PROPERTIES of CONCRETE
Admixtures

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Chemical Admixtures In Concrete

What Are They?

- Ingredients other than:
  - Cement
  - Water
  - Aggregates

- Added before or during mixing.

Why Are They Used?

- To modify properties of fresh & hardened concrete
- To ensure the quality of concrete during mixing, transporting, placing & curing
- To overcome certain unexpected emergencies during concrete operations (ie, set retarders)

How Applied?

- Most admixtures are supplied in a ready-to-use form and added at plant or jobsite.
- Pigments and pumping aids are batched by hand in VERY small amounts

Effectiveness

- Factors effecting results of use:
  - Type & amount of cement:
    - Chemistry effects due to portland components
  - Water content & Slump
    - Flowability will effect how well admixtures are activated due to internal agitation actitivity
  - Mixing time
    - Effects of admixtures are dependent on time allowed to react.

ADMIXTURES

- Materials added to the concrete besides cement, water and aggregate.
- To improve the properties of the concrete required.
- Admixtures can be divided in 2 groups that is:
  a) Chemical admixtures
  b) Mineral admixtures

Admixtures

- Air-entraining admixtures
- Water-reducing admixtures
- Plasticizers
- Accelerating admixtures
- Retarding admixtures
- Hydration-control admixtures
- Corrosion inhibitors
- Shrinkage reducers
- ASR inhibitors
- Coloring admixtures
- Miscellaneous admixtures

Primary admixture properties

PLASTICISERS

- Dispersion of cement particles increases fluidity
- Water reduction increases strength
- Water reduction reduces permeability, increases durability
- Cement reduction reduces cost

AIR ENTRAINERS

- Increase cohesion, Reduce bleed and segregation
- Easier to pump
- Impart freeze thaw resistance

RETARDERS

- Prolong period over which concrete may be placed
- Reduce problems with cold joints

ACCELERATORS

- Reduce the time to reach initial set
- Increase the early age strength of the concrete

FUNCTION OF ADMIXTURE

- To improve workability of fresh concrete
- To improve durability by entrainment of air
- To reduce the water required
- To accelerate setting & hardening & thus to produce high early strength
- To aid curing
- To impart water repellent / water proofing property

- To cause dispersion of the cement particles when mixed with water
- To retard setting
- To improve wear resistance (hardness)
- To offset / reduce shrinkage during setting & hardening
- To cause expansion of concrete and automatic prestressing of steel
- To aerate mortar / concrete to produce a light-weight product

- To impart colour to concrete
- To offset or reduce some chemical reaction
- To reduce bleeding
- To reduce the evolution of heat

- Among the type of chemical admixture used are:
  a) Accelerator
  b) Water reducing Admixture
  c) Superplasticizer
  d) Air Entraining Admixtures
  e) Retarding Admixtures
  f) Corrosion Inhibitors
  g) Alkali-Aggregate Reaction Inhibiting Admixtures
  h) Shrinkage Reducing Admixtures

ACCELARATOR

- Added to increase the rate of hydration of concrete mix which then lead to the increases in the rate of development of strength and greater heat evolution.
- And to shorten the setting time
- More rapid gain of strength & rapid setting
- Disadvantages is possible cracking due to heat evolution & possibility of corrosion of embedded reinforcement

WATER REDUCING ADMIXTURE / PLASTICISERS

- Used to reduce the amount of water necessary to produce a concrete of a given consistency
- To increase the slump for a given water content
- To obtain specified strength at lower cement content
- Increases workability with faster gain of strength
- Increase the slump, reduce water content, save cement
- Disadvantages, it has the risk of corrosion

SUPERPLASTICIZER

- By adding to a hydraulic binder, gives very high workability and allows a large decrease in water content for a given workability
- Allows the particles to be more workable where it enable working with low w/c ratio
- Enhances hydration process, increases strength
- Eliminate concrete segregation & allow good dispersion of cement particles in water, accelerating the rate of hydration.

- Uniform distribution of cement particles is partly responsible for the highly early strength in concrete made with superplasticizer.
- Advantages of using Superplasticizers are
  a) Decreased time to place and finish
  b) Accelerated curing period
  c) Early removal of formwork
- Excessive dosage may render concrete too fluid, causing severe segregation

Water Reducers

- Internal lubricant
- Allows for reduction of water/cement ratio while maintaining workability (increased strength)
- Can reduce water requirement at least 5-10%
- Obtain higher slump without adding water
- *Mid-range* water reducers result in at least 8%
  - *Mid-range* water reducers provide more consistent setting times than standard water reducers.

Air Entrainment

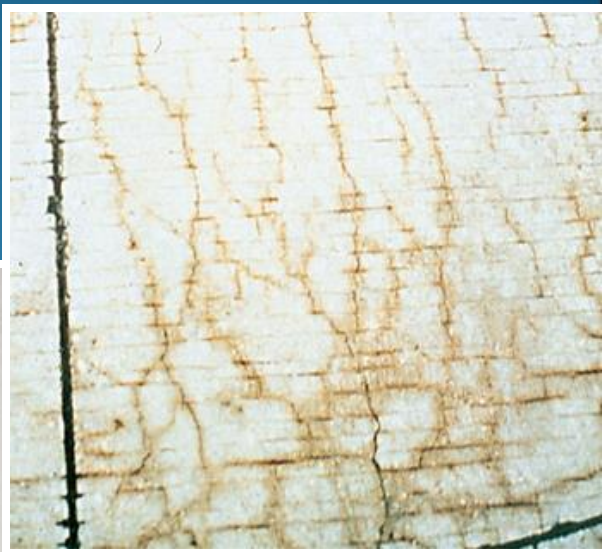
- Developed in 1930s
- Today, recommended for all concretes exposed to freeze/thaw cycles
- Imposes microscopic air cells that relieve internal pressure of freezing water
- Typical target air values are 5%-8%
- Will also increase slump (workability)

