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Effect of Simultaneous Replacement of Cement with Ground Granulated Blast Furnace Slag (GGBS) and Sand with Quarry Dust in Concrete

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***Abstract*— India is developing at a rapid rate with a result that demand for engineering materials is far more than the current pace of construction. With growing standards of living and the presence of multinationals in India, the expectations on quantity and quality have also increased. This has led to adaption of partial or full replacement materials in construction which reduces the consumption of the engineering materials and also increases the usage of eco-friendly materials which are meant to be the waste or end products of various industries like GGBS and fly-ash, thereby imparting them into the replacement genre of cement and increasing the efficiency of construction. All high -raised and eco-friendly buildings include these replacement materials on par with cement in order to have high strength characteristics. Now-a-days the green rating systems in India (like IGBC) and other parts of the world has given credits for using these eco-friendly materials which can be used as a partial replacement materials, one of such kinds are GGBS and Quarry dust .**

Keywords—GGBS; Quarry Dust; Compressive Strength; Tensile Strength

I. INTRODUCTION

Concrete is the mostly used construction material in the world. Due to its high structural stability, strength and specialty of being cast in any attractive shape, it has replaced stone and brick masonry. Cement replacement materials can partially replace Portland cement to some extent. GGBS is used to replace the ordinary Portland cement used in concrete and it improve the durability of concrete. The Construction industry and the engineering professionals have witnessed fundamental changes over the recent years in the promotion of environmentally responsible buildings. Concrete technology has made tremendous changes to the construction industry. Concrete is now no longer a material consisting of cement, aggregates, water and admixtures but it is an engineered material with a number of new constituents performing suitably under different exposure conditions. Concrete today is a tailor made for specific applications and it contain different materials like micro silica, colloidal silica, binders, fillers and pozzolanic materials. One of the main reasons for the deterioration of concrete in the past is that too much emphasis is laid on concrete compressive strength rather than on the performance of concrete. So there is a need for studying the Pozzolanic materials like GGBS and fly-ash which not only increases the compressive strength but also improves the performance of concrete with time.

Substantial energy and cost savings can result when industrial products are used as partial replacements for energy-intensive Portland cement. This will not only reduce the emission of greenhouse gases into the atmosphere but also will be the sustainable way of managing of waste. Now-a-days the Green building rating systems (i.e. IGBC) has given vital importance to those buildings or constructions where there is optimum usage of these industrial by-products as partial replacement for cement. So the prime focus is laid on these cement replacement materials which are available in abundance.

In this paper presents the various strength characteristics of concrete when cement and fine aggregates are simultaneously replaced by materials like GGBS and Quarry dust in different proportions.

II. EXPERIMENTAL INVESTIGATION

A. materials

Ordinary Portland cement (53 grade) available in the local market of standard brand is used in the investigation. The cement procure is tested for physical requirements in accordance with IS: 12269-1987 and for chemical requirements in accord with IS: 4032-1977.The details are given in table2 .The cement conforms to 43 grade.

Blast furnace slag is collected from iron manufacturing industry Vijayawada, AP, India. Iron ore, coke and limestone are fed into the furnace, and the results molten slag floats above the molten iron at a temperature of about 1500^0c to 1600^0c. The molten slag has the composition of 30% to 40% silicon dioxide (SiO2) and approximately 40% CaO, which is close to the chemical composition of Portland cement.

B. Testing

a) Preparation of testing

Mixing: The object of mixing is to coat the surface of all aggregate particles with Cement paste and to combine all the ingredients of concrete into a uniform mass. Mixing of ingredients is done in pan mixer of capacity 40 liters. The aggregate is added and mixed followed by gradual addition of water and mixing.

Casting of specimens: The test moulds is kept ready before preparing the mix. The cast iron moulds are cleaned of dust particles and applied with mineral oil on all side before concrete is poured into the moulds. The moulds are placed on

International Journal of Engineering Research & Technology (IJERT)
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the level platform. The concrete is filled into the moulds in three layers and then vibrated. Excess concrete is removed with a trowel and top surface is finished level and smooth as per IS 516-1959.

