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An Experimental Investigation on Partial Replacement of Waste Foundary Sand in Plane Concrete

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ABSTRACT

The increased quest for sustainable and eco friendly materials in the construction industry has led to research on partial replacement of selected waste material in concrete. The attempt is made on replacing waste Foundry sand as a partial replacement for fine aggregate in concrete. In this project work, 20%,40%,60%,80%,100% of fine aggregate is replaced by the Foundry sand in M20, M40, M60 mix concrete . the compressive strength and split tensile strength of concrete mix at 28thday of curing period is determined. Test results indicate an increase in compressive strength of plain concrete by replacing of WFS instead of fine aggregate. The maximum compressive strength, split tensile strength and Flexural strength was obtained at 40% of replacement. after that it losses strength in compressive strength, split tensile strength and Flexural strength.

Keywords : Waste Foundry Sand, Compression Strength, Split Tensile Strength And Flexural Strength.

I. INTRODUCTION

Concrete is the most popular material in construction. concrete have good compression strength, it's a construction material that consists of cement, coarse aggregate, fine aggregate and chemical admixture. The concrete industry is constantly looking for replacing of industrial by product as supplementary material. Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products. Waste foundry sand (WFS) is one of such industrial by-product. Ferrous and non ferrous metal casting industries produce several tons of by-product in India. WFS is major by-product of metal casting industry and successfully used as a land filling material for many years. But use of waste foundry sand for land filling is becoming a problem due to rapid increase in disposal cost. 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 as "Waste Foundry Sand". These WFS is black in color and contain large amount of fines. The typical physical and chemical property of WFS is depend upon the type of metal being poured, casting process, type of furnaces and type of finishing process.

II. METHODS AND MATERIAL

2. Literature Review

2.1 General

This chapter deals with the review of literature related to strength properties of concrete made from Waste Foundry Sand as a replacement of fine aggregate on strength properties of concrete.

D.Lawrence and M.Mavroulidou [11] (2009) Found out the properties of concrete containing waste foundry sand.

Following conclusions were drawn from the research. From the results it was shown that mixes with chemically bound foundry sand had properties, workability, strengths and moduli of elasticity comparable to those of normal concrete. Based on these findings they concluded that these types of foundry sand can be used as a substitute for regular sand for concrete with no apparent adverse effects on the concrete.

Rafat Siddique, Geert de Schutter and Albert Noumowec [1] (2008) presented the results of an experimental investigation carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (regular sand) was partially replaced with waste foundry sand. Fine aggregate was replaced with three percentages (10%, 20%, and 30%) of WFS by weight. Tests were performed for the properties of fresh concrete. Compressive strength, splitting- tensile strength, flexural strength, and modulus of elasticity were determined at 28, 56, 91, and 365 days. Test results indicated a marginal increase in the strength properties of plain concrete by the inclusion of WFS as partial replacement of fine aggregate (sand) and that can be effectively used in making good quality concrete and construction materials.

Yogesh Aggarwal, Paratibha Aggarwal, Rafat Siddique, El-Hadj Kadri and Rachid Bennacer [2] (2010) presented the design of concrete mixes made with waste foundry sand as partial replacement of fine aggregates up to 40%. Various mechanical properties are evaluated (compressive strength, and split tensile strength). Durability of the concrete regarding resistance to chloride penetration, and carbonation is also evaluated. Test results indicate that industrial by-products can produce concrete with sufficient strength and durability to replace normal concrete. Compressive strength, and split-tensile strength, was determined at 28, 90 and 365 days. Comparative strength development of foundry sand mixes in relation to the control mix i.e. mix without foundry sand was observed. Thereby, indicating effective use of foundry sand as an alternate material, as partial replacement of fine aggregates in concrete.

Gurpreet Singh and Rafat Siddique [3] (2011) carried out 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. 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. Test results indicate a marginal increase in strength properties of plain concrete by inclusion of WFS as a partial replacement of fine aggregate.

