# Effect of waste water on GGBS based Concrete

Elisha D. Shinde[1], Shashir N. Daule[2]

[1]Student, Department of civil Engineering, PDVVP COE, Ahmednagar, Maharashtra, India

[2]Associate Professor, Department of civil Engineering, PDVVP COE, Ahmednagar, Maharashtra, India

## ABSTRACT

*Water is life. This is a great statement that's really true. In the present scenario, as a result of continuous growth in population, rapid industrialization and the accompanying technologies involving waste disposal, the rate of discharge of pollutants into the atmosphere and water are done on large scale. Hence this natural resources are being polluted. So there are two issues which are to be seriously considered. First is the use of this waste material given out from the industries eg. Copper slag, GGBS etc. And the second is the use of polluted water. Various treatment methods are invented to purify this water. But if this water is used in construction industry it would be a great thing. The water is used on a large scale in construction, especially for casting concrete. So if this water is used for casting concrete containing waste material. It would be a good thing. This paper is based on GGBS based concrete casted with the sewage water.*

**Keywords:** *Concrete, Carbon Dioxide, GGBS, Tap Water, Waste water, Strength, partial replacement of cement.*

## 1. INTRODUCTION

Concrete is one of the world's most used construction material due to its availability, durability and economy. India uses about 7.25 million cubic meters of ready-mixed concrete every year. It finds applications in highways, tunnels, bridges, high-rise buildings, dams etc. Greenhouse gas like CO2 causes global warming and it leads to about 65% of global warming. The global cement industry emits about 7% of greenhouse gas to the earth's atmosphere. To minimize this environmental impact alternative binding material are introduced to make concrete.

Ground Granulated Blast Furnace Slag is a by-product of iron and steel-making industries obtained from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. As it possess same chemical composition as that of ordinary Portland cement with little variation in its proportion, hence it can be used as a partial replacement for cement in concrete. In this study, finely powdered Ground Granulated Blast Furnace Slag is used as a partial replacement of cement in concrete production, casted by using two water samples, obtained from municipal corporation from water treatment plant. And other sample is waste water obtained from Sina river. Concrete mixtures were casted for different proportions of GGBS ranging from 10 % to 50% with an increment of 10 % and casted for two water samples, tested for compressive strength, Tensile, and Flexural strength and Pull – out strength after 7, 28 days of curing.

## 2. MATERIAL USED

**2.1 Cement:** Ordinary Portland Cement of 53 grade confirming to IS 8112-1989.

**2.2 Fine aggregate:** Locally available sand confirming to zone II with specific gravity 2.66 was used. The test on sand was conducted as per Indian Standard Specification IS: 383-1970.

**2.3 Coarse aggregate:** Coarse aggregate used was 20 mm and less size and specific gravity 2.70. Tests on coarse aggregate was conducted as per Indian Standard Specification IS: 383-1970.

**2.4 GGBS :** In this experiments cement was partially replaced by GGBS having particle size less than 75 micron was used. Physical and Chemical properties are tabulated as follows:

**Table 1**: Physical Properties of GGBS

| Sr. No. | Physical Property of GGBS | Value |
|---|---|---|
| 1 | Specific Gravity | 2.43 |
| 2 | Colour | Off – White |
| 3 | pH | 8.5 |

**Table 2:** Chemical composition of GGBS

| Sr. No. | Composition | Percentage (%) |
|---|---|---|
| 1 | CaO | 30-50 |
| 2 | $SiO_2$ | 28 – 38 |
| 3 | $Al_2O_3$ | 8 – 24 |
| 4 | MgO | 1 – 18 |
| 5 | $Fe_2O_3$ | 0.9 – 1.2 |

**2.5 Water :**

Sample 1 - The water used was potable, colourless and odourless that is free from organic impurities of any type (Tap Water)

Sample 2 - The water used was waste water obtained from natural stream polluted due waste discharged into it.

