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A Review on Utilization of Waste Foundry Sand for Producing Economical and Sustainable Concrete

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Abstract *– This paper deals with a state of art review on utilization of waste foundry sand in civil engineering practice. The over exploitation of non-renewable energy materials is becoming a threat and therefore it is necessary to seek the possibility of recycling them, once their durability is obsolete. Metal foundries uses large amounts of sand as part of the metal casting process. Foundries satisfyingly reclaim and reuse the sand many times in casting process. When the sand cannot be reused in the foundry, it is remove from the foundry and is called as "waste foundry sand." The constant depletion of sand beds at all major sources of availability is a major concern and thus efforts are taken in order to replace sand in construction activities.*

In this study, effect of waste foundry sand over fine aggregate replacement on the compressive strength and split tensile strength of concrete with M-20 mix proportion of 1:1.82:2.89:0.5 is investigated at different curing periods (7 days, 14 days and 28days). The percentage of waste foundry sand used for replacement are 10%, 20%, 30%, 40%, 50% and 60% by weight of fine aggregate. Test shows magnificent results, showing capability of waste foundry sand for being a component in concrete for imparting strength. Making eco-friendly concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable and economical environment.

Keywords- *Compressive strength, Partial replacement, Recycling, Split tensile strength, Sustainable concrete, Waste foundry sand.*

I. INTRODUCTION

Now-a-days the construction sector is exploring rapidly on a large scale and also involves new techniques for rapid and comfort works on the field. Concrete as a building material plays an important role in this sector. The consumption of natural resources as an ingredient of concrete, costs high as well as it is on verge of extent. These problems force us to recover the natural resources or to find an alternative option to overcome the problems. Presently, the manufacture of waste foundry sand as a by-product of metal casting industries causes various environmental problems. Usage of this waste in building material would help in reduction of stress on environment.

The waste produce from the industries and it creates environmental problems. Hence the reuse of this waste material can be emphasized. Foundry sand is high quality silica sand that is a by-product from the manufacture of both ferrous and nonferrous metal casting industries. 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 casting process, molding sands are recycle and reused multiple times. Eventually, however, the recycle sand degrades to the point that it can no longer be reused in the casting process. Over the last decades, much research has been conducted on the mechanical, chemical and physical aspects of foundry sand. But in adequate research focus is given to the study of the strength and durability aspects of foundry sand concrete.

Concrete is a material which is composed of coarse aggregate, fine aggregate, cement, admixtures and water these each material in concrete contributes its strength. So, by partial or percentage replacing of material affects different properties of concrete. By using such waste material which harms the environment can be used for the development of low cost and eco-friendly building materials. In this study an experimental investigation is carried out by varying percentage of fine aggregate with used foundry sand to produce low cost and eco-friendly concrete

II. LITERATURE REVIEW

The literature review showed there is a lack of information regarding the influence of the incorporation of waste foundry sand on the mechanical behaviour of concrete. The general features of a few selected experimental researches concerning the properties of concrete with these wastages analyzed in the present article are briefly described next.

Amitkumar D. Raval et al. (2015) studied in this research to replace OPC cement with ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30% 40%, & 50% by weight for M-25 grade concrete. He concluded that the Compressive Strength of M25 grade concrete increases when the replacement of cement with ceramic waste up to 30% by weight of cement and further replacement of cement with ceramic powder decreases the compressive strength.

Concrete on 30% replacement of cement with ceramic waste, compressive strength obtained is 26.77 N/mm2 and vice versa the cost of the concrete is reduced up to 13.27% in M-25 grade and hence it becomes more economical without compromising concrete strength than the standard concrete.

Shyam Makwana 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 calcined-clay 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 SiO_2 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

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 economical 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.

