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An Experimental Investigation on Strength Properties of Plain Concrete Using Waste Foundry Sand

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ABSTRACT:

An acute shortage of river sand which is generally used as a fine aggregate in concrete has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower- and middle-income groups to own a house. There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are searching alternatives that can be used for construction.Ferrous and non ferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is a major byproduct of metal casting industry and successfully used as a land filling material for many years. In an effort to use the WFS in large volume, research is being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.This experimental investigation was performed to evaluate the strength properties of concrete mixtures, in which river sand was partially replaced with Waste Foundry Sand by weight. Compression test was carried out at the age of 28 days of curing. Split tensile test was performed at the age of 28 days. Flexural strength was tested at 28 days of curing. Test results indicate an increase in compressive strength of plain concrete by inclusion of WFS as a partial replacement of fine aggregate. The maximum strength was achieved at 40% replacement, after which there was loss in compressive strength, split tensile strength and Flexural strength decreased.

The results indicate in concrete. However, the partial replacement should not exceed 40% in plain concrete.

Keywords:
Plain Cement Concrete, Foundry Sand, bentonite, Compression strength, Split tensile strength, Flexural strength.

1. Introduction:

Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products and waste materials. Due to lack of land filling space and its ever increasing cost, utilization of waste material and by-products has become an attractive alternative to disposal. Waste foundry sand (WFS) is one of such industrial by-product. Ferrous and non ferrous metal casting industries produce several million tons of by-product in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is major by-product of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed “Waste Foundry Sand”. Foundry industry 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. Over 70% of the total by-product material consists of sand because moulds consist usually of molding sand, which is easily available, inexpensive, resistance to heat damage and easily bonded with binder and other organic material in mould. Foundry industry use high quality specific size silica sand for their molding and casting process. These WFS is black in color and contain large amount of fines.

The typical physical and chemical property of WFS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces (induction, electric arc and cupola) and type of finishing process (grinding, blast cleaning and coating).

Fig: 1 Waste Foundry Sand

2. Chemical Composition:

Chemical Composition of the foundry sand relates directly to the metal molded at the foundry. This determines the binder that was used, as well as the combustible additives. Typically, there is some variation in the foundry sand chemical composition from foundry to foundry. Sands produced by a single foundry, however, will not likely show significant variation over time.

Moreover, blended sands produced by consortia of foundries often produce consistent sands. The chemical composition of the foundry sand can impact its performance. Waste foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust.

Fig: 2 Deleterious Materials in WFS

3. Objectives of Present Investigation:

•To investigate the effect of waste foundry sand as a partial replacement of fine aggregate on strength properties of M20, M40 and M60 grades of concrete
•To reduce the problem of disposal of industrial waste.

4. Scope of the Present Work:

The present experiment is carried out to investigate on strength properties of concrete mixes of grade M20, M40 and M60 in which fine aggregate (river sand) is to be partially replaced with Waste Foundry Sand. Fine aggregate will be replaced with six percentages (0%, 20%, 40%, 60%, 80% and 100%) of WFS by weight. Some of the strength properties such as Compressive strength, Split tensile strength and Flexural strength of Plain Concrete.

5.Preliminary Investigation on Foundry Sand

5.1 Chemical Composition of Waste Foundry Sand

S.NO.	Constituent	Percentage
1	SiO_2	83.8
2	Al_2O_3	0.81
3	TiO_2	0.22
4	CaO	1.42
5	MgO	0.87
6	Fe_2O_3	5.39
7	Na_2O	0.87
8	K_2O	1.14
9	SO_3	0.21
10	Mn_3O_4	0.047

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5.2 Sieve Analysis Chart for Waste Foundry Sand

IS sieve size	Weight retained (gms)	Cumulative weight retained (gms)	Cumulative percentage weight retained	Cumulative percentage passing
4.75mm	7	7	0.70	99.30
2.36mm	10	17	1.71	98.29
1.18mm	10	27	2.72	97.28
600µ	80	107	10.77	89.23
300µ	493	600	60.42	39.58
150µ	293	893	89.92	10.08
Pan	100	993	-----	-----
		ΣF=	166.24	

