Utilisation of Blast-Furnace Slag as an Alternative of Natural Sand in Cement-Mortar and Concrete

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Abstract—This paper present Utilisation of Blast Furnace Slag as an Alternative of Natural Sand in Cement-Mortar and Concrete. Present experimental work explores the possibility granulated blast furnace slag as replacement of natural sand in mortar. In this work, cement mortar mix with 1:4 and 1:6 was selected for 0, 20, 40, 60, 80 and 100 % substitutions of natural sand with GBS for constant w/c ratio of 0.4 and 0.5. Its compressive strength is investigated. Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube of 150x150x150 mm for number of days to determine the mechanical properties of concrete.

I. INTRODUCTION

River sand, which is one of the constituents used in the production of conventional concrete and cement mortar, has become highly expensive and also scarce martial. In the construction industry, river sand is used as an important building material, and the world consumption of river sand in concrete generation along is around 1000 million tons per year, making its scarce and limited. Our nation has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc. to meet the requirements of globalization, in the construction of buildings and other structures, concrete plays the rightful role and a large quantum of river sand is being utilized.(13)

In nearby local area river sand is widely used as a fine aggregate in production of cement mortar and concrete. Common river sand is becoming expensive due to scarcity and excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. Since river sand is most commonly used fine aggregate in the production of concrete and cement mortar possesses the problem of acute shortage in many areas.(1) Whose continued use has started possessing serious problems with respect to its availability, cost and environmental impact.

The developing country like India facing shortage of good quality river sand and particularly in India, river sand deposits are being used up and causing serious threat to environment as well as the society. The rapid extraction of sand from the river bed causes problems like deepening of the river beds, loss of vegetation on the bank of rivers, disturbance to the aquatic life as well as agriculture due to lowering the water table in the well etc. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for river sand. Hence, partial or full substitution for of river sand by the other compatible materials like crushed rock dust, quarry dust, glass powder, recycled concrete dust, and others are being researched from past two decades, in view of conserving the ecological balance. The reuse of this waste will help to save cost, conserve limited resources and ultimately protect the environment.

The facts like in India are almost same in other countries also. So therefore the need to find an alternative concrete and mortar aggregate material to river sand in construction works has assumed greater importance now a days. Researchers and Engineers have come out with their own ideas to decrease or fully replace the use of river sand and use recent innovations such as M-Sand (manufactured sand), robot silica or sand, stone crusher dust, filtered sand, treated and sieved silt removed from reservoirs as well as dams besides sand from other water bodies.

With indiscriminate mining destroying the riparian ecology of many areas, the scientific Community has been busy to find alternatives to river sand for construction purposes. Because of the ban on mining, there are cost escalations and delays in project delivery. Currently, the river sand is being replaced by sand from private lands and also by mining in submerged areas. Even where sand is available at higher prices, at times it contains higher than normal percentage of silt and organic impurities, which can be detrimental to the quality of construction.

The excessive and non-scientific methods of mining sand from the river beds has led to lowering of water table and sinking of bridge piers. Further, it has caused environmental degradation like removal of minerals from too-soil due to erosion and change in vegetative properties leading to soil infertility problems thereby affecting agricultural productivity, change in river courses leading to floods and alteration of river eco-system affecting flora and fauna. Hence, the current focus of construction industry should be to partially or completely replace river sand in concrete by waste material or a material that is obtained through recycling, without compromising the quality of the end product.

In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste and growing environmental restrictions to the exploitation of sand from riverbed in a search of alternative sand, particularly near the large metropolitan areas. This has brought in severe strains on the availability of sand forcing the construction industry to look for an alternative construction material.

Now a day the construction sector is exploring rapidly on a large scale and also involves new techniques for rapid and comfort works on the field. Concrete and Cement mortar as a building materials plays an important role in this sector. The consumption of natural resources as an ingredient of concrete and Cement mortar, costs high as well as it is on verge of extent. These problems force us to recover the natural resources or to find an alternative option to overcome this problem. Presently, the production of blast furnace slag as a by-product of steel industries causes various environmental problems. Usage of this waste in building material would help in reduction of stress on environment. Steel industries use blast furnace slag which is uniform sized, high quality silica sand that is bound to form a mould for casting of ferrous and non-ferrous steel metal. Use of blast furnace slag as a partially replacement or total replacement by fine aggregate in concrete leads in production of economic, light weight and high strength concrete. Concrete is material which is composed of coarse aggregate, fine aggregates, cement, admixture and water these each material in concrete contributes its strength. So, by partial or percentage replacement of material affects different proportion of concrete. By using such a waste material which harms the environmental can be used for the development of low cost and eco-friendly concrete.

II. LITERATURE REVIEW

1.SohailMd, Abdul Wahab, Arfath Khan Md "A Study on the Mechanical Properties of Concrete by Replacing Sand with Waste Foundry Sand" International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 11, November 2013.