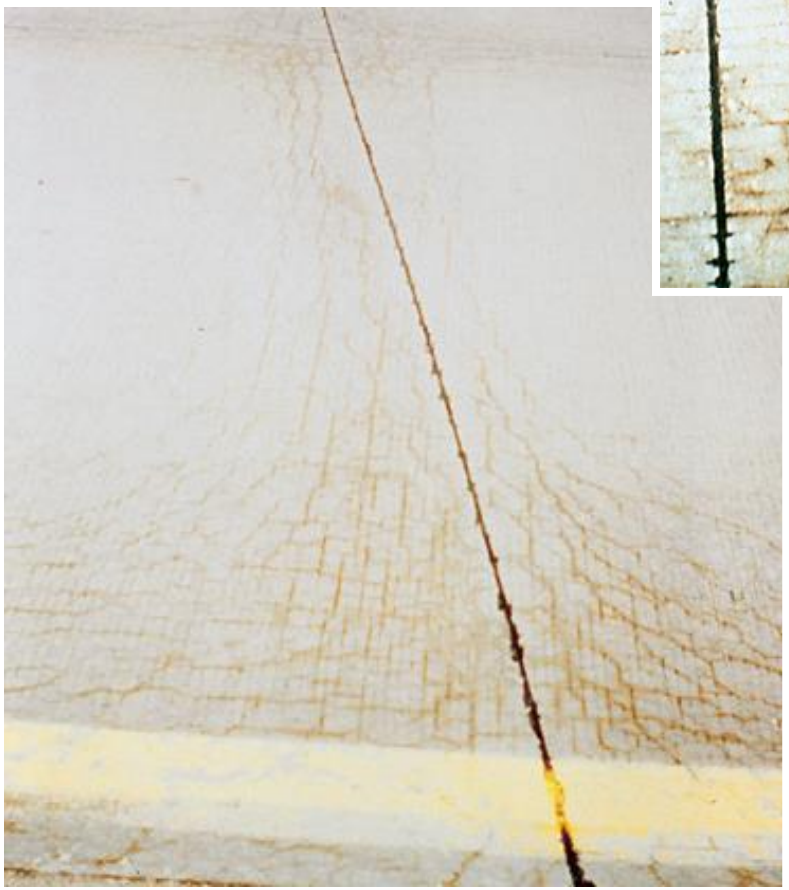
Air-Entraining Admixtures

ASTM C 260 or AASHTO M 154

- Improve durability in concrete exposed to
  - Freeze-thaw
  - Deicers
  - Sulfates
  - Alkali-reactive environments
- Improve workability

