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Effect of Waste Foundry Sand (WFS) on the Mechanical properties of concrete with artificial sand as Fine Aggregate

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***Abstract*— Nowadays good quality natural river sand is not readily available; it is to be transported from a long distance. These resources are also exhausting very rapidly. So there is an urge to find some alternative to natural river sand. Natural river sand takes millions of years for its formation and is not renewable. As a substitute to natural sand, Artificial (Manufactured) sand is used as a complete replacement. Considering the gap in research, this paper presents the effect of the use of Foundry sand as fine aggregate in concrete as a substitute to Artificial Sand. The experimental work is mainly concerned with the study of mechanical properties like compressive strength, split tensile strength as well as flexural strength of concrete by partial replacement of artificial sand by foundry sand as fine aggregate. Tests were carried out on cubes, cylinders and unreinforced beams to study the mechanical properties of concrete using foundry sand and compared with concrete with artificial sand as fine aggregate. Artificial sand was replaced with five percentage (0%, 5%, 10%, 15%, and 20%) of WFS by weight. A total of five concrete mix proportions (CM, F-1, F-2, F-3 and F-4) with and without WFS were made. Compression test, splitting tensile strength test and flexural strength tests were carried out to evaluate the strength properties of concrete at the age of 7 and 28 days. Test result showed a nominal increase in strength and durability properties of concrete by addition of WFS as a partial replacement of fine aggregate.**

Keywords—Waste foundry sand, Artificial sand, compressive strength, flexural 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. The concrete as a building material plays an important role in this sector. The consumption of natural resources as constituents of concrete, costs high also it is on the verge of extent. These problems alarm us to recover the natural resources or to find an alternative option to overcome this problem. Presently, the large production of waste foundry sand as a by-product of metal casting industries causes various environmental hazards. Usage of this waste foundry in building material would help in reduction of stress on environment. Metal industries use foundry sand which is uniformly sized, high quality silica sand that is bound to form a mould for the casting of ferrous as well as 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". In India, an estimated 2 million tons of waste foundry sand is produced every year. Use of waste foundry sand as a partial or total replacement for 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

The properties of various materials used in making the concrete (M30) are discussed in the following sections.

A. CEMENT:

Cement in concrete acts as a binding material which hardens after the addition of water. It plays a very important role in the deciding the strength and durability of concrete. In this study the Ordinary Portland Cement (OPC) of 43 grade (ACC Cement) is used according to IS: 8112-1989. Following were the properties of the cement.

Table I: Physical Properties of OPC

Physical Properties		IS-8112 (1989)	Test Results
Setting time (min)	Initial	30	93
	Final	600	251
Specific Gravity		---	3.1

B. FOUNDRY SAND:

Metal industries use sand casting in which moulds are made of uniform sized, clean, high silica sand. 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. Its harmful effect on environment and disposal problem can be minimized if used in engineering structures. Waste foundry sand for the experimentation was brought from Aditya Foundry from Ambad MIDC, Satpur Nashik. For grain size distribution, 3.35-mm, l.70-mm, 850-micron, 600-micron, 425-micron, 300-micron, 212-micron, 150-micron, 106-micron, 75-

micron and 53-micron IS Sieves were used as per IS 1918 (1966) recommendations.

C. ARTIFICIAL/MANUFACTURED SAND:

The crushed sand having fineness modulus of 3.9 was used for the experimentation after washing it with clean water. The specific gravity of this artificial sand was found to be 2.966. The water absorption and moisture content values obtained for the sand used was found to be 6.33% and 3.2% respectively.

D. COARSE AGGREGATE:

Crushed stone aggregates of 20mm size obtained from local quarry site were used for the experimentation. The specific gravity of the coarse aggregates were found to be 2.26. The water absorption and moisture content values obtained for the sand used was found to be 2.04% and 1.78% respectively.

E. 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

The mix was designed for M30 grade as per IS: 10262-1982 manually and same design was used in the preparation of test samples. The table shows mix design proportion.

