Application of Waste Foundry Sand for Evolution of Low-Cost Concrete

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Abstract–***Generation of waste foundry sand as by-product of metal casting industries causes environmental problems because of its improper disposal. Thus, its usage in building material, construction and in other fields is essential for reduction of environmental problems. This research is carried out to produce a low-cost and eco-friendly concrete. This paper demonstrates the use of waste foundry sand as a partial replacement by fine aggregate in concrete. An experimental investigation is carried out on a concrete containing waste foundry sand in the range of 0%, 20%, 40%, and 60% by weight for M-25 grade concrete(PPC). Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube of 150*150*150* mm for 7, 14 and 28 days to determine the mechanical properties of concrete. Through experimental result we conclude that the compressive strength increases with increase in partial replacement of waste foundry sand and split tensile strength decreases with increases in percentage of waste foundry sand. The aim of this research is to know the behaviour and mechanical properties of concrete after addition of industrial waste in different proportion by tests like compressive strength and split tensile.***

Keywords: - **Industrial waste, Foundry sand, PPC, Low-cost, Eco-friendly, Compressive strength, Split tensile strength.**

I. INTRODUCTION

Now-a-days the construction sector is exploring rapidly on a large scale and also involves new techniques for rapid and comfort works on the field. Concrete as a building material plays an important role in this sector. The consumption of natural resources as an ingredient of concrete, costs high as well as it is on verge of extent. These problems force us to recover the natural resources or to find an alternative option to overcome this problem. Presently, the production of waste foundry sand as a by-product of metal casting industries causes various environmental problems. Usage of this waste in building material would help in reduction of stress on environment.

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. The burnt sand after the casting process of metal is reuse for many times but when it cannot be longer used it is removed from foundry as a waste for disposal known as "Waste foundry sand". Use of waste foundry sand as a partial replacement or total replacement by fine aggregate in concrete leads in production of economic, light weight and high strength concrete.

Concrete is a material which is composed of coarse aggregate, fine aggregate, cement, admixtures and water these each material in concrete contributes its strength. So, by partial or percentage replacing of material affects different properties of concrete. By using such waste material which harms the environment can be used for the development of low cost and eco-friendly building materials. In this study an experimental investigation is carried out by varying percentage of fine aggregate with used foundry sand to produce low cost and eco-friendly concrete

II. EXPERIMENTAL MATERIALS

(a) Foundry sand

Most of the metal industries prefer sand casting system. In this system mould made of uniform sized, clean, high silica sand is used. After casting process foundries recycle and reuse the sand several times but after sometime it is discarded from the foundries known as waste foundry sand. The application of waste foundry sand to various engineering sector can solve the problems of its disposal and harmful effect to environment.

Foundry sand is clean, uniformly sized, high-quality silica sand that is bounded to form moulds for ferrous (iron and steel) and non-ferrous (copper, aluminum, brass) metals. Type of foundry sand depends on the casting process in foundries. Foundry sand is generally of two types: Green sand, Chemically bounded sand. Additive in sand depends on type of metal casting. Use of waste foundry sand as full or partial replacement by fine aggregate helps to achieve different properties or behaviour of concrete.

FIGURE: 1 Waste foundry sand

SOURCE: Concrete Lab, Sigma Institute of Engg.

TABLE-1
CHEMICAL PROPERTIES OF FOUNDRY SAND

Constituent	Value (%)
SiO_2	83.93
Al_2O_3	0.021
Fe_2O_3	0.950
CaO	1.03
MgO	1.77
SO_3	0.057
LOI	2.19

SOURCE: Geo-Test House, Gorwa, Vadodara.

(b) Cement

Cement in concrete acts as a binding material that harden after the addition of water. It plays an important role in construction sector. In this study the Portland Pozzolana Cement (PPC) of 53 grade (Sanghi Cement) is used according to IS: 1489-1991. Various tests were performed on cement they are: Soundness test, Consistency test, Initial and final setting time.

