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Research Paper

MIXING OF WASTE FOUNDRY SAND IN CONCRETE

M Sowmya[1]* and J D Chaitanya Kumar[2]

*Corresponding Author: **M Sowmya** ✉ jd2sai@gmail.com

This paper present studied usage of alternate materials in concrete which includes upcoming changes in concrete technology that paves the way to utilise some of the alternative materials that can be utilized as a composition to the ingredients of concrete that can be partially or completely be replaced with one or more materials that can be used other than the traditional concrete that we are using since time immoral. This paper covers the applications of the waste foundry sand in concrete. Various aspects about the using of waste materials in concrete as alternate aggregate and changes in strength parameters with different composition mixture of concrete and usage of alternate materials in concrete at present scenario.

Keywords: Concrete, Foundry sand, Compressive strength, Flexural strength

INTRODUCTION

The impetus for foundry sector in India was given by the Jute industry in Bengal and the cotton industry in Mumbai in late 19th century. The establishment of TISCO, Bengal Iron Company and the IISCO led to some remarkable new uses of castings, in domestic as well as industrial areas. India ranks second in the world based on the number of foundry units present (4550 units)—after China—and fourth in terms of total production (7.8 million tons) (42nd Census of World Casting Production – 2007).

The foundry produces a wide variety of castings such as manhole covers, pipe and pipe fittings, sanitary items, tube well body, metric weights, automobile components, railway parts, electric motor, fan body, etc., 90% of the castings produced are from the SSI sector. Most of these units are situated in clusters, with cluster size ranging from 30-500 units.

Foundry sand can be suitable for a variety of beneficial reuses. Terminology for defining uses varies across states. For the purposes of this study, common uses of sand in consultation with industry experts. The following are uses of foundry sand approved in one or more states:

Foundry sand can be used as support for structures such as roadways, parking lots, buildings, and pieces of equipment. Foundry sand is useful as a raw material in manufacturing other products, such as controlled, low-strength material (CLSM or flow able fill), asphalt, cement,

[1] M.Tech Scholar Department of Civil Engineering, MVR College of Engineering and Technology Vijayawada Rural, 521180.
[2] Assistant Professor, Department of Civil Engineering, KL University, Green Fields, Vaddeeswaram, Guntur Dst-522502.

concrete, grout, lightweight aggregate, concrete block, bricks, roofing materials, plastics, paint, glass, ceramics, and rock wool.

Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: clay bonded systems (Green sand) and chemically- bonded systems. Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics. Green sand (clay bonded) is used for mould making and is mixture of silica sand (80-95%), bentonite clay (4-10%), carbonaceous additive (2-10%) and water (2-5%). Large portion of the aggregate is sand which can be either silica or olivine. There are many recipes for the proportion of clay, but they all strike different balance between moldability, surface finish and ability of the hot molten metal to design. It still remains very cheapest way to cast metal because of easy availability.

Chemically bonded sand is used in both core making and mould making. In core making, high strength is necessary to withstand against high temperature. Chemically bonded sand is mixing of silica sand and chemical binder (1-3%) for mould and core.

PROPERTIES OF WASTE FOUNDRY SAND

Generally, Waste Foundry Sand (WFS) is sub-angular to round in shape. Green sands are black or grey, whereas chemically bonded sands are of medium tan or off-white color. Grain size distribution of waste foundry sand is uniform with 85-95% of the material in between 0.6 mm to 0.15 mm and approximately 5 to 20% of foundry sand can be smaller than 0.075 mm. Dayton *et al*. (2010) mentioned that sand (0.05 to 2 mm) was the dominant size fraction in the 39 spent foundry sands ranging from 76.6% to 100% with a median of 90.3%.The specific gravity of foundry sand varies between 2.39 and 2.79. Waste foundry sand has low absorption capacity and is non-plastic.

Chemical composition of the foundry sand relates directly to the metal moulded at the foundry. This determines the binder that was used, as well as the combustible additives. Typically, there is some variation in the foundry sand chemical composition from foundry to foundry. Sands produced by a single foundry, however, will not likely show significant variation over time.

Waste foundry sand has good durability properties as measured by low Micro-Deval abrasion (Ontario Ministry of Transportation, Canada 1996). Javed and Lovell (1994) have revealed relatively high soundness loss, which may be due to the samples of bound sand loss and not a breakdown of individual sand particles. The angle of shearing resistance (also known as friction angle) of waste foundry sand varies between 33 and 40 degrees, which is comparable to that of conventional sands.

The success of using foundry sand depends upon economics. The bottom line issues are cost, availability of the foundry sand and availability of similar natural aggregates in the region. Since foundry sand has nearly all the properties of natural or manufactured sands, it can normally be used as a sand replacement. It can be used directly as a fill material in embankments. It can be used as a sand replacement in hot mix asphalt.

LITERATURE REVIEW

Gurpreet Singh and Rafat Siddique has studied on Effect of WFS as partial replacement of sand on the strength, ultrasonic pulse velocity and permeability of concrete. performed experimental investigations to evaluate the strength and durability properties of concrete mixtures, in which natural sand was partial replaced with (WFS).

