

Experimental Study on Effect of High-Volume Fly Ash as Partial Replacement of Cement on Properties of Concrete

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Abstract -The waste product of power stations that burn coal in their pulverized form is known as flyash(FA).The carbon and volatile substances are burnt off when the powdered coal is ignited in the combustion chamber. Because of this, cement production must be decreased. Finding alternative building materials that can significantly reduce construction costs has been the subject of a large body of research. Partially replacing cement with fly ash in varying ratios is the goal of this project. Now we may talk about alternatives to cement, such as using agricultural or industrial waste, which has properties that make concrete stronger. Fly ash is one of the most pervasive types of garbage on a global scale. As a result of its high silica content, fly ash makes an excellent pozzolanic material when burned. Therefore, it might be a viable alternative to cement in concrete production, lowering cement production and easing disposal issues with fly ash. Fly ash concrete was the subject of an experimental examination that examined its residual strength, ductility, rotation capacity, compressive strength, split tensile strength, and flexural strength. To make high volume fly ash concrete, we mixed it with cement at different percentages (50 and 60 percent, for example), and we also made control concrete to see how it turned out. In order to determine the ductility, stiffness, and residual strength, we used the maximum compressive strength of a concrete cube test beam that was 1200 mm in length, 200 mm in depth, and 150 mm in breadth. We then performed basic tests on the concrete and mortar, and we acquired the results for different proportions.

Keywords: Fly ash, Concrete, Cement

burnt and the carbon and volatile chemicals are burnt off [1-3]. The combustion chamber releases fumes that contain some of the impurities, such as clay, shale, feldspar, and others, which are combined in suspension. The molten materials solidify into round, glassy specks called fly ash when the exhaust fumes cool.

There are usually two main categories for fly ashes based on their origin, chemical composition, and mineralogical composition. Burning lignite or sub-bituminous coal typically results in fly ash with a high calcium level, while burning anthracite or bituminous coal typically results in fly ash with a low calcium content.

The two types of glass are primarily composed of amorphous glass.

Moreover, hematite, magnetite, and quartz are common components of fly ash with low calcium level, whereas gehlenite, anhydrite, mullite, lime, and cement minerals such as C3A and C2S are common components of fly ash with high calcium content. Both types of fly ash are pozzolanic, although the high-calcium version has more noticeable cementitious properties[4-5].

Fly ash particles typically take on the shape of small solid spheres or hollow cenospheres as a result of the fusion-in-suspension process. A small percentage of particles can even be pleospheres, which are larger spheres that contain even smaller ones. Particles of fly ash can be as little as a hair to as massive as type I Portland cement, with the latter being the more common. Bag filters or electrostatic precipitators for exhaust gases collect the fly ash [6-7]. The primary chemical elements of fly ash, a type of silicate glass, are silica and alumina

I. INTRODUCTION

Power stations that use pulverized coal as a fuel source produce fly ash (FA) as a byproduct. In the combustion chamber, the powdered coal is

II. OBJECTIVES

The purpose of this research is to find a viable substitute for cement using a substance like fly ash. Find out how compression, tension, and flexural

strength are affected when fly ash class(F) is used in place of cement. Both regular concrete and concrete with a superplasticizer

- i) Cement concrete was utilized in mortar and concrete stages at 300, 350, and 400 kg/m³ ratios, respectively.
- ii) The characteristics of cement and concrete were tested after 7 and 28 days.
- (iii) So that the mechanical qualities can be assessed. The strengths of compression, splitting tensile, and flexure.
- iv) Low-volume fly ash concrete vs. high-volume conventional concrete cost comparison.

III METHODOLOGY

EXPERIMENTAL PROCEDURE HARDENED TEST

General

Once concrete has set, it can be tested in a variety of ways to see if it works as expected or to find out what it is like if its background is unknown. Compression strength, split tensile strength, and flexural strength are some of the short-term characteristics that describe the behavior of hardened concrete.

