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RETARDING ADMIXTURE

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Abstract: **Concrete inhibitors are used in fresh concrete to delay chemical setting or hardening of concrete for up to an hour. They are typically used in hot weather conditions to reduce rapid hardening due to high temperature, thus allowing time for mixing, transfer and pouring. Concrete retarders are also used as mix water reducers. Concrete surface retarders Concrete surface retarders are also called "surface retarders", and are applied to fresh concrete to chemically reduce the hardening of the concrete surface. Unlike concrete retarders, they allow the rest of the concrete to react normally, without affecting the rate of hardening or strength gain.**

Keywords: **Retarding Admixture, Concrete surface retarders, Concrete inhibitors.**

1. ADMIXTURE & RETARDING ADMIXTURE

1.1– Introduction:

Instead of using special cement, its possible to change some of the properties of the more commonly used cement by incorporating a suitable additive or an admixture. Additive: refer to a substance which is added at the cement manufacturing stage. Admixture: refer to a substance which is added to the concrete at the mixing stage.

Concrete should be:

- Workable
- Strong
- Durable
- Watertight
- Wear resistant

Retarding Water-Reducers & Retarding high Range water Reducers are Used to:

- Give workability retention to the concrete
- Delay the setting time of concrete
- Prevent the formation of cold joints
- Increase initial workability
- Increase ultimate strength
- Produce economies in mix designs.
- To maintain the quality of concrete during stages of mixing, transporting, placing, and curing, in adverse weather conditions.
- To over come certain emergencies during concreting.

Those ingredients in concrete other than Portland cement, Water, and Aggregates that are added to the mixture immediately before or during mixing.

1.2- Classification of Admixtures by Function:

1. Retarding
2. Air-Entraining
3. Water Reducing (Plasticizers)
4. Accelerating
5. Hydration Control
6. Corrosion Inhibitors
7. Shrinkage Reducers
8. ASR Inhibitors
9. Coloring
10. Miscellaneous: workability, bonding, damp proofing, permeability reducing, grouting, gas-forming, anti-washout, foaming & pumping admixtures.

For more information see Table No. (A-1) in Appendix [1]

1.2.1 - Retarding Admixtures (Set-Retarders):

Admixtures used to delay the setting or (rate of setting) of concrete, as measured by the penetration test. Useful when concreting in hot weather, where high temperature increase the rate of hydration and shorten the setting time. Useful in preventing the formation of cold joints between successive lifts. Instead, cold water and cool aggregates can be used.

Retardation can be exhibited by the addition of:

- Sugar.
- Carbohydrate derivatives.
- Soluble zinc salts, and other.

In General

- In practice, retarders which are water-reducing are commonly used.
- 0.05% of sugar by mass of cement will delay setting time by about (4 hrs).
- 0.2 – 1% of sugar by mass of cement will prevent setting of cement (useful in case of malfunction of concrete mixer).
- Reduce early strength but later the rate of strength development is higher.
- Increase plastic shrinkage because plastic stage is extended but drying shrinkage is un affected.

1.2.2- Air -Entraining Admixtures:

Used to purposely introduce & stabilize microscopic air bubbles in concrete in order to:

- Improve durability of concrete exposed to freezing & thawing.
- Improve resistance to surface scaling caused by chemical deicers.
- Improves workability of fresh concrete significantly.
- Reduce or eliminate segregation & bleeding.

1.2.3 - Water-Reducers & (Plasticizers):

Used to reduce quantity of mixing water required to produce concrete of certain slump, reduce (w/c), reduce cement content, or increase slump.

Used for three purposes

1. To achieve higher strength by decreasing the (w/c) ratio at the same workability as an admixture-free mix.

2. To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete.

3. To increase the workability so as to ease placing in inaccessible locations.

Mechanism

1. Surface acting agents

2. Absorbed on the cement particles, (-ve charge).

3. Repulsion between particles….. Stabilizes their dispersion.

4. Air bubbles are repelled and can not attach to cement particles.

5. -ve charge cause development of a cover of oriented water molecules around each particle, thus separating the particles.

