Experimental Investigation of Basic Oxygen Furnace Slag (BOFS) As Fine Aggregate With Partial Replacement of Natural Sand For Use In Masonary Mortar

Ms. Anjali Targe[1], Prof. Jagruti Chavan[2]
[1, 2] Dept of Civil Engineering
[1, 2] P.L.I.T. Yelgaon Buldana, India

Abstract- *This experimental research work investigates the possibility of utilizing Basic Oxygen Furnace Slag which was taken from Kalika Steel Industry Jalna 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 replacement to natural sand for constant w/c ratio of 0.5 is considered. The work is extended to 75% 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 3 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.*

Keywords- BOFS, Compressive Strength, Workability 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 minimize 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. *M. Shariq, J. Prasad and A.K. Ahuja Department of Civil Engineering, IIT Roorkee, India.*

"In the present study, the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag is studied. The compressive strength development of cement mortar incorporating 20, 40 and 60 percent replacement of GGBFS for different types of sand and strength development of concrete with 20, 40 and 60 percent replacement of GGBFS on two grades of concrete is investigated. The compressive strength of cement mortar and concrete obtained at the ages of 3, 7, 28, 56, 90, 150 and 180 days. Tests results show that the incorporating 20% and 40% GGBFS is highly significant to increase the compressive strength of mortar after 28 days and 150 days respectively. The magnitude of compressive strength of mortar for standard sand is higher than the magnitude of river sand. Incorporating 60% BFS replacement is showing lower strength at all ages and water-cement ratio for both types of sand. The compressive strength of OPC concrete shows higher strength as compare to the GGBFS based concrete for all percent replacement and at all ages. Incorporating 40% GGBFS is highly significant to increase the compressive strength of concrete after 56 days than the 20 and 60% replacement. Among GGBFS based concrete 40% replacement is found to be optimum."

B. Ansu John and Elson John

"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."

*C. ZHENG Shao-peng (YIWl)!,h', TIAN Bo(milt)!, WANG Da-peng (::E*JlIl) !, HOU Zi-yi (1*T 502)*

"A cement mortar mixer that can test torque is designed to realize online observation of working performance of the cement mortar and to predict cement mortar slump. The influence of different rotating speeds and mixing timeson cement mortar quality is analyzed using factors of slump and torque. The best stirring speed is determined to be 180 min and the best mixing time 60 -180 s. The relation between cement mortar slump and torque at different shear rates is studied, and different power functions for different shear rates are found. At a given shear rate, i.e. , a rotation speed of 180 min, the relation between slump and torque is set up, which could provide a test method and theoretical basis for cement mortar online quality control and slump forecast."

D. Nourredine Arabi1 and Raoul Jauberthie2

"This paper deals with progressive substitution of hydrated lime by granulated blast furnace slag to produce new calcium silicate materials obtained by autoclaving, representing an alternative economic raw material. The slag grain-size grinding and the heat treatment in saturated vapor pressure autoclave conditions were investigated to study the compressive strength behavior of the new material. The results showed a decrease in compressive strength from the substitution. The microstructure analysis showed that reaction products consist mainly of 11 Å tobermorite and xonotlite. When increasing the autoclave temperature, it results in an increase in xonotlite relative to tobermorite. It is also observed that the amorphous composition of granulated blast furnace slag does not release new distinct phases of hydrates."

E. Weerachart Tangchirapat1; Chai Jaturapitakkul2; and Kraiwood Kiattikomol3

"This research aims to utilize palm oil fuel ash _POFA_ as a pozzolanic material for replacing portland cement. The effects of POFA fineness on the setting times, compressive strength, and expansion of mortars exposed to a 5% MgSO4 solution were investigated. It was found that the use of POFA to replace portland cement Type I caused an increase in water demand for normal consistency and setting times, depending on the fineness and level replacement of POFA. The results suggest that ground POFA is a good pozzolanic material and can be used to increase both the compressive strength and the sulfate resistance of mortar."

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

Properties of a good Mortar:

1. If should be capable of developing good adhesion with the building units such as bricks stones etc.
2. If should be capable of developing the designed stresses
3. It should be cheap
4. It should be durable
5. It should be easily workable
6. It should so quickly so that speed in construction may be achieved.

Uses of mortar:

1. To bind the building Units such as bricks stones.
2. To carry out pointing & plaster wooden exposed sureness of masonary.
3. To form an even & soft bedding layer for building units.
4. To form joints of pipes.
5. To hide the open joint of brick work & stonework.
6. To improve the general appearance of structure.

Function of Sand in Mortar:

1. Bulk
2. Setting
3. Shrinkage: It prevents excessive shrinkage of the mortar during the course of drying & hence, cracking of mortar during setting is avoided
4. Strength: It helps in the adjustment of strength of mortar or concrete by variation of its proportion with cement or lime.

