Usage of Waste Foundry Sand in Concrete

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ABSTRACT:
`Now a days good quality natural river sand is not readily available, it is to be transportated from a long distance. These resources are also exhausting very rapidly. So there is a need to find 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 sand is used as a complete replacement. In this project the behavior of concrete is assured by partially replacing the natural sand with foundry sand which is a waste product from machine industries. The experimental work is mainly concern with the study of mechanical properties like compressive strength, split tensile strength and as well as flexural strength of concrete by partial replacement of artificial sand by foundry sad as fine aggregate. Tests over carried out on cubes, cylinders to studies the mechanical properties o concrete using foundries and compare with concrete with natural sand as fine aggregate. Artificial sand was replaced with five percentages (0%,5%,10%,15%& 20%) of Waste Foundry Sand by weight. A total of five concrete mix proportions are made with and without foundry sand. Compression test, splitting tensile strength test and flexural strength test were carried out to evaluate the strength properties of concrete at the age of 7 &28 days. Test results showed a nominal increasing strength and durability properties of concrete by the addition of waste foundry sand as a partial replacement of natural sand.

KEYWORDS: *The experimental work is mainly concern with the study of mechanical properties like compressive strength.*

I.INTRODUCTION

Argillaceous materials have been used by mankind for construction from time immemorial. The every rising functional requirement of the structures and the capacity to resist aggressive elements has necessitated developing new materials and composites to meet the higher performance and durability criteria. The environmental factors and pressure of utilizing waste materials from industry have also been the major contributory factors in new developments in the field of concrete technology. Since concrete is the most important part in structural construction, it should be in a form of good strength for structural purposes. Concrete is made up of aggregate, cement and water. Though this combination of three – quarter of the mix is governed by aggregate. The aggregate itself is categorized as fine and coarse aggregate.

In this study, scope of project report will be focused on the use of fine aggregate using foundry sand. Before further discussion, it shall be better to have a knowledge and clear understanding about the foundry sand and its properties and performances. Foundry sand is one of the aggregate to be used in concrete, other than normal sand. 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 the sand can no longer be reused in the foundry, it is removed from the foundry and is termed “foundry sand.” Foundry sand production is nearly 6 to 10 million tons annually. Like many waste products, foundry sand has beneficial applications to other industries.

Types of Foundry Sand

There are two basic types of foundry sand available, green sand (often referred to as molding sand) that uses clay as the binder material, and chemically bonded sand that uses polymers to bind the sand grains together.

GREEN SAND consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, such as sea coal, and 2-5% water. Green sand is the most commonly used molding media by foundries. The silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity. The carbonaceous additives prevent the “burn-on” or fusing of sand onto the casting surface. Green sands also contain trace chemicals such as MgO, K2O, and TiO2. CHEMICALLY BONDED SAND consists of 93-99% silica and 1-3% chemical binder. Silica sand is thoroughly mixed with the chemicals; a catalyst initiates the reaction that cures and hardens the mass. There are various chemical binder systems used in the foundry industry. The most common chemical binder systems used are phenolic-urethanes, epoxy-resins, furfyl alcohol, and sodium silicates.

Significance of research:

Foundry sand is basically fine aggregate. It can be used in many of the same ways as natural or manufactured sands. This includes many civil engineering applications such as embankments, flowable fill, hot mix asphalt (HMA) and portland cement concrete (PCC). Foundry sands have also been used extensively agriculturally as topsoil.

Currently, approximately 500,000 to 700,000 tons of foundry sand are used annually in engineering applications. The largest volume of foundry sand is used in geotechnical applications, such as embankments, site development fills and road bases.

The advantages of this study are :-

1. To provide some information about the use of foundry sand
2. Beneficial and Economical value to local people
3. New attempt during the test and methods required to overcome the problems
4. Have chances to explore the use of local waste material in steel industries

A brief literature is presented in the coming chapter over this area so as to know the status of the project.

II.RELATED WORK

Most metalcasting sand (FS) is high quality silica sand with uniform physical characteristics. It is a byproduct of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a molding material because of its unique engineering properties. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates are that approximately 100 million tons of sand are used in production annually. Of that, four (4) to seven (7) million tons are discarded annually and are available to be recycled into other products and industries.

Sand used at foundries is of a high quality, much of it supplied by members of the Industrial Minerals Association of North America (IMA-NA). Stringent physical and chemical properties must be met as poor quality sand can result in casting defects. Foundries and sand producers invest significant resources in quality control of their sand systems, with extensive testing done to maintain consistency. As a result, FS from an individual facility will generally be very consistent in composition, which is an advantage for most end use applications.

