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Experimental Investigation of Waste Foundry Sand on Strength Properties of Plain Concrete and Comparison With Binary Blended Concrete

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ABSTRACT

An acute shortage of river sand which is generally used as a fine aggregate in concrete has been affecting the construction sector. The scarcity has led to the skyrocketing price of sand, escalating construction costs. The situation has dashed the dreams of many in the lower- and middle-income groups to own a house. There were studies about the depletion of river sand and the need for scientific management and exploitation of the available resource. Following the shortage of river sand, some research institutions are searching alternatives that can be used for construction. Ferrous and non ferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is a major byproduct of metal casting industry and successfully used as a land filling material for many years. In an effort to use the WFS in large volume, research are being carried out for its possible large scale utilization in making concrete as partial replacement of fine aggregate. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, 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 fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete. This experimental investigation was performed to evaluate the strength properties of concrete mixtures, in which river sand was partially replaced with Waste Foundry Sand by weight. Compression test was carried out at the age of 7, 28 and 56 days of curing. Split tensile test was performed at the age of 28 and 56 days. Flexural strength was tested at 28 days of curing.10% Cement was replaced with Micro Silica and Fine aggregate was partially replaced with waste foundry sand by weight. Compressive strength at 7 and 28 days, Split tensile test at 28 days and Flexural strength was tested at 28 days of curing.

KEYWORDS : plain concrete, waste foundry sand, binary blend, Micro silica and super plasticizer.

INTRODUCTION

Waste Foundry Sand (WFS)

Solid waste management has become one of the global environmental issues, as there is continuous increase in industrial by-products and waste materials. Due to lack of land filling space and its ever increasing cost, utilization of waste material and by-products has become an attractive alternative to disposal. Waste foundry sand (WFS) is one of such industrial by-product.

Ferrous and non ferrous metal casting industries produce several million tons of byproduct in the world. In India, approximately 2 million tons of waste foundry sand is produced yearly. WFS is major byproduct 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.

Foundry industry produces a large amount of by-product material during casting process. The ferrous metal casts in foundry are cast iron and steel, non ferrous metal are aluminum, copper, brass and bronze. Over 70% of the total by-product material consists of sand because moulds consist usually of molding sand, which is easily available, inexpensive, resistance to heat damage and easily bonded with binder and other organic material in mould. Foundry industry use high quality specific size silica sand for their molding and casting process. These WFS is black in color and contain large amount of fines. The typical physical and chemical property of WFS is dependent upon the type of metal being poured, casting process, technology employed, type of furnaces (induction, electric arc and cupola) and type of finishing process (grinding, blast cleaning and coating).

Micro silica is "very fine non-crystalline silica produced in electric arc furnaces as a by-product of the production of elemental silicon or alloys containing silicon". It is usually a gray colored powder, somewhat similar to Portland cement or some fly ashes. Micro silica is a by-product of producing silicon metal or ferrosilicon alloys in smelters using electric arc furnaces. Micro silica is added to Portland cement concrete to improve its hardened properties, in particular its compressive strength, bond strength, and abrasion resistance. These improvements stem from both the mechanical improvements resulting from addition of a very fine powder to the cement paste mix as well as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste.

EXPERIMENTAL PROGRAMME

In the present experimental program standard cubes of size (150x150x150mm) conforming to IS : 10086-1982 were casted and tested for compressive strength, standard cylinders of size 150mm diameter and 300mm height conforming to IS : 10086-1982 were casted and tested for split tensile strength and standard beams (100x100x500mm) were casted and tested for finding the flexural strength property of plain cement concrete and binary blended concrete.

Materials

The materials used in this experimental study were cement, fine aggregate, coarse aggregate, water, waste foundry sand, micro silica and super plasticizer.

Waste Foundry Sand

Waste foundry sand was obtained locally from Mak's Casting Uppal Hyderabad. WFS was used as a partial replacement of fine aggregate (natural river sand). Metal poured in the foundry is gray iron. The sand was tested for various properties like specific gravity, bulk density etc., and in accordance with IS 2386-1963.

