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Modified Behaviour of Concrete by Replacing Fine Aggregates with Coal Fly Ash

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ABSTRACT

The prime objective of the study was to evaluate the structural properties and potential of concrete containing coal fly ash that of concrete containing no coal fly ash of corresponding mix proportions and strength. The cubes were tested for the compressive strength and beams specimens were tested for flexural strength. Splitting tensile strength tests were conducted on cylinder specimens. The total numbers of 60 cubes, 40 beams specimens and 40 numbers of cylinders were tested for compressive strength, flexural strength and splitting tensile strength respectively at different ages to study the following aspect. The effect on unit weight of concrete after incorporating varying proportions of bottom ash. The effect of coal fly ash on workability (C.F) of fresh concrete. The effect on compressive, flexural and splitting tensile strength using bottom ash in varying percentages as a partial replacement of fine aggregates. Mix containing 30% and 40% bottom ash, at 90 days, attains the compressive strength equivalent to 109.13% and 105.17% of compressive strength of normal concrete at 28 days and attains flexural strength in the range of 112-116.3% at 90 days of flexural strength of normal concrete at 28 days.

Keywords: *Coal fly ash, Compressive Strength, Split tensile Strength, flexural Strength*

I. INTRODUCTION

Fly ash is a finely divided residue resulting from the combustion of pulverized coal in boilers. It is transported from the boilers by flue gases and collected by means of electric precipitators and mechanical collectors.

It is a pozzolanic material and consists of small spheres of glassy surface of complex chemical composition together with small quantities of quartz, Mullica, haematite, magnetite and unburnt carbon. It is finer than Portland cement and varies in colour from light grey to dark, depending on carbon content. The greater the carbon content darker is the colour. The quality of fly ash varies from the source to source and it is seldom uniform from same source. This is because of the fact that the quality of fly ash is affected by several factors, like control of combustion process, uniformity of load and mode of fly ash collection. The estimated average ash content of Indian coal use for the thermal power generation ranges between 35% - 40%. The coarser material, which falls into furnace bottom in modern large thermal power plants and constitute of 20% of total ash content of the pulverized coal which is fed in the boilers, is known as bottom ash.

II. Review of Literature

In order to make use of coal ash popular in masonry mortar and structural concrete, research is going on worldwide. In India, research is also going on to utilize huge stocks coal ash in the different zones of the country. This chapter deals with major and significant developments regarding performance that have been reviewed in brief and emphasis has been laid on the compressive and flexural strength.

2.1 REVIEW OF LITERATURE

Khushal Chandra Kesharwani et.al (2017) Fly ash utilization in concrete as partial replacement of cement is gaining importance day by day. Technological improvements in thermal power plant operations as well as collection systems of fly ash improved the quality of fly ash. To study the use of fly ash in concrete, cement is replaced partially by fly ash in concrete. In this experimental work concrete mix prepared with replacement of fly ash by 0%, 25%, 50%, 75% and 100%. Effect of fly ash on workability, setting time, compressive strength and water content are studied. To study the impact of partial replacement of cement by fly ash on the properties of concrete, experiments were conducted on different concrete mixes.

Aayush Choure (2017) In India, currently a large amount of fly ash is generated mainly in thermal power plants with an imperative blow on environment and living organism. The use of fly ash in concrete can reduce the consumption of natural resources and also diminishes the effect of pollutant in environment. In recent studies, many researchers found that the use of additional cementitious materials likes fly ash in concrete is economical and reliable. This investigation is a part of experimental programme carried out to study the utilization of non-conventional building material (fly ash) for development of new materials and technology. It is aimed at materials which can fulfil the expectations of the construction industry in different areas. In this study,

cement has been replaced by fly ash accordingly in the range of 0% ,5%10%,15%, 20% by weight of cement for M-30 mix with 0.43 water cement ratio. The most important mechanical property of concrete is compressive strength and it is evaluated on 150X150X150 mm cubes by The compressive strength is obtained for 28 day strength and results are analyses.