5.3 Physical Properties of Waste Foundry Sand

A. S.No.	*B. Property*	Test Method	Test Results
1	Fineness modulus	Sieve analysis (IS 2386-1963 Part 2)	1.66
2	Specific gravity	Pycnometer (IS 2386-1963 Part 3)	2.35
3	Bulk density (kg/m^3)	(IS 2386-1963 Part 3)	1350

6. Concrete Mix Design:

In the present investigation using the properties of cement, aggregate concrete mix of M20, M40 and M60 grade was designed as per IS 10262-1982 the mix design procedure and calculations are presented in Appendix A the following proportions by weight were obtained.

GRADE OF CONCRETE	CEMENT	F.A	C.A	W/C Ratio
M 20	1	1.85	3.42	0.5
M 40	1	1.33	2.55	0.38
M 60	1	1.01	2.06	0.32

GRADE OF CONCRETE	CEMENT	F.A	C.A	WATER
M 20	350	650	1200	175
M 40	430	575	1100	164
M 60	520	530	1075	166

7. Results and Discussions

7.1 Compressive Strength of Concrete

Cube specimens were tested for compression and the ultimate compressive strength was determined from failure load, measured using compression testing machine. The average values of compressive strength of 3 specimens for each category at the age of 28 days are tabulated in the Table 4.2. The relative compressive strength of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades (M20, M40 and M60) of concrete.

Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for Different Grades of Concrete

Sl. No.	Mix ID	Compressive Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	26.89	48.69	69.76
2	WFS20	30.37	52.76	72.23
3	WFS40	33.86	54.65	73.83
4	WFS60	26.31	45.63	61.62
5	WFS80	21.95	41.57	57.41
6	WFS100	19.77	34.59	43.45

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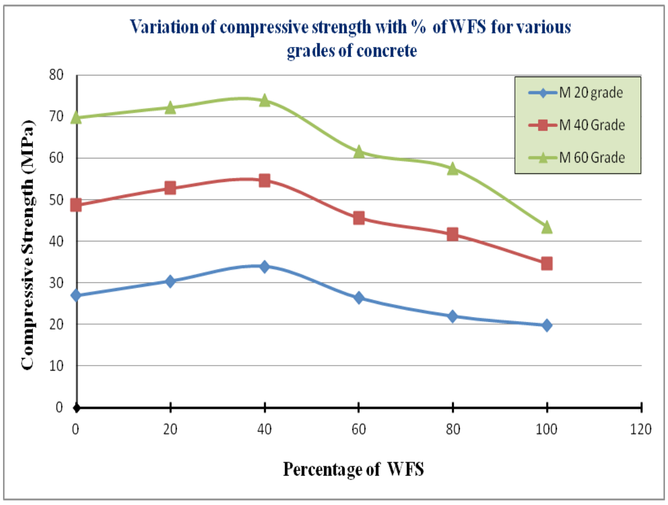
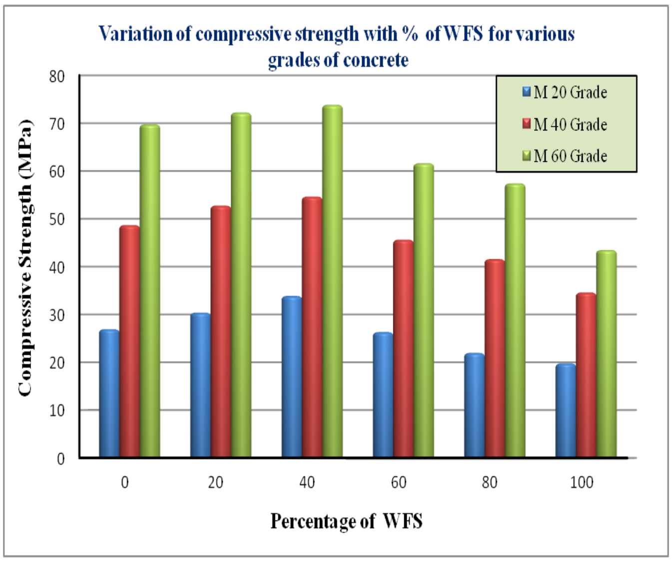