Compression Strength

Since the majority of concrete's defining qualities are qualitatively tied to its compression test, this is by far the most popular way to evaluate hardened concrete. After 7 and 28 days of curing, specimens measuring 150 mm X 150 mm X 150 mm are evaluated [8]. A Compression Testing Machine was used to examine all specimens in a surface-dry condition in accordance with IS: 516 (1959). Both the compression testing equipment (Figure) and the cube testing (Figure) are illustrated.



Fig.1 Compression Testing Machine

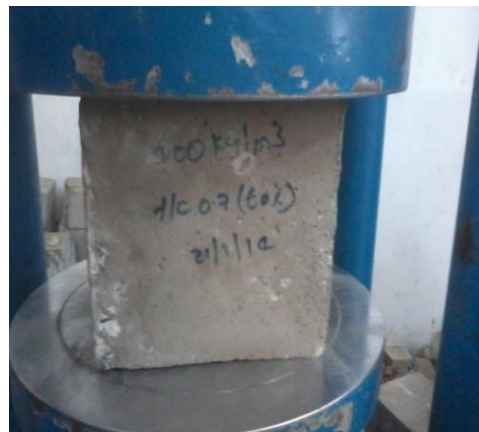


Fig.2 Testing of Cube

Split Tensile Strength

Undoubtedly, the tensile strength is a fundamental and crucial attribute of concrete. Due to its brittleness and poor tensile strength, concrete is typically not anticipated to withstand direct tension. But to find out how much weight the concrete components might break under, we need to know the concrete's tensile strength. We use specimens that are 100 mm in diameter and 200 mm in height. A cylinder specimen is placed horizontally between the loading surfaces of the compression testing equipment to conduct the test. The test is done according to IS 5816-1999 [9-10]. Figure 3.4 shows testing of cylinder in compression testing machine,

Figure 3 shows failure of cylinder. Equation shows calculation of split tensile strength.

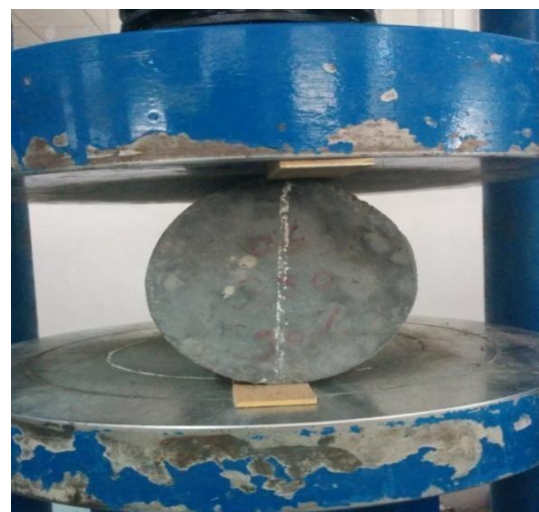


Fig.3 Testing of Cylinder



Fig.4 Failure of Cylinder

Flexural Strength

One way to evaluate concrete's tensile strength is by looking at its flexural strength. This is the bending strength of an unreinforced concrete beam. A total of thirty-six beam specimens, each measuring 1000 mm in length and 100 mm by 100 mm in cross-section. The specimen is positioned in the machine with two lines 14 cm apart, so that the load is applied along the uppermost surface as it was cast in the mould. The specimen's axis aligns precisely with the loading device's axis. In accordance with IS: 516 (1959), the test is conducted. Figures show the testing of beams and failure of beams respectively.



Fig.5 Testing of Beam



Fig.6 Failure of Beam

IV. RESULTS & DISCUSSION

COMPRESSIVE STRENGTH OF MORTAR CUBE

The cement with a high compressive strength of 35 N/mm² after 7 days is replaced in half. As can be seen from Table 4.1, the compressive strength at 7 days was 28 N/mm², which is much lower than what would be expected with 70% fly ash replacement. Compressive strength vs. fly ash replacement percentage is illustrated in Figure

