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# Experimental Investigation on High Volume Fly Ash Concrete using Manufactured Sand

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***Abstract* - Fly ash is one of the residues generated from thermal power plants. Fly Ash can be used as a low cost mineral admixture in concrete. Usage of High Volume Fly Ash (HVFA) in concrete has gained importance as it is one of the durable options and it provides resistance to all forms of deterioration. The addition of fly ash in cement resulted in great benefits such as reduction in heat of hydration, resistance to corrosion, sulphate attack, alkali-silica reaction, acid attack, reduction of cement consumption and decreased permeability. Due to the demand and scarcity of river sand, an alternative material such as Manufactured sand (M Sand) is used in concrete as fine aggregate. In this paper, M 40 grade is prepared with high volume fly ash in concrete with various proportions as a partial replacement of cement and M Sand is used 100% replacement as fine aggregates. In this paper, mechanical and durability properties of HVFAC are studied.**

***Keywords: High Volume Fly Ash Concrete, Fly Ash, M Sand, Mechanical and Durability Properties.***

## I. INTRODUCTION

The most suitable and widely used construction material is concrete and is composed of Portland cement, Aggregates and Water. The production of cement results in emission of carbon dioxide and at the same time the cost of production of cement is also increasing. The usage of waste materials or by product from the manufacturing industries can be used as a partial replacement of cement in concrete without any reduction on its desired strength. Fly Ash is one of the pozzolanic materials produced by burning coal in thermal power plants. It is also known as pulverised fuel ash, hopper ash; chimney ash constitutes about 80% of total ash generated in power plants. Instead of disposing this huge amount of fly ash in land, it can be effectively used as replacement in concrete. Cement, the second most important material in construction field had became a major contributor for the emission of greenhouse gases and thereby depleting the environmental factors. Many research and studies shows that in concrete fly ash can be replaced about 50-60% of cement. This type of concrete is known as High Volume Fly Ash Concrete and this concrete produces mixtures that show high workability, high ultimate strength, and high durability. Utilization of fly ash in concrete minimises the carbon dioxide emission problems to certain extent and also fly ash is less expensive compared to Portland cement. Now-a-days good sand is not readily available and these resources are also exhausting very rapidly. So it is a necessary to find some substitute to natural river sand. The
artificial sand produced by proper machines can be a better substitute to river sand. The sand must be of proper gradation and such sand will have few voids and will be more economical. Demand for manufactured fine aggregates for making concrete is increasing day by day as river sand cannot meet the demands in construction. River sand is not graded properly and has excessive silt and organic impurities and these can affect the durability in concrete whereas manufactured sand has no silt or organic impurities.

In this paper, an attempt has been made to use high volume fly ash and M Sand as fine aggregate in concrete. Various mechanical and durability properties of HVFA concrete have been studied for various percentages of fly ash in cement.

Objectives of the project: The primary objective of this experimental work is to evaluate effective use of fly ash for achieving the desired needs,

- To study the physical properties of materials used.
- To prepare the design mix for M40 grade of concrete
- To cast the concrete specimens of cubes, cylinders and beams with various percentages of fly ash in cement and 100% of M Sand as fine aggregates.
- To study about the mechanical and durability properties of concrete.

## II. MATERIALS USED

### A. *Cement*

Ordinary Portland Cement – 53 grade was used in this investigation. As per IS 4031:1988 the cement was tested and its properties are given in Table I.

TABLE I
PHYSICAL PROPERTIES OF CEMENT

| S.No | Properties | Values |
|---|---|---|
| 1 | Specific Gravity | 3.15 |
| 2 | Normal Consistency | 30% |
| 3 | Initial Setting Time | 30 min |
| 4 | Final Setting Time | 600 min |

### B. *Fine aggregate*

Manufactured Sand is used as fine aggregate for making the concrete specimens. Sand is tested as per IS 2386-1963 and it is confirmed as per IS 383-1970.Its properties are given in Table II.

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TABLE II
PROPERTIES OF FINE AGGREGATE

| S.No | Properties | Values |
|---|---|---|
| 1 | Specific Gravity | 2.55 |
| 2 | Water Absorption | 2.67% |
| 3 | Bulk Density | 1903.33 kg/m$^3$ |
| 4 | Fineness Modulus | 3.52 |
| 5 | Grading Zone | II |

### C. *Coarse aggregate*

The material retained on the test sieve 4.75 mm was termed as coarse aggregate. Locally available coarse aggregates of 12 mm and 20 mm are used for making concrete specimens. Aggregates are tested as per IS 2386-1963 and it is confirmed as per IS 383-1970.Its properties are given in Table III.

TABLE III
PROPERTIES OF COARSE AGGREGATES

| S.No | Properties | Values | |
|---|---|---|---|
| | | 12 mm | 20 mm |
| 1 | Specific Gravity | 2.73 | 2.76 |
| 2 | Water Absorption | 0.50 % | 0.33 % |
| 3 | Bulk Density | 1556.67 kg/m$^3$ | 1612 kg/m$^3$ |
| 4 | Fineness Modulus | 2.42 | 3.08 |
| 5 | Grading Zone | Graded | Single sized |

### D. *Fly Ash*

Fly ash is one of the commonly known pozzolanic materials and it primarily comes from coal-fired electricity generating power plants. Two types of fly ash are Class C and Class F. In this study, Class F Fly Ash is used as a replacement material in cement. Specific gravity of fly ash is 2.14

### E. *Water*

Water is an important constituent of concrete as it is necessary for the chemical reaction with cement. The water is required for preparation of mortar, mixing of cement concrete and also for curing the specimens. Locally available potable tap water is used in this investigation.

