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Utilization of Foundry Waste Sand as a Masonry Mortar

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Abstract: *The objective of this work is to develop foundry waste sand as a masonry mortar and plastering mortar. Since there is acute shortage of sand the efforts are made on finding the alternate material to the sand. This has lead to study the properties of mortar using foundry waste sand obtained from ALSTOM industry Shahabad. Tests for physical properties of various material used in preparation of mortar such as cement, local sand and foundry waste sand were conducted. Based on trail flow table test mix proportion and w/c ratio were fixed. Specimens caste for different tests were 21 for masonry mortar, 27 for plastering mortar, 9 for water retentivity and 18 for sulphate attack test respectively. Thus in all 81 specimens were caste for the experimental studies. The compressive strength values for masonry mortar were 5.10, 3.70 ,3.80 N/mm^2 and plastering mortar were 4.60, 2.95, 3.23 N/mm^2 for local sand, weathered sand and burnt black sand respectively. The compressive strength results of clay brick masonry wall are 0.486, 0.411, 0.471 N/mm^2 and for fly ash brick wall 0.613, 0.587, 0.612 N/mm^2 for local sand , weathered sand and burnt black sand respectively.*

Keywords: *foundry waste sand, used foundry sand*

I. Introduction

Foundry sand is high quality silica sand with uniform physical characteristics. It is a 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. When the sand can no longer can be used it is refused in the foundry, it is removed from the foundry and it is termed as "Foundry Waste Sand". **T.R.Naik et.al**. [1] reported that excavatable flow table slurry with desirable physical properties can be manufactured using foundry sand as a replacement for fly ash up to 85%. Based on the test results they concluded that, the addition of foundry sand caused a decrease in concrete workability. Compressive strength of concrete decreased slightly due to the replacement of regular coarse aggregate with foundry slag. However, compressive strength observed for both 50 and 100 percent slag mixes were appropriate for structural uses. **Khatib et al. [**2] investigated **s**ome mechanical and fresh properties of concrete containing waste foundry sand (FWS) and 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 FWS. The mixes (with and without FWS) show an increase in strength with curing time. The compressive strength of concrete also decreases with increasing amounts of FWS. **Saveria Monosi, Daniela Sani and Francesca Tittarelli**,[3] 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, 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 superplasticizer dosage. 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. It is observed that in FWS literature no one discussed about masonry mortar using instead of that discussed only about FWS on concrete. In this I have researched on masonry mortar. The objective of present work is to utilize foundry waste sand in the preparation of mortar and study the compressive strength.

II. Materials Used

Pazzolonic Portland cement conforming to IS 1489 -1991[4]. 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 50 minutes and 260 minutes respectively. 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 locally available sand 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[5] was used. FWS is of three types Burnt Black sand, weathered sand and local sand. Physical properties and sieve analysis results for foundry waste sand are presented in Table 2.

Table1: comparison of Fine Aggregate and foundry waste sand

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

Table2: sieve analysis results of foundry waste sand

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 for zone III	
4.75mm	100	100	100	90-100	
2.36mm	100	100	100	85-100	All The sands belongs to ZONE III Finer
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 sand 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 three types of sand is nearly same but local sand has resulted marginally higher value. Water absorption for foundry waste sand are quit high compared to local sand 0.61% because polymer resin 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 foundry waste sand are belonging to zone-III and locally available sand belongs to zone-II finer side. The sand particle sizes of all the four types of sand are nearly same.

III. Chemical Tests

Since there is polymer resin chemical present in the foundry waste sand (weathered sand and burnt black sand) the chemical test was conducted and results are compared with local sand.

3.2.1Chloride Test

To determine the percentage of chloride present in the local sand and foundry waste sand the chloride test was carried out as per ASTM D-512.

Table 3: chloride content in sand

Sl.no	Type of sand	% of chloride content in total aggregate
1.	Local sand	0.0127
2.	Weathered sand	0.0126
3.	Burnt black sand	0.0128

Calculation:

Determination of chloride ion concentration (weight percent) as follows

% chloride = 3.545 VN/S

Where,

V= ml of silver nitrate solution

N= normality of silver nitrate solution

S= sample weight, grams

From the Table 3 it is noted that the percentage of chloride content in total aggregate for local sand , weathered sand ,burnt black sand is nearly same with marginal variation and the obtained results are satisfactory limits indicated by BS 882:1992 (0.05% for local sand , weathered sand ,burnt black sand respectively).

