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Utilization of Foundry Waste Sand in the Preparation of Concrete

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Abstract: *In the présent work, experimental investigations were performed such as compressive strength test, Split tensile strength test, flexural strength test on the concrete containing (0%, 10% and 100% replacement of e foundry waste sand in place of fine aggregate. The tests were conducted for the above replacements of foundry sand for M20 and M25 Grade concrete at diffèrent curing periods of (7, 28 and 56 days). The results of compressive strength of M20 and M25 grade concrete were in the range of 31.06N/mm^2 to 33.92N/mm^{2}and 31.24 N/mm^2 to35.41N/mm^2 respectively. The Flexural Strength results of M20and M25 grade concrete were in the range of 2.52 to 2.96N/mm^2 and 2.94 to 3.43N/mm ^{2} respectively.The split tensile strength results for M20 and M25 grade concrete were in range of 2.23 to 2.69N/mm^2 and 2.81 to 3.18 N/mm^2 respectively.*
Keywords: *Compressive strength , Split Tensile strength , Flexural Strength*

I. Introduction

Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in casting process. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as "foundry waste sand." Like many waste products. Published literature has shown that FWS could be used in manufacturing Controlled Low-Strength Materials (CLSM) and concrete. Use of foundry waste sand as a partial replacement or total replacement by fine aggregate in concrete leads in production of economic, light weight and high strength concrete. Foundry sand can be used in concrete to improve its strength and other durability factors.Eknath etal[1] studied the effect of foundry waste sand (FWS) on the slump concrete. They inferred that the Slump value were decreasing with the introduction of FWS. They observed that compressive strength of concrete mixtures with 10%, 20% and 30 % of foundry sand as sand replacement was higher than the control mixture at 7 days age and the strength was maximum at 20% replacement level for both types of sands. They studied the split tensile strength of concrete having different percentages of waste foundry sand and observed that for 20% ferrous FWS and 20% non ferrous FWS the values of split tensile strength were higher.PathariyaSarawastiC etal2] investigated the compressive strength of the concrete by replacement of the local sand by waste foundry sands by 0%, 20%, 40% and 60% and they found that for 60% replacement of local sand by waste foundry sand they obtained maximum compressive strength values. Further study was conducted out as the Split tensile strength of the concrete for different percentages of waste foundry sand and they observed that for 20% replacement of local sand by waste foundry sand resulted in higher split tensile strength values. SohailMd etal[5] conducted the workability test for the concrete and they concluded that as the waste foundry sand percentage increased in the concrete the workability was reduced. Results for the compressive strength of the concrete was improved considerably with increase in the percentage of waste foundry sand up to 90%. Split tensile strength tests for the concrete were conducted and observed that there is a considerable improvement in the split tensile strength of concrete with increase in the percentage of foundry waste sand up to 70%. RafatSiddique etal [6] carried out the split tensile strength study at the age of 7, 28 and 56 days. Splitting tensile strength of concrete mixes increased with the increase in FWS content. Higher value of splitting tensile strength was observed at 15% FWS. Test for resistance of the concrete for the sulphate attack was determined and that for the mix containing 10% foundry waste sand an increase in strength is observed at all ages as compared to the control mix even after immersing the cubes in magnesium sulphate solution. However, for both 15% and 20% replacement levels, a decrease in strength was observed when compared to the standard 28 days strength of the related concrete mix, at all ages after immersion in the sulphate solution. This indicates that, the strength loss will be much larger if the concrete is immersed in the solution for a longer period of time.The Objective of the Present work is to utilize foundry waste sand in the preparation of M20 and M25 grade concrete and study compressive strength at 7 days , 28days and 56days for 100% replacement .

