of forces involved in the transmission of mechanical stresses on the concrete. During handling and placing of fresh concrete, it is subjected to normal and shearing forces.

Relation b/w shear stress & shear rate are represented graphically in flow curve.

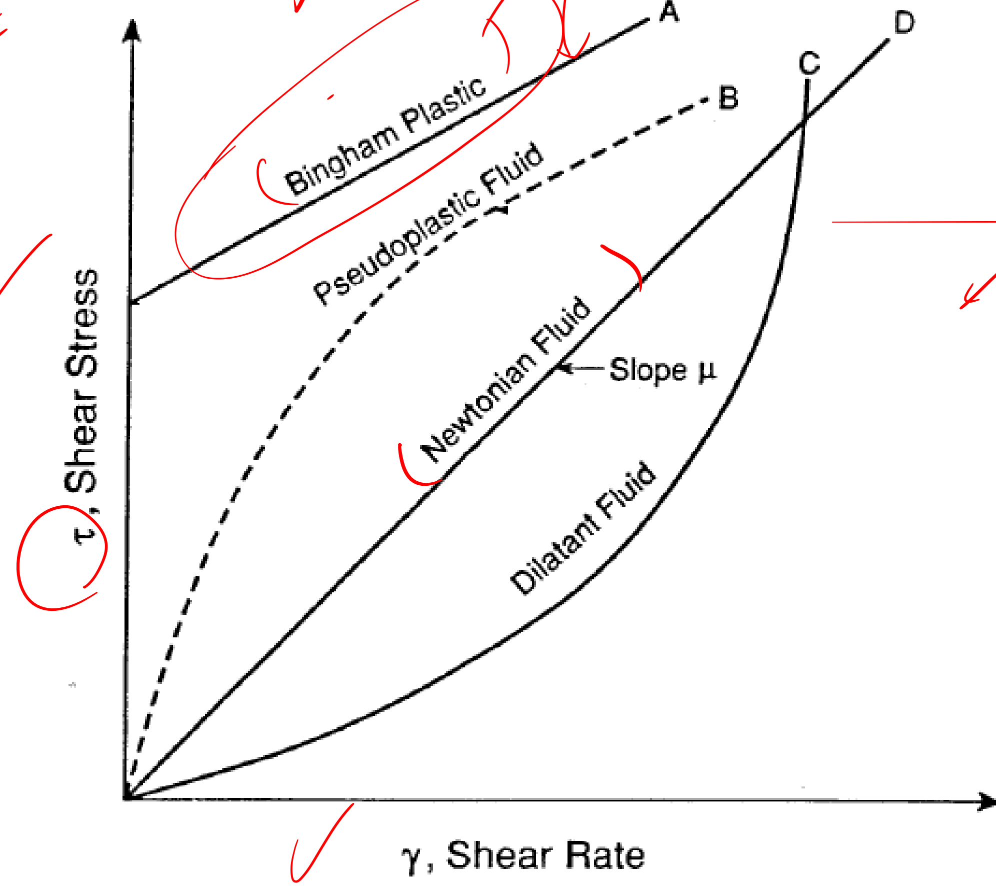
Rheology