Curing of Specimens: The specimens are left in the moulds without disturbed at room temperature for about 24 hours after casting. The specimens are removed from the moulds and immediately transferred into the different curing environment tubs then cubes, cylinders and beams are kept for curing in fresh water.

b) Testing of specimens

Series of tests are conducted on concrete specimens to obtain the strength of concrete in which cement is replaced with GGBS and simultaneously replaced sand with quarry dust, the experimental investigation values have been tabulated and represented graphically to show the compressive strength, split tensile strength and flexural strength of concrete.

III. RESULTS AND DISCUSSION

Test results shows that the variation of compressive strength, flexural strength and tensile strength of curing periods of 7days and 28days with replacement of GGBS, and also replacement of sand with quarry dust. Tables 1-2 and Figures 1-4 shows test data.

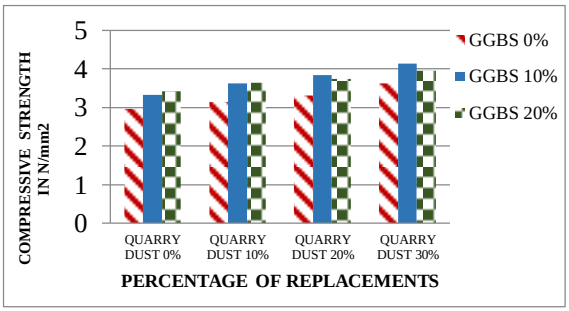

Fig.1 variation of compressive strength of curing period of 7days with GGBS and quarry dust

The compressive strength at age of 7 days is increased up to 10% replacement of cement with GGBS and simultaneously 20% replacement of fine aggregate with quarry dust and compressive strength is decreased thereafter.

The compressive strength of concrete with 0% to 20% replacement of cement with GGBS and simultaneously 20% replacement of fine aggregate with quarry dust at the age of 28 days have reached the target mean strength and further increase in replacement of GGBS and Quarry dust there is a decrease in strength. This shows that 20% replacement of cement and fine aggregate with GGBS and Quarry dust shows better results

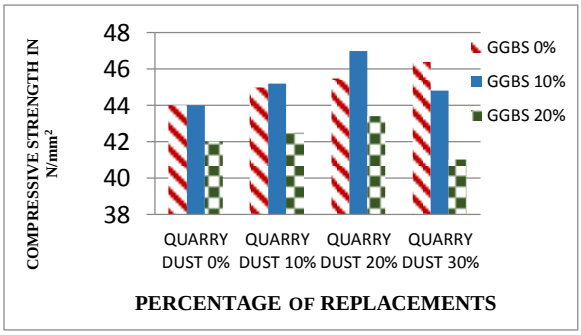

Fig.2 variation of compressive strength of curing period of 28days with GGBS and quarry dust

Table 1. Effect of compressive strength with GGBS and quarry dust

GGBS	Quarry Dust	Compressive strength for curing periods of (N/mm^2)	
		7days	28days
0	0	30.27	44
0	10	31.50	45
0	20	32.5	45.5
0	30	31	46.4
10	0	29.2	44
10	10	30	45.2
10	20	31.3	47
10	30	29.6	44.8
20	0	29	42
20	10	29.4	42.5
20	20	28.5	43.4
20	30	27.4	41

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Table 2. Variation of strength parameters with GGBS and Quarry dust

GGBS	Quarry Dust	Split tensile strength (N/mm^2)	flexural strength (N/mm^2)
0	0	3.22	5.171
0	10	3.37	5.227
0	20	3.45	5.260
0	30	3.63	5.312
10	0	3.26	5.171
10	10	3.43	5.243
10	20	3.70	5.347
10	30	3.31	5.220
20	0	3.426	5.054
20	10	3.538	5.0845
20	20	3.61	5.135
20	30	3.14	4.993

