An introduction to
Use of Admixtures in concrete

by
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ADMIXTURES:-

As per AC-ACI Education Bulletin E4-12, ACI-212 and ASTM-C 125:

- Admixture is a material other than water, aggregates, hydraulic cement and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch immediately before or during its mixing.

According to RILEM (International Union of Testing and Research Laboratories for Materials and Structures);

- Admixtures for concrete, mortar or paste are inorganic or organic materials which are added to the normal components of a mix not normally exceeding 5% by mass of cement or cementations materials.

ADMIXTURES:-

- Admixtures interact with hydrating cement by physical, chemical or physicochemical actions.
- Added in small quantity either in powder or liquid form or the combination is used when more than one property needs to be altered.
- These may also economize the concrete construction with improved efficiency.

BACKGROUND:-

Materials used in early concrete and masonry included:

- milk and lard (fat, grease or cooking oil) by the Romans;
- eggs during the middle ages in Europe;
- polished glutinous (sticky) rice paste, lacquer (varnish), tung oil, and
- extracts from elm (a tree) soaked in water and boiled bananas by the Chinese;

and

- juice and latex from rubber plants.
- Similarly it is known that the Mayans (a tribe in maxico) used bark extracts and other substances as set retarders to keep stucco workable for a long period of time.

Major reasons for using admixtures are:

- To reduce the cost of concrete construction.
- To achieve certain properties in concrete more effectively than by other means.
- To maintain the quality of concrete during the stages of mixing, transporting,placing, and curing in ad-verse weather conditions.
- To overcome certain emergencies during concreting operations.

Admixtures can modify?

1.To modify fresh property
- Increase the workability without increasing the water cement ratio or decrease the water content at the same workability.
- Retard or accelerate the time of initial setting.
- Reduce or prevent the settlement or create slight expansion.
- Modify the rate or capacity of bleeding.

2. To modify harden property
- Reduce the heat of evolution.
- Accelerate the rate of strength development at early stages.
- Increase the durability
- Decrease the permeability of concrete.

ADMIXTURES CAN MODIFY?

To modify fresh **properties**:

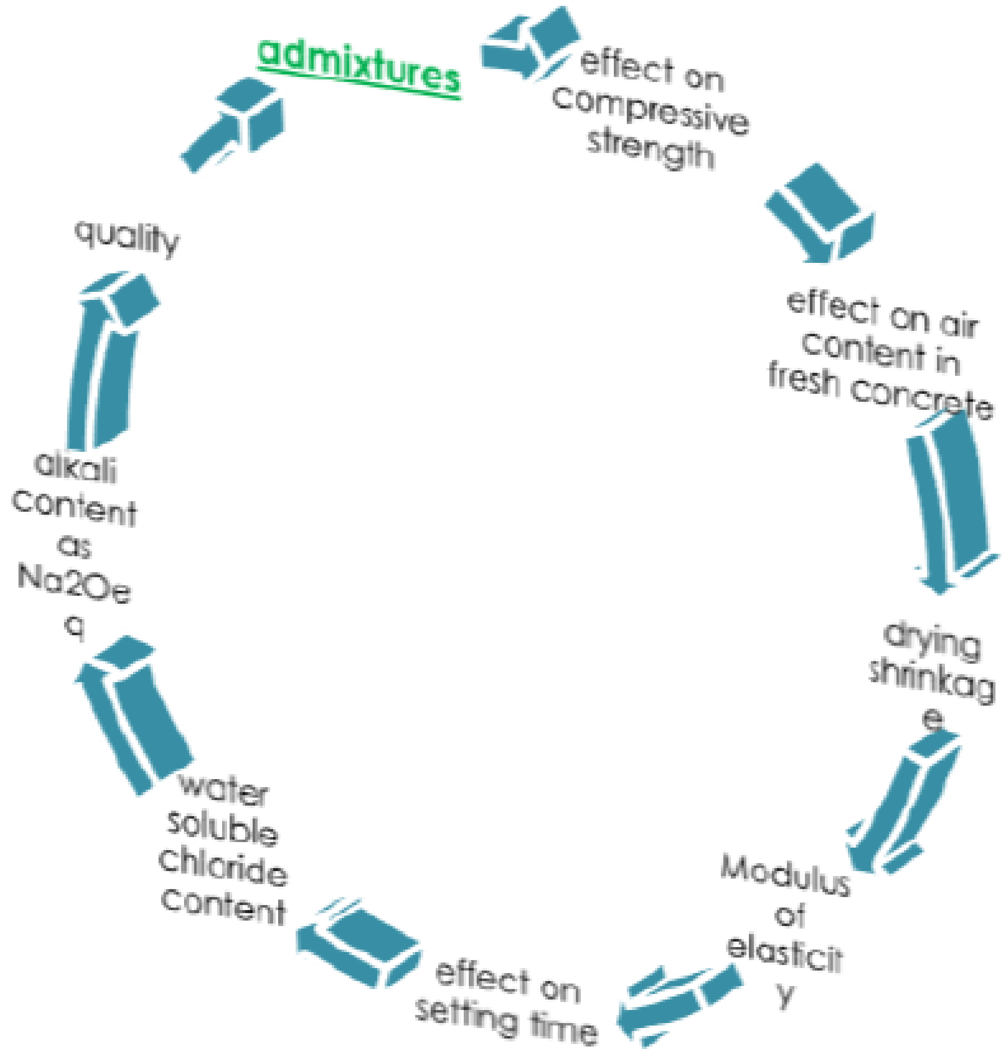
- Increase workability without increasing water content or decrease the water content at the same workability
- Retard or accelerate time of initial setting
- Reduce or prevent settlement or create slight expansion
- Modify the rate and/or capacity for bleeding
- Reduce segregation
- Improve pumpability
- Reduce the rate of slump loss

To modify **hardened properties of concrete** to:

- Retard or reduce heat evolution during early hardening
- Accelerate the rate of strength development at early ages
- Increase strength (compressive, tensile, or flexural)
- Increase durability or resistance to severe conditions of exposure, including application of deicing salts
- Decrease permeability of concrete
- Control expansion caused by the reaction of alkalies with certain aggregate constituents
- Increase bond of concrete-to-steel reinforcement
- Increase bond between existing and new concrete
- Improve impact resistance and abrasion resistance
- Inhibit corrosion of embedded metal
- Produce colored concrete or mortar

➢ GENERAL PERFORMANCE REQUIREMENTS

- Each class of admixture is defined by its primary function.
- It may have one or more secondary functions, however, and its use may affect, positively or negatively, concrete properties other than those desired.




Cost-Effective
Durability
Handling properties
making placing
compaction easier
Permeability
freeze/thaw(air content)
Consistence and sustainability
Density
strength development
prevent shrinkage
capacity for bleeding
Reduce segregation
bond of concrete to ...
impact and abrasion resistance
colored concrete

There are two major varieties of admixtures:-

- Mineral Admixtures / Additives
  - (Generally referred to as Secondary Cementitious Materials (SCMs), Cement Replacement Materials (CRMs) or Pozzolans and are found in solid from)

- Chemical Admixtures (Generally found in liquid form)

ADMIXTURES:- Types

- Chemical Admixtures

- Mineral Admixtures

DOSE OF ADMIXTURE:

BS EN 934–2 advises that “trial tests should be carried out with the materials to be used on site to find the dosage necessary to achieve the desired result”. The concrete producer may well have the results of such tests, which should be obtained before specifying the type and dose of admixture for a specific concrete mix.

1. Admixtures of the same type from different manufacturers may well require different doses to achieve the desired effect;
2. The effect of admixtures is dependent on the particular cement, additions and aggregates used in the concrete.

➢ Mineral Admixtures

Today, most concrete mixtures contain SCMs that make up a portion of cementitious component in concrete. These are generally the byproduct from other processes or natural materials. They may or may not be further processed for use in concrete. Some of these materials are called **pozzolans**, which by themselves do not have any cementitious properties but if used with OPC react to form cementitious compounds.

For use in concrete, SCMs, sometimes referred to as **Mineral admixtures**, may be used individually or in combination in concrete. They may be added in concrete mixture as a blended cement or as a separately batched ingredient at the ready mixed concrete plant

➢ Mineral Admixtures

Mineral admixtures are “inorganic” materials that also have pozzolanic properties. These very fine grained materials are added to the concrete mix to improve the properties of concrete, or even as a replacement for portland cement. Mineral admixtures are generally used in concrete to help make it stronger as well as to make it more economical.

SCMs such as fly ash, slag, silica fume etc. enable the concrete industry to use hundreds of millions of tons of byproduct materials that would otherwise be landfilled as waste. Furthermore, their use reduces the consumption of portland cement per unit volume of concrete(so called CRMs).

➢ Pozzolans (Mineral Admixtures)

- The name Pozzolan comes from the town Pozzuoli, Italy.
- Ancient Romans (~100 B.C.) produced a hydraulic binder by mixing hydrated lime with soil (predominantly volcanic ash)
- Mixing lime with finely divided burned clay, is extensively used by Ottomans

Nowadays, the word pozzolan covers a broad range of natural and artificial materials.

➢ ***Natural*** *(Volcanic ash, pumicite, etc.)*

➢ ***Artificial*** *(fly ash, silica-fume, granulated blast furnace slag, Rice husk ash)*

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.

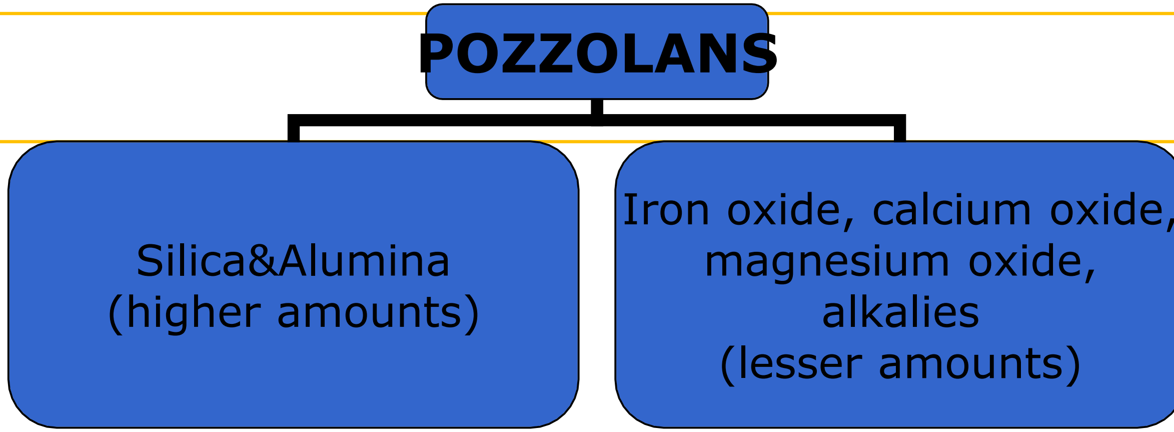
TYPES OF MINERAL ADDITIVES

Natural Pozzolans

- Metakaoline
- Clay and Shales
- Volcanic Tuffs and Pumicite
- Diatomaceous Earth

Artificial Pozzolans

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



POZZOLANIC REACTIONS

Calcium Hydroxide+Silica+Water → "Calcium-Silicate-Hydrate"

(C-S-H)

C-S-H provides the hydraulic binding property of the material.

Pozzolanic Activity: Capacity of pozzolan to form alumino-silicates with lime to form cementitious products.

The **pozzolanic activity** is a measure for the degree of reaction over time or the reaction rate between a **pozzolan** and Ca^{2+} or $Ca(OH)_2$ in the presence of water.

FACTORS THAT AFFECT THE ACTIVITY OF POZZOLANS

1) Content of $SiO_2 + Al_2O_3 + Fe_2O_3$, The greater amount of these will result in greater will be its activity.

2) The degree of amourpheness of its structure:

- For chemical reaction → pozzolans must be amorphous.

Clays contain high amounts of silica & alumina but have a crystallic structure! However, by heat treatment, such as calcining at ~700-900°C crystallic structure is destroyed & a quasi-amorphous structure is obtained.

- Clay → does not possess pozzolanic property
- Burnt clay → possess pozzolanic property

3) Fineness of its particles:

- Pozzolanic activity increases as fineness increases.
- Volcanic ash, rice husk ash, fly ash, condensed silica fume are obtained in finely divided form.
- Volcanic tuff, granulated blast furnace slag & burnt clay must be ground.

Natural Pozzolans:

Various naturally occurring materials possess or can be processed to possess pozzolanic properties (covered in ASTM C 618).

Natural pozzolans are generally derived from volcanic origin as these silicious materials tend to be reactive if they are cooled rapidly like metakaoline and calcined shale or clay. These materials are manufactured by controlled calcining (firing) of naturally occurring minerals. Metkaoline is produced from relatively pure metakaoline clay and it is used at 5% to 15% by mass of the cementitious mterials. Other natural pozzolans are volcanic glass, wheat and rice husk ashes.

METAKAOLIN

- Highly reactive metakaolin is made by water processing to remove unreactive impurities to make100% reactive pozzolan.
- Such a product, white or cream in colour, purified, thermally activated is called High Reactive Metakaolin (HRM).
- The high reactive metakaolin is having the potential to compete with silica fume.

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.

Metakolin

ARTIFICIAL POZZOLANS

Rice Husk Ash

Wheat Husk Ash

Fly ash

Ground Granulated
Blast Furnace Slag (GGBFS)

Silica Fume

RICE HUSK ASH

It is **obtained** by

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

Contains:

- Amorphous silica (90% SiO_2) in very high proportion when burnt in controlled manner.
- 5% carbon and • 2% K_2O.

Amount used

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

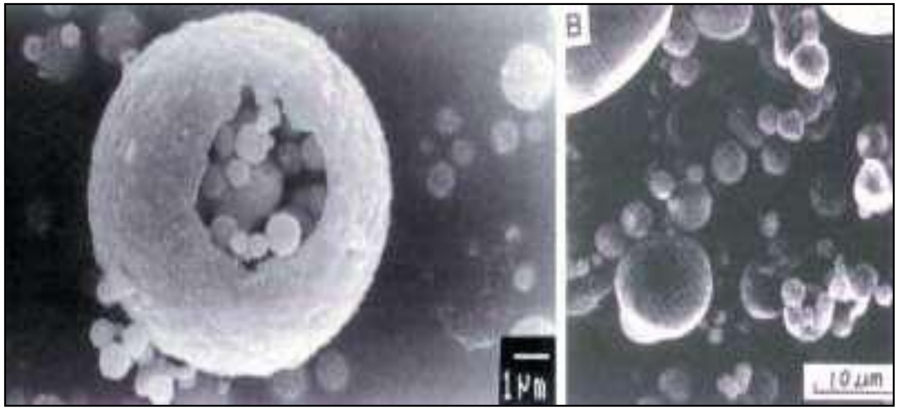
EFFECTS

- 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 CO2 attack.
- Enhances resistance to corrosion of steel in concrete.
- Reducing micro cracking and improving freeze-thaw resistance.
- Improves capillary suction and accelerated chloride diffusivity.

FLY ASH:

Fly ash is finely divided residue resulting from the combustion of powdered coal in thermal power plant and transported by the flue gases and collected by;• Electrostatic and • 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.

Amount used

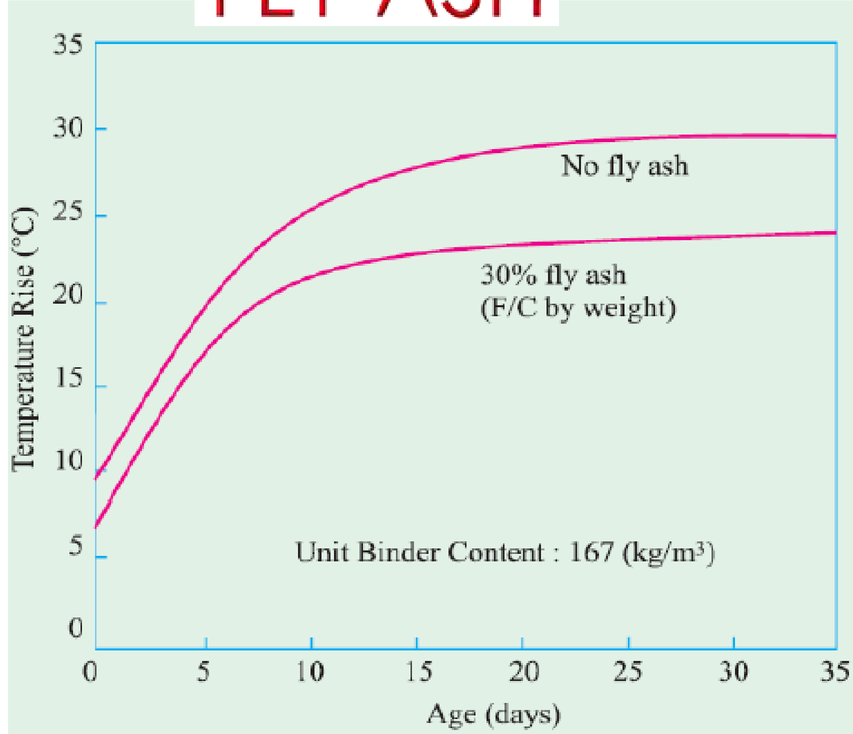
- Up to 35% by mass of cement & minimum shall not be less than 15%.

