CONSTRUCTION OF A BUILDING USING FLY ASH CONCRETE

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ABSTRACT

The concept of partial replacement of cement with fly ash can accomplish sustainable development. Presently large amounts of fly ash are generated in thermal industries which are dumped as waste, have an adverse impact on environment and humans. This fly ash in the powdered form can be used in concrete to replace cement. The utilization of by-products as the partial replacement of cement has important economic, environmental and technical benefits such as the reduced amount of waste materials, cleaner environment, reduced energy requirement, durable service performance during service life and cost effective structures. The objective of the paper is to evaluate a building in terms of cost and durability, by doing partial replacing of cement with fly ash. Firstly, the intensive literature survey is conducted from which it is understood that 25% partial replacement of cement with fly ash is suitable for M30 concrete. The quantity and cost estimate of a G+5 residential building is carried out which uses concrete without fly ash. Then the quantity and cost estimate is done for the same building by using fly ash concrete (concrete in which 25% of cement is replaced by fly ash). A comparative study is carried out in terms of cost is carried out between the two to understand the best economic structure.

Key words: Fly ash concrete, cost estimation, quantity estimation.


1. INTRODUCTION

Fly ash is very much similar to volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term “pozzolan”. A pozzolan is a siliceous or siliceous / aluminous material which when mixed with lime and water forms a
cementitious compound. Fly ash is the best known, and one of the most commonly used, pozzolans in the world. Fly ash is the notorious waste product of coal based electricity generating thermal power plants known for its ill effects on agricultural land, surface and subsurface water pollution, soil and air pollution and diseases to mankind. Researchers have proposed few ways of reusing fly ash for variety of application. One of the most common reuse of fly ash is in cement concrete. Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures. That capability is one of the properties making fly ash a desirable admixture for concrete.

These materials greatly improve the durability of concrete through control of high thermal gradients, pore refinement, depletion of cement alkalis, resistance to chloride and sulphate penetration, and continued micro structural development through a long-term hydration and pozzolanic reaction. The utilization of by-products as the partial replacement of cement has important economical, environmental and technical benefits such as the reduced amount of waste materials, cleaner environment, reduced energy requirement, durable service performance during service life and cost effective structures.

Hence it is a safe and environmentally consistent method of disposal of fly ash. However, the rate of strength development is less. Due to lesser rate of strength development, fly ash finds specific application in mass concreting eg. dam construction. It can be concluded that power plant waste is extensively used in concrete as a partial replacement for cement and an admixture [1]. When (Cube 150x150x150 mm): The 20%FA,18%PA mix will give a high compressive strength of 44.65 N/mm² for 28 days curing period. The 20% FA,15%PA mix will give a low compressive strength of 33.77 N/mm². The 20%FA,18%PA mix will give a 4% higher strength compared to normal concrete. And (Beam 100x100x500 mm): The 20%FA,18%PA mix will give a high compressive strength of 10N/mm² for 28 days curing and 20%FA,15%PA will give a low flexural strength of 6.15 N/mm². The 20%FA,18%PA mix will give higher strength compared to normal concrete [2].

Compressive and split tensile strength showed an increased value with the fly ash is replaced up to 50% at the end of 28 days. Compressive and split tensile strength reduces when cement replaced by fly ash percentage is increased beyond 50% at the end of 28 days. The results indicate that replacing cement with fly ash up to 50% is possible to be used in structural concrete [3]. Based on limited experimental investigation concerning the flexural strength of concrete, the following observations are made regarding the resistance of partially replaced fly ash and hypo sludge: (a) Flexural strength of the concrete increases when the 20% replacement of cement by fly ash is increased up to 11.08 %. (b) Flexural strength of the concrete increases when the 10% replacement of cement by hypo sludge is increased up to 8.91%. (c) Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this project. (d) A better measure by a New Construction Materials formed [4].

