IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 11, November 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

# A Study on Strength Characteristics of Partial Replacement of Cement with Fly ash & Addition of Fibres

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***Abstract*:** Fly ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation reported in this paper is carried out to study the utilization of fly ash in cement concrete as a partial replacement of cement as well as an addition of steel fibres so as to provide an environmentally consistent way of its disposal and reuse. This paper deals with the strength properties of fly ash concrete, on the effect of different percentages partial replacement of cement by 0% fly ash with addition of steel fibres 0%, 1% &1.5%, 10% fly ash with addition of steel fibres 0%, 1% &1.5%, 20% fly ash with addition of steel fibres 0%, 1% &1.5% and 30% fly ash with addition of steel fibres 0%,1% &1.5%. Each series consists cubes and beams as per ISstandard. The tests are conducted to find out the compressive strength and flexural strength at the age of 7 days and 28 days.

***Key Words:*** Fibre concrete, compressive strength, flexural strength, fly-ash concrete, steel fibre.

## I. INTRODUCTION

Concrete is currently the most widely used construction material as it can be cast to any form and shape at site very easily. However, the relative low tensile strength to weight ratio and limited ductility of plain cement concrete poses major difficulty in its direct applications. To overcome these deficiencies, reinforcing of tensile zone with steel bars and pre-stressing of plain cement concrete has been invariably used. But all these measures do not improve all the strength aspects of concrete.Fly- ash is the fine powder produced as a product from the combustion of pulverized coal. The disposal of fly ash is one of the major issues as dumping of fly ash as a waste material may cause severe environmental problems. Therefore, the utilization of fly ash as an admixture in concrete instead of dumping it as a waste material can have great beneficial effects of lowering the water demand of concrete for similar workability, reduced bleeding and lowering evolution of heat. The use of fly ash in concrete is found to affect strength characteristics adversely. One of the ways to compensate for the early-age strength loss associated with the usage of fly ash is by incorporating fibres. In fibre reinforced concrete, short discontinuous fibres are added to plain and reinforced concrete to improve the post cracking behaviour and other strength aspects of the concrete. Plain, unreinforced concrete is a brittle material, with a

low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post-cracking "ductility". If the fibres are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage.Thus this project deals with the study of behaviour of concrete and its strength characteristics when cement is replaced with certain proportions of fly ash, when fibres are added to this fly ash replaced concrete.

## II. LITERATURE REVIEW

Ramadevi K, venkatesh babu D.L. Concluded the workability of hybrid fibre reinforced concrete mix was increased by addition of a super plasticizer. The test results of the research shows that use of hybrid fibre reinforced concrete improves flexural performance of the beams during loading.

Venkata Sairam Kumar have studied on Partial Replacement of fine aggregates with waste material (wooden powder, sugarcane residue).The waste material such as wooden powder, sugarcane residue , rubber tyres etc. emits the gases that pollutes the environment . The aim is to use of the waste material with the aggregates without further change in properties of concrete. The aim of the experiment was to find the maximum content of waste material (wooden powder, sugarcane) used as partial replacement of aggregates in concrete. The percentages of waste material (wooden powder, sugarcane residue) as partially replacement of aggregates in concrete were25% - 50%.From the experimental studied 25% of partial replacement of aggregates with waste material (wooden powder , sugarcane residue) improves hardened concrete properties. Siva kumar.A and Manu Santhanam. Studied on high strength concrete reinforced with hybrid fibres (combination of hooked steel and a non metallic fibre) up to a volume fraction of 0.5% and found the flexural toughness of steel polypropylene hybrid fibre concrete was better to steel fibre concrete.

A.V.S.Sai. Kumar and Krishna Rao[1] has studied on Strength of Concrete with Partial Replacement of Cement with Quarry Dust and Metakaolin Concrete a composite material made from cement, water, and fine aggregate and coarse aggregate. The present paper deals with partial replacement of cement with quarry dust and metakaolin which are having silica used as admixture for making concrete. They have stated that use of quarry dust as partial replacement of cement up to 25% of partial replacement is beneficial to concrete without loss of strength of cement. They have also done research on effect of quarry and metakaolin on concrete and they have made experiment on 25% quarry dust and 2.5%, 5.0%, 7.5%, 10.0%, 12.5% metakaolin as an partial replacement of cement. Results were found that quarry dust and metakaolin usage in partial replacement to cement can be made.

