

Replacement of Fine Aggregate with Foundry Sand and Refractory Waste

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ABSTRACT: Generally many materials are used to replace constituents in concrete to improve its strength and other properties. Fine aggregate replacement is remarkable one, since the requirement for river sand is increased rapidly and so the cost. Foundry sand is the well-known replacement for fine aggregate as it matches with the chemical properties of cement upto some extent and it is also easily available freely as a waste from various industries. Foundry sand can be used in concrete to improve its strength and other durability factors. It is also a waste produced from industries which when not used cause environmental depletion. Previous studies are made in this idea and found that 15% replacement will give the same result as that of conventional concrete. In addition to this refractory waste is also the one which can be used to replace fine aggregate. It can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. This research was conducted to investigate the performance of fresh and hardened concrete containing discarded foundry sand and refractory waste as a replacement of fine aggregate. In our project we used the foundry sand and the refractory waste in the following proportion: refractory waste (15% constant); foundry sand 10%, 20%, 30% and 40%. Concrete performance was evaluated with respect to compressive strength, tensile strength and modulus of elasticity.

KEYWORDS: refractory waste, Foundry sand, strength

I. INTRODUCTION

Most metal casting sand (FS) is a byproduct of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a molding material because of its unique engineering properties. It is high quality silica sand with uniform physical characteristics. Approximately 100 million tons of sand are used in production and are discarded as solid waste. The current urge for the foundry industries is to reduce the cost of disposal and also to minimize the space occupied for landfill.

A refractory material is a material that retains its strength at high temperatures. They are used in linings for furnaces, kilns, incinerators, and reactors. In the concern to the industrial pollution, safety and waste management the wastes from the foundry industries are recommended to use some other fields like in construction materials, flow filling, ceramic industry, bricks (Hollow blocks), embankment construction & repair, mineral wool products etc., it will get profit & production cost of the industry where sand is to be reused will get reduced & by this way we can achieve a sustainable disposal of spent foundry sand.

The total of four trial mixes, each containing constant proportion of 15% refractory waste and varying with 10% partial replacement with foundry sand like 10%, 20%, 30% and 40% respectively.

These mixes were tested to determine compressive strength, tensile strength, flexural strength, modulus of elasticity and poisson's ratio.

II. LITERATURE REVIEW

Several researchers investigated the use of WFS and RW in various civil applications. Bahoria reported Cement of natural sand in concrete by waste products: a state of art, usage of waste products in the concrete in certain ratio increases the performance of the concrete.

T.R. Naik conducted an investigation to evaluate the performance of foundry by-products in concrete & masonry products. Based on the test results they concluded that the addition of foundry sand decrease the workability of concrete.

Khatib investigated some mechanical and fresh properties of concrete containing waste foundry sand (WFS). With reference to the properties investigated, they reported that (a) There is systematic loss in workability as the foundry sand content increases which was found by observing the percentage decrease in slump with increase in WFS. (b) The compressive strength of concrete also decreases with increasing amounts of WFS. (c) The control mix shows the least water absorbed and generally the water absorption increases as the WFS in the concrete increases. (d) The shrinkage increases as the WFS in the concrete increases and this increase is systematic.

Saveria Monosi, Daniela Sani and Francesca Tittarelli, investigated the properties of mortars and concretes containing different dosages of used foundry sand (UFS) as partial replacement of sand in both fresh and hardened conditions. According to the obtained test results, they concluded that, (a) UFS reduces the workability when added as natural sand replacement (at same w/c); higher amount of superplasticizer is required in order to maintain the same workability. The control mortar sample with w/c equal to 0.50 requires an addition of 0.5% by cement weight, while mortars containing UFS need an addition up to 1.8%. Similarly, concrete mixture containing UFS needs a super plasticizer dosage. (b) Fresh mixture unit weight and entrapped air content do not point out any relevant differences with and without foundry sand. (c) Despite the absolute value of compressive strength, the negative influence ascribed to the presence of UFS in reducing the compressive strength seems greater when lower w/c is adopted. Although the absolute value of the compressive strength is high at low w/c ratio, as usual, it achieves negligible advantages when w/c is lower than 0.50.

