Fresh Concrete: Workability

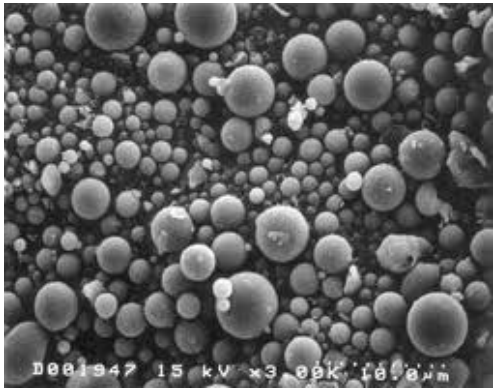
Lecture No. 10

Workability

- The function of water is also to lubricate the concrete so that the concrete can be compacted with specified effort forthcoming at the site of work.
- The lubrication required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forth-coming and to finish it sufficiently easily, the presence of a certain quantity of water is of vital importance.
- *Workability* is the ability of a fresh (plastic) concrete mix to fill the form/mold properly with the desired work (vibration) and without reducing the concrete's quality.

Workability

Workability depends on water content, aggregate (shape and size distribution), cementitious content and age (level of hydration) and can be modified by adding chemical admixtures, like superplasticizer



Factors Affecting Workability

a) Water Content

b) Mix Proportions

c) Size of Aggregates

d) Shape of Aggregates

e) Surface Texture of Aggregate

f) Grading of Aggregate

g) Use of Admixtures.

Water content or Water Cement Ratio

- More the water cement ratio more will be workability of concrete. Since by simply adding water the inter particle lubrication is increased.
- High water content results in a higher fluidity and greater workability. Increased water content also results in bleeding. another effect of increased water content can also be that cement slurry will escape through joints of formwork.
- More water can be added, provided a correspondingly higher quantity of cement is also added to keep the water/cement ratio constant, so that the strength remains the same.

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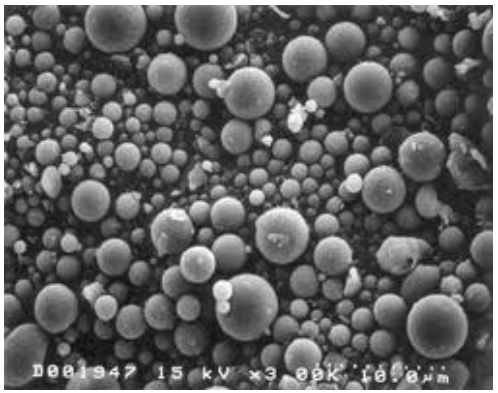
Mix Proportions

- The higher the aggregate/cement ratio, less quantity of paste is available for providing lubrication, per unit surface area of aggregate and hence the mobility of aggregate is restrained.
- On the other hand, in case of rich concrete with lower aggregate/cement ratio, more paste is available to make the mix cohesive and fatty to give better workability.



Size of Aggregate & Surface Texture

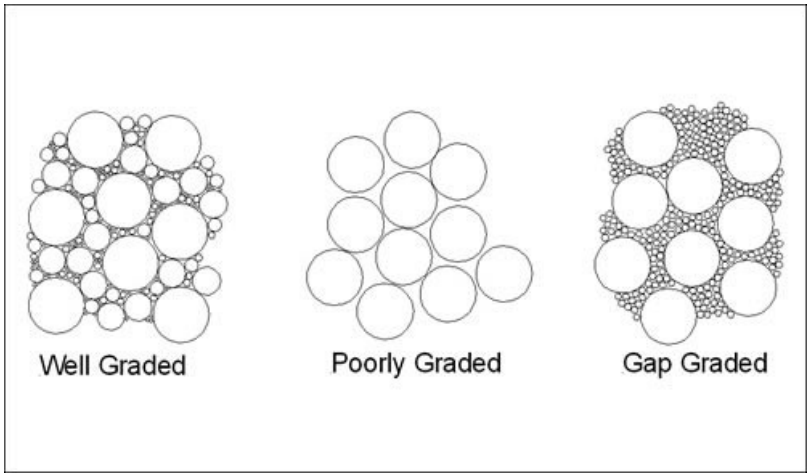
- The bigger the size of the aggregate, the less is the surface area and hence less amount of water is required for wetting the surface and less matrix or paste is required for lubricating the surface to reduce internal friction.
- Greater size of Aggregate- less water is required to lubricate it, the extra water is available for workability
- Porous aggregates require more water compared to non absorbent aggregates for achieving same degree of workability.

