A Study on Mechanical Properties of Reinforced High Strength of Concrete using Rice Husk Ash and GGBS

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Abstract

Development of High strength Concrete using Rice husk ash and Slag: Hectic industrial activities are envisaged by India and the other developing and under developing countries aiming in this twenty first century, for gigantic improvement in Civil Engineering. India presently is facing problems due to pushing up the cost of construction materials. Already a partial substitution of fly-ash was used for ordinary Portland cement. High strength and high performance concrete are being widely used all over the world. Most of the applications of high strength concrete have been found in high rise buildings, long span bridges etc. The potential of rice husk ash as a cement replacement material is well established .Earlier researches showed an improvement in mechanical properties of high strength concrete with finely ground RHA as a partial cement replacement material. One of the agro-based wastes in our country is rice-husk. Some progress has been made to convert this rice-husk to ash by incineration and use it as a partial substitute replacement for the ordinary portland cement. Rice-husk ash contains 85-95% silica when open burnt and ground to a fineness of 16000Sq-cm/gm. Some investigations were reported on using rice-husk ash concretes and were shown to be good when comparable with concretes with no replacements. Another such mineral admixture is ggbs, confirming to IS12089 which is also a bi-product of iron manufacture industry. Due to its highly cementitious nature, when ground to cement fineness, hydrates like cement. The ground granulated blast furnace slag is a waste product from the iron manufacturing industry, which may be used as partial replacement of cement in concrete due to its inherent cementing properties. This paper presents an experimental study of compressive Split tensile and flexural strength of concrete prepared with Ordinary Portland Cement, partially replaced by Rice husk ash and ground granulated blast furnace slag in different proportions varying from 0% to 25%.Hence a project work is planned to check the suitability of use of RHA and GGBS in developing High strength cement concrete.

Keywords: RCC, Rice Husk Ash, GGBS

I. INTRODUCTION

The term Fiber Reinforced Concrete (F.R.C) is defined by ACI Committee 544 as a concrete made of hydraulic cements containing fine and coarse aggregates and discontinuous discrete fibers. Inherently concrete is brittle under tensile loading. Mechanical properties of concrete can be improved by reinforcement with randomly oriented short discrete fibers, which prevent and control initiation, propagation and coalescence of cracks.

Fiber Reinforcement is commonly used to provide toughness and ductility to brittle cementitious matrices. Reinforcement of concrete with a single type of fiber may improve the desired properties to a limited level.

Fiber Reinforced Concrete is the type of concrete which contains Fibrous materials which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented.

Fibers include steel fibers, polypropylene fibers glass fibers, natural fibers. Within these different fibers, that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometrics, distribution, orientation and densities.

In Fiber Reinforced Concrete, fibers can be effective in arresting cracks at both macro and micro levels.

A. High Strength Concrete

The term high-strength concrete (HSC) is generally used for concrete with compressive strength higher than 41 MPa. ACI Committee had defined High Strength Concrete (HSC) is the concrete that can attain specified compressive strength for design of

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at least 41 MPa, or more. With the development of high grade cement and availability of proper mineral admixtures and chemical admixtures, it has become quite common to adopt concrete with compressive strength of 60 MPa and above.

Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete and has no alternative in civil construction industry. But, production of cement involves emission of large amount of carbon dioxide gas into the atmosphere which results to global warming. So it is advisable to search for another material or partly replace it by other material that should lead to lowest environmental impact.

A number of studies are going in India and abroad to study the use of industrial by products as partial replacement of cement and results are encouraging. These industrial-by products also called as pozzolanic materials because of the pozzolanic action. Industrial-by products such as rice husk ash, fly ash GGBS and high reactive metakaoline which are highly available in India, are used for partially replacing the cement.

Investigations have been done in India and abroad indicated that rice husk ash can be used as a binding material along with limes and cement. Raw husk contains 20-25% silica, while its ash contains as much as 85-95% silica in a highly reactive form with cellular structure. Portland cement primarily a siliceous and calcareous material. When rice-husk ash is mixed with cement or lime, the highly reactive silica vigorously reacts and results a good binding material.