Khatib *et al*. investigated some mechanical and fresh properties of concrete containing WFS. With reference to the properties investigated, they reported that 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. 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

Siddique *et al.* investigated compressive strength, splitting tensile strength and MOE of concrete at the age of 28 and 56 days. Replacement % of natural ûne sand with WFS was 10%, 20% and 30%. Siddique *et al.* determined the compressive strength, split- ting tensile strength, exural strength and modulus of elasticity of concrete containing WFS at 28, 56, 91 and 365 days. Fine aggregate were replaced with waste foundry sand with 10%, 20% and 30%. Guney *et al.* investigated the re-usage of WFS in high strength concrete. In this study the natural sand was replaced by WFS by 0%, 5%, 10% and 15. Eknath P Salokhe and D B Desai performed experimental investigations to evaluate the comparative study of the properties of fresh and hardened concrete containing ferrous and non-ferrous foundry waste sand as fine aggregate replacement. Fine aggregates replaced with four percentages of foundry sand.

Dushyant Rameshbhai Bhimani, Prof. Jayeshkumar Pitroda, Prof. Jaydevbhai J Bhavsar. This research work is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing fine aggregate via 10%, 30%, and 50% of used foundry sand. The main objective of this study was to evaluate the compressive strength of concrete by utilizing three types of used foundry sand; with bentonite clay, with sodium silicate & with phenolic resin as partial replacement of fine aggregates.

Pradeep Kumar and Basil Baby are studied on "Strength Characteristics of Structural Concrete Elements Using Foundry Sand". In this study, effect of foundry sand as fine aggregate replacement on the compressive strength, flexural strength and split tensile strength of concrete with a mix proportion of 1: 1.28: 2.56: 0.45 was investigated at different limited curing periods (7 days and 28 days).

Ranjitham *et al.*, worked on Investigation on High Performance Concrete with Partial Replacement of fine aggregate by Foundry Sand with cement by Mineral Admixtures. were carried out on strength properties such as compressive strength, split tensile strength and flexural strength of M75 grade of HPC mixes with different replacement levels such as 10%, 20%, and 30% of foundry sand with fine aggregate and 10%, 20%, 30% and replacing cement by mineral admixtures such as fly ash and ground granulated blast furnace slag by adopting water-binder ratio of 0.3. Ishwar Parkash Rawat, Mechanical Properties and Sulphate Resistance of Concrete, Incorporating Used Foundry Sand, Silica Fume and Metakaolin.

The primary aim of this study is to investigate the strength properties (compressive strength and splitting tensile strength) and sulphate resistance of concrete incorporating foundry sand mixed with Silica fume and Metakaolin. Siddique and Dhanoa worked on Design and Development of Concrete Using Waste Foundry Sand as Partial Replacement of Fine Aggregate. Investigate the effect of waste foundry sand content on compressive strength, splitting tensile strength and chloride ion permeability of M30 (46 MPa) Grade of concrete. Fine aggregate was replaced by 0%, 5%, 10%, 15% and 20% of WFS by mass. All tests were conducted at the age of 28 and 365 days. According to the obtained test results.

Sohail Md. Abdul *et al*., "Study on the Mechanical Properties of Concrete by Replacing Sand with Waste Foundry Sand". The effect of foundry sand as fine aggregate replacement on the compressive strength, split tensile strength and flexural strength having mix proportions of M30 was investigated. Fine aggregates were replaced with eleven percentages of foundry sand.

Khatib *et al.*, Capillarity of concrete incorporating waste foundry sand. The results of an experimental investigation into concrete produced by replacing the fine aggregates (natural sand) with various amounts of WFS. The natural fine aggregate was replaced with 0%, 30%, 60% and 100% WFS.

Tarun *et al*., "Effects of Fly Ash and Foundry Sand on Performance of Architectural Precast Concrete", conducted to establish the effects of fly ash and used foundry sand on strength and durability of concrete. Gurpreet Singh, Strength and Durability Studies of Concrete Containing Waste Foundry Sand, investigation was performed to evaluate the strength and durability properties of M20 (30 MPa) and M30 (40 MPa) grades of concrete mixes, in which natural sand was partial replaced with waste foundry sand.

CONCRETE DESIGN MIX

The experiments are conducted to know the properties materials (Cement, fine and coarse Aggregates, water and foundry sand) and from the properties design mix is prepared. The compressive strength of concrete is considered as the index of its quality. In the present study Mix Design for M25 grade concrete is done according to BIS: 10262-2009.

Concrete mix has been designed based on Indian Standard Recommended Guidelines IS: 10262-2009. The proportions for the concrete, as determined were 1:1.73:1.76:1.17 with a water cement ratio of 0.52 by weight. The mix designation and quantities of various materials for each designed concrete mix have been tabulated in Tables 1 and 2.