Shape of Aggregates

- Angular, elongated or flaky aggregate makes the concrete very harsh when compared to rounded aggregates or cubical shaped aggregates.
- Contribution to better workability of rounded aggregate will come from the fact that for the given volume or weight it will have less surface area and less voids than angular or flaky aggregate.
- Not only that, being round in shape, the frictional resistance is also greatly reduced. This explains the reason why river sand and gravel provide greater workability to concrete than crushed sand and aggregate.

Grading of Aggregates

- A well graded aggregate is the one which has least amount of voids in a given volume and higher the workability.
- Other factors being constant, when the total voids are less, excess paste is available to give better lubricating effect.
- With excess amount of paste, the mixture becomes cohesive and fatty which prevents segregation of particles.



Use of Admixtures

- Chemical admixtures can be used to increase workability.
- Use of air entraining agent produces air bubbles which acts as a sort of ball bearing between particles and increases mobility, workability and decreases bleeding, segregation.
- The use of fine pozzolanic materials also have better lubricating effect and more workability.

Weather Conditions

- If temperature is high, evaporation increases, thus workability decreases.
- If wind is moving with greater velocity, the rate of evaporation also increase reduces the amount of water and ultimately reducing workability.

Measurement of Workability

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

a) Slump Test

b) Compacting Factor Test

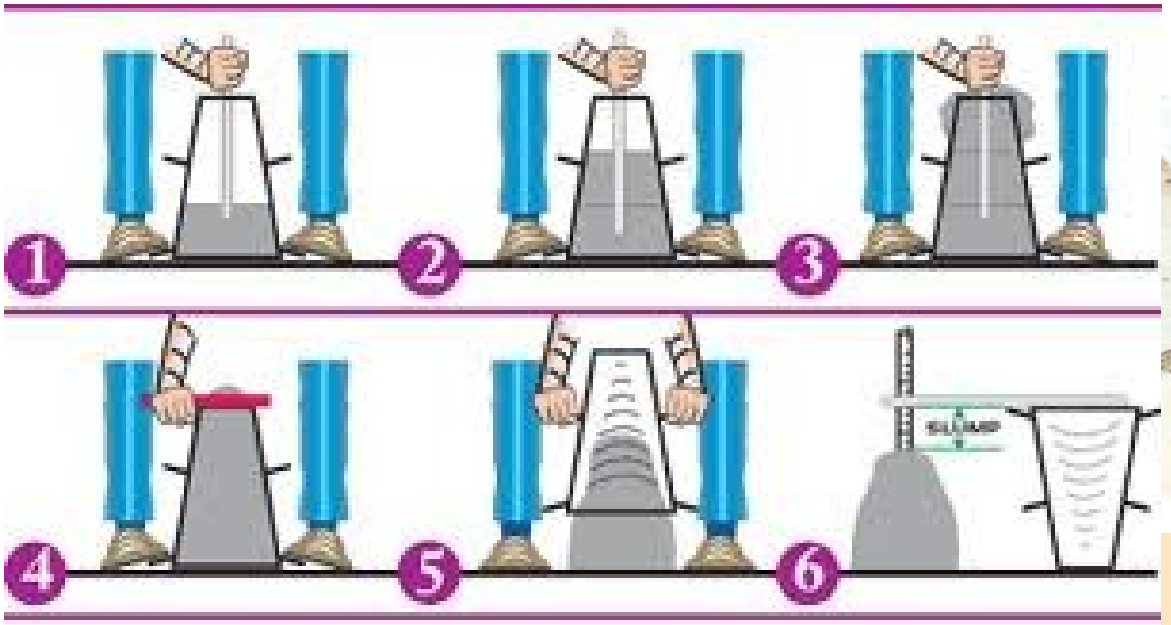
c) Flow Test

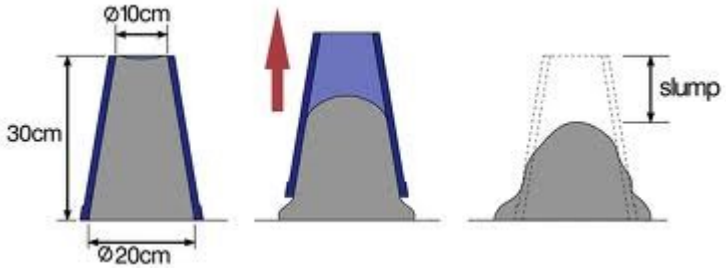
d) Vee Bee Consistometer Test.

Slump Test

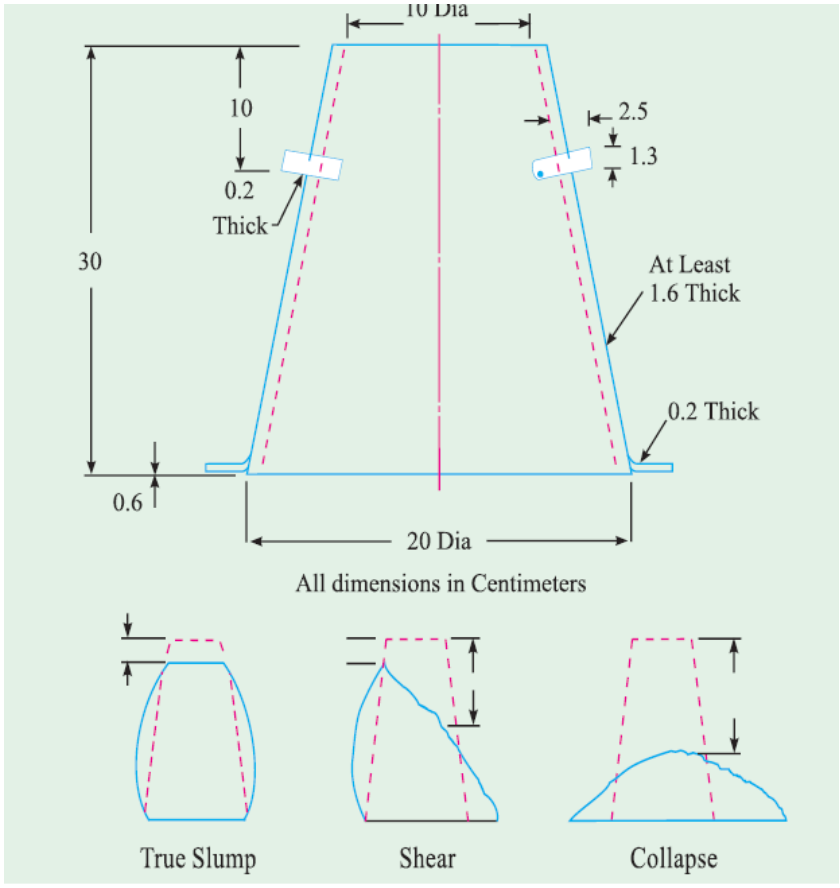
- Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work.
- It is not a suitable method for very wet or very dry concrete.
- Additional information on workability and quality of concrete can be obtained by observing 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
0.2
Thick
2.5
1.3
30
At Least
1.6 Thick
0.2 Thick
0.6
20 Dia
All dimensions in Centimeters
True Slump
Shear
Collapse

