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EXPERIMENTAL INVESTIGATION ON PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND FINE AGGREGATE WITH FOUNDRY SAND

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Abstract: The main aim of the research is to study the effects of fly ash and foundry sand on strength and durability of concrete. Foundry sand is a major byproduct of metal casting industry. Hence an effort is made to use foundry sand as a partial replacement of fine aggregate and 10% fly ash as replacement of cement in concrete. For all the materials physical properties are carried out and mechanical properties such as compressive strength and split tensile strength of concrete were examined and compared with the normal concrete. M30 grade of concrete was designed to prepare the conventional mix. Fine aggregate was replaced with foundry sand as 10%, 20%, 30%, 40% & 50% in concrete of grade M30. Concrete cubes of 15 X 15 X15 cm and cylinders of 15 X 30 cm were casted and cured. Compressive strength test and Split tensile strength test were conducted on concrete cubes and cylinders at curing ages of 7 and 28 days. The result showed increase in the compressive and split tensile strength with increase in percentage replacement of foundry sand. Hence it can be concluded that foundry sand can be replaced with fine aggregate in concrete safely and thereby increase the strength of concrete.

KEYWORDS: Foundry sand (FS), Fly ash (F.A), PPC, Compressive Strength, Split Tensile Strength.

I. INTRODUCTION

Fly Ash (F.A): The quantity of fly ash produced from thermal power plants in India is approximately 80 million tons each year, and its percentage utilization is less than 10%. Majority of fly ash produced is of Class F type. Fly ash is used as a replacement of cement, as an admixture in concrete. So, concrete containing fly ash as partial replacement of cement will have no delayed early strength development, but rather will enhance its strength on long-term basis. This study explores the possibility of replacing part of cement with fly ash as a means of incorporating significant amounts of fly ash. Foundry Sand (FS): Foundry sand (FS) is one of an industrial byproduct. Ferrous and non ferrous metal casting industries produce approximately 2 million tons of byproduct of foundry sand in India yearly. It produces a large amount of by-product material during casting process. The ferrous metal casts in foundry are cast iron and steel, non ferrous metal are aluminum, copper, brass and bronze. Foundry industry use high quality specific size silica sand for their molding and casting process. These FS contain large amount of finess. The physical properties of FS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces and type of finishing process. Assessment of foundry sand has replaced by a fine aggregate on fresh and hardened characteristics of concrete revealed that compressive strength of concrete decreases with increase in foundry sand. Research has been conducted on fresh and hardened properties of M30 grade of concrete, by replacing foundry sand with a fine aggregate has revealed that the compressive strength increased normally at 7 & 28 days, however the strength gradually decrease as foundry sand content increases at 30%, which is similar for other kind of replacements. This sand has properties similar to that of the properties of natural sand used in the construction processes therefore it can be made use of by replacing it in place of natural sand in construction works. Up till now the innovative use of used foundry sand in concrete formulations as a fine aggregate replacement material was tested as an alternative to traditional concrete.

II. MATERIALS USED AND ITS PROPERTIES

A. Cement

Pozzolana Portland cement of 53 Grade conforming to IS 12269 – 1987 was used for the present experimental investigation. The cement was tested as per the Indian Standards IS 4031 – 1988.

Table I: Properties of Cement

S.No	Description	Result
1	Fineness of cement	93%
2	Normal Consistency	32%
3	Initial Setting time	30 min
4	Final Setting time	240 min
5	Specific gravity	3.10
6	Compressive strength 7 days 28 days	 29.24 N/mm2 38.88 N/mm2

B. Fly ash

It was sieved through 90micron sieve for the purpose of concreting samples. The various characteristics of fly ash were tested as per Indian Standards IS: 3812-1981.

Table II: Properties of Fly ash

S.No	Description	Result
1	Specific gravity	2.10
2	Fineness	310 m3/kg
3	Bulk density	0.749 gm/cm3

C. Foundry Sand

Foundry sand is made up of mostly natural sand material. Its properties are similar to the properties of natural sand. Thus it can normally be used as a replacement of sand. Source of FS for this research was from Dhana Lakshmi Minerals, Chennai.

Table III: Properties of Foundry Sand

S.No	Description	Results
1	Specific gravity	2.18
2	Water absorption	0.42%
3	Bulk density	1480 Kg/m3
4	Fineness modulus	1.89
5	Moisture content	0.11%

D. Fine aggregate

In this study locally available river sand which is free from impurities is used. Natural river sand confirming to Zone 2 grading as per IS: 383 – 1987 was used.

