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# An Experimental Investigation on Utilization of Waste Foundry Sand and Granulated Blast Furnace Slag as Partial Replacement to Sand in Fly Ash Bricks

H A Vijaya Kumar
[*] *Assistant Professor, Department of Civil Engineering, Government Engineering College, Hassan.*

***Abstract***
*In the present study Fly ash procured from the local thermal power plant, the industrial wastes like waste foundry sand (WFS) from Naetek Ferro castings PVT LTD, Shimoga and Granulated Blast Furnace Slag (GBFS) from VISL, Bhadravathi were used in the manufacture of fly ash bricks. Three different types of fly ash bricks were produced among which the conventional one was manufactured using only sand as fine aggregate. The other two types of bricks were manufactured by replacing natural river sand partially with the waste foundry sand upto 50% by weight and then with the granulated blast furnace slag upto 60%. In both these types, the fly ash and cement quantities were kept the same. All the three types of bricks with varying percentage of sand were tested for various properties at various curing periods.*

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## I. INTRODUCTION

1.1: GENERAL In India around 960 tons of solid waste is being generated annually as byproduct from industrial, mining, agricultural and other processes. Out of these 960 million tons, around 360 million tons are organic, 290 million tons are inorganic and 4.5 tons are hazardous in nature. In order to safeguard the environment from the effects of these wastes several efforts are being made for recycling these industrial wastes and to utilize them in value added applications. The iron and steel industry in India is on an upswing because of the strong and global and domestic demand. India is the fourth largest producer of crude steel and the largest producer of sponge iron in the world as per July 2014 report. Steel Authority of India Limited is one of the largest state owned steel making companies based in New Delhi, India and one of the top steel makers in the world. It owns 5 integrated steel plants at Rourkela, Bhilai, Durgapur, Bokaro, Burnpur and 3 special steel plants at Salem, Durgapur and Bhadravathi. Blast Furnace Slag is formed when iron ore or iron pellets, coke and a flux (either limestone or dolomite) are melted together in a blast furnace. During the period of cooling and hardening from its molten state, Blast furnace slag can be cooled in several ways to form any of several types of Blast furnace slag products. Granulated slag is obtained by rapidly cooling the blast furnace slag by large quantity of water. The foundry sand is obtained from the metal casting industries as a waste which has been used several times for molding purpose.

**AIM AND OBJECTIVES**

- The main aim of this work is to examine the utilization potential of industrial wastes as alternative raw materials to sand in the production of fly ash bricks.
- To fix up the proportion of materials which would result in the production of economical fly ash bricks.
- To study the effect of replacement of sand with WFS and GBFS on the properties of Fly ash bricks.
- To determine the replacement level of sand with the industrial waste which corresponds to the maximum compressive strength.
- To compare the results of tests on the fly ash bricks made with sand partially replaced by WFS and those with sand replaced partially by granulated blast furnace slag with the results of the fly ash bricks made with zero replacement of Sand.

**AVAILABLE SIZES OF FLY ASH BRICKS**

The fly ash bricks are available in different sizes. The following are some of the sizes of fly ash bricks.

- 230×150×80 mm
- 230×150×100 mm
- 230×110×75 mm

- 230×110×100 mm

**COMPARISON BETWEEN FLY ASH BRICKS AND BURNT CLAY BRICKS**

| Sl No | Properties | Fly ash bricks | Burnt clay bricks |
|---|---|---|---|
| 1 | Color | Dark grey  | Red  |
| 2 | Density | 1700-1850 kg/m³ | 1600-1750 kg/m³ |
| 3 | Compressive strength | 90-100 kg/cm² | 30-35 kg/cm² |
| 4 | Absorption | 10-14% | 15-20% |
| 5 | Dimensional stability | High tolerance | Very low tolerance |
| 6 | Wastage during transit | Less than 2% | Up to 10% |
| 7 | Plastering | Even on both sides | Thickness vary on both sides of wall |

**EXPERIMENTAL METHODOLOGY**

**GENERAL**

This chapter deals with the development process of making fly ash bricks with the use of different industrial wastes as sand substitute and the best procedure adopted to evaluate the properties of these bricks.

**MATERIALS USED IN THE PRESENT WORK**

- ***Binder***
  - Cement(OPC 43 grade)
  - Fly ash
- ***Fine aggregates***
  - Sand
  - Waste foundry sand
  - Granulated Blast Furnace slag
- **Water**

**BINDER**

In the present study OPC was used in combination with the fly ash. Both fly ash and cement were tested for their physical properties.