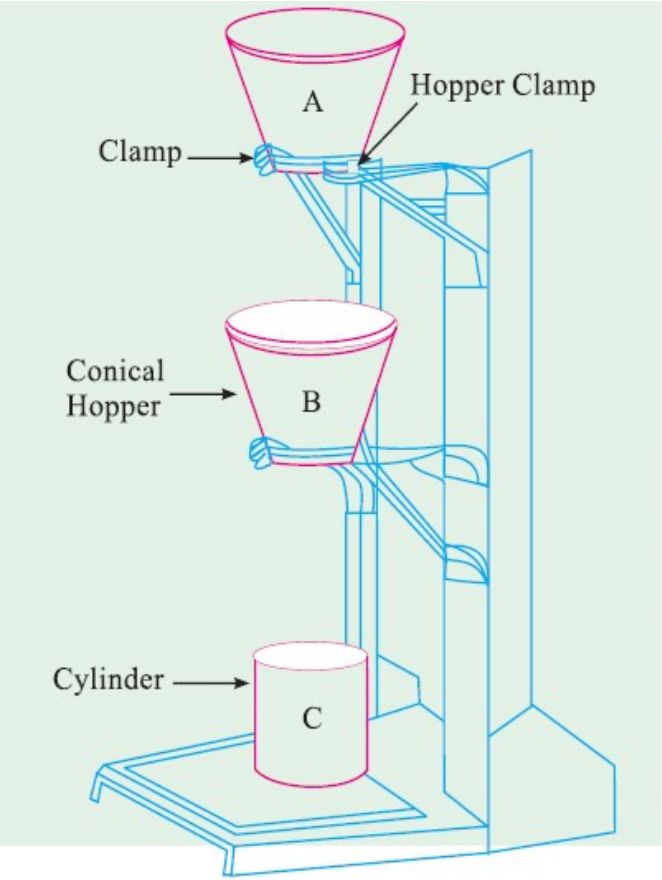
Slump Test

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.

Compacting Factor Test

- It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration.
- The compacting factor test has been developed at the Road Research Laboratory U.K.
- This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.
- The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio of the density actually achieved in the test to density of same concrete fully compacted.

Compacting Factor Test



Compacting Factor Apparatus

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

Compacting Factor Test

Upper Hopper, A	Dimension cm
Top internal diameter	25.4
Bottom internal diameter	12.7
Internal height	27.9
Lower hopper, B	
Top internal diameter	22.9
Bottom internal diameter	12.7
Internal height	22.9
Cylinder, C	
Internal diameter	15.2
Internal height	30.5
Distance between bottom of upper hopper and top of lower hopper	20.3
Distance between bottom of lower hopper and top of cylinder	20.3