III. MATERIALS USED

3.1 Cement:

Cement can be defined as the bonding material having cohesive and adhesive properties which is capable to unite the different construction materials and form the compacted assembly. Ordinary Portland cement is used of grade 43. Portland cement is the main ingredient in concrete, which is made by adding rock, sand and water to form paste that hardens.

Specific gravity = 3.15

Fineness = 7%

Consistency = 33%

Initial setting time = 85min

Final setting time = 197min

3.2 Fine aggregate:

The particles that are passing through 4.75mm sieve and retained on 75 μ m are called as fine aggregate. A usual sand of size passing 2.36mm sieve is used. Its specific gravity is 2.7 and it belong to zone II. Its bulk density is recorded as 1520 kg/m³.

3.3 Coarse aggregate:

The particles that are predominantly retained on the 4.75mm sieve are called as coarse aggregate. Aggregate used are angular and well graded and are of size 20mm. Its specific gravity is 2.7 and its bulk density is recorded as 1750 kg/m³.

3.4 Water:

Water which is free from alkalinity, oils, organic wastes, harmful chemicals and any other substances that affect the quality of concrete is used in the production of concrete. The pH of the water used should be in the range of 6.5 to 7.5.

3.5 Foundry sand:

The raw materials used for making sand molds for metal castings are usually recycled. After a repeated use they lose their characteristics, thereby becoming unsuitable for further use in the manufacturing process. All these materials are then discarded as a waste.

The industrial waste that cause environmental pollution and occupies large space as solid waste. It can be reused as fine aggregate replacement for certain extent and reduce the cost of concrete and also reduce the waste.

Here we are using the foundry sand in various proportions as 10%, 20%, 30% and 40%.

3.6 Refractory waste:

A refractory brick is built primarily to withstand high temperature, but will also usually have a low thermal conductivity for greater energy efficiency. After certain period these bricks are not usable and thrown as a waste. It can be used to replace the fine aggregate upto certain percent.

Here we are replacing 15% of total volume of fine aggregate with refractory wastes.

3.7. Mixing and casting:

We used the standard mix of M20 and M25 concrete, with the reference to IS10262. We casted few cubes of size 150mm and cylinders of 150mm dia and 300mm height and prism of size 500mm x 100mm x 100mm. We casted 3 samples in each shapes and each proportion of waste foundry sand that are partially replaced for river sand. Every sample has constant 15% of refractory waste and increment of 10% of foundry sand at each set of moulds.

3.8 Curing and Testing:

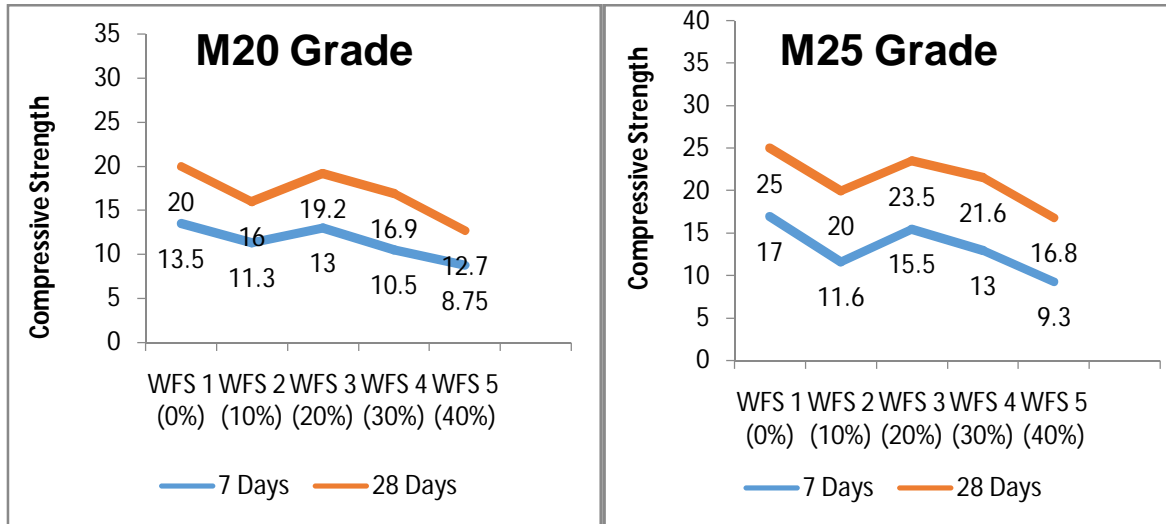
All the materials were mixed in the concrete mixer machine. Required number of specimens for various combinations were casted. Perfect markings were done and continuous curing was maintained up to the age of 7 & 28 days. Mixing, casting, curing and testing were carried out as per the standard specifications.

