EFFECT OF SUPERPLASTICIZERS ON THE BEHAVIOUR OF FLY ASH CONCRETE BEAMS IN FLEXURE

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Abstract—Fly ash is an expensive replacement of Ordinary Portland cement (OPC) used in concrete, while it improves fresh and hardened properties of the concrete. Fly ash, a byproduct from coal burning in thermal power stations is currently disposed of in landfills. It is essential that the utilization of fly ash in useful applications should increase dramatically to reduce the use of land for waste disposal. This paper presents the experimental investigation on the mechanical properties of high volume fly ash concrete. Portland cement was replaced with 50% fly ash. Compressive strength and flexural strength of fly ash concrete were experimentally found out and compared with ordinary concrete. Two different superplasticisers were used to cast the specimens. The investigation revealed that the compressive strength and flexural strength of fly ash concrete specimens are comparable to that of ordinary concrete specimens.

Key words: Fly Ash concrete, ordinary Portland cement, Compressive strength, Flexural strength and Moment-curvature.

I. INTRODUCTION

Concrete is typically the most massive individual material element in the built environment. Concrete is primarily comprised of Portland cement, aggregates, and water. Although Portland cement typically comprises only 12% of the concrete mass, it accounts for approximately 93% of the total embodied energy of concrete and 6% to 7% of the worldwide CO2 emissions. If concrete is mixed with High Volume Fly Ash as a partial replacement for Portland cement, it would provide environmental and economic benefits and the required workability, durability, and strength necessary for the design of the structures.

Fly ash from modern thermal power plants generally does not require processing prior to being incorporated into concrete and is therefore considered to be an “environmentally free” input material. When used in concrete, fly ash is a cementation material that can act as a partial substitution for Portland cement without significantly compromising the compressive strength. The pozzolanic properties of a good-quality fly ash are governed primarily by the mineralogy, low carbon content, high glass content, and 75% or more of particles finer than 45 μm. The two main types of fly ash used for concrete are Class F and Class C. Class F fly ash was used for the HVFA concrete testing in this study.

II. NEED OF THE STUDY

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 in to the atmosphere, a major contributor for greenhouse effect and the global warming. Hence it is inevitable either to search for another material or partly replace it by some other material. 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.

Fly ash is one such pozzolanic material which can be used in concrete as partial replacement of cement. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacement. But scant literature is available to study the effect of superplasticisers on fly ash concrete beams in flexure.

III. OBJECTIVE OF THE STUDY

The main objectives of the study is,

1) To find out the material properties of cement, sand, aggregate and fly ash.
2) To arrive at the mix proportions for M30 grade concrete with and without fly ash.
3) To conduct experiments to determine the compressive strength of concrete cubes of M30 grade concrete.
4) To study the effect of superplasticisers on fly ash concrete beams in flexure.
5) To study the ductility, moment-curvature, stress-strain and end rotation characteristics of fly ash concrete beams in flexure.

IV. EXPERIMENTAL ANALYSIS

A. Mix Design

In the current investigation 50% of cement was replaced with Fly Ash in the casting of RC beams. Glenium B233 and Conplast SP430 superplasticisers was incorporated in the mix to increase the workability. Beams were made with M30 grade concrete. The mix calculations are given in appendix A. Table. 1 shows the mix design details of concrete with and without fly ash.

<table>
<thead>
<tr>
<th>Water-cement ratio</th>
<th>% of Admixtures</th>
<th>Cement (kg/m³)</th>
<th>Fine Aggregate (kg/m³)</th>
<th>Coarse Aggregate (kg/m³)</th>
<th>Mix ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>0.70% (B233)</td>
<td>394.31</td>
<td>713.65</td>
<td>472</td>
<td>1:1.8:2:9</td>
</tr>
<tr>
<td>0.45</td>
<td>0.70% (SP430)</td>
<td>416.22</td>
<td>703.35</td>
<td>465</td>
<td>1:1.7:2:8</td>
</tr>
</tbody>
</table>
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Concrete With 50% Fly Ash Replacement

<table>
<thead>
<tr>
<th>Water cement ratio</th>
<th>% of Admixtures</th>
<th>Cement (kg/m³)</th>
<th>Fly Ash (kg/m³)</th>
<th>Fine Aggregate (kg/m³)</th>
<th>Coarse Aggregate (kg/m³)</th>
<th>Mix Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>1% (B233)</td>
<td>197.15</td>
<td>197.15</td>
<td>684.81</td>
<td>453</td>
<td>1:1.7:2.9</td>
</tr>
<tr>
<td>0.45</td>
<td>1.5% (SP430)</td>
<td>208.11</td>
<td>208.1</td>
<td>664.22</td>
<td>440</td>
<td>1:1.6:2.6</td>
</tr>
</tbody>
</table>

Table. 1 mix design details of concrete with and without fly ash.

