International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 05 | May 2020 www.irjet.net p-ISSN: 2395-0072

Laboratory Studies on Utilization of Waste Foundry Sand as a Partial Replacement for Fine Aggregates in Conventional Concrete

Dileep Kumar S N[1], Ajay N[2], Aravind Sagar B[3], Ashwin M Joshi[3]

[1] PG Student, ICM, RASTA, Bangalore, India.
[2,3]Assistant Professor, ICM, RASTA, Bangalore, India.

Abstract - *Developing concrete using alternatives to natural resources is an important issue for environmental protection along with preserving the natural resources and saving of energy for sustainable development. Metal foundries use large amount of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in the casting process. When the sand can no longer be reused in the foundry, it is removed from the foundry it is termed as "waster foundry sand". The constant depletion of sand beds at all major sources of availability is major concern and thus effects are taken in order to either abolish or replace sand in construction activities particularly in concrete.*
In present experimental investigation is carried out to evaluate the properties of fresh and hardened concrete containing waste foundry sand as fine aggregate partial replacement. The percentages of replacement 0%, 15%, 20%, and 25% by weight of fine aggregate and tests like slump test, compression strength test, split tensile strength test, flexural strength test and sulphate attack test were performed for all replacement levels of foundry sand for M40 grade concrete. From the test result, the waste foundry sand can be replaced partially up to 20% of fine aggregate in concrete, will be both economical and for high strength purpose.

Key Words: Compressive strength, Waste Foundry Sand, Flexural strength, Split tensile strength, Sulphate Attack Test

1. INTRODUCTION

Concrete is the most used construction material in the world. Increasing rate of urbanization and industrialization has lead to over exploitation of natural resources such as river sand and gravels, which is giving rise to sustainability issues. It has now become imperative to look for alternatives of constituent materials of concrete [1]. To overcome these problems use of marginal material from the industrial by-products are emphasized [1,2]. Management of waste products from industries is a very challenging task because waste material or by-product from the industry is not easily bio-degradable even after long period of land filling [1,2]. Finding new way to dispose of the waste material or by-product in concrete will enhance the understanding on how to use the waste from the industry in engineering practice [2]. The utilization of industrial marginal materials and by-products in concrete not only makes economical but also helps in reducing in disposal concern [2].
Waste foundry sand (WFS) is also one of the industrial waste material or by-product [3,4]. Both Ferrous and non-ferrous metal casting industries uses WFS. For the casting purpose foundry sand is used in industries, this sand is reused and recycled for many times and when this sand cannot be used in metal casting industry it is to be disposed of as a WFS [3,4]. Utilization of WFS in construction industry is considered as the most feasible application. It can be used as a partial replacement to the fine aggregate will reduce the consumption of natural river sand and it will help to dispose the waste foundry in efficient way this leads to solve disposal problem of large quantity of WFS [3,4].

2. LITERATURE REVIEW

Several journals are referred during the starting the project to explore the various behavior of concrete when fine aggregate is partially replaced by WFS and the factors influencing its characteristics such as strength and durability of the concrete.
Pranita Bhandari and Tanjne [5] carried out experimental investigation on the develop the M 25 grade of concrete and they replace the fine aggregate by WFS in the range of 0%, 10%, 20%, 30%, 40%, 60%, 80%, and 100% by the weight . The concrete tested and compared with the conventional concrete in both fresh and hardened properties and also acid attack test. The water to cement ratio is keep constant 0.40 for all mixes. The hardened test was performed for 3, 7 and 28 days. The results shows that 20% of replacement of WFS gives better results in-terms strength and increasing above 20% of WFS will decreases the compressive and flexural strengths of concrete.
Rafat Siddique and Gurpreet Singh [6] carried out investigation on utilization of WFS for developing the concrete and controlled low-strength materials. The work shows that WFS exhibits lower unit weight, higher water absorption, and higher percentage of voids compare to conventional concrete. Vema Reddy Chevuri and Sridhar [7] carried out experimental study on primarily concern with the study of mechanical characteristics of concrete such as compressive, split tensile and flexural strengths of concrete when partially replaced with WFS with artificial M-Sand as a fine aggregate. Tests were carried out on the casted specimens of cubes, cylinders and flexural beams to evaluate the mechanical properties of the concrete containing WFS partially.

