Experimental Investigation on Partial Replacement of Cement by GGBS & RHA and Natural Sand by Quarry Sand in Concrete

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Abstract: **Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. The concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem. Ground granulated blast furnace slag (GGBS) Rice husk ash (RHA) and Quarry sand (QS) are among the solid wastes generated by industry. To overcome from this crisis, partial replacement of natural sand (NS) with Quarry sand and partial replacement of cement with GGBS and RHA can be an economic alternative. This research is carried out in two phase, in second phase mix of M40 grade concrete with replacement of 0%,15%,30%,45%,60%,75%,90% and 100% of quarry sand with natural sand is carried out to determine the optimum percentage of replacement at which maximum compressive strength is achieved. In literature review, it is observed that when natural sand is partially replaced with 60% quarry sand maximum strength is achieved. The composition of 22.5% GGBS + 7.5% RHA with 60% of quarry sand gives good strength results.**

Keywords- Admixture, Cement, Ground granulated blast furnace slag (GGBS), Quarry sand (QS), Rice husk ash (RHA).

I. INTRODUCTION

Concrete is a heterogeneous mix of cement, aggregates and water. The global consumption of natural sand is too high due to its extensive use in concrete. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. To overcome from this crisis, partial replacement of natural sand with quarry sand is economic alternative. The concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem. Ground granulated blast furnace slag (GGBS), Rice husk ash (RHA) and Quarry sand (QS) are among the solid wastes generated by industry. Substantial energy and cost savings can result when industrial by-products are used as partial replacements for the energy- intensive Portland cement. This investigation attempts to study the feasibility of using locally available GGBS, RHA and QS as partial replacements for cement and sand in concrete. In this research we prepared specimen of cubes for compressive strength test, cylinder for split tensile strength test, beams for flexure strength test and permeable voids test. Three samples for each set of percentage have been taken for conducting test and average of results are taken. The samples were tested at the age of 7 days, 28 days and 56 days. The test on hardened concrete are destructive test while the destructive test includes compressive strength test as per IS: 516-1959, split tensile strength test as per IS: 5816-1999, flexure strength test as per IS: 516-1959, permeable voids test as per ASTM C642-97.

The objectives and scope of present study are –

1. To find the optimum percentage of replacement of natural sand with quarry sand at which maximum strength is obtained.
2. To use pozzolanic material such as GGBS and RHA in concrete by partial replacement of cement.
3. To conduct compressive strength test, split tensile strength test, flexural test.
4. To study and find permeable voids of the concrete mix and its relation with compressive strength of concrete.
5. To provide economical construction material.
6. Provide safeguard to the environment by utilizing waste properly.

II. LITERATURE REVIEW

M. Shariq, J. Prasad and A.K. Ahuja(2009) carried out an experimental study on, the effect of curing procedure on the compressive strength development of cement mortar and concrete incorporating ground granulated blast furnace slag is studied. The compressive strength development of cement mortar incorporating 20, 40 and 60percent replacement of GGBFS for different types of sand and also on two grades of concrete is investigated. The compressive strength of cement mortar and concrete obtained at the ages of 3, 7, 28, 56, 90 days. Tests results show that the incorporating 20% and 40% GGBFS is highly significant to increase the compressive strength of mortar after 28 days and 150 days respectively.

Pazhani.K. and Jeyaraj.R(2004) carried out an experimental study on durability of high performance concrete with industrial Waste concrete. The following are

major by products from these industries: copper slag - a by-product of copper refinery, and ground granulated blast furnace slag (GGBS) - a by-product in the manufacture of iron in steel industry. If they are not disposed off properly, they may cause environmental hazards to the surrounding area. Considering the long term performance and stability of structures, this study suggests replacing some percentage of fine aggregate with copper slag and some percentage of cement with GGBS to develop high performance concrete. This paper presents an experimental investigation to assess the durability parameters of high performance concrete with the industrial wastes. Durability parameters such as water absorption and chloride penetration are to be studied.