Frost Damage



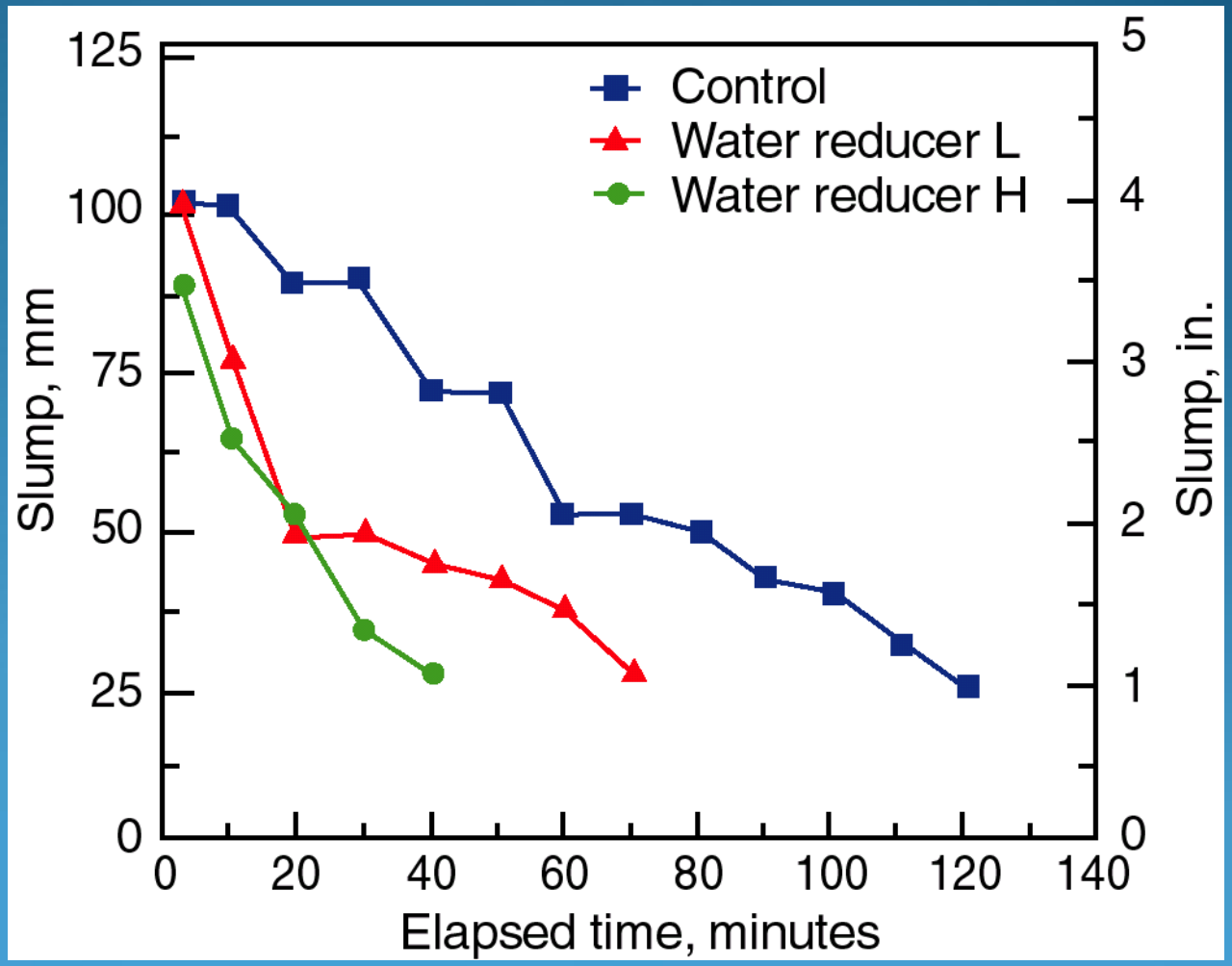


Water-Reducing Admixtures

Primarily used to:

- Reduce mixing water required to produce a certain slump
- Reduce water-cement ratio
- Reduce cement content
- Increase slump
- Typically reduce water by 5-10%

Water Reducer and Slump Loss



Mid-Range Water Reducing Admixtures

- Reduce water content 6% to 12%
- Reduce cement content
- Reduce water-cement ratio
- No retardation
- Improve placeability and finishability

High-Range Water-Reducing Admixtures

ASTM C 494 or AASHTO M 194

Type F— Water Reducing

Type G — Water Reducing and Retarding

- Reduce H_2O content 12% -30%
- Reduced W/C produces conc. with:
  - Compressive Strength > 10,000 psi
  - Increased early strength gain
  - Reduced Cl ion penetration

