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Experimental Investigation on Partial Replacement of Fine Aggregate by Foundry Sand and Addition of Crimped Steel Fibers in Concrete

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Abstract:

Concrete is the most commonly utilized construction material due to its low cost, availability of raw materials, strength, and durability. In recent years, development has progressed, resulting in an increase in the cost of construction supplies. It's also due to a paucity of natural-resource materials. As a result, it's vital to seek out environmentally friendly alternatives. This highlights the importance of this research, which looks at the strength and durability of partially rebuilt concrete. Natural river sand is one of the most important ingredients in cement concrete production. Natural river sand, on the other hand, is both costly and scarce. Natural resource protection has become vital, as it is a prerequisite for any development. As a result of continuous population development, rapid industrialization, and accompanying waste disposal technologies, the rate of pollutant discharge into the atmosphere has increased in the current setting. Foundry sand is an industrial byproduct of the iron industry. An Experimental Study on M40 Grade Concrete with Partial Replacement of Fine Aggregate with Waste Foundry Sand in the range of 0%, 18%, 20%, 22% and 24%, with the addition of crimped steel fibers as a strength material in concrete.

Keywords: Sand replacement, Waste Foundry sand, Crimped steel fibers, Super plasticizer, Compressive strength, Flexural Strength, Split Tensile Strength.

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1 INTRODUCTION

Foundry sand is high-grade silica sand produced as a by-product of ferrous and non-ferrous metal casting. The ferrous family includes iron and steel, while the nonferrous family includes aluminium, copper, brass, and bronze. The type of casting method utilized and the firms that manufactured it determine the physical and chemical qualities of foundry sand. In the metal casting process, a lot of sand is consumed, which can be recycled and reused several times in a foundry. When the sand in the foundry can no longer be used, it is removed and referred to as "foundry sand." Each year, between 6 and 10 million tons of foundry sand are produced.

1.1 OBJECTIVES

- To explore the use of Waste Foundry Sand as Fine Aggregate and impact Strength on concrete made with various substitution levels.
- To check the impact of usage of Waste Foundry Sand in concrete on properties of new concrete and Strength boundaries.
- To reduce the cost of construction.

2 LITERATURE REVIEW

Anil Kumar, Bijo Sabu et.al (2019), the waste foundry sand is used as partial replacement of fine aggregate in M25 grade concrete. In this experiment study, waste foundry sand was replaced from 0 - 40% of fine aggregate. It is observed that the compressive strength of 10%, 20%, and 30% replaced concrete has similar properties as that of conventional concrete, but in case of 40% replaced concrete the compressive strength was decreased.
Somya Madvariya et.al (2019), in this study waste foundry sand is replaced by natural sand in different ratio

such as (0%, 10%, 20%, 30%, 40%, 50% and 60%) by weight.
From this experiment we get maximum compressive strength at 40% replacement of fine aggregate with waste foundry sand. The utilization of waste foundry sand will develop economical and sustainable concrete.
Mr. Aniket Abasaheb Bandal, Mr. Suraj Laxman Patil, et.al (2020), in this study, the effect of concrete using waste foundry sand as fine aggregate replacement. In this project work the concrete grade M30 was selected. The fine aggregate was replaced by waste foundry sand in various percentages (0%, 20%, 40% and 60%). The result showed that compressive strength, split tensile strength and flexure strength of concrete specimens increased providing maximum strength at 40% replacement on 7 and 28 days, and beyond that the strength parameters showed a decline in their respective values. Maximum compressive strength is gained at 40% replacement of fine aggregate which is higher than normal concrete (M30) by 21.44%.

3. MATERIALS

3.1 Cement: the ordinary Portland cement of 53 grade (Birla A1 premium) conforming to IS: 8112-1989 is used. Many tests were conducted on it.
3.2 Fine Aggregate: The regular waterway sand is utilized for this trial work was locally accessible and adjusted to Zone II according to IS: 383-1970. The sand was sieved through 4.75mm strainer what's more, having explicit gravity of 2.62.
3.3 Coarse Aggregate: Coarse totals which were locally accessible having the size of 20mm were utilized in the trial program. Testing of coarse total was finished to adjusting according to IS: 383-1970. The particular gravity of coarse total is 2.77.
3.4 Foundry Sand: The foundry sand was acquired from steel organization, dissolve and testing of sand was finished and explicit gravity of coarse total is 2.47.

3.5 Water: Portable tap water is used and conforming to standard specified in IS: 456-2000 is used.
3.6 Crimped steel fibers: they are low carbon, cold drawn steel wire strands intended to give substantial temperature and shrinkage break control, upgraded flexural support, further developed shear strength and increment the break opposition of cement. The quantity of fibers used in this study is 1% by weight of cement.

3.7 Super plasticizer: Conplast WL Xtra is used as a high range water reducer. 1% by weight of cement is used in the present investigation.