Hence the cementitious efficiency factor of fly ash in concrete is found to be reliable. Thus, the efficiency factor could be helpful in the design of fly ash concrete of any specific strength and at any percentage replacement by trying to bring together the cementitious material ratio to strength relations for both normal and fly ash concrete [5].

From the present investigation and limited observations reported, the combined use of quarry rock dust and fly ash exhibited excellent performance due to efficient micro filling ability and pozzolanic activity. It was observed that the decrease in early strength by the addition of fly ash is ameliorated by the addition of quarry dust. Therefore, the results of this study provide a strong recommendation for the combined use of quarry rock dust and fly ash in mortar/concrete manufacturing [6].
2. METHODOLOGY

- The objective of the paper is to evaluate a building in terms of cost and durability, by partially replacing cement with fly ash.
- Firstly, the intensive literature survey is conducted from which it is understood that 25% partial replacement of cement is apt for M30 concrete.
- The quantity and cost estimate of a G+5 residential building is carried out which uses concrete without fly ash.
- Then the quantity and cost estimate is done for the same building by using fly ash concrete (concrete in which 25% of cement is replaced by fly ash).
- A comparative study is carried out between the normal building and the partially replaced fly ash building.
- Taking into consideration the strengths parameter, durability, environmental impact and cost a comparative study is made between the two structures to understand the best suitable one.

3. RESULT & DISCUSSION

3.1. Calculation of Concrete in Residential Building

A G+5 residential building, by Adharva constructions at Visakhapatnam is taken for the conducting the study. This project uses concrete without partial replacement of fly ash.

From PCC bed to RCC pedestal, concrete quantity for 72 footings = 245.25 m$^3$.

Total plinth beam concrete quantity = 34.02 m$^3$.

Total concrete quantity for columns:
- Cellar = 1986 m$^3$
- G.F & 1$^{st}$ floor = 2550 * 2 = 5100 m$^3$
- 2$^{nd}$ & 3$^{rd}$ floor = 2550 * 2 = 5100 m$^3$
- 4$^{th}$ and 5$^{th}$ floor = 2550 * 2 = 5100 m$^3$

Total concrete quantity for columns = 17286 ft$^{3}$ = 489.96 m$^3$.

Slab and beam concrete quantity for the one floor = 251 m$^3$.

Slab and beam concrete quantity for 6 floors = 251 * 6 = 1506 m$^3$.

Cost estimation: RMC concrete is used on site whose rate is Rs. 4200 per m$^3$.

<table>
<thead>
<tr>
<th>SL NO</th>
<th>DESCRIPTION OF CONCRETE</th>
<th>NO</th>
<th>CUBIC METER</th>
<th>TOTAL (CUBIC METER)</th>
<th>TOTAL COST (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Concrete quantity of footings (PCC to RCC pedestal)</td>
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<td>245.25</td>
<td>245.25</td>
<td>1047217.5</td>
</tr>
<tr>
<td>2</td>
<td>Plinth beam concrete quantity</td>
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<td>34.02</td>
<td>34.02</td>
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<tr>
<td>3</td>
<td>Column concrete quantity</td>
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<td>490</td>
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<tr>
<td>4</td>
<td>Slab and beams concrete quantity</td>
<td>6</td>
<td>251</td>
<td>1506</td>
<td>6430620</td>
</tr>
<tr>
<td>5</td>
<td>Staircase concrete quantity</td>
<td>14</td>
<td>2.55</td>
<td>35.7</td>
<td>152439</td>
</tr>
</tbody>
</table>

Total cost of concrete = Rs. 98,67,841.9/-
3.2. Calculation of Fly Ash Concrete

Using IS 10262 : 2009, the quantity of fly ash can be calculated,

From Table – 5 of IS 456 – 2000, maximum water cement ratio for M 30 is 0.45. Based on the survey and opinion of experts, adopt water cement ratio is 0.40 (0.40<0.45). Therefore the assumed water cement ratio holds good.