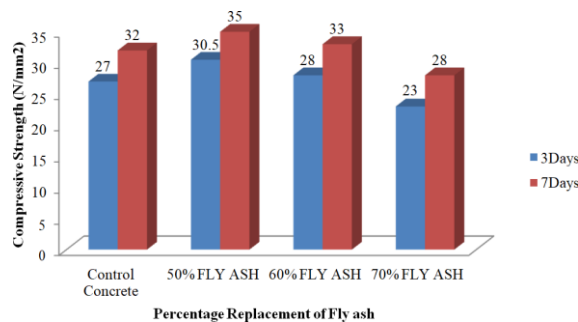


Fig.7

Comparison graph between control cement mortar cube vs percentage replacement of fly ash

EFFECT OF HIGH-VOLUME FLY ASH CONCRETE ON COMPRESSIVE STRENGTH OF CONCRETE

The concrete was used as a test specimen to determine the compressive strength. Our concrete test results are summarized in the tables below. Cubes of partially replaced fly ash concrete had a higher compressive strength than the control concrete.

All types of concrete showed a linear relationship between curing time and strength. Adding a lot of fly ash to different types of concrete weakens the mixture under compression. Mix-1 concrete with an F/C 0.6 ratio has an average reference compressive strength of 32.34 N/mm² after 28 days. On the other hand, Mix-3's average compressive strength is 27.01 N/mm² when 60%

fly ash is substituted [11-13]. At 28 days, large volume fly ash concrete had a marginally lower percentage of 8.09 percent compared to regulated concrete. Here, we observed that higher cement proportions resulted in stronger HVFA concrete. Mixtures with a greater cement percentage require more hydration products for pozzolanic reactions than mixes with a lower cement %. This is the rationale behind this. The testing of cubes is illustrated in Figure



Fig.8 Cubes during Testing

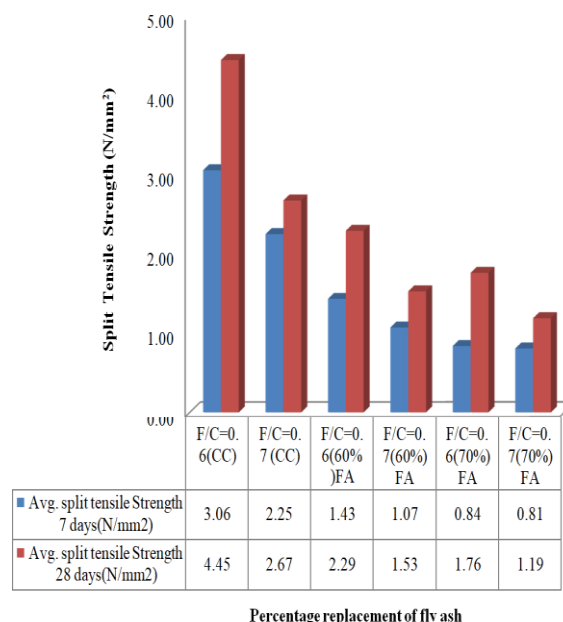
EFFECT OF HIGH-VOLUME FLY ASH ON SPLIT TENSILE STRENGTH

These tests were conducted on concrete with and without large volume fly ash, and on concrete with different cement amounts and F/C ratios (ranging from 0.6 to 0.7). We tested the split tensile strength of cylinders filled with conventional concrete and those partially filled with fly ash.

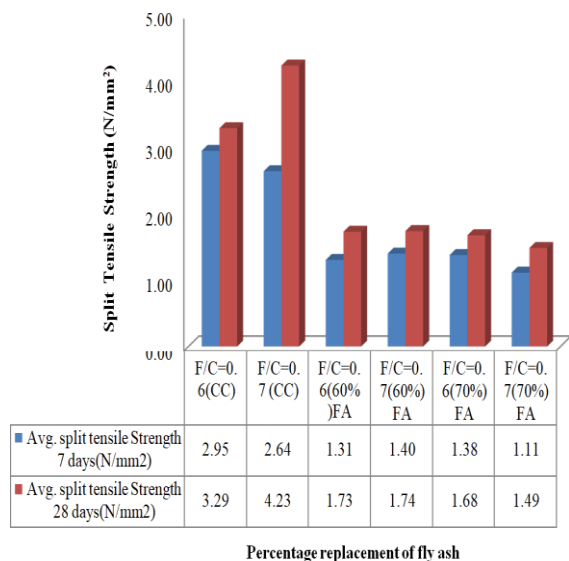
After 28 days with an F/C 0.6 ratio, we discovered that Concrete Mix-1 has an average reference split tensile strength of 4.45 N/mm², while Concrete Mix-3, which is 60% fly ash, has an average of 2.29 N/mm². We discovered a 5.0% increase in split tensile strength when compared to the control concrete. Regardless of the mix and increasing variety, strength was noticeably increased [14-15]. A look at the tested cylinders can be seen in Figure



