Laboratory Study on Strength Assessment of Concrete By Using Binary Cement Incorporating Combination of Rice Husk Ash & GGBS

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Abstract- *The main component of concrete is Cement and also one of the most important materials for all kinds of construction. Cement production emits approximately 5% of global carbon dioxide (CO2) and 5% of global energy consumption. Big attention is being focused on the environment and recycling of wastes materials. One of the new waste materials used in the concrete industry is industrial wastes. The consumption of agricultural and industrial wastes has grown rapidly across the world which leads to create large quantities of wastes. It reflects the problem of having a limited number of landfills due to a huge amount of waste produced. Therefore, the solution is recycle the agricultural and industrial wastes as one of the materials use in concrete. One of these important biogenic waste is the rice husk ash (RHA) - generated as by-product from rice mills. The production of RHA increases every year, it is disposed for landfills without any return value and now becomes a burden. Reducing the use of cement which is one of the major productions of Carbon Dioxide (CO2) gas emissions. For solving the disposal of large amount of industrial waste materials. Those industrial waste materials have some pozzolanic nature which can react with water and act as binders. To study the use of alternative materials for construction and to reduce the disposal problem of industrial waste. In this work along with cement, Ground Granulated Blast furnace Slag (GGBS) with 0%, 10%, 20% and 30% as a replacement to the cement along with Rice Husk Ash (RHA) of 0%, 3% and 6%. Workability of fresh concrete and Split Tensile Strength & Compressive Strength of M40 grade concrete at different curing periods like 3 Days, 7 Days, 14 Days & 28 Days.*

Keywords- Ground Granulated Blast furnace Slag (GGBS),Rice Husk Ash (RHA),workability, compressive strength, split tensile strength test, water absorption test

I. INTRODUCTION

In the last decades, environmental sustainability has become one of the most important issues. Cement is the most Important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. it's known that some industrial waste product like nano silica are having some building material and silicious properties. So the use of the commercial and agricultural wastages in concrete part as cement replacement, scale back the price of constructing concrete, additionally causes improvement within the properties of concrete

Cement is the most important ingredient of the concrete which produces carbon dioxide which is May harmful. So it is a main concern to reduce the usage of cement. The increase in price of the cement not only will increase the budget of a construction however additionally poses a significant threat to the country's development. It's known that some waste product like nano silica and metakaolin are having some building material and siliceous properties. The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Ground Granulated Blast furnace Slag (GGBS)and Rice Husk Ash (RHA)like waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. Rapid industrial expansion produces severe difficulties all around the world, including as the depletion of natural resources and the creation of vast amounts of waste materials throughout the manufacturing, construction, and demolition stages; one option to mitigate this problem is to utilize wastes.

The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Metakaolin is industrial waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction.

The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. Rice husk ash and ground granulated blast-furnace slag (GGBS) are the waste materials comprise pozzolanic properties but their disposal is causing acute environmental setbacks. The utilization of industrial and agricultural waste product in concrete has been a major step on waste reduction. Ground granulated blast-furnace slag and Rice husk ash can by effectively used in concrete as partial replacement of cement because of their high content of silica and pozzolanic properties which plays an important role in achieving high strength and durability in concrete.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength and impact resistance of concrete with different percentages replacement of cement with Rice husk ash and GGBS and to study the tensile behaviour on adding with steel fibres.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

1. Workability
2. Compressive strength
3. Flexure strength
4. Tensile strength

II. REVIEW OF LITERATURE

Considering above background, an experimental investigation was carried out to consider the both types and amount of contents of different types of cement and sand replacement materials on the properties of concrete. A lot of work has been done to explore the benefits of using pozzolanic materials in making and enhancing the properties of concrete. Literature review.Ground Granulated Blast furnace Slag (GGBS) and Rice Husk Ash (RHA)in concrete exposure to environment is presented in the following sections.

Deb, P. S., Nath, P., & Sarker, P. K. (2014): Junaid, M. T., Kayali, O., Khennane, A., and Black, J. (2015): In this paper he decided the mix proportions geopolymer concrete (GPC) by utilizing Calcium Class F Flay Ash and Alkaline solutions of sodium silicates and sodium hydroxide. For the distinctive mix plans he discovered ideal substance of alkaline fluid to fly ash (AL/FA) proportion, water to geopolymer concrete (W/GPS) proportion and Alkaline to water (AL/W) proportion.