Results - effects

- Reduction of water demand for desired slump. With the reduction of unit water content, bleeding and drying shrinkage will also be reduced.

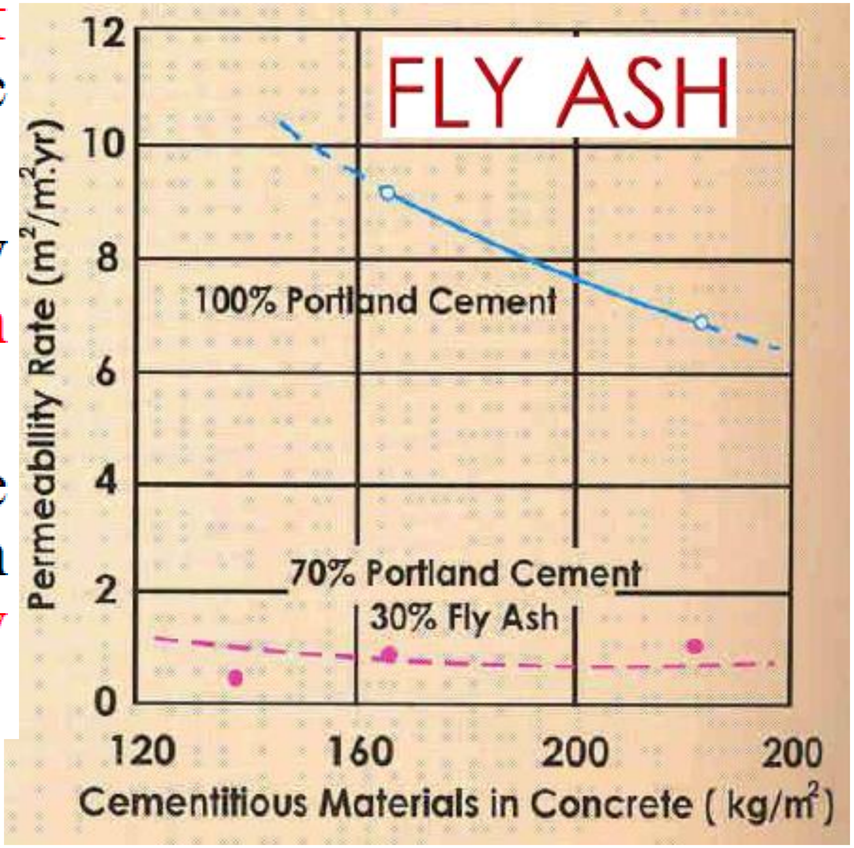
- fly ash is not highly reactive, the heat of hydration can be reduced through replacement of part of the cement with fly ash.

FLY ASH



Effect 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.



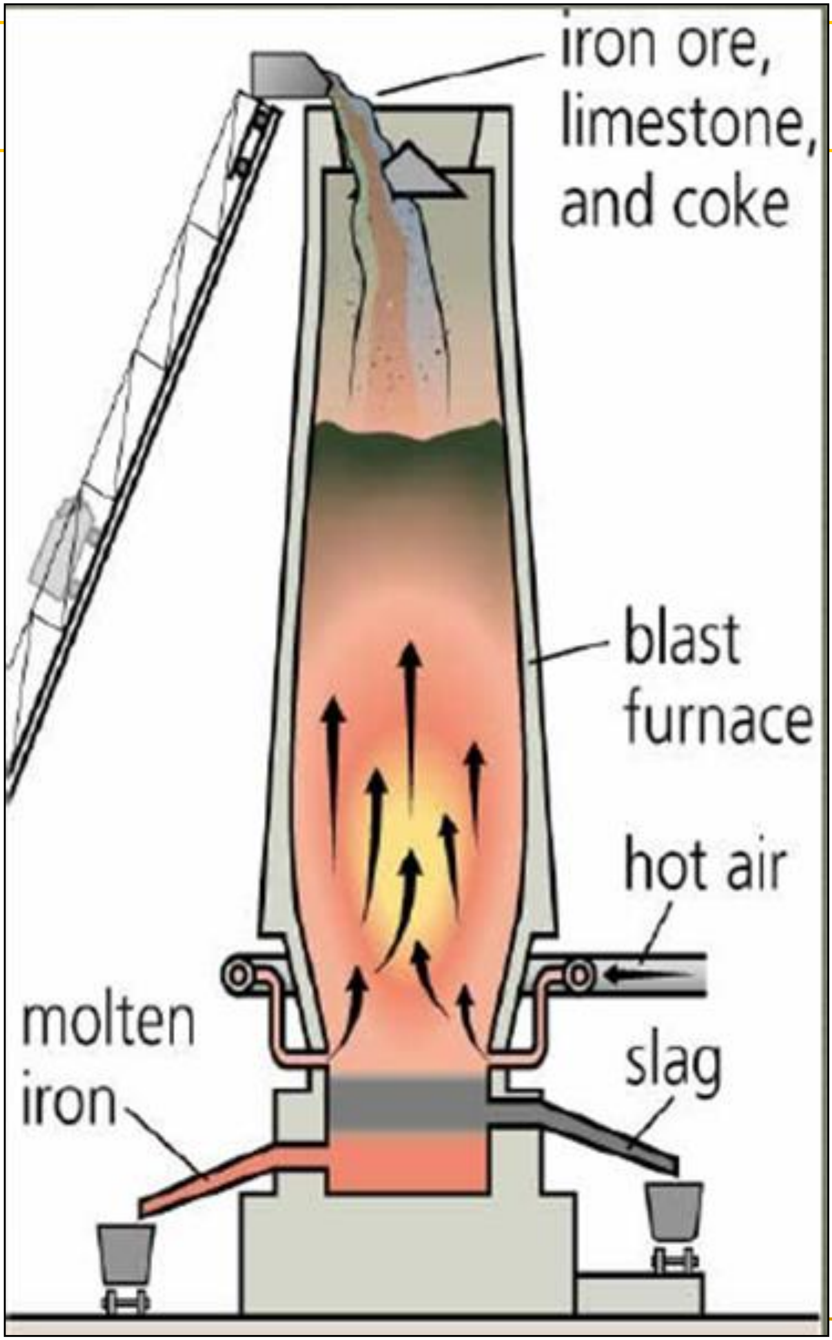
Used at

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

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

BLAST FURNACE SLAG

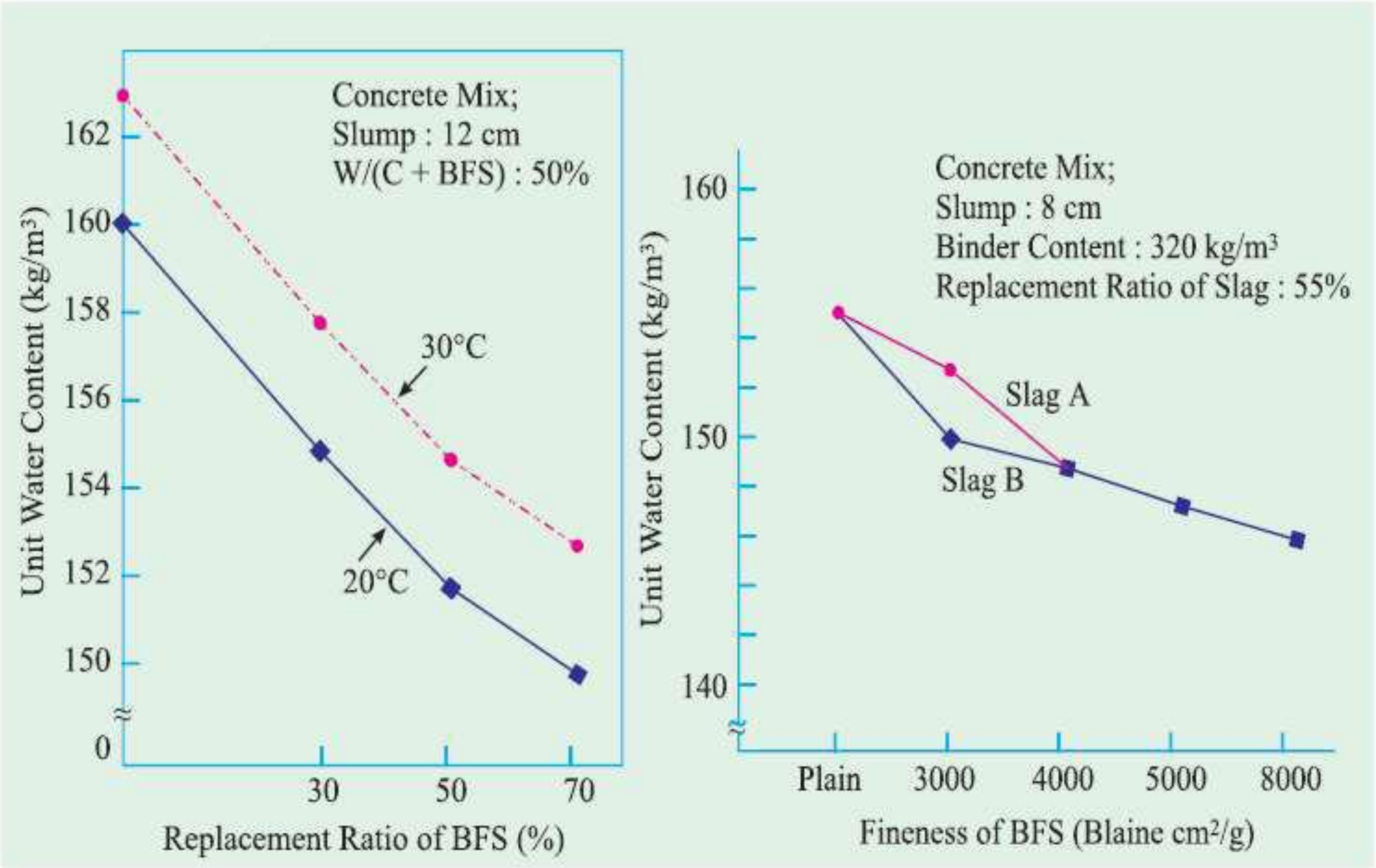
- Blast-furnace slag is a nonmetallic by product of pig iron manufacture consisting essentially of silicates and aluminates of calcium and other bases.
- The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material.
- The granulated material when further ground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


iron ore,
limestone,
and coke
blast
furnace
hot air
molten
iron
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.
- Reduced heat of hydration
- Refinement of pore structures
- Reduced permeabilities to the external agencies
- Increased resistance to chemical attack.

REDUCTION IN UNIT WT. OF WATER



SILICA FUMES

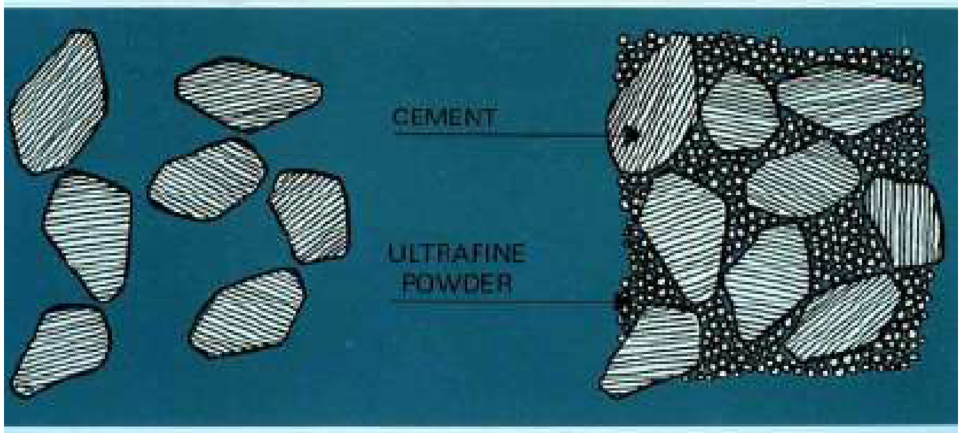
- Silica fume is an industrial by-product consisting of ultrafine particle. It is recovered from electric furnace by means of dust collectors from the waste gas emitted during the production of ferro-silicon metal.
- It can be used as an water reducing admixture.

SILICA FUME

1. fine micro-crystalline silica produced in electric arc furnaces as a by product.

2. Very fine non-crystalline silica produced in electric arc furnaces as a by product.

The transition zone is a thin layer between the bulk hydrated cement paste and the aggregate particles in concrete. This zone is the weakest component in concrete, and it is also the most permeable area. Silica fume plays a significant role in the transition zone through both its physical and chemical effects.

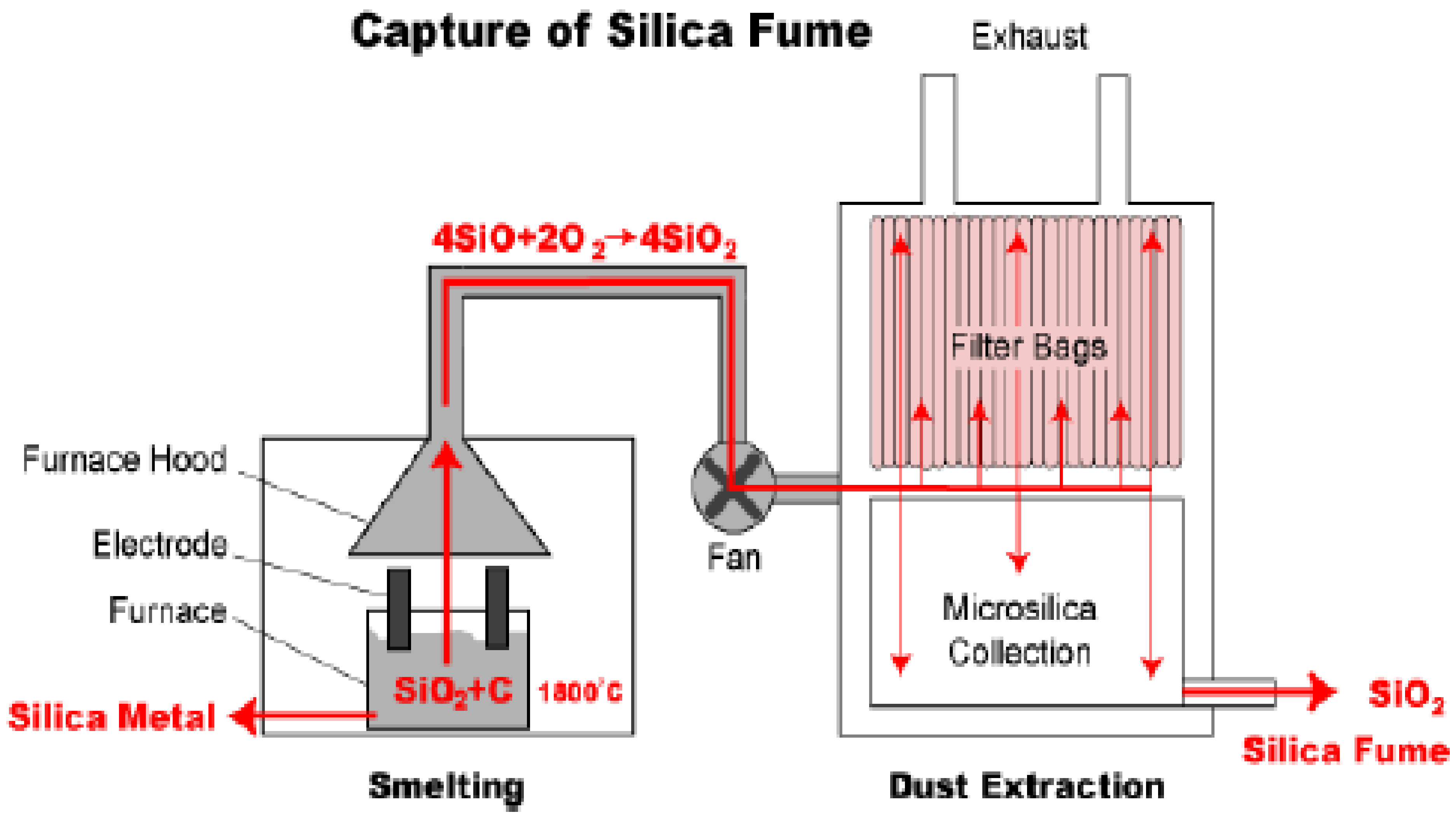


PRODUCTION:

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.

