Study on Pozzolanas Effect on Fiber Reinforced Concrete

Satya Rama Chandra Kumar
Department of Civil Engineering
DNR College of Engineering & Technology Bhimavaram , Andhra Pradesh, India

K.M.V Ratnam
Department of Civil Engineering
DNR College of Engineering & Technology Bhimavaram , Andhra Pradesh, India

U. Ranga Raju
Department of Civil Engineering
DNR College of Engineering & Technology Bhimavaram , Andhra Pradesh, India

V. Sai Kupa
Department of Civil Engineering
DNR College of Engineering & Technology Bhimavaram , Andhra Pradesh, India

SK. Subhan Alisha
Department of Civil Engineering
DNR College of Engineering & Technology Bhimavaram , Andhra Pradesh, India

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 fibe) 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.

Keywords: Pozzolanas, Fiber Reinforced Concrete

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 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.

The setback in the health of newly constructed concrete structures prompted the most direct and unquestionable evidence of the last two/three decades on the service life performance of our constructions and the resulting challenge that confronts us is the alarming and unacceptable rate at which our infrastructure systems over all the world are suffering from deterioration when exposed to real environments.

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 greenhouse 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.

II. LITERATURE REVIEW

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. The spectacular increase in compressive strength is directly related to a number of recent technological developments, in particular the discovery of the extraordinary dispersing action of superplasticizers with which flowing concretes can be made with about the same mixing water that is actually required to hydrate all the cement particles or even less. The reduction in water/cement ratio results in a hydrated cement paste with a microstructure so dense and strong that coarse aggregate can become the concrete's weakest constituent. Silica fume, a highly reactive pozzolana, considerably enhances the paste/aggregate interface and minimizes debonding. Lastly, the use of supplementary cementitious materials, such as fly ash and especially slag, helps solve slump loss problems which become critical at low w/c ratios.

Ajdukiewicz and Radomski[2] (2002) delve into Trends in the Polish research on high-performance concrete. They analysed the main trends in the research on high- performance concrete (HPC) in Poland. There they sighted on some examples of the relevant investigations. The fundamental engineering and economical problems concerning the structural applications of HPC in Poland are presented as well as the needs justifying the increased use of this material are briefly described.

Aitcin[3] (2003) studied on the durability characteristics of high performance concrete. He examined durability problems of ordinary concrete can be associated with the severity of the environment and the use of inappropriate high water/binder ratios. High- performance concrete that have a water/binder ratio between 0.30 and 0.40 are usually more durable than ordinary concrete not only because they are less porous, but also because their capillary and pore networks are somewhat disconnected due to the development of self- desiccation. In high-performance concrete (HPC), the penetration of aggressive agents is quite difficult and only superficial. However, self-desiccation can be very harmful if it is not controlled during the early phase of the development of hydration reaction, therefore, HPC must be cured quite differently from ordinary concrete. Field experience in the North Sea and in Canada has shown that HPCs, when they are properly designed and cured, perform satisfactorily in very harsh environments. However, the fire resistance of HPC is not as good as that of ordinary concrete but not as bad as is sometimes written in a few pessimistic reports. Concrete, whatever its type, remains a safe material, from a fire resistance point of view, when compared to other building materials.

Al-Khalaf and A. Yousif [4] (1984) examined on use of RHA in concrete. They studied the actual range of temperature require to burn rice husk in order to get the desired pozzolanic product, use of rice husk as partial replacement of cement on compressive strength and volume changes of different mixes. And showed that up to 40% replacement can be made with no significant change in compressive strength compared with the control mix. He tested on mortar cube, by testing on 50 mm cubes. In his investigation alsohe deduced that the most convenient and economical burning conditions required to convert rice husks into a homogenous and well burnt ash is at 500^{0} C for 2 hours. Also for a given grinding time, there is a considerable reduction in the specific surface area of RHA as burning temperature increases. For mortar mix with constant RHA content, the water requirement decreases as the fineness of the ash increases. The minimum pozzolanic activity can be obtained, when the ash has a specific surface of about 11,500 cm^{2}/gm. The strength of cement-RHA mortar approaches the strength of the corresponding plain mortar when the specific surface of RHA about 17000cm^{2}/gm. For 1:2 and 1:3 mortar mixes of standard consistency the maximum percentage of rice husk ash that can be replaced by weight of cement without 60 days strength being less than that of plain mortar was 30% and 40 % respectively. Also he found higher the percentage or RHA, higher is the volume change characteristic corresponding to plain mortar.

Ismail and waliuddin[5] (1996) had worked on effect of rice husk ash on high strength concrete. They studied the effect of rice husk ash (RHA) passing 200 and 325 micron sieves with l0-30% replacement of cement on the strength of HSC. The RHA was obtained by burning rice husk, an agro-waste material which is abundantly available in the developing countries. A total of 200 test specimens casted and tested at 3,7,28 and 150 days. Compressive and split tensile strengths of the test specimens.Cube strength over 70 MPa was obtained without any replacement of cement by RHA. Test results indicated that strength of HSC decreased when cement was partially replaced by RHA for maintaining same level of workability. They observed that optimum replacement of cement by RHA was 10-20%, and even from crystalline form of RHA good result may be obtained by fine grinding.

