Effect of Fly ASH on Properties of Concrete

P. R. Wankhede¹, V. A. Fulari²
¹,²Assistant Professor, IBSS College of Engineering, Amravati

Abstract—This paper presents an Effect of Fly Ash on Properties of Concrete. In the present study, Use of fly ash in concrete imparts several environmental benefits and thus it is ecofriendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Fly ash is pozollanic material & it improving the properties of concrete like compressive strength & Durability. The results obtained are discussed and compared with the available literature.

Keywords—Fly Ash, Ecofriendly, pozollanic, Durability

I. INTRODUCTION

Present days construction industries needs faster development and also require high strength of concrete to facilitate the fast construction and economically construction. For that purpose we used high early strength of cement, to gain early strength of concrete. This demand of high early strength gain of concrete put forth the use of low w/c ratio. But when Use of fly ash in concrete imparts several environmental benefits and thus it is ecofriendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Fly ash is pozollanic material & it improving the properties of concrete like compressive strength & Durability.

Several researchers in the past investigated the effect of mineral and chemical admixtures on the properties of the concrete adopting different theories. Some of the major research works are listed below.

Malhotra, 1990, studied in detail the properties of concrete with a wide range of Canadian fly ashes at 58% of the total cementitious materials. These concretes were tested for compressive strength, creep strain and resistance to chloride ion penetration at various ages up to one year. The results of study by Joshi et al (1994), indicated that with fly ash replacement level up to 50% by cement weight, concrete with 28 days strength ranging from 40 to 60 mpa and with adequate durability can be produced with cost saving of 16% by 50% replacement level.

Bouzouboa, 2004 at Canmet Canada have done studies on the mechanical properties of concrete made with blended high volume fly ash cements. Physical properties of high volume fly ash cements and mortars had also been studied.

The use of the high volume fly ash cements improves the resistance of the concrete to the chloride ion penetration. The present study investigates the potential of fly ash as cement replacement in concrete. The objectives are to reduce the amount of ordinary Portland cement needed in building construction so as to achieve economic construction and sustainable development through the preservation of the environment.

Li Yijin 2009 studied that the addition of ultra-fine fly ash (UFA) to cement paste, mortar and concrete can improve their fluidity, but some coarse fly ash can’t reduce water. This paper investigates the effect of fineness and replacement levels of fly ash on the fluidity of cement paste, mortar, and concrete. The fly ash is collected by electro-static precipitators and airflow classing technology. Three different finenesses were chosen, and their replacement levels were 20%, 30%, and 40%, respectively. The experiment results show that particle size distribution, Zeta potential, density and particle morphologies of fly ash are the major factors affecting their fluidity.

Manas Kumar Sahoo, 2010-11 His experiments helped in determining the potential of the fly ash for use, in manufacture of bricks, in highway embankments, as an aggregate material in Portland cement, filling of low lying and mine void areas etc. Composite material made of fly ash is subject to a variety of different loading conditions, and so different types of stresses develop. Based on the different strength of composites it can be used in various geotechnical applications like construction of roads, Embankment, dams and reservoirs and mine filling.

Sarath Chandra Kumar, October, 2011 observed that the utilization of fly ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement of the long term durability of concrete combined with ecological benefits. Technological improvements in thermal power plants operation and fly ash collection systems have resulted in improving the consistency of fly ash. To study the effect partial replacement of cement by fly ash, studies have been conducted on concrete mixes with 300 to 500 kg/cum cementitious material at 20%, 30%, 40% and 50% replacement level. In their work the effect of fly ash on workability, setting time, density, air content, compressive strength, modulus of elasticity, shrinkage and permeability by Rapid Chloride Permeability Test (RCPT) are studied.
Xianyu Jin January, 2012 reported the results of experimental study on the effects of mineral admixtures such as silica fumes, slag, fly ash and metakaoline, on the mechanical behavior of young concrete under either uniaxial compression or tension. In their work uniaxial compression and uniaxial tension tests have been conducted on the concrete specimens at ages of ½, 1, 2, 3, 7, and 28 days. They utilizes the circumferential control and adaptive deformation control and made the complete stress-strain curves for young concrete under either uniaxial compression or uniaxial tension. Their experimental results shows that the different mineral admixtures do have different influences on properties of young concrete also metakaoline shows the best results on the mechanical properties of young concrete.