**Table 3:** : Properties of Waste Water

| Sr. No. | Property of Water | Value |
|---|---|---|
| 1 | Hardness | 712 ppm |
| 2 | Alkalinity | 620 ppm |
| 3 | Chloride Content | 157.27 ppm |
| 4 | Total Dissolved Solids | 166 mg/lit. |
| 5 | Dissolved Solids | 90 mg/lit. |
| 6 | Suspended Solids | 56 mg/lit. |
| 7 | Volatile Solids | 20 mg/lit. |
| 8 | BOD | 130 mg/lit |
| 9 | COD | 192 mg/lit |
| 10 | Sludge Volume Index | 178.57 |

## 3. EXPERIMENTAL WORK

**3.1 Mix Design:** Mix design carried out for M35 grade of concrete by IS 10262:2009, having mix proportion of 1:1.52:2.04 with water cement ratio of 0.42. The partial replacement of cement by 10 % to 50 % at an increment of 10% each. Chemical admixtures are not used in the work.

**3.2 Preparation of Specimens :**

| Sr. No. | Properties studied | Specimen shape | Sizes of specimens (mm) |
|---|---|---|---|
| 1 | Compressive strength | Cube | 150×150×150 |
| 2 | Flexural strength | Beams | 100×100×500 |
| 3 | Split tensile strength | Cylinders | 150×300 |
| 4 | Pull out Strength | Cube | 150×150×150 |
| 5 | Water absorption test | Cube | 150×150×150 |

## 4. TEST RESULTS AND DISCUSSION

### 4.1 Compressive Strength

According to IS: 516:1959 for the compression test the cubes of size 150 mm x 150 mm x 150 mm (According to IS: 10086-1982) are placed in machine in such a manner that the load is applied on the forces perpendicular to the direction of cast. The rate of loading is gradual and failure (crushing) load is noted.Specimens

were prepared by partially replacing cement by GGBS, percentage variation from 10% to 15% with an increment of 10% each and casted by using two water samples.
Following table shows the compressive strength for all proportions after 28 days.

**Table 4**: Results of Compressive Strength of concrete with partial replacement of cement by GGBS casted by using two water samples

| Mix Notation | % replacement of cement by GGBS | Compressive Strength in MPa ( 7 Days ) | |
|---|---|---|---|
| | | Tap Water | Waste Water |
| A2 | 0 | 28.78 | - |
| A10 & B10 | 10 | 29.271 | 30.55 |
| A20 & B20 | 20 | 31.056 | 39.87 |
| A30 & B30 | 30 | 35.88 | 34.72 |
| A40 & B40 | 40 | 32.57 | 29.02 |
| A50 & B50 | 50 | 31.97 | 28.30 |

**4.2 Flexural strength**

All beams of size 100 mm X 100 mm X 500 mm were cured for 28 days and tested under two-point loading in beam reaction appratus. The load as increased until the specimen failed and the failure load is recorded. The test results obtained are as follows:

**Table 5**: Results of Flexural Strength of concrete with partial replacement of cement by GGBS casted by using two water samples

| Mix Notation | % Replacement of cement by GGBS | Flexural Strength in MPa ( 28 Days ) | |
|---|---|---|---|
| | | Tap Water | Waste Water |
| A2 | 0 | 4.46 | - |
| A10 & B10 | 10 | 4.31 | 4.25 |
| A20 & B20 | 20 | 4.36 | 4.58 |
| A30 & B30 | 30 | 3.96 | 4.336 |
| A40 & B40 | 40 | 4.16 | 4.01 |
| A50 & B50 | 50 | 3.88 | 3.92 |

**4.3 Split Tensile Strength**

Split tensile strength of cylinder specimens is determined by placing between the two plates of Compression Testing Machine, Plywood strips of 3 mm thick, 25 mm wide and 300 mm long, were placed between the plates and surface of the concrete specimens. Following table shows the Split Tensile strength for all proportions after 28 days.