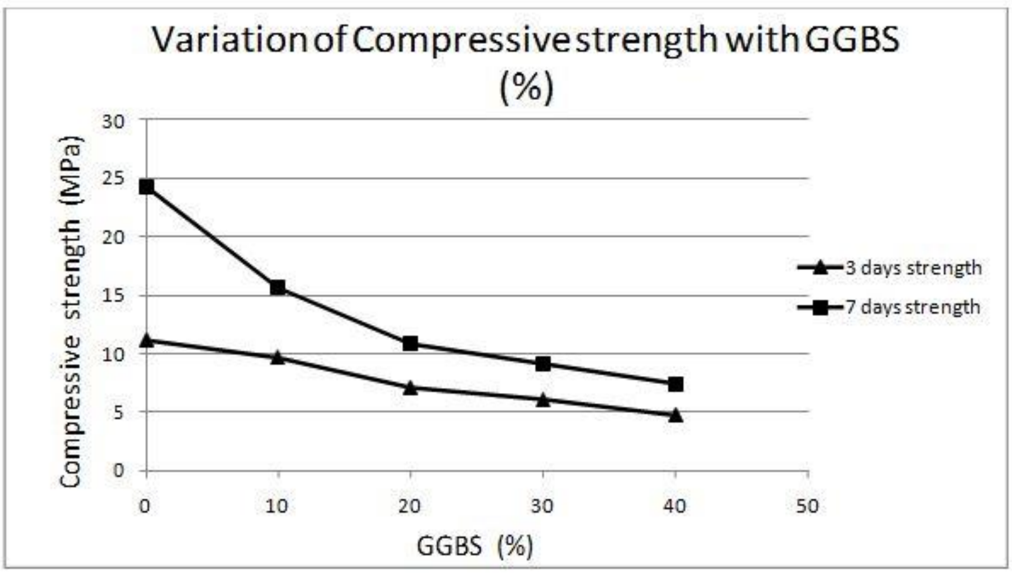
De Sensale[6] (2006) studied on strength development of concrete using rice husk ash. This paper presents a study on the development of compressive strength up to 91 days of concretes with rice-husk ash (RHA), in which residual RHA from a rice paddy milling industry in Uruguay and RHA produced by controlled incineration from the USA were used for comparison. Two different replacement percentages of cement by RHA, 10% and 20%, and three different water/cementicious material ratios

(0.50, 0.40 and 0.32), were used. The results are compared with those of the concrete without RHA, with splitting tensile strength and air permeability. It is concluded that residual RHA provides a positive effect on the compressive strength at early ages, but the long term behavior of the concretes with RHA produced by controlled incineration was more significant. Results of splitting tensile and air permeability reveal the significance of the filler and pozzolanic effect for the concretes with residual RHA and RHA produced by controlled incineration.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

A. Effect of GGBS on Compressive strength of cement:

% of GGBS with cement replacement	3 days strength (MPa)	7 days strength (MPa)
0	11.176	24.31
10	9.66	15.63
20	7.117	10.85
30	6.10	9.15
40	4.74	7.46



Variation of Compressive strength of mortar with different GGBS %

B. Effect of Recron fiber on Compressive strength using slag cement:

Fiber content (%)	7 days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)	60 days compressive strength (N/mm^2)	90 days compressive strength (N/mm^2)
0.0	29.036	31.77	33.723	34.612
0.1	24.63	27.4067	28.965	31.745
0.2	26.43	32.148	35.243	37.709
0.3	17.2	25.48	26.960	29.412

C. Effect of recron fiber on Splitting Tensile Strength using slag cement:

Fiber content (%)	7 days splitting tensile strength (N/mm^2)	28 days compressive strength (N/mm^2)	60 days compressive strength (N/mm^2)	90 days compressive strength (N/mm^2)
0.0	2.523	2.873	2.945	3.107
0.1	2.12	2.452	2.654	2.914
0.2	2.569	3.018	3.556	3.923
0.3	1.533	2.280	2.578	2.743

D. Effect of recron fiber on Flexural Strength using slag cement:

Fiber content (%)	7 days flexural strength (N/mm2)	28 days flexural strength (N/mm2)	60 days compressive strength (N/mm2)	90 days compressive strength (N/mm2)
0.0	5.750	7.75	9.056	10.745
0.1	5.875	6.33	7.927	8.725
0.2	6.560	8.04	10.353	12.742
0.3	4.501	6.04	7.934	9.371

E. Effect of silica fume on Compressive strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days Compressive strength (N/mm2)	28 days Compressive strength (N/mm2)	60 days Compressive strength (N/mm2)	90 days Compressive strength (N/mm2)
0.0	26.43	32.148	35.642	37.542
10.0	23.55	30.813	33.521	35.756
20.0	26.07	34.814	37.942	39.109
30.0	21.778	29.03	31.845	33.712

