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FOUNDRY SAND: UTILISATION AS A PARTIAL REPLACEMENT OF FINE AGGREGATE FOR ESTABLISHING SUSTAINABLE CONCRETE

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ABSTRACT

Foundry waste is one of the most active research areas that encompass a number ofdisciplinesincluding civil engineering andconstruction materials. They can stand close to the concept of green concrete which is in compatible with the environment. Foundry sand from casting industries is a waste material which is dumped extensively and in this study an attempt has been made to evaluate the usage of this waste material in concrete. The constant depletion of sand beds at all major sources of availability is a major concern and thus efforts are taken in order to replace sand in construction activities. In this study, effect of foundry sand as fine aggregate replacement on the compressive strengthof concrete with a M25mix proportioninvestigated at different limited curing periods (7 days, 14 daysand 28 days). The percentage of foundry sand used for replacement were 10%, 20%, 30%, 40% and 50% by weight of fine aggregate. Test showed impressive results, showing capability of foundry sand for being a component in concrete for imparting strength. Making concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable environment.

KEYWORDS: Casting industry, Concrete, Foundry waste, Foundry sand, Landfill, Sustainable environment.

INTRODUCTION

The waste generated from the industries cause environmental problems. Hence the reuse of this waste material can be emphasized. Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal casting Industries. From centuries foundry sand has been used as a molding casting material because it's high thermal conductivity. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. In the casting process, molding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as byproduct, new sand is introduced, and the cycle begins again. Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: clay bonded systems (Green sand) and chemically- bonded systems. Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics. Over the last decades, much research has been conducted on the mechanical, chemical and durability aspects of foundry sand. But inadequate research focus is given to the study of the strength and durability aspects of foundry sand concrete.

OBJECTIVE

The main objective of this paper is to study the behavior of concrete in which fine aggregate in normal concrete is replaced with foundry sand at room temperature. The main parameters studied are compressive strength, durability studies and their results are studied and compared with control mix concrete.

METHODOLOGY

Strength is one among the most important properties of concrete, since the first consideration in structural design is that the structural members must be capable of carrying the imposed loads. The mix of concrete used in this study is M25. Concrete mix with 0% waste material is the control mix and water cement ratio adopted is 0.48 in accordance with the Indian Standards specification IS 10262 - 2009. A design mix proportions of 1: 1.10: 3.38: 0.48was investigated for the research. The percentages of replacements are 10%, 20%, 30%, 40% and 50% by weight of fine aggregate. Tests were performed for compressive strengthof concrete for all replacement levels of fine aggregate at different curing period (7 days, 14 days and 28 days). Besides, the physical and chemical properties of the foundry sand are also studied.

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EXPERIMENTAL MATERIALS

Cement (OPC)

The Ordinary Portland Cement of 53 grades conforming to IS: 8112 is used. The cement used is fresh and without any lumps. Physical property of cement is as per table 1.

Table 1. Physical Properties Of (Opc) Cement

Characteristic	Value
Specific Gravity	3.12
Consistency	33%
Initial setting time	30 minimum
Final setting time	600 maximum

Aggregate

Aggregate give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is a good gradation of aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

Coarse Aggregate

The fractions from 20 mm to 4.75 mm are used as coarse aggregate. The Coarse Aggregates from crushed Basalt rock, conforming to IS: 383 is being use. The Flakiness and Elongation Index were maintained well below 15%.

Table 2. Physical Properties of Course Aggregate

Characteristic	Value
Specific Gravity	2.76
Total Water Absorption	0.38%
Fineness Modulus	6

Fine Aggregate

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383.

Table 3. Physical Properties of Fine Aggregate

Characteristic	Value
Type	Medium
Specific Gravity	2.38
Bulk Density	1613 kg/m3
Fineness Modulus	2.7

Foundry sand

The physical and chemical properties of foundry sand used in this project are listed in Table 4 and Table 5 respectively. The leachate from the foundry sand may contain trace element concentrations but the concentrations are not different from other construction materials such as native soils or fly ashes, hence they fall within the permissible limits for construction standards.

