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Effect of Rice Husk Ash and GGBS on Performance of Concrete

B. N. Sangeetha
M.Tech Student
Department of civil engineering
KIIT University, Bhubaneshwar,
India

***Abstract*—now-a-days, one of the greatest threat to living beings is environmental pollution. It is due to the release of waste materials which are produced in agricultural industries and other industries. These products contain high amount of organic and inorganic compounds which can be used in cement to increase its strength. Rice husk ash and GGBS are one of those industrial waste products which are used as replacement of cement. During the manufacture of concrete large amount pf co2 is released into atmosphere. Rice husk ash is a carbon neutral green product. Replacement of Rice husk ash and GGBS reduces the emission of greenhouse gasses. In many countries there is a need to decreases the cost of construction with increase in demand. So by using these waste products there is decrease in consumption of cement which decreases the cost and also these materials are easily available for people. Research has shown that the replacement of cement with Supplementary Cementing Materials improves the mechanical properties of concrete. In this paper we study the strength and durability of concrete when subjected to different temperatures and atmospheric conditions. It was observed that upto 30% replacement of Rice husk ash and 50% replacement with GGBS in concrete give good increase in strength.**

Keywords— Waste Material; GGBS; RHA; Compressive Strength; Partial Replacement; Durability; Sulaphate Attack; Thermal Resistance.

I. INTRODUCTION

Every year about 2.6 trillion tons of waste is produced worldwide which creates ecological imbalance. In developed countries, action is taken to reduce the pollution caused due to release of agricultural and industrial wasted.. These released products contain high amounts of inorganic and inorganic compounds. By using these industrial waste products a huge amount of land is saved which was used for their disposal [1, 2]. By the addition of these products strength of concrete can be enhanced. In many countries there is a need of locally manufactured building materials, as the demand for housing is greater than the expensive and traditional building materials [3]. During the production of cement about 1ton of carbon dioxide is produced. So there will be more pressure from the government to decrease the production of cement in the upcoming years. With growing environmental consciousness the pollution and health hazards' associated with concrete and cement industries are under intense scrutiny [2,4,8].Most commonly available waste materials are fly ash, rice husk ash, silica fume, ground granulated blast furnace slag and demolished building materials.

A. RICE HUSK ASH

India is major rice producing country. About 649.7 million tons of rice husks are produced worldwide. Rice husk ash is about 25% by weight of rice husk when burnt in boilers [6]. Rice husk is transferred from the mill to the furnace where it is used as fuel for burning. Hot air is passed from the ignition chamber which helps in burning of rice husk. The steam produced heats the water present in the boilers, and along with steam the ash particles travels and theses settled particles are collected at different stages. Hence the rice husk ash is obtained.RHA is a carbon neutral green product. The chemical composition of rice husk is found to vary from one sample to another due to the differences in the type of paddy, crop year, climate and geographical conditions [28, 11]. RHA when burnt below 750^0C generates amorphous silica. While when burnt at temperatures greater than 800^0C generates crystalline silica [7, 17, 23].

B. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

GGBS has been used in construction industry for years as replacement of ordinary Portland cement when molten iron slag is quenched in steam or water, a glassy product is obtained. It is then dried and made into powder. It is called ground granulated blast furnace slag (GGBFS OR GGBS). [24]Addition of GGBS to cement increases the life span from 50 to 100 years. So it gives greater durability. It has longer settling time. So there is a risk factor when the work at the site should be done quickly. It has low heat of hydration and temperature rise is also less [5, 28, 25].

II. XRD analysis of RHA

The properties of RHA depend upon its burning conditions. It was observed that with increase in temperature the crystalline form of RHA decreases. There are two types of RHA. The RHA burnt at high temperatures is white in color while the color of RHA burnt at lower temperature is black in color. Black RHA contains high amount of carbon compared to white RHA [11, 19]. The XRD graphs for the two different types of RHA is shown below

Fig 1[19]

