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

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Abstract: Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in the casting process. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as foundry waste sand. The generation of waste foundry sand as a byproduct of metal casting industries causes environmental problems because of its improper disposal. Thus, its usage in building material, construction, and other fields is essential for the reduction of environmental problems. Like many waste products, foundry sand has beneficial applications to other industries. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins), and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as a supplementary addition to achieve different properties of concrete. This research is carried out to produce a low-cost and eco-friendly concrete. This work 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%,10%,20%,30% 40%, and 50% by weight for m-25 grade concrete(pcc). Material was produced, tested, and compared with conventional concrete in terms of workability and strength. These tests were carried out on a standard cube of 150*150*150* mm for 7, 14, and 28 days to determine the mechanical properties of concrete. Through experimental results the variation of compressive strength with the partial replacement of waste foundry sand can be found out. This work aims to know the behavior and mechanical properties of concrete after the addition of industrial waste in different proportions by tests like compressive strength.

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I. INTRODUCTION

In India, there is great demand for aggregates mainly from the civil engineering industry for road and concrete constructions. But nowadays it is a very difficult problem for the availability of fine aggregates. So researchers developed waste management strategies to apply for the replacement of fine aggregates for specific needs. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. Sustainable development for construction involves the use of unconventional and innovative materials, and recycling of waste materials to compensate for the lack of natural resources and to find alternative ways of conserving the environment. Foundry sand is one of the materials that is considered as a waste material that could have a promising future in the construction industry

as a partial or full substitute of either cement or aggregates. It is a byproduct obtained during the metal casting process of ferrous and non-ferrous industries. The annual generation of foundry sand in the United States is believed to range from 9 to 13.6 million metric tons (10 to 15 million tons). Typically, about 1 ton of foundry sand is required for each ton of iron or steel casting produced.

Foundry sand is an inert material and its physical properties are similar to natural sand. A laboratory study was carried out in the Institute to investigate the potential of using foundry sand as a partial replacement for sand in cement concrete. The use of foundry sand in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of foundry sand isproduced.

In many countries, there is a scarcity of natural aggregate that is suitable for construction, whereas in other countries the consumption of aggregate has increased in recent years, due to increases in the construction Industry. To reduce the depletion of natural aggregate due to construction, artificially manufactured aggregate and some industrial waste materials can be used as alternatives. Thus, our project is to utilize the foundry sand by the replacement of fine aggregate for maintaining the economy and increasing the strength of concrete. By this project, we can also solve the problem of disposal of this industrial waste**.**

II. AIM OF THE WORK:

The present study is aimed at studying the strength characteristics of concrete by partially replacing the fine aggregate with foundry sand which is available near Rajahmundry (East Godavari District), Andhra Pradesh.

III. OBJECTIVES OF THE WORK:

The main objective of the study is to determine the strength parameters of M25 grade concrete with replacement of fine aggregate by foundry sand:

- To know the fresh concrete properties of foundry sand concrete.
- To find the efficiency of the foundry sand for civil constructions.
- To know the behavior of compressive strength of concrete when replaced with foundry sand.
- To analyze the different areas of civil engineering inwhich foundry sand can be used efficiently.

LITERATURE REVIEW

Guney et al. (2010), investigated the potential reuse of waste foundry sand in high concrete production the natural fine sand is replaced with waste foundry sand (0%,5%,10%,15%) the findings from a series of the test program have shown a reduction in compressive and tensile strengths, and the elasticity modulus which is directly related to waste foundry inclusion of concrete. Nevertheless, the concrete with 10% waste foundry sand exhibits almost similar results to that of the control one. The slump and the workability of fresh concrete decrease with the increase of the waste foundry sand ratio.

- **Siddique et al. (2011),** presents the design of concrete mixes with used foundry sand **(UFS)** as partial replacement of fine aggregate. Various mechanical properties are evaluated (compressive strength and splitting tensile strength) test results indicate that industrial by-products can produce concrete with sufficient strength and split tensile strength was determined at 28,90and 365

days along with carbonation and rapid chloride penetration resistance at 90 and 365 days. The replacement of fine aggregate with foundry sand was found to be optimum at 30% and should not exceed 50%. The rate of gain was closer to that of the control mix at 90days and at 365 the rate of gain for all the mixes with foundry sand was higher than the CM mix, the compressive strength of cubes and cylinders, and split tensile strengths were observed to increase with age.

