Study on Behaviour of High Volume Fly-Ash Concrete

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***Abstract* - Cement is the main ingredient and acts as a binding material in preparation of concrete, which is largely produced to reach its requirement in construction industry and out of all types of cements, ordinary portland cement is commonly used. In the process of manufacturing cement large amount of carbon-dioxide is emitted into the atmosphere and to control the emission pozzolanic and cementitious such as Fly-Ash, GGBS, Lime stone fines and Silica fume are used as substitutes for cement in concrete. Fly-ash is mainly used as substitute of cement and sand to produce concrete in construction industry. Fly-ash is a product of coal which is composed of fine particles that are driven out of the boiler with the fuel gases and captured by electrostatic precipitators. Fly-ash has the potential and ability to be replaced as substitute to cement in construction industry and has good strength performances and 50% replacement of cement by fly-ash in concrete is recommended in the studies. The present study is aimed to determine the mechanical properties of concrete when ordinary portland cement is replaced by 80% of fly-ash (Class F) in concrete. The study is focused on concrete mix of M50 grade having mix proportions of 1: 1.6: 3.1, with a water/cement ratio 0.42. The variation in percentage of fly-ash that replaces cement in concrete is 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70% and 80%. The specimens of cubes (150mm x 150mm x 150mm) and cylinders (150mm x 300mm) are casted to evaluate properties like compression strength and split tensile strength of high volume fly-ash concrete.**

***Keywords:* Fly-ash, compression strength, split tensile strength**

I. INTRODUCTION

Concrete is a material with the combination of cement, fine aggregate, coarse aggregate and water which is strong in compression and weak in tension. To reduce initial cost of concrete cement is replaced with other cementitious materials. Cement acts as a binding material in preparation of concrete and out of all types of cements, portland cement is the common type of cement which is used in concrete, widely around the world. To reduce the production of cement and emission of carbon-dioxide in to the environment, use of other pozzolanic and cementitious materials in concrete is studied and encouraged. The cementitious materials such as fly-ash, GGBS, limestone fines and silica fume are used as substitutes for cement in concrete. Fly-ash is mainly used as substitute of cement and sand to produce concrete in construction industry.

Fly-ash:

Fly-ash is classified into two types by ASTM C618 as Class C and Class F. The main difference between the classes of fly-ash is the amounts of calcium, silica, alumina, iron and loss of ignition in fly-ash.

High volume fly-ash concrete and mix proportions:

High volume fly-ash concrete is a concrete in which cement is replaced by 50 to 60 percentage of fly-ash. But as per IS: 456 – 2000 (code of practice for plain and reinforced concrete), it only allows replacement of OPC by 35% of fly-ash as binding material. The grade of concrete used in this study is M50 having mix proportions 1: 1.6: 3.1 with a water/cement ratio of 0.42.

II. PROPERTIES OF MATERIALS

Cement:

In present study, ordinary Portland cement (OPC) of 53grade, Birla A1 brand is used confirming to IS: 8112 – 1989, and following table shows the physical properties of cement. The properties of cement like fineness of cement, specific gravity, standard consistency, initial and final setting time and compression test of cement are determined.

Table – 1 Properties of cement

Properties	**Results**
Specific gravity	3.11
Standard consistency (%)	36
Fineness (%)	8
Initial setting time (min)	110
Final setting time (min)	270
Compression strength of cement (7days) (Mpa)	31.5

Fine aggregate:

In present study, he fractions from 4.75mm to 150 micron are termed as fine aggregate. The river sand and crushed sand is used as fine aggregate confirming to the requirements of IS: 383.The sand was found to be zone – III as per IS: 10262 – 2009. The following table shows the properties of fine aggregates. The properties of fine aggregate like fineness modulus, bulk density, void ratio and specific gravity are determined.

Table – 2 Properties of fine aggregate

Properties	**Results**
Fineness modulus	2.72

Bulk density (g/cc)	1.62
Void ratio	0.59
Specific gravity	2.6

Coarse aggregate:

In present study, the fraction from 12.5mm passing and 10mm retaining are used as coarse aggregate. The coarse aggregate from crushed Basalt rock confirming to IS: 383 is used, flakiness index and elongation index were maintained below 15%. The following table shows the properties of coarse aggregate. The properties of coarse aggregate like fineness modulus, bulk density, void ratio and specific gravity are determined.

Table – 3 Properties of coarse aggregate

Properties	Results
Fineness modulus	7.32
Bulk density (g/cc)	1.5
Void ratio	0.75
Specific gravity	2.78

Water:

The water which is used for mixing and curing should be clean and free from alkalis, oil, acids, salts, sugar, organic materials and other substances that may affect the concrete or steel. Generally, potable water is considered for mixing and curing and pH value should not be ≥ 6 as per IS: 456-2000.

Fly-ash:

The fly-ash used in present study is termed as class f fly-ash is brought from KAKATIYA THERMAL POWER STATION, Chelpur, Bhupalpally. The particles are spherical in shape and finer than cement particles, but also contains some fractions of un-burnt coal particles.