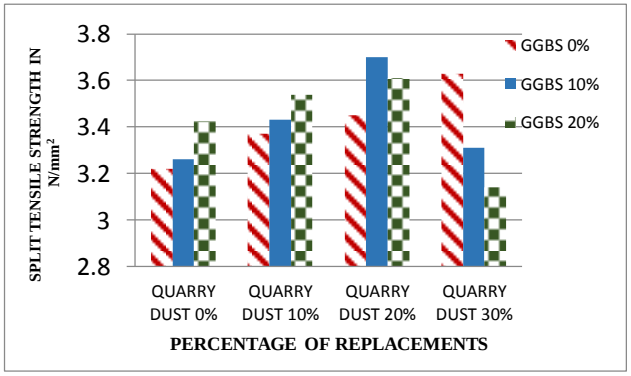

Fig.3 variation of split tensile strength of curing period of 7days with GGBS and quarry dust

The split tensile strength of concrete with 0% to 10% replacement of cement with GGBS and simultaneously 20% replacement of fine aggregate with quarry dust at the age of 28 days strength is increased with respect to normal concrete. Further increase in replacement of GGBS and Quarry dust there is a decrease in strength from Table-12. This shows that 10% replacement of cement with GGBS and 20% replacement of fine aggregate with Quarry dust shows better results

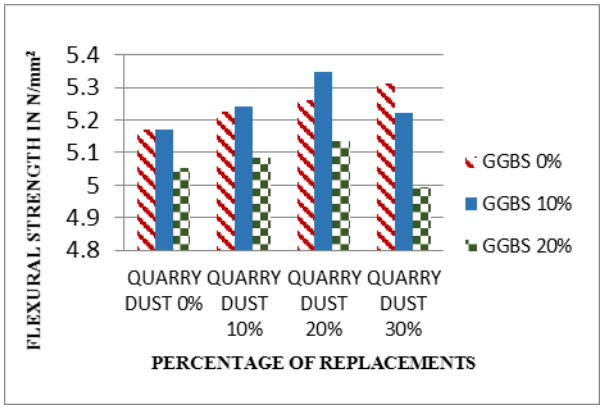

Fig.4 variation of flexural strength of curing period of 7days with GGBS and quarry dust

The flexural strength of concrete with 0% to 20% replacement of cement with GGBS and simultaneously 20% replacement of fine aggregate with quarry dust at the age of 28 days strength is increased with respect to normal concrete. Further increase in replacement of GGBS and Quarry dust there is a decrease in strength from Table-13. This shows that 20% replacement of cement and fine aggregate with GGBS and Quarry dust shows better results

The proportion of GGBS and Quarry dust that would result in maximum strength of concrete is 10% and 20% respectively.

GGBS powder is almost white in colour in its dry state; it is observed that fresh GGBS concrete showed greenish areas on the surface of the cube, this is due to the presence of small amount of sulphide. However it doesn't affect the Compressive strength of concrete.

The near-white colour of GGBS cement permits architects to achieve a lighter colour for exposed fair-faced concrete finishes, at no extra cost.

IV. CONCLUSIONS

1. The maximum compressive strength at the age of 28 days is obtained at 10% replacement of Cement with GGBS and simultaneously 20% replacement of fine aggregate with Quarry Dust
2. The split tensile strength of concrete with 20% replacement of cement with GGBS and simultaneously 30% replacement of fine aggregate with quarry dust is 4% less than the split tensile strength of normal concrete.
3. The maximum split tensile strength at age of 28 days is obtained at 10% replacement of Cement with GGBS and simultaneously 20% replacement of fine aggregate with Quarry Dust.
4. The flexural strength of concrete with 20% replacement of cement with GGBS and simultaneously 30% replacement of fine aggregate with quarry dust is 3.5% less than the split tensile strength of normal concrete.
5. The maximum flexural strength at 28 days is obtained at 10% replacement of Cement with GGBS and simultaneously 20% replacement of fine aggregate with Quarry Dust.

International Journal of Engineering Research & Technology (IJERT)
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6. The study observed that concrete with 20% replacement of cement with GGBS and simultaneously 20% replacement of fine aggregate with Quarry Dust gives better results comparative to normal concrete.
7. On comparison of the results on simultaneous replacements of cement and fine aggregate with GGBS and Quarry dust, though both results are quite encouraging, the optimum usage of these materials without losing the cementitious property of the materials used for concrete mix is of vital importance.

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