- **Wahab et al. (2013),** investigated the effect of foundry sand as a fine aggregate replacement on the compressive strength, split tensile strength, and flexure strength having a mix proportion of M30 was investigated. Fine aggregates were replaced with eleven percentages of foundry sand. The percentages of replacements were 0,10,20,30,40,50,60,70,80,90, and 100% by weight of fine aggregate. Tests were performed for compressive strength, split tensile strength, and flexural strength tests for all replacement levels of foundry sand at different curing periods (7-days, 28-days, and 56-days). Maximum compressive strength and flexure strength were achieved with 50% replacement of fine aggregate with waste foundry sand at 28 days compared to normal concrete.

MATERIAL AND ITS PROPERTIES

A. Cement:

43 Grade Ordinary Portland Cement is used for this study. Ordinary Portland Cement (OPC) is by far the most important type of cement. The OPC was classified into three grades, namely 33 grade, 43 grade, and 53 grade depending upon the strength of the cement at 28 days after curing process when tested as per IS 4031-1988. If the 28 days strength is not less than 33N/mm2, 43N/mm2, and 53 N/mm2 it is called 43-grade and 53-grade cement respectively. Ordinary Portland cement of 43 grade (Zuari brand cement) was used in this experiment.

Physical properties of (OPC) cement.

Properties	Test results	Standard values
Specific gravity	3.12	
Initial setting time(min)	32	>30
Final setting time(min)	450	<600
Fineness	8.0 (92%)	<10

B. FINE AGGREGATE:

The aggregate size is lesser than 4.75 mm is considered as a fine aggregate. The sand particles should be free from any clay or inorganic materials and found to be hard and durable. It was stored in an open space free from dust and water. In our region, fine aggregate can be found from the bed of Rajahmundry.

Physical properties of conventional sand.

Property	Test results
Grading of sand	Zone-II as per IS-383
Specific gravity of sand	2.6
Bulk density Loose state Compacted state	 1555.56kg/m3 1717.11kg/m3
Fineness modulus	2.483

C. COARSE AGGREGATE:

The aggregate size bigger than 4.75 mm, isconsidered as coarse aggregate. It can be found from original bedrocks. Coarse aggregates are available in different shapes like rounded, Irregular or partly rounded, Angular, Flaky. It should be free from any organic impurities and the dirt content was negligible.

Physical properties of coarse aggregates.

Property	Test results
Specific gravity	2.82
Bulk density Loose state Compacted state	 1525.92kg/m3 1718.51kg/m3
Water absorption	0.90%
Fineness modulus	7.0

D. FOUNDRY SAND:

In this experimental work, foundry sand was used as a partial replacement for normal sand Zone IV is used. A foundry is a manufacturing facility that produces metal castings by pouring molten metal into a preformed mould to yield the resulting hardened cast. Foundry sand is high- quality silica sand that is a by-product of the production of both ferrous and nonferrous metal castings. 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. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When sand can no longer be reused in the foundry, it is removed from the foundry and

is termed foundry sand.

Physical Properties of foundry sand.

Physical Properties	Foundry sand
Particle size	Irregular
Appearance	Reddish-brown
Type	Air Cooled
Specific Gravity	2.41
Fineness modulus offoundry sand	1.6
Water Absorption	1.3%
Moisture Content	0.1%

WATER:

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement.It gives strength to cement and workability to the concrete. Drinking water is used for casting and curing concrete blocks.

EXPERIMENTAL WORKWORKABILITY:

Workability is the ability of a fresh (plastic) concrete mix to fill the farm or mould properly with the desired work (vibration) and without reducing the concrete's quality. Workability depends on the water content, aggregate (shape and size distribution), cementitious content, and age (level of hydration). Increasing the water content will increase concrete workability. Excessive water will lead to increased bleeding (surface water) and segregation of aggregates (when the cement and aggregate start to separate), resulting in concrete having reduced quality.

IV. SLUMP CONE TEST ACCORDING TO IS: 7320–1974:

The slump test is the most commonly used method of measuring the consistency of concrete which can be employed in a laboratory (or) at the site of work. It is not a suitable method of very wet(or) very dry concrete; it does not measure all the factors contributing to workability, nor is it always representative of the place ability of concrete from batch to batch. It is used to indicate the degree of wetness. The workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable when compared to drier mixes, but concrete of the same consistency may vary in between in workability.