Plasticizers for Flowing Concrete

Also known as —

Superplasticizers

ASTM C 1017

Type 1 —Plasticizing

Type 2 — Plasticizing and Retarding

- Essentially High-Range Water Reducer

Plasticizers for Flowing Concrete

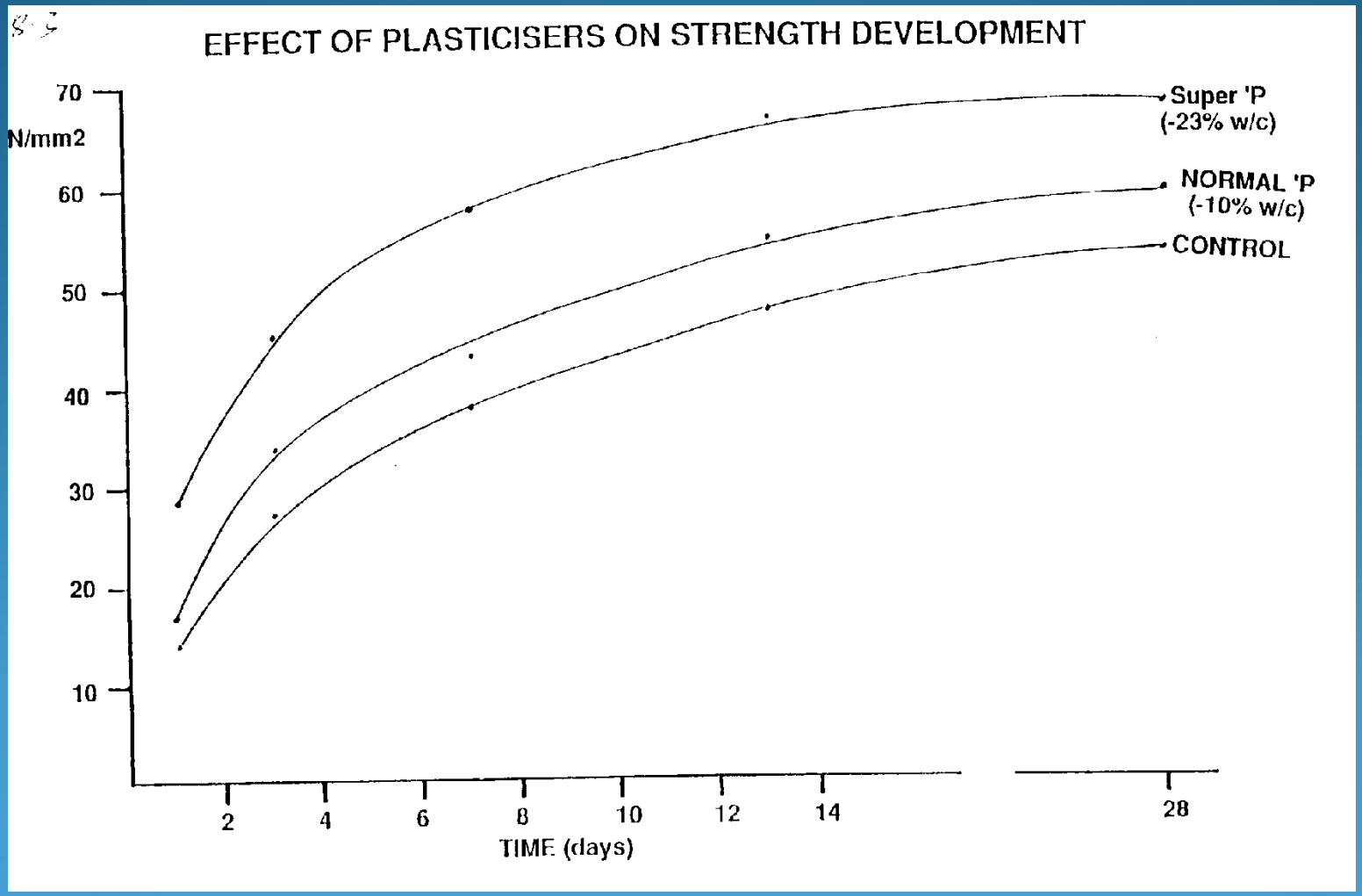
Superplasticizers

ASTM C 1017

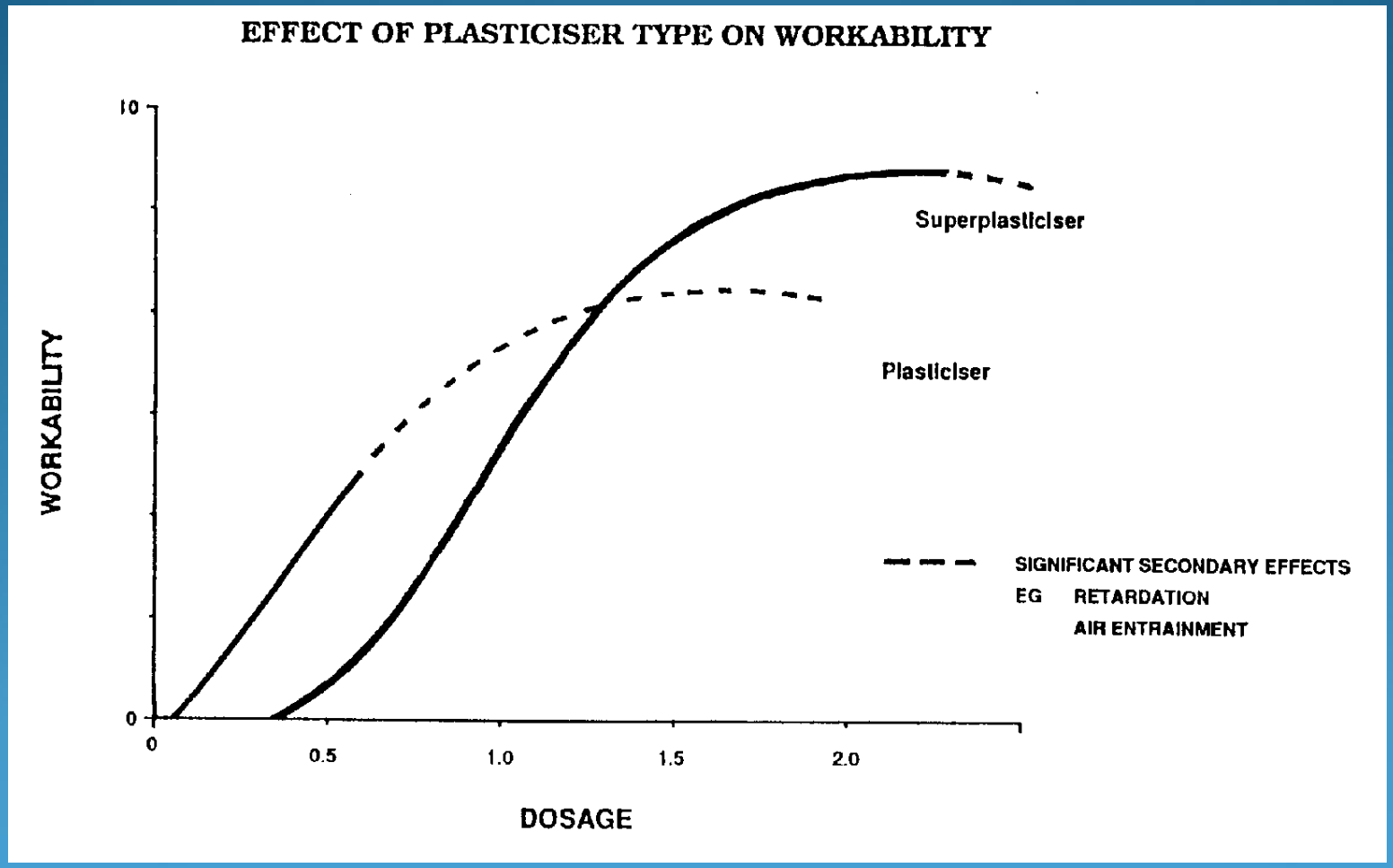
- Produce flowing concrete with high slump (7.5 in.)
- Reduce bleeding
- Extended-slump-life plasticizer reduces slump loss.

