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Study on Strength Characteristics of Concrete by Replacing Sand Partially With the Foundry Sand

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Abstract: ***In the Present study we are investigating on mechanical (compressive strength and split tensile test) and durability (Resistance to sulfate attack test) properties of concrete by adding waste foundry sand as partial replacement of sand in various percentages, 10%, 20%,30% and 100% respectively. This report demonstrates the possibilities of using waste foundry sand as partial replacement of sand in concrete Tests were performed for compressive strength, split tensile strength and sulfate resistant test for all replacement levels of waste foundry sand at different curing periods (7-days & 28 days).***

Keywords: Waste Foundry Sand, Chemically Bonded Foundry Sand, Compressive Strength, split Tensile Strength.

1. INTRODUCTION

Concrete is a composite advancement material made basically with aggregate, cement and water. There are various arrangements of concrete, which give varied properties and concrete is the most by and largely used man-made advancement material all around the globe. Around five billion tons of concrete have been used around the general reliably. Concrete is for the most part used for making outline structures, foundations, square dividers, pavements, compasses/ spans, boulevards, runways, halting structures, dams, stores, footings and various more improvement purposes. Everyone has picked concrete in an infrastructural change in perspective of its specific qualities like malleable in the midst of fresh stage and cementing in the wake of the setting of concrete. This gives quality and robustness to the concrete structure.

2 .Waste foundry sand

Waste foundry sand is amazing silica sand with uniform physical qualities. It is a by-result of ferrous and nonferrous metal throwing businesses, where sand has been utilized for quite a long time as a trim material due to its warm conductivity. It is a by-item from the generation of both ferrous and nonferrous metal castings.

Types of Waste Foundry Sands

Two general types of binder systems are used in metal casting depending upon which the waste foundry sands are classified as clay bonded systems (Greensand) and chemically bonded system.

Material Properties

Physical Characteristics of Waste foundry sand

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Physical Properties

Table: Typical physical properties of spent green waste foundry sand

S.NO	DESCRIPTION	TEST RESULTS	IS CODE LIMITS	IS CODES
1	Specific gravity	2.39-2.55	2.3 – 2.7	IS 2386 PART III-1963
2	Fineness modulus	4.02 %	4.94 % - 4.97%	IS 383 : 1970
3	Moisture content	1%	1% - 3%	IS 2720 : 1973 (PART II)
4	Bulk density of sand	0.26 @ 6% water content	< 10 %	IS 2386 PART III-1963
5	Absorption, %	0.45	-	IS 2386 PART III-1963

Chemical Composition

Constituent	**SiO_2**	**Al_2O_3**	**TiO_2**	**CaO**	**MgO**	**Fe_2O_3**	**Na_2O**	**K_2O**	**SO_3**
Value (%)	83.8	0.81	0.22	1.42	0.86	5.39	0.87	1.14	0.21

3. Replacement of fine aggregate with waste foundry sand showed an increase in the split tensile strength of plain concrete up to 70% and then there was a marginal decrease in the strength.

1) There was an increase in flexural strength of concrete up to 50% replacement.
2) Thus, sand replaced with waste foundry sand up to 70% is suitable for the construction work

Test Results of Materials Used In Present Work

1. Portland Cement

Table Properties of cement

S.NO	**DESCRIPTION**	**TEST RESULTS**	**IS CODE LIMITS**	**IS CODES**
1	Specific gravity	3.12	3.10 - 3.15	IS: 269- 1989
2	Fineness modulus	4.16 %	<10 %	IS: 4031-1988)
3	Normal consistency	29 %	>26 %	IS: 4031 - 1988 (Part 4)
4	Initial setting time	60 mints	> 30 minutes	IS: 269- 1989
5	Final setting time	9 hours 45 minutes	< 10 hours	IS: 269- 1989
6	Compressive strength (53 grade)	34Mpa	>16 Mpa(3D)	IS: 12269-1987
		45 Mpa	>22 Mpa(7D)	
		58 Mpa	>53 Mpa(28D)	

Waste foundry sand

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Table Physical Properties of Waste foundry sand

S.NO	DESCRIPTION	TEST RESULTS	IS CODE LIMITS	IS CODES
1	Specific gravity	2.39-2.55	2.3 – 2.7	IS 2386 PART III-1963
2	Fineness modulus	4.02 %	4.94 % - 4.97%	IS 383 : 1970
3	Moisture content	1%	1% - 3%	IS 2720 : 1973 (PART II)
4	Bulk density of sand	0.26 @ 6% water content	< 10 %	IS 2386 PART III-1963
5	Absorption, %	0.45	-	IS 2386 PART III-1963

