Optimization of Concrete Mix Proportion by Replacing Sand with The Hazardous Industrial Waste

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***Abstract*—Concrete is the material which gives the strength to the structures with more durability. Concrete is used in all types of structures because it can be fabricated and can be easily prepared. In the modern civilization, the construction of structure is rapidly increases which results the shortage of construction materials (sand). Various percentages of fly ash, sequentially 0%, 10%, 20%, 30%, 40% and 50% were implemented in the mixes based on partial weight replacement of its components and the water-binder ratios were calculated based pozzolanic cementing efficiency method. Tests on concrete after replacement are quite good such as Compressive Strength, Split Tensile Strength, and Flexural Strength. After test we found that, 30% sand can be replace by Fly ash. However, a new technique for the complete replacement of the fine aggregate was introduced which incorporates the polymerization technique in the byproducts (Fly Ash).**

Keywords: Fly ash, Sand, Admixture (Super plasticizer SP430) and Pozzolanic Efficiency Cement.

I. INTRODUCTION

Concrete, Being the second highest material used in the structure after the water across the world. Fine aggregate is used as binding material in concrete is in high demand as the current period. So, the sand (fine aggregate) is used from a decade which is extracted from riverbed. Thus, this is called as river sand. Now days there is shortage of the river sand due to overuse and increasing the price of sand. To solve this shortage problem engineers are trying to find and alternative of river sand. i.e., M-Sand and Fly ash. M-sand is in practice now on the construction of structure.

In the modern era, electricity is required to live a life. To generate the electricity Thermal Power Plant is used which generates the huge amount of fly ash. In India only huge amount of fly ash is generated (80 million ton per year). Fly ash also can be used as fine aggregate in certain amount (30%). Which can also reduce the price of construction. Fly ash is generally used as replacement of cement, as an admixture in concrete and in manufacturing of cement. Concrete containing fly ash as partial replacement of cement poses problems of delayed early strength development. All the previous studies have reported effect of sand replacement by fly ash on concrete and mortar with Ordinary Portland Cement. As Government of India is encouraging the use of Portland Pozzolana Cement, PPC is used in the present study. Concrete containing fly ash as partial replacement of fine aggregate will have no delayed early strength development, but rather will enhance its strength on long-term basis.

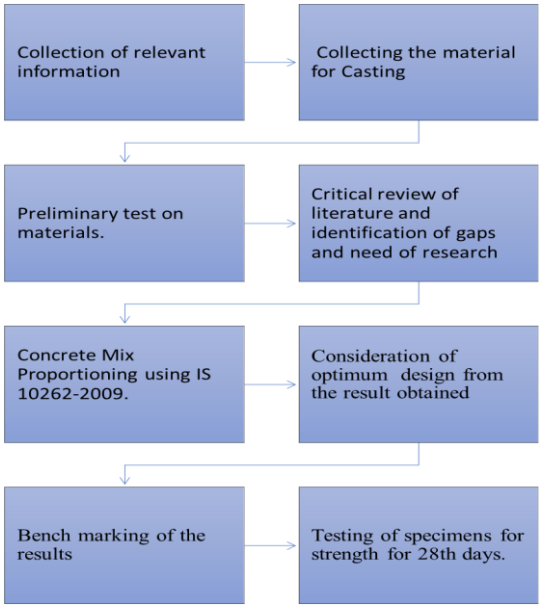
II. LITERATURE REVIEW

Study on Partial replacement of Sand with fly ash in Concrete Mixes Based on Pozzolanic Cement to the strength Weight and cost Strength Ratio". By using the fly ash as the sand in the concrete reduces the cost of the concrete. Fly ash is the alternative solution for the depletion of sand resources in the region like Bangalore. This study shows the effects of sand partial replacement with fly ash without decreasing the strength of the concrete. The strength weight ratio was used for mechanical evaluation with higher value considered as better, in cost strength ratio indicates its economic efficiency with lower value mean more efficient. Fly ash is partially replaced for sand at 0%, 10%, 20%, 30%, 40%, and 50%. The effect of thermal power plant wastes on compressive strength is studies by using specimens' size 150 X 150 X 150 mm cubes. After 28 days of curing, the specimens are dried and tested. The result is compared with normal concrete with same water cement ratio. By seeing this context fly ash can be much more effective material used as replacement in concrete as fine aggregate along with cement combination is summarized in this study.