Goriparthi, M. R., & TD, G. R. (2017): He arranged geopolymer concrete consolidating fly ash and ground granulated blast furnace slag (GGBS) as a limiting material, Alkaline materials Sodium silicate ($Na2SiO3$) and Sodium Hydroxide (NaOH) as activators. And contrasted the consequences of both OPC and geopolymer concrete and closed the accompanying aftereffects of two evaluations of concrete GPC20 AND GPC50. Significant boundaries of corrosive mass misfortune factor (AMLF) by submerging in 5% of $H2SO4$ solution and strength properties (Compressive, Tensile and Flexure) were resolved..

MoslihAmerSalih (2014) focused on producing high strength mortar from the alkali activation of palm oil fuel ash (POFA) blended with GGBS. Compression test was applied to evaluate the mechanical properties, TGA/DTG, and DSC tests were conducted to study the chemical composition of the geopolymeric binding phase. POFA activated with sodium silicate and sodium hydroxide at room ambient temperature. Results showed that 50% of POFA blended with 50% of GGBS was applicable to produce high strength geopolymer mortar with 70 MPa compressive strength at the age of 28 days and 85 MPa at the age of 90 days.

Sunny AJagtap, Mohan N Shirsath, Sambhaji L Karpe (2017) studied the Effect of Metakaolin on the Properties of Concrete. Environmental issues are playing essential role in the sustainable development of concrete industry. Cement replacement by glass powder in the range 5% to 25% with an interval of 5% is to be studied. It was tested for compressive strength, Split tensile strength and flexural strength at the age of 7, 28 days and compared with the results of conventional concrete. The overall test results shows that Metakaolin could be used in concrete as a partial replacement of cement.

Saxena, S. K., Kumar, M., & Singh, N. B. (2018): In this paper he compared results of geopolymer cement with ordinary portland cement in terms of compressive strength, durability test by using sulphuric acid. The geopolymer cement was made by using fly ash, Alkaline Solution (14M NaOH) and Silicate solution (Sodium silicate solution) and also he used alccofine powder which has have similar properties of silica fume. Finally he concluded that compared to OPC this designed mix (geopolymer mix) giving better reliable results than OPC in terms of durability, Compressive strength.

Hadi, M. N., Zhang, H., & Parkinson, S. (2019): In this paper he compared the result of OPC paste vs proposed geopolymer concrete mix. In suggested mix he used ground granulated blast furnace slag (GGBFS) and Class F fly ash (FA) as silicate fount and Instead of using W/C ratio he used , sodium silicate solution to sodium hydroxide solution SS/SH, Aw/Bi ratio & alkaline solution to binder (Al/Bi) ratio in his proposed mix. Finally he concluded that at given alkaline solution to binder (Al/Bi) ratio of 0.5, sodium silicate solution to sodium hydroxide solution (SS/SH) ratio of 2, Aw/Bi of 0.15 & 40% GGBS proposed geopolymer paste given better results in respect of compressive strength, Slump test & setting time.

It has been noted that the sunshine fastness of banana fibre is inferior to cotton. this could be attributed to the impurities gift within the banana fibre within the variety of polymer and therefore the different insoluble matter. The revealed analysis works on flexural plasticity of nylon fiber ferroconcrete beam are studied by several researches few mentioned the influence of nylon fiber issue on flexural plasticity of beam and terminated that plasticity indexes increase with increasing of fiber issue.

Mr. U.R. Kawade et al., had studied on “Effect of use of pulp ash on Strength of Concrete” that they had with chemicals and Physically characterised and partial replaced within the magnitude relation of 1/3, 10%, 15%, 20%, twenty fifth and half-hour by weight of cement in concrete. The results show that the POFA concrete had considerably higher compressive strength compared to it of the concrete while not POFA. it's found that the cement may be well replaced with POFA up to most limit of V-J Day. though the optimum level of POFA content was achieved with V-J Day replacement. Partial replacement of cement by POFA will increase workability of recent concrete, thus use of Super softener isn't essential.