Magnesium Sulphate
Specimen details

Table proposed specimen details of cubes and cylinders

S.NO	AGE OF CONCRETE	PERCENTAGE	CUBES		CYLINDERS	
			For Water Curing	For Mgso4 Curing	For Water Curing	For Mgso4 Curing
1	7 Days	0%	3	3	3	3
		10%	3	3	3	3
		20%	3	3	3	3
		30%	3	3	3	3
2	28 Days	0%	3	3	3	3
		10%	3	3	3	3
		20%	3	3	3	3
		30%	3	3	3	3
3	Total		**24**	**24**	**24**	**24**
4	Grand total		**96**			

MIX DESIGN

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Mix design for M_{20} grade of concrete:

- Characteristic compressive strength f_{ck}= 20 N/mm^2
- Target mean strength $T_{MS} = f_{ck} + K \cdot S$ (IS 10262:2009) Where, K = Constant = 1.65

  S = Standard Deviation = 4.6 (according to IS 10262:2009)
- Target mean strength $T_{MS} = f_{ck} + K \cdot S$

  = 20+ 1.65 * 4.6 = 27.59 N/mm^2

  Therefore water content on the code provision IS10262:2009 clause no- 4.2, A-5, B-5 for the size of 20 MM aggregates = 186 lit/m^3 and 34% of fine aggregate according to IS 383-1970 clause No 4.3 table no -4

PROPERTIES OF MATERIALS

1 CEMENT

1) Specific gravity - 3.1247
2) Fineness of cement – 4.16%
3) Free moisture - NILL

2 FINE AGGREGATE

1) Specific gravity - 2.566
2) Fineness of cement – 4.02%
3) Free moisture – 1%
4) Water absorption - NILL

3 COARSE AGGREGATE 10 MM 20 MM

1) Specific gravity 2.64 2.681
2) Water absorption 0.81% 1.2

FINAL MIXES PROPORTION:-

CEMENT: FINE AGGREGATE: COURSE AGGREGATE: WATER

395.156: 625.531948 : 1178.039367 : 197.578

1 : 1.6 : 3 : 0.5

Table Proportions of Concrete Mixtures

Mix Design ation	Water (W) kg/m3	Cement (C) kg/m3	FA kg/m3	WFS kg/m3	CA kg/m3	Ratio of W:C:FA:WAS:CA
M_{20}	197.578	395.15	625.5	0	1178.0	0.5 : 1 : 1.58 : 0 : 2.98
M_{20}	197.578	395.15	562.9	62.5	1178.0	0.5 : 1 : 1.42 : 0.15 : 2.98
M_{20}	197.578	395.15	500.4	125.1	1178.0	0.5 : 1 : 1.26 : 0.316 : 2.98
M_{20}	197.578	395.15	437.8	187.6	1178.0	0.5 : 1 : 1.11 : 0.47 : 2.98

Test Methods

The procedures of methods used for testing concrete specimens are given below

Compressive Strength of Concrete:

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Table Compressive Strength of CM

S.NO	MIX	COMPRESSIVE STRENGTH (N/MM^2)		AVG. COMPRESSIVE STRENGTH (N/MM^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	24.4	33.33	23.8	33.47
		23.5	33.33		

Split Tensile Strength of Concrete:

Table: SPLIT TENSILE STRENGTH of CM

S.NO	MIX	SPLIT TENSILE STRENGTH (N/MM^2)		AVG. SPLIT TENSILE STRENGTH (N/MM^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	4.0	7.55	4.1467	7.55
		4.44	7.55		
		4	7.55		

Sulphate Resistance Test

Table: Compressive Strength of CM in MgSo4

S.NO	MIX	COMPRESSIVE STRENGTH (N/MM^2)		AVG. COMPRESSIVE STRENGTH (N/MM^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	25.78	32.88	28.74	33.47
		25.78	33.33		
		34.667	34.22		

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Table: SPLIT TENSILE STRENGTH of CM in MgSo4

S.NO	MIX	SPLIT TENSILE STRENGTH (N/MM^2)		AVG. SPLIT TENSILE STRENGTH (N/MM^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	6.22	5.77	5.776	6.21
		5.78	6.22		
		5.33	6.66		

RESULTS AND DISCUSSION

The experimental program included the following:

- Testing of properties of materials used for making concrete.
- Design mix (M20).
- Casting and curing of specimens.
- Tests to determine the compressive strength and split tensile strength and sulfate resistance of concrete.