6. Results in greater particles mobility

7. Water becomes available to lubricate the mix so the workability is increased.

- Reduction in mixing water varies between (5 – 15%).
- Actual decreases in mixing water depend on (Cement content, Aggregate type, Pozzolans and air-entraining agents).
- Increase rate of loss of workability as initial workability increase.
- Its dispersing ability results in a greater surface area of cement exposed to hydration, which results in an increase in strength at early ages.

Superplastisizers (High Range Water Reducers):

- Dosage level is higher than normal water reducers, and possible undesirable effects are reduced. Used to :

➢ Produce flowing concrete.

➢ Production of very high strength concrete using normal workability but a very low (w/c)

- Water reduction can reach up to (25 – 35%)
- Higher strength can be achieved also by steam curing.
- Improved workability is of short duration (after 30 – 90 min.) workability returns to normal (i.e. high rate of slump loss).
- Should be added immediately prior to placing.
- Do not significantly affect setting.
- High cost.

• Flowing concrete: highly fluid but workable concrete that can be placed with little or no vibration while still free from excessive bleeding or segregation

• Flow concrete is used in:

- Thin sections.
- Closely spaced reinforcement.
- Pumped concrete.
- Tremie pipes (under water concreting).

- Where conventional consolidation is impractical.
- Reducing handling cost.

1.2.4 - Accelerating Admixtures:

Used to accelerate the rate of hydration and strength development (hardening) of concrete at early ages.

Other methods to accelerate strength development:

- Using Type III cement.
- Lowering (w/c) by adding cement.
- Using water reducers.
- Curing at high temperatures.

Calcium Chloride ($CaCl_2$) most commonly used:

- Used for concreting at low temperatures.
- Used when urgent repair work is required.
- It increases the rate of heat development during first few hours after mixing.
- Using $CaCl_2$ reduces the alkalinity of the concrete and promotes the hydration of the silicates.
- Used with Type I & III cement.
- Must not be used with HAC.
- Accelerate setting and over dose can cause flash setting.
- Dissolved in mixing water for uniform distribution.
- Increase concrete resistance to erosion and abrasion.

Important Note: Calcium Chloride ($CaCl_2$) Undesirable effect:

- $CaCl_2$ reduce cement resistance to sulphate attack.
- Risk of ASR increase for active aggregates.
- Increase shrinkage & creep.
- Lower the resistance of air-entrained concrete to freezing & thawing at later ages.
- Cause corrosion of reinforcement (Subject of controversy).

Acceleration without risk of corrosion can be achieved by:

- Use of very rapid hardening cement
- Chloride free admixtures.
- Used of corrosion inhibitors (soluble nitrates, chromates…).

1.2.5 - Hydration Control Admixtures:

- Retarders: Stop hydration for 72 hrs.
- Activators: Re-establish normal hydration and setting.

1.2.6 - Corrosion Inhibitors:

Used in concrete (where chloride salts is present):

- Parking structures

- Marine structures
- Bridges

Example: Calcium nitrates, Na nitrates, amines, and phosphates).

They block the corrosion reaction of the chloride ions by chemically reinforcing and stabilizing the passive protective film on the steel.

1.2.7- Shrinkage Reducing Admixtures:

Used in concrete for bridge decks, critical floor slabs, and buildings where cracks and curling must be minimized.

1.2.8 - Alkali Silica Reactivity (ASR) Inhibitors:

Used to reduce or prevent formation of ASR.

1.2.9 - Coloring Admixtures:

Used for safety purposes Red concrete (gas & electrical lines) Yellow concrete (curbs).

1.2.10 - Bonding Admixtures:

- Polymer emulsions (Latexes) which improve the adherence of fresh concrete to hardened concrete.
- Suitable for repair works.
- High cost.
- Improve tensile & flexural strength.
- Improve durability.
- improve bonding properties

1.2.11 - Water-repellent Admixtures:

- Reduce hardened concrete's capillary absorption of fluids and therefore lower its permeability.
- Mineral and vegetable oils or metallic soaps (Calcium stearate).
- These materials can not prevent water penetration into or through concrete, therefore they can not be used for water proofing.