FIGURE: 2 Sanghi cement (53 grade PPC)

TABLE-2
PROPERTIES OF (PPC) CEMENT

Physical properties of SANGHI Cement (PPC) 53 grade	Result	Chemical properties of SANGHI Cement (PPC) 53 grade	Result (%)
Specific gravity	2.90	SiO_2	23.7
Standard consistency (%)	31.6%	Al_2O_3	12.4
Initial setting time (min)	210 min	CaO	48.0
Final setting time (min)	250 min	MgO	1.83
Compressive strength N/mm^2 at 28 days	52 N/mm^2	Fe_2O_3	2.01
-	-	Loss on ignition	1.00

(c) Aggregate

Aggregate is a natural deposit of sand and gravel and also give structure to the concrete. It occupies almost 75% to 80% of volume in concrete and hence shows influence on various properties such as workability, strength, durability and economy of concrete. To increase the density of concrete aggregate is frequently use in different sizes. Aggregate acts as reinforcement and introduce strength to the overall composite material. Aggregate is also used as base material for roads, railroads and under foundation due to its good strength.

(d) Coarse aggregate

The aggregate having size more than 4.75 mm is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc. 80mm size is the

maximum size that could be conveniently used for making concrete. In this study coarse aggregate is conformed to IS: 383. The Flakiness and Elongation Index were maintained well below 15%.

FIGURE: - 3 Coarse aggregate

FIGURE: - 4 Grit

(e) Fine Aggregate

Aggregate that pass through a 4.75 mm IS sieve and having not more than 5 percent coarser material are known as fine aggregate. Main function of fine aggregate is to fill the voids in between coarser particles and also helps in producing workability and uniformity in mixture. In this study fine aggregate is conform to IS: 383.

FIGURE: - 5 Fine Aggregate

TABLE-3
PROPERTIES OF FINE AND COARSE AGGREGATE

Property	Fine Aggregate	Coarse Aggregate	
		Less than 20 mm	Less than 10 mm (Grit)
Fineness modulus	3.30	7.52	3.20
Specific gravity	2.38	2.76	2.69
Bulk density (gm/cc)	1752	1744	1714
Water absorption (%)	1.25	1.80	1.36

f) Water

Water plays an important role as it contributes in chemical reaction with cement. Water is used for mixing as well as for curing purpose also it should be clean and free from salts, acids, alkalis and other harmful materials. Generally, ordinary water is used for mixing concrete.

III. MIX DESIGN

As per IS: 10262-1982 mix design was prepared for M25 grade and same design was used in preparation of test samples.TABLE-4 shows mix design proportion.

TABLE-4
MIX DESIGN PROPORTION FOR M25 grade

	Water (lit.)	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)
By weight (gms)	191.60	479	485.75	1197.03
By volume (m^3)	0.40	1	1.01	2.50

TABLE-5
CONCRETE MIX DESIGN (M25 grade)

Sr no.	Type of concrete	Concrete mix design proportion				
		w/c ratio	C	FA	CA	WFS
1.	B0	0.40	1	1.01	2.50	-
2.	B2	0.40	1	0.81	2.50	0.20
3.	B4	0.40	1	0.61	2.50	0.40
4.	B6	0.40	1	0.41	2.50	0.60

C=Cement, FA=Fine Aggregate, CA=Coarse Aggregate, WFS=Waste Foundry Sand

TABLE-6
LIST OF SYMBOL AND ABBREVIATION

Sr no.	Type of concrete	Fine aggregate replaced by waste foundry sand
1.	B0	Traditional concrete
2.	B2	20% replacement
3.	B4	40% replacement
4.	**B6**	**60% replacement**

IV. EXPERIMENTAL METHODOLOGY

Concrete contains waste foundry sand as a partial replacement of fine aggregate is tested. Concrete is composed of cement, coarse aggregate, fine aggregate, waste foundry sand and water. The waste foundry sand is replaced in the range of 0%, 20%, 40% and 60% by weight of fine aggregate. The mixture was prepared and three standard cubes of 150*150*150 mm were casted. After curing for 24hrs the samples were demoulded and subjected to compressive strength test and tensile split test for 7, 14 and 28 days.

(a) Compressive strength test

Compressive strength tests were performed on compression testing machine of 2,000 KN capacity. Three cubes of 150*150*150 mm from each batch were subjected to this test. The comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 20%, 40% and 60%.

FIGURE: - 6 Compression strength test for cube

TABLE-7
COMPRESSIVE STRENGTH OF CUBES FOR M25 grade AT 7, 14, 28 DAYS.