**CEMENT**

TESTS ON CEMENT (IS: 4031-1988)

The cement is tested as per IS:4031-1988 and the test results are tabulated in table . For this experimental study the cement used was Zuari OPC 43 grade.

**FLY ASH**

**TESTS ON FLY ASH (as per IS: 4031-1988)**

The fly ash was tested as per IS: 4031-1988. The Fly ash confirmed to the requirements of IS: 3812. The test results are tabulated in table 4.3. Class F fly ash was used in the present work

**Plate..1. Fly ash**

**Physical Properties of Zuari 43 grade Cement**

| Sl. No. | PROPERTY | VALUES OBTAINED | REQUIREMENS AS PER IS. 8112: 1989 |
|---|---|---|---|
| 1 | Consistency (%)<br>(as per IS 4031, Part 4, 1988) | 32 | No standard value. |
| 2 | Setting Time<br>(as per IS: 4031, Part 5, 1988)<br>(minutes)<br>a. Initial<br>b. Final | <br><br><br>167<br>252 | <br><br><br>Minimum 30 minutes<br>Maximum 600 minutes |
| S3 | Fines retained in IS. 90 micron sieve (as per IS: 4031, Part 1– 1988)<br>(% by weight) | 2.5 | Not more than 10 percent. |
| 4 | Specific Gravity<br>(as per IS: 4031, Part 2- 1988) | 3.15 | No standard value. |
| 5 | Soundness by Le-Chatelier's method<br>(As per IS: 4031, Part 3- 1988)<br>(mm) | 1.5 | Not more than 10 mm. |
| 6 | Compressive Strength of cement (As per IS 4031, Part 6- 1988)<br>($N/mm^2$) | 3 days: 22.53<br>7 days: 34.20<br>28 days: 46.27 | Minimum 43 $N/mm^2$ after 28 days of curing |

**Physical Properties of Class F Fly ash**

| SL NO. | PROPERTY | VALUES OBTAINED |
|---|---|---|
| 1 | Particle size | 90 Microns |
| 2 | Specific gravity | 2.10 |
| 3 | Colour | Dark grey |

**Chemical Composition of Class F Fly ash**

| CONSTITUENT | VALUE (%) |
|---|---|
| Silicon Dioxide | 55.3 |
| Aluminum Oxide | 25.70 |
| Ferric Oxide | 5.3 |
| SiO2+Al203+Fe203 | 85.9 |

| | |
|---|---|
| Calcium Oxide | 5.6 |
| Magnesium Oxide | 2.1 |
| Titanium Oxide | 1.3 |
| Potassium Oxide | 0.6 |
| Sodium Oxide | 0.4 |
| Sulfur Trioxide | 1.4 |
| Loss on ignition (1000º C) | 1.9 |
| Moisture | 0.3 |

**FINE AGGREGATES**

The fine aggregates used in the present work are locally available Natural Sand, Waste foundry sand and Granulated blast furnace slag.

**SAND**

**TESTS ON SAND (as per IS: 2386-1963)**

The locally available sand was used in the present work and was tested as per IS: 2386-1963 which confirmed to Zone II as per IS:383-1970.The results of the tests on sand are tabulated in table 4.4.

**Physical Properties of Natural Sand**

| SL NO. | PROPERTY | UNIT | VALUES OBTAINED |
|---|---|---|---|
| 1 | Bulking of sand (as per IS: 2386-Part 3 , 1963) | % | 32 |
| 2 | Loose bulk density of sand (as per IS:2386-Part 3,1963) | kg/m³ | 1748 |
| 3 | Rodded bulk density of sand (as per IS:2386-Part 3, 1963) | kg/m³ | 1872 |
| 4 | Fineness modulus (as per IS:2386-Part 1,1963) | % | 2.80 |
| 5 | Specific gravity of sand (as per IS:2386-Part 3,1963) | - | 2.66 |
| 6 | Percentage voids for loose sand (as per IS:2386-Part 3,1963) | | 0.342 |
| 7 | Percentage voids for rodded sand (as per IS:2386-Part 3,1963) | | 0.296 |
| 8 | Zone | | II |

