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# Strength of Steel Fiber Concrete Using Coal Fly Ash and Silica Fume

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***Abstract*:-- In this growing world there has always been a strong competition in the market amongst industries in term of economy, profits, shares etc. one such industry is construction industry where concrete is the key building substance which is in limelight. Since past, we have seen much advancement in concrete because of the research which is in progress on concrete to come out with a product which should be economical and strong enough to resist all kind of loads. In this thesis, Coal fly ash and silica fume are used as a replacement for cement along with steel fibers by volume of concrete. Here, Coal fly ash is replaced by 0%, 10%, 20% and 30% with silica fume is replaced by 0%, 5%, 10% and 15% for cement. Initially, a set of concrete specimens were casted with 0%, 10%, 20% and 30 Coal fly ash and 0%, 5%, 10% and 15% silica fume with 0% addition of steel fibers and tested for compressive, flexural and split tensile strength. Secondly, another set of concrete specimens were casted with 0%, 10%, 20% and 30 Coal fly ash and 0%, 5%, 10% and 15% silica fume with 0.5% addition of steel fibers and tested for the same. Similarly, another set of samples were casted 0%, 10%, 20% and 30 Coal fly ash and 0%, 5%, 10% and 15% silica fume with 2% addition of steel fibers and tested to determine the mechanical properties of concrete. And it was observed that maximum compressive, flexural and split tensile strength was attained at 15% Coal fly ash and 20% silica fume with 2% steel fiber.**

***Keywords:*-- Recycled Coarse Aggregate; Steel Fibre; Silica Fume; Fly Ash, Compressive Strength, Flexural Strength Etc.**

## I. INTRODUCTION

The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete. Unfortunately, production of cement involves emission of large amounts of carbon dioxide gas into the atmosphere, a major contributor for green house effect, the global warming, and it is bit expansive hence it is inevitable either to search for another material or partially replace it by some other material. So as to protect environment and make our concrete more cost effective. 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 and lowest possible cost.

Use of more and more environment-friendly materials in any industry in general and construction industry in particular, is of paramount importance. Environment of this 'only living' planet is much polluted due to emissions of a host of green house gases from industrial processes. Present day construction industry consumes huge amount of concrete and cement, where cement is the binding material used for making concrete. During production of cement huge amount of energy is needed and about 8% of $CO_2$ is released to atmosphere during cement production. The striking feature of this form of concrete is that its important ingredient cement is partially replaced by, by-products of steel industries, yet having similar performance record as any other conventional concrete material. Aesthetically gives good pleasing view and performance wise it has an excellent resistance to wear and tear. It also utilizes the waste products of industries like blast furnace slag and steel slag which otherwise would pose problem for their safe disposal and sometimes degrades the environment.

## II. OBJECTIVE OF STUDY

As our work title suggests, the objective of our project is to find out the strength parameters, in specific, the compressive and flexural strengths of fibre reinforced triple blended high strength concrete and compare the same with that of ordinary concrete.

In turn, our work is aimed towards experimentally proving the advantages of fibre reinforced triple blended concrete over ordinary concrete and thus fostering its usage for not only greater strength and durability but also in view of the economic and environmental considerations previously mentioned. More specifically, the aim of this study is:

- To prepare the concrete cubes & beams using cement partly replaced by silica fume and fly ash .
- To determine compressive strength of hardened concrete at 7 and 28 days of curing & compare various mixes.
- To determine flexural strength at 7 and 28 days of curing & compare various mixes In the process of testing,

## III. Experimental Methodology

*3.1 Mix Design:*

Mix design is known as the selection of mix ingredients and their proportions required in concrete mix M30mix has been designed with and without steel fibers.

In the present study method for mix design is the Indian standard Method Coal fly ash is replaced by 0%, 10%, 20% and 30% with silica fume is replaced by 0%, 5%, 10% and 15% for cement. Initially, a set of concrete specimens were casted with 0%, 10%, 20% and 30 Coal fly ash and 0%, 5%, 10% and 15% silica fume with 0% addition of steel fibers and tested for compressive, flexural and split tensile strength. Secondly, another set of concrete specimens were casted with 0%, 10%, 20% and 30 Coal fly ash and 0%, 5%, 10% and 15% silica fume with 0.5% addition of steel fibers .

The mix design involves the calculation of the amount of cement, fine aggregate and coarse aggregate in addition to other related parameters dependent on the properties of constituent material.