Table II: Mix Proportion for Group-I Concrete (M30)

Grade of Concrete	Quantity per m³ of Concrete (kg)			
	Water (lit)	Cement	Sand	Aggregate
M30	181	420.92	620.42	1181.7
	0.43	1	1.47	2.8

Table III: Replacement of Natural Sand in WFS

Notation	***w/c ratio***	***C (kg)***	***FA (kg)***	***CA (kg)***	***WFS %***
CM	0.43	1	1.47	2.8	-
F1	0.43	1	1.396	2.8	0.0735
F2	0.43	1	1.323	2.8	0.147
F3	0.43	1	1.249	2.8	0.22
F4	0.43	1	1.176	2.8	0.29420

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

IV. EXPERIMENTAL METHODOLOGY

The exact amount of concrete ingredients were weighed and mixed thoroughly in laboratory concrete mixer till the consistent mix was achieved. The standard cube of 150 mm size is steel mould, cylinder of 150 mm. diameter and 300 mm. length and unreinforced beams of 100*100*500 compacted on vibrating table. Thirty cubes, thirty cylinders and thirty beams with varying percentage of artificial and Waste foundry sand were casted for testing. Compressive Strength, Splitting Tensile and Flexural Strength were carried out on hardened concrete at 7 and 28 days. The average strength was calculated the acceptance criteria using IS 456 – 2000 is followed and the average values are illustrated in tables.

A. Compressive strength test:

Compressive strength of concrete was carried out on Compression Testing Machine of 2000kN. Three cubes of each batch were subjected to this test. A comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 5%, 10%, 15% and 20%.

Figure 1: Compressive Strength Test Set up.

B. Split tensile test:

The tensile strength of concrete is approximately 10% of its compressive strength. After curing of 7 and 28 days the specimens were tested for splitting tensile strength using a calibrated compression testing machine of 2000 KN capacity.

Figure 2: Splitting Tensile Strength Test Set up

C. *Flexural Strength Test:*

The tests on beams were carried out on Flexural testing machine of 100kN capacity under two point loading system.

Figure 3: Flexural Strength Test Set up.

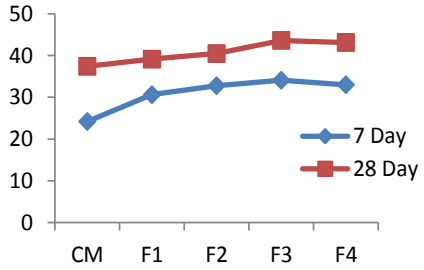
V. OBSERVATIONS

Following Graphs show the test results on the hardened concrete on 7 days and 28 days.

A. *Compressive strength:*

Table IV: Compressive Strength Test Results

Batch	***7 day N/mm²***	***28 day N/mm²***
CM	24.22	37.42
F1	30.63	39.14
F2	32.78	40.49
F3	34.088	43.63
F4	33.018	43.13

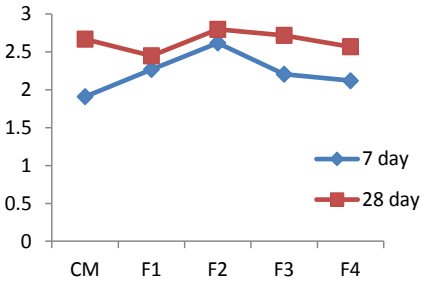


Graph I: Average Ultimate Compressive Strength

B. *Splitting tensile strength:*

Table V: Splitting Tensile Strength Test Results

Batch	***7 day***	***28 day***
CM	1.91	2.67
F1	2.27	2.45
F2	2.62	2.799
F3	2.206	2.72
F4	2.12	2.57

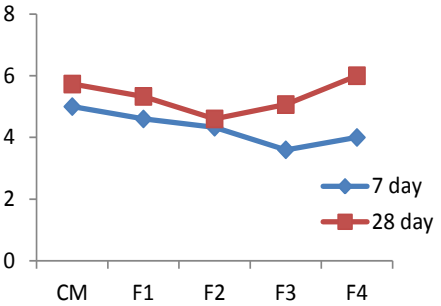


Graph II: Ultimate Splitting Tensile Strength

C. *Flexural strength:*

Table VI: Flexural Strength Test Results

Batch	***7 day***	***28 day***
CM	5	5.73
F1	4.6	5.33
F2	4.33	4.6
F3	3.6	5.066
F4	4	6



Graph III: Average Flexural Strength

VI. CONCLUSIONS

Based on above study the following observations are made regarding the properties and behavior 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 compared to traditional concrete.

(2) In this study, maximum compressive strength is obtained at 15% replacement of fine aggregate by waste foundry sand.

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

(4) The Flexural strength is found to be marginally increase with increase in WFS content.

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

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

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

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