3.2.2 sulphate test

To determine sodium sulphate content in the local sand and foundry waste sand the sulphate test was carried out as per IS 2720-1977.

Table 4: sodium sulphate content in sand

Sl.no	Type of sand	% of sodium sulphate by weight of cement as per IS456-2000
1.	Local sand	0.1062
2.	Weathered sand	0.1602
3.	Burnt black sand	0.2928

Calculation:

sodium sulphate in sand, % by mass = 0.0177×100(x-y)

Where,

x= volume of N/4 barium chloride added, ml.

y= volume of N/4 potassium chromate solution used in back titration.

From the Table 4 it is clear that the percentage of sodium sulphate content by weight of for local sand, weathered sand ,burnt black sand were 0.1062, 0.1602, 0.2928 respectively and the obtained results satisfactory as per IS 456-2000.

IV. Experimental Results And Discussion

3.1 Fresh state properties

41.1 In order to use the mortar in the preparation of masonry mortar minimum workability is required. Published literature [8] indicated minimum flow of 75% is required for masonry mortar. Therefore in order to access the workability in terms of flow the workability of fresh mortar mixes were determined by flow table test as per IS: 2250-1981.

Table 5: Flow table test results for masonry mortar**.**

Sl.No	Type Of Sand	Mix proportion	W/C	Super plasticizer in %	Flow in %
1	Local Sand	1:6	0.7	0.00	74.50
			0.9	0.00	77.00
			1.1	0.00	80.00
2	Weathered Sand	1:6	0.7	3.00	75.00
			0.9	2.80	76.00
			1.1	2.20	77.50
3	Burnt Black Sand	1:6	0.7	3.00	75.00
			0.9	2.20	75.5
			1.1	1.80	76.65

It is clear from the Table 4 that local sand, weathered sand and burnt black sand have resulted in required flow percentage of 74.5%, 77.8%, 80% and 75%,76%,77.5% and 75%,75.5%,76.65% for w/c 0.7,0.9 and 1.1 respectively. Therefore keeping in view strength requirement and percentage of flow (75%) w/c ratio of 0.7 fixed for all the 3 types of sand. These finalized w/c ratio (0.7) and mix proportion (1:6) were used for construction of wallets for load carrying capacity [8].

Fig1: Flow of local sand , weathered sand Black burnt sand masonry mortar

3.2 Harden state properties

3.2.1 compression strength of cubes

To determine compressive strength of masonry mortar two mortar proportions were used i.e one proportion is the proportion and w/c ratio taken by the mason and second proportion is decided (1:5) based on trail results in the lab. Minimum compressive strength required for masonry mortar as published in literature [8] is 3-5Nmm^2. Therefore in order to ascertain the compressive strength of the mortar for w/c ratio 0.7 and mix proportion 1:6 as finalized earlier is used for compressive strength test. The compressive strength test was conducted as per IS 2250-1981.

Table 5: compressive strength results for masonry mortar (mason proportion)

Sl.no	Type of sand	Mix proportion	w/c ratio	Size (mm2)	Failure load (N)	Average failure load (N)	Compressive strength (N/mm2)	Compressive strength values as per IS2250-1981 standard (N/mm^2)
1.	Local sand	1:5	1.00	5184	18632.63			
					15690.64	17161.63	3.55	
					17651.97			
2.	Weathered sand	1:5	1.00	5184	16060.00			3-5 N/mm^2
					15997.00	16222.33	3.2	
					16610.00			
3.	Burnt black sand	1:5	1.00	5184	14709.97			
					14709.97	15363.74	3.3	
					16671.30			

From the Table 15 it is noted that compressive strength test was conducted for the w/c ratio 1 and mix proportion 1:5 and the obtained compressive strength results of all the 3 types of sand are 3.55, 3.20, 3.30 for local sand , weathered sand and burnt black sand respectively. The obtained compressive strength results of all 3 types of sand (local sand, weathered sand and bunt black sand) are satisfactory as per IS 2250-1981(3-5 N/mm^2) [9]

Table 6: Compressive Strength results for masonry mortar (standard proportion).