*3.2 Indian Standard Recommended Method of Concrete Mix Design (IS 10262 – 2009)*

The Bureau of Indian Standards recommended a set of procedure for design of concrete mix mainly based on the work done in national laboratories. The mix design procedures are covered in IS 10262 - 2009. The methods given can be applied for both medium strength and high strength concrete.

Before we proceed, describing this method step by step. The following short comings in this method are pointed out. Some of them have arisen in view of the revision of IS 456-2000. The procedures of concrete mix design needs revision and at this point of time (2000AD) a committee has been formed to look into the matter of Mix Design.

Various steps used in design mix are given here:-

1. Stipulations for proportioning
2. Test data for materials
3. Target strength for mix proportioning
4. Selection of water cement ratio
5. Selection of water content
6. Calculation of cement content.
7. Proportion of volume of coarse aggregate and fine aggregate content.
8. Mix Calculations
9. Mix proportions for trial number 1.
10. The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trail, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.
11. Two more trials having variation of +- percent of water – cement ratio in 10. Shall be carried out and a graph between three water – cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials . However, durability requirement shall be met.

## IV. Experimental Programmes

*4.1 GENRAL*

Concrete for M30 grade were prepared as per I.S.-10262: 2009. Water cement ratio to get a characteristic strength of M30 was considered for this study. The exact quantity of materials for each mix was calculated.

In this experimental study Cement , sand, coarse aggregate, water, steel fibers silica fume and Coal fly ash were used

- *Cement* :- Ordinary Portland cement of 43 grade was used.
- *Sand* :- Locally available river sand used.
- *Water* :- Potable water was used for the experimentation
- *Steel Fibers:* - In this experimentation 0.5 mm thickness & 50mm length was used.
- *Coal fly ash:* - Coal fly ash is available in dry powder form and is procured from Sanjay Gandhi Thermal power plant Birsingpur pali M.P.
- *Silica fume* :- Silica fume is available from DCW engineering Jabalpur.

The use of Coal fly ash in concrete is abounded with data from mechanical and chemical strengths to assess the material parameters. Studies focusing on material properties with different replacement of cement with Coal fly ash and silica fume are presented and on structural component with use of multi blend concrete and fiber concrete composites. The tests results obtained from fiber reinforce concrete. But in this studies not focusing on application of this type of composites and hence there is a need to assess the structural properties of fiber reinforced concrete composites using different locally available natural and artificial fiber but this beyond the scope of this study. and Sofyanli, to improve the quality of recycled concrete.

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Portland cement has been replaced at 0%, 5% and 10% by SF. Specimens were produced by substituting natural aggregates for recycled aggregates. Four group of concrete mixtures and two size fractions (4/12 and 8/22 mm) were used. A consistent water / binder proportion of 0.50 has been used in all mixtures and concrete were prepared with a preliminary target slump of the class S4 (16 to 21 cm). The results showed that mechanical and physical characteristics of concrete were enhanced by 10% SF as cement replacement for RAC. The tensile strength increases in the NA concrete mix with and without SF was higher during all the test times than that of the RAC mixtures. The strength of the RAC incorporating SF was observed for continuous and significant improvement. Concrete with 10% SF and 4/12 mm fraction RA have shown improved performance between recycled compound concretes.

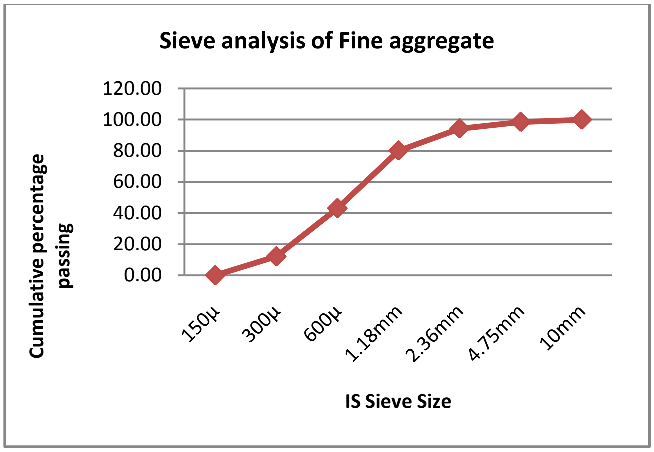
**Table No. 1**
**Various Combinations of Coal fly ash and Steel Fibers**

| Mix Code | Cement % | SF % | CFA % | FA % | CA % | Steel fiber % |
|---|---|---|---|---|---|---|
| M30 | 100 | 0 | 0 | 100 | 100 | 0 |
| M-1 | 85 | 5 | 10 | 100 | 98 | 2 |
| M-2 | 70 | 10 | 20 | 100 | 98 | 2 |
| M-3 | 55 | 15 | 30 | 100 | 98 | 2 |