Dr. Pradeep Kumar et al. (2014) investigated the recycle materials can be use effectively in architectural and civil engineering fields. They can stand close to the concept of green concrete which is in compatible with the environment. Foundry sand from casting industries is a waste material which is dumped extensively and in this study an attempt has made to evaluate the usage of this waste material in concrete. In this study, effect of foundry sand over fine aggregate replacement the compressive strength and split tensile strength of concrete with a mix proportion of 1: 1.28: 2.56: 0.45 investigated at different curing periods (7 days and 28 days). The percentage of foundry sand used for replacement were 10%, 20%, 30%, 40%, 50%, 75% and 100% by weight of fine aggregate.
They determined the compressive strength and split tensile strength of concrete specimens increased, with increase in fine aggregate replacement by foundry sand, providing maximum strength at 50 % replacement and after that the strength parameters shows a decline in their respective values. The replacement of natural sand with used foundry sand up to 50 % is desirable, cost effective, reduces the amount of virgin fine aggregate, reduces land fill problems and preserves nature.

Sohail Md et al. (2013) investigated the foundry sand can be used as a partial replacement of cement or fine aggregates or total replacement of fine aggregate as a supplementary addition to achieve different properties of concrete. In the present study, effect of foundry sand over fine aggregate replacement on the compressive strength, split tensile strength and flexural strength having mix proportions of M-30 has determined. Fine aggregates replaced with eleven percentages of foundry sand. The percentages of replacements were 0, 10, 20, 30, 40, 60,70,80,90 & 100 % by weight of fine aggregate. Tests has performed for compressive strength, split tensile strength and flexural strength tests for all replacement levels of foundry sand at different curing period (7 days, 28 days & 56 days).

Gurpreet Singh and Rafat Siddique (2011) carried out an experimental investigation to evaluate the strength and durability properties of concrete mixtures, in which natural sand is partially replace with (WFS). Natural sand is replace with five percentage (0%, 5%, 10%, 15%, and 20%) of WFS by weight. Compression test and splitting tensile strength test are carried out to evaluate the strength properties of concrete at the age of 7, 28 and 91 days. Test results indicate a marginal increase in strength properties of plain concrete by inclusion of WFS as a partial replacement of fine aggregate.

Eknath P.Salokhe and D.B.Desai investigated the comparative study of the properties of fresh & hardened concrete containing ferrous & non-ferrous foundry waste sand replaced with four (0%, 10%, 20% and 30%) percentage by weight of fine aggregate & tests were performed for M20 grade concrete. Result showed that (i) addition of both foundry sand gives low slump mainly due to the presence of very fine binders; (ii) Compressive strength at 7 days of both ferrous & nonferrous mixtures increases and maximum increase was observed with 20% WFS of both types of sand, at 28 days 30% addition of ferrous WFS & 10% addition of nonferrous WFS gives same strength as ordinary concrete and goes on

decreasing for higher percentages of replacement; (iii) Split tensile strength gives maximum values with 20% WFS for both types of sand; (iv) water absorption is minimum with 20% ferrous WFS & with 10% nonferrous WFS.

III. METHODOLOGY

Strength is one among the most important properties of concrete, since the first deliberation in structural design is that the structural members must be capable of moving the impose loads. The mix of concrete use in this study is M-20. Concrete mix with 0% waste material is the control mix and water cement ratio adopted is 0.50 in accordance with the Indian Standards specification IS: 10262-2009. A design mix proportions of 1:1.82:2.89:0.50 has investigated for the research. The percentages of replacements are 10%, 20%, 30%, 40%, 50% and 60% by weight of fine aggregate. Tests are performed for slump cone test, compressive strength and split tensile strength of concrete for all replacement levels of fine aggregate at different curing period (7 days, 14 days and 28 days).

IV. EXPERIMENTAL MATERIAL

A. CEMENT

Cement is a fine, grey powder. The cement use is 'Bharathi' OPC 53 Grade confirming to IS: 12269-1987. Testing of cement is done as per IS: 8112-1989. The cement are fresh and without any lumps. It is mix with water and materials such as sand, gravel, and squeezed stone to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardens.

B. FINE AGGREGATE

The sand is use for the experimental program is locally procured and conformed to grading zone III as per IS: 383-1970. The sand is first sieves through 4.75 mm sieve to remove any particles greater than 4.75 mm. To increase the density of concrete aggregate is frequently use in different sizes. Aggregate acts as reinforcement and initiate strength to the overall composite material.

