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Comparison of High Volume Fly Ash Fibre Concrete Strengths With Controlled Fibre Concrete

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Abstract— Concrete consumption has becomes multi-fold over last few decades, and such usage of concrete has increased on large scale world over. The production of one tone of cement liberates one tone of carbon dioxide and it is enhancing the global warming. Some of the industrial wastes like Fly ash, Meta-kaolin, GGBS, Silica fume, Rice husk ash etc., have already established their usage in concrete. To maintain workability for lower water/cement ratio and to maintain the effect of admixture added, Superplasticizer is added by trial and error method .Glass fibre also increases mechanical properties like compressive strength, flexural strength and split tensile strength of concrete. And also increase the durability of concrete. This paper discussed an experimental study on M30 Grade of concrete comparision High Volume Fly ash concrete and controlled concrete strengths using 55% replacement of fly ash by weight of binder. Aim of the experimental work was to achieve a proportion of ingredients and obtain strengths of M30 Grade. The moulds were prepared for controlled with 100% OPC, 5%silica fume,0.5%,1% glass fibres were casted for 7 days and 28 days respectively and with fly ash 55% replacement of binder, 7.5% silica fume, 0.5%,1% glass fibres were casted for 7 days and 28 days respectively. Test were done for compressive strengths and split tensile strengths. The test results indicates that replacing 55% fly ash has good performance on concrete compared to controlled concrete.

Index Terms – Glass Fibres, Silica fume, Fly Ash.

1. INTRODUCTION

Cement is the most widely used composite material in concrete structures. Cement manufacture causes environmental issues like depletion of natural resources, production of greenhouse gases and energy consumption. India's total installed capacity of cement stood at 320 million tonnes per annum .By Production of one ton cement, it generates one ton of CO2 emissions which leads to greenhouse gas emission. Carbon concentration in cement spans from approximately 5% in cement structures to 8% in the case of roads in cement.

The development of human activity results in environmental degradation. The main challenge is to minimize this degradation to a level consistent with sustainable development. The means of achieving it is to consume the waste products in construction industry. Fly ash is the by-product of coal combustion material. Generally fly ash is considered as a waste material and its disposal in thermal plants creates numerous ecological and environmental problems. However, researches conducted on fly ash it had high Pozzolonic activity which is attributed by SIO2 and AL2O3. In addition of fly ash in concrete it gains strength without affecting mechanical and durability properties of concrete. After many investigation partial replacement of cement by fly ash gives good mechanical and durability properties. Fly ash can be successfully used in concrete due to the numerous advantages over ordinary plain concrete, such as increased compressive strength, improved workability, reduced permeability, reduced shrinkage, less bleeding and more economically.

The introduction of fibers is brought in as a solution to develop concrete with enhanced flexural and tensile strength, which is a new form addition to concrete. Fibers are most generally discontinuous, randomly distributed throughout the cement matrices. Concrete is relatively a brittle material when subjected to normal stresses and impact loads, where tensile strength is approximately just one tenth of its compressive strength.

2. LITERATURE REVIEW

Sanjeev. N, [2003] investigated in the strength appraised of HVFA concrete in RCC[1] in which HVFA concrete with 50% replacement of cement by fly ash investigated for deflections grade widths at tensile load and ultimate load as far that these parameters were same in controlled concrete columns and beams and HVFA concrete columns and beams.

Rafter Siddique and El-Hadj Kadri [2017] investigated in Properties of High Volume Fly Ash Concrete Reinforced with Natural Fibers[2] in which three concrete mixtures were made with 35%, 45%, and 55% of Class F fly ash partial replacement of cement. After this, three percentages (0.25, 0.50, and 0.75%) of san fibres (25 mm length) were added in each of the fly ash concrete mixtures. San is a natural bast fibre. Tests were performed for compressive strength, splitting tensile strength, flexural strength, and impact strength at the ages of 28, 91 and 365 days.