Micro Silica

Amorphous Micro Silica of Grade 920-D was obtained from Elkem Materials. Oxide composition of micro silica used in the present program.

Super Plasticizer

Super plasticizer by trade name Conplast SP 430 manufactured by Fosroc Chemicals (India) limited obtained from United Engineering, Rani Ganj, Hyderabad was used as a water reducing agent to achieve the required workability. The dosage of super plasticizer was kept constant throughout the experimental program at 0.5% of the weight of the binder.

Compressive Strength Test

Cube specimens were tested for compression and ultimate compressive strength was determined from failure load measured using compression testing machine. The average value of compressive strength of 3 specimens for each category at the age of 7 days, 28 days and 56 days are tabulated in the Table . The relative compressive strength of various concrete mixes at different ages is shown in Figure

Failure of Cube Specimen of MSC

Split Tensile Strength Test

Split tensile strength of concrete at 28 days of curing with 10% micro silica and various percentage replacement of fine aggregate with waste foundry sand were tested. Test results are given in Table and represented in Fig

Failure of Cylindrical Specimen MSC

Flexural Strength Test

Flexural strength of concrete at 28 days of curing with 10% micro silica and various percentage replacement of fine aggregate with waste foundry sand were tested. Test results are given in Table and represented in Fig

Failure of Beam Specimen of MSC

Compressive Strength of PCC and MSC with Various Percentages of Waste Foundry Sand at 28 days

S. No.	MIX ID	Compressive Strength (MPa)	
		PCC	MSC
1	WF0	52.14	58.96
2	WF20	53.55	61.48
3	WF40	54.51	62.66
4	WF60	46.95	52.14

Split Tensile Strength of PCC and MSC with Various Percentages of Waste Foundry Sand at 28 days

S. No.	Mix id	Split Tensile Strength (MPa)	
		PCC	MSC
	WF0	4.60	5.16
2	WF20	4.95	5.30
3	WF40	5.09	5.58
4	WF60	4.66	5.02

Flexural Strength of PCC and MSC with Various Percentages of Waste Foundry Sand at 28 days

S. No.	MIX ID	Flexural Strength (MPa)	
		PCC	MSC
1	WF0	6.9	7.5
2	WF20	6.4	6.9
3	WF40	5.9	6.4
4	WF60	5.6	6.0

CASE STUDY

Binary blended concrete incorporating micro silica showed better results when compared to plain concrete. About 8% increase in the flexural strength was observed in binary blended concrete mixes when compared to plain concrete mixes at all percentage replacement of fine aggregate with waste foundry sand.

Hence for plain concrete mix 40% replacement of fine aggregate with waste foundry sand is beneficial whereas on using 10% micro silica, 60% replacement of fine aggregate with waste foundry sand is beneficial with good workability.

CONCLUSIONS

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

When percentage of waste foundry sand was increased beyond 40% the mix started losing its workability.

Replacement of fine aggregate with waste foundry sand showed increase in the compressive strength of plain concrete of grade M40 up to 40% and then there was a considerable decrease in the strength. Maximum strength was achieved at 40%.

For Plain Concrete mix at 60% replacement of fine aggregate strength of 46.95 MPa was achieved at 28 days which is less than the target strength.

Flexural strength of concrete decreased with the inclusion and increase in the percentage of waste foundry sand for plain concrete.

10% replacement of cement with micro silica was found to be optimum for M40 grade of concrete. Binary Blended Concrete mix containing 60% waste foundry sand was still workable.

For Binary Blended Concrete mix at 60% replacement of fine aggregate, strength of 52.14 MPa was achieved at 28 days which is more than the target strength.

Binary Blended Concrete incorporating micro silica showed better performance when compared to plain concrete.

13.08% increment in the compressive strength was found at 28 days using micro silica.

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, flyash, metakaolin, rice husk ash etc, with addition of different percentages of fibers.

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