*4.2 FINE AGGREGATE.*

**Table 2**
**Sieve analysis of fine aggregate**

| S. No. | IS Sieve Size | Weight retained (gm) | percentage weight retained | Cumulative percentage weight retained | Cumulative percentage passing | |
|---|---|---|---|---|---|---|
| | | | | | Fine aggregate | IS 383(1970)-zone II requirement |
| 1 | 10mm | 0 | 0.00 | 0.00 | 100.00 | 100% |
| 2 | 4.75mm | 30 | 1.50 | 1.50 | 98.50 | 90-100% |
| 3 | 2.36mm | 90 | 4.50 | 6.00 | 94.00 | 75-100% |
| 4 | 1.18mm | 340 | 17.00 | 23.00 | 77.00 | 55-90% |
| 5 | 600u | 660 | 33.00 | 56.00 | 44.00 | 35-59% |
| 6 | 300u | 638 | 31.90 | 87.90 | 12.10 | 8-30% |
| 7 | 150u | 242 | 12.10 | 100.00 | 0.00 | 0-10% |
| Total Weight retained | | 2000 | | 274.40 | | |




**Graph 1 Sieve analysis of fine aggregate**

**Table 3**
**Physical Properties of Fine Aggregate**

| S.No. | Characteristics | Result |
|---|---|---|
| 1 | Aggregate type | Natural |
| 2 | Specific gravity | 2.62 |
| 3 | Fineness modulus | 2.74 |

*4.3 COARSE AGGREGATES*

**Table 4**
**Sieve analysis of 40 mm coarse aggregate**

| S. No. | IS Sieve Size (mm) | Wt. retained (gm) | % weight retained | Cumulative percentage wt. retained | Cumulative percentage passing | |
|---|---|---|---|---|---|---|
| | | | | | Coarse aggregate | IS 383(1970)-zone II requirement |
| 1 | 40 | 0 | 0.00 | 0.00 | 100.00 | 100 |
| 2 | 20 | 146 | 7.30 | 7.30 | 92.70 | 95-100 |
| 3 | 10 | 1192 | 59.60 | 66.90 | 33.10 | 25-55 |
| 4 | 4.75 | 622 | 31.10 | 98.00 | 2.00 | 10.00 |
| 5 | 2.36 | 40 | 2.00 | 100.00 | 0.00 | 0.00 |
| Total Weight retained | | 2000 | | 272.20 | | |

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**Table 5**
**Physical properties of 40 mm coarse aggregate**

| S.No. | Characteristics | Result |
|---|---|---|
| 1 | Aggregate type | Crushed Stone |
| 2 | Maximum size of aggregate | 40 mm |
| 3 | Specific gravity | 2.67 |
| 4 | Fineness modulus | 2.72 |

**Table 6**
**Physical properties of 20 mm coarse aggregate**

| S.No. | Characteristics | Result |
|---|---|---|
| 1 | Aggregate type | Crushed stone |
| 2 | Maximum size of aggregate | 20 |
| 3 | Specific gravity | 2.71 |
| 4 | Fineness modulus | 2.94 |

*4.4 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. There are different types of cement, out of that I have used two types i.e,

**Table 8**
**Mix proportion by(Saturated surface dry) mass**

| Cement | Water | Fine aggregate | Coarse aggregate |
|---|---|---|---|
| 414 | 186 | 697.88 | 1128.06 |
| 1 | 0.45 | 1.68 | 2.72 |

**Table 9**
**The Final Trial Batches percentages of Silica Fume, Steel fiber and Coal fly ash Per of Concrete M30 are**

| Mix Code | SF % | CFA % | FA % | CA % | Steel fiber % | SF % | Water kg/m | W/C ratio |
|---|---|---|---|---|---|---|---|---|
| M-1 | 100 | 0 | 0 | 100 | 100 | 0 | 161 | 0.45 |
| M-2 | 85 | 5 | 10 | 100 | 98 | 2 | 161 | 0.45 |
| M-3 | 70 | 10 | 20 | 100 | 98 | 2 | 161 | 0.45 |
| M-4 | 55 | 15 | 30 | 100 | 98 | 2 | 161 | 0.45 |

