Comparison of Blast Furnace Slag and Crushed stone as an Alternative of Natural Sand in Concrete

Harshwardhan M. Waware[1]

[1]*Lecturer, Dept. of Civil Engineering, PRP&T, Talegaon, India*

Abstract - *Construction Industry plays a crucial role in the economic development of any country. In India Construction industry is the second largest after agriculture, contributes about 11% in the GDP. Construction industry is directly related with the consumption of cement in the world. India is the second largest cement producer in the world after China. Sand is a major material used for preparation of mortar and concrete and plays a important role in mix design. Sand is required about two times the volume of cement used in concrete construction. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. As demand of natural sand is increasing day by day there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. In present study alternatives of natural sand, blast furnace slag and crushed stone were evaluated for their suitability of replacing natural sand for making concrete. Blast furnace slag as by–product, which is a non–biodegradable waste material from that only a small percentage of it is used by cement industries to manufacture cement; Crushed stone is formed by crushing the hard rock found in stone quarry in proper gradation to form the artificial sand .Concrete of M-25grades for 0%, 25%, 50%, 75% and 100% replacement cube were prepared respectively. From this study we compare Blast furnace slag and crushed stone for used as an alternative to natural sand up to 60% and 75% in concrete respectively.*

Key Words: Concrete, Natural sand, Blast furnace slag, compressive strength, crushed stone.

1.INTRODUCTION

Aggregate is the main constituent of concrete, occupying more than 70% of the concrete matrix. The global consumption of natural sand is very high, due to the extensive use of concrete. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. Increasing extraction of natural sand from river beds causing many problems, loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table etc. are few examples. In past decade variable cost of natural sand used as fine aggregate in concrete increased the cost of construction. In this situation research began for inexpensive and easily available alternative material to natural sand. (Jadhava and Kulkarni,2012). Khajuria and Siddique (2014) shows that the iron slag added to the concrete had greater strength than the plain concrete. Sudarvizhi and Ilangovan (2011) observed that upto 80% replacement, CS and FS can be effectively used as replacement for fine aggregate. Sankh et al. (2014) presents the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasize on the physical and mechanical properties and strength aspect on concrete. Nataraja et al. (2013) observed that GBFS could be utilized partially as alternative construction material for natural sand in mortar applications.

1.1 Materials

Cement-

The cement used was Portland Pozzolana cement (Ultratech). It was tested as per Indian standard specification IS: 4031 (part 10):1989.

Table -1: Properties of portland pozzolana cement

S. No.	Descriptions	Test Values	IS:4031 (part I):1989
1.	Fineness, Sieve analysis (%)	93.85	Min 90
2.	Setting time (min) Initial setting time: Final setting time:	 90 247	 30 min, Min 600 min, Max
3.	Soundness, Le-Chatelier method (mm)	3	10
4.	Compressive Strength (Mpa) After 3 days: After 7 days:	 16.85 28	 72 ± 1 h, Min 16 168 ± 2 h, Min 22

Fine Aggregate-
Locally available Wardha sand was tested for its suitability as fine aggregate as per IS: 383-1970. Results of the tests are as summarized in Table 2.

Table -2: Physical properties of natural sand

S. No.	Properties	Test Values	Range as per code IS: 383-1970
1.	Specific gravity	2.71	2.30-2.90
2.	Bulk density (kg/m^3)	1503	1280-1920
3.	Fineness modulus	2.83	2.10-3.20
4.	Water absorption (%)	1.32	0-8

Coarse Aggregate-
Well graded aggregates available at crusher stone nearby plant in Mardi road, Amravati was tested for its Suitability for this study as per IS: 383 -1970 (Reaffirmed 1997).

Table -3: Physical properties of coarse aggregate

S. No.	Properties	Test Values	Range as per code IS: 383-1970
1.	Aggregate Impact Value	14.40%	Not more than 45%
2.	Aggregate Abrasion Value	18.03%	Not more than 50%
3.	Aggregate Crushing Value	17.25%	Not more than 45%
4.	Fineness Modulus	6.54	5.50-8.00

Blast Furnace Slag-

The non-metallic product, consisting essentially of silicates and alumina silicates of calcium and of other bases that is developed in a molten condition simultaneously with iron in a blast furnace.