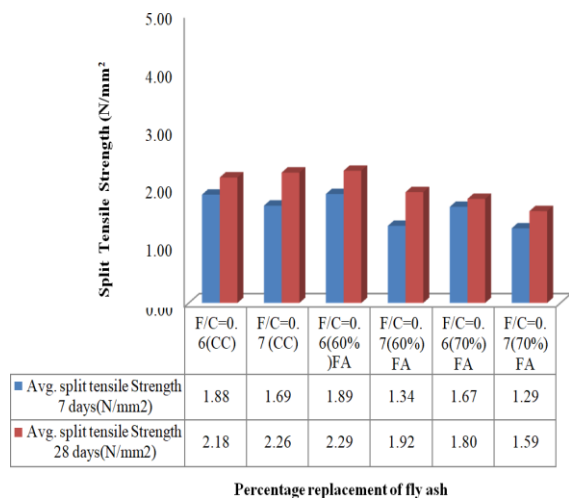
Fig.9 Cylinders during Testing



Percentage replacement of fly ash
 Fig.10 Average Split Tensile Strength of Cylinders at 7 & 28 days for F/C=0.6 & 0.7 Proportions M I
 The average split tensile strength of non-fly ash concrete and fly ash concrete is 7 [16]. The relationship between the percentage of fly ash replacement and the split tensile strength is illustrated in Figure



Percentage replacement of fly ash
 Fig.11 Average Split Tensile Strength of Cylinders at 7 & 28 days for F/C=0.6 & 0.7 Proportions M II
 Concrete with and without fly ash was tested at 7 and 28 days for their average split tensile strengths. The graph in Figure demonstrates the relationship between the percentage of fly ash and the split tensile strength.



Percentage replacement of fly ash
 Fig.12 Average Split Tensile Strength of Cylinders at 7 & 28 days for F/C=0.6 & 0.7 Proportions M III

EFFECT OF HIGH-VOLUME FLY ASH ON FLEXURAL STRENGTH

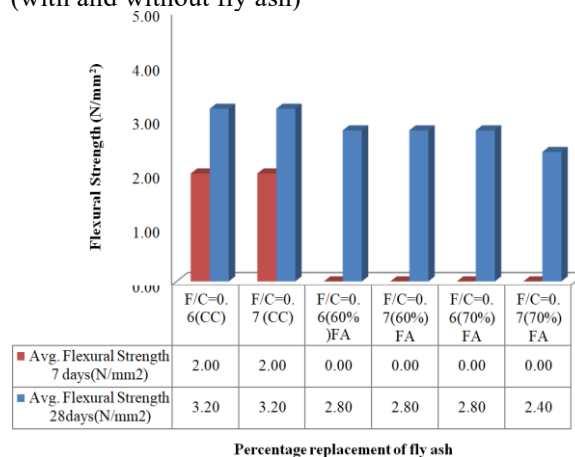
The findings of the flexural strength tests on concrete with and without large volume fly ash are summarized in Table. From 0.6 to 0.7, the cement contents and F/C ratios of the concrete samples varied. The beam's flexural strength was tested using regular concrete, with a partial substitution of fly ash. To evaluate the different mixes, 100 mm X 100 mm X 500 mm beam specimens were cast and put to compressive force at 7 and 28 days. See

the tables below for various mix patterns' flexural strengths after 7 and 28 days in concrete. The average flexural strength of concrete Mix-2 and Mix-3 was 4.93 N/mm² after 28 days with an F/C ratio of 0.7, and it was 3.20 N/mm² after 28 days with a ratio of 0.6, utilizing 60% fly ash [17-18]. The concrete's flexural strength was discovered to be 11% lower compared to the control concrete. The results of the beam flexural tests are shown in Figure.