Type of concrete	Average ultimate compressive strength at 7 days (N/mm^2)	Average ultimate compressive strength at 14 days (N/mm^2)	Average ultimate compressive strength at 28 days (N/mm^2)
B0	27.70	30.81	37.93
B2	25.78	32.15	39.26
B4	25.90	32.30	39.70
B6	33.19	35.70	40.74

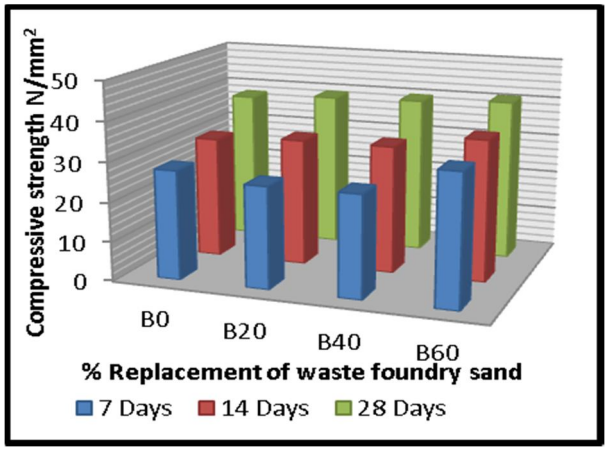

FIGURE: - 7 Graph of % replacement of waste foundry sand v/s compressive strength (N/mm^2) for 7, 14, 28 days.

(b) Split tensile test

The tensile strength of concrete is approximately 10% of its compressive strength. Tensile splitting strength tests of concrete block specimens were determined as per IS: 5816-1999. After curing of 28 days the specimens were tested for tensile strength using a calibrated compression testing machine of 2000 KN capacity.

FIGURE: - 8 Split tensile test for cube

TABLE-8
SPLIT TENSILE STRENGTH OF CUBE FOR M25 grade AT 28 DAY.

Type of concrete	Average ultimate split tensile strength at 28 days (N/mm^2)
B0	4.3
B2	3.61
B4	3.53
B6	3.15

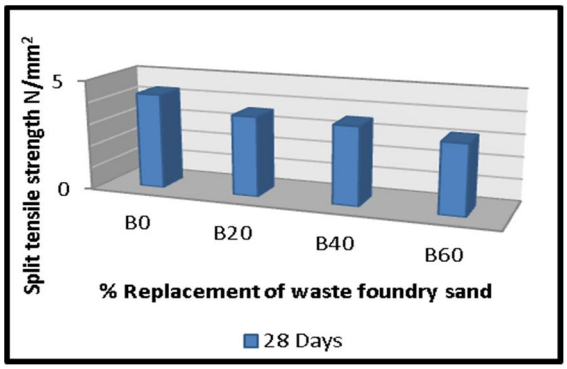

FIGURE:-9 Graph of % replacement of waste foundry sand v/s split tensile strength (N/mm^2) for 28 days.

V. COST FEASABILITY

TABLE-9
MATERIALS COST

Sr no.	Material	Rate (Rs/Kg)
1.	Cement	6.00
2.	Fine aggregate (sand)	0.60
3.	Coarse aggregate (> 20mm)	0.65
4.	Grit	0.65
5.	Foundry sand	0.15

TABLE-10
TOTAL COST OF MATERIALS FOR M25 grade PER m^3.

CT	Consumption of mix design proportions for M25 grade					Total cost/m^3	% cost change
	C	F.A	C.A	G	W.F.S		
B0	479.00	485.75	718.22	478.81	0.00	3751.92	0
B2	479.00	388.60	718.22	478.81	97.15	3708.20	-1.16
B4	479.00	291.45	718.22	478.81	194.40	3664.50	-2.33
B6	479.00	194.30	718.22	478.81	291.45	3620.77	-3.50

CT=Concrete type, F.A=Fine Aggregate, C.A=Coarse Aggregate, G=Grit, W.F.S=Waste Foundry Sand.

VI. CONCLUSION

Based on above study the following observations are made regarding the properties and behaviour of concrete on partial replacement of fine aggregate by waste foundry sand:

(1) Compressive strength increases on increase in percentage of waste foundry sand as compare to traditional concrete.

(2) In this study, maximum compressive strength is obtained at 60% replacement of fine aggregate by waste foundry sand.

(3) Split tensile strength decrease on increase in percentage of waste foundry sand.

(4) Use of waste foundry sand in concrete reduces the production of waste through metal industries i.e. it's an eco-friendly building material.

(5) The problems of disposal and maintenance cost of land filling is reduced.

(6) Application of this study leads to develop in construction sector and innovative building material.

(7) The result of percentage cost change reduces up to 3.5 for 60% replacement of waste foundry sand. This shows that the concrete produced is economical.

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