An Experimental Study on Strength Characteristics of 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 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. 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 super plasticizer, which plays an important role for the production of high performance concrete. So we herein the project have tested on different materials like rice husk ash, Ground granulated blast furnace slag, silica fume to obtain the desired needs. Also X-ray diffraction test was conducted on different pozzolanic material used to analyse their content ingredients. We used synthetic fiber (i.e Recron fibe) in different percentage i.e 0.0%, 0.1%, 0.2%, 0.3% to that of total weight of concrete and casting was done. Finally we used different percentage of silica fume with the replacement of cement keeping constant fiber content and concrete was casted. In our study it was used two types of cement, Portland slag cement and ordinary Portland cement. We prepared mortar, cubes, cylinder, prism and finally compressive test, splitting test, flexural test are conducted. Finally porosity and permeability test conducted. Also to obtain such performances that cannot be obtained from conventional concrete and by the current method, a large number of trial mixes are required to select the desired combination of materials that meets special performance.**

I. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementitious materials, water, aggregate and sometimes admixtures in required proportions. Fresh concrete or plastic concrete is freshly mixed material which can be moulded into any shape hardens into a rock-like mass known as concrete. The hardening is because of chemical reaction between water and cement, which continues for long period leading to stronger with age. The utility and elegance as well as the durability of concrete structures, built during the first half of the last century with ordinary portland cement (OPC) and plain round bars of mild steel, the easy availability of the constituent materials (whatever may be their qualities) of concrete and the knowledge that virtually any combination of the constituents leads to a mass of concrete have bred contempt. 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 greenhouse effect and the global warming, hence it is inevitable either to search for another material The search for any such material,

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.

HIGH PERFORMANCE CONCRETE:

In recent years, the terminology "High-Performance Concrete" has been introduced into the construction industry. The American Concrete Institute (ACI) defines high-performance concrete as concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely when using conventional constituents and normal mixing, placing and curing practices. A commentary to the definition states that a high-performance concrete is one in which certain characteristics are developed for a particular application and environment. Examples of characteristics that may be considered critical for an application are:

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

Because many characteristics of high-performance concrete are interrelated, a change in one usually results in changes in one or more of the other characteristics. A high-performance concrete is something more than is achieved on a routine basis and involves a specification that often requires the concrete to meet several criteria. For example, on the Lacey V. Murrow floating bridge in Washington State, the concrete was specified to meet compressive strength, shrinkage and permeability requirements. The latter two requirements controlled the mix proportions so that the actual strength was well in excess of the specified strength. This occurred because of the interrelation between the three characteristics.

A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete. ACI defines a high-strength concrete that has a specified compressive strength for design of 6,000 psi (41 MPa) or greater. Other countries also specify a maximum compressive strength, whereas the ACI definition is open-ended.

The specification of high-strength concrete generally results in a true performance specification in which the performance is specified for the intended application, and the performance can be measured using a well-accepted standard test procedure. The same is not always true for a concrete whose primary requirement is durability.

Durable concrete Specifying a high-strength concrete does not ensure that a durable concrete will be achieved. In addition to requiring a minimum strength, concrete that needs to be durable must have other characteristics specified to ensure durability. In the past, durable concrete was obtained by specifying air content, minimum cement content and maximum water-cement ratio. Today, performance characteristics may include permeability, deicer scaling resistance, freeze-thaw resistance, abrasion resistance or any combination of these characteristics. Given that the required durability characteristics are more difficult to define than strength characteristics, specifications often use a combination of performance and prescriptive requirements, such as permeability and a maximum water-cementitious material ratio to achieve a durable concrete. The end result may be a high-strength concrete, but this only comes as a by-product of requiring a durable concrete.

Concrete materials most high-performance concretes produced today contain materials in addition to Portland cement to help achieve the compressive strength or durability performance. These materials include fly ash, silica fume and ground-granulated blast furnace slag used separately or in combination. At the same time, chemical admixtures such as high-range water-reducers are needed to ensure that the concrete is easy to transport, place and finish. For high-strength concretes, a combination of mineral and chemical admixtures is nearly always essential to ensure achievement of the required strength.

Most high-performance concretes have a high cementitious content and a water-cementitious material ratio of 0.40 or less. However, the proportions of the individual constituents vary depending on local preferences and local materials. Mix proportions developed in one part of the country do not necessarily work in a different location. Many trial batches are usually necessary before a successful mix is developed. High-performance concretes are also more sensitive to changes in constituent material properties than conventional concretes.

