

## Effect of Pozzolanas on Fiber Reinforced Concrete



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### ABSTRACT

*High-performance concrete is defined as concrete that meets special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices.*

*Ever since the term high-performance concrete was introduced into the industry, it had widely used in large-scale concrete construction that demands high strength, high flowability, and high durability. A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete. Durable concrete Specifying a high-strength concrete does not ensure that a durable concrete will be achieved. It is very difficult to get a product which simultaneously fulfill all of the properties. So the different pozzolanic materials like Ground Granulated Blast furnace Slag (GGBS), silica fume, Rice husk ash, Fly ash, High Reactive Metakaolin, are some of the pozzolanic materials which can be used in concrete as partial replacement of cement, which are very essential ingredients to produce high performance concrete. So we have performed XRD tests of these above mentioned materials to know the variation of different constituent within it. Also it is very important to maintain the water cement ratio within the minimal range, for that we have to use the water reducing admixture i.e superplasticizer, which plays an important role for the production of high performance concrete. So we herein the project have tested on different materials like rice husk ash, Ground*

*granulated blast furnace slag, silica fume to obtain the desired needs. Also X-ray diffraction test was conducted on different pozzolanic material used to analyse their content ingredients. We used synthetic fiber (i.e Recron fibre) in different percentage i.e 0.0%, 0.1%, 0.2%, 0.3% to that of total weight of concrete and casting was done. Finally we used different percentage of silica fume with the replacement of cement keeping constant fiber content and concrete was casted. In our study it was used two types of cement, Portland slag cement and ordinary Portland cement. We prepared mortar, cubes, cylinder, prism and finally compressive test, splitting test, flexural test are conducted. Finally porosity and permeability test conducted. Also to obtain such performances that cannot be obtained from conventional concrete and by the current method, a large number of trial mixes are required to select the desired combination of materials that meets special performance.*

### 1.HIGH PERFORMANCE CONCRETE:

"High-Performance Concrete" has been introduced into the construction industry. The American Concrete Institute (ACI) defines high-performance concrete as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely when using conventional constituents and normal mixing, placing and curing practices.

The specification of high-strength concrete generally results in a true performance specification in which the performance is specified for the intended application,

and the performance can be measured using a well-accepted standard test procedure. The same is not always true for a concrete whose primary requirement is durability.

### Salient Features of HPC:

- High Compressive strength
- Low water-binder ratio
- Reduced flocculation of cement grains
- Wide range of grain sizes
- Densified cement paste
- No bleeding homogeneous mix
- Less capillary porosity

### 2.High Strength Concrete:

**High-strength concrete** columns can hold more weight and therefore be made slimmer than regular strength concrete columns, which allows for more useable space, especially in the lower floors of buildings. High-strength concrete is specified where reduced weight is important or where architectural considerations call for small support elements. By carrying loads more efficiently than normal-strength concrete, high-strength concrete also reduces the total amount of material placed and lower the overall cost of the structure.

### There are special method of making high strength concrete such that:

- Seeding
- Revibration
- High speed slurry mixing
- Use of admixtures
- Inhibition of cracks
- Sulphur impregnation
- Use of cementitious aggregate

## REVIEW OF LITERATURE

### 2.1. Introduction:

As our aim is to develop concrete which does not only concern on the strength of concrete, it also having many other aspects to be satisfied like less porous, capillary absorption, durability. So for this we need to go for the addition of pozzolanic materials along with

superplasticizer with having low water cement ratio. The use of silica fume is many, which is having good pozzolanic activity and is a good material for the production high performance concrete. Also now a days one of the great application in various structural field is fiber reinforced concrete, which is getting popularity because of its positive effect on various properties of concrete.

## MATERIALS & PROPERTIES

### 3.1. GROUND GRANULATED BLAST FURNACE SLAG:

Ground Granulated Blastfurnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. If slag is properly processed then it develops hydraulic property and it can effectively be used as a pozzolanic material. However, if slag is slowly air cooled then it is hydraulically inert and such crystallized slag cannot be used as pozzolanic material.

**Table 3.1. Chemical composition (%) of GGBS:**

SiO <sub>2</sub>	39.18
Al <sub>2</sub> O <sub>3</sub>	10.18
Fe <sub>2</sub> O <sub>3</sub>	2.02
CaO	32.82
MgO	8.52
Na <sub>2</sub> O	1.14
K <sub>2</sub> O	0.30

### Performance of Ground Granulated Blast furnace Slag in Concrete:

The replacement of cement with GGBS will reduce the unit water content necessary to obtain the same slump. This reduction of water content is more pronounced with increase in slag content and also on the fineness of slag. This is because of the surface configuration and particle shape of slag being different than cement particle. Surface hydration of slag is slightly slower than that of cement. Reduction of bleeding is not significant with slag of 4000 cm<sup>2</sup>/g fineness but significant when slag fineness of 6000 cm<sup>2</sup>/g and above.