Gurpreet Singh and Rafat Siddique [6] (2011) investigated the abrasion resistance and strength properties of concrete containing waste foundry sand (WFS). Sand (fine aggregate) was replaced with 0%, 5%, 10%, 15% and 20% of WFS by mass. The water-to-cement ratio and the workability of mixtures were maintained constant at 0.40 and 85 ± 5 mm, respectively. Properties examined were compressive strength, splitting tensile strength, modulus of elasticity and abrasion resistance expressed as depth of wear. Test results indicated that replacement of sand with WFS enhanced the 28-day compressive strength by 8.3–17% and splitting tensile strength by 3.6–10.4% depending upon the WFS content, and showed continuous improvement in mechanical properties up to the ages of 365 days.

Rafat Siddique and El-Hadj Kadri [7] (2011) dealt with the effect of foundry sand (FS) and metakaolin (MK) on the near surface characteristics of concrete. A control concrete having cement content 450 kg/m^3 and w/c of 0.45 was designed. Cement was replaced with three percentages (5%, 10%, and 15%) of metakaolin weight, and fine aggregates were replaced with 20% foundry sand. Tests were conducted for initial surface absorption, sorptivity, water absorption and compressive strength at the ages of 35, 56, and 84 days.

Jayesh kumar and Jayadev bhai (2013) this research work is concerned with experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing fine aggregate in the range of 0% ,10%, 30% & 50 of used foundry sand by weight for M 20 grade concrete . These tests were carried out to evaluate the mechanical properties for 7 , 14 and 28 days Keeping all this view , the aim of investigation is the behaviour of concrete while adding of waste with different proportions of used foundry sand in concrete by using tests like compression strength and water absorption.

The following observations are made regarding the resistance of partially replaced foundry sand.

- The water absorption decreased up to 50% replacement of fine aggregate by used foundry sand.
- Compressive strength increase when replacement of used foundry sand percentage increases when compare to traditional concrete.

- Use of foundry sand in concrete can save the ferrous and non-ferrous metal industries disposal, cost and produce a 'greener' concrete for construction.
- Environment effects from wastes and disposal problems of waste can be reduced through this research. A better measure by an innovation Construction Material is formed through this research.

2.2 Critical Appraisal of Literature Review

- Literature papers conclude marginal increase in the strength properties of concrete with the inclusion of WFS.
- The water absorption decreased with replacement of fine aggregate by waste foundry sand.
- Waste Foundry Sand has been used with admixtures such as Metakaolin to study durability properties of concrete and with Fly ash to study properties of self compacting concrete

2.3 Summary

In this chapter, the literature review of papers on Waste Foundry Sand was done. The reviews of the above papers suggest that by replacement of regular sand with waste foundry sand have significant effect on strength properties of concrete. The experimental program of the present study is discussed in the next chapter.

3.1 Materials

A. Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together. It plays an important role in construction sector. In this study the ordinary Portland Cement (OPC) of 53 grades (jaypee Cement) is used.

B. Aggregate

Aggregate is a natural deposit of sand and gravel and also give structure to the concrete. It occupies almost 75% to 80% of volume in concrete and hence shows influence on various properties such as workability, strength, durability and economy of concrete. To increase the density of concrete aggregate is frequently use in different sizes. Aggregate acts as reinforcement and introduce strength to the overall composite material. Aggregate is also used as base material for roads, railroads and under foundation due to its good strength.

C. Fine Aggregate

Fine aggregate is to make the concrete dense, by filling voids of coarse aggregate and reduce the Shrinkage of cement and makes an economical mix. Natural sand or crushed stone dust is used as a fine aggregate in concrete mix. The locally available river sand was used as fine aggregate in the present investigation. Aggregate that pass through a 4.75mm IS sieve.

D. Coarse Aggregate

The aggregate having size more than 4.75 mm is termed as coarse aggregate. in this project we used 20 mm size aggregate. and it is free from dust and organic material.

E. Waste Foundry Sand

in construction uniform size and high silica sand is used so waste foundry sand is also best useful for construction. After casting process foundries recycle and reuse the foundries known as waste foundry sand. Waste Foundry sand is clean, uniformly sized and it contains high-quality of silica and it obtained from ferrous and non ferrous metals.

