

# Experimental Study on High Volume Fly Ash Concrete (HVFAC)

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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 become 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 flyash 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.

### 1.1 Definition of Fly Ash

Fly ash is a siliceous material that has the capacity to create cementitious compounds when combined with water. However, due to differences in coals from different sources and designs of coal-fired boilers, not all fly ash produced is similar in composition. The chemical composition of fly ash could differ depending on where it was produced and by which company. Due to this variation in composition, standards were created to regulate the composition of fly ash used for specific purposes. For example, fly ash meant to be used as a replacement of portland cement in concrete must meet requirements set in ASTM C618-12, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete." ASMT C618-12 defines two classes of fly ash, Class F and Class C, which are acceptable for use in concrete.

Class F Fly ash: Fly ash normally produced from burning anthracite or bituminous coal falls in this category. This class

of fly ash exhibits pozzolanic property but rarely if any, self-hardening property.

Class C Fly ash: Fly ash normally produced from lignite or sub-bituminous coal is the only material included in this category. This class of fly ash has both pozzolanic and varying degree of self-cementitious properties. (Most class C fly ashes contain more than 15 % CaO. But some class C fly ashes may contain as little as 10 % CaO.

### 1.2 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

Construction materials are the fundamental substances used in the building and infrastructure development process. They play a crucial role in determining the strength, durability, safety, and overall performance of a structure. The selection of appropriate construction materials depends on factors such as availability, cost, environmental conditions, and the intended use of the structure.

### 2.1 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 1: Physical Properties of Cement

Sr. no	Properties	Values
1	Specific gravity	3.15
2	Normal consistency	30%
3	Initial setting time	30 min
4	Final setting time	600 mm

### 2.2 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 2.

Table 2: Physical Properties of Fine Aggregate

Sr. no	Properties	Values
1	Specific gravity	2.55
2	Water absorption	2.67%
3	Bulk density	1903 kg/m <sup>3</sup>
4	Fineness modulus	3.52
5	Grading zone	II

### 2.3 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 3.

Table 3: Physical Properties of Coarse Aggregate

Sr. 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 kg/m <sup>3</sup>	1612 kg/m <sup>3</sup>
4	Fineness modulus	2.42	3.08
5	Grading zone	Graded	Single sized

### 2.4 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

### 2.5 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.

## 2.6 Chemical admixture

In this project, Fosroc Auramix series- High range, retarding superplasticizer is used which complies with IS 9103-1999. The relative density of admixture is 1.09. Auramix 200 is a high-performance superplasticizer based on polycarboxylic ether (PCE) polymers, designed for producing high-quality concrete with enhanced workability and strength. It is a ready-to-use liquid admixture used in both low and high-grade concrete applications.

## 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 4: 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 <sup>3</sup>
Workability	100 mm (slump)
Exposure condition	Very severe
Method of concrete placing	Hand
Degree of supervision	Good

Table 5: Mix Variations (For 1 M<sup>3</sup>)

Grade	M40 Grade				
	Mix no. (%)	1 (0%)	2 (30%)	3 (40%)	4 (50%)
OPC		475	337	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 demolded and it was placed in water curing until the period of test. The specimens are tested at 7, 14, and 28 days.

## V. RESULTS

### 5.1 Compressive strength

Compressive strength of concrete cubes are tested at 7, 14, and 28 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.

Table 6: Compressive Strength at 14 Days

S. No	Specimens (%)	Compressive strength (N/mm <sup>2</sup> )
1	0	40.05
2	30	37.50
3	40	32.00
4	50	24.10

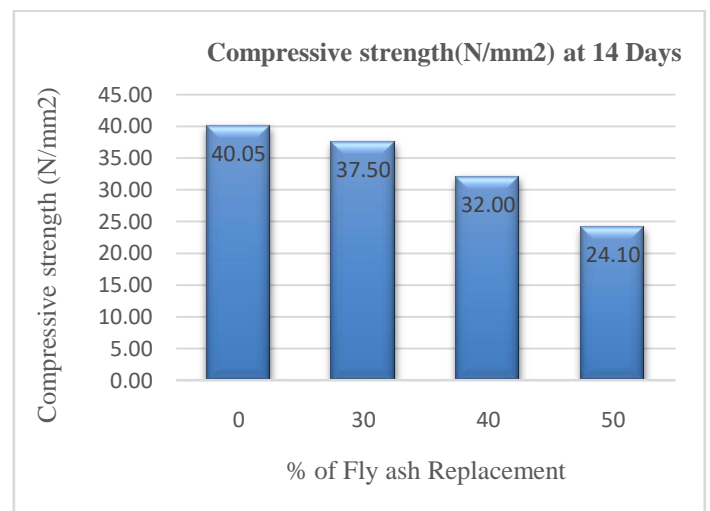


Figure 1: Compressive strength at 14 days (N/mm<sup>2</sup>)

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### Citation of this Article:

Shilpa S. Nandane, & Amar B. Dehane. (2026). Experimental Study on High Volume Fly Ash Concrete (HVFAC). *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 10(4), 149-152. Article DOI <https://doi.org/10.47001/IRJIET/2026.104021>

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