Table 1: Mix Designation

Designation	Cement Kg/m	Fine Aggregate kg/m 3	Coarse Aggregate		Waste Foundry Sand Kg/m 3	Water (Lts/m 3)
			(10mm) Kg/m 3	(20mm) Kg/m 3		
M-1	388	672	455	682	0	202
M-2	388	604.80	455	682	67.20	202
M-3	388	537.60	455	682	134.40	202
M-4	388	470.4	455	682	201.6	202
M-5	388	403.2	455	682	268.8	202

Table 2: Abbreviation of Various Series

Grade of Concrete	Concrete Type	Designation	Percentage Binder Ratio		Slump Test (mm)
			Sand (%)	Waste Foundry Sand (%)	
M-25	Control Mix	M-1	100	0	120
	Foundry Sand concrete	M-2	90	10	100
		M-3	80	20	80
		M-4	70	30	45
		M-5	60	40	35

RESULTS AND DISCUSSION

Various properties of concrete containing waste foundry sand at various replacement levels with fine aggregate were studied. Waste foundry sand was used as a partial replacement of fine aggregate at the percentage of 0, 10, 20, 30 and 40%. Results were compared and checked for workability, compressive strength, split tensile strength, flexural strength and durability properties of concrete. The results are plotted with corresponding Figures 1 to 10.

Workability (Slump Value)

The measured slump values of natural sand with waste foundry sand with constant water/cement ratio, i.e., w/c ratio (0.52) are 120, 100, 80, 45, and 35 mm for different mixes such as M-1 (0% WFS), M-2 (10% WFS), M-3 (20% WFS), M-4 (30% WFS), M-5 (40% WFS) respectively. The variations of slump value with WFS percentage. It is observed that the slump value decreases with increase in percentage replacement of natural sand with WFS for the same w/c ratio. Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreased workability of the mix.

Compressive Strength

In this research the values of compressive strength for different replacement levels of waste foundry sand contents (0%, 10%, 20%,30% and 40%) at the end of different curing periods (7 days, 28 days). These values are plotted in the variation of compressive strength with fine aggregate

Figure 1: Variation of slump value of fresh concrete with Waste Foundry Sand content

