INTERNATIONAL RESEARCH JOURNAL OF MULTIDISCIPLINARY TECHNOVATION (IRJMT)

MAPLE TREE PUBLISHING HOUSE

http://www.mapletreejournals.com/index.php/IRJMT
Received 30 August 2019 ISSN 2582-1040
Accepted 27 September 2019 2019; 1(6); 172-178
Published online 02 November 2019

A Study of Strength parameters of Structural Concrete Elements Using Foundry Sand

A. Deiveegan[1*], P.R. Dhevasenaa [2]

[1]*Assistant professor, Department of civil Engineering, University College of Engineering, Thirukkuvalai, Tamil Nadu India.*

[2]*Assistant Professor, Department of Civil Engineering, Government college of Engineering, Srirangam, Tamil Nadu India.*

**Corresponding author E-Mail ID: deiveegan.cdm@gmail.com*

Doi: https://doi.org/10.34256/irjmtcon22

ABSTRACT

The over exploitation of non-renewable materials is becoming a threat and therefore it is necessary to seek the possibility of recycling them, once their durability is expired. The recycled materials can be used effectively in architectural and civil engineering fields. 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 strength, flexural strength and split tensile strength of concrete with a mix proportion of 1: 1.28: 2.56: 0.45 was investigated at different limited curing periods (7 days and 28 days). The percentage of foundry sand used for replacement were 10%, 20%, 30%, 40%, 50%, 75% and 100% 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, Foundry sand, Landfill, Recycling, Sustainable environment

1. INTRODUCTION

The recycling of waste from construction materials implies a significant reduction in amounts, destined to disposal by land filling, which enhances the achievement of recycling rates established by law, leads to a reduction in the use of non-renewable resources and produces a positive outcome on environment. Additionally, in several places, conventional building materials may prove to be too expensive and insufficient to face the worldwide growing need for housing development. Accordingly, the use of waste as alternative material may help to meet the above shortages. The mixing of wastes with inert fractions to produce construction materials should be done to improve functionality rather than merely to dilute wastes. As natural resource raw materials become more costly with ever higher global demand caused by developing nations undergoing economic expansion, the incentive to explore and locate low cost, environmentally beneficial alternative uses of production by-products becomes an ever more near-term goal. Recycling involves processing used materials into new products in order to prevent the waste of potentially useful materials, reduce energy usage, reduce air and water pollution by reducing the need for conventional waste disposal, lower greenhouse gas emissions as compared to virgin production. Several types of by-products and waste materials are generated. Each of these specific wastes has special effects on the properties of cement based materials. The utilization of such materials in concrete not only makes it economical, but also do help in reducing disposal problems. Now days, the engineers are interested on "green concrete" defining the closeness of structural concrete elements to the sustainable environment with less greenhouse gas emission and preserving non-renewable resources.

The term "industrial sands" refers to any sand like material that is a by-product of industrial processes. Many, if not properly handled, may be harmful or strenuous to the environment. It includes manufactured sands or natural sands that have been used in some face of industrial operations. There are a number of different types of industrial sands, including filter sands, quarry settling pond sands and foundry sands. Foundry sand is high quality silica sand with uniform physical characteristics which is a by-product of ferrous and non-ferrous metal casting industries, where sand has been used as a moulding material because of its thermal conductivity. This sand normally uses a small amount of betonies clay to act as the binder material. Chemical binders are also used to create sand cores. Depending upon the geometry of the casting, sand cores are inserted into the mould cavity to form internal passages for the molten metal. Once the metal has been solidified, the casting is separated from the moulding and core sands, in the shakeout process. In the casting process, moulding sands are recycled and reused multiple times. After many times, it loses its characteristics especially the cleanliness and the uniformity, becoming unsuitable in the manufacturing process.

Detailed quantitative data on the various beneficial applications of foundry sand have not been well documented in the past. Moreover, the environmental aspects and compatibility have been investigated in order to point out the prerequisites for the foundry sand utilization.

II. 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, split tensile strength and flexural strength, and their results are studied and compared with control mix concrete.

III. 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 0.45 in accordance with the Indian Standards specification IS 10262 - 2009. A design mix proportions of 1: 1.28: 2.56: 0.45 was investigated for the research. The percentages of replacements are 10%, 20%, 30%, 40%, 50%, 75% and 100% by weight of fine aggregate. Tests were performed for compressive strength, flexural strength and split tensile strength of concrete for all replacement levels of fine aggregate at different curing period (7 days and 28 days). Besides, the physical and chemical properties of the foundry sand are also studied.

