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EFFECT OF POZZOLANAS ON FIBRE REINFORCED CONCRETE

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Abstract:

High-performance concrete is defined as concrete that meets special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing, and curing practices. Ever since the term high-performance concrete was introduced into the industry, it had widely used in large-scale concrete construction that demands high strength, high flow ability, 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 fulfills 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. 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. super plasticizer, which plays an important role for the production of high performance concrete. So we herein the projects have tested on different materials like rice husk ash and silica fume to obtain the desired needs. We used synthetic fiber (i.e. Recron fiber) 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 type of cement called ordinary Portland cement. We prepared mortar, cubes, cylinder, prism and finally compressive test, splitting test, flexural test are 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: Rice Husk ash,slica fume,Recorn fibre

1. 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

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contempt. Strength was emphasized without a thought on the durability of structures. As a consequence of the liberties taken, the durability of concrete and concrete structures is on a southward journey; a journey that seems to have gained momentum on its path to self– destruction. This is particularly true of concrete structures which were constructed since 1970 or thereabout by which time (a) the use of high strength rebars with surface deformations (HSD) started becoming common, (b) significant changes in the constituents and properties of cement were initiated, and (c) engineers started using supplementary cementitious materials and admixtures in concrete, often without adequate consideration.The 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 all over 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 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, there was a continual quest in human being for the development of high strength and durable concrete. The history of high strength concrete is about 35 years old, in late 1960s the invention of water reducing admixtures lead to the high strength precast products and structural elements in beam were cast in situ using high strength concrete. Since then the technology has come of age and concrete of the order of M60 to M120 are commonly used. Concrete of the order of M200 and above are a possibility in the laboratory conditions. The definition of high strength concretes is continually developing. In the 1950s 34N was considered high strength, and in the 1960s compressive strengths of up to 52N were being used commercially. More recently, compressive strengths approaching 138N have been used in cast-in-place buildings. The advent of prestressed concrete technology has given impetus for making concrete of high strength. In India high strength concrete is used in prestressed concrete bridges of strength from 35 MPa to 45 MPa. Presently (in 2000) Concrete strength of 75 MPa is being used for the first time in one of the flyover at Mumbai. Also in construction of containment Dome at Kaiga power project used HPC of 60MPa with silica fume as one of the constituent.

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 fulfill the needs. The concrete of these properties will have a peculiar Rheological behaviour.Now a day the construction industry turning towards pre-cast elements and requirement of post-tensioning has made the requirement of the high strength of concrete invariable and the engineers had to overcome these drawbacks, which to a great extent

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we have been able to do. The construction today is to achieve savings in construction work. This has now turned into one of the basic requirement of concreting process.

SCOPE AND OBJECTIVE OF PRESENT WORK:

The objective of the present work is to develop concrete with good strength, so that durability will be reached. For this purpose it requires the use of different pozzolanic materials like rice husk ash and silica fume along with fiber. So the experimental programme to be undertaken;

- To determine the mix proportion with rice husk ash and silica fume with fiber to achieve the desire needs.
- To determine the water/ binder ratio, so that design mix having proper workability and strength.
- To investigate different basic properties of concrete such as compressive strength, splitting tensile strength, flexural strength etc and comparing the results of different proportioning.

MATERIALS & PROPERTIES

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 SiO^2 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 m^2/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 micro-silica. In USA highly pozzolanic rice husk as his patented under the trade name of Agro-silica and is marketed it is having super pozzolanic property when used in small quantity i.e.. 10% by weight of cement and it greatly enhances the workability and impermeability of concrete.

Table 3.1 Chemical composition (%) of RHA:

SiO_2	85.88
Al_2O_3	0.47
Fe_2O_3	0.18
CaO	1.12
MgO	0.46
Na_2O	1.15
K_2O	4.10
SO_3	1.24
P_2O_3	0.34

Advantage of Rice husk ash:

Even with small dosages, for instance 10 percent by weight of cement rice husk ash can produce a very strong transition zone and very low permeability rating in concrete mixtures. In the cement having large size particles introduction of rice husk ash particles, which are micro porous blokes the channels of flow and internal pore of concrete improves. The major advantage of rice husk ash and silica fume is that they are very strong absorbents of sodium, potassium and other ions which are good conductors of electricity. A highly durable concrete with little or no corrosion in a severe environment can be obtained by improving the electrical resistivity of concrete by adding rice husk ash or silica fume.

