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Research Article

Utilization of Waste Foundry Sand as Partial Replacement of Fine Aggregate for Low Cost Concrete

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Abstract

Present experimental work describes the utilization of foundry sand, a waste material, which is easily available. It is a by-product which is produced in metal casting industries at the time of casting. It causes environmental problems (like water quality impurities) because of its improper disposal. Continuous technological and industrial developments are taking place and also the rate of generated waste products are increasing. In construction industries demand of construction materials are never come down and that is why there is need to focus on alternative construction materials. If waste material like foundry sand is used as construction material, it can help to reduce the amount of disposal material. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (sea coal, resins) and dust. It can be used as a partial replacement of fine aggregate. In this investigation, fine aggregate has been replaced by foundry sand accordingly in the range of (10-60% at the interval of 10%). Concrete mixes were cost and tested for workability and compressive strength. It was observed that at 10% replacement of fine aggregate by foundry sand compressive strength was increased. Also, up to 20% replacement of fine aggregate by foundry sand strength is comparable to referral concrete.

Keywords: *Foundry sand, Portland Pozzolana cement (PPC), water cement ratio, compressive strength, split tensile strength, flexural strength.*

Introduction

In this era challenges of the civil engineers are how to enhance the work culture of using waste by-product in construction and in the evolution of low cost concrete. Construction sectors are deploying rapidly on a large scale and also marching to involvement of new construction technologies. The consumption of natural resources in construction has common from decades, which is the result of high cost. To overcome the use of natural resources and use of waste material like foundry sand in concrete could be make possible to achieve the low cost construction. Also the use of waste foundry sand in construction could help to avoid the problems related to environment pollution. Metal industries use foundry sand which is uniform sized, high quality silica sand that is bound to form a mould for casting of ferrous and non-ferrous metal. Finer sand than normal sand is used in metal casting process (Amritkar et. al 2015). The natural sand used as fine aggregate in concrete is directly comes from the rivers. To fulfill the regular demand and to reduce the consumption of natural sand, waste foundry sand can be partially replaced to natural sand by weight. In the metal casting industries million tons of waste materials generated every year, they simply used to dispose these waste by product in the nearby land. Earlier it was considered as land filling material but gradually its disposal becoming a big problem against environment.

Though the sand, cement aggregate and water are the parent material of concrete but waste foundry sand which is harmful for environment can be used partially as sand replacement for the evolution of low cost construction material.

The main objective of this experimental work is to compare the effect of foundry sand in PPC concrete with the conventional cement concrete and to see the effect of foundry sand inclusion in PPC concrete. Also the study is summarize based on compressive strength, split tensile strength and flexural strength of PPC replaced foundry sand with fine aggregate.

Materials and Methodology

Cement

To the present investigation PPC obtained from single batch was used as binder throughout the investigation. The physical properties of PPC are given in table 1.

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Table-1 Properties of cement

Properties (IS 8112-1989)	Experimental Code requirement
Initial setting time (Not less than 30 min)	104 Min
Final setting time (Not more than 600 min)	310 Min
Soundness of Cement (Not more than 10 mm)	6mm
Fineness of Cement (%age retained on 90 micron IS sieve)	2.5% <10%
Specific gravity of Cement 3.15	3.15
Compressive Strength	
3 Days 23 N/mm^2	23.33
7 Days 33 N/mm^2	33.66
28 Days 43 N/mm^2	43.66

Table- 2 Result of sieve analysis of Fine Aggregate

Sieve Size	Weight Retained(gm)	Cumulative Weight Retained	Cumulative% Weight Retained	Passing%	Standard % Weight Passing for Zone II India
4.75mm	-	-	-	100	100
2.36 mm	56	56	5.6	94.4	75-100
1.18mm	192	248	24.8	75.2	55-90
600µ	305	553	55.3	44.7	35-59
300µ	365	918	91.8	8.2	8-30
150µ	69	987	98.7	1.3	0-10
Pan	12	999	100	0	0

Fineness Modulus = 276.2/100 =2.76

Table-3 Sieve analysis of coarse aggregate (10 mm size)

Sieve Size	**Weight Retained(gm)**	**Cumulative Weight Retained**	**Cumulative% Weight Retained**	**Passing%**
20mm	-	-	-	100
10mm	2376.0	2376	47.56	52.44
4.75mm	2340	4716	94.4	5.6
2.36 mm	280	4996	100	-
1.18mm	0	4996	100	-
600µ	0	4996	100	-
150µ	0	4996	100	-
Pan	0	4996	100	-