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

PRODUCTION:



Capture of Silica Fume
Exhaust
$4SiO+2O_2 \rightarrow 4SiO_2$
Filter Bags
Furnace Hood
Electrode
Furnace
Fan
Microsilica
Collection
SiO_2+C
1800°C
Silica Metal
SiO_2
Silica Fume
Smelting
Dust Extraction

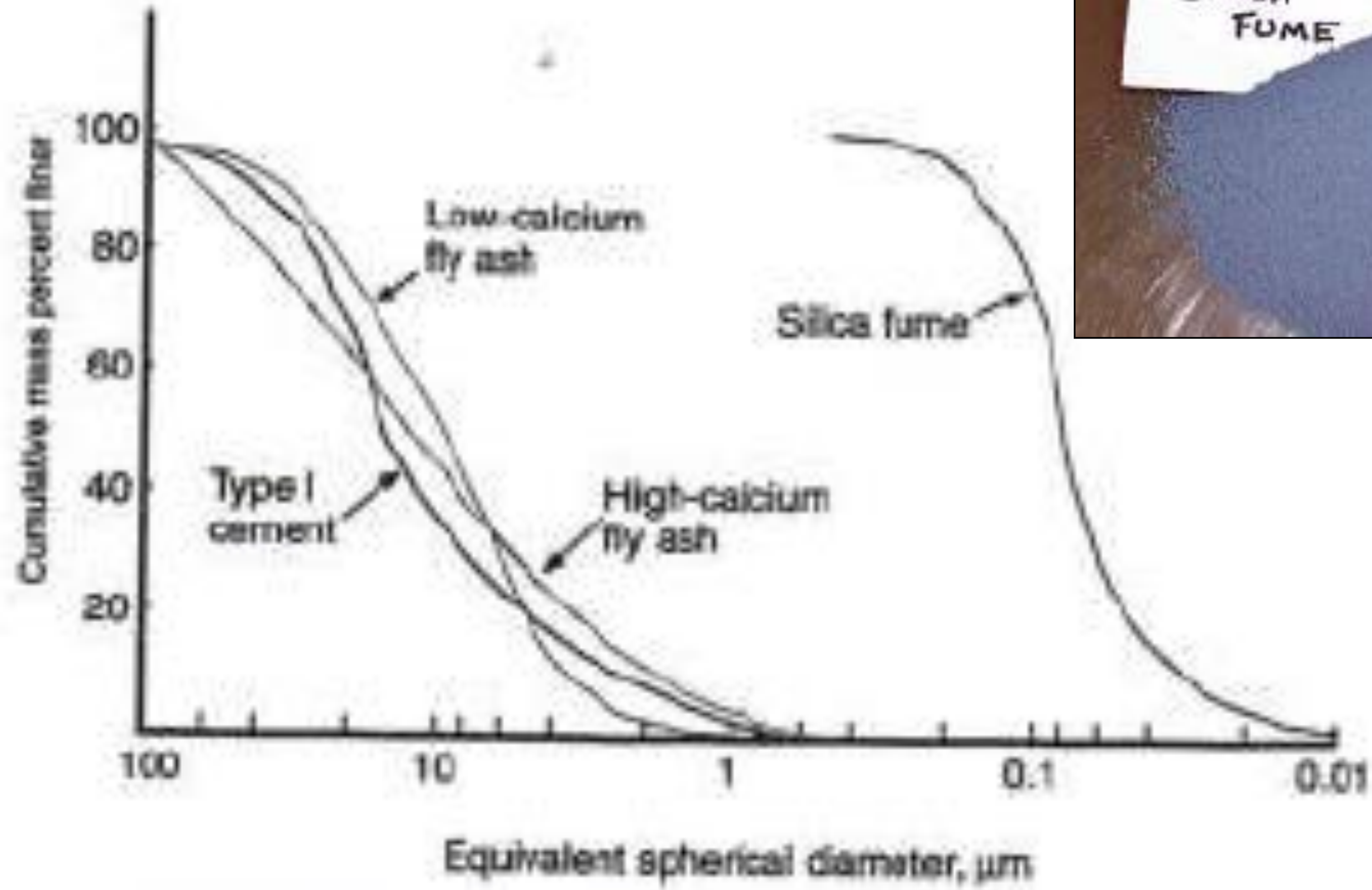


Figure 2.5.2. Particle size distribution plots for condensed silica fume, fly ashes, and portland cement (adapted from Mehta, 1986).

Micro silica is available in the following forms:

1. Undensified forms with bulk density of 200–300 kg/m3
2. Densified forms with bulk density of 500–600 kg/m3
3. Micro-pelletised forms with bulk density of 600–800 kg/m3
4. Slurry forms with density 1400 kg/m3
5. Admixtures and Construction Chemicals.
6. 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.
7. Surface area 15–20 m2/g.
8. Standard grade slurry pH value 4.7, specific gravity 1.3 to 1.4, dry content of micro silica 48 to 52%.

EFFECT ON FRESH CONCRETE

- The increase in water demand of concrete containing microsilica will be about 1% for every 1% of cement substituted.
- Leads to lower slump but more cohesive mix.
- makes 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.
- 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.

EFFECT ON HARDENED CONCRETE

1. Modulus of elasticity of microsilica concrete is less.
2. Improvement in durability of concrete.
3. Resistance against frost damage.
4. Addition of silica fume in small quantities actually increases the expansion.
5. Conserve cement
6. Produce ultra high strength concrete of the order of 70 to 120 Mpa.
7. Increase early strength of fly concrete.
8. Control alkali-aggregate reaction.
9. Reduce sulfate attack & chloride associated corrosion.

Chemical Analysis of Different Pozzolans

	Artificial Pozzolans				Natural Pozzolans		
	Class F fly ash	Class C fly ash	Groundslag	Silica fume	Calcined clay	Calcined shale	Meta-kaolin
SiO_2, %	**52**	**35**	35	**90**	58	50	**53**
Al_2O_3, %	**23**	**18**	12	0.4	29	20	**43**
Fe_2O_3, %	**11**	**6**	1	0.4	4	8	0.5
CaO, %	5	**21**	**40**	1.6	1	8	0.1
SO_3, %	0.8	4.1	9	0.4	0.5	0.4	0.1
Na_2O, %	1.0	5.8	0.3	0.5	0.2	—	0.05
K_2O, %	2.0	0.7	0.4	2.2	2	—	0.4
Total Na eq. alk, %	2.2	6.3	0.6	1.9	1.5	—	0.3

LIMITING AMOUNTS OF POZZOLANS IN CONCRETE

➢ Fly ash	
Class C (Less silica)	15% to 40% (by mass of binder)
Class F (more silica)	15% to 20%
➢ Slag	30% to 45%
➢ Silica fume	05% to 10%
➢ Calcined clay	15% to 35%
➢ Metakaolin	10%
➢ Calcined shale	15% to 35%

TERNARY BLEND CONCRETE

- Ternary concrete mixtures include three different cementitious materials i.e. combinations of portland cement, slag cement, and a third cementitious material. The third component is often fly ash, but silica fume is also common.
- Other material in combination with portland and slag cement, such as rice husk ash are not currently in common usage.
- Slag cement has been used in ternary mixtures for decades.

BENEFITS OF TERNARY BLEND CONCRETE

1. High strength, 2. Low permeability 3. Corrosion resistance

4. Sulphate resistance 5. ASR resistance

6. Elimination of thermal cracking

USAGE:

1. General construction (residential, commercial, industrial)

2. Paving, 3. High performance concrete,

4. Precast concrete, 5. Masonry units,

6. Mass concrete, 7. Shotcrete

PROPORTIONING OF MIXTURE

- The optimum mixture proportions for ternary blends, as with other concrete, will be dependent on the final use of the concrete, construction requirements and seasonal considerations. As with other concrete, cold weather will affect the early strength gain and mixture proportions may need to be adjusted to assure job-site performance. In low W/CM applications such as paving, mixtures with 15percent fly ash and 30% slag cement component have been used successfully.



POLYMER CONCRETE

- Polymer concrete is part of group of concretes that use polymers to supplement or replace cement as a binder. The types include polymer-impregnated concrete, polymer concrete, and polymer-Portland- cement concrete.

POLYMER CONCRETE

In polymer concrete, thermosetting resins are used as the principal polymer component due to their high thermal stability and resistance to a wide variety of chemicals.

- Polymer concrete is also composed of aggregates that include silica, quartz, granite, limestone, and other high quality material.
- Polymer concrete may be used for new construction or repairing of old concrete.
- The low permeability and corrosive resistance of polymer concrete allows it to be used in swimming pools, sewer structure applications, drainage channels, electrolytic cells for base metal recovery, and other structures that contain liquids or corrosive chemicals.

POLYMER CONCRETE

- It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems.
- It can also be used as a replacement for asphalt pavement, for higher durability and higher strength.
- Polymer concrete has historically not been widely adopted due to the high costs and difficulty associated with traditional manufacturing techniques

POLYMER CONCRETE

- Advantages

1. Rapid curing at ambient temperatures
2. High tensile, flexural, and compressive strengths
3. Good adhesion to most surfaces
4. Good long-term durability with respect to freeze and thaw cycles
5. Low permeability to water and aggressive solutions
6. Good chemical resistance
7. Good resistance against corrosion
8. Lighter weight (only somewhat less dense than traditional concrete, depending on the resin content of the mix)
9. May be vibrated to fill voids in forms
10. Allows use of regular form-release agents (in some applications)

- Disadvantages

1. Product hard to manipulate with conventional tools such as drills and presses due to its strength and density. Recommend getting pre-modified product from the manufacturer
2. Small boxes are more costly when compared to its precast counterpart however pre cast concretes induction of stacking or steel covers quickly bridge the gap.

USE OF POLYMER CONCRETE ON OLD SURFACE

COLOURED CONCRETE

Coloured concrete can be produced by using coloured aggregates or by adding colour pigments (ASTM C 979) or both.

- If surfaces are to be washed with acid, a delay of approximately two weeks after casting is necessary.
- Coloured aggregates may be natural rock such as quartz, marble, and granite, or they may be ceramic materials.
- synthetic pigments generally give more uniform results.
- The amount of colour pigments added to a concrete mixture should not be more than 10% of the mass of the cement. For example, a dose of pigment equal to 1.5% by mass of cement may produce a pleasing pastel colour, but 7% may be needed to produce a deep colour.
- Use of white portland cement with a pigment will produce cleaner, brighter colours and is recommended in preference to gray cement, except for black or dark gray colours

COLOURED CONCRETE

Chemical Admixtures (ASTM-C494)

Generations / Families of Admixtures:

Lignosulfonate ----------------------- (Plasticizer)

1) Sulfonated Malamine- Formaldehyd
2) Sulfonated Nephthalene Formaldehyde } ***(S.P)***
3) Polyether-polycarboxylates , (High performance S.P)

More effective than others two

- 3rd generation **S.P** are used for pump, flowing and self compacting concrete production

a) High Range Water Reducers (HRWR) like:

Reobuild and Glenium by BASF construction chemicals

b) Viscosity Modifying Admixtures (VMA) like:

Rheomac, by BASF construction chemicals ,

IMPORTANT CHEMICAL ADMIXTURES

1. Plasticizers
2. Super plasticizers
3. Retarders and Retarding Plasticizers
4. Accelerators and Accelerating Plasticizers
5. Air-entraining Admixtures
6. Damp-proofing and Waterproofing Admixtures
7. water retaining (Note: this type is intended to reduce bleeding from concrete);
8. dual function or Multiple admixtures (are included in an amendment to BS EN 934–2)
9. Specialty Admixtures

Table 1: Principal performance requirements for admixtures given in BS EN 934–2

Type of admixture	Performance requirement	Value in BS EN 934–2
Water reducing/plasticizing	Water reduction at equal consistence	Reduction ≥ 5%
High-range water reducing/ superplasticizing	Water reduction at equal consistence Increase in consistence at equal w/c ratio	Reduction ≥ 12% Slump increase ≥ 120 mm
Water retaining	Reduction in bleeding	Reduction ≥ 50%
Water resisting	Reduction in capillary absorption	Reduction ≥ 50% by mass
Air entraining	Air void characteristics in hardened concrete	Spacing factor ≤ 0.200 μm
Set accelerating	Reduction in initial setting time	Reduction ≥ 40% at 5°C

Hardening accelerating	Compressive strength at 1 day Compressive strength at 2 days	Increase ≥ 20% at 20°C Increase ≥ 30% at 5°C
Set retarding	Increase in initial and final setting times	Initial increase ≥ 90 min. Final increase ≤ 360 min.
Set retarding/water reducing/ plasticizing	Water reduction at equal consistence Increase in initial and final setting times	Reduction ≥ 5% Initial increase ≥ 90 min. Final increase ≤ 360 min.
Set retarding/high-range water reducing/super plasticizing	Water reduction at equal consistence Increase in consistence at equal w/c ratio Increase in initial and final setting times at equal consistence	Reduction ≥ 12% Slump increase ≥ 120 mm Initial increase ≥ 90 min. Final increase ≤ 360 min.
Set accelerating/water reducing/plasticizing	Water reduction at equal consistence Reduction in initial setting time	Reduction ≥ 5% Reduction ≥ 30 min. at 20°C and ≥ 40% at 5°C

PLASTICIZERS (WATER REDUCER)

- In general, these chemicals act as dispersants for portland cement particles. By separating and spreading out the cement particles, internal friction is reduced, and slump and workability of the concrete is increased
- Lowering w/cm is a key method for improving durability

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 basic products constituting plasticizers are as follows:

- Anionic surfactants such as lignosulphonates and their modifications and derivatives, salts of sulphonates hydrocarbons.
- Non ionic surfactants, such as polyglycol esters, acid of hydroxylated carboxylic acids and their modifications and derivatives.
- Other products, such as carbohydrates etc.

PLASTICIZERS (WATER REDUCERS)

Amount used

- Plasticizers are used in the amount of 0.1% to 0.4% by weight of cement.

Limitations

- A good plasticizer is one which does not cause air-entrainment in concrete more than 1 or 2%.

Results - effects

- At constant workability –

The reduction in mixing water is expected to be of the order of 5% to 15%.

Naturally increases the strength.

- At constant w/c ratio –

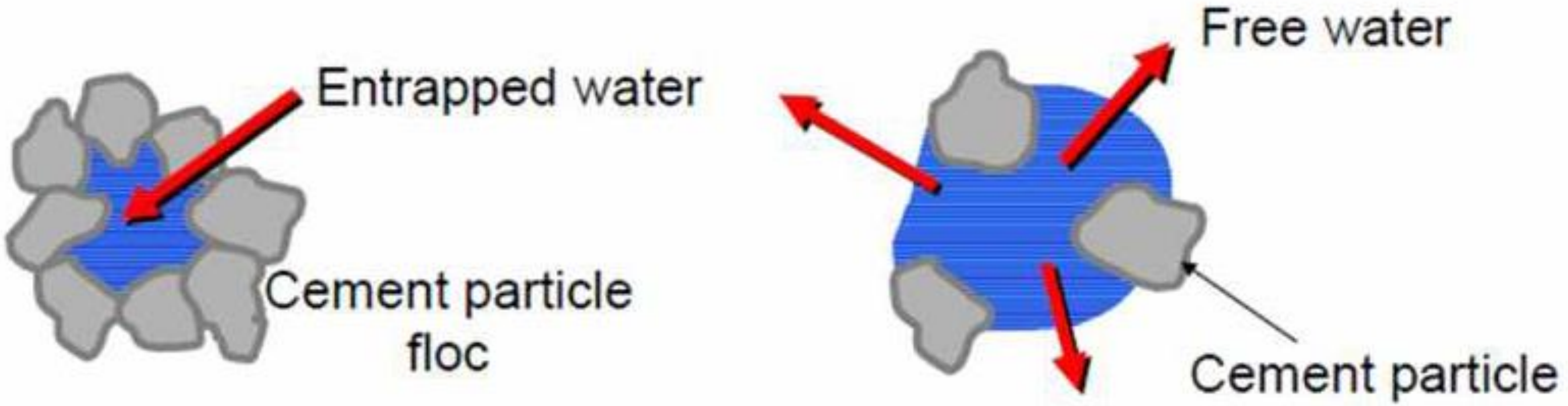
Increased workability.

Slump of 30mm to 150 mm.

