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Effect of Mineral Admixtures on Recron Synthetic Fiber Reinorced Concrete

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ABSTRACT

This 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 analyses 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 in cubes, cylinder, and prism then compressive test, splitting test, flexural test, porosity and permeability test are conducted.

Keywords: Aggregate, Cement, GGBS, Mix Design, Recron fiber,Rice husk ash, Silica fume, Strength, Superplasticizer, Water.

INTRODUCTION

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.

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. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacements and the results are encouraging. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing

The reasons for these demands are many, but as engineers, we need to think about the durability aspects of the structures using these materials. With long term durability aspects kept aside we have been able to fulfil the needs. The concrete of these properties will have a peculiar Rheological behavior.

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.

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 economic 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.

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, He tested on mortar cube, by testing on 50 mm cubes. In his investigation also he 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. 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 specimen's .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/cementitious 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.

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. Test concretes were obtained by adding GGBS to concretes in an amount equivalent to approximately 0%, 15%, 30%, 50%, 70%, 90% and 110% of cement contents of control concretes with 250, 300, 350 and 400 kg/m3 dosages. All specimens were moist cured for 7, 14, 28, 63, 119, 180 and 365 days before compressive strength testing. The test results proved that the compressive strength of concrete mixtures containing GGBS increases as the amount of GGBS increase. After an optimum point, at around 55% of the total binder content, the addition of GGBS does not improve the compressive strength. This can be explained by the presence of unreacted GGBS, acting as a filler material in the paste.

Qian Jueshi and Shi Caijun [8] (2000) studied on high performance cementing materials from industrial slag. They found most industrial slags are being used without taking full advantage of their properties or disposed rather than used. In this paper, the recent achievements in the development of high performance cementing materials based on activated slags such as blast furnace slag, steel slag, copper slag and phosphorus slag are reviewed.

Here they reviewed the recent progresses in the activation of latent cementitious properties of different slag. Alkali-activated slag, such as blast furnace slag, steel slag, copper slag and phosphorus slag exhibit not only higher early and later strength, but also better corrosion resistance than normal Portland cement. The production of Portland cement is an energy-intensive process, while the grinding of metallurgical slag needs only approximately 10% of the energy required for the production of Portland cement. Activation of latent pozzolanic or cementitious properties of metallurgical slag should be a prime topic for construction materials researchers.

Ganesh Babu K and Sree Rama Kumar V[9] (2000) studied on efficiency of GGBS in Concrete. According to them the utilization of supplementary cementitious materials is well accepted because of the several improvements possible in the concrete composites and due to the overall economy. This method recognizes that the ``overall strength efficiency factor (k)" of the pozzolan is a combination of the two factors-the ``general efficiency factor (ke)" and the ``percentage efficiency factor (kp). The evaluations have shown that at 28days, the ``overallstrength efficiency factor (k)" varied from 1.29 to 0.70 for percentage replacement levels varying from 10% to 80%. It was also seen that the overall strength efficiency factor (k) was an algebraic sum of a constant ``general efficiency factor (ke)," with a value of 0.9 at28 days, and a percentage efficiency factor (kp), varying from +0.39 to -0.20, for the cement replacement levels varying from 10% to 80% studied.

Papayianni, Tsohos, Mavria[11] (2005) studied on Influence of superplasticizer type and mix design parameters on the performance of them in concrete mixtures. According to them use of superplasticizers in concrete plays a central role in the development of high strength and performance concrete. Superplasticizers are admixtures, which are added to concrete mixture in very small dosages. Their addition results in significant increase of the workability of the mixture, in reduction of water/cement ratio or even of cement quantity. Their performance depends on the type of the superplasticizer, the composition of the concrete mixture, the time of addition and the temperature conditions during mixing and concreting. They tested on three type of superplasticizer. for study the performance of the admixtures, three Dosage of admixture(1%, 1.5%, 2% per weight of cement) were checked for every type of superplasticizers in concrete casting. He casted concrete and compressive strength was observed.

Zollo[12] (1997) overviewed on fiber reinforced concrete over the 30 years of development. It discusses commonly applied terminology and models of mechanical behavior that form a basis for understanding material performance without presenting mathematical details. They reviewed properly about FRC rather than as historical reporting.

A. M. Alhozaimy, P. Soroushian& F. Mirza [13] (1996) studied on mechanical properties of polypropylene fiber reinforced concrete and the effects of pozzolanic materials. A comprehensive set of experimental data were generated regarding the effects of collated fibrillated polypropylene fibers at relatively low volume fractions (below 0.3%) on the compressive, flexural and impact properties of concrete materials with different binder compositions. Statistical analysis of results produced reliable conclusions on the mechanical properties of polypropylene fiber reinforced concrete, and also on the interaction of fibers and pozzolanic admixtures in deciding these properties.

He studied on the effects of collated fibrillated polypropylene fibers at volume fraction ranging from 0.05% to 0.30% on the compressive and flexural strength and toughness, and impact resistance of conventional concrete materials and concretes incorporating different pozzolanic materials experimentally. Polypropylene fibers affect the flexural toughness significantly at 95% level of confidence. On the average, the addition of 0.l%, 0.2%, and 0.3% volume fraction of fibers increases the flexural toughness by 44%, 271% and 387%, respectively. Silica fume increases the flexural toughness by 48% and 79% in the case of plain and fibrous concretes, respectively.