Fineness Modulus = 641.96/100 =6.42

Table- 4 Sieve analysis of coarse aggregate (20 mm size)

Sieve Size	Weight Retained(gm)	Cumulative Weight Retained	Cumulative% Weight Retained	Passing%
40mm	-	-	-	100
20mm	487	487	9.76	90.24
10mm	4059	4546	91.08	8.92
4.75mm	445	4991	100	-
1.18mm	0	4991	100	-
600µ	0	4991	100	-
300µ	0	4991	100	-
150µ	0	4991	100	-

Fineness Modulus = 600.84/100 =6.01

Table- 5 Physical Properties of Foundry sand

Property	Results
Specific Gravity	2.39-2.55
Bulk Relative Density ,kg/m3 (lb/ft3)	2589(160)
Absorption, %	0.45
Moisture content, %	0.1-10.1

Table-6 Compressive strength of foundry sand cubes

Cube designation	Compressive strength (N/mm2)			Foundry sand%
	7d	28d	56d	
A1	11.9	24.4	25.7	0
A2	13.6	25.5	29.0	10
A3	13.3	23.4	24.1	20
A4	10.1	20.1	22.2	30
A5	9.85	18.2	18.9	40
A6	9.48	17.1	17.6	50
A7	9.25	15.5	16.2	60

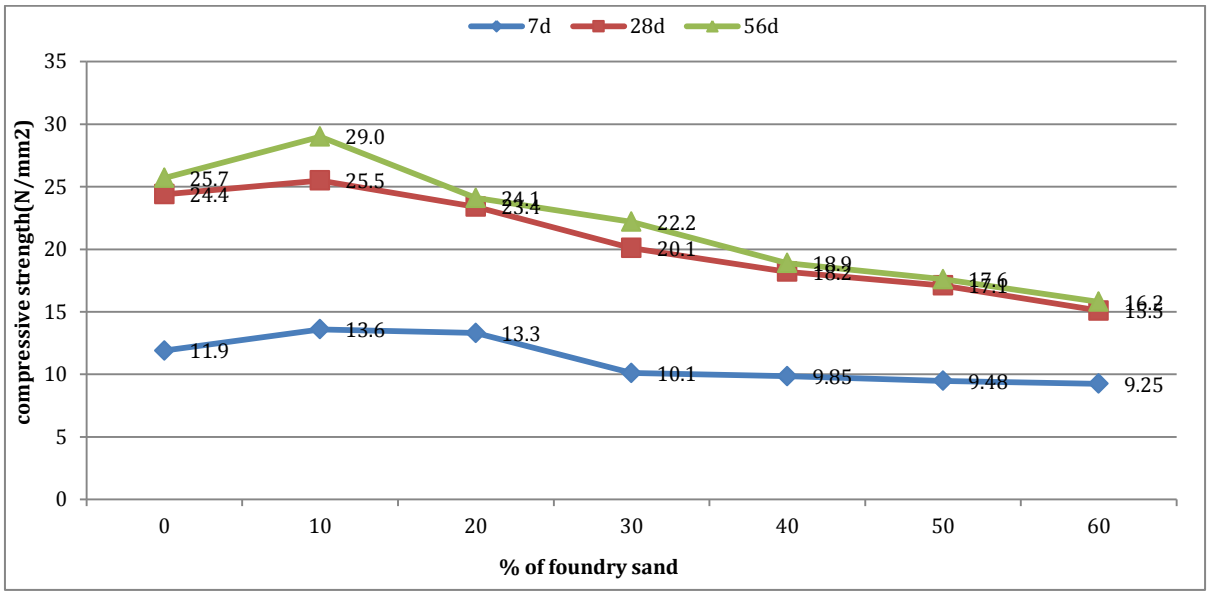

Fig. (i) Compressive strength of foundry sand concrete (line chart) (w/c=0.50)

Fine aggregate

The fine aggregate was locally available river sand which was passed through 4.75 mm sieve. The specific gravity of fine aggregate was 2.6 and fineness modulus of fine aggregate was 2.76. Result of sieve analysis is given in table.