From table 2 of IS 456 – 2000: maximum water content for 20mm aggregate = 186 lit (25 to 50 mm slump range). For 100mm slump water quantity = 186+(6/100)*186 = 197 lit. When super plasticizers is used, the water content can be further reduced up to 30%.

Based on trials with super plasticizers water content reduction of 29% has been achieved. Hence the arrived water content 197*0.71 = 140 lit.

Cementitious material (cement + fly ash) content = 140/0.40 = 350 kg/ m$^3$.

From table 5 of IS 456, minimum cement content for ‘severe’ exposure condition =320 kg/ m$^3$. Thus, Cementitious material content = 350 * 1.10 = 385 kg/ m$^3$.

Water content = 140/385 = 0.364.

Fly ash @ 25% of total cementitious material content = 385 * 25% = 96.25 kg/m$^3$. = 96 kg/ m$^3$.

Cement (OPC) = 385 - 96 = 289 kg/m$^3$.

Saving of cement while using fly ash = 350 -289 = 61 kg/m$^3$.

Therefore, Fly ash being utilized = 96 kg/m$^3$.

For 1 m$^3$ of concrete, 289 kg cement and fly ash of 96 kg.

3.3. Mix Calculations

The mix calculation per unit volume of concrete shall be as follows:

- Volume of concrete = 1 m$^3$
- Volume of cement = mass of cement/sg of cement *1/100
  = (289/3.15)*(1/1000) = 0.092 m$^3$
- Volume of fly ash = mass of fly ash/sg of fly ash * 1/1000
  = 96.25/2.2*1/1000 = 0.043 m$^3$
- Volume of water = mass of fly ash/sg of fly ash * 1/1000
Construction of a Building Using Fly Ash Concrete

\[ \frac{140}{1} \times \frac{1}{1000} = 0.140 \text{ m}^3 \]

- Volume of chemical admixture = mass of admixture/sg of admixture * 1/1000
  
  \[ \frac{7}{1.145} \times \frac{1}{1000} = 0.0007 \text{ m}^3 \]

- Volume of all in aggregate = \[a-(b+ c+ d+e)]\)
  
  \[1-(0.092+0.043+0.140+0.007) = 0.718 \text{ m}^3 \]

- Mass of coarse aggregate = \[0.718 \times 0.58 = 0.42 \text{ m}^3 \]

- Mass of fine aggregate = \[0.718 \times 0.42 = 0.3 \text{ m}^3 \]

Cost of 1 m3 of fly ash cement concrete = cost of cement + cost of fly ash + cost of fine aggregate + cost of coarse aggregate

\[= 6 \times 320 + 96 \times 0.7 + 0.3 \times 2200 + 0.42 \times 2500 \]

\[= 3697.2 \text{ Rs/-} \]

Total cost of fly ash concrete in building = \[2310.97 \times 3697.2 = 85,44,118.28 \]

Cost of cement concrete = Rs. 98,67,841.9/-

Cost savings when fly ash is bring used = Rs. 13,23,723.62/-

4. CONCLUSION
Considering the cost of disposal problem of fly ash and hidden cost of environmental protection, the use of fly ash in concrete is indeed successful. Fly ash is actually a solid waste. So, it is priceless. If it can be used for any purpose then it will be good for both environment and economy. Also the addition of fly ash increases the concrete strength and its workability. Use of this fly ash as a raw material in Portland cement is an effective means for its management and leads to saving of cement and economy consequently. Fly ash can also be added to concrete at the time of mixing.

In this paper a case study has been carried out to understand the variation in cost of constructing a residential building, when fly ash concrete is used. The cost of constructing the building using RMC is Rs 98,67,841.9., while that of using fly ash concrete is Rs 85,44,118.28. There is a considerable savings of Rs 13,23,723.62. When fly ash concrete is used. Hence it can be said that fly ash, which is an industrial waste and poses difficulty in disposal and environmental problems, can be effectively used in fly ash concrete for building construction without causing cost over run.

REFERENCES