Variations in the chemical and physical properties of the cementitious materials and chemical admixtures need to be carefully monitored. Substitutions of alternate materials can result in changes in the performance characteristics that may not be acceptable for high-performance concrete. This means that a greater degree of quality control is required for the successful production of high-performance concrete.

Salient Features of HPC:

- High Compressive strength
- Low water-binder ratio
- Reduced flocculation of cement grains
- Wide range of grain sizes
- Densified cement paste
- No bleeding homogeneous mix
- Less capillary porosity
- Discontinuous pores
- Stronger transition zone at the interface between cement paste and aggregate
- Low free lime content
- Endogenous shrinkage
- Powerful confinement of aggregates
- Little micro-cracking until about 65-70% of fck
- Smooth fracture surface

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.

Considering the grade of cements high strength of cement of grades 43 & 53 are desirable for design of High strength concretes. To achieve the quest of high performance concrete we should accentuate on the replacement of OPC with industrial by-products. The utilization of pozzolanic materials in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvements in the long-term durability of concrete combined with ecological benefits. Fly ash (a waste product from coal thermal power plant), ground granulated blast furnace slag, silica fumes (a waste by-product of the manufacture of Silicon or Ferro-silicon alloys from high purity quartz and coal in a submerged-arc electric furnace), rice husk ash (waste by-product from co-generation electric power plant burning rice husk), high reactive metakaoline (HRM) as partial replacement for cement which are largely available in India. To study the effect of partial replacement of cement by these pozzolanic materials, studies have been conducted on concrete mixes with

350 to 500 kg/cum cementitious material at 30%, 40%, and 50% replacement levels of fly ash; 50% and 60% replacement levels of GGBS and 7.5% and 10% replacement levels of HRM.

II LITERATURE SURVEY

Aitcin[1] (1995) cited on development in the application of high performance concrete. Over the last few years, the compressive strength of some of the concrete used has increased dramatically. In 1988, a 120 MPa concrete was delivered on site, while, until relatively recently, 40 MPa was considered indicative of high strength. The spectacular increase in compressive strength is directly related to a number of recent technological developments, in particular the discovery of the extraordinary dispersing action of superplasticizers with which flowing concretes can be made with about the same mixing water that is actually required to hydrate all the cement particles or even less. The reduction in water/cement ratio results in a hydrated cement paste with a microstructure so dense and strong that coarse aggregate can become the concrete's weakest constituent. Silica fume, a highly reactive pozzolana, considerably enhances the paste/aggregate interface and minimizes debonding. Lastly, the use of supplementary cementitious materials, such as fly ash and especially slag, helps solve slump loss problems which become critical at low w/c ratios.

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

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

Al-Khalaf and A. Yousif [4] (1984) examined on use of RHA in concrete. They studied the actual range of temperature require to burn rice husk in order to get the desired pozzolanic product, use of rice husk as partial replacement of cement on compressive strength and volume changes of different mixes. And showed that up to 40% replacement can be made with no significant change in compressive strength compared with the control mix. He tested on mortar cube, by testing on 50 mm cubes. In his investigation alsohe deduced that the most convenient and economical burning conditions required to convert rice husks into a homogenous and well burnt ash is at 5000 C for 2 hours. Also for a given grinding time, there is a considerable reduction in the specific surface area of RHA as burning temperature increasesThe minimum pozzolanic activity can be obtained, when the ash has a specific surface of about 11,500 cm2/gm. The strength of cement-RHA mortar approaches the strength of the corresponding plain mortar when the specific surface of RHA about 17000cm2/gm. For 1:2 and 1:3 mortar mixes of standard consistency the maximum percentage of rice husk ash that can be replaced by weight of cement without 60 days strength being less than that of plain mortar was 30% and 40 % respectively. Also he found higher the percentage or RHA, higher is the volume change characteristic corresponding to plain mortar

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

III. OBJECTIVE

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

- To determine the mix proportion with rice husk ash, ground granulated blast furnace slag 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.
- Determination of porosity and capillary of different proportioned concrete.

IV. EXPERIMENTAL INVESTIGATION

Materials

Cement

In the present study Ordinary Portland Cement (OPC) of 53 as well as Portland slag cement Grade Confirming to IS specifications has been used. The specific gravity of the cement was 3.1& 2.96.

Fine aggregate

Locally available river sand (Zone - II) confirming to IS specifications with fineness modulus of 2.47 and specific gravity 2.62 was used as the fine aggregate in the concrete mix.