4 MIX PROPORTION

The mix proportion was done as per the IS 10262- 2019. The concrete cubes, beams, cylinder moulds were cured in the tank for 7, 14, and 28 days for compression strength test, Flexural strength test and tensile strength test.

Table 4.1: Concrete mix proportion for M40 design mix

Materials	Quantities
Cement	324.41 kg/m3
Water	139.50 kg/m3
W/C ratio	0.43
Super plasticizer	3.24
Coarse aggregate	1306.59 kg
Fine aggregate	713.43 kg

5. TESTS ON HARDENED CONCRETE

Tests were done as per following codes of Bureau of Indian Standards. The test for compressive strength, Split tensile test and Flexure test is done at 7, 14 and 28 days respectively.

5.1 COMPRESSIVE STRENGTH TEST

The compressive strength of various replacement amounts of WFS contents is tested at the end of 7 days, 14 days, and 28 days. Each batch produced three 150×150×150 mm cubes for this test. When fine aggregate was replaced with waste foundry sand in percentages of 0%, 18%, 22%, and 24%, the characteristics of concrete were compared. The compressive strength was then determined using the following formula:

$\sigma = \frac{P}{A}$ Where,

σ = Compressive Strength (N/mm^2).

P = Maximum load (N).

A = Cross section area of cube (mm^2).

Figure 1: Compressive Strength Test

5.2 SPLIT TENSILE TEST

The split tensile strength for various replacement amounts of WFS contents is measured after 7 days, 14 days, and 28 days. This test was carried out on cylinders with a diameter of 150mm and a height of 300mm from each batch. When fine aggregate was replaced with waste foundry sand in percentages of 0%, 18%, 20%, 22%, and 24%, the characteristics of concrete were compared.

Split Strength = $\sigma = \frac{2P}{\pi DL}$ (N/mm^2).

Where σ = Tensile Stress (N/mm^2).

P = Applied load at failure (N).

d = Diameter of cylinder (mm).

L = Length of cylinder (mm).

5.3 FLEXURE STRENGTH TEST

The flexural strength of various replacement amounts of WFS contents is tested at the end of 7 days, 14 days, and 28 days. Each batch of 100mmx100mmx500mm beams was subjected to this test. When fine aggregate was replaced with waste foundry sand in percentages of 0%, 18%, 20%, 22%, and 24% the characteristics of concrete were compared. Flexural strength is calculated using the following formula F= $\frac{Pl}{bd^2}$.

Where, F= Flexural strength of concrete (N/mm^2).

P= Failure load (in N).

L= Effective span of the beam (400mm).

b= Breadth of the beam (100mm).

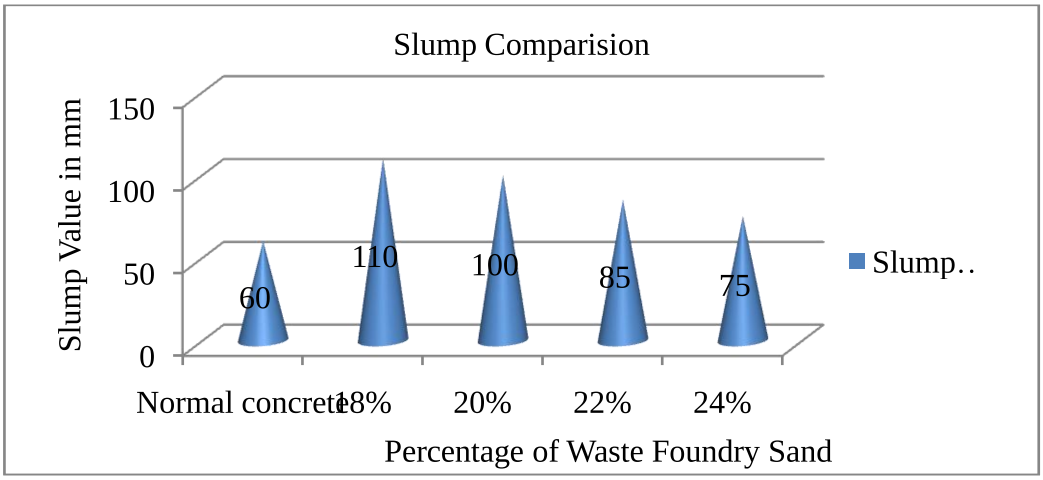
Figure 2: Flexure Strength Test

6 EXPERIMENTAL RESULTS

Results of M40 grade concrete with OPC-53 grade Birla A1 premium cement with addition of 1% of steel fiber and 1% of super plasticizer by weight of cement in the concrete for calculation of compressive strength, Split strength and Flexure strength at 7, 14 and 28 days of curing of concrete specimens.
Workability: It is the property of the concrete with which it can be mixed, placed and compacted easily.
Slump test: It is the test carried on the concrete when the concrete is at fresh state and the result showed that there is decrease in the slump value as the percentage of waste foundry sand increases in the concrete.