B. Rice Husk Ash

The primary work on RHA was started during 1974 at the Asian Institute of Technology by Columna, it was found that open air burnt husks were converted to ash at temperature less than 3000C and contains considerable amount of carbon which has an adverse effect on its pozzolanic activity. A study on the efficiency and effects of burning methods on the quality and properties of RHA was carried out by Prof. P.K.Mehta. Silica phases in RHA obviously influenced by incineration temperature of rice husk and it is an important factor in the chemical reactivity of silica in RHA. If the incineration temperature is lower than 700, silica in RHA remains in amorphous state, if the temperature is between 700-8000C, it contains highly reactive silica of amorphous state. If the temperature is gradually raised more than 8000 C , the silica in RHA crystallizes as cristobalite or tri-dymite, which have low reactive silica, compared to the amorphous state of silica.

Besides the temperature of burning, fineness of ash plays a vital role in the reactivity for silica. For the same fineness, amorphous ash requires less grinding than for the crystalline one. In India the Cement Research Institute, the Central Building Research Institute, various IIT's and Anamalai University have made beginning in investigating the usefulness of rice husk ash as binder

C. Ground Granulated Blast Furnace Slag-GGBS

Ground Granulated Blast Furnace Slag (GGBS) which is a byproduct formed from the production of cast iron, also called pig iron, if the slag is cooled slowly in air, the chemical components of slag are usually present in the form of crystalline melilite (C2AS-C2MS2, solid solution), which does not react with water at ordinary temperature. If it ground to very fine particles, the material will be weak cementitious and pozzolanic. However, when the liquid slag is rapidly quenched from high temperature by either water or a combination of air and water most of the lime, magnesia, silica and alumina are held in non-crystalline or glassy state. The water-quenched product is called granulated slag due to the sand-sized particles, while the slag quenched by air and a limited amount of water which is in the form of pellets is called palletized slag. Normally, the former contains more glass, however, when ground to 400-500 m²/kg Blaine, both products develop satisfactory cementitious properties. Keeping the above in mind, an attempt has been made in the present study to investigate into potentialities of using rice husk ash and GGBS admixtures in cement concretes and compared to similar characteristics of concretes made with ordinary Portland cement alone without replacement

D. Results of Strength Parameters

Table - 1
Compressive strength of cubes replaced with RHA at 28, 56 & 90 days

Sample Designation	*% of RHA*	*Compressive Strength of Cube Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*65.77*	*79.11*	*89.77*
M-5	*5*	*64.00*	*73.33*	*84.00*
M-10	*10*	*57.33*	*65.77*	*72.00*
M-15	*15*	*52.00*	*59.11*	*66.66*
M-20	*20*	*45.77*	*52.88*	*61.77*
M-25	*25*	*42.22*	*47.11*	*56.00*

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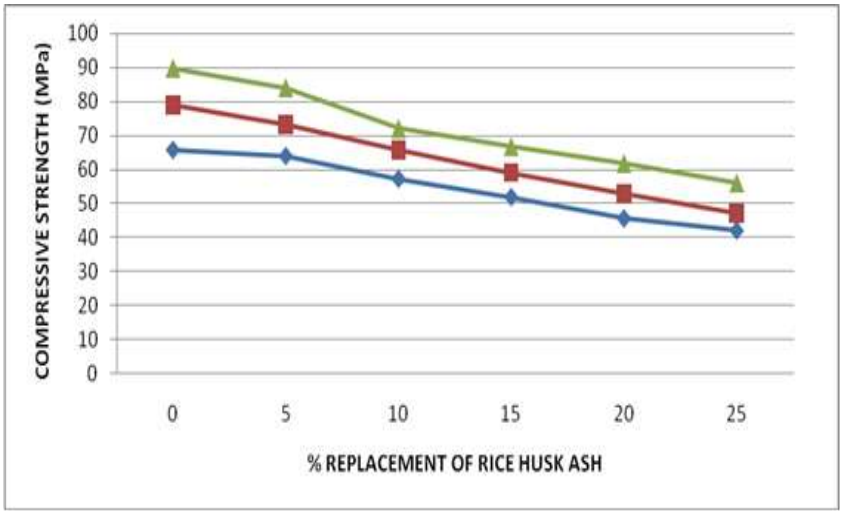