**Table.4.5. Sieve analysis test results of Natural Sand**

| | Weight retained (kg) | Percentage weight retained | Cumulative percentage weight retained (w) | Percentage passing (100-w) |
|---|---|---|---|---|
| 4.75 | 0.037 | 3.7 | 3.7 | 96.3 |
| 2.36 | 0.087 | 8.7 | 12.4 | 87.6 |
| 1.18 | 0.161 | 16.1 | 28.5 | 71.5 |
| 0.6 | 0.310 | 31.0 | 59.5 | 40.5 |
| 0.3 | 0.280 | 28.0 | 87.5 | 12.5 |
| 0.15 | 0.080 | 8.0 | 95.5 | 4.5 |
| Pan | 0.045 | 4.5 | 100 | 0 |

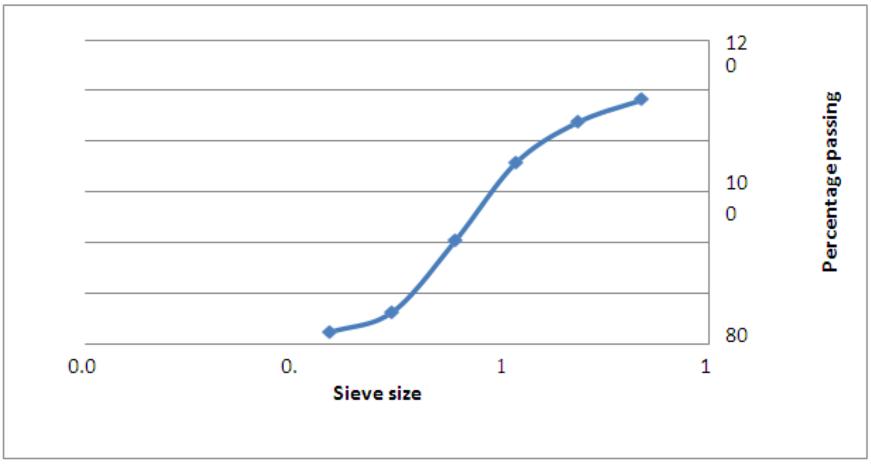



**Fig.. Grain Size Distribution curve for Natural Sand**
**Sieve analysis test results of WFS**

| Sieve size (mm) | Weight retained (kg) | Percentage weight retained | Cumulative percentage weight retained (w) | Percentage passing (100-w) |
|---|---|---|---|---|
| 4.75 | 0.001 | 0.1 | 0.1 | 99.9 |
| 2.36 | 0.007 | 0.7 | 0.8 | 99.2 |
| 1.18 | 0.015 | 1.5 | 2.3 | 97.7 |
| 0.6 | 0.087 | 8.7 | 11 | 89 |
| 0.3 | 0.392 | 39.2 | 50.2 | 49.8 |
| 0.15 | 0.348 | 34.2 | 85 | 15 |
| Pan | 0.150 | 15.0 | 100 | 0 |

