An Experimental Investigation on Concrete Manufactured by Partial Replacement of M-sand with Waste Foundry Sand and Polycarboxylate Ether

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***ABSTRACT** - Waste foundry sand, a by-product of metal casting industries causes Environmental problems because of its improper disposal. Thus, its usage in building material, construction and in other fields is essential for reduction of environmental problems. This research is carried out to produce a low-cost and eco-friendly concrete. The aim of this research is to know the behaviour and mechanical properties of concrete after addition of waste foundry sand and Polycarboxylate Ether (Superplasticizer) in different proportions. An experimental investigation is carried out for M-25 grade concrete containing waste foundry sand in the range of 10%, 15%, 20%, 25% and 30% and adding Polycarboxylate Ether (Superplasticizer). Material test was conducted and concrete manufactured by replacing of M-sand with waste foundry sand is compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube and cylinder for 7, 14 and 28 days in order to determine the mechanical properties of concrete. Through the experimental result we conclude that the compressive and split tensile strength of concrete increases in 10%, 15%, and 20% and decreases in 25% and 30%.*

Keywords- Metal Casting Industrial, Foundry sand, Low-cost, Eco-friendly, Compressive strength, Split tensile strength and Polycarboxylate Ether.

INTRODUCTION

CONCRETE:

Concrete is a composite construction material, composed of cement and other cementations materials such as fly ash slag cement, aggregate, water and chemical admixture. Concrete solidifies and hardens after mixing water and cement due to a chemical process known as hydration. The word concrete comes from the Latin word "concretes"

(means compact or condensed), the perfect passive principle of "concrescere", from "con" (together)and "crescere" (to grow). When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolans or superplasticizers) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete.

FOUNDRY SAND:

Foundry sand is a clean, uniformly sized, high quality silica sand used in foundry casting processes. The sand is bonded to form moulds or patterns used for ferrous (iron and steel) and nonferrous (copper, aluminium, brass) metal castings. Shake-out sand from completed metal casting are often reclaimed back in to the foundry sand process.

In modern foundry practice, sand is typically recycled and reused through many production cycles. Industries use large amount of sand as a part of metal casting process, which can be recycle and reuse the sand many times in a foundry but when these sands can no longer be reused in the foundry. It is removed from the foundry and it termed as foundry sand. Foundry and production nearly 6 to 10 million tons annually, like many wastes products foundry sand has beneficial application to other industries. there are two types of foundry sand Green sand and Bonded sand.

CEMENT:

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Cement is the most widely used material in existence and is only behind water as the planet's most-consumed resource. Cements used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as either hydraulic or non-hydraulic, depending on the ability of the cement to set in the presence of water (hydraulic and non-hydraulic lime plaster).

Most of the cement concrete work in building construction is done with ordinary Portland cement at present. Ordinary Portland Cement is a fully automated and dry manufacturing process. It is available in two different grades-OPC-43 & OPC-53.

M-SAND:

Manufactured sand(M-sand) is sand produced from hard rock by crushing. The size of M-sand is less than 4.75mm. The M-sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased, crushing deficiency of suitable river sand is most part of the world hence the use of manufactured sand has been increased. M-sand is readily available at nearby place so the transportation cost can be reduced. Does not have the presence of impurities such as clay, dust and slit coating. Presence of M-sand in concrete increases quality and durability of concrete. M-sand is produced by feeding hard stones of varying sizes to primary and secondary crushers, for the size reduction and these crushed stone are further crushed in vertical shaft impact crusher to reduce particle size to that of sand. The manufactured sand has required gradation of fines, physical properties such as shape, smooth, surface textures and consistency which make it the best sand suitable for construction. The physical properties of sand provide greater strength to the concrete reducing segregation, bleeding, honey combing, voids and capillary.

COARSE AGGREGATE:

Coarse aggregate is one of the materials of concrete. Crushed stone or gravel used in concrete are called coarse aggregate. Which is retained on 4.75mm. Rounded, angular, flaky, elongated and irregular are some of the common shapes of coarse aggregate. Shape is the vital property affecting the workability, strength and durability of fresh concrete. Material strength of coarse aggregate is indicated by crushing strength of rock, aggregating crushing value, aggregate impact value, aggregate abrasion value. Coarse aggregates are classified in to two groups.

i. Single -size aggregate

ii. Graded aggregate

LITERATURE REVIEW

Dushyant R. Bhimani (2013) investigated that the Foundry Sand Opportunities for Sustainable and Economical Concrete. This study states that for 1m3 M20 grade of concrete consumption of fine aggregate is 538.45 kg. Here he replaces fine aggregate by 162 kg of foundry sand for 1m3 M20 grades of concrete. And he got the average compressive strength as 30 MPa. So, we can say that up to 30% of foundry sand is utilized for economical and sustainable development of concrete. Uses of foundry sand in concrete can save the metal industry's disposal costs and produce a 'greener' concrete for construction.