III. RESULTS AND DISCUSSION

4.1 General

Results obtained from experimental investigation to study the strength properties of plain concrete mixes in which fine aggregate is replaced by waste foundry sand at various percentages are presented here for discussion. The study was conducted to find out the influence of waste foundry sand on strength properties of plain concrete.

The effect of following parameter was studied.

- The various percentage replacement of fine aggregate with waste foundry sand on some of the strength properties of plain concrete with different grades of concrete mixes of M20, M40 and M60.

4.2 Test Results of Plain Concrete

Various tests were done to investigate the effect of replacement of fine aggregate with waste foundry sand for different Grades of Concrete on compressive strength, split tensile strength and flexural strength on plain concrete. The replacement percentage of waste foundry sand was taken at 0%, 20%, 40%, 60%, 80% and 100%.

The test results of the experimental investigations performed on Plain Concrete are tabulated in the Table 4.1to 4.4.Test results are also shown graphically in the Figures 4.1 to 4.4.

4.2.1 Compressive Strength Test

Cube specimens were tested for compression and the ultimate compressive strength was determined from failure load, measured using compression testing machine. The average values of compressive strength of 3 specimens for each category at the age of 28 days are tabulated in the Table 4.2. The relative compressive strength of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades (M20, M40 and M60) of concrete is shown in Figure 4.2.

Table 4.1 Compressive Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for Different Grades of Concrete

Sl. No.	Mix ID	Compressive Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	27.23	47.34	70.12
2	WFS20	30.20	53.01	71.24
3	WFS40	34.34	54.21	73.21
4	WFS60	25.31	46.23	66.52
5	WFS80	21.46	43.12	61.02
6	WFS100	19.10	37.26	54.86

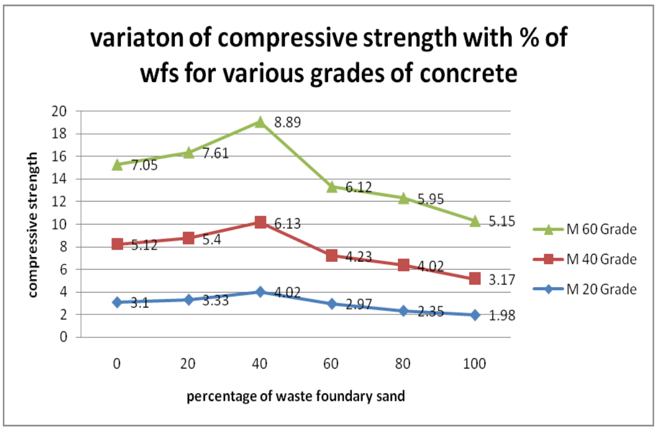

Figure 4.1: Compressive Strength of concrete with various % of WFS

Compressive strength of 27.23 MPa for (M20 grade), 47.34 MPa for (M40 grade) was achieved at 28 days which is higher than the target strength of 26.90 MPa for (M20 grade), 46.95 MPa for (M40 grade) and 70.10 MPa for (M60 grade) at 28 days is lower than the target strength of 73 MPa for (M60 grade) concrete losing its workability and hence the compressive strength decreases.

From table 4.1 shows that a considerable improvement in the compressive strength of concrete with inclusion and increase in the percentage of waste foundry sand up to 40% i.e. 34.34 MPa for (M20 grade), 54.21 MPa for (M40 grade) and 73.21 MPa for (M60 grade) which was higher than the control concrete 0% 27.23 MPa for (M20 grade), 47.34 MPa for (M40 grade) and 70.12 MPa for (M60 grade). Referring to Table 3.3 and Table 3.8, 48% of the aggregate lies between 600μ and 150μ size whereas 80% of foundry sand lies between 600μ and 150μ size. Hence foundry sand is finer than aggregate thus increasing the strength of concrete up to 40% replacement.