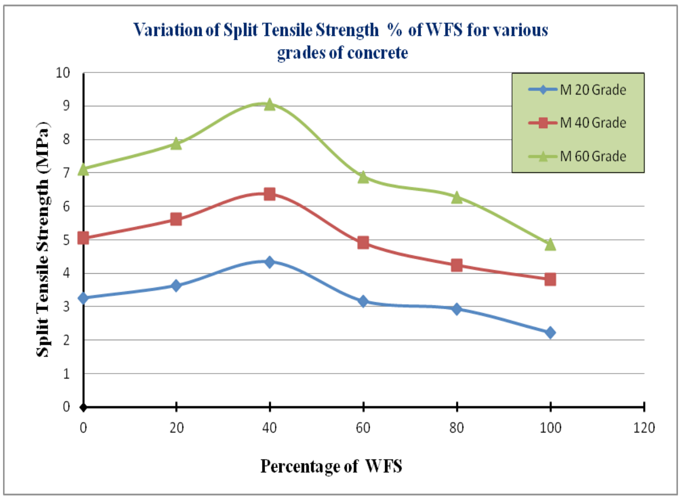


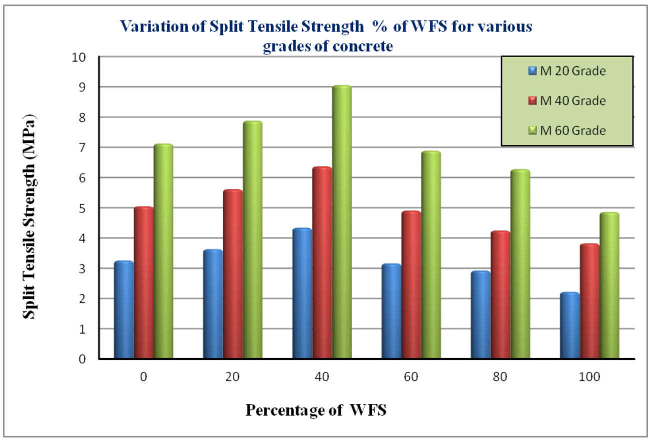
7.2 Split Tensile Strength of Concrete:

Cylinder specimens were tested for split tensile strength and strength was determined from failure load, measured using compression testing machine. The average values of split tensile strength of 3 specimens for each category at the age of 28 days are tabulated in the Table 4.3 and Figure 4.3 show the graphical representation of variation of split tensile strength of plain concrete of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades (M20, M40 and M60) of concrete.

Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for Different Grades of Concrete

Sl. No.	Mix ID	Split Tensile Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	3.26	5.05	7.12
2	WFS20	3.63	5.61	7.88
3	WFS40	4.34	6.37	9.06
4	WFS60	3.16	4.91	6.89
5	WFS80	2.93	4.25	6.28
6	WFS100	2.22	3.82	4.86





7.3 Flexural Strength of Concrete:

Beam specimens were tested for flexural strength using universal testing machine. The tests were carried out confirming to IS 516-1959; the specimens were tested under two point loading.