Fig. 1: Graph showing variations in compressive strengths replaced with RHA at 28, 56 & 90 days

The compressive strengths were decreasing with the increase in the replacement content of Rice Husk Ash Content

Table - 2

Compressive strength of cubes replaced with RHA at 28, 56 & 90 days

Sample Designation	*% of RHA*	*Split Tensile Strength of Cylinder Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*8.53*	*10.26*	*11.64*
M-5	*5*	*8.48*	*10.02*	*11.04*
M-10	*10*	*8.33*	*9.55*	*10.46*
M-15	*15*	*7.26*	*8.25*	*9.30*
M-20	*20*	*6.15*	*7.10*	*8.29*
M-25	*25*	*5.48*	*6.11*	*7.26*

Table - 3

Compressive strength of cubes replaced with GGBS at 28, 56 & 90 days

Sample Designation	*% of GGBS*	*Compressive Strength of Cube Specimens in Mpa*		
		28 days	*56 days*	*90 days*
M-0	*0*	*65.77*	*79.11*	*89.77*
M-5	*5*	*67.55*	*83.11*	*93.33*
M-10	*10*	*72.00*	*88.88*	*96.00*
M-15	*15*	*71.11*	*84.00*	*90.66*
M-20	*20*	*69.33*	*79.11*	*87.11*
M-25	*25*	*65.77*	*73.77*	*81.77*

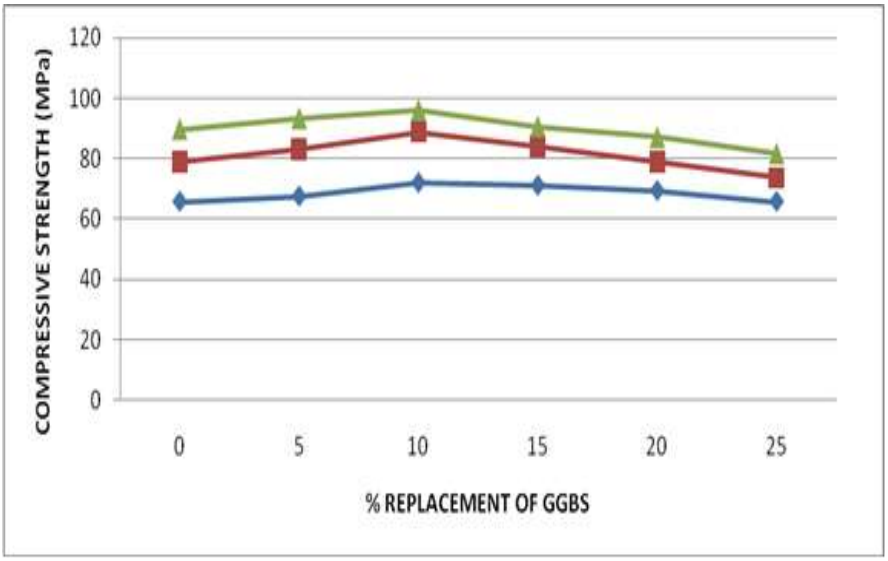

Fig. 2: Graph showing variations in compressive strengths replaced with GGBS at 28, 56 & 90 days

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Table - 4
Split Tensile strength of cylinders replaced with GGBS at 28, 56 & 90 days

Sample Designation	*% of GGBS*	*Split Tensile Strength of Cylinder Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*8.53*	*10.26*	*11.64*
M-5	*5*	*9.57*	*11.77*	*13.22*
M-10	*10*	*10.80*	*13.33*	*14.4*
M-15	*15*	*10.27*	*12.13*	*13.09*
M-20	*20*	*9.69*	*11.05*	*12.17*
M-25	*25*	*8.54*	*8.84*	*9.80*

