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# Experimental and Characteristics Study of Foundry Sand as Fine Aggregate in Concrete

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**ABSTRACT—**

Good quality natural river sand is not readily available nowadays. River sand is commonly used as a fine aggregate in concrete. Due to the restriction for the use of river sand in several parts of the world to protect river beds, the demand for alternative fine aggregates is significantly increased in the construction sector and also natural river sand takes millions of years for its formation. So, to overcome this problem, the material which has the properties almost similar to that of the Fine Aggregate may be used as a replacement in Concrete. Now–a-days, increasing in quantities of waste materials and industrial by-products is a prime concern in the world. The disposal of industrial by-products is a major concern because of stringent environmental regulations. Metal foundries use large amounts of sand as a part of the metal casting process. Foundry Sand is basically a Fine Aggregate and commonly used in hand and machine type moulds. Foundry Sand is typically sub-granular to round in shape after being used in foundry process. 1:1.23:2.19 mix is adopted for partial and full replacement sand with foundry sand. Cubes and cylinders are cast and cured to conduct compressive strength test and split tensile test on control specimens for 7 days and 28 days test. The remaining replacement mixes will be cast and test in future. By this, the optimum replacement of foundry sand in concrete can be concluded.

Keywords—Foundry Sand, Fine aggregate, Industrial byproduct.

## I. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures. Concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. River sand, which is one of the constituents used in the production of conventional concrete, has become very expensive and also becoming scarce due to depletion of river bed. Therefore manufactured sand is introduced in the place of sand.

In the recent revision of IS: 456:2000, one of the major points discussed is the durability aspects of concrete. So, the use of concrete is unavoidable. At the same time the scarcity of aggregates is also greatly increased nowadays. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources. For many years, by products such as fly ash, silica fume and Foundry Sand were considered as waste materials. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates. Some of the by products are also used as a Portland cement substitute.

The objectives of the study are to prove that the industrial waste from metal industries can be a replacement for fine aggregate, to replace the fine aggregate by industrial waste in different ratios such as 20%, 40%, 60%, 80% and 100% in M30 mix concrete, and to determine the compressive strength and lateral deflection, and compare it with conventional concrete member.

## II. REVIEW OF LITERATURES

Gulchain Singh, Manju Suthar, Volume 2558-issue 1(February 2023) studied the Utilization of waste foundry sand as partly substitution of fine aggregates for establishing sustainable concrete. Natural sand is in high demand as a fine aggregate in concrete for construction projects. In India, metal casting sectors created waste foundry sand (WFS) in million tons. WFS disposal and environmental concerns were kept to a minimum. WFS can be utilized in concrete as a partly substitution of fine aggregate. The usage of WFS in concrete makes it economical. This research discusses the influence of combining WFS with fine aggregate in concrete. In M40 grade concrete, fine aggregate is partly substituted with WFS in the interval of 0%, 15%, 30%, and 45% by weight. The results of experimental research to check the compressive strength and split tensile strength of WFS at all substitution levels for curing periods of 7, 14, and 28 days. Experimental test findings indicated a minor improvement in the compressive and split tensile strength upto 30% substitution of WFS.

Jawad Ahmad , Zhiguang Zhou , March 2022 carried out a research to "Waste Foundry Sand in Concrete Production Instead of Natural River Sand" This paper examined the utilization of WFS as a fine aggregate in concrete production. In this review, all the essential properties, such as the physical and chemical composition of WFS, fresh properties, mechanical and durability performance of concrete have been discussed and compared. Even though WFS has a few harmful impacts on concrete performance when utilized in a higher or full substitution instead of natural sand in concrete production; it can be utilized in concrete production up to a certain extent. Several investigations have been conducted regarding the use of WFS in concrete. The optimum substitution dose is determined to be 30% concerning most of the properties tested. Finally, this overall review concluded that WFS up 20 to 30% can be used as fine aggregate in concrete production without any negative effect on the mechanical and durability performance of concrete. Furthermore, less information is available on the durability performance of concrete with WFS. Therefore, this review strongly recommended a detailed study on the durability performance of concrete with partially substituted WFS.