SILICA FUME:

Silica fume also referred as 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 is subjected to 2000^0C 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 oxidized vapour, oxidation takes place and the product is condensed in low temperature zones. When the silica is condensed, it attains non-crystalline 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 m^2/g which is 6 to 7 times finer than Silica Fume. Finer the particle of pozzolana, higher will be the modulus of elasticity, which enhances the durability characteristics of the High performance concrete. Application of high performance concrete (HPC) has got momentum in various fields of construction globally in the near past. High performance concrete is being practiced in the fields like construction of nuclear reactors, runways at airport, railway sleepers, cooling towers, silos, chimneys and all kinds of bridges. Considerable amount of development has been made in the field of High performance concrete and high strength concrete can be obtained using silica fume as a mineral admixture. Silica fume has been used for one of the fly over at Mumbai, India with concrete strength of 75 MPa.

Chemical composition of silica fumes in %:

SiO_2	93
Al_2O_3	0.4
Fe_2O_3	0.2
CaO	1.2
MgO	1.2

Na_2O	0.1
K_2O	1.1
SO_3	1.3

Advantages of Silica fume:

- High strength concrete made with silica fume provides high abrasion/corrosion resistance.
- Silica fume influences the rheological properties of fresh concrete, the strength, porosity and durability of hardened mass.
- Silica fume concrete with low water content is highly resistant to penetration of chloride ions.
- The extreme fineness of silica fume allows it to fill or pack the microscopic voids between cement particle and especially in the voids at the surface of the aggregate particles where the cement particles cannot fully cover the surface of the aggregate and fill the available space.
- Silica fume can also be proportioned as a water reducer with the reduction in water cementitious material ratio, so it is hydrophilic in nature, thus super plasticizer demand for additional water can be minimized.
- Silica fume reduces bleeding segregation of fresh concrete significantly. This effect is caused due to high surface area.
- Highly durable concrete can be obtained by improving the electrical resistivity of concrete by the addition of silica fume.

Achieving adequate levels of durability in order to improve the performance and reduce the life cycle costs of concrete structures continues to be a serious problem for engineers. Benefits, in terms of high-strength concrete durability, of using additional binder materials. Some attempts were made to increase the early-age properties of the high-volume fly ash concrete by incorporating some activators and early-strength agents or small percentage (3%and 8.5%) of silica fume in the system. However, activators and early strength agents are generally alkaline substances, which may lead to alkali-silica reaction. At the same time, studies have shown that the use of silica fume did not significantly affect the early-age properties of the high-volume fly ash high-strength concrete (HFAC). The results of a study by researchers suggest that certain natural pozzolan-silica fume combinations can improve the compressive and splitting tensile strengths, workability, and elastic modulus of concretes, more than natural pozzolanas or silica fume alone. Jianyong and Pei concluded that blending Sand SF synergizes the advantages of these two admixtures so that the compressive strength, split tensile strength and rupture strength are improved while the fresh concrete mixture keeps a good workability.

Pozzolanic Action:

Silica fume is much more reactive than any other natural pozzolana. The reactivity of a pozzolana can be quantified by measuring the amount of Ca(OH)2 in the cement paste.15percentage of silica fume reduces the Ca(OH)2 of cement sample from 24% to 90% at 90days and from 25% to 11% in 180 days. The effect of silica fume can be explained by two mechanism i.e. pozzolanic reaction and micro filler effect. The first product is calcium silicate-hydrate (C-S-H) gel, that is cementitious and binds the aggregate together in concrete and $Ca(OH)_2$ The C-S-H formed by the reaction between micro-silica and the product $Ca(OH)_2$ which comprises 25% of volume of hydration product. Silica fume reacts with calcium hydroxide to produce more aggregate binding C-S-H gel. Simultaneously reducing Ca(OH)2. The net result is increase in strength and durability the second mechanism is through the micro filler effect. The extreme fineness of silica fume allows it to fill or pack the microscopic voids.

SUPERPLASTICIZER:

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

1) Mineral admixtures:

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

2) Chemical admixture:

- Accelerating admixture
- Retarding admixture
- Water-reducing admixture
- Air entering admixture
- Super- plasticizing admixture

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 30 to 60 minutes, depending on composition and dosage and is followed by rapid loss in workability. One of the important factors that govern the issue water–cement ratio during the manufacture of concrete, lower the water-cement ratio lower will be the capillary pores and hence lower permeability and enhanced durability. Although Superplasticizer are essential to produce a truly high performance concrete (HPC) characterized by low water-cement ratio and workability level without high cement content. Concrete are being produced with w/c ratio of as low as 0.25 or even 0.20 enabled the production of highly durable high performance concrete. The workability also increases with an increase in the maximum size of aggregate. But smaller size aggregate provides larger surface area for bonding with the mortar matrix, which increases the compressive strength. For concrete with higher w/c ratio use of larger size aggregate is beneficial.