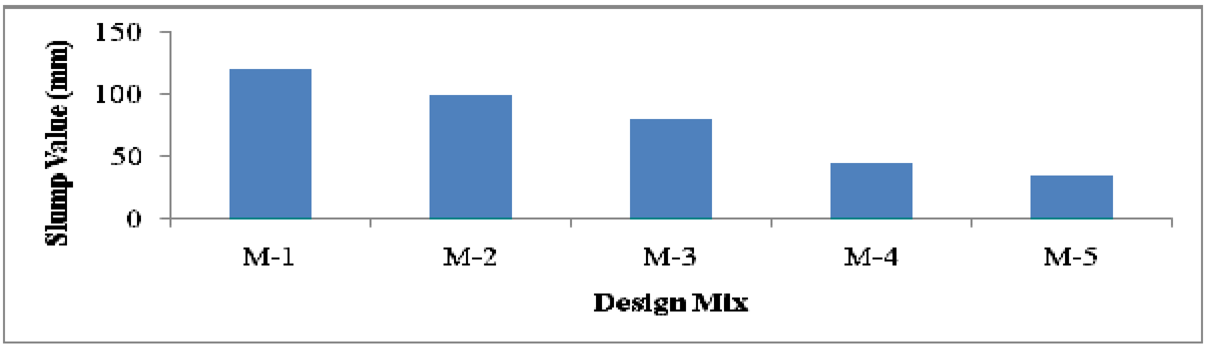


Figure 2: Compressive Strength vs. Replacement of Waste Foundry Sand at 7-days

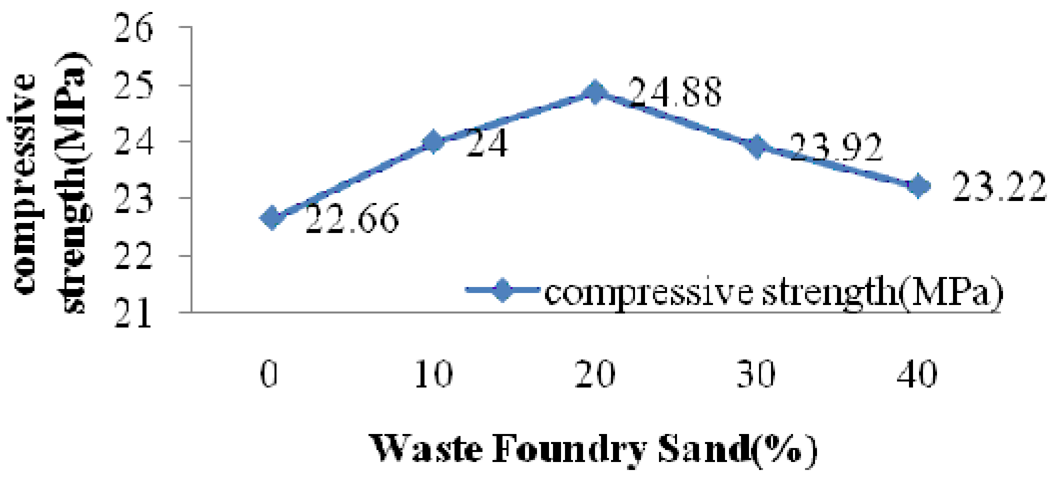


Figure 3: Compressive Strength vs. Replacement of Waste Foundry Sand at 28-days

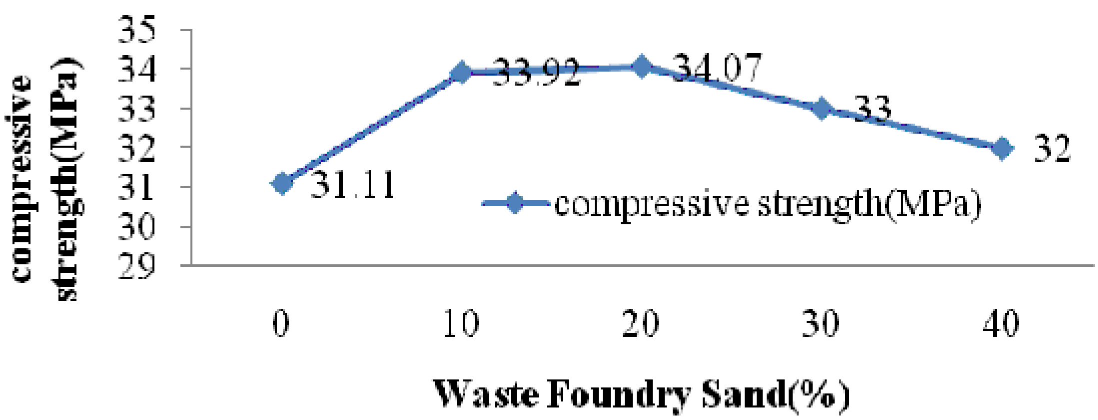


Figure 4: Compressive Strength vs. Various Replacement Levels of Waste Foundry Sand Split Tensile Strength