II. Materials used

Portland Pozzolona cement confirming to IS:1489-1991[7] was used. Ultratech cement PPC procured from single source was used .The cement used in the project has Specific gravity of 3.15, Normal consistency of 33% and has a initial and final setting time of 50minutes and 260 minutes respectively. Basalt aggregate of two fractions i.e. 20mm and 12.5 mm were used in the project with specific gravity of 2.81, Finess modulus of aggregate was 8.26, Bulk density in the loose and compacted condition was 1.49 and 1.74g/cc ,aggregates had a crushing value of 15.29%, Impact Value of 13.94% and water absorption of 2.34%. The Sieve analysis test was carried to determine the grading of the aggregate and it was found that the aggregates were nearly graded .Good quality zone-II fine aggregate locally available was used. The different tests for physical properties of fine aggregate were carried out in the laboratory and the same is presented in Table 1 The fine aggregate conforming to IS:383-1970[8] was used. Waste foundry sand are of three and they are Burnt Black sand, Used and weathered sand and Current used sand.Sieve analysis results for foundry waste sand are presented in Table 2.

Black sand Used and Weathered Sand Current Used sand

Table 1: Comparison of Fine Aggregate and waste foundry sand

Sl. No	Properties	Burnt Black Sand	Used and weathered sand	Currently used sand	Local Fine Aggregate
1.	Specific gravity	2.42	2.52	2.50	2.74
2.	Fineness modulus	4.09	4.25	4.24	3.60
3.	Water absorption	8.1%	11.02%	11.08%	0.61%
4.	Silt Content	Nil	Nil	Nil	Nil
4.	Bulk density a)Loose b)Compacted	1.47g/cc 1.64g/cc	1.38g/cc 1.56g/cc	1.4g/cc 1.5g/cc	1.51g/cc 1.69g/cc

Table 2: Sieve analysis results of Foundry Waste Sands

Sieve size	Cumulative % finer for Burnt Black sand	Cumulative % finer for Used and weathered sand	Cumulative % finer for Currently used sand	Values as per IS standards Zone III	
4.75mm	100	100	100	90-100	All The sands belongs to ZONE III
2.36mm	100	100	100	85-100	
1.18mm	99.294	99.295	99.398	75-100	
600µ	68.72	63.345	66.065	60-79	
300µ	20.29	10.377	8.636	12-40	
150µ	2.03	1.12	1.307	0-10	
75µ	0.31	0.21	0.203		
Pan	0.01	0.01	0.002		

Table 1 represents physical properties of local fine aggregate and 3 types of waste foundry sand (Burnt Black sand, currently used sand and Used and weathered sand). It is observed from the Table that fineness modulus for all the four types of sand are nearly same. Water absorption for waste foundry sand is quit high compared to local sand 0.61%. because polymer resign chemical is used in foundry sand for moulding process. Therefore water absorption of foundry waste sand is to be taken into account in the water requirement for the mix preparation using these three types of foundry waste sand otherwise there will be a drastically reduction in the workability of the mix. It is observed from Table 2 that all the three waste foundry sand are belonging to Zone 3 and local fine aggregate belongs to Zone 2 finer side. The Particle size of all the three types of sand are nearly the same except local sand.

Table 3: Bulk Density

Sl No.	Local Sand	Foundry Waste sand	Bulk Density in g/cc
1.	100%	0%	1.7069
2.	90%	10%	1.7069
3.	80%	20%	1.6795
4.	70%	30%	1.6689
5.	60%	40%	1.6496

The bulk density values for 0% and 10% replacement is the same therefore percentage replacement of the local sand by foundry waste sand is less or is lower than 10%

III. MIX DESIGN

Grades of concrete mix M20 and M25 were designed as per IS 10262-2009.. The Trial casting of both grades M20 and M25 for different W/c ratio and for different moist curing periods of 7 days and 28 days were caste and the W/c ratio which resulted in the maximum strength satisfying the requirement of M20 and M25grade concrete was used for the final castings The mix proportions are given in Table. 4 and 5

Table 4: Mix Proportion for the combination of basalt aggregate and Local sand for M20 and M25 grade Concrete

Sl o.	Grade of Concrete	Cement	Local Sand	Coarse Aggregate 12.5mm	Coarse Aggregate 20mm	W/c	% of Super Plasticizer	Compressive Strength in N/mm2 [Normal Curing] [7 days]
1.	M20	1	2.109	2.014	1.342	0.56	--	21.51
2	M25	1	1.949	1.907	1.272	0.53	--	24.85

