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STRENGTHENING OF R.C COLUMN WITH FOUNDRY DUST AND CARBON STEEL

Ragavi. G[1], Sathish. P[2], Mohan. K[2], Neeladharan. C[2], Muralidharan. A[2]

P.G student, Department of Structural Engineering, Global Institute of Engineering and Technology, Vellore, Tamilnadu, India[1]

Assistant Professor, Department of Civil Engineering, C. Abdul Hakeem College of Engineering and Technology, Vellore, Tamilnadu, India[2]

***Abstract*— Metal foundries comprise of huge measure of sand as a piece of metal throwing procedure. The paper puts forward the partial replacement of natural river sand by foundry dust as an attempt towards sustainable development. It will help to find viable solution to the declining availability of River Sand to make eco-balance. In the present investigation the workability, strength and durability of concrete with foundry dust as replacement to river sand in proportions of 0%, 50% and 100% is studied on M30 grade concrete. The 50% replacement showed an increase in strength. Concrete columns were casted, tested and analysed for 7, 14 and 28 days. Strength and buckling behavior of RC column, yield failure comparison of concrete RC short column and buckling failure comparison of RC long column were examined.**

***Index Terms*— River Sand (RS), Foundry Dust (FD) , High Carbon Steel (HCS).**

I. INTRODUCTION

GENERAL

The column is one of the most important to every framed structures and it is used to transfer super structural loads on substructures. The important concrete raw material is cement, fine aggregate and coarse aggregate. Foundry dust is one of the waste materials in hundreds of stone crushing plants in our country generate several thousand tons of foundry dust every day .Moreover, the utilization of foundry dust, which can be called as manufactured sand after removal of micro fines below 150 micron size by sieving, has been accepted in the industrially advanced countries of the West as the river sand, which is one of the constituents used in preparation of cement mortar/concrete, has become highly expensive and scarce. Generally current period of construction the usage of foundry dust as partial replacement to river sand/natural sand in cement mortar/concrete.

The alternate reinforcement of carbon steel is used in reinforced concrete columns. The strength, buckling behavior of concrete column (carbon steel + foundry dust + coarse aggregate + binding materials) is determined by experimentally.

CARBON STEEL:

The bridge piers and apartment pillars are required to withstand heavy loads. The high carbon steel having high tensile strength compared with torsion steel reinforcement and it is consider to rectify the corrosion of steel and increase load carrying capacity of vertical member. This carbon steel having following ingradients

Carbon - 0.60%
Manganese Mn=0.50%
Silica Si = 0.30max

FOUNDRY DUST:

Foundry sand is also known as **molding** sand. It is a sand that when moistened and compressed or oiled or heated tends to pack well and hold its shape. It is used in the process of sand casting for preparing the mould cavity. Its principal use is in making molds for metal casting. The largest portion of the aggregate is always sand, which can be either silica or olivine. There are many recipes for the proportion of clay, but they all strike different balances between mold ability, surface finish, and ability of the hot molten metal to degas. The coal typically referred to in foundries as sea-coal, which is present at a ratio of less than 5%, partially combusts in the surface of the molten metal leading to off gassing of organic vapors. Sand casting is one of the earliest forms of casting practiced due to the simplicity of materials involved. It still remains one of the cheapest ways to cast metals because of that same simplicity. Other methods of casting, such as those using shell moulds, boast higher quality of surface finish, but higher cost.

II. PHYSICAL PROPERTIES OF CEMENT

The cement used was Ordinary Portland cement (53 grades of zuwari cement). The various laboratory tests conforming to Indian standard specification, IS: 4031-1996 specification, were carried out and the physical properties are shown in Table 1.

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These table shows percentage of fineness, consistency and initial and final setting time of OPC 53 grade cement as per IS 8112 – 1989.

Table – 1

PROPERTIES OF CEMENT

Property	Units	Results obtained	Specified value as per IS: 8112-1989
Specific gravity		3.13	3.15
Fineness (90 µ sieve)	%	6.72	<10
Normal consistency (%ge of cement by weight)	%	28.00	30
Setting Time i)Initial ii)Final	Minutes	28 560	30(minimum) 600(maximum)

FINE AGGREGATE:

Ordinary sand from river Stone having fineness modulus of 2.60 was used. Sand after sieve analysis (Table 2) conforms to zone II as per IS: 383-1970. Natural river sand of maximum size 4.75 mm was used as fine aggregate and was tested following IS: 383-1970. The sand confirmed to zone-II. Coarse aggregate were 20mm maximum nominal size. Both fine and coarse aggregates confirmed to BIS specifications.