Potrzebowski[14] (1983) researched on the splitting test applied to steel fiber reinforced concrete. He tested on cube specimen cut from flexural test prisms, which were themselves obtained from slabs. The results show that the splitting tensile strength is strongly influenced by the number of fibers intersecting the failure plane and their orientation. Specimens subjected to the loads perpendicular to the plane of vibration are shown to give consistent results whereas specimens loaded parallel to the plane of vibration gave low results.

Bhanja and Sengupta[16] (2005) worked on Influence of silica fume on the tensile strength of concrete. Extensive experimentation was carried out over water–binder ratios ranging from 0.26 to 0.42 and silica fume–binder ratios from 0.0 to 0.3. For all the mixes, compressive, flexural and split tensile strengths were determined at 28 days. The compressive, as well as the tensile, strengths increased with silica fume incorporation, and the results indicate that the optimum replacement percentage is not a constant one but depends on the water–cementitious material (w/cm) ratio of the mix. Compared with split tensile strengths, flexural strengths have exhibited greater improvements. Based on the test results, relationships between the 28-day flexural and split tensile strengths with the compressive strength of silica fume concrete have been developed using statistical methods.

Zain, Safiuddin and Mahmud [17] (2000) worked on Development of high performance concrete using silica fume at relatively high water-binder ratios. For this purpose, water-binder ratios of 0.45 and 0.50 were considered. Test specimens were air and water cured and exposed to a medium temperature range of 20°C to 50°C. The compressive strength, modulus of elasticity and initial surface absorption (ISA) of hardened concrete were determined in the laboratory. Test results indicated that concrete under water curing offers the best results. The highest level of compressive strength and modulus of elasticity and the lowest level of ISA were produced by SF concrete under water curing and at temperature of 35°C. Data collected also revealed that, under controlled curing conditions, it is possible to produce HPC at relatively high water-binder ratios.

Bozkurt and Yagicioglu[18] (2010) studied on strength and capillary water absorption of light weight concrete under different curing conditions. Here they studied to investigate the influence of addition of pozzolanic materials and curing regimes on the mechanical properties and the capillary water absorption characteristics of lightweight concrete. They prepared specimens with volcanically pumice containing only Portland cement and 20% flyash and 10% silica fume as a replacement of cement. Specimens were cured for 3, 7, 28 days. Compressive, tensile, ultrasonic pulse velocity test were carried out. Capillary absorption coefficient were determined. Greater compressive, tensile strength and low capillary coefficient obtained in silica fume specimens.

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). The concretes were prepared with the water–cement ratios of 0.50 and 0.60, and tested at ages of 7 and 28 days. Based on the test results of permeable porosity, the efficiency of the saturation techniques has been compared. In addition, the compressive strength of concretes was determined to justify the results of permeable porosity. The slump test was also performed to observe the workability. The overall experimental results reveal that vacuum saturation technique is more efficient than cold-water or boiling-water saturation and therefore this technique should be recommended for measuring the permeable porosity of concrete.

PROPERTIES OF MATERIAL

A. Ground Granulated Blast Furnace Slag

Ground Granulated Blast furnace 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.

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. 5.1.

Table .1. Chemical composition (%) of GGBS:

SiO2	39.18
Al2O3	10.18
Fe2O3	2.02
CaO	32.82
MgO	8.52
Na2O	1.14
K2O	0.30

B. Rice Husk Ash:

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.

Table 2. Chemical composition (%) of RHA:

SiO2	85.88
K2O	4.10
SO3	1.24
CaO	1.12
Na2O	1.15
MgO	0.46
Al2O3	0.47
Fe2O3	0.18
P2O5	0.34

C. Silica Fume:

Silica fume also referred as micro silica 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. When quartz are subjected to 20000C reduction takes place and SiOvapours get into fuels. In the course of exit, oxidation takes place and the product is condensed in low temperature zones. In the course of exit, Silica fume rises as an oxidizedvapour, it is further processed to remove impurities and to control particle size. Condensed silica fume is essential silicon dioxide (SiO2) more than 90 percent in non-crystalline form. Silica fume has specific surface area of about 20,000m2/kg, as against 230 to 300 m2/kg. The use of silica fume in conjunction with superplasticizer has been back bone of modern high performance concrete. High fineness, uniformity, high pozzolanic activity and compatibility with other ingredients are of primary importance in selection of mineral admixture. As Silica fume has the minimum fineness of 15,000 m2/ kg, whereas the fumed Silica has the fineness of 190,000 m2/g which is 6 to 7 times finer than Silica fume. Finer the particle of pozzolano, higher will be the modulus of elasticity, which enhances the durability characteristics of the High performance concrete.

Table 3. Chemical composition of silica fumes in %:

SiO2	93
Al2O3	0.4
CaO	1.2
Fe2O3	0.2
MgO	1.2
Na2O	0.1
K2O	1.1
SO_3	0.30

D. Super plasticizing admixture:

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. These can be added to concrete mix having a low-to-normal slump and water cement ratio to produce high slump flowing concrete. The effect of superplasticizers lasts only for 30to 60 minutes, depending on composition and dosage and is followed by rapid loss in workability.

E. 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,

1. Ordinary Portland cement
2. Portland slag cement

Table 4. Properties of Portland slag cement:

Specific gravity	2.96
Initial setting time (min)	125
Final setting time (min)	235

Table 5. Properties of Ordinary Portland cement:

Specific gravity	3.1
Initial setting time (min)	90
Final setting time (min)	190

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.