Flowing Concrete

Increasing strength



Plasticiser and superplasticiser



Examples of superplasticiser use

DIN 1048 Water Permeability (7 Bar Pressure)

Mix	Cement kg/m^3	w/c	Slump mm	Water penet-ration mm
Control	310	0.52	60	27
Superplast-icised (Conplast 430)	310	0.52	155	26
High range water reduced (Conplast 430)	310	0.42	60	17

Fig 2.8.5

Effect of cement content and water cement ratio on accelerated carbonation

Admixt-ure	Nominal OPC kg/m^3	w/c	Strength N/mm^2	Estimated carbonation depth after 20 years mm
Control	250	0.76	21.0	33
Conplast 337	250	0.62	30.5	18
Control	310	0.62	31.5	22
Control	350	0.54	41.5	14
Conplast 337	350	0.43	58.0	3
Control	460	0.43	58.0	6

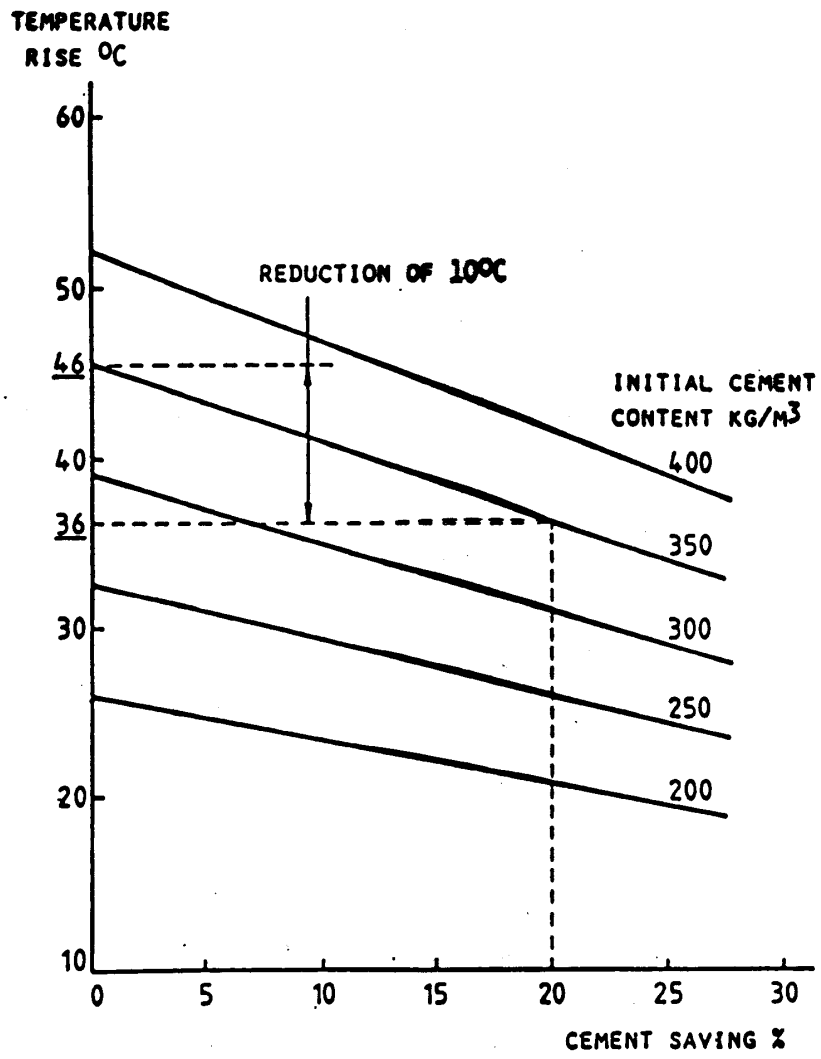
Fig 2.8.7

Chloride ion diffusion with plasticisers used as water reducers and cement reducers

Mix	Cement kg/m^3	w/c ratio for 80mm slump	Chloride diffusion $\times 10^{-8}$ cm^2/sec	28 D stre-ngth N/mm^2
Control	305	0.61	51.0	31.5
Conplast 337	305	0.50	22.0	45.0
Conplast 337	260	0.61	48.0	30.5
Control	375	0.50	28.0	44.5
Conplast 337	360	0.40	8.1	58.0
Conplast 337	305	0.50	22.0	45.0

