International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 06 | June 2023 www.irjet.net p-ISSN: 2395-0072

Waste Foundry Sand as Partial Replacement of Fineaggregate in Concrete

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Abstract - *Concrete serves a major role as foundation for construction and development projects worldwide. Each component of concrete has an environmental influence. Overexploitation of these resources has led to an increase in their cost in various countries and are on the verge of extinction. Fine aggregate is one of the most expensive and excessively depleted resource among them. There is a need for an alternative to control and overcome this problem. Waste Foundry Sand (WFS) is one such alternative which is a byproduct of foundry industry. Usage of this industrial waste gives an additional benefit since the negative environmental impact on the landfills is reduced to a greater extend. Fine aggregate was volumetrically replaced with WFS (10%, 20%, 30%and 40%). The concrete was tested for workability, compression test, flexural test, split tensile test for 28 days. It was found that 30 % was the optimum percentage of replacement.*

Key Words: WFS, compressive strength, splitting tensile strength, flexural strength, workability

1.INTRODUCTION

Due to its exceptional durability, concrete is a significant building construction material that is utilized extensively globally. Large- scale removal of river sand increases the distance of the river bed, lowers the water table, causes land to be lost to river erosion, etc. Due to limits on river sand withdrawal making it more expensive, the construction industry is in danger of going out of business. In order for concrete to consolidate and provide the necessary strength, sand or fine aggregate is crucial.

Since WFS is more affordable & environmentally friendly than genuine sand, it is regarded as a superior sand substitute. Due to the rapid release of hazardous chemicals into the environment, the stockpiling of WFS in industries leads them to dispose of this waste in landfills. However, landfilling is not seen as the ideal choice because it undermines the UN's zero-waste aim and imposes costly disposal fees on enterprises.

1.1 Objectives

- To determine the workability of concrete replaced with fine aggregate by 0%, 10%, 20%, 30% and 40% of WFS
- To determine the optimum compressive, split tensile and flexural strength of concrete obtained on replacement
- To determine the optimum proportion of fine aggregate that is replaced with WFS

2. METHODOLOGY

- Material Collection
- Preliminary testing
- Mix Design (M25, Proportion 1:1.53 :1.92)
- Slump test for conventional concrete and for various replacements
- Casting of specimens with 0 %, 10 %, 20 %,30 %, 40% replacement of sand with WFS
- Curing for 28 days
- Compressive, splitting tensile and flexural strength test on specimens

3. EXPERIMENTAL PROCEDURE

3.1 Waste Foundry Sand

High grade, uniformly sized silica sand is utilized in the casting process and is also known as spent foundry sand, used foundry sand, or waste foundry sand. Moulds are created by bonding sand, and these moulds are used to cast both ferrous and non-ferrous metals. Foundry sand is regarded as waste when it ceases to be useful, or when it fails to bind with other binders and organic ingredients.

WFS is categorized based on the type of binder system utilized into Green Sand and Chemically Bonded Sand.

3.2 Properties

Owing to the presence of carbon, sand bonded with clay, also known as green sand, is black in colour. It is the moulding material that foundries most frequently utilize. The bulk material that withstands high temperatures is silica sand, which is bound by a clay layer. Plasticity is increased by water. The carbonaceous additions stop the "burn-on" or fusing of sand onto the casting surface. In addition, MgO, K_2O, and TiO_2 are found in trace amounts in green sands.

Chemically bonded sands are utilized in the construction of moulds as well as the manufacture of cores, where strong materials are required to withstand the heat of melting metal.

Fig 1: Green sand

Table -1: Constituents of Green Sand

Ingredient	%
Superior silica sand	85 – 95 %
Clay made of Bentonite	4- 10 %
Additives made of carbon	2 – 10 %
Water	2 – 5 %
Mg0, K_2O, TiO_2,	traces

Table – 2: Constituents of Chemically Bonded Sand

Ingredient	%
Silica sand	93-99%
Chemical adhesive	1-3%

4.MATERIALS COLLECTED

- Cement - OPC grade 53, Ramco Cements, Rs 410 / bag
- Fine aggregate -M – sand, Rs 50 / cft
- Coarse aggregate – 20 mm coarse aggregate, Rs 40/ cft
- Waste Foundry Sand – Autokast Ltd., Cherthala, Alappuzha

5.PRELIMINARY TEST RESULTS

The physical properties of cement, fine aggregate, WFS and coarse aggregate was tested as per respective IS codes. The various test results are given below:

Table- 3: Results obtained for Cement

Parameter	Result	Standard values
Specific gravity	3.14	3.1- 3.16
Initial setting time	52 minutes	Minimum 30 minutes
Final setting time	302 minutes	Maximum 600 minutes
Standard consistency	33 %	25 – 35 %

Table – 4: Results obtained for Fine aggregate, WFS

Parameter	Test Results		Range
	Fine aggregate	WFS	
Specific gravity	2.71	2.34	2.5 – 3.0
Fineness modulus	3.11	2.8	2.6 – 2.9
Bulk Density (kg / m^3)	1667	1533	1200 - 1750

Table- 5: Results obtained for coarse aggregate

Parameter	Result	Range
Specific gravity	2.71	2.5- 3.0
Fineness modulus	7.86	5.5-8.0
Bulk Density (kg / m^3)	1533	1200 - 1750

6.MIX DESIGN

M25 grade concrete with w/c 0.47 based on IS 456:2000
Quantity of materials for 1 m^3 of normal concrete are:
Cement weight requisite = 419.12 kg
Fine aggregate weight requisite = 643.1 kg
Coarse aggregate weight requisite = 806.3 kg

7.PREPARATION OF SPECIMENS

- While mixing on a watertight, non-absorbent surface, cement and fine aggregate should be well integrated and colour consistent.
- Once the coarse aggregate is evenly spread throughout the batch, add it and combine it with the cement and fine aggregate.
- When the appropriate consistency and homogeneity of the concrete are apparent, add water and mix the mixture.
- Apply oil to the moulds after cleaning.
- Layers of concrete around 5 cm thick should be placed inside the moulds.
- Use a table vibrator to compact each layer.
- Using a trowel, level and smooth the top surface.
- The test specimens are labelled, removed from the moulds, and stored in clear, fresh water until they are required.
- They are then kept for 24 hours in moist air.

Fig 2 : Mixing and compaction of specimens

Fig 3: Cubes, beams and cylinders

8. TEST FOR WORKABILITY

- Apply oil after cleaning the mould's inside surfaces.
- Place the mould on a flat, smooth surface that is free of pores.
- Four roughly equal layers of the prepared concrete mixture should be added to the mould.
- Over the mould's cross section, tamp each layer with 25 regular strokes of the rounded end of the tamping rod.
- The tamping should pierce the base layer for the next layers.
- With a trowel, remove any extra concrete and level the surface.
- Remove any mortar or water that has spilled out between the mould and the base plate.
- Raise the mould from the concrete carefully and steadily in a vertical direction.
- The slump is determined by subtracting the mould's height from its highest point.

Table 6. Slump values obtained after slump cone test

% of WFS	Slump value (mm)
0	50
10	18
20	26
30	40
40	33

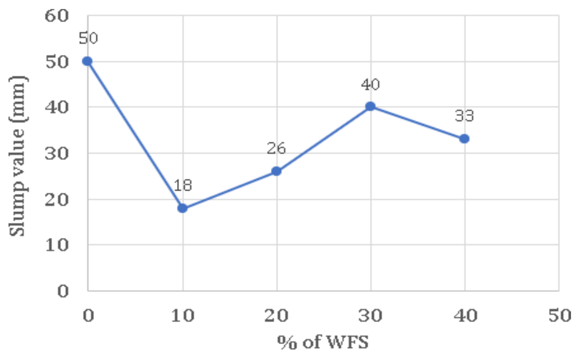

Chart 1: Variation in slump values

9.SPECIMEN TESTING

- For determination the compressive, splitting tensile and flexural strength of 0 %, 10 %, 20 %, 30 %, 40 % WFS, 15 cubes,15cylinders,15 beams (3 for each replacement) were casted.
- Compressive strength
  Size of cubes – 15 x 15 x 15 cm
- Splitting tensile strength
  Size of cylinders – diameter = 15 cm, height = 30 cm
- Flexural strength
  Size of beams – 50 x 10 x 10 cm
- They were evaluated in accordance with IS 516:1959 after 28 days of cure.