Ichhar Ahmed (Nov-Dec. 2012) Has presented the results of an investigation dealing with Concrete cubes of 100 mm size, to replace 0%, 5%, 10% and 15% cement with fly ash. To cover a wide range of concrete mixes water cementitious material ratio (W/C) of 0.3, 0.4 and 0.5 were used for water content of 186 kg/m3, 191.58 kg/m3 and 197.16 kg/m3 each. The effect of various parameters such as replacement of cement by fly ash, water to cementitious material ratio and water content is studied on fresh and hardened properties of concrete. The study mainly consisted of establishing relation between these parameters in the form of Graphs to specify proportioning of required mix. We performed work for nominal mix M25 grade concrete for 0.35 w/c ratio. With mineral admixture 10%, 20%, and 30% replacement by mass of cement. In this work we studied the effects of different w/c ratio, percentage of mineral admixture over the properties of concrete like workability & strength further more we studied the effect with age of concrete and slump loss. Quality is essence of good work. Good quality of concrete is a homogenous mixture of water, cement, aggregate and admixture. Only the mixing of these materials is not the matter but to obtain the concrete which governs all the properties of concrete mixes in fresh as well as hardened concrete. To produce good quality concrete the following steps are involved in concrete preparation.

A. K. Mathur An effort to present information regarding fly ash as a resource material for strong and durable concrete is attempted through this book. We do hope that this book will be useful to prospective users of fly ash, builder, developers and construction agencies. With the increased awareness in this area fly ash will be used as an essential ingredient of the concrete. This will help to increase fly ash utilization in such value added and environment friendly activities.

Sherzad Hakkari studied the effect of various mineral admixture such as fly ash, silica fume, pozzolan, rice-husk ash (RHA), ground granulated blast-furnace slag (GGBFS) and cutting stone & tile waste (CSTW). He observed that pozzolans lower the heat of hydration, increase later strength and increase durability.

II. Objective

Properties of concrete depend upon properties of ingredients and their relative proportion. Addition of mineral in concrete mixes, while designing of mixes has become increasingly complex. This is due to the chemical composition and pozzolonic properties of admixtures. Above complexity will be experimentally studied in this research. The study will investigate the effect over the various properties of concrete with use of mineral admixtures. Based on above mechanism & combination the main objectives of this study are

1. To increase strength & durability of concrete by reducing water content & cement content.
2. Reduce disposal problem by using industrial waste as a concrete ingredient.

III. Problem Definition

We performed work for nominal mix M25 grade concrete for 0.35 w/c ratio. With mineral admixture 10%, 20%, and 30% replacement by mass of cement. In this work we studied the effects of different w/c ratio, percentage of mineral admixture over the properties of concrete like workability & strength further more we studied the effect with age of concrete and slump loss. Quality is essence of good work. Good quality of concrete is a homogenous mixture of water, cement, aggregate and admixture. Only the mixing of these materials is not the matter but to obtain the concrete which governs all the properties of concrete mixes in fresh as well as hardened concrete. To produce good quality concrete the following steps are involved in concrete preparation.

1. Batching of materials.
2. Mixing
3. Compaction.
4. Finishing.
5. Curing and Demoulding.
6. Cube testing.

To produce good quality of concrete the selection of materials as well as selection of required grade of concrete is necessary.
We have used M25 grade of concrete with the ratio 1:1:2 i.e. 1 part of cement, 1 part of fine aggregate and 2 part of coarse aggregate.

A. Materials Specification

Following are the materials used
- Cement: 53 grade of ordinary Portland cement
- Aggregate: 20mm retaining size
- Sand: Fine aggregate
- Water: Potable water
- Mineral admixtures: Fly ash

B. Characteristic of Material

- Cement: 53 grade of ordinary Portland cement
- Aggregate: 20 mm maximum nominal size of aggregate
- Sand: Fine aggregate
- Water: Potable water
- Admixture: We have used mineral admixture as fly ash.
- Mineral admixtures- Fly ash
- Ultra-fine fly ash
- Collected by electro-static precipitators in SOFIA power plant

C. Experimental Investigation and Authentication

We have casted cubes of size 150X150X150 mm. Following material proportion and various dosage combination of admixture for 0.35 w/c ratio have been studied. For nominal mix of M25 grade of concrete (1:1:2)
- Cement: 1 kg
- Fine aggregate: 1 kg
- Coarse aggregate: 2 kg
- Water: W/c ratios is 0.35
- Fly ash: Replacement of cement 10%, 20%, and 30% by weight of cement

IV. Results Interpretation

In this research we show the effect of mineral admixture (fly ash) on the properties of concrete, which has been investigated in laboratory and result obtained. So we present it graphically and discussed about it. The study has been carried out by preparing concrete cubes for M25 grade of nominal mix and tested after 7, 14 and 28 days of curing. Cubes are casted for 0%, 10%, 20% and 30% replacement of fly ash (mineral admixture) with the weight of cement.