WFS is replaced in five percentages i.e. 0%, 5%, 10%, 15%, 20% by the weight of fine aggregates. The strength properties of the concrete are tested at the age of 7 and 28 days. The results indicate that nominal increase in strength and durability parameters of the concrete by the addition of WFS as a partial replacement to fine aggregates. Lee et al. [8] carried out studies on WFS by determining the physical and chemical characteristics of the concrete containing WFS as the partial replacement to the natural river sand. The results shows that 30% of replacement of WFS gives better results in-terms strength and increasing above 30% of WFS will decreases the compressive and flexural strengths of concrete.
In present experimental investigation is carried out to evaluate the properties of fresh and hardened concrete containing WFS as fine aggregate partial replacement. The percentages of replacement 0%, 15%, 20%, and 25% by weight of fine aggregate and tests like slump test, compression strength test, split tensile strength test, flexural strength test and sulphate attack test were performed for all replacement levels of WFS for M40 grade concrete.

3. EXPERIMENTAL PROGRAM
3.1 Materials

Ordinary Portland cement (C 53 grade) conforming to the requirements of IS-12269-2013 [9] was used in the study. The specific gravity values of the cement 3.0 and the Blaine fineness were 255 m^2/kg. Manufactures sand (M- sand) and waste foundry sand (WFS) were used as fine aggregate. They confirm to zone II based on IS 383-2016 [10]. Crushed granite stone was used as coarse aggregate with a maximum size of 20 mm. The bulk specific gravities of the M sand, WFS and coarse aggregate were 2.7, 2.6 and 2.6 respectively, and their absorption values were 3.0%, 0.3% and 0.35%. Commercially available modified polycarboxylic ether base superplasticizer (SP) was used as chemical admixture. The product has specific gravity of 1.09 and solid contents not less than 30% by weight.

3.2 Mix Design
Concrete mix has been designed based on Indian standard recommended guidelines IS: 10262-2009 [11]. The proportion for the concrete, as determined were M40 grade. The Table 1 shows the mix proportion details.

Table -1: Details of Mix Proportions by Mass

Mix No	Cement (kg/m^3)	Water (l/m^3)	w/c ratio	Fine Aggregate (kg/m^3)		Coarse Aggregate (kg/m^3)	SP (%)
				M-sand	WFS		
D0	394	158	0.40	673	0	1220	0.05
D15				573	100	1220	0.05
D20				540	133	1220	0.05
D25				505	168	1220	0.05

3.3 Test Details
Fresh concrete properties were ascertained by conducting slump test as per IS 1199-1959 [12]. The hardened properties tests like compressive strength test on cube and cylinder specimen, split tensile test and flexural test were conducted as per IS 516-1959[13]. The sulphate attack test also conducted on each specimen as per ASTM standards [14].

4. RESULTS AND DISCUSSION
4.1 Workability of concrete
Workability of concrete is determined from slump come test using slump cone apparatus and it is the main test conducted on fresh concrete. Table 2 shows the different values of slump for different mix proportion.

Table -2: Slump Values for Different Mixes

Mix No	Cement (kg/m^3)	Water (l/m^3)	w/c	SP (%)	Slump (mm)
D0	394	158	0.40	0.05	125
D15				0.05	110
D20				0.05	105
D25				0.05	100

From the Table 2, clearly indicating that maximum slump value is obtained for conventional concrete with 120 mm and when percentage of WFS content increases, the slump value will be gradually decreases. This is because due to WFS contain high percentage of clayey particles hence it effects the flow of concrete.

4.2 Compressive Strength

Compression strength test were performed on compression testing machine of 2000 KN capacity. Cube and cylinder specimens casted to determine compressive strength at the age of 7, 14 and 28days. The specimens were de-moulded 24 hours after casting and were cured under water at 27 ± 2°C until the test age. The tests were conducted as per the codal provisions of IS 516-1959[13]. Table 3 and chart 1 and chart 2 shows the comparison of the different mix proportions of cube compressive strength at different ages of curing period of 7, 14, and 28days respectively.