Although there are other casting methods including die casting, investment casting, and permanent mold casting, sand casting is by far the most prevalent casting technique. Sand is used in two different ways in metalcasting : as a molding material, which forms the external shape of the cast part, and as cores, which form internal void spaces in products such as engine blocks. Since sand grains do not naturally adhere to each other, binders must be introduced to cause the sand to stick together and hold its shape during the introduction of the molten metal into the mold and the cooling of the casting.

THEORY AND ORIGIN OF FOUNDRY SAND:

Foundry sand consists primarily of clean, uniformly sized, high-quality silica sand or lake sand that is bonded to form molds for ferrous (iron and steel) and nonferrous (copper, aluminum, brass) metal castings. Although these sands are clean prior to use, after casting they may contain Ferrous (iron and steel) industries account for approximately 95 percent of foundry sand used for castings. The automotive industry and its parts suppliers are the major generators of foundry sand.

The most common casting process used in the foundry industry is the sand cast system. Virtually all sand cast molds for ferrous castings are of the green sand type. Green sand consists of high-quality silica sand, about 10 percent bentonite clay (as the binder), 2 to 5 percent water and about 5 percent sea coal (a carbonaceous mold additive to improve casting finish). The type of metal being cast determines which additives and what gradation of sand is used. The green sand used in the process constitutes upwards of 90 percent of the molding materials used.

In addition to green sand molds, chemically bonded sand cast systems are also used. These systems involve the use of one or more organic binders (usually proprietary) in conjunction with catalysts and different hardening/setting procedures. Foundry sand makes up about 97 percent of this mixture. Chemically bonded systems are most often used for "cores" (used to produce cavities that are not practical to produce by normal molding operations) and for molds for nonferrous castings.

The annual generation of foundry waste (including dust and spent foundry sand) in the United States is believed to range from 9 to 13.6 million metric tons (10 to 15 million tons).[(2)] Typically, about 1 ton of foundry sand is required for each ton of iron or steel casting produced.

III. OBJECTIVES & SCOPE OF PRESENT STUDY

The construction industry and concrete manufacturers have realized that they will need to use available aggregate rather than search for the perfect aggregate to make an ideal concrete suitable for all purposes. Simultaneously, significant increase in the other construction materials production like steel will produce a lot of industrial waste such as used foundry sand. This can be used in the production of concrete for specific purposes.

It has been well established that foundry sand aggregate can be used for all structural elements in civil engineering. Based on review of literature , it is clear

that very little research has been carried out so far on the behavior of Foundry Sand (FS).
The main objectives of the present experimental work are discussed below :

- To find the efficiency of the Foundry Sand for civil constructions.
- To know the fresh concrete properties of foundry sand concrete.
- To know the behavior of compressive and split tensile strength of foundry sand.
- To analyse the different areas of civil engineering in which Foundry Sand can be used efficiently.

To obtain the above objectives of the experimental work , the test programmer is planned as presented below.
Total 36 concrete specimens are prepared. 6 specimens with natural concrete and other 30 specimens
Are prepared with foundry sand concrete as replacement of foundry sand in proportion of 20, 40, 60, 80, 100% by absolute volume method. The details of each category are described below :

Obejctives of the test programme:
3 cubes and 3 cylinders for each mix proportion.

a) Size of cube specimen : 150X150mm
Mix proportion is : 1:1.41:3.099
Water Cement ratio : 0.52
Number of specimens : 18 No. of cubes (3-0%,3-20%,3-40%,3-60%,3-80%,3-100%)

b) Size of cylinder specimen : l=300mm , d= 150mm
Mix proportion is : 1:1.41:3.099
Water Cement ratio : 0.52
Number of specimens :18 No. of cylinders (3-0%,3-20%,3-40%,3-60%,3-80%,3-100%)

SCOPE OF PRESENT WORK:
Based on the availability of equipment in the laboratory , experimental work was conducted on cubes and cylinders so that it leads to evaluate compression and split tensile strengths. There is need to study the microstructure of concrete by conducting the X-Ray diffraction and SEM analysis. Due to limitation of the equipments,it was confined to finding of above said strengths only.

IV. EXPERIMENTAL INVESTIGATION AND PRESENTATION OF TEST RESULTS

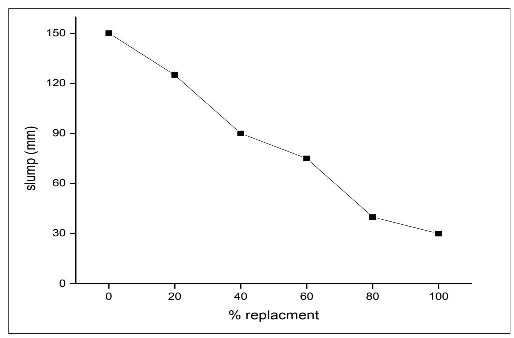
General:
The following materials were used for the experimental work so as to achieve the specified objectives , which were mentioned in the previous chapter. The aggregate based on the specifications has been divided in to fine and coarse aggregate. Of these fine aggregate used in this project comprises of normal sand as well as steel industry waste foundry sand. Coarse aggregate is the same all through the project. Cement used is JSW 53 Grade of cement. The following is the brief description of each and every material specifying their physical and chemical properties.