Table 7. Test result of compressive strength

% ofWFS	Average compressive strength (N/ mm^2)	% of increase
0	31.70	-
10	34.88	10.03
20	36.50	15.41
30	37.68	18.86
40	36.14	14.00

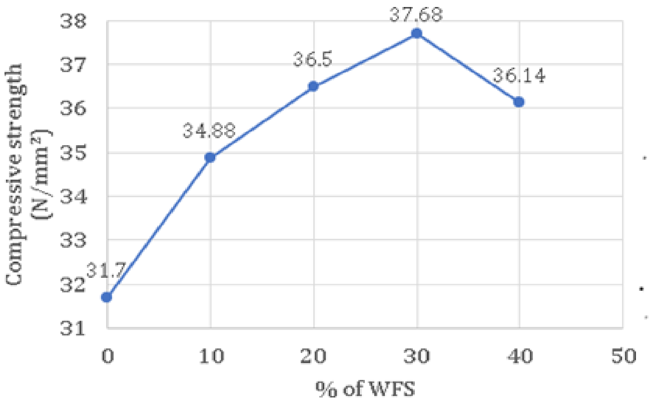

Chart -2: Compressive strength after 28 days

Inference

- Compressive strength of concrete increases with increase in replacement and is maximum at 30 %.
- Maximum compressive strength is 37.68 N/mm^2 and it is 18.86 % greater than strength of normal concrete.

Table 8: Test result of splitting tensile strength

% of WFS	Average splitting tensile strength (N/ mm^2)	% Increase
0	2.79	-
10	2.84	1.76
20	2.97	6.34
30	3.13	11.97
40	3.01	7.74

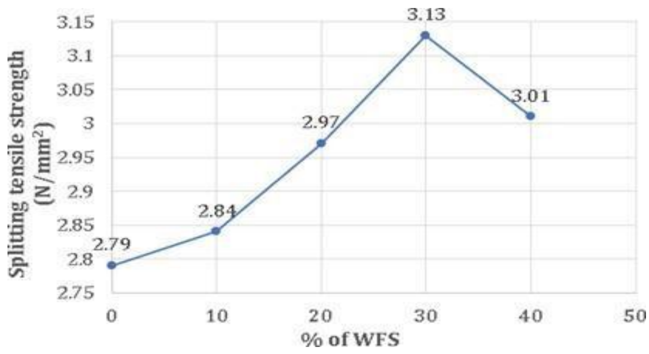

Chart- 3: Splitting tensile strength after 28 days

Inference

- Splitting tensile strength of concrete increases with increase in replacement and is maximum at 30 %.
- Maximum splitting tensile strength is 3.13 N/mm^2 and it is 11.97 % greater than strength of normal concrete.

Table 9: Test result of flexural strength

% of WFS	Average flexural strength (N / mm^2)	% Increase
0	2.55	-
10	2.68	5.09
20	2.89	13.33
30	3.17	24.31
40	2.99	17.25

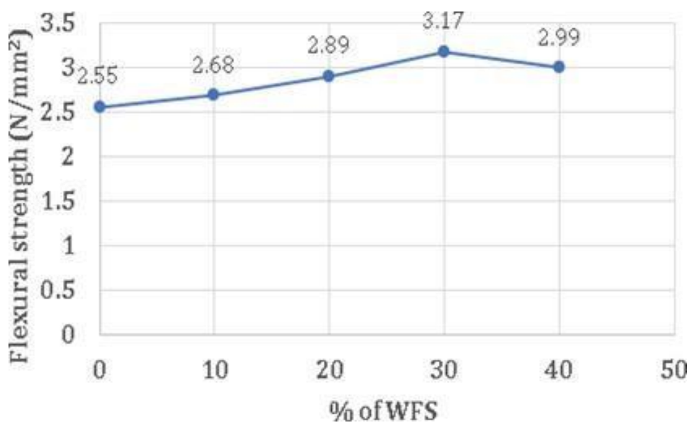

Chart – 4: Flexural strength after 28 days

Inference

- Flexural strength of concrete increases with increase inreplacement and is maximum at 30 %.
- Maximum flexural strength is 3.17 N/mm^2 and it is 24.31 % greater than strength of normal concrete.

10.RESULT AND DISCUSSION

- Maximum compressive strength is 37.68 N/mm^2 and it is 18.86 % greater than strength of normal concrete.
- Maximum splitting tensile strength is obtained as 3.13 N/mm^2 and it is 11.97 % greater than that of normal concrete.
- Maximum flexural strength is 3.17 N/mm^2 and it is 24.31% greater than strength of normal concrete.

11.CONCLUSION

- A 30 % replacement rate for fine aggregate using WFS was determined to be optimal.
- WFS was found to have a low workability. Hence as per IS 456, it can be used in roads with vibration and mass concrete foundations without vibration.
- Cost of 1 cubic metre of WFS replaced concrete was found to be less than that of conventional concrete.

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