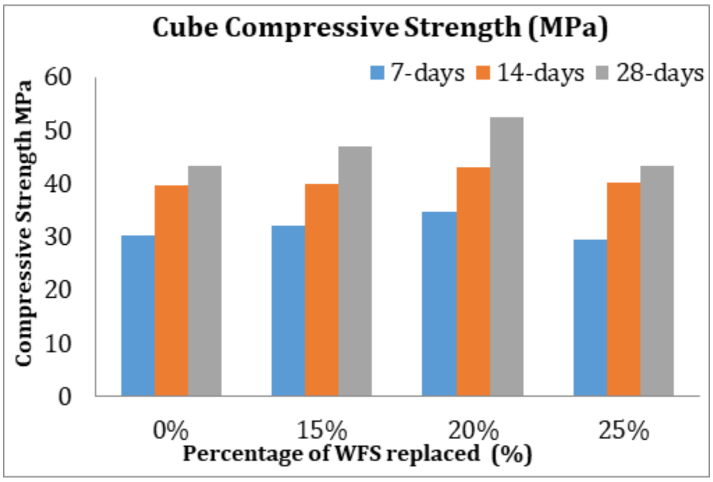

Chart -1: Average Cube Compressive Strength Values at 7, 14, 28 days

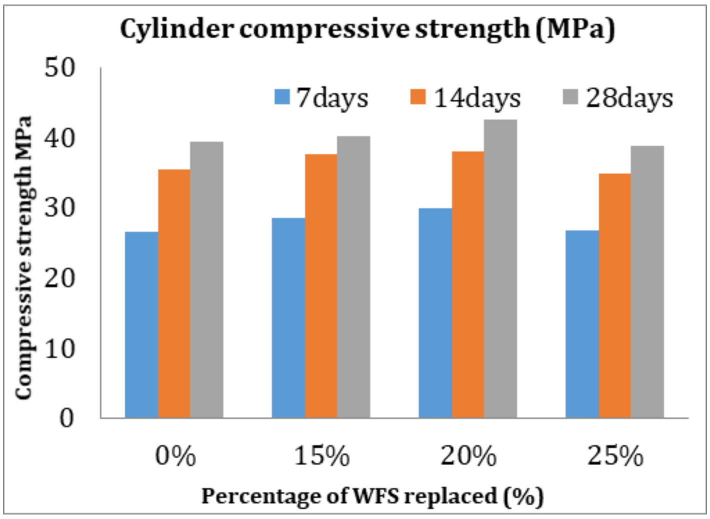

Chart -2: Average Cylinder Compressive Strength Values at 7, 14, 28 days

Table -3: Average Compressive Strength of Cubes and Cylinder at 7,14, 28 days

Mix No	w/c	Cube Compressive Strength (MPa)			Cylinder Compressive Strength (MPa)		
		7 days	14 days	28 days	7 days	14 days	28 days
D0	0.40	30	39	43	26	35	39
D15		32	40	46	28	36	40
D20		34	43	52	29	38	42
D25		29	40	43	26	34	38

It was observed that from Chart 1 and 2 respectively, the conventional mix (D0) with zero replacement of WFS at the age of 7days it was found that the concrete achieved 61% target strength was achieved, at 14days it is observed that 91% was achieved. When 15% (D15) of WFS is replaced it was observed that there is slightly increase in compressive strength when compared to the conventional concrete at different ages of curing period. In the 20% (D20) replacement of WFS it is observed that 15% increase in the compressive strength of all the ages of concrete (i.e. 7days, 14days, and 28days) when compared to conventional concrete. In the 25% (D25) replacement of WFS it clearly observed that there is a gradual decrease in compressive strength of all the specimens of different ages of concrete.

From the above results its clearly shows that for 20% replacement of WFS there is increase in compressive strength of cubes and cylinders at 7, 14, 28days of curing. Replacing WFS above 20% by the weight of fine aggregates will not give satisfactory results even after the specimens are cured for 28days. The same trend also seen in some of the published literatures [5,7,8]

4.3 Split Tensile Strength

The tests were conducted as per the codal provisions of IS 516-1959 [13]. Table 4 and Chart 3 shows the split tensile strength of various mix proportions obtained by 7, 14, and 28 days respectively.