Flow Test

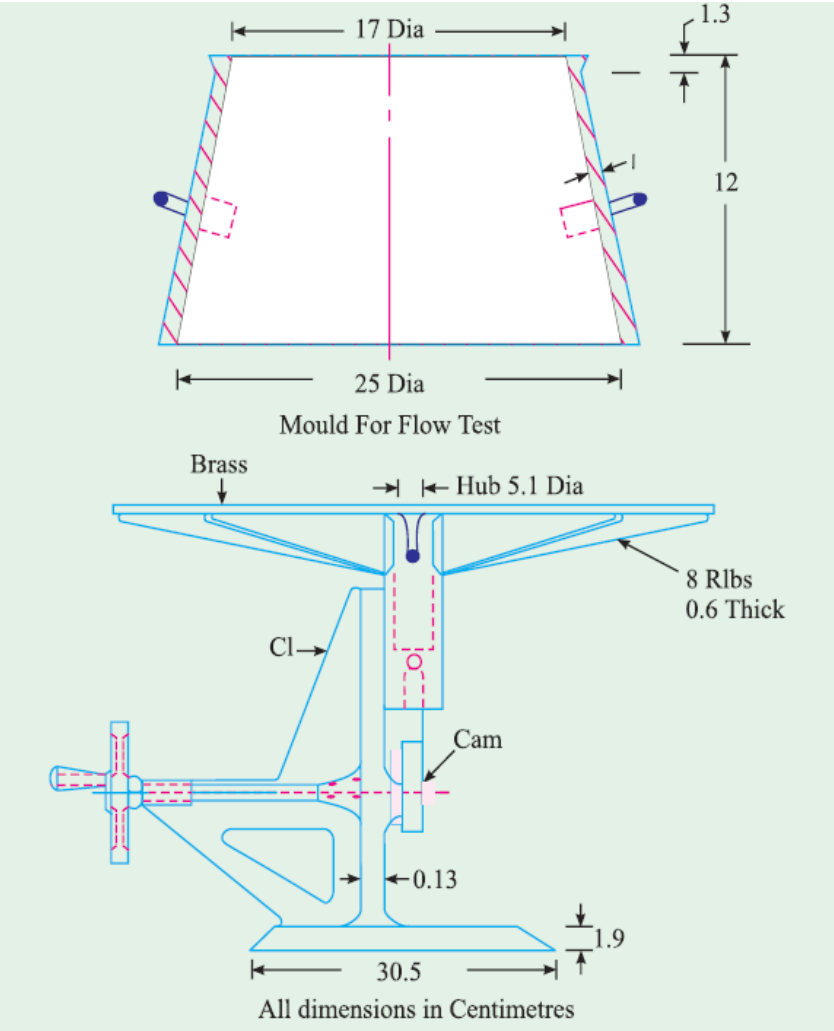
- This is a laboratory test, which gives an indication of the quality of concrete with respect to consistency, cohesiveness and the proneness to segregation.
- The table top is cleaned of all gritty material and is wetted. The mould is kept on the centre of the table, firmly held and is filled in two 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.
- The mould is lifted vertically upward and the concrete stands on its own without support.

Flow Test

- 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 andthe average spread is noted.