M.S. Krishna Hygrive (2017) We are vigilant that an intense damage is done to environment in the manufacturing process of cement which involves emission of majority of carbon associated with other chemicals. There are evidences from researches that every one ton of cement manufactured releases half ton of carbon dioxide so there is an instant need to control the usage of cement. On the other hand material wastes such as fly ash is difficult to dispose which in turn is an obstacle to the environmental safety. Fly ash is a finely divided d residue resulting from the combustion of pulverized coal and transported by the flue of boilers that carries gaseous combustion away from the point of combustion. The fly ash initially imparts high strength to concrete and also reduce the permeability of concrete. It was obtained from Thermal power station, dried and used. This project mainly deals with the substitution of cement by Fly ash taken in fixed proportions and analyzing the effects of fly ash blended concrete. The concrete mix is prepared by varying the proportions of fly ash for 30%, 40% and 50% of cubes and prisms cured in normal water for up to 28 days and the properties like Slump cone test, Compaction factor test for fresh concrete and Compressive strength for hardened concrete are verified and the results are analyzed.

III. Methodology

To investigate the strength considerations the following tests were conducted

1. Compressive strength test
2. Flexural strength test
3. Split tensile strength test

Along with this test for workability was also conducted. The compression test was carried out on 150mm X 150mm X 150mm cubes, flexural strength tests was carried on 100mm X 100mm X 500mm prisms and split tensile strength test was carried out on 150mm X 300mm cylinders.

IV. Test Result

Designation of the concrete mixes

Mix designation	Replacement level of bottom ash (%age)	Type of concrete
M1	0	Control mix
M2	20	Fly ash concrete
M3	30	Fly ash concrete
M4	40	Fly ash concrete
M5	50	Flyash concrete

1. Compressive strength

It is observed from the tables that fly ash concrete attains the compressive strength at a slower rate than that of plain cement concrete. 'M3' fly ash concrete at the age of 90 days attains compressive strength equivalent to 109.13% of the compressive of plain concrete at 28 days where as 'M2', 'M4' and 'M5' attains 104.95-107.32% of strength at the same age.

Table: Compression behavior of Fly Ash with age

Mix Type	Compressive strength (f_c) N/mm^2				f_{c7}/f_{c90}	f_{c28}/f_{c90}	f_{c56}/f_{c90}
	7 days	28 days	56 days	90 days			
M1	28.74	37.33	39.40	41.18	0.697	0.906	0.956
M2	27.26	34.43	36.15	40.07	0.680	0.859	0.902
M3	26.48	33.55	35.78	40.74	0.649	0.823	0.878
M4	25.70	32.00	34.60	39.26	0.654	0.815	0.881
M5	25.15	30.37	34.44	39.18	0.641	0.775	0.879

Table: Compression behavior of Fly Ash concrete v/s Plain Concrete

Mix Type	Strength gain = Strength of Fly Ash concrete x100 / Strength of Plain concrete at 28 days			
	7 days	28 days	56 days	90 days
M2	73.02	91.96	96.83	107.32
M3	70.93	89.87	95.84	109.13
M4	68.84	85.72	92.68	105.17
M5	67.37	81.35	92.25	104.95

