EXPERIMENTAL STUDY ON FIBER REINFORCED CONCRETE BY USING POZZOLANAS

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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 highstrength 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..***

Keywords: High Performance Concrete, Pozzolanic Material, Water Reducers, Recron Fiber.

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 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 carbondioxide 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. 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. With the passage of time to meet the demand,

HIGH STRENGTH CONCRETE:

- To put the concrete into service at much earlier age, for example opening the pavement at 3-days.
- To build high-rise buildings by reducing column sizes and increasing available space.
- To build the superstructure of long span bridges and to enhance the durability of bridge decks.
- To satisfy the specific needs of special applications, such as durability, modulus of elasticity and flexural strength. Some of these applications include dams, grandstand roofs, marine foundations, parking garages and heavy duty industrial floors.(Note that high strength concrete does not guarantee durable 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.

II. MATERIALS & PROPERTIES

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. Though the use of GGBS in the form of Portland slag cement is not uncommon in India, experience of using GGBS as partial replacement of cement in concrete in India is scanty. GGBS essentially consists of silicates and alumino silicates of calcium and other bases that is developed in a molten condition simultaneously with iron in a blast furnace. The chemical composition of oxides in GGBS is similar to that of Portland cement but the proportions varies. The four major factors, which influence the hydraulic activity of slag, are glass content, chemical composition, mineralogical composition and fineness. The glass content of GGBS affects the hydraulic property, chemical composition determines the alkalinity of the slag and the structure of glass. The compressive strength of concrete varies with the fineness of GGBS.

Table 1. Chemical composition (%) of GGBS:

SiO_2	39.18
Al_2O_3	10.18
Fe_2O_3	2.02
CaO	32.82
MgO	8.52
Na_2O	1.14
K_2O	0.30

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. 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 Agrosilicaand 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.

Table 2. Chemical composition (%) of RHA :

SiO_2	85.88
K_2O	4.10
SO_3	1.24
CaO	1.12
Na_2O	1.15
MgO	0.46
Al_2O_3	0.47
Fe_2O_3	0.18
P_2O_5	0.34

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. When quartz are subjected to 20000C reduction takes place and SiO vapours 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 oxidised vapour, oxidation takes place and the product is condensed in low temperature zones. When the silica is condensed, it attains noncrystalline state with ultra fine particle size. The super fine particles are collected

through the filters. It cools, condenses and is collected in bags. 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. Since it is an airborne material like fly ash, it has spherical shape. It is extremely fine with particle size less than 1 micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement particles. 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 Fume:

SiO_2	93
Al_2O_3	0.4
CaO	1.2
Fe_2O_3	0.2
MgO	1.2
Na_2O	0.1
K_2O	1.1
SO_3	0.3

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.

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

(I) Fine aggregate

(II) 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.

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.

FIBER:

An overview on 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 microcraking, impact resistance, resistance to fatigue, reduced permeability, improved strength in shear, tension, flexure and compression.

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, Sinthetic Fiber Reinforced Concrete, including carbon fibers; and Natural Fiber Reinforced Concrete.

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. Further when the loads imposed on concrete approach that for failure, cracks will propagate, sometimes rapidly. Addition of RECRON 3s in concrete and plaster prevents/arrests cracking caused by volume change (expansion & contraction). A cement structure free from such micro cracks prevents water or moisture from entering and migrating throughout the concrete. This in turn helps prevent the corrosion of steel used for primary reinforcement in the structure. This in turn improves longevity of the structure. The modulus of elasticity of RECRON 3s is high with respect to the modulus of elasticity of the concrete or mortar binder. The RECRON 3s fibres help increase flexural strength. RECRON 3s fibres are environmental friendly and non hazardous. They easily disperse and separate in the mix. 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.

