# Experimental Study on Concrete using Industrial Waste Foundry Sand as Partial Replacement of Fine Aggregate

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**Abstract- The extraction of building materials for various construction projects has been substantially increasing day by day. Foundries are used in various industrial purposes like automotive, construction, and mining industries etc., for metal casting. Only a small portion of the millions of tons of discarded foundry sand produced annually is recycled. An effort has been attempted in this study to use foundry sand, a partial replacement for fine aggregate in concrete.**

**This study examines the characteristics of concrete that have been both freshly mixed and hardened using foundry sand. Foundry sand has been substituted for 0%, 30%, 40%, 50%, and 60% of the natural fine aggregate. The chemical and physical properties of foundry sand were studied to utilize it as a replacement for natural fine aggregates. M25 grade of concrete was considered for study OPC 53 grade was used for the production of concrete. The mechanical properties of the concrete considered were compression strength, split tensile strength, and flexural strength. The findings suggested that concrete produced using 50% foundry sand replacement had better mechanical properties. A beneficial outcome may be seen when foundry sand is used instead of natural sand.**

## I.INTRODUCTION

### 1.1 GENERAL

Concrete is the second most consumed composite material in the world next to water. Hence the demand for the ingredients of concrete grows day by day, and this leads to the illegal extraction of building materials. The extraction of building materials has risen dramatically and the natural resources have been exploited. At this point, many researchers and engineers who have the foresight to maintain sustainability and to keep developmental activities abreast should look out for other alternative building materials. Sustainability in the construction industry can be achieved by making use of non-conventional and innovative materials and also by making use of industrial products.

Industries generate large amounts of waste materials or by-products every year. Disposal of these waste materials into the environment causes severe pollution and health hazards. Industrial by-products are used in concrete nowadays and thereby give a solution for their disposal. Natural resources are saved from exploitation by using other alternative building materials like industrial by-products.

### 1.2 FOUNDRY SAND

Foundry sand (FS), which can be utilized as a fine aggregate replacement in concrete, Is one such resource that warrants further attention. In the foundry industry during the casting process, a large amount of by-product material is produced. The metals usually cast in the foundry industry are cast iron, steel, aluminums, copper, brass and bronze. Sand is a by-product of both foundries working with ferrous and non-ferrous metals, but it is more common in foundries working with ferrous metals. Over two third of the total by-product material consists of silica and one-third of the total by-product material consists of metals which is cast on the sand. In the foundry industry, they use high-quality silica sand for Maudling the metals and also for casting purposes. The sand commonly used in the foundry industry should be easily available; it should possess very high resistance to heat and should be cost-effective. In the foundry industry, the same sand will be used for many castings until it loses its original properties fully or until if it is used again, it will affect the casting materials by changing their physical as well as chemical properties. The sand which cannot be reused again in the foundry industry for casting purposes then it is termed waste foundry sand. The disposal of waste foundry sand becomes a major issue and creates land pollution. The color of the casting purposes, and the method used in the casting purposes.

foundry sand will be blackish, grey and also brownish in color based on the material which is c ast on it, the number of times it is used for the byproduct of waste foundry sand will have some of the properties of the material which is cast on it. Due to this when it is used as a partial replacement for fine aggregate in concrete, the compressive strength of the concrete can be increased, land pollution due to waste foundry sand can also be reduced to a greater extent, and the demand for the fine aggregate can also be reduced.

Fig: Waste Foundry Sand

Its form, which can range from sub-angular to round, and high heat conductivity make it an excellent material for casting and Moulding.Metal alloy casting foundries produce only a few million tons of what is called "Foundry Sand" (FS). It has been put to good use as a dump for quite some time, but rising disposal prices have made it problematic in that regard as well. Every year, over 2500 foundry plants identified in the United States consume around 1 Lakh tons of sand to produce their goods, and between 6 and 12 million metric tons of waste foundry sand are dumped into landfills. Due to foundry waste fees being greater than the national average, landfills are out of the question. When compared to the United States and China, India produces the third-most castings worldwide. About 9.5 million metric tons were produced in 2013–14, and there were 4,900 foundries with a combined annual output capacity of 15, 00,000 metric tons. The installed capacity and output may be greater than projected because around 85% of the sector is not organized and does not share information with the public. The annual trash produced by these foundries is approximately 1.7 metric tons. Waste is being studied