Sl.no	Type Of Sand	Mix proportion	Size Of Cube (mm^2)	W/C	Super plasticizer in %	Failure Load (N)	Avg. Failure Load (N)	Compressive strength (N/mm^2)	Compressive strength values as per IS2250-1981 standard (N/mm^2)
1	Local Sand	1:6	5184	0.7	0.0	25497.29			
						30298.68	25549.60	5.21	
						20552.81			
				0.9	0.0	21593.96			
						20593.96	23215.51	4.74	
						27458.62			
				1.1	0.0	27458.62			
						20593.96	22555.29	4.60	
						19613.30			3-5N/mm^2
2	Weathered sand	1:6	5184	0.7	3.0	18150.00			
						18135.00	18130.00	3.70	
						18105.00			
				0.9	2.8	13263.17			
						16690.64	14870.81	3.03	
						14658.64			
				1.1	2.2	12062.17			
						15690.64	14221.60	2.90	
						12648.64			
3	Burnt Black Sand	1:6	5184	0.7	3.0	18625.00			
						18600.00	18620.00	3.80	
						18635.00			3-5N/mm^2
				0.9	2.2	18632.63			
						15690.64	17161.63	3.55	
						17651.97			
				1.1	1.8	14709.97			
						14709.97	15363.74	3.30	
						16671.30			

From the table 6 it is noted that for local sand using w/c ratio 0.7, 0.9 and 1.1 measured compressive strength were 5.21, 4.74, 4.60 N/mm^2 respectively. Remaining two sand i.e weathered sand and burnt black sand without super plasticizer mortar can not be prepared for the same w/c ratio 0.7,0.9 and 1.1 as mix is lacking in water content. Therefore for weathered sand dosage of super plasticizer used was 3%, 2.8% and 2.2% and corresponding compressive strength were 3.70,3.03 and 2.90 N/mm^2 . similarly for burnt black sand dosage of super plasticizer added was 3%, 2.2% and 1.8% and corresponding compressive strength were 3.80,3.55 and3.30 N/mm^2 respectively. The obtained compressive strength results of all 3 types of sand (local sand, weathered sand and bunt black sand) are satisfactory except w/c ratio1.1 for weathered sand as per IS 2250-1981(3-5 N/mm^2) [9]

3.2.2 compressive strength of masonry wall

To determine the compressive strength of masonry wall, walls of size 1.5m×0.6m×0.1m were constructed using clay bricks and flyash blocks. A mix proportion of 1:6 and w/c ratio 0.7 is used for constructing masonry wall and curried for 28 days. The rate of loading applied for the masonry wall is

Table 7: Compressive Strength results for masonry mortar.

Types of wall	Types of sand	Super plasticizer	Avg Proving ring reading@1st crack (KN)	Avg proving ring reading @failure(KN)	Compressive strength for 1st crack(N/mm2)	Compressive strength for failure (N/mm2)	Basic Compressive strength for 1st crack(N/mm2)	Basic Compressive strength for failure (N/mm2)
		(%)						
Brick	Local sand	0%	67.002	73.002	0.446	0.486	0.446	0.486
	Weathered sand	3%	61.752	66.252	0.411	0.441	0.411	0.441
	Burnt black sand	3%	62.252	70.752	0.415	0.471	0.415	0.471
Fly ash blocks		0%	75.313	92.563	0.502	0.613	0.502	0.613
		3%	71.563	88.063	0.477	0.587	0.477	0.587
		3%	86.313	91.811	0.575	0.612	0.575	0.612

From the table 7 it is observed that the resulted basic compressive strength for brick wall using local sand is marginally higher than weathered sand and burnt black band sand resulted higher strength than weathered sand. For fly ash brick wall the resulted strength of local sand is also higher than weathered sand and burnt black sand[10]

Fig4: Failure pattern of Brick wall

Fig5: Failure pattern of flyash block wall

V. Conclusion

1) Foundry waste sand is finer than local sand, fineness modulus of all the three waste foundry sands are nearly same.
2) Chloride content of local sand and FWS is nearly same. chloride content of all the sands are within the limits of BS: PART 1: 1985
3) Sulphate content in aggregate content for local sand is within the moderate limit but for FWS crossing the limit of moderate and marginally entering into the sever limit.
4) High dosage of super plasticizer is required for FWS to attain same flow as for local sand for the same w/c ratio.
5) The compressive strength of local sand is high compared to weathered sand and burnt black sand. However, results obtained by FWS are satisfactory as per IS 2250-1981.
6) Basic compressive strength of masonry wall (using clay brick and flyash brick) is marginally higher for local sand compared to weathered sand and burnt black sand.

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