To study slump loss and workability of concrete slump cone test has been performed. The result has been interpreted in terms of various combination forms as follows.

1. Variation in slump for different w/c ratio.
2. Variation in ultimate compressive strength for different w/c ratio (0.35, 0.45, 0.55)
3. Variation in slump for different proportion of fly ash.
4. Variation of compressive strength with replacement of fly ash in different quantity and for different curing period.

This study performed over nominal mix of M25(1:1:2) grade of concrete only. In this project first we used different w/c ratio as 0.35, 0.45 & 0.55, to know variation in slump loss and higher strength of M25 concrete for different w/c ratio. We casted three cubes for each w/c ratio and cured these for four days. And from this we get that M25 concrete delivers higher compressive strength with 0.35 w/c ratio. It shows in table I and figure I

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>W/C ratio</th>
<th>Compressive Strength N/Sq.mm</th>
<th>Avg. Comp. Strength N/Sq.mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.35</td>
<td>21.32</td>
<td>22.45</td>
</tr>
<tr>
<td>2.</td>
<td>0.45</td>
<td>23.74</td>
<td>20.89</td>
</tr>
<tr>
<td>3.</td>
<td>0.55</td>
<td>20.62</td>
<td>11.10</td>
</tr>
<tr>
<td>4.</td>
<td>0.35</td>
<td>23.74</td>
<td>22.45</td>
</tr>
<tr>
<td>5.</td>
<td>0.45</td>
<td>20.90</td>
<td>20.89</td>
</tr>
<tr>
<td>6.</td>
<td>0.55</td>
<td>21.15</td>
<td>11.10</td>
</tr>
<tr>
<td>7.</td>
<td>0.35</td>
<td>23.74</td>
<td>22.45</td>
</tr>
<tr>
<td>8.</td>
<td>0.45</td>
<td>20.90</td>
<td>20.89</td>
</tr>
<tr>
<td>9.</td>
<td>0.55</td>
<td>21.15</td>
<td>11.10</td>
</tr>
</tbody>
</table>
FIGURE I VARIATION IN COMPRESSIVE STRENGTH FOR DIFFERENT W/C RATIO

We also study of variation in slump for different w/c ratio. For 0.35 w/c ratio concrete does not show fluidity. In table II and Figure II shows slump loss for 0.35, 0.45 and 0.55 w/c ratio respectively. In this we observed that fluidity of concrete increases with the increment in w/c ratio. For 0.55 w/c ratio fluidity of concrete is more.

TABLE II
SLUMP OF CONCRETE WITH DIFFERENT W/C RATIO

<table>
<thead>
<tr>
<th>W/C Ratio</th>
<th>0.35</th>
<th>0.45</th>
<th>0.55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump in MM</td>
<td>00</td>
<td>35</td>
<td>180</td>
</tr>
</tbody>
</table>

FIGURE II VARIATION IN SLUMP FOR DIFFERENT W/C RATIO

From fig II we can see the variation in slump loss with different proportion of fly ash and in figures III, IV, V, VI & VII it is clear that, variation in ultimate compressive strength (N/mm2) with different age of concrete. In this study we used different proportion of fly ash in 0%, 10%, 20% & 30%. We also measured slump loss for different proportion of fly ash as shown in table III and figure III

FIGURE III SLUMP WITH DIFFERENT PROPORTION OF FLY ASH

Compressive strength for different proportion of fly ash after 7 days curing

TABLE III
SLUMP WITH DIFFERENT PROPORTION OF FLY ASH

<table>
<thead>
<tr>
<th>% Of Fly Ash With Weight Of Cement</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump in MM</td>
<td>00</td>
<td>00</td>
<td>16</td>
<td>24</td>
</tr>
</tbody>
</table>

