Partial Replacement of Fine Aggregate by Used Foundry Sand in Concrete

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Abstract - *Now a day the worldwide consumption of sand as fine aggregate in concrete production is very high. Several developing countries have encountered some strain in the supply of natural sand in order to meet the increasing need of the infrastructural development in recent year, to overcome the stress and demand of river sand, researchers and practitioners in the construction industry have identified some alternative. One of them is foundry sand, it is a high quality silica sand with uniform physical characteristics and by product of ferrous and non-ferrous metal casting industry. It is proved that foundry sand used as fine aggregate will enhance the strength of concrete to a greater extend. This paper presents an experimental investigation on the properties of concrete in which fine aggregate is partially replacing by used foundry sand. The only variable considered in this study is volumetric replacement (10%, 20%, 30%, 40%, and 50%) of sand. Out of these 5 replacement levels best 3 were choose by trial works. The concrete was tested for slump test, compression test, flexural test, split tensile test for 7 & 28 days and acid attack test for 7 days.*

***Key Words*: foundry sand, ordinary Portland cement, compressive strength, split tensile strength, flexural strength, acid attack test.**

1. INTRODUCTION

Concrete is a major construction material that is used world-wide, because of its considerable durability than other construction materials. But now a day there is a scarcity in fine aggregates. So we have to look for different materials to reduce the quantity of basic natural materials in the concrete mix without changing any mix design procedure and consideration. The use of cheaper materials without loss of performance is very crucial to growth of developing countries. We cannot replace the whole basic materials in the concrete, but we can replace with other materials to some extent. So this study was undertaken to explore the possibility of waste foundry sand as a sand replacement in concrete.

The main objective of this experimental work is to compare the effect of foundry sand in concrete with the conventional concrete and to see the effect of foundry sand inclusion in concrete. Also the study is summarize based on compressive strength, split tensile strength, flexural strength and acid attack test of concrete with the replacement of fine aggregate by foundry sand.

2. LITERATURE REVIEW

Several studies have been carried out for analysis the properties of foundry sand and also the strength of concrete by in cooperating foundry sand in partial as a fine aggregate. Some of them were discussed below.

By Amitkumar D Raval et al., [1]

They carried out an experimental investigation on the topic 'effect of foundry sand as fine aggregate replacement in concrete' with an M25 grade at different limited curing periods (7 days, 14 days and 28 days). Fine aggregate was replaced with 10%, 20%, 30%, 40% and 50% of WFS by weight. The test result showed that the compressive strength increased with an increase in the amount of foundry sand, up to 30% replacement in concrete, beyond that it decreases.

By Dushyant Rameshbhai Bhimani et al., [3]

They carried out an experimental investigation on the topic 'Strength Behavior of Foundry Sand on Modified High Strength Concrete'. Fine aggregate was replaced with 0, 15, 25 & 35% of WFS by weight in concrete. Compressive strength, split tensile strength and flexural strength tests were carried out to evaluate the strength properties of concrete. Based on their result values they stated that, 25% replacement give higher strength. They also stated that using of foundry sand for construction work will be more effective and efficient than land filling.

By Eknath P. Salokhe et al., [4]

They investigated on the topic 'Application of Foundry Sand in Manufacture of Concrete'. They have done their experiment in M20 grade concrete. They replaced fine aggregate by foundry sand in 10, 20 & 30%. They tested the compressive strength and tensile strength of concrete specimen. From their test result, they concluded that Split tensile strength is maximum at 20% replacement. However Ferrous WFS gives slightly more strength than Non-Ferrous WFS. Compressive strength is maximum at 10% & 30% replacement for Ferrous & Non-Ferrous WFS respectively.

By Dr. B. Kameshwari et al., [7]

They investigated on the topic 'Strength of concrete incorporating waste foundry sand'. They had done their experiment in Grade M20. They replaced the fine aggregate by foundry sand in 10, 20, 30 & 40% by weight in concrete. From their test they concluded that Maximum compressive strength is obtained at 30% replacement and then decreases.