C. COARSE AGGREGATE

Locally available coarse aggregates are used in the present work. The aggregate having size more than 4.75 mm is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc. 80mm size is the maximum size that can be conveniently used for forging concrete. In this study coarse aggregate is conformed to IS: 383-1970.

D. FOUNDRY SAND

Waste foundry sand has obtained locally from Devyani Alloys Private Limited Company, Baramati and conformed to grading zone III as per IS: 383-1970. WFS were used as a partial replacement of fine aggregate (natural river sand). Metal poured in the foundry is gray iron. The sand has tested for disparate properties like specific gravity, bulk density etc, and conformed with IS: 2386-1963. The fine aggregate are conforming to standard specifications.

Metal foundries use large amounts of the metal moulding process. Foundries satisfyingly reclaim and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. This study presents the intimation about civil engineering applications of foundry sand, which is technically sound and environmentally safe. 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 or fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.

E. WATER

Water plays an important role as it contributes in chemical reaction with cement. Locally available water are use for mixing and curing which is potable and is free from detrimental amounts of oil, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Generally, ordinary water is used for mixing concrete

V. MIX DESIGN AND TEST PERFORMED

A. MIX DESIGN

Mix had been designed based on Indian Standard Recommended Guidelines IS: 10262-1982 and IS: 10262-2009. The proportion for concrete, determined as per IS: 10262-2009 was 1:1.82:2.89 with water cement ratio of 0.50. The mix designation and quantities of various materials for each designed concrete mix have been tabulated in Table 1 for cubes

Table1. Proportion of Concrete Material at Different Percentages

% of Foundry sand	Cement (Kg)	Sand (Kg)	Foundry sand (Kg)	Aggregates (Kg)	Water (Kg)
0	1.33	2.42	0	3.85	0.66
10	1.33	2.18	0.24	3.85	0.66
20	1.33	1.94	0.48	3.85	0.66

30	1.33	1.69	0.73	3.85	0.66
40	1.33	1.45	0.97	3.85	0.66
50	1.33	1.21	1.21	3.85	0.66
60	1.33	0.97	1.45	3.85	0.66

B. TEST PERFORMED

SLUMP CONE TEST

The slump test has conducted on fresh concrete mix immediately after mixing over. The test has performed using a slump test apparatus. The dimension of slump cone is 200 mm x 100 mm x 300 mm.The slump cone filled with concrete in three equal layers. Each layer has approximately one third the volume of cone. Moreover, each layer has tamped with 25 strokes using a tamping rod. As soon as the cone has filled with concrete, it tamping has removed from the concrete by raising it in a vertical direction, avoiding lateral motion. The slump has immediately measured by determining the vertical difference between the top of the cone and the displaced original center of the top surface of the concrete.

COMPRESSIVE STRENGTH TEST

Compressive strength test conducted on hardened concrete after 7, 14 and 28 days curing. Compressive strength tests have performed on compression testing machine of 2,000 KN capacities. Three cubes of 150 mmx150 mmx150 mm from each cube were subjected to this test. The comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 10%, 20%, 30%, 40%, 50% and 60%.

SPLIT TENSILE STRENGTH TEST

Split tensile strength test conducted on hardened concrete after 28 days curing. The tensile strength of concrete is approximately 10% of its compressive strength. Cylindrical moulds of size 150 mm diameter and 300 mm height were used to prepare the concrete specimens. Tensile splitting strength tests of concrete block specimens were determined as per IS: 5816-1999. After curing of 28 days the specimens were tested for tensile strength using a calibrated compression testing machine of 2000 KN capacity.

VI. RESULT AND DISCUSSION

The study was conducted to find out the affect of waste foundry sand on strength properties of plain concrete. The effects of following parameters were studied. Compressive strength and Split tensile strength at various percentage replacement of fine aggregate with waste foundry sand on some of plain concrete.

