Experimental investigation on waste foundry sand for effective utilization in building construction

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Abstract
The Indian metal casting industry is well established and producing estimated 9.99 million tons of various grades of casting as per international standards. There are an estimated 5000 foundries in India producing casting of Grey iron, Ductile iron, SG iron, Non-ferrous and steel totaling approximately 9.9 million metric tons annually.

This work outlines the study of physical and chemical properties of the waste foundry (WFS) from Sakthi Auto-Component ltd, Erode and its effective utilization as a building material. The WFS sample along with fly-ash with different proportions are to be experimented into concrete cubes and its strength results are to be compared for identifying the optimum usage in constructions. Based cost comparison between conventional concrete and concrete with WFS shows economical aspect of effective utilization.

Keywords: Metal casting, Waste foundry sand, Non-ferrous, Concrete cube, Cost effective.

Introduction
Foundry sand is high quality silica sand with uniform physical characteristics. It is by-product of ferrous and non-ferrous metal casting industries, where sand has been used for centuries as a molding material because of its thermal conductivity. It is a by-product from the production of both ferrous and non-ferrous metal castings. Waste foundry sand is the effluent of the metal cast industries and automobile industries which act as the mould for the preparation of complicated mechanical materials. The raw sand is used for the process for minimum 100 times. Some resins and chemicals are used for the binding of the sand.

After a single use it is reused in rotation. After continuous usage it ejected from the industries. This waste foundry sand consists of highly silica coated with a thin film of burnt carbon, residual binder (Bentonite, Sea coal, resins). Depending upon binder used, WFS classified as Green sand and chemically bonded sand. Phenolic urethane as chemical binder mostly used in automobile industries. Recently researchers did work in this waste material utilization, and mostly conclude 10% of WFS of replacement in natural sand in concrete mix behaves same and chemical properties. Also, Chemical composition of WFS mostly depends casting process and industry type.

Review of Literature
At present waste foundry sand is obtained from foundry industries are used in structural fills such as filling embankments, in road construction as filling material for sub bases etc., Latest innovations prove it can also be used in normal concrete as a replacement for fine aggregate for certain level of replacement.

Mariana et al[4] did a research on incorporating the waste foundry sand on paving units. Waste foundry sand in self-compacting concrerte was a milestone achieved in research field. High strength concrete was also set up using waste foundry sand. All these experiments were made either on concrete was also setup using waste foundry sand. All the experiments were made either on concrete or its properties.

Yucel et al studied the reuse of waste foundry sand in high strength concrete production. The natural fine sand is replaced with waste foundry sand of 0%, 5%, 10% and 15%. The workability of fresh concrete decrease with increase in proportion of waste foundry sand. The freezing and thawing significantly reduces the mechanical and physical properties of the concrete[4].

Dushyant et al[3] does work on manufacturing the green concrete by utilizing the waste foundry waste. As a partial replacement of cement in concrete by Pozzocrete P60, which is processed quality assured fly ash introduces many benefits from economy, technical and environmental point of view. Metal casting process generate several kinds of waste, used foundry sand is the main waste. They discusssed the results obtained of the concrete having mix proportions of 1:1.48:3.21 in which cement is partially replaced by Pozzocrete P60 as 30 % by weight of cement and fine aggregate is replaced by used foundry sand obtained from ferrous and non-ferrous metal casting industries[3].

Mahima et al[2] studied the replacement of waste foundry sand as a replacement for fine aggregate in High strength solid mansory blocks. This study targeted to gives the solutions for making of commercially available solid mansory blocks to high strength. Design of blocks were made following IS 10262 – 2009 guidelines and testing of blocks were satisfied using the IS 2185- 1979. It was inferred that about 20 to 30 % of replacement of fine aggregate to waste foundry sand to gave good results for all practical purposes[2].