By Tarun R Naik et al., [10]

They investigated on the topic of 'Utilization of Used Foundry Sand in Concrete'. Here they tested the values of the Compressive strength & Split tensile strength of concrete of M30 grade with the replacements of 25 & 35% by weight of fine aggregate at different curing periods of 7 & 28 days. They concluded that the compressive strength values having 25% and 35% replacement of used foundry sand are lower than the concrete with no replacement. But it shows higher compressive strength when it is replaced by clean/new foundry sand.

3. MATERIALS USED

1. Cement:

Ordinary port land cement of 53 grade was used. It was tested as per IS specifications. Test results were tabulated below.

Table -1: Physical Properties of Cement

Physical Properties	Test Results
Normal Consistency	Around 30 minutes
Initial Setting Time	32 %
Specific Gravity	3

2. River Sand:

The locally available river sand used as fine aggregate which was passed through 4.75 mm sieve. It was tested as per IS standard.

Table -2: Physical Properties of River Sand

Physical Properties	Test Results
Specific Gravity	2.223
fineness	2.067
Density	880 Kg/m^3
Bulking of Sand	Maximum is at 4% of water

3. Used Foundry Sand:

Used foundry sand is a waste product from metal casting industry and was obtained from HMT Machine Tool Ltd., Kalamassery, Ernakulam. In this work, used foundry was used as fine aggregate partially.

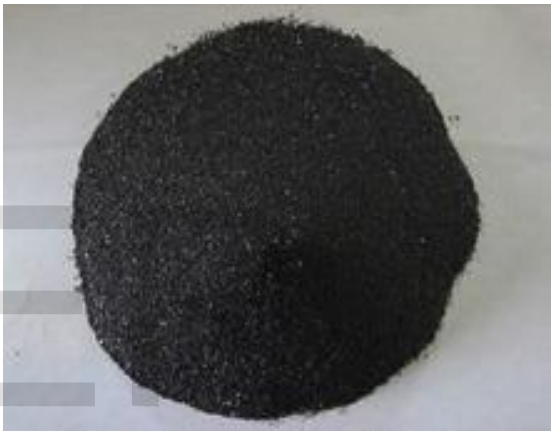


Fig: Foundry Sand

Table -3: Physical Properties of Used Foundry Sand

Physical Properties	Test Results
Specific Gravity	2.447
fineness	3.057
Density	1910 Kg/m^3
Bulking of Sand	Maximum is at 4% of water

4. Coarse Aggregate:

The coarse aggregate was locally available quarry having maximum size of 20 mm, were used in this research investigation for the preparations of concrete specimens.

Table -4: Physical Properties of Coarse Aggregate

Physical Properties	Test Results
Specific Gravity	2.08
Density	1110 Kg/m^3
Fineness Modulus	3.325

4. MIX DESIGN

Concrete mix design is a process of choosing suitable ingredient of concrete and determining the relative quantities with the object of producing economically as possible concrete of certain minimum properties, notable workability, strength and durability.

Table -5: Mix Design

Title	Specifications
Grade of Concrete	M25
Type and Grade of Cement	OPC 53 Grade
Size of Coarse Aggregate	20 mm
Specific Gravity of Cement	3
Specific Gravity of Coarse Aggregate	2.08
Specific Gravity of Fine Aggregate	2.223
W/C Ratio	0.50
Target Strength	31.6 N/mm^2

Mix proportion: 1:1.19:2:59

5. EXPERIMENTAL RESULT AND DISCUSSION

5.1. Casting of Concrete Specimen

The concrete specimens were casted in 1:1.19:2.59 ratios. For compression test, cube of size 150 mm was used. For split tensile test, mould of size 150mm diameter and 30mm height were used. As such for flexural test, beam of size 500x100x100 mm were used.

5.2. Trial Testing

For the trial casting of concrete, specimens with a replacement of fine aggregate by foundry sand as 10%, 20%, 30%, 40% and 50% were casted. The replacements were designated as F_1, F_2, F_3, F_4 and F_5 respectively and conventional concrete was designated as F_0. Then 7 day compressive strength of the casted specimens were computed. From the results, maximum compressive strength was obtained at 30% of replacement thus for further studies 20% (F_2), 30% (F_3) and 40% (F_4) were chosen.