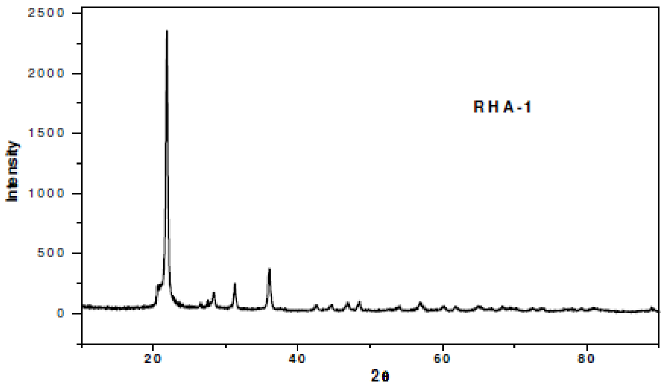
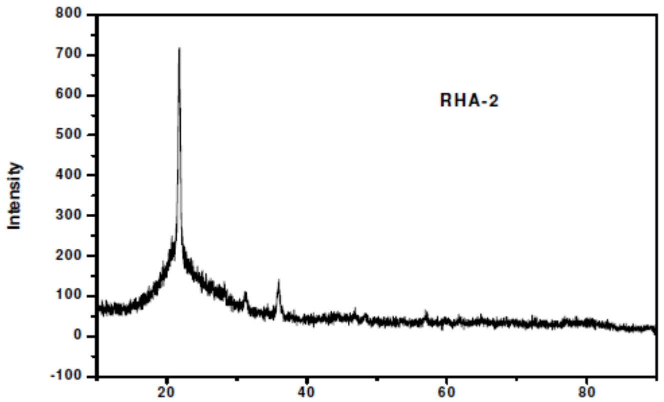


Fig 2[19]



RHA 1= BLACK RHA
RHA 2= WHITE RHA

III. COMPRESSIVE STRENGTH

Padma Rao [9] at el observed that there was significant increase in compressive strength from 7 to 28 days and from 28 days to 56 days compared to the early age strength. By using rice husk ash the emission of green house gasses can be decreased. Vijaya Gowri at el [10] reported that GGBS has good pozzolanic properties. They added high volumes of slag without the addition of superplasticiser in it. But the workability of concrete was maintained. Cement is replaced by 50% of GGBS, i.e. cement: GGBS =50:50. W/B ratio varied from 0.27 to 0.55 for which it was seen that there was significant increase in compressive strength. Compressive strength, split tensile strength and flexural strength of 90 days, 180 days and 360 days were found to have maximum strength at W/B ratio of 0.27, i.e. high volumes of slag gives good compressive strength with increase in time. It was seen that 15% to 40% of strength is increased. A relation between compressive strength and split tensile strength was obtained and also a relation was established between compressive strength and flexural strength.

$ft = 0.10069 (fc)^{0.9019}$ is the relation for compressive and split tensile strength

$fr = 1.2631 (fc)^{0.327}$ is the relation between compressive strength and flexural strength

