Comparative Analysis of High Strength Concrete by using Admixture & Cost Effectiveness

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Abstract— Concrete is one kind of a composite material that is formed of fine and rough or harsh in texture bonded together with one kind of cement paste to get harden over time. There are various types of concretes used for constructing walls like lime-based concrete which forms by Portland cement and some of them are formed by hydraulic cements like calcium aluminate cements. Although there are various types of composite materials, one among the most commonly used composite is asphalt concrete, mostly used for constructing the road surfaces formed by a material like bitumen. The main role of concrete is development of infrastructure i.e. for buildings and highways. If we look at the other side of the concrete usage, cost plays a vital role in choosing the best and accurate composition. In order to achieve the efficient mixture, there was a high strength concrete which is formed by a fresh water to give smooth states. In this paper we mainly focus on effective utilization of mineral admixture i.e. replacing fly in the place of cement & also adding a super plasticizer CONPLAST SP 430 as Mineral Admixture to obtained High Strength Concrete. By using the fly-ash in the composition we can able to reduce a lot of excess water usage during the construction.

Key words: High Strength Concrete, Super Plasticizer, Fly Ash

I. INTRODUCTION

High strength concrete (HSC) may be defined as concrete with a specified characteristic cube strength between 40 and 100 N/mm2, although higher strengths have been achieved and used. Strength levels of 80 to 100 N/mm2 and even higher are being used for both precast and in-situ works. High Strength Concrete is specified where reduced weight is important or where architectural considerations require smaller load carrying elements. The use of high strength concrete offers numerous advantages in the sustainable and economical design of structures.

II. LITERATURE REVIEW

J.HEGGER (Aachen University of Technology, Institute of Concrete Structures, and 52056 Aachen, Germany) studied the economical and constructional advantages of High Strength Concrete ERNTROY AND SHACKLOCK have done many experimental investigations and indicated that in HSC mixes, workability, type and maximum size of aggregate and strength requirement influence the selection of water-cement ratio. ABDULWAHAB, B.DEANKUMAR, M.BHASKAR, S.VIJAYA KUMAR, B.L.P.SWAMY (IJSER, Volume4, Issue 5, and May 2013) studied the mechanical properties of High Strength Concrete.

N.SIVAKUMAR, S.MUTHUKUMAR, V.SIVA KUMAR, D.GOWTHAM, V.MUTHURAJ International Journal of Engineering And Science Vol.4,Issue 01 January 2014), have done Experimental Studies on High Strength Concrete by using Recycled Coarse Aggregate

III. EXPERIMENTAL INVESTIGATION

A. Materials Used

1) Cement

Ordinary Portland cement (OPC) of grade 43 conforming to IS 8112-1989 is used. Various lab tests conforming to 4031-1996(part-1) carried out.

2) Fly Ash

Fly ash (classF) obtained from NTPC Visakhapatnam is used. Fly ash is not processed and used as received.

Sl no.	Physical Properties	Observed value for cement	Observed values for fly ash
1	Specific Gravity	3.14	2.2
2	Initial Setting (minutes)	30 min	45 min
3	Final Setting (minutes)	600 min	280 min
4	Consistency (%)	30%	35
6	Fineness (m^2/kg)	225 /kg	368 /kg

Table 1: Physical Properties of Cement & FlyAsh

Sl. No.	Test Conducted	Observed Values (%)	Requirement as per IS:3812 (Part- I):2003 Reaffirmed: 2013
1	Loss of Ignition	2.53	5.0(max)
2	Silica as SiO_2	59.51	35 (min)
3	SiO_2+Al_2O_3+Fe_2O_3	86.85	70(min)
4	Available alkalis as Na_2O	0.43	1.5 (max)
5	Reactive silica	29.32	20(min)
6	Magnesium as MgO	1.97	5.0 (max)
7	Sulphate as SO_3	2.07	3.0 (max)
8	Total Chloride	0.032	0.05 (max)
9	Lime Reactivity	4.9 N/mm^2	4.5(min)

Table 2: Chemical Properties of Fly Ash

3) Admixture

Chemical admixture is used to alter the physical as well as chemical properties of concrete. The admixture used is a super plasticizer CONPLAST SP 430. Super plasticizers made it possible to use W/C ratio as low as 0.25 or even lower

and to make flowing concrete to obtain the strength of the order 125 N/mm².