**Table 10**
**The Final Trial Batches Quantities of Silica Fume, Steel fiber and Coal fly ash Per Cubic Meter of Concrete M30**

| Mix Code | SF % | CFA % | FA % | CA % | Steel fiber % | SF % | Water kg/m | W/C ratio |
|---|---|---|---|---|---|---|---|---|
| M-1 | 414 | 0 | 0 | 697.88 | 1128.06 | 0 | 161 | 0.45 |
| M-2 | 331.2 | 41.4 | 41.4 | 697.88 | 1105.5 | 22.56 | 161 | 0.45 |
| M-3 | 314.64 | 16.56 | 82.8 | 697.88 | 1105.5 | 22.56 | 161 | 0.45 |
| M-4 | 159.804 | 47.196 | 124.2 | 697.88 | 1105.5 | 22.56 | 161 | 0.45 |

## V. RESULT AND DISCUSSION

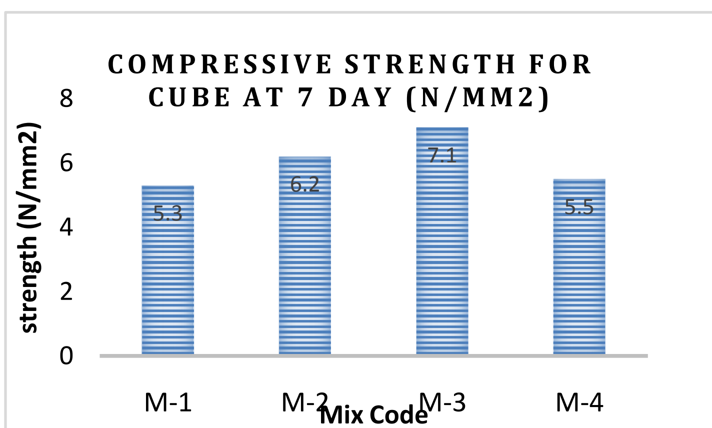
### *5.1 Experimental Results*

*1. Hardened Concrete Compressive Strength results*

Compressive Strength that results after 7, 28 days of curing are given in Table 11,12 and figure 2 and 3.

**Table No. 11**
**Compressive Strength for cube at 7 day (N/mm$^2$)**

| Mix Code | Cement % | silica fume% | Coal fly ash % | Steel fiber % | compressive strength for cube(N/mm2) |
|---|---|---|---|---|---|
| M-1 | 100 | 0 | 0 | 0 | 24.5 |
| M-2 | 85 | 5 | 10 | 2 | 24.3 |
| M-3 | 70 | 10 | 20 | 2 | 26.5 |
| M-4 | 55 | 15 | 30 | 2 | 22.6 |




**Graph No. 2 Compressive Strength for cube at 7 day (N/mm$^2$)**

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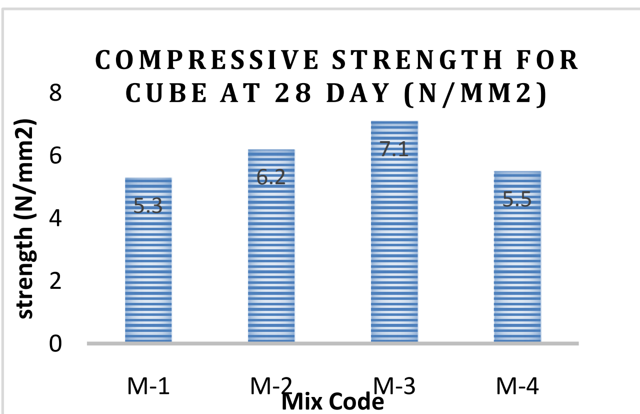
**Table 12**
**Compressive Strength for cube at 28 day (N/mm$^2$)**

| Mix Code | Cement % | silica fume% | Coal fly ash % | Steel fiber % | compressive strength for cube(N/mm2) |
|---|---|---|---|---|---|
| M-1 | 100 | 0 | 0 | 0 | 38.60 |
| M-2 | 85 | 5 | 10 | 2 | 37.80 |
| M-3 | 70 | 10 | 20 | 2 | 39.70 |
| M-4 | 55 | 15 | 30 | 2 | 34.45 |