MATERIAL

Under this experimental investigation, following materials are used which are described as below:-

Material Selection:

1. Cement
2. Natural Sand
3. Basic Oxygen Furnace Slag (BOFS)
4. Water

Cement: Grade: 53

Type: Ordinary Portland cement (OPC)

SR.NO	OPC	CODES
01	OPC 53 Grade	IS 12269 : 1987

Fig 1: Grade Chart

Basic Oxygen Furnace Slag *(BOFS):*

Basic Oxygen Furnace Slag which was taken from Kalika Steel Industry Jalna.

Fig 2: BOFS

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 becubesofsize 70.6mm×70.6mm× 70.6mm.
- Tamping Rod - A metal bar 25 mm square and 200 mmlongTrowel- Thisshallhaveasteelblade100to150mminlengthwithstraightedges.

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/mm2 to 6N/mm2 per minute until failure occurs. The maximum load at failure shall be noted.

C. CalculationA-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.

IV. TEST PERFORMED ON MORTAR

A. Compressive Strength

Compressive Strength Test was done as per IS 2250-1981 on test specimen of 70.6mm x70.6mmx70.6mm and 3 samples were tested for 7, 14, 28 days of curing.

B. Workability

Workability may be defined as the behavior of a mix in respect of all the properties required during application, subsequently working and finishing.

ADVANTAGES:

- The higher long term compressive and flexural strength.
- Reduced permeability.
- The ASR mitigation properties.
- Improved durability and resilience.
- Operating costs are low.
- Scrap iron can be used.

DISADVANTAGES:

- The uneven particle size.
- Subsequent Crushing.
- Large processing volume.
- Long processing cycle.

V. RESULT

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

Sr. No.	MixPro portion	Percentre placement	Curing Days	Compressive Strength inN/mm²
1.	1:5	0	7	6.8413
			14	10.122
			28	11.438
		25	7	7.56
			14	10.42
			28	12.28
		50	7	7.82
			14	9.67
			28	13.78
		75	7	9.38
			14	10.89
			28	15.182

I. The result for the compressive strength of 1:4

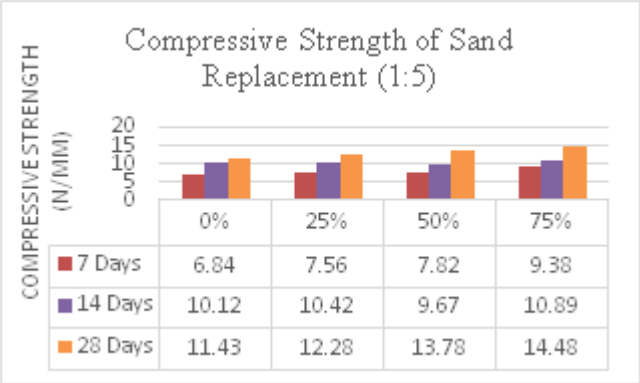
Sr. No.	MixPro portion	Percentre placement	Curing Days	Compressive Strength inN/mm²
2.	1:4	0	7	9.02
			14	13.68
			28	15.16
		25	7	9.85
			14	13.74
			28	14.89
		50	7	13.53
			14	15.26
			28	19.72
		75	7	17.22
			14	18.58
			28	23.71

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

Sr. No.	MixPro portion	Percentre placement	Curing Days	Compressive Strength inN/mm²
3.	1:3	0	7	16.69
			14	17.23
			28	25.21
		25	7	19.3
			14	20.22
			28	28.34
		50	7	18.72
			14	21.63
			28	30.61
	1:3	75	7	21.2
			14	21.84
			28	38.79

GRAPHICAL REPRESENTATION OF RESULTS

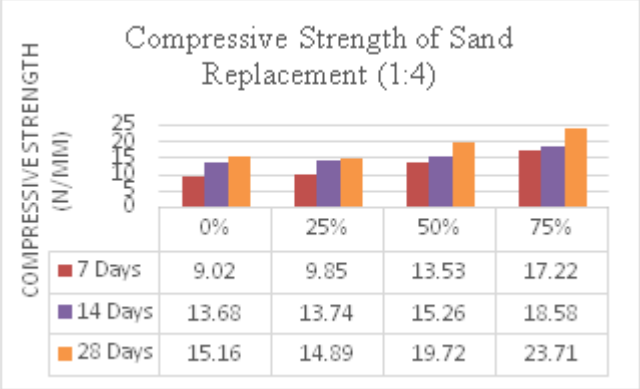
The result for the compressive strength of 1:5 is shown below.