Saveria and Francesca[5] studied the properties of mortors and concretes containing different proportions. An Elastic modulus determination of concrete hardened material was carried out on the test. A low amount of used foundry sand does not change the mortar performances.

In the presence of higher additions, a workability decreasing can be outlined and then a higher dosage of super-plasticizer is required in order to keep it constant. Mechanical performances lower of about 20-30% than those of the conglomerate without used foundry sand are observed. The higher penalization it seems to concern to the conglomerates of better quality[5].

Experimental Study

Using waste foundry sand in casting concrete by replacing the natural fine aggregate (River sand) gives effective solution for avoid dumping the waste and prevent natural resource mining. This paper discusses the strength of concrete cubes were casted with waste foundry sand replacing the natural fine aggregate in different proportions. The properties of mix ingredients cement, aggregate and waste foundry sand are discussed below.

Table 1
Physical properties of cement

S.N.	Properties	Test Results	Permissible Value as per IS
1	Fineness	4%	10%
2	Consistency	36%	26% - 33%
3	Soundness	0.5mm	10mm
4	Initial setting time	40 mins	>30min

Table 2
Physical properties of Coarse Aggregate

S. N.	Properties	Coarse Aggregate	
		Test Results	Permissible value as per IS
1	Specific Gravity	2.6	2.5 – 3
2	Water absorption	1.8%	0.1 – 2%

Table 3
Physical properties of Fine Aggregate

S.N.	Properties	Fine Aggregate	
		Test Results	Permissible value as per IS
1	Specific Gravity	2.62	2.6-2.9
2	Water absorption	3.75%	0.1 – 2%

Table 4
Chemical analysis on waste foundry sand

Constituents	Coarse WFS sample	Fine WFS sample
Silica – Soluble SiO_2	24%	30%
Calcium Oxide CaO	16%	13%
Magnesium Oxide MgO	11.3%	11.8%
Sulphur Trioxide	4.7%	5.2%
Iron oxide & Aluminium oxide	20%	12%
Loss of Ignition	7%	15%
Insoluble residue	17%	17%

Based on above results, magnesium and lime content is higher in WFS sample. So, replacing the WFS sample for fine aggregate in conventional concrete is not feasible.

Lime sludge treatment: More binders are used in foundry sand for good molding purpose. Mostly the lime sludge treatment will be used in wastewater treatment plant. Adequate lime is added to raw sludge to increases its pH. The needed lime dose varies with the kind of sludge and also concentration of solids. The lime solution was prepared by adding water and lime sludge by weight percentage. The sample was soaked in lime solution and it should be placed about 6 hours. By these soaking, Lime content at exothermic reaction removing the resinous particles present in the sample. Actual process is the resins lost its binding capacity when more lime is added and the exothermic reaction accelerates the process.

Results and Discussion

All concrete mixing and testing was performed in the concrete technology laboratory, Department of Civil Engineering, Dr. Mahalingam College of Engineering and Technology, Pollachi-03. Cube was moulded with a size of 150mm*150mm*150mm to determine the compressive strength of the concrete mixtures. The cubes were tested at 7 days, 14 days and 28 days.

In conventional concrete mix proportion of 1:1.5:3, mass of fine aggregate and coarse aggregate as 2.1 kg and 4.2 kg respectively with volume of water 0.63 litres. The strength and density of specimen cubes in 7, 14 and 28 days were given below.

Table 4
Compressive strength without WFS

Specimen No	Compressive strength (MPa)		
	At 7 days	At 14 days	At 28 days
A	14.8	18	19.8
B	13.6	17.9	19.69
C	15.6	16.9	18.59
Average	**14**	**17.6**	**19.36**

At 10 % WFS replacement to fine aggregate of mix proportion of 1:1.5:3, mass of fine aggregate and coarse aggregate as 1.8 kg and 4.2 kg respectively with volume of water 0.63 litre. The mass of WFS added was 0.21 kg. The strength and density of specimen cubes in 7, 14 and 28 days were given below.