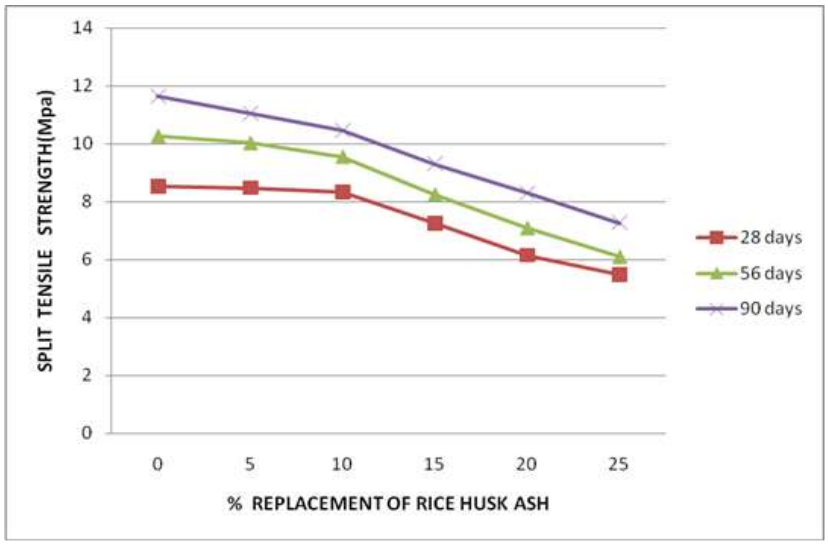

Fig. 3: Graph showing variations in Splitting tensile strengths replaced with RHA at 28,56 & 90 days

Table - 5
Flexural Strength of Beams replaced with RHA at 28, 56 & 90 days

Sample Designation	*% of RHA*	*Flexural Strength of Beam Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*13.14*	*15.80*	*17.93*
M-5	*5*	*12.86*	*14.54*	*17.12*
M-10	*10*	*12.05*	*13.82*	*15.13*
M-15	*15*	*10.68*	*12.14*	*13.69*
M-20	*20*	*9.14*	*10.55*	*12.33*
M-25	*25*	*7.59*	*8.46*	*10.06*

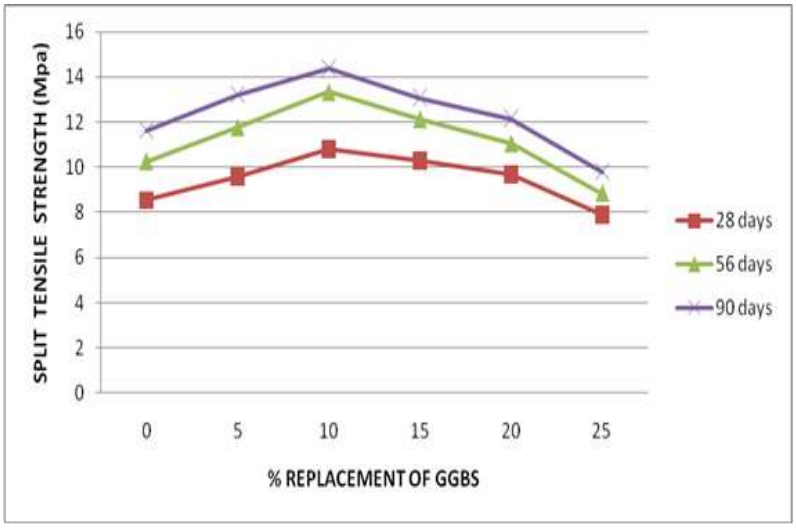

Fig. 4: Graph showing variations in Splitting Tensile Strength replaced with GGBS at 28, 56 & 90 days.

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Table - 6
Flexural Strength of Beams replaced with GGBS at 28, 56 & 90 days

Sample Designation	*% of GGBS*	*Flexural Strength of Beam Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*13.14*	*15.80*	*17.93*
M-5	*5*	*13.87*	*17.06*	*19.16*
M-10	*10*	*15.82*	*19.52*	*21.09*
M-15	*15*	*15.25*	*18.01*	*19.44*
M-20	*20*	*14.54*	*16.59*	*18.26*
M-25	*25*	*11.85*	*13.29*	*14.73*