TABLE.2 SIEVE ANALYSIS TEST FOR RIVER SAND

IS Sieve	Weight retained (kg)	Cumulative weight(kg)	% retained	% passed
4.75mm	0.00	0.00	0.00	100.00
2.36mm	0.64	0.64	64.00	36.00
1.18mm	0.14	0.200	20.00	80.00
600mic	0.162	0.362	36.2	63.30
300mic	0.425	0.787	78.7	21.30
150mic	0.185	0.972	97.2	2.30

FOUNDARY DUST:

The foundry dust used in this study was used as a partial replacement for fine aggregate and was obtained locally. The sample of foundry dust, shown in Figure e, was analyzed in terms of physical properties and sieve analysis results are presented in Table 3. The water absorption is presented in Table 4.

TABLE 3

IS Sieve	Weight retained (kg)	Cumulative weight(kg)	% of retained	% of passing
4.75mm	0.00	0.00	0.00	100.00
2.36mm	0.065	0.065	6.50	93.50
1.18mm	0.113	0.178	17.8	82.20
600mic	0.156	0.334	33.4	66.60
300mic	0.460	0.794	79.4	20.60
150mic	0.200	0.994	99.4	0.600

TABLE 4 WATER ABSORPTION TEST

SL.NO	PROPERTY	NATURAL SAND	FOUNDARY DUST
1	Specific gravity	2.63	2.48
2	% of water absorption	1.23	1.42

COARSE AGGREGATE:

Coarse aggregates are transported from stone quarries and 4.75mm to 20mm size as per IS sieves. It is most impartment ingredient of concrete.

TABLE 5 Physical properties of coarse aggregate:

SL.NO	PROPERTY	20MM COURSE AGG.
1	Specific gravity	2.72
2	%ge. of water absorption	0.96
3	Impact Value	2.56

CARBON STEEL

Tensile tests were performed in accordance with ASTMA 370 on three coupon specimens for each different diameter of steel bar. The yield strength was calculated averaging the results of each set of three samples. For Φ16, Φ18, and Φ22 bars, the average yield strength was 449, 559, and 511 MPa, respectively. Carbon steel was selected for both bars and laminates. Two different types of carbon steel bars were used. Type 1 bars with diameter equal to 9.5 mm, showed an average tensile strength equal to 2155 MPa, elastic modulus equal to 113.9 GPa, and an ultimate strain equal to 1.89%. For Type 2 bars with diameters equal to 8 mm, the average tensile strength was equal to 2014 MPa, elastic modulus equal to

108.3 GPa, and an ultimate strain equal to 1.86%. Figure 4 and 5 allow observation of the different surface properties of Type 1 and 2 bars.

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III. DESIGN MIX FOR M30 GRADE OF CONCRETE

DESIGN DATA

Grade of concrete =M30

Max. Nominal size of agg. =20mm

Characteristic strength f_{ck} =30Mpa

Type of cement = OPC 53 grade

Standard deviation = 5

Target Mean Strength = Fck + 1.65x S.D

Fck'= 30+1.65x5 = 38.15Mpa

MATERIAL PROPERTIES:

Specific Gravity of Coarse agg. =2.72

Specific gravity of fine agg. =2.63

Specific gravity cement =3.14

Specific gravity of water =1.00

Water Absorption

i) Coarse agg. =0.96

ii) Fine agg. =1.23

Mix Design

Slump value = 70mm

Water cement ratio = 0.40

(From IS 10262 – 1982 for M30 Grade

Percentage of total fine agg. = 36%

Select water content for 20mm agg. =186kg/m^3

Hence the volume of cement content =186/0.40

=465kg/m^3

Percentage of chemical admixture = 20%

Volume of all agg.(e) = 1-(0.11+0.140+0.006)

= 0.743

Volume of F.A = e x volume F.A x Sp.gravity of F.A.