Table -4: Average Split Tensile Strength Values at 7,14, 28 days

Mix No	w/c	Split Tensile Strength (MPa)		
		7 days	14 days	28 days
D0	0.40	2.3	3.3	4.0
D15		2.8	3.8	4.1
D20		2.9	3.9	4.3
D25		2.1	2.7	3.1

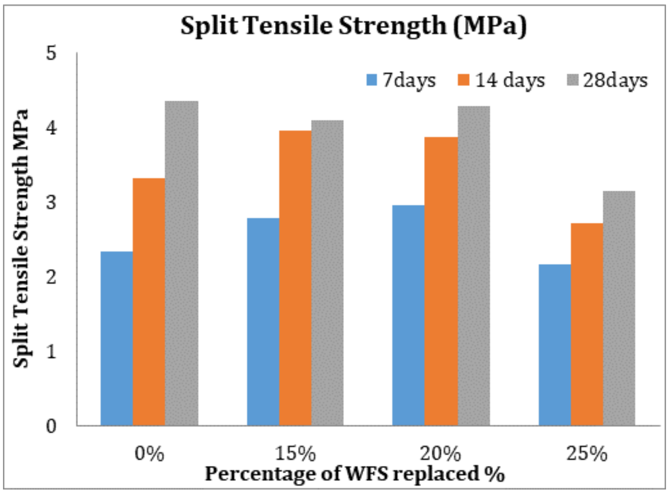

Chart -3: Average Split Tensile Strength Values at 7, 14, 28 days

From the Chart 3, it is clearly shows that split tensile strength of D20 mix which 20% WFS is replaced to fine aggregates strength will increases as WFS content increase, when compared to conventional concrete.

4.4 Flexural Strength

The tests were conducted as per the codal provisions of IS 516-1959 [13]. Table 5 and Chart 4 shows the split tensile strength of various mix proportions obtained by 7, 14, and 28 days respectively.

Table -5: Average Flexural Strength Values at 7,14, 28 days

Mix No	w/c	Flexural Strength (MPa)		
		7 days	14 days	28 days
D0	0.40	5.4	6.7	7.0
D15		4.8	5.8	6.5
D20		6.2	7.1	7.7
D25		4.7	5.0	5.9

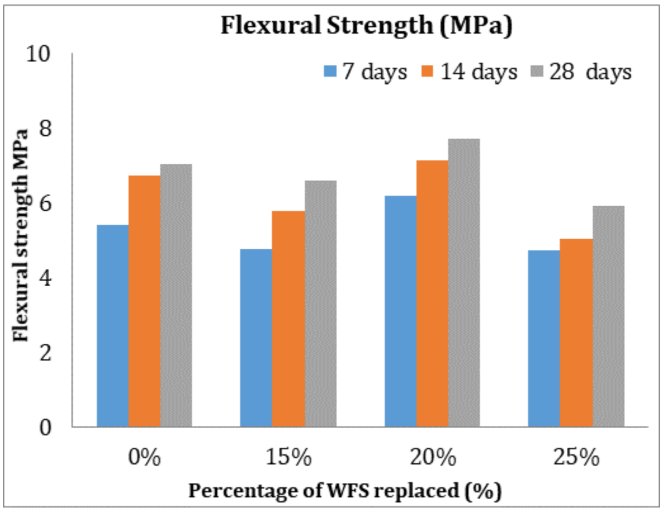

Chart -4: Average Flexural Strength Values at 7, 14, 28 days

From the chart 4, it clearly indicates that there is an increase in flexural strength of concrete up to 20% replacements and replacing above 25% will decrease the strength of concrete and also decreases the bond strength.

4.5 Sulphate Attack Test

Sulphate Attack test is conducted as per ASTM standard [14]. Concrete specimen is immersed in the tank, which contain 5% of sodium sulphate solution to the distill water for 28days. After 28 days the specimens are tested for weight of loss and respective compressive strength. The results are shown in Table 6 and Chart 5 respectively.

Table -6: Sulphate Attack Test Values

Mix No	Percentage of Weight loss (%)	Compressive strength (MPa)	Percentage of Strength loss (%)
D0	0.90	45	4.4
D15	0.75	48	3.2
D20	0.55	54	2.6
D25	0.42	46	2.0