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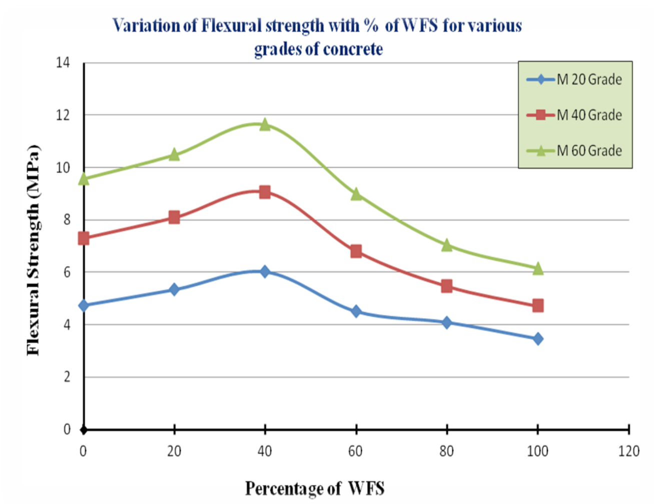
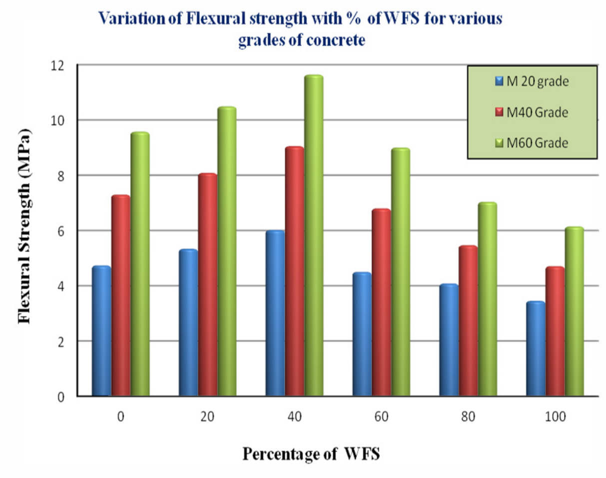
The average value of 3 specimens for each category at the age of 28 days is tabulated in the Table 4.4. Figure 4.4 shows the graphical representation of variation of flexural strength of plain concrete of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades (M20, M40 and M60) of concrete.

Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for different Grades of Concrete

Sl. No.	Mix ID	Flexural Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	4.73	7.30	9.57
2	WFS20	5.34	8.08	10.49
3	WFS40	6.02	9.05	11.64
4	WFS60	4.50	6.80	9.00
5	WFS80	4.08	5.47	7.04
6	WFS100	3.45	4.71	6.15





CONCLUSIONS :

•Increase in compressive strength of the concrete with increases in waste foundry sand up to 40% and the maximum compressive strength is achieved at 40% replacement of natural fine aggregate with waste foundry sand which comes to be 33.86 MPa for (M20 grade), 54.65 MPa for (M40 grade) and 73.83 MPa for (M60 grade) respectively and then there was a considerable decrease in the strength.

•Replacement of fine aggregate with waste foundry sand showed increase in the split tensile strength of plain concrete of grade M20, M40 and M60 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40% i.e. 4.34 MPa , 6.37 MPa and 9.06 MPa respectively.

•Replacement of fine aggregate with waste foundry sand showed increase in the Flexural strength of plain concrete of grade M20, M40 and M60 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40% i.e. of 6.02 MPa, 9.05 MPa and 11.64 MPa respectively.

•When percentage of waste foundry sand was increased beyond 40% the mix started losing its workability.

•Use of foundry sand in concrete can save the ferrous and non-ferrous metal industries disposal, cost and produce a ‘greener’ concrete for construction.

•Environmental effects from wastes and disposal problems of waste can be reduced through this research.

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•A better measure by an innovative Construction Material is formed through this research.

The used foundry sand can be innovative Construction Material but judicious decisions are to be taken by engineers

Future scope of work:

•Further research can be carried out to study the durability properties of concrete incorporating waste foundry sand as a partial replacement of fine aggregate.

•The investigation of concrete incorporating waste foundry sand can be carried out with addition of different types of fibers like steel fibers, recron fibers, synthetic fibers, dura fibers, natural fibers and glass fibers and with different aspect ratio.

•Further research can be carried out to study the properties of concrete with partial replacement of fine aggregate with waste foundry sand and partial replacement of cement with different mineral admixtures like GGBS, fly-ash, metakaolin, micro silica, rice husk ash etc, with addition of different percentages of fibers.

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