F. Aggregate:

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

(I) Fine aggregate
(II) Coarse aggregate

Table 6. Properties of fine aggregate:

Properties	Results Obtained
Specific Gravity	2.65
Water absorption	0.6%
Fineness Modulus	2.47

Table 7. Properties of coarse aggregate:

Properties	Results Obtained
Specific Gravity	2.65
Water absorption	0.4%
Fineness Modulus	4.01

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, whereas 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.

According to IS 383:1970 the fine aggregate is being classified in to four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV. Also in case of 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.

G. 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.

Application of RECRON 3s fibre reinforced concrete used in construction. The thinner and stronger elements spread across entire section, when used in low dosage arrests cracking. RECRON 3s prevents the shrinkage cracks developed during curing making the structure/plaster/component inherently stronger.

In this project work it was used Recron fiber. It is a type of synthetic fiber. In different weight fraction (0.0%, 0.1%, 0.2%, 0.3%) to concrete it was used.

Table 8. Specification of Recron:

Denier	1.5d
Cut length	6mm,12mm,24mm
Tensile strength	About 6000 kg/cm2
Melting point	250° C
Dispersion	Excellent
Acid resistance	Excellent
Alkali resistance	Good

RESULTS AND DISCUSSIONS

A. XRD TEST

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

i. 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. 4.1.

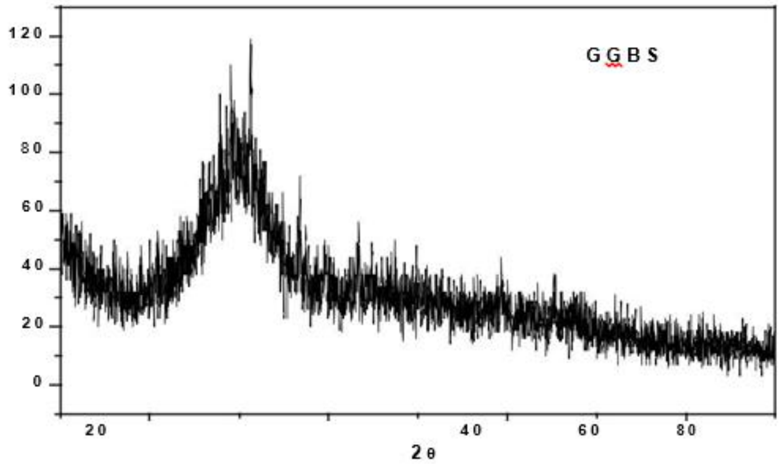

Fig. 4.1 X-Ray Diffraction test of GGBS

ii. Rice husk ash:

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 shown below in fig no. 4. 2 and fig no. 4.3.

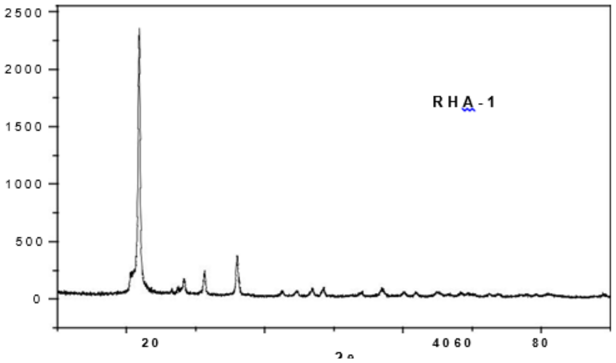

Fig.4.2 X-Ray Diffraction test of RHA-I

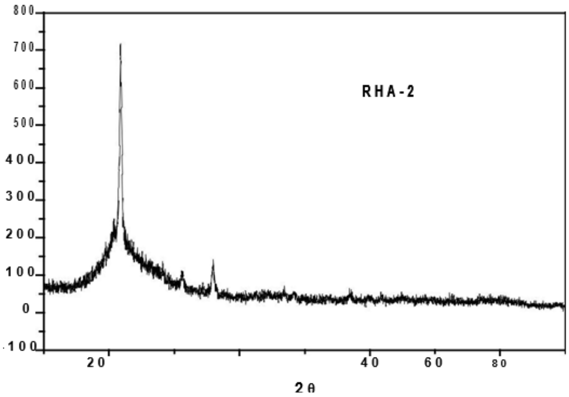

Fig. 4.3 X-Ray Diffraction test of RHA-II

iii. Silica fume:

Silica fume is used in different percentage (0%, 10%, 20%, 30%) with the replacement of cement for its greater pozzolanic activity along with fiber. The specific gravity of silica fume was found out using Le-Chatelier apparatus and found to be Specific gravity- 2.36. X-Ray diffraction test was conducted shown below in figure no. 4.4.

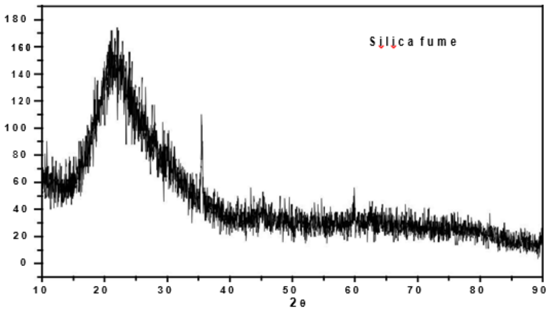

Fig. 4.4 X-Ray Diffraction test of silica fume

iv. RESULTS AND DISCUSSION OF XRD TEST:

In case of GGBS from the graph it is inculcated that compound purely in amorphous form. Here we got the formation of $Mg_2Al_2O_4$ corresponding to no. 74-1133 and Mg_2SiO_4 with no.74-1680. From the XRD graphs of RHA-I and RHA-II obtained from X-pert High Score software, it was visualized that RHA-I (black type) somehow is in crystalline form as compared to RHA-II (white type). But in both the form of rice husk ash we found crystabalite low temperature silica type with no. 76-0939 as to that of software. The graph shows silica fume also is in amorphous state with having compound SiO_2 and CaO with nos. 03-0865 and 80-2146 respectively in the software used.