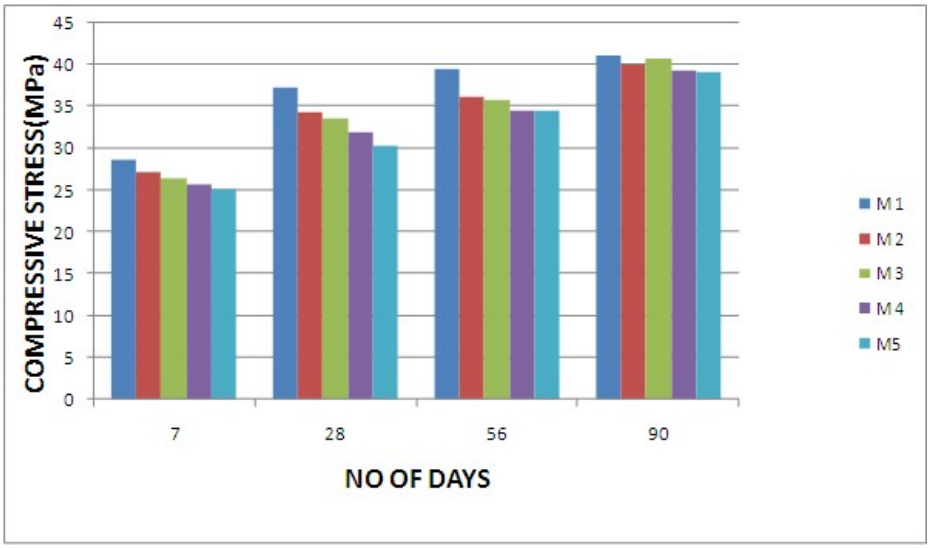

Fig.4.2: Compressive Strength of Concrete

2. FLEXURAL STRENGTH

It is observed from the table that the fly ash concrete gain flexural strength at slow rate than plain concrete. The flexural strength gain depends upon the percentage replacement of fine aggregates. The flexural strength gain is more at 20% replacement of fine aggregates with fly ash. At higher percentages the strength gain decreases and it is minimum at 40% and 50% replacement level. Plain concrete attains 59, 77 and 83.9% strength at 7, 28, and 56 days of its flexural strength at 90 days respectively. Whereas the fly ash concreter mixes attains flexural strength between 64-90.6%, 55-95% and 63-91%, 58-92% for mixes 'M2', 'M3', 'M4' and 'M5'.

Table: Flexural behaviour of Fly Ash concrete with age.

Mix Type	Flexural strength (f_t) N/mm^2				f_{t7}/f_{t90}	f_{t28}/f_{t90}	f_{t56}/f_{t90sss}
	7 days	28 days	56 days	90 days			
M1	2.82	3.66	3.98	4.74	0.594	0.772	0.839
M2	2.74	3.54	3.86	4.26	0.643	0.830	0.906
M3	2.28	3.26	3.90	4.10	0.556	0.795	0.951
M4	2.62	2.86	3.78	4.14	0.632	0.690	0.913
M5	2.38	2.74	3.78	4.10	0.580	0.668	0.921

Table: Flexural Behavior of Fly Ash Concrete v/s Plain Concrete.

Mix Type	Strength gain = Strength of Fly Ash concrete x100 / Strength of Plain concrete at 28 days			
	7 days	28 days	56 days	90 days
M2	74.8	96.7	105.4	116.3
M3	62.2	89.0	106.5	116.3
M4	71.5	78.1	103.2	113.1
M5	65.0	74.8	103.27	112.0

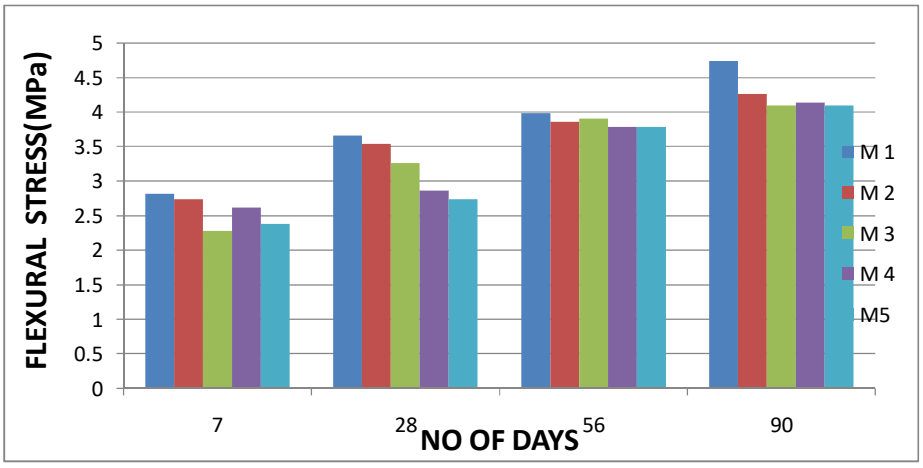

Fig.: Flexural Strength of Concrete

3. SPLITTING TENSILE STRENGTH

The splitting tensile strength gain is more at 20% replacement of fine aggregates with fly ash. At higher percentages the strength gain decreases and it is minimum at 50% replacement level. Plain concrete attains 67%, 79% and 89% strength at 7, 28 and 56 days of its splitting tensile strength at 90 days respectively shown in table 4.19. Whereas the fly ash concrete attains splitting tensile strength between 65-87%, 64-85%, 60-85% and 57-86% for mixes 'M2', 'M3', 'M4' and 'M5'.

The strength gain of fly ash concrete w.r.t. plain concrete at 28 days is comparable, so we can use bottom ash concrete for the construction application.