Plasticizer

Lignosulphonates- Effectiveness

- Electrostatic inter particle repulsion
- Reduced surface tension
- Retarding the hydration process
- Entrapped water is liberated
- Workability is improved
- Water reduction up to 10%



USED AT:

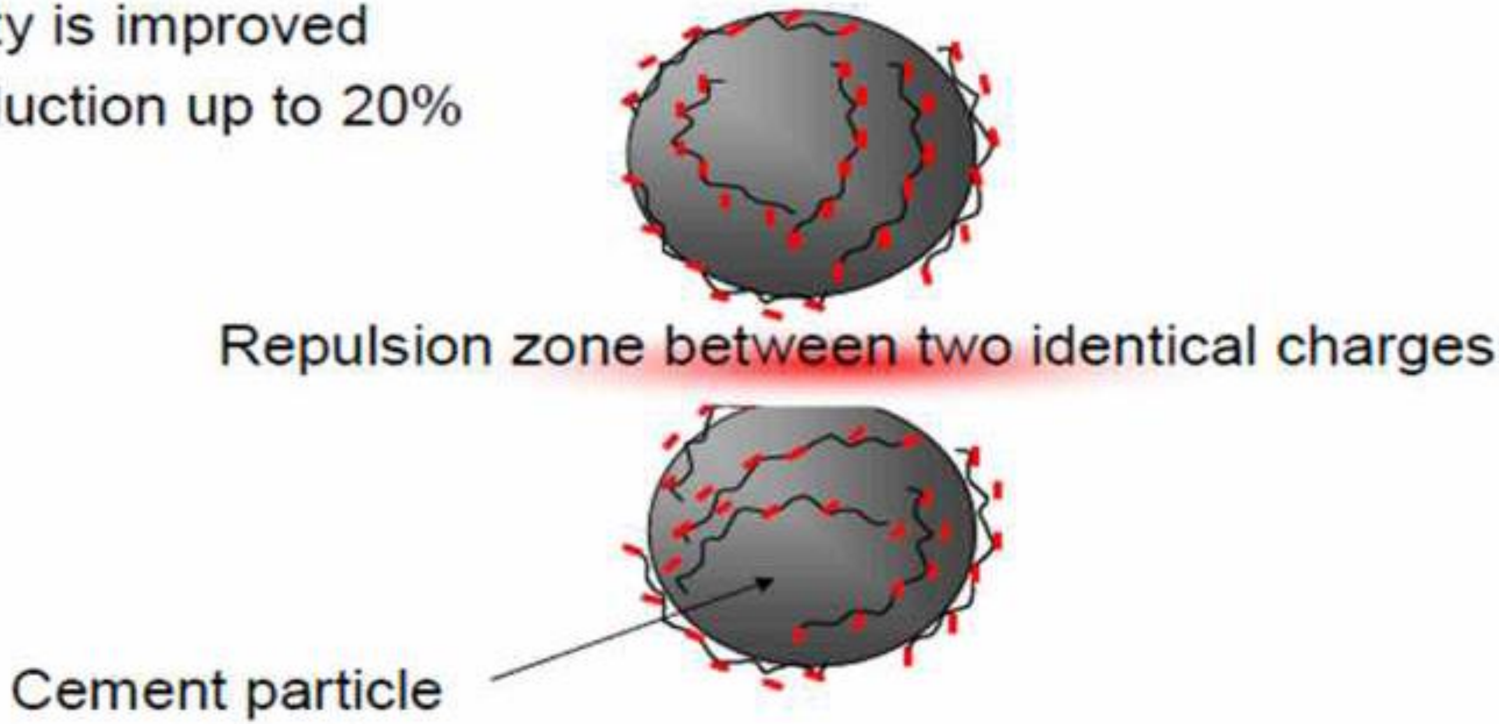
Where high degree of workability is required

1. Thin walls of water retaining structures with high percentage of steel reinforcement
2. Deep beams, column and beam junctions
3. Tremie concreting
4. Pumping of concrete
5. Hot weather concreting
6. Concrete to be conveyed for considerable distance and in ready mixed concrete industries.

Superplasticizers

Naphtalenes and Melamines- Effectiveness

- Electrostatic inter particle repulsion
- Negative charged molecules attach to cement grains and repel each other
- Workability is improved
- Water reduction up to 20%



SUPERPLASTICIZERS

Amount used

- Based on various types of superplasticizers different amount is used.
- Lignosulphonates – not more than 0.25%
- Carboxylic acids – 0.1%
- Sulphonated malanie-formaldehyde condensates (SMF) – 0.5 to 3%
- Sulphonated naphthalene-formaldehyde condensates (SNF) – 0.5 to 3%

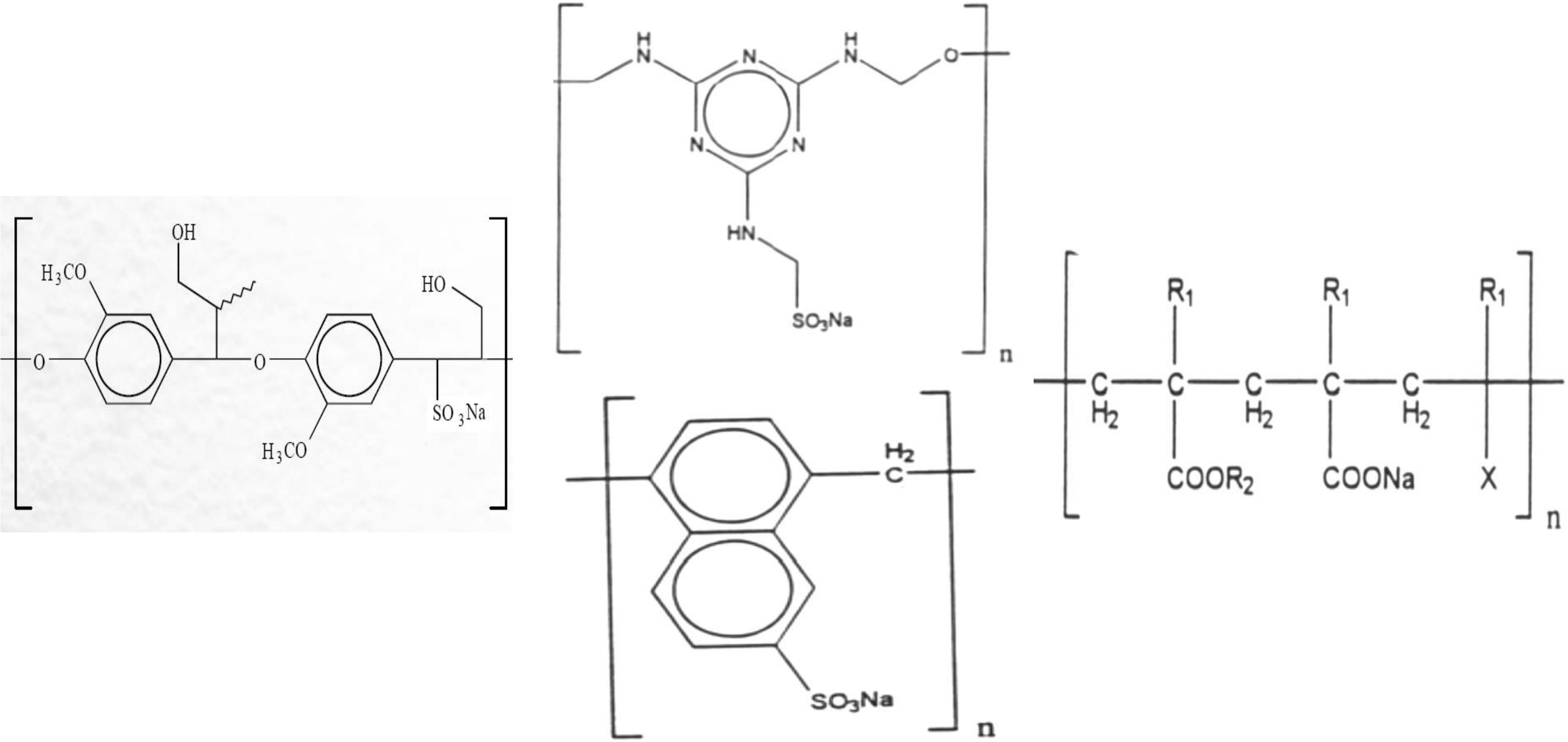
Results - benefits

- Permits reduction of water content about 30% without reducing the workability
- It is possible to use w/c ratio as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of order 120 Mpa or more.

Superplasticizer is practiced for:

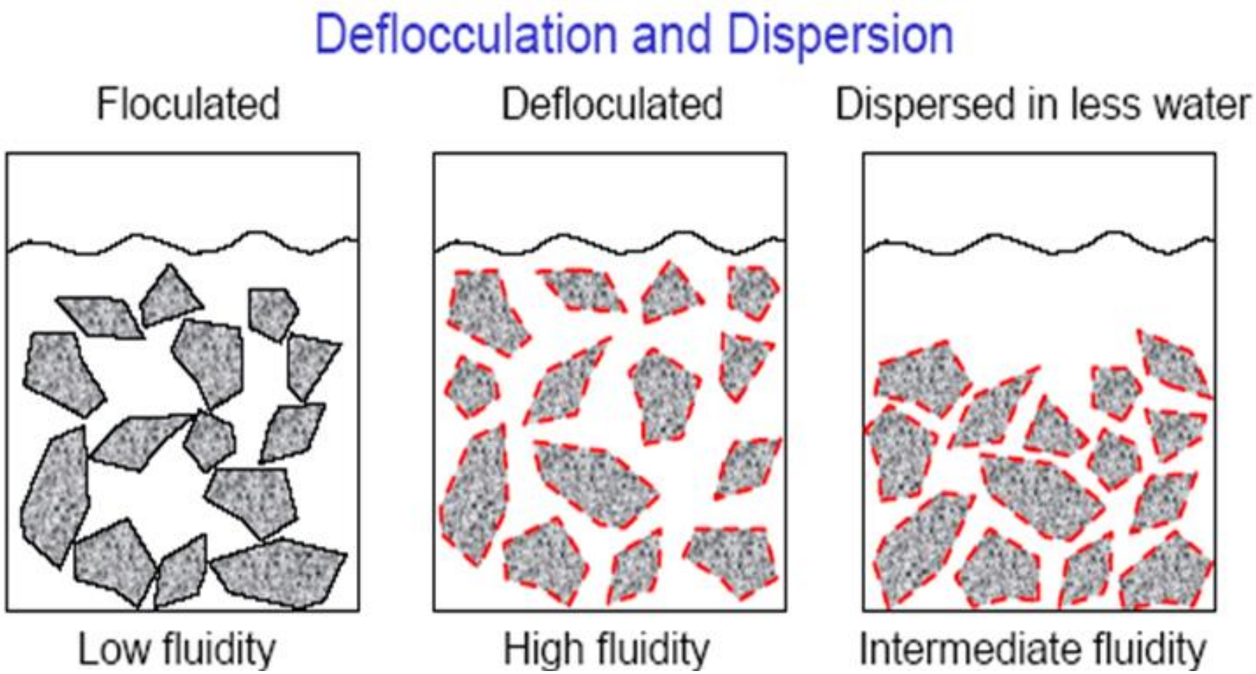
- Production of flowing, self levelling, self compacting concrete
- Production of high strength and high performance concrete.

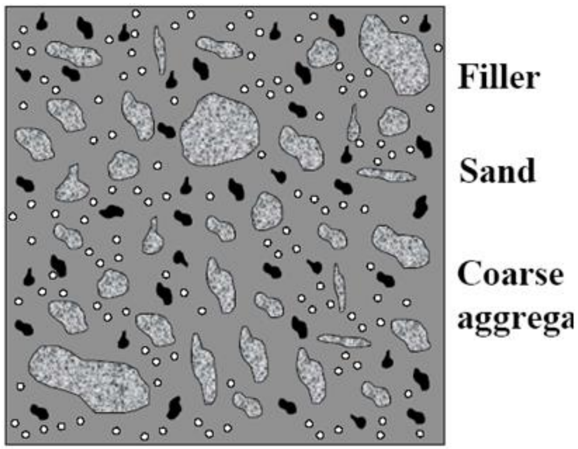
Molecular structures for HRWRs

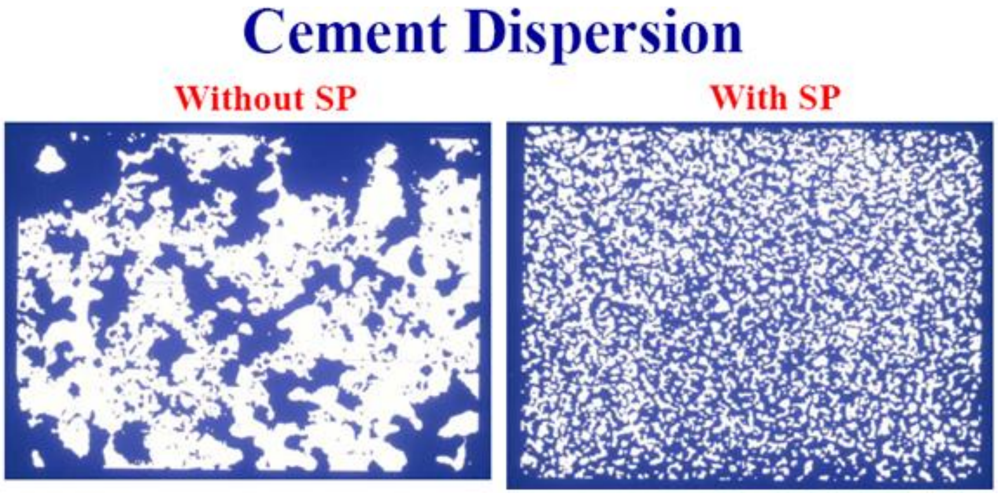


Molecular structures of (a) Ligno sulfate b) SMF & SNF and (c) PCE- where R_1 stands for H or CH_3, R_2 for polyethylene oxide and X is a polar or ionic group

