Fresh Concrete

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in the wet state as well as in the hardened state.

- it is defined as the “ease with which concrete can be compacted hundred per cent having regard to mode of compaction and place of deposition.”
- Workable concrete is the one which exhibits very little internal friction between particle and particle or which overcomes the frictional resistance offered by the formwork surface or reinforcement contained in the concrete with just the amount of compacting efforts forthcoming.

Degree of workability

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

- Water content in a given volume of concrete, will have significant influences on the workability. The higher the water content per cubic meter of concrete, the higher will be the fluidity of concrete, which is one of the important factors affecting workability.

Mix Proportions

- The higher the aggregate/cement ratio, the leaner is the concrete. In lean concrete, 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 Aggregates

- 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. For a given quantity of water and paste, bigger size of aggregates will give higher 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.

Surface Texture of Aggregate

- The influence of surface texture on workability is again due to the fact that the total surface area of rough textured aggregate is more than the surface area of smooth rounded aggregate of same volume.

Grading of Aggregate

- A well graded aggregate is the one which has least amount of voids in a given volume. 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

- plasticizers and superplasticizers greatly improve the workability many folds. It is to be noted that initial slump of concrete mix or what is called the slump of reference mix should be about 2 to 3 cm to enhance the slump many fold at a minimum doze.

Measurement of Workability

(a) Slump Test

(b) Compacting Factor Test

(c) Flow Test

(d) Kelly Ball Test

(e) Vee Bee Consistometer Test.

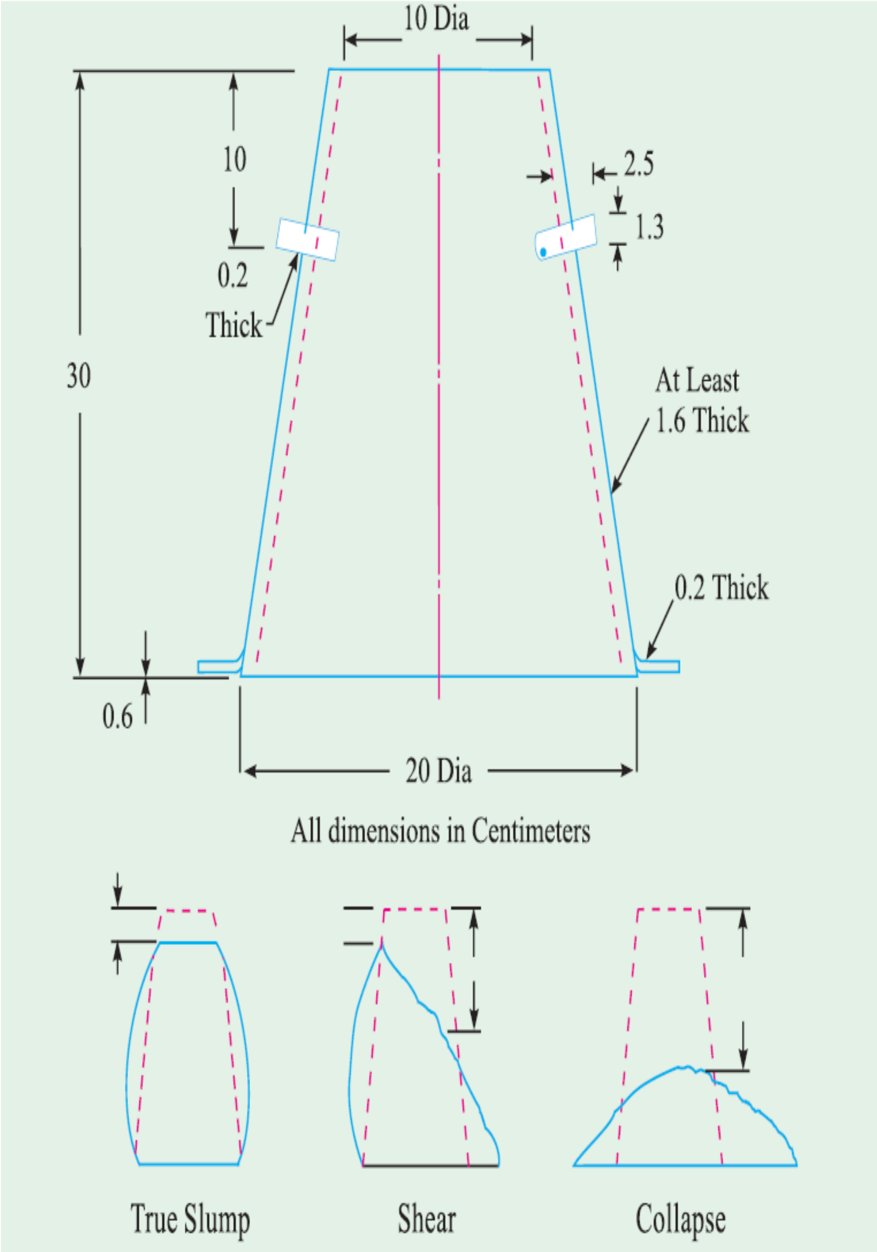
Slump Test

- 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. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete.
- However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, brought to the same slump, will have the same water content and water cement ratio, provided the weights of aggregate, cement and admixtures are uniform and aggregate grading is within acceptable limits.

- The apparatus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:
- Bottom diameter : 20 cm
- Top diameter : 10 cm
- Height : 30 cm

- The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid and non-absorbant surface The mould is then filled in four layers, each approximately 1/4 of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section.

- If the concrete slumps evenly it is called true slamp. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation.



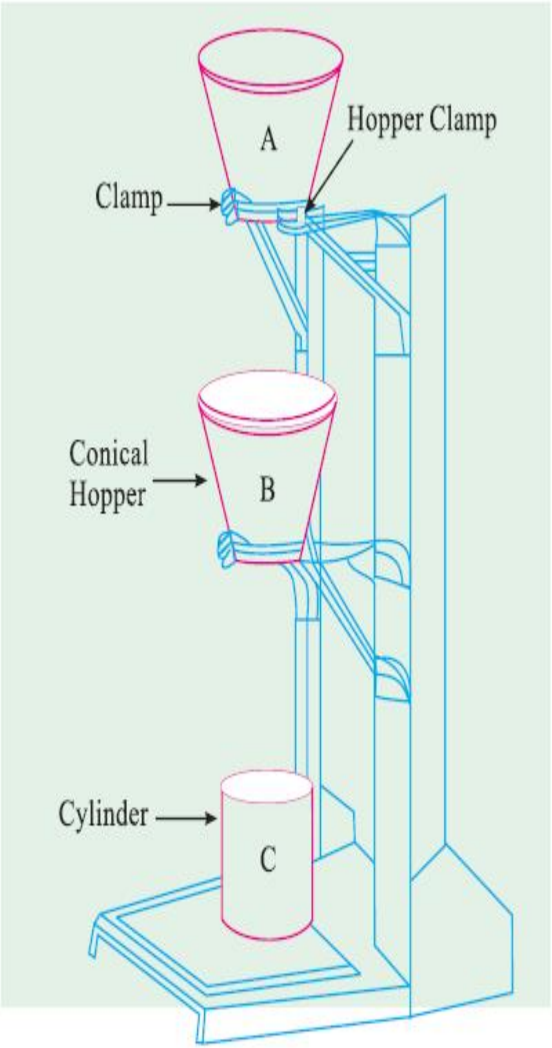
Degree of workability	Slump mm	Compacting factor		Use for which concrete is suitable
		Small appartus	Large appartus	
Very Low compacting factor is suitable	–	0.78	0.80	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated 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

- The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. 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. Such dry concrete are insensitive to slump test. The diagram of the apparatus is shown in Figure. The essential dimensions of the hoppers and mould and the distance between them are shown in Table.
- 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.

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

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



Compacting Factor Apparatus

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.

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.
- 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 Water

Process of Manufacture of Concrete

- The various stages of manufacture of concrete are:

(a) Batching

(b) Mixing

(c) Transporting

(d) Placing

(e) Compacting

(f) Curing

(g) Finishing.

(a) Batching

- The measurement of materials for making concrete is known as batching. There are two methods of batching:

(i) Volume batching (ii) Weigh batching

(i) Volume batching:

- Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume. Volume of moist sand in a loose condition weighs much less than the same volume of dry compacted sand. The amount of solid granular material in a cubic metre is an indefinite quantity. Because of this, for quality concrete material have to be measured by weight only. However, for unimportant concrete or for any small job, concrete may be batched by volume.
- Cement is always measured by weight. It is never measured in volume. Generally, for each batch mix, one bag of cement is used. The volume of one bag of cement is taken as thirty five (35) litres. Gauge boxes are used for measuring the fine and coarse aggregates.

(ii) Weigh Batching:

- Weigh batching is the correct method of measuring the materials. For important concrete, invariably, weigh batching system should be adopted.
- Use of weight system in batching, facilitates accuracy, flexibility and simplicity. Different types of weigh batchers are available, The particular type to be used, depends upon the nature of the job. Large weigh batching plants have automatic weighing equipment.
- The use of this automatic equipment for batching is one of sophistication and requires qualified and experienced engineers. In this, further complication will come to adjust water content to cater for the moisture content in the aggregate.
- In some of the recent automatic weigh batching equipments, recorders are fitted which record graphically the weight of each material, delivered to each batch. They are meant to record, and check the actual and designed proportions.
- the measurement of water must be done accurately. Addition of water by graduated bucket in terms of litres will not be accurate enough for the reason of spillage of water etc. It is usual to have the water measured in a horizontal tank or vertical tank fitted to the mixer. These tanks are filled up after every batch.

(b)Mixing

- There are two methods adopted for mixing concrete:

(i) Hand mixing (ii)Machine mixing

(i)Hand Mixing:

- Hand mixing is practised for small scale unimportant concrete works. As the mixing cannot be thorough and efficient, it is desirable to add 10 per cent more cement to cater for the inferior concrete produced by this method.
- Spread out the measured quantity of coarse aggregate and fine aggregate in alternate layers. Pour the cement on the top of it, and mix them dry by shovel, turning the mixture over and over again until uniformity of colour is achieved.
- Water is taken in a water-can fitted with a rose-head and sprinkled over the mixture and simultaneously turned over. This operation is continued till such time a good uniform, homogeneous concrete is obtained.

(ii)Machine Mixing:

- Mixing of concrete is almost invariably carried out by machine, for reinforced concrete work and for medium or large scale mass concrete work. Machine mixing is not only efficient, but also economical, when the quantity of concrete to be produced is large.
- Many types of mixers are available for mixing concrete. They can be classified as batch-mixers and continuous mixers. Batch mixers produce concrete, batch by batch with time interval, whereas continuous mixers produce concrete continuously without stoppage till such time the plant is working. This type of mixers are used in large works such as dams. In normal concrete work, it is the batch mixers that are used.
- Batch mixer may be of pan type or drum type. The drum type may be further classified as tilting, non-tilting, reversing or forced action type.