Table IV: Properties of Fine aggregate

S.No	Description	Results
1	Sand zone	Zone- II
2	Specific gravity	2.64
3	Water absorption	5%
4	Bulk density	1560 Kg/m^3
5	Fineness modulus	3.2
6	Moisture content	1.50%

E. Coarse aggregate

The aggregate fractions larger than 4.75mm are termed as coarse aggregates. The natural broken stone (coarse aggregate) used for the study was of 20mm size maximum. It is conforming to IS: 383-1970.

Table V: Properties of coarse aggregate

S.No	Description	Results
1	Specific gravity	2.72
2	Impact value	14.5
3	Water absorption	1.17%
4	Crushing value	17.9%
5	Bulk density	1935.3 kg/m^3
6	Moisture content	1.20%

III. METHODOLOGY AND ITS CONCRETE MIX

M30 grade of concrete was designed by following the specification given in the IS 10262: 1982.

Mix proportion obtained for M30 mix is 1: 1.20: 2.29. Water cement ratio (w/c) was selected as 0.38 based on conducting slump tests for different design trails. The evaluation of fly ash use as a replacement of cement material begins with the concrete testing. Concrete contains cement, water, fine aggregate and coarse aggregate. With the normal concrete, i.e. 10%, 20%, 30%, 40%, and 50% of the cement is replaced with fly ash, the results from the fly ash concrete is compared with results from a normal concrete without use of foundry sand as a fine aggregate. After gaining highest strength at mix 10% fly ash + 90% cement then the percentage of fine aggregate is replaced with foundry sand were 10%, 20%, 30%, 40% and 50% the results of concrete is compared with normal concrete and with use of foundry sand. Six cube samples were cast on the mould of size 15x15x15 cm and six cylinder samples were cast on the mould size of 15x30 cm. After about 24 h the specimens were demould and keep it in water curing tank. Tests were done as per following codes of Bureau of Indian Standards. The test for Compressive Strength on cubes were measured at 7 and 28 days of curing as per IS:516-1959, and test for Split Tensile Strength on cylinder was measured at 7 and 28 days of curing as per IS:5816-1999.

Table VI: Combinations of materials & casting of specimens

S.No	Mix	Cement %	Fly Ash %	Fine aggregate %	Foundry sand %	Coarse aggregate %	No of cubes and cylinders	
							7 days	28 days
1	AK 0	100	0	100	0	100	3	3
2	AK 1	90	10	100	0	100	3	3
3	AK 2	80	20	100	0	100	3	3
4	AK 3	70	30	100	0	100	3	3
5	AK 4	60	40	100	0	100	3	3
6	AK 5	50	50	100	0	100	3	3
7	AK 6	90	10	90	10	100	3	3
8	AK 7	90	10	80	20	100	3	3
9	AK 8	90	10	70	30	100	3	3
10	AK 9	90	10	60	40	100	3	3
11	AK 10	90	10	50	50	100	3	3

IV. EXPERIMENTAL RESULTS

The objective of this study was to determine the strength of concrete containing foundry sand (FS) as partial replacement of fine aggregate. For this purpose different test on harden concrete were conducted at the age of 7 and 28 days like compressive strength on 15X15X15 cm size cube and splitting tensile strength on 15cmX30cm cylinder. As per IS 516-1959 & IS 5816-1999 Total 132 numbers of specimen were tested and Results are tabulated as below:

Fig.1: Compressive strength test

Fig.2: Split tensile strength

Table VII: Average strength for test results (M30)

Mix ID	Compressive Strength (N/mm^2)		Split Tensile Strength (N/mm^2)	
	7 days	28 days	7 days	28 days
AK 0	38.37	45.12	2.43	3.30
AK 1	39.68	49.72	2.57	3.59
AK 2	34.20	44.72	2.07	3.33
AK 3	25.53	40.04	1.75	2.46
AK 4	22.32	33.49	1.42	2.26
AK 5	16.13	27.68	1.04	1.90
AK 6	39.65	47.55	2.51	3.46
AK 7	40.29	49.34	2.66	3.59
AK 8	41.37	49.73	2.74	3.63
AK 9	31.34	43.78	2.31	2.43
AK 10	30.56	37.21	2.08	2.30