Denier	1.5d
Cut length	6mm,12mm,24mm
Tensile strength	About 6000 kg/cm^2
Melting point	➢ 250° C
Dispersion	Excellent
Acid resistance	Excellent
Alkali resistance	good

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

This can be used in various aspects such as,

☐ PCC and RCC plastering

☐ Shortcrete and gunniting

☐ Slabs, footings, foundations, walls and tanks

☐ Pipes, prestressed beam etc

☐ Concrete blokes, railway sleepers, manhole cover and tiles etc

☐ Roads and pavements

☐ Bridges and dams

1.Materials Used
Cement:
For the experiment following two types cements were used,
(a) Portland Slag Cement
(b) Ordinary Portland cement (43 grade)
The chemical composition and different properties are shown below.
Fineness – 340 m2/kg
Specific gravity- 2.96
Initial setting time - 120 min
Final setting time – 240 min

Table 5. Properties of Portland slag cement:

Specific gravity	2.96
Initial setting time (min)	120
Final setting time (min)	240

Table 6. Properties of Ordinary Portland cement:

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

Fine aggregate:
In this study it was used the sand of Zone-II, known from the sieve analysis using different sieve sizes (10mm, 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, 150μ) adopting IS 383:1963.

Table 7. Properties of fine aggregate:

Properties	Results Obtained
Specific Gravity	2.65
Water absorption	0.6%
Fineness Modulus	5.03

Coarse aggregate:
The coarse aggregate used here with having maximum size is 20mm. We used the IS 383:1970 to find out the proportion of mix of coarse aggregate, with 60% 10mm size and 40% 20mm.

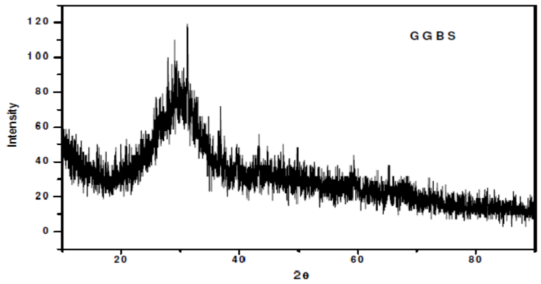
Table 8. Properties of coarse aggregate:

Specific gravity	2.67
Water absorption	0.4%
Fineness modulus	4.01

Fiber:
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.

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

Fig.1 X-Ray Diffraction test of GGBS



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 higer 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

Fig2 X-Ray Diffraction test of RHA-I

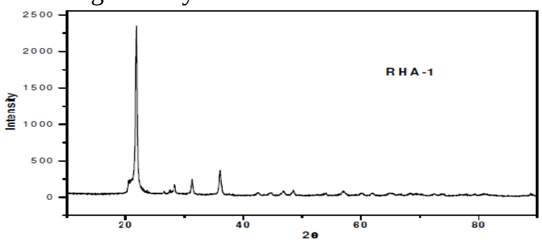
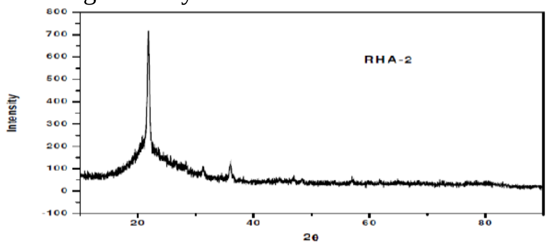
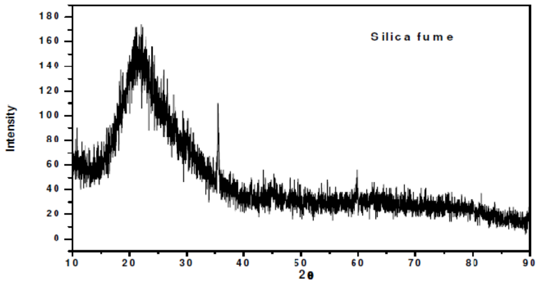


Fig 3 X-Ray Diffraction test of RHA-II



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.