Fig 2.8.6

EFFECT OF CEMENT REDUCTION WITH A SUPERPLASTICISER TO REDUCE TEMPERATURE RISE IN LARGE POURS

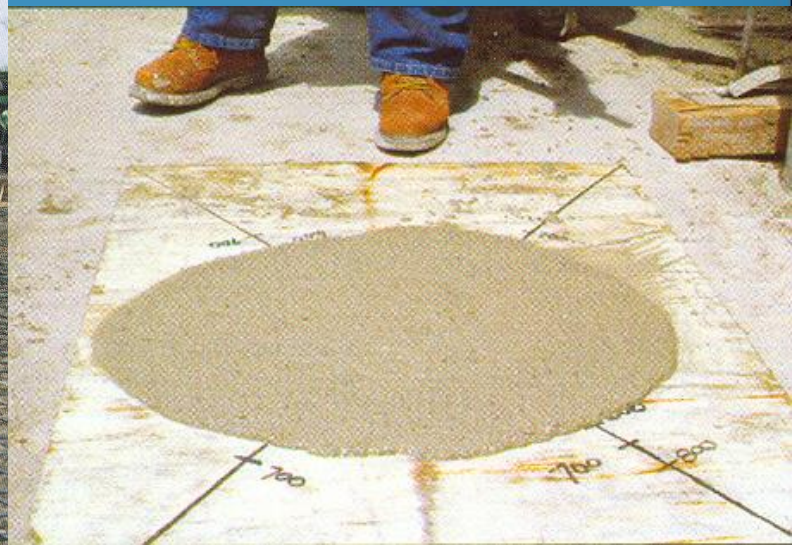


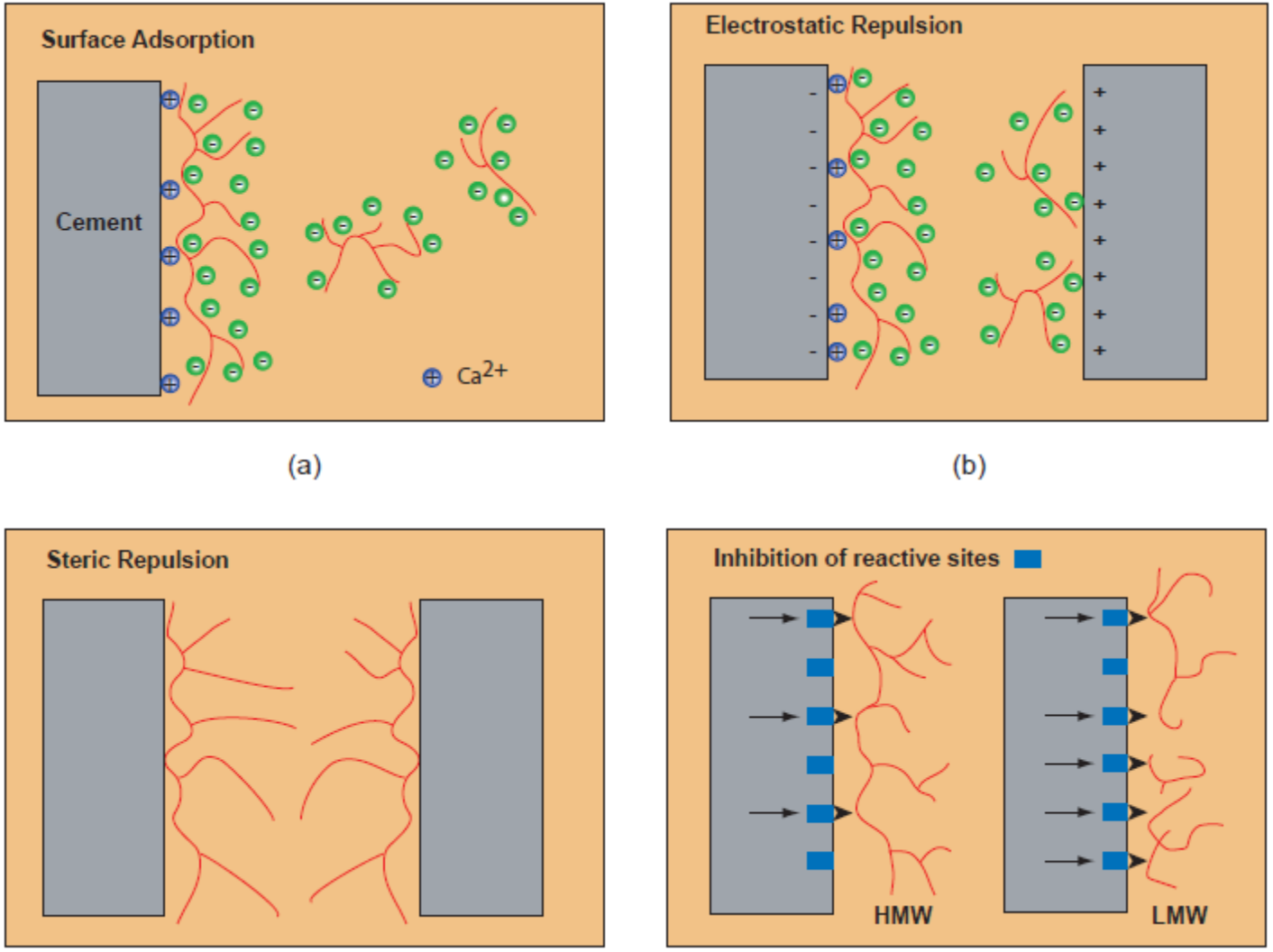
Based on 13°C rise / 100 kg OPC. Blundell & Bamforth(6)