Table - 7
Flexural Strength of Beams replaced with RHA at 28, 56 & 90 days

Sample Designation	*% of RHA*	*Flexural Strength of Beam Specimens in Mpa.*		
		28 days	*56 days*	*90 days*
M-0	*0*	*13.14*	*15.80*	*17.93*
M-5	*5*	*12.86*	*14.54*	*17.12*
M-10	*10*	*12.05*	*13.82*	*15.13*
M-15	*15*	*10.68*	*12.14*	*13.69*
M-20	*20*	*9.14*	*10.55*	*12.33*
M-25	*25*	*7.59*	*8.46*	*10.06*

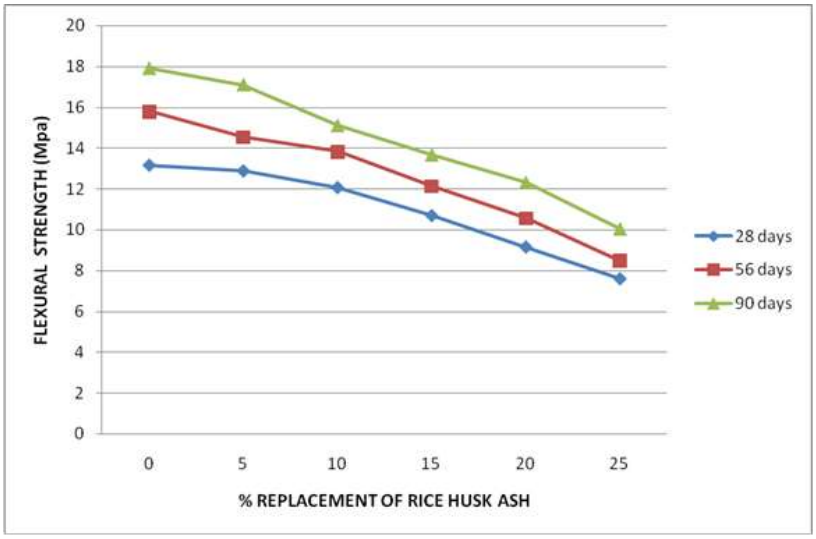

Fig. 5: Graph showing variations in Flexural strengths replaced with RHA at 28,56 & 90 days.

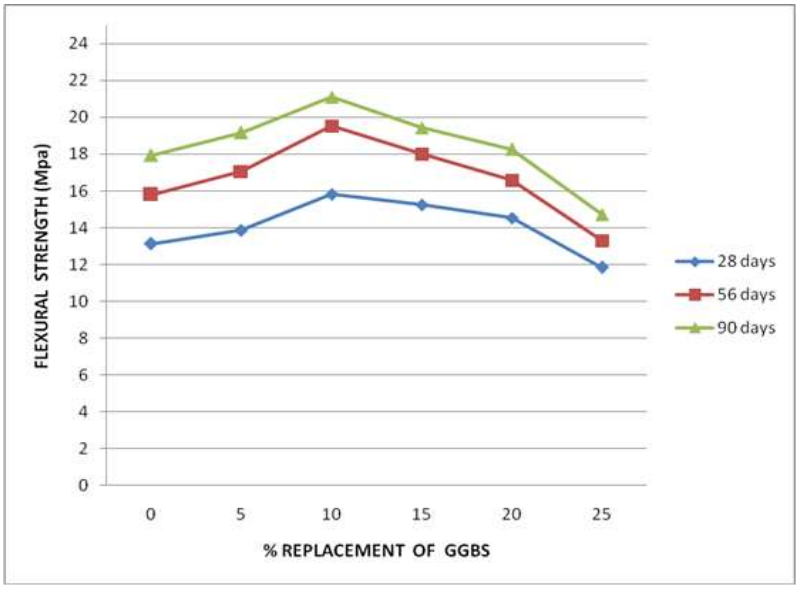

Fig. 6: Graph showing variations in Flexural Strengths replaced with GGBS at 28,56 & 90 days.