According to Dr.Viet-Thein-An Van [11] to obtain high compressive strength in UHPC, optimum content of GGBS and RHA was replaced in the cement. At a Superplasticizer dose of 0.8% and 1.2%, with increase in percentage of GGBS the strength of concrete first increases and then again decreases. At low dosage of superplasticizer highest compressive strength was observed. 20% GGBS with 15% RHA and superplasticizer dosage of 0.8% gave highest 28days compressive strength. Oner A and Akyuz S[12] replaced GGBS in cement by 0%, 15%, 30%, 50%, 70%, 90% and 110% . Specimens were moist cured for 7, 14, 28, 63, 119, 180 and 365 days. They observed that with increase in percentage of GGBS compressive strength also increased. But after 55% there was no further increase in compressive strength. So it was concluded that compressive strength increases with replacement of GGBS till certain percentage only i.e. optimum level only. Sonali k.gapalliwar at el[13] observed the effect of replacement of cement by GGBS and RHA and natural sand by quarry sand. GGBS replacement values were about 10%, 20% and 30%.while the percentages of replacement of GGBS and RHA was (25%+5%), (22.5+7.5%) and (20%+10%).the super plasticizer used was AC-PLAST-BV M4 PLASTICIZER which is a high range water reducing agent. a slump value of 60mm was maintained for all mixtures. the replacement level of (22.5%+7.5%) gives good increase in compressive strength, while the rest of the mixtures of GGBS with RHA gives lower strength compared to the controlled mixture. Prasanna venkatesan ramani and pazhani kandukalpatti chinnaraj[14] reported that when GGBS was replaced with BRHA by 10%, 20% and 30%, and NaOH and Na2SiO3 solutions added to the mix, the compressive strength of geopolymer was improved. They observed that replacement of 10% of BRHA in 100% GGBS geopolymer gave higher compressive strength and tensile strength. Upto 20% replacement of GGBS with BRHA strength is greater than target strength even though there was retarding effect with increase in percentage of BRHA. But 30% replacement did not give high strength and durability. So it was concluded that use of higher percentages of BRHA is not required. Similar report as given by padma rao was recorded by Ravi Prasad at el[15]. They showed good increase in compressive strength when cement was replaced with RHA. Concrete containing GGBS was subjected to high temperatures and the compressive strength was observed by Rajat siddique at el [16]. Superplasticizer SNP (sulphonated naphthalene polymer) with a dosage of 1.1% by weight of cement was added to reduce the use of water in concrete. No significant deterioration of mechanical properties of concrete was seen between temperatures of 27^0C to 100^0C. At 350^0C reduction in tensile and compressive strength is less than 40% of initial value. 20% of GGBS can be suitable for construction of nuclear structures. According to Surya Veera Vasudeva Rao and Manideep Tummalapudi [17] (2012) studied on the performance of RHA at elevated temperatures. Superplasticizer used was SP430A2 to obtain a workable mix. Slump value of 75mm was maintained in all mixes. 5% to 10% replacement of RHA with cement doesn't change the strength but workability decreases with increase in RHA. So 10ml, 12ml, 14ml, 16ml superplasticizer was added for replacement level of RHA of 5%, 10%, 15%, and 20% respectively. Compressive strength increases till 100^0C to 150^0C then decreases up to 700^0C. 15% replacement is found to be optimal as the residual compressive strength at various temperatures in the range of 100^0C to 700^0C shows similar strength to that of concrete without RHA. 10% replacement with RHA shows good performance for both 7 days and 28 days when compared to normal concrete. G Hassan abood [18] studied on properties of RHA and its use as cement replacement material. In this paper test was conducted on specimens of RHA of 3 different grades. They were ground for 180 min, 270 min and 360 min. they maintained the slump value in between 200mm and 240mm, so the workability of concrete was found to be good. The Compressive strength for 1day, 3days, 7days and 28 days were investigated. The 28days strength has increased from 39.6MPA to 50.2MPA for 10% RHA ground for 270 min, i.e. 30% of strength was increased compared to control mix. The replacement of 15% RHA increased the compressive strength by 5%. The use of 20% replacement mix did not give any increase in compressive strength so further replacement of RHA in concrete is not desirable and should be avoided. Yun Young Kim at el [19] prepared a alkali activated geopolymer mortar. The compressive strength of concrete was reported by them when subjected to elevated temperatures. Alkali solutions (NaOH) of different molarities were used i.e. 7M, 8M, 9M & 10M.they was thermally cured. Temperature increase was 4^0C per minute. They increased the temperatures to 300^0C, 500^0C & 700^0C. It was seen that at 300^0C very less strength was observed due to presence of moisture. But control specimens have lost 88% of original compressive strength. When temperature is increased from 300^0C to 900^0C rapid free water evaporation takes place and reaches it maximum limit, which creates pressure inside the geopolymer and leads to the failure. The figure below shows compressive strength of concrete containing GGBS and concrete containing RHA subjected to elevated temperatures cured for 28 days.

Fig 3[16]

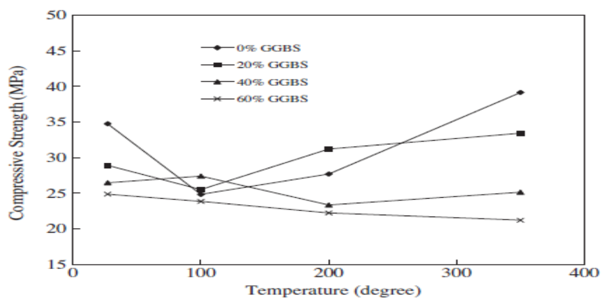


Fig. 1 Effect of temperature on the compressive strength of concrete at the age of 28 days.

Fig 4 [17]

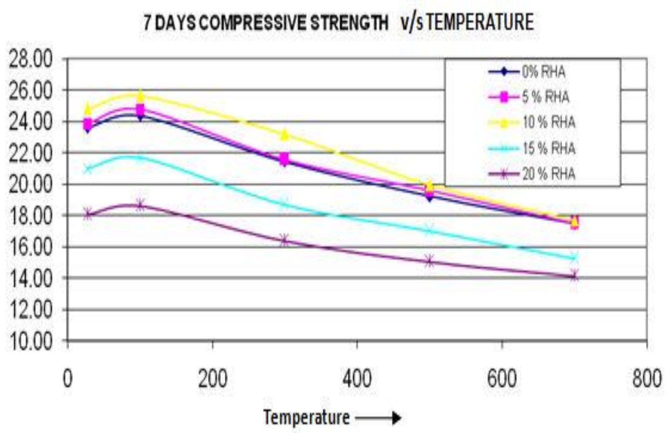


Fig 5[26]

