Experimental Investigation of Basic Oxygen Furnace Slag (BOFS) as Fine Aggregate with Partial and Full Replacement of Natural Sand for Use in Masonary Mortar

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Abstract— This experimental research work investigates the possibility of utilizing Basic Oxygen Furnace Slag which was taken from Lloyds Steel Industry Wardha as a sand substitute in cement mortar. The natural sands which are used in this study are local Sand. In this investigation, BOFS at 0, 25, 50, 75 and 100% replacement to natural sand for constant w/c ratio of 0.5 is considered. The work is extended to 100% replacements of natural sand with BOFS and Cement mortar mix 1:5, 1:4, 1:3 by weight were selected. The w/c ratio was taken as per standard consistency test of cement. For compressive strength test 2 samples were tested for 7, 14 and 28 days for all the replacements. The study gave comparative results for mortar compressive strength test. The experimental results obtained show that fully substitution of ordinary sand by slag gives better results in both the sands from this study it is observed that BOFS could be utilized fully as alternative construction material for natural sand in mortar applications for good compressive strength result.

Key words: BOFS, Compressive Strength, Natural Sand

I. INTRODUCTION

In India, natural river sand (fine aggregate) is traditionally used in mortars and concrete. However, growing environmental restrictions to the exploitation of sand from riverbeds have resulted in a search for alternative sand, particularly near the larger metropolitan areas. This has brought in severe strains on the availability of sand forcing the construction industry to look for an alternative construction material. Thus manufactured fine aggregates appear as an attractive alternative to natural fine aggregates for cement mortars and concrete. Manufactured sand is totally different from natural river sand. The surface characteristics are different. Most of the artificial sand is irregular and more porous. Grading will vary over wide range resulting in internal porosity and reduction in workability of mortar or concrete. Various types of slag from copper and steel industry are being used in mortar and concrete.

In the developing country like India, as the construction scope is increasing tremendously, therefore the demand of the materials used for the construction is also increasing. For the construction industry concrete is the most important material. For good quality of concrete cement, fine aggregate, course aggregate and portable water is used. And similarly in the case of mortar, the same materials are being used except course aggregate. The natural sand, one of the most important construction materials which are located in river beds only is being used continuously and therefore the water table level below the river bed is going down. Due to this the problems like flood, unexpected rainfall, and such natural calamities arises. So to minimise these problems we have to reduce the use of natural sand by replacing it with manufactured sand and which is Basic Oxygen Furnace Slag (BOFS).

Basic Oxygen Furnace Slag is easily and cheaply available in India. In very huge amount BOFS is disposes of from many steel and copper industries as a waste product. As production of steel industry from last 20 years is increasing therefore the production of BOFS is increasing day by day. The nature is facing the problem of land disposal and also the human beings are going through the various diseases and hence in this critical situation we must approach to use BOFS as material for mortar and concrete is very beneficial idea. And therefore in my project I am trying to utilize BOFS in compressive strength test, water absorption test and drying shrinkage test.

II. LITERATURE REVIEW

A. Dariusz Wilk, Łukasz Bratasz, Roman Kozłowski. (2013) "Shrinkage cracking in Roman cement pastes and mortars"

"Roman cements were key materials used in the architecture of the nineteenth and early twentieth century's.Fine cracks, caused by restrained shrinkage during drying, are a distinct characteristic of all Roman cement stuccoes. Today, cracking has become an important barrier preventing broader acceptance of Roman cement as a material by the restoration and construction sector. Drying shrinkage and tensile properties of Roman cement pastes and mortars submitted to various curing and drying regimes were determined as key parameters controlling cracking. A higher volume of aggregate in the mortar mix and a moderate curing time produce optimum Roman cement mortars from the standpoint of reducing the risk of cracking. Fast drying produced significant micro cracking due to moisture gradients and differential shrinkage across the specimens. Stress relaxation observed during the long-time loading of the materials reduced their vulnerability to cracking

B. M C Nataraja1,P G Dileep Kumar2, A S Manu1 and M C Sanjay1 (2013 IJSCER) "Use of granulated blast furnace slag as Fine aggregate in cement mortar"*

"This paper investigates the possibility of utilizing Granulated Blast Furnace Slag (GBFS) as a sand substitute in cement mortar, in order to reduce environmental problems related to aggregate mining and waste disposal. In this investigation, cement mortar mix 1:3 and GBFS at 0, 25, 50, 75 and 100% replacement to natural sand for constant w/c ratio of 0.5 is considered. The work is extended to 100% replacements of natural sand with GBFS for w/c ratios of 0.4 and 0.6.The flow characteristics of the various mixes and their compressive strengths at various ages are studied. From this study it is observed that GBFS could be utilized partially as alternative construction material for natural sand in mortar

applications. Reduction in workability expressed as flow can be compensated by adding suitable percentage of super plasticizer.