4) Aggregates

Coarse aggregate: Locally available crushed stone of 20mm graded size has been used as coarse aggregate.

Test property	Natural coarse aggregate
Specific gravity	2.75
Water absorption	0.25%
Aggregate crushing (%)	24
Aggregate impact (%)	29

Table 3: Characteristics of CA

5) Fine Aggregate

River sand from river bed having following characteristics.

Specific gravity	2.63
fineness	2.60
Water absorption	2.56

Table 4: Characteristics of FA

6) Mix Proportioning

In this study HSC mixes of M60 grade are produced as per code IS 10262-2009 with six different weight percentages of Fly ash as replacement of cement The detailed proportions of various ingredients of HSC below

SNo.	Cement (Kg)	Fine Agg (Kg)	Coarse Agg. (Kg)	Water (Kg)	%of flyash	Fly Ash (Kg)	SP 430 (Kg)
1	394	693.59	1277.18	122	0	0.0	5.122
2	392	689.67	1269.98	118	5	19.6	5.096
3	387	689.62	1269.88	116	7	27.09	5.031
4	387	684.50	1260.47	116	10	38.7	5.031

Table 5: Mix Proportion M60 with different % of Fly ash

7) Test Procedure

a) Fresh Concrete Tests

For fresh concrete in lab workability tests are generally conducted, in workability i) Slump, ii) Compaction factor tests are conducted.

1) Slump

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. The slump test is the most simple workability test for concrete, involves low cost and provides immediate results. The equipment required for concrete slump test is Mould for slump test, non-porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end. Sampling of the materials to carry out the test is a concrete mix with suitable water- cement ratio. In this project six different concrete mixes with different percentages of Fly Ash are made and the slump test is carried out.

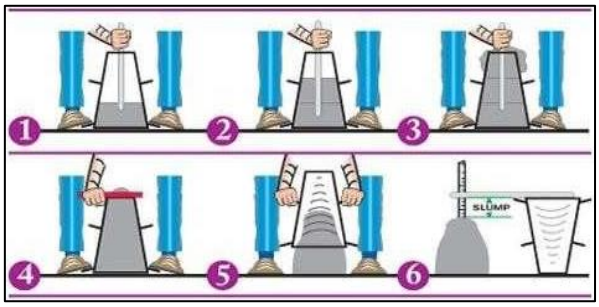


Fig. 1: Concrete Slump Test Procedure

Fig. 2: Slump Cone Test at Site

2) Compaction factor test

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus.

Procedure to determine workability of fresh concrete by compacting factor test.

1) The sample of concrete is placed in the upper hopper up to the brim.
2) The trap-door is opened so that the concrete falls into the lower hopper.
3) The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.
4) The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.
5) The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.
6) The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete.

Compaction factor =(weight of partially compacted concrete)/(weight of fully compacted concrete)

b) Harden Concrete Test

1) Compressive Strength Test (IS: 516-1959)

Compressive strength is the maximum compressive stress that, under a gradually applied load, a given solid material can sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compression test. The compressive strength of concrete is the most common performance

measure used by engineers in designing buildings and other structures. Three types of strength test specimens are used cubes, cylinders and prisms. In the present work cylindrical mould of 150 mm diameter and 300 mm height conforming to IS: 10086-1982 and prisms were of size 500 ×100 ×100 mm according IS: 516- 1959.Cube Moulds were 150 mm size conforming to IS: 10086-1982, the test procedure is carried out as per IS: 516- 1959.