## II.LITERATURE REVIEW

### 2.1 LITERATURE

A.NAVEENARASU et.al -2017, "Experimental analysis of waste foundry sand in partial replacement of fine aggregate in concrete", Casting industries produce millions of tons of by-products throughout the world. In India, millions of tons of waste foundry sand are produced yearly. WFS is a major by-product of the casting industry and creates land pollution. The river fine aggregate will be replaced with waste foundry sand (0%, 5%, 10%, and 15%) in the concrete. So that land pollution can be reduced and the demand for river sand can be reduced. Research has been carried out to know the exact percentage of waste foundry sand (WFS) that should be replaced for fine aggregate in concrete. This experimental investigation was done and found that with the increase in the WFS ratio. Natural sand was replaced with five percentages (0%, 5%, 10%, 15%, and 20%) of WFS by weight. The sum of five concrete mix proportions (M-1, M-2, M-3, M-4 and M-5) with and without WFS were cast and found out how to reduce the slump and increase the workability of fresh concrete. A compression test has been done to find out the compressive strength of concrete at the age of 7, 14, 21 and 28 days. The test result indicates an increasing compressive strength of plain concrete by the inclusion of WFS as a partial replacement of fine aggregate. The results also satisfy the acceptable limits the American Concrete Institute (ACI) set.

VEMA REDDY CHEVURIet.al. 2015, "Usage of Waste Foundry Sand in Concrete'', 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 a need to find alternatives to natural river sand. Natural river sand takes millions of years for its formation and is not renewable. As a substitute for 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 concerned 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 with foundry sand as fine aggregate. Tests were carried out on cubes, and cylinders to study the mechanical properties of 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 tests, splitting tensile strength tests and flexural strength tests 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.

SOHAILMDet.al. 2013, "A Study on the Mechanical Properties of Concrete by Replacing Sand with Waste Foundry Sand' 'Conservation of natural resources and preservation of the environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the materials are found suitable in concrete making not only cost of construction can be put down, but also safe disposal of waste materials can be achieved. 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 in other industries. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (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 as a partial replacement of fine aggregates or a total replacement of fine aggregate and as a supplementary addition to achieve different properties of concrete. In the present study, the effect of foundry sand as a fine aggregate replacement on the compressive strength, split tensile strength and flexural strength having mix proportions of M30 was investigated. Fine aggregates were replaced with eleven per cent of foundry sand. The percentages of replacements were 0, 10, 20, 30, 40, 60,70,80,90 & 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 &56 days).

YOGESHAGGARWALet.al.2014, "Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates'', The possibility of substituting natural fine aggregate with industrial by-products such as waste foundry sand and bottom ash offers technical, economic and environmental advantages which are of great importance in the present context of sustainability in the construction sector. The study investigated the effect of waste foundry sand and bottom ash in equal quantities as partial replacement of fine aggregates in various percentages (0–60%), on concrete properties such as mechanical (compressive strength, splitting tensile strength and flexural strength) and durability characteristics (rapid chloride penetration and deicing salt surface scaling) of the concrete along with micro structural analysis with XRD and SEM. The results showed that the water content increased gradually from 175 kg/m3 in the control mix (CM) to 238.63 kg/m3 in the FB60 mix to maintain the workability and the mechanical behavior of the concrete with fine aggregate replacements was comparable to that of conventional concrete except for FB60 mix. The compressive strength was observed to be in the range of 29–32 MPa, splitting tensile strength in the range of 1.8–2.46 MPa, and flexural strength in the range of 3.95–4.10 MPa on the replacement of fine aggregates from 10% to 50% at the interval of 10%. Furthermore, it was observed that the greatest increase in compressive, splitting tensile strength, and flexural strength compared to that of conventional concrete was achieved by substituting 30% of the natural fine aggregates with industrial by-product aggregates. The inclusion of waste foundry sand and bottom ash as fine aggregate does not affect the strength properties negatively as the strength remains within limits except for 60% replacement. The morphology of the formations arising as a result of the hydration process was not observed to change in the concrete with varying percentages of waste foundry sand and bottom ash.

SAVERIA MONOSIet.al. 2010, "Used Foundry Sand in Cement Mortars and Concrete Production'', Used foundry sands represent the highest number of solid wastes generated by foundries. Classified by European Union regulations as non-hazardous waste, they represent a relevant source to be reused in several industrial sectors, in building construction primarily. In the present paper, the properties of mortars and concretes containing different dosages of used foundry sand (UFS) as a partial sand replacement were investigated in fresh and hardened conditions. In particular, higher percentages of addition, but lower if referred to the whole aggregate (fine and coarse), were considered in concretes than in mortars. Both mortars and concretes were evaluated concerning the consistency of the fresh mixture and the compressive strength of the hardened material. Elastic modulus determination of the hardened material was carried out on concretes. A low (10%) amount of used foundry sand does not change the mortar 's performance. In the presence of higher additions, a workability decrease can be outlined, and then a higher dosage of super plasticizer is required to keep it constant. Mechanical performances lower by about 20-30% than those of the conglomerate without used foundry sand are observed. The higher penalization seems to concern the conglomerates of better quality. aggregate were 10, 20, and 30 per cent by weight. During varied curing times, compressive strength, split tensile strength, and elastic modulus tests were conducted on all replacement sand levels (14-days & 28-days) Test findings revealed a modest improvement in compressive strength, split tensile strength, and modulus of elasticity when fine aggregates were replaced with a certain amount of foundry sand. This indicates