Table 5: Mix Proportion for the combination of basalt aggregate and FWS for M20 and M25 grade Concrete

Sl No.	Grade of Concrete	Cement	FWS 100%	Coarse Aggregate 12.5mm	Coarse Aggregate 20mm	W/c	% of Super Plasticizer	Compressive Strength in N/mm2 [Normal Curing] [7 days]
1.	M20	1	1.841	2.080	1.386	0.56	---	22.091
2	M25	1	1.949	1.907	1.272	0.53	--	22.41

IV. Expermental Results & Discussions

4.1 General

Various properties of concrete incorporating foundry sand at various replacement levels ()%, 10% &100%)with the fine aggregate were studied , results were compared for compressive strength , split tensile strength, flexural strength and sulphate attack of foundry sand mix with Control mix.

4.2 Hardened State Concrete Properties

4.2.1 Compressive strength: The compression test was carried out using the guidelines from IS:516-1959 code.

4.2.1.1 M20 GRADE

Table 6: Results for different combination of M20 grade concrete at different Curing periods.

Grade of concrete	w/c ratio	Mix Combinations of Coarse Aggregate and	Avg. 7 days comp. Strength in N/mm2	Avg. 28days comp. Strength in N/mm2	Avg. 56days comp. Strength in N/mm2
M20	0.56	Local Sand	23.92	33.92	35.98
	0.56	90 %sand and 10 %FWS	23.85	33.28	----
	0.56	FWS(100%)	21.902	31.06	32.93

From Table 6 it is observed that 7 day and 28 day compressive strength for all the 3 types of mixes that is CA + Local sand , CA + FWS and CA + 90% local sand and 10% FWS have resulted in nearly the same strength. Even the compressive strength of the two mixes that is CA + Local sand and CA+ FWS at 56 days is nearly same and there is marginal increase in strength after 28 days.. Foundry waste sand can be used(100% replacement) for preparation of M20 grade concrete subject to study long term strength of 90 days .

5.2.1.2 M25 GRADE

Table 7 : Results for different combination of M25 grade concrete at different Curing periods.

Grade of concrete	Mix combinations of coarse aggregate and	w/c ratio	Flexural strength in N/mm2	Flexure strength required as per IS 456
M20	Local sand	0.56	2.96	3.13
	90 % Sand & 10% FWS	0.56	2.88	
	FWS(100%)	0.56	2.52	

From the table 7 it is observed that 7 day compressive strength is nearly same for both the mixes that is CA + Local sand and CA + WFS. For 28day compressive strength second mix that is (CA +FWS) resulted in marginal lower strength than the control mix but it is satisfying the requirement of M25 grade concrete . FWS can be used for preparation of M25 grade concrete subject to study long term strength of 90 days. The percent replacement of FWS, results are varying narrowly compared to control mix and 100% replacement concrete. Therefore only two mixes are considered for M25 grade concrete.

4.2.2 Discussion Of Flexural Strength Results

At the ends of the curing period i.e. 28 days the prism were taken out of curing tank and they are exposed to laboratory temperature , till the surface becomes dry. Prisms are tested under the flexural strength testing machine .the loading arrangement with symmetric loads (P) at 1/3 points procedures a pure bending zone with constant bending moment and zero shear on the middle third of the span. The Flexural test was carried out using the guidelines of IS 516-1959 code.

4.2.2.1 M20 Grade

Table 8: Flexural Strength Results for different mixes for 28 days curing

Grade of concrete	Mix combinations of coarse aggregate and	w/c ratio	Flexural strength in N/mm2	Flexure strength required as per IS 456
M20	Local sand	0.56	2.96	3.13
	90 % Sand & 10% FWS	0.56	2.88	
	FWS(100%)	0.56	2.52	

It is observed from Table 8 that flexural strength of all the mixes is nearly same but mix using foundry waste sand results in marginally lower flexural strength . WFS is subjected for burning and wearing action in the moulding process therefore observed flexural strength is less compared to Local Sand. But all the flexural strength results are nearly 1/8 th of the compressive strength results.