Rooban Chakravarthy et al., [2010] investigated in Mechanical Properties of High Volume Fly Ash concrete Reinforced With Hybrid Fibres[3] in Which Fly Ash to cement is approach to reduce CO2 emissions. Though Fly Ash Concrete is having brittle behavior, it have shown that addition of fibres could reduce brittle behavior. Some research papers have utilized single or two types of fibres. In this research, three types of fibres Steel, Polypropylene, and Basalt as 0%, 0.50%, 0.75%, and 1% by volume of concrete, were it is mixed with different proportions with concrete specimens substituted with 50% fly ash. All specimens were tested for compressive strength, indirect tensile strength, and flexural strength over a period of 3 to 56 days of curing. Test results showed that significant improvement in mechanical properties could be obtained by a particular hybrid fiber reinforcement combination.

Jo Jacob Raju and Jino John [2014] investigated in Strength Study of High Volume Fly Ash Concrete With Fibres[4] in which High volume Fly Ash Concrete includes all the sustainability issues. It is recommended over the ordinary concrete as it considerably saves cement and prevents environmental pollution. The use of fibres improves material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, and ductility. An attempt is made to study the mechanical properties of high volume fly ash concrete with addition of fibres at 0.1, 0.2, and 0.3% of cement and with 60% fly ash replacement with cement. It is found that addition fibres increased the strength characteristics over the ordinary cement concrete. The major parameter that affected strength was total binders and water binder ratio.

Dasari Venkateswara Reddy, Prashant Y. Pawade [2012] investigated in Combine Effect of Silica Fume And Steel Fiber On Mechanical Properties On Standard Grade Of Concrete And Their Interrelations[5] in which it carried out on concrete due to the effect of silica fume with and without steel fibers on Portland Pozzolana cement. In this study used concrete mixes with Silica Fume of 0%, 4%, 8% and 12%, with addition of crimped steel fibers of diameter 0.5mm with aspect ratio of 60, at various percentages as 0%, 0.5%, 1.0% and 1.5% by the volume of concrete on M35 grade of concrete.

Saravana Raja Mohan K, Parthiban K [2011] investigated in Strength and Behaviour of Fly Ash Based Steel Fiber Reinforced Concrete Composite [6] in which this is to study the effects of replacement of cement (by weight) with five percentage of fly ash and the effects of addition of steel fiber composite. A control mixture of proportions 1:1.49:1.79 with w/c of 0.45 was designed. Cement was replaced with five percentages (10%, 15%, 20%, 25% & 30%) of Class C fly ash. Four percentages of steel fibers (0.15%, 0.30%, 0.45% & 0.60%) having 20mm length were used. This study reports the feasibility of use of steel fibers and their effect due to variation in fiber length, fiber content on structural properties such as cube compressive strength, cylinder compressive strength, split tensile strength, modulus of rupture and modulus of elasticity of this composite. Tests were conducted on beams with optimum fiber parameters, and the results compared with those of identical Reinforced Concrete beam.

3. EXPERIMENTAL PROGRAMME

Materials used: In this experimental investigation, Cement, fine aggregate, coarse aggregate, water, fly ash, glass fibers, silica fume and chemical admixture were used.

Cement: In this experiment Ordinary Portland cement of 53 grade is used and thus tested for physical properties in accordance with IS 4031-1968 and found to be conforming various specifications of I.S-12269:1987.

Coarse aggregates: Locally available 20mm size coarse aggregates were used and tested for physical properties in accordance with IS 2386-1963.

Fine aggregates: The fine aggregates available from local sources and passing through 4.75mm IS sieve is used and tested for physical properties in accordance with IS 2386-1963.

Water: Water plays a vital role in achieving the strength of concrete. Water used for mixing and curing shall be clean and free from oil, acid, alkalis, salt, sugar, organic materials or other substance that may be deleterious to concrete or steel. Portable water is generally considered for mixing concrete.

Fly ash: Fly ash of Class F conforming to IS: 3812: Part-II-2003 obtained from Ramagundam thermal power plant.