**Table 6**: Results of Split Tensile Strength of concrete with partial replacement of cement by GGBS casted by using two water samples

| Mix Notation | % Replacement of cement by GGBS | Spilt Tensile Strength in MPa ( 28 Days ) | |
|---|---|---|---|
| | | Tap Water | Waste Water |
| A2 & A2W | 0 | 4.16 | - |
| A10 & B10 | 10 | 4.341 | 3.60 |
| A20 & B20 | 20 | 4.78 | 4.286 |
| A30 & B30 | 30 | 4.68 | 3.92 |
| A40 & B40 | 40 | 4.19 | 3.68 |
| A50 & B50 | 50 | 3.78 | 3.25 |

**4.4 Pull Out Test**

Specimens are prepared by filling the concrete of M35 grade in mould having internal dimensions 150 mm × 150 mm × 150 mm and mild steel or TMT bar is inserted at the center of specimen. Specimens are cured for 28 days and tested in UTM. Pull out test results obtained are given as follows:

**Table 7**: Results of Pull Out Test of concrete block with partial replacement of cement by GGBS casted by using two water samples

| Mix Notation | % Replacement of cement by GGBS | Pull - out Strength in MPa ( 28 Days ) | |
|---|---|---|---|
| | | Tap Water | Waste Water |
| A2 | 0 | 9.16 | - |
| A10 & B10 | 10 | 9.18 | 9.59 |
| A20 & B20 | 20 | 8.98 | 8.77 |
| A30 & B30 | 30 | 8.91 | 8.84 |
| A40 & B40 | 40 | 8.64 | 7.82 |
| A50 & B50 | 50 | 7.14 | 6.053 |

**4.5 Alkalinity Test**

For conducting the alkalinity test specimen are taken out from curing tank after 28 days of curing. Then oven dried the specimens at 105°C for 24 hours. Mortar was separated from the dry concrete by breaking down the dry specimen. Then the mortar was grinded into powder form. The powdered mortar sieved in 90µ.10gm of mortar taken and it was diluted in 50ml distilled water and stirred it completely. Then immersed the pH meter into the solution and pH value of the solution noted.

**Table 8**: Results of Alkalinity Test of concrete with partial replacement of cement by GGBS casted by using two water samples

| Mix Notation | % Replacement of cement by GGBS | PH Value (pH Paper) | |
|---|---|---|---|
| | | Tap Water | Waste Water |
| A2 | 0% | 9.96 | |
| A10 & B10 | 10% | 9.83 | 10.53 |
| A20 & B20 | 20% | 9.24 | 10.34 |
| A30 & B30 | 30% | 9.54 | 10.41 |
| A40 & B40 | 40% | 9.76 | 10.73 |
| A50 & B50 | 50% | 10.03 | 10.58 |

**4.6 Water Absorption (Porosity) Test**

Water absorption test or the porosity test was carried to find out the percentage water absorption. The test results obtained are as follows:

**Table 9**: Results of Porosity Test of concrete with partial replacement of cement by GGBS casted by using tap water

| Mix Notation | % replacement of cement by GGBS | Wet Weight (gm) | Dry Weight (gm) | Water Absorbed (gm) | % water Absorption |
|---|---|---|---|---|---|
| A2 | 0 % | 8.86 | 8.51 | 0.35 | 4.16 |

| | | | | | |
|---|---|---|---|---|---|
| A10 | 10 % | 8.48 | 8.096 | 0.384 | 4.825 |
| A20 | 20 % | 8.403 | 8.057 | 0.346 | 4.29 |
| A30 | 30 % | 8.58 | 8.25 | 0.33 | 4.005 |
| A40 | 40 % | 8.34 | 8.01 | 0.33 | 4.185 |
| A50 | 50 % | 8.903 | 8.558 | 0.345 | 4.033 |

**Table 10**: Results of Porosity Test of concrete with partial replacement of cement by GGBS casted by using Waste water

| Mix Notation | % replacement of cement by GGBS | Wet Weight (gm) | Dry Weight (gm) | Water Absorbed (gm) | % water Absorption |
|---|---|---|---|---|---|
| A10 | 10 % | 8.219 | 8.113 | 0.106 | 4.03 |
| A20 | 20 % | 8.60 | 8.27 | 0.33 | 4.234 |
| A30 | 30 % | 8.65 | 8.288 | 0361 | 4.439 |
| A40 | 40 % | 8.63 | 8.243 | 0.387 | 4.73 |
| A50 | 50 % | 8.43 | 8.00 | 0.489 | 5.30 |

### 4.7 Carbonation Test:

This test is carried out to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. A spray of 0.2% solution of phenolphthalein is used as pH indicator of concrete. The change of colour of concrete to pink indicates that the concrete is in good health, where no change in colour takes place, it is suggestive of carbonation affected concrete.

