Production of Low Cost Concrete Using Waste Foundry Sand and Recycled Aggregate concrete

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Abstract

Foundry sand consists primarily of clean, uniformly sized, high-quality silica sand or lake sand that is bonded to form moulds for ferrous (iron and steel) and nonferrous (copper, aluminium, brass) metal castings used by foundries. This sand can be recycled and reused three to five times before disposal. The disposed sand is known as Waste Foundry Sand (WFS). The opportunity to replace the natural fine aggregate with industrial by products embodies various technical, economic and environmental advantages resulting into a more sustainable construction sector. Different experiments have been carried out to assess the strength and characteristics of concrete using WFS. Proposed work is an effort to determine the strength and economic feasibility of using WFS and recycled aggregates an alternative to fine and coarse aggregate respectively in preparation of structural concrete. Concrete mixes were prepared with 0%, 10% and 15% replacement (by weight) of fine aggregate by waste foundry sand and 20% replacement (by weight) of coarse aggregate by recycled aggregate. Mechanical and physical properties of the materials were evaluated using various tests. It includes Fineness Modulus, Bulk Specific Gravity and Water Absorption test.

These materials were used to cast the sample in a cylinder of dimensions 6″ × 12″ for compression testing. Testing was carried out at 7th, 14th and 28th day. From the tests it was found that WFS based concrete has acceptable working strength and can be used in civil structures.

Keywords: WFS: Waste Foundry Sand, CA: Coarse Aggregate, RA: Recycled Aggregate, F.M: Fineness Modulus

1. NTRODUCTION:

The word concrete originated from the Latin word "Concretus" which means compact or condensed [1]. It is a very strong construction material and consists of cement, sand and coarse aggregate mixed with water. It is the most used material after water and its utilization is about a metric ton per annum per capita. Its remarkable properties in fresh and hardened state have raised its usage to 12 billion tons per year globally. It is a cheaper material and performs better than aluminium and steel

Waste materials like waste foundry sand and recycled aggregate concrete which are burden on environment can be used as a new technique in construction industry that is exploring rapidly on a large scale Waste foundry sand is obtained by burning 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. Use of waste foundry sand as a partial replacement or total replacement by fine aggregate in concrete results in production of economic, light weight and high strength concrete[2]..

Recycled aggregate can be generated from demolished construction structure which comprises of broken members or components likes the slab, beam, brick wall and others. Since the quality data of these broken materials are often unknown, such as water cement ratio, kind of admixtures, aggregate origins and gradations, as well as the differentiation of its properties during the performance time, thus it should refer to historical data of the components, physical characteristics, mechanical characteristics and environmental characteristics [3].

Due to rapid growth in population the demand of building construction and hence the demand of construction materials like concrete is also rising. So other than using natural sources we have to find other alternative sources of concrete constituents to produce concrete of adequate strength. Waste foundry sand from metal industry causes various environmental problems. Such waste material which is harmful for the environment can be used for the development of low cost and eco-friendly building materials. Concrete is a material which is composed of coarse aggregate, fine aggregate, cement, admixtures and water, all of these each material in concrete contributes towards its strength. So, by partial replacing of material affects different properties of concrete. The purpose of this research work is to study the effect of partial replacement of waste foundry sand (WFS) with natural sand on mechanical properties of concrete using recycled aggregate concrete. And to produce low cost and eco-friendly concrete using waste foundry sand and recycled aggregate concrete.

2. EXPERIMENTAL PROCEDURES:

2.1 Materials

The Ordinary Portland Cement (OPC) ASTM Type 1 of Grade: 42.5 with 32 % consistency was used. The initial and final setting time of OPC was 31 minutes and 130 minutes respectively. The Lawerancepur sand was used as fine aggregates. The physical characteristics of fine and coarse aggregates are summarized in table 1.

