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STUDY ON PROPERTIES OF CEMENT CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY GGBS WITH QUARRY STONE DUST AS FINE AGGREGATE

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ABSTRACT: In this paper the results of an experimental investigation on the combined application of concrete with partial replacement of cement at 10%, 15%, 20%, 30% and 40% by Ground Granulated Blast Furnace Slag (GGBS) and 100% replacement of sand by Crushed stone (Granite stone dust) and coarse aggregate remains same on various properties of concrete are presented. In the present investigation, the structural applications the various properties, such as Compressive strength, Water absorption test, Acid Resistant test, Sulphate Resistant test, Rapid Chloride Permeability Test (RCPT) of M25 grade concrete containing of replacement mix are evaluated and the results are compared with the controlled concrete. From the results, it is observed that the partial replacement of cement by GGBS and complete replacement of fine aggregate by crushed stone dust (Granite stone dust) shall increase in the Compressive strength gradually up to 40% of replacement of GGBS. Hence, it can be concluded and suggest that 100% replacement of sand by crushed stone (Granite Stone dust) as fine Aggregate and partial replacement of cement by GGBS in the concrete are having good performance for mechanical properties, durability properties with reference to the control concrete mix. As the natural sand is huge scarcity in all the river regions due to depletion of natural river banks, stone dust (Granite stone dust) can be used in the place of sand for all constructional civil Engineer works.

IndexTerms: Ground Granulated Blast Furnace Slag, Crushed stone (Granite stone dust), Cement Replacement, Compressive Strength and Water absorption test, Acid Resistant test, Sulphate Resistant test, Rapid Chloride Permeability Test (RCPT)

I. INTRODUCTION

The characteristics of concrete can be obtained by proper selection and proportioning of the ingredients. The present study is aimed at study on properties of cement concrete with partial replacement of cement by GGBS with Crushed stone (Granite stone dust) as fine aggregate and normal coarse Aggregate. Manufacturing Portland cement (PC) is a major contributor of greenhouse gases, responsible for about 5% of all global carbon dioxide emissions. In comparison, the production of ground granulated blast furnace slag (GGBS) requires less than a fifth of the energy and produces less than a tenth of the carbondioxide emissions. It is well known that blast furnace slag cement (BFSC) has been manufactured by integrating GGBS with cement clinker or by separate grinding. For a long period of time, the application of GGBS was limited to the production of BFSC. Due to its less grindability, the surface area of the produced BFSC was even lower than that of commercial PC and its reactivity was limited. With advancement in technology, finer GGBS (particle size less than 10 μm) with increased reactivity was produced. The secondary pozzolanic reactions can result in reduced pore connectivity in the concrete. Therefore, partial replacement of PC with GGBS can significantly reduce the risk of sulphate attack, alkali silica reactions and chloride penetration and increase compressive strength. River sand is expensive due to excessive transportation cost from natural sources. Also the depletion of sources of natural sand creates environmental problems. These constraints make the availability and use of river sand less attractive. Thus there arises a need for a substitute of natural sand in concrete. To overcome the above limitations, Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete.

The present study evaluated the possibility of incorporating industrial waste materials such as Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement in Cement with Crushed stone (Granite stone dust) as a Fine Aggregate, coarse aggregate using hard broken granite metal 12 mm, 20mm size as usual in the making of concrete. The Conventional Concrete mix has been designed for M_{25} grade concrete with the above components and replacement mix has been designed for M_{25} grade concrete with partial replacement of cement by GGBS as per the percentage as stated. The various Strength and properties such as Compressive strength, Water absorption Test, Rapid Chloride Permeability Test (RCPT), Acid Resistance Test, Sulphate Resistance Test are included in this dissertation. Hence, we can infer that 30% replacement of Cement by Ground Granulated Blast Furnace Slag (GGBS) is optimum proportion among the proportions tested for the properties studied in the present dissertation.

