

## Chemical Admixtures



*Presentation by-*

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**Sika Corporation**

## Admixtures

Admixtures are those ingredients in concrete other than cement, water, and aggregates that are added to the mixture immediately before or during mixing to give the concrete special properties.



# Reasons For Using Admixtures



- ▲ Increase Strength
- ▲ Improve Mix Workability
- ▲ Improve early strengths
- ▲ Control set time
- ▲ Reduce Permeability
- ▲ Control Efflorescence
- ▲ Improve Color Vibrancy
- ▲ Meet Durability Requirements
- ▲ Control Shrinkage
- ▲ Improve mix economics

## Admixture Types

- ▲ Water-Reducers
- ▲ Accelerators
- ▲ Retarders
- ▲ Air Entrainment
- ▲ Specialty
  - ▲ Viscosity Modifiers
  - ▲ Corrosion Inhibitors
  - ▲ Anti Wash-out
  - ▲ ASR Controlling
  - ▲ Shrinkage Reducers
  - ▲ Water-Repellent Admixtures...etc
- ▲ Manufactured concrete products (MCP) Admixtures



## ASTM Classification of admixtures

- ▲ ASTM C 494
  - ▲ Type A – Water reducer
  - ▲ Type B – Retarding admixture
  - ▲ Type C – Accelerating admixture
  - ▲ Type D – Water reducing and retarding
  - ▲ Type E – Water reducing and accelerating
  - ▲ Type F – High range water reducer
  - ▲ Type G – High range water reducing and retarding admixture
  
- ▲ Air entraining admixtures (ASTM C 260)



# Water Reducers



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## Water Reducers

▲ Definition as per ACI 116.R-2:

Admixtures that either increase slump of freshly-mixed mortar or concrete without increasing water content OR maintain slump with a reduced amount of water, the effect being due to factors other than air entrainment.

▲ Benefits:

- ▲ Increase in strength
- ▲ Increase in workability
- ▲ Cement reduction



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# Water Reducer- Types

- ▲ Lignosulfonates
- ▲ Naphthalene based (SNF)
- ▲ Melamine based (SMF)
- ▲ Vinyl Copolymers
- ▲ Polycarboxylate based







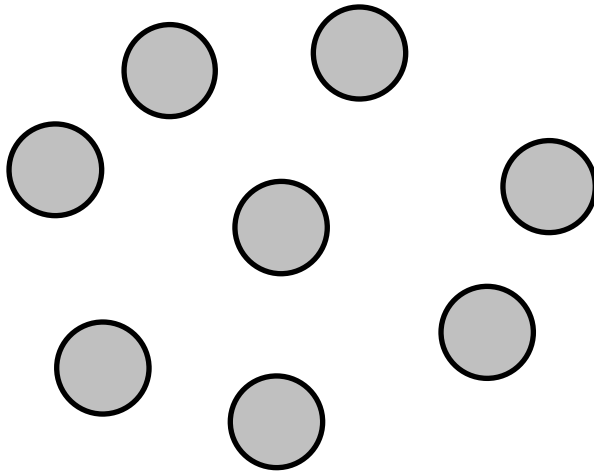
**.40 w/c ratio  
695lbs cement  
NO ADMIXTURES**

**.40 w/c ratio  
Water Reducer  
3" Slump**

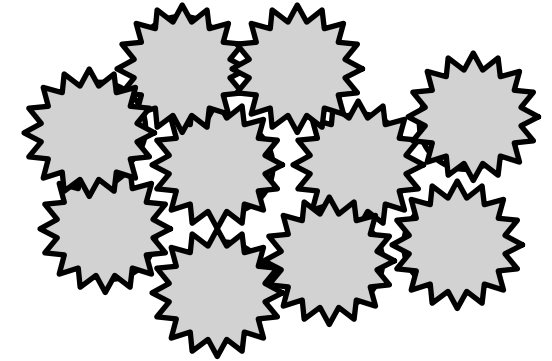
**.40 w/c ratio  
Superplasticizer  
7.5" Slump**