Chemical Admixture: Super Plasticizer-Conplast SP430 is used.

Glass fiber: The properties of glass fibers used in this investigation are appearance=white, length=18mm, dia=0.014mm, aspect ratio=1285, density 2.7gm/cm³, odorless and insoluble in water. Percentages used glass fibres are 0.5%, 1%.

Silica fume: Silica fume is used with percentage 5 and 10%

Mix Proportions Of Concrete:

M30 grade of concrete was obtained as per I.S.10262:2009 with w/c 0.35. Mix proportion for M30 grade concrete for tested material as follows.

Table1. Mix proportions

Materials	**Quantities (Kg/m³)**
Cement	400
Fly ash	457.12
Water	140litres
Coarse aggregate	1400
Fine aggregate	720

4. WORKABILITY

Slump test is the most commonly used to determine the workability and consistency of fresh concrete. It is not suitable method for very wet or very dry concrete. it is used conveniently as a control test and gives a indication of the uniformity of concrete from batch to batch. The steel mould is in the form of frustum of cone which is used in slump test it has top diameter 100mm, bottom diameter 200mm and height 300mm.Firstly the mould is cleaned from surface moisture and placed on the base plate and apply oil to the mould properly. Fill the mould with 3 layers and each layer is tamped with a tamping rod of diameter 16mm and length 0.6meterand it is tamped 25 times carefully. Remove the concrete around the bottom of mould. After filling concrete in the mould immediately raise the mould carefully in the vertical direction and measure the difference between the height of the mould and height of the specimen. The distance will be the slump of the concrete.

Table 2: Slump values:

Mix	Slump values(mm)
C1	75
C2	74
F1	73
F2	71

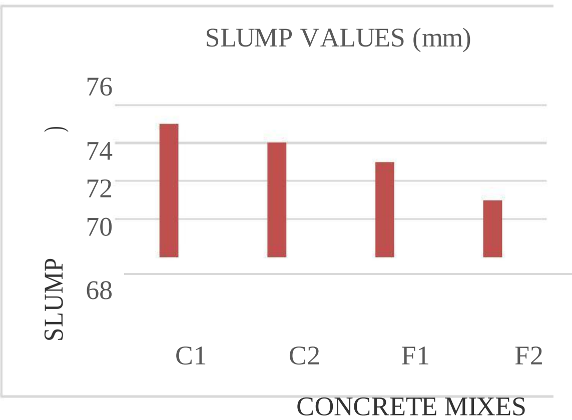

Figure 1. Slum values (mm)

Conventional mix:

C1: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 0.5% by weight of binder

C2: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 1% by weight of binder

Mixes with cement replaced by fly ash:

F1: 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5% by weight of binder

F2: : 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 1% by weight of binder.

5. EXPERIMENTAL METHODOLOGY

Compressive Strength Test:

For compressive strength test, cube specimens of dimensions 150mm×150mm×150mm were casted for M30 grade of concrete. The moulds were filled with controlled concrete, and high volume fly ash concrete The moulds are vibrated using needle vibrator and the top surface of the specimen was leveled and finished. The specimens were demoulde after 24 hours and were shifted to curing tank in which it is allowed to cure for 7 days and 28 days. After 7 and 28 days curing, these cube were tested on compression testing machine. The failure load was noted. In each category, three sample of cubes were tested and their average value is reported. The compressive strength was calculated as follows: Compressive strength (MPa) = Failure load / cross sectional area.

Tensile strength test:

For split tensile strength test, cylinder specimens of dimension 150mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank in which it is allowed to cure for 7 and 28 days. These specimens were tested under compression testing machine. In each category, three sample of cylinders were tested and their average value is reported. Tensile strength was calculated as follows

Split tensile strength:

Tensile strength (MPa) = $2P / \pi DL$,

Where, P = failure load,

D = diameter of cylinder,

L = length of cylinder.

Mechanical properties of controlled concrete and high volume fly ash concrete using glass fibres with addition of mineral admixtures (silica fume)

Compressive strength

The compressive strength values for all mixes are shown in the table.