High range superplasticizer was used in all the concrete mixes to achieve good workability. Superplasticizers are added to reduce the water requirement by 15 to 20%without affecting the workability leading to a high strength and dense concrete. To achieve the uniform workability, the admixture dosage was adjusted without changing the unit water content. This ensured the identical W/C ratio for a particular cementitious content and the effect of pozzolanic material replacement can directly be studied on the various properties of concrete.

Advantage of water reducing admixture:

- By the addition of admixture with the reduction in water-cement ratio, a concrete having the same workability and greater compressive strength can be obtained.

- By adding of the admixture with no decrease in water cement-ratio a concrete having same compressive strength but greater workability can be obtained.
- With the addition of admixture, a concrete with same workability and compressive strength can be obtained at lower cement content.

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. I have used the type of cement called Ordinary Portland Cement (OPC)

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 benefits is the faster rate of development of strength.

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

A. Fine aggregate

B. 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 Fibre:

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 micro-cracking, impact resistance, resistance to fatigue, reduced permeability, and improved strength in shear, tension, flexure and compression.The character and performance of FRC changes with varying concrete binder formulation as well as the fiber material type, fiber geometry, fiber distribution, fiber orientation and fiber concentration.

3.6.1. RECRON 3S POLYPROPYLENE FIBRE:

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

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

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

Specification of Recron 3s Polypropylene Fibre:

Appearance	Form: Short-Cut Staple Fibre
Diameter	0.036mm
Cut length	12mm
Aspect ratio	334
Elasticity Modulus	3500 – 6800 N/mm^2
Tensile strength	550 - 700 N/mm^2
Relative Density	890 – 940 kg/m^3
Acid resistance	Excellent
Alkali resistance	Good

EXPERIMENTAL PROGRAMMES:

TESTING RESULTS OF MATERIALS:

Cement:

For the experiment type of cement used was Ordinary Portland cement (53 grade)

Properties of Ordinary Portland cement:

Specific gravity	Initial setting time (min)	Final setting time (min)
3.15	30	690

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.

Properties of fine aggregate:

Specific Gravity	Water absorption	Fineness Modulus
2.64	0.6%	2.47

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.

Properties of coarse aggregate:

Specific Gravity	Water absorption	Fineness Modulus
2.84	0.4%	4.01

Fiber:

In this project work it was used Recron 3s fiber. It is a type of synthetic fiber. In different weight fraction (0.0%, 0.1%, 0.2%, 0.3%) was added to concrete.

Rice husk ash:

In this study we have used Rice husk Ash which was having lower percentages of carbon (which is having positive impact on strength development), so looking white because it was being burnt in higher temperature. In this type of RHA the percentage of carbon is low. The specific gravity test was carried out using Le- Chatelier apparatus and found 2.20 for RHA.

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.

Table; Effect of RHA on Normal Consistency of OPC:

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

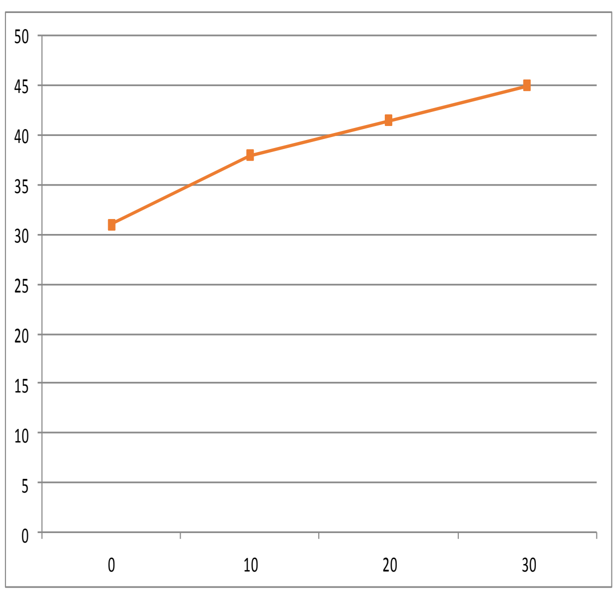
Table 4.5 Effect of RHA on Compressive strength of OPC:

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

Compressive strength of mortar with use of RHA

Table:Effect of silica fume on normal consistency of OPC:

% of cement replaced by Silica Fume	Normal Consistency (%)
0	31.0
10	38.0
20	41.5
30	45.0



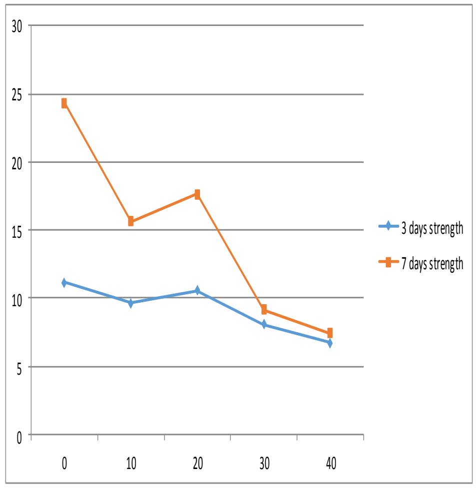


Fig.4.4 Variation of Compressive strength of mortar with different SF %

Table:Mix Proportions of M25 Grade for Recron 3s fiber

SL.NO.	RECRON FIBRE (%)	W/C RATIO	Mix Proportion (Kg/m^3)				
			CEMENT	FIBRE	FA	CA	WATER
1	0	0.5	360	0	396	864	180.5
2	0.1	0.5	359.64	0.36	396	864	180.5
3	0.2	0.5	359.28	0.72	396	864	180.5
4	0.3	0.5	358.92	1.08	396	864	180.5

Determination of splitting tensile strength of cylinder

Fig. Determination of Flexural strength of prism

Compressive Strength, C = $\frac{P}{A}$

Where, P= load in Newton

A= area of cross section of cube in mm^2

Splitting tensile strength, S = $\frac{2P}{\pi \, X \, l \, X \, d}$

Where, P= load in Newton

l= length of cylinder in mm i.e. 300mm

d= diameter of cylinder in mm i.e. 150mm

Flexural strength, F = $\frac{P \, X \, l}{b \, X \, h^2}$

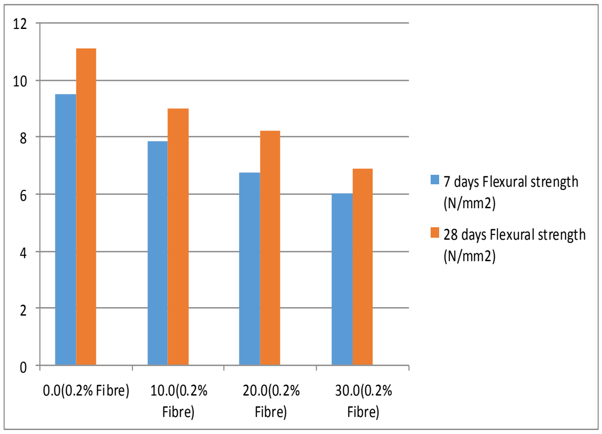
Where, P= load in Newton shown in dial gauge

l= length of rectangular prism i.e. 500 mm
b= breadth of rectangular prism i.e. 100 mm
h= height of rectangular prism i.e. 100 mm

With Ordinary Portland cement, the effects of fiber and SF on strength of concrete are shown below then using OPC.

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(0.2% 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



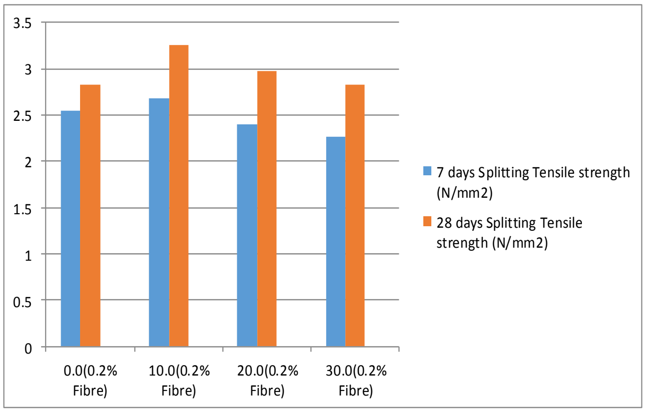


Fig.Effect of silicaon splitting strength using OPC:

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,

- 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.
- As the replacement of cement with different percentages with Silica fume increases the consistency increases.
- So it is inculcated that 0.2% Recron fiber and 20% SF is the optimum combination to achieve 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, 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%.
- Ordinary Portland cement gives good compressive strength result as compared to Portland slag cement in case of mix with SF and 0.2% Recron.

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