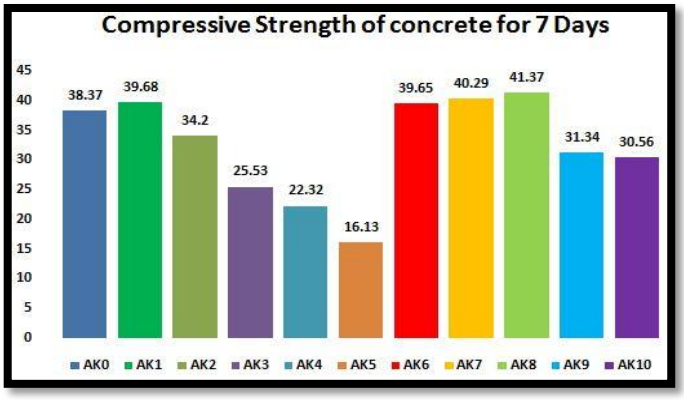

Fig.3: Compressive strength 7 days

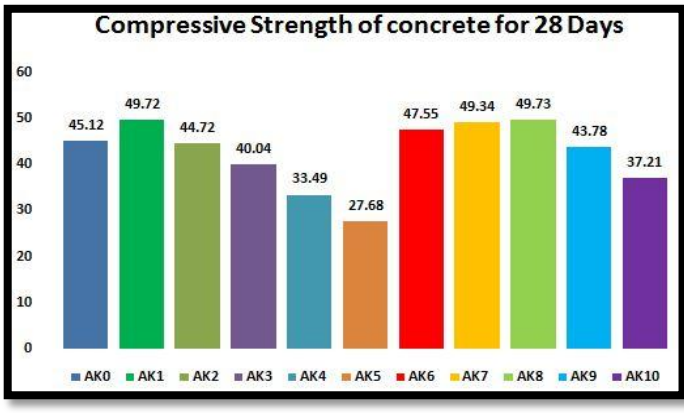

Fig.4: Compressive strength 28 days

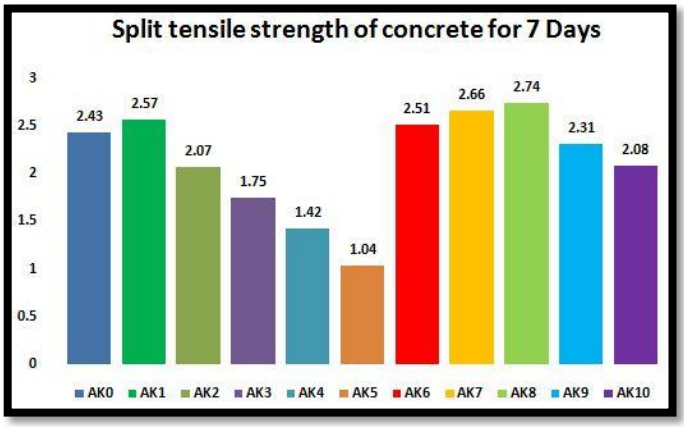

Fig.5: Split tensile strength for 7 days

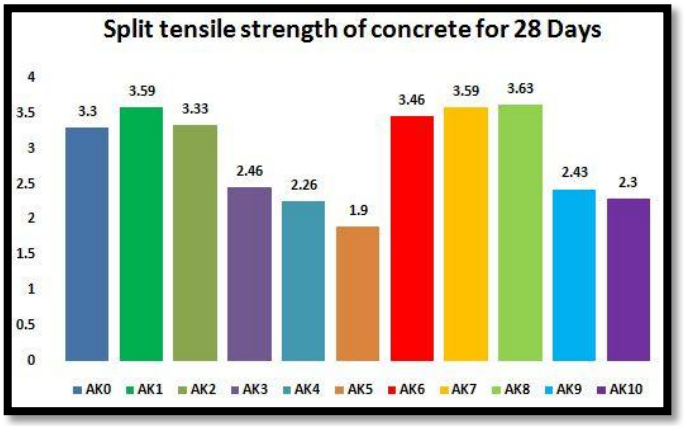

Fig.6: Split tensile strength for 28 days

V. CONCLUSION

Based on above results following conclusion were made regarding properties of concrete incorporating foundry sand. Compressive strength was higher than normal concrete for 30% FS and FA replacement at 7 and 28 days of curing ages. FS and FA replacements greater than 30% (M30) had lower strength than normal concrete. Split tensile strength of FS and FA concrete were comparable with normal concrete up to 30% FS and FA replacement. However, concrete with 40% FS and FA had lower split tensile strength than normal concrete. Use of waste foundry sand in concrete reduces the production of waste through metal industries i.e. it's an ecofriendly building material. The problems of disposal and maintenance cost of land filling is reduced. Application of this study leads to develop in construction sector and innovative building material. This shows that the concrete produced is economical.

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