A.N.Dancygier and Z.Savir studied the influence of nylon fiber on flexural performance of high strength concrete beam with low longitudinal reinforcement magnitude relation, that tried that nylon fiber enhance crispiness of beam compared to it of beam with minimum longitudinal reinforcement magnitude relation. Compared to nylon fiber concrete, the hybrid fiber with completely different kind and size will improve effectively strength and toughness of concrete, kind hybrid result throughout completely different fiber, play various useful influence from completely different level. However, few researches on flexural performance of hybrid fiber strengthened RC beam were studied.

Sasikumar&Tamilvanan Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. The main parameters investigated in this study is M30 grade concrete with partial replacement of cement by silica fume0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when the silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. As well the split tensile strength is high when using 25% silica fume replacement for cement.

Ghutke&Bhandari Examine the Influence of silica fume in concrete. Results indicated that the silica fume is a better replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage is varying from 10% to 15% replacement level.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Fine Aggregates
3. Coarse Aggregates
4. Rice husk ash
5. Ground Granulated Blast Furnace Slag
6. Admixtures

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Rice Husk Ash

Rice husk is a potential material, which is amenable for value addition. The usage of rice husk either in its raw form or in ash form is many. Most of the husk from the milling is either burnt or dumped as waste in open fields and a small amount is used as fuel for boilers, electricity generation, bulking agents for composting of animal Manure, etc. The exterior of rice husk are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica Jauberthie et al., confirmed that the presence of amorphous silica Is concentrated at the surfaces of the rice husk and not within the husk itself. The chemical composition of rice husk is similar to that of many common organic fibers and it contains of cellulose 40-50 percent, lignin 25-30 percent, ash 15-20percent and moisture 8- 15 percent.

After burning, most evaporable components are slowly lost and the silicates are left. No other plant except paddy husk is able to retain such a huge proportion of silica in it. Plants absorb various minerals and silicates from earth into their body.

The rice husk ash is collected from the brick manufacturing unit, East Godavari District, Andhra Pradesh.

5. GGBS

Ground Granulated Blast Furnace Slag (GGBS) is a recyclable material created when the molten slag from melted iron ore is quenched rapidly and then ground into a powder. This material has cementitious properties and has been used as a replacement for cement for over 100 years. Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel industry. Blast furnace slag is defined as “the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace. Concrete made with ground granulated blast furnace slag cement sets more slowly than concrete made with ordinary Portland cement, depending on the amount of ground granulated blast furnace slag in the cementitious material. For the present study the GGBS was brought from the Visakhapatnam steel plant by using wet bags.

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M40.

V. RESULTS AND DISCUSSIONS

The chapter presents the results of strength tests (Compressive, Split tensile and flexural strengths) conducted on concrete with rice husk ash and Ground granulated blast furnace slag different proportions of M40 grade. The tests conducted on concrete specimens subjected to mechanical characteristics are also presented. Finally, the comparisons of all results are done and graphs were prepared. In the laboratory, various experiments i.e. workability test (Slump Cone) for fresh concrete and Compressive tests for hardened concrete for different curing periods were conducted by replacing of different percentages RHA & GGBS.

The results for various tests were shown below as a tabulated form and also graphical representation.

5.1 REPLACEMENT DETAILS

The replacement details of Rice husk ash and ground granulated blast-furnace slag (GGBS) has been given in the below table. The replacement of cement percentages by 0, 10, 20 and 30% with GGBS varying the cement replacement percentages by RHA with 0%, 3% & 6%.

5.2 WORKABILITY OF CONCRETE (SLUMP CONE TEST)

Slump test is used to determine the workability of concrete. The apparatus used for doing slump test are slump cone and tamping rod. Slump test is used to determine the workability of concrete. The apparatus used for doing slump test are slump cone and tamping rod. This is the most commonly used test of measuring the consistency of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing neither workability, not it is always a representative of the place ability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. It is performed with the help of a vessel, shaped in form of a frustum of a cone opened at both ends. Diameter of top end is 10cm while that of the bottom end is 20cm, height of the vessel is 30cm, a 16mm diameter and 60cm long steel rod is used for tamping purposes.