## III.CONCRETE MIX DESIGN

### 3.1 GENERAL:

Mix Design is the process of selecting suitable ingredients for the concrete and determining their relative proportion with the object of producing concrete possessing certain minimum desirable properties like workability in the fresh state, and minimum desirable strength and durability in the hardened state. There are a number of methods available for mixed design like the ACI method. IRC method, DOE method and IS method.

### 3.2 MIX DESIGN PROCEDURE

From the above methods of mix design, IS code method of mix design is chosen to get a mix ratio for M25-grade conventional concrete. The procedure consists of a series of steps, which when completed provided a mixture meeting strength and workability based on the combined properties of the individual selected and proportioned ingredients. The following is the step-by-step procedure followed for this study as per IS 10262:2019
$f'ck = 31.6 N/mm^2$

Step 2: Selection of W/C Ratio
transported, placed, and compacted with minimum loss of homogeneity. The measurement of workability is done by slump test as described below.

### 3.3 SLUMP TEST

Slump test is the most commonly used method of measuring the workability of concrete. The apparatus for the conduction of the slump test consists of metallic mould in the form of a frustum of a cone having a 200mm bottom diameter, 100mm top diameter and 300mm height. The mould is filled with concrete in three layers. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross-section. The mould is removed from the concrete by raising it slowly and carefully in a vertical direction. The difference in level between the height of the mould and the height of subsided concrete is noted and it is taken as slump value. Based on the target slump 0f 75-100mm.

### 3.4 TESTING ON HARDENED PROPERTIES OF CONCRETE

The compressive strength test for 7, 14 and 28 days was carried out in hardened concrete as per IS 516 (part 1): 2021 is explained below.

3.5 COMPRESSIVE STRENGTH TEST

The compressive test is used to determine the compressive strength of cubical specimens of size 100mm×100mm×100mm. It is tested by using a Compressive Test Machine (CTM). The cubes are placed in the compression testing machine in such a manner that the load is applied to the opposite sides of the cube as cast. The load is applied at the rate of 140 $kg/cm^3/min$ (approximately) until the failure of the specimen. Specimens are tested for 7-day compressive strength in Compression Test Machine. The compressive strength is calculated by the following formula.

Compressive strength $f = P/A$ ($N/mm^2$)

Where,

P= maximum applied load in N.

A= Cross-sectional area of specimen in $mm^2$

3.6 SPLIT TENSILE STRENGTH TEST

This test is carried out by placing cylindrical specimens (100mm diameter and 200mm height) horizontally between the loading surface of a compressive testing machine and the load applied until failure. The load shall be applied without shock and increased continuously at a nominal rate within the range $1.2 N/mm^2/min$ to $2.4 N/mm^2/min$.

The tensile strength of the specimen is calculated by the following formula,

The magnitude of tensile stress $=2P/\pi DL$ ($N/mm^2$),

Where,

P is applied load

D and L are the diameter and length of the cylinder.

3.7 FLEXURAL STRENGTH TEST

The standard specimen of size 150×150×700 mm is used for the flexural strength test. The Bearing surface of the supporting and the loading roller were wiped. Cleaned and any dirt must be removed before placing the rollers. The specimen was then placed in the apparatus such that load was applied to the top surface along two lines spaced 5cm apart from each end. The axis of the specimen was carefully aligned with the axis of the loading surface. Then the load was applied gradually, the Load was increased until the specimen failed, and the maximum load applied to the specimen during the test was recorded in units.

The flexural strength of the specimen is expressed as the modulus of rupture which equals the distance between the line of fracture and the nearest support, measured on the centre line of the tensile side of the specimen which is calculated as follows.

Flexural strength $= (P \times L)/(B \times D^2)$

Where,

P = test value (units)

L = length of the specimen.

B = width of the specimen.