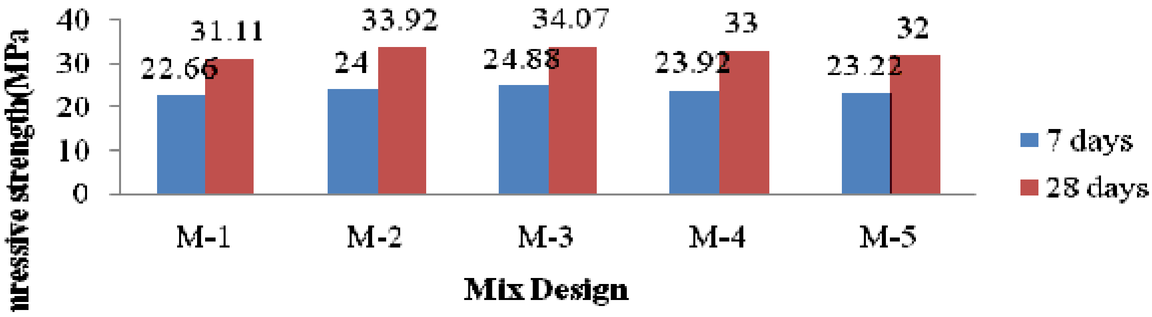


Figure 5: Split Tensile Strength vs. Replacement of Foundry Sand at 7-days

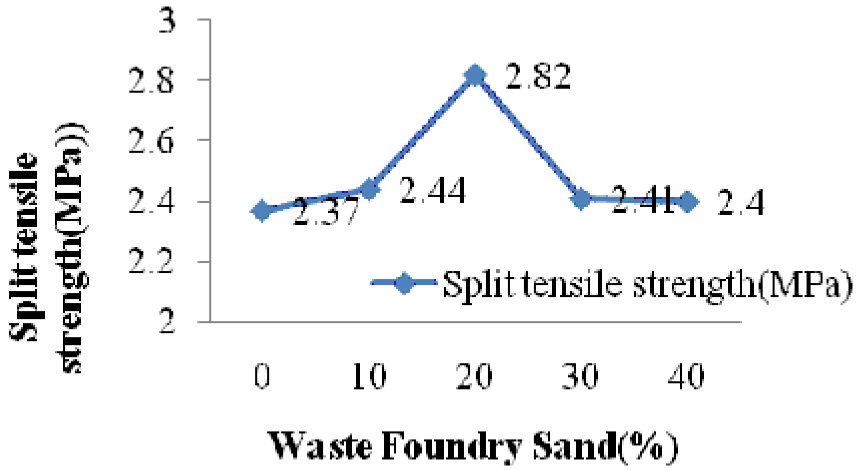


Figure 6: Split Tensile Strength vs. Replacement of Foundry Sand at 28-days

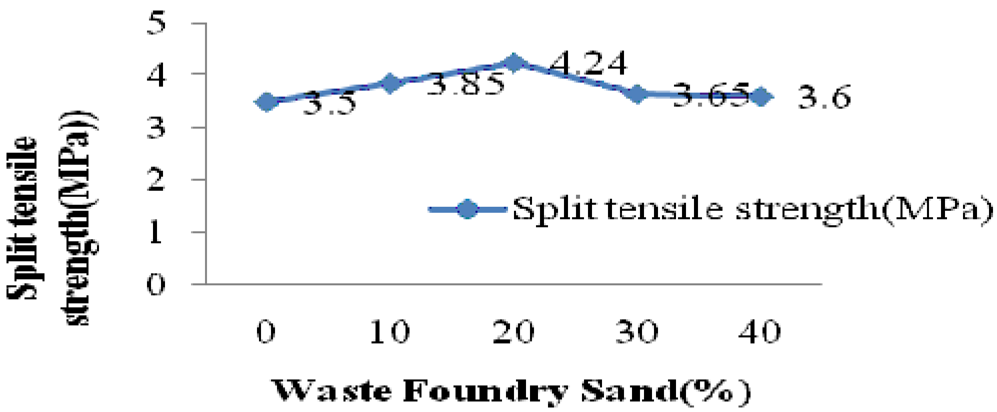
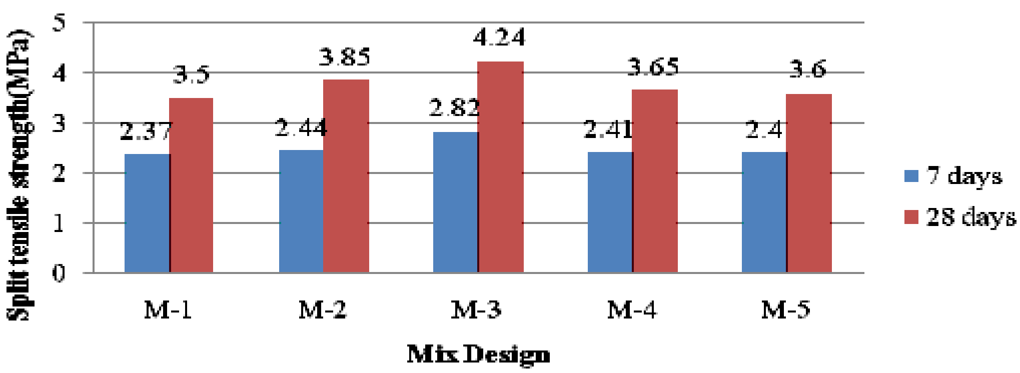


Figure 7: Split Tensile Strength vs. Various Replacement Levels of Foundry Sand



replacements at different curing ages respectively.

It is observed that compressive strength of concrete mixtures with 10%, 20%, 30% and 40% of waste foundry sand as sand replacement was higher than the control mixture (M-1) at all ages and that the strength of all mixtures continued to increase with the age.

The compressive strength increases by 5.91%, 9.79%,5.56 and 2.47% when compared to ordinary mix without waste foundry sand at 7-days and higher value of compressive strength was observed at 20% WFS. Compressive strength at 28 days increases by 9.03%, 9.51%, 6.07% and 2.86% compared to ordinary mix. It was again observed that up to 20% replacement of natural sand with WFS, concrete mixture M-3 (20% WFS) showed higher value of concrete mixture also increased with age.

The compressive strength ratio (at 7 and 28 days) with respect to percentage replacement of sand by waste foundry sand.

Split Tensile Strength

It was found that split tensile strength of concrete containing waste foundry sand (using 10%, 20%, 30% and 40% replacement levels with fine aggregate and a w/c of 0.52) depended on the percentage of waste foundry sand used. The variation of split tensile strength the variation of split tensile strength with replacements of waste foundry sand with various levels of fine aggregate at 7-days. Split tensile strength was increase by 2.95%, 18.98%, 1.68% and 1.26% with respect to different replacement levels of sand with waste foundry sand at 7 days and higher value of splitting tensile strength was observed at 20% WFS at 28 days the split tensile strength varies as 10%, 21.14%, 4.28% &2.85% than control mix without waste foundry sand to the various replacement levels .It was again observed that up to 20% replacement of natural sand with WFS, concrete mixture M-3 (20% WFS) showed higher value of concrete mixture also increased with age the split tensile strength ratio (at 7 and 28 days) with respect to age at various replacement levels of fine aggregates by waste foundry sand.

