CHEMICAL ADMIXTURES USED IN CONCRETE MIX DESIGN TO IMPROVE THE QUALITY OF CONCRETE AND FOR THE MAINTENANCE OF CONCRETE

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Abstract— Chemical admixtures are the ingredients in concrete other than portland cement, water, and aggregate that are added to the mix immediately before or during mixing to improve the quality and durability of concrete. These admixtures also used for the maintenance purpose of concrete. The admixture should be employed only after an appropriate evaluation of its effect on performance of concrete under the condition in which the concrete intended to be used. The benefits in the uses of water reducers not limited to this. When water reduces shrinkage and porosity of concrete are reduces which provides the durability to concrete structures. There is a wide range of High Range Water reducing admixtures for concrete which used to improve the quality and strength of concrete. The chemical named Dr. Fixit Pidicrete CF 21 and Dr. Fixit Pidicrete CF 111-S used as high range water reducing admixtures for concrete.

Keywords- Admixtures, GGBFS (Ground granulated blast furnace slag) Cement reduction.

1. INTRODUCTION

CONCRETE is a most widely used construction material. It is a mixture of cement, aggregate, sand, and water. However concrete is more complicated than 15 years ago. The research on each raw material has made new concrete designs and applications possible, for example Slag cement and Fly-ash cement are produced because more Pozzolana materials have been used. Researchers changed their concrete study from traditional macroscopic discussions to microscopic investigations. Concrete based on the 28 day strength, is classified as high strength concrete so and so forth. Till about 1970s the concretes that could achieve strength of above 40Mpa were classified as high strength concrete. When concrete mixtures of about 60Mpa and above were commercially produced the bench mark for the high strength concrete was raised to 55Mpa or more.

Admixtures are no substitute for good concreting practice. An admixture should be employed only after an appropriate evaluation of its effects on the performance of concrete under the condition in which the concrete is intended to be used. It is often necessary to conduct tests under simulated job conditions in order to obtain reliable information on the performance of concrete containing admixture. Admixture that contains relatively large amounts of chloride may accelerate corrosion of prestressing steel.

Concrete design has been more complicated in recent years because of new factors, for example: resource conservation (CaCO), waste recovering (Slag & Flyash), and durability increase. Concrete industry has put lots of efforts for researches of concrete durability improvements. It’s been confirmed the necessary raw materials in concrete, Cement and Water, contribute major damages to the durability of concrete. Chemical admixtures are the ingredients in concrete other than portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Producers use admixtures primarily to reduce the cost of concrete construction; to modify the properties of hardened concrete; to ensure the quality of concrete during mixing, transporting, placing, and curing and to overcome certain emergencies during concrete operations.

Successful use of admixtures depends on the use of appropriate methods of batching and concreting. Most admixtures are supplied in ready-to-use liquid form and are added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

Three to four decades ago despite the availability concrete as versatile construction material. Most of the highrise buildings all over the world have used steel elements as structural frame. The famous Twin Towers at
Manhattan (World Trade Centre) had steel frames. The reason was that with the strength of concrete available in those days the members made of concrete would have been bulky and ugly.

With advent of high strength the bulkiness in the concrete members are gone and we are able to make slender sections in concrete too. Since then high strength concrete has come a long way and is running a race to reach the strength of steel. The concrete of the order of 200 MPa has become a reality at least at the laboratory conditions and concrete of the order of M60 to M120 are commonly used at sites. The properties of the high strength concrete are well studied and understood by the engineers today, the use of very high strength concrete no longer raises eye brows. The drawbacks of the high strength concrete have been countered by the user.

1.1 TYPES OF ADMIXTURES

- **Chemical admixtures** - Accelerators, Retarders, Water-reducing agents, Super plasticizers, Air entraining agents etc.
- **Mineral admixtures** - Fly-ash Blast furnace slag, Silica fume and Rice husk Ash etc.

1.2 FUNCTION OF ADMIXTURES

Over decades, attempts have been made to obtain concrete with certain desired characteristics such as high compressive strength, high workability, and high performance and durability parameters to meet the requirement of complexity of modern structures.

- To achieve a higher strength by decreasing the water cement ratio at the same workability as an admixture free mix.
- To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete.
- To increase the workability so as to ease placing in accessible locations.
- Water reduction more than 5% but less than 12%.
- The commonly used admixtures are Ligno-sulphonates and hydrocarbolic acid salts.
- To improve the quality and strength of concrete.
- To improve the penetration and pumpability of concrete.
- To increase the resistance of chemical attack.
- To produce non-skid wearing surfaces.
- To reduce heat of hydration.
- Plasticizers are usually based on lignosulphonate, which is a natural polymer, derived from wood processing in the paper industry.