Pathariya Saraswati, et al., (2013) investigated that the Application of Waste Foundry Sand for Evolution of Low-Cost Concrete. This study says that the Compressive strength increases on increase in percentage of waste foundry sand. Maximum compressive strength is obtained at 60% replacement of fine aggregate by waste foundry sand. And the Split tensile strength decreases on increase in percentage of waste foundry sand. The result of percentage cost reduces up to 3.5 for 60% replacement of waste foundry sand. This shows that the concrete produced is economical.

Augustine Uchechukwu Elinwa (2014) investigated that the Spent Foundry Sand as Partial Replacement of Fine Aggregate in the Production of Concrete. This study says that the foundry sand has pozzolanic properties and can reduce water absorption by approximately 8 % to 28 % at 90 days of curing. With this property, the durability of the concrete is enhanced and also the foundry sand will perform well as a hydraulic barrier. Addition of FS in concrete reduces the workability of the concrete and therefore, there will be a need to use this Foundry sand with a plasticizer that will enhance the workability of the concrete and encourage higher replacement levels. The compressive strength of concrete decreases with increase in the replacement levels and the best behaviour is at 10 % replacement.

Preeti Pandey, et al., (2015) investigated that the Utilization of Waste Foundry Sand as Partial Replacement of Fine Aggregate for Low Cost Concrete. This study says that the workability of concrete made using foundry sand observed to be decreased slightly with replacement level. Compressive strength of concrete at 10% replacement level was more than that of referral conventional concrete. At 20% replacement level compressive strength of concrete was comparable to referral conventional concrete. Optimum replacement level of foundry sand is 10%.

Minakshi B. Jagtap, et al., (2015) investigated that the Utilization of Waste Foundry Sand for Producing Economical and Sustainable Concrete. This study says that the waste foundry sand can be effectively used as fine aggregate in place of regularly river sand in concrete. Compressive strength increases on increase in percentage of waste foundry. In this study, optimum compressive strength is obtained at 40% replacement of fine aggregate by waste foundry sand. Split tensile strength decreases with increase in waste foundry sand. The result for 40% replacement of waste foundry sand shows that the concrete produced is an economical, sustainable and high strength concrete.

Deepak Chaurasiya, et al., (2016) investigated that the Utilization of Foundry Sand, An Art to Replace Fine Sand with Foundry Sand. This study says that the Compressive strength of concrete increased with increase in various replacement levels of foundry sand. However, at each replacement level of fine aggregate with foundry sand, an increase in strength was observed with increase in age. The compressive strength increased by 2.5% and 3.7%, when compared to conventional concrete. And decrease in compressive strength shown when 30% replacement is done. Split Tensile Strength also showed an increase with increase in 10% and 20% replacement levels of Foundry Sand with fine aggregate but sudden fall in 30% replacement is seen.

Sarita Chandrakanth, et al., (2016) investigated that the Partial Replacement of Waste Foundry Sand and Recycled Aggregate in Concrete. This study says that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand and recycled aggregate as compare to normal concrete. The optimum compressive strength is at 40% of replacement. Split tensile strength increases with increase in percentage of waste foundry sand.

Mohamed Anjum, et al., (2017) investigated that the Partial Replacement of Fine Aggregates with Foundry Sand in Concrete. This study says that the workability by slump of fresh concrete decreases with increase in the percentage of foundry sand while replacing fine aggregate. The optimum compressive strength is at 20%. The Split Tensile Strength increases with increase in the percentage of foundry sand.

Saif ali, et al., (2017) investigated that the Utilization of Waste Foundry Sand. This study says that increase in the compressive strength was achieved when the replacement of foundry sand is between 10-20%. And decrease in compressive strength shown when 30% replacement done.

A.Naveen Arasu, et al., (2017) investigated that the Experimental analysis of waste foundry sand in partial replacement of fine aggregate in concrete. This study says that the fineness and high-water absorption properties of the WFS reduces the workability of the concrete, and the workability of the concrete also decreases with an increase in the WFS in substitution rate. Water absorption, voids, porosity decreases with addition of WFS.

OBJECTIVES

To study and compare the properties of conventional concrete with partial replacement of foundry sand and using polycarboxylate ether as a Super Plasticizer.

To experimentally investigate the compressive strength and split tensile strength of concrete manufactured by partial replacement of M-sand with foundry sand and adding polycarboxylate ether.

To estimate the consumption potential of replacement of M-sand (10%,15%,20%,25% and 30%) with foundry sand for effective waste management of foundry sand.

MATERIAL TESTING

The material testing is done for Foundry sand, Manufacturing sand, Cement, Coarse aggregate. The test results are given below.