II. EXPERIMENTAL PROGRAMME

2.1 Materials

2.1.1 Cement

In the present investigation Ordinary Portland Cement (OPC) of 43 Grade confirming to IS specifications was used. The specific gravity of the cement is 3.15

2.1.2 Coarse Aggregate

Machine crushed aggregate confirming to IS 383-1970 obtained from the local quarry is used as coarse. The nominal sizes of coarse aggregate adopted in the present investigation were 20 mm and 12 mm. The properties of Coarse Aggregate used in the present investigation are shown in the Table. 1

Table.1: Properties of Coarse Aggregate

Property	Coarse Aggregate
Specific Gravity	2.64
Water Absorption (%)	0.25

2.1.3 Crushed Stone (Granite Stone Dust)

River sand is expensive due to excessive transportation cost from natural sources. Also the depletion of sources of natural sand creates environmental problems. These constraints make the availability and use of river sand less attractive. Thus there arises a need for a substitute of natural sand in concrete. To overcome the above limitations, Quarry dust has been proposed as an alternative to river sand that gives additional benefit to concrete.

The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

2.1.4 Ground Granulated Blast Furnace Slag (GGBS)

For this project GGBS is collected from Astra Chemicals, Chennai, Tamil Nadu.

Ground Granulated Blast Furnace Slag is a nonmetallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material. The granulated material when further ground to less than 45 micron will have a specific surface of about 400 to 600 m^2/kg.

In India we produce about 7.8 million tons of blast furnace slag. All the blast furnace slags are granulated by quenching the molten slag by high power water jet, making 100% glassy slag granules of 0.4 mm size.

2.1.5 Water

Potable water is used for casting and curing concrete test specimens, which is free from acids, organic matter, suspended solids and impurities when present can adversely affect the strength of concrete.

2.2 Concrete Mix Proportions

In the present research work the combined use of Crushed Stone (Granite Stone Dust) as FA with 100% replacement of sand and GGBS as partial replacement of cement by 10%, 15%, 20%, 30% and 40% in M_{25} grade of concrete is studied. Concrete cubes were prepared with the replacement mix and reference mix.

M_{25} grade of concrete was designed as per the Indian Standard method of mix proportioning. The mix proportion of M_{25} concrete by weight is shown in Table. 2.

Table.2: Concrete Mix Proportions

Cement in kgs	FA in kgs	20 mm CA in kgs	12 mm CA in kgs	Water in lit
375	643	710	472	176
1	1.71	1.89	1.26	0.47

2.3 Preparation of Concrete Test Specimens

In this investigation, the Cement has been replaced by Ground Granulated Blast Furnace Slag with the percentage of 10%, 15%, 20%, 30% and 40% with Crushed Stone (Granite stone dust) as a fine aggregate.
150mm x 150mm x 150mm cube were made for each reference mix and replacement mix. And circular specimens of size 100mm x 50mm were made for each reference mix and replacement mix. The cubes were used to find Compressive strength of concrete,

Water absorption capacity, Acid Resistance capacity, Sulphate Resistance capacity. The circular specimens were used to find evaluation of the electrical conductance of concrete by Rapid Chloride Permeability Test (RCPT).

2.4 Tests on Concrete Specimens

The concrete cubes were tested for the Compressive strength, water absorption, Acid attack, Sulphate attack test and Rapid Chloride Permeability test for reference mix and replacement mix.

III. RESULTS AND DISCUSSION

3.1 Compressive Strength

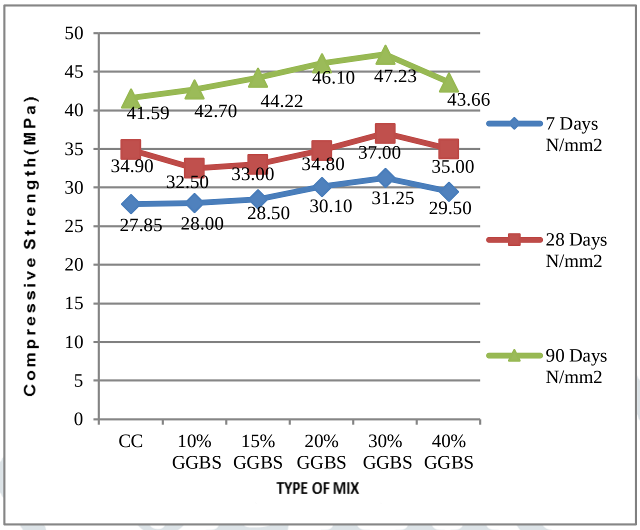

Fig.3.1 Compressive strength versus Type of mix.