=0.743x0.36x2.63

Volume of fine agg. = 620.98 kg/m^3

Volume of C.A = e x volume of ca x Sp.gravity of C.A

Volume coarse agg. = 1141.62kg/m^3

IV. RESULTS

TABLE 6

Cement content	Weight of water	Sand content	Coarse agg.
432.56kg/m^3	186kg/m^3	620.91kg/m^3	1141.62kg/m^3

Mix ratio for ordinary concrete 1:1.435:2.64 using fine sand

FOR FOUNDRY DUST:

1) **FD** is added for 30% of fine sand

2) **FD** is added for 50% of fine sand

TABLE 7

Cement content	Weight of water	Sand content	Coarse agg.
432.56kg/m^3	186kg/m^3	712.61kg/m^3	1141.62kg/m^3

Table 8 showing the results for workability of ordinary mix

S.No	Water-cement ratio	Height of the cone (in cm)
1	0.40	30.00
2	0.43	30.00
3	0.50	28.00
4	0.55	26.80

Table 9 Showing the Results of Workability for Mix Having Sand Replacement Percentage Of 30%

S.No	Water-cement ratio	Height of the cone (in cm)
1	0.40	30.00
2	0.43	29.00
3	0.50	27.50
4	0.55	26.00

Table 10 Showing the Results of Workability for Mix Having Sand Replacement Percentage Of 50%

S.No	Water-cement ratio	Height of the cone (in cm)
1	0.40	29.00
2	0.43	28.60
3	0.50	27.00
4	0.55	26.00

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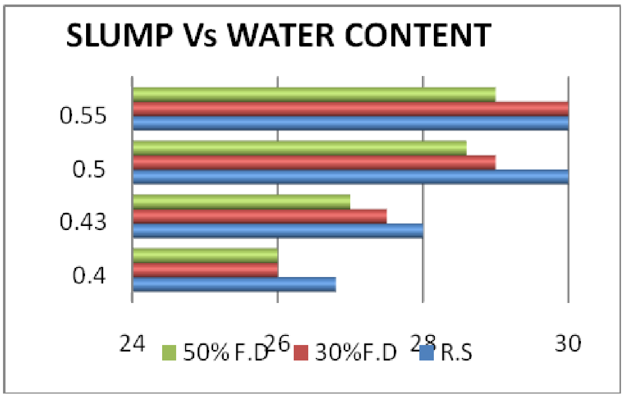

V. COMPRESSION AND SPLIT TENSILE STRENGTH:

Tests were conducted on concrete cubes using varying percentage of foundry dust to check for variations in compressive strength. The cubes were then transferred to curing tank for the required period of curing and tested. The results of compressive strength of M30 grade concrete cubes on 7th, 14th and 28th day are as tabulated. There was a significant improvement in the results of the compressive strength as in the case of other conventional foundry dust. But as a part of the study, for conducting the tests of splitting tensile strength, the cylinders were cast in the cylindrical mould of size 15 cm diameter and 30cm height. Two sets of ten cylinders of M30 mix were cast as control specimens. Later, different sets of cylinders were cast, with foundry dust content ratio as 50% and 100%. The cylinders were then, on the second day of casting, transferred to curing tank for a period of 7 days and 28 days and tested.

TABLE 11 COMPRESSION STRENGTH RESULT

Sl.no	7th day comp. Strength N/mm^2	14th day comp. Strength N/mm^2	28th day comp. Strength N/mm^2
1	29.72	30.53	35.62
2	30.24	31.64	34.83
3	29.53	33.27	36.44
Avg	29.60	32.15	35.63

TABLE 12 COMPRESSION STRENGTH RESULTS (30% FOUNDRY DUST)

Sl.no	7th day comp. Strength N/mm2	14th day comp. Strength N/mm2	28th day comp. Strength N/mm2
1	32.34	35.43	42.42
2	31.43	34.52	40.36
3	32.68	36.24	39.25
Avg	32.15	35.43	41.34

TABLE 13 COMPRESSION STRENGTH RESULTS (50% FOUNDRY DUST)

S.No	7th day comp. Strength N/mm^2	14th day comp. Strength N/mm^2	28th day comp. Strength N/mm^2
1	30.66	33.24	36.40
2	31.21	31.56	35.62
3	30.32	32.34	36.43
Avg	30.73	32.38	36.15

Graph Result: (Curing Days Vs Cube Strength)