B. Cube Testing

The cube specimens of size 150mm x 150mm x 150mm are tested by compression testing machine after 7 and 28 days of curing. Samples were weighed before being put in the Compression Testing machine (CTM).

Concrete without Fly Ash

<table>
<thead>
<tr>
<th>Admixtures</th>
<th>Water-binder ratio</th>
<th>28th day Strength (N/mm²)</th>
<th>28th day Average strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.70% (Glenium)</td>
<td>0.45</td>
<td>42.80</td>
<td>45.45</td>
</tr>
<tr>
<td>0.70% (Conplast)</td>
<td>0.45</td>
<td>40.89</td>
<td>41.25</td>
</tr>
</tbody>
</table>

Concrete with 50% Fly Ash

<table>
<thead>
<tr>
<th>Admixtures</th>
<th>Water-binder ratio</th>
<th>28th day Strength (N/mm²)</th>
<th>28th day Average strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% (Glenium)</td>
<td>0.45</td>
<td>41.94</td>
<td>42.25</td>
</tr>
<tr>
<td>1.5% (Conplast)</td>
<td>0.45</td>
<td>38.50</td>
<td>36.75</td>
</tr>
</tbody>
</table>

Table. 2: details of concrete with 50% and without fly ash.

C. CASTING OF BEAMS

Four numbers of reinforced concrete beams with and without fly ash were cast. Experiments were carried out on Reinforced Concrete (RC) beams using fly ash at 50% cement replacement level. Two types of superplasticisers (Conplast SP430 & Glenium B233) were used for the casting of the beams.

D. Test Setup

The testing was carried out in a loading frame of 400 kN capacity. TML strain gauge was fixed at the mid span of the tension bar and then protected using coating tape to avoid accidental damage during pouring of concrete. Linear Voltage Displacement Transducers (LVDT) were used for measuring deflections at several locations, one at mid span, two directly below the loading points and two near the end supports.

E. Load-Deflection curve

Figure 3 shows the experimental load-deflection curves of the RC beams with and without fly ash when tested at 28th day. The average ultimate loads for both the reinforced OPC concrete beams and 50% fly ash concrete beams are 190 kN & 160 kN respectively at 28th day. Though the ultimate load for the fly ash concrete beam is 15.7% less than the OPC beam at 28th day. The average span-deflection ratios under the design service loads for the fly ash beams are 288 at 28th day, which are within allowable limit as per IS 456: 2000.

![Fig. 2: test set-up](image)

![Fig. 3: G-0%-28](image)

![Fig. 4: G-50%-28](image)
F. Moment-curvature

Moment-curvature diagrams were generated for all the beams based on the concrete strain and steel strain. The moment-curvature of the beams at 28 days is shown in Figure 6. The curvature of the beams with fly ash is comparable with OPC concrete beams.

V. CONCLUSION

Comparison of maximum load, maximum deflection and maximum moment are shown in figure 6, 7 at 28 days, the ultimate load carrying capacity of the specimens with Glenium superplasticisers is 5% more than the specimens with Conplast superplasticisers.

A. Beams with Conplast Sp430 Superplasticisers

1) The ultimate moment capacity of fly ash concrete beam is 16% less than the ordinary concrete beam when tested at 28th day.
2) The deflections under design service loads for fly ash concrete beams were within the allowable limit provided by IS: 456-2000.
3) Fly ash concrete beams shows adequate displacement ductility and can be considered for structural members subjected to large displacement.

B. Beams with Glenium B233 Superplasticisers

1) The ultimate moment capacity of fly ash concrete beam is 15.7% less than the ordinary concrete beam when tested at 28th day.
2) The deflections under design service loads for fly ash concrete beams were within the allowable limit provided by IS: 456-2000.
3) Fly ash concrete beams shows adequate displacement ductility and can be considered for structural members subjected to large displacement.

From this study it is found that there is not much difference in the flexural behavior of beams with the usage of Glenium and Conplast superplasticisers.

REFERENCES