HARDENED CONCRETE TEST: (ACCORDING TO IS: 516 -

1959) Mechanical properties of concrete are mainly related to the calculation of its strength. The calculation of mechanical properties includes the testing of concrete for its performance in Compressive strength, Split tensile strength and modulus of rupture. The procedures and calculations of these three tests are confirmed by the standard specification IS 516 – 1959.

COMPRESSIVE STRENGTH TEST:

Concrete cubes specimen of size 150×150×150 mm are used to determine compressive strength of concrete and were tested as per IS 516-1959. Compression test on cubes is conducted on time 300T compression testing machine. The cube was placed in the compression testing machine and the load on the cube is applied at constant rate of 2.5kN/sec until the failure of the specimenhappens and the ultimate load is noted. The cube compressive strength of the concrete mix is then computed. The compressive strength of the specimen is calculated by dividing the maximum load applied on the specimen during the test by the cross-sectional area. Specimens are cast for different ages of 3, 7 and 28days. A sample calculation for determination of cube compressive strength is presented in Appendix. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per IS 516-1959.

SPLIT TENSILE STRENGTH

Split tensile strength is the most important property of concrete. Concrete generally weak in tension. So, to improve tensile behavior of concrete, split tensile strength is important. It is also important in reducing formation of cracks

in concrete. Cylinders are casted for calculating split tensile strength. The cylindrical specimens are also tested in compression testing machine. The cylinders are placed in axial direction by facing cylindrical face to the loading surface. Here the cylinder split into the two parts and reading observed on the top of the machine.

FLEXURAL STRENGTH

Most of the beam failures are occurred due to their failure in flexural strength. It is important that prediction of flexural strength by calculating modulus of rupture for reducing failure problems in beams. The calculation of modulus of Rupture in terms of Flexural strength is the main aim in casting beam specimens. In this modulus of rupture is calculated by testing specimens in the universal testing machine. In this line of facture is the main important property in formulating the modulus of rupture.

RESULTS AND DISCUSSIONS

Tests like compressive strength, workability are conducted for concrete made of different replacement of sand with foundry sand 7, 14 and 28 days of curing. The specimens are tested for 7, 14, 28days for 0%, 10%, 20%

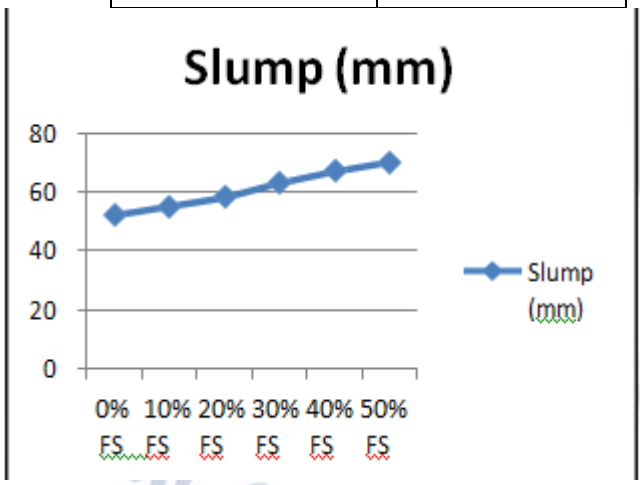
30%, 40% 50% replacement of foundry sand. The results are tabulated and discussions have been made.

V. SLUMP CONE TEST

The variation of slump with increase in percentage of foundry sand 0%, 10%, 20% 30%, 40%, 50% are tabulated and graph is plotted below.

VI. WORKABILITY IN TERMS OF SLUMP CONE TEST

Description	Slump(mm)
Plain concrete	52
FS 10%	55
FS 20%	58
FS 30%	63
FS 40%	67
FS 50%	70



Description of result:

The variation of slump for the partial replacement of fine aggregate with foundry sand increased in the order of increasing of replacement.