In this paper, the effect of using waste foundry sand as constituents of fines in concrete by partially reducing quantities of fine aggregate has been studied. The percentages of replacement were 0, 10, 20, 30, 40, 60,70,80,90 & 100 % by weight of fine aggregate. Tests were performed for compressive strength, split tensile strength and flexural strength tests for all replacement levels of foundry sand at different curing period (7-days, 28days & 56-days).

2 Mahendra R. Chitlange and Prakash S. Pajgade "Strength appraisal of artificial sand as fine aggregate in SFRC" VOL. 5, NO. 10, OCTOBER 2010 ARPN Journal of Engineering and Applied Sciences.

This paper presents the study of steel fiber reinforced concrete with artificial sand as fine aggregate. Three matrices with compressive strength 20, 30 and 40 MPa were designed and reinforced with crimpled steel fibers at dosage rate of volume fraction 0, 0.5, 1.0, 1.5 and 2.0 percent. The specimens were prepared, cured and tested for compressive strength, flexural strength and split tensile strength.

3 R. Ilangovana et al (2008) "Strength and durability properties of concrete containing quarry rock dust as fine aggregate" VOL.3, NO. 5, OCTOBER 2008 ISSN 1819-6608 Journal of Engineering and Applied Sciences PP 20-26.

This paper presents the feasibility of the usage of Quarry Rock Dust as hundred percent substitutes for Natural Sand in concrete. Mix design has been developed for three grades using d IS, ACI, USBR, RN.NO.4 and BRITISH design approaches for both conventional concrete and quarry dust concrete.

The literature survey reveals that, majority of research on the BFS is replacing the cement in the form of Ground Granulated blast furnace Slag (GGBS). The use of Granulated Blast Furnace Slag (GBS) as substitute for natural sand in cement mortar and concrete has not been done in earlier work. The trial of GBS as substitute for natural sand for cement mortar and concrete is promising work. The use of GBS as substitute in high grade concrete will be challenging work.

Table No. 1. Physical Characteristics of Fine Aggregate

Sr. No.	Description	Sand / Fine Aggregate	
1	Identification	Sand	
2	General Description	Natural Sand	
3	Particle Shape	Rounded & Coarser	
4	Surface Texture	Rough	
5	Colour	Black	
6	Particle Size Distribution		
	Grading of Particle (I.S. Sieve)	Percentage Weight Retained	Percentage Finer
	80 mm	-	-
	40 mm	-	-
	20 mm	-	-
	10 mm	-	-
	4.75mm	0.32	87.6935
	2.36 mm	0.3	76.36
	1.18 mm	1.448	21.6979
	600 µ	0.268	11.5809
	300 µ	0.274	1.2374
	150 µ	0.018	0.5579
	Passing 150 micron	0.015	0
7	Fineness Modulus	4.008	
8	Specific gravity	2.67	
9	Absorption %	2.29%	

III. OBSERVATION AND DISCUSSION

1. As percentage substitution of GBS increases, the compressive strength of concrete has reduced.
2. The 7th day compressive strength of concrete of mix EM6 (100% GBS) is reduced by 44% when compared to mix EM1 (100% NS).
3. The 28th day compressive strength of concrete of mix EM6 (100% GBS) is reduced by 60% when compared to mix EM1 (100% NS).
4. The strength gaining as per age of the concrete is reasonable for EM1, EM2, EM3 mixes but the gain in strength is found very less for MN4, EM5 & EM6 (Refer fig. 4.26).
5. The substitution of GBS affects the workability resulting reduction in strength. The % substitution of GBS is high in EM5 & EM6 mixes whose compaction factor and compressive strength value is found low.

A] A small field experiment for plaster and brick work is carried out.
Plaster Work- A 300 Sq.ft wall selected for plastering with mortar 1:4 with 20% GBS substitution for sand. The w/c ratio for the mortar is 0.5.

Fig.1 Dry Mixing of mortar with GBS

Fig.2 Wet Mixing of mortar with GBS

Fig. 3 Finish Surface of plaster

2.Brick Work-4 inch thick brick masonry is constructed with 1:6 with w/c ratio 0.5.

1.No significant difference in dry mixing of GBS substituted mortar and regular mortar is observed.

2.The nature of wet mix of regular cement mortar & GBS substitution mortar is observed same.

Fig.4. 40% GBS substituted mortar used for Brick work

Due to substitution of GBS the concrete becomes under sand. The fines of GBS may be the reason for the under sand concrete. The deviation of strength of concrete due to GBS substitution has not observed.

Fig 5.Sand Concrete

Fig no. 5 Table Vibrating Machine

Fig No.6 Curing Of Cubes in Curing Tank

CONCLUSION

1. The substitution by Granulated blast furnace slag makes the fine aggregate more fine.
2. As percentage of Granulated blast furnace slag is increased, the fines modulus is reduced.

3. The % passing of F.A with 40% GBS substitution is in between Zone I & II. The gradation of F.A is observed nearer to Zone II. The profile of grading curve is also expectable.

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