

The Study of Effect of Pozzolanas on Fiber Reinforced Concrete

Er.Yogesh, Er. Rahul Sikka, Dr. Arvind Dewangan, Er. Bhavana Arora

Abstract— 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. 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.

Index Terms— Rice husk ash, silica fume, Ground Granulated Blastfurnace slag (GGBS).

Sub Area : Construction Technology & Management

Broad Area :Civil Engineering

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger

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with age. The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials (whatever may be their qualities) of concrete and the knowledge that virtually any combination of the constituents leads to a mass of concrete have bred contempt. Strength was emphasized without a thought on the durability of structures. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction. This is particularly true of concrete structures which were constructed since 1970 or thereabout by which time (a) the use of high strength rebars with surface deformations (HSD) started becoming common, (b) significant changes in the constituents and properties of cement were initiated, and (c) engineers started using supplementary cementitious materials and admixtures in concrete, often without adequate consideration.

The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial replacement of cement. With the passage of time to meet the demand, there was a continual quest in human being for the development of high strength and durable concrete. The history of high strength concrete is about 35 years old, in late 1960s the invention of water reducing admixtures lead to the high strength precast products and structural elements in beam were cast in situ using high strength concrete. More recently, compressive strengths approaching 138N have been used in cast-in-place buildings. The advent of prestressed concrete technology has given impetus for making concrete of high strength. In India high strength concrete is used in prestressed concrete bridges of strength from 35 MPa to 45 MPa. Presently (in 2000) Concrete strength of 75 MPa is being used for the first time in one of the flyover at Mumbai. Also in construction of containment Dome at Kaiga power project used HPC of 60MPa with silica fume as one of the constituent.

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Now a day the construction industry turning towards pre-cast elements and requirement of post-tensioning has made the requirement of the high strength of concrete invariable and the engineers had to overcome these drawbacks, which to a great extent we have been able to do. The construction today is to achieve savings in construction work. This has now turned into one of the basic requirement of concreting process.

II. HIGH PERFORMANCE CONCRETE

In recent years, the terminology "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. A commentary to the definition states that a high-performance concrete is one in which certain characteristics are developed for a particular application and environment. Examples of characteristics that may be considered critical for an application are:

- Ease of placement
- Compaction without segregation
- Early age strength
- Long-term mechanical properties
- Permeability
- Density
- Heat of hydration
- Toughness
- Volume stability
- Long life in severe environments

III. REVIEW OF LITERATURE

Aitcin[1] (1995) cited on development in the application of high performance concrete. Over the last few years, the compressive strength of some of the concrete used has increased dramatically. In 1988, a 120 MPa concrete was delivered on site, while, until relatively recently, 40 MPa was considered indicative of high strength. De Sensale[6] (2006) studied on strength development of concrete using rice husk ash. This paper presents a study on the development of compressive strength up to 91 days of concretes with rice-husk ash (RHA), in which residual RHA from a rice paddy milling industry in Uruguay and RHA produced by controlled incineration from the USA were used for comparison. Oner A and Akyuz S [7] (2007) studied on optimum level of ground granulated blast furnace slag (GGBS) on compressive strength of concrete. In their study GGBS was added according to the partial replacement method in all mixtures. A total of 32 mixtures were prepared in four groups according to their binder content. Eight mixes were prepared as control mixtures with 175, 210, 245 and 280 kg/m³ cement content in order to calculate the Bolomey and Feret coefficients (KB, KF). For each group 175, 210, 245 and 280 kg/m³ dosages were determined as initial dosages, which were obtained by removing 30 percent of the cement content of control concretes with 250, 300, 350, and 400 kg/m³ dosages. Safiuddin and Hearn[19] (2005) worked on Comparison of ASTM saturation techniques for measuring the permeable porosity of concrete. There permeable

porosity of two ordinary concretes has been determined by three ASTM saturation techniques, namely cold-water saturation (CWS), boiling-water saturation (BWS) and vacuum saturation (VAS).

IV. MATERIALS & PROPERTIES

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. 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.

ADVANTAGES OF USING GGBS

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

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When it is properly brunt it has high SiO₂ 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% K₂O. The specific surface of RHA is between 40000-100000 m²/kg. 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. A substance which imparts very high workability with a large decrease in water content (at least 20%) for a given workability. A high range water reducing admixture (HRWRA) is also referred as Superplasticizer, which is capable of reducing water content by about 20 to 40 percent has been developed.

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 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.

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.

EXPERIMENTAL PROGRAMMES

The granulated material when further ground to less than 45 micron will have specific surface of about 400-600 m²/kg (Blaine). But here in our present study we have delved into the use of GGBS in different percentages in mortar testing, where we have used GGBS passing through 75 micron sieve. Here the specific surface of about 275-550 m²/kg. We are going to use of GGBS as partial replacement of cement because of its advantages like lower energy cost, higher abrasion resistance, lower hydration heat evolution, higher later strength development.

Synthetic fiber i.e Recron fiber is used in concrete for the production of fiber reinforced concrete. We are going to use Recron fiber in different percentage i.e, 0%, 0.1%, 0.2%, 0.3% to the weight of concrete and study the 7 days and 28 days compressive strength, splitting tensile and flexural strength of concrete to that of normal concrete with maintaining the water cement ratio in the range of 0.35-0.41.

GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

As pozzolanic activity greatly depends on fineness, so GGBS passing through 75 micron whose fineness of order of 275-550 m²/kg was used. Specific gravity test was conducted using Le-Chatelier apparatus and found to be 2.77. X-Ray diffraction test was conducted shown below in figure no.-1.

