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Mechanical Properties of High volume Fly ash concrete

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Abstract : An experimental investigation was carried to study the mechanical properties of the high volume fly ash concrete. Fly ash is a by-product of burning pulverized coal. M_{40} mix was prepared with various Fly ash replacement propositions of cement such as 0%, 40%, 50%, 55 % and 60% with 0.330 water cement ratio. These test results were noted at 7, 28, 56 days intervals. Based on the results the 50 % replacement of fly ash with cement gave higher compressive strength, hence the result is followed for split tensile strength and flexural strength[9]. From the results, enhancement of Mechanical properties of high volume fly ash concrete attained at the later stage as compare to the Reference concrete.
Keywords : High volume fly ash (HVFA), Ordinary portland cement(OPC), Split tensile, Flexural.

1.0 Introduction

In developing country like India depends on the production value of power and consequently its consumption as energy, Fossil fuel plays an important part in meeting the demand for power generation .Coal is considered to be one of the world's richest and widely distributed fossil fuel. Fly ash is a by-product of burning pulverized coal in an electrical generating station. It is a finely-divided amorphous alumino-silicate with varying amounts of calcium, which when mixed with portland cement and water, will react with the calcium hydroxide released by the hydration of portland cement to produce various calcium-silicate hydrates (C-S-H) and calcium-aluminate hydrates [1]. Some fly ashes with higher amounts of calcium will also display cementitious behavior by reacting with water to produce hydrates in the absence of a source of calcium hydroxide. Both of these mechanisms enhance the durability of the concrete [12]. From the study mechanical properties of the high volume fly ash replaced cement concrete was compared to the reference concrete[8].

2.0 Experimental investigation:

2.1 Cement - Ordinary Portland cement of 53-grade in Ultra tech brand was used.Opccement was tested in accordance with the IS: 4031-1968[5].

2.2 Fine Aggregate – River sand is collected from locally available area. Physical properties of the fine aggregate were tested with respect to IS 2386-1963.Particle size distribution of sand shows, it is in Zone II of IS 383-1970 [4].

2.3 Coarse Aggregate –Maximum size of 20 mm crushed blue granite stone is collected from the locally available area. Physical properties of the Coarse aggregate were tested with respect to IS 2386-196.[5]

2.4 Fly ash – Class F Fly ash was imported from Eklahare thermal Power Station from Nashik. It is branded as Dirk Pozzocrete 60.Which confines as per IS 3812 (Part 2) – 2003 [6].

2.5 Superplasticizer –Polycarboxylate ether based superplasticizeris used to reduce the water content as well improve the workability of the concrete. This is named as Master Glenium sky 8233.

2.6 Water – Potable water.

Table 1 M_{40}Mix Proposition

Mix	Cement (kg)	Fly Ash (%)	Fly Ash (kg/m^3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	w/c	water kg/m^3	super plasticizer (0.5 %)
1	448	0	0	732	1125	0.330	148	2.240
2	268	40	180	732	1125	0.330	148	2.240
3	224	50	224	732	1125	0.330	148	2.240
4	246	55	202	732	1125	0.330	148	2.240
5	180	60	268	732	1125	0.330	148	2.240

3.0Mix Design

Mix design is carried out for a particular compressive strength of concrete with adequate workability so that the fresh concrete can be properly mixed, placed and compacted. As per IS 10262: 2000 [2] mix of M_{40}(1: 1.678: 2.538) was preferred for the replacement of cement with high volume of fly ash [7]. Mix propositions are shown in table 1.

4.0 Casting and Curing of specimens

The Cubes were Casted at 150x150x150 mm for Compressive Strength, Cylinder of 150 mm diameter, 300 mm length for tensile strength and 100x100x500 mm of prism for flexural strength and demoulded after 24 hours, immersed in a curing tank after that test were done at 7, 28, 56 days interval.

5.0 Results and discussion

5.1 Slump cone test

Slump cone test is used determine the Workability property of High volume fly ash concrete. Fly ash is added to improve the workability of the concrete and similar workability values were observed by T.sankaralingam [10].A spherical shape fly ash particle helps to reduce friction between aggregates and concrete [3]. From the table 2, slump value was increased gradually with respect to the fly ash concentration.M_4 mix have a high workability as compare to other mixes.

Table 2 Slump value

Mix	M_1	M_2	M_3	M_4	M_5
Slump Value(mm)	102	118	138	160	178

5.2 Compressive Strength

Compressive strength for the mix M40 with the various fly ash replacement of cement, results given in the table 3 and Fig 1.Compressive strength was calculated at 7, 28, 56 days. In a long time period fly ash based concrete attains an optimum result. At 7 days results the reference concrete (M_0) gains the higher strength but from 7 to 56 days of time intervals M_2 mix gains higher strength as compare to the other replacements[10]. Though 56 days compressive strength for M_2 replacement is higher than the reference concrete. M_2 mix values are higher than M_0 by 5.01%.Fig 2 shows the partial replacement (M_2) of fly ash with cement gains the higher compressive strength, Simliar strength was obtained by G.Venkatesan and S.Ragu [11]. From the Fig 1 represents the graphical model for the test results. From the model observed M_0, M_1, M_2, M_3 mix gives above 50 Mpa compressive strength. The compressive strength was calculated by using the following formula.