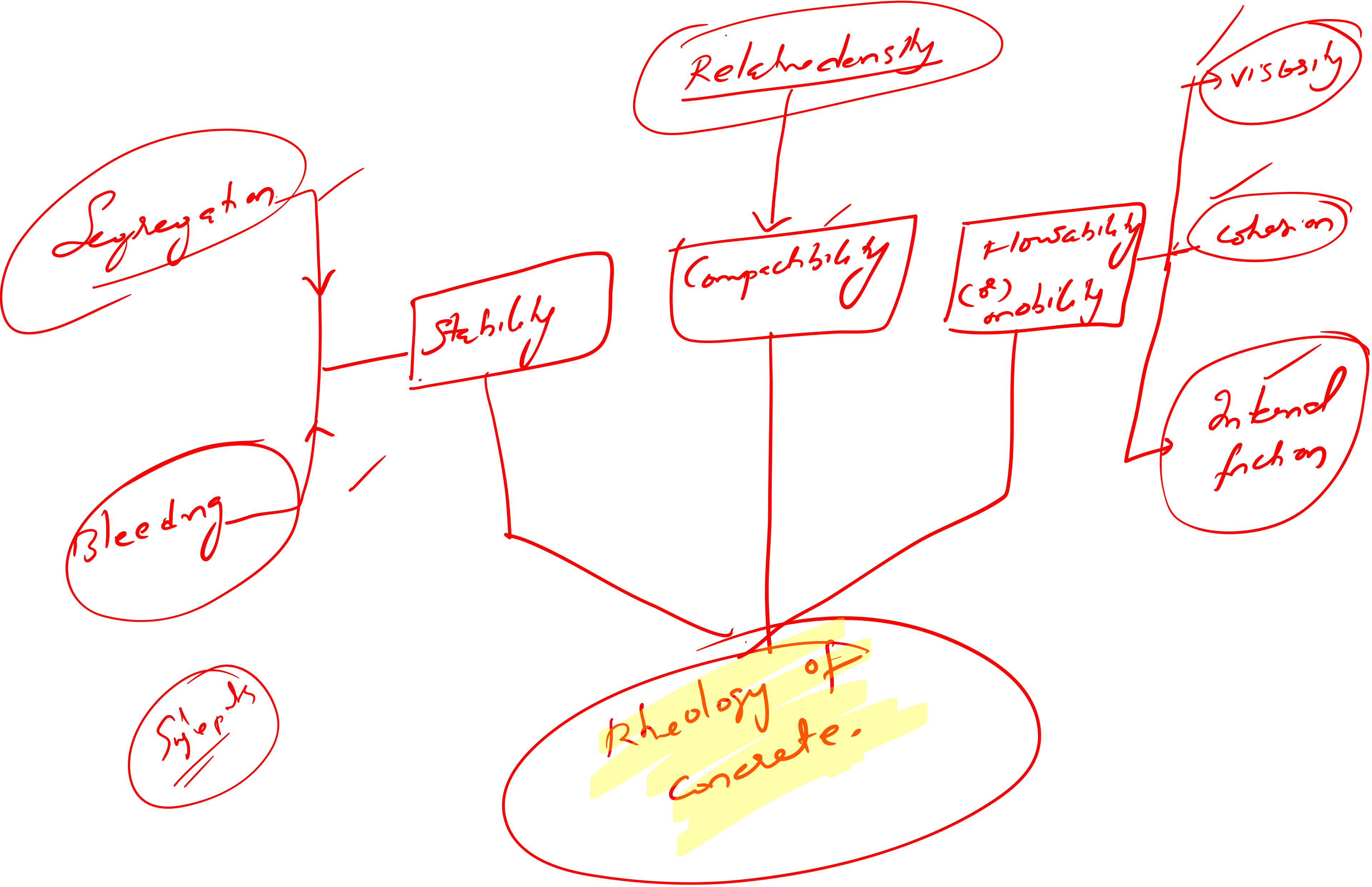
$\tau = \mu \frac{du}{dy}$ Newtons laws of viscosity

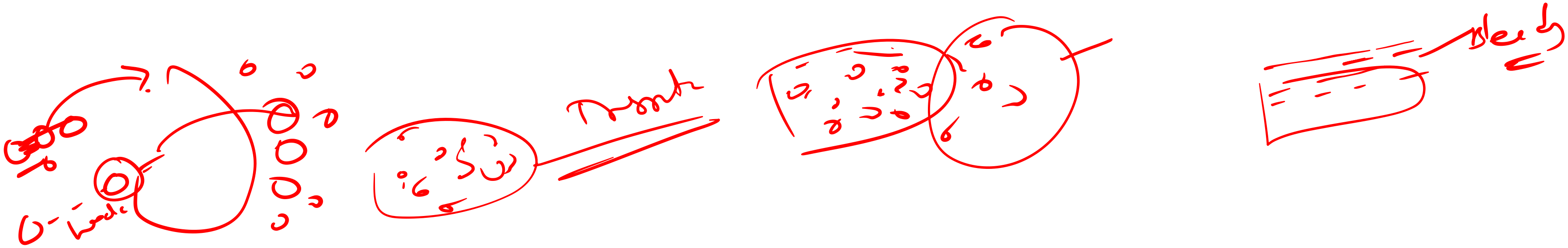
Fm → Fluid

Blood

paste




Relative density
Compactibility
Flowability
(or) mobility
Viscosity
Cohesion
Internal friction
Stability
Segregation
Bleeding
Rheology of concrete.

