MECHANICAL BEHAVIOUR OF CONCRETE MADE WITH QUARRY DUST AND GGBS

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Abstract : *In construction industry, there is a great demand for lime on earth which is a major constituent for manufacturing cement. This situation leads to think to do research work on cement replacing material and use of it. Industrial waste like Ground Granulated Blast Furnace Slag (GGBS) show similar chemical properties as that of cement. Use of this GGBS would considerably reduce the consumption of cement and also reduces the cost of concrete. This study reports the mechanical behavior of concrete with quarry dust and GGBS. This research work focuses on the mechanical behavior of M20 grade concrete with replacement of sand by Quarry dust with 25%, 50% , 75%, 100% and replacement of cement by GGBS with 20%, 30%, 40%, 50% and 60% with plain cement concrete. It is found that the compressive strength is higher for 60% replacement of cement with GGBS in concrete.*

Key words: GGBS, quarry dust, replacement, compressive strength, split tensile, flexure.

1. INTRODUCTION

Concrete is the most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like cementitious material, aggregates and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of application. Quarry dust can be defines as a residue, tailing or other non voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm.quarry rock dust is used for manufacturing of hollow blocks and lightweight concrete prefabricated elements. The use of quarry dust in concrete is desirable because of its benefits such as useful disposal of by products, reduction of river sand consumption as well as increasing the strength parameters and increasing the workability of concrete. GGBS (ground granulated blast furnace slag) is a by product of the manufacturing of pig iron. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500°c to 1600°c. The molten slag has a composition close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue is then water-quenched rapidly,resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size, which is known as ground granulated blast furnace slag (GGBS).

2. METHODOLOGY

The aim of work is to analyze mechanical behavior of concrete with quarry dust and GGBS. The tests of concretes were carried out as per IS code for this proposed investigation work. Optimum replacement of sand with Quarry dust in concrete have to be performed. For successful investigation, tests have to be performed on normal concrete and on GGBS concrete with proportion 20%, 30%, 40%, 50% and 60% cement replacement. The comparative report has to be prepared before arriving at the final conclusion of plain concrete and GGBS concrete with quarry dust and natural sand.
Following methodology was followed for this proposed work:

- Collection of review of journals and articles to get idea of research work conducted on proposed subject of work.
- Studying the properties of cement with GGBS by conducting tests as per BIS such as standard consistency test, initial and final setting time test.
- Mix design of concrete is done for preparation of concrete as per IS10262:1983.
- Tests on fresh concrete were conducted at the time of casting work of different specimens required for proposed work.
- UTM was used to conduct the tests. Test procedure used was per IS 516.

1. Compression test- For this test cubes of standard size of 150mm x 150mm x 150 mm were used.
2. split tensile strength – For this test cylinders of standard Size of 150mm x 300mm.

3. Flexural tensile strength- It is measured by testing beams under central point load of size 100mm x 100mm x 150mm.

- Analysis is carried out with test result.

3. PROPERTIES OF GGBS

3.1. GGBS

The chemical composition of blast furnace slag is similar to that of cement clinker.

Table 1. chemical composition of GGBS

s.no	Chemical formula	Percentage
1	Cao	30-45%
2	Sio^2	17-35%
3	Al_2O_3	15-20%
4	Fe_2O_3	0.5-1.8%
5	MgO	4.1-16.95%
6	MnO_2	1.0-5.2%
7	Glass	89-98%

3.2. Mix design for M20 grade concrete

The mix proportion as per IS 10262:2009 guidelines is given in table3.

Table 3. mix design proportion

Cement	FA	CA	Water
437.77	655.55	1152.29	197
1	1.497	2.632	0.45

4. MECHANICAL PROPERTIES OF CONCRETE

Compressive strength of cubes were determined at 7 and 28 days using compression testing machine (CTM) of capacity 2000KN. Flexural testing setup of UTM machine of capacity 40 tonnes and split tensile strength is also determined in the same (CTM) is used to determine the various strength.

4.1.Compressive strength test on cube

A cube test was performed on standard cubes of GGBS concrete with natural sand and 50% quarry dust of size 150mmx150mmx150mm at 28 days of immersion in water for curing. Results are shown in table 4 & 5 and graphical presentation between compressive strength and percentage GGBS volume fraction is shown in figure 2.

4.2. Split tensile strength test on cylinders

A cylinder test were performed on standard cylinders of normal concrete and GGBS with natural sand and 50% quarry dust of size 150mmx300mm at 28days of immersion in water for curing.

Results are shown in table 6 and graphical presentation between split tensile strength and percentage GGBS volume fraction is shown in figure 3.

4.3. Flexural test on GGBS concrete with natural sand and 50% quarry dust

Standard beams of size 100mmx100mmx500mm were supported symmetrically over a span of 400mm subjected central points loading till failure of the specimen.

4.4. Experimental flexural strength

Maximum experimental flexural strength of the beam specimen was computed by the following equation from theory of strength of materials . the flexural strength of concrete beam specimen was calculated as

$Fb=3Pxa/bd^2$ if a<20

Where,

Fb= flexural stress, MPa

b= width in cm

d=depth in mm

l= length in mm

p= maximum load in kg applied to the specimen.