Compressive Strength = $\frac{\text{Load}}{\text{Area}}$

Table 1 Compressive strength

Mix	Fly Ash Replacement %	Compressive Strength In Mpa			Com. strength Increase in %
		7 days	28 days	56 Days	
M0	0	34.22	50.32	53.4	
M1	40	28.10	47.01	54.45	1.95
M2	50	30.80	48.61	56.08	5.01
M3	55	25.50	46.52	53.20	-0.37
M4	60	24.62	41.22	47.20	-13.14

5.3 Split Tensile Strength

Split Tensile Strength was calculated at 28, and 56 days of Reference concrete and various replacement of fly ash with cement, results given in the table 4 and Fig 3,4. From the graph and table, partially replaced fly ash (M_2) based concrete has attained optimum strength at 28, 56 days of time periods [13]. But in56 days of tensile strength of M_3 and M_4 mix decreased as compare to the reference concrete.

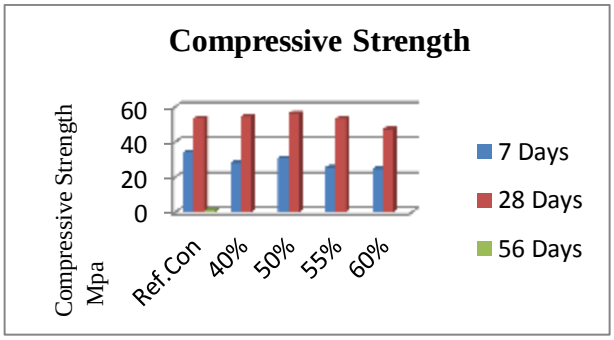

Fig 1 Compressive strength

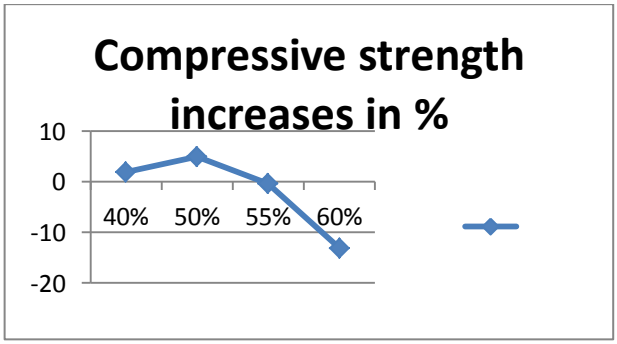

Fig 2 Compressive strength increases

The tensile strength has increased 3.93 % in M_2 mix as compared to the M_0 at 56 days of time period. Increment of tensile strength was begins at M_1 and M_2mixes at 28 and 56 days. The split tensile strength was calculated by using the following formula.

$f_{st} = 2P / \pi ld$

Table 4Split Tensile Strength

Mix	Fly Ash Replacement %	Split Tensile Strength		Split Tensile Strength Increases %
		28 days	56 Days	
M0	0	2.83	3.82	
M1	40	3.45	3.87	1.30
M2	50	3.52	3.97	3.93
M3	55	3.10	3.52	-8.52
M4	60	2.78	3.25	-17.53

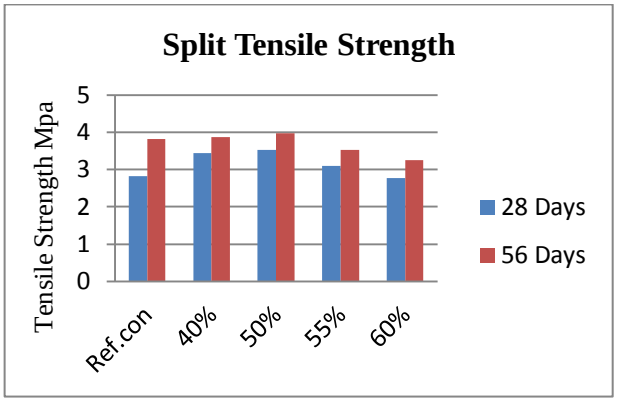

Fig 3 Split Tensile Strength

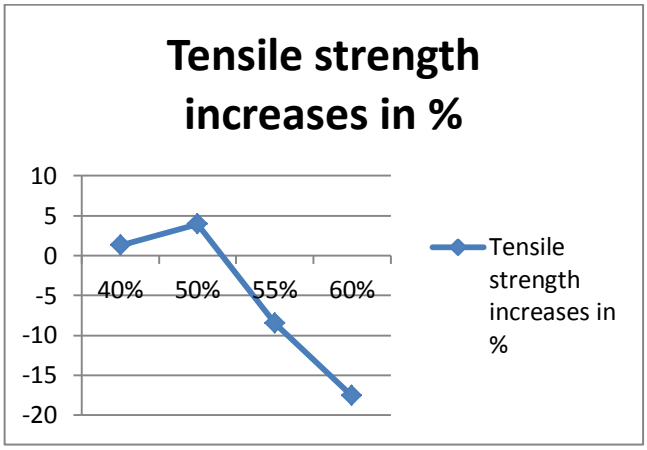

Fig 4 Split Tensile Strength

5.4 Flexural Strength

Flexural Strength of prism was calculated at 28 days of Reference concrete and various replacement of fly ash with cement, results given in the table 5 and Fig 5. From the table flexural strength was obtained only in M_1 and M_2 mixes as compared to M_0, but M_3 and M_4 results fallen suddenly as compare to the M_2 mix. M_4 mix result fallen 39 % from the M_0 value. The Flexural strength was calculated by using the following formula.

Flexural strength = $\frac{P \times L}{B \times D^2}$

P - ultimate load in KN

6.0 Conclusion

1. It is concluded that sufficient work ability was attained for M_{40} grade of concrete at 0.330 water cement ratio and 0.5 % of super plasticizer content.
2. From the Results, higher compressive strength was attained at 50% replacement of fly ash (M_2) with cement at 56 days of curing and M_3mix has an similar strength as compared to the reference concrete.
3. It results shows, high volume fly ash concrete attained higher strength at a later days of curing. The similar trends were followed in split tensile and flexural strength.

7.0 Reference

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