Pan / paddle mixer

Concrete mixer with hydraulic hopper 10/7

(C) Transporting Concrete

- Concrete can be transported by a variety of methods and equipments. The precaution to be taken while transporting concrete is that the homogeneity obtained at the time of mixing should be maintained while being transported to the final place of deposition. The methods adopted for transportation of concrete are:

(a) Mortar Pan

(b) Wheel Barrow, Hand Cart

(c) Crane, Bucket and Rope way

(d) Truck Mixer and Dumpers

(e) Belt Conveyors

(f) Chute

(g) Skip and Hoist

(h) Tansit Mixer

(i) Pump and Pipe Line

(d)Placing Concrete

- It is not enough that a concrete mix correctly designed, batched, mixed and transported, it is of utmost importance that the concrete must be placed in systematic manner to yield optimum results. The precautions to be taken and methods adopted while placing concrete in the under-mentioned situations:

(a) Placing concrete within earth mould.

(example: Foundation concrete for a wall or column).

(b) Placing concrete within large earth mould or timber plank formwork.

(example: Road slab and Airfield slab).

(c) Placing concrete in layers within timber or steel shutters.

(example: Mass concrete in dam construction or construction of concrete abutment or pier).

(d) Placing concrete within usual from work.

(example: Columns, beams and floors).

(e) Placing concrete under water.

- Form work: Form work shall be designed and constructed so as to remain sufficiently rigid during placing and compaction of concrete. The joints are plugged to prevent the loss of slurry from concrete.

Sr. No.	*Type of Formwork*	*Minimum period before striking formwork*
1.	Vertical formwork to columns walls and beams	16 – 24 hours
2.	Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
3.	Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
4.	Props to slab	
	spanning up to 4.5 m	7 days
	spanning over 4.5 m	14 days
5.	Props to beam and arches	
	Spanning up to 6 m	14 days
	Spanning over 6 m	21 days

(e)Compaction of Concrete

- Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In the process of mixing, transporting and placing of concrete air is likely to get entrapped in the concrete. The lower the workability, higher is the amount of air entrapped.
- In other words, stiff concrete mix has high percentage of entrapped air and, therefore , would need higher compacting efforts than high workable mixes.
- Insufficient compaction increases the permeability of concrete resulting in easy entry for aggressive chemicals in solutin, which attack concrete and reinforcement to reduce the durability of concrete. Therefore, 100 per cent compaction of concrete is of paramount importance.

- The following methods are adopted for compacting the concrete:

(a) Hand Compaction

(i) Rodding (ii) Ramming (iii) Tamping

- Rodding is nothing but poking the concrete with about 2 metre long, 16 mm diameter rod to pack the concrete between the reinforcement and sharp corners and edges.
- Ramming should not be permitted in case of reinforced concrete or in the upper floor construction, where concrete is placed in the formwork supported on struts.
- Tamping is one of the usual methods adopted in compacting roof or floor slab or road pavements where the thickness of concrete is comparatively less and the surface to be finished smooth and level.

(b) Compaction by Vibration

(i) Internal vibrator (Needle vibrator)

(ii) Formwork vibrator (External vibrator)

(iii) Table vibrator

(iv) Platform vibrator

(v) Surface vibrator (Screed vibrator)

(vi) Vibratory Roller.

(c) Compaction by Pressure and Jolting

(d) Compaction by Spinning.

Plate Vibrator

Screed Board Vibrator

Table Vibrator

Needle Vibrator
Electric

Needle Vibrator
Petrol

(f)Curing

- Curing methods may be divided broadly into four categories:

(a) Water curing

(b) Membrane curing

(c) Application of heat

(d) Miscellaneous

(a) Water Curing

- This is by far the best method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration.
- Water curing can be done in the following ways:

(a) Immersion

(b) Ponding

(c) Spraying or Fogging

(d) Wet covering

- The precast concrete items are normally immersed in curing tanks for a certain duration. Pavement slabs, roof slab etc. are covered under water by making small ponds. Vertical retaining wall or plastered surfaces or concrete columns etc. are cured by spraying water. In some cases, wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., are wrapped to vertical surface for keeping the concrete wet.

(b) Membrane curing

- It has been pointed out earlier that curing does not mean only application of water, it means also creation of conditions for promotion of uninterrupted and progressive hydration.

Membrane curing by spraying.

(C) Application of heat

- The development of strength of concrete is a function of not only time but also that of temperature. When concrete is subjected to higher temperature it accelerates the hydration process resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite. Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.
- A faster attainment of strength will contribute to many other advantages mentioned below.

(a) Concrete is vulnerable to damage only for short time.

(b) Concrete member can be handled very quickly.

(c) Less space will be sufficient in the casting yerd.

(d) A smaller curing tank will be sufficient.

(e) A higher outturn is possible for a given capital outlay.

(f) The work can be put on to service at a much early time,

(g) A fewer number of formwork will be sufficient or alternatively with the given number of formwork more outturn will be achieved.

(h) Prestressing bed can be released early for further casting.

- The exposure of concrete to higher temperature is done in the following manner:

(a) Steam curing at ordinary pressure.

(b) Steam curing at high pressure.

(c) Curing by Infra-red radiation.

(d) Electrical curing.

(d) Finishing

- Finishing operation is the last operation in making concrete. Finishing in real sence does not apply to all concrete operations. For a beam concreting, finishing may not be applicable, whereas for the concrete road pavement, airfield pavement or for the flooring of a domestic building, careful finishing is of great importance.

Admixtures

Introduction

- Admixture is defined as a material, other than cement, water and aggregates, that is used as an ingredient of concrete and is **added** to the batch **immediately before or during mixing.**
- **Additive** is a material which is added at the time of grinding cement clinker at the cement factory.
- Concrete is being used for wide varieties of purposes to make it suitable in different conditions. In these conditions ordinary concrete may fail to exhibit the required quality performance or durability.
- In such cases, admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation.

Admixtures

- Plasticizers
- Superplasticizers
- Retarders and Retarding Plasticizers
- Accelerators and Accelerating Plasticizers
- Air-entraining Admixtures
- Pozzolanic or Mineral Admixtures
- Damp-proofing and Waterproofing Admixtures
- Gas forming Admixtures

Admixtures

- Air-detraining Admixtures
- Alkali-aggregate Expansion Inhibiting Admixtures
- Workability Admixtures
- Grouting Admixtures
- Corrosion Inhibiting Admixtures
- Bonding Admixtures
- Colouring Admixtures

Construction Chemicals

- Concrete Curing Compounds
- Polymer Bonding Agents
- Polymer Modified Mortar for Repair and Maintenance
- Mould Releasing Agents
- Protective and Decorative Coatings
- Installation Aids
- Floor Hardeners and Dust-proofers
- Non-shrink High Strength Grout
- Surface Retarders
- Bond-aid for Plastering
- Ready to use Plaster
- Construction Chemicals for Water-proofing

Plasticizers (Water Reducers)

- A high degree of workability is required in situations like **deep beams**, thin walls of **water retaining structures** with high percentage of steet reinforcement, **column and beam junctions**, **tremie concreting, pumping of concrete**, **hot weather concreting**, for concrete to be conveyed for considerable distance and in **ready mixed concrete industries.**
- The **conventional methods** followed for obtaining **high workability** is by improving the gradation, or by the use of relatively **higher percentage** of fine aggregate or by **increasing the cement content**.
- There are **difficulties** and **limitations** to obtain high workability in the field for a given set of conditions.
- The easy method generally followed at the site in most of the conditions is to **use extra water** unmindful of the harm it can do to the **strength** and **durability** of concrete.

- One must remember that **addition of excess water**, will only improve the **fluidity or the consistency** but **not** the **workability** of concrete.
- The **excess water** will **not improve** the inherent good qualities such as **homogeneity** and **cohesiveness** of the mix which reduces the tendency for segregation and bleeding.
- Whereas the **plasticized concrete** will **improve** the **desirable qualities** demanded of plastic concrete.
- The **organic substances** or combinations of **organic and inorganic substances**, which allow a **reduction in water content** for the given workability, or give a **higher workability** at the same water content, are termed as **plasticizing admixtures.**

- The advantages are considerable in both cases : in the former, concretes are **stronger**, and in the latter they are more **workable**
- The basic products constituting plasticizers are as follows:
- **Anionic surfactants** such as **lignosulphonates** and their modifications and derivatives, salts of **sulphonates hydrocarbons.**
- **Nonionic surfactants**, such as **polyglycol esters**, acid of **hydroxylated carboxylic acids** and their modifications and derivatives.
- Other products, such as **carbohydrates** etc.

- Among these, **calcium, sodium and ammonium lignosulphonates** are the most used. Plasticizers are used in the amount of **0.1% to 0.4%** by weight of cement.
- At these doses, at constant workability the **reduction in mixing water** is expected to be of the order of **5% to 15%.**
- This naturally **increases the strength**.
- The **increase in workability** that can be expected, at the same w/c ratio, may be anything from **30 mm to 150 mm slump**, depending on the dosage, initial slump of concrete, cement content and type.

Action of Plasticizers

- The action of plasticizers is mainly to fluidify the mix and improve the workability of concrete, mortar or grout.

Dispersion

- Portland cement, being in fine state of division, will have a tendency to **flocculate** in wet concrete.
- These **flocculation** entraps **certain amount of water** used in the mix and thereby all the **water is not freely available** to fluidify the mix.
- When **plasticizers** are used, they get **adsorbed** on the cement particles.
- The adsorption of **charged polymer** on the particles of cement creates **particle-to-particle repulsive forces** which overcome the **attractive forces**.
- This repulsive force is called **Zeta Potential**, which depends on the base, solid content, **quantity of plasticizer used**.
- The overall result is that the **cement particles** are **deflocculated** and **dispersed.**

- When cement particles get **flocculated** there will be **interparticles friction** between particle to particle and floc to floc.
- But in the **dispersed condition** there is **water** in between the **cement particle** and hence the **interparticle friction** is **reduced.**

Retarding Effect

- **Plasticizer** gets adsorbed on the surface of cement particles and form a **thin sheath.**
- This thin sheath **inhibits** the **surface hydration** reaction between **water and cement** as long as sufficient plasticizer molecules are available at the particle/solution interface.
- The **quantity of available plasticizers** will progressively **decrease** as the **polymers become entrapped** in **hydration products**.

Effect of Plasticizers on concrete

- Reduction in the surface tension of water.
- Induced electrostatic repulsion between particles of cement.
- Lubricating film between cement particles.
- Dispersion of cement grains, releasing water trapped within cement flocs.
- Inhibition of the surface hydration reaction of the cement particles, leaving more water to fluidify the mix.
- Change in the morphology of the hydration products.
- It may be noted that all plasticizer are to some extent set retarders, depending upon the base of plasticizers, concentration and dosage used.

Superplasticizers

- The use of superplasticizer is practiced for **production of flowing**, **self levelling**, **self compacting** and for the production of **high strength** and **high performance concrete**.
- Only thing is that the superplasticizers are more powerful as **dispersing agents** and they are **high range water reducers**.
- It is the use of superplasticizer which has made it possible to use w/c as low as **0.25** or even lower and yet to make **flowing concrete** to obtain strength of the order **120 Mpa** or more.
- It is the use of **superplasticizer** which has made it possible to **use fly ash, slag** and particularly **silica fume** to make **high performance concrete**.

Superplasticizers can produce:

- At the same w/c ratio much **more workable concrete** than the **plain ones**.
- For the same workability, it permits the use of **lower w/c ratio**.
- As a consequence of **increased strength** with lower w/c ratio, it also permits a **Reduction of cement content**.