4.1 DISCUSSION OF TEST RESULTS

WORKABILITY:
The workability of mixes have been measured by compaction factor test and slump cone test. The values of slump cone test results are presented in below table. From this it is observed that the slump decrease with increase in the % of foundry sand in the concrete mix. The decrease of workability may be due to higher water absorption and rough surface of foundry sand than the normal sand.

Slump Test values:

% replacement	0	20	40	60	80	100
Slump (mm)	150	130	90	70	40	30

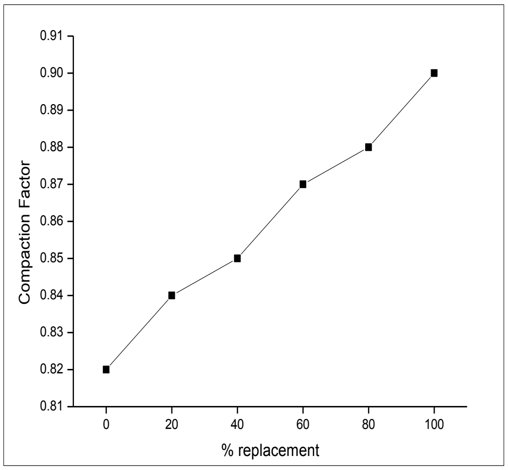


slump values vs % replacement

The values of compaction factor test results are presented in below table. From this it is observed that the compaction factor increase with increase in the % of foundry sand in the concrete mix. The increase of workability may be due to higher water absorption and smooth surface of foundry sand than the normal sand.

Compaction factor test values:

% replacement	0	20	40	60	80	100
Compaction Factor	0.82	0.83	0.85	0.86	0.87	0.89



compaction factor vs % replacement

COMPRESSIVE STRENGTH:

The compressive strength for all mixes are represented in table. From this, it can be observed that the 7 days compressive strength increase with the increase in % of foundry sand up to 60% and after that decrease till 100%. This may be due to different surface texture of aggregates.

For 20 % replacement of foundry sand aggregate there is increase in cube compressive strength by +13.42 % over normal sand.

For 40 % replacement of foundry sand aggregate there is increase in cube compressive strength by +11.05 % over normal sand.

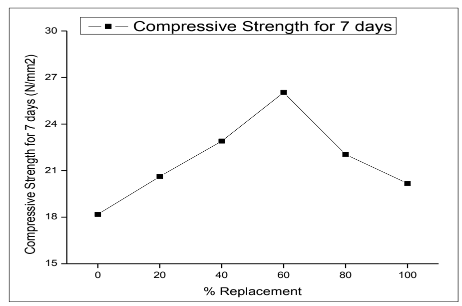
For 60 % replacement of foundry sand aggregate there is increase in cube compressive strength by +16.28 % over normal sand.

For 80 % replacement of foundry sand aggregate there is decrease in cube compressive strength by -15.32 % over normal sand.

For 100 % replacement of foundry sand aggregate there is decrease in cube compressive strength by -8.49 % over normal sand.

7-DAYS CUBE COMPRESSIVE STRENGTH FOR FOUNDRY SAND CONCRETE

S.no	Nomenclature	Ultimate load (KN)	Average Ultimate load (KN)	Average stress (N/mm^2)	% change in compressive strength
1	NC1 NC2 NC3	408 390 429	409	18.18	-
2	FSC1-20 FSC2-20 FSC3-20	420 462 508	464	20.62	+13.42
3	FSC1-40 FSC2-40 FSC3-40	515 464 567	516	22.9	+11.05
4	FSC1-60 FSC2-60 FSC3-60	527 587 645	586	26.03	+16.28
5	FSC1-80 FSC2-80 FSC3-80	446 497 546	496	22.04	-15.32
6	FSC1-100 FSC2-100 FSC3-100	408 455 500	454	20.17	-8.49



compressive strength Vs % replacement

The compressive strength for all mixes are represented in table. From this, it can be observed that the 28 days compressive strength increase with the increase in % of foundry sand up to 60% and after that decrease till 100%. This may be due to different surface texture of aggregates.

For 20 % replacement of foundry sand aggregate there is increase in cube compressive strength by +13.32 % over normal sand.

For 40 % replacement of foundry sand aggregate there is increase in cube compressive strength by +11.21 % over normal sand.

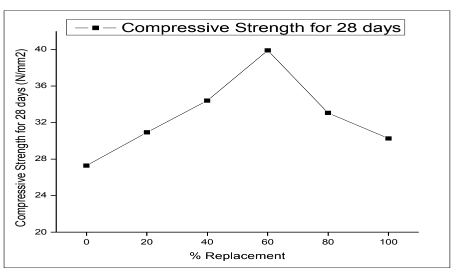
For 60 % replacement of foundry sand aggregate there is increase in cube compressive strength by +15.98 % over normal sand.