Fig. 4 X-Ray Diffraction test of silica fume



III. RESULTS AND DISCUSSIONS

RESULTS AND DISCUSSION OF 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 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) 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 SiO2 and CaO with nos. 03-0865 and 80-2146 respectively in the software used.

4.3. 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 9. 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. 5 Variation of Consistency of cement containing different % of GGBS

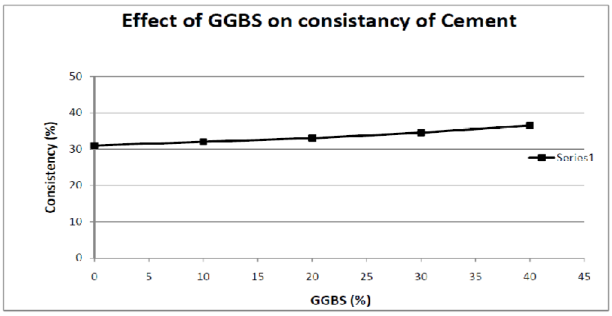


Table 10. Effect of GGBS on Compressive strength of cement:

% 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 6 . Variation of Compressive strength of mortar with different GGBS %

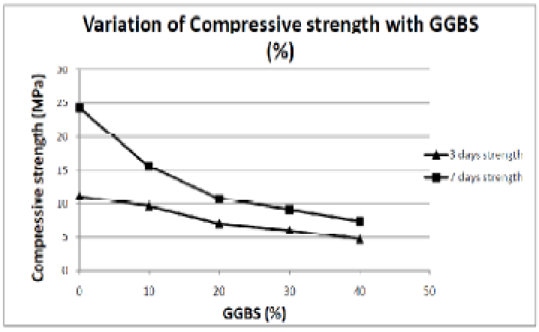


Table 11. Effect of RHA on Normal Consistency of cement:

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

Fig. 7 Variation in Consistency of cement with different % of RHA

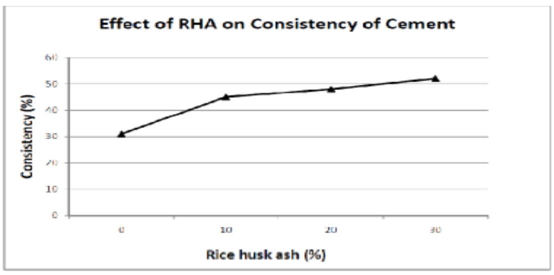


Table 12. Effect of RHA on Compressive strength of cement:

% 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. 8 Variation in Compressive strength of mortar with use of RHA I

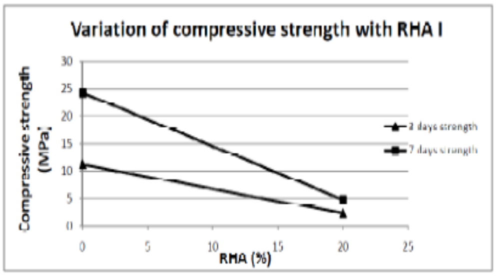
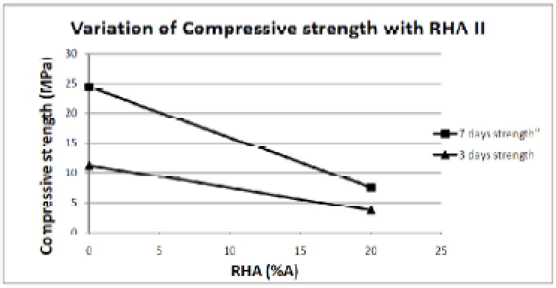


Fig. 9 Variation in Compressive strength of mortar with use of RHA II



MIX PROPORTIONING OF RECRON-FIBER REINFORCED CONCRETE:

To develop Recron fiber reinforced concret and to study the effect of silica fume keeping fiber percentage constant concrete specimen were casted. For this purpose it was used two types of cement i.e Portland slag cement and ordinary Portland cement (43 grade). Coarse aggregate of maximum size 20 mm size and sand of zone- II were used. In case of fiber reinforced concrete, Recron fiber in different percentages i.e 0, 0.1, 0.2, 0.3% to the weight of concrete was used. Then it was varied the percentages of silica fume i.e 10, 20, 30% keeping the percentage of fiber constant to study the effect of silica fume. It was maintained the slump in 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 from 0.6%-1.4% (0.6, 0.9, 1.2, 1.4%) and 1.4%-1.7% (1.4, 1.5, 1.7%) for ordinary fiber reinforced concrete 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 IS 456: 2000,IS 5816:1999, IS 561:1959, IS 9399-1979 and IS 10262-1982. 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.

Test Result:

Table 13. Effect of Recron fiber on Compressive strength using slag cement:

Fiber content (%)	7days compressive strength (N/mm^2)	28 days compressive strength (N/mm^2)
0.0	18.22	42
0.1	15.33	30.44
0.2	16.44	35.55
0.3	10.8	28.22

Fig. 10 Effect of Recron fiber on compressive strength

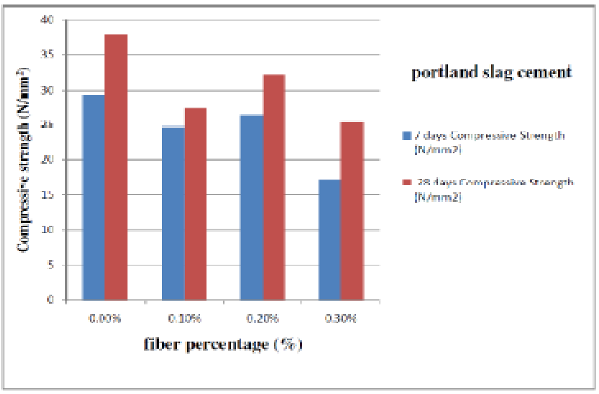


Table 14. Effect of recron fiber on Splitting Tensile Strength using slag cement:

Fiber content (%)	7 days splitting tensile strength (N/mm^2)	28 days splitting tensile strength (N/mm^2)
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. 11 Effect of Recron fiber on splitting tensile strength

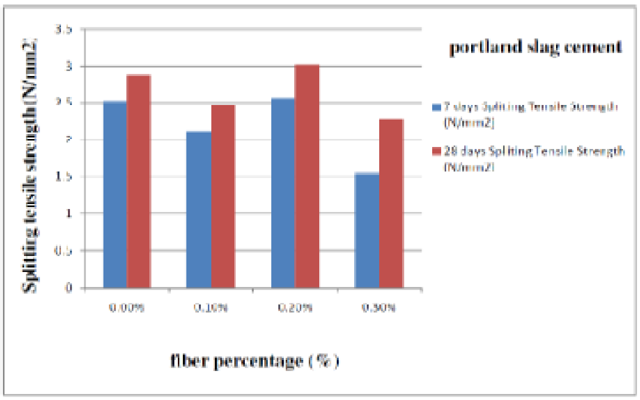


Table 15. Effect of recron fiber on Flexural Strength using slag cement:

Fiber content (%)	7 days flexural strength (N/mm^2)	28 days flexural strength (N/mm^2)
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. 12 Effect of Recron fiber on flexural strength

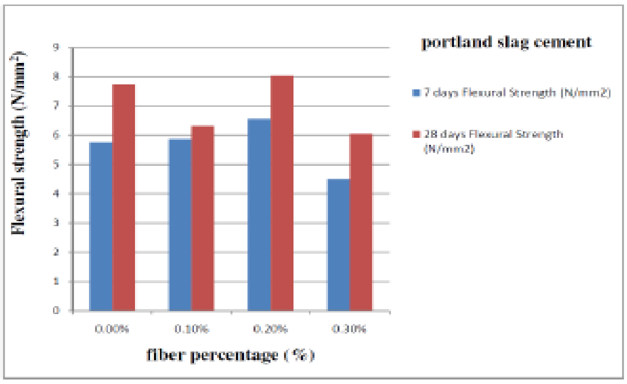


Table 16. Effect of silica fume on normal consistency of cement:

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

Fig. 13 Effect of silica fume on consistency of cement

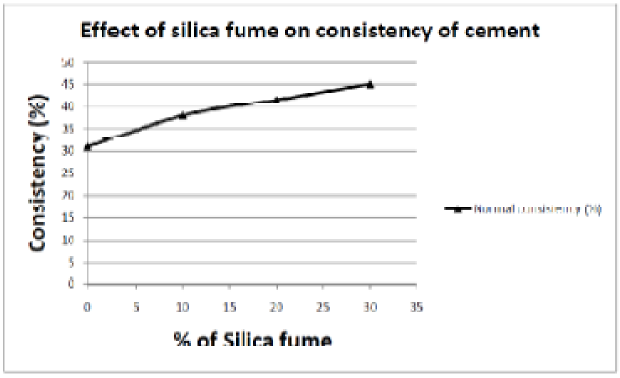


Table 17 . Effect of silica fume on Compressive strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days Compressive strength (N/mm^2)	28 days Compressive strength (N/mm^2)
0.0	19.77	22.44
10.0	17.55	21.55
20.0	19.33	24.22
30.0	16.22	20.22

Fig. 14 Effect of silica fume on compressive strength at 0.2% fiber with slag cement

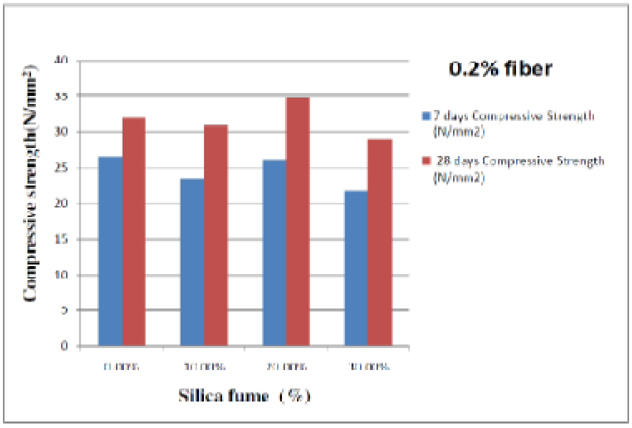


Table 18. Effect of silica fume on splitting tensile strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days splitting tensile strength (N/mm^2)	28 days splitting tensile strength (N/mm^2)
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. 15 Effect of silica fume on splitting tensile strength at 0.2% fiber with slag cement

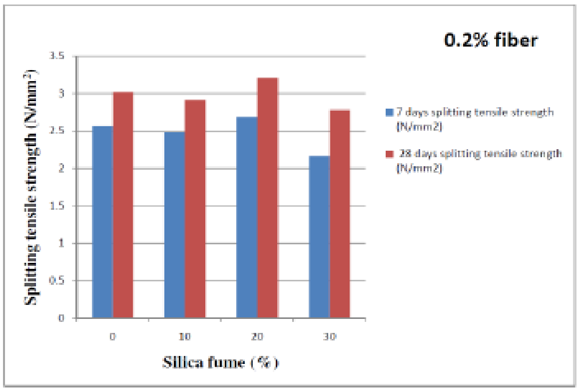


Table 19. Effect of silica fume on flexural strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days flexural strength (N/mm^2)	28 days flexural strength (N/mm^2)
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. 16 Effect of silica fume on flexural strength at 0.2% fiber with slag cement

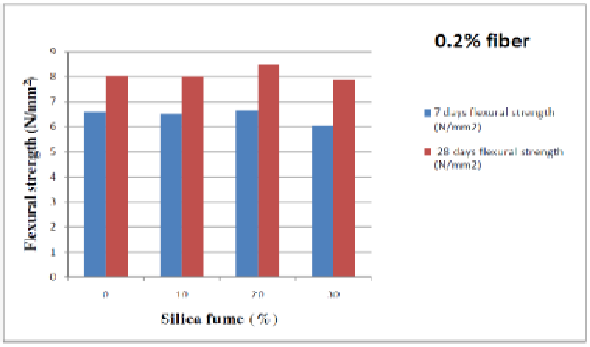


Table 20. Effect of silica fume on Compressive strength using OPC:

Silica fume (%)	7 days Compressive strength (N/mm^2)	28 days Compressive strength (N/mm^2)
0.0(0.2%fibre)	18.66	26.44
10.0(0.2%fibre)	18.88	26.88
20.0(0.2%fibre)	20.44	28.44
30.0(0.2%fibre)	22	31.55

Fig. 17 Effect of silica fume on compressive strength at 0.2% fiber and OPC

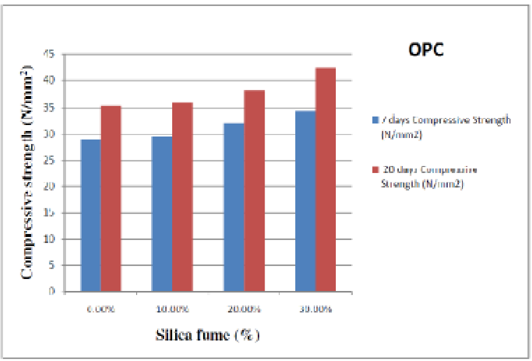


Table 21. Effect of silica fume on splitting tensile strength using OPC:

Silica fume (%)	7 days splitting tensile strength (N/mm^2)	28 days splitting tensile strength (N/mm^2)
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. 18 Effect of silica fume on splitting tensile strength at 0.2% fiber and OPC

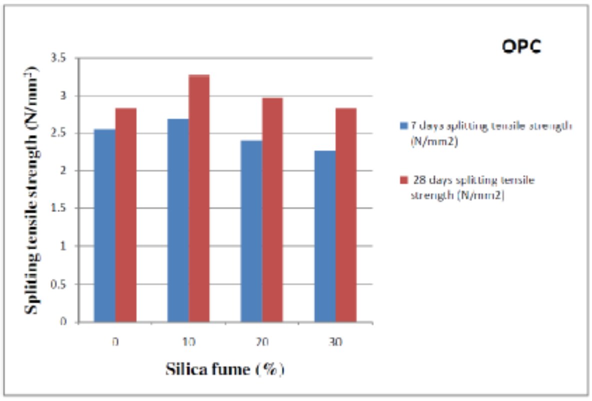
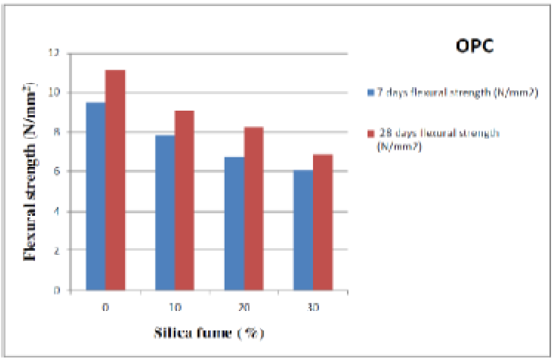


Table 22. Effect of silica fume on flexural strength using OPC:

Silica fume (%)	7 days flexural strength (N/mm^2)	28 days flexural strength (N/mm^2)
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. 19 Effect of silica fume on flexural strength at 0.2% fiber and OPC



CAPILLARY AND POROSITY TEST:
Capillary and porosity test was conducted on specimens prepared with fiber and (fiber + silica 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:

$$k = \frac{W}{A \times \sqrt{t}}$$

where,
W = Amount of water absorbed in gm
A = Cross sectional area in cm2 contact with water
t = Time in seconds

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.