IV. EXPERIMENTAL MATERIALS 4.1

Cement

Portland Pozzolona cement is used for all concrete mixes. The cement used is fresh and without any lumps.

4.2. Coarse Aggregate

Locally available coarse aggregates are used in the present work. Testing of coarse aggregate is done as per IS: 383 – 1970. The values obtained are tabulated in Table 1.

Table1. Properties of coarse aggregate

Characteristic	Value
Characteristic	Value
Maximum size	20 mm
Specific Gravity	2.61
Total Water	0.38%
Absorption	
Fineness Modulus	6

4.3. Fine Aggregate

The sand used for the experimental program is locally procured and conformed to grading zone II as per IS: 383-1970. The sand is first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. Properties of the fine aggregate used in the experimental work are tabulated in Table 2.

Table 2. Properties fine aggregate

Characteristic	Value
Type	Medium
Specific Gravity	2.65
Bulk Density	1613 kg/m^3
Fineness Modulus	2.7

4.4. Foundry sand

The physical and chemical properties of foundry sand used in this project are listed in Table 3 and 4 respectively. The leach ate 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 3.Physical properties of foundry sand

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

Tested at SITARA (South Indian Textile research Association, Coimbatore)

4.5. Water

Water having qualities of potable water was used in the experiment.

4.6. 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. Cylindrical moulds of size 150 mm Diameter, 300 mm height and beam moulds of size 500 mm × 100 mm × 100 mm were used to prepare the concrete specimens for the determination of split tensile strength and flexural strength of foundry sand concrete respectively. 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.

Table 4. Foundry sand chemical oxide combination

Constituent	Value (%)
SiO_2	67.21
Al_2O_3	4.28
Fe_2O_3	7.32
CaO	0.15
MgO	0.23
SO_3	0.89
Na_2O	0.48
K_2O	0.46
P_2O_5	0.00
Mn_2O_3	0.12
SrO	0.19
TiO_2	0.48
Loss On Ignition	16.25
Total	98.06

Tested at SITARA (South Indian Textile research Association, Coimbatore)

V. ENVIRONMENTAL CONSIDERATION

Spent foundry sand may contain high concentrations of cadmium, lead, copper, nickel, and zinc. However, studies have proved that foundry sand is less contaminated with metallic elements than foundry dust and slag. Studies also suggest that the constituents in the bulk waste stream of foundry sand are not necessarily leachable. The extraction conditions for standard leaching tests are outlined in Table 5.

Table 5. Extraction conditions for Standard Leaching

Test Procedure	**Evaluating**	**Leaching**
	Parameter	Medium
Water Leach	Aqueous extract	Deionized
Test		water
Extraction	Leachate	0.04 M
Procedure	concentrations	acetic
Toxicity		acid(pH =
		5.0)
Multiple	Waste leaching	Same as EP
Extraction	under acidic	Toxicity,
Procedure	condition	then at pH =

		3.0
Synthetic	Metal mobility	Deionized
Precipitation	under actual field	water. pH
Leaching	conditions, i.e.	adjusted
Procedure	rain or snow	from 4.2 to
		5.0

Leachates were analyzed for concentrations of Cadmium (Cd), Chromium (Cr), Selenium (Se), and Silver (Ag) and compared to groundwater quality standards. With the application of dilution factors to account for the reduction in concentration expected between the bottom of the structure and the groundwater table, concentrations would not exceed the groundwater quality standards if the foundry sand concentrations are at least 1 m above the groundwater table. The binder system is the primary source of organic contaminants in foundry sand. It was found that most organic compounds are burned out during the casting process. Leaching Tests showed that contaminants were well below regulation limits for hazardous material. Leachates from foundry sand fell within the 95th percentile of metallic element concentrations, below the threshold values.

VI. EXPERIMENTAL RESULTS

6.1. Compressive Strength

The compressive strength for different replacement levels of foundry sand contents (0%, 10%, 20%, 30%, 40%, 50%, 75% and 100%) at the end of 7 days and 28 days results are given in Table 6.

