

b Effect of temperature on hydration - At low temperature, the hydration rate slows rate and gets fast at higher temperature. Ideal temperature of hydration - $27 \pm 3^\circ \text{C}$.

c Effect of age on concrete strength - Strength of concrete increases with age. Therefore, W/C ratio law is applicable only when strength of concrete at same age is compared.

d Effect of size of specimen on concrete strength - In concrete, different size specimen should be used to be strengthful and economical.

- * However strength of W/C ratio may vary due to -
 - Change in aggregate properties.
 - Different types of cements and admixtures used.
 - Length of curing time.

Chapter 4-

Workability

- It is defined as the amount of work required to place concrete and to compact it thoroughly.
- The ability to work in any concrete, place it & use it is known as its workability.

* Concepts associated with workability-

a. Internal Friction- It is the friction, which works internally between the ingredients of concrete. To increase workability, it is necessary to reduce internal friction. It can be done by -

- i. Increasing the amount of water for lubrication.
- ii. Decreasing total surface area of aggregates.

b. Harshness- The concrete mix, which causes difficulty in obtaining a smooth finish is known as harsh mix. It is caused by excess of medium size particles, deficiency of fine aggregates and deficiency of water.

c. Segregation- The separation of coarse aggregates from the concrete mix in plastic stage is termed as segregation. It affects the workability of concrete, its strength and durability.

It is caused by - a. Excess use of water.

b. Poorly graded aggregates.

c. When concrete is placed from more than one meter height.

d. Under water concreting.

Prevention - i. Concreting operations should be supervised.

ii. Optimum use of water.

d Bleeding - The appearance of water with fine particles on the surface of freshly placed concrete after compaction is known as bleeding. It affects workability of concrete.

It is caused by :-

- a Presence of excess water.
- b Deficiency of fine aggregates.

* Prevention -

- i Properly designing W/C ratio.
- ii By providing graded fine aggregates.
- iii Controlling the amount of compaction.

* Factors affecting Workability -

a Water content.

b Shape of aggregates - Round aggregates increase workability, whereas angular & flanky aggregates reduce workability.

c Size of aggregates - Workability increases with size of aggregates.

d Surface texture of aggregates - Aggregates with rough and porous surface require more cement and water to produce workable concrete. But rough surface gives better bonding.

e Porosity / Water absorption of aggregates - Non-porous and saturated aggregates contribute to increase workability.

f Temperature - Maintaining normal temperature ($27 \pm 3^\circ$) increases workability of concrete.

g. Temperature and mixing time - With increase in mixing time upto 2 min. the workability increases.

h. Admixtures - Admixtures are chemicals, added to concrete to obtain special properties in concrete.

* Measurement of Workability - A number of different empirical tests are available for measuring the workability of fresh concrete. Each test measures a particular aspect.

Following are empirical methods of measuring workability :-

- a. Slump test.
- b. Compacting factor test.
- c. V-Bee consistometer test.

• Slump Test - It is one of the simplest and widest used test in construction sites. This test is performed every time / whenever the mix doesn't seem right to adjust water amount.

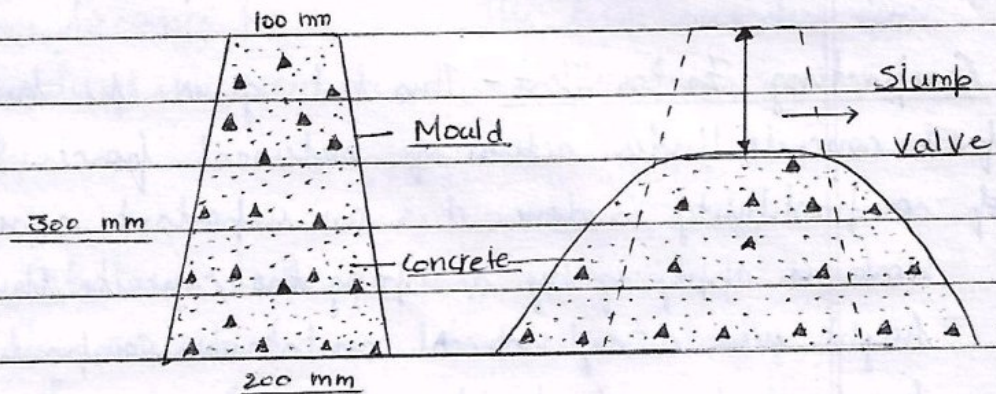
* Apparatus - a. A fulcrum with -

top dia = 100 mm, bottom dia = 200 mm
height = 300 mm.

- b. A steel tempering bullet head. (60 cm)
- c. A water proof hard base plate.
- d. A scoop, float, rules and cloth.

* Procedure - i. Put base plate and place the mould (cone) over it.
ii. Hold the mould and place concrete in it in 4

- layers of 75 mm each, each after tapping.
- iii. After placing and compacting the layer, level it with float and remove the mould.
 - iv. Slump is measured immediately by determining the vertical distance (mm) as slump value.



Following 3 results are given :-

- a. True Slump - The even subsidence of slump is true slump. It has correctly designated W/C cement ratio.
- b. Shear Slump - When the concrete specimen moves sideways as seen as mould is removed. It is formed in harsh mix.
- c. Collapse Slump - If the specimen gets flattened, it is known as collapse slump. It happens in case of excessive water.

Slump Value	Less than 25	25-50	50-100	100-150
Workability	Very low	Low	Medium	High.

Advantages of slump test -

- i. Simple and widely accepted.
- ii. Apparatus is cheap, handy and suitable.
- iii. Ensures similarity under same batch concrete.

* Limitations of slump test -

- i. It only checks medium to high workability.
- ii. Not suitable for wet mix.
- iii. True value of slump cannot be measured corrected.

• Compacting Factor Test - This test gives the behaviour of fresh concrete under action of external forces. If the measure of compactibility is done, it is an important aspect.

Work is applying by dropping the concrete through a standard height into a cylindrical container. Compaction is achieved by dissipation of kinetic energy of concrete. Its degree of compaction is compacting factor.

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

* Apparatus - compacting factor apparatus.

Compaction Factor	0.75 - 0.8	0.85	0.94	0.96
Workability degree	Very low	Low	Medium	High

• Suitability - i. More accurate than slump test.

ii. Suitable in laboratories with size of concrete not to exceed 300 mm.

• Advantages -

a. More precise and satisfactory result.

• Limitations -

a. This is not suitable for site as this equipment is not portable (only for laboratory).

• Vee-Bee Consistometer Test - It is suitable for stiff concrete mix having even very low workability.

Procedure - Fill the slump mould with concrete and cover it with glass plate sides. Then the mould is vibrated and continued, until the surface becomes horizontal. The time recorded for complete remoulding in seconds is considered as a measure of workability.

Suitability - a. Laboratory testing.

b. For concrete having low workability.

Advantages - i. For dry / harsh mixes.

Workability	Placing Conditions
a. Very Low	Binding concrete, shallow sections, pavements using spavess.
b. Low	Mass concrete, light reinforcement, floors, hand placed pavement, canal linings
c. Medium	Heavily reinforced section, slab, beam, walls, pumped concrete, slipform work.
d. High	Trench fill, piling.