# Water/Cement System Without a Water Reducing Admixture

CEMENT GRAINS



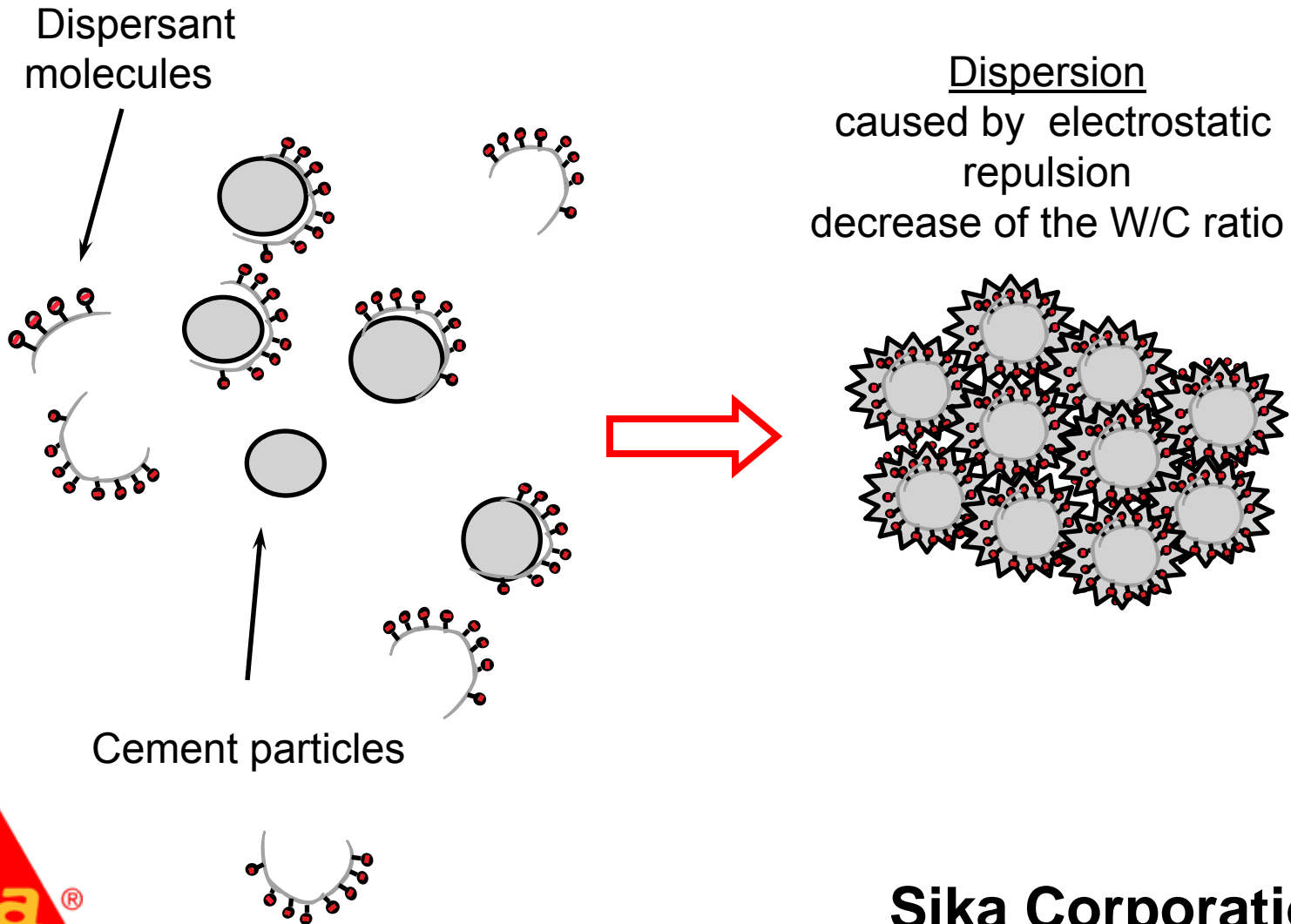
Further growth of hydration products will cause stiffness and LOSS OF WORKABILITY



Attractive forces between cement grains will give flocculation with LOSS OF FLUIDITY

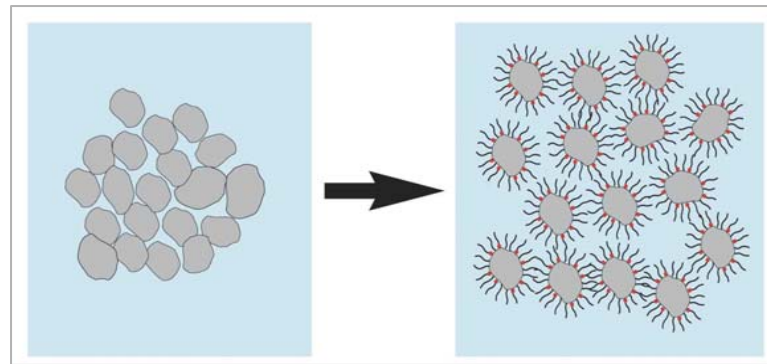


# Mechanism of Action for a Conventional Water Reducing Admixture



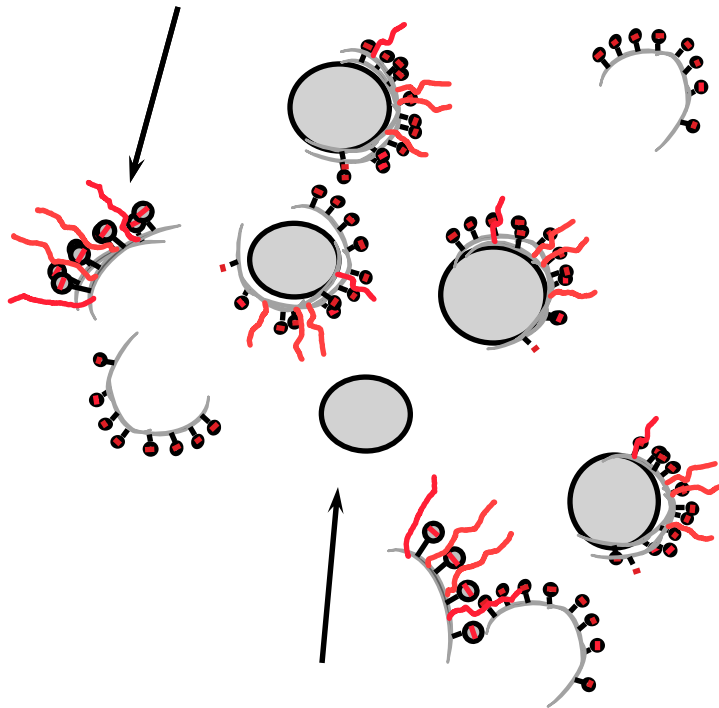
## Mechanism of Polycarboxylate-Based Admixtures

- ▲ Dual mechanism of
  - ▲ Electrostatic Repulsion
  - ▲ Steric Hinderence
  
- ▲ This dual mechanism results in improved dispersion, mix lubrication and performance