C. Ansu John and Elson John (2013-AJER) "Study on the partial replacement of fine aggregate using induction furnace slag"

"This paper highlights the feasibility study on the utilization of induction furnace slag as an alternative for conventional fine aggregate. In this study the compressive strength characteristics of mortar and concrete made with partial replacement of fine aggregate using induction furnace slag was considered. For the experimental investigation, mixes were prepared with fine aggregate replacement using 20 percent, 30 percent, 40 percent, 50 percent and 60 percent induction furnace slag. Compressive strength test on mortar and concrete were conducted and the test results indicated that fine aggregate replacement using 30 percent induction furnace showed a better performance compared to control mix."

III. Introduction of Mortar

Mortar is a homogeneous mixture, produced by intimately mixing cementations materials, water and inert materials, such as sand, for use in binding together the masonry units.
The purpose of mortar is to bond masonry units to produce a continuous load bearing element which will provide protection from wind and rain. In order to perform for an adequate period, generally the order of decades, and the mortar must be formed of durable materials; the requirements of a mortar can be complex in that it has to satisfy one range of parameters when plastic and a further set of parameters when hardened.

In the plastic state, mortar must be workable in order to enable the bricklayer to spread the material easily and of a consistency for it to adhere but not stiffen too rapidly. In the hardened state, mortar must provide a degree of resistance to rain penetration, be frost resistant & contribute to the strength of the masonry.

A. Classification of mortar

- Mortars could be broadly classified as:-
- Cement mortars,
- Lime mortars and
- Cement lime mortars

IV. Methodology

The Compressive strength of masonry mortar which was casted cured & tested as Per "IS: 2250-1981Code of practice for preparation and use of masonry mortars."

A. Preparation of Cement Mortar

- Specimen and Moulds - The test specimens shall be cubes of size 70.7 mm × 70.7 mm × 70.7 mm.
- Tamping Rod - A metal bar 25 mm square and 200 mm long Trowel -This shall have a steel blade 100 to 150 mm in length with straight edges.

B. Curing and Storage of Test Specimens

The specimen shall be tested immediately on removal from the curing water in which it has been stored and while it is still in a wet condition. Any loose material shall be removed from the sides of the specimen. The dimensions of the specimen shall be noted before testing. The bearing surfaces of the testing machine shall be wiped clean and the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cube as cast, that is, not to the top and bottom.
The load on the specimen shall be applied without shock and at a uniform rate of $2N/mm^2$ to $6N/mm^2$ per minute until failure occurs. the maximum load at failure shall be noted.

C. Calculation A-7.1

The compressive strength shall be calculated as follows: Compressive strength (N/mm^2) = Maximum load at failure (N)/ Cross-sectional area (mm^2)

The individual results shall be calculated to the nearest 0.05 N/mm^2

The average of all the determinations shall be reported

V. Test Performed on Mortar

A. Compressive Strength

Compressive Strength Test was done as per IS 2250-1981 on test specimen of 70.7cm x70.7cmx70.7cm and 2 samples were tested for 7, 14, 28 days of curing.

VI. Results

Sr. No.	Mix Proportion	Percent replacement	Curing Days	Compressive Strength in N/mm^2
1.	01:05	0	7	6.841368
			14	9.081816
			28	10.4821
		25	7	6.55
			14	9.46
			28	12.28
		50	7	6.98
			14	9.02
			28	13.07
		75	7	8.39
			14	9.44
			28	14.18
		100	7	9.32
			14	9.76
			28	14.77
2.	01:04	0	7	8.59
			14	13.24
			28	14.16
		25	7	9.72
			14	13.22
			28	15.50
		50	7	13.01
			14	14.26
			28	20.72
		75	7	16.58
			14	18.26
			28	23.46
		100	7	18.05
			14	19.15

			28	25.17
3.	01:03	0	7	17.96
			14	17.35
			28	26.21
		25	7	19.20
			14	20.60
			28	28.56
		50	7	18.73
			14	21.67
			28	29.33
		75	7	20.21
			14	21.01
			28	30.55
		100	7	19.42
			14	22.00
			28	41.66

Table 1: Results

VII. Graphical Representation of Results

The result for the compressive strength of 1:5 is shown below.