B. EFFECT OF GGBS AND RHA ON PROPERTIES OF CEMENT

To know the properties of GGBS and RHA on mortar we performed different tests

- Consistency test
- Compressive strength

The amount of water required to produce a standard cement paste to resist a specified pressure is known as normal or standard consistency. In other word it is the limit of water required at which the cement paste resist the penetration of standard plunger (1 mm diameter) under a standard loading up to a distance of 5-7 mm from the base of Vicat apparatus. The consistency of cement depends on its type and fineness. More water is required in cement with higher fineness value. The water quantity was calculated by [(P/4) + 3] % of 800 gm. Consistency test was performed with both GGBS and rice husk ash of different percentage content. That is GGBS with 0, 10, 20, 30, 40 % and RHA with 0, 10, 20, 30 %. Then mortars of standard size were casted with different percentage of GGBS (0%, 10%, 20%, 30%, 40%) and RHA (0% and 20%) with the replacement of cement. Portland slag cement and sand of zone- II was used in this experiment. Then compression test was conducted of mortars in Compression testing machine.

TEST RESULT:

Table 4.1. Effect of GGBS in normal consistency of cement:

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

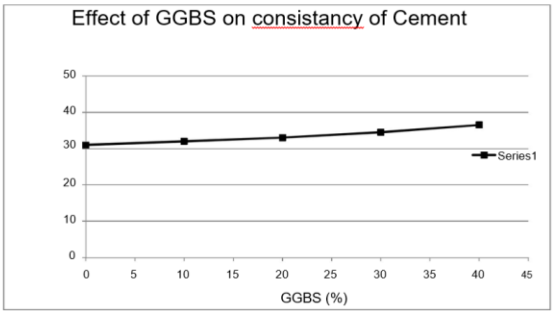

Fig. 4.5 Variation of Consistency of cement containing different % of GGBS

Table 4.2. 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

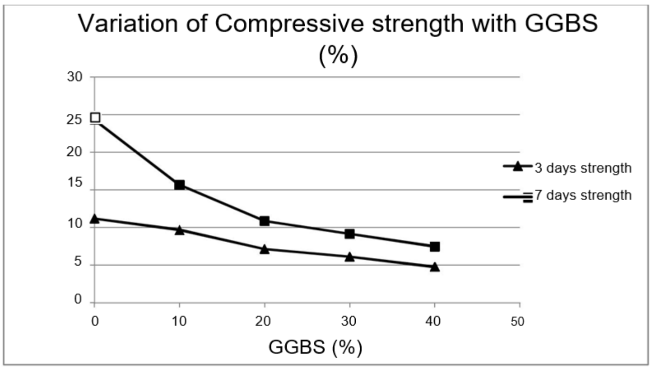

Fig. 4.6. Variation of Compressive strength of mortar with different GGBS %

Table 4.3. Effect of RHA on Normal Consistency of cement:

% of cement replaced by RHA	Consistency (%)
0	31.0
10	45.0
20	48.0
30	52.0

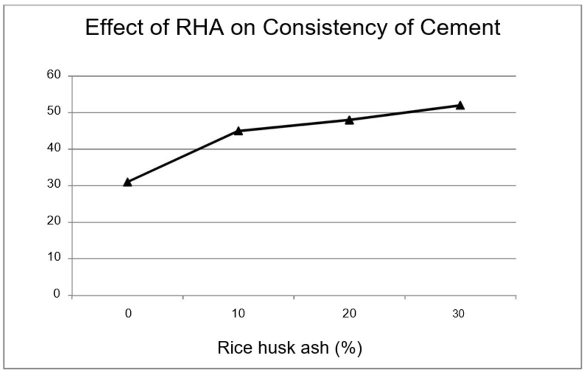

Fig. 4.7 Variation in Consistency of cement with different % of RHA

Table 4.4. Effect of RHA on Compressive strength of cement:

% of cement replaced by RHA	3 days strength (MPa)	7 days strength (MPa)
0	11.176	24.31
20% (RHA I)	2.23	4.74
20% (RHA II)	3.65	7.45

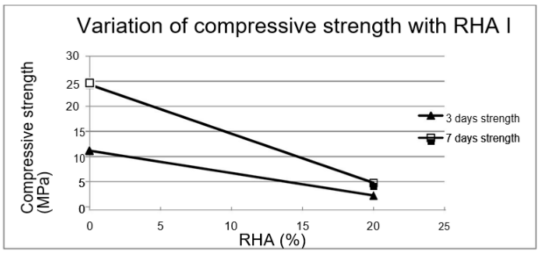

Fig. 4.8 Variation in Compressive strength of mortar with use of RHA I

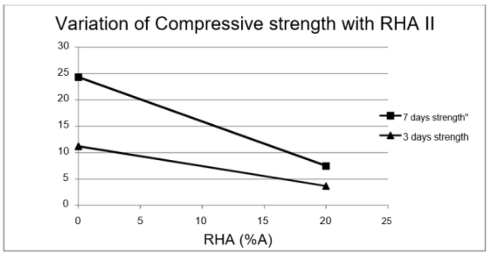

Fig. 4.9 Variation in Compressive strength of mortar with use of RHA II

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.