Table 4. Physical Properties Of Foundry Sand

Characteristic	Value
Specific Gravity	2.49
Bulk Relative Density	2592 kg/m3
Absorption	0.43 %
Moisture Content	0.1 – 9.8
Clay Lumps and Friable Particles	1 – 42
Coefficient of permeability	10-3 – 10-6 cm/s
Plastic Limit	Non Plastic

Source: GEO TEST HOUSE, Baroda, Gujarat

Table 5. Foundry Sand Chemical Oxide Combination

Constituent	Value (%)
SiO2	67.21
Al2O3	4.28
Fe2O3	7.32
CaO	0.15
MgO	0.23
SO3	0.89
Na2O	0.48
K2O	0.46
P2O5	0.00
Mn2O3	0.12
SrO	0.19
TiO2	0.48
Loss on Ignition	16.25
Total	98.06

Source: GEO TEST HOUSE, Baroda, Gujarat

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

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Moulds

Cubical moulds of size 150mm × 150mm × 150mm were used to prepare the specimens for determining the compressive strength of foundry sand concrete. Care was taken during casting and vibrator was used for proper compaction. All the specimens were prepared in accordance with Indian Standard Specifications IS: 516 – 1959. All the moulds were cleaned and oiled properly. They were securely tightened to correct dimensions and prevent leakage of slurry.

EXPERIMENTAL CONSIDERATION

Design Mix

A mix M25 grade was designed as per Indian Standard method (IS 10262-2009) and the same was used to prepare the test samples.
The design mix proportion is done in Table 5.

Table 6. Design Mix Proportion for (M25 Mix)

		By weight [kg]	By volume [m^3]
WATER (Lit)		174.8	0.48
CEMENT (Kg/m3)		364.3	1.00
F.A. (Kg/m3)		696.9	1.80
C.A. (Kg/m3)	**20mm**	749.6	2.07
	10mm	499.7	1.31
Chemical Admixture		2.5	--

W= Water,
C= cement,
F.A. = Fine Aggregate,
C.A. = Coarse Aggregate

Experimental Set Up

Table7. Design Mix Proportion for Various Concrete

Sr. No.	Concrete Type	(%) of Foundry sand Replaced with Fine Aggregate
1	**B0**	Standard Concrete
2	**B1**	10% replacement
3	**B2**	20% replacement
4	**B3**	30% replacement
5	**B4**	40% replacement
6	**B5**	50% replacement

EXPERIMENTAL RESULTS

Compressive Strength

The compressive strength for different replacement levels of foundry sand contents (0%, 10%, 20%, 30%, 40%, and 50%) at the end of 7 days, 14 days and 28 days results are given in Table 8.

Table 8. Compressive strength at 7 , 14 and 28 days

Foundry Sand Content (%)	Compressive Strength at 7 days (N/mm2)	Compressive Strength at 14 days (N/mm2)	Compressive Strength at 28 days (N/mm2)
0 %	19.70	26.78	29.32
10%	20.46	28.19	30.55
20%	20.69	28.53	31.36
30%	21.87	30.28	33.65
40%	15.63	21.48	24.41
50%	14.20	20.59	23.67

The compressive strength increased with increase in the amount of foundry sand, up to 30% replacement in concrete, compared to the control mix. But as the amount of foundry sand exceeded the amount of fine aggregate in concrete, the compressive strength gradually decreased. The progressive strength attainment rate of concrete with foundry sand replacement is more, in comparison with control mix concrete, up to 30 % replacement results. The replacement of whole fine aggregate with foundry sand adversely affects the compressive strength of concrete by giving the lowest values.

CONCLUSIONS

Based on limited experimental investigation the following conclusions are made:

1) Compressive strength, split tensile strength and flexural strength of concrete specimens increased, with increase in fine aggregate replacement by

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foundry sand, providing maximum strength at 30 % replacement, and beyond that the strength parameters showed a decline in their respective values.

2) The increase in strength parameters may be due to fineness of the foundry sand. The foundry sand fineness is higher than fine aggregate and reduces the porous nature in concrete thereby increasing density and strength. But reduction in compressive strength of concrete specimen with replacement percentage beyond 30 % is attributed to binders present in foundry sand, composed of very fine powder of clay and carbon, which results in a weak bond between cement paste and aggregate.

3) The replacement of natural sand with used foundry sand up to 30 % is desirable, as it is cost effective, reduces the amount of virgin fine aggregate, reduces land fill problems and preserves nature.

4) Making concrete using recycled materials(foundry sand) saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainable environment.

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