From the fig.3.1, it is observed that maximum compressive strength of 30% replacement mix are 31.25 MPa, 37.00 MPa, 47.23 MPa for 7, 28, 90 days. After 30% replacement the compressive strength is gradually reduced.

3.2. Water Absorption Test

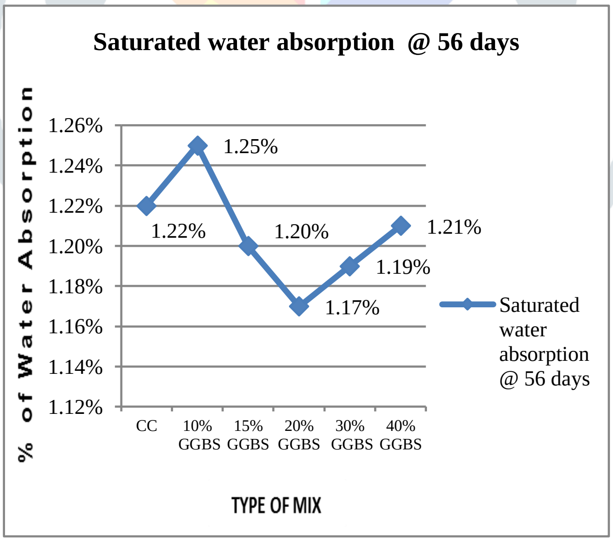

Fig. 3.2 Water Absorption capacity versus Type of mix

From the fig 3.2, it is observed that, the low value of water absorption is 20% replacement of GGBS mix is 1.17%.

3.3. Rapid Chloride Permeability Test (RCPT)

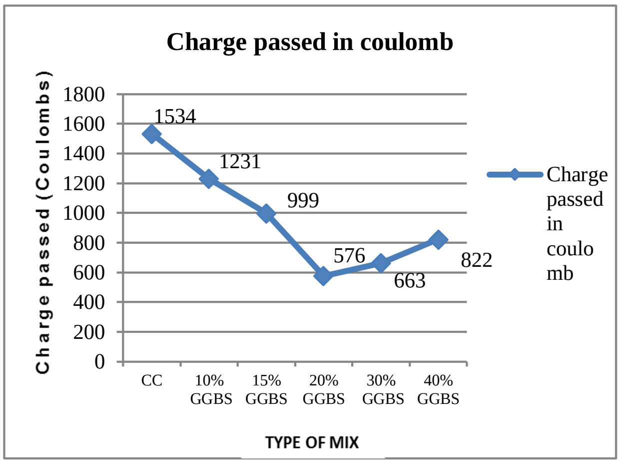

Fig. 3.3 Charge passed versus Type of mix at 90 days age

From fig. 3.3, it is observed that the 90 days permeability of Control Concrete mix is 1534 Coulombs and the minimum permeability of 20% replacement of GGBS mix is 576 Coulombs.

3.4 Acid Resistance Test:

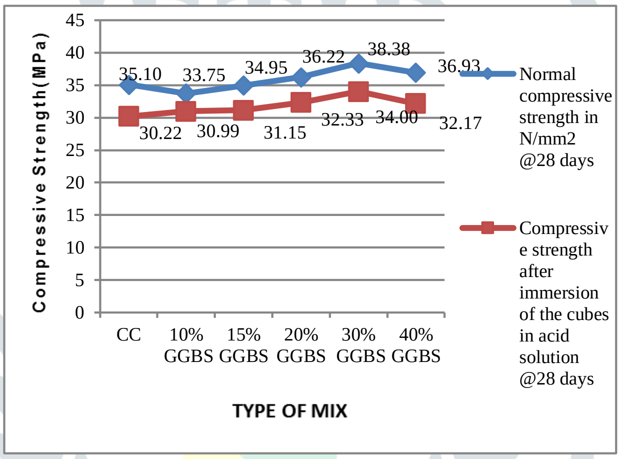

Fig. 3.4 (a) Compressive strength of cubes with and without immersion of Acid solution versus Type of mix