Compressive Strength

Table: Compressive strength of concrete mixes of specimen size

S.NO	**MIX**	**COMPRESSIVE STRENGTH (N/MM^2)**		**AVERAGE COMPRESSIVE STRENGTH (N/MM^2)**	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	24.4	33.33	23.8	33.4793
		23.5	33.33		
		23.5	33.77		
2	10%	25.33	34.222	25.33	34.075
		25.78	33.333		
		24.88	34.64		
3	20%	27.555	35.56	26.0736	34.67
		23.555	33.78		
		27.111	34.67		
4	30 %	28.44	35.93	27.998	36.50
		26.667	36.56		
		28.89	37.02		
5	100 %	28.444	37.4	28.2133	37.23
		27.56	37.52		
		28.60	36.78		

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Splitting Tensile Strength

S.NO	MIX	SPLITTING TENSILE STRENGTH (N/MM^2)		AVG. SPLITTING TENSILE STRENGTH (N/MM^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	CM	4.0	7.55	4.1467	7.55
		4.44	7.55		
		4	7.55		
2	10%	4.44	8	4.44	8.29
		4.44	8.44		
		4.44	8.44		
3	20%	4.44	8.88	4.74	8.883
		4.0	8.44		
		5.78	9.33		
4	30 %	4.44	9.25	5.0369	8.98
		4.889	8.75		
		5.778	8.96		
5	100 %	4.25	8.95	5.25	9.1067
		5.85	9.25		
		5.65	9.12		

Resistance to Sulphate Attack of Concrete

MIX	**7 DAYS COMPRESSIVE STRENGTH (Mpa)**		**28 DAYS COMPRESSIVE STRENGTH (Mpa)**	
	IMMERSED	**CONTROL (7 Days)**	**IMMERSED**	**CONTROL (28 Days)**
0 %	28.74	23.8	33.47	33.4793
10 %	30.370	25.33	34.22	34.074
20 %	27.168	26.07	33.33	34.67
30 %	25.43	27.99	31.23	36.50
100 %	24.56	28.21	30.26	37.23

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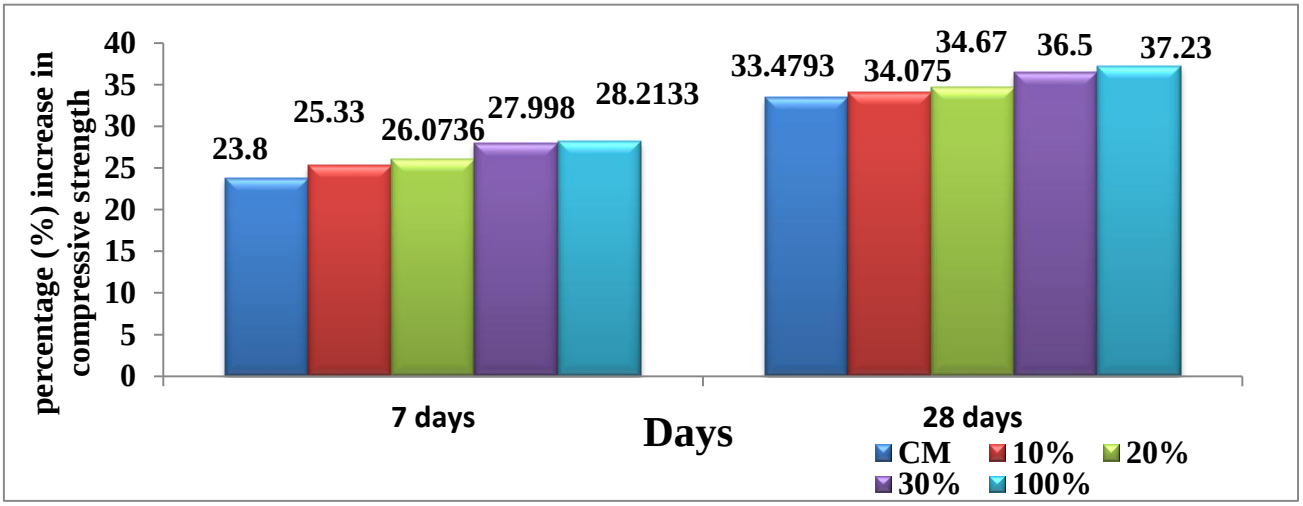

Fig: Percentage (%) increase in compressive strength of waste foundry sand concrete