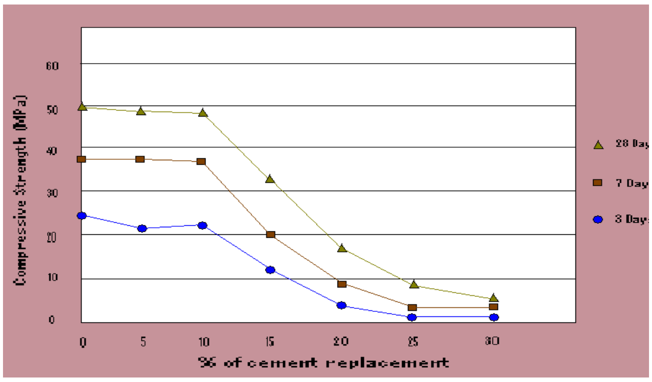
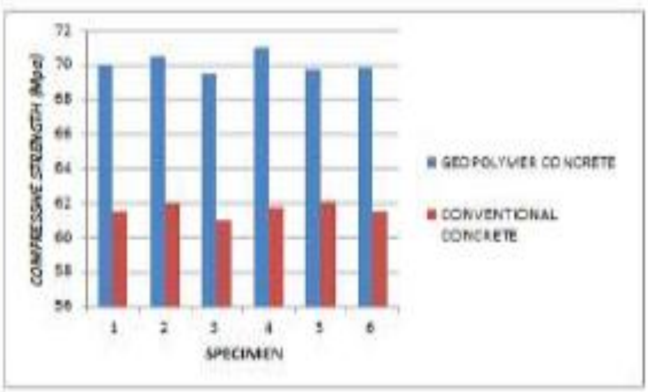


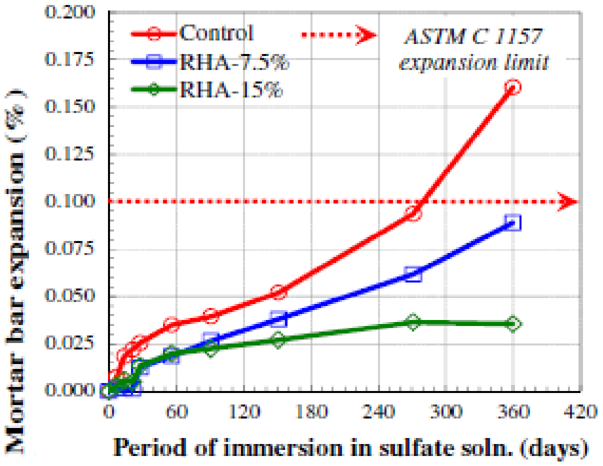
Fig 6[27]