1.3 THE COMMON TYPES OF CHEMICAL ADMIXTURES

- Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are CaCl₂, Ca(NO₃)₂, and NaNO₃. However, use of chlorides may cause corrosion in steel reinforcing and is prohibited in some countries, so that nitrates may be favored. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.
- Retarders slow the hydration of concrete and are used in large or difficult pours where partial setting before the pour is complete is undesirable. Typical polyl retarders are sugar, sucrose, sodium gluconate, glucose, citric acid, and tartaric acid.
- Air entrainments add and entrain tiny air bubbles in the concrete, which reduces damage during freeze-thaw cycles, increasing durability.
- Plasticizers increase the workability of plastic or “fresh” concrete, allowing it be placed more easily, with less consolidating effort. A typical plasticizer is lignosulfonate. Plasticizers can be used to reduce the water content of a concrete while maintaining workability and are sometimes called water-reducers due to this use. Such treatment improves its strength and durability characteristics.
- Superplasticizers (also called high-range water-reducers) are a class of plasticizers that have fewer deleterious effects and can be used to increase workability more than is practical with traditional plasticizers.
Pigments can be used to change the color of concrete, for aesthetics.

Corrosion inhibitors are used to minimize the corrosion of steel and steel bars in concrete.

Bonding agents are used to create a bond between old and new concrete (typically a type of polymer) with wide temperature tolerance and corrosion resistance.

Pumping aids improve pumpability, thicken the paste and reduce separation and bleeding. Inorganic materials that have pozzolanic or latent hydraulic properties, these very fine-grained materials are added to the concrete mix to improve the properties of concrete (mineral admixtures), or as a replacement for Portland cement (blended cements). Products which incorporate limestone, fly ash, blast furnace slag, and other useful materials with pozzolanic properties into the mix are being tested and used. This development is due to cement production being one of the largest producers (at about 5 to 10%) of global greenhouse gas emissions, as well as lowering costs, improving concrete properties, and recycling wastes.

1.4 THE COMMON TYPES OF MINERAL ADMIXTURES

Fly Ash: A by-product of coal-fired electric generating plants; it is used to partially replace Portland cement (by up to 60% by mass). The properties of fly ash depend on the type of coal burnt. In general, siliceous fly ash is pozzolanic, while calcareous fly ash has latent hydraulic properties.
- **Ground Granulated Blast Furnace Slag (GGBFS or GGBS):** A by-product of steel production is used to partially replace Portland cement (by up to 80% by mass). It has latent hydraulic properties.
- **Silica Fume:** A by-product of the production of silicon and ferrosilicon alloys. Silica fume is similar to fly ash, but has a particle size 100 times smaller. This results in a higher surface-to-volume ratio and a much faster pozzolanic reaction. Silica fume is used to increase strength and durability of concrete, but generally requires the use of superplasticizers for workability.

![Figure 3. Composition of Concrete](image)

- **High Reactivity Metakaolin (HRM):** Metakaolin produces concrete with strength and durability similar to concrete made with silica fume. While silica fume is usually dark gray or black in color, high-reactivity metakaolin is usually bright white in color, making it the preferred choice for architectural concrete where appearance is important.

1.5 **Fly Ash or Pulverised Fuel Ash (PFA)**

It is a finely divided powder thrown out as a waste material at the thermal power plants using pulverized coal for raising steam in the boilers. In the building industry, the use of fly ash as a part replacement of cement in mortar and concrete at the construction site has been made all over the world including India and is well known. The important building materials which can be produced from fly ash are:
- Portland fly ash cement
- Ready-mixed fly ash concrete
- Precast fly ash concrete building units
- Sintered fly ash lightweight aggregate for concrete
- Lime fly ash cellular concrete
- Fly ash building bricks
- Fly ash stabilized high-magnesia cement
- Oil-well cementing composition
- Hydraulic binders and
- Bituminous products

1.6 **The Advantages of Fly Ash Concrete over the Corresponding Plain Cement Concrete**

- Improved workability.
- Lower heat of hydration.
- The increase in creep with fly ash content upto 15% is negligible.
Increases the modulus of elasticity of concrete when concretes of the same strength with and without fly ash are compared.
Superior resistance to freezing and thawing.
Improved sulphate resistance.
Lower water and air permeability.
Lower leaching of lime liberated during hydrated of cement.
Reduced alkali-aggregate reactions.
Greater resistance to attack of aggressive waters.

Since a huge quantity of cement is used in concrete in mass concrete construction and the cost of fly ash is negligible as compared to that of the cement, the use of fly ash concrete brings about a substantial saving in cement consumption and overall construction cost.