Table 1: Test for Foundry Sand

S: No	Properties	Standard Value	Test Value
1	Specific Gravity	2. 1 to 2. 84	2. 32
2	Fineness Modulus	2.0 to 4.0	4. 08
3	Bulk Density	1520 - 1680 kg/m3	1350 Kg/m^3
4	Water absorption	0 to 3%	1.81%

Table 2: Test for Manufacturing Sand

S: No	Properties	Standard Value	Test Value
1	Specific Gravity	2.1 to 2. 84	2 .46
2	Fineness Modulus	2.0 to 4. 0	4. 96
3	Bulk Density	1520 - 1680 kg/m3	1440 Kg/m^3
4	Water absorption	0 to 20%	5%

Table 3: Property Test for Cement

S: No	Properties	Standard value as per IS	Test value
1	Specific Gravity	3.12-3.19	3.1
2	Normal Consistency	26- 33 %	29%
3	Initial Setting Time (min)	Greater than 30 min	31
4	Final Setting Time	Less than 600 min	595
5	Soundness	Not exceed 10 mm	8 mm
6	Fineness	10 %	8.3%

Table 4: Test for Coarse Aggregate

Si. No	Properties	20mm Aggregate
1	Specific Gravity	2.64
2	Impact Test	22.2%
3	Sieve Analysis	6.8
4	Water Absorption	0.5%
5	Elongation Test	12.2%
6	Flakiness Test	11%

EXPERIMENTAL METHODOLOGY

Concrete contains waste foundry sand as a partial replacement of fine aggregate is tested. Concrete is composed of cement, coarse aggregate, fine aggregate, waste foundry sand and water. The waste foundry sand is replaced in the range of 10%, 15%, 20% 25% and 30% by weight of fine aggregate. The mixture was prepared and three standard cubes and cylinders were casted. After curing for 24hrs the samples were demoulded and subjected to compressive strength test and tensile split test for 7, 14 and 28 days.

(a)Compressive Strength Test

Compressive strength tests were performed on compression testing machine of 2,000 KN capacity. The comparative study was made on properties of concrete after replacement of fine aggregate by waste foundry sand in the range of 10%, 15%, 20%, 25% and 30%.

TABLE 5: COMPRESSIVE STRENGTH OF CUBES

Percentage Replacement Of Waste foundry sand	Average ultimate compressive strength at 7 days (N/mm²)	Average ultimate compressive strength at 14 days (N/mm²)	Average ultimate compressive strength at 28 days (N/mm²)
0%	21.22	29.12	32.1
10%	21.89	29.75	32.23
15%	22.78	30.67	33.49
20%	23.92	31.53	34.68
25%	22.01	29.68	32.89
30%	20.82	28.53	31.32

Fig 1: Compression strength test for cube

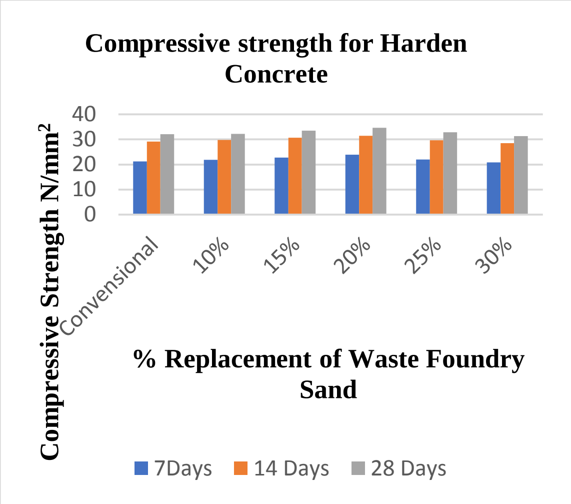


TABLE 6: SPLIT TENSILE STRENGTH OF CUBES

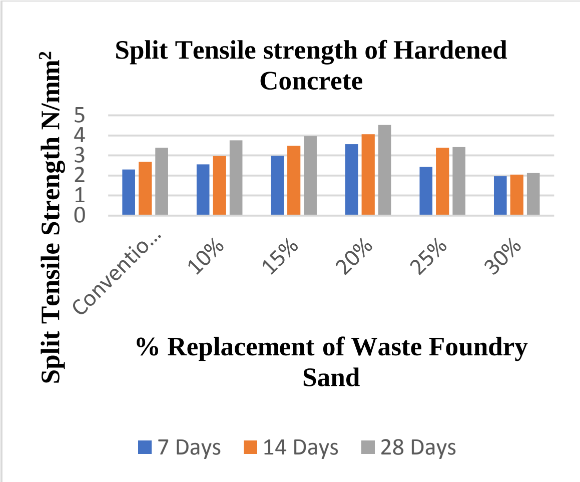
Percentage Replacement Of Waste foundry sand	Average ultimate Split Tensile strength at 7 days (N/mm^2)	Average ultimate Split Tensile strength at 14 days (N/mm^2)	Average ultimate Split tensile strength at 28 days (N/mm^2)
0%	2.31	2.68	3.39
10%	2.56	2.98	3.76
15%	2.99	3.48	3.96
20%	3.57	4.06	4.53
25%	2.43	3.39	3.42
30%	1.97	2.04	2.12