1. Air-cooled blast-furnace slag is the material resulting from solidification of molten blast-furnace slag under atmospheric conditions; subsequent cooling may be accelerated by application of water to the solidified surface.
2. Expanded blast-furnace slag is the lightweight, cellular material obtained by controlled processing of molten blast furnace slag with water, or water and other agents, such as steam or compressed air, or both.
3. Blast-furnace slag is the glassy granular material formed when molten blast-furnace slag is rapidly chilled, as by immersion in water .

Blast furnace slag (4.75mm to 75 micron) was collected from Jadhao Steel Plant located at Amravati, Maharashtra for replacement to natural sand. The physical properties of blast furnace slag is shown in Table 4.

Table -4: Physical properties of blast furnace slag

S. No.	Properties	Test Values	Range as per code IS: 383-1970
1.	Specific gravity	2.73	2.30-2.90
2.	Bulk density (kg/m^3)	1305	1280-1920
3.	Fineness modulus	2.40	2.10-3.20
4.	Water absorption (%)	1.62	0-8

Crushed stone –

The raw material is fed regularly by the vibrating feeder to the primary jaw and secondary jaw/cone crusher for crushing. The crushed material is then transported by belt conveyor to the following vibrating screen for separation. Proper sizes (usually there would be an upper limit for different model of sand making machinery) would be transported to the sand making machine directly, while unrequired materials will be returned to the secondary jaw/cone crusher for repeated crushing until getting required sizes. The crushed material from the sand making machine will be transported to/ returned to the vibrating screen for final separation. Required sand size product would be returned to the sand washing machine for clearance, and then retained as final product. Unrequested product will be returned to the sand making machine for repeated crushing until getting all required size.

Table -5: Physical properties of crushed stone

S. No.	Properties	Test Values	Range as per code IS: 383-1970
1.	Specific gravity	2.52	2.30-2.90
2.	Bulk density (kg/m^3)	1750	1280-1920
3.	Fineness modulus	2.84	2.10-3.20
4.	Water absorption (%)	2.5	0-8

2. OBJECTIVES

1. To study the effect of partially replace fine aggregates with blast furnace slag and crushed stone and find its effect on the strength characteristics of concrete.
2. Study of strength properties of concrete at the ages 7 and 28 days for 0%, 25%, 50%, 75% and 100% replacement of natural sand.
3. Comparative study of strength properties results of both the Artificial sand for M25 grade of concrete containing natural sand and blast furnace slag as well as natural sand and blast furnace slag.
4. Compare the result of replacement of blast furnace slag and crushed stone.

3. COMPRESSIVE STRENGTH OF CONCRETE WITH NATURAL SAND REPLACEMENT BY BLAST FURNACE SLAG

Standard mix proportions for commonly used M-25 grade concrete were selected. Standard concrete cube of 15 cm were prepare with natural sand and their 7 and 28 days strength was determined. Table 6 shows the compressive strength of M-25 Grade concrete after 7 and 28 days. This compressive strength was compared with the compressive strength of cubes prepared with the blast furnace slag..

Table -6: Comparison of Compressive strength of natural sand with blast furnace slag

Replacement (%)	W/C ratio	Slump (mm)	Compressive strength at 7 days (N/mm²)	Compressive strength at 28 days (N/mm²)
0% BFS + 100% NS	0.45	75	25.25	31.93
25% BFS + 75% NS	0.45	45	18.70	22.73
50% BFS + 50% NS	0.45	30	16.10	21.0
75% BFS + 25% NS	0.45	50	34.84	33.64
100% BFS + 0% NS	0.45	60	16.77	36.59

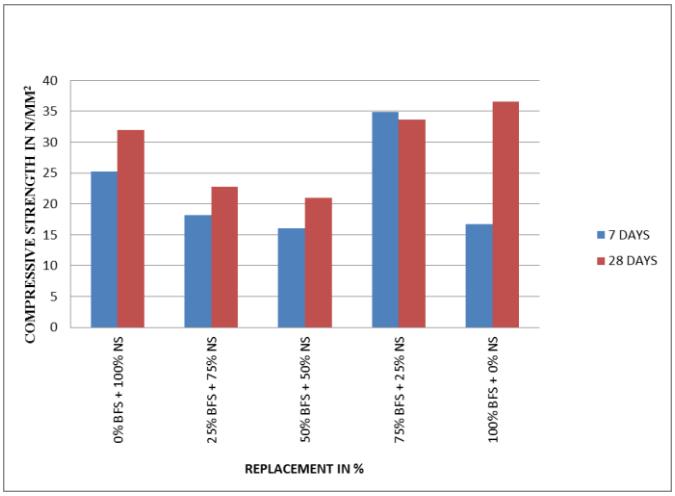

Chart -1: Comparison of compressive strength of natural sand and blast furnace slag

REPLACEMENT BY CRUSHED STONE

Standard mix proportions for commonly used M-25 grade concrete were selected. Standard concrete cube of 15 cm were prepare with natural sand and their 7 and 28 days strength was determined. Table 4.13 shows the compressive strength of M-25grade concrete after 7 and 28 days. This compressive strength was compared with the compressive strength of cubes prepared with crushed stone.