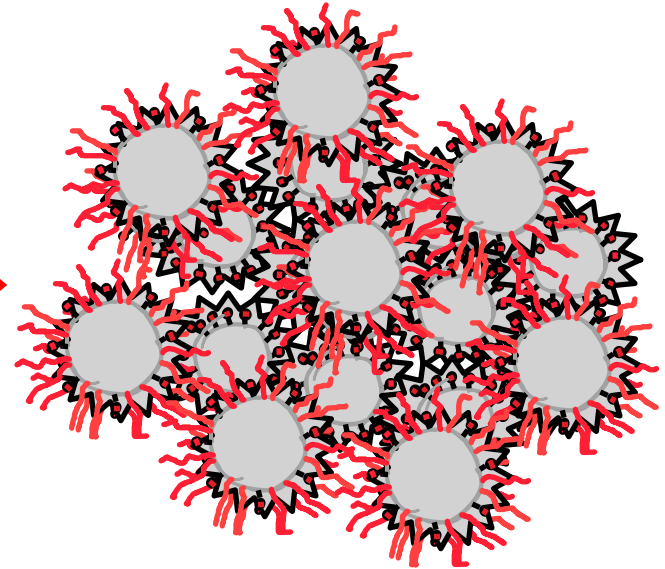
# Mechanism of Action for a Polycarboxylate based Water Reducing Admixture

Polycarboxylate dispersant molecules

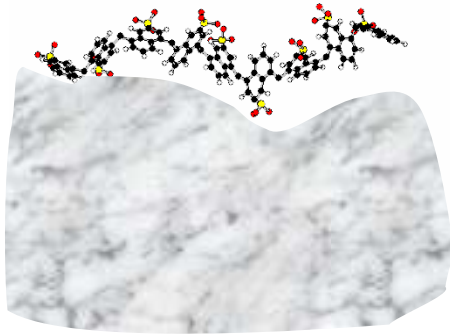
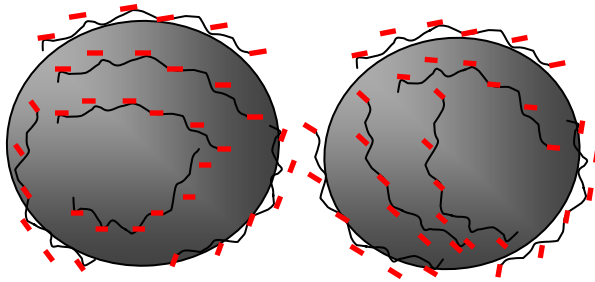


Cement particles

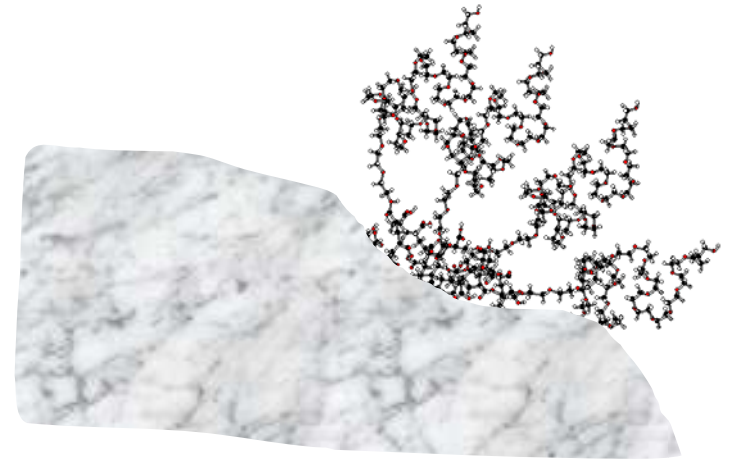
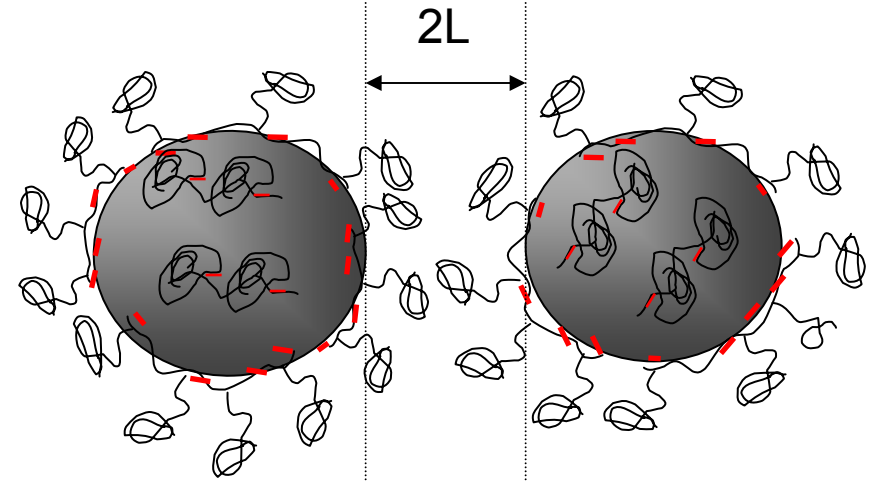
Dispersion  
caused by electrostatic repulsion  
and steric hindrance  
decrease of the W/C ratio



## Conventional Water Reducer



## Polycarboxylate Water Reducer





## Accelerators and Retarders



## General Definition

### Accelerators

- ▲ Increase the rate of hydration of the cement
- ▲ Reduce the set time of concrete
- ▲ Increase the early age strength of concrete