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II. DISCUSSIONS & CONCLUSIONS

The following are the Discussions & conclusions drawn from various experimental results reported from this work:

1) RHA can be successfully used as a mineral admixture for replacement of cement. But the compressive strength values were found to be slightly lesser when compared with the control mix concrete.
2) The trial mix M-5 i.e 5% replacement of RHA along with super-plasticizer gave the compressive strength up to 64 MPa, which is more than that of designed M60 grade compressive strength.
3) The other trail mixes M-10,M-15,M-20,M-25 i.e replacement levels of RHA viz., 10%,15%,20% & 25%, the compressive strength values were found to be decreasing with the increase in the percentage replacement of the mineral admixture which were tested after 28 days of curing.
4) The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 2.69%, 12.8%,20.9%,30.4%,35.8% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 28 days of curing.
5) The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 7.30%, 16.86%,25.28%,33.15%,40.4% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 56 days of curing.
6) The percentage decrease in compressive strength when compared with control mix for the replacement of RHA were 6.42%, 19.79%,25.74%,31.19%,37.61% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 90 days of curing.
7) Mixing of GGBS to concrete significantly affected the strength parameters of concrete.
8) The optimum replacement of GGBS was found to be 10% replacement and the compressive strength was found to be 72 MPa when compared with control mix and other trial mixes of RHA & GGBS, after 28 days of curing.
9) The increase compressive strength when compared with control mix for the replacement of GGBS were 2.7%, 9.4%,8.1%, 5.4%, 0% respectively for the trail mixes M-5,M-10,M-15,M-20,M-25 after 28 days of curing.
10) The percentage increase in compressive strength when compared with control mix for the replacement of GGBS were 5.05%,12.34%,6.18%,0% respectively for the trail mixes M-5,M-10,M-15,M-20, and a decrease in M-25 with a percentage of 6.75% after 56 days of curing.
11) The percentage increase in compressive strength when compared with control mix for the replacement of GGBS were 3.96%, 6.93%,0.9%,respectively for the trail mixes M-5,M-10,M-15 and decrease in strength for M-20 & M-25 with a percentages of 2.96%,8.91% after 90 days of curing.
12) RHA can be successfully used as a mineral admixture for replacement of cement. But the Splitting tensile strength values were found to be slightly lesser when compared with the control mix concrete.
13) The Trail mixes M-5, M-10, M-15, M-20 & M-25 i.e replacement levels of RHA viz., 5%,10%,15%,20% & 25%, the Splitting tensile strength values were found to be decreasing with the increase in the percentage replacement of the mineral admixture which were tested after 28 days of curing.
14) The percentage decrease in Splitting tensile strength when compared with control mix for the replacement of RHA were 0.58%, 2.34%,14.88%,27.90%,35.75% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 28 days of curing.
15) The percentage decrease in Splitting tensile strength when compared with control mix for the replacement of RHA were 2.33%, 6.92%,19.59%,30.79%,40.44% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 56 days of curing.
16) The percentage decrease in Splitting tensile strength when compared with control mix for the replacement of RHA were 5.15%, 10.13%,20.10%,28.78% & 37.62% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 90 days of curing.
17) The optimum replacement of GGBS was found to be 10% replacement and the Splitting tensile strength was found to be 10.80 MPa when compared with control mix and other trial mixes of RHA & GGBS, after 28 days of curing.
18) The increase Splitting tensile strength when compared with control mix for the replacement of GGBS were 12.19%, 26.61%,20.39%, 13.59% & 0.1% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 28 days of curing.
19) The percentage increase in Splitting tensile strength when compared with control mix for the replacement of GGBS were 14.71%,29.92%,18.22%,7.69% respectively for the trail mixes M-5,M-10,M-15 & M-20, and a decrease in M-25 with a percentage of 13.84% after 56 days of curing.
20) The percentage increase in Splitting tensile strength when compared with control mix for the replacement of GGBS were 13.57%,23.71 %,12.45% & 4.55% respectively for the trail mixes M-5,M-10,M-15 & M-20 and decrease in strength for M-25 with a percentage of 15.80% after 90 days of curing.
21) The Flexural strength values were found to be slightly lesser when compared with the control mix concrete.
22) The percentage decrease in Flexural strength when compared with control mix for the replacement of RHA were 2.13%,8.29 %,18.72%,30.44% & 42.23% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 28 days of curing.
23) The percentage decrease in Flexural strength when compared with control mix for the replacement of RHA were 7.97%,12.53%,23.16%,33.22% & 46.45% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 56 days of curing.