Fig.4.13 Flexural Beam Strength

There is a correlation between fly ash replacement percentage and flexural strength, and the average split flexural strength of concrete at 7 and 28 days (with and without fly ash)



Percentage replacement of fly ash
 Fig.4.14 Average Flexural Strength of Beams at 7 & 28 days for F/C=0.6 & 0.7 Proportions M I

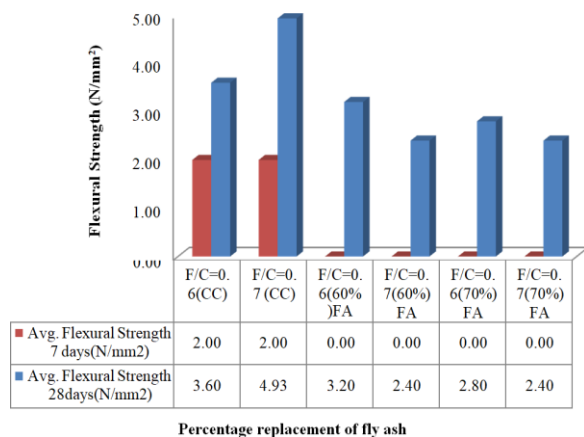


Fig.4.15 Average Flexural Strength of Beams at 7 & 28 days for F/C=0.6 & 0.7 Proportions M II

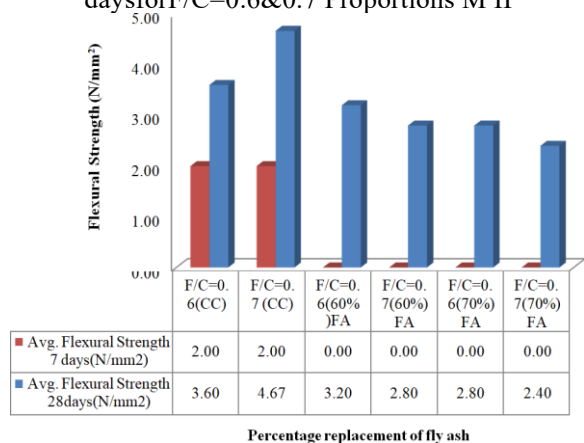


Fig.4.16 Average Flexural Strength of Beams at 7 & 28 days for F/C=0.6 & 0.7 Proportions M III

FLEXURAL STRENGTH FOR BEAM Materials and Mix Design

The combination included water, fly ash, river sand, and Ordinary Portland Cement (OPC). The concrete used to make the beams is of the Mix 3 variety. With a water-cement ratio of 0.32 and a super plasticizer (1:1.875:3.12), the OPC reinforced concrete beams were manufactured.

Flexure Test

Specimens were tested for flexural strength using loading frames that were loaded centrally. Deflection was measured using the dial gauges, and load was measured using the load indicator. We took the following notes while the tests were running.

Residual Strength of Beam

An analysis was conducted to quantify the beam's residual strength in relation to the ultimate load [19-20]. For both the usual control and large volume fly ash concrete beams, Table 4.13 displays the residual strength as a proportion of the ultimate load difference. After 14 days, the

residual strength has decreased by 14%.