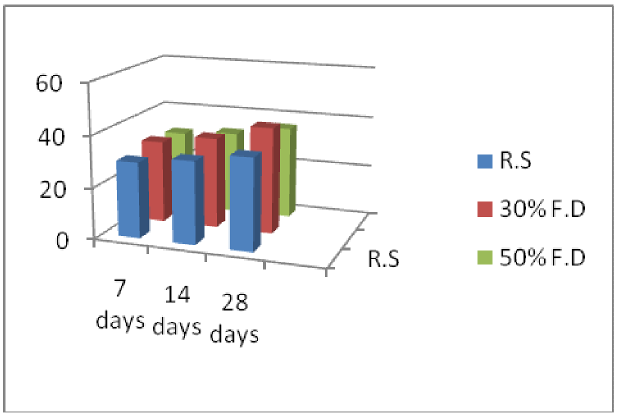

TABLE 14 SPLIT TENSILE STRENGTH TEST RESULTS.

S.No	7th day split tensile. Strength N/mm2	14th day tensile strg.. Strength N/mm2	28th day split tensile strg. Strength N/mm2
1	2.54	2.53	3.12
2	2.63	2.62	3.23
3	2.77	2.72	3.67
Avg.	2.64	2.62	3.34

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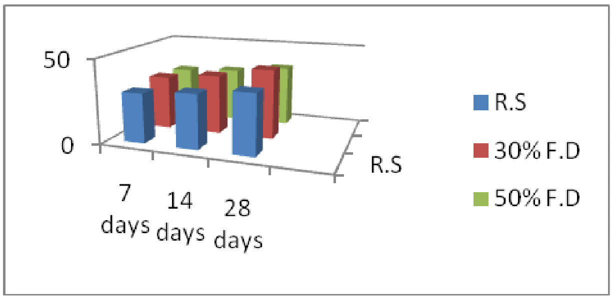
TABLE 15 SPLIT TENSILE STRENGTH TEST RESULTS. (30% FOUNDRY DUST)

S.No	7th day split tensile. Strength N/mm2	14th day tensile strg.. Strength N/mm2	28th day split tensile strg. Strength N/mm2
1	2.42	2.62	3.34
2	2.53	2.73	3.57
3	2.55	2.84	4.22
Avg	2.50	2.73	3.71

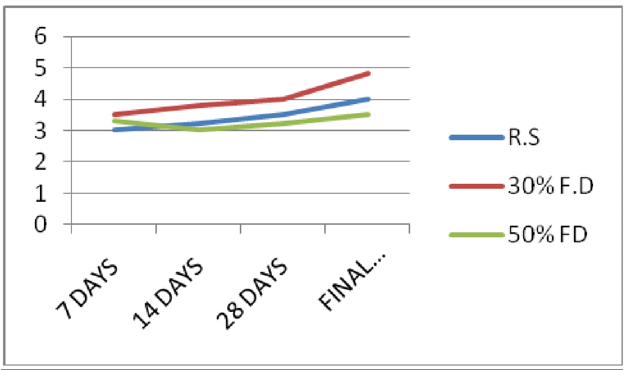
TABLE 16 SPLIT TENSILE STRENGTH TEST RESULTS. (50% FOUNDRY DUST)

S.No	7th day split tensile. Strength N/mm2	14th day tensile strg.. Strength N/mm2	28th day split tensile strg. Strength N/mm2
1	2.32	2.53	2.92
2	2.47	2.61	3.04
3	2.44	2.57	3.10
Avg	2.41	2.57	3.02

GRAPHS RESULT: (Curing days Vs Cylinder strength in N/mm^2)



GRAPH SHOWING EFFECTIVE % OF F.D REPLACEMENT



VI. CONCULUSION

The following conclusions are observed from above experimental programs and results from tabulated value. It is recommended that the FD with a substitution rate up to **30% is favorable** for the concrete production without adversely affecting the strength and durability criteria. The workability of concrete as per design mix M30 grade of concrete is arrived required value from foundry dust as fine aggregate. The different percentage of foundry dust as fine aggregate in concrete there is no change in slump value, but **if % of replacement increases the electrical resistance and sulphate resistance is affected**. The presence of sulphur traces in the FD increased the strength but on further replacement of FD , causing the deterioration of concrete. From the test results, it is suggested that FS with a substitution rate of up to 30% can be effectively used in concrete production without affecting the strength and durability properties of the concrete. The split tensile strength of concrete and compressive strength of cylinders reached required strength and result is shown in graph. This obtained strength is considered to design the compression member.

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