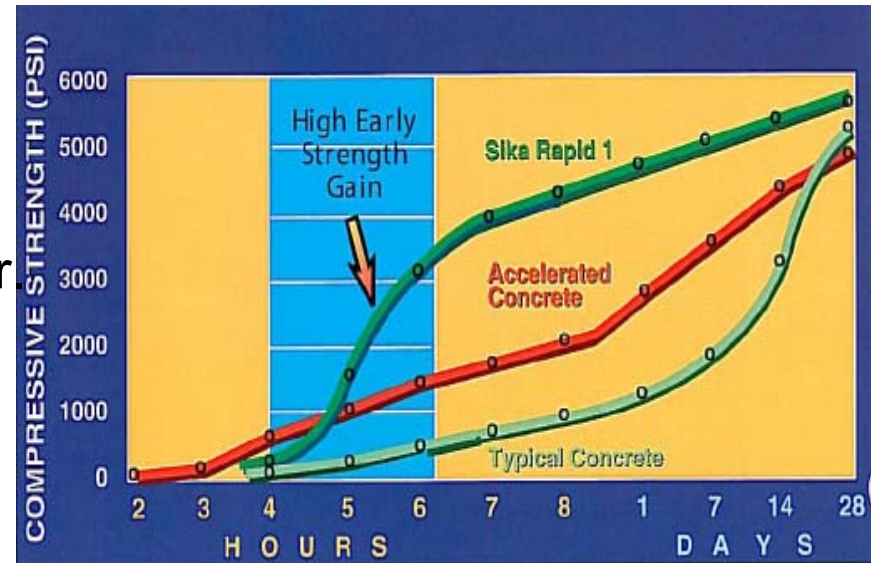
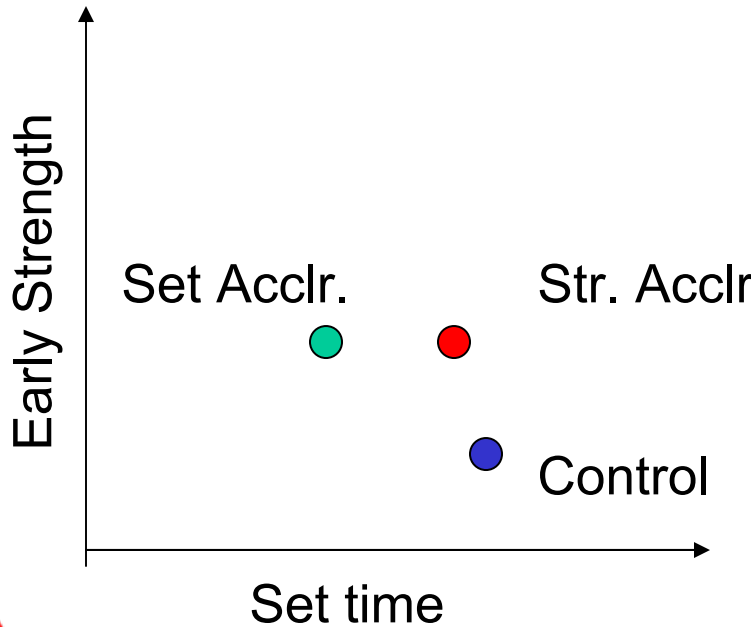
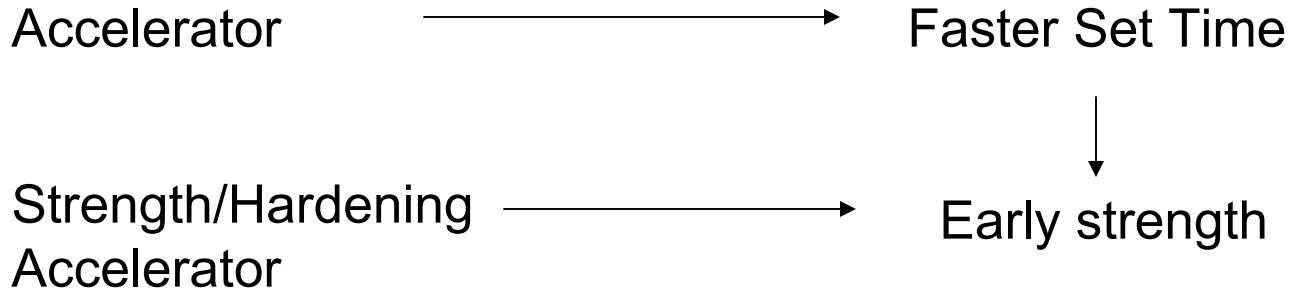
### Retarders

- ▲ Slows down the rate of hydration of cement
- ▲ Increases the time of set
- ▲ Slow down the rate of early age strength development





# Accelerators



## Accelerators

### Uses

- ▲ In cold weather, to avoid concrete from freezing when it is plastic or/and to maintain normal setting behavior and strength development.
- ▲ To increase productivity (faster stripping of formwork)
- ▲ Compensate for the delay in set or strength gain due to use of SCMs such as Fly ash or Slag.
- ▲ Rapid repair of pavement sections