Flexural Strength

In this research the values of flexural strength for

Figure 8: Flexural Strength vs. Replacement of Foundry Sand at 7-days

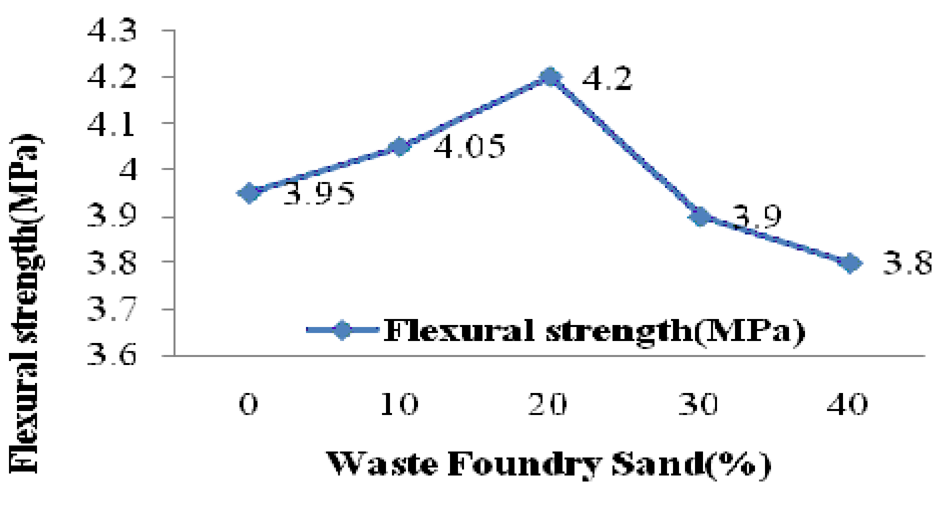


Figure 9: Flexural Strength vs. Replacement of Foundry Sand at 28-days

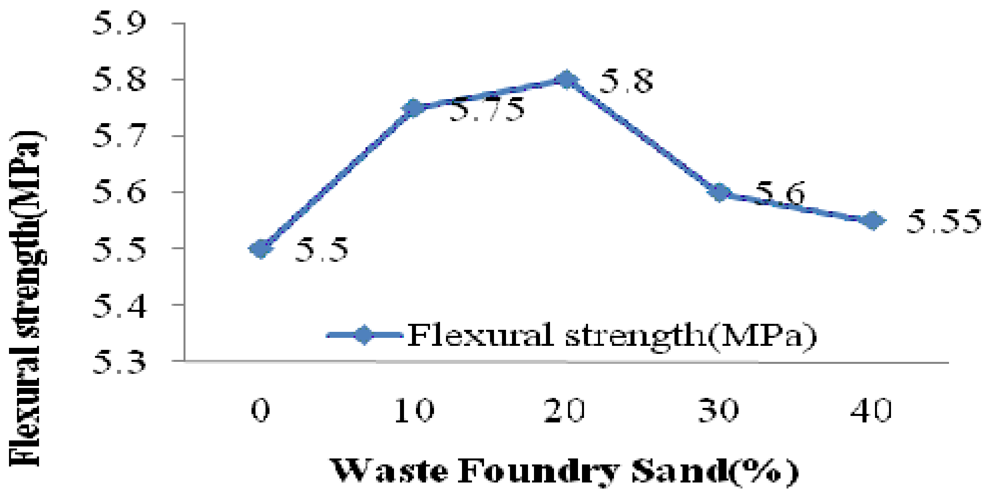
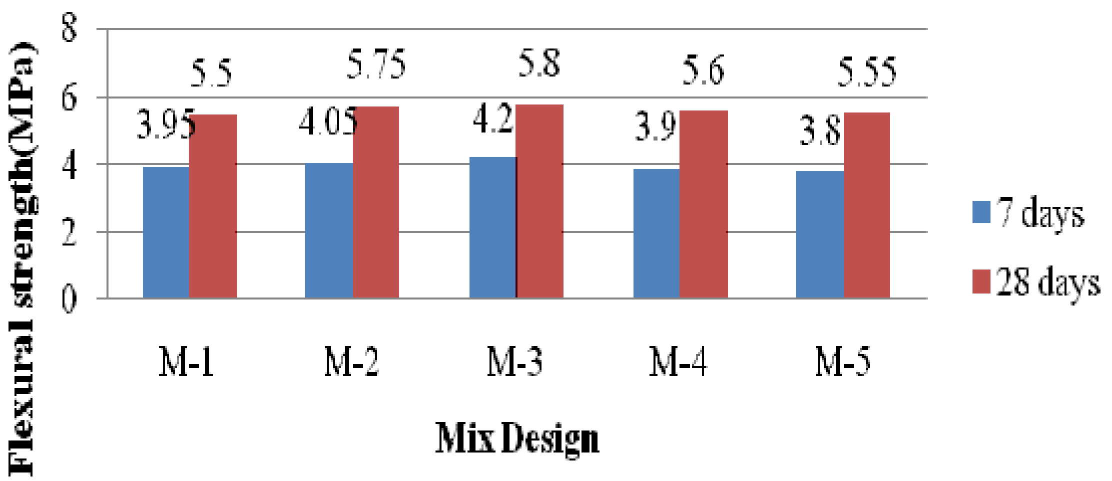


Figure 10: Flexural Strength vs. Various Replacement Levels of Foundry Sand



different replacement levels of waste foundry sand contents (0%, 10%, 20%,30% and 40%) at the end of different curing periods (7 days, 28 days, which show the variation of flexural strength with fine aggregate replacements at different curing ages respectively.