1.3- Mineral Additives:

- Pozzolan & blast-furnace slag additives with cementations properties.
- Inert (finely divided materials added to the mix): hydrated lime or aggregate dust.
- Inserts used as workability aids for grouts and masonry and not strength enhancers.
- Coloring pigments are classified as inert admixtures.
- Powdered zinc or aluminum liberates hydrogen in the presence of alkalis or of calcium hydroxide. Utilized in the manufacturing of gas concrete or aerated concrete which is used for thermal insulation.
- Also known as gas forming admixtures.

1.4-Keep in Mind:

- Reputable supplier will provide technical data for the particular application and advice on possible side effects.
- Trial tests should be carried out using the actual constituents of the mix to be used.
- Adequate supervision should be provided at the batching stage so as to ensure correct levels of dosage of the admixture specially if not provided by the supplier.

2. AIMS AND OBJECTIVES

2.1 - The aim of this dissertation is to understand the effect of retarding admixture on concrete under hot and humid climate.

2.1.1 – Objectives

1. To investigate different types of retarding admixtures.
2. To investigate the change in concrete properties when retarding admixture is added.
3. To investigate various tests carried out on concrete with additives and those without.

3. LITERATURE REVIEW

3.1 – Retarding Admixtures

Retarding admixtures are used to delay the rate of setting of concrete. High temperatures of fresh concrete (30°C [86°F]) are often the cause of an increased rate of hardens that makes placing and finishing difficult. One of the most practical methods of counteracting this effect is to reduce the temperature of the concrete by cooling the mixing water and/or the aggregates. Retarders do not decrease the initial temperature of concrete. The bleeding rate and bleeding capacity of concrete is increased with retarders.

Retarding admixtures are useful in extending the set- ting time of concrete, but they are often also used in attempts to decrease slump loss and extend workability, especially prior to placement at elevated temperatures. The fallacy of this approach is appeared in Fig. 6-15, where the addition of a retarder resulted in an increased rate of slump loss compared to the control mixtures **[Whiting and Dziedzic 1992].**

Retarders are sometimes used to: (1) offset the accel- erating effect of hot weather on the setting of concrete; (2) delay the initial set of concrete or grout when difficult or unusual conditions of placement occur, such as placing concrete in large piers and foundations, cementing oil wells, or pumping grout or concrete over considerable distances; or (3) delay the set for special finishing tech- niques, such as an exposed aggregate surface.

The amount of water reduction for an ASTM C494 (AASHTO M 194) Type B retarding admixture is normally Below han that obtained with a Type A water reducer. Type D admixtures are designated to provide both water reduc- tion and retardation.

In general, some reduction in strength at early ages (one to three days) accompanies the use of retarders. The effects of these materials on the other properties of con- crete, such as shrinkage, may not be predictable. There- fore, acceptance tests of retarders should be made with actual job materials under anticipated job conditions. The classifications and components of retarders are listed in Appendix One.

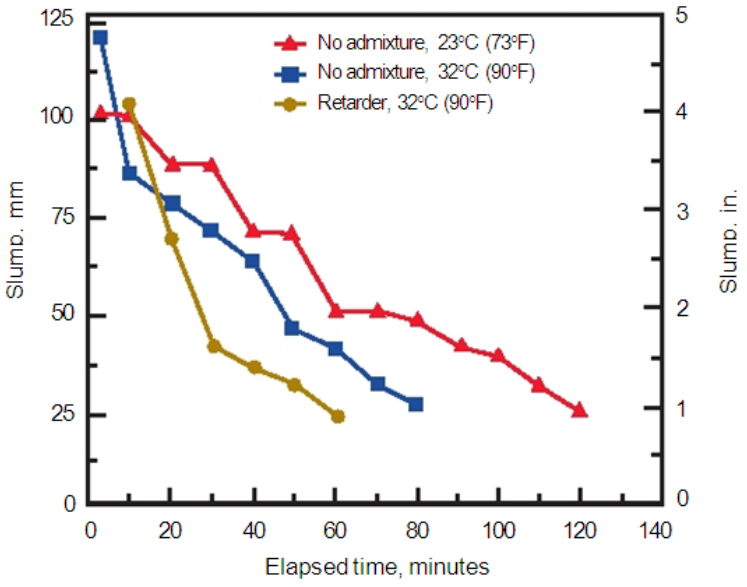

Figure: No. (3.1)

Slump loss at various temperatures for conven- tional concretes prepared with and without set-retarding admixture (Whiting and Dziedzic 1992).