Srimathi E,Venkateswan M (International Journal of Civil Engineering and Technology (IJCIET) Volume & Issue : Volume 08, Issue 04 (April – 2019) studied Experimental Investigation of Foundry Sand in Concrete , Based on the above investigations the following observations are made regarding the properties and behavior of concrete on partial replacement of fine aggregate by waste foundry sand are fresh concrete shows that the addition of foundry sands gives low slump values mainly due to the presence of very fine binders, so these mixtures require high superplastizer dosage in order to maintain a good workability, Compressive strength, Split tensile strength, flexural strength increases on increase in percentage of waste foundry sand as compare to the conventional mix., Based on the results, The replacement of natural sand with used foundry sand up to 30 % is desirable. as it is cost effective, reduce the amount of fine Use of waste foundry sand in concrete reduces the production of waste through metal industries; it is an ecofriendly building material.

Gurpreet Singh (International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 7, July 2018) Carried out a research to evaluate Replacement of natural sand with foundry sand offers optimum strength at 30% alternative then there is a marginal reduction in the strength but it is still above than the standard concrete. It is observed by the research that there is 7.93%, 14.96%, 32.95% and 19.33% increase in compressive strength after 28 days of curing at replacement of 10, 20, 30 and 40% respectively. And also it is observed by the research that there is 3.7%, 5.6%, 6.29% and 6.02% increase in Modulus of elasticity after 28 days of curing at replacement of 10, 20, 30 and 40% respectively.

Shyam Mak wana and Prof. Yashwantsinh Zala (2015) studied the physical and chemical properties of ceramic waste and foundry sand. They made a review on utilization of ceramic waste and foundry sand in civil engineering practice. In the world, there are large amounts of calcinedclay wastes and waste foundry sand produce from the industry each year. So, these wastes are use in landfills. Reusing these wastes in concrete can be very beneficial situation for society. Therefore, at one side, we can solve the problems of industries and at the other side, they can make more sustainable concrete by reducing non-renewable resources like cement, aggregates and also solve the environmental problems related to land fill wastes. They determine the proportion of SiO2 is about 60- 70% and in foundry sand is 80-90% which is responsible to improve the strength and durability of concrete. So, it can be used in concrete to improve the properties of concrete and reduce disposal problems on land and environmental problem.

C. Dr. B. Kameshwari et al. (2014) Studied the use of waste foundry sand in concrete causes a systematic decrease in strength at certain end point of addition. At 30% and 40% replacement of sand with waste foundry sand concrete has gained full strength at the end of 7 days. However, an acceptable concrete strength can be achieving using foundry sand. A suitable recycling of the discarded foundry sand as building construction material could be suggested. Recycling not only helps to reduce the disposal cost but it will help to conserve the natural resources and it provides technical and economic benefits. Environmental effects of waste and disposal problems of waste can be reduced through this research. This experimental investigation performed to evaluate the strength of concrete, in which natural sand are partially replace with waste foundry sand. Natural sand replaced with various percentages (10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%) of waste foundry sand weight. Compressive strength test were for all replacement level of foundry sand for M-20 grade concrete.

Gurpreet Singh and Rafat Siddique (Construction and Building Materials vol.26, 2012) performed an experimental investigation to evaluate the strength and durability properties of concrete mixtures, in which natural sand was partial replaced with (WFS). Natural sand was replaced with five percentage (0%, 5%, 10%, 15%, and 20%) of WFS by weight. A total of five concrete mix proportions (M-1, M-2, M-3, M-4 and M-5) with and without WFS were developed. Compression test and splitting tensile strength test were carried out to evaluate the strength properties of concrete at the age of 7, 28 and 91 days. Modulus of elasticity and ultrasonic pulse velocity test were conducted at the age of 28 and 91 days. In case of durability property, Rapid Chloride Permeability test was performed on all five mix proportion at the age of 28 and 91 days. Test result indicated a marginal increase in strength and durability properties of plain concrete by inclusion of WFS as a partial replacement of fine aggregate.

Eknath P.Salokhe & D.B.Desai. (IOSR Journal of Mechanical and Civil Engineering 2012) In this work, experimental investigations were performed to evaluate the comparative study of the properties of fresh & hardened concrete containing ferrous & non-ferrous foundry waste sand as fine aggregate replacement. Fine aggregates were replaced with four percentages of foundry sand. The percentages of replacements were 0, 10, 20, & 30% by weight of fine aggregate & tests were performed for all replacement levels of foundry sand for M20 grade concrete at different curing periods (7 & 28 days). The fresh concrete data shows that addition of both foundry waste sands gives low slump. The compressive strength at 28 days increases with the increase in ferrous FWS and at 30% addition.10% addition of nonferrous FWS gives same strength as ordinary concrete and goes on decreasing for higher percentages. Split tensile strength gives maximum values with 20% FWS for both types.