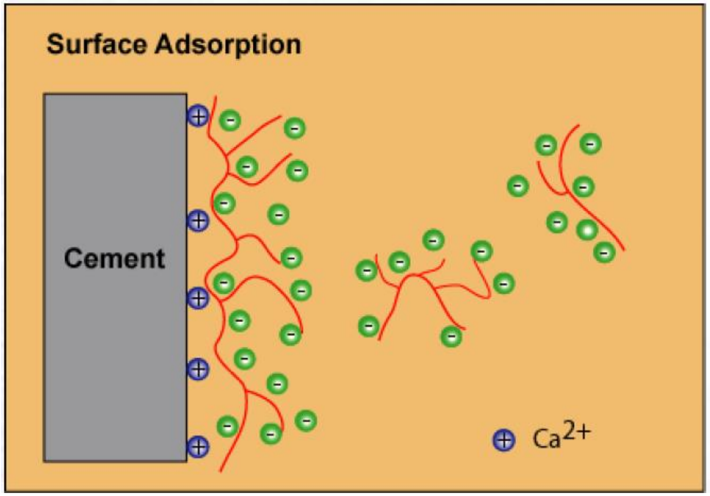
Working mechanism of SP



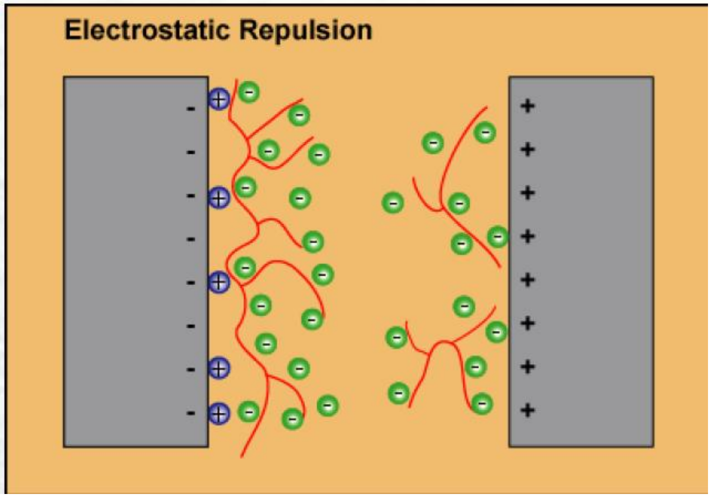




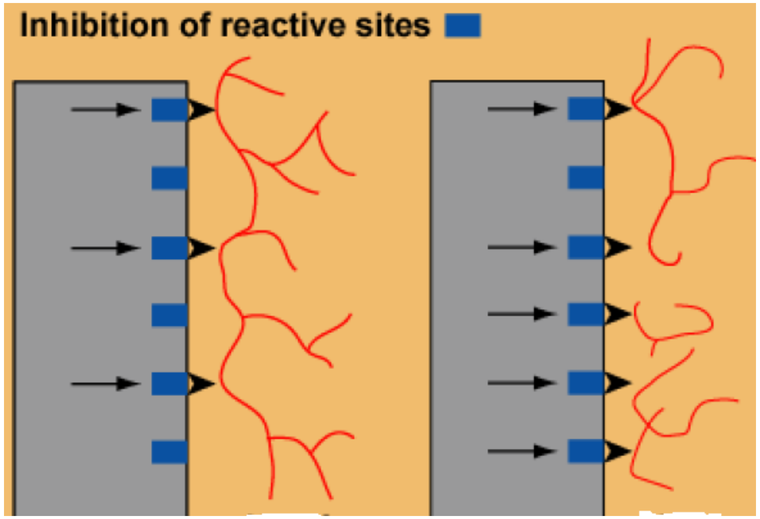
Mechanism of Action in general



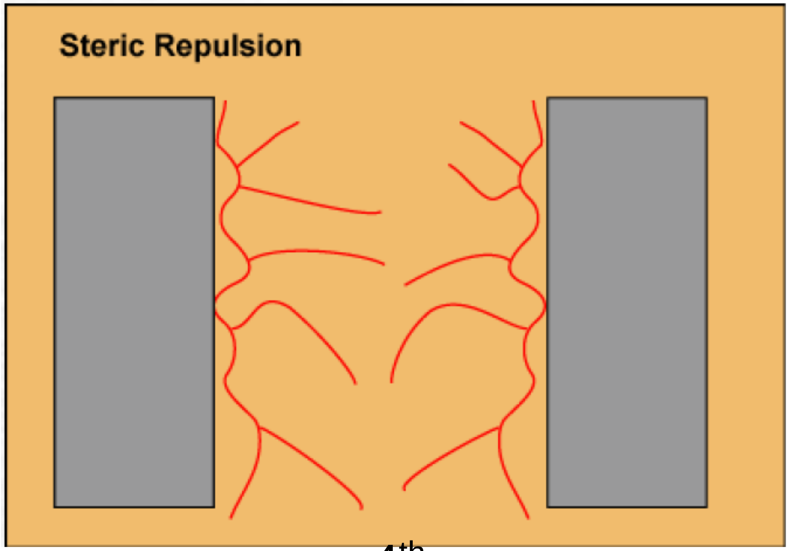
1st



2nd



3rd



4th

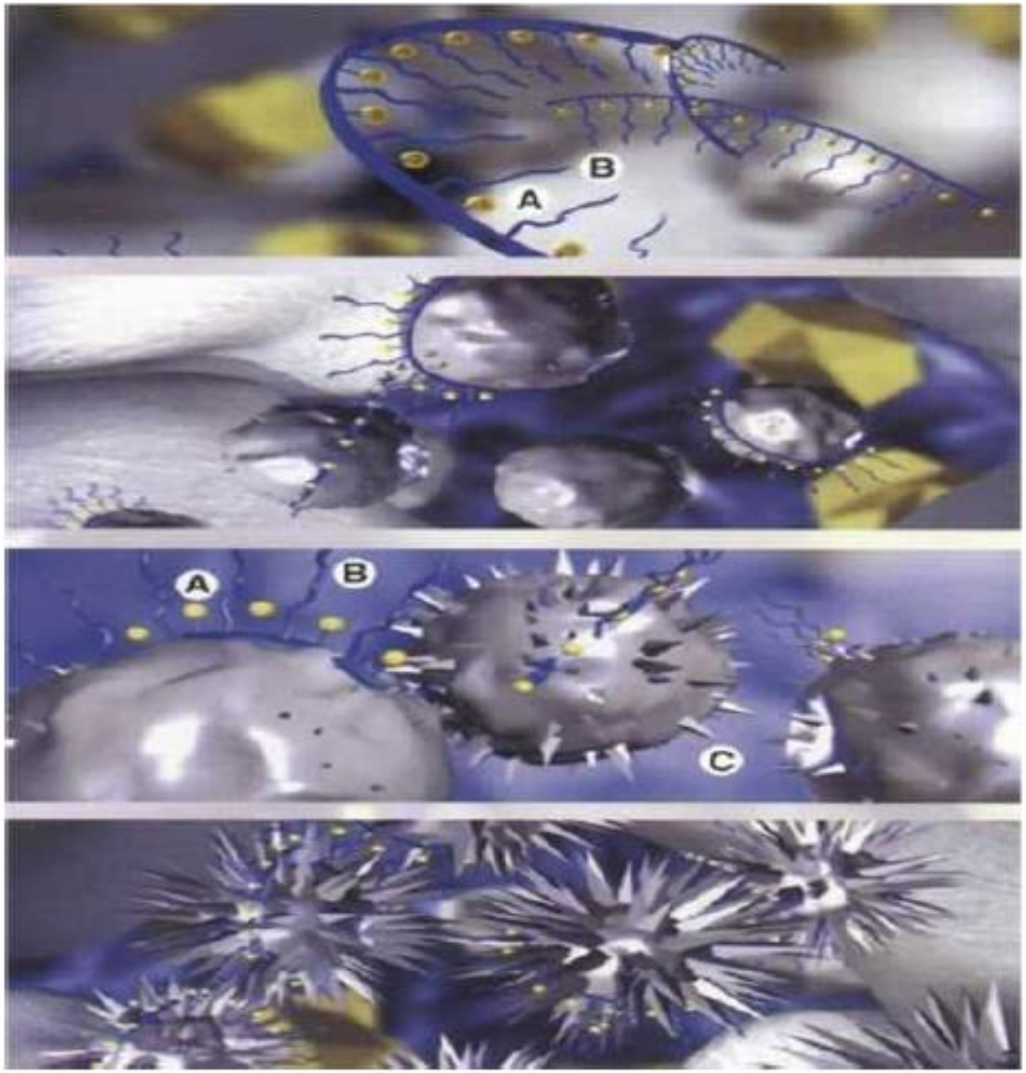
High Performance Superplasticiser (HPSP)

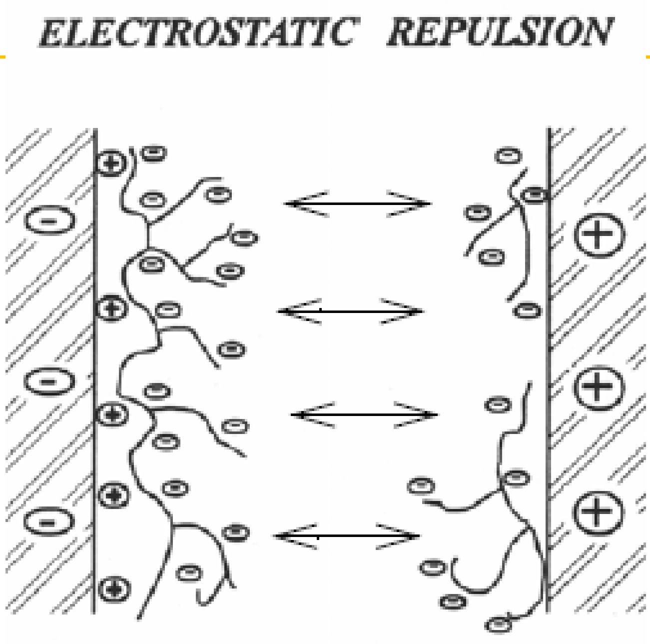
Polycarboxylate ether

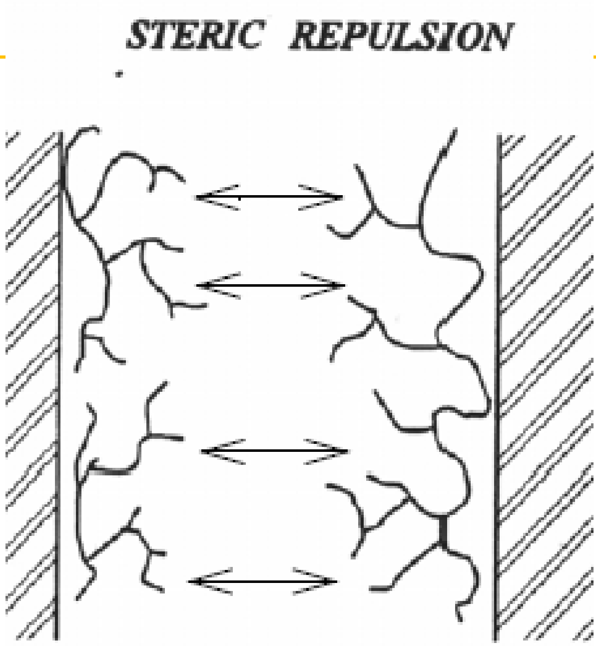
Cement Hydration

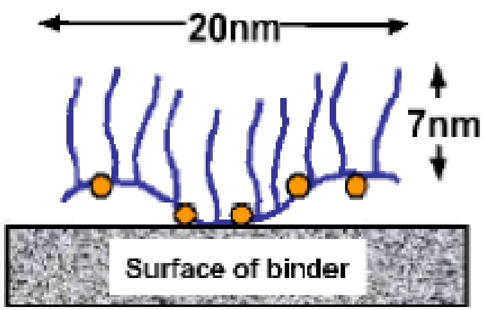
Dispersion effect (A)

Steric effect (B)