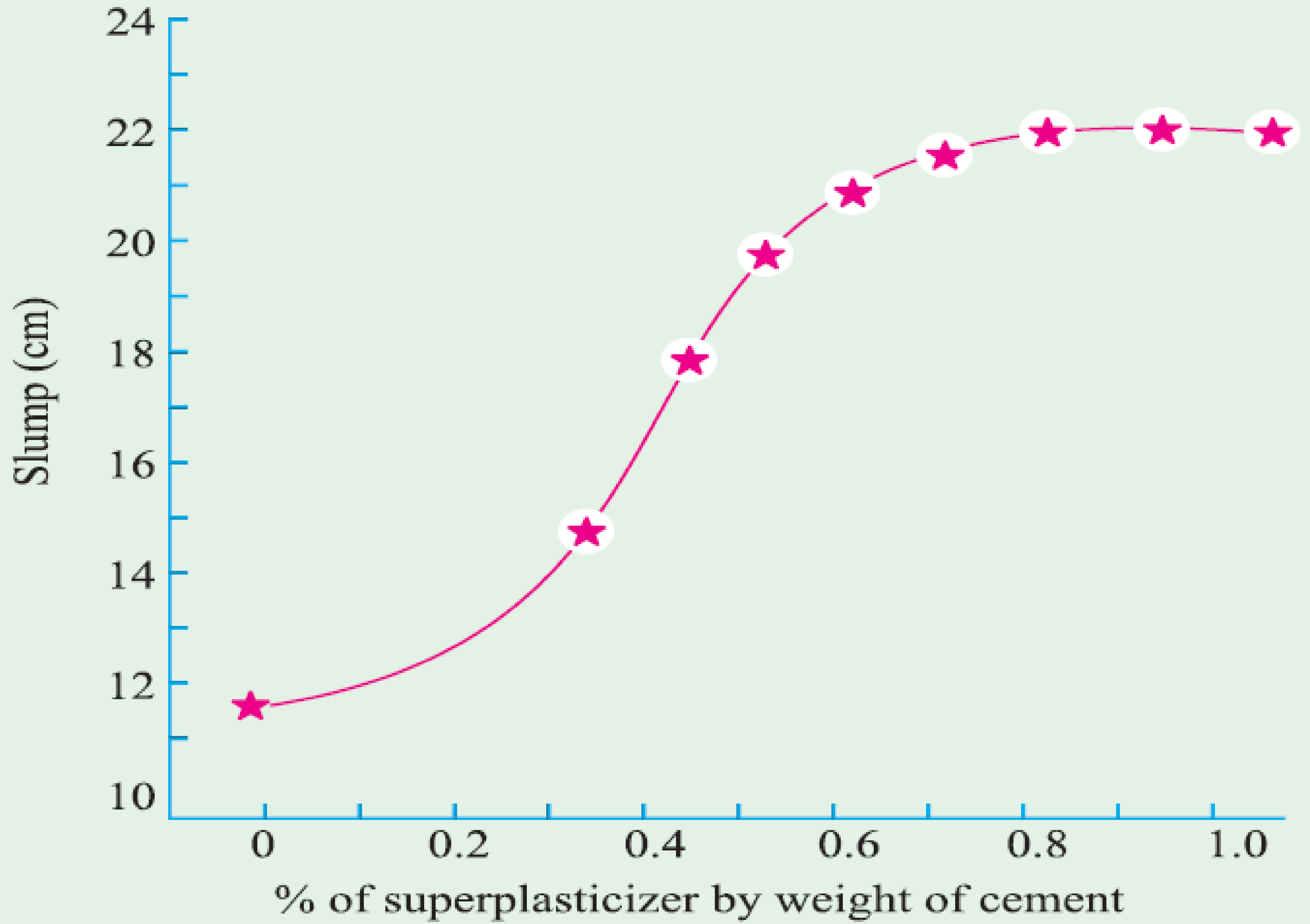
Classification of Plasticizer

Classification of Superplasticizer. Following are a few polymers which are commonly used as base for superplasticizers.

- Sulphonated malanie-formaldehyde condensates (SMF)
- Sulphonated naphthalene-formaldehyde condensates (SNF)
- Modified lignosulphonates (MLS)
- Acrylic polymer based (AP)
- Copolymer of carboxylic acrylic acid with acrylic ester (CAE)
- Cross linked acrylic polymer (CLAP)
- Polycarboxylate ester (PC)
- Multicarboxylatethers (MCE)

Effects of Superplasticizers on Fresh Concrete

- There is **not** much **increase** in **workability**, When plasticizers or superplasticizers are added to very stiff or what is called **zero slump concrete** at nominal dosages.
- A mix with an initial slump of about **2 to 3** cm can only be **fluidised** by plasticizers or superplasticizers at nominal dosages.
- It is often noticed that **slump increases with increase in dosage**. But there is **no appreciable increase** in slump beyond **certain limit** of dosage



24
22
20
18
16
14
12
10
Slump (cm)
0
0.2
0.4
0.6
0.8
1.0
% of superplasticizer by weight of cement

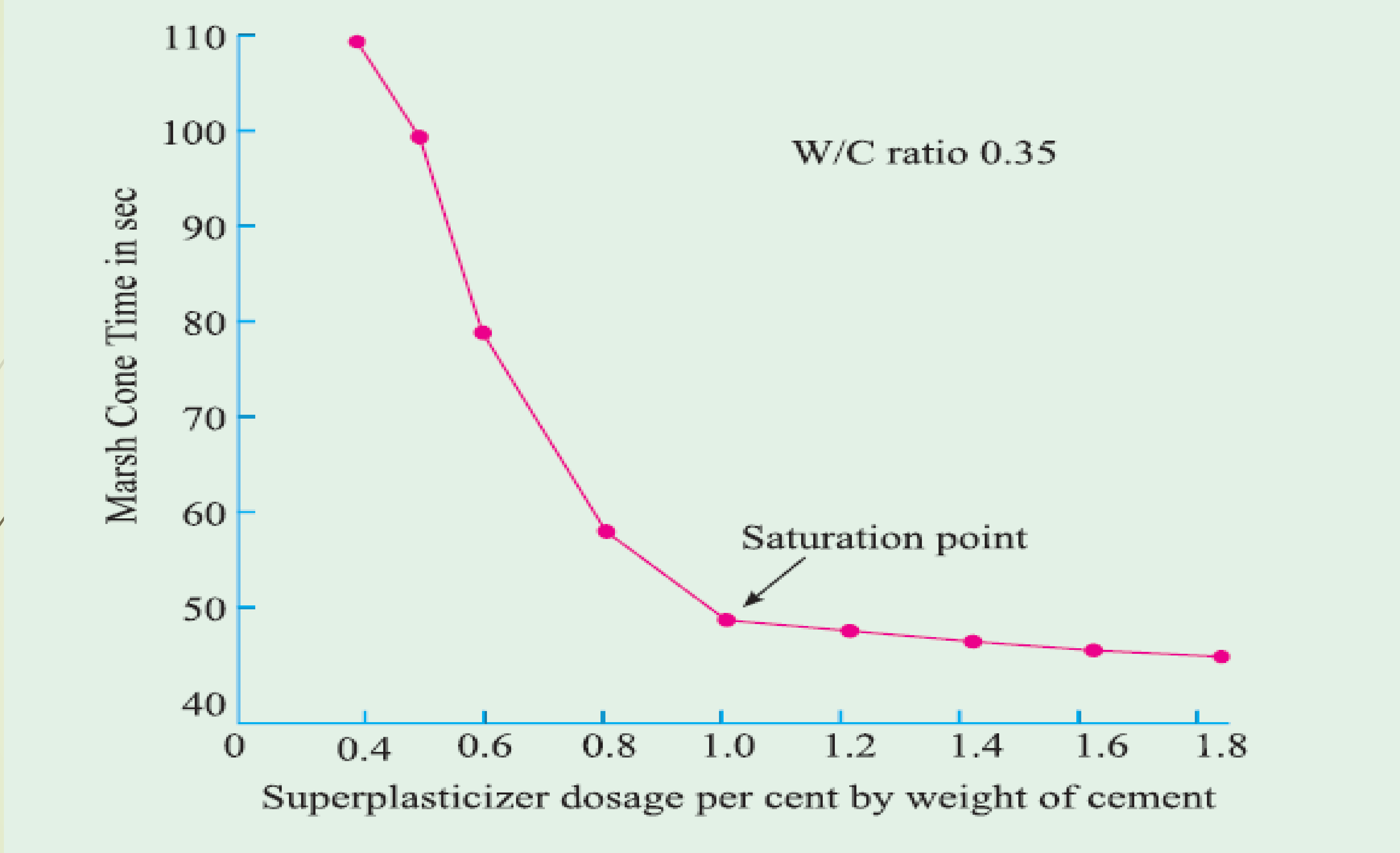
Compatibility of Superplasticizers and Cement

- It has been noticed that all **superplasticizers** are not showing the same extent of **improvement in fluidity** with **all types of cements**.
- Some **superplasticizers** may show **higher fluidizing effect** on some type of cement than other cement.
- **Optimum fluidizing effect** at lowest dosage is an economical consideration.
- Giving **maximum fluidizing effect** for a particular superplasticizer and a cement is very complex involving many factors like **composition of cement, fineness of cement** etc.
- Although compatibility problem looks to be very complex, it could be more or less solved by **simple rough and ready field method**.
- **Mini slump test**
- **Flow table test**

Marsh Cone Test

- In the Marsh cone test, cement slurry is made and its flowability is found out.
- Take 2 kg cement, proposed to be used at the project. Take one litre of water (w/c = 0.5) and say 0.1% of plasticizer.
- Mix them thoroughly in a mechanical mixer (Hobart mixer is preferable) for two minutes.
- If hand mixing is done, the slurry should be sieved through 1.18 sieve to exclude lumps.
- Take one litre slurry and pour it into marsh cone duly closing the aperture with a finger. Start a stop watch and simultaneously remove the finger.
- Find out the time taken in seconds, for complete flow out of the slurry. The time in seconds is called the "Marsh Cone Time".
- Repeat the test with different dosages of plasticizer. Plot a graph connecting Marsh cone time in seconds and dosages of plasticizer or superplasticizer.
- A typical graph is shown in Fig. The dose at which the Marsh cone time is lowest is called the saturation point.
- The dose is the optimum dose for that brand of cement and plasticizer or superplasticizer for that w/c ratio.


Orifizi
drills


110
100
90
80
70
60
50
40
Marsh Cone Time in sec
W/C ratio 0.35
Saturation point
0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
Superplasticizer dosage per cent by weight of cement

Factors Effecting the Workability

- Type of superplasticizers
- Dosage
- Mix composition
- Variability in cement composition and properties
- Mixing procedure
- Equipments

Type of superplasticizers

- It is a well established fact that the **average molecular weight** of the plasticizer is of primary importance for its efficiency as plasticizer in concrete.
- The **higher the molecular weight**, the higher is the **efficiency**.
- However, it should be noted that there is **a maximum value of molecular weight** beyond which **efficiency is expected to decrease**.
- It may be further noted that several intrinsic properties of the superplasticizers may influence the performance.

Dosage

- It has been already explained while describing the Marsh cone test that the **dosage of superplasticizer** influences the **viscosity of grout** and hence the **workability of concrete**.
- The **optimum dosage** can be ascertained from Marsh cone test if brand of cement, plasticizer and w/c ratio is already fixed.
- In our country generally low dosage is adopted for normal concreting operations. A dosage more than **2.5% by weight** of cement is rarely used.
- But in other countries much higher dosages up to **4 to 5%** are used in special situations. It has been reported in literatures that upto a dosage of about. **3%** there are **no harmful effect** on the **hardening properties** of concrete
- **Higher dosage** is said to have affected the **shrinkage** and **creep** properties.