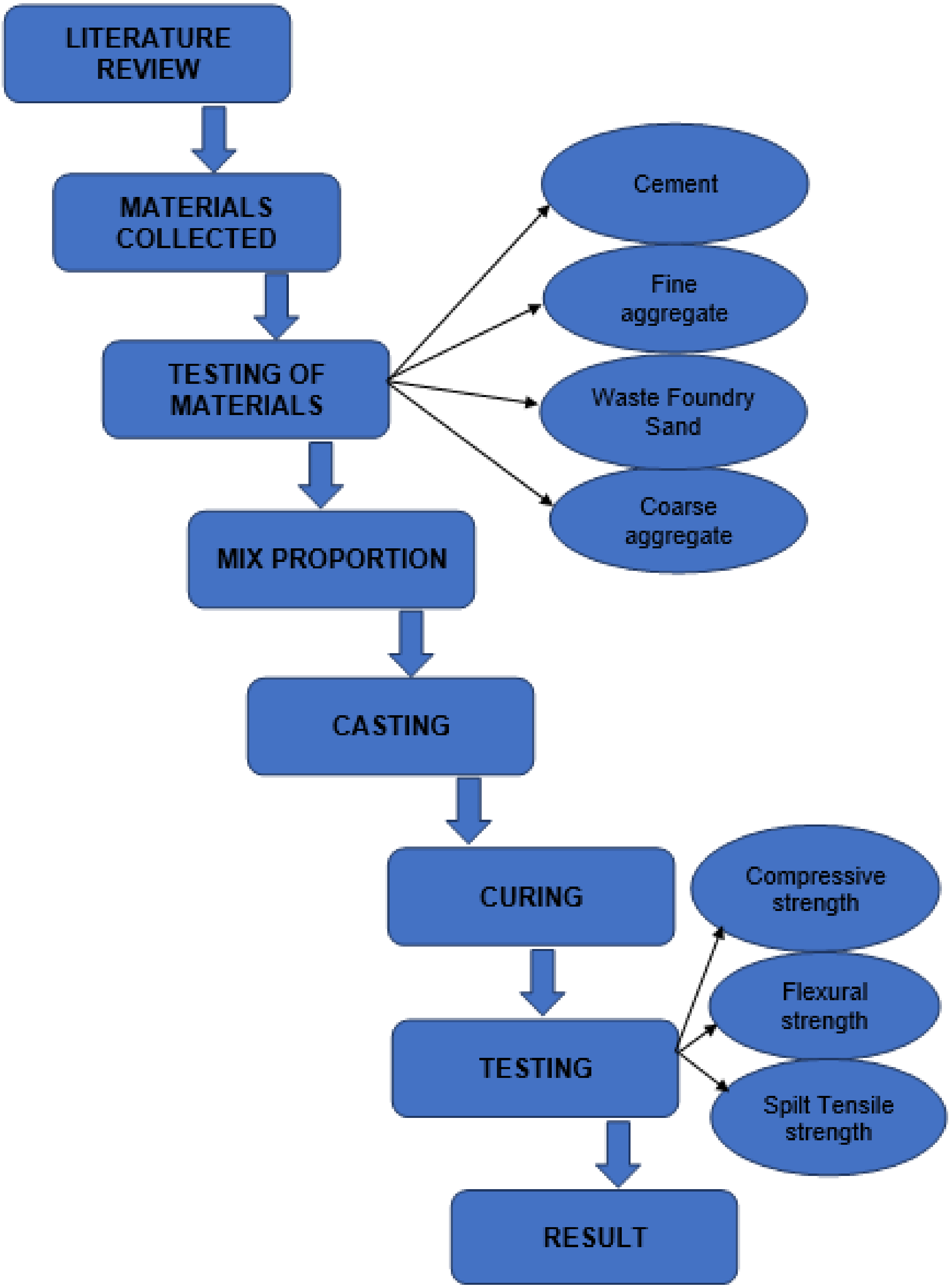
D = depth of the specimen.

3.8 MIX PROPORTION

From the above methods of mix design, IS code method of mix design is chosen to get a mix ratio for M25-grade conventional concrete. The concrete cube is cast for 7 days, 14 days and 28 days.

| MIX ID (Partial replacement of M-sand) | CEMENT ($kg/m^3$) | FINE AGGREGATE ($kg/m^3$) | WASTE FOUNDRY SAND (WFS) ($kg/m^3$) | COURSEAGGREGATE ($kg/m^3$) | WATER ($kg/m^3$) |
|---|---|---|---|---|---|
| CONVENTIONAL CONCRETE | 384 | 672 | 0 | 1122 | 192 |
| WFS30% | 384 | 470.4 | 201.6 | 1122 | 192 |
| WFS40% | 384 | 403.2 | 268.8 | 1122 | 192 |
| WFS50% | 384 | 336 | 336 | 1122 | 192 |
| WFS60% | 384 | 268.8 | 403.2 | 1122 | 192 |

Table 5.1 MIX PROPORTION


LITERATURE REVIEW
MATERIALS COLLECTED
TESTING OF MATERIALS
Cement
Fine aggregate
Waste Foundry Sand
Coarse aggregate
MIX PROPORTION
CASTING
CURING
TESTING
Compressive strength
Flexural strength
Spilt Tensile strength
RESULT