Fly ash concrete may be used in general RCC structures including high strength concrete without any risk of steel corrosion. Researchers have proved that concrete with approved quality fly ash does not induce corrosion of reinforcing steel even in marine and industrial aggressive environments. With proper mix design the 7 and 28-days strength of fly ash concrete may be equal or even more than plain concrete. The 90 days strength of fly ash concrete may be more than 140% of plain concrete. The cost of fly ash is negligible. Therefore the use of fly ash in structural concrete may bring a substantial saving in cement consumption and overall cost of concrete production. The fly ash is an industrial waste and great hazard for our environment. The designers of concrete structures therefore must incorporate the use of fly ash in their structural concrete.

1.7 Method of Fly Ash Concrete Mixing For obtaining the best result the fly ash concrete should be prepared by the following mixing method

About 3/4th quantity of the mixing water be taken in the concrete mixer. Weighted amount of the required quantity of fly ash then added to it and mixed for 30 sec. To the slurry of fly ash so obtained, weighted quantities of coarse aggregate, fine aggregate, cement and remaining quantity of the mixing water be added and mixed for 90 sec.

However, if this is not convenient normal mixing method may be adopted i.e. weighted quantities of coarse aggregate, fine aggregate cement and fly ash should be put together in the concrete mixer and mixed dry for 30 sec. The required quantity of the mixing water then added and the mixing continued for 90 sec. The superplasticizer by added just before discharge of the mix from mixer.

1.8 High Range Water Reducing Admixtures for Concrete

There is a wide range of chemicals which used to improve the quality and strength of concrete. There is following admixtures which are used for water reducing for concrete.

1.8.1 Dr. Fixit Pidicrete CF 21

Dr. Fixit Pidicrete CF 21 is a solution of sulphonated naphthalene formaldehyde and additives in water. It is a superplasticising admixture to produce pumpable or flowable concrete with a low w/c ratio. When added to the concrete mix it gives a high slump without any bleeding or segregation in the fresh state and high early and ultimate strengths in the hardened state. Standard Compliance or Specification meets the requirement of IS: 9103-1999 and ASTM-C-494-86, Type F.

1.9 Areas of Application

- High performance concrete used for columns, beams, decks & dams.
- General purpose ready mix concrete, prestressed & precast concrete.
- Complex & heavily reinforced concrete Railway sleepers.
- High strength & low permeable concrete.
- Mass concrete.
1.10 FEATURES & BENEFITS

- Water reduction - Reduces water up to 25% without affecting the workability.
- Workability - Increases workability at a given w/c ratio, easy compaction hence eliminates honeycombing.
- Bleeding & segregation - Provides highly cohesive concrete mix & reduces the chance of bleeding & segregation.
- Permeability - Makes concrete less permeable and hence improves the durability.
- Chloride content – chloride free hence suitable for RCC.
- Compatibility - Compatible with all types of Portland cement/including slag/SRC.
- Cement reduction - Helps in reducing cement content for a required strength, hence economical.
- Strength - High early and ultimate compressive strength concrete.
- Toxicity – Nontoxic.

1.11 METHOD OF APPLICATION

- The correct quantity of Dr. Fixit Pidicrete CF 21 should be measured with recommended dispenser and should bethoroughly dispersed with approximately 5 - 10% of the recommended water content (based on mix design by weight.)
- Mix concrete constituents along with balance approximately 90 - 95% of the recommended water content (based on mix design by weight) for 3 minutes.
- As soon as step 2 is over, the admixture dispersed in water (as in step-1) is to be added to the wet concrete and mix it further for 2-3 minutes to get a homogeneous mix.

1.12 PRECAUTIONS & LIMITATIONS

- Dr. Fixit Pidicrete CF 21 should not be added in dry mixes under any circumstances.
- Keep the liquid above freezing temperature.
- Overdosing may lead to delay in setting time.
- Dosage, 200 ml to 750 ml per 50 kg of cement. Higher dosage may require for special application (depending upon site)

1.13 TECHNICAL INFORMATION

<table>
<thead>
<tr>
<th>PROPERTIES</th>
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<th>RESULTS</th>
</tr>
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<tbody>
<tr>
<td>Appearance</td>
<td>FREE FLOWING LIQUID</td>
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Other technical properties such as slump, setting time, compressive strength & permeability varies & depends on type & grade of cement, quality & size of aggregates, w/c ratio & mix design.

1.14 SHELF LIFE & STORAGE

- Shelf life is 12 months from date of manufacturing in unopened containers.
- Store at cool & dry place, away from sun heat.

1.15 HEALTH & SAFETY PRECAUTIONS

- Use rubber hand gloves & safety goggles, while using Dr. Fixit Pidicrete CF 21.
- In case of contact with skin, wash with plenty of water.
- Keep out of reach of children's.

1.15.1 Dr. Fixit Pidicrete CF 111 - S

Dr. Fixit Pidicrete CF 111 - S is a solution of modified Sulfonated Naphthalene Formaldehyde based super plasticiser and additives in water, which helps in achieving high workability and high early strength in all grades of concrete.

It provides excellent retention of slump at economical dosages.

