Strength Investigation on Partial Replacement of Fine Aggregate With Waste Foundry Sand In Concrete

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Abstract- *Casting industries produce millions of tons of by-product throughout the world. In India, millions of tons of waste foundry sand is produced yearly. Foundry sand is a high quality silica sand with uniform physical characteristics and by product of ferrous and non-ferrous metal casting industry. WFS are major by-product of casting industry and create land pollution. The management of solid industrial waste is of big global concern nowadays. The disposal of waste foundry sand is of prime importance due to the big volume produced from the foundries all over the world. This experimental investigation discuss on partial replacement of fine aggregate with waste foundry sand with six percentage (0%, 10%, 20%, 30%, 40% and 50%). The grade of concrete selected for the study is* M_{25}*. The concrete was tested for compression strength test, for 7, 14 & 28 days and the result found that there is a increase in strength for 50% replacement of foundry sand in concrete.*

Keywords- Foundry sand, Ordinary Portland Cement. Compression strength test, Fine aggregate, Industrial waste.

I. INTRODUCTION

Foundry sand is high quality silica sand with uniform physical characteristics. It is a byproduct of ferrous and nonferrous metal casting industries, where sand has been used for centuries as a molding material because of its 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 modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates that approximately 100 million tons of sand is used in production annually of that 6 -10 million tons are discarded annually and are available to be recycled into other products and in industry. The automotive industries and its parts are the major generators of foundry sand. Foundries purchase high quality size specific silica sand for use in their molding and casting operations.

Foundries purchase high quality size-specific silica for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sand used in fill construction sites. The sand forms the outer shape of foundry model cavity. These sand normally a small amount of bentonite clay to act as the binder material. Chemical binders are also used to create sand “cores”. Depending upon the geometry of the casting, sands cores are inserted into the mould cavity to form internal passages for the molten metal. Once the metal has solidified, the casting is separated from the moulding and core sands in the shakeout process. 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 casting process. At that point, the old sand is disposed from the cycle as byproduct, new sand is introduced, and the cycle begins again.

II. OBJECTIVES

1. To effectively utilize the foundry waste material from the industries.
2. To reduce the problem of disposal of industrial foundry waste.
3. To determine the compressive strength and compare it with the conventional concrete.

III. METHODOLOGY

- Cement – OPC 43 grade
- Coarse aggregate- 20mm downsize
- Fine aggregate- 4.75mm downsize
- Water
- Foundry Sand

Fig 1. Foundry sand

- Preparation of the mix design for M25 grade of concrete.
- Conduction of basic material tests
- Partial replacement of foundry sand in 0%, 10%, 20%,30%, 40%, & 50%.
- Casting cubes of size 150*150*150mm.
- Curing of conventional and foundry replaced concrete is done normally with water.
- Testing for compressive strength.

IV. BASIC TEST ON MATERIALS

1. Cement

Physical properties	Result	Standard values
Specific gravity	3.15	3.16
Standard consistency (%)	30%	-
Initial setting time (min)	110 min.	Not less than 30min.
Final setting time (min)	6 hr	Not less than 600 min.

2. Foundry sand

Physical properties	Result
Specific gravity	2.44
Absorption, %	0.467
Fineness modules	2.68

3. Coarse and fine aggregate

Property	Fine aggregate	Coarse aggregate
Fineness Modulus	2.50	7.67
Specific gravity	2.64	2.63
Bulk density (gm/cc)	1752	1744

V. MIX DESIGN

<u>Design of M25 grade concrete mix</u>

Design stipulations:

The design procedure followed is as per IS:10262-2009
Desired characteristic strength of concrete, f_{ck}= 25 N/mm^2
Maximum size of aggregates = 20 mm
Type of exposure = Mild
Maximum water cement ratio = 0.6

Data:

- Cement used –UltraTech cement of 43 grade OPC
- Specific gravity of
  1) Cement : 3.15
  2) Fine aggregate: 2.64
  3) Coarse aggregate (CA) : 2.74
- Sieve analysis – Fine aggregate confirming to Zone II gradation requirements as per IS:383-1970

Procedure:

Step 1: Target mean strength

TS = fck+ 1.65 x S
Standard deviation, S = 4 (As per table 8 IS:456-2000)
Target strength, TS = 25 + 1.65 x 5.3 = 31.95 N/mm^2

Step 2: Selection of water cement ratio

From table 5 IS:456-2000, maximum W/C ratio = 0.6
Therefore, select water cement ratio = 0.43

Step 3: Selection of water content

From table 2 of IS 10262: 2009
Max water content for 20mm aggregate =186liters

Step 4: Selection of cement content

Determination of cement content
Water cement ratio = 43 %
Water = 186 kg/m3
Cement = 186/0.43
= 432.55 kg/m3

Step 5: Proportion of volume of coarse aggregate and fine aggregate content.