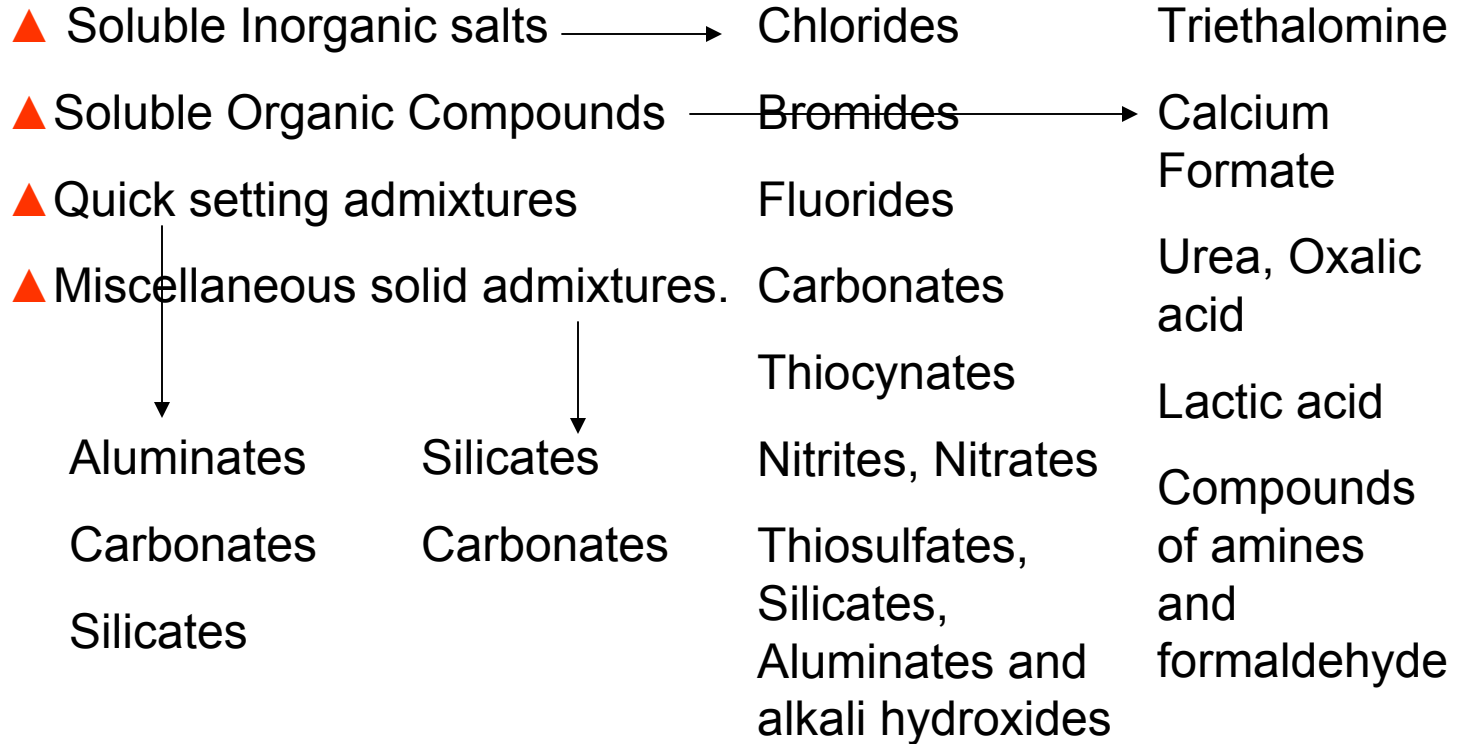
Accelerators need to confirm to ASTM C 494 as:

Type C – Accelerating admixtures and/or

Type E – Water reducing and accelerating admixtures



# Accelerator - Types



Cement Compounds:

C3S, C2S, C3A, C4AF



## Calcium Chloride

- ▲ One of the most effective accelerators known.

### Disadvantages

- ▲ Potential for corrosion
- ▲ Acceleration of Alkali Silica reaction
- ▲ Reduction in freeze thaw and sulfate resistance

Due to the above Non- Chloride Accelerators are used for RCC.



# Hardening Accelerator / Strength Accelerator

Advantages:

- ▲ Increases high early strength, but may not significantly influence the time of set.
- ▲ Enables addition of accelerator at the plant rather than addition at site



## Factors influencing accelerator performance

- ▲ Ambient temperature
- ▲ Concrete temperature
- ▲ Requirements of early set and strength
- ▲ Accelerator dosage
- ▲ Cement content, Cement Type, SCM
- ▲ W/Cm
- ▲ Testing method



## Retarders

- ▲ Slows down the rate of hydration of cement
- ▲ Increases the time of set

### Uses

- ▲ Reduces faster slump loss during hot weather.
- ▲ Enables longer haul times
- ▲ Delays set time, allows time for finishing operations
- ▲ Reduces temperature of concrete at early stages



# Retarders

Retardation →

Delayed Set Time

Slump Retention →

Longer slump life





## Retarders - Types

- ▲ Sugar derivatives
- ▲ Hydroxycarboxylic acid
- ▲ Lignosulphonates
- ▲ Tartaric acid and salts

Retarders need to confirm to ASTM C 494 as:

Type B – Retarding admixtures and/or

Type D – Water reducing and retarding admixtures



## Hydration Control admixture

- ▲ Can completely stop the hydration process of cement up to several hours or days
- ▲ Once set, strength development continues just as regular concrete
- ▲ Applications:
  - ▲ High retardation or long slump life
  - ▲ Returned concrete



## Factors influencing performance of retarders

- ▲ Ambient temperature
- ▲ Concrete temperature
- ▲ Control concrete (slump)
- ▲ Cement content, Cement type, SCM
- ▲ W/Cm



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# Air Entraining Admixtures



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# Why do we use Air Entraining Admixtures (AEA's) ?

- ▲ Freeze Thaw durability
- ▲ Resistance against deicer scaling
- ▲ Workability and placing



## QUIZ QUESTION :

- ▲ What happens to water when freezes and what is causing concrete damage during freezing cycle?



## ANSWER :

- ▲ During freezing process, water increases its volume up to 9%.
- ▲ Pressure developed during this volume change reaches up to 200MPa (29 000psi)



## Freeze thaw conditions

Freezing temperatures are not always detrimental for concrete. To observe freeze thaw damage, following two conditions must be fulfilled.

- ▲ Concrete pore saturation must be higher than 91.7%
- ▲ Temperatures must be low enough to cause water to freeze.



PRESSURE





## How do AEA's work?

- ▲ When temperatures surrounding concrete decreases below the freezing point of water, water present in pores and capillaries of concrete starts to freeze and expand.
- ▲ AEA entrain minute size air bubbles uniformly throughout the concrete
- ▲ Air entrained voids acts as small reservoirs for freezing water, which can freely freeze and expand without building up the pressure within the concrete.
- ▲ Properly air entrained concrete should provide enough voids to accommodate all the water contained within the concrete.