Standard Compliances /Specification, Meets the requirement of IS: 9103-1999 and ASTM-C-494-86, Type G standard

1.16 AREAS OF APPLICATION

- RCC columns
- Bridge decks,
- Dams, water-retaining structures,
- Slip-form shuttering and any mass concreting
- Pump concreting - where the internal friction of the mix is reduced to a minimum.

1.17 FEATURES & BENEFITS

- Water reduction - Reduces water upto 25 % hence dense & compact concrete achieved.
- Workability - Higher retention of workability, up to 2 hours depending on the mix design.
- Permeability - Improves workability and makes dense concrete thereby reducing permeability.
- Strength - Achieves high early strength.
- Cement reduction - Helps in reducing cement content for a required strength, hence economical.
- Toxicity – Non-toxic.
- Chloride content - Chloride free hence suitable for RCC.

1.18 METHOD OF APPLICATION

- The correct quantity of Dr. Fixit Pidicrete CF 111-S should be measured with recommended dispenser and should be thoroughly mixed with approx. 5 - 10 % of the recommended water content (based on mix design by weight.)
- Mix concrete constituents along with balance approx. 90 - 95 % of the recommended water content (based on mix design by weight) for 2 minutes.
- As soon as step 2 is over, the admixture mixed in water (as in step-1) is to be added to the wet concrete and mix it further for 2-3 minutes to get a homogeneous mix.
1.19 PRECAUTIONS & LIMITATIONS

- Dr. Fixit Pidicrete CF 111-S should not be added in dry mixes under any circumstances. If used for cement reduction without loss in strength, the dose of Dr. Fixit Pidicrete CF 111-S will depend on mix design.
- Overdosing may lead to delay in setting of concrete. F 111

Table 2: Technical Information

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Other technical properties such as slump, setting time, compressive strength & permeability varies & depends on type & grade of cement, quality & size of aggregates, w/c ratio & mix design.

**Dosage**, 200 ml to 750 ml per 100 kg of cement. Higher dosage may require for special application (depending upon site requirements and trials).

**Shelf Life & Storage**

- Shelf life is 12 months from date of manufacturing in unopened containers.
- Store at cool & dry place, away from sun heat.

**Health & Safety Precaution**

- Use rubber hand gloves & safety goggles, while using Dr Fixit Pidicrete CF 111 - S.
- In case of contact with skin, wash with plenty of water.
- Keep out of reach of children’s.

In India 0.93 kg of CO₂ is emitted in the production of one kg of cement. In the financial year 2009-10 India produces 200 million tonnes of cement. In the production of this cement 186 million tonnes of CO₂ was emitted in the atmosphere during financial year of 2009-10.

If 50 million tonnes cement in making concrete uses water reducers 7500000 tonnes of cement can be saved. 3750000 kl of potable water will be saved and the saving of Rs. 3300 crores per year to construction industry. This amount is worked out after adjusting the cost of water reducers. Less cement used means less cement required to be produce by the cement factories resulting 6975000 tonnes of CO₂ will be prevented to be emitted to the atmosphere. These are worked out with an average saving of 15% cement and 15% water.

CO₂ emission is word problem, but for India in addition to CO2 it has problems of Air, Water, Soil, Food and Noise pollutions. Less densely populated countries may cope with these problems but for India it is of the top concern. The population figures of 2009 are, India 350 person per sq.km, China 132 person per sq.km and USA only 34 person per sq.km. The figures of 2006 CO₂ emissions are USA 658.60 tonnes per sq.km, China 611.76 tonnes per sq.km and India 459.35 tonnes per sq.km. Everyone should contribute his or her efforts to save the environment from pollution.
2. CONCLUSION

- For M-30 Grade concrete having same material and requirement, but without water reducer, the PPC and OPC required will be $190/0.45 = 422\text{ kg/m}^3$.
- With the use of superplasticizer the saving in cement is $92 \text{ kg/m}^3$ and water $45 \text{ lit/m}^3$ for PPC and OPC.
- In the Fly ash concrete the saving in cement is $163 \text{ kg/m}^3$ and water $52 \text{ lit/m}^3$ including utilization of $111 \text{ kg/m}^3$ of fly ash which is a waste material.
- If 50 million tonnes cement in making concrete uses Water Reducers 750000 tonnes of cement can be saved. 3750000 KL of potable water will be saved and the saving of Rs. 3300 crores per year to the construction Industry. 6975000 tonnes of CO2 will be prevented to be emitted to the atmosphere.
- The benefits in the uses of water reducers not limited to this. When water reduces shrinkage and porosity of concrete are reduces which provides the durability to concrete structures.
- India is facing serious air, water, soil, food and noise pollution problems. Every effort therefore are necessary to prevent pollution on top priority basis.
- Chemical admixtures help to improve the quality of the concrete and also strength of the concrete.

3. REFERENCES