Splitting tensile behavior of Fly Ash concrete with age

Mix Type	Splitting Tensile Strength (MPa) (f_{st}) N/mm^2				f_{st7}/f_{st90}	f_{st28}/f_{st90}	f_{st56}/f_{st90}
	7 days	28 days	56 days	90 days			
M1	2.53	2.96	3.35	3.74	0.676	0.791	0.895
M2	2.39	2.86	3.17	3.64	0.656	0.785	0.870
M3	2.32	2.71	3.06	3.60	0.644	0.752	0.850
M4	2.14	2.60	3.03	3.56	0.601	0.730	0.851
M5	2.04	2.57	3.03	3.52	0.579	0.730	0.860

Table: Splitting tensile behaviour of Fly Ash concrete v/s Plain concrete

Mix Type	Strength gain = Strength of Fly Ash concrete x100 / Strength of Plain concreteat 28 days			
	7 days	28 days	56 days	90 days
M2	80.7	96.62	107.09	122.9
M3	78.37	91.5	107.09	121.6
M4	72.29	87.83	102.36	120.2
M5	68.91	86.82	102.3	118.91

It is observed from the tables that the splitting tensile strength of concrete decreases with the increase in the percentage of fine aggregates replacement with the bottom ash, but the splitting tensile strength increases with the age of curing. The rate of increase of splitting tensile strength decreases with the age.

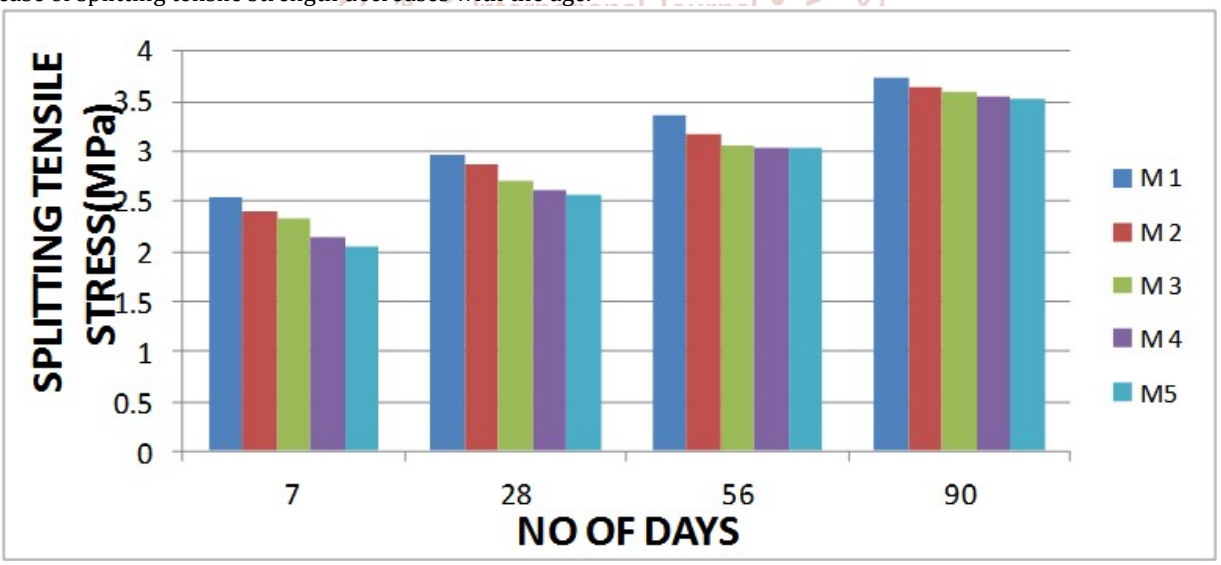

Fig.: Splitting Tensile Strength of Concrete

V. CONCLUSIONS

1. From the study it concludes M3 mix that is replacement of 30% of bottom fly ash give the better strength and after the M3 mix strength will be decreased.
2. Mix containing 30% and 40% bottom ash, at 90 days, attains the compressive strength equivalent to 109.13% and 105.17% of compressive strength of normal concrete at 28 days and attains flexural strength in the range of 112-116.3% at 90 days of flexural strength of normal concrete at 28 days. The time required to attain the required strength is more for fly ash concrete and fly ash concrete attains splitting tensile strength in the range of 118-122.9% at 90 days of splitting tensile strength of normal concrete at 28 days.

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