IV. EFFECT ON HARDENED CONCRETE PROPERTIES

4.1. Compressive strength:

The resistance of the concrete block to breaking under compression is called compressive strength. Specimen used for this test is cube of size 150mm as per the IS standards. The test results for various type of mixes were listed below.

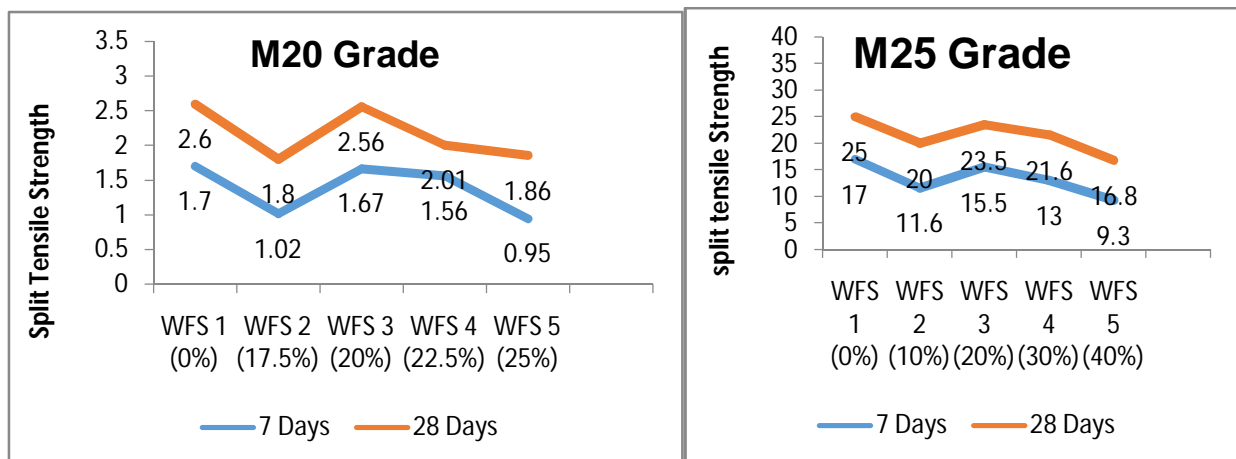
S.No	Specimen ID	Compressive Strength (N/mm ²)			
		M20		M25	
		7 Days	28 Days	7 Days	28 Days
1.	WFS 1 (0%)	13.5	20	17	25
2.	WFS 2 (10%)	11.3	16	11.6	20
3.	WFS 3 (20%)	13	19.2	15.5	23.5
4.	WFS 4 (30%)	10.5	16.9	13	21.6
5.	WFS 5 (40%)	8.75	12.7	9.3	16.8



4.2. Split tensile strength:

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus it is necessary to determine the tensile strength of concrete. Cylindrical moulds are used in this test are of size 150mm dia and 300mm height. The test results of various proportional are shown in the table.