For 80 % replacement of foundry sand aggregate there is decrease in cube compressive strength by -17.14 % over normal sand.

For 100 % replacement of foundry sand aggregate there is decrease in cube compressive strength by -8.49 % over normal sand.

28-DAYS CUBE COMPRESSIVE STRENGTH FOR FOUNDRY SAND CONCRETE

S.no	Nomenclature	Ultimate load (KN)	Avg Ultimate load (KN)	Average stress (N/mm²)	% change in Compressive Strength
1	NC1 NC2 NC3	408 390 429	409	27.28	-
2	FSC1-20 FSC2-20 FSC3-20	420 462 508	464	30.93	+13.32
3	FSC1-40 FSC2-40 FSC3-40	515 464 567	516	34.4	+11.21
4	FSC1-60 FSC2-60 FSC3-60	527 587 645	586	39.9	+15.98
5	FSC1-80 FSC2-80 FSC3-80	446 497 546	496	33.06	-17.14
6	FSC1-100 FSC2-100 FSC3-100	408 455 500	454	30.25	-8.49



compressive strength Vs % replacement (28 days)

SPLIT TENSILE STRENGTH:

The variation of 28 days split tensile strength of concrete mixes is represented in tables and figure. From these it is observed thatthe 28 days split tensile strength increase with the increase in % of foundry sand up to 60% and after that decrease till 100%.

V.CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from present experimental work.

1. The workability of foundry sand increases
2. The compressive strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%
3. The split tensile strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%
4. There is an enhancement in the strengths for respective replacement of aggregate with incorporation of foundry sand with natural sand
5. The failure modes are similar for both natural sand and foundry sand. The use of foundry sand for concrete works is demonstrated in compression, split tensile strength
6. This study could enlighten the people to use foundry sand for concrete works

Recommendations for future investigations

1. The studies can be conducted to know the performance under impact and torsion loading
2. Studies can be conducted by incorporation of platicizers, admixture, accelerators.
3. Mathematical / Emperical models can be developed for the foundry sand concrete
4. Durability studies such as resistance to sulphate attack, acid resistance etc., can be carried out on foundry sand concrete

VI.APPENDIX

EXAMPLE OF MIX DESIGN(ABSOLUTE VOLUME METHOD)

Here we followed ACI ABSOLUTE VOLUME METHOD ,due to the differences in the specific gravities of the replacement material .

Mix component Properties:

Cement
grade: 53

Specific Gravity: 3.078
Corse Aggregate Nominal Maximum particle Size: 10mm
SSD Bulk Specific Gravity: 2.58
Fine Aggregate SSD Bulk Specific Gravity : 2.6

Fineness Modulus: 2.727

Desired Mix Properties:

A 30 kg batch on non-air –entrained concrete with a slump in the 80 to 100 mm range and a water/cement ratio of 0.5 is required.

SOLUTION:

1. Densities of all materials to be used: ρ=G*ρw

Material	Quantity(kg/m^3)	Specific Gravity	* ρw=	Density(kg/m3)
Water	186	1.0	*1000	1000
Cement	383	3.078	*1000	3078
SSD Fine aggregate	532	2.6	*1000	2600
SSD coarse aggregate	1187	2.58	*1000	2580
Entrapped air	2%			

1. Absolute volume calculations:

Material	Volume required M^3
Water	$\frac{186}{1.0 * 1000} = 0.186$
Cement	$\frac{383}{3.078 * 1000} = 0.1244$
Coarse Aggregate	$0.627 * \frac{1440}{2.58 * 1000} = 0.349$
Entrapped Air	$\frac{2}{100 * 1000} = 0.00002$

2. Sum of known volumes = (0.186+0.1244+0.349+0.00002) = 0.6594 m^3

SSD volume of Fine Aggregate = 1-0.6594 = 0.3406 m^3

Mass calculations for Fine Aggregates for the 20% replacement of Foundry sand.

Fine Aggregate	Mass required Kg/m^3
Normal sand	0.3406 * 0.8 * 2.6 * 1000 = 708.24
Foundry sand	003406 * 0.2 * 4.6 * 1000 = 313.24

5 . Total required volume for 3 cubes and 3 cylinders = 0.026 m^3

Mass of Normal sand required for a mix = 0.026 * 708.24 =18.41 kg

Mass of Foundry sand required for a mix = 0.026 * 313.24 =8.144kg

Mass of cement required for a mix = 0.026 * 383 =9.96 kg

Mass of Coarse Aggregate required for a mix = 0.026 * 1187 =30.9 kg

Amount of Water required for a mix = 0.026 * 186 = 4.9 lit

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