Table 1: physical characteristics of fine and coarse aggregates

Properties	Fine Aggregates	Coarse Aggregates	Non-Ferrous waste foundry sand
Bulk Specific Gravity (Oven Dry)	2.52	2.63	2.14
Bulk Specific Gravity (SSD Condition)	2.58	2.64	2.27
Apparent Specific Gravity	2.69	2.66	2.48
Water Absorption (%)	2.48	0.546	6.40
Fineness modulus	2.64	7.96	0.93
Bulk Density (Compacted) lbs/ft^3	-	96.76	-
Bulk Density (Loose) lbs/ft^3	-	88.16	-
Flakines index (%)	-	5.10	-
Elongation index (%)	-	13.72	-

2.2 Concrete Mix Design

Table 2: Mix Design Ratio

Cement (C)	**Sand (S)**	**Coarse aggregate (CA)**
364	673	1088
1	673/364	1088/3644
1	1.94	2.98

- Ratio for concrete mix design is 1:2:3

Table 3: Mix Proportion

Sr.No	**Mix ID**	**No of Specimen (6″× 12″ Cylinder)**	**Cement**	**Sand**	**W.F.S**	**NA**	**RA**	**Water**
			Kg/m^3					**Lit/m^3**
1	Conventional Concrete	09	19.5	39	0	58.50	0	11.70
2	10 % W.F.S	09	19.5	35.10	3.90	117	0	11.70
3	15 % W.F.S	09	19.5	33.15	5.85	58.50	0	11.70
4	0 % W.F.S + 20 % RA	09	19.5	39	0	46.80	11.70	11.70

5	10 % W.F.S + 20 % RA	09	19.5	35.10	3.90	46.80	11.70	11.70
6	15 % W.F.S + 20 % RA	09	19.5	33.15	5.85	46.80	11.70	11.70
	Total no of specimen	54						

a. b. c.

Figure 1: Recycled Aggregates and Waste Foundry Sand

2.3 Casting of Concrete Specimens

Cylindrical concrete specimen with 6” diameter and 12” high were made for compressive strength. The concrete constituents were mixed in a revolving drum type mixer for approximately three to six minutes to obtain uniform consistency. Addional mixing time of about two minutes was provided for the waste foundry sand mixed concrete mixtures to ensure homogeneity. After mixing, the cylindrical moulds were filled in three layers and fully consolidated on a vibrating table to remove any entrapped air.

3. Compression Test

The compressive strength of the sample was calculated on 7th and 28th day by dividing the maximum load achieved during the test on the transverse region. The test was made following the standard procedure described in ASTM C39. Cylindrical specimens 6” x 12” were used. The specimens were cured in lab curing tank until the age of testing. Each value of the compressive strength represents an average of three. Cylindrical specimens were capped with plaster of Paris and tested in saturated state. Rate of loading was kept at 200 to 400 lbs/sec according to ASTM standard and peak loading was kept 23 to 68 lbs. Testing procedure was followed as described in ASTM C 39.

4. RESULTS AND DISCUSSION

4.1 Slump Test

Workability of concrete mixture is measured by slump test: The slump test was conducted in accordance with the ASTM C-143 guidelines. In this test the slump cone was used. Three equal layers of concrete were filled in the sliding cone and compressed using 25 strokes of crimping rod. The rod was tempered having a diameter of 5/8in and length of 24 in. The slump test provides a good estimate of expected operability.

Figure 2: Slump test

Table 2: Slump test values of various mixes of WFSC

Sr.#	Mix ID	Percentage replacement of WFS + RA	Slump Value (inch)
1	NRAWFS 0	Traditional concrete 100 % natural sand 0 % W.F.S	3
2	NRAWFS 10	10% replacement by WFS	4
3	NRAWFS 15	15% replacement by WFS	6
4	RAWFS 0	0 % W.F.S + 20 % RA	3
5	RAWFS 10	10 % W.F.S + 20 % RA	5
6	RAWFS 15	15 % W.F.S + 20 % RA	6

4.2 Results of compressive strength test:

At each age average of three cylinders was taken for determination of average compressive strength. Compressive strength is significantly increased. The behaviour can be seen through table 3.