Reducing temperature rise with sp

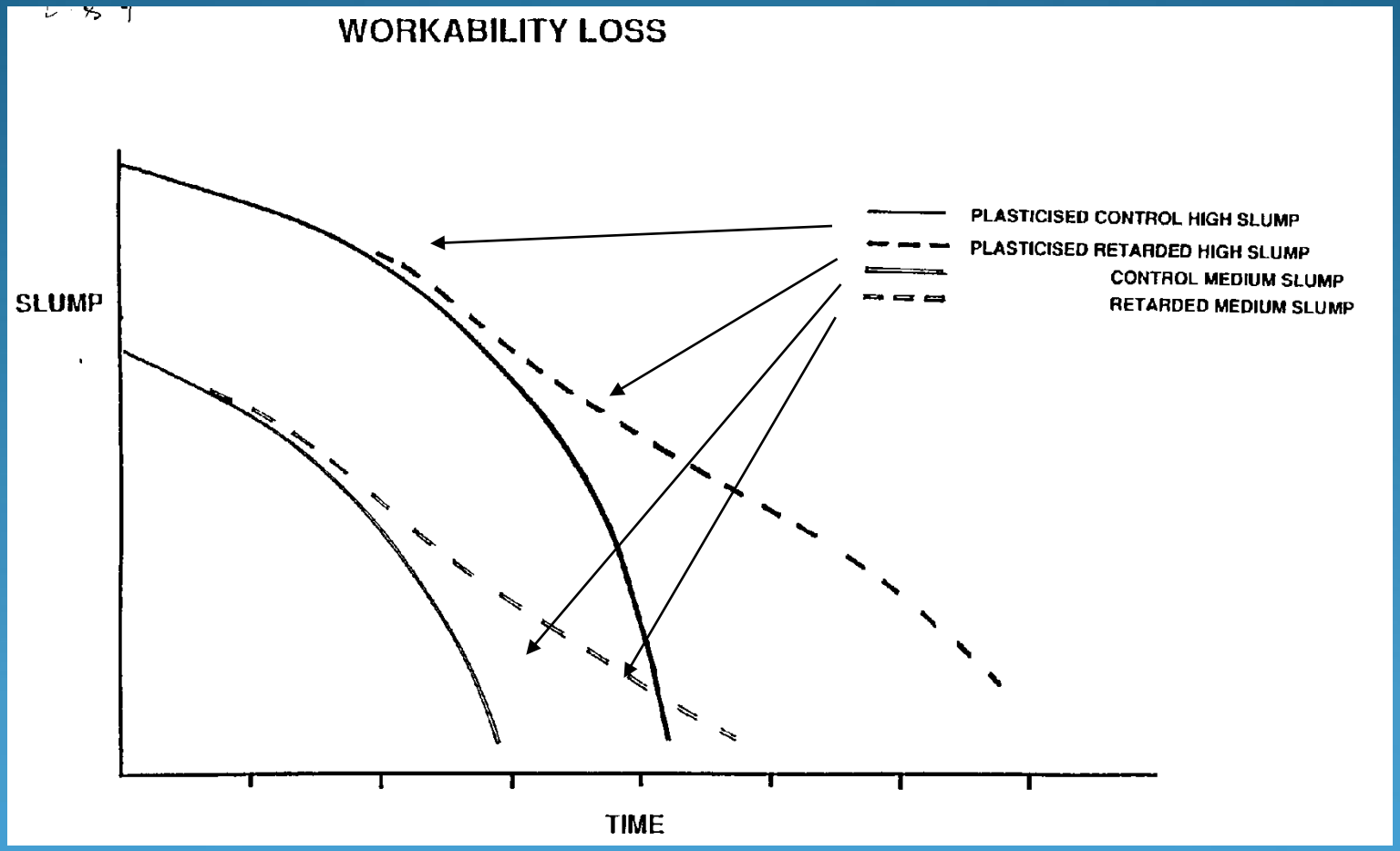
Self compacting concrete

Self Compacting Concrete




Surface Adsorption
Cement
Ca2+
(a)
Electrostatic Repulsion
(b)
Steric Repulsion
Inhibition of reactive sites
HMW
LMW

Workability loss



AIR ENTRAINING ADMIXTURES

- An entraining concrete containing air in a rather special form of a bubble that trapped in concrete
- Workability improved, increase in slump, easier placing, increased durability, better resistance to frost action
- Able to reduce segregation tendency and control of bleeding
- It is necessary to have a careful control of air content and mixing time

- Wetter mixes tend to result in higher air content while mixes rich in sand entrain less air as fine material competes for available waterIf air entrainment is to be used, sand content need to be reduced
- Bubbles produced by air entrainment are quite different from entrapped air because:
- They are sealed and wouldn't be filled with water during normal saturation of the concrete
- They are very small and well distributed.

- Used to increase concrete durability by protecting it against freeze-thaw cycle damage.
- By entraining air in concrete to form a microscopic air-void system , the expansion is provided a relief valve system.
- The air void system in the hardened concrete paste allows water to freeze, with the empty air voids providing room for the expansion that occurs as water changes to ice.

RETARDING ADMIXTURE

- Prolong or delay the setting time of cement paste in concrete
- Used in hot weather to reduce any premature stiffening of the concrete and consequent loss of workability
- Often carried by ready mixed concrete vehicles to prevent the concrete setting in the drum in the event of brakdown
- Disadvantage is, it may promote bleeding

CORROSION INHIBITORS

- Able to reduce the rate of corrosion to a level that major damage to concrete will be avoided or at least greatly reduced.

ALKALI AGGREGATE REACTION INHIBITING ADMIXTURES

- Lithium and Barium salts can reduce the expansion and cracking associated with alkali-silica reaction

SHRINKAGE-REDUCING ADMIXTURES

- Able to reduce the amount of shrinkage that occurs as hardened concrete dries.

MINERAL ADMIXTURES

- Are natural pozzolanic materials or industrial by-products that are commonly used in concrete to replace part of the cement or sand.
- Types of mineral admixtures are:
  Fly ash
  Silica Fume
  slag etc.

Set Retarders

- Slows curing rate
- Used to counteract hot weather conditions that cause increased rate of hardening.
  - This makes placing and finishing difficult
- Pozzolith 961
  - Performance & dosage (see handout)

Set Accelerators

- Increase curing rate for achievement of high early strength
- Speeds up start of finishing operations
- Used for speeding curing rate in cold weather concreting
- Pozzolith 122
  - Performance & Dosage (see handout)

Retarding Admixtures

ASTM C 494 or AASHTO M 194, Type B

Delay setting or hardening rate for:

- Hot-weather concreting
- Difficult placements
- Special finishing processes

The retarder therefore helps to:-

- Hold the workability of initially high workability superplasticised concrete at a medium workability by delaying the onset of hydration.
- Assist with the removal of the casing after introduction of concrete into deep piles by holding some workability in the mix.
- Give monolithic concrete between batches placed with a time interval between them.
- Reduce the incidence and intensity of surface lift marks, surface blemishes and colour changes due to poor intermixing between pours.
- Reduce the incidence of cold joints between pours.