Tan Chien Yet, R.Hamid are research The addition of steel fibres into concrete mix can significantly improve the engineering properties of concrete. The mechanical behaviors of steel fibre reinforced high-performance concrete with fly ash (SFRHPFAC) are studied in this paper through both static compression test and dynamic impact test. Cylindrical and cube specimens with three volume fractions of end-hooked steel fibres with volume fraction of 0.5%, 1.0%, and 1.5% (39.25, 78.50, and 117.75 $kg/m^3$) and aspect ratio of 64 are used. These specimens are then tested for static compression and for dynamic impact by split Hopkinson pressure bar (SHPB) at strain rate of 30–60 $s^{-1}$. The results reveal that the failure mode of concrete considerably changes from brittle to ductile with the addition of steel fibres. The plain concrete may fail under low-strain-rate single impact whereas the fibrous concrete can resist impact at high strain rate loading. It is shown that strain rate has great influence on concrete strength. Besides, toughness energy is proportional to the fibre content in both static and dynamic compressions.

Jashandeep singh, Er. R S Bansal: The study the behaviour of concrete, having partial replacement of cement with waste marble powder M25 grade for which the marble powder is replaced by an experimental study was carried out and the effect on compressive strength and split tensile strength characteristics (0%, 4%, 8%, 12%, 16%, 20%) was studied. The result of this present investigation indicates that the replacement of 12% of cement with waste marble powder attains maximum compressive and tensile strength. The optimum

percentage for replacement of marble powder with cement and it is almost 12%cement for both cubes and cylinders and it also minimize the costs for construction with usage of marble powder which is freely or cheaply available more importantly.

## II. MATERIALS & METHODOLOGY

***A. Cement*:** Portland pozzolana cement conforming to IS: 269-1976 and IS: 7031-1968 was used in this study. The cement is of 53grade and the tests conducted on cement are tabulated in Table No.1

Table No: 1 Properties of cement

| S. No | Property | Test results |
|---|---|---|
| 1 | Normal consistency | 29% |
| 2 | Specific gravity | 3.13 |
| 3 | Initial setting time | 92 minutes |
| 4 | Final setting time | 195 minutes |
| 5 | Compressive strength at<br>3days<br>7days<br>28days | <br>27.40 N/mm$^2$<br>29.23 N/mm$^2$<br>41.62 N/mm$^2$ |

***B. Coarse Aggregate:*** Coarse aggregate obtained from local quarry processing units has been used for this study.

Table No: 2 Physical properties of coarse aggregate

| S. No | Property | Value |
|---|---|---|
| 1 | Specific gravity | 2.72 |
| 2 | Fineness modulus | 8.50 |
| 3 | Bulk density<br>Loose<br>Compacted | <br>15 kN/m$^3$<br>16 kN/m$^3$ |
| 4 | Nominal maximum size | 20 mm |

***C. Fine Aggregate:*** The sand which was locally available and passing through 4.75mm IS sieve is used.

Table No: 3 Properties of fine aggregate

| S. No | Property | Value |
|---|---|---|
| 1 | Specific gravity | 2.60 |
| 2 | Fineness modulus | 2.51 |
| 3 | Bulk density:<br>Loose<br>Compacted | <br>14kN/m$^3$<br>15kN/m$^3$ |
| 4 | Grading | Zone-II |

***D. Water:*** The water used for experiments was potable water.

Table No: 4 Physical properties of water

| S. No | Property | Value |
|---|---|---|
| 1 | $_p$H | 7.1 |
| 2 | Taste | Agreeable |
| 3 | Appearance | Clear |
| 4 | Turbidity(NT units) | 1.75 |

***E. Fly Ash:*** Fly ash is a finely divided residue that results from the combustion of ground (or) pulverized coal and is transported from boilers by flue gases are known as “fly ash”. It is an industrial waste from thermal power stations on very scale.