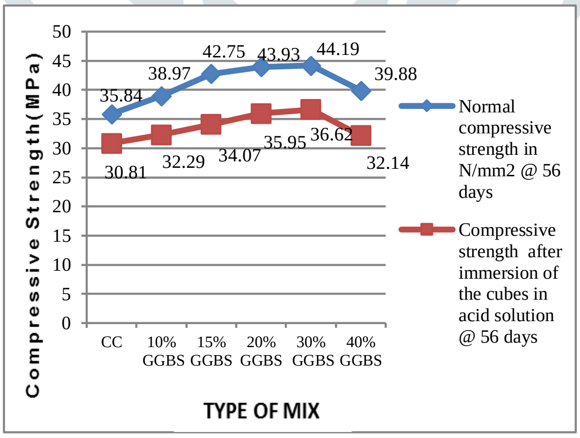

Fig. 3.4 (b)Compressive strength of cubes with and without immersion of Acid solution versus Type of mix

From fig. 3.4(a) and 3.4(b), it is observed that, the percentage of reduction of compressive strength is more in @ 56 days strength than the @ 28 days strength.

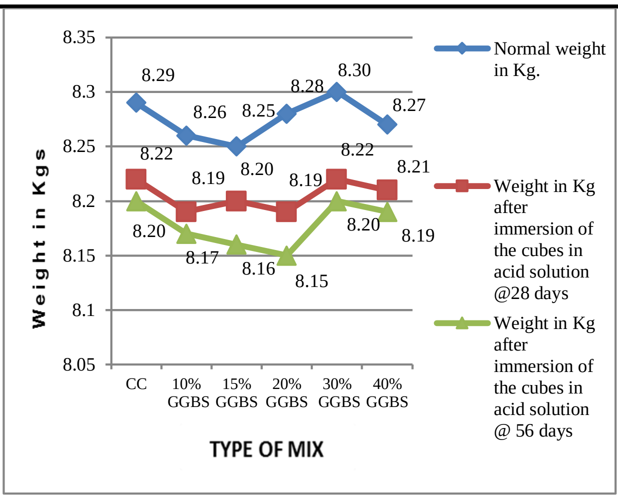

Fig. 3.4(c) Weight of cubes with and without immersion of Acid solution versus Type of mix

From fig. 3.4(c), it is observed that in the Acid attack test, the percentage of reduction in weight of control concrete mix and in replacement mix is almost all same when compared to the results.

3.5 Sulphate Resistance Test:

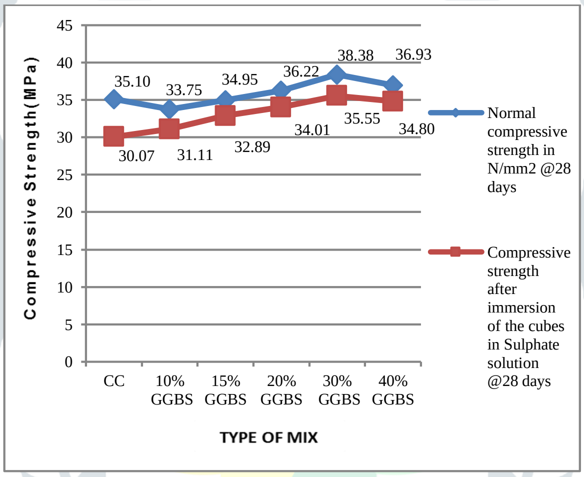

Fig. 3.5(a) Compressive strength of cubes with and without immersion of Sulphate solution versus Type of mix