Fig. 3: Compressive Strength Test

IV. STUDY OF COST EFFECTIVENESS

Rate analysis or coast analysis is the estimation of total expenditure or the rates of the individual items used in the construction project. It also gives an idea of total quantity of material and the total coast of the project.

A. Purpose of Analysis of Rates

- To work out the actual cost of per unit of the items.
- To work out the economical use of materials and processes in completing the particulars item.
- To work out the cost of extra items which are not provided in the contract bond, but are to be done as per the directions of the department.
- To revise the schedule of rates due to increase in the cost of material and labour or due to change in technique.

In this project cost analysis is carried out for individual items used in concrete mix to compare the cost of the two concrete mixes i.e. normal M60 concrete and 5% flyash M60 concrete.

V. RESULTS & DISCUSSIONS

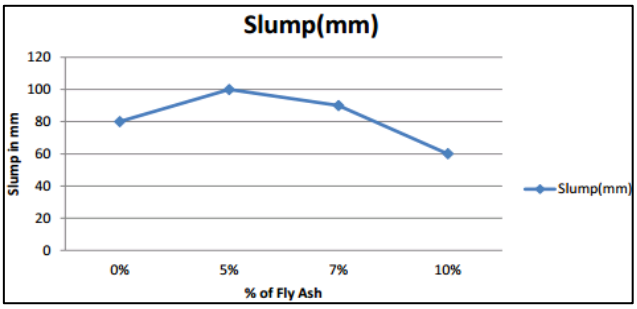
The following are the results obtained in various laboratory tests carried out in this study.

A. Workability Test Results

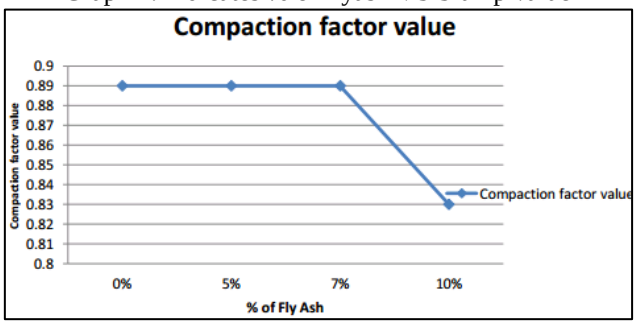
Workability is defined as the ease with which concrete can be mixed, placed, consolidated and finished. A concrete is said to be workable if it is easily transported, placed, compacted and finished without any segregation. The results of the slump & Compaction Factor tests are presented in table 10 and comparative study with varying percentage of Fly Ash with slump is shown in graph-1

Mix No.	Slump(mm)	Compaction Factor
1	110	0.91
2	90	0.89
3	75	0.88
4	60	0.83

Table 6: Slump & Compaction factors results



Graph 1: Indicates % of flyash VS Slump value



Graph 2: Indicates %of flyash vs Compaction factor

– Slumps and Compaction factors of control mixes of M60 designed on the basis of IS: 10262:2009

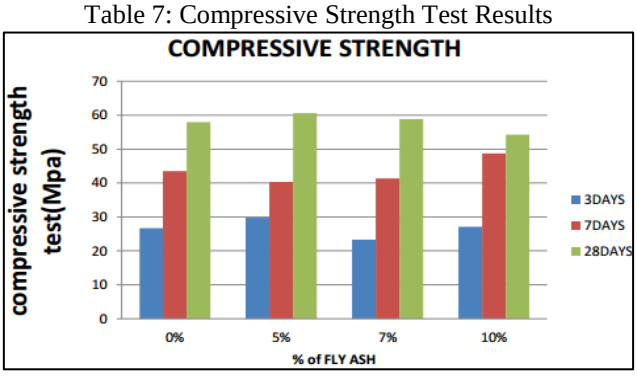
The overall slump value varied between 60mm – 100mm for all the mixes. It is observed that with increase in percentage of Fly Ash, the slump value increases which indicates the improved workability shows in graph 1& 2, graphically the variation of slump with different percentages of Fly ash. From graph it can be seen that as the fly ash percentages as partial replacement for cement increases workability of concrete increases.