6.1 Slump Results

S.NO	% of Waste Foundry Sand			SLUMP VALUE(mm)
1	0%			60
2	18%	1% Steel fibers	1% Super plasticizer	110
3	20%	1% Steel fibers	1% Super plasticizer	100
4	22%	1% Steel fibers	1% Super plasticizer	85
5	24%	1% Steel fibers	1% Super plasticizer	75

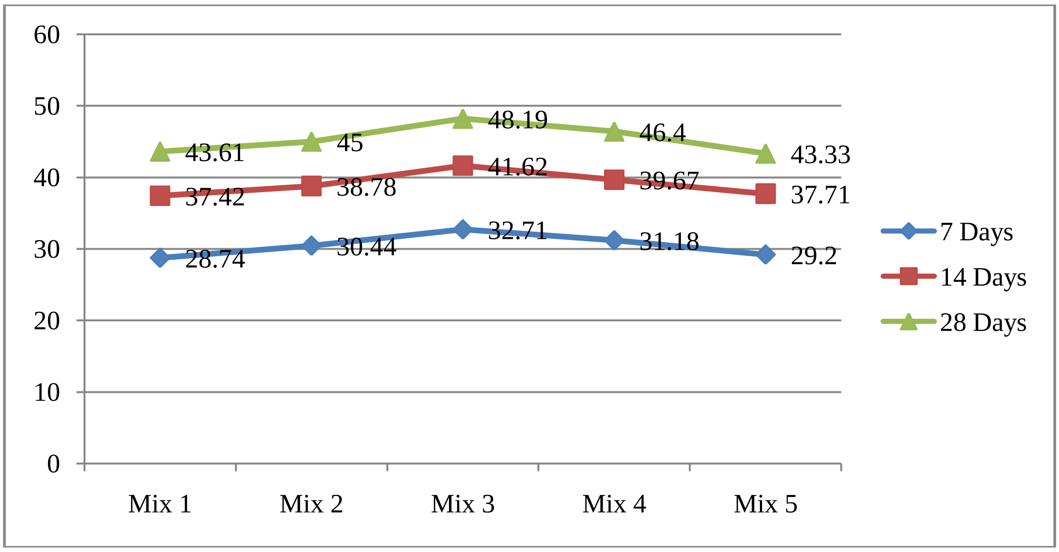


Graph1: Slump value VS various Percentages of Waste Foundry Sand

Table 6.2: Compressive Strength results

Sample	% of Waste Foundry Sand			Compressive Strength (N/mm^2)		
				7 Days	14 Days	28 Days
Mix 1	0%			28.74	37.42	43.61
Mix 2	18%	1% Steel Fibers	1% Super plasticizer	30.44	38.78	45.0
Mix 3	20%	1% Steel Fibers	1% Super plasticizer	32.71	41.62	48.19

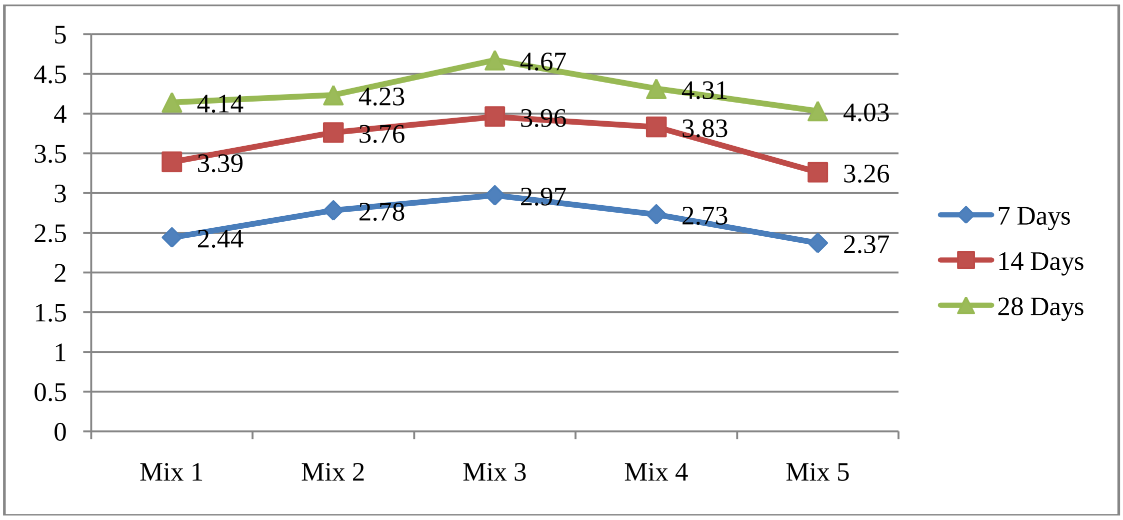
Mix 4	22%	1% Steel Fibers	1% Super plasticizer	31.18	39.67	46.40
Mix 5	24%	1% Steel Fibers	1% Super plasticizer	29.20	37.71	43.33