Table 5
Compressive strength at 10 % WFS

Specimen No	Compressive strength (Mpa)		
	At 7 days	At 14 days	At 28 days
A	13	17.64	19.404
B	12.6	16.78	18.46
C	13.4	19.71	19.7
Average	**13**	**18.01**	**19.188**

At 20 % WFS replacement to fine aggregate of mix proportion of 1:1.5:3, mass of fine aggregate and coarse aggregate as 1.56 kg and 4.2 kg respectively with volume of water 0.63 litres. The mass of WFS added was 0.42 kg. The strength and density of specimen cubes in 7, 14 and 28 days were given below.

Table 6
Compressive strength at 20 % of WFS

Specimen No	Compressive strength (MPa)		
	At 7 days	At 14 days	At 28 days
A	12.8	18.67	18.9
B	12.7	20.31	20.6
C	11.03	18.38	19.2
Average	**12.18**	**19.12**	**19.5**

At 30 % WFS replacement to fine aggregate of mix proportion of 1:1.5:3, mass of fine aggregate and coarse aggregate as 1.47 kg and 4.2 kg respectively with volume of water 0.63 litre. The mass of WFS added was 0.63 kg. The strength and density of specimen cubes in 7, 14 and 28 days were given below

Table 7
Compressive strength at 30 % of WFS

Specimen No	Compressive strength (MPa)		
	At 7 days	At 14 days	At 28 days
A	11.4	18.84	19.2
B	14.7	19.91	20.2
C	13.33	17.87	18.1
Average	**13.14**	**18.87**	**19.1667**

At 40 % WFS replacement to fine aggregate of mix proportion of 1:1.5:3, mass of fine aggregate and coarse aggregate as 1.47 kg and 4.2 kg respectively with volume of water 0.63 litre. The mass of WFS added was 0.84 kg. The strength and density of specimen cubes in 7, 14 and 28 days were given below.

Table 8
Compressive strength at 40 % of WFS

Specimen No	Compressive strength (Mpa)		
	At 7 days	At 14 days	At 28 days
A	14.7	18.39	19.7
B	16.4	16.76	17.3
C	12.5	17.04	18.1
Average	**14.533**	**17.39**	**18.36**

Physical and chemical properties of waste foundry sand sample collected from industry depends casting process and recycle usage. Concrete with WFS gains equal strength compared to conventional by initial thermal properties of WFS which accelerates the hydration of cement. In later stages, the hydration gets decreased strength should not achieved.

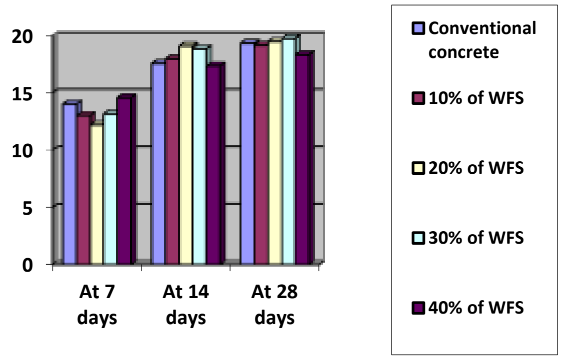

Fig. 1: Comparison of concrete strength with WFS replacement

The commercial rate of one ton of sand is Rs 8000 (Average). Waste foundry sand is freely available now. 40% of replacement in fine aggregate gives effective strength in concrete. By utilizing the waste the environmental issues due to dumping can be minimized effectively

Conclusion

Partial replacement of WFS sample up to 40% to fine aggregate proportion in concrete is found to be efficient and it gives 86% strength of conventional concrete at 28 days. By adding Fly-ash to this composition the strength may be improved after 28 days curing of the concrete specimen at later stages. By replacing the WFS sample to fine aggregate in concrete, the natural land resources can be served and also the waste utilization also can be effectively used in the concrete construction.

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