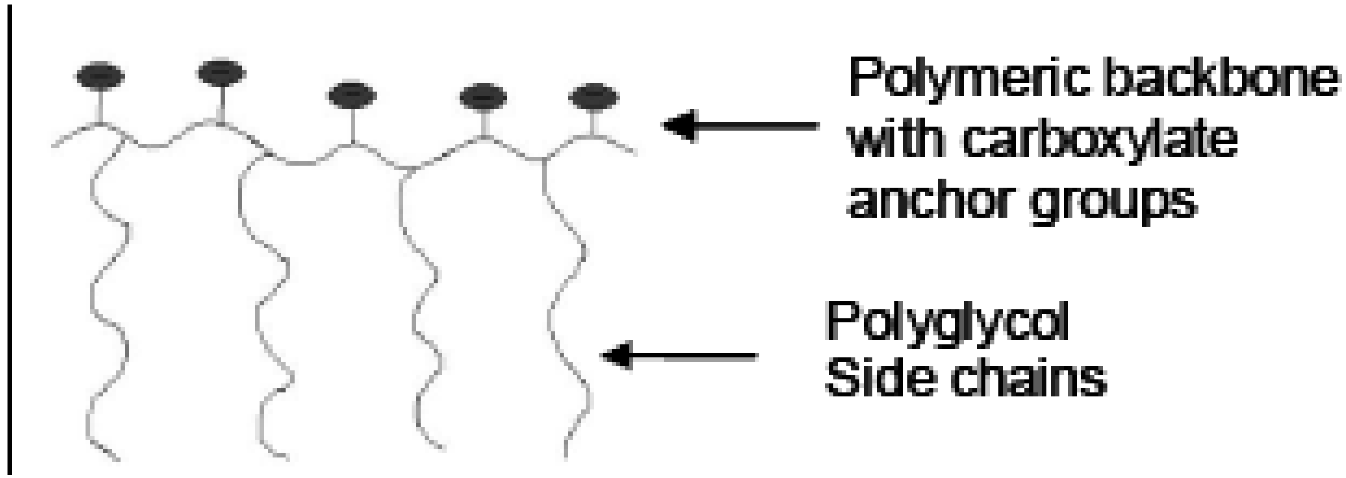


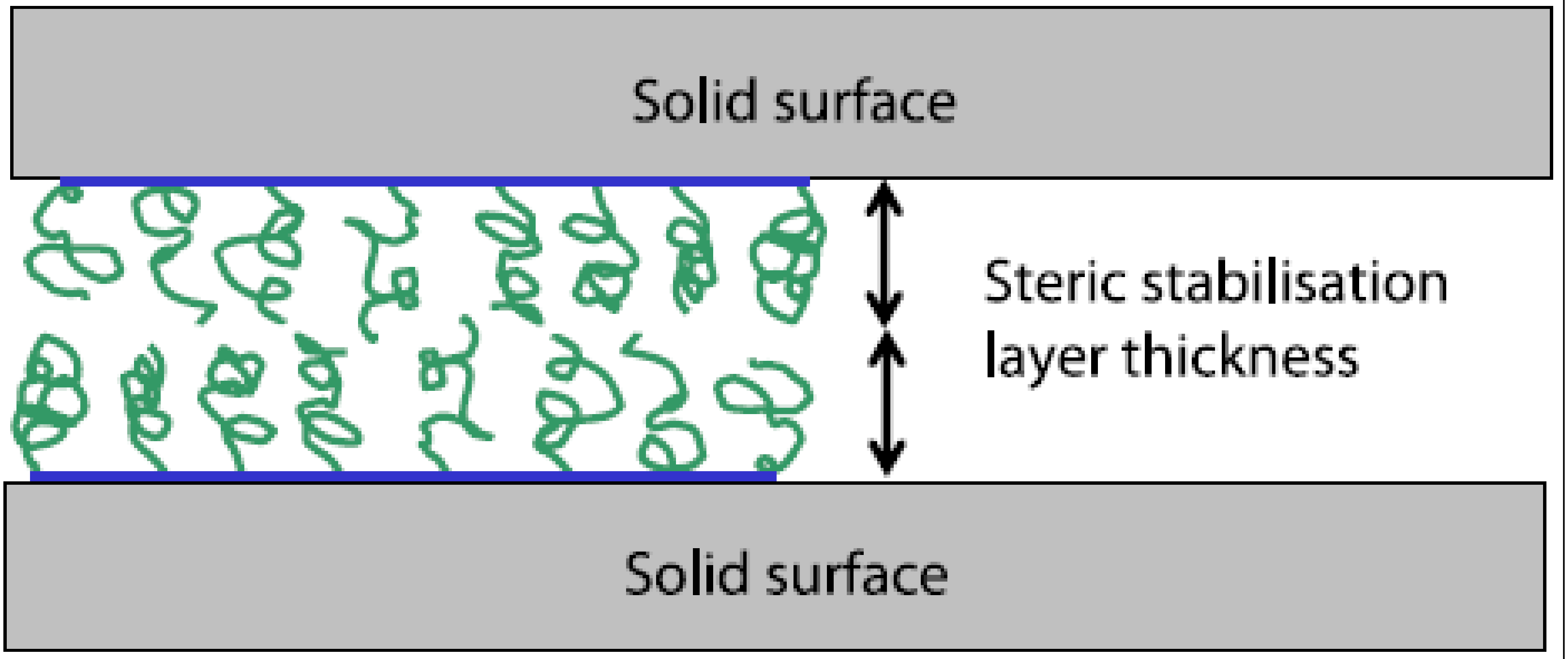






c) Stable conformation on binder surface

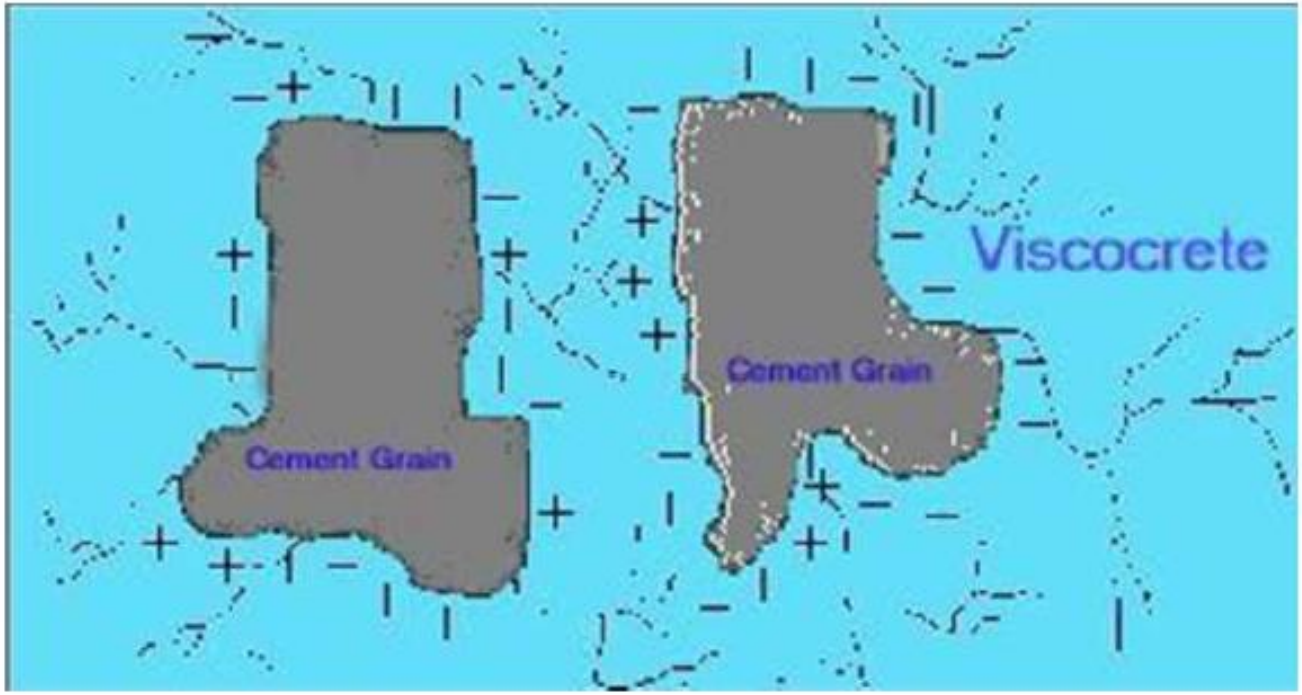




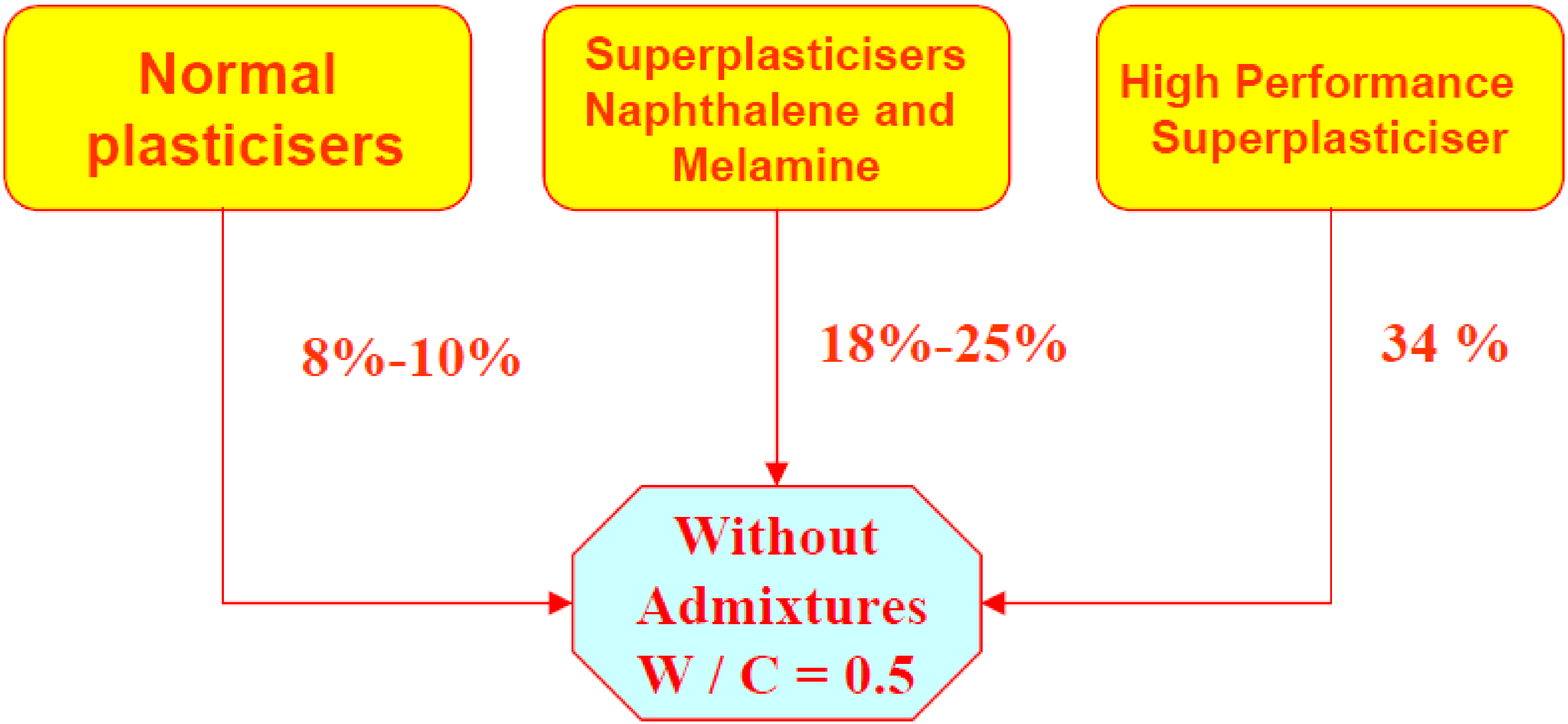
Repulsion of adsorbed superplasticiser disperses the cement particles.

HIgh Performance SuperplastIcIser How It Is work ?

Based on Japanese technology blended with property enchancing Polymers, High Performance Superplasticiser works by mean of electrostatic repulsion and steric hindrance .



Water Reduction in Concrete Using Different Admixtures



Flowing Concrete

RETARDER

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.

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

Amount used and effects

RETARDERS

Admixture addition litres/ 50 kgs	Setting time hrs.		W : C ratio	Compressive Strength MPa		
	Initial	Final		3 days	7 days	28 days
0	4.5	9	0.68	20	28	37
0.14	8.0	13	0.61	28	36	47
0.21	11.5	16	0.58	30	40	50
0.28	16.0	21	0.58	30	42	54

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 percent 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.

ACCELERATOR:

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

Why accelerators?

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

Commonly used materials as an accelerator:

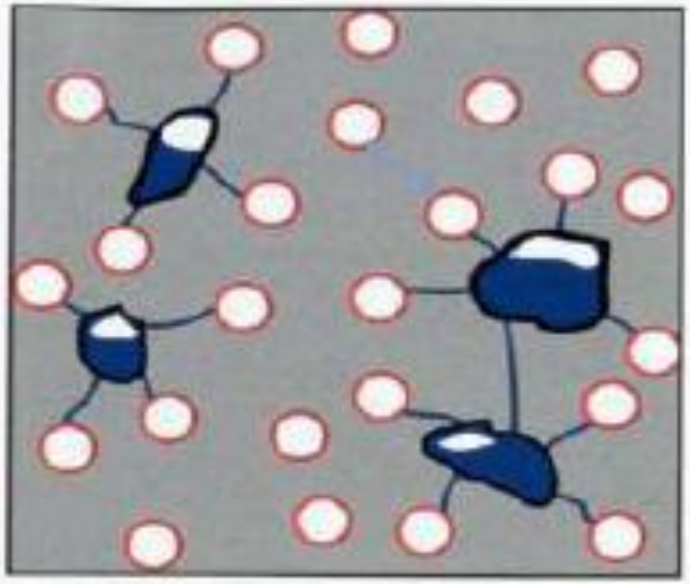
- ✓ Calcium chloride (Not used now)
- ✓ Some of the soluble carbonates
- ✓ Silicates fluosilicates (Expensive)
- ✓ Some of the organic compounds such as triethenolamine (Expensive)

- Accelerators 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.

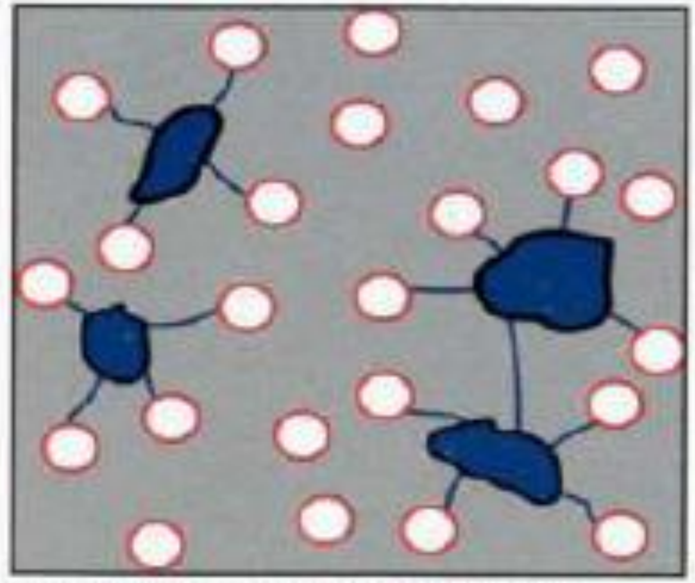
AIR ENTRAINING ADMIXTURES

One of the important advancements made in concrete technology was the discovery of air entrained concrete. (was made during the 1930s)

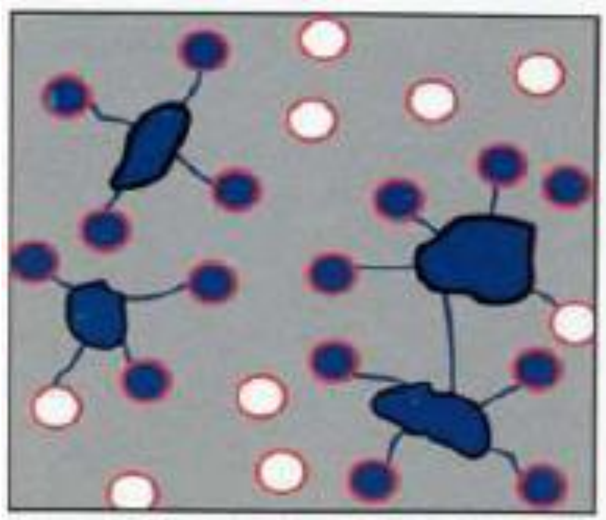
- In the United States and Canada, due to the recognition of the merits of air entrained concrete, about 85% of concrete manufactured in America contains one or the other type of air entraining agent. By mixing a small quantity of air entraining agent or by using air entraining cement.
- Minute spherical bubbles of size ranging from 5 microns to 80 microns distributed evenly in the entire mass of concrete. (10 and 1000 mm in ACI)
- the spacing factor should not be greater than 0.2 mm



As temperatures drop, pores created by air entrainment allow the water a place to go as it freezes.

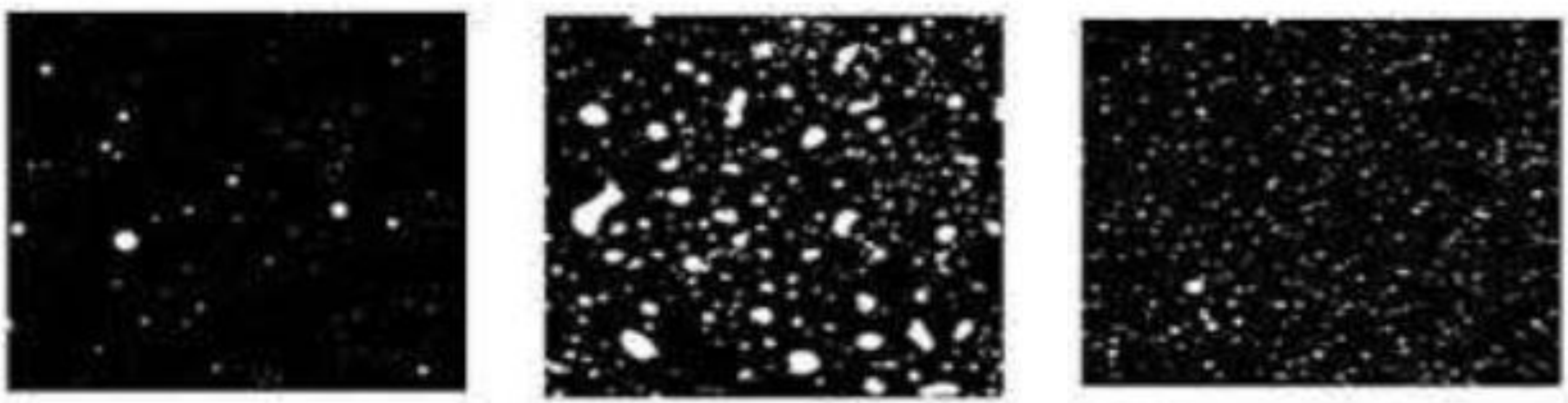


During freezing, water in the capillary pores expands; however, water is also going toward air-entrained pores.



Under pressure, the water will be pushed into the air entrainment pores and not crack the concrete matrix.

- 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.
- It also modifies the properties of hardened concrete regarding its resistance to frost action and permeability



Reference:
Few randomly distributed air-voids

AE:
Large-size evenly distributed air-voids

PMHS:
Small evenly distributed air-voids

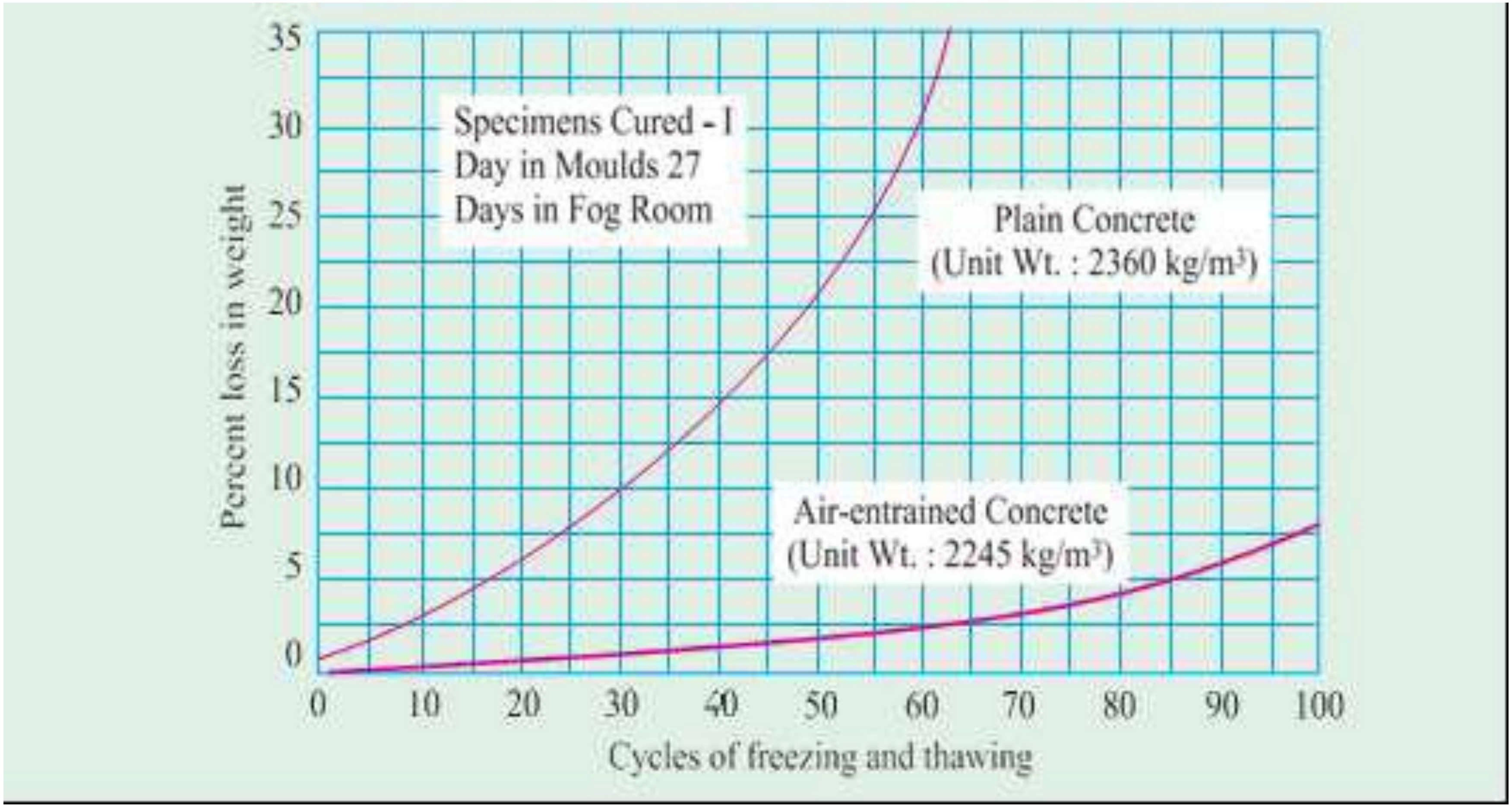
The following types of air entraining agents are used for making air entrained concrete.

- 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, hydrogenperoxide and aluminium powder, etc.
- Vinsol resin and Darex are the most important air-entraining agents.