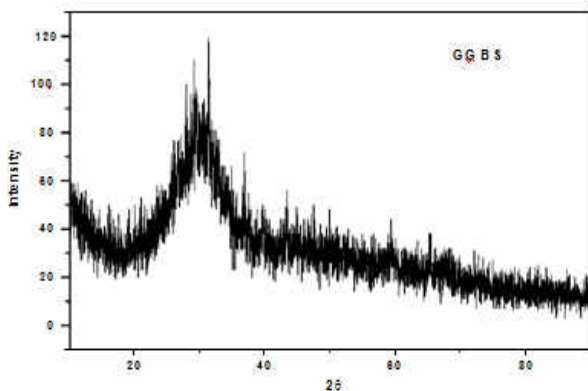


Fig. no.-1.X-Ray Diffraction test of GGBS

In this study we have used two types of Rice husk Ash. First type which was low burned having greater percentages of carbon (which is having negative impact on strength development), so looking black and second type is looking

white because it was being burnt in higher temperature. Here in second type of RHA the percentage of carbon is low. The specific gravity test was carried out using Le-Chatelier apparatus and found to be 2.21 for RHA- I and 2.20 for RHA-II. X-Ray diffraction test was carried out.

V. RESULTS AND DISCUSSION OF XRD TEST

XRD was conducted on RHA-I, RHA-2, GGBS and Silica fume, to idealize the different chemical composition of these pozzolanic material. Test was performed at an angle 45° with 2θ equal to 90° and different graphs are obtained, which were analysed using “X-pert High Score” software.

In case of GGBS from the graph it is inculcated that compound purely in amorphous form. Here we got the formation of Mg₂Al₂O₄ corresponding to no. 74-1133 and Mg₂SiO₄ with no.74-1680. From the XRD graphs of RHA-I and RHA-II obtained from X-pert High Score software, it was visualised that RHA-I (black type).

Table - Effect of GGBS in normal consistency of cement:

% of cement replaced by GGBS (%)	Consistency (%)
0	31.0
10	32.0
20	33.0
30	34.5
40	36.5

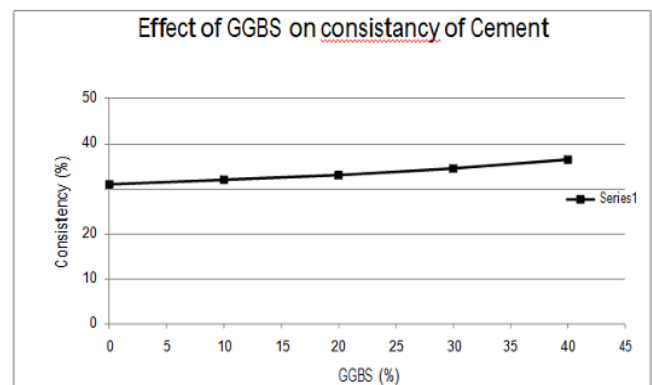


Fig.-2:Variation of Consistency of cement containing different % of GGBS

VI. DISCUSSION

It is observed here that the consistency percentage is increasing as the percentage of GGBS increases as a cement replacement, but the change is not so abrupt. But found that as we go on increasing the percentage of Rice husk ash the consistency percentage increases rapidly.

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The variation of compressive strength of mortar mix with different proportion of GGBS partial replacement of cement is shown in fig. It was observed that 3 days and 7 days compressive strength reduces about 13% and 35% that is from 11.176 MPa to 9.66 MPa and 24.31 to 15.63 respectively, as GGBS percentage increases from 0 to 10%. If percentage of GGBS was further increased the compressive strength reduces greatly. Finally when the GGBS percentage increased to 40% the strength reduces by about 60% and 70% in 3 days and 7 days respectively of its initial values. So it was concluded that the use of GGBS specially in Portland slag cement leading to adverse effect on strength of mortar. Also use of Rice husk ash as a partial replacement of cement is not giving satisfactory strength. Although RHA II (white type) is giving better strength as compared to that of RHA I, still it was not of to the mark.

Before using silica fume consistency test was conducted on silica fume with the replacement of different percentage of cement to analyse the water absorption. Then porosity and capillary absorption test were conducted on half cylinder to analyse the effect of silica fume on voids in different concrete mixes.

Firstly with Portland slag cement the effect of fiber and SF on strength of concrete are shown below then using OPC.



Fig. -Determination of compressive strength of cube



Fig.- Determination of splitting tensile strength of cylinder



Fig.- Determination of Flexural strength of prism

Table- Effect of Recron fiber on Compressive strength using slag cement:

Fiber content (%)	7 days compressive	28 days compressive
0.0	29.036	37.77
0.1	24.63	27.4067
0.2	26.43	32.148
0.3	17.2	25.48

Consistency of cement depends upon its fineness. Though silica fume having greater fineness than cement and greater surface area so the consistency increases greatly, when silica fume percentage increases compare to plain cement. It was observed that normal consistency increases about 45% when silica fume percentage increases from 0% to 30%.

CONCLUSION

Use of GGBS as cement replacement increases consistency. Although fineness greatly influenced on proper pozzolanic reaction still GGBS passing 75 micron sieve not giving good strength of mortar. Using GGBS more than 10% in Portland slag cement the strength reducing rapidly. With the use of superplasticizer it possible to get a mix with low water to cement ratio to get the desired strength. In case of Portland slag cement with the use of Recron fiber , the 28 days compressive strength at 0.2% fiber content the result obtained is maximum. The 28 days splitting tensile and flexural strength also increases about 5% at 0.2% fiber content to that of normal concrete. Further if fiber percentage increases then it was seen a great loss in the strength. As the replacement of cement with different percentages with Silica fume increases the consistency increases. 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

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