Chemical Admixtures

Presentation by-
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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

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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
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
Water Reducer- Types

- Lignosulfonates
- Naphthalene based (SNF)
- Melamine based (SMF)
- Vinyl Copolymers
- Polycarboxylate based
Water/Cement System Without a Water Reducing Admixture

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

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

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Mechanism of Action for a Conventional Water Reducing Admixture

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

Dispersant molecules
Cement particles

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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

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

Cement particles

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Conventional Water Reducer

Polycarboxylate Water Reducer

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Construction Accelerators and Retarders

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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

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Accelerators

Accelerator → Faster Set Time
Strength/Hardening Accelerator → Early strength

Set Acclr.    Str. Acclr    Control

Early Strength

Set time

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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

- Soluble Inorganic salts
  - Chlorides
  - Triethalolmine
- Soluble Organic Compounds
  - Bromides
  - Calcium Formate
- Quick setting admixtures
  - Fluorides
  - Urea, Oxalic acid
- Miscellaneous solid admixtures
  - Carbonates
  - Thiosulfates, Silicates, Aluminates and alkali hydroxides
  - Nitrites, Nitrates
  - Lactic acid
  - Compounds of amines and formaldehyde

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 \[\rightarrow\] Delayed Set Time
- Slump Retention \[\rightarrow\] Longer slump life

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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
Air Entraining Admixtures
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.

\[ \text{PRESSURE} \]

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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%
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Specialty Admixtures and Specialty Concrete Products

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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

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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
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

\[
2 \text{Fe}^{++} + 2 \text{OH} + 2 \text{NO}_2 \rightarrow 2 \text{NO} + \text{Fe}_2\text{O}_3 + \text{H}_2\text{O}
\]

△ Dosages: 10 – 30 liters per m³.
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 m³
Alkali silica reaction mitigating admixture

Lithium Nitrate based admixture

What is ASR?

Alkali’s (Na, K from Cement) + Reactive Silica (Aggregates) → ASR Gel

ASR Gel + Moisture → Expansive ASR Gel

Cracks Concrete
ASR mitigating admixture

[Graph showing relative expansion compared to control vs. molar ratio of Li/(Na + K)]

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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 / m3

Other admixtures for pervious concrete
- Water reducers
- Retarders
- Viscosity modifiers
Flowable fill admixture

Uses:
△ To produce controlled low strength materials (CLSM) used as flowable fill

Application:
△ Use 454 gram bag (1 lb) to produce 0.77 m³ (1 cyd) of CLSM
△ Add all mix ingredients and mix for 5-7 minutes.
△ Material volume increases by 25 to 35%.

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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

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MCP Applications

Segmental Retaining Walls (SRW’s)

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MCP Applications

Concrete Pavers

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Construction
MCP Applications

Concrete Roof Tile

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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
Thank you........