III. OBJECTIVE OF WORK

i. Natural sand is replaced by fly ash in different percentage such as 0%, 10%, 20%, 30%, 40% and 50%.
ii. To study the workability in terms of slumps for all mixes.
iii. To study the effect of superplasticizers in all the mixes.
iv. To study near surface characteristics water absorption and soroptivity for all mixes.
v. Strength characteristics such as compressive strength, split tension strength and flexural strength, are found when natural sand is replaced by fly ash.
vi. To find the optimum content of fly ash that can be replaced in natural sand.

IV. METHODOLOGY



V. EXPERIMENT

MATERIALS: Sand, Cement, Coarse aggregate, Water, Fly ash and Admixture.

Properties of Aggregate

Properties	Sand	Coarse Aggregate	Fly ash
Specific Gravity	2.6	2.72	2.98
Water Absorption	1.25%	0.86%	
Fineness	2.40	7.50	0.96
SiO2 content	-	-	47.26%

VI. MIX DESIGN

Using IS 10262-2009 and IS 456-2000
W/C ratio =0.45
Water =3% (interval of 25mm)
Volume calculation = (mass of cement /specific gravity of cement* 1000)
Design ratio = 1:1.5:2.91 (Cement: Sand: Coarse Aggregate)

VII. CALCULATION:

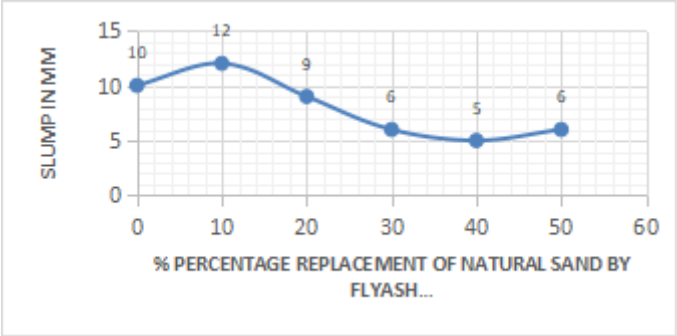
<u>For Replacement of Sand</u>

S.N.	% Replacement of fly ash	Sand	Fly Ash
1.	0%	7.47	0
2.	10%	6.723	0.747
3.	20%	5.976	1.494
4.	30%	5.234	2.241
5.	40%	4.482	2.988
6.	50%	3.735	3.735

VIII. EXPERIMENTAL RESULT

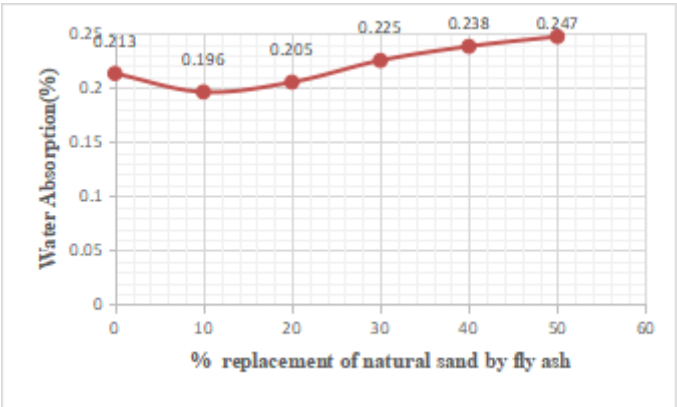
1. Slump Cone

Replacement % of Fly Ash	Slump in mm
0%	50mm
10%	30mm
20%	20mm
30%	20mm
40%	15mm
50%	15mm



