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# Strength Appraisal of High Volume Fly Ash Fibre Concrete

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**Abstract –** Concrete is the most commonly used construction material in the world. Ordinary Portland Cement is used as primary binder material to produce concrete. For every one ton of production of cement, one ton of $CO_2$ is emitting into environment adding to global warming. To reduce the global warming and to utilise the disposal problem associates industrial waste of thermal plants i.e., fly ash is extensively used. The main objective is to study the strength appraisal of high volume fly ash fibre concrete. In this experimental investigation, binder constitutes 40% OPC and 60% fly ash. The specimens were casted and tested for compressive strength and split tensile strength of conventional concrete and high volume fly ash fibre concrete and tested at the age of 7 days and 28 days. The tested results are comparatively less in case of high volume fly ash fibre concrete when 60% fly ash is used than conventional concrete.

**Index Terms –** Ordinary Portland Cement, Global warming, High volume fly ash fibre concrete, Conventional concrete, Compressive strength, Split tensile strength.

## 1. INTRODUCTION

Concrete is the most commonly used construction material in the world OPC is conventionally used as primary binder material to produce concrete. Every one ton of cement production leads to the generation of one ton of $CO_2$. The production of cement is exceeding 2.6 billion tons per year worldwide production of cement is a major contributor for the emission of green house gas which is implicated to global warming and other environmental problems.

For more effective option to reduce the emission of $CO_2$ when produced during the cement manufacturing replacement of cement either partially or fully by supplementary cementitious materials such as fly ash, GGBS, Silica fume etc. Fly ash is an industrial waste which is produced from the combustion of pulverized coal in thermal power stations.

In order to increase the utilization of fly ash rather than dumping on the earth which pollutes the ground, it is necessary to use in concrete by partial replacement of cement. The fly ash production is about 131 million tons per year during 2011-12 in India. This is expected to increase to 300-400 million tons per year by 2016-17.

The overall objective of this study is to determine the behaviour of mechanical properties of glass fibre reinforced concrete containing large volume of Class F fly ash. The objectives of present study are listed below.

- To study the compressive strength of concrete mix of M 30 grade with high replacement of Class F fly ash with required w/c ratio of the age of 7 and 28 days.
- To test the strength properties of concrete which includes compressive and split tensile strength at different ages of curing.
- To compare the strengths appraisal of high volume fly ash fibre concrete with conventional concrete for different levels of fibre added.

## 2. MATERIALS USED

The materials used for the present study are cement, fine aggregate, coarse aggregate, fly ash, glass fibres, silica fume, super plasticizer and water. The materials were casted according to the IS code specifications. The materials used for casting were discussed below in detail.

### 2.1 Ordinary Portland Cement

The cement used was Ordinary Portland Cement of 53 grade confirming to IS 12269:1987 (reaffirmed in 2004) in all concrete mixes. The physical properties are given in below table

### 2.2 Fine aggregate

River sand is used as fine aggregate without any organic impurities confirming to IS 383:1970. This sand is sieved through 4.75mm sieve. Sand contains well graded particles and water demand will be less for natural sand. The physical properties of fine aggregate were tested such as specific gravity and water absorption confirming to IS 2386:1963. The tested value of specific gravity of fine aggregate is 2.64. The water absorption of fine aggregate is 1%.

Table 1. Physical properties of OPC

| S. No | Property | Test Results | IS Standards |
|---|---|---|---|
| 1 | Specific gravity | 3.15 | |
| 2 | Fineness | 311.4 | Min. 225$m^2$/Kg |
| 3 | Normal Consistency | 33% | |
| 4 | Compressive strength<br>3Days<br>7Days<br>28Days | 25Mpa<br>35.8Mpa<br>53Mpa | |
| 5 | Initial setting time<br>Final setting time | 65minutes<br>255minutes | Not less than 30min<br>Max 10 hrs |
| 6 | Soundness | 1.5mm | <10mm |

### 2.3 Coarse aggregate

Crushed angular aggregate was used confirming to IS 383-1970. The aggregates were tested for its physical properties like specific gravity and bulk density in accordance with IS 2386-1963. In this study, 20mm aggregate were used. The tested result of specific gravity of coarse aggregate is 2.9. The water absorption of coarse aggregate is 0.5%.