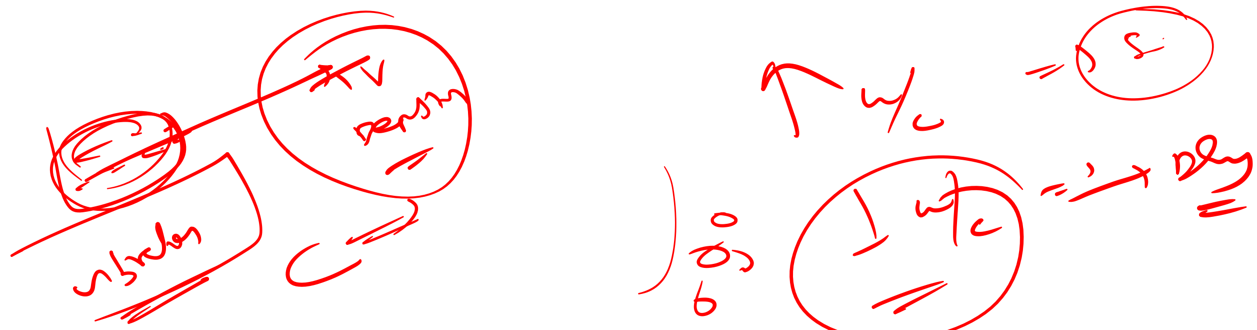


1. Stability:

It can be defined as a condition in which the aggregate particles are held in a homogeneous dispersion by matrix and random sampling has shown the same particle size distribution during transportation, placing and compaction. The stability of concrete is measured by the characteristics of its segregation and bleeding.

2. Segregation:

It is defined as the mixture's instability caused by the weak matrix that cannot hold the individual aggregate particles in homogeneous dispersion. The resistance to segregation depends upon the cohesion between the particles of the mix. Segregation in concrete may occur in wet as well as dry consistencies.



3. Segregation in Wet Mix:

Segregation in wet mix may occur when water content in the mix is such that the paste is unable to hold the aggregate particles in the distributed position during the transportation, placement and compaction of the concrete.

4. Dry Segregation:

Dry segregation occurs when the concrete is of low water-cement ratio which results in crumbly mix during handling. If concrete is vibrated then crumbly mixes often have been found satisfactory as during vibration the matrix becomes fluid momentarily and develops shear resistance and cohesion.

5. Bleeding:

It occurs when the mortar is unstable and releases free water. Bleeding should be controlled and reduced to a minimum.

6. Mobility:

Mobility of fresh concrete can be defined as its ability to flow under mechanical stresses. The flow is restricted by cohesive, viscous and frictional forces. The cohesive force is developed due to adhesion between the matrix and aggregate particles. It provides tensile strength to fresh concrete that resists segregation. The viscosity of the matrix contributes to the ease with which the aggregate particles can move and rearrange themselves with in the matrix.

[redacted]

At low stresses no flow takes place and the mix behaves as a solid of extremely high viscosity. As the stresses increase, the viscosity gradually decreases and the bond strength between particles becomes insufficient to prevent the flow and the concrete behaves like a liquid. The internal friction develops when a mixture is displaced and the aggregate particles translate and rotate.

The resistance to deformation depends on the following factors:

i. Shape and texture of aggregate,

ii. Type of cement used,

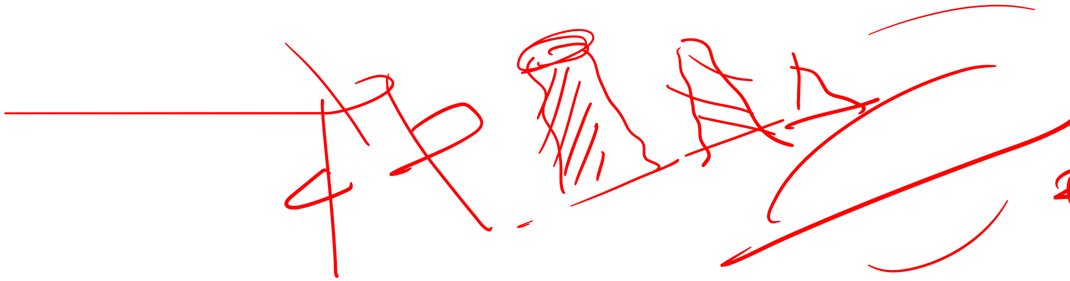
opc, ppc

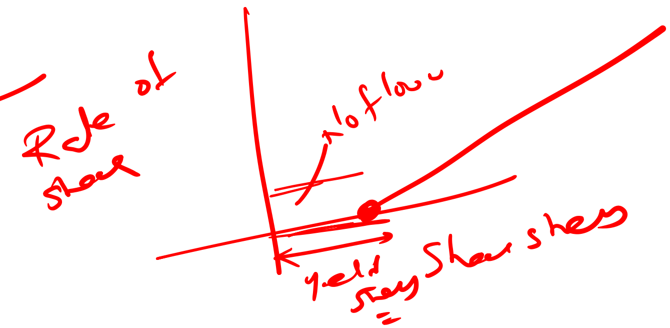
iii. Richness of the mix, and

w/c

iv. Water-cement ratio of the mix etc.

Thus the angle of internal friction plays an important role in the mobility of a concrete mixture. The mobility of a concrete mix may be determined by the laboratory tri-axial compression test. At the construction site the relative mobility characteristics may be determined by the Vee Bee flow test in conjunction with compacting factor test.





Representation of Rheological Behaviour in Concrete:

The ideal liquids which obey the Newton's law of viscous flow, (Shear stress being proportional to the rate of shear strain) are called Newtonian liquids. The constant of proportionality may be used as a physical constant characteristic of the materials. The flow behaviour of fresh concrete does not follow this law. The ratio of shear stress to shear rate is not constant, but depends upon the shear rate at which it is measured and it may also depend on the shear history of the concrete sample investigated.

At low shear rates which are important in practice, the rheological behaviour of concrete can be represented by a straight line which does not pass through the origin, i.e., which has an intercept on the stress axis. This intercept indicates the minimum value of stress below which no flow takes place. This straight line is of the form $\boxed{Y = mx + c}$.

The fact that concrete can stand in a pile (as in the case of slump test) suggests that for a flow to develop some minimum stress is necessary. This minimum stress is known as yield stress and denoted by the symbol τ_0.

Thus the flow equation of concrete as suggested by Bingham can be written as:

$\tau = \mu g + \tau_0$ ...(1)

$\tau = \mu g + \tau_0$

where,

τ = shear stress

μ = a constant, having dimensions of viscosity and called plastic viscosity

τ_0 = value of yield stress

γ = Rate of shear stress

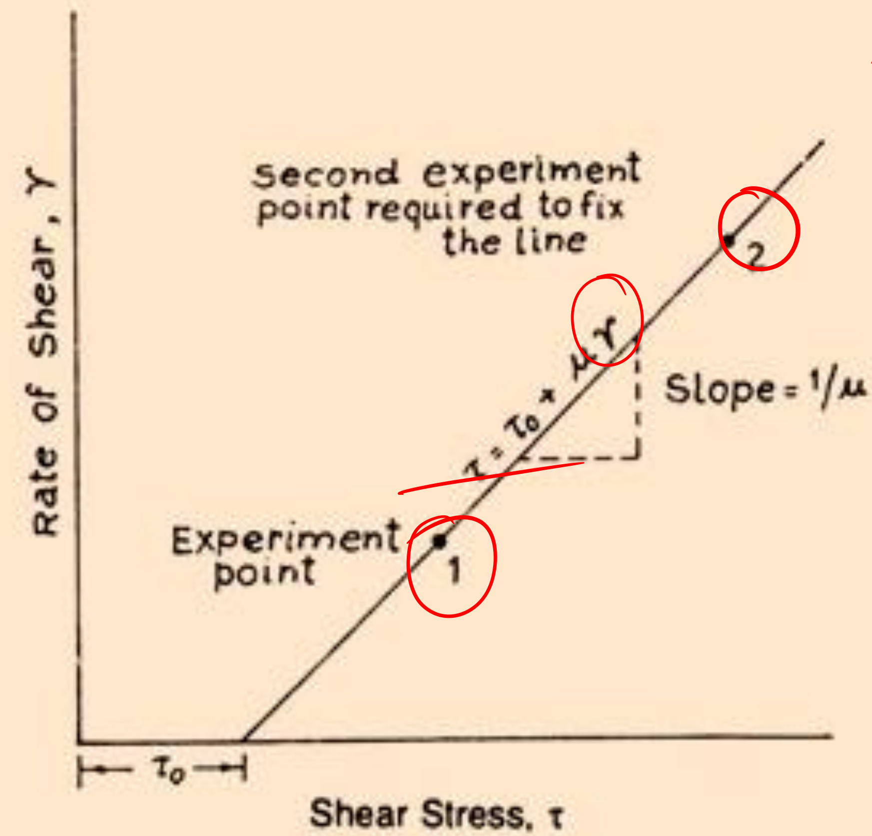


Fig. 28.2. Bingham model

Actual practice

It has been observed that concrete behaviour departs from the Bingham model significantly at least in one of the following respects:

1. The flow curve is not linear except over a very limited range of shear rates.

2. The yield stress is not well defined.

In case the flow curve is concave up wards i.e. its slope increases with shear rates. It shows that the sharing forces are destroying some structures that existed in the unstressed material. The progress of destruction of structure has been found greater for the higher rates of shear. If the rate of shear is increased gradually, a curve ABC is obtained as shown in Fig. 28.3.

Compaction factor test.

Determining the power required to mix concrete @ various speeds & calculate Torque = power / speed

By DMdg

Suppose consider 2 mixtures

Torque is selected to mixing speed rps

$T = g + hN$

power required

constant proportional to plastic viscosity

Consistency

Compaction factor

Vee-Bee time

Breakdown in the structure under shear & process reversed

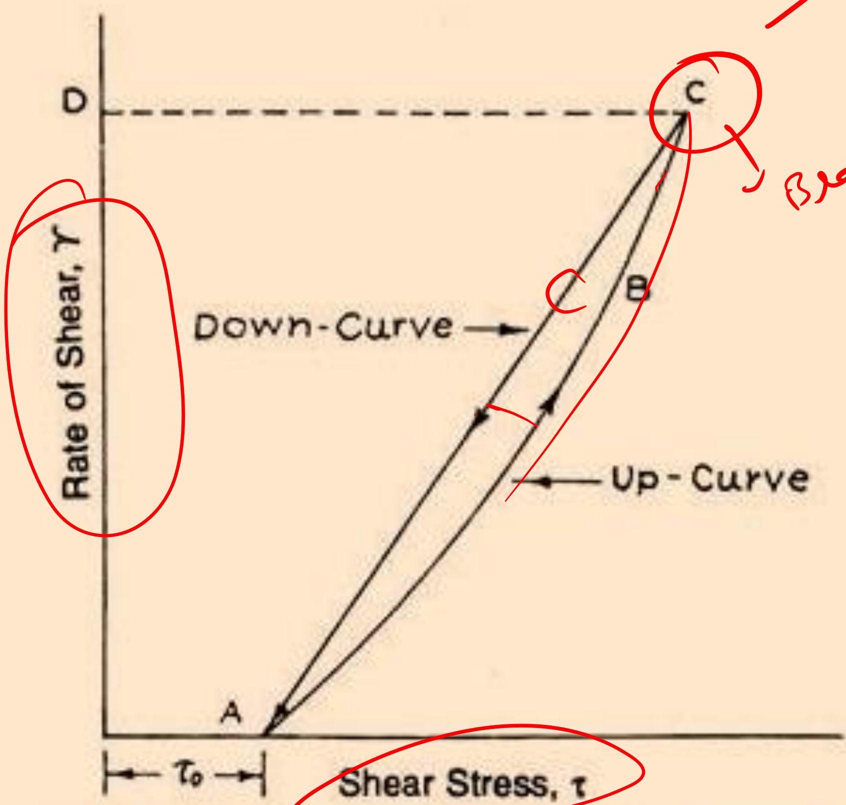


Fig. 28.3. Deformation curve for fresh concrete

If reaching at point C, the rate of shear is decreased steadily to zero the descending curve obtained does not coincide with the up curve. If the point C represents the break down in the structure under shear and the process of structural break down immediately and instantaneously is reversed, the decrease in shear rate from D will result in the progressive built up of the structure to the same level as it had on the up curve at the start, but time is required to rebuild the structure of the material.

Thus as the rate of shear is decreased, the shear stress at any particular rate of shear on the down curve will be less than the shear at the same rate on the up curve. Therefore the up and down curves will not be coincident and a hysteresis loop will be formed. The Bingham model can be applied to the fresh concrete under practical situations provided the limits are recognized.


Thank you!!! ...