TABLE IV
COMPRESSIVE STRENGTH FOR DIFFERENT PROPORTION OF FLY ASH AFTER 7 DAYS CURING

<table>
<thead>
<tr>
<th>SN</th>
<th>% Of Fly Ash</th>
<th>Date Of Casting</th>
<th>Date Of Crushing</th>
<th>Comp. Strength N/Sq.mm</th>
<th>Avg. Comp. Strength N/Sq.mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td>26/02/1</td>
<td>13/03/1</td>
<td>27.03</td>
<td>23.12</td>
</tr>
<tr>
<td>2</td>
<td>0%</td>
<td>26/02/1</td>
<td>13/03/1</td>
<td>23.16</td>
<td>22.32</td>
</tr>
<tr>
<td>3</td>
<td>0%</td>
<td>26/02/1</td>
<td>13/03/1</td>
<td>20.58</td>
<td>19.73</td>
</tr>
<tr>
<td>4</td>
<td>10%</td>
<td>28/02/1</td>
<td>15/03/1</td>
<td>23.49</td>
<td>23.18</td>
</tr>
<tr>
<td>5</td>
<td>10%</td>
<td>28/02/1</td>
<td>15/03/1</td>
<td>28.31</td>
<td>28.06</td>
</tr>
<tr>
<td>6</td>
<td>10%</td>
<td>28/02/1</td>
<td>15/03/1</td>
<td>27.19</td>
<td>26.60</td>
</tr>
<tr>
<td>7</td>
<td>20%</td>
<td>01/03/1</td>
<td>16/03/1</td>
<td>27.48</td>
<td>27.18</td>
</tr>
<tr>
<td>8</td>
<td>20%</td>
<td>01/03/1</td>
<td>16/03/1</td>
<td>23.87</td>
<td>23.53</td>
</tr>
<tr>
<td>9</td>
<td>20%</td>
<td>01/03/1</td>
<td>16/03/1</td>
<td>26.44</td>
<td>26.10</td>
</tr>
<tr>
<td>10</td>
<td>30%</td>
<td>04/03/1</td>
<td>19/03/1</td>
<td>23.65</td>
<td>23.23</td>
</tr>
<tr>
<td>11</td>
<td>30%</td>
<td>04/03/1</td>
<td>19/03/1</td>
<td>20.84</td>
<td>20.56</td>
</tr>
<tr>
<td>12</td>
<td>30%</td>
<td>04/03/1</td>
<td>19/03/1</td>
<td>21.74</td>
<td>21.47</td>
</tr>
</tbody>
</table>
Compressive strength for different proportion of fly ash after 7 days curing

Table V
Compressive Strength for Different Proportion of Fly Ash after 14 Days Curing

<table>
<thead>
<tr>
<th>SN</th>
<th>% Of Fly Ash</th>
<th>Date Of Casting</th>
<th>Date Of Crushing</th>
<th>Comp. Strength N/Sq.mm</th>
<th>Avg. Comp. Strength N/Sq.mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td>26/02/1 4</td>
<td>13/03/1 4</td>
<td>35.66</td>
<td>34.03</td>
</tr>
<tr>
<td>2</td>
<td>10%</td>
<td>28/02/1 4</td>
<td>15/03/1 4</td>
<td>39.01</td>
<td>37.23</td>
</tr>
<tr>
<td>3</td>
<td>20%</td>
<td>01/03/1 4</td>
<td>16/03/1 4</td>
<td>38.58</td>
<td>35.68</td>
</tr>
<tr>
<td>4</td>
<td>30%</td>
<td>04/03/1 4</td>
<td>19/03/1 4</td>
<td>27.06</td>
<td>27.47</td>
</tr>
</tbody>
</table>

FIGURE V Compressive Strength for Different Proportion of Fly Ash after 14 Days Curing

In the following figure we can compare variation of ultimate compressive strength of concrete for different proportion of fly ash and for different age of concrete.

From the results obtained it can be clearly seen that for 10% to 20% replacement of fly ash with weight of cement for w/c ratio 0.35, ultimate compressive strength is increases and then if we further increases percentage of fly ash, ultimate compressive strength decreases.
V. CONCLUSIONS

This research concludes the study on “the effect of fly ash on the properties of concrete” for nominal mix of M25 grade of concrete are as follows.

1. Slump loss of concrete increases with increase in w/c ratio of concrete.
2. For w/c ratio 0.35 without any admixtures, initial slump cannot be measured by slump cone test as it is very less.
3. Ultimate compressive strength of concrete goes on decreasing with increase in w/c ratio of concrete.
4. Slump loss of concrete goes on increasing with increase of quantity of fly ash.
5. Concrete with 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days than normal concrete for 0.35 w/c ratio.

REFERENCES


[10] Semsi Yazici & Hasan Sahan Arel Department of Civil Engineering, Engineering Faculty, 35100 ˙Izmir, Turkey “Effects of fly ash fineness on the mechanical properties of concrete”.