### 2.4 Fly Ash

Class F fly ash is a mineral admixture used in this study. The cement is replaced by 60% of fly ash. According to ASTM C 618 (2003) fly ash is used as additive material. The specific gravity of fly ash is 2.3.

### 2.5 Silica Fume

It is another mineral admixture used in this study. It is used 5% to 10% of binder.

### 2.6 Water

The water used in potable water which is easily available near the lab premises for mixing of concrete ingredients and for curing the concrete specimens. The pH value of water shall not be less than 6.

### 2.7 Alkali Resistant (AR) Glass Fibre

The fibres used are AR glass fibres which are randomly distributed in the concrete mix different in the concrete mix different percentage 0.5% and 1% for each mix.

Table 2. Physical properties of Alkali Resistant Glass fibre

| S.No | Property | Test Result |
|---|---|---|
| 1 | Apperance | White |
| 2 | Size | 18mm |
| 3 | Diameter | 14micro meter |
| 4 | Moisture % | 0.3max |
| 5 | Aspect Ratio | 857:1 |
| 6 | Odour | Odour less |
| 7 | Solubility | Insoluble in water |
| 8 | Density | 2.7g/$cm^3$ |
| 9 | Tensile strength | 1700Mpa |
| 10 | Elastic modulus | 72Gpa |
| 11 | Elongation at break | 2.3% |
| 12 | Melting point | Higher than $1450^0$C |
| 13 | Number of fibre | >200million/Kg |
| 14 | Specific Surface area | 105$m^2$/Kg |
| 15 | Typical addition rate | 0.6Kg/$m^3$ of Concrete |

### 2.8 Super Plasticizer

To increase the workability of concrete super plasticizer is added. Conplast SP 430 is sulphonated napthalene, formaldehyde based polymer. As per IS 9103-1999, it is recommended that super plasticizer can be added up to 1 to 2% of binder. In this study, the super plasticizer adopted is 1.7% of binder.

## 3. EXPERIMENTAL INVESTIGATIONS

### 3.1 General

The experimental investigation was done to study the strength appraisal of high volume fly ash fibre concrete with variable percentages of fibres. High volume fly ash concrete is defined as the replacement of cement by more than 50% of fly ash by total mass of binder. In this study, fibres of 0.5% and 1% of binder are added to conventional and high volume fly ash concrete. The mineral admixture silica fume was added up to 5% to 10% of binder. The replacement levels of cement with class F fly ash have varied by 0% and 60%. The glass fibres used in the concrete mix are 0.5% and 1% of binder. The water binder ratio adopted was 0.35. The present work has been carried out to study the mechanical properties such as compre ssive and split tensile strength of each high volume f ly ash concrete and controlled concrete with different percentages of fibres. The samples were casted and tested for finding the mechanical properties such as compressive and split tensile strengths at the age of 7 and 28 days of curing.

### 3.2 Mix Proportion

The mix proportion for the present st udy designrd as per 10262-2009 is 0.35:1:1.8:3.5.

**The Four Different types of Concrete Mixes are (Conventional Mix)**

**C1**: 100% OPC + Fine Aggregate + C oarse Aggregate + silica fume @ 5% by weight of binde r + Addition of Fibres @ 0.5% by weight of binder

**C2**: 100% OPC + Fine Aggregate + C oarse Aggregate + silica fume @ 5% by weight of binde r + Addition of Fibres @ 1% by weight of binder

**Mixes of Cement Replaced with Fly Ash:**

**M1**:40% OPC + 60% of Fly ash + F ine aggregate + Coarse aggregate + silica fume @ 10 % by weight of binder + Addition of Fibres @0.5% by weight of binder

**M2**: 40% OPC + 60% of Fly ash + Fine aggregate + Coarse aggregate + silica fume @ 10 % by weight of binder + Addition of Fibres @ 1% by w eight of binder

## 4. EXPERIMENTAL RESULTS

### 4.1 Workability of controlled concrete and high volume fly ash concrete using glass fi bres with addition of mineral admixtures (silica fume)

Slump test was carried out for each mix separately to know the workability of controlled co ncrete and high volume fly ash concrete. The water red ucing admixture added 1.7% of binder is constant for all mixes. The slump test results for all mixes were tab ulated below.