Lim et al. (2012) also studied the effect of Ground Granulated Blast Furnace Slag on the mechanical behavior of engineering cement composites (ECC) in which he used slag as replacements of 20 and 40%, Specimens were casted for testing compression, tensile and flexure strengths for 7 days, 28 days and 90 days. The author's study reported that the use of ground granulated blast furnace slag as a replacement not only increased the strength but also created a better bridging property that resulted in better ductility.

Maiti & Raj (2010) did an experimental study on concrete mix design on Portland cement replacements by GGBS from 50 to 65% for M20 grade concrete. Tests were conducted to determine the compressive strength of concrete after moist curing of 28 and 90 days. The test results led to the conclusion that with the increase of percentage of GGBS in concrete, the chloride ion permeability decreases. It was recommended to increase more than 50% GGBS in concrete to reduce harmful alkali-silica reaction. The heat of hydration of concrete using flyash and GGBS was less than that of concrete with only ordinary Portland cement. Ground granulated blast furnace slag is the safest option to mitigate alkali – silica reaction in concrete.

Ilangovan (2008) conducted on strength and durability properties of concrete containing quarry dust as fine aggregate revealed that the overall workability value of quarry dust concrete is less, when compared to conventional concrete. Quarry dust concrete experiences better sulphate and acid resistance and its permeability is less, compared to that of conventional concrete. However, the water absorption of quarry dust concrete is slightly higher than conventional concrete. The use of higher water cement ratio demands high cement content for a required strength.

Dr. P.B.Sakthivel, C.Ramya (2013) Partially replace quarry dust in place of sand in M35 grade concrete. On the experimentation, it was found that the partial replacement of sand with 10% of quarry dust has given the optimum results. This study has brought out positive results that quarry dust can be effectively used as a partial replacing material up to 10% of natural river sand in M35 concrete. Reducing the usage of river sand in concrete will not only cut down the cost of construction, but also reduce the level of illegal extraction of sand from the river beds. Certainly help in preserving the natural resources and solve some sustainability issues.

Materials Used

The materials used in experimental investigation include:

1.Cement

Ordinary Portland cement of 43-grade was used in this study

Specific gravity 3.15, Normal consistency 32%.

2.Ground Granulated Blast Furnace Slag (GGBS)

The GGBS used in research is obtained from Bhilai Steel Plant (Bhilai, Chattisgarh). Ground granulated blast-furnace slag is the granular material formed when molten iron blast furnace slag is rapidly chilled by immersion in water. It is a granular product with very limited crystal formation, is highly cementitious in nature and, ground to cement fineness, and hydrates like port land cement. The specific gravity of GGBS is 2.85.

3.Rice Husk Ash (RHA)

Rice husk ash used was obtained from Ellora Paper Plant located in Tumsar, Bhandara . RHA, produced after burning of Rice husk (RH) has high reactivity and pozzolanic property. The Specific gravity of rice husk ash is 2.12 and fineness of 71.80.

4.Aggregate

Good quality river sand was used as a fine aggregate conforming to Zone- II of IS: 383- 1970 have fineness modulus of 2.735, specific gravity of 2.5 and water absorption 0.98%. Quarry sand from sidheshwar quarry plant Pachgaon, Nagpur, conforming to Zone- II of IS: 383-1970 have fineness modulus of 2.85 , specific gravity of 3 and water absorption 1%. The coarse aggregate passing through 20 mm and retained on 10 mm sieve was used in research. Its specific gravity is 2.85 and water absorption 0.8%.

Water

In this research potable water free from organic substance was used for mixing as well as curing of concrete.