A retarder is an admixture that slows down the chemical process of hydration so that concrete remains plastic and workable for a longer time than concrete without the retarder. Retarders are used to overcome the accelerating effect of high temperature on setting properties of concrete in hot weather concreting. The retarders are used in casting and consolidating large number of pours without the formation of cold joints. They are also used in grouting oil wells. **[M.S. SHETTY-2005]**

Oil wells are sometimes taken upto a depth of about 6000 meter deep where the temperature may be about 200°C. The annular spacing between the steel tube and the wall of the well will have to be sealed with cement grout. Sometimes at that depth stratified or porous rockstrata may also require to be grouted to prevent the entry of gas or oil into some other strata. For all these works cement grout is required to be in mobile condition for about 3 to 4 hours, even at that high temperature without getting set. Use of retarding agent is often used for such requirements.

Sometimes concrete may have to be placed in difficult conditions and delay may occur in transporting and placing. In ready mixed concrete practices, concrete is manufactured in central batching plant and transported over a long distance to the job sites which may take considerable time. In the above cases the setting of concrete will have to be retarded, so that concrete when finally placed and compacted is in perfect plastic state. **[M.S. SHETTY-2005]**

Retarding admixtures are sometimes used to obtain exposed aggregate look in concrete. The retarder sprayed to the surface of the formwork, prevents the hardening of matrix at the interface of concrete and formwork, whereas the rest of the concrete gets hardened. On removing the formwork after one day or so, the unhardened matrix can be just washed off by a jet of water which will expose the aggregates. The above are some of the instances where a retarding agent is used.

Perhaps the most commonly known retarder is calcium sulphate. It is interground to retard the setting of cement. The appropriate amount of gypsum to be used must be determined carefully for the given job. Use of gypsum for the purpose of retarding setting time is only recommended when adequate inspection and control is available, otherwise, addition of excess amount may cause undesirable expansion and indefinite delay in the setting of concrete. **[M.S. SHETTY-2005]**

In addition to gypsum there are number of other materials found to be suitable for this purpose. They are: starches, cellulose products, sugars, acids or salts of acids. These chemicals may have variable action on different types of cement when used in different quantities.

Unless experience has been had with a retarder, its use as an admixture should not be attempted without technical advice. Any mistake made in this respect may have disastrous consequences.

Common sugar is one of the most effective retarding agents used as an admixture for delaying the setting time of concrete without detrimental effect on the ultimate strength. Addition of excessive amounts will cause indefinite delay in setting. At normal temperatures addition of sugar 0.05 to 0.10 per cent have little effect on the rate of hydration, but if the quantity is increased to 0.2 per cent, hydration can be retarded to such an extent that final set may not take place for 72 hours or more. Skimmed milk powder (casein) has a retarding effect mainly due to sugar content.

Other admixtures which have been fruitfully used as retarding agents are Lignosulphonic acids and their salts, hydroxylated carboxylic acids and their salts which in addition to the retarding effect also reduce the quantity of water requirement for a given workability. This also increases 28 days compressive strength by 10 to 20 per cent. Materials like mucicacid, calcium acetate and commercial products by name "Ray lig binder" are used for set retarding purposes. These days' admixtures are manufactured to combine set retarding and water reducing properties. They are usually mixtures of conventional water reducing agents plus sugars or their salts. Both the setting time and the rate of strength build up are effected by these materials **[M.S. SHETTY-2005]**.

Table. No. (3.1): Effect of Retarding Admixtures on Setting Time & Strength build up

Admixture Addition litres/50 kgs.	Setting time in Hours		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

3.2 – Effect on Strength:

As we added more and more admixtures, the ultimate shear strength will increase with water reducing admixtures. As with water reducing admixtures, ultimate strength gain is increased with increasing water reduction Retardation of set effect of increasing ultimate strength with its allows the slower formation of a more cementitous matrix relative to an un-retarded mix with the same water cement ratio **[Dodson, 1990].** Opposite effect recorded when we accelerate the strength by heat with the rapid formation of a coarse matrix.