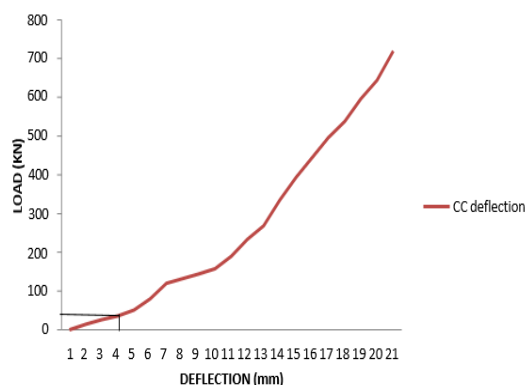


Fig.4.17 Stiffness for optimum control concrete M III

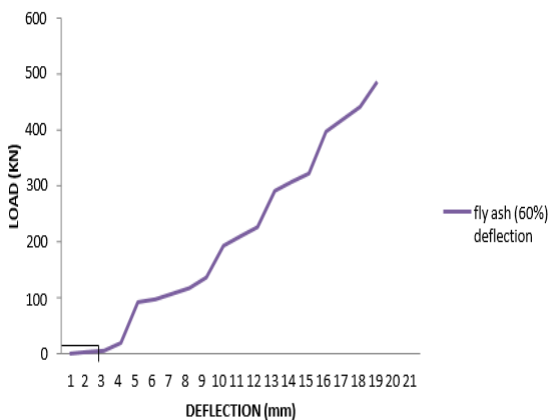


Fig.4.18 Stiffness for optimum HVFA concrete M III Load-Deflection Graph

The specimens' deflection was measured at mid-span along the length of the span using the dial gauges. We plotted the deflections in the experimental data against the corresponding load levels [21-22]. Every load deflection curve shows that the deflection grows linearly with increasing values until it reaches the maximum value. Midway over the span, control concrete experiences a maximum deflection of 7.20 mm, whereas HVFA concrete experiences a maximum deflection of 4.9 mm [23-24]. The load-deflection curve is displayed in Figure

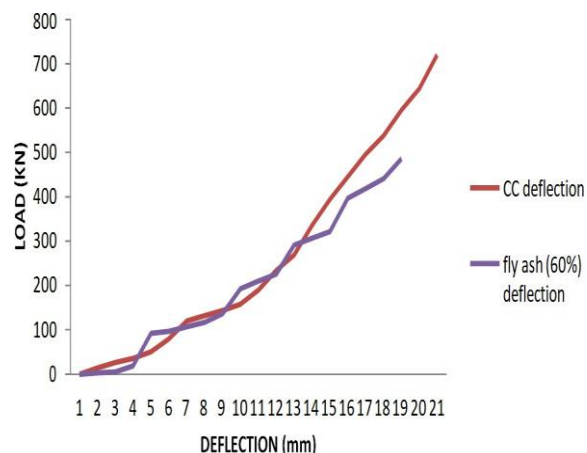


Fig.4.19 Load Vs Deflection

V. CONCLUSION

From the experimental study of concrete mixes with and without fly ash, the following results have been drawn:

i) The amount of super plasticizers required for high volume fly ash concrete to obtain theological characteristics tends to rise with fly ash fineness.

ii) At 28 days, the compression strength of 400 kg/m³ of HVFA concrete with F/C=0.6 for 60% substitution is 8.09% lower than that of standard cube concrete.

iii) The highest compression strength after 28 days for 60% replacement of HVFA concrete at 400 kg/m³ and F/C=0.6 is 27.01 N/mm².

iv) The Split Tensile Strength for 400 kg/m³ at 28 days, with F/C=0.6 for 60% substitution of HVFA concrete, is 5.0% higher than that of conventional cylinders.

v) For 60% replacement of HVFA concrete at 400 kg/m³ and F/C=0.6, the maximum split tensile strength at 28 days is 2.29 N/mm².

vi) When compared to conventional beams, the Flexural Strength for 400 kg/m³ at 28 days, with F/C=0.6 for 60% replacement of HVFA concrete, is 11.0% lower.

vii) The highest flexural strength after 28 days for 60% replacement of HVFA concrete at 400 kg/m³ and F/C=0.6 is 3.20 N/mm².

vii) At 14 days the maximum deflection of HVFA concrete is 31.9% is reduced compared to conventional beam

viii) Load factor for HVFA at 60% replacement is 0.72 for 14 days

ix) At 14 days the residual strength of HVFA concrete is 14% is reduced compared to conventional beam

x) At 14 days the ductility of HVFA concrete is 55.7% is reduced compared to conventional beam

xi) The optimum cost reduction of HVFA concrete and CC is 40% for 400 kg/m³ F/C=0.7 (70% Fly Ash)

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