Table3: Compressive strengths N/mm^2

MIX	COMPRESSIVE STRENGTHS N/mm^2	
	7 days	28 days
C1	27	36
C2	28	37.5
F1	27.5	38.5
F2	28.5	41

Conventional mixes:

C1: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 0.5% by weight of binder

C2: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 1% by weight of binder

Mixes with cement replaced by fly ash:

F1: 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5% by weight of binder
F2: : 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 1%by weight of binder

Inference of 7 days strength:

Compressive strength of concrete mix F1 increases slightly about 1.85% compared to compressive strength of concrete mix C1.

Compressive strength of concrete mix F2 increases 1.85% compared to compressive strength of concrete mix C2.

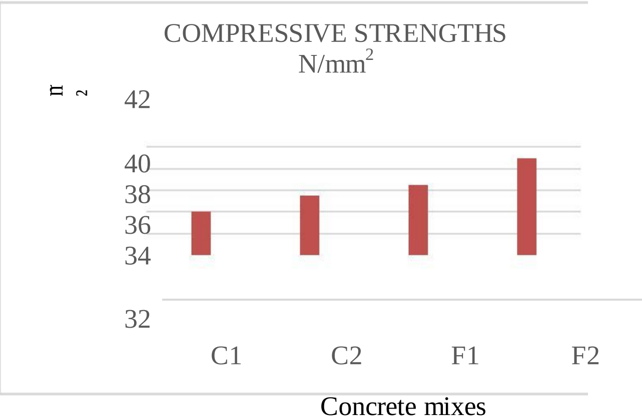

Figure 2. 28-days compressive strength

Conventional mixes:

C1: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 0.5% by weight of binder
C2: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 1% by weight of binder

Mixes with cement replaced by fly ash:

F1: 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5 by weight of binder
F2: : 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5 by weight of binder

Inference of 28 days strength:

Compressive strength of concrete mix F1 increases 6.9% compared to compressive strength of concrete mix C1.

Compressive strength of concrete mix F2 increases 9.3% compared to compressive strength of concrete mix C2.

The split tensile strength values for all mixes are shown in the table. It is observed that the split tensile strength of mix C2 is maximum @1% glass fibres. The results obtained are represented graphically as shown in figure.

Table4: Split tensile strengths N/mm^2

MIX	SPLIT TENSILE STRENGTHS N/mm^2	
	7 days	28 days
C1	2.7	3.6
C2	2.8	3.7
F1	2.75	3.85
F2	2.9	4.1

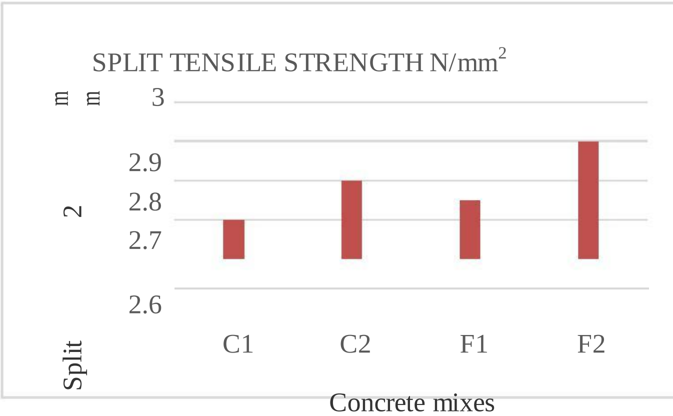

Figure 3. 7 days split tensile strength

Controlled mixes:

C1: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 0.5% by weight of binder
C2: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 1% by weight of binder

Mixes with cement replaced by fly ash:

F1: 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5 by weight of binder
F2: : 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 1% by weight of binder

Inferences of 7 days strength

Split tensile strength of concrete mix F1 increases 1.85% compared to compressive strength of concrete mix C1

Split tensile strength of concrete mix F2 increases 3.5% than compressive strength of concrete mix C2