Coarse aggregate

Aggregate confirming to IS 383-1970 obtained from the local quarry is used as coarse aggregate. The nominal sizes of coarse aggregate adopted in the present investigation were 20 mm and 12 mm. The properties of coarse aggregate and fine aggregate used in the present investigation are shown in the Table. 1

S. No	Property	Value
1	Specific Gravity	2.71
2	Water Absorption	0.4%
3	Fineness Modulus	4.01

Table 1. Properties of Coarse Aggregate

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.

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.

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

Table 2. Specification of Recron

Ground Granulated Blast furnace slag (GGBS)

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.

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

Table 3. Chemical composition (%) of RHA:

RICE HUSK ASH

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
P2O5	0.34

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

Table 4. Chemical composition of silica fumes in %:

V. RESULTS AND DISCUSSIONS

Table 5.1. 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

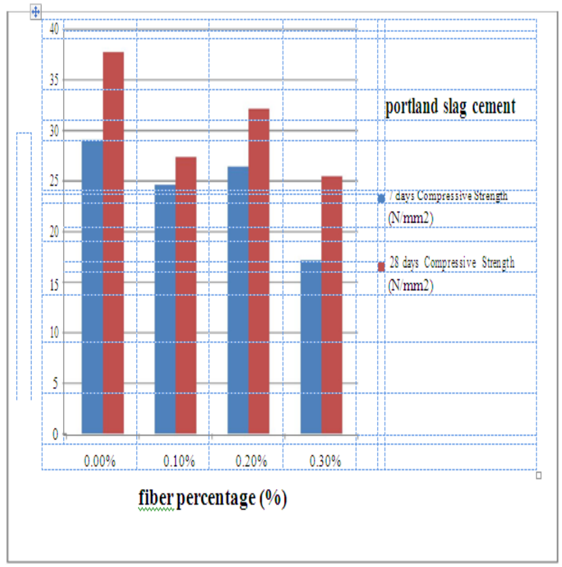

Fig. 5.1 Effect of Recron fiber on compressive strength

Table 5.2. Effect of silica fume on Compressive strength with 0.2%fiber using slag cement:

Silica fume (%)	7 days Compressive	28 days Compressive
	strength (N/mm2)	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

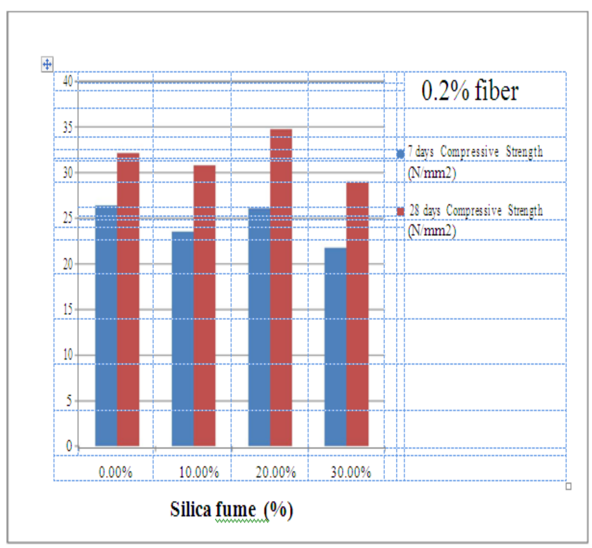

Fig. 5.2 Effect of silica fume on compressive strength at 0.2% fiber with slag cement

Table 5.3. 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

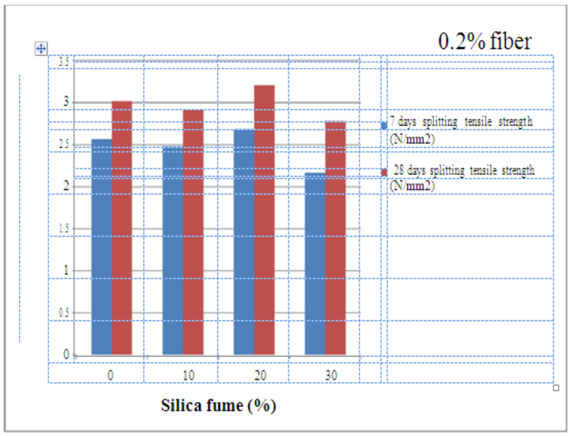

Fig. 5.3 Effect of silica fume on splitting tensile strength at 0.2% fiber with slag cement