Graph 2: Compression Test Results

Table 6.3: Split Tensile Strength results

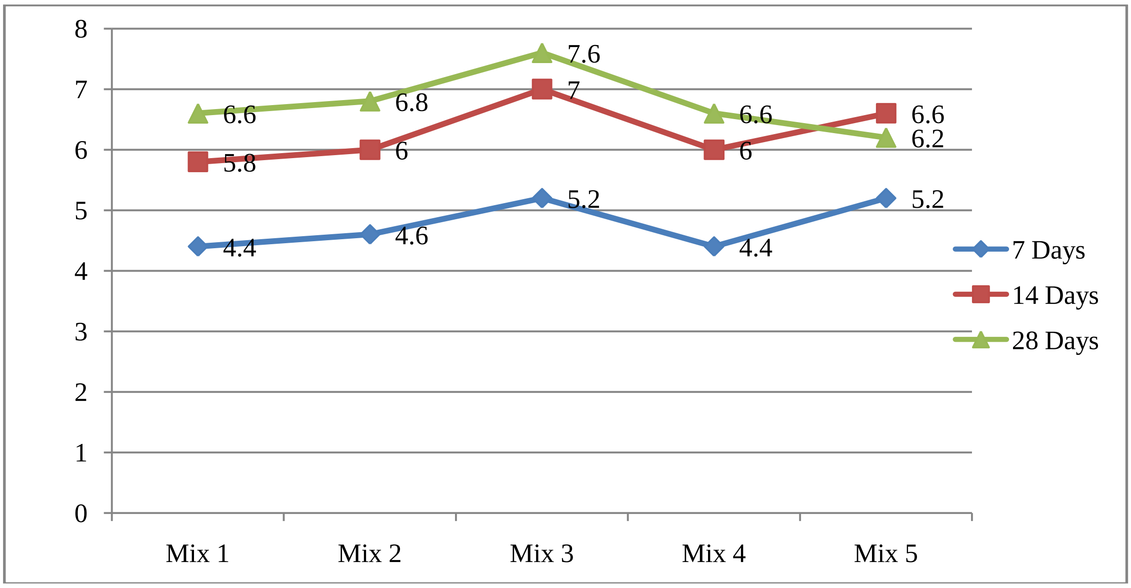
Sample	% of Waste Foundry Sand			Split Tensile Strength (N/mm^2)		
				7 Days	14 Days	28 Days
Mix 1	0%			2.44	3.39	4.14
Mix 2	18%	1% Steel Fibers	1% Super plasticizer	2.78	3.76	4.23
Mix 3	20%	1% Steel Fibers	1% Super plasticizer	2.97	3.96	4.67
Mix 4	22%	1% Steel Fibers	1% Super plasticizer	2.73	3.83	4.31
Mix 5	24%	1% Steel Fibers	1% Super plasticizer	2.37	3.26	4.03



Graph 3: Split Tensile Test Results

Table 6.4: Flexure Strength results

Sample	% of Waste Foundry Sand			Flexure Strength (N/mm^2)		
				7 Days	14 Days	28 Days
Mix 1	0%			4.4	5.8	6.6
Mix 2	18%	1% Steel Fibers	1% Super plasticizer	4.6	6	6.8
Mix 3	20%	1% Steel Fibers	1% Super plasticizer	5.2	7	7.6
Mix 4	22%	1% Steel Fibers	1% Super plasticizer	4.4	6	6.6
Mix 5	24%	1% Steel Fibers	1% Super plasticizer	4.2	6.6	6.2



Graph 4: Flexural Strength Test Results

7 CONCLUSIONS

1. It shows compressive strength increases at 20% replacement for 7 days by 5.9% and for 14 days by 3.6% and for 28days by 3.1% and after 20% there is a decrease in the compressive strength with the use of waste foundry sand.
2. It shows split tensile strength increases at 20% replacement when compared to normal concrete. For 7 days concrete there is an increase of strength by 13.9% and for 14 days by10.9% and for 28 days by 2.17% and after 20% there is fall of strength of the concrete.
3. It shows flexural strength increases at 20% of replacement of sand by waste foundry sand for 7 days of beam specimen there is an increase by 4.5% and for 14 days 3.4% and for 28 days 3% hence we can say that there is reduction in the strength as we replace the sand content by waste foundry sand.
4. The study show cases us to increase the waste foundry sand at higher percentages by addition of steel fibers.
5. The maximum compressive strength, split tensile strength and flexure strength is achieved at 20% replacement of sand by waste foundry sand.

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