B. Compressive Strengths

Cube specimens prepared for compressive strength were tested in laboratory and different crushing strengths were found which are substantiated in table 7. The results of cube compressive strength test are also shown in graph-2

Mix No.	%Flyash	Compressive strenght(Mpa)		
		3Days	7Days	28Days
1	0	30.34	58.46	77.12
2	5	28.80	56.88	76.12
3	7	28.10	55.41	75.98
4	10	27.65	55.00	75.28

Table 7: Compressive Strength Test Results



Graph 3: Graph indicates % of fly ash vs Compressive strength (Mpa)

From the results it is seen that at 0 % Fly Ash content the early strength gain of 16.72Mpa in 3days is observed

which is desired for High Strength Concrete. With increase in % Fly Ash content up to 5% increase in early strength is observed. Further increase in Fly Ash content resulted in decrease in early strength, however which is in acceptable limit. Examining the strength at 28 days age it can be seen that increasing the Fly Ash content from 0% to 5% has caused increase in compressive strength by 3% as compared to reference mix. But when the Fly Ash replacement was increased to 7%, the compressive strength decreased by 2%.Further increase in Fly Ash content from 10% reduced the compressive strength by 4% when compared to 7% replacement of cement with Fly Ash.From Graph-3, it is clear that the compressive strengths of Fly Ash High Strength Concrete mixtures are increasing. The increase was almost 5% replacement. With further increase in Fly Ash content has resulted in remarkable loss of strength.

C. Cost Effectiveness

For M60 grade concrete mix the total cost of materials used is 7647.83/- and that of M60 Fly ash induced concrete is 7380.84/-respectively which is less with a difference of 266.98/- rupees. Therefore it can be concluded that usage of fly ash in concrete is recommended as it results in cost-effective concrete.

VI. CONCLUSIONS

The Fly Ash is a by-product in the manufacture of Coal industry. The replacement Of Portland cement with Fly Ash will lead to a significant reduction of carbon dioxide gas emission. Fly ash is therefore an environmentally friendly construction material. Fly Ash as is used effectively as cementations material to obtain High Strength Concrete of desired strength.

From the present investigation and limited observations reported, on the effect of partial replacement of cement with Fly Ash in High Strength Concrete mixes, following conclusions can be drawn:

1) The compressive strengths of the concrete vary with change in percentage of fly ash i.e. with increase in fly ash content the compressive strength decreases.
2) Also the value of slump increased with decrease in the content of mineral admixture.
3) Compaction factor of the concrete decreased with increase in percentage of mineral admixture.
4) Also the values of 28 days compressive strength decreased with percentage increase in fly ash.
5) It is observed that Fly Ash -based concretes have achieved an increase in strength for 5% replacement of cement at the age of 28 days. Increasing the Fly Ash content from 0% to 5 % has caused increase in compressive strength by 3% as compared to reference mix.
6) In the case of replacement of Fly Ash beyond 5% there will be decrease in the compressive strength values of cube.
7) The optimum Fly Ash replacement as cementation material is characterized by high compressive strength and cost-effectiveness.
8) From the above experimental results, it is proved that Fly Ash can be used as an alternative material for cement, reducing cement consumption and reducing the cost of construction.
9) The partial replacement of OPC in concrete by Fly Ash, not only provides the economy in the construction but it also facilitates environmental friendly disposal of the waste slag which is generated in huge quantities from the Coal industries
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15) The partial replacement of OPC in concrete by Fly Ash, not only provides the economy in the construction but it also facilitates environmental friendly disposal of the waste slag which is generated in huge quantities from the Coal industries

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