Effect of Silica Fume with fiber on 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. So the different pozzolanic materials like Ground Granulated Blast furnace Slag, 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 superplasticizer. We used Recron fiber in different percentage i.e. 0.0% - 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 cubes and finally compressive strength test are conducted. A large number of trial mixes are required to select the desired combination of materials that meets special performance.*

Keywords: Silica Fume, Fiber, Cement, Fine Aggregates,Coarse Aggregates, Compressive Strength.

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 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. The reasons for these demands are many, but as engineers, we need to think about the durability aspects of the structures using these materials. With long term durability aspects kept aside we have been able to fulfil the needs. The concrete of these properties will have a peculiar Rheological behavior. 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 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. 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, silica fume along with fiber. So the experimental program to be undertaken;

- To determine the mix proportion 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 and comparing the results of different proportioning.

II. REVIEW OF LITERATURE

- Silica fume is one of the popular pozzolans used in concrete to get improved properties. The use of silica fume in conjunction with superplasticizers has become the backbone of high strength and high performance concrete. Silica fume is very reactive pozzolan, which is used in concrete because of its fine particles, large surface area and high SiO_2 content. A detailed experimental investigation has been carried out to study the effect of silica fume in conjunction with superplasticizers on some of the properties of fresh

concrete. The investigation revealed that by maintaning a constant dosage of high performance superplasticizer along with silica fume, it is possible to maintain a optimum slump value i.e. workability, thereby satisfying most of the modern structural applications.

- The strengthening effect in high strength concrete is dependent on the water cement ratio and is inversely related to the value of water/cement ratio. Addition of silica fume in concrete introduces an inherent effect that leads to an increase in strength of concrete at the same water cement ratio. The water reducing effect is an important benefit of silica fume concrete. Silica fume has been recognised as a pozzolanic admixture that is effective in greatly enhancing mechanical properties. The addition of silica fume in concrete also increases the durability by reducing permeability and refining pore structure. It is suggested that its origin is in the improved Aggregate matrix bond. The interfacial transition zone usually governs all the properties of concrete being the weakest zone. This paper present test results indicate that use of Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.
- The current manuscript deals with subject of addition of natural fibers to concrete in order to study the strength properties and also to observe if there is reduction in propagation of shrinkage crack problems. Basically natural fibers are of two types. Natural inorganic fibers such as Basalt, Asbestos…etc and the other are the natural organic fibers such as coconut , palm, kenaf, jute, sisal, banana, pine, sugarcane, bamboo…etc. This study may include the fiber properties, characteristics and compatibility between themselves. Also the comparisons and conclusion to be studied for different fiber-cement proportions. However all properties of concrete may not improve for the same proportions of different fibers. Some properties may be improved and same may be reduced, since each fiber has its own different properties. Totally the study deals with comparisons and differences between the different natural fibers
- Natural fibers are available in abundant quantities in many developing countries, more elaborate research should be directed toward the various problems associated with the use of these fibers. This presents a critical review of the factors that affect the properties and behavior of natural fiber reinforced concrete (NFRC). Test results for concretes obtained by using water blended with yeast granules are also reported in this paper.

1.Critical observation from the literature:

- It was observed that not much work has been proceeded to find the optimum use of silica fume to produce good strength and durable concrete.
- The maximum percentage of synthetic fiber to be used in concrete along with silica fume to get good outcome.

III MATERIALS &EXPERIMENTAL PROGRAMMES

1. OUTLINE OF PRESENT WORK: Synthetic fiber i.e. Recron fiber is used in concrete for the production of fiber reinforced concrete. We are going to use Recron fiber in different percentage i.e. 0%, 0.1%, 0.2%, 0.3% to the weight of concrete and study the 7 days and 28 days compressive strength of concrete to that of normal concrete with maintaining the water cement ratio in the range of 0.35-0.41. Then with different percentages of silica fume i.e. 5%, 10%, 15% fixing constant fiber percentage at 0.2% cubes, cylinders and prisms were casted and tested to analyze the change in compressive strength. We used two types of cement for our study i.e. Portland slag cement and ordinary Portland cement (53 grade). Different materials used in this study are given below for the strength evaluation of concrete using Silica fume, fiber and superplastisizer.

A. Cement: For the experiment following two types cements were used,

(a) Portland Slag Cement

(b) Ordinary Portland cement (53 grade

Table 1. Properties of Portland slag cement and Ordinary Portland cement:

Properties	Portland slag cement	Ordinary Portland cement
Specific Gravity	2.96	3.1
Initial setting time	36	33
Final setting time	510	540

B.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.

C. 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 2. Properties of fine aggregate & coarse aggregate:

Properties	Fine aggregate	coarse aggregate
Specific Gravity	2.65	2.67
Water absorption	0.60%	0.40%
Fineness Modulus	2.47	4.01

D. 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.

E. 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 and found to be Specific gravity- 2.36.

2. 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 (53 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 5%, 10%, 15% 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 (5%, 10%, 15 %) 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, of sizes 150mm cubes. All specimen were demoulded after 24 hour. Finally all the specimen were cured for 7 days and 28 days. compressive strength, were evaluated on cubes, cylinders, prisms respectively according to the Indian standard codes. i.e IS 456: 2000 and IS 10262-1982.

3. Test Result:

Table 3. 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	29.0	37.8
0.1	24.6	27.4
0.2	26.4	32.1
0.3	17.2	25.5

Table 4. Effect of silica fume on normal consistency of cement:

% of cement replaced by silica fume	Normal consistency (%)
0	31
5	38
10	41.5
15	45

***Table 5. Effect of silica fume on Compressive strength with 0.2%fiber using slag cement*:**

Silica fume (%)	7 days Compressive strength (N/mm²)	28 days Compressive strength (N/mm²)
0.0(0.2%fibre)	26.43	32.148
5.0(0.2%fibre)	23.55	30.813
10.0(0.2%fibre)	26.07	34.814
15.0(0.2%fibre)	21.778	29.03

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

Table 6. Effect of silica fume on Compressive strength with 0.2%fiber using OPC:

Silica fume (%)	7 days Compressive strength (N/mm²)	28 days Copressive strength (N/mm²)
0.0(0.2%fibre)	29	35.33
5.0(0.2%fibre)	29.5	36
10.0(0.2%fibre)	32	38.28
15.0(0.2%fibre)	34.5	42.32

IV. CONCLUSION

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

_ 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.

_ 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 strength affected remarkably. Using 10% silica fume with 0.2% fiber percentage the 28 days compressive strength increases 7% more than concrete with 0.2% fiber only.

_ So it is inculcated that 0.2% Recron fiber and 10% 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 0-15% and 0.2% Recron fiber and it is about 10% more than strength of normal concrete with OPC.

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

V. SCOPE OF FURTHER WORK:

The research work on pozzolanic materials and fiber along with pozzolanas is still limited. But it promises a great scope for future studies. Following aspects are considered for future study and investigation;

_ Replacing cement with different percentage of silica fume to judge the optimum percentage of silica fume to be used to get better strength result.

_ Research on Recron fiber and silica fume with greater fineness as a partial cement replacing material, by which we can minimise the cost and at the same time achieve the durability and strength for the production of High Performance Concrete.

_ It requires a proper mixing propertions for the development of high strength, high performance concrete which may not be possible manually. So it needs some global optimisation techniques to develop the desire result with greater accuracy and time saving.

VI. REFERENCES

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