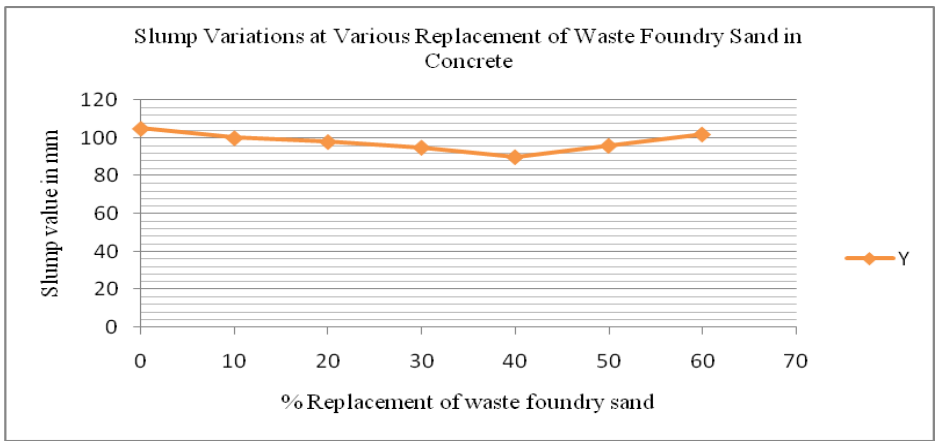
A. COMPRESSIVE STRENGTH TEST

In this test, the values of slump test and compressive strength for different replacement levels of foundry sand contents (0%, 10%, 20%, 30%, 40%, 50% & 60%) at the end of different curing periods (7 days, 14 days and 28 days) are given in Table 2.

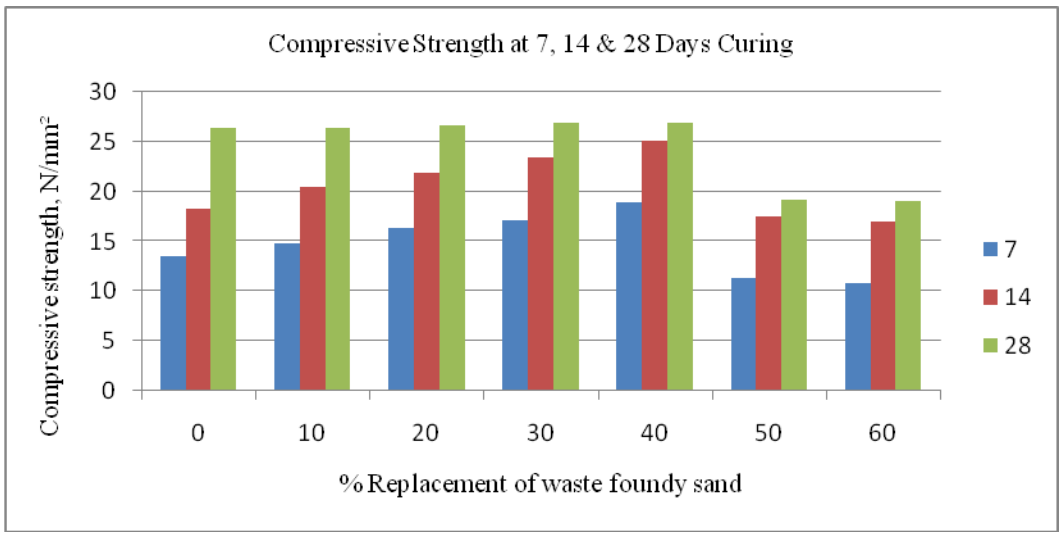
These values are plotted in Graph 1, 2 & 3 shows the variation of slump test value and compressive strength with fine aggregate replacements at different curing ages respectively.