5.3. Slump Test

This is a test extensively used in construction site. It is very useful in detecting the variation in the uniformity of mix of given nominal proportion. It also gives an idea of water cement ratio need for concrete to be used for different works

Table -6: Slump Value

Mix	F_0	F_2	F_3	F_4
Slump Value (mm)	50	60	55	70

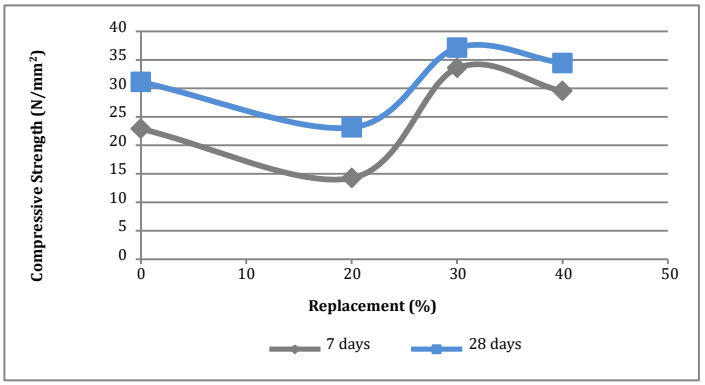
5.4. Compressive Strength

In this research, it was found that the compressive strength of concrete incorporating foundry sand depended on the percentage of foundry sand used. The compressive strength at 7 and 28 days of cured concrete specimen are shown in table 7. Concrete specimen of size 150x150x150 mm was used for compression test. 3 specimens with each proportion were subjected to compressive strength test. This test is done as per IS 516:1959.

Table -7: Compressive Strength Results

Compressive Strength Results		
Mix	**At 7 Days (N/mm^2)**	**At 28 Days (N/mm^2)**
F_0	23	31
F_2	14	23
F_3	34	37
F_4	30	34

Graph – 1: Compressive Strength Values



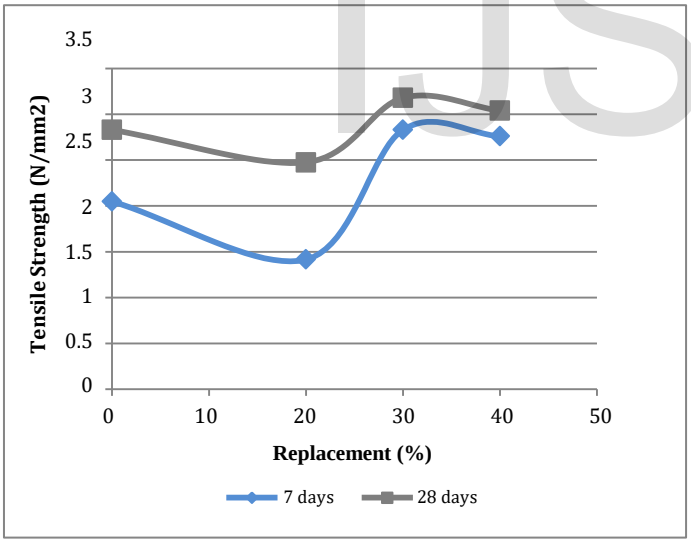
5.5. Split Tensile Test

Split tensile test was conducted as per IS 516:1959. A cylindrical concrete specimen of 150 mm diameter and 300 mm height is used. The tensile strength of concrete specimen cured at 7 and 28 days are shown in table 8. Tensile strength is varying with varying foundry sand proportion.