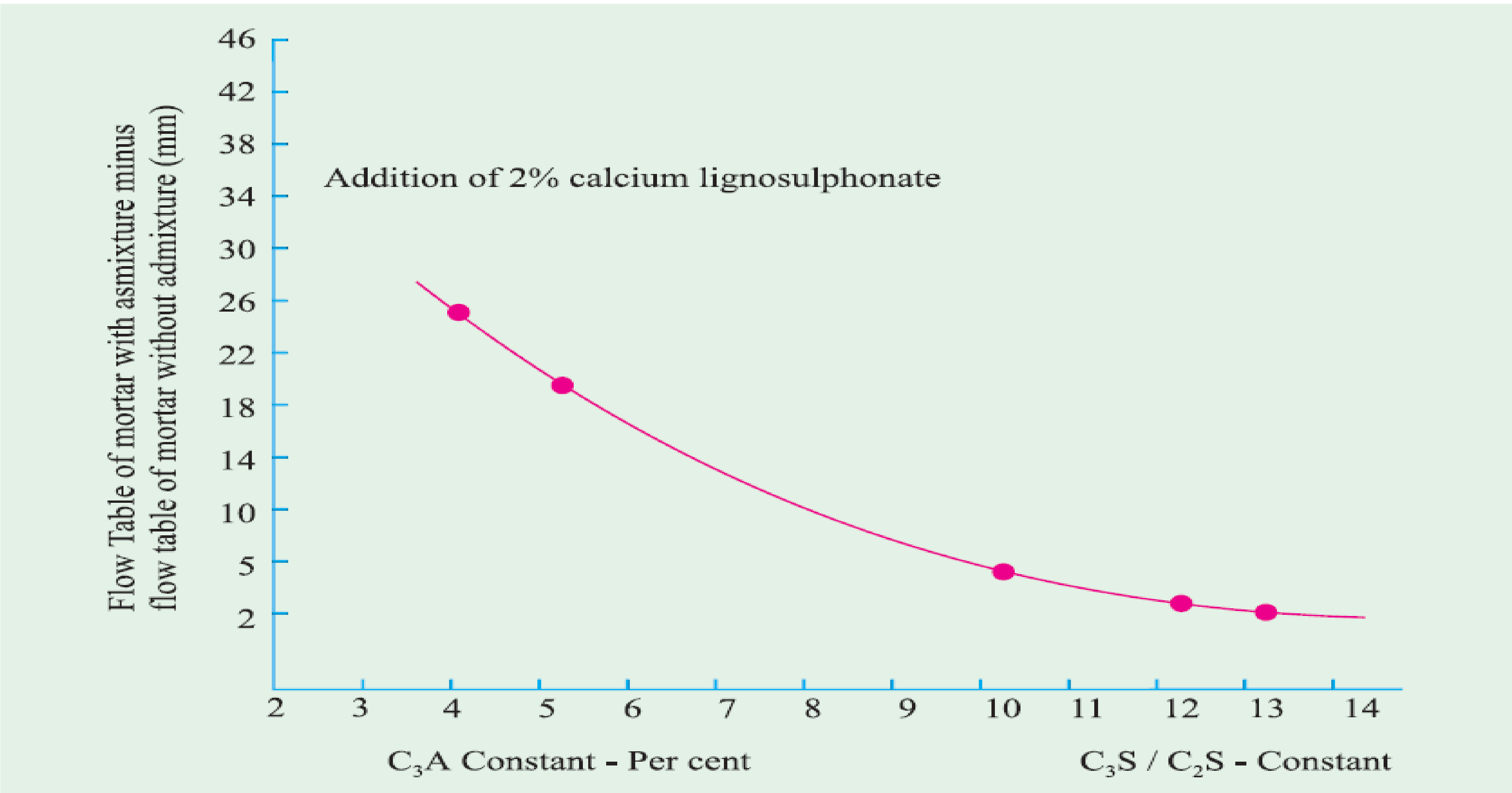
Mix Composition

- The mix composition particularly the **aggregate/cement ratio or richness of the mix, w/c ratio**, and use of other **supplementary cementing materials** like **fly ash or silica fume** affects the **workability**.
- **Wetter the mix better** is the **dispersion of cement** grains and hence **better workability**.
- The **size and shape of aggregate**, sand grading will also have influence on the **fluidifying effect**.

Variability in Cement Composition

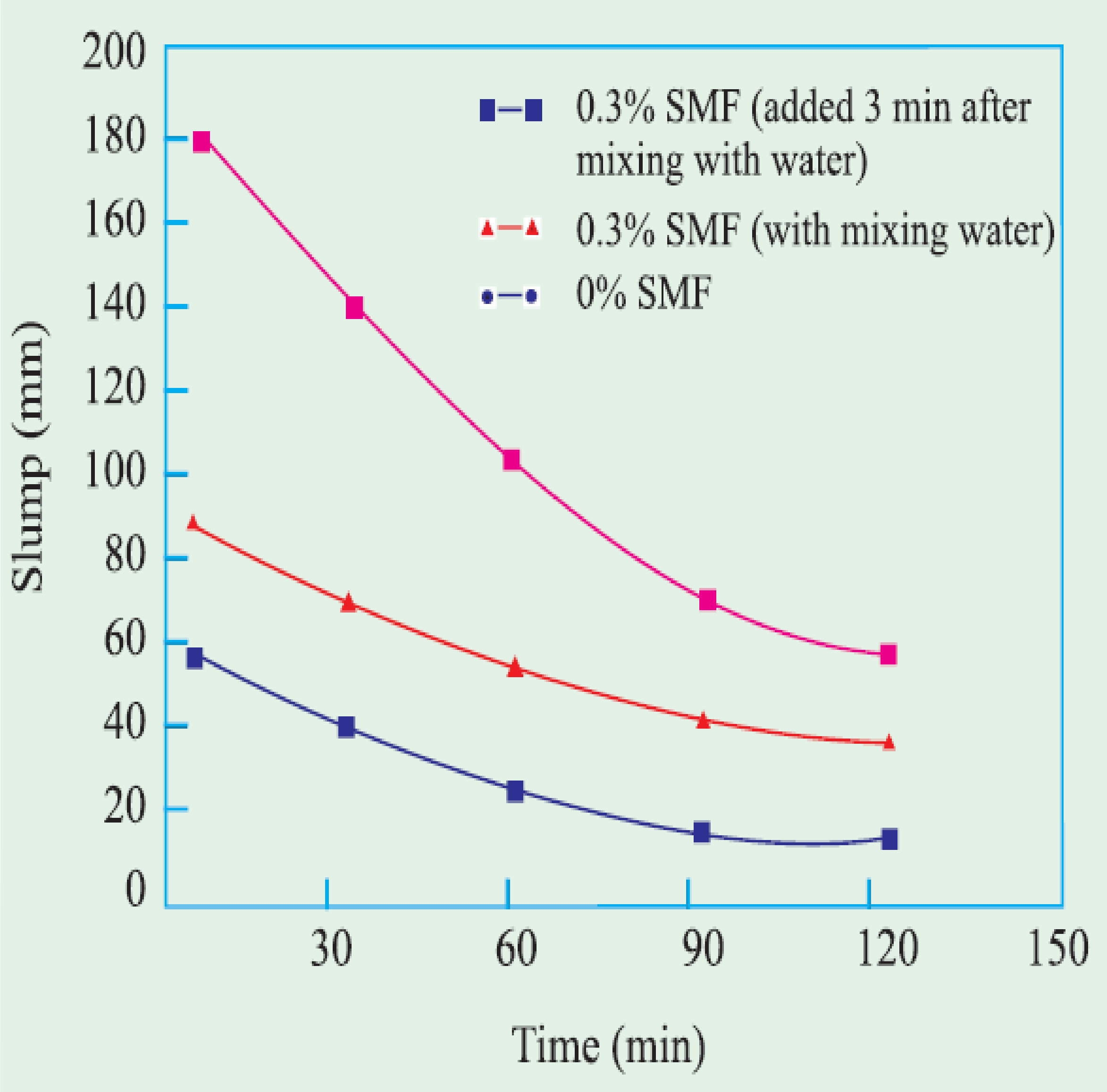
- The **variability in cement** with respect to compound composition, in particular **C_3A content, C_3S/C_2S ratio, fineness of cement, alkali content and gypsum** content are responsible for the **lack of compatibility** with a **particular type of superplasticizer** and their performance in concrete.
- Out of the above **C_3A content will have over-riding influence** on the performance of superplasticizer. Fig. shows the effect of C_3A content.

Effect of % variation of C_3A, C_2S and C_3S



Mixing Procedure

- When you use superplasticizer, it is better to add all the water to the drum keeping about **one litre** of water in **spare**.
- The exact quantity of **superplasticizer** is **diluted** with that one litre of water and thrown into the drum in **two or three instalments** over the **well mixed concrete** so that **proper dispersion of plasticizer** actually takes place in the drum.
- When the plasticizer is added, the **concrete** must be mixed for about **one more minute** before discharging. The practice of adding superplasticizer along with the **bulk mixing water** is not giving **good results**.
- Experimental result showed that adding plasticizer after three minutes of mixing has yielded better results



Equipment

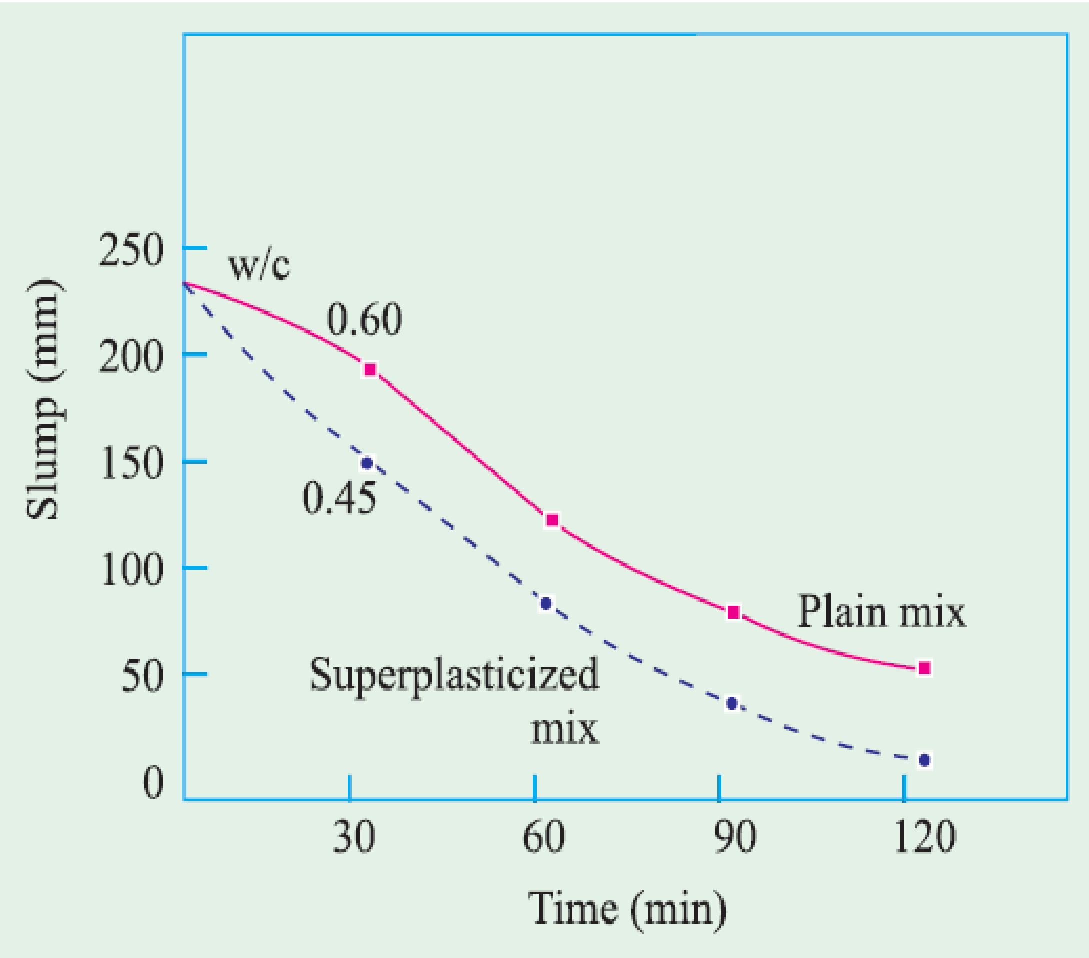
- The mixers in the batching plant are of capacity half a cubic meter and above. They are generally of pan type.
- They are well designed and fabricated and as such every efficient. The mixing time is around 20 seconds. Within this short spell of 20 seconds, very intimate mixing is done.
- It is observed that for identical parameters concrete mixed in the batching plant gives about 20 to 30 mm more slump than trial mix carried out in laboratory using small, inefficient mixers.