Accelerating Admixtures

ASTM C 494 or AASHTO M 194, Type C

Accelerate the rate of:

- Hydration (setting)
- Early-age strength gain

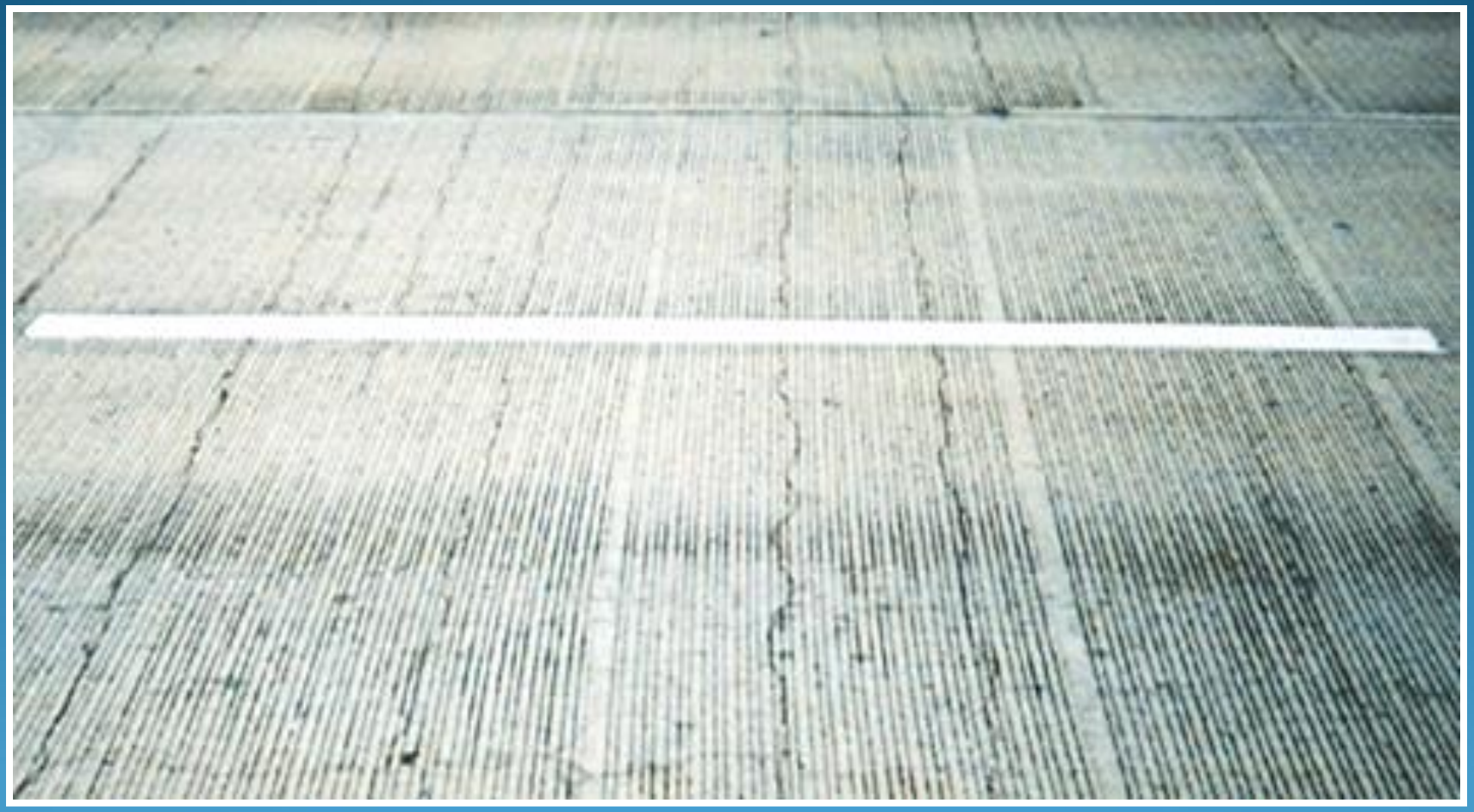
Calcium chloride accelerators:

- Increase drying shrinkage, potential reinforcement corrosion, potential scaling
- Darken concrete

Corrosion Inhibitors

- Control Corrosion of Steel Reinforcement
- Dosage dependent on anticipated chloride level

Shrinkage-Reducing Admixtures



Coloring Admixtures (Pigments)

Other Admixtures

- Viscosity modifiers for use with superplasticisers when making self compacting concrete
- Foaming agents "Foamed concrete" is a non-structural void filler which can be dug out with excavators.
- Shrinkage compensators.
- Corrosion Inhibitors. Calcium Nitrite is used as an anode inhibitor. Other admixtures can inhibit the cathode.
- Alkali Aggregate Reaction Inhibitors. Lithium based compounds are used to reduce AAR.

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When using more than one admixture

- Never pre-mix admixtures before adding them to the concrete
- The order and timing of admixture addition can be critical

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