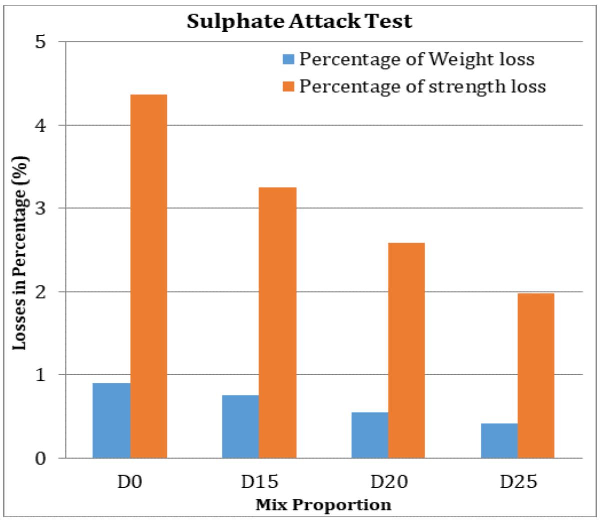

Chart -5: The weight and strength loss in percentage of different mix proportions.

From the chart 5, it clearly shows that the maximum weight loss and strength loss observed in D0 mix proportion which contains 0% WFS and approximately 0.9% of weight loss for 28 days of acid curing. Also mix D15 has 0.75% of weight loss and 3.25% of compressive strength loss, D20 mix have 0.55% of weight loss and 2.59% of strength loss and D25 mix have 0.42% of weight loss and 1.98% of strength loss.

From the above test results indicates that increase in WFS content in concrete can reduce the percentage of weight loss and compressive strength.

3. CONCLUSIONS

The strength properties of concrete was observed that there is increase in strengths of concrete with the increasing WFS content up to 20% by the weight of fine aggregates. Further increase in WFS content (above 20%) will decrease the strength gradually.

ACKNOWLEDGEMENT

The authors sincerely acknowledge the Material laboratory Technicians, for their help in conducting these experiments

REFERENCES

[1] Eknath.P.Salokhe and D.B.Desai, Application of Foundry Waste Sand in Manufacture of Concrete, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 2016, pp. 38-42.
[2] Shruthi.N and R.B.Gadag, Utilization of Waste Foundry Sand, Demolished Aggregate and Waste Plastic in Making Pervious Concrete, International Research Journal Of Engineering and Technology (IRJET) vol 2, 2015,pp.1331-1335.
[3] Joju Jose and Nabil Hossiney, Characteristics of Concrete Containing Waste Foundry Sand and Slag Sand, International Journal of Earth Science and Engineering, vol. 9(3), June, 2016, pp. 54-59.
[4] Minakshi.B.Jagtap, Vikram.B, Gadade, Ganesh B. Salunke, A Review on Utilization of Waste Foundry Sand for Producing Economical and Sustainable Concrete, International Journal of Advance Engineering and Research Development, vol. 2, April, 2015, pp.580-587.
[5] Pranita Bhandari and Tanjne, Use of Foundry Sand in Concrete, International Journal of Latest Trends in Engineering and Techology (IJLTET), vol. 6(3), Jan. 2016, pp.249-254.
[6] Rafat Siddique and Gurpreet Singh, Utilization of Waste Foundry Sand in Concrete Manufacturing, Resources Conservation and Recycling, vol. 55 (11), Sept. 2011, pp. 885-892.
[7] Vema Reddy Chevuri, and S.Sridhar, Usage of Waste Foundry Sand in Concrete, SSRG International Journal of Civil Engeneering (SSRG-IJCE), vol. 12, Dec. 2015,pp-5-10.
[8] B.J.Lee, G.Prabhu, J.W.Bang, J.H..Hyun, Y.Y.Kim, Mechanical and Durability Properties of Concrete made with used Foundry Sand as Fine Aggregates, Advance in Materials Science and Engineering, vol. 3, Jan. 2015, pp 1-11. https://doi.org/10.1155/2015/161753.
[9] IS: 12269:2013, Ordinary Portland Cement – 53 grade Specification, Indian Standards, New Delhi, 2013.
[10] IS: 383-2016, Coarse and Fine Aggregate for Concrete – Specification, Indian Standards, New Delhi, 2016.
[11] IS: 10262:2009, Concrete Mix Proportioning - Guidelines, Indian Standards, New Delhi, 2009.
[12] IS: 1199-1959, Methods of Sampling and Analysis of Concrete, Indian Standards, New Delhi, 1959.
[13] IS: 516-1959, Method of Test for Strength of Concrete, Indian Standards, New Delhi, 1959.
[14] ASTM C1012-95a, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution, Annual Book of ASTM Standards, 1989.