3.3 – Effect on Setting Time:

For the determination of the initial setting time and the final setting time, neat cement paste of a standard consistence has to be used. Therefore, it necessary to determine for any given cement the water content which will produce a paste of standard consistence. Consistence is determined by the vicat apparatus, which measures the depth of penetration of a 10mm (3/8 in.) diameter plunger under its own weight. When the depth of penetration reaches a certain value, the water content required gives the standard consistence of between 26 and 33 (expressed as a percentage by mass of dry cement).

The prime function of a retarder is to extend the setting (stiffening) time of concrete, usually in order to prevent the formation of cold joints between deliveries of concrete. Even if workability has fallen to almost zero slump, fresh concrete can be vibrated into, and will bond with, a preceding, older pour. **[Test method C 403/C 403M]**

3.4- Retarding Plasticizers:

It is mentioned earlier that all the plasticizers/ super-plasticizers by themselves show Certain extent of retardation. Many a time this extent of retardation of setting time offered by admixtures will not be sufficient. Instead of adding retarders separately, retarders are mixed with plasticizers or super-plasticizers at the time of commercial production. Such commercial brand is known as retarding plasticizers or retarding super plasticizers. ASTM type D is retarding plasticizers and ASTM type G is retarding super-plasticizer. In the commercial formulation we have also retarding and slump retaining version.

Retarding plasticizers or super-plasticizers are important category of admixtures often used in the Ready mixed concrete industry for the purposes of retaining the slump loss, during high temperature, long transportation, to avoid construction or cold joints, slip form construction and regulation of heat of hydration. **[M.S. SHETTY-2005]**

One must be careful in the selection of such ready made retarding admixtures. On account of heterogeneous nature and different molecular weight of retarders used with plasticizers, they tend to separate out. It happens when sugar solution is used as cheap retarders. When retarders like glaciate is used such separation or settlement of retarders do not happen. It is cautioned that such retarding plasticizers should forever be shaken thoroughly or well stirred before use. There are cases that settlement of retarders from rest of the ingredients causing excessive retardation or failure of structures**. [M.S. SHETTY-2005]**.

3.5 –Effect on Workability of the Concrete:

- Not a very significant effect upon initial workability but beneficial effect upon workability retention, particularly at elevated temperature **[Older, 1992]**.
- To enable workability to be increased to a greater extent, at a typical dosage level of 0.3 to 1.0% **[Dodson, 1990].**

3.6 - Slump loss Effecting:

At elevated temperature, retarding admixtures used to reduce slump loss. The best effective nature of Retarding water reducing admixtures are noticeable in reducing slump loss with increase the initial workability of the mix, but less so when used as a water reducer. Indeed, if water reduction is taken at the expense of high initial workability, initial slump loss may be slightly faster and will slow when about half the initial slump is reached.

3.7 - Air Entrainment:

Retarding admixtures do not normally entrain air, and some types, especially those based on hydroxycarboxylic acid, may actually reduce air content.

3.8 - Bleeding:

The plasticizing component of a retarding water reducing admixture may help to offset this effect and some types are formulated to slightly air entrain in order to reduce bleed.

3.9 - Heat of Hydration:

Retarding admixtures do not reduce the heat output of concrete but do serve to delay the time of peak temperature rise by exactly the same time interval by which it was retarded.

3.10 - Durability:

Retarded water reduced concrete will have a lower water content than the equivalent plain concrete, and will be correspondingly more durable **[Dodson, 1990].**

3.11 - Mix Composition:

The mix composition particularly the aggregate/cement ratio or richness of the mix, w/c ratio, and use of other supplementary cementing materials like fly ash or silica fume affects the workability. Wetter the mix better is the dispersion of cement grains and hence better workability. The size and shape of aggregate, sand grading will also have influence on the fluidifying effect. **[M.S. SHETTY-2005]**