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 especially 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. Though RHA I having higher carbon percentage, it is not suitable for using as a pozzolanic material leads to give very poor strength and RHA II which was burnt more than as compared to RHA I, so here the carbon percentage was less and looking white in colour.

C. Mix Proportioning Of Recron-Fiber Reinforced Concrete:

To develop Recron fiber reinforced concrete and to study the effect of silica fume keepingfiber percentage constant concrete specimen were casted. For this purpose it was used twotypes of cement i.e. Portland slag cement and ordinary Portland cement (53 grade). Coarseaggregate of maximum size 20 mm size and sand of zone- II were used. In case of fiberreinforced concrete, Recron fiber in different percentages i.e. 0, 0.1, 0.2, 0.3% to the weight ofconcrete was used. Then it was varied the percentages of silica fume i.e. 10, 20, 30% keepingthe percentage of fiber constant to study the effect of silica fume. It was maintained the slumpin the range of 50-75mm for proper workability for the easy handling and placing in all cases.To maintain this admixture Sika was used keeping water cement ratio in the range of 0.35-0.41 (0.35, 0.37, 0.39, 0.41) and 0.41-0.45 (0.41, 0.42, 0.45) and super plasticizer rages from0.6%-1.4% (0.6, 0.9, 1.2, 1.4%) and 1.4%-1.7% (1.4, 1.5, 1.7%) for ordinary fiber reinforcedconcrete and FRP with the addition of silica fume respectively. Aggregate binder ratio= 3.08, coarse aggregate to fine aggregate ratio= 2.34. In case OPC, mix was obtained with water cement ratio 0.38 and admixture at 0.8% for normal concrete mix. Then with different percentage of silica fume (10, 20, 30%) with constant 0.2% fiber content keeping water cement ratio (0.422, 0.44, 0.46) and admixture (1.4, 1.6, 1.7%).

All mixtures were mixed in a conventional rotary drum concrete mixer. The mixer was first loaded with the coarse aggregate and a portion of the mixing water, then sand, cement and the rest of water were added and mixed for 3 min. The fibers in the case of fibrous mixtures was randomly distributed. The admixture Sika was added to the mixing water and in case of (cement + silica fume) was added with cement simultaneously. Then concrete was casted, vibrated in vibrating machine and moulded to cubes, cylinders and prisms of sizes 150mm cubes, cylinder of height 300mm and diameter 150, prism of length 500 mm height and breadth of 100 mm each. All specimen were demoulded after 24 hour. Finally all the specimen were cured for 7 days and 28 days. Compressive strength, splitting tensile strength and flexural strength were evaluated on cubes, cylinders,prisms respectively according to the Indian standard codes. i.e. 1959, IS 9399-1979 and IS 10262-1982.

TEST RESULT:

Table 4.5. Effect of Recron fiber on Compressive strength using slag cement:

Fiber content (%)	7 days compressive strength (N/mm2)	28 days compressive strength (N/mm2)
0.0	29.036	37.77
0.1	24.63	27.4067
0.2	26.43	32.148
0.3	17.2	25.48

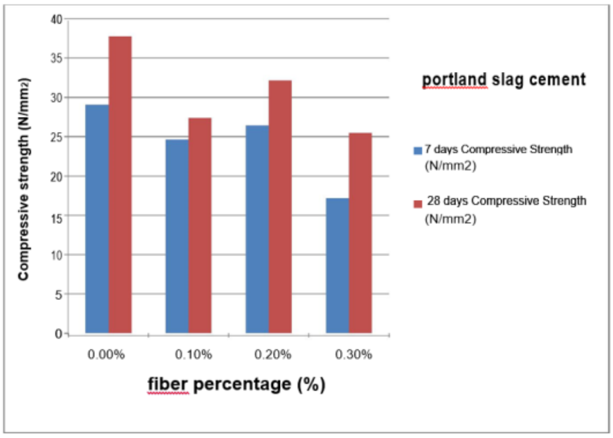

Fig. 4.10 Effect of Recron fiber on compressive strength

Table 4.6. Effect of Recron fiber on Splitting Tensile Strength using slag cement:

Fiber content (%)	7 days splitting tensile strength (N/mm2)	28 days splitting tensile strength (N/mm2)
0.0	2.523	2.873
0.1	2.12	2.452
0.2	2.569	3.018
0.3	1.533	2.280

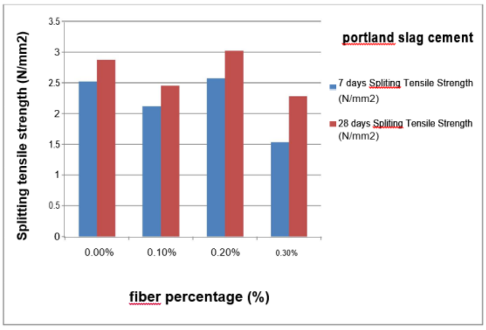

Fig. 4.11 Effect of Recron fiber on splitting tensile strength

Table 4.7. Effect of Recron fiber on Flexural Strength using slag cement:

Fiber content (%)	7 days flexural strength (N/mm2)	28 days flexural strength (N/mm2)
0.0	5.750	7.75
0.1	5.875	6.33
0.2	6.560	8.04
0.3	4.501	6.04

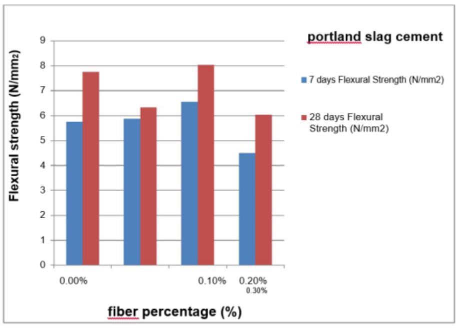

Fig. 4.12 Effect of Recron fiber on flexural strength

Table 4.8. Effect of silica fume on normal consistency of cement:

% of cement replaced by silica fume	Normal consistency (%)
0	31.0
10	38.0
20	41.5
30	45.0

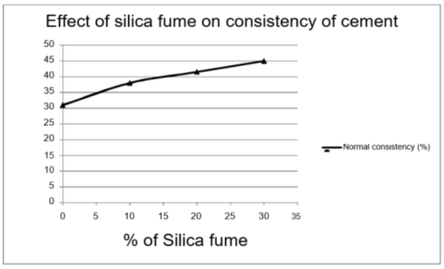

Fig. 4.13 Effect of silica fume on consistency of cement

Table 4.9. 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)
0.0	26.43	32.148
10.0	23.55	30.813
20.0	26.07	34.814
30.0	21.778	29.03

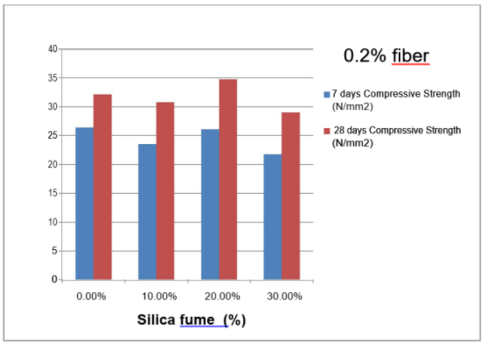

Fig. 4.14. Effect of silica fume on compressive strength at 0.2% fiber with slag cement

Table 4.10. 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)
0.0	2.569	3.018
10.0	2.482	2.92
20.0	2.687	3.206
30.0	2.169	2.782

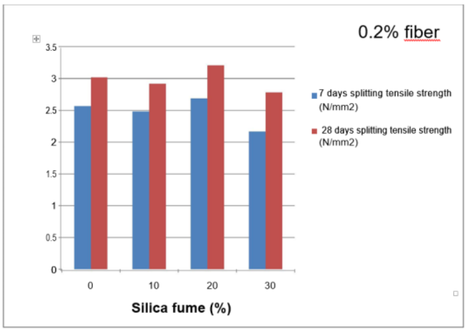

Fig. 4.15. Effect of silica fume on splitting tensile strength with 0.2%fiber using slag cement:

Table 4.11. 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)
0.0	6.56	8.04

10.0	6.50	8.00
20.0	6.625	8.458
30.0	6.04	7.875

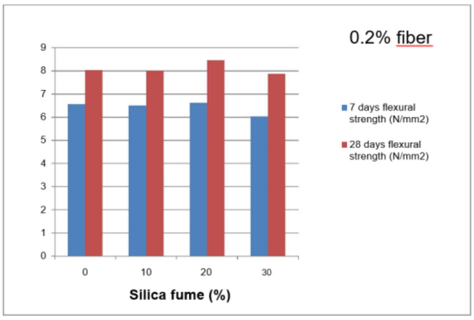

Fig. 4.16 Effect of silica fume on flexural strength at 0.2% fiber with slag cement

i. **Effect of silica fume with constant fiber percentage (0.2%) using ordinary Portland cement is given below;**

Table 4.12. Effect of silica fume on Compressive strength using OPC:

Silica fume (%)	7 days Compressive strength (N/mm2)	28 days Compressive strength (N/mm2)
0.0(0.2%fibre)	29.00	35.33
10.0(0.2%fibre)	29.50	36.00
20.0(0.2%fibre)	32.00	38.28
30.0(0.2%fibre)	34.50	42.32

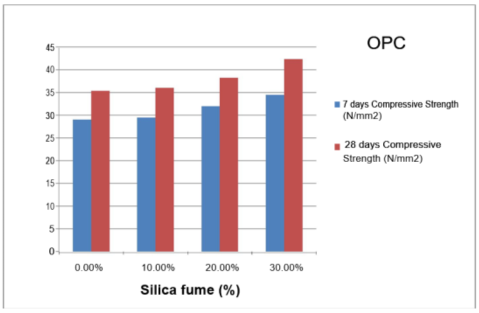

Fig. 4.17 Effect of silica fume on compressive strength at 0.2% fiber and OPC

Table 4.13. Effect of silica fume on splitting tensile strength using OPC:

Silica fume (%)	7 days splitting tensile strength (N/mm2)	28 days splitting tensile strength (N/mm2)
0.0(0%fibre)	2.546	2.829
10.0(0.2%fibre)	2.687	3.253
20.0(0.2%fibre)	2.405	2.970
30.0(0.2%fibre)	2.263	2.829