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24) The percentage decrease in Flexural strength when compared with control mix for the replacement of RHA were 4.51%,15.61 %,23.64%,31.23% & 43.89% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 90 days of curing.
25) Mixing of GGBS to concrete significantly affected the strength parameters of concrete.
26) The optimum replacement of GGBS was found to be 10% replacement and the Flexural strength was found to be 15.82 MPa when compared with control mix after 28 days of curing of GGBS and all trial mixes of RHA after 28,56 & 90 days of curing
27) The increase Flexural strength when compared with control mix for the replacement of GGBS were 5.55%, 20.39%,16.05%, 10.65% & 9.81% respectively for the trail mixes M-5,M-10,M-15,M-20 & M-25 after 28 days of curing.
28) The percentage increase in Flexural strength when compared with control mix for the replacement of GGBS were 7.97%,23.54 %,13.98% & 5% respectively for the trail mixes of M-5,M-10,M-15 & M-20 and a decrease in M-25 with a percentage of 15.88% after 56 days of curing.
29) The percentage increase in Flexural strength when compared with control mix for the replacement of GGBS were 6.86%,17.62 %,8.42% & 1.84% respectively for the trail mixes of M-5,M-10,M-15 & M-20 and a decrease in M-25 with a percentage of 17.84 % after 90 days of curing.
30) Combination of RHA & GGBS can be successfully used as a mineral admixture for the replacement of cement.
31) The compressive strength values were found to be increased when compared with the designed M 60 grade compressive strength.
32) The percentage decrease in compressive strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 2.69%,0.98%,0.28%,2.53% & 6.05% respectively for the trail mixes of M-5,0.,M-5,5.,M-5,15.,M-5,20. & M-5,25. and increase in M-5,10. with a percentage of 1.35% after 28 days of curing.
33) The percentage decrease in compressive strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 7.30%,2.11%,3.46%,7.36% & 11.46% respectively for the trail mixes of M-5,0.,M-5,5.,M-5,15.,M-5,20. & M-5,25. and increase in M-5,10. with a percentage of 0.50% after 56 days of curing.
34) The percentage decrease in compressive strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 6.42%,2.21%,1.71%,5.55%,8.36% & 12.07% respectively for the trail mixes of M-5,0.,M-5,5.,M-5,10.,M-5,15.,M-5,20. & M-5,25 .after 90 days of curing.
35) The percentage decrease in Splitting tensile strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 0.58% & 8.67% respectively for the trail mixes of M-5,0. & M-5,25. and increase inM-5,5., M-5,10.,M-5,15. & M-5,20 with a percentage of 4.68%,10.78%,6.68%,2.34% after 28 days of curing.
36) The percentage decrease in Splitting tensile strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 2.33%,1.36% & 12.47% respectively for the trail mixes of M-5,0.,M-5,20. & M-5,25. and increase in M-5,5., M-5,10. & M-5,15. with a percentage of 5.06%,11.5% & 4.77% after 56 days of curing.
37) The percentage decrease in Splitting tensile strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 5.32%,4.29% & 14.86% respectively for the trail mixes of M-5,0.,M-5,20. & M-5,25. and increase in M-5,5., M-5,10. & M-5,15. with a percentage of 3.26%,7.04% & 0.51% after 90 days of curing.
38) The percentage decrease in Flexural strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 2.13% & 10.5% respectively for the trail mixes of M-5,0. & M-5,25. and increase in M-5,5., M-5,10.,M-5,15. & M-5,20 with a percentage of 0.68%,6.92%,3.80% & 0.22% after 28 days of curing.
39) The percentage decrease in Flexural strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 7.97%,1.01%,0%,5.31% & 16.13% respectively for the trail mixes of M-5,0.,M-5,5.,M-5,15.,M-5,20 & M-5,25. and increase in M-5,10. with a percentage of 5.63% after 56 days of curing.
40) The percentage decrease in Flexural strength when compared with the control mix for the constant percentage replacement of RHA and variable percentage replacement of GGBS combindly were 4.51%,1.05%,5.07% & 15.44% respectively for the trail mixes of M-5,0.,M-5,15.,M-5,20 & M-5,25. and increase in M-5,5. & M-5,10., with a percentage of 0.16% & 4.46% after 90 days of curing.

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