Table 3: Results of compressive strength test of WFSC

Sr.#	Mix ID	Percentage Replacement Of WFS	Compressive Strength Psi		
			7 Days	14 Days	28 Days
1	NRAWFS 0	Traditional concrete 100 % natural sand 0 % W.F.S	2980	3240	3465
2	NRAWFS 10	10 % replacement by W.F.S	2900	2980	3155

3	NRAWFS 15	15 % replacement by W.F.S	2740	2750	2835
4	RAWFS 0	0 % W.F.S + 20 % RA	3370	3125	3220
5	RAWFS 10	10 % W.F.S + 20 % RA	2840	2840	3080
6	RAWFS 15	15 % W.F.S + 20 % RA	2690	2670	2970

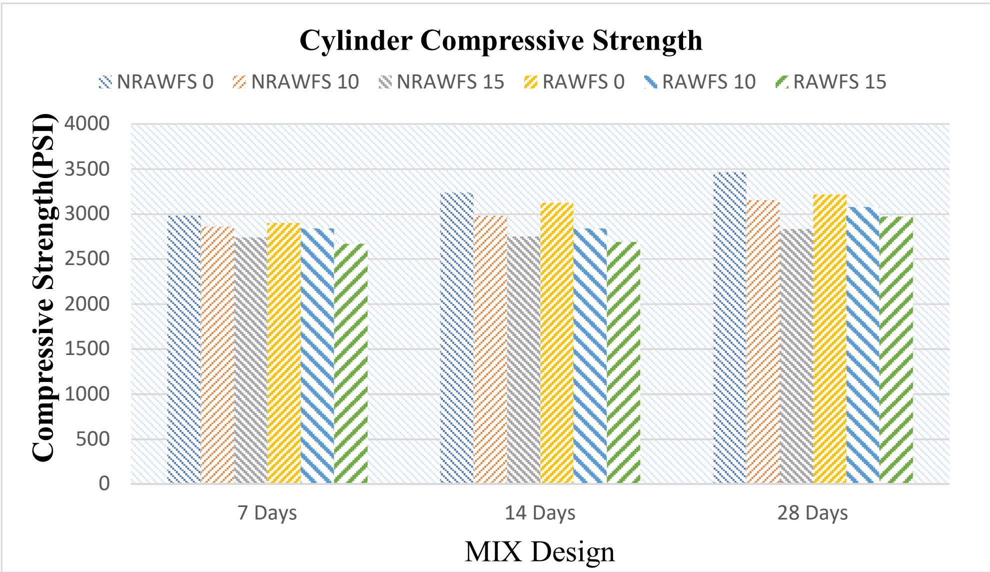

Figure 3: Graphical representation of compressive strength of N-WFSC at all ages

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6. RECOMMENDATIONS:

In this research WFS and recycled aggregate used and recommend that it is safe to use partial replacement of fine aggregate with WFS up to 10% replacement. And coarse aggregates partially replaced with recycled aggregates for 20% obtained from demolished concrete structures to produce normal strength concrete.

7. CONCLUSIONS:

The reuse of non-ferrous waste foundry sand and recycled coarse aggregate as a substitute for natural sand and coarse aggregate respectively in concrete production was evaluated based on the mechanical properties of the resulting concrete. Following conclusions are drawn from the finding of literature survey and results of the detailed experimental work of this project:

- Concrete prepared with non-ferrous waste foundry sand concrete has various benefit characteristics such as reduced the cost and environmental problem from the foundry waste disposal.

- The workability of fresh concrete increased with increase in the percentages dosage of non-ferrous waste foundry sand content.
- The compressive strength values for concrete with 10% and 15% regular sand replacements with Non-ferrous waste foundry sand are lower than the concrete with no replacement.
- Compressive strength of non-ferrous waste foundry sand concrete also decreases with increase in content of non-ferrous waste foundry sand.
- Concrete containing 0% replacement of fine aggregate with Non-ferrous waste foundry sand and 20% recycled coarse aggregate showed flexural strength higher to that of the control mix at 14 days.
- Compressive and flexure strength of non-ferrous waste foundry sand concrete is observed to decrease with increase in dosages.
- The analysis of non-ferrous waste foundry sand indicated that non-ferrous foundry sand can be a very suitable material for concrete production. However, the fineness and high water absorption of this sand increases the water demand of the concrete, and by increase in the workability of the concrete due to its fineness and composition and chemical reaction.
- Recycled coarse aggregate increases bond strength and hence effective to use as partial replacement without sacrificing strength at all and economy can also be achieved.
- This sand and recycled coarse aggregate can be used in those projects where low or medium strength is required because these will contribute towards economy.
- Cost of non-ferrous waste foundry sand is not more due to their free availability, however this sand is cheaper than natural fine aggregate resulted in economy.

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