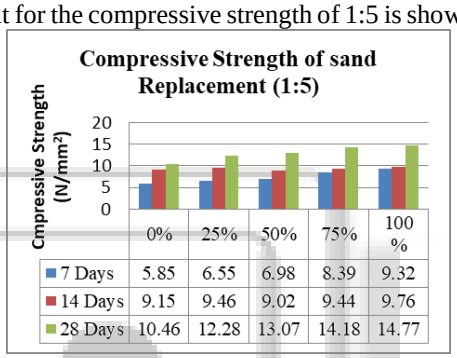

Fig. 1: The result for the compressive strength of 1:5

The result for the compressive strength of 1:4 is shown below.

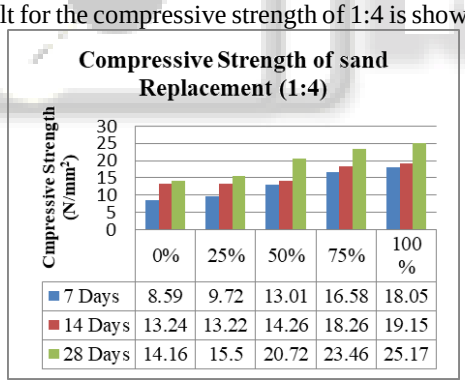

Fig. 2: The result for the compressive strength of 1:4

The result for the compressive strength of 1:3 is shown below.

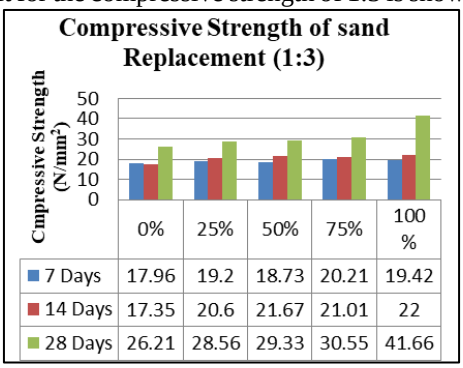

Fig. 3: The result for the compressive strength of 1:3

VIII. Conclusion

- The data obtained shows that the compressive strength of cement mortar increases as the replacement level of BOFS increases.
- This trend is true for all ages of testing. .
- From this it is clear that BOFS can be used as an alternative to natural sand from the point of view of strength.
- Use of BOFS up to 100% can be recommended.
- The study comprises of the experimental results obtained show that fully substitution of ordinary sand by slag gives better results.
- It is also observed that the flow of mortar decreases as the percentage of BOFS increases.
- As the sand is artificial, its long term performance from the point of view of durability is very important and further studies in this direction is in progress.

IX. Future Scope

- In this investigation, at 100% BOFS replacement the mix gives maximum strength. But we have not tested the chemical properties of BOFS and therefore the chemical reaction of cement with BOFS is the part of investigation
- Further investigation is needed when the BOFS is available in different shapes.
- It is a free of cost in any steel industry.
- All knowledge shows that BOFS is best replacement of natural sand. And its help that to maintained water level of nature.
- Using of BOFS in reducing the environment pollution during the storage of BOFS

References

[1] Dariusz Wilk, Łukasz Bratasz, Roman Kozłowski. (2013) "Shrinkage cracking in Roman cement pastes and mortars"
[2] M C Nataraja1*, P G Dileep Kumar2,A S Manu1 and M C Sanjay1(2013 IJSCER) "Use of granulated blast furnace slag as Fine aggregate in cement mortar"
[3] Ansu John and Elson John (2013-AJER) "Study on the partial replacement of fine aggregate using induction furnace slag"
[4] [ZHENG Shao-peng (YIWl)!,h', TIAN Bo(milt)!, WANG Da-peng (::E*JIIl) !, HOU Zi-yi (1*T 502 (2013 JHTRD)"Cement Mortar Liquidity Testing Method by Rheological Properties
[5] S.A. Abo-El-Eneina, A.H. Ali b, Fatma N. Talkhanc, H.A. Abdel-Gawwadb. (April 2013HBRC) "Application of microbial biocementation to improve the physico-mechanical properties of cement mortar"
[6] T. Mauroux a,b,c, F. Benboudjema b, P. Turcrya, A. Aït-Mokhtara, O. Devesc.(2012) "Study of cracking due to drying in coating mortars by digital image correlation.