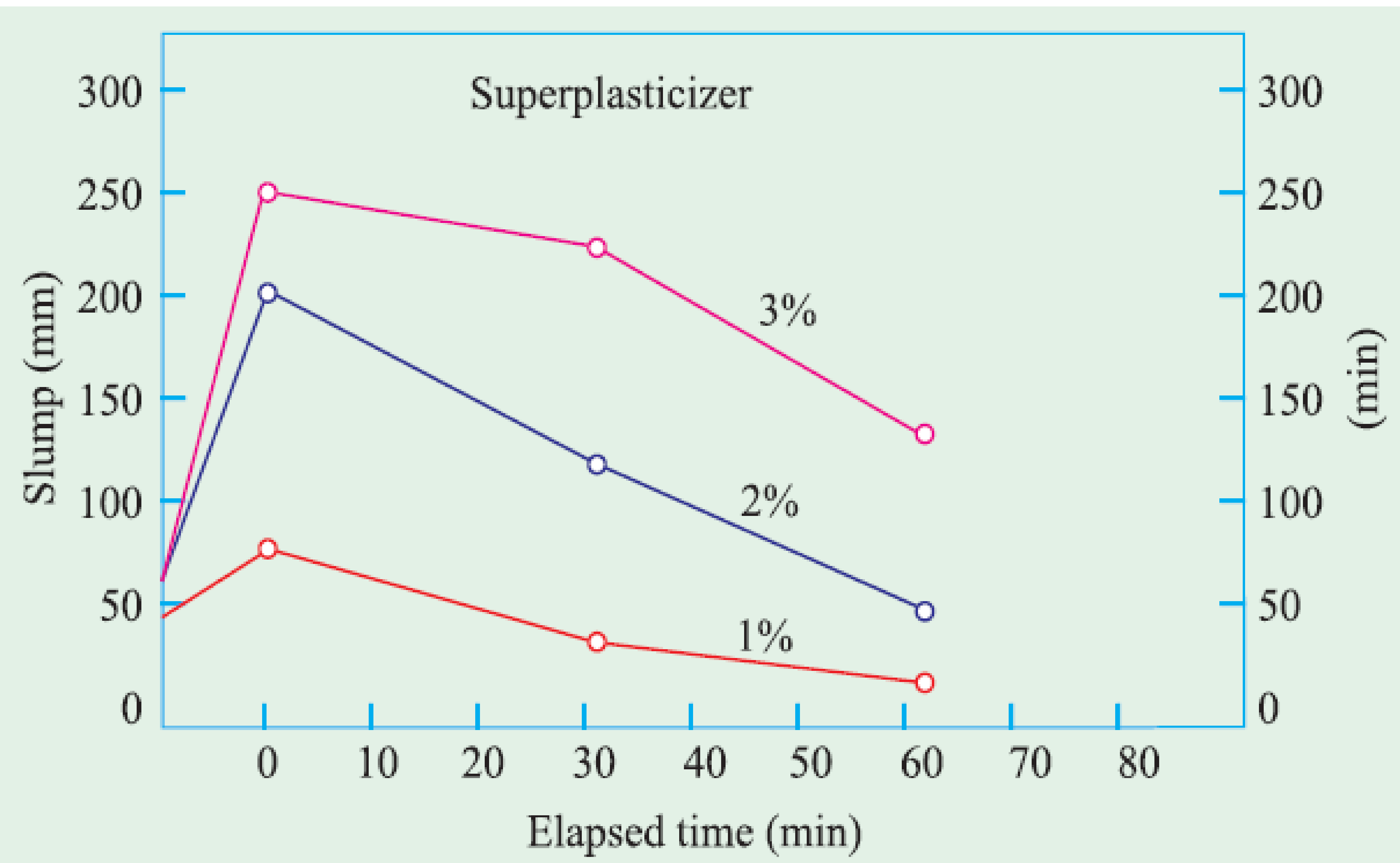
Site Problems in the use of Superplasticizers

- Slump of reference mix. (i.e., concrete without plasticizer)
- Inefficient laboratory mixer for trial.
- Sequence of addition of plasticizer.
- Problem with crusher dust.
- Problem with crushed sand.
- Importance of shape and grading of coarse aggregate.
- Compatibility with cement.
- Selection of plasticizer and superplasticizer.
- Determination of dosage.
- Slump loss.
- How to reduce slump loss.
- Casting of cubes.
- Compaction at site.
- Segregation and bleeding.
- Finishing.
- Removal of form work.

Slump Loss

- One of the most important nagging site problem is the loss of slump.
- Slump at mixing point is not of much importance, but the slump at placing point is of primary importance.
- Often there is delay between mixing and placing. Achieving high slump at the mixer, only to be lost with time, before placing is a bad economy.
- Loss of slump is natural even with unplasticized concrete, but rate of loss slump is little more in case of superplasticized concrete




Superplasticizer
Slump (mm)
300
250
200
150
100
50
0
3%
2%
1%
(min)
0
10
20
30
40
50
60
70
80
Elapsed time (min)

Steps for Reducing Slump Loss

- Initial high slump.
- Using retarders.
- Using retarding plasticizer or superplasticizer.
- By repetitive dose.
- By dosing at final point.
- By keeping temperature low.
- By using compatible superplasticizer with cement.

Retarders

A retarder is an admixture that slows down the chemical process of hydration so that concrete remains plastic and workable for a longer time than concrete without the retarder.

- Retarders are used to overcome the accelerating effect of high temperature on setting properties of concrete in hot weather concreting.
- Very useful when concrete has to be place in very difficult conditions and delay may occur in transporting and placing.
- Gypsum and Calcium Sulphate are well known retarders.
- Other examples are: starches, cellulose products, sugars, acids or salts of acids

Retarders

Limitations

- Retarders should be used in proper amount. Access amount will cause indefinite setting time.
- At normal temperatures addition of sugar 0.05 to 0.10 per cent have little effect on the rate of hydration, but if the quantity is increased to 0.2 percent, hydration can be retarded to such an extent that final set may not take place for 72 hours or more.

Used at

- Casting and consolidating large number of pours without the formation of cold joints.
- Grouting oil wells, where temperature is about 200 °C, at a depth of 6000 meters.

Initial High Slump

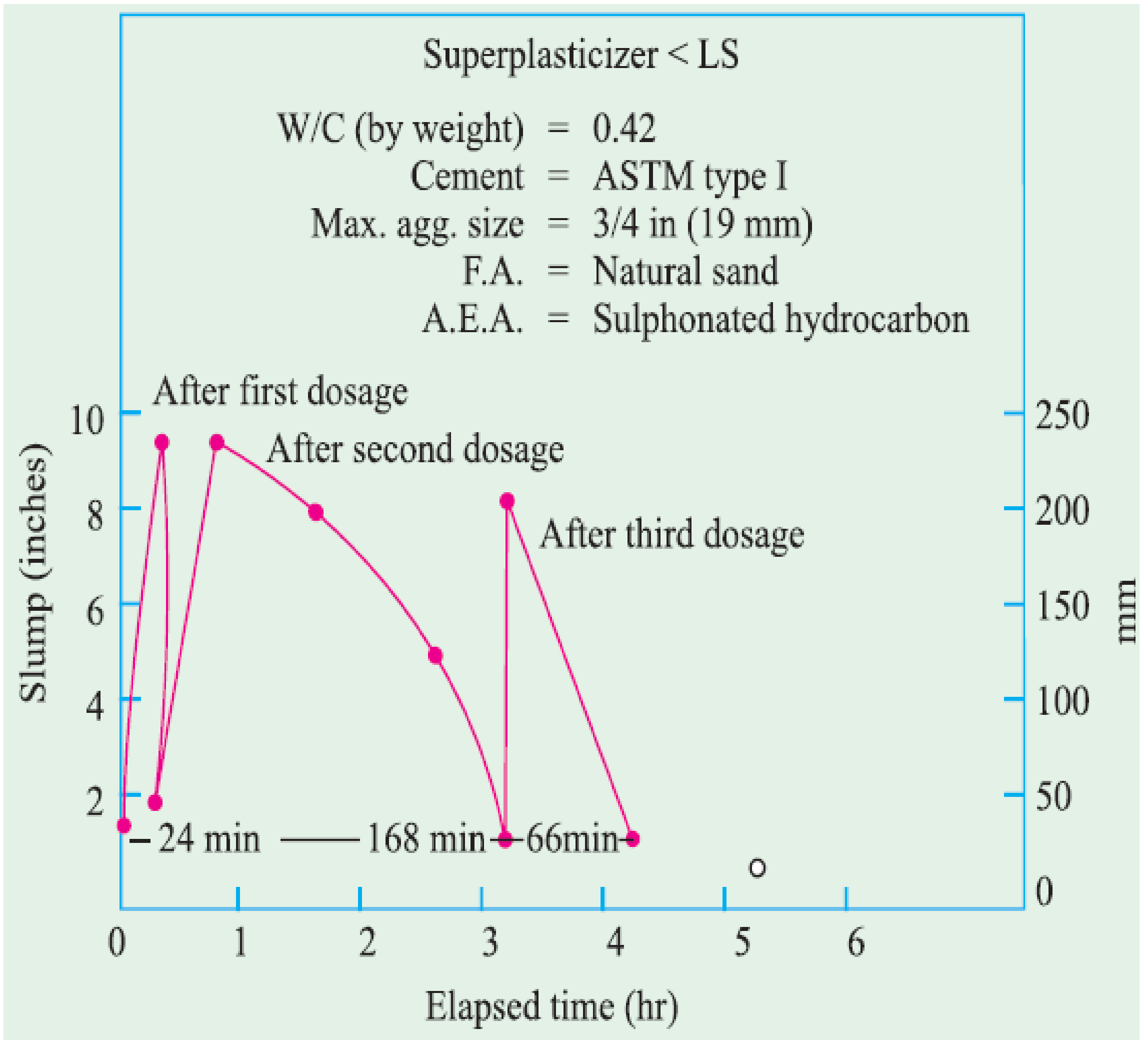
- When very high slump is managed at the mixing point, even if loss of slump takes place, still the residual slump will be good enough for satisfactory placing of concrete.
- Although this method is not a good and economical method some time this method is adopted

Using retarders or retarding plasticizer or superplasticizer

- Pure retarders are used at the time of mixing. This will keep the concrete in a plastic condition over a long time.
- Add retarders Just before adding an appropriate dose of plasticizer or superplasticizer which will give desirable slump value for placing requirements.
- Some time instead of using pure retarders and plasticizer separately, a retarding plasticizer, or retarding superplasticizer is used in an appropriate dose in the initial stage itself.