### F. *Chemical admixture*

In this project, Master Rheobuild 1125- High range, retarding superplasticiser is used which complies with IS 9103-1999. The relative density of admixture is 1.22. This superplasticiser is composed of synthetic polymers specially designed to allow considerable reduction of mixing water. It is chloride free and it gives longer workability retention mainly for ready mix concrete.

## III. MIX DESIGN

In this investigation, the mix proportions are designed as per IS 10262-1982 and IS 456-2000.The concrete mix of M40 grade is designed and the specimens are casted. The Ordinary Portland Cement (OPC) was partially replaced with high volume fly ash in various proportions (i.e.) 0%, 30%, 40% and 50%.The stipulations for proportioning are given in Table IV and the mix variations are tabulated in Table V.

TABLE IV
STIPULATIONS FOR PROPORTIONING

| Stipulations | |
|---|---|
| Grade of cement | M40 |
| Type of cement | OPC |
| Type of mineral admixture | Fly Ash |
| Nominal size of aggregates | 12 mm,20 mm |
| Minimum cement content | 360 kg/m$^3$ |
| Workability | 100 mm(slump) |
| Exposure condition | Very severe |
| Method of concrete placing | Hand |
| Degree of supervision | Good |

TABLE V
MIX VARIATIONS (For 1 m$^3$)

| Grade | M40 Grade | | | |
|---|---|---|---|---|
| Mix No | Mix 1 (0 %) | Mix 2 (30%) | Mix 3 (40%) | Mix 4 (50%) |
| OPC | 475 | 335 | 285 | 240 |
| Fly Ash | - | 140 | 190 | 235 |
| Coarse aggregate-20 mm | 673 | 653 | 646 | 638 |
| Coarse aggregate-12 mm | 443 | 430 | 425 | 420 |
| Manufactured sand | 675 | 654 | 647 | 636 |
| Total Water | 193 | 193 | 193 | 193 |
| W/C ratio | 0.36 | 0.36 | 0.36 | 0.36 |

## IV. PREPARATION AND DETAILS OF SPECIMENS

In this investigation, the physical properties of the materials are tested as per Indian Standards. The specimens are prepared and casted in the laboratory under controlled supervision. The specimens of cubes, cylinders and prisms/beams are casted for determining the mechanical and durability properties of concrete. The fresh concrete was tested for slump value and further the specimens are casted for other studies.12 cubes of 150 x 150 x 150 mm, 3 cylinders of 70 x 150 mm, 3 cylinders of 150 x 300 mm, 2 cylinders of 100 x 200 mm and 3 beams of 100 x 100 x 500 mm were casted for each mix. After 24 hours of casting, the specimens were demoulded and it was placed in water curing until the period of test. The specimens are tested at 14, 28 and 56 days.

## V. RESULTS

### A. *Compressive strength*

Compressive strength of concrete cubes are tested at 14, 28 and 56 days. The size of the specimens is 150 x 150 x 150 mm and three samples were tested for each mix at the age of testing. The compressive strength at 14 days are tabulated in Table VI and a graph is plotted as shown in Fig. 1.

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TABLE VI
COMPRESSIVE STRENGTH AT 14 DAYS

| S.No | Specimens | Compressive strength(N/mm$^2$) |
|---|---|---|
| 1 | Control mix | 40.10 |
| 2 | 30 % | 37.83 |
| 3 | 40 % | 33.16 |
| 4 | 50 % | 24.06 |

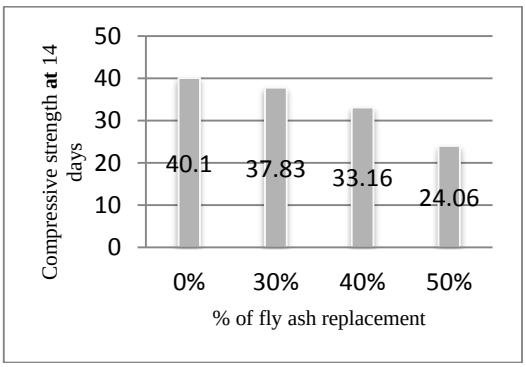


Fig.1 Compressive strength at 14 days (N/mm$^2$)

## VI. FURTHER SCOPE OD STUDY

The specimens will be tested for the various proportions of mix at 28 and 56 days. Mechanical characteristics such as compressive strength test at 28 and 56 days, split tensile test, flexural strength test and stress-strain behaviour will be tested at 56 days on the concrete specimens. Durability characteristics like water permeability test (WPT), rapid chloride penetration test (RCPT) and sorptivity test will be tested on the specimens at 56 days. These can be considered as the scope of further studies.

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