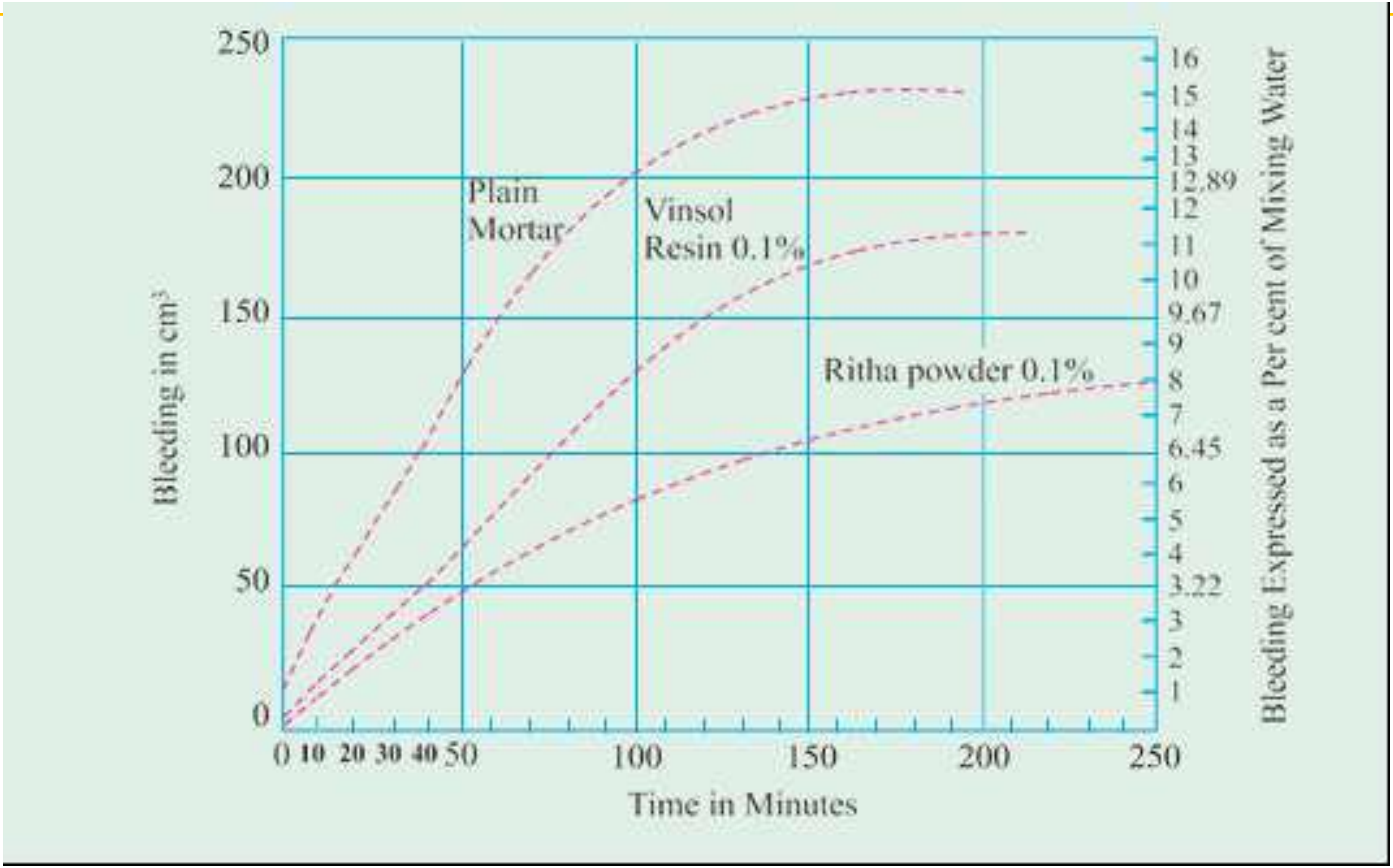
The Effect of Air Entrainment on the Properties of Concrete

1. Increased resistance to freezing and thawing.
2. Improvement in workability and pumpability
3. Reduction in strength.
4. Reduces the tendencies of segregation.
5. Reduces the bleeding and laitance.
6. Decreases the permeability.
7. Increases the resistance to chemical attack.
8. Permits reduction in sand content.
9. Improves place ability, and early finishing.
10. Reduces the cement content, cost, and heat of hydration.
11. Reduces the unit weight.
12. Permits reduction in water content.
13. Reduces the alkali-aggregate reaction.
14. Reduces the modulus of elasticity.

Effect on freezing and thawing



Effect on bleeding



DAMP PROOFING & WATER PROOFING ADMIXTURES

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.

(permeability-reducing admixture for hydrostatic conditions (PRAH)

- Secondly, to the absorption of surface water by capillary action.

(Permeability reducing admixture for non-hydrostatic conditions (PRAN).

DAMP PROOFING & WATER PROOFING ADMIXTURES

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- & WATERPROOFING

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

- One method that can simplify the protective process is to make concrete with admixtures that reduce its permeability—in effect to make the concrete itself waterproof.
- These consists of hydrophobic, or water-repellent, chemicals derived from soaps or fatty acids, vegetable oils, and petroleum.

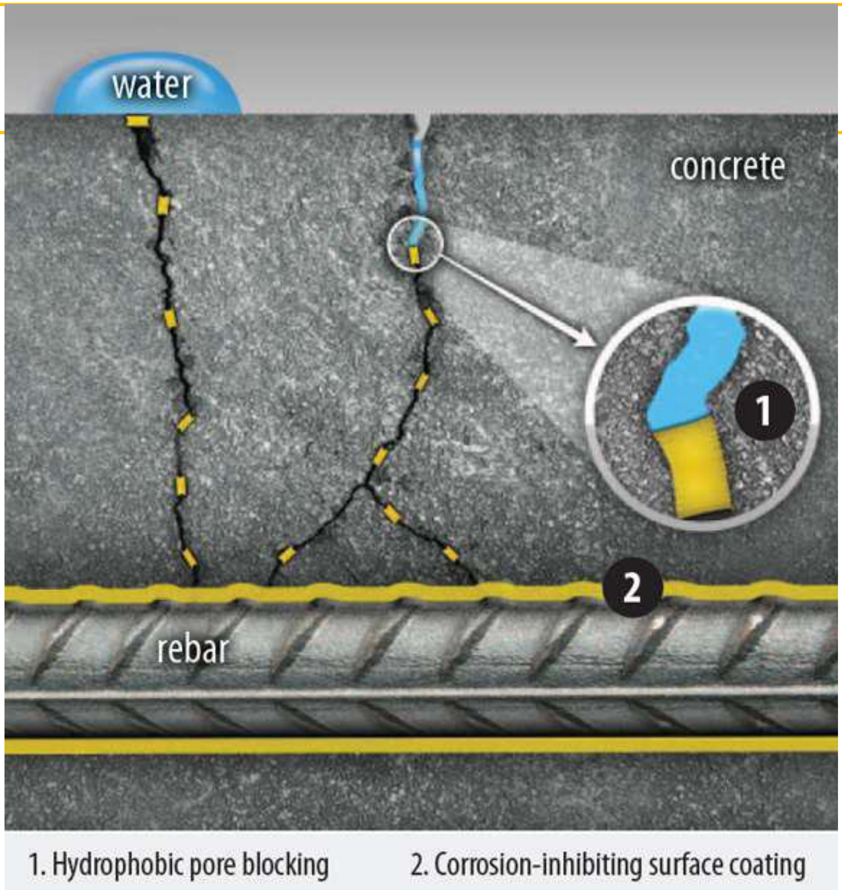
CORROSION INHIBITING ADMIXTURES

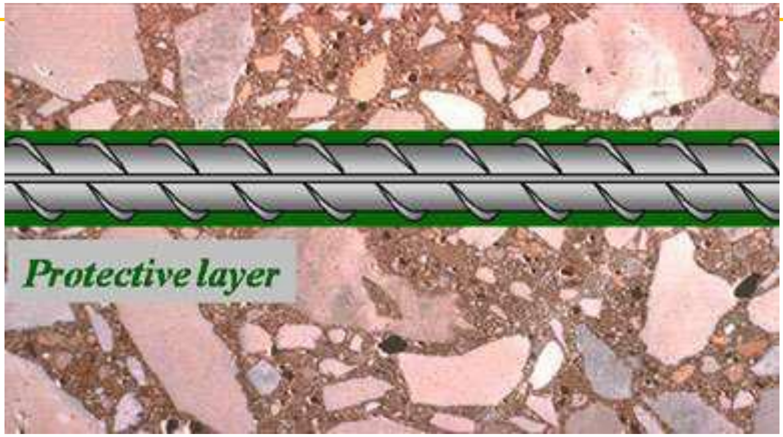
- Reinforcing steel corrosion is a major concern with regard to the durability of reinforced concrete structures. Each year, numerous bridges, parking garages, and other concrete structures undergo extensive repair and rehabilitation to restore their structural integrity as a result of corrosion damage.
- There are several ways of combating chloride-induced corrosion, one of which is the use of corrosion inhibiting admixtures
- they protect embedded reinforcement by delaying the onset of corrosion and also by reducing the rate of corrosion after initiation
- inorganic materials such as calcium nitrite, and organic materials such as amines and esters

CORROSION INHIBITING ADMIXTURES

- Calcium nitrite resists corrosion by stabilizing the passive layer in the presence of chloride ions
- Organic inhibitors function by forming a protective film at the surface of the steel to help resist moisture and chemical attack.

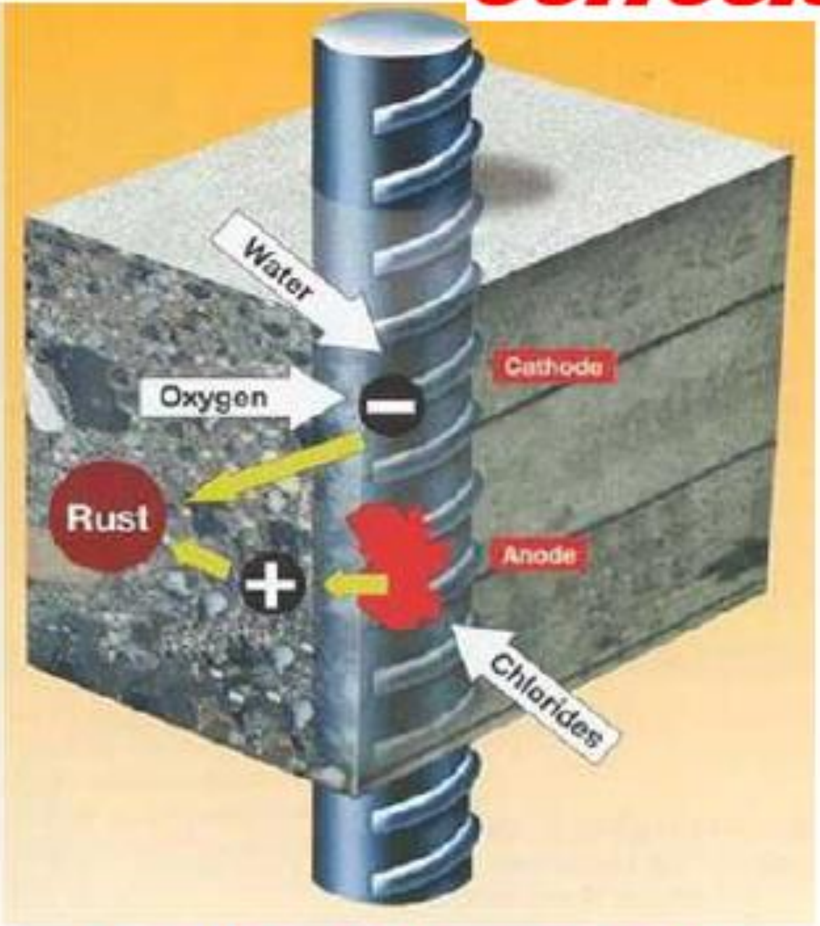
- Some available corrosion inhibitors will accelerate the time of set in concrete and therefore retarding admixtures may be necessary to improve working time
- corrosion resistance can also be increased by reducing the permeability of the concrete through the use of low *w/cm (possibly with the aid* of a HRWR admixture) or with a permeability reducing admixture


water
concrete
1
2
rebar
1. Hydrophobic pore blocking
2. Corrosion-inhibiting surface coating

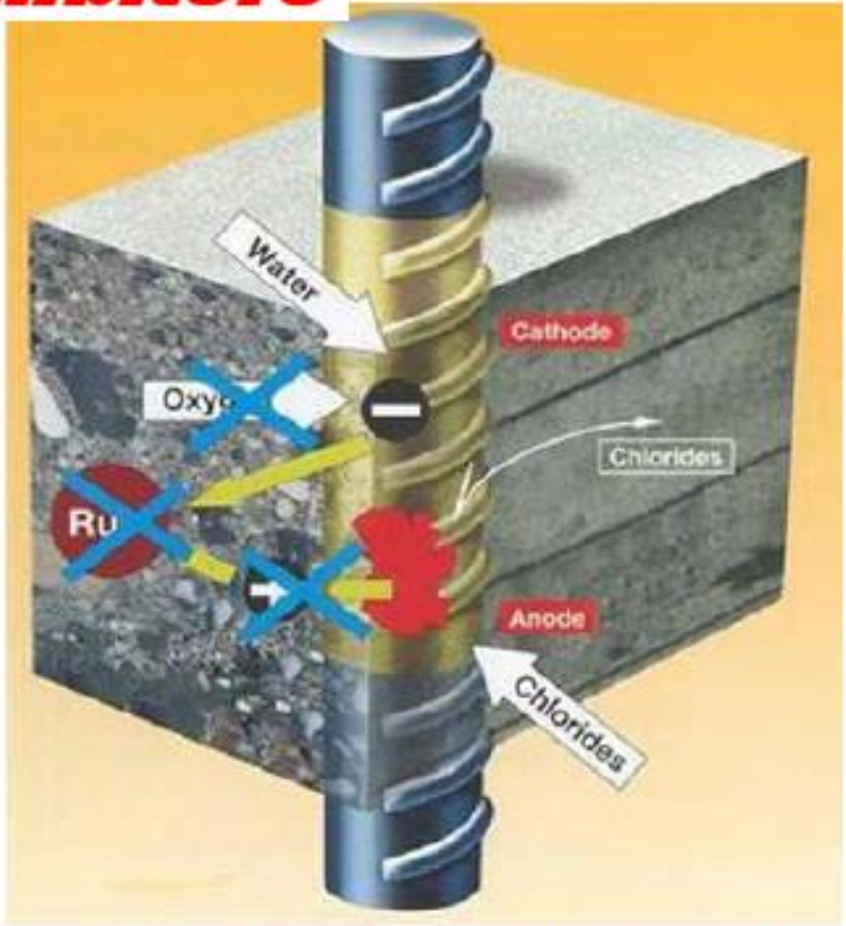

Protective layer


KRYTON KIM (2%)
XYPEX ADMIX C-2000 (2%)

Corrosion Inhibitors



Condition for Corrosion and Damage exit .



Corrosion are greatly reduced by the effect of Corrosion Inhibitors .

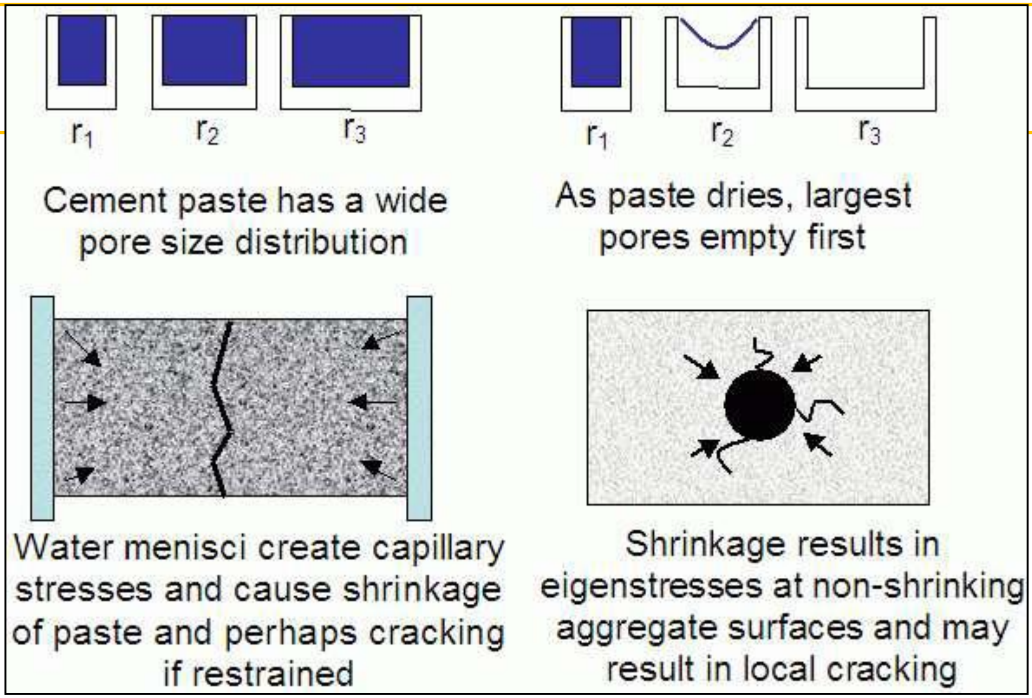
SHRINKAGE REDUCING ADMIXTURE

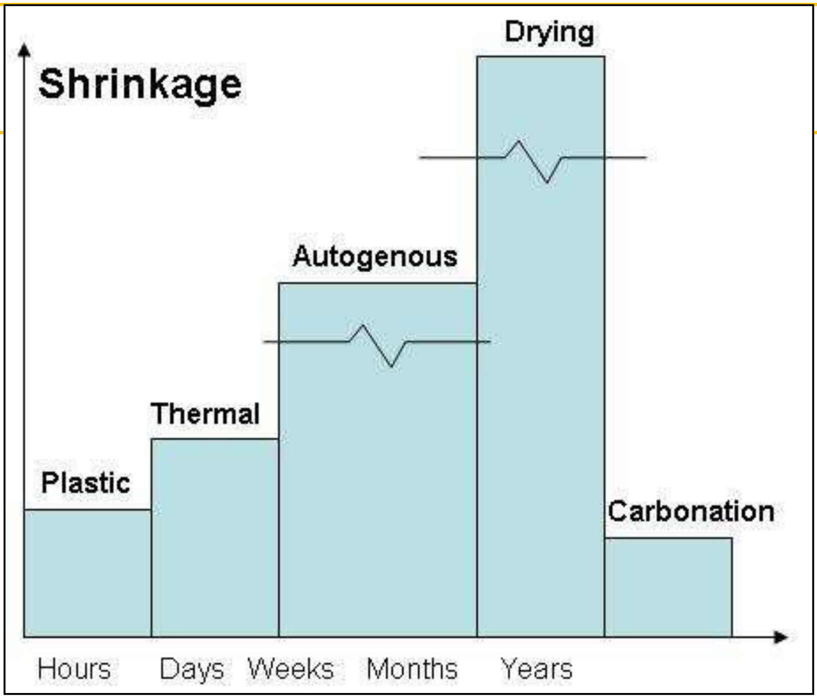
- The loss of moisture from concrete as it dries results in a volume contraction called drying shrinkage
- Drying shrinkage tends to be undesirable when it leads to cracking due to either internal or external restraint
- The magnitude of drying shrinkage can be reduced by minimizing the unit water content of a concrete mixture, using good-quality aggregates, and using the largest coarse aggregate size and content consistent with the particular application.