By Repetitive Dosage

- One of the common methods to combat the slump loss is to give repetitive doses at intervals and thereby boosting the slump so that required slump is maintained for long time.
- The time interval should be chosen in such a way that the concrete will have such a residual slump value which can be boosted up.



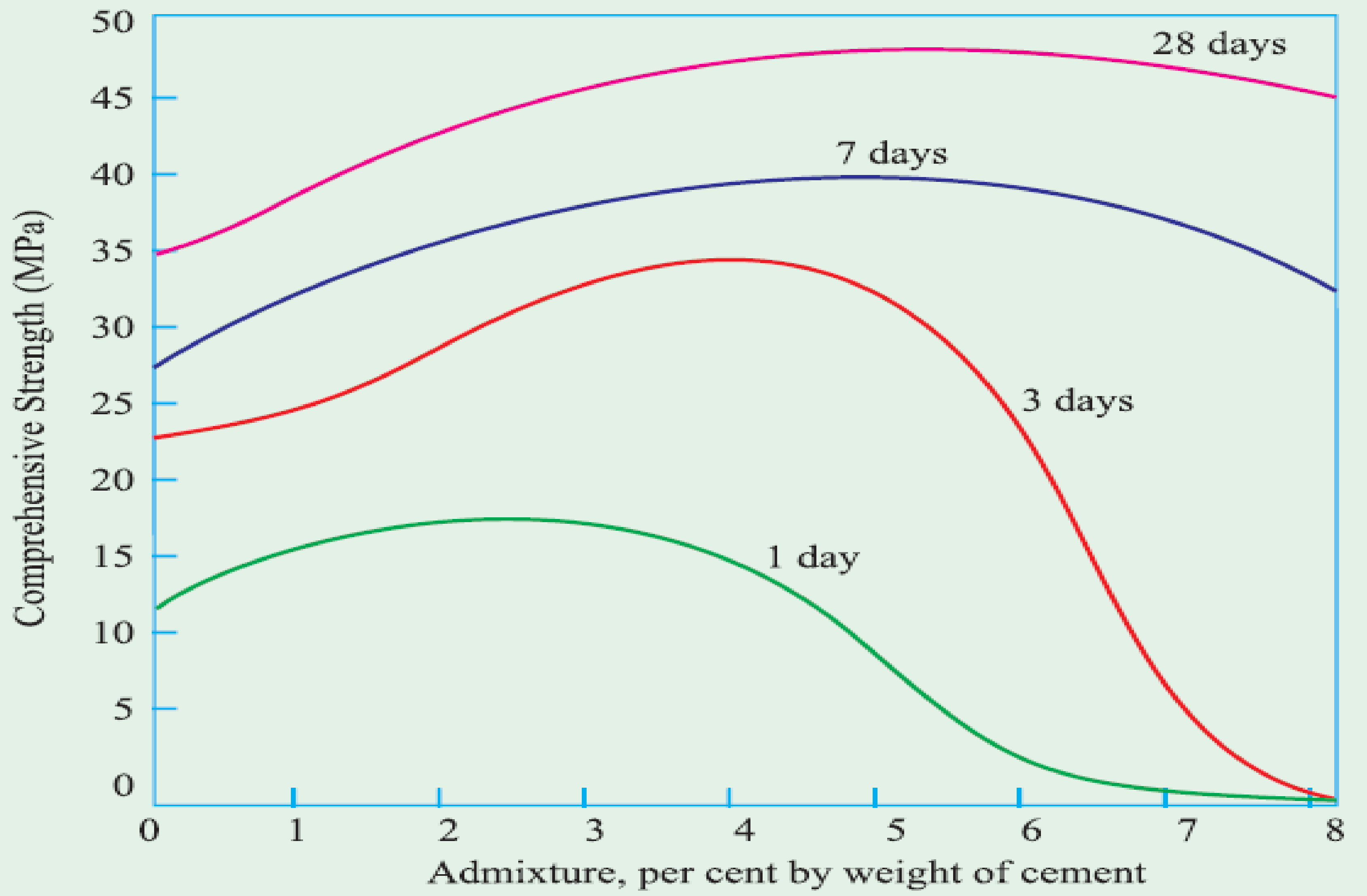
Keeping Temperature Low

- It is a common knowledge that hydration process can be retarded by keeping the temperature of the concrete low. At low temperature the slump loss is also slow.
- Use of ice flakes instead of water is resorted to reduce the slump loss. Often the use of ice flakes is an additional step to reduce the slump loss.

Using Compatible Superplasticizer With Cement

- Use of highly compatible admixture with the given cement will also reduce the problem of slump loss.
- A cement with low C3A content will be of use in this regard.

Effect of plasticizer or superplasticizer on hardened concrete



Accelerators

Accelerating admixtures are added to concrete to increase the rate of early strength development

Why accelerators?

- Permit earlier removal of formwork
- Reduce the required period of curing
- Advance the time that a structure can be placed in service
- Partially compensate for the retarding effect of low temperature during cold weather concreting
- In the emergency repair work.

Accelerators

Commonly used materials as an accelerator:

- Calcium chloride (Not used now)
- Some of the soluble carbonates
- Silicates fluosilicates (Expensive)
- Some of the organic compounds such as triethenolamine (Expensive)

Accelerators

Benefits of Accelerators

- Accelerators are so powerful that it is possible to make the cement set into stone hard in a matter of five minutes are less.
- With the availability of such powerful accelerator, the under water concreting has become easy.
- Similarly, the repair work that would be carried out to the waterfront structures in the region of tidal variations has become easy.
- The use of such powerful accelerators have facilitated, the basement waterproofing operations.

Air-entraining Admixture

- One of the important advancements made in concrete technology was the discovery of air entrained concrete.
- In the United States and Canada, due to the recognition of the merits of air entrained concrete, about 85% of concrete manufactured in America contains one or the other type of air entraining agent.
- By mixing a small quantity of air entraining agent or by using air entraining cement.
- These incorporated millions of non-coalescing air bubbles, which will act as flexible ball bearings and will modify the properties of plastic concrete regarding workability, segregation, bleeding and finishing quality of concrete. The air voids present in concrete can be brought under two groups:
- (a) Entrained air (b) Entrapped air.
- Entrained air is intentionally incorporated, minute spherical bubbles of size ranging from 5 microns to 80 microns distributed evenly in the entire mass of concrete. The entrapped air is the voids present in the concrete due to insufficient compaction. These entrapped air voids may be of any shape and size normally embracing the contour of aggregate surfaces. Their size may range from 10 to 1000 microns or more and they are not uniformly distributed throughout the concrete mass. It also modifies the properties of hardened concrete regarding its resistance to frost action and permeability.

Air-entraining Admixture

The following types of air entraining agents are used for making air entrained concrete.

- Natural wood resins
- Animal and vegetable fats and oils, such as tallow, olive oil and their fatty acids such as stearic and oleic acids.
- Various wetting agents such as alkali salts or sulphated and sulphonated organic compounds.
- Water soluble soaps of resin acids, and animal and vegetable fatty acids.
- Miscellaneous materials such as the sodium salts of petroleum sulphonic acids, hydrogen peroxide and aluminium powder, etc.
- Vinsol resin and Darex are the most important air-entraining agents.