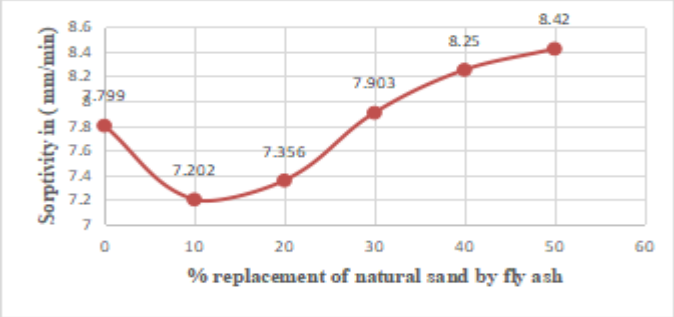
2. Water Absorption

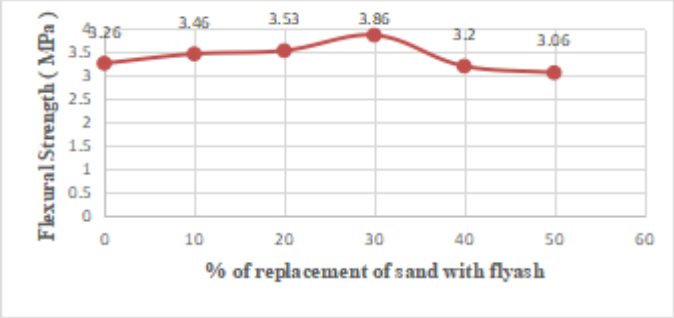
Replacement % of Fly Ash	Water Absorption
0%	0.213
10%	0.196
20%	0.205
30%	0.69
40%	0.51
50%	0.61



3. Soroptivity

Replacement % of Fly Ash	Soroptivity in (mm/min)
0%	7.2
10%	7.799
20%	7.202
30%	7.903
40%	8.25
50%	8.42



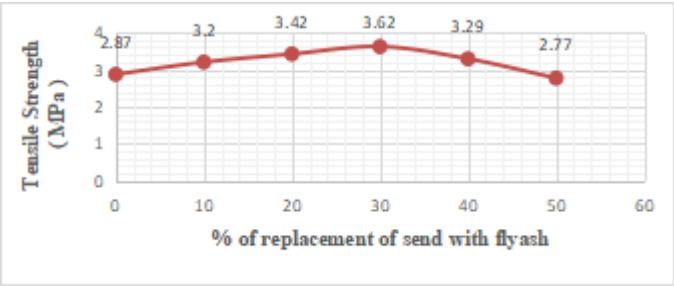


4. Compressive Strength

Replacement % of Fly Ash	Compressive Strength (MPa)	Increase/Decrease % in 28 days
0%	30.29 MPa	
10%	32.88 MPa	+8.71%
20%	33.91 MPa	+12.11%
30%	34.87 MPa	+15.28%
40%	32.48 MPa	+7.93%
50%	28.40 MPa	-6.07%

5. Split Tensile Strength

Replacement % of Fly Ash	Tensile Strength (MPa)	Increase/Decrease % in 28 days
0%	2.87 MPa	
10%	3.20 MPa	+11.49%
20%	3.42 MPa	+19.16%
30%	3.62 MPa	+26.21%
40%	3.29 MPa	+14.36%
50%	2.77 MPa	+3.48%



6. Flexural Strength

Replacement % of Fly Ash	Flexural Strength (MPa)	Increase/Decrease % in 28 days
0%	3.26 MPa	
10%	3.46 MPa	+6.13%
20%	3.53 MPa	+2.28%
30%	3.86 MPa	+18.40%
40%	3.2 MPa	+1.84%
50%	3.06 MPa	-6.13%

IX. RESULT AND DISCUSSION

1. It is observed that the workability as measured from slump, for concrete produced by replacing natural sand by fly ash and goes on increasing up to 10 % replacement level. After this replacement level the workability drastically decreases. Thus, the higher workability is achieved when natural sand is replaced by 10 % of fly ash. This is due to the fact that at a replacement level of 10 % the fly ash will induce a ball bearing effect in the concrete thereby inducing flow characteristics. It is evident from the result that slump increases with the partial replacement of the sand with the fly ash and addition of the super plasticizer Addition of fly ash as re placement of sand has more pronounced lubricating effect and ball bearing action in the concrete. This concrete also has lesser voids hence more cement paste will be available for lubrication and hence concrete becomes more workable. Beyond this replacement, the concrete becomes harsher. This result indicates that the use of fly ash as sand partial replacement. Consequently, cause to a reduction fresh concrete workability. The natural dry condition of fly ash when used for concrete mixing leads to the decrease of concrete workability due to its hygroscopic characteristics. This condition can be obtained because fly ash was able to absorb most of the free water content. Thus, it can be concluded that the workability of concrete produced by replacing natural sand by fly ash is high at 10 % replacement level.