Table -7: Comparison of compressive strength of natural sand and crushed stone

Replacement (%)	W/C ratio	Slump (mm)	Compressive strength at 7 days (N/mm²)	Compressive strength at 28 days (N/mm²)
0% CS + 100% NS	0.45	75	25.25	31.93
25% CS + 75% NS	0.45	45	24.47	36
50% CS + 50% NS	0.45	50	22.285	33.66
75% CS + 25% NS	0.45	75	18.25	31.84
100% CS + 0% NS	0.45	35	14.34	17.51

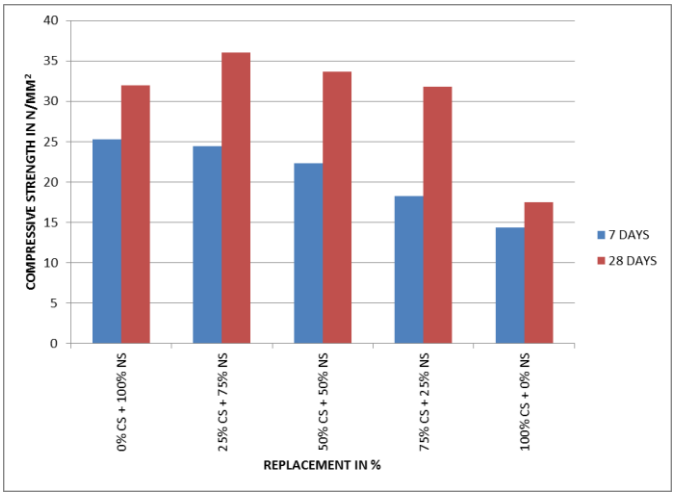

Chart -2: Comparison of compressive strength of natural sand and crushed stone

COMPARISON OF COMPRESSIVE STRENGTH OF BFS AND CS

The compressive strength of the concrete was determined in accordance with Indian Standards, To find compressive strength 40 cubes of size 150 x 150 x150 mm for each of eight mixes were casted. The cube specimens were tested under uniaxial compression. The average compressive strength results are reported at the age of 7 days and 28 days of both blast furnace slag and crushed stone in Table no.6,7

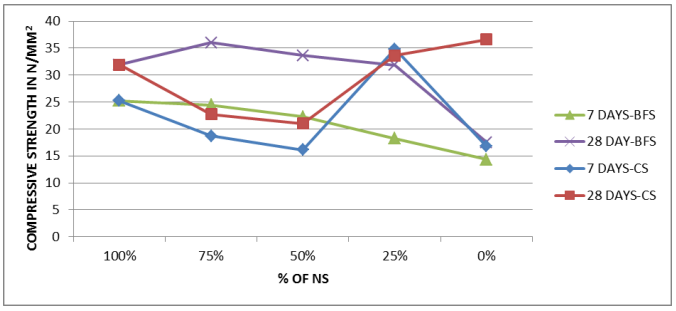

Chart -3: Comparison of compressive strength of blast furnace slag and crushed stone

4. CONCLUSIONS

1. Using of blast furnace slag as a replacement of fine aggregate will might prove an economical and environmentally friendly solution.
2. Chemical Composition with respect to Silica, Aluminum, Oxygen, Calcium and magnesium are nearest to normal sand in Blast furnace slag.
3. At 100% replacement of natural sand by crushed stone, compressive strength get increases when compared with the cube prepared with 100% blast furnace slag.
4. Blast furnace slag can be used as alternative of fine aggregates in making concrete up to 75% replacement, which reduces the consumption of natural sand.
5. When blast furnace slag was examined as replacement of natural sand for making concrete, compressive strength of cubes (28 days) is comparable with that of the cubes prepared with natural sand up to 75% replacement. Beyond this, compressive strength decreases with increase in the replacement.
6. At 25% replacement of natural sand by blast furnace slag and crushed stone gives better result. Beyond this, compressive strength decrease with increase in the replacement.

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