	0%	25%	50%	75%
7 Days	6.84	7.56	7.82	9.38
14 Days	10.12	10.42	9.67	10.89
28 Days	11.43	12.28	13.78	14.48

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

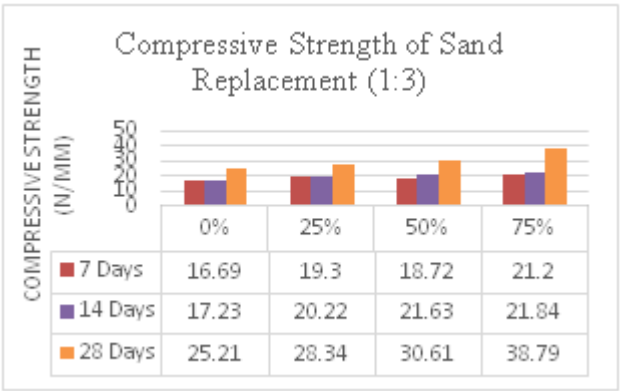
The result for the compressive strength of 1:4 is shown below



	0%	25%	50%	75%
7 Days	9.02	9.85	13.53	17.22
14 Days	13.68	13.74	15.26	18.58
28 Days	15.16	14.89	19.72	23.71

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

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



	0%	25%	50%	75%
7 Days	16.69	19.3	18.72	21.2
14 Days	17.23	20.22	21.63	21.84
28 Days	25.21	28.34	30.61	38.79

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

VI. 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 75% 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.
- The compressive strength tends to increase with increase in the percentage of basic oxygen furnace slag by weight to the concrete.

VII. FUTURESCOPE

- In this investigation, at 75% 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] M. Shariq⁎, J. Prasad and A.K. Ahuja*Department of Civil Engineering, IIT Roorkee, India.* “Strength development of cement mortar and Concrete incorporating ggbfs”M. Shariq⁎, J. Prasad and A.K. Ahuja*Department of Civil Engineering, IIT Roorkee, India.*

[2] Ansu John and Elson John.] “Study on the partial replacement of fine aggregate using induction furnace slag.”

[3] ZHENG Shao-peng (YIWl)!,h', TIAN Bo(milt)!, WANG Da-peng (::E*Jlll□) !, HOU Zi-yi (1*T 502). “Cement Mortar Liquidity Testing Method by Rheological Properties”

[4] Nourredine Arabi1 and Raoul Jauberthie2“Calcium Silicate Materials: Substitution of Hydrated Lime by Ground Granulated Blast Furnace Slag in Autoclaving Conditions”**.**

[5] Weerachart Tangchirapat1; Chai Jaturapitakkul2; and Kraiwood Kiattikomol3.“Compressive Strength and

Expansion of Blended CementMortar Containing Palm Oil Fuel Ash**"**

[6] "Investigations on Pastes and Mortars of Ordinary Portland Cement Admixed with Wollastonite and Microsilica".G. D. Ransinchung R. N.1 and Brind Kumar2.

[7] S.A. Abo-El-Eneina, A.H. Ali b, Fatma N. Talkhanc, H.A. Abdel-Gawwadb,* "Application of microbial biocementation to improve the physico-mechanical properties of cement mortar."

[8] DariuszWilk∗, ŁukaszBratasz, Roman Kozłowski. "Shrinkage cracking in Roman cement pastes and mortars".

[9] ilhamidemir, #hasbiyaprak*, osmansimsek** "Performance of cement mortars replaced by ground waste brick in different aggressive conditions.

[10] IS: 383-1970 Specification for Coarse and Fine Aggregates from Natural Sources For Concrete [CED 2: Cement and Concrete]

[11] IS: 456-2000 Plain and Reinforced Concrete - Code of Practice [CED 2: Cement and Concrete]

[12] IS: 516-1959 Method of Tests for Strength of Concrete [CED 2 Cement and Concrete]

[13] IS: 2386-1 (1963) Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape [CED 2: Cement and Concrete]

[14] IS: 2386-3 (1963) Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption and bulking [CED 2: Cement and Concrete]

[15] IS: 2386-4 (1963) Methods of test for aggregates for concrete, Part 4: Mechanical properties [CED 2: Cement and Concrete]

[16] IS: 4031 (Part 4, 5&6)-1988Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standard, New Delhi-1988.

[17] IS: 5816 (1999) Method of Test Splitting Tensile Strength of Concrete [CED 2: Cement and Concrete]

[18] IS: 8112-1989 (Reaffirmed 2005) Specification for 43 Grade Ordinary Portland Cement Bureau of Indian Standard, New Delhi-2005.

[19] IS: 10262 (2009) Guidelines for concrete mix design proportioning [CED 2: Cement and Concrete]