Table 2. Compressive Strength of Concrete After 7days, 14 days and 28 days

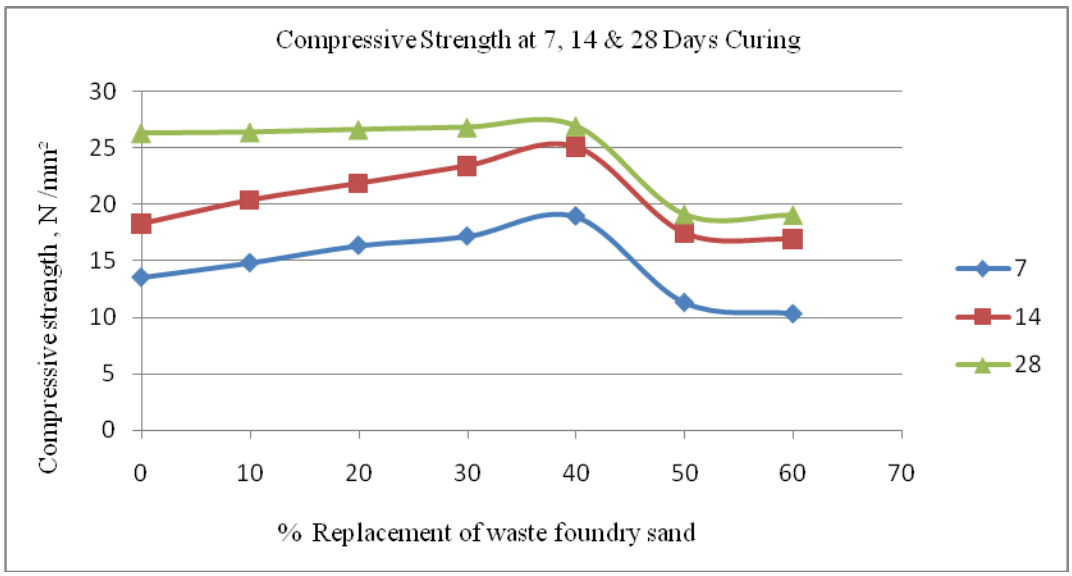
Foundry sand (%)	Slump Test (mm)	Compressive strength (Mpa)		
		7 days	14 days	28 days
0	105	13.54	18.32	26.34
10	100	14.83	20.41	26.42
20	98	16.36	21.89	26.65
30	95	17.18	23.43	26.85
40	90	18.95	25.11	26.97
50	96	11.32	17.53	19.18
60	102	10.82	16.95	19.11



Graph 1. Slump Variation at Various Replacement of Waste Foundry Sand in Concrete



Graph 2. Percentage Replacement of Waste Foundry Sand V/s Compressive Strength for 7, 14, 28 days.



Graph 3. Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at for 7, 14, 28 days.

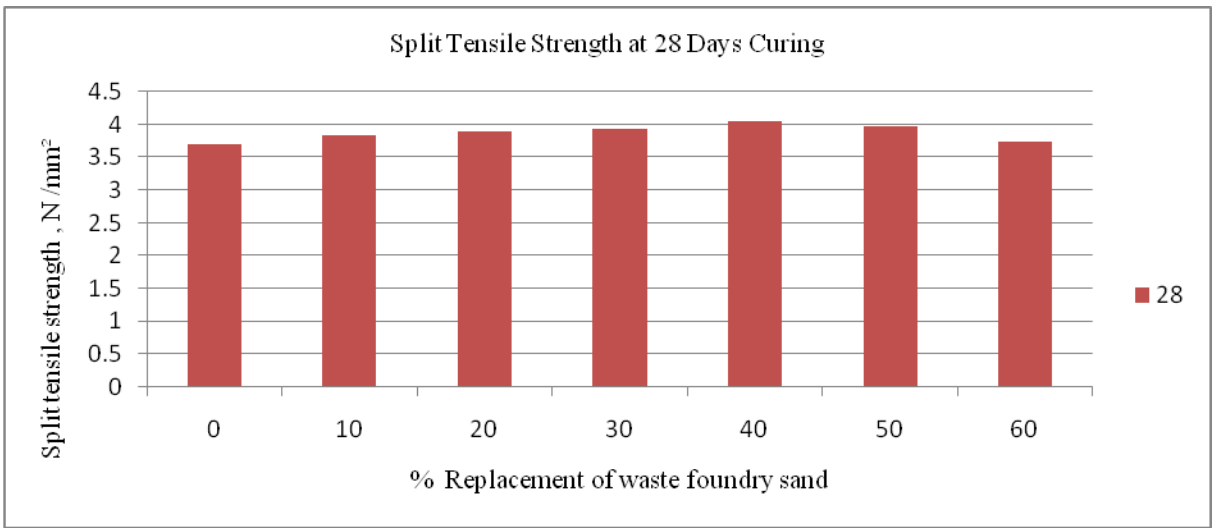
B. SPLIT TENSILE STRENGTH TEST

In this test, the values of split tensile strength for different replacement levels of foundry sand contents (0%, 10%, 20%, 30%, 40%, 50% & 60%) at the end of different curing periods (28 days) are given in Table 3.