Table -8: Split Tensile Strength Results

Split Tensile Strength Results		
Mix	**At 7 Days (N/mm²)**	**At 28 Days (N/mm²)**
F_0	2.050	2.830
F_2	1.415	2.476
F_3	2.830	3.180
F_4	2.760	3.040

Graph -2: Split Tensile Strength Values



5.6. Flexural Test

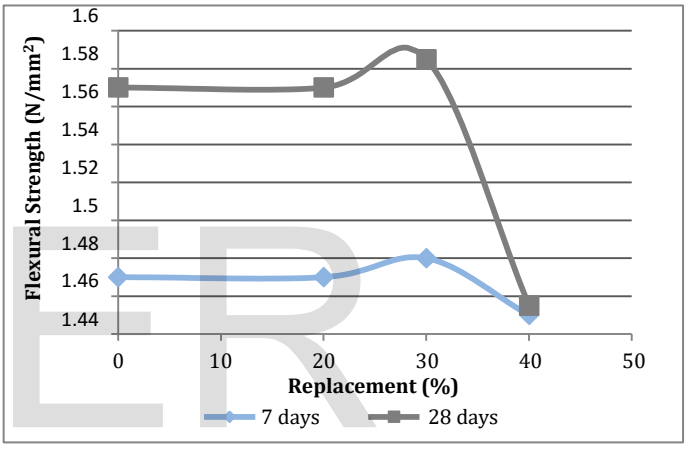
Flexural strength test is carried out on concrete beam

specimen of size 50x10x10 mm. Flexural test is conducted as per IS 516:1959. Three specimen of each percentage (20%, 30% and 40%) is subjected for flexural test. The flexural strength at 7 and 28 days of cured specimen is shown in table 9.

Table -9: Flexural Strength Results

Flexural Strength Results		
Mix	**At 7 Days (N/mm²)**	**At 28 Days (N/mm²)**
F_0	1.47	1.570
F_2	1.47	1.570
F_3	1.48	1.585
F_4	1.45	1.455

Graph -3: Flexural Strength Values



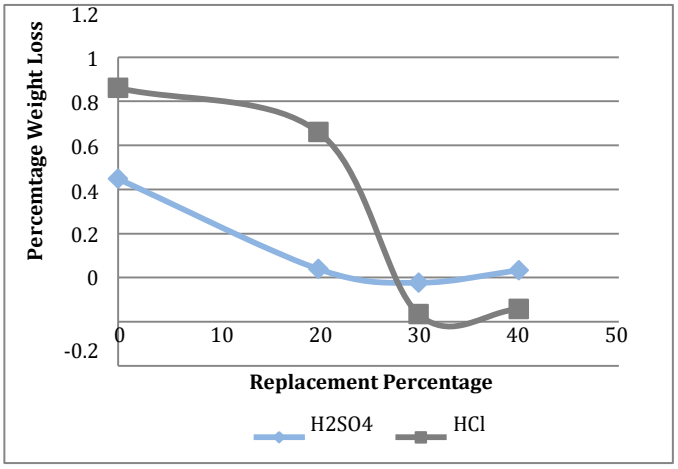
5.7. Acid Attack Test

The durability property of concrete is analyzed by immersing the concrete specimen in concentrated 1N HCl and 1N H_2SO_4 solution. The weight loss at 7th day was noted. The percentage weight losses in concrete specimens were tabulated in table 10. As the foundry sand percentage in concrete increases the weight loss is decreasing.

Table -10: Acid Attack Test Results

Acid Attack Test Results		
Mix	**Percentage Weight loss in H_2SO_4**	**Percentage Weight Loss in HCL**
F_0	0.648	1.060
F_2	0.239	0.861
F_3	0.177	0.034
F_4	0.233	0.057

Graph -4: Acid Attack Test Values



CONCLUSION

From our research it is concluded that,

The maximum compressive strength, flexural strength and split tensile strength is obtained for F_3 mix. And this is due to high density in F_3 specimen.

There is a compressive strength increase of 46.63% and 19.28% in 7 and 28 day curing respectively for F_3 specimen than conventional concrete.

Tensile strength of F_3 mix is increased by 38.04% and 12.36% at 7 and 28 days respectively compared to conventional concrete.

There is a slight increase in flexural strength of 0.68% and 0.955% at 7 and 28 days respectively in F_3 specimen compared to conventional concrete.

In acid attack test, weight loss decreased as the composition of foundry sand increases. This is due to increase in siliceous content in foundry sand.

There is a cost reduction of 2.56% at the level of 30% replacement as compared to conventional concrete.

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