Fig 4.1 shows that maximum compressive strength was achieved with 40% of waste foundry sand with 20.6% for (20M grade), 10.9% for(M 40 grade) and 5.50% for (M 60 grade) increase in the strength compared to control mix 0%. However on replacement of waste foundry sand beyond 40% aggregate(fine aggregate) the concrete started losing its workability and hence the compressive strength decreased. At 60%, 80% and 100% replacement of fine aggregate compressive strength at 28 days which is less than the control concrete and target strength.

It was observed that the maximum compressive strength was achieved with 40% replacement of fine aggregate with waste foundry sand for different Grades of concrete.

4.2.2 Split Tensile Strength Test

Cylinder specimens were tested for split tensile strength and strength was determined from failure load, measured using compression testing machine. The average values of split tensile strength of 3 specimens for each category at the age of 28 days are tabulated in the Table 4.3 and Figure 4.3 show the graphical representation of variation of split tensile strength of plain concrete of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades(M20, M40 and M60) of concrete.

Table 4.2 Split Tensile Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for Different Grades of Concrete.

Sl. No.	Mix ID	Compressive Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	3.10	5.12	7.05
2	WFS20	3.33	5.40	7.61
3	WFS40	4.02	6.13	8.89
4	WFS60	2.97	4.23	6.12
5	WFS80	2.35	4.02	5.95
6	WFS100	1.98	3.17	5.15

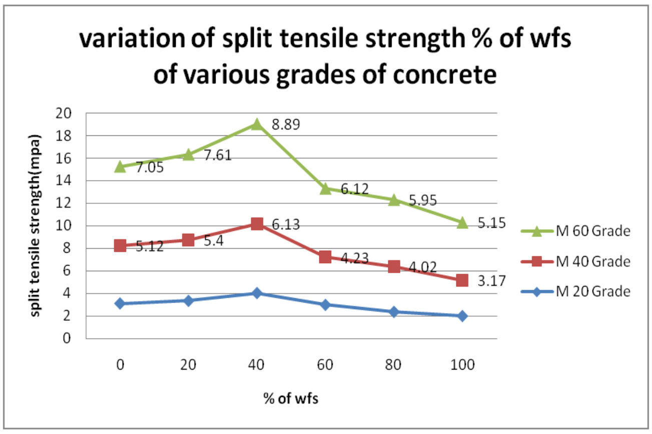

Figure 4.2: Split Tensile Strength of Concrete with various % of WFS

Fig 4.2 shows that Split tensile strength of 3.10 MPa for (M20 grade), 5.12 MPa for (M40 grade) and 7.05 MPa for (M60 grade) for control mix was achieved at 28 days. Split tensile strength of concrete mixes increased up to 40% replacement of fine aggregate with waste foundry sand.

Fig 4.2 shows that maximum split tensile strength of 4.02 MPa for (M20 grade), 6.17 MPa for (M40 grade) and 8.89 MPa for (M60 grade) was achieved at 40% replacement which was 25% for (M20 grade), 20.7% for(M 40 grade) and 21.3% for (M 60 grade) higher than the control mix. With further increase in the percentage of waste foundry sand 60%, 80% and 100% the split tensile strength of concrete mix started decreasing.

4.2.3 Flexural Strength Test

Beam specimens were tested for flexural strength using universal testing machine. The tests were carried out confirming to IS 516-1959; the specimens were tested under two point loading. The average value of 3 specimens for each category at the age of 28 days is tabulated in the Table 4.4. Figure 4.4 shows the graphical representation of variation of flexural strength of plain concrete of various concrete mixes (0%, 20%, 40%, 60%, 80% and 100%) for different grades (M20, M40 and M60) of concrete.

Table 4.3 Flexural Strength of Various Concrete Mixes with Replacement of Fine Aggregate over Waste Foundry Sand for different Grades of Concrete.