Table 3. Slump values of different mixes

| Mix | Slump Values(mm) |
|---|---|
| C1 | 75 |
| C2 | 73 |
| M1 | 74 |
| M2 | 70 |

From the above results we observe that there is a slight increase in the slump values when glass fibres are added in 0.5%, there is a slight decrease in the slump values when 1% of glass fibres are ad ded. Therefore, we observe that there is a decrease in sl ump value when percentage of fibres added is increased. Thus water reducing admixture i.e., super plasticizer is added to get required workability of concrete. Theref ore, we observe that there is a decrease in slump value when percentage of fibres added is increased. Thus, water reducing admixture i.e., super plasticizer is added to get required workability of concrete.

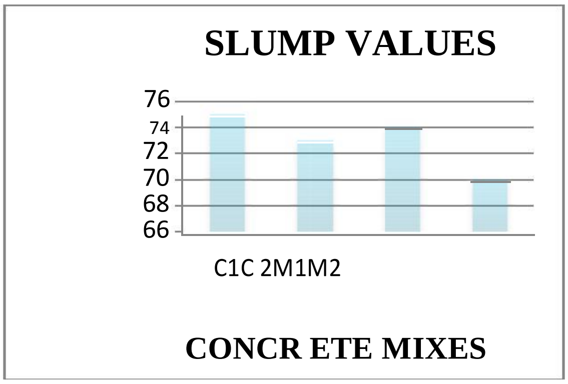


Figure 1. Slump V alues for all mixes

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

4.2.1Compressive Strength

The compressive strengt h values for all mixes are shown in the table (4). It is observed that the compressive strength of mix C2 is maximum @ 1% of glass fibres. The result obtained are represented graphically as shown in the figure 2,3.

Table 4: Compressive Strength

| Mix | Compressive strength N/mm² | |
|---|---|---|
| | 7da ys | 28days |
| C1 | 26.5 | 35 |
| C2 | 28 | 37 |
| M1 | 25 | 33 |
| M2 | 24 | 35.5 |

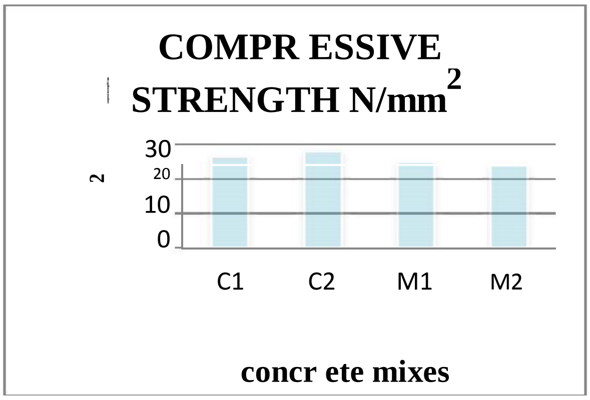


Figure 2. 7day Co mpressive strength

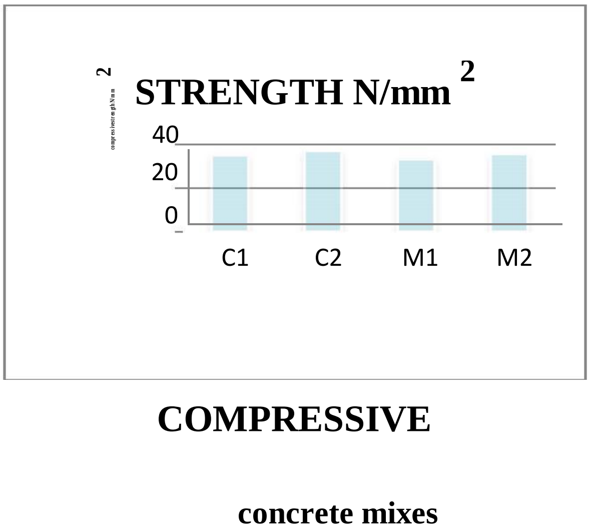


Figure 3. 28day Compressive strength

4.2.2 Split Tensile Strength

The split tensile strength values fo r all mixes are shown in the table (5). It is observed that the spilt tensile strength of mix C2 is maximum @ 1% of glass fibres. The results obtained are represe nted graphically as shown in figure 4,5.