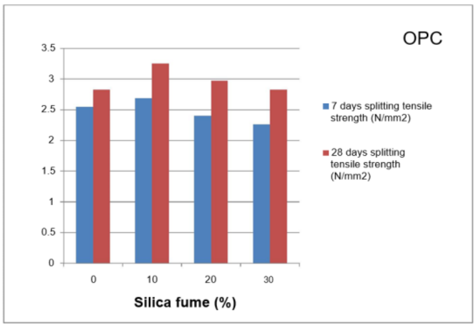

Fig. 4.18 Effect of silica fume on splitting tensile strength at 0.2% fiber and OPC

Table 4.14. Effect of silica fume on flexural strength using OPC:

Silica fume (%)	7 days flexural strength(N/mm2)	28 days flexural strength(N/mm2)
0.0 (0% fibre)	9.50	11.125
10.0(0.2%fibre)	7.875	9.00
20.0(0.2%fibre)	6.75	8.25
30.0(0.2%fibre)	6.04	6.875

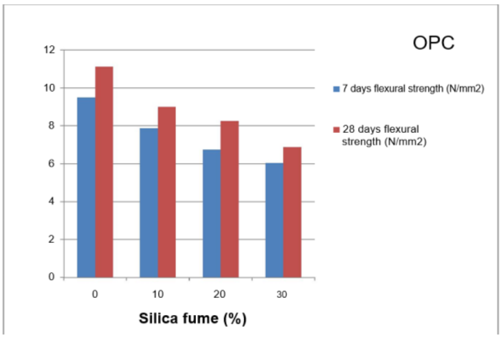

Fig. 4. 19 Effect of silica fume on flexural strength at 0.2% fiber and OPC

DISCUSSION:

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%. In case of Portland slag cement it was observed that using Recron fiber from 0.0% to 0.1% the compressive strength is not increased, but as the fiber percentage was increased from

0.1% to 0.2% the compressive strength was increased and on further increment of fibre content the strength reduces. The 28 days compressive strength of concrete is higher at with 0.2% fiber compared to other fibre composition but lower than unreinforced concrete. In addition to fiber silica fume was used as a partial replacement to cement. The different percentage of silica fume such as 10%, 20%, 30% replacement was used with 0.2% Recron fiber. The 20% replacement of slag cement with of silica fume gave maximum strength compared to other percentages of replacement, whereas the strength is higher with 30%replacement of silica fume in case of ordinary Portland cement.

In case of Portland slag cement it was observed that addition of Recron fiber from 0.0% to 0.1% the splitting tensile strength decreases. But as the fiber percentage was increased that to 0.2% the 28 days splitting tensile strength is about 5% more than that of concrete without fiber. And with further addition of fiber the strength reduces. At 20% silica fume replacement to cement at 0.2% fiber content strength again increases about 12% more than that of normal concrete and maximum to other percentage of replacement, where as in case of ordinary Portland cement the tensile strength at 28 days is 15% more than normal concrete at 10% silica fume replacement and 0.2% fiber. The strength reduces gradually on other percentages of silica fume.

Flexural strength using Recron fiber from 0.0% to 0.1% is reducing. As the fiber percentage increases from 0.1%-0.2% the flexural strength is increasing about 5% and as further increasing the fiber content the strength decreases. In case of silica fume replacement at 0.2% fiber content the flexural strength gives positive outcome. At 20% silica fume there is higher strength about 10% more than normal concrete, which is the maximum strength than other percentages of silica fume replacement. In case of ordinary Portland cement keeping 0.2% fiber content and varying silica fume percent (10%, 20%, 30%) it was observed that the 28 days flexural strength decreases as the of silica fume percentage increases. The strength decreases about 40% at 30% silica fume replacement than normal concrete.

D. CAPILLARY AND POROSITY TEST:

Capillary and porosity test was conducted on specimens prepared with fiber and (fibersilica fume) of Portland slag cement to observe the amount of water absorption and voids percentage present within the casted concrete.

Capillary test:

In case of capillary test cube specimen cured for 28 days were tested. Firstly the specimens were dried in oven at about 1050C until constant mass was obtained. Specimens were cooled down to room temperature for 6hr. The sides of the specimen were coated with paraffin to achieve unidirectional flow. The specimens were exposed to water on one face by placing it on slightly raised seat (about 5 mm) on a pan filled with water. The water on the pan was maintained about 5mm above the base of the specimen during the experiment as shown in the figure below. The weight of the specimen was measured at regular 30 minutes interval up to 2hr 30 min to get the little absorption variation of water. The capillary absorption coefficient (k) was calculated by using formula

K=W/Ax root t
Where,
W = Amount of water absorbed in gm
A = Cross sectional area in cm2 contact with water t = Time in seconds
The experimental set up is shown below,

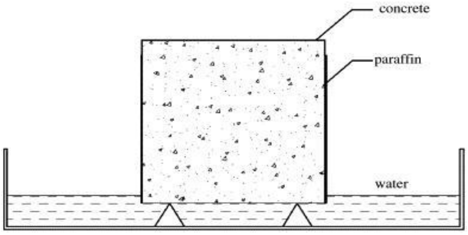

Fig. 4.20 Experimental set up for capillary absorption test

Firstly cubes with different percentage of fibers (0.0%,0.1%, 0.2%, 0.3%) are tested then secondly cubes of different silica fume percentage (10%, 20%, 30%) with constant 0.2% fiber were tested. All the specimens of Portland slag cement. The value of capillary absorption coefficient (k) was determined for different mixes.