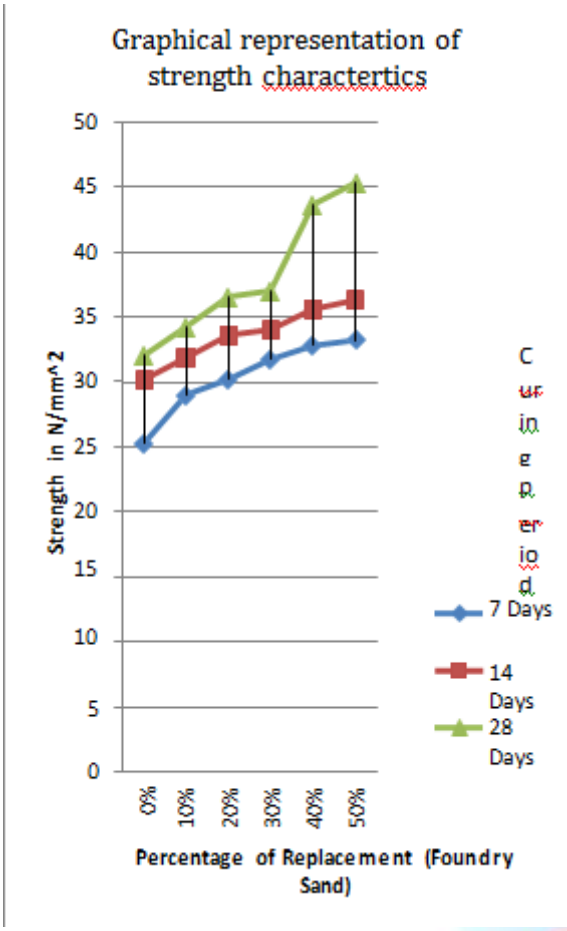
VII. COMPRESSIVE STRENGTH TEST

Concrete cubes of size 150x150x150mm were cast for 0%, 10%,20% 30%, 40%,50% foundry sand replacement. The compressive strength for M25 grade is tested for 7,14,28 days of curing and results are tabulated and plotted below.

VIII. COMPRESSIVE STRENGTH WITH DIFFERENT REPLACEMENTPERCENTAGES OF FOUNDRY SAND

% of foundry sand replacement	Compressive Strength(N/mm²)		
	Avg 7days	Avg 14days	Avg 28 days
0	25.29	30.2	32.05
10	29	31.88	34.25
20	30.2	33.6	36.58
30	31.73	34.02	37.01
40	32.8	35.6	43.64

50	33.21	36.31	45.33



CONCLUSION

Based on the results of the laboratory carried out on foundry sand as a replacement of fine aggregate, the following specific conclusions have been drawn for using it in concrete making.

- Compressive strength of concrete increased with the increase in sand replacement with various replacement levels of foundry sand. However, at each replacement level of fine aggregate with foundry sand, an increase in strength was observed with the increase in age
- The workability of concrete is decreased with an increase in the replacement of fine aggregate.
- The use of waste foundry sand in concrete reduces the production of waste through metal industries

i.e. it's an eco-friendly building material.

- The problems of disposal and maintenance cost of landfilling are reduced.
- The application of this study leads to development in the construction sector and innovative building material.

REFERENCES

[1] Nithin Kumar A, "Experimental Study Of Partial Replacement Of Waste Foundry Sand On Strength Properties Of Concrete", Department Of Civil Engineering, Vardhaman College Of Engineering, Hyderabad.

[2] Smit M. Kacha, "Use Of Used Foundry Sand In Concrete: A State Of Art Review", P.G. Student Civil Engineering Departmentmarwadi Education Foundation, Gujarat, India.

[3] Sanjay K. Sharma, "Development of Paver Block by Using Foundry Sand Based Geopolymer Concrete", Professor & HOD, NITTTR Chandigarh

[4] Gurdeep Kaur, "Utilization Of Fungal Treated Waste Foundry Sand Concrete", Department of Biotechnology Thapar University, Patiala-147004 Punjab (India) 2013

[5] Ankit Kumar Abrol, "Effect Of Foundry Sand And Steel Fibres On The Strength Characteristics Of Pavement Quality Concrete", Masters Of Engineering In Civil Infrastructure Engineering

[6] Pathariya Saraswati C, "Application of Waste Foundry Sand for Evolution of Low- Cost Concrete", 1Student of final year B.E. Civil, Sigma Institute of Engineering College, Vadodara.

[7] Avi Sikchi, "Applications of Foundry Sand", Final Year Student B.E. Civil Engineering PRCOE&M

[8] Ankit Kumar Abrol, "Effect Of Foundry Sand And Steel Fibres On The Strength Characteristics Of Pavement Quality Concrete", Department Of Civil Engineering Thapar University, Patiala Thapar University, Patiala

[9] IS 456: 2000, "plain and reinforced concrete code of practice", Fourth Revision, Bureau of Indian Standard's, Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi 110002.[10] IS 10262: 2009, "concrete mix proportioning", First Revision, Bureau of Indian Standard's, Manak Bhavan, Bahadur Shah Zafar Marg, New Delhi 110002.