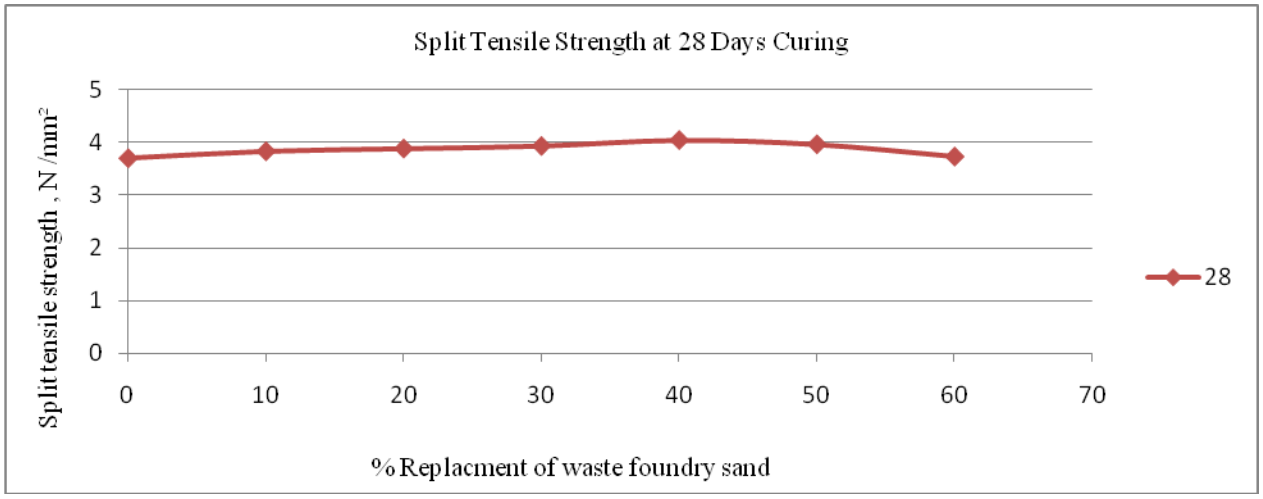
These values are plotted in Graph 4 & 5, which show the result of split tensile strength with fine aggregate replacements at 28 days curing ages respectively.

Table 3. Split Tensile Strength of Concrete after 28 days curing.

Foundry sand Content (%)	Split Tensile Strength after 28 days(Mpa)
0	3.95
10	3.70
20	3.82
30	3.89
40	4.05
50	3.97
60	3.74



Graph 4. Percentage Replacement of Waste Foundry Sand V/s Split Tensile Strength for 28 days



Graph 5. Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand at 28 days.

VII. CONCLUSION

Based on above study, the following conclusions are made regarding the properties and behaviour of concrete on partial replacement of fine aggregate by using waste foundry sand:

1. Waste foundry sand can be efficacious used as fine aggregate in place of regularly river sand in concrete.
2. Compressive strength increases on increase in percentage of waste foundry sand as compare to traditional concrete.
3. In this study, more compressive strength is obtained at 40% replacement of fine aggregate by waste foundry sand.
4. Split tensile strength increases with increase in some percentage of waste foundry sand and there after it decreases.
5. Use of waste foundry sand in concrete reduces the production of waste through metal industries i.e. it's an eco-friendly building material.
6. The problems of discarding and maintenance cost of land filling is minimized.
7. Application of this study guide to develop in construction sector and inventive building material.
8. The result for 40% replacement of waste foundry sand shows that the concrete produce is an economical, sustainable and high strength concrete.

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