## What does entrained air voids do in concrete?

- ▲ If air content increases 1%, then compressive strength decreases about 5%
- ▲ If air content decreases 1%, then yield will decrease about 1/4 cubic foot per cubic yard
- ▲ If air content decreases 1%, then slump decreases about 1/2 inch
- ▲ If air content decreases 1%, then durability decreases about 10%





## Specialty Admixtures and Specialty Concrete Products



# Specialty products

- ▲ Anti-washout and viscosity modifying admixture
- ▲ Shrinkage Reducing admixture
- ▲ Corrosion inhibitors
- ▲ ASR mitigation admixture
- ▲ Admixture for Pervious Concrete
- ▲ Flowable Fill admixture (CLSM)
- ▲ Surface Retarder
- ▲ Finishing Aid



## Anti- Washout Admixtures & Viscosity Modifying Admixtures

How they work:

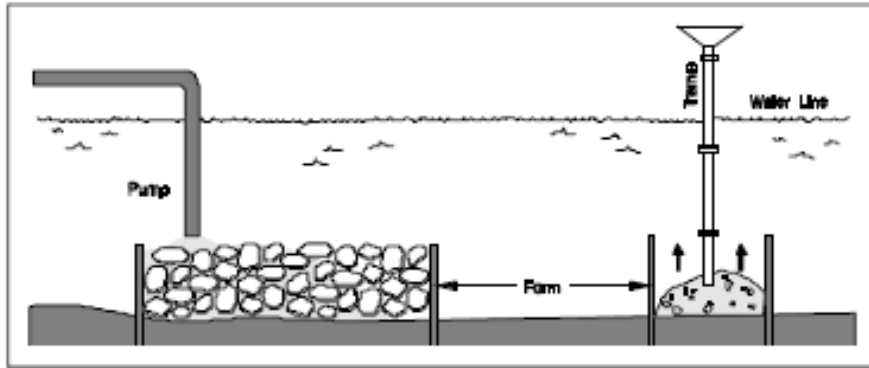
- ▲ Water soluble cellulose ether or acrylic type polymers
- ▲ They increase the viscosity of water in the mix.
- ▲ This results in increased thixotropy and improved resistance to segregation

Applications:

- ▲ Under water concreting
- ▲ Self Compacting concrete
- ▲ Increase cohesion in case of gap graded aggregate mixes.



# Anti- Washout Admixtures & Viscosity Modifying Admixtures



Under water concreting



Self compacting concrete



## Shrinkage Reducing Admixtures (SRA)

What do SRA's do:

- ▲ Minimizes volume changes due to Drying Shrinkage cracking.

- ▲ Drying Shrinkage:

- ▲ Loss of moisture from hardened concrete surface

- ▲ Volume of concrete reduces and it shrinks

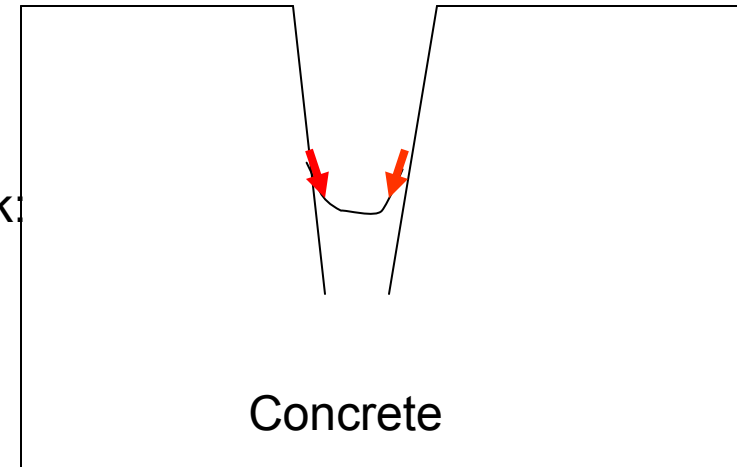
- ▲ Water in capillary exerts forces on capillary wall

How Shrinkage reducing admixtures work:

- ▲ Reduces surface tension of the liquid

- ▲ Forces on the wall are reduced

- ▲ Less Shrinkage



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# Corrosion Inhibitors types

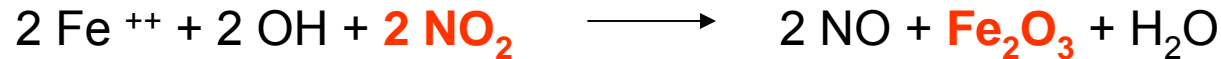
- ▲ Calcium Nitrite based
- ▲ Migration corrosion inhibitors ( based on a combination of Amino alcohol and Organic and inorganic inhibitors)





## Calcium Nitrite based

- ▲ A layer of Ferric oxide protects the steel from corrosion in concrete
- ▲ This layer can be damaged by carbonation or chloride ingress, which can lead to corrosion.
- ▲ Calcium nitrite admixture fortifies the ferric oxide passivating layer
- ▲ Thereby protects steel from corroding



- ▲ Dosages: 10 – 30 liters per m<sup>3</sup>.