IV. SULPHATE ATTACK

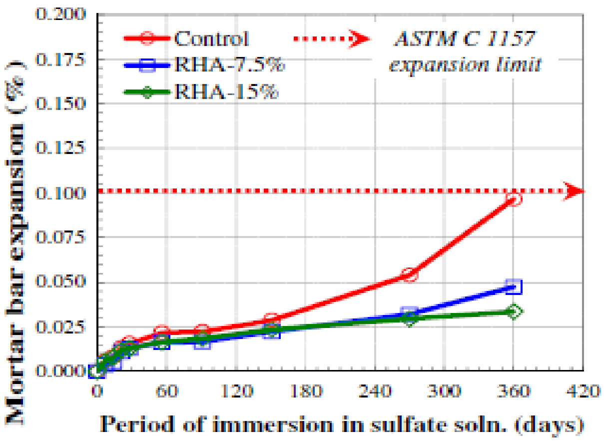
Harish Kizhakkumodom venkatanarayanan at el[20] reported that with increase in period of immersion in sulphate solution there was increase in expansion of mortar containing RHA. They observed that at lower w/c ratios, the expansion of mortar is less. OPC itself is good resistant to sulphate attack but with increase in time its resistance decreases. At 360 days concrete containing RHA showed greater resistance than concrete without RHA. They also observed that as the w/c ratio increases there was decrease in resistance to sulphate attack for concrete without RHA, while the resistance of concrete with RHA was good. The compressive strength of concrete containing RHA percentage of 7.5% and 15% was found and compared with the compressive strength of control mix. They immersed the cubes in different sulphate solution to compare the compressive strength. They found a significant increase in compressive strength for concrete with RHA at 28 days. They also reported that the loss of compressive strength was slightly lesser than the controlled mix concrete. Stephen O. Ekolu and Adam Ngwenya [21] reported that the expansion of concrete without water curing was greater than concrete cured in water for 21 days (for controlled mix). The mass loss was less when GGBS was added to it. The failure of mortar occurred at 4% to 6% expansion. They studied the effect of concentration of sulphate solution on concrete. They reported that at lower concentration high expansion was observed. Ramezanianpour at el [22] also observed similar behavior of concrete when immersed in sulphate solution. They found very less change in compressive strength for concrete. They replaced the concrete with 7%, 10% and 15% of RHA. There was an increase in compressive strength when the cubes were immersed for 2 months in 5%Na2So4 and 5%MgSo4 solutions. For 15% replacement the weight loss was found to be lower than other mixes, when concrete was immersed for 1 month. While the weight loss for 2 month and 3 month was slightly higher than that of controlled mix. The surface deterioration was not visible for concrete containing RHA, but for controlled mix deterioration was visible. Concrete immersed in 5% Na2So4 solution showed less deterioration than concrete immersed in MgSO4 solution. Controlled mix and 7% RHA replaced concrete showed slight surface deterioration. So it was concluded that RHA replaced cement showed good compressive strength and also showed good resistance to sulphate attack. It also decreased the loss of mass when exposed to sulphate solutions. The below figures show the compressive strength and mass loss of concrete.

Fig 7 [20]



Na_2SO_4 solution, w/cm = 0.57

Fig 8[20]



$MgSO_4$ solution, w/cm = 0.57

Fig 9[22]

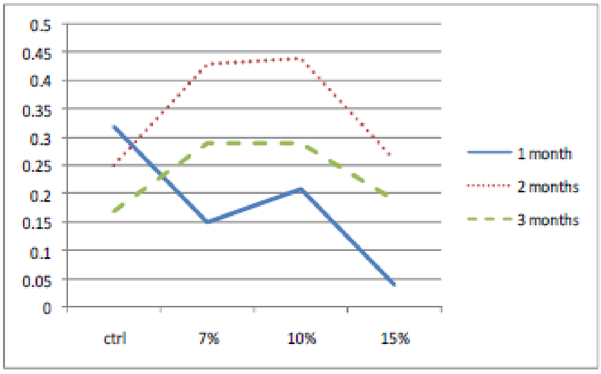


Fig 10[22]

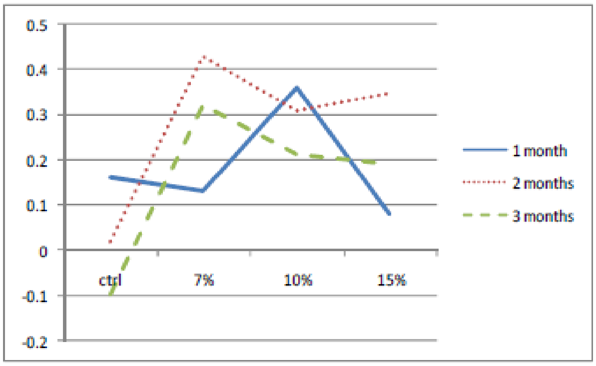


Figure 4. Relative mass change (%) In 5% $MgSo_4$

RECOMMENDATIONS FOR FUTURE RESEARCH

- Tensile strength of concrete containing GGBS and RHA
- Further research can be done on concrete taking different molarities of sulphate solution
- Flexural strength of concrete containing RHA and GGBS
- Compare the strengths when 2 or more different types of pozzolan are added to cement
- Workability of concrete containing GGBS and RHA
- Effect of w/c ratio on concrete with RHA and GGBS
- Investigate the resistance to chloride attack

CONCLUDING REMARKS

RHA replacement level upto 30% is recommended. Higher replacements of cement with RHA will not give any further increase in strength. Amorphous silica gives good compressive strength than crystalline silica. GGBS replacement level must be within 50%, as higher level of replacement may decrease the compressive strength of concrete.RHA and GGBS both give good resistance to high temperatures. Use of GGBS decreases the loss of mass and gives good resistance to sulphate attack use of RHA in concrete increases the compressive strength of concrete under sulphate attack. So the concrete can be used in nuclear structures or as refractory concrete. As it shows good resistance to sulphate attack, it can be used in marine structures.

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