Table 5.4. 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	3.66	3.93
10.0	3.42	3.68
20.0	3.47	4.29
30.0	3.31	3.69

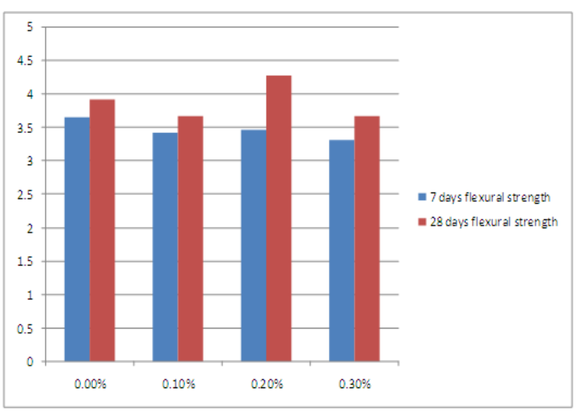

Fig. 5.4 Effect of silica fume on flexural strength at 0.2% fiber with slag cement

Table 5.5. 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

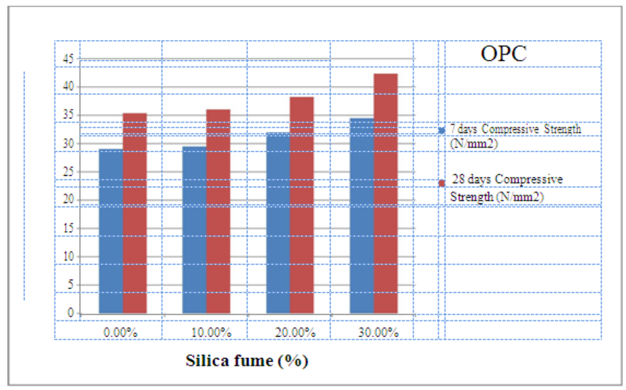

Fig. 5.5 Effect of silica fume on compressive strength at 0.2% fiber and OPC

Table 5.6. Effect of silica fume on splitting tensile strength at 0.2% fiber and 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

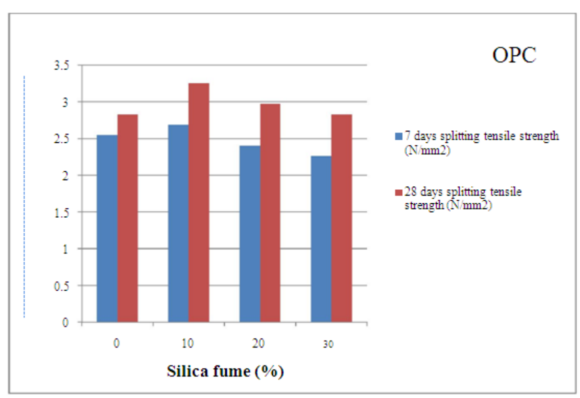

Fig. 5.6 Effect of silica fume on splitting tensile strength at 0.2% fiber and OPC

Table 5.7. Effect of silica fume on flexural strength at 0.2% fiber and OPC:

Silica fume (%)	7 days flexural strength(N/mm2)	28 days flexural strength(N/mm2)
0.0 (0% fibre)	3.56	3.89
10.0(0.2%fibre)	3.31	3.52
20.0(0.2%fibre)	3.98	4.36
30.0(0.2%fibre)	3.16	3.65

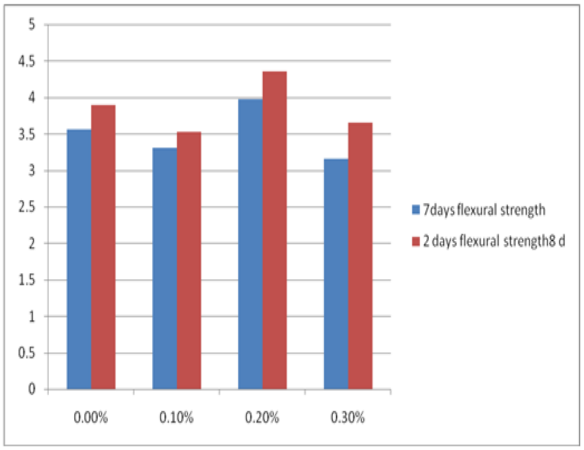

Fig. 5. 7 Effect of silica fume on flexural strength at 0.2% fiber and OPC

VI. 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,
- 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 super plasticizer 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 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, 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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