## Migratory corrosion inhibitors

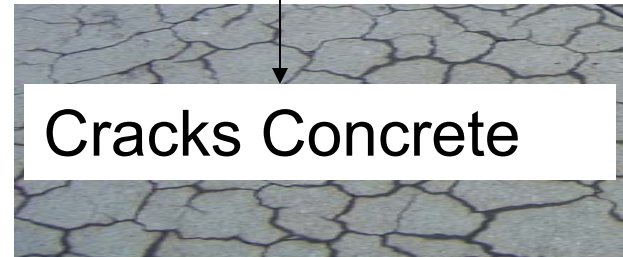
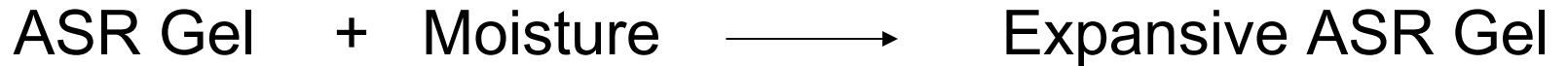
- ▲ Dual mechanism
  - ▲ Migrating inhibitor – Penetrates through the concrete to the steel reinforcement and gets absorbed on the surface
  - ▲ Displaces chloride ions from steel surface and forms a continuous film
- ▲ Hence reduces overall corrosive activity
- ▲ Dosages : 10 – 15 liters per m<sup>3</sup>



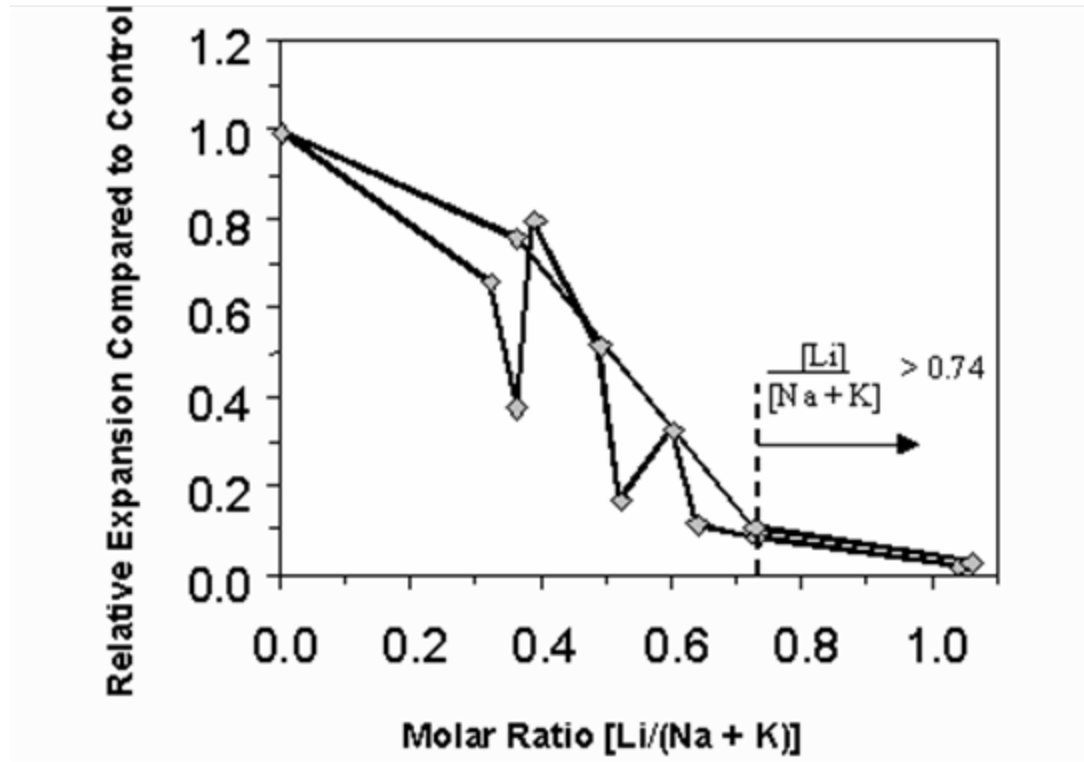
# Alkali silica reaction mitigating admixture

Lithium Nitrate based admixture

- What is ASR?



## ASR mitigating admixture



## Pervious concrete

A concrete

- that contains little or no sand
- which forms a system of highly permeable and interconnected voids
- allows 3-8 gallons of water per minute to pass through 1 sq.ft



### Typical Properties:

Compressive strength – 500 – 4000 psi

Voids – 15 to 25%

Unit weight – 100 to 125 pcf

Permeability – 3 to 8 gallons/ minute per sf.ft



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## Pervious concrete admixture

- ▲ Polymer based liquid admixture

### Benefits:

- ▲ Improves aggregate to cement paste bond
- ▲ Improves Strength and workability
- ▲ Aids discharge from truck, easy to place
- ▲ Reduces bleeding and improves cohesion

- ▲ Dosage : 10 – 25 liter / m<sup>3</sup>

### Other admixtures for pervious concrete

- ▲ Water reducers
- ▲ Retarders
- ▲ Viscosity modifiers



## Flowable fill admixture

### Uses:

- ▲ To produce controlled low strength materials (CLSM) used as flow able fill

### Application:

- ▲ Use 454 gram bag (1 lb) to produce 0.77 m<sup>3</sup> (1 cyd) of CLSM
- ▲ Add all mix ingredients and mix for 5-7 minutes.
- ▲ Material volume increases by 25 to 35%.