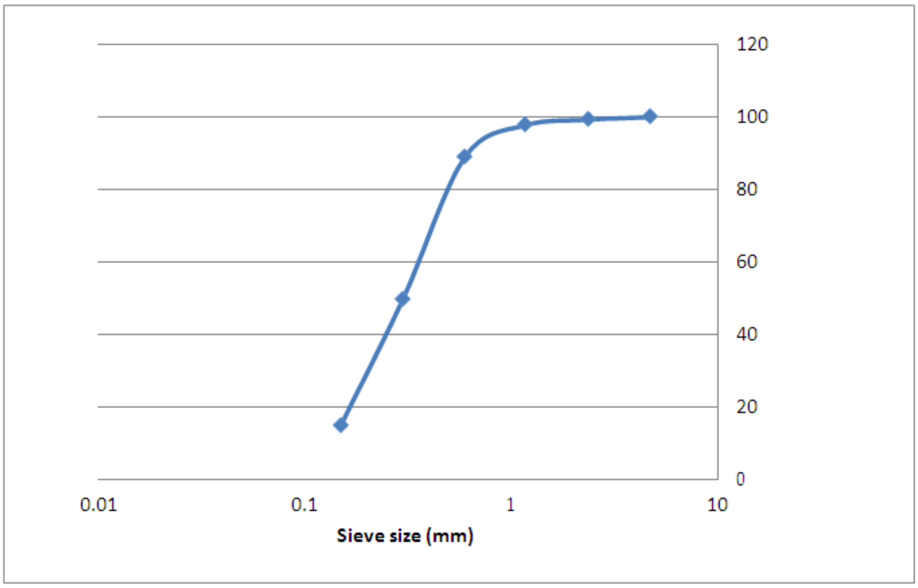
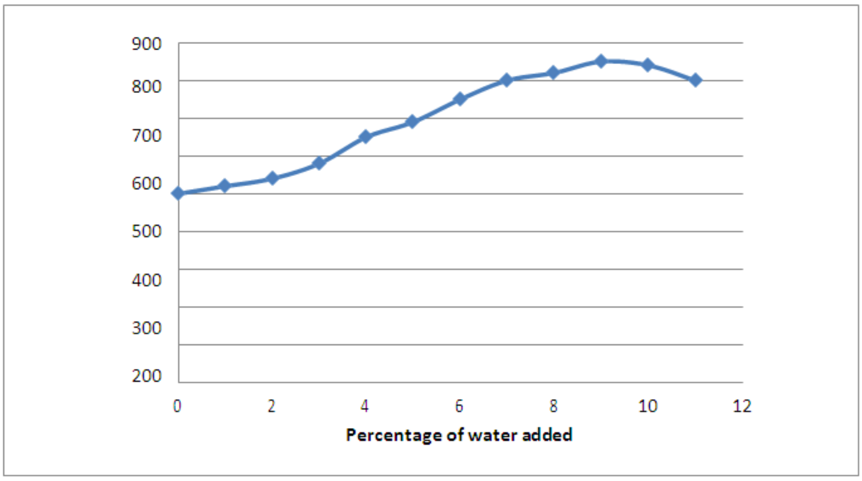
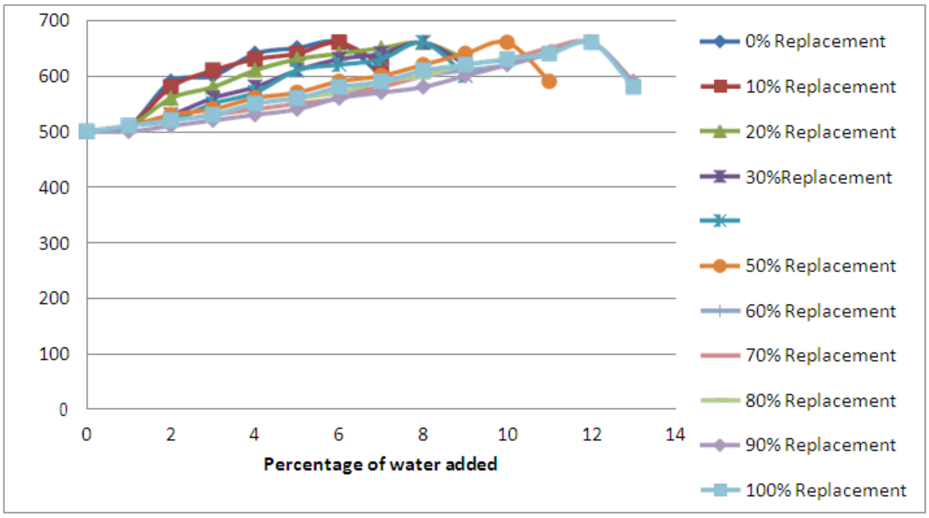



**Table Bulking test results of WFS**

| Percentage of water added | Volume of water added (ml) | Volume of foundry sand (ml) |
|---|---|---|
| 0 | 0 | 500 |
| 1 | 5 | 520 |
| 2 | 10 | 540 |
| 3 | 15 | 580 |
| 4 | 20 | 650 |
| 5 | 25 | 690 |
| 6 | 30 | 750 |
| 7 | 35 | 800 |
| 8 | 40 | 820 |
| 9 | 45 | 850 |
| 10 | 50 | 840 |
| 11 | 55 | 800 |




**Bulking curve for various replacement levels of NS with GBFS**




## II. CONCLUSION

Based on the above study the following conclusions are drawn,

- WFS and GBFS fulfill the basics properties of fine aggregates, hence can be used as a Sand substitute in Fly ash bricks.
- The Dry as well as Wet Compressive Strengths increase with increase in the replacement level of Sand by WFS and GBFS up to 40% and 50% respectively as compared to conventional Fly ash brick.
- The Water absorption of bricks decrease with increase in the percentage replacement of Sand by WFS and increase with the increase in the replacement of Sand by GBFS.
- The density of Fly ash bricks decrease with increase in the replacement of Sand by WFS as well as by GBFS.
- The IRA of Fly ash bricks increase with the increase in the replacement of Sand by WFS as well as by GBFS.
- The Fly ash bricks have good dimensional stability and the results of the dimensionality test are well within the limits.