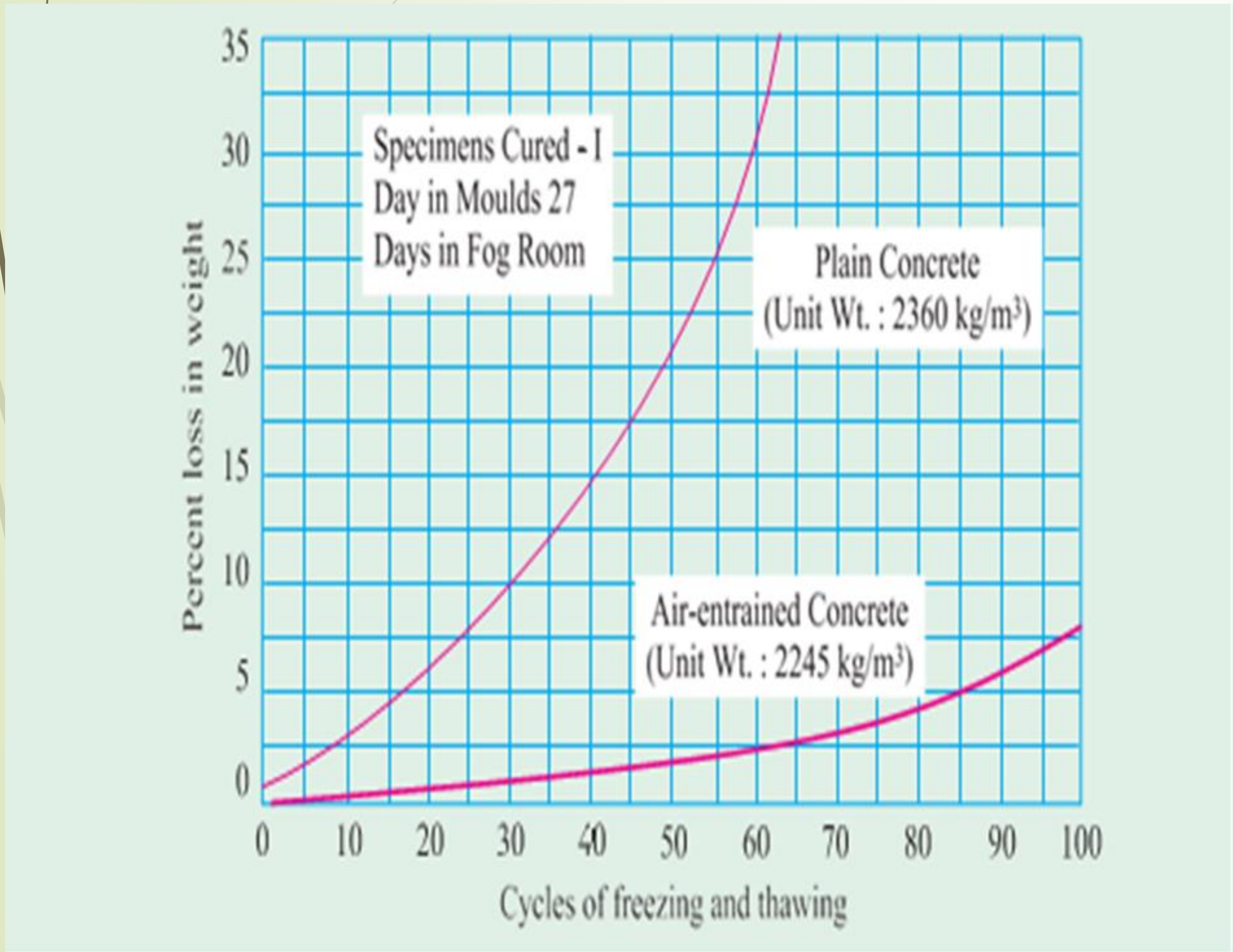
Air-entraining Admixture

The Effect of Air Entrainment on the Properties of Concrete

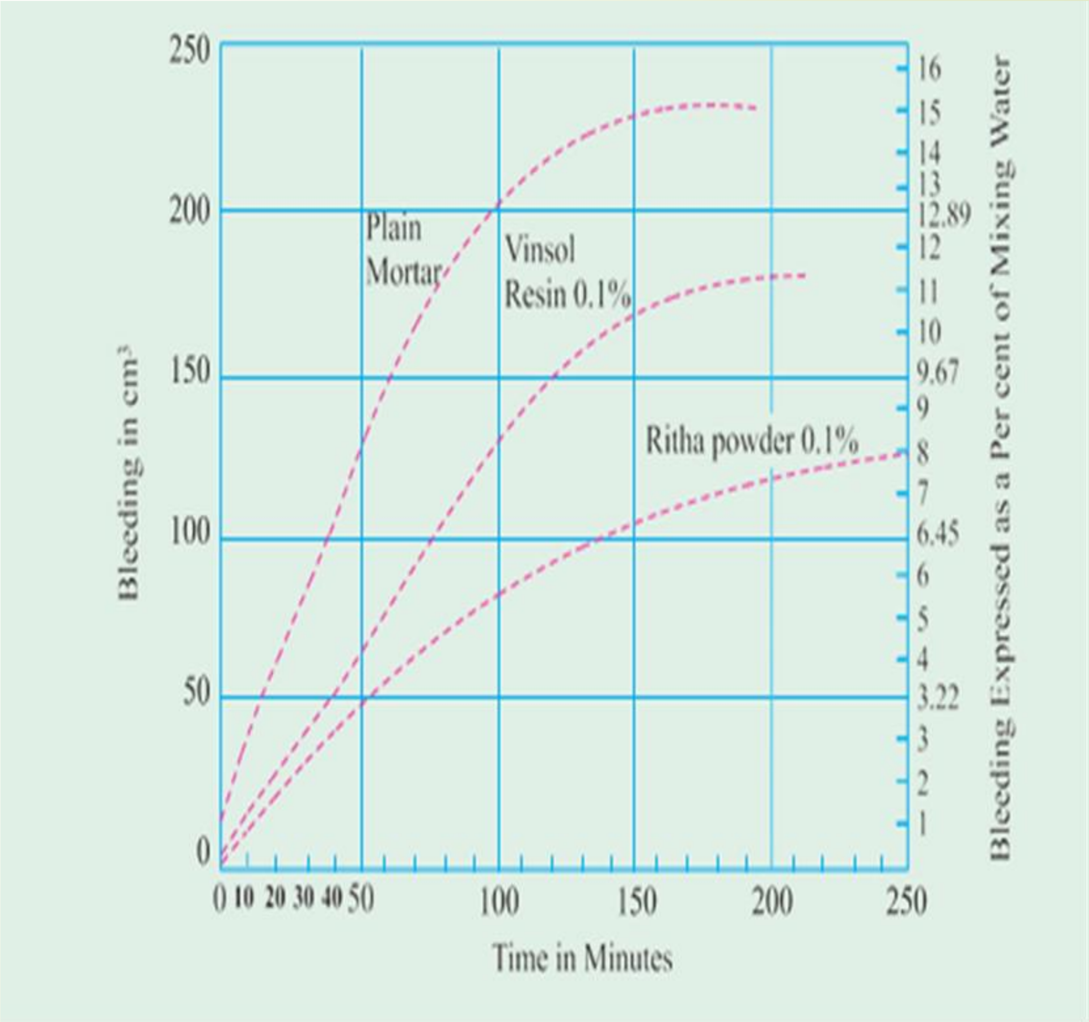
- Increased resistance to freezing and thawing.
- Improvement in workability.
- Reduction in strength.
- Reduces the tendencies of segregation.
- Reduces the bleeding and laitance.
- Decreases the permeability.
- Increases the resistance to chemical attack.
- Permits reduction in sand content.
- Improves place ability, and early finishing.
- Reduces the cement content, cost, and heat of hydration.
- Reduces the unit weight.
- Permits reduction in water content.
- Reduces the alkali-aggregate reaction.
- Reduces the modulus of elasticity.

Air-entraining Admixture

Effect on freezing and thawing



Effect on bleeding



Damp-proofing & Waterproofing Admixture

In practice one of the most important requirements of concrete is that it must be impervious to water under two conditions;

- Firstly, when subjected to pressure of water on one side.
- Secondly, to the absorption of surface water by capillary action.

Waterproofing admixtures are available in powder, paste or liquid form and may consist of pore filling or water repellent materials.

- Chemically active pore filling materials: silicate of soda, aluminium/zinc sulphates and aluminium/calcium chloride.
- Chemically inactive filling material: chalk, fullers earth and talc.

Damp-proofing & Waterproofing Admixture

Amount used

Depends upon various damp-proofing and water proofing admixtures.

Limitations

- Use of admixture should in no case be considered as a substitute for bad materials, bad design or workmanship.
- In no case can an admixture be expected to compensate for cracks or large voids in concrete causing permeability.

Results - effects

- Chemically active pore fillers accelerates the setting of concrete and thus render the concrete more impervious at early age.
- Chemically inactive pore fillers improve the workability and to facilitate the reduction of water for given workability and to make dense concrete which is basically impervious.
- Water repelling materials like soda, potash soaps, calcium soaps, waxes, fats, vegetable oils repel water and make the concrete impervious

Mineral additives

Pozzolanic materials are:

- Siliceous or siliceous-aluminous materials,
- Little or no cementitious value,
- In finely divided form and in the presence of moisture,

Chemically react with calcium hydroxide liberated on hydration, at ordinary temperature, to form compounds, possessing cementitious properties.

They are also known as POZZOLANIC materials.

Why Mineral additives?

Improves many qualities of concrete, such as:

- Lower the heat of hydration and thermal shrinkage;
- Increase the water tightness;
- Reduce the alkali-aggregate reaction;
- Improve resistance to attack by sulphate soils and sea water;
- Improve extensibility;
- Lower susceptibility to dissolution and leaching;
- Improve workability;
- Lower costs.

Types of mineral additives

Natural Pozzolonas

- Clay and Shales
- Opalinc Cherts
- Diatomaceous Earth
- Volcanic Tuffs and Pumicites.

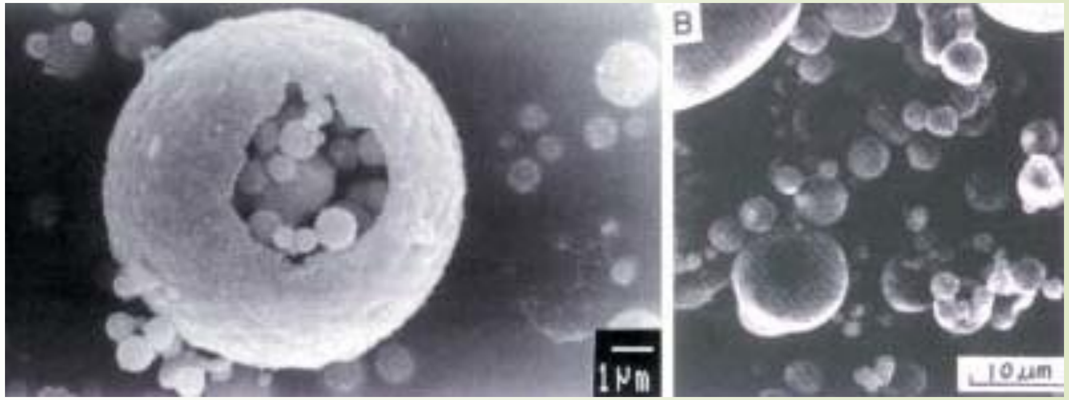
Artificial Pozzolonas

- Fly ash
- Blast Furnace Slag
- Silica Fume
- Rice Husk ash
- Metakaoline
- Surkhi

Fly Ash

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by;

- Electrostatic Precipitator



Fly ash is the most widely used

pozzolanic material all over the world.

Types of fly ash

Class F

- Fly ash normally produced by burning anthracite or bituminous coal, usually has less than 5% CaO. Class F fly ash has pozzolanic properties only.

Class C

- Fly ash normally produced by burning lignite or sub-bituminous coal. Some class C fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties, class C fly ash also possesses cementitious properties.

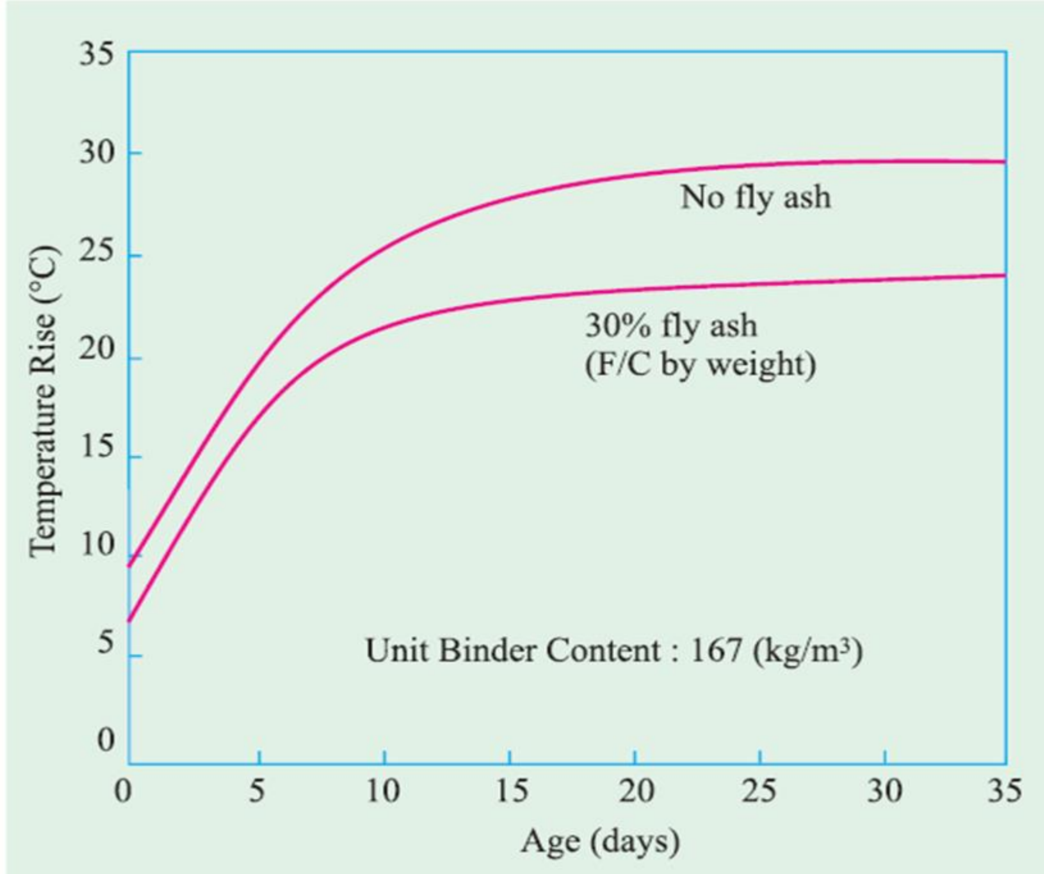
Fly ash

Amount used

Up to 35% by mass of cement & minimum shall not be less than 15%.