Table No: 5 Physical Properties of Fly ash

| S. No | Properties | Range |
|---|---|---|
| 1 | Percentage passing 75 micron I.S sieve | 71.4 to 95.90 |
| 2 | Percentage passing 45 micron I.S sieve | 45.0 to 88.80 |
| 3 | Fineness(Blain’s air method) (cm$^2$/gm) | 3300 to 6250 |
| 4 | Lime reactivity (kg/cm$^2$) | 50 to 62.40 |

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Table No: 6 Chemical composition of fly ash

| Constituents | Values (% by weight) |
|---|---|
| Loss on Ignition | 0.87 |
| Silica as $Sio_2$ | 62.93 |
| Iron Oxide as $Fe_2O_3$ | 3.56 |
| Alumina as $Al_2O_3$ | 22.61 |
| Manganese as Mn | 0.14 |
| Titanium Oxide as $TiO_2$ | 0.53 |
| Calcium Oxide as CaO | 4.58 |
| Magnesium Oxide as MgO | 0.60 |
| Sodium Oxide as $Na_2O$ | 0.89 |
| Potassium Oxide as $K_2O$ | 1.74 |
| Phosphorus as P | 0.32 |
| Sulphate as $SO_3$ | 1.23 |

***G. Mix design procedure:*** In present study M15 grade concrete was designed as per IS: 10262-2009. The weight ratio of mix proportion is 1:2:4. It was proposed to investigate the properties of concrete, cast with partial replacement of cement with 0%, 10%, 20% & 30% of fly-ash and addition of steel fibres 0%, 1% & 1.5% proportions and cured in water.

## III. CASTING&TESTINGDETAILS

6 cubes and 6 beams conforming to IS: 516-1964 are casted After 24 hours the moulds were de-moulded and subjected to water curing. Before testing the cubes were air dried for 2 hours. Size of cubes 150*150*150mm and size of beams 150*150*700mm. Crushing loads and flexural strength were noted and average of 3 specimens was determined at 7days and 28days. The results are tabulated below.

Table No: 7 Compressive strength results

| S.No | Mix no | Compressive strength ($N/mm^2$) | |
|---|---|---|---|
| | | 7 Days | 28 Days |
| 1 | Mix 1 | 20.62 | 30.86 |
| 2 | Mix 2 | 21.05 | 32.07 |
| 3 | Mix 3 | 23.06 | 37.62 |
| 4 | Mix 4 | 19.95 | 29.95 |
| 5 | Mix 5 | 20.40 | 31.62 |
| 6 | Mix 6 | 20.61 | 31.85 |
| 7 | Mix 7 | 18.86 | 27.66 |
| 8 | Mix 8 | 18.95 | 31.20 |
| 9 | Mix 9 | 19.85 | 31.78 |
| 10 | Mix 10 | 16.50 | 24.51 |
| 11 | Mix 11 | 17.66 | 29.09 |
| 12 | Mix 12 | 17.89 | 30.50 |

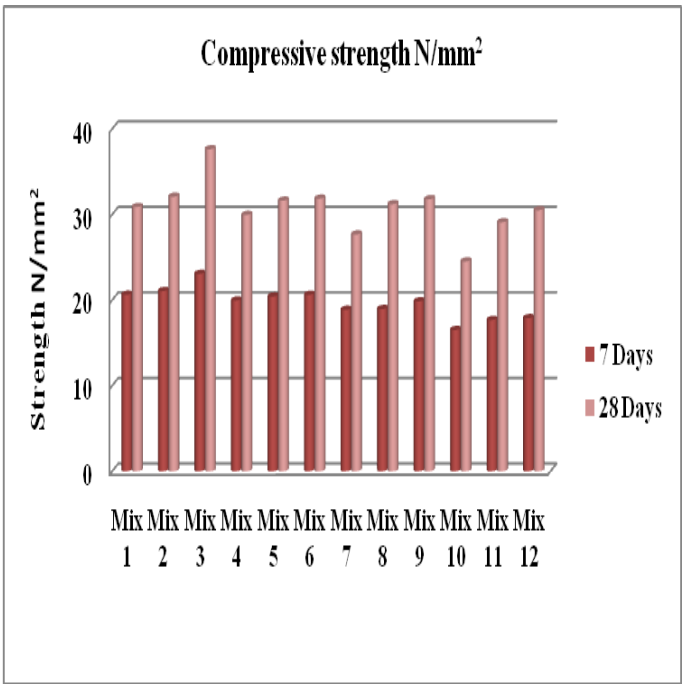
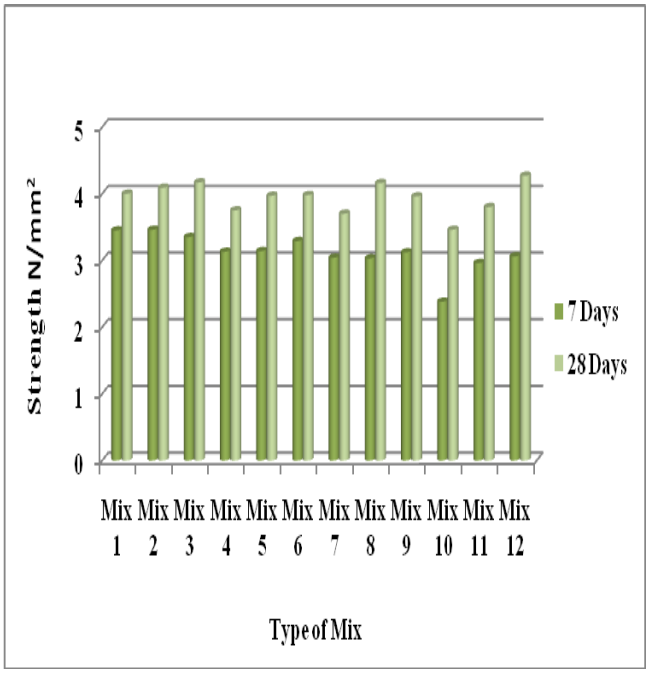