Coarse aggregate

The coarse aggregate was locally available quarry having two different sizes, one fraction is passing through 20mm sieve and another fraction passing through 10mm sieve. The specific gravity of coarse aggregate is 2.7 for both fractions. The grading of coarse aggregate of 10mm and 20mm size are given in table 3 and table 4

Foundry sand

In the present work foundry sand is obtained from metal industries in Dadagang Kanpur Uttar Pradesh. The physical properties of the foundry sand is given in table 5

For this study 63 cubes, 45 cylinder and 15 beams were cast by replacing fine aggregate by foundry sand. Compressive strength, split tensile strength and flexural strength of foundry sand concrete were observed and compared with those of natural concrete. To achieve this comparative study cubes, cylinder and beams were cast replacing sand by 10%, 20%, 30%, 40%, 50%, and 60% with foundry sand. These specimen were tested after 7, 28 and 56 days. To identify strength a nominal mix of 1:1.667:3.333 was used during the investigations.

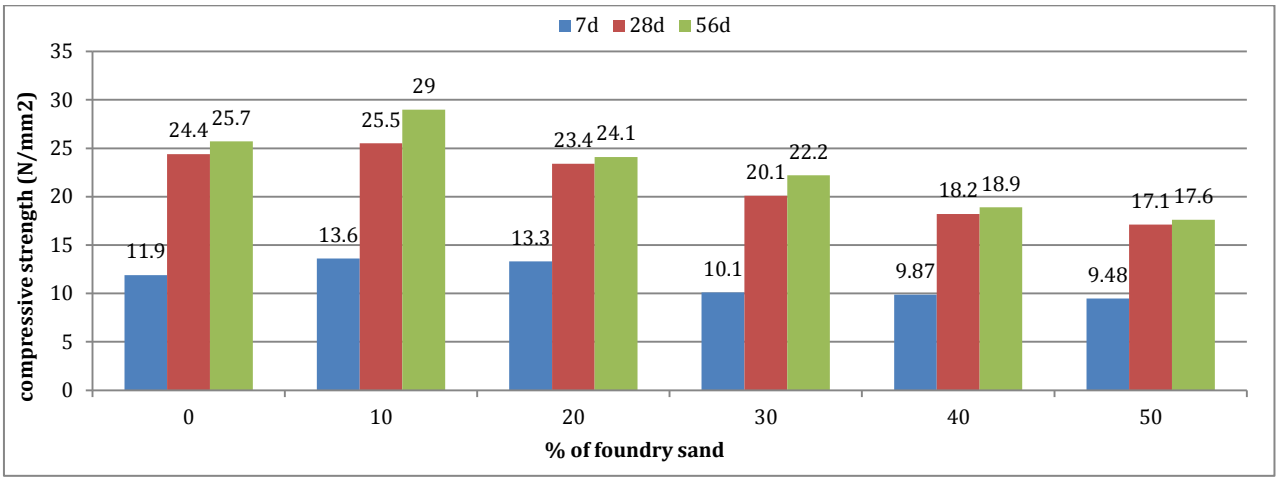

Fig. (ii) Compressive strength of foundry sand concrete (bar chart) (w/c=0.50)

Results and discussion

Workability

Workability is property of concrete which determines each in mixing placing and compaction. In the present investigation it was observed that workability increased slightly with replacement level.

Compressive strength

Compressive strength is the maximum compressive stress that, under a gradually applied load, a given solid material can sustain without fracture.

Result of compressive strength concrete made using foundry sand as partial replacement of fine aggregate are given in table 6 and the same result are also shown in fig (i) and fig (ii) for visual observation.

It is evident from table 6 that at 10% replacement level compressive strength of concrete made using of foundry sand is more than that of referral conventional concrete at all the ages. The increase in strength may be due to the fact that foundry sand was finer and lighter than natural fine aggregate. On equal weight basis foundry sand occupy more volume in concrete filled more voids in concrete than that of natural fine aggregate resulting in increased compressive strength. At 20% replacement level compressive strength was found comparable to the referral conventional concrete. Beyond 20% replacement level compressive strength of concrete made using foundry sand decreased substantially with increase in replacement level. The reason behind decrease in compressive strength is more volume of foundry sand at equal weight basis as compare to the natural fine aggregate. The more volume excess to that of required for filling the voids between coarse aggregate lead to lesser density of concrete resulting with decrease in compressive strength is reported.

Conclusion

The following conclusions were made based on the finding of the study:

1-workability of concrete made using foundry sand observed to be increased slightly with replacement level.

2-compressive strength of concrete at 10% replacement level was more than that of referral conventional concrete.

3-At 20% replacement level compressive strength of concrete was comparable to referral conventional concrete.

4-Optimum replacement level of foundry sand as is 10%.

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