Results - effects

- Reduction of water demand for desired slump. With the reduction of unit water content, bleeding and drying shrinkage will also be reduced.
- fly ash is not highly reactive, the heat of hydration can be reduced through replacement of part of the cement with fly ash.



Fly ash

Effects of Fly Ash on Hardened Concrete

- contributes to the strength of concrete due to its pozzolanic reactivity.
- continued pozzolanic reactivity concrete develops greater strength at later age not at initial stage.
- contributes to making the texture of concrete dense, resulting in decrease of water permeability and gas permeability.

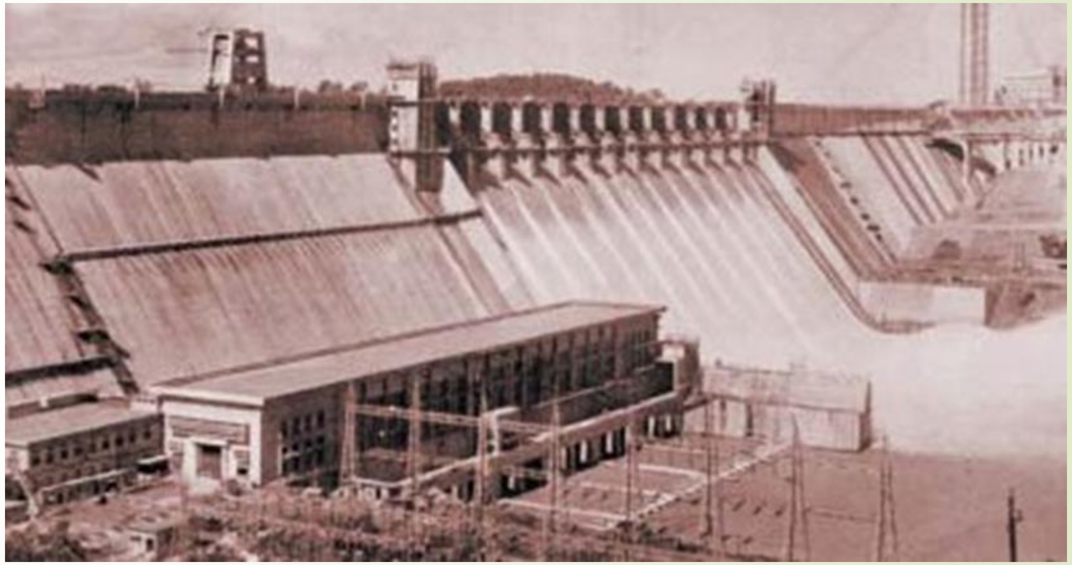
High volume Fly Ash has been used in the Barker Hall Project, University of California at Berkeley for the construction of shear walls.

Fly ash

Used at

- Flyash Bricks
- Many high-rise buildings
- Industrial structures
- Water front structures
- Concrete roads
- Roller compacted concrete dams.

In India, fly ash was used for the first time in the construction of Rihand Irrigation Project, Uttar Pradesh in 1962, replacing cement up to about 15 per cent



Silica fume

It is a product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy.

- Micro silica is initially produced as an ultrafine undensified powder
- At least 85% SiO_2 content
- Mean particle size between 0.1 and 0.2 micron
- Minimum specific surface area is 15,000 m^2/kg
- Spherical particle shape

Silica fume

Micro silica is available in the following forms:

- Undensified forms with bulk density of 200–300 kg/m^3
- Densified forms with bulk density of 500–600 kg/m^3
- Micro-pelletised forms with bulk density of 600–800 kg/m^3
- Slurry forms with density 1400 kg/m^3
- Admixtures and Construction Chemicals.
- Slurry is produced by mixing undensified micro silica powder and water in equal proportions by weight. Slurry is the easiest and most practical way to introduce micro silica into the concrete mix.
- Surface area 15–20 m^2/g.
- Standard grade slurry pH value 4.7, specific gravity 1.3 to 1.4, dry content of micro silica 48 to 52%.

Silica fume

Effect on fresh concrete

- The increase in water demand of concrete containing microsilica will be about 1% for every 1% of cement substituted.
- lead to lower slump but more cohesive mix.
- make the fresh concrete sticky in nature and hard to handle.
- large reduction in bleeding and concrete with microsilica could be handled and transported without segregation.
- to plastic shrinkage cracking and, therefore, sheet or mat curing should be considered.
- produces more heat of hydration at the initial stage of hydration.
- the total generation of heat will be less than that of reference concrete.

Silica fume

Effect on hardened concrete

- Modulus of elasticity of microsilica concrete is less.
- Improvement in durability of concrete.
- Resistance against frost damage.
- Addition of silica fume in small quantities actually increases the expansion.

Used for

- Conserve cement
- Produce ultra high strength concrete of the order of 70 to 120 Mpa.
- Increase early strength of fly concrete.
- Control alkali-aggregate reaction.
- Reduce sulfate attack & chloride associated corrosion.

Rice husk ash

Rice husk ash is obtained by

- Burning rice husk in a controlled manner without causing environmental pollution.
- Material of future as mineral additives.

Rice husk ash

Amount used

- 10% by weight of cement.
- It greatly enhances the workability and impermeability of concrete.

Contains

- Amorphous silica (90% SiO2) in very high proportion when burnt in controlled manner.
- 5% carbon.
- 2% K_2O.

Rice husk Ash

Effects

- Reduces susceptible to acid attack and improves resistance to chloride penetration.
- Reduces large pores and porosity resulting very low permeability.
- Reduces the free lime present in the cement paste.
- Decreases the permeability of the system.
- Improves overall resistance to CO_2 attack.
- Enhances resistance to corrosion of steel in concrete.
- Reducing micro cracking and improving freeze-thaw resistance.
- Improves capillary suction and accelerated chloride diffusivity.

Blast furnace slag

- Blast-furnace slag is a nonmetallic product consisting essentially of silicates and aluminates of calcium and other bases.
- The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material.
- The granulated material when further ground to less than 45 micron will have specific surface of about 400 to 600 m2/kg (Blaine).

Blast furnace slag

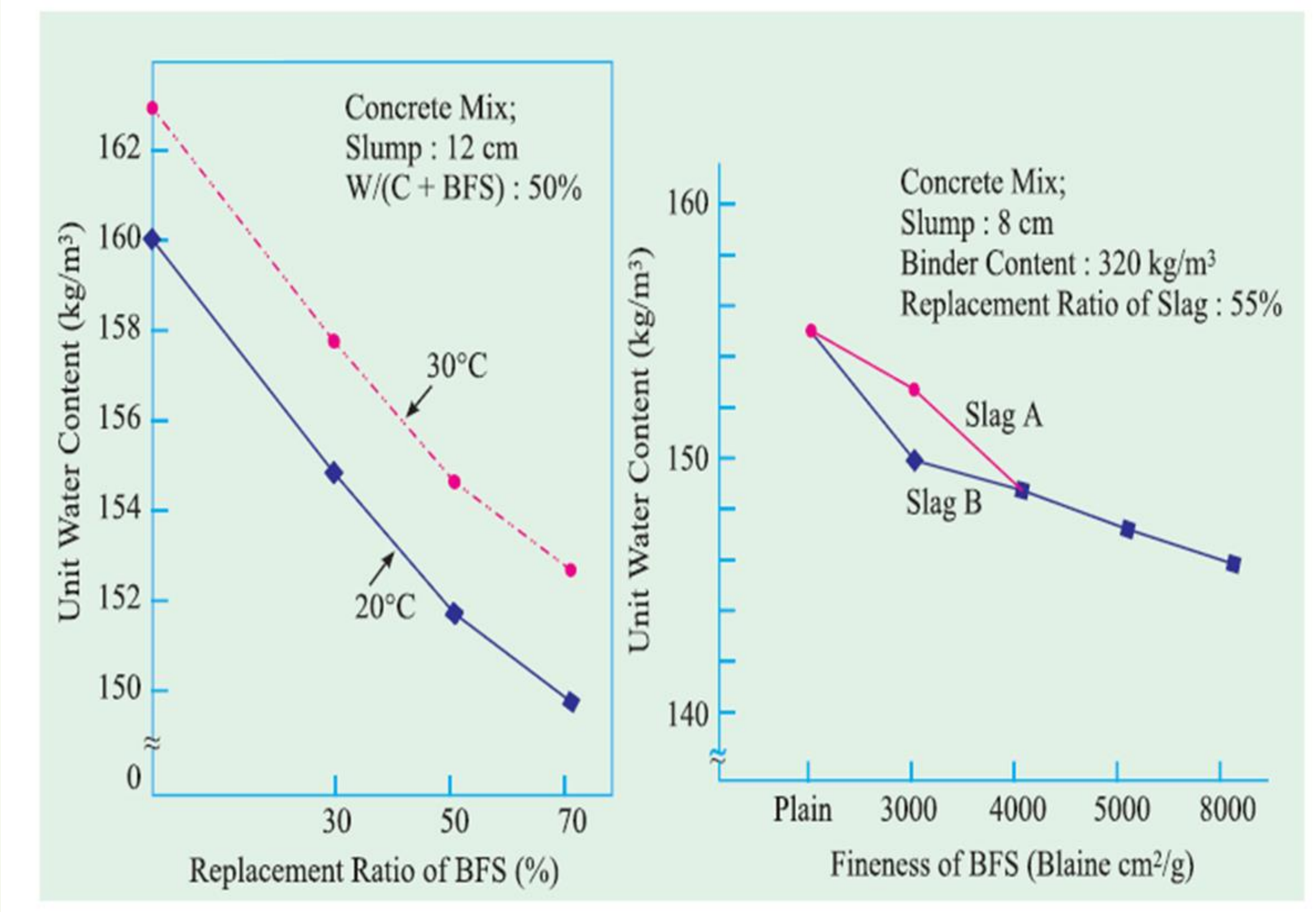
Effects on fresh concrete

- Reduces the unit water content necessary to obtain the same slump.
- Water used for mixing is not immediately lost, as the surface hydration of slag is slightly slower than that of cement.
- Reduction of bleeding.

Effects on hardened concrete

- Reduced heat of hydration
- Refinement of pore structures
- Reduced permeabilities to the external agencies
- Increased resistance to chemical attack.

Blast furnace slag



Metakaolin

- Highly reactive metakaolin is made by water processing to remove unreactive impurities from kaolin to make100% reactive pozzolana.
- Such a product, white or cream in colour, purified, thermally activated is called High Reactive Metakaolin (HRM).

Metakaolin

Effects of Metakaolin

- High reactive metakaolin shows high pozzolanic reactivity and reduction in $Ca(OH)_2$ even as early as one day.
- The cement paste undergoes distinct densification.
- Densification includes an increase in strength and decrease in permeability.

Use of Metakaolin

- The high reactive metakaolin is having the potential to compete with silica fume.