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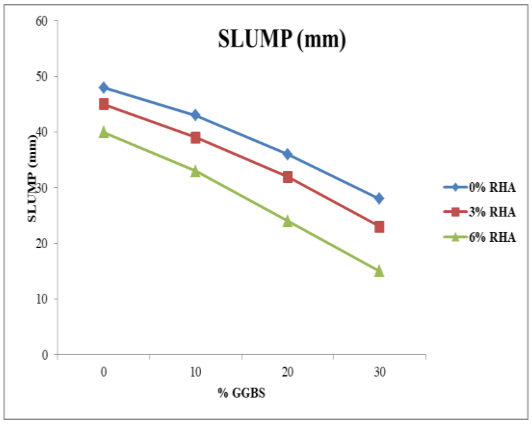
The slump of the freshly mixed concrete was measured by using a slump cone in accordance to ASTM C143.

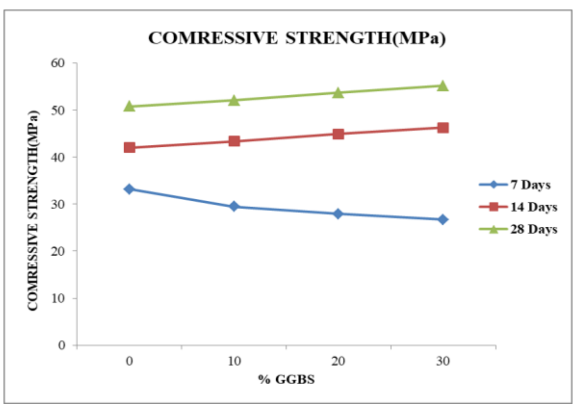


Graph 5.1 Effect of GGBS and RHA on slump values of concrete

5.3 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal.

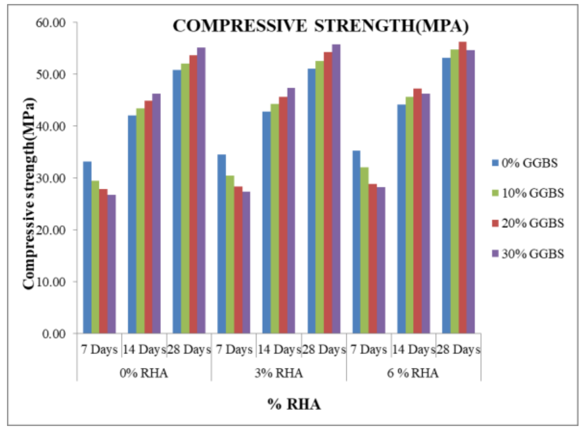
Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days.



Graph 5.2 Effect of GGBS on compressive strength of concrete at 0% RHA

5.4 VARIATION OF COMPRESSIVE STRENGTH FOR ADDITION OF METAKAOLIN TO OPTIMUM PERCENTAGE OF NANO SILICA

Compressive strength of concrete keeping 10% nano silica as constant and with different percentages of metakaolin for curing period of 7-days and 28-days respectively and fig shows the summarized Compressive strength Results for different curing periods– M30 grade.



Graph 5.3 shows the summarized results on the effect of GGBS & RHA on compressive strength of concrete

5.5 SPLIT TENSILE STRENGTH TEST

The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine compressive strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999).

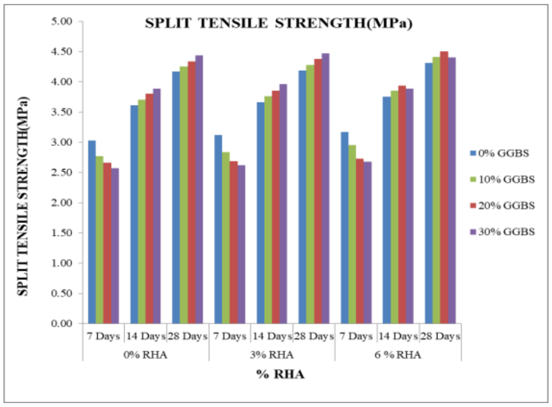
The Split Tensile strength of the concrete mix for with partial replacement of cement by metakaolin showed higher Strength against splitting after 7 and 28 days for M30 grade.

Compressive stress = $2P/\pi LD\ \{D^2 / (D-r) - 1\}$

Tensile stress = $2P / \pi LD$

Where, P = Compressive load on cylinder
L = Length of cylinder =300 mm
D = Diameter of cylinder = 150mm

r& (D-r) are distance of the element from the two loads respectively.