## III. EXPERIMENTAL INVESTIGATION

Cement, Fine aggregate, Foundry sand & coarse aggregate are the various Materials used in this project. Before casting the specimens various tests of materials has been conducted and a study on them is presented.

**A. Experimental Investigation**

The grade of concrete to be adopted for this project work has to be similar to M30. Since comparison is to be made with the standard M30 mix. Tests are done with constant strength for conventional Mix of strength = 30 MPa. Mix design calculation was done as per IS 10262: 2009. Based on the % of foundry sand, the strength and density of conventional concrete mix will get vary. % of foundry sand added = 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%,100%.

The concrete after workability was used for casting test specimens. Moulds were used to cast the specimen. Since the maximum size of the aggregate is 20 mm, cube moulds of size 150x150x150 mm were used. The cube moulds were used for compression test specimens. The inner surface of the mould was coated with a thin layer of waste oil in order to help the de moulding easy and to have sharp corners. Before applying oil, the inner surface was thoroughly cleaned and freed from moisture. The concrete was filled in three layers. Each layer

was compacted with the standard tamping bar and the strokes of the bar were uniformly distributed across the cross section of the mould. The strokes were given such that it penetrated the underlying layer and the bottom layer was tamped throughout it its depth. The tamping bar of 16mm diameter and 60 cm long was, the lower end was butted pointed. After the top layer was compacted, the surface of the concrete was finished in level with top of the mould using a trowel.

TABLE I. MIX PROPORTION

| **Water** | **Cement** | **Fine Aggregate** | **Coarse Aggregate** |
|---|---|---|---|
| 0.38 | 1 | 1.23 | 2.19 |

*A. Strength Test*

- Compressive Strength of Concrete cube Specimens is tested after 7thand 28th days. The test is done using Compression Testing Machine. As per IS456:2000 and IS516:1959 the compressive strength value of cube specimen should not less than 30 $N/mm^2$.
- Split Tensile Strength of Concrete Cylinder Specimens is tested after 28th days. The test is done using Compression Testing Machine.
- As per IS 456:2000 and IS5816:1999 the split tensile strength of concrete should not less than 1/10 of fck.

*B. Result and Discussion*

TABLE II. COMPRESSION TEST RESULTS FOR SPECIMENS WITH 0% FOUNDRY SAND (7 DAYS)

| **Trial No.** | **Dry Weight (Kg)** | **Load Applied (KN)** | **Loading Area ( $mm^2$)** | **Compressive Strength ($N/mm^2$)** | **Avg Compressive Strength ( $N/mm^2$)** |
|---|---|---|---|---|---|
| 1 | 9.00 | 653.85 | 22500 | 29.06 | 28.79 |
| 2 | | 647.77 | 22500 | 28.79 | |
| 3 | | 641.92 | 22500 | 28.53 | |

TABLE III. COMPRESSION TEST RESULTS FOR SPECIMENS WITH 0% FOUNDRY SAND (28 DAYS)

| **Trial No.** | **Dry Weight (Kg)** | **Load Applied (KN)** | **Loading Area ( $mm^2$)** | **Compressive Strength ($N/mm^2$)** | **Avg Compressive Strength ( $N/mm^2$)** |
|---|---|---|---|---|---|
| 1 | 9.00 | 872.55 | 22500 | 38.78 | 39.06 |
| 2 | | 885.60 | 22500 | 39.36 | |
| 3 | | 878.4 | 22500 | 39.04 | |

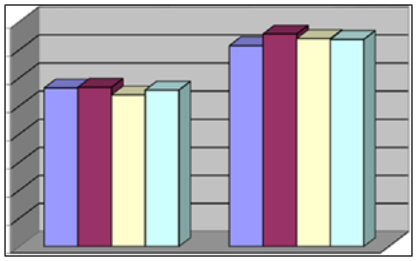

Fig 1 Compression Test Result for Specimens with 0% Foundry Sand

TABLE IV. SPLIT TENSILE TEST RESULTS FOR SPECIMENS WITH 0% FOUNDRY SAND

| **Mix** | **28 Days** |
|---|---|
| Specimen 1 | 3.95 |
| Specimen 2 | 4.03 |
| Specimen 3 | 3.98 |
| Average | 3.99 |