**Table 11**: Results of Carbonation Test of concrete with partial replacement of cement by GGBS casted by using Tap water and Waste Water

| % replacement of cement by GGBS | Tap Water Concrete cube Sample | Waste Water Concrete cube Sample | Remark |
|---|---|---|---|
| 10 % | Color changed to pink | Color changed to pink | Concrete is in good condition |
| 20 % | Color changed to pink | Color changed to pink | |
| 30 % | Color changed to pink | Color changed to pink | |
| 40 % | Color changed to pink | Color changed to pink | |
| 50 % | Color changed to pink | Color changed to pink | |

## 5. CONCLUSIONS

Based on experimental observations, following conclusions can be drawn:

1) GGBS in concrete increases the compressive, flexural, split tensile, and pull out strength effectively as compared with conventional concrete. Results are good for 30% replacement of GGBS in case of tap water.
2) In case of waste water casted concrete partially replaced by GGBS, 20% replacement showed good values as compared to conventional concrete.
3) In case of alkalinity test, the PH of concrete after 28 days are, 8.5 in case of tap water casted concrete. But in case of waste water casted concrete PH increases to 10.5. As there is alkaline environment in concrete, hence no corrosion of reinforcement will occur for reinforcement.
4) For porosity test, percentage water absorption is less for GGBS based concrete as compared to conventional concrete.
5) For Carbonation test, there is no any effect of atmospheric carbon dioxide on concrete.

6) Use of GGBS along with waste water in concrete will reduce the disposal problem of GGBS and water and prove to be environment friendly.

## 7. REFERENCES

[1]. Huiwen Wan, Zhonghe Shui, Zongshou Lin, "Analysis of geometric characteristics of GGBS and their influences on cement properties" Cement and Concrete research 34 (2004) 133-137

[2] Folarin T. Olorunsogo· and Peter J. Wainwrighe," Effect of GGBFS Particle-Size Distribution on Mortar Compressive Strength", ASCE

[3] W. C Jau, D, S, Tsay, A study of the basic engineering properties of slag cement concrete and its resistance to seawater corrosion, Cem. Concr. Res, 28 (10) (1998) 1363 – 1371

[4] K. Tan X. Pu, Strengthing, Effect of finely ground fly ash, granulated blast furnace slag, and their combination, Cem. Concr. Res. 28 (12) (1998) 1819 - 1826

[5] Mehta P K. Pozzolanic and cementitious by-products as mineral admixtures for concrete – a critical review, SP–79 ACI; 1983 P. 1-48

[6] Malhotra V M, Mehta P K. Pozzolanic and cementitious materials. Advances in concrete Technology. London; Gordon and Breach; 1996

[7] Roy D M, Idorn G M. Hydration, structure, and properties of blast – furnace slag cements, mortars, and concrete. J Am Concrete Inst. 1982; 79:445-57

[8] Ganesh Babu K, Sree Rama Kumar V, Efficiency of GGBS in concrete, Cement Concrete Res. 2000;1031-6

[9] ACI Committee 233. Ground granulated blast-furnace slag as a cementitious constituent in concrete, ACI 233R-95, American Concrete Institute; 1995

[10] N Nakamura, M Sakai, R.N. Swamy, Effect of slag fineness on the development of concrete strength and microstructure, ACI SP 132, Detroit (1992) 1343-1365

[11] J. W. Meusel, J.H. Rose, Production of Granulated blast furnace slag at sparrows point and the workability and strength potential of concrete incorporating the slag, ACI SP 79, Detroit (1983) 867-890

[12] Indian Standard code of practice for plain and Reinforced Concrete, IS456:2000, Bureaue of Indian Standards, New Delhi.

[13] M.S.Shetty, "Concrete Technology Theory and Practice" (S.Chand and Company Ltd.New Delhi, 2006)

[14 ]Method of tests for strength of concrete, IS 516:1959, Bureau of Indian Standards, New Delhi.

[15] Splitting tensile strength concrete method of test, IS5816:1999, Bureau of Indian Standards, New Delhi.

[16] Recommended guidelines of concrete mix design, IS 10262:1982, Bureau of Indian Standards, New Delhi.