4.2.2.2 M25 Grade

Table 9: Flexural strength results for different mixes for 28 days curing

Grade of concrete	Mix combinations of coarse aggregate and	w/c ratio	Flexural strength in N/mm2	Flexure strength required as per IS 456
M25	Local sand	0.53	3.43	3.50
	FWS(100%)	0.53	2.94	

It is observed from Table 9 that flexural strength of all the mixes is nearly same but mix using foundry waste sand results in marginally lower flexural strength . But all the flexural strength results are nearly $1/10^{th}$ of the compressive strength results.

Testing of Beams for Flexural strength test

4.3 Discussion Of Split Tensile Strength Results

At the ends of the curing period i.e. 28 days the Cylinders were taken out of curing tank and they are exposed to laboratory temperature, till the surface becomes dry. Cylinders are tested under the Universal Testing machine by keeping the cylinder in the horizontal position. The Split tensile test was carried out using the guidelines from IS 5816-1999 code.

4.3.1 M20 Grade

Table 10: Split Tensile strength results for different mixes for 28 days curing

Grade of concrete	Mix combinations Of Coarse aggregate and	w/c ratio	Split Tensile Strength in N/mm2	Split Tensile Strength required as per IS 456
M20	Local Sand	0.56	2.696	3.13
	90 % Sand & 10% FWS	0.56	2.688	
	FWS(100%)	0.56	2.235	

It is observed from Table 10 that Split tensile strength of all the mixes is nearly same but mix using foundry waste sand results in marginally lower Split Tensile Strength . But all the Split tensile strength results are nearly $1/7^{th}$ of the compressive strength results.

4.3.2 M25 Grade

Table 11:Split Tensile strength results for different mixes for 28 days curing

Grade of concrete	Mix combinations of coarse aggregate and	w/c ratio	Split Tensile Strength in N/mm2	Split Tensile Strength required as per IS 456
M25	Local Sand	0.53	3.18	3.50
	FWS(100%)	0.53	2.815	

It is observed from Table 11 that Split tensile strength of all the mixes is nearly same but mix using foundry waste sand results in marginally lower Split Tensile Strength . But all the Split tensile strength results are nearly1/9th of the compressive strength results.

Testing of the cylinders for the Split Tensile Test

4.4 Reaction To Sulphate Attack Of Concrete

4.4..1 M20 Grade

Table 12 : Results of weights for different combination of M20 grade concrete

Sl No.	Weight before immersion in Magnesium sulphate solution in Kg	Weight after immersion for 7 days in Magnesium sulphate solution in Kg
1.	8.810	8.724
2.	8.494	8.506
3.	8.735	8.750
4.	8.689	8.717
5.	8.965	8.968

It is observed from table 12 that no weight loss was observed fort the samples immersed in magnesium sulphate solution for a duration of 7 days. Small increase weight of samples after immersion is due to entry of Magnesium solution in pores

Table13 : Results for different combination of M20 grade concrete at different Curing periods**.**

Grade of concrete	w/c ratio	Mix Combinations	Avg. 28 days comp. Strength in N/mm2	Avg. comp. Strength in N/mm2 of the cubes after immersion in magnesium sulphate solution for 7 days
M20	0.56	Basalt + sand	33.92	36.89
	0.56	Basalt + WFS	31.06	33.45

It is observed from Table 13 that compressive strength of both the mixes after immersing in magnesium sulphate solution for 7 days that no degradation in strength was observed. Some more samples are kept to study degradation in strength of long term at 90 days.

V. Conclusion

Following conclusions are drawn from this investigation.

1. Foundry waste sand fineness is nearly same as that of the local sand
2. Foundry waste sand has lower specific gravity compared to local sand
3. Water absorption for foundry waste sand is higher than local sand
4. Concrete made using foundry waste sand satisfies the compressive strength requirement for M20 and M25 grade concrete at 28 days curing.
5. Concrete using foundry waste sand is resistant to sulphate attack after immersion for a period of 7 days
6. Comparing with the conventional concrete the results so obtained by compressive and flexural strength were nearly same as that of the conventional concrete.

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