Table 5. Split Tensile Strength

| Mix | Split Tensile strength N/mm$^2$ | |
|---|---|---|
| | 7Days | 28days |
| C1 | 2.6 | 3.5 |
| C2 | 3 | 3.8 |
| M1 | 2.3 | 3.2 |
| M2 | 2.7 | 3.7 |

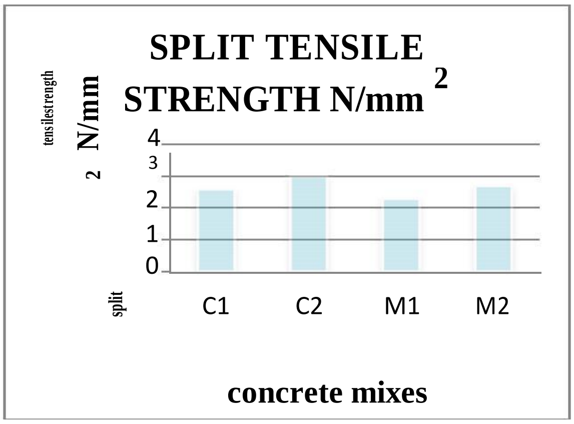


Figure 4. 7day Split Tensile Strength

## 5. CONCLUSIONS

Based on the study, the following conclu sions are made

- The workability of concrete is observed to be decreased with addition of mineral admixtures and further decreased by adding glass fibres. However, required workability can be achieved b y adding super plasticizer.
- The compressive strength of controlled concrete when 1% of fibres are used h as increased by 5.3% compared to 0.5% fibres for 7 days.

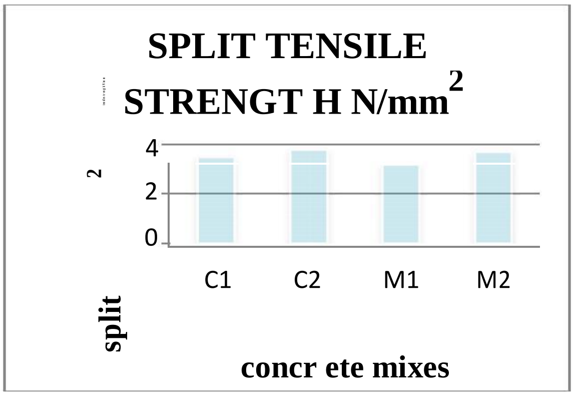


Figure 5. 28day Split Tensile Strength

- In case of high volume fly ash concrete, the compressive strength of concrete when 0.5% fibres are used has increased by 4.1% compared to 1% fibres for 7 days.
- The compressive strength of controlled concrete when 1% of fibres are used has increased by 5.4% compared to 0.5% fibr es for 28 days.
- In case of high volume fly ash concrete, the compressive strength of concrete when 0.5% fibres are used has decreased by 7% co mpared to 1% fibres for 28 days.
- The split tensile str ength of controlled concrete when 1% of fibres are used has increased by 13% compared to 0.5% fibres for 7 days.
- In case of high volume fly ash concrete, the split tensile strength of con crete when 0.5% fibres are used has increased by 14.8 1% compared to 1% fibres for 7 days.
- The split tensile str ength of controlled concrete when 1% of fibres are us ed has increased by 7.8% compared to 0.5% fibres for 28 days.
- In case of high volume fly ash concrete, the split tensile strength of con crete when 0.5% fibres are used has decreased by 13.5% compared to 1% fibres for 28 days.
- The presence of fib res in concrete acts as crack resistors.
- The failure of fibr e concrete is gradual and hence the ductility property has improved.
- The strength for the adopted percentage replacement of OPC are not appropriate. So the percentage of fly ash us ed is not significant in increasing compressive and split tensile strength.

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