Graph 5.4Summarized results on the effect of GGBS & RHA on Split tensile strength of concrete

5.6 FLEXURAL STRENGTH TEST

In the flexural strength test theoretical maximum tensile stress reached at the bottom fibers of the test beam is known as the modulus of rupture. When concrete is subjected to bending stress, compressive as well as tensile stresses are developed at top and bottom fibers respectively. If the largest nominal size of aggregate does not exceed 20mm, the dimension of specimen may be 150mm×150mm×700mm.

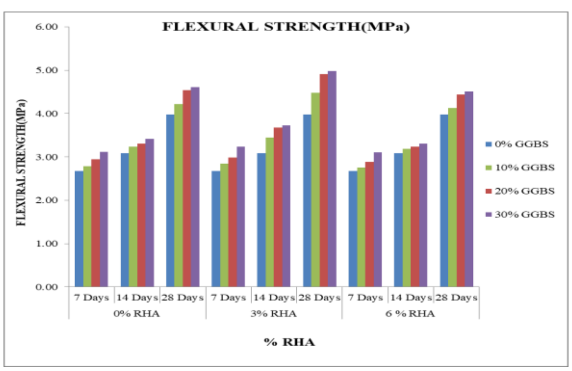
$$f = \frac{M}{Z} = \frac{(PL/6)}{(bd^2/6)}$$

$$f_b = \frac{PL}{Bd^2}$$

When 'a' greater than 20 cm for a 15cm specimen,

$$f_b = \frac{3Pa}{bd^2}$$

The Flexural strength of the concrete mix for with partial replacement of cement by Silica fume and Cenosphere respectively showed higher Strength against splitting after 7 , and 28 days for M30 grade.



Graph 5.6Summarized results on the effect of GGBS & RHA on Split tensile strength of concrete

From the workability test, it was observed that there is decrease in the slump value with increase in both the RHA & GGBS quantities. The slump value was decreased by 68% at 64% Cement + 6% RHA + 30% GGBS compared with conventional concrete. Results (Figure 1) show that Compressive strength of M40 grade concrete gradually increased with the increase in % RHA and GGBS up to 20%, but for 30% GGBS it decreased for 6% RHA. The compressive strength at 64% Cement + 6% RHA + 20% GGBS was improved by about 11% when compared with conventional concrete. This improvement in strength can be attributed to the enhanced gel formation due to the availability of reactive silica present in GGBS & RHA. The Split tensile strength of M40 grade concrete had shown a similar trend as of the compressive strength. From the above discussions, it can be concluded that usage of proposed industrial waste materials in concrete as a replacement to the cement will give us a better strength concrete along with a solution for disposal of such an industrial waste

VI. CONCLUSIONS

The purpose of this study was to investigate the use of Ground granulated blast furnace slag (GGBS) and Rice husk ash (RHA) in concrete as a waste material by assessing their effect in concrete specimens cured under normal water. The following conclusions are made based on the laboratory experiments carried out in this investigation.

- Workability is decreased with increase in both Rice Husk Ash (RHA) & Ground Granulated Blast furnace slag (GGBS) as a replacement to the cement.
- The significant improvements in strength characteristics were observed with Rice Husk Ash (RHA) & Ground Granulated Blast furnace slag (GGBS) in concrete.
- Compressive strength of M40 grade concrete was decreased for 7 days of curing with increase in GGBS content. For 14 days and 28 days of curing periods the compressive strength was observed to be increase with increase in GGBS up to 30%.
- The compressive strength of 6% RHA + 30% GGBS was decrease when compared with 3% RHA + 30% GGBS as a replacement to the cement.
- The compressive strength at 67% Cement + 3% RHA + 30% GGBS was improved by 10% when compared with conventional concrete.
- Split tensile strength of M40 grade concrete was decreased for 7 days of curing with increase in GGBS content. For 14 days and 28 days curing periods the split tensile strength was observed to be increase with increase in GGBS.
- The Split Tensile Strength at 67% Cement + 3% RHA + 30% GGBS was improved by 7.19% when compared with conventional concrete.

From the above conclusions we can say that usage of proposed industrial waste materials in concrete as a replacement to the cement will give us a better strength improved concrete along with a solution for disposal of such an industrial waste.

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