The above graphs shows the variation of compressive strength of hardened concrete at 7 days 14 days and 28 days. The above three graphs clearly shows that up to 20% replacement of waste foundry sand the compressive strength increases and decreases at the percentage of 25 and 30. So we can determine that replacing the foundry sand up to 20% will give the good result in compressive strength.

(b) Split Tensile Strength Test

Split tensile strength tests were performed on compression testing machine of 2,000 KN capacity. The comparative study was made on properties of concrete after replacement of fine aggregate by waste foundry sand in the range of 10%, 15%, 20%, 25% and 30%.

Fig 2: Split Tensile strength test for cylinder



The above graphs show the variation of split tensile strength of hardened concrete at 7 days ,14 days and 28 days. The above three graphs clearly shows that up to 20 % replacement of waste foundry sand the split tensile strength increases and decreases at the percentage of 25 and 30. So we can determine that replacing the foundry sand up to 20% will give the good result in split tensile strength.

CONCLUSION

The present work investigated that the concrete manufactured by partial replacement of M-sand with waste foundry sand in the range of 10%, 15%, 20%, 25% and 30%. The fineness and high-water absorption properties of WFS reduce the workability of the concrete and hence the Polycarboxylate Ether (Superplasticizer) is added in a substitution rate. In all ages of concrete, the strength properties of the concrete mixtures containing WFS up to 20% was relatively close to the strength value of the conventional mix. The concrete mixtures of WFS 25% and 30% showed a decrease in compressive strength, at the age of 28 days when compared to the conventional concrete. Hence the result conclude that the compressive and split tensile strength of concrete is optimum at 20% replacement of WFS. Use of waste foundry sand in concrete reduces the production of waste through metal casting industries so it is considered as an eco-friendly building material. Application of this project leads to develop in construction sector and innovative building material.

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REFERENCES

[1] Amithkumar D. Raval, Arti Pamnani, et. al., (2015) 'Foundry Sand: Utilization as a Partial Replacement of Fine Aggregate for Establishing Sustainable Concrete', ISSN: 2277-9655, PP308-311.

[2] Augustine UchechukwuElinwa (2014) 'Spent Foundry Sand as Partial Replacement of Fine Aggregate in the Production of Concrete', (IOSR-JMCE)- (2014).

[3] Bakis R, Koyuncu H, et. al., (2006) ' Experimental Investigation of Waste Foundry Sand on Asphalt Concrete Mixtures'.

[4] Deepak Ch aurasiya, Kiran Koli, et. al., (2016) 'Utilization of Foundry Sand: An Art to Replace Fine Sand with Foundry Sand', College of SGOI, Pine, (IJTARME) Volume: 5, No: 1, ISSN (Print): 2319- 3182.

[5] D. Lawrence and M. Mavroulidou (2009) 'Properties of Concrete Containing Foundry Sand', London.

[6] Dr. B. Kameshwari, Vignesh Kumar M, et. al., (2014) 'Strength of Concrete Incorporating Waste Foundry Sand', IJIRS ISSN 2319-9725, Vol 3, Issue 4.

[7] Dushyant R. Bhimani, JayeshkumarPitroda, et. al., (2013) 'A Study on Foundry Sand: Opportunities for Sustainable and Economical Concrete', Vallabh Vidyanagar-Gujarat, (GRA) Volume: 2, Issue: 1.

[8] Eknath P. Salokhe and D.B Desai 'Application of Foundry Waste Sand in Manufacture of Concrete', Kohlapur,India.

[9] IS 10262: 2009 'Guidelines for Concrete Mix Design', Bureau of Indian Standards, New Delhi, India.

[10] IS: 1199-1959 ' Indian Standard Methods of Sampling and Analysis of Concrete', Bureau of Indian Standards, New Delhi, India.

[11] IS 383: 1970 'Specification of Coarse and Fine Aggregates from Natural Sources for Concrete', Bureau of Indian Standards, New Delhi, India.

[12] IS: 5816-1999 'Splitting Tensile Strength of concrete Method of Test', Bureau of Indian Standards, New Delhi, India.

[13] IS 456: 2000 'Plain and Reinforced Concrete-Code of Practice', Bureau of Indian Standards, New Delhi, India.