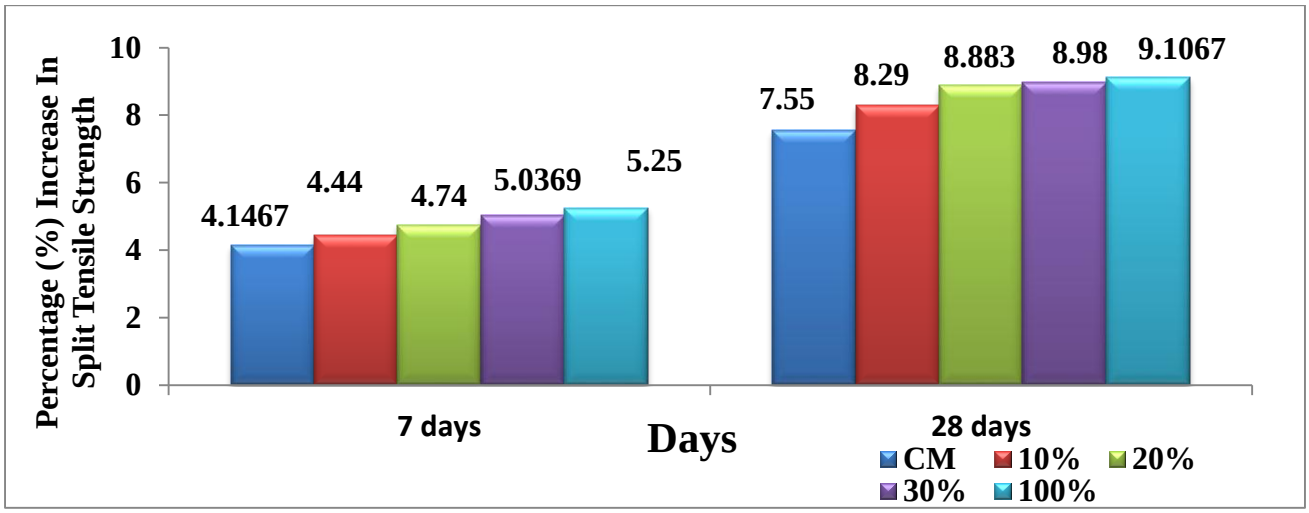

Fig: Percentage increase in spilled tensile strength of waste foundry sand concrete

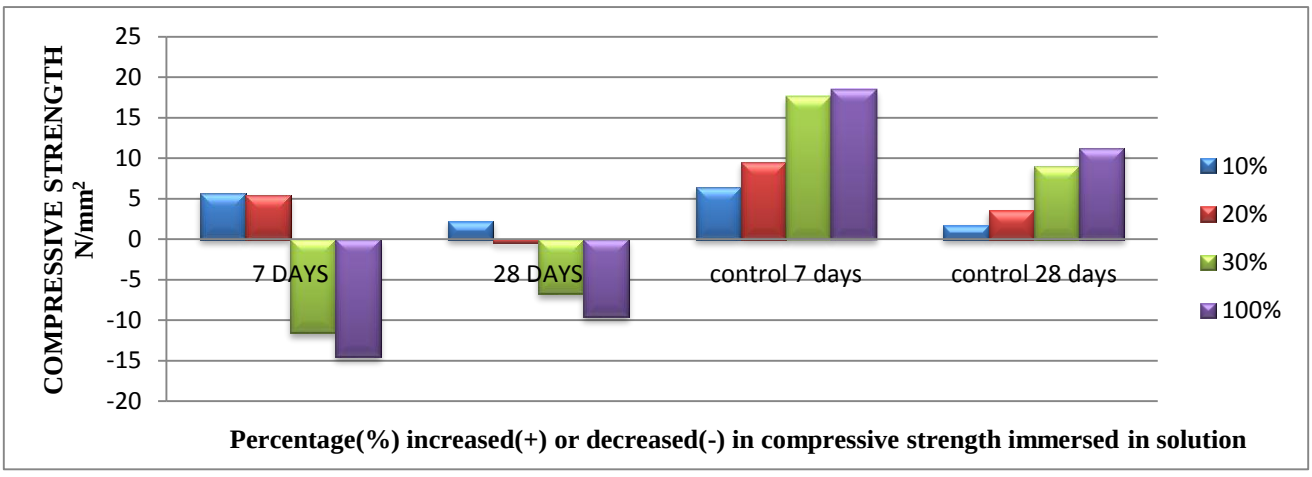

Fig: Percentage (%) increased (+) or decreased (-) in compressive strength after immersion in MgSo4 solution (50g/l) as compared with the compressive strength of specimens cured in normal water at same ages.

CONCLUSIONS

Compressive Strength

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The compressive strength increases as compared to control mix as the percentage of waste foundry sand are increased. After adding 10% waste foundry sand in the mix, there is an increase of 6.46% after 7 days, 43.1217% increase after 28 days. By adding 20% and 30% waste foundry sand, there is a large amount of increase in percentage i.e. 45.67%, 53.36%, 7 and 28 days respectively.

6.3 Split Tensile Strength

- The Split tensile strength also tends to increase with increase percentages of waste foundry sand in the mix.

6.4 Sulphate Resistance

- The compressive strength of 10% waste foundry sand specimens when immersed in 50g/l MgSo4 solution gives more strength than standard mix value when immersed in water at 7 and28days. But when the percentage of waste foundry sand increase to 20% and 30%, the compressive strength of the mix tends to decrease when compared with the compressive strength of specimen cured in water at same ages.

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