It is evident from that flexural strength of concrete mixtures with 10%, 20%, 30% and 40% of waste foundry sand as sand replacement was higher than the control mixture (M-1) at all ages and that the strength of all mixtures continued to increase with the age.

The flexural strength increases by 2.53%, 6.33%, and 9.8% when compared to ordinary mix without waste foundry sand at 7-days and higher value of flexural strength was observed at 20% WFS. Flexural strength at 28 days increases by 1.0 %, 5.18 %, and 14.3% compared to ordinary mix. It was again observed that up to 20%

replacement of natural sand with WFS, concrete mixture M-3 (20% WFS) showed higher value of concrete mixture also increased with age.

The flexural strength ratio (at 7 and 28 days) with respect to percentage replacement of sand by waste foundry sand.

Acid Resistance Test

Figures 11 to 14 display the results of mass loss of control mix and natural sand with WFS concrete due to acid attack and the mass loss is consider as a function of time. The resistance of cement based materials to chemical attack is mainly due to permeability and alkalinity of concrete mass. The Control mix suffered the most deterioration in terms of mass loss when immersed in 5% H_2SO_4 solutions. The mass loss of 28 days cured M25 grade normal mix specimens was 6.68%, 8.89% and 12.79% at 14, 28 and 56 days respectively. The mass losses of the WFS concrete specimens were reduced when the WFS content increases. The time taken to cause mass loss due to the acid attack it can be seen that the control mix specimens losses

Figure 11: Mass loss (14days) of Concrete Specimen Due to Immersion in 5% H_2SO_4 Solution

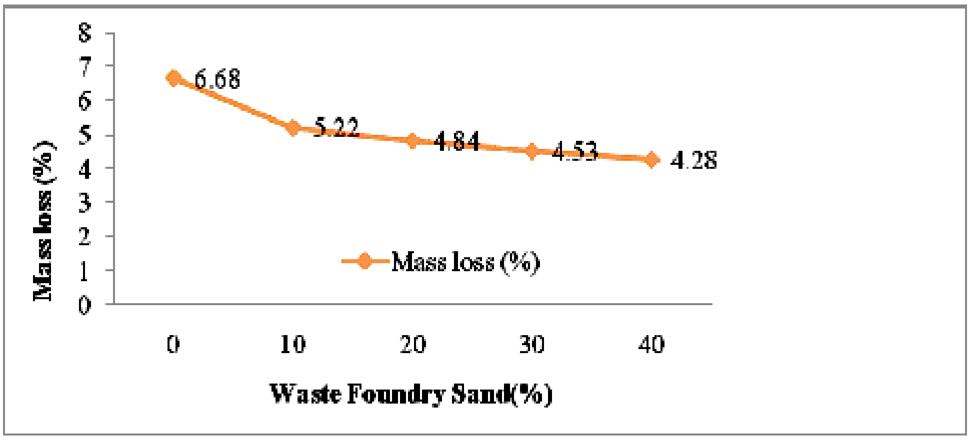


Figure 12: Mass loss (28days) of Concrete Specimen Due to Immersion in 5% H_2SO_4 Solution

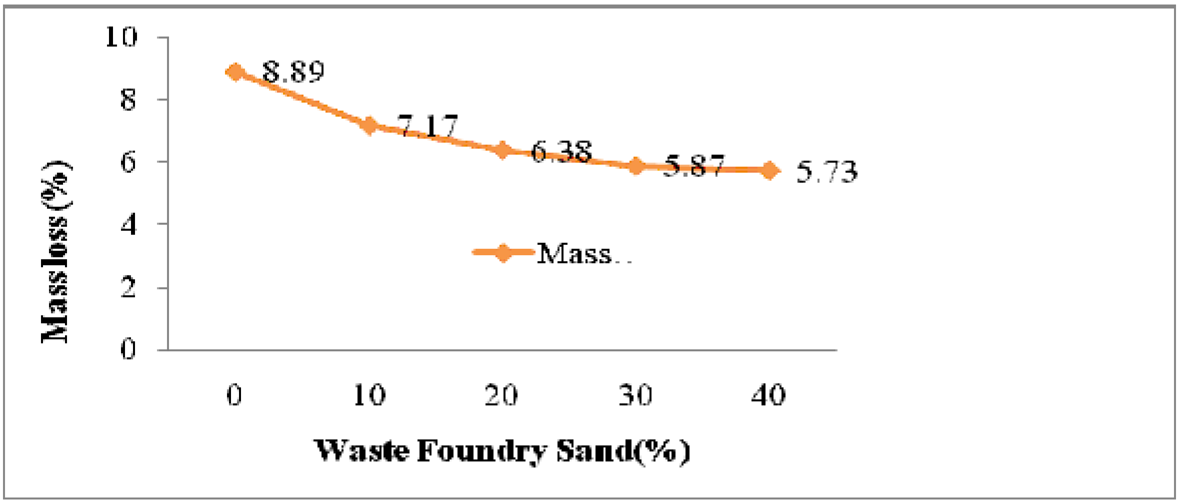


Figure 13: Mass loss (56days) of Concrete Specimen Due to Immersion in 5% H_2SO_4 Solution