Sl. No.	Mix ID	Compressive Strength (MPa)		
		M 20 Grade	M 40 Grade	M 60 Grade
1	WFS0	4.56	7.11	9.12
2	WFS20	5.21	7.95	9.97
3	WFS40	5.95	8.73	10.53
4	WFS60	4.60	6.42	8.22
5	WFS80	4.21	5.21	6.75
6	WFS100	3.05	4.69	6.05

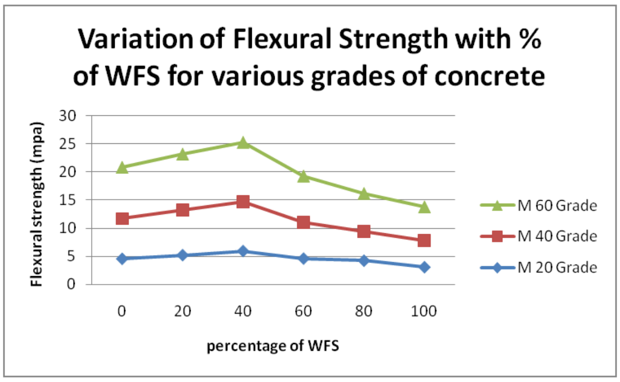

Figure 4.3: Flexural Strength of Various Concrete with various % of WFS

Fig 4.4 shows that Flexural strength of 4.56 MPa for (M20 grade), 7.11 MPa for (M40 grade) and 9.12 MPa for (M60 grade) for control mix was achieved at 28 days. Flexural strength of concrete mixes increased up to 40% replacement of fine aggregate with waste foundry sand.

Fig 4.4 shows that maximum Flexural strength of 5.95 MPa for (M20 grade), 8.73 MPa for (M40 grade) and 10.53 MPa for (M60 grade) was achieved at 40% replacement which was 21.3% for (M20 grade), 19.3% for(M 40 grade) and 17.75% for (M 60 grade) higher than the control mix. With further increase in the percentage of waste foundry sand 60%, 80% and 100% the Flexural strength of concrete mix started to decrease.

4.3 Summary

In this chapter, the results obtained from the experimental program are tabulated and are represented in the form of graphs. The results were studied and based on the study, the conclusions were drawn. The conclusions for the present study are given in the next chapter.

IV. CONCLUSION

5.1 General

From the experimental investigation on waste foundry sand as a replacement of fine aggregate on some strength properties of concrete the following conclusions are drawn.

5.2 Conclusions

- Increase in compressive strength of the concrete with increases in waste foundry sand up to 40% and the maximum compressive strength is achieved at 40% replacement of natural fine aggregate with waste foundry sand which comes to be 34.34 MPa for (M20 grade), 54.21 MPa for (M40 grade) and 73.21 MPa for (M60 grade)respectively and then there was a considerable decrease in the strength.
- Replacement of fine aggregate with waste foundry sand showed increase in the split tensile strength of plain concrete of grade M20, M40 and M60 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40% i.e. 4.02 MPa , 6.13 MPa and 8.8 9 MPa respectively.
- Replacement of fine aggregate with waste foundry sand showed increase in the Flexural strength of plain concrete of grade M20, M40 and M60 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40% i.e. of 6.02 MPa, 9.05 MPa and 11.64 MPa respectively.
- When percentage of waste foundry sand was increased beyond 40% the mix started losing its workability.
- Use of foundry sand in concrete can save the ferrous and non-ferrous metal industries disposal, cost and produce a ‘greener’ concrete for construction.
- Environmental effects from wastes and disposal problems of waste can be reduced through this research.
- A better measure by an innovative Construction Material is formed through this research.
- The used foundry sand can be innovative Construction Material but judicious decisions are to be taken by engineers.

5.3 Scope for Further Investigations

- Further research can be carried out to study the durability properties of concrete incorporating waste foundry sand as a partial replacement of fine aggregate.
- The investigation of concrete incorporating waste foundry sand can be carried out with addition of different types of fibers like steel fibers, recron fibers, synthetic fibers, dura fibers, natural fibers and glass fibers and with different aspect ratio.
- Further research can be carried out to study the properties of concrete with partial replacement of fine aggregate with waste foundry sand and partial replacement of cement with different mineral admixtures like GGBS, fly ash, metakaolin, micro silica, rice husk ash etc, with addition of different percentages of fibers.

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