In addition, admixtures have been introduced to help further reduce drying shrinkage

SHRINKAGE REDUCING ADMIXTURE

- These are based on organic materials such as propylene glycol or related compounds that reduce the surface tension of water in the capillary pores of concrete, thereby reducing the tension forces within the concrete matrix that lead to drying shrinkage
- Manufacturer's recommendations should be followed with regard to dosage and suitability of shrinkage-reducing admixtures for use in freezing-and thawing environments.

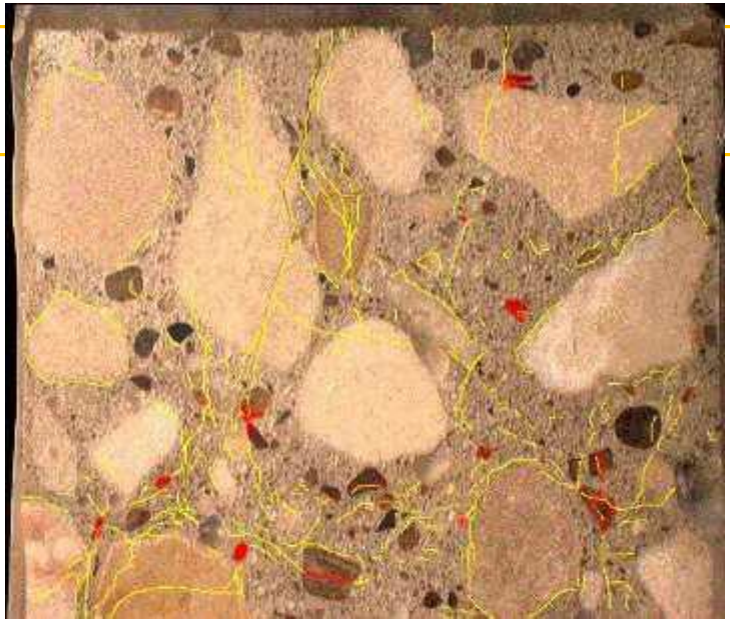

r1 r2 r3
Cement paste has a wide pore size distribution
r1 r2 r3
As paste dries, largest pores empty first
Water menisci create capillary stresses and cause shrinkage of paste and perhaps cracking if restrained
Shrinkage results in eigenstresses at non-shrinking aggregate surfaces and may result in local cracking


Shrinkage
Drying
Autogenous
Thermal
Plastic
Carbonation
Hours
Days
Weeks
Months
Years

ASR CONTROLLING ADMIXTURE

- Alkali-silica reactivity (ASR) is a destructive reaction between soluble alkalis in concrete and reactive silica in certain types of aggregate.
- Reactive forms of silica will dissolve in the highly alkaline pore solution, and then react with sodium or potassium ions to produce a water-absorptive gel that expands and fractures the concrete.
- ASR can be mitigated by using low-alkali cement, sufficient amounts of pozzolans or slag cement, and if economically feasible, non-reactive aggregates.

Alternatively, ASR can be mitigated by using lithium-based chemical admixtures



Wall built with ASR susceptible aggregate showing ASR gel extruding from the cracks

Polished slab of concrete showing cracks through aggregate particles and paste (stained yellow) and alkali-silica reaction gel (stained red).

- Lithium compounds are effective at reducing ASR because if lithium ions are present in a sufficient ratio to sodium and potassium, they will preferentially react with silica to form non-absorptive lithium silicates. The required dose of lithium admixture is calculated based on the alkali content of the concrete to supply the correct ratio of lithium to other alkalis.
- Lithium admixtures can accelerate the time of set in concrete. Commercially available retarding admixtures are used when increased working time is needed

UNDERWATER CONCRETE ADMIXTURES

Placing concrete underwater can be particularly challenging because of the potential for washout of the cement and fines from the mixture, which can reduce the strength and integrity of the in-place concrete

- Although placement techniques, such as tremies, have been used successfully to place concrete underwater.

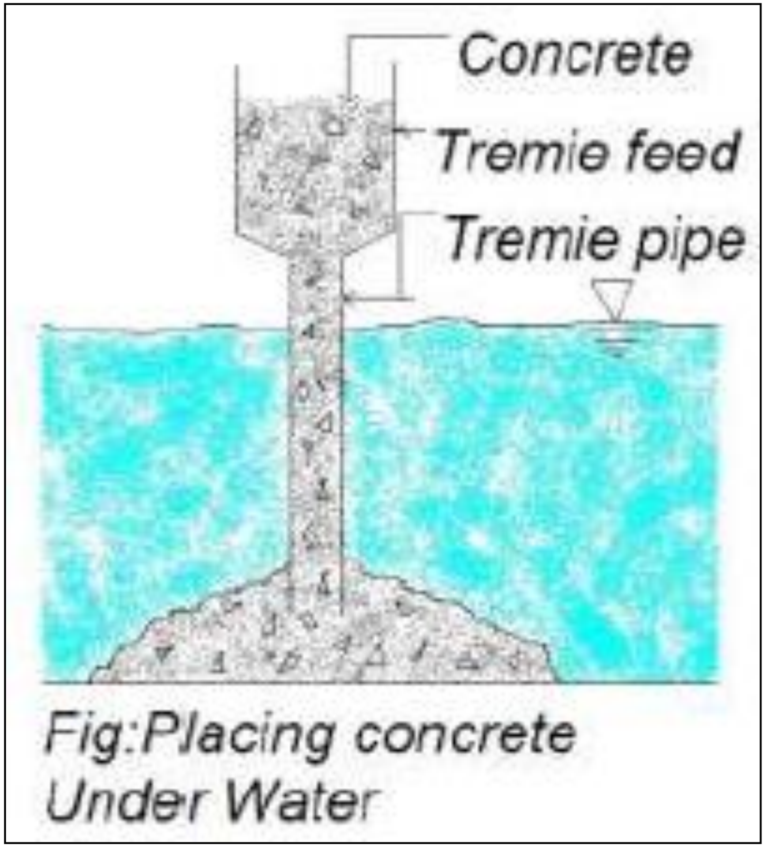
there are situations where enhanced cohesiveness of the concrete mixture is required,

necessitating the use of an antiwashout or **viscosity modifying admixture** (VMA).

UNDERWATER CONCRETE ADMIXTURES

- Some of these admixtures are formulated from either cellulose ether or Whelan gum, and they work simply by binding excess water in the concrete mixture, thereby increasing the cohesiveness and viscosity of the concrete.
- The overall benefit is a reduction in washout of cement and fines, resistance to dilution with water as the mixture is placed, and preservation of the integrity of the in-place concrete
- Another use of VMAs is to prevent segregation in high-slump concrete, SCC, or mixtures deficient in fines

UNDERWATER CONCRETE ADMIXTURES



APPLICATION CONSIDERATION AND COMPATIBILITY

- Admixture dispensing systems are complex, using parts made of different materials. Therefore, the admixture dispensed through this system should be chemically and operationally compatible with these materials.
- The basic rules of application and injection are that the admixtures should not be mixed together. Table 3contains some suggested practices for admixture sequencing. Other sequencing practices may be used if test data supports the practice.

APPLICATION CONSIDERATION AND COMPATIBILITY

Table 3—Suggested Admixture Sequencing Practices

ADMIXTURES	INJECTION SEQUENCE
Air-entraining admixture	With early water or on sand
Water-reducing admixtures	Follow air-entraining solution
Accelerating admixtures	With water, do not mix with air-entraining admixture
High-range, water-reducing admixtures	With the last portion of the water at the batch plant
Polycarboxylate high-range, water-reducing admixtures	With early water or with the last portion of the water at the batch plant
Other admixtures types	Consult manufacturer

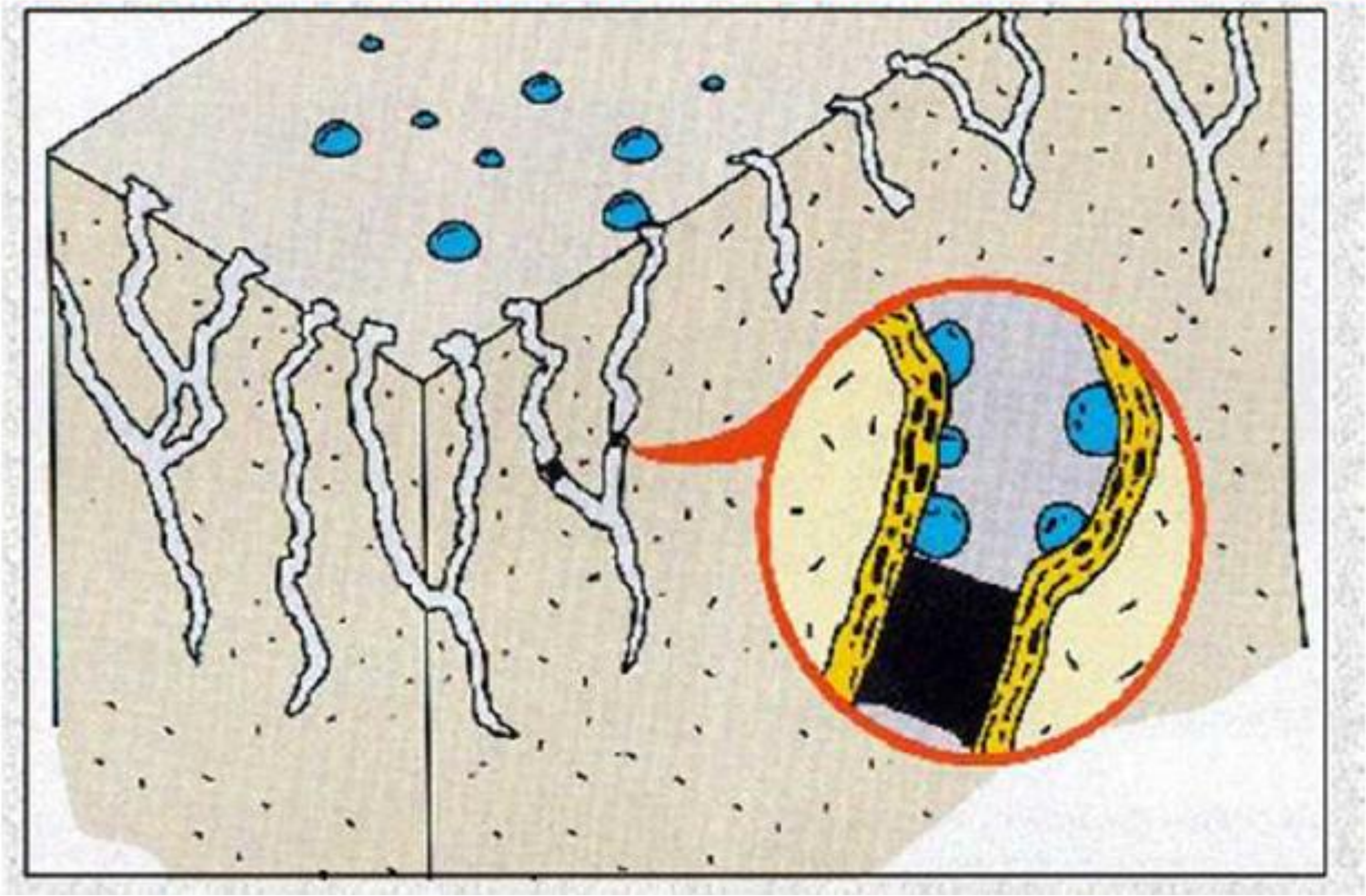
GROUTING ADMIXTURES

It is a powder admixture which can be used for making neat cementitious grouts. It comprises a water reducing / plasticising agent and a gas producing expansion medium.

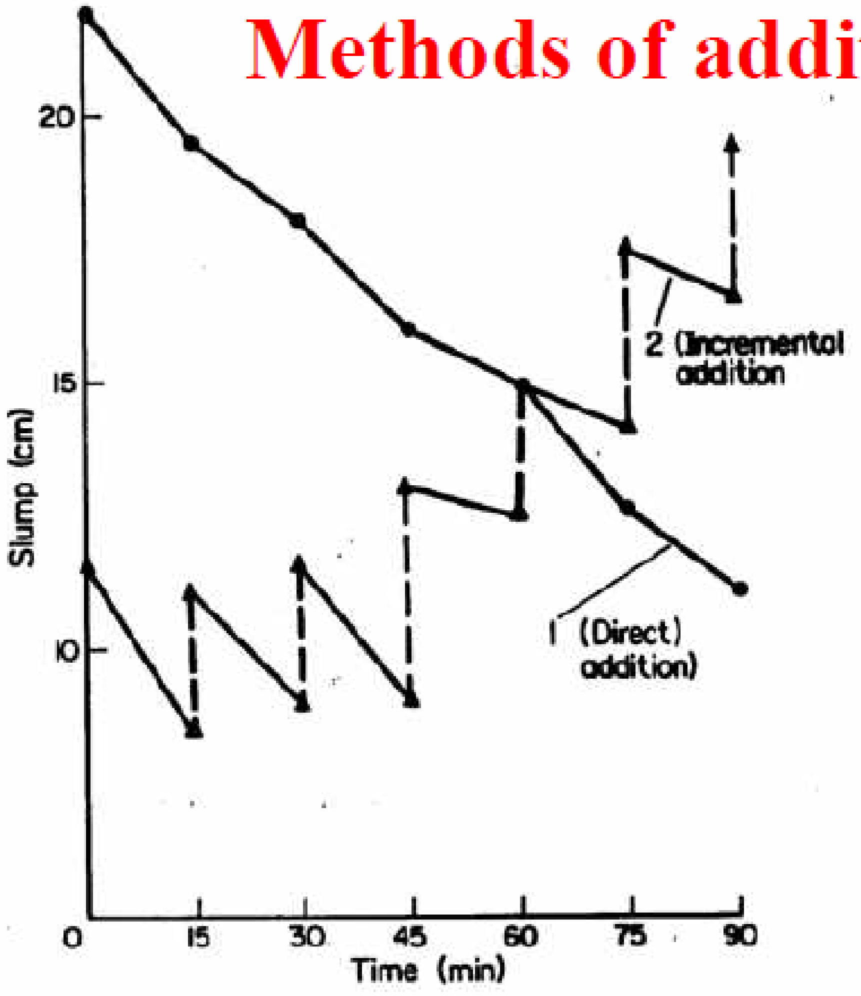
ADVANTAGES

- Higher Strength
- Higher fluidity
- Lower permeability
- Reduced bleeding

Pore Blocker Swells in Concrete Capillaries



Methods of addition of Superplasticizers



It may be advantageous to add the superplasticizers to the mix in two, or even three, operations. Such re-dosage, is possible if an agitator truck is used to deliver the concrete to site.

Fig. 1.44 Workability can be maintained for a longer time by incremental additic of a superplasticizer.