Therefore volume of coarse aggregate= 0.62x0.9=0.558
Therefore volume of fine aggregate= 1-0.558=0.442

Step 6 : Determination of fine aggregate content

V = [W + C/Sc + 1/p x Fa/SFa] x 1/1000
0.98 = [186 + 432/3.15 + 1/0.35 X fa/2.64] x 1/1000
Fa = 608.20 kg/m^3

Step 7 : Determination of coarse aggregate content

V = [W + C/Sc + 1/(1-P)x Ca/SFa] x 1/1000
0.98 = [186 + 432/3.15 + 1/0.65 X Ca/2.64] x 1/1000

Ca = 1132.51 kg/m^3

MIX PROPORTIONS

Cement = 432.55 kg / m^3
Water = 186 liters
Fine aggregates = 608.2 kg / m^3
Coarse aggregate = 1132.00 kg / m^3
W/c ratio = 0.43
Foundry sand = Replacing fine aggregate by same amount by volume

VI. RESULTS & DISSCUSSIONS

1. Compression Strength Test

In this research the values of compressive strength of cubes for different replacement levels of foundry sand contents(10%, 20%, 30%, 40%, 50%) at the end of different curing periods(7, 14, 28 days) are given in table. These value are plotted in figures. Which show the variation of compressive strength of cubes with fine aggregate replacement at different curing ages respectively. It is evident from fig. that compressive strength of cubes of concrete mixture with 10%, 20%, 30%, 40%, and 50% of foundry sand as sand replacement was higher than the control mixture M_{25} at all ages and that the strength of all mixtures continued to increase with age. Below figures shows that compressive strength increase with increase in foundry sand.

Foundry sand content in %	Compressive strength (Mpa)		
	7 days	14 days	28 days
0 (Nominal mix)	21.4	28.2	31.1
10	28.14	29.1	31.44
20	27.62	29.7	33.95
30	29.1	30.3	35.15
40	29.7	31.2	36.45
50	31.4	32.5	37.7

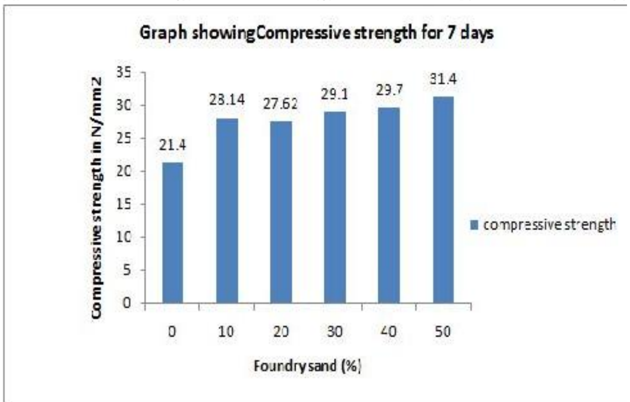

Fig 2. Compression strength at 7 days

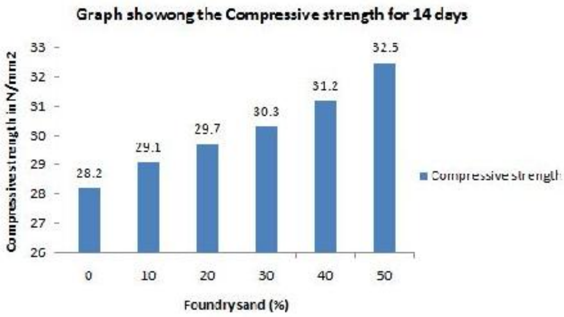

Fig 3. Compression strength at 14 days

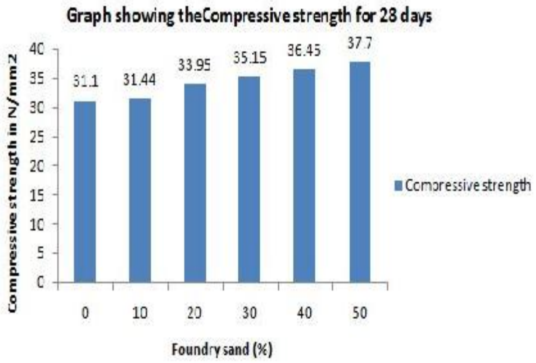

Fig 4. Compression strength at 28 days

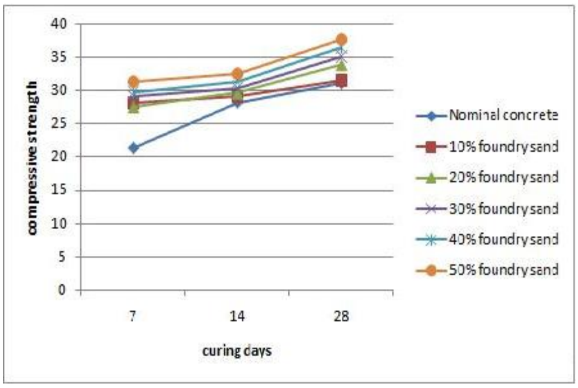

Fig 5. Comparison of compressive strength between nominal and foundry sand

VII. CONCLUSION

- Waste foundry sand can be effectively used partially as fine aggregate in place of conventional river sand, in concrete.
- In this case of foundry sand replacement good variation is observed in compressive strength with curing duration.
- At the end of 7 days curing it was observed that the strength was increased with 46.7% for 50% replacement of foundry sand as compared to that of conventional concrete.

- At the end of 14 days curing it was observed that the strength was increased with 15.24% for 50% replacement of foundry sand as compared to that of conventional concrete.
- At the end of 28 days curing it was observed that the strength was increased with 21.2% for 50% replacement of foundry sand as compared to that of conventional concrete.
- Foundry sand can be utilized in production of concrete hence reducing the problem of disposal.

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