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 Ww 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,

$$\eta = Vv/V = \frac{Wsat - Wdry}{V} = Ww/V$$

Where,
Vv = volume of voids in cc
V = total volume of specimen in cc

4.5.1 Test Result:

Table 23. Capillary absorption coefficient (k) for different fiber content:

Fiber %	Capillary absorption coefficient (k)
0.0	1.19×10^{-3}
0.1	1.31×10^{-3}
0.2	1.67×10^{-3}
0.3	3.57×10^{-3}

Fig. 20 Capillary absorption coefficient (k) for different fiber content

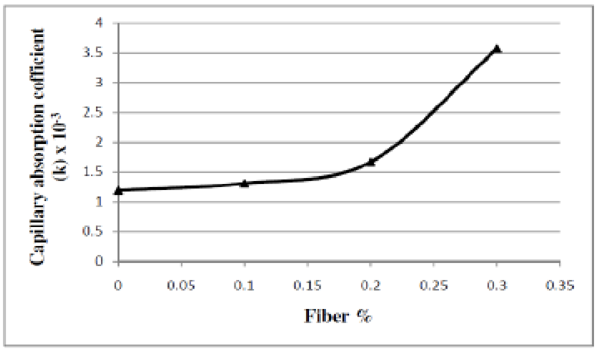


Table 24. Capillary absorption coefficient (k) for different SF content:

Silica fume%	Capillary absorption coefficient (k)
10	7.49×10^{-4}
20	5.62×10^{-4}
30	1.124×10^{-3}

Fig. 21 Capillary absorption coefficient (k) of different SF content

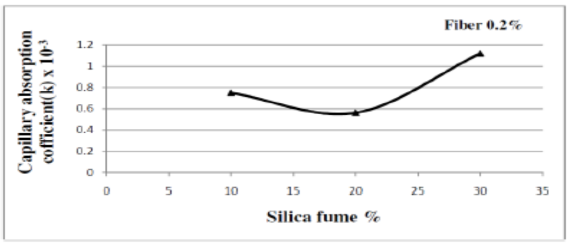


Table 25. Porosity of different fiber mix:

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

Fig. 22 Porosity of different fiber content

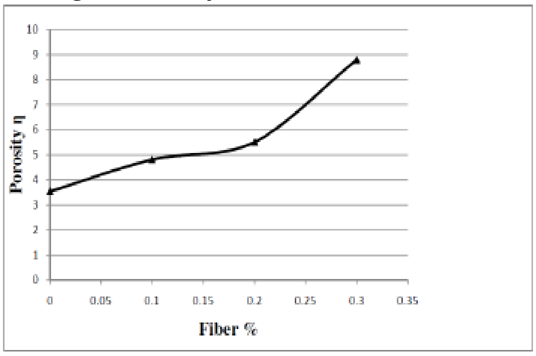
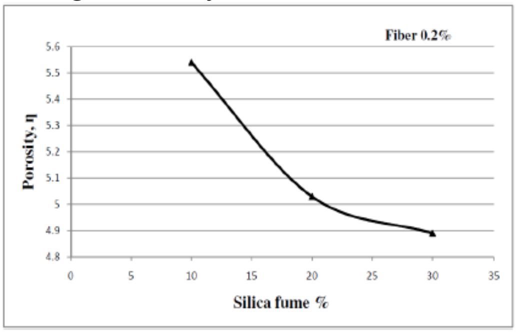


Table 26. Porosity of different Silica Fume mix:

Fiber %	Porosity, η
10	5.54
20	5.03
30	4.89

Fig. 23 Porosity of different SF content



IV. CONCLUSIONS

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,

☐ 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 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.

☐ 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.

☐ 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.

☐ So it is inculcated that 0.2% Recron fiber and 20% SF is the optimum combination to achive the desired need.

☐ 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.

☐ 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%.

☐ Ordinary Portland cement gives good compressive strength result as compared to Portland slag cement in case of mix with SF and 0.2% Recron.

☐ 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.

☐ The porosity value also decreases as the SF value increases from 0-30% in Recron fiber reinforced concrete.

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