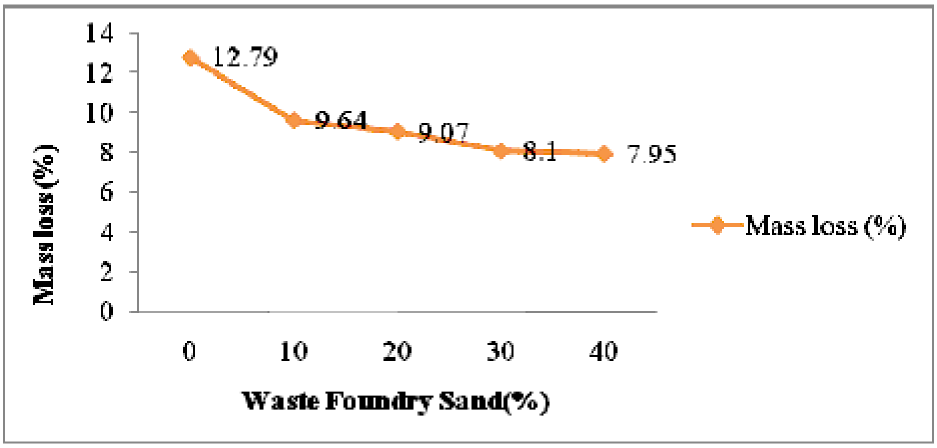
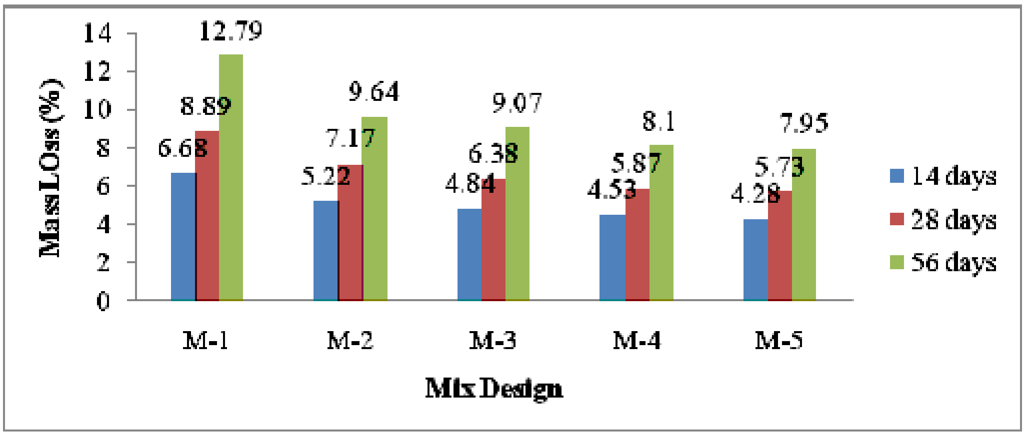


Figure 14: Comparison of Mass Loss (14, 28 and 56 days)



their weight more than natural sand with WFS concrete specimen of immersion in 5% H_2SO_4.

CONCLUSION

The present work investigated the influence of waste foundry sand as partial replacement of fine aggregate (natural sand) on the properties of concrete. On the basis of the results from the present study, following conclusions are drawn

WORKABILITY (SLUMP VALUE)

- It is observed that the slump value decreases with increase in percentage replacement of natural sand with WFS for the same w/c ratio. Increased fineness require greater amount of water for the mix ingredients to get closer packing, results in decreased workability of the mix.

Strength Properties

- Partial replacement of natural sand with WFS (up to 20%) increases the strength properties like compressive strength, splitting tensile strength and flexural strength of concrete.
- Maximum compressive strength of concrete was achieved with 20% replacement of fine

aggregate with WFS. Beyond 20% replacement it goes to decrease, but was still higher than control concretes.

- Maximum splitting tensile strength of concrete was achieved with 20% replacement of fine aggregate with WFS. Beyond 20% replacement it goes to decrease, but was still higher than control concretes.
- Also maximum flexural strength of concrete was achieved with 20% replacement of fine aggregate with WFS. Beyond 20% replacement it goes to decrease, but was still higher than control concretes.
- Maximum increase in compressive strength, splitting tensile strength and flexural strength of concrete was observed with 20% WFS, both at 7 and 28 days.
- Use of foundry sand in concrete can save the ferrous and non-ferrous metal industries disposal, cost and produce a 'greener' concrete for construction.
- Environmental effects from wastes and disposal problems of waste can be reduced through this research.

Durability Property

Acid Attack Test (Mass Loss)

- The Control mix suffered the most deterioration in terms of mass loss when immersed in 5% H_2SO_4 solutions.
- The mass loss of 28 days cured M25 grade normal mix concrete specimen was 6.68%, 8.89% and 12.79% at 14, 28 and 56 days respectively.
- The mass losses of the WFS concrete specimens were reduced when the WFS content increases.

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