Fig. 4.21 Capillary absorption test of cubes

Porosity test:

This test was conducted to evaluate the percentage of voids present in the specimens prepared. First of all saturated weights Wsat of the specimens cured for 28 days were obtained. Then specimens were dried in oven at about 1050C until constant mass Wdry was obtained. Then weight of water absorbed W was calculated in grams, which was converted to cc. this signifies the volume of voids present within the specimen. The test was conducted on half cylinder of different mixes of Portland slag cement. Finally porosity was calculated using the formula given below,

Porosity,*n*= **W**sat-**W** dry / v
Where, Vv = volume of voids in cc
V = total volume of specimen in cc

TEST RESULT:

Table 4.15. Capillary absorption coefficient (k) for different fiber content:

Fiber %	Capillary absorption coefficient (k)
0.0	1.19 x 10-3
0.1	1.31 x 10-3
0.2	1.67 x 10-3
0.3	3.57 x 10-3

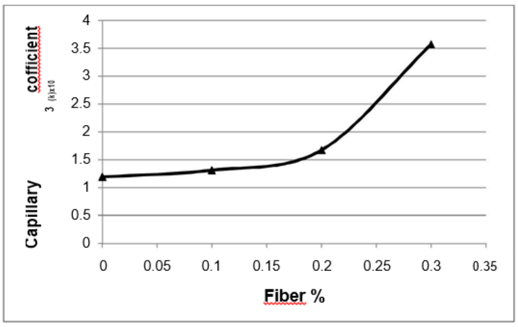

Fig. 4.22 Capillary absorption coefficient (k) for different fiber content

Table 4.16. Capillary absorption coefficient (k) for different SF content:

Silica fume%	Capillary absorption coefficient (k)
10	7.49 x 10-4
20	5.62 x 10-4
30	1.124 x 10-3

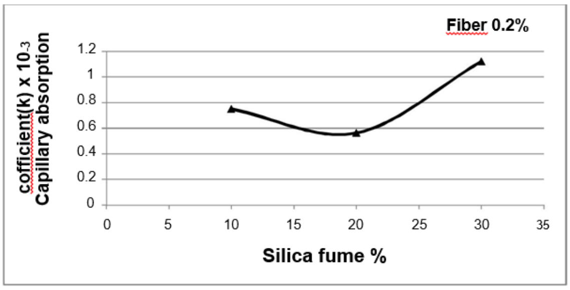

Fig. 4.23 Capillary absorption coefficient (k) of different SF content

Table 4.17. Porosity of different fiber mix:

Fiber %	Porosity ,
0.0	3.54
0.1	4.806
0.2	5.51
0.3	8.79

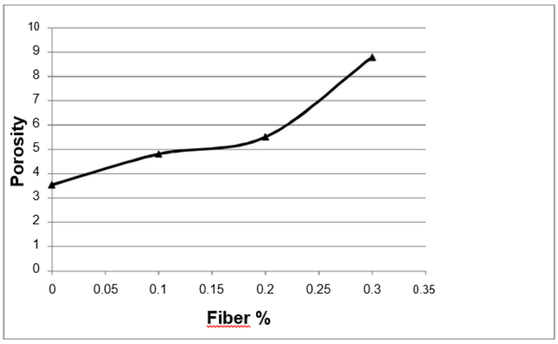

Fig. 4.24 Porosity of different fiber content

Table 4.18. Porosity of different Silica Fume mix:

Fiber %	Porosity ,
10	5.54
20	5.03
30	4.89

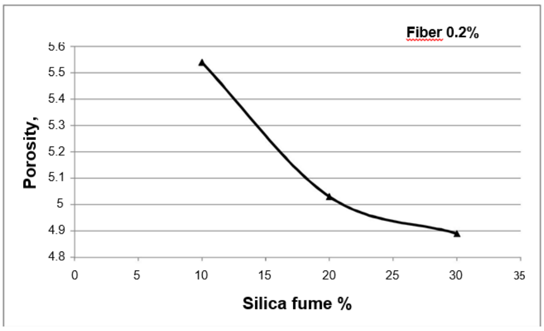

Fig. 4.25 Porosity of different SF content

DISCUSSION:

The capillary absorption coefficient is greatly influenced by the addition of silica fume in Recron fiber reinforced concrete. With 10% SF the capillary decreases by two times and at 20% SF the capillary decreases about 70% to capillary with 0.2% fiber only. Then at 30% SF it is increased slightly again.

The porosity of concrete decreases with silica fume. As the percentage of silica fume increases from 0 to 30% the porosity of concrete goes on decreasing. It was reduced about 12% that of fiber reinforced with 0.2% fiber.

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,

a) 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.
b) 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.
c) With the use of superplasticizer it possible to get a mix with low water to cement ratio to get the desired strength.
d) 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.
e) As the replacement of cement with different percentages with Silica fume increases the consistency increases.
f) 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.
g) So it is inculcated that 0.2% Recron fiber and 20% SF is the optimum combination to achieve the desired need.
h) 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.
i) The splitting tensile strength increases about 15% at 10% SF and constant 0.2% Recron fiber, 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%.
j) Ordinary Portland cement gives good compressive strength result as compared to Portland slag cement in case of mix with SF and 0.2% Recron.
k) 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.
l) The porosity value also decreases as the SF value increases from 0-30% in Recron fiber reinforced concrete.

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. Percentage and actual fineness of GGBS require as partial cement replacement for good 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 minimize the cost and at the same time achieve the durability and strength for the production of High Performance Concrete.

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