Table 6. Compressive strength at 7 days and 28 days

Foundry Sand Content (%)	Compressive Strength at 7 days (N/mm^2)	Compressive Strength at 28 days (N/mm^2)
0	17.8	27.89
10	18.12	29.52
20	18.89	31.89
30	21.34	32.42
40	21.82	33.12
50	23.29	33.56
75	17.56	23.98
100	14.65	22.08

The compressive strength increased with increase in the amount of foundry sand, up to 50% 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 50 % replacement results. The replacement of whole fine aggregate with foundry sand adversely affects the compressive strength of concrete by giving the lowest values.

6.2. Split Tensile Strength

The split tensile strength for different replacement levels of foundry sand contents (0%, 10%, 20%, 30%, 40%, 50%, 75% and 100%) at the end of 28 days results are given in Table 7.

Table 7. Split tensile strength at 28 days

Foundry Sand Content (%)	**Split Tensile Strength** at 28 days(N/mm^2)
0	2.65
10	2.72
20	2.79
30	3.12
40	3.29
50	3.56
75	2.81
100	2.42

From the observation of results for 28 days it is evident that the split tensile strength showed an increasing trend towards 50% replacement of fine aggregate with foundry sand in concrete. But beyond that the split tensile strength variation showed a declining trend.

6.3 Flexural Strength

The flexural strength property of concrete incorporating foundry sand at various replacement levels with fine aggregates was studied and results are compared with control mix. The Table 8 shows the variation of flexural strength of concrete for different proportion of fine aggregate replacements with foundry sand.

Table 8. Flexural strength at 28 days

Foundry Sand Content (%)	Flexural Strength at 28 days (N/mm^2)
0	3.76
10	3.95
20	5.19
30	7.26
40	7.69
50	7.98
75	5.36
100	4.65

At 28 days, the control mix concrete achieved flexural strength of 3.82 N/mm^2. But as the Amount of foundry sand in concrete increased the flexural strength of the concrete specimen also increased by reaching a value of more than double the flexural strength of controlled mix.

VII. 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 foundry sand, providing maximum strength at 50 % 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 50 % 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 50 % 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.
5) The chemical analysis of foundry sand shows that the silica content and alkali content are high. Hence the alkali-silica and alkali-aggregate reaction should be studied in detail.

REFERENCES

1. Reddi, Lakshmi, Rieck, P. George, Schwab, Chou and Fan, Stabilization of Phenolics in Foundry Sand Using Cementious Materials, Journals of Hazardous Materials, 45, 1995, 89-106.
2. T R Naik and S S Singh, Permeability of Flowable Slurry Materials Containing Foundry Sand and Fly Ash, Journal Of Geotechnical and Geoenvironmental Engineering-ASCE, 123(5), 1997, 446-452.
3. Tikalsky, J. Paul, Smith, Earl, Regan and W. Raymond, Proportioning Spent Casting Sand in Controlled Low-Strength Materials, ACI Material Journal, 95(6), 1998, 740-746.
4. Tikalsky, J. Paul, Smith, Earl, Regan and W. Raymond, Properties of Controlled Low Strength Materials Containing Foundry Sand, ACI Material Journal, 97, 2000, 698-702.
5. T R Naik, and S S Singh, Performance and Leaching Assesment of Flowable Slurry, Journal of Environmental Engineering, 127(4), 2001, 359 – 368.
6. T R Naik, Kraus, N. Rudolph, Chun Yoon-moon, Ramme, W. Bruce and Singh S. Shiw, Properties of Field Manufactured Cast-Concrete Products Utilizing Recycled Materials, Journal of Materials in Civil Engineering-ASCE, 15(4), 2003, 400-407.
7. T R Naik, Kraus, N. Rudolph, Chun Yoon-moon, Ramme, W. Bruce and Siddique Rafat, Precast Concrete Products Using Industrial By-Products, ACI Materials Journal, 101 (3), 2004, 199- 206.
8. R. Siddiquea, G. de Schutterb, and A. Noumowec, Effect of used foundry sand on the mechanical properties of concrete, Constr. Build. Mater, 23, 1999, 976-980.
9. Abichou T Benson, C Edil, Database on Beneficial Reuse of Foundry Byproducts,Recycled Materials in Geotechnical Applications Geotech. ASCE, Spec.Publ.,79, 1992, 210 – 223.

Conflict of Interest

None of the authors have any conflicts of interest to declare.

About the License