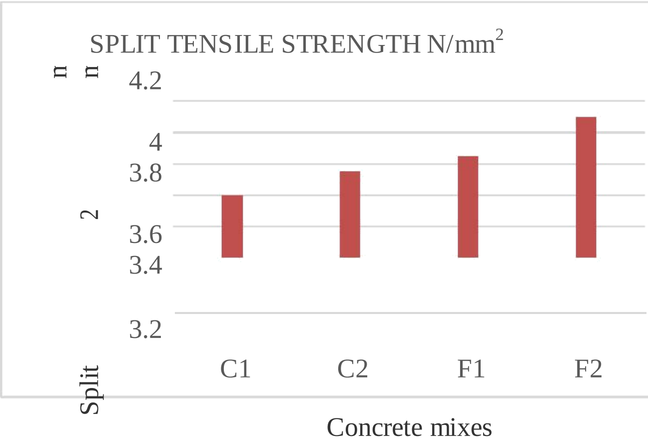

Figure 4. 28 days split tensile strength

Controlled mixes:
C1: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 0.5% by weight of binder
C2: 100% OPC + 5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ 1% by weight of binder
Mixes with cement replaced by fly ash:
F1: 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 0.5 by weight of binder
F2: : 45% OPC + 55% fly ash + 7.5% silica fume + fine aggregate + coarse aggregate + addition of fibres @ of 1% by weight of binder
Inference of 28 days strength:
Split tensile strength of concrete mix F1 increases 6.94% compared to compressive strength of concrete mix C1
Split tensile strength of concrete mix F2 increases 9.33% compared to compressive strength of concrete mix C2

6. CONCLUSION

• Based on the research studies the following conclusions can be made:
• It is observed that the workability of concrete decreases with the addition of mineral admixtures and by adding glass fibres.
• It shows that the strengths when compared to conventional concrete increased by replacement of cement with flyash by 55% in addition with 1% glass fibres.
• By comparing the compressive strength of conventional concrete with addition of glass fibres and cement replaced by mineral admixtures concrete mix of compressive strength has slight increase at the 7 days.
• The percentage increases of compressive strength of concrete mix with replacement of cement by 55% Fly ash and addition of 1.0% glass fibres when compared with 7 days compressive strength of control concrete with glass fibres is observed as 1.85%
• The percentage increases of split tensile strengt h of concrete mix with replacement of cement by 55% Fly ash and addition of 0.5% glass fibres when compared with 7 days compressive strength of control concrete with glass fibres is observed as 1.85%
• The percentage increases of compressive strength of concrete mix with replacement of cement by 55% Fly ash and addition of 1% glass fibres when compared with 28 days compressive strength of control concrete with glass fibres is observed as 9.3%
• The percentage increases of split tensile strengt h of concrete mix with replacement of cement by 55% Fly ash and addition of 1.0% glass fibres when compared with 28 days compressive strength of control concrete with glass fibres is observed as 9.33%
• The result concludes an increase in compressive strength and split tensile strength for mix of 55% replaced mineral admixture with 1% glass fibre when compared to controlled concrete.
• Also it was found from the failure pattern of the specimens that the formation of cracks is more in the case of controlled concrete whereas less in glass fibred concrete.
• The ductility characteristics have improved with addition of glass fibres. The failure of fiber concrete is gradual as compared to that of brittle failure of plain concrete.
• Replacing cement with fly ash and glass fibres he lps concrete to increase compressive strength to some extent. By increasing more percentages in glass fibres, it may decrease in strength properties.

Therefore, the use of mineral admixtures as partial replacement of OPC gives the required strength. Additions of fibres have significant importance in increasing the compressive and tensile properties of concrete thus leading to reduction in the quantity of reinforcement to certain extent. It reduces the demand for natural resource and also decreases the cost of overall construction.

The study on the effect of hybrid fibers with different proportions can still be a promising work as there is always a need to overcome the problem of brittleness of concrete. The following conclusions could be drawn from the present investigation.

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