F. Effect of silica fume on splitting tensile strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days splitting tensile strength (N/mm2)	28 days splitting tensile strength (N/mm2)	60 days Compressive strength (N/mm2)	90 days Compressive strength (N/mm2)
0.0	2.569	3.018	3.558	3.667
10.0	2.482	2.92	3.012	3.211
20.0	2.687	3.206	3.870	3.910
30.0	2.169	2.782	2.986	3.098

G. Effect of silica fume on flexural strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days flexural strength (N/mm2)	28 days flexural strength (N/mm2)	60 days Compressive strength (N/mm2)	90 days Compressive strength (N/mm2)
0.0	6.56	8.04	9.045	9.783
10.0	6.50	8.00	8.789	9.358
20.0	6.625	8.458	9.567	9.982
30.0	6.04	7.875	8.786	9.423

IV. CONCLUSION

In this present study with the stipulated time and laboratory set up an afford has been taken to enlighten the use of so called pozzolanic material like ground granulated blast furnace slag, rice husk and silica fume in fiber reinforced concrete in accordance to their proficiency. It was concluded that,

1) 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.
2) With replacement of cement with RHA the consistency increases. Use of RHA which burned properly in controlled temperature improves the strength of mortar. But use of RHA not giving satisfactory strength result.
3) With the use of superplasticizer it possible to get a mix with low water to cement ratio to get the desired strength.
4) 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.
5) As the replacement of cement with different percentages with Silica fume increases the consistency increases.
6) With Portland slag cement keeping 0.2% Recron fiber constant and varying silica fume percentage the compressive, splitting tensile, flexural strength affected remarkably. Using 20% silica fume with 0.2% fiber percentage the 28 days compressive strength increases 7% more than concrete with 0.2% fiber only. 28days split tensile and flexural strength increases further, about 12% and 10% that of normal concrete.
7) So it is inculcated that 0.2% Recron fiber and 20% SF is the optimum combination to achive the desired need.
8) In case of OPC the compressive strength is increasing as the percentage of silica fume increases from 0-30% and 0.2% Recron fiber and it is about 20% more than strength of normal concrete with OPC.

9) The splitting tensile strength increases about 15% at 10% SF and constant 0.2% Recron fiber, and then decreases with increasing the SF percentage. Flexural strength is not giving good indication and goes on decreasing and it is about 40% decrement as the SF percentage increases to 30%.
10) Ordinary Portland cement gives good compressive strength result as compared to Portland slag cement in case of mix with SF and 0.2% Recron.
11) The capillary absorption coefficient (k) with decreases great sign as SF percentage increases at constant fiber percentage i.e 0.2%. At 20% SF content the k value decreases progressively with 70% reduction that to without SF content concrete.
12) The porosity value also decreases as the SF value increases from 0-30% in Recron fiber reinforced concrete.

REFERENCES

[1] Pierre-Claude Aitcin, "Developement in the application of high performance concrete", Construction and Building Material, Vol. 9. No. 1, 1995, 13-17
[2] Andrzej Ajdukiewicz and Wojciech Radomski, "Trends in the Polish research on high- performance concrete", Cement and Concrete Composite, Vol. 24, 2002, 243-251
[3] Pierre-Claude Aitcin, "The durability characteristics of high performance concrete", Cement & Concrete Composite, Vol. 25, 2003, 409-420
[4] Moayad N Al-Khalaf and Hana A Yousif, "Use of Rice husk ash in concrete", The International Journal of Cement Composites and Lightweight Concrete, Vol. 6, November 4 1984.
[5] Muhammad Soaib Ismail and A. M. Waliuddin, "Effect of rice husk ash on high strength concrete", Construction and Building Material, Vol. 10. No. 7, 1996, 521-526
[6] Gemma Rodriguez de Sensale, "Strength development of concrete with rice-husk ash", Cement & Concrete Composite, Vol. 28, 2006,158-160
[7] A Oner & S Akyuz, "An experimental study on optimum usage of GGBS for the compressive strength of concrete", Cement & Concrete Composite, Vol. 29, 2007, 505-514.
[8] Caijun Shi and Jueshi Qian, "High performance cementing materials from industrial slags", Resourses Conservation & Recyclin, Vol. 29, 2000, 195-207
[9] K Ganesh Babu and V. Sree Rama Kumar, "Efficiency of GGBS in Concrete", Cement and Concrete Research, Vol. 30, 2000, 1031-1036.
[10] M. Collepardi, "Admixtures used to enhance placing characteristics of concrete", Cement & Concrete Composite, Vol. 20, 1998, 103-112
[11] I. Papayianni , G. Tsohos, N. Oikonomou, P. Mavria, "Influence of superplasticizer type and mix design parameters on the performance of them in concrete mixtures", Cement & Concrete Composite, Vol. 27, 2005, 217-222
[12] Ronald F. Zollo, "Fiber-reinforced Concrete: an Overview after 30 Years of Development", Cement & Concrete Composite, Vol. 19, 1997, 107-122
[13] A. M Alhozaimy, P Soroushian & F Mirza, "Mechanical Properties of Polypropylene Fiber Reinforced Concrete and the Effects of Pozzolanic Materials, Cement & Concrete Composite, Vol. 18, 1996, 85-92.