2. It is observed that the water absorption and soroptivity values of concrete produced by replacing natural sand by fly ash show the least value at replacement level of 10 %.

   There after the water absorption and soroptivity go on increasing. This is due to the fact that at a replacement level of 10 % the fly ash may fill up all the voids in the concrete mass there by arresting the capillary action of concrete. Thus, it can conclude that the water absorption and soroptivity values of concrete produced by replacing natural sand by blends of fly ash is minimum at 10 % replacement level.

3. It is observed that the compressive strength, split tensile strength and flexural strength of concrete produced by replacing natural sand by blends of fly ash go on

increasing up to 30 % replacement level. After this replacement level the compressive strength, split tensile strength and flexural strength goes on decreasing. Thus, the higher Compressive strength, split tensile strength and flexural strength is achieved when the natural sand is replaced by 30% blends of fly ash. The percentage increase in the 28 days compressive strength, split tensile strength and flexural strength at a replacement level of 30% are found to be 15.28%, 26.21 % and 18.40 % respectively. This may be due to the fact that at a replacement level of 30 %, the fly ash and may induce a higher pozzolanic reactivity thereby increasing C-S-H gel. Also, it may be due to the filler action of fly ash which can fill the voids.

This increase in strength can be attributed to the replacement of fine aggregate with fly ash split tensile strength and flexural strength which encourages the pozzolanic action and fills gaps between cement and sand. This additional strength allows either reduction of thickness of section of cement mortar or reduction in cement quantity for the same thickness. At the early age, fly ash reacts slowly with calcium hydroxide liberated during hydration of cement, and does not contribute significantly to the densification of the cement mortar matrix. Cement mortar with fly ash shows higher strength at all ages because inclusion of fly ash as partial replacement of sand encouraged pozzolanic action irrespective of its low calcium content at the same time acted as a filler material and which helps to spread the cement mortar fly ash. This is true for 28 days compressive strength. Thus, it can be concluded that the compressive strength of concrete produced by replacing natural sand by fly ash is higher at 30 % replacement level.

X. CONCLUSION

1. The workability of concrete produced by replacing natural sand b fly ash is high at 10 % replacement level.
2. The water absorption and sorptivity values of concrete produced by replacing natural sand by fly ash is minimum at 10% replacement level.
3. The compressive strength of concrete produced by replacing natural sand by fly ash is higher at 30% replacement level.
4. The split strength of concrete produced by replacing natural sand by fly ash is higher at 30% replacement level.
5. The flexural strength of concrete produced by replacing natural sand by fly ash is higher at 30% replacement level.
6. Internal curing effect of fly ash as partial replacement of sand may reduce cracks in concrete.
7. Proposed concrete is environment friendly green concrete as it will save scarcely available natural sand and utilize equal amount of fly ash per cubic meter of concrete.
8. It could be finally concluded that fly ash could be very conveniently used as partial replacement of sand in structural concrete where is proportion and replacement of sand could be efficiently done by using minimum one voids method for higher compressive strength, flexural strength and workability and low voids.

XI. SCOPE OF FUTURE STUDY

1. Effect of replacement of natural sand by blends of fly ash and bottom ash in concrete on the near surface characteristics.
2. Effect of replacement of natural sand by blends of GGBS and red mud in concrete on the near surface characteristics.
3. Effect of replacement of natural sand by blends of fly ash in concrete on the permeability characteristics.
4. Effect of replacement of natural sand by blends of fly ash in concrete on the Shrinkage and creep characteristics of concrete
5. Resistance of concrete to sulphate attack when natural sand is replaced by fly ash.
6. Resistance of concrete to chloride attack when natural sand is replaced by fly ash.
7. The concept of replacement of natural fine aggregate by fly ash highlighted in the present investigation could be taken into consideration during mix design of the pumpable concrete with high workability which generally demands more fine aggregates for smooth and uninterrupted flow of the mix.
8. Comparative study can be taken up for experimental and mathematical model using regression analysis.

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