### Advantages of using GGBS:

- Reduce heat of hydration
- Refinement of pore structures
- Reduce permeability to the external agencies
- Increase resistance to chemical attack.

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Ground granulated blast furnace slag now a days mostly used in India. Recently for marine out fall work at Bandra, Mumbai. It has used to replace cement to about 70%. So it has become more popular now a day.

### Advantages of using GGBS:

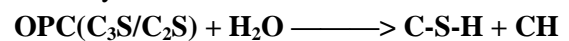
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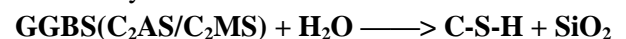
### Reaction Mechanism of Ground Granulated Blast furnace Slag:

Although GGBS is a hydraulically latent material, in presence of lime contributed from cement, a secondary reaction involving glass (Calcium Alumino Silicates) components sets in. As a consequence of this, cementitious compounds are formed. They are categorized as secondary C-S-H gel. The interaction of GGBS and Cement in presence of water is described as below:

Product of hydration of OPC



Product of hydration of GGBS



### RICE HUSK ASH:

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When it is properly burnt it has high SiO<sub>2</sub> content and can be used as a concrete admixture. Rice husk ash exhibits high pozzolanic characteristics and contributes to high strength and high impermeability of concrete. Rice husk ash essential consists of amorphous or non crystalline silica with about 85- 90% cellular particle, 5% carbon and 2% K<sub>2</sub>O. The specific surface of RHA is between 40000-100000 m<sup>2</sup>/kg.

India produces about 122 million ton of paddy every day. Each ton of paddy produces about 40 kg of RHA. There is a good potential to make use of RHA as a valuable pozzolanic material to give almost the same properties as that of microsilica. In USA highly pozzolanic rice husk ash is patented under the trade name of Agrosilica and is marketed. It is having superpozzolanic property when used in small quantity i.e. 10% by weight of cement and it greatly enhances the workability and impermeability of concrete.

### Advantage of Rice husk ash:

Even with small dosages, for instance 10 percent by weight of cement rice husk ash can produce a very strong transition zone and very low permeability rating in concrete mixtures. In the cement having large size particles introduction of rice husk ash particles, which are micro porous blocks the channels of flow and internal pore of concrete improves.

The major advantage of rice husk ash and silica fume is that they are very strong absorbents of sodium, potassium and other ions which are good conductors of electricity. A highly durable concrete with little or no corrosion in a severe environment can be obtained by improving the electrical resistivity of concrete by adding rice husk ash or silica fume.

### SILICA FUME:

Silica fume also referred as microsilica or condensed silica fume is another material that is used as an artificial pozzolanic admixture. It is a product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy.

The use of silica fume in conjunction with superplasticizer has been back bone of modern high performance concrete.

### Advantages of Silica fume:

- High strength concrete made with silica fume provides high abrasion/corrosion resistance.
- Silica fume influences the rheological properties of fresh concrete, the strength, porosity and durability of hardened mass.
- Silica fume concrete with low water content is highly resistant to penetration of chloride ions.
- The extreme fineness of silica fume allows it to fill or pack the microscopic voids between cement particle and especially in the voids at the surface of the aggregate particles where the cement particles cannot fully cover the surface of the aggregate and fill the available space.

### SUPERPLASTICIZER:

There are two types of admixtures i.e Mineral admixtures and Chemical admixtures.

#### 1) Mineral admixtures:

- Silica fume
- Ground granulated blast furnace slag
- Rice husk ash
- Fly ash

#### 2) Chemical admixture:

- Accelerating admixture
- Retarding admixture
- Water-reducing admixture

### CEMENT:

Cement is a material that has cohesive and adhesive properties in the presence of water. Such cements are called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay.

There are different types of cement, out of that I have used two types i.e,

- Ordinary Portland cement
- Portland slag cement

**Ordinary port land cement (OPC)** is the basic Portland cement and is best suited for use in general concrete construction. It is of three type, 33 grade, 43 grade, 53 grade. One of the important benefit is the faster rate of development of strength.

**Portland slag cement** is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag in suitable proportion and grinding the mixture to get a thorough and intimate mixture between the constituents.

This type of cement can be used for all purposes just like OPC. It has lower heat of evolution and is more durable and can be used in mass concrete production.



## AGGREGATE:

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete. The aggregate are classified as

- Fine aggregate
- Coarse aggregate

Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge beyond which they are known as coarse aggregate. Coarse aggregate form the main matrix of the concrete, where as fine aggregate form the filler matrix between the coarse aggregate. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. The fine aggregate also helps the cement paste to hold the coarse aggregate particle in suspension.