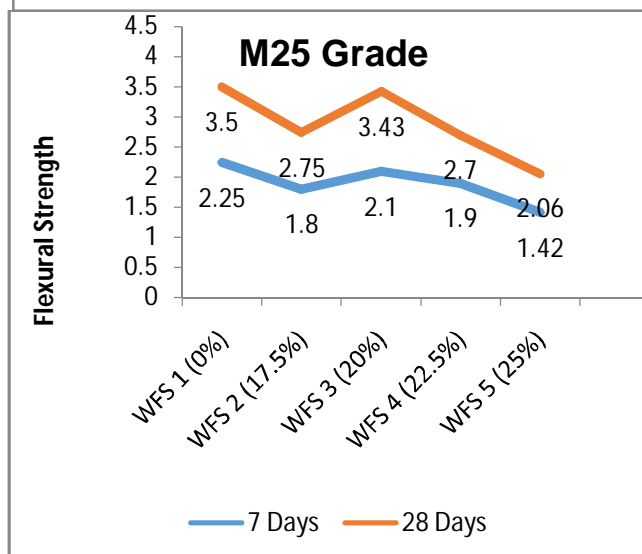
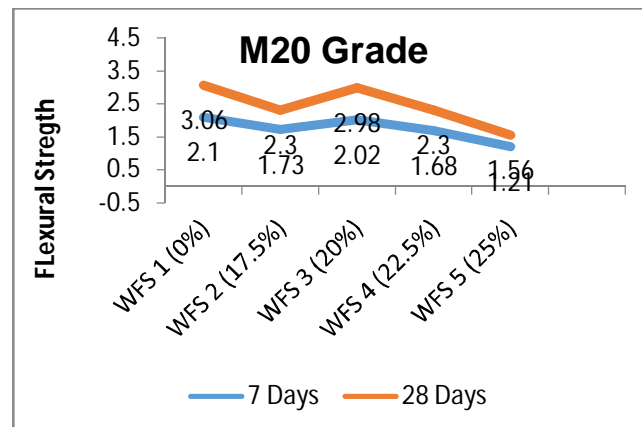
S.No	Specimen ID	Split tensile Strength (N/mm ²)			
		M20		M25	
		7 Days	28 Days	7 Days	28 Days
1.	WFS 1 (0%)	1.7	2.6	2.5	3.41
2.	WFS 2 (10%)	1.02	1.8	1.35	1.72
3.	WFS 3 (20%)	1.67	2.56	2.42	3.37
4.	WFS 4 (30%)	1.56	2.01	1.98	2.64
5.	WFS 5 (40%)	0.95	1.86	1.26	1.9



4.3 Flexural strength:

The flexural strength is the stress at failure in bending. It is one measure of the tensile strength of concrete. Samples used for this test are prism of 100mm x 100mm cross section with 550mm length. The test results are listed below:

S.No	Specimen ID	Flexural Strength (N/mm ²)			
		M20		M25	
		7 Days	28 Days	7 Days	28 Days
1.	WFS 1 (0%)	2.10	3.06	2.25	3.5
2.	WFS 2 (10%)	1.73	2.3	1.8	2.75
3.	WFS 3 (20%)	2.02	2.98	2.10	3.43
4.	WFS 4 (30%)	1.68	1.81	1.9	2.7
5.	WFS 5 (40%)	1.21	1.36	1.42	2.06



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V. CONCLUSION

It was noted from the above detailed analysis on the replacement of the foundry sand with the fine aggregate that increase in the content of the foundry sand results with the increase in the strength of the concrete. The equivalent values in the strength were obtained when the fine aggregate is replaced between 20% to 30% of foundry sand. Beyond these assortment the replacement shown a lesser values in the results when compared to conventional concrete. Based on the above results it was concluded that the 20 to 30% of foundry sand and 15% of refractory waste substitution in concrete as a replacement of fine aggregate have the acceptable results for the research. Likewise, the scope of research is also had a successful solution for economical usage of waste foundry sand and refractory bricks obtained from the foundries and industries.

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