# Surface Retarding admixture

- ▲ Retards the set of concrete surface

Applications:

- ▲ Exposed aggregate surface for architectural purposes
- ▲ Used when concreting done in layers to improve mechanical key





## Finishing aid admixture

### Benefits:

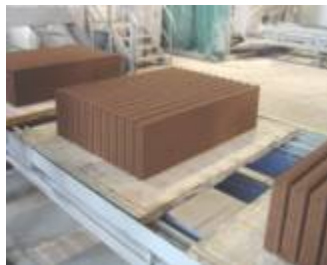
- ▲ Enhances finish on concrete flatwork
- ▲ Eliminates addition of water to aid finishing
- ▲ Prevents plastic shrinkage cracking





## Admixtures for Manufactured concrete products

# Construction



***MCP Market Segment***



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# MCP Applications



▲ **Standard Gray Block**



# MCP Applications



## ▲ **Architectural Split-Face Block**



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# MCP Applications

## ▲ Concrete Pipe

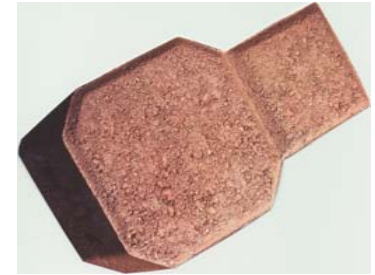


# MCP Applications

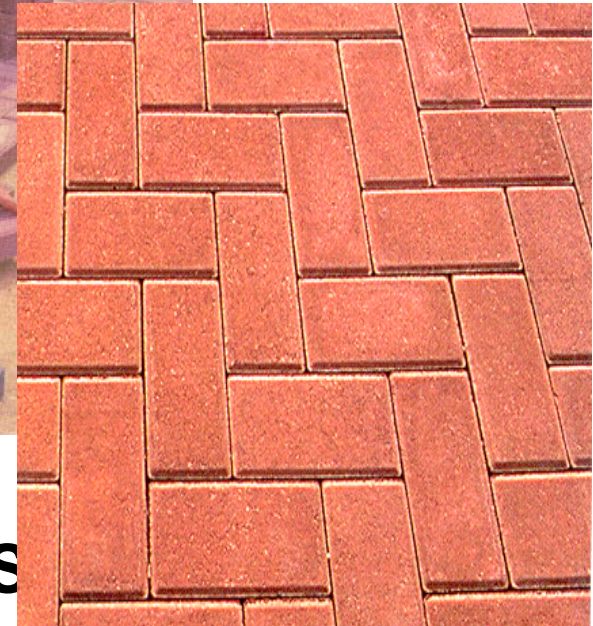
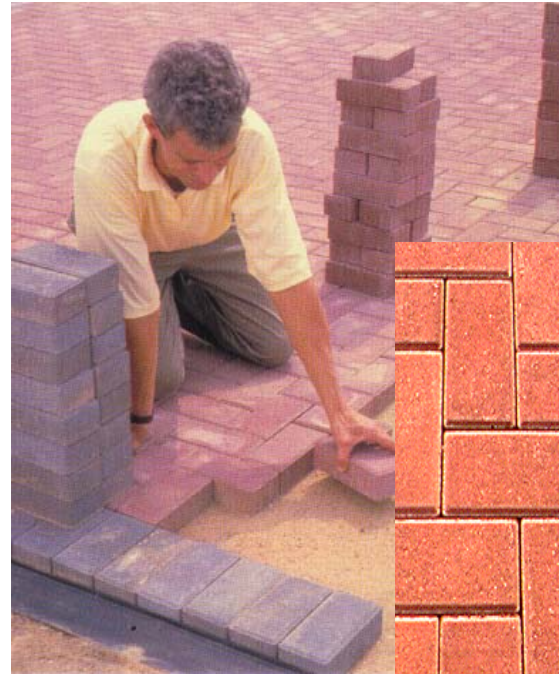
## ▲ Segmental Retaining Walls (SRW's)



# MCP Applications



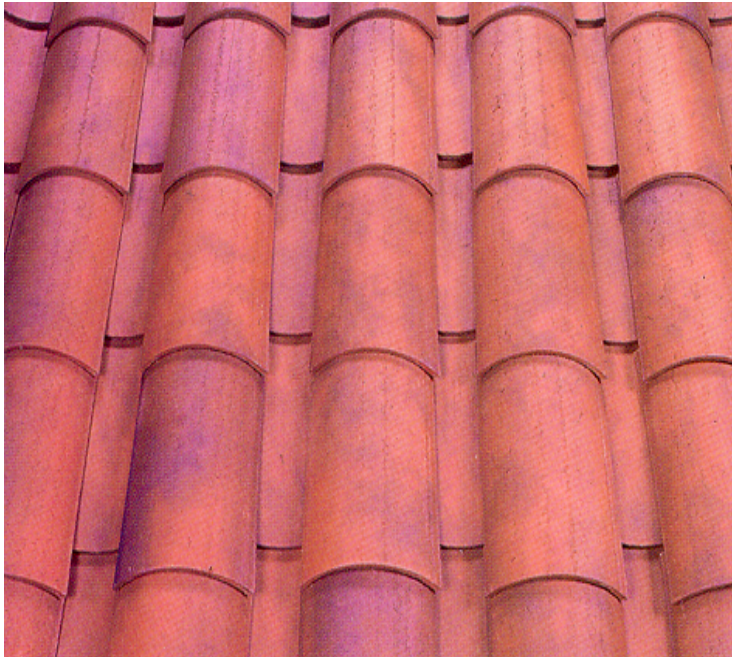
## ▲ Concrete Pavers





# MCP Applications

## **Concrete Roof Tile**



# MCP Applications



## ▲ **Extruded Hollow-Core Plank**



## Why use admixtures for MCP products?

- ▲ Produce Desired Texture
- ▲ Speed Production Rate
- ▲ Improve Edge Definition
- ▲ Increase Strength
- ▲ Reduce Absorption
- ▲ Control Efflorescence
- ▲ Water Repellency
- ▲ Improve Color Vibrancy
- ▲ Meet Durability Requirements
- ▲ Increase Profitability



# MCP Admixtures

- ▲ Plasticizers
- ▲ Accelerating Plasticizers
- ▲ Accelerators
- ▲ Water-Repellent Admixtures
- ▲ Efflorescence-Controlling



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Thank you.....