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

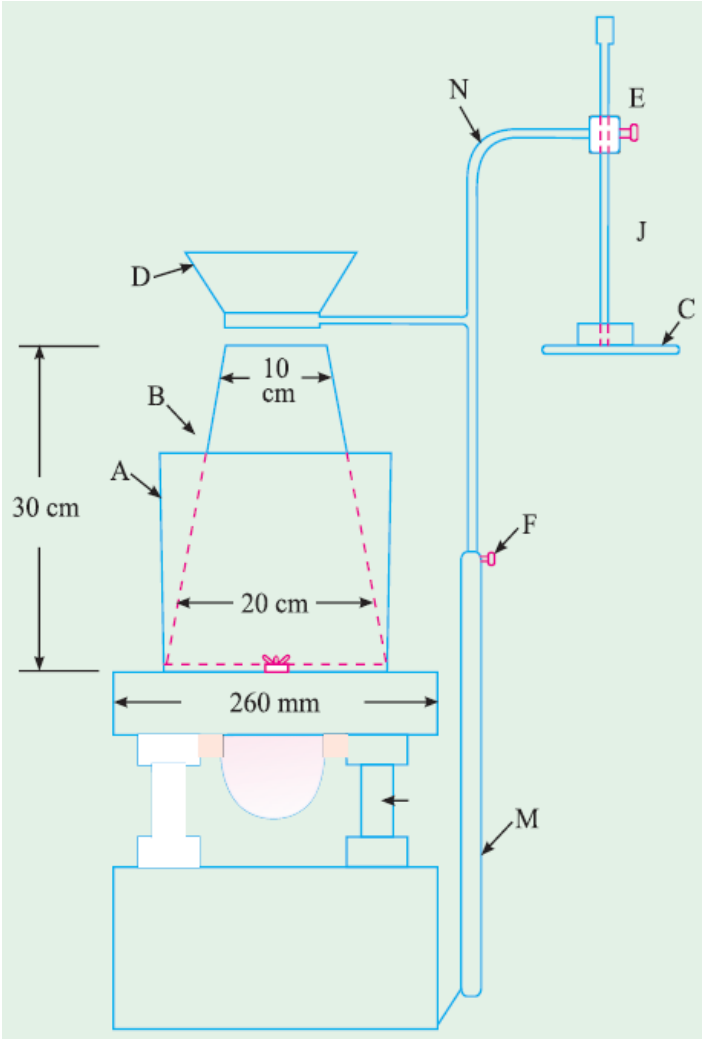
Flow Test


17 Dia
1.3
12
25 Dia
Mould For Flow Test
Brass
Hub 5.1 Dia
8 Rlbs
0.6 Thick
Cl
Cam
0.13
1.9
30.5
All dimensions in Centimetres

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.
- 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 very suitable for very dry concrete whose slump value cannot be measured by Slump Test, but the vibration is too vigorous for concrete with a slump greater than about 50 mm.

Vee Bee Consistometer Test



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.
- There are considerable differences in the sizes and specific gravities of the constituent ingredients of concrete.
- Therefore, it is natural that the materials show a tendency to fall apart.

Segregation

- Badly proportioned mix where sufficient matrix is not there to bind and contain the aggregates
- Insufficiently mixed concrete with excess water content
- Dropping of concrete from heights as in the case of placing concrete in column concreting
- When concrete is discharged from a badly designed mixer, or from a mixer with worn out blades
- Conveyance of concrete by conveyor belts, wheel barrow, long distance haul by dumper, long lift by skip and hoist are the other situations promoting segregation of concrete

Bleeding

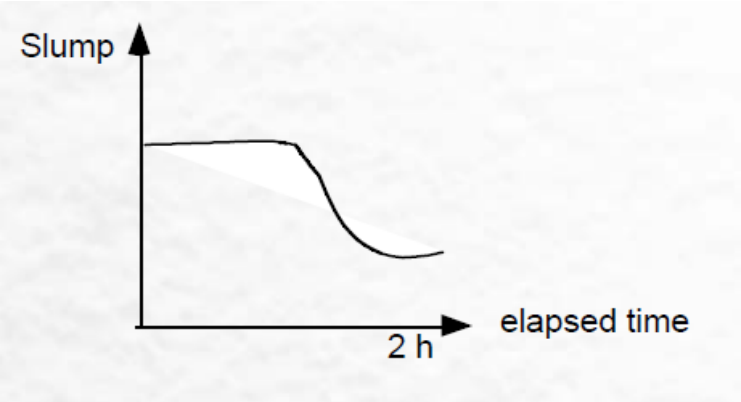
- Bleeding is sometimes referred as water gain. It is a particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete, being of the lowest specific gravity among all the ingredients of concrete.
- Bleeding is predominantly observed in a highly wet 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.

Bleeding

- Bleeding can be reduced by proper proportioning and uniform and complete mixing.
- Use of finely divided pozzolanic materials reduces bleeding by creating a longer path for the water to traverse.
- Air-entraining agent is very effective in reducing the bleeding.
- 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.

Slump Loss

- f mix for too long, hydration products start to from --> requires more water --> slump goes down when transport time and temperature increases
- Use of an abnormal setting cement
- unusual long time for mixing, transporting or finishing
- High T due to excessive heat of hydration.



Slump Loss

- Type II cement (low in C3A ~6%)
- T= 70 F

Initial Slump	30 min	60 min	2h
5 in	4 3/8	3 1/8	1 1/2

Type I cement (10% C3A)

Initial Slump	30 min	60 min	2h
5 in	3 1/4	2 1/4	1

Increasing the water content

	Initial	30 min	60 min	2h
Type II	7 1/2	7	5 1/2	2
Type I	7 1/2	4 3/4	3 1/4	1 1/2

so, adding more water does not solve the problem