TABLE V. COMPRESSIVE STRENGTH OF CONCRETE MIXES WITH VARIOUS % OF FOUNDRY SAND

| **Sl No** | **Mix** | **7 Days (MPa)** | **28 Days (MPa )** |
|---|---|---|---|
| 1 | M-1 | 28.33 | 39.35 |
| 2 | M-2 | 29.35 | 39.58 |
| 3 | M-3 | 29.48 | 39.93 |
| 4 | M-4 | 29.83 | 41.46 |
| 5 | M-5 | 31.57 | 42.95 |
| 6 | M-6 | 29.45 | 40.34 |
| 7 | M-7 | 29.32 | 39.86 |
| 8 | M-8 | 28.65 | 39.69 |
| 9 | M-9 | 28.16 | 38.94 |
| 10 | M-10 | 27.58 | 38.18 |

TABLE VI. SPLIT TENSILE STRENGTH OF CONCRETE SPECIMEN WITH

| **SL No** | **MIX** | **28 DAYS** |
|---|---|---|
| 1 | M-1 | 4.43 |
| 2 | M-2 | 4.74 |
| 3 | M-3 | 5.02 |
| 4 | M-4 | 5.71 |
| 5 | M-5 | 5.78 |
| 6 | M-6 | 5.25 |
| 7 | M-7 | 4.45 |
| 8 | M-8 | 4.32 |
| 9 | M-9 | 4.23 |
| 10 | M-10 | 3.90 |

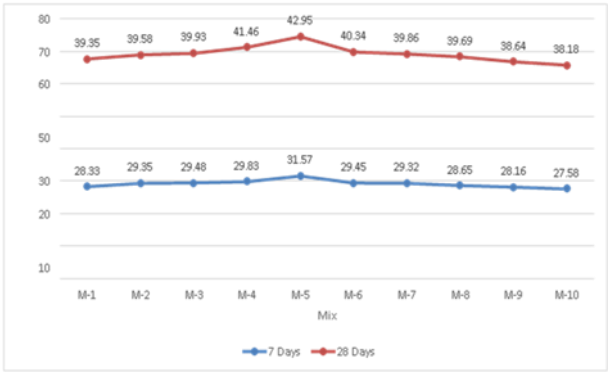


Fig II. Graphical Representation of Compressive Strength for Different % of Foundry Sand

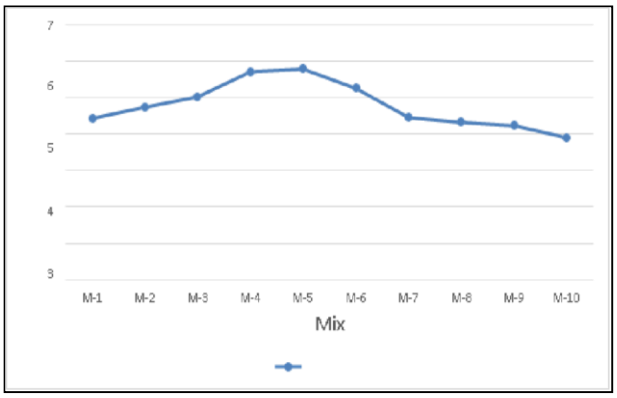


FIG III. GRAPHICAL REPRESENTATION OF SPLIT TENSILE STRENGTH

## IV. FUTURE SCOPE

The present study can be extended for future research with consideration to the following points:

- Replacement of cement with additives such as fly ash can be done
- Application of foundry sand in other structural members.
- Casting of column in different shapes
- This test can be done in slender column.

## V. CONCLUSION

Based on the experimental study undertaken following conclusions are drawn.

- The properties of materials are found to be good
- Replacement of fine aggregate with WFS showed increase in the compressive strength and split tensile strength of plain concrete up to 50%
- 50% replacement of fine aggregate with WFS was taken as the optimized mix.
- The value of maximum compressive strength and split tensile strength achieved using 50% replacement of fine aggregate with WFS at 28 days is 42.95 N/mm2 and 5.78 N/mm2.
- Using the optimized mix ,the compression member were cast.
- Proved that , the concrete using 50% replacement of fine aggregate with foundry sand can be use in structural member.

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