Table No: 8 Flexural strength results

| S.No | Mix no | Flexural strength (N/mm$^2$) | |
|---|---|---|---|
| | | 7 Days | 28 Days |
| 1 | Mix 1 | 3.45 | 4.00 |
| 2 | Mix 2 | 3.46 | 4.09 |
| 3 | Mix 3 | 3.35 | 4.17 |
| 4 | Mix 4 | 3.13 | 3.75 |
| 5 | Mix 5 | 3.14 | 3.97 |
| 6 | Mix 6 | 3.29 | 3.98 |
| 7 | Mix 7 | 3.04 | 3.70 |
| 8 | Mix 8 | 3.03 | 4.16 |
| 9 | Mix 9 | 3.12 | 3.96 |
| 10 | Mix 10 | 2.38 | 3.46 |
| 11 | Mix 11 | 2.96 | 3.80 |
| 12 | Mix 12 | 3.06 | 4.27 |




Mix 1: Plain concrete with 0% fly ash

Mix 2: Plain concrete with 0% fly ash 1% steel fibres
Mix 3: Plain concrete with 0% fly ash 1.5% steel fibres

Mix 4: Concrete with 10% fly ash
Mix 5: Concrete with 10% fly ash and 1% steel fibres
Mix 6: Concrete with 10% fly ash and 1.5% steel fibres

Mix 7: Concrete with 20% fly ash
Mix 8: Concrete with 20% fly ash and 1% steel fibres
Mix 9: Concrete with 20% fly ash and 1.5% steel fibres

Mix 10: Concrete with 30% fly ash
Mix 11: Concrete with 30% fly ash and 1% steel fibres
Mix 12: Concrete with 30% fly ash and 1.5% steel fibres

## IV. CONCLUSIONS

This study investigated steel fibre influence on the compressive and flexural strengths of 10 different mixes with varying proportions of cement, fly ash and steel fibres. Concrete mixes containing 10, 20 and 30% of fly ash along with the steel fibres contents investigated were 1 and 1.5% by volume. A number of conclusions can be drawn from this study. The compressive strength of the concrete mixes measured at 7 and 28 days curing are presented in Table No.24 and the results of flexural strength test are presented in Table No.37 from those results we can say that First, the most noticeable variables effecting compressive strength were time, fly ash percentage and steel fibre percentage. Second, the optimum parameters for compressive strength can be obtained with increase in age of the concrete. Third, the addition of steel fibres into the concrete mixes was very effective in resisting flexural tensile stresses. Thus From the results of compressive strength and flexural strength we notice that strength of concrete specimens decrease with increase in replacement of fly ash content and also the strength increases when percentage of steel fibres added increases. Hence we can say that addition of fly ash alone cannot increase the strength and also the observations says that in fly ash based fibre reinforced concrete the strength increases with age i.e., the initial strength may be low when compared to the conventional concrete but it increases with age . Finally, compressive

and flexural strength ratios can enhance a lower steel fibre content coupled with the addition of more fly ash.

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