Table – 4 properties of fly-ash

Properties	Results
Fineness (% retained on 75µ sieve)	10
Specific gravity	2.08

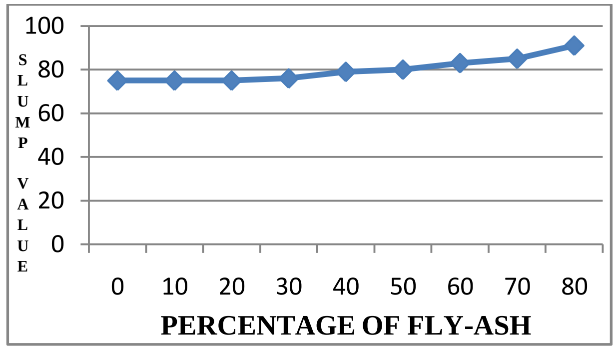
III. RESULTS

Slump test:

Table – 6 Values of slump test

Percentage of fly-ash in each concrete mix (%)	Slump value (mm)
0	75
10	75
20	75
30	76
40	79
50	80
60	83
70	85
80	91

Graph – 1 Variation of slump values with different % of fly-ash

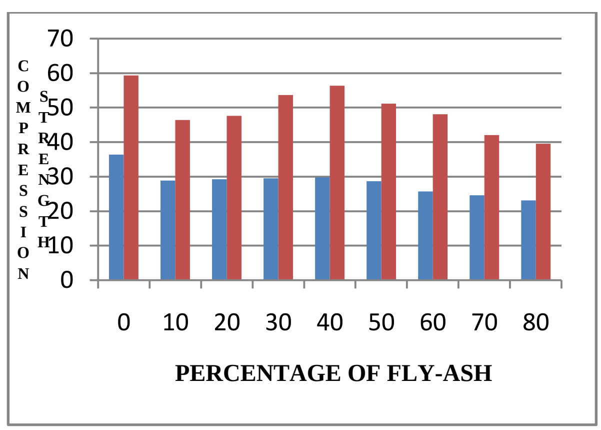


Compression strength:

Table – 7 Values of compression strength

Sl. No	Percentage of fly-ash in each concrete mix (%)	Compression strength = P/A (N/mm^2)	
		7 days	28 days
		Test value (N/mm^2)	Test value (N/mm^2)
1	**0**	36.4	59.3
2	**10**	28.9	46.44
3	**20**	29.2	47.6
4	**30**	29.5	53.7
5	**40**	29.8	56.35
6	**50**	28.7	51.2
7	**60**	25.7	48.1
8	**70**	24.6	42.1
9	**80**	23.1	39.55

Graph – 2 Variation of compression strength values with different % of fly-ash (7 & 28 days)

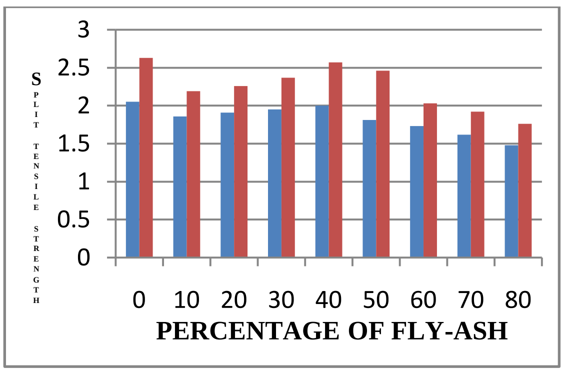


Split tensile strength:

Table – 8 Values of split tensile strength

Sl. No	Percentage of fly-ash in each concrete mix (%)	Split tensile strength = 2P/ΠDL (N/mm^2)	
		7 days	28 days
		Test value (N/mm^2)	Test value (N/mm^2)
1	**0**	2.05	2.63
2	**10**	1.86	2.19
3	**20**	1.91	2.26
4	**30**	1.95	2.37
5	**40**	2.0	2.57
6	**50**	1.81	2.46
7	**60**	1.73	2.03
8	**70**	1.62	1.92
9	**80**	1.48	1.76

Graph – 4 Variation of split tensile strength values with different % of fly-ash (7 & 28 days)



IV. CONCLUSIONS

1. The obtained slump values are increased from 30% to 80% addition of fly-ash in concrete mix. The values of slump are increased by 16%, but the obtained values are within the range of slump for beams.
2. Compression strength values of concrete at 7 and 28 days of curing are obtained. The strength obtained is high at 28 days of curing compared to 7 days of curing. The strength obtained at 28 days age of concrete is increased by 9.91% up to 40% replacement of cement by fly-ash in concrete and it is decreased by 16.8 % up to 80 % replacement of cement by fly-ash in concrete. The highest compressive strength is obtained at 40% replacement of cement by fly-ash in concrete.
3. Split tensile strength values of concrete at 7 and 28 days of curing are obtained. The strength obtained is high at 28 days of curing compared to 7 days of curing. The strength obtained at 28 days age of concrete is increased by 38% up to 40% replacement of cement by fly-ash in concrete and it is decreased by 81% up to 80 % replacement of cement by fly-ash in concrete. The highest tensile strength is obtained at 40% replacement of cement by fly-ash in concrete.
4. It concludes that, 40 to 50% of cement can be replaced by fly-ash without using any super-plasticizer in manufacturing of bricks, construction of residential buildings and laying of roads etc.

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