V. RESULTS AND DISCUSSIONS

Table 4 shows the compressive strength of conventional concrete and quarry dust replaced concrete

Table 4. compressive strength of conventional concrete and quarry dust for 7 and 28 days

Sample	7days (N/mm^2)	28days (N/mm^2)
100% OPC	16.63	21.99
100% quarry dust	16.78	20.51
75% quarry dust	16.67	22.95
50% quarry dust	24.18	29.40
25% quarry dust	20.44	24.36

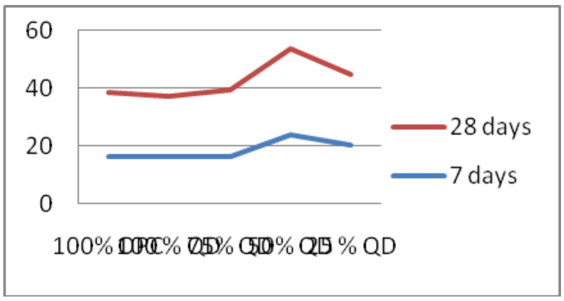

Figure 1. compressive strength of OPC and percentage of quarry dust

From figure 1 we can find out that 50% replacement of sand with quarry dust has attained higher value

Table 5 shows the compressive strength of concrete with different percentages of GGBS with 100% natural sand and 50% quarry dust

Table 5. compressive strength of M20 concrete over different percentage GGBS with 100% natural sand and 50% Quarry dust for 28 days

s.no	% GGBS	100% natural sand (N/mm^2)	50% quarry dust(N/mm^2)
1	100%OPC	22.22	22.55
2	20	33.29	40.15
3	30	38.60	40.16
4	40	34.29	34.44
5	50	38.45	40.29
6	60	38.87	44.96

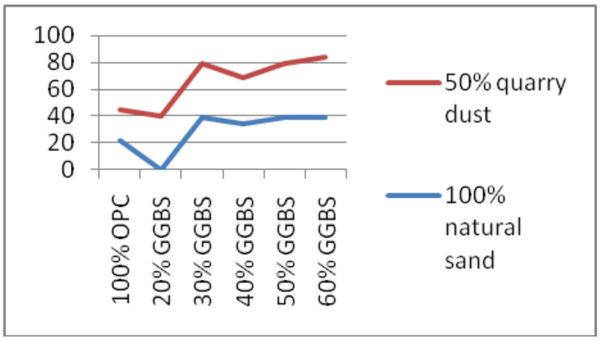

Figure 2 compressive strength of concrete over different percentages of GGBS with natural sand and 50% quarry dust

From figure 2 we can find out that 60% is the optimum replacement of cement with GGBS in both natural sand and quarry dust.

Table 6 shows the split strength values for concrete with different percentages of GGBS with 100% natural sand and 50% quarry dust.

Table 6. split tenile strength of M20 concrete over different percentages of GGBS with natural sand and 50% quarry dust

s.no	% of GGBS	100% natural sand(N/mm^2)	50% quarry dust(N/mm^2)
1	20	2.18	2.68
2	30	2.51	2.75
3	40	2.61	2.85
4	50	2.91	3.08
5	60	3.04	3.18

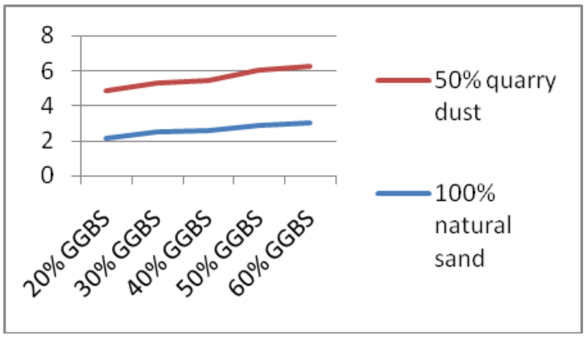

Figure 3 split tensile strength of concrete over different percentages of GGBS with natural sand and 50% quarry dust

From figure 3 we can find out the split tensile strength gradually increases and 60% replacement has got higher values

Table 7 shows the flexural strength of concrete with different percentages of GGBS with 100% natural sand and 50% quarry dust.

Table 7 flexural strength of M20 concrete over different percentages of GGBS with natural sand and 50% quarry dust

S.no	% of GGBS	100% natural sand	50% quarry dust
1	20	3.64	3.48
2	30	3.84	3.54
3	40	3.59	3.42
4	50	3.45	3.19
5	60	3.89	3.62

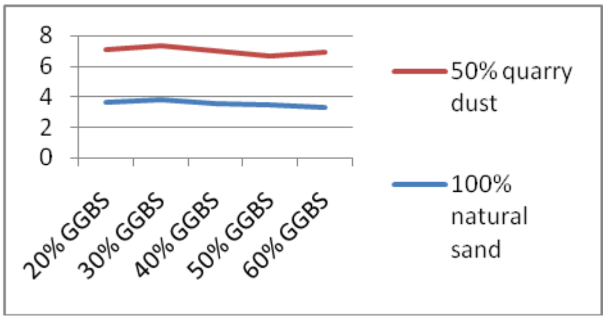

Figure4 flexural strength of concrete over different percentages of GGBS with natural sand and 50% quarry dust

From Figure 4 we can find out that flexural strength does not have a linear increase

VI. CONCLUSION

1. sand can be partially replaced with quarry dust. 50% replacement of sand with quarry dust is the optimum replacement.

2. similarly cement can be replaced partially by GGBS. 60% is the optimum replacement level of cement with GGBS.
3. split tensile strength carried out on specimen with 50% quarry dust replacement on sand and 60% GGBS replacement on cement showed an increase value.
4. flexural strength carried out on specimen with 50% quarry dust replacement on sand and 60% replacement on cement showed an increase value, but it doesn't show the increase linearly.

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