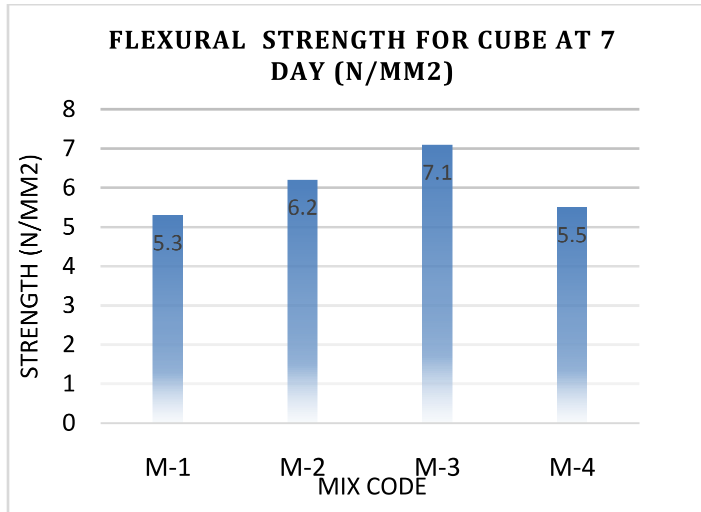

**Graph No.3 Compressive Strength for cube at 028day (N/mm$^2$)**

*Hardened Concrete Flexural Strength results*

Flexural Strength that results after 7, 28 days of curing are given in Table 13,14 and figure 4 and 5.

**Table No. 13**
**Flexural Strength for cube at 7 day (N/mm$^2$)**

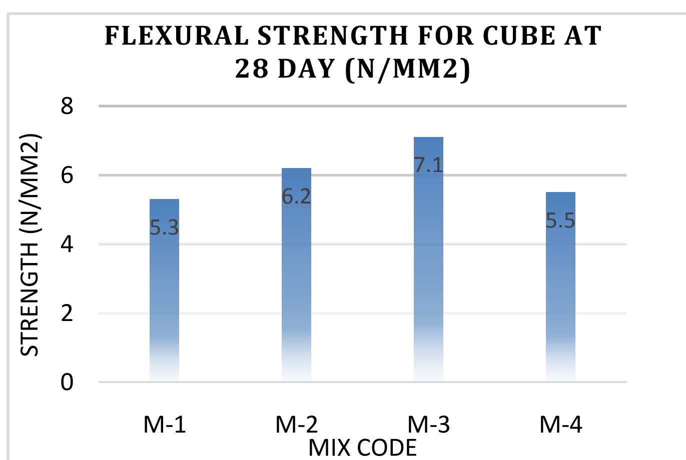
| Mix Code | Cement % | silica fume% | Coal fly ash % | Steel fiber % | Flexural strength for cube(N/mm$^2$) |
|---|---|---|---|---|---|
| M-1 | 100 | 0 | 0 | 0 | 3.8 |
| M-2 | 85 | 5 | 10 | 2 | 4.1 |
| M-3 | 70 | 10 | 20 | 2 | 5.3 |
| M-4 | 55 | 15 | 30 | 2 | 2.9 |




**Graph No. 4 Flexural Strength for cube at 7 day (N/mm$^2$)**

**Table No. 14**
**Flexural Strength for cube at 28 day (N/mm$^2$)**

| Mix Code | Cement % | silica fume% | Coal fly ash % | Steel fiber % | Flexural strength for cube(N/mm$^2$) |
|---|---|---|---|---|---|
| M-1 | 100 | 0 | 0 | 0 | 5.3 |
| M-2 | 85 | 5 | 10 | 2 | 6.2 |
| M-3 | 70 | 10 | 20 | 2 | 7.1 |
| M-4 | 55 | 15 | 30 | 2 | 5.5 |




**Graph No. 5 Flexural Strength for cube at 28 day (N/mm$^2$)**

## VI. CONCLUSIONS

The study on the effect of steel fibers with Coal fly ash and silica fume can still be a promising work as there is always a need to overcome the problem of brittleness of concrete and disposal of Coal fly ash produced from power plants. The following conclusions could be drawn from the present investigation.

1. Density of concrete is more as the percentage of steel Fiber increases with Coal fly ash 10% silica fume 20% .
2. Super plasticizer agent is required to produce workable mix.
3. For small quantity of Coal fly ash 10% silica fume 20% Compressive Strength is more for 2.0% Steel Fibers.

The study on the effect of steel fibers still is 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.

1. The maximum strength of specimen after 28$^{th}$ day is 39.70 MPa for 2% of fibers.
2. An increase of 15% in strength, if fibers added to mix by 2%. Is observed. There is an upward trend in strength up to 2 % of fibers but further increment of fibers causes the reduction in strength.

## VII. SCOPE IN FUTURE

By the use of SF and FA the better strength will be achieved which will result in less amount of cement is use and long time work on this can prove more than 50% of cement can be replaced by doing the certain change which show how to use waste of coal power plant waste in huge amount.

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