5.Superplasticizer

AC-PLAST-BV M4 PLASTICIZER as a high range water reducing admixture for obtaining a workable mix was used in research, Strength incr eased 0.20 and Specific gravity 1.14

Experimental Programme

Mixture Proportioning

The M40 mix proportioning is designed as per guidelines, according to the Indian Standard Recommended Method IS 10262- 2009. The total binder content was 400 kg/m^3, fine aggregate is taken 668.9529 kg/m^3 , coarse aggregate is taken 1301.122 kg/m^3. The super plasticizer content was varied to maintain a slump of 60 mm for all mixtures. This research is carried out in three phase, in first phase mix of M40 grade concrete with replacement of 0%,15%,30%,45%,60%,75%,90% and 100% of quarry sand

with natural sand is carried out to determine the optimum percentage of replacement at which maximum compressive strength is achieved. In second phase, cement is partially replaced with GGBS by 10%, 20% and 30%. And in third phase combination of GGBS and RHA is partially replaced with cement. Cubes, beams and cylinder moulds were used for casting. The total mixing time was 5 minutes; Compaction of concrete in three layers with 25 strokes of 16mm rod was carried out for each layer is done. The concrete was left in the mould and allowed to set for 24 hrs before the cubes were demoulded and placed in curing tank until the day of testing.The three specimens of each set was prepared and left for curing in the curing tank for 7,28 and 56 days. Aggregates are graded not only to maintain cohesiveness of mix, but also to meet the grading requirements of IS:383. According to mix design the finalized proportion is 66.044% of coarse aggregate 60:40 (20mm:10mm) with 33.955% of sand content (45% quarry sand and 55% natural sand).

Combined Gradation of All in Aggregates

TESTING METHOD

Testing is done as per following IS code. The testing is carried out for compressive strength on cubes as per IS : 516 – 1959, split tensile strength on cylinder as per IS : 5816 – 1999, flexural strength on beam of as per IS: 516 – 1959. Permeable voids tests is carried out as per ASTM C642-97.

Durability Test

The durability of concrete with the optimum percentage replacement of natural sand with quarry sand, partial replacement of cement with GGBS, and combination of GGBS and RHA partially replaced with cement and control mix is studied by the following tests.

Acid Resistant Test

In this study concrete cubes of control mix and maximum compressive strength with replacement of Quarry sand by natural sand and replacement of GGBS and RHA and 20%, 30% replacement of GGBS with cement and combination of GGBS and RHA is partially replaced with cement with optimum percentage of quarry sand is tested for Acid Resistant Test. These specimens were weighted after 28 days of curing and immersed in diluted 1% of sulphuric acid solution for 30 days. Then the cubes are taken out and before testing each specimen is removed from the bath and brushed with the soft nylon brush and rinsed in a tap water and weighed. The percentage loss in weight and percentage reduction in compressive strength are calculated and compared with that of control mix.

Chloride Attack Test

chloride attack is one of the important aspects to be considered while dealing with the durability of concrete because it primarily causes corrosion of reinforcement. concrete cubes of control mix and maximum compressive strength with replacement of Quarry sand by natural sand and replacement of GGBS and RHA and 20%, 30% replacement of GGBS with cement and combination of GGBS and RHA is partially replaced with cement with optimum percentage of quarry sand is tested for chloride attack test . The cubes are immersed in a solution of 3% hydrochloric by weight of water for 28-days.then the cubes are taken out and weighted and percentage loss in weight percentage reduction in compressive strength are calculated

Permeable Voids Test

This test method covers the determination of density, percent absorption, and percent voids in hardened concrete. This test method is useful in developing the data required for conversions between mass and volume for concrete. It can be used to determine conformance with specifications for concrete and to show differences from place to place within a mass of concrete. The sample consist of any desired shape or size, except that the volume of each portion shall be not less than 800gm and each portion is free from observable cracks, fissures or shattered edges. In this research permeable voids test is carried out for each sample as per ASTM C 642-97

III. SUMMARY AND FUTURE WORK

The concrete industry is constantly looking for supplementary cementitious material with the objective of reducing the solid waste disposal problem. Ground granulated blast furnace slag (GGBS) Rice husk ash (RHA) and Quarry sand (QS) are among the solid wastes generated by industry. To overcome from this crisis, partial replacement of natural sand (NS) with Quarry sand and partial replacement of cement with GGBS and RHA can be an economic alternative. This research is carried out in two phase. In first phase I have Examination of strength characteristics such as compressive strength, split tensile strength of concrete mix are found for 7 days, 14 days, 28 days, of curing period and results are analyzed and compared with the nominal mix is going to be done.

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