Coarse aggregate maximum 20 mm coarse aggregate is suitable for concrete work. But where there is no restriction 40 mm or large size may be permitted. In case of close reinforcement 10mm size also used.

## FIBER:

In recent years, several studies have been conducted to investigate the flexural strengthening of reinforced concrete (RC) members with fiber reinforced composite fabrics. Recently, the use of high strength fiber-reinforced polymer (FRP) materials has gained acceptance as structural reinforcement for concrete.

In this composite material, short discrete fibers are randomly distributed throughout the concrete mass. The behavioral efficiency of this composite material is far superior to that of plain concrete and many other construction materials of same cost. Due to this benefit, the use of FRC has steadily increased during last two decades and its current field of application includes airport and highway pavements, earthquake resistant and explosive resistant structures, mines and tunnel linings, bridge deck overlays, hydraulic structures, rock slope stabilization. Extensive research work on FRC has established that the addition of various types of fibers such as steel, glass, synthetic and carbon, in plain concrete improves strength, toughness, ductility, and

post cracking resistance etc. The major advantages of fiber reinforced concrete are resistance to microcracking, impact resistance, resistance to fatigue, reduced permeability, improved strength in shear, tension, flexure and compression

The character and performance of FRC changes with varying concrete binder formulation as well as:

**Fiber materials:** According to terminology adopted by the American Concrete Institute (ACI) Committee 544, Fiber Reinforced Concrete, there are four categories of FRC based on fiber material type. These are Steel Fiber Reinforced Concrete, Glass Fiber Reinforced Concrete, Synthetic Fiber Reinforced Concrete, including carbon fibers; and Natural Fiber Reinforced Concrete.

**Equivalent diameter:** For fibers that are not circular and prismatic in cross-section, it is useful to determine what would be the diameter of an individual fiber if its actual cross-section were formed as a prismatic circular cross-section. The equivalent diameter of a fiber is the diameter of the circle having the same area as that of the average cross-sectional area of an actual fiber.

**Fiber aspect ratio:** The fiber aspect ratio is a measure of the slenderness of individual fibers. It is computed as fiber length divided by the equivalent fiber diameter for an individual fiber. Fibers for FRC can have an aspect ratio varying from approximately 40 to 1000 but typically less than 300. This parameter is also a measure of fiber stiffness and will affect mixing and placing.

**Fiber denier:** Principally when discussing about Synthetic fiber reinforced concrete, the term fiber denier is often used. This is terminology that evolved from the textiles industry. The denier of a fiber is defined as the weight, in grams, of 9000 metres of fiber.

## Recron Fiber:

Recron Fibrefill is India's only hollow Fibre specially designed for filling and insulation purpose. Made with technology from DuPont, USA, Recron Fibrefill

adheres to world-class quality standards to provide maximum comfort, durability, and ease-of-use in a wide variety of applications like sleep products, garments and furniture. Reliance Industry Limited (RIL) has launched Recron 3s fibres with the objective of improving the quality of plaster and concrete.

Only 0.2-0.4% by cement RECRON 3s is sufficient for getting the above advantages. Thus it not only pays for itself, but results in net gain with reduced labour cost & improved properties. So we can briefly summarize the advantages of Recron 3s fiber as,

- Control cracking
- Increase flexibility
- Reduction in water permeability
- Reduction in rebound loss in concrete
- Safe and easy to use

### **Fiber count and specific surface:**

Fiber count (FC) and fiber specific surface (FSS) are the number of fibers in a unit volume of FRC and the surface area of fiber in a unit volume of FRC, respectively. Consider the mass of an FRC composite based on volume basis. The total volume of fiber in any given unit of volume of composite, i.e. the volume fraction (or percentage if multiplied by 100), may consist of only one single (large) fiber or it may be any number of smaller individual fibers.

### **SCOPE OF FURTHER WORK:**

The research work on pozzolanic materials and fiber along with pozzolanas is still limited. But it promises a great scope for future studies. Following aspects are considered for future study and investigation;

Percentage and actual fineness of GGBS require as partial cement replacement for good strength development.

Use of RHA as cement replacement with properly burned in controlled temperature and grinded which may lead proper strength development.

Replacing cement with different percentage of silica

fume to judge the optimum percentage of silica fume to be used to get better strength result.

Research on Recron fiber and silica fume with greater fineness as a partial cement replacing material, by which we can minimise the cost and at the same time achieve the durability and strength for the production of High Performance Concrete.

It requires a proper mixing proportions for the development of high strength, high performance concrete which may not be possible manually. So it needs some global optimisation techniques to develop the desired result with greater accuracy and time saving.

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