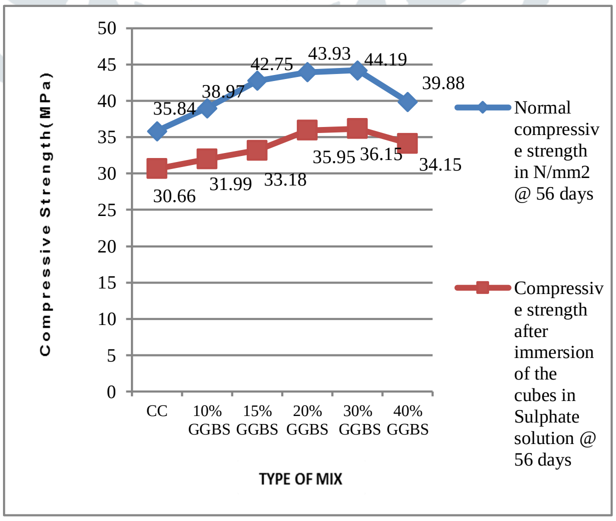

Fig. 3.5(b) Compressive strength of cubes with and without immersion of Sulphate solution versus Type of mix

From fig. 3.5(a) and 3.5(b), it is observed that, the percentage of reduction of compressive strength is more in @ 56 days strength than the @ 28 days strength.

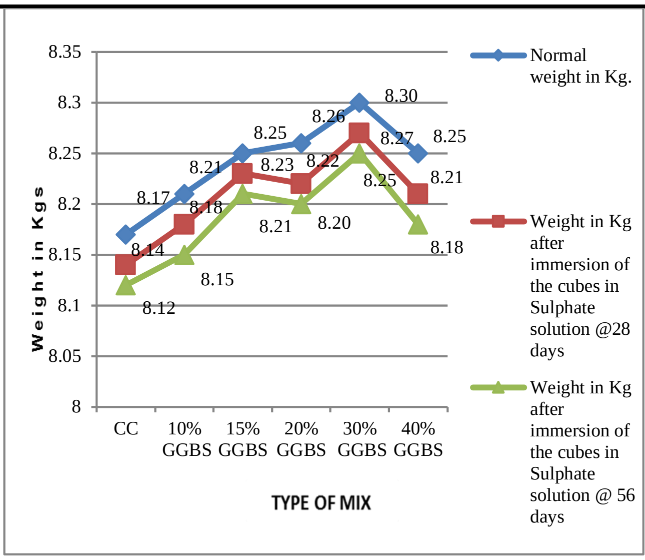

Fig. 3.5(c) Weight of cubes with and without immersion of Sulphate solution versus Type of mix

From fig. 3.5(c), it is observed that in the Sulphate attack test, the percentage of reduction in weight of control concrete mix and in replacement mix is almost all same when compared to the results.

IV. CONCLUSIONS

1. The Compressive Strength at all test days i.e., 7 days, 28 days & 90 days for M25 design mix concrete by the cement having 30% of replacement by GGBS is increased significantly, when compared to reference mix. For all other percentages (10%, 15%, 20% & 40%) of replacement mix, the Compressive Strength is insignificant.

2. The water absorption capacity for all the replacement mix and the reference mix , are almost same for all mixes i.e., with the range of 1.17% to 1.25%.

3. The permeability of chloride based on the Rapid Chloride Permeability Test (RCPT) is, ‘’low’’ for the reference mix and replacement mix of 10% and ‘’very low’’ for replacement mixes of more than 30%.

4. On conducting Acid Resistance Test, the compressive strength of concrete cubes for reference mix and replacement mix immersed in Acid solution for 56 days, are decreased significantly when compared to the compressive strength of the cubes with same reference mix and replacement mix immersed in Acid solution for 28 days.

5. On conducting Acid resistance test, the weight reduction in the concrete cubes for reference mix and replacement mix immersed in Acid solution for 28 days and for 56 days, are very meager and are insignificant.

6. On conducting Sulphate Resistance Test, the compressive strength of concrete cubes for reference mix and replacement mix immersed in Sulphate solution for 56 days, are decreased significantly when compared to the compressive strength of the cubes with same reference mix and replacement mix immersed in Sulphate solution for 28 days.

7. On conducting Sulphate resistance test, the weight reduction in the concrete cubes for reference mix and replacement mix immersed in Sulphate solution for 28 days and for 56 days, are very meager and are insignificant.

V. REFERENCES

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