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Review Paper on Geopolymer Concrete by using GGBS and Rice Husk Ash

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Abstract: This paper outlines the use of industrial products such as ground granulated blast furnace slag (GGBS) and rice husk ash (RHA) for the construction of sustainable geopolymer concrete. This item is a matrix compound consisting of GGBS and Rice Husk, with great durability. Due to the presence of GGBS and Rice Husk, the potential for concrete cracking is increasing. Geopolymer cement is replaced by cement, Ground Granulated Blast-furnace Slag (GGBS) and Rice Husk Ash (RHA) were added during the concrete mix. However, the RHA has the potential to be used as a source material in Geopolymer concrete as the RHA is a pozzolanic material containing about 85-90% of silicon dioxide (SiO2). This paper briefly reviews the work carried out by various researchers & scientists on RHA based Geopolymer concrete as well as focuses on sustainable utilization and potential benefits of using RHA in the field of Geopolymer concrete.
Keywords: Ground Granulated Blast-furnace Slag (GGBS), Rice husk (RHA), compressive strength, split tensile strength, flexural strength and durability properties

I. INTRODUCTION

Nowadays, the main interest of research is to control pollution. The main causes of pollution are industrialization, urbanization, and population growth. Consumption of cement is also increased to 1m3 of concrete per person per year to meet infrastructure development. Growing demand for concrete using ordinary portland cement (opc) has produced more co2 (6-7%), and is responsible for environmental inequality due to the continued depletion of natural resources. At the same time, it is important to protect the environment by preventing dumping of waste or product by unsustainable practices. The use of such products as a form of cement has many benefits such as durability, resource conservation and solving the disposal problem. An effort in this trend is to build a geopolymer concrete, resulting in economically friendly materials with similar mechanical properties that can be obtained from opc.

RHA :- The rice husk ash is a green supplementary material that has applications in small to large scale. It can be used for waterproofing. It is also used as the admixture to make the concrete resistant against chemical penetration. Rice husk is an agricultural residue which accounts for 20% of the 649.7 million tons of rice produced annually worldwide. 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.

Fig : 1 Rice husk

1) *GGBS:* Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by dissolving molten metal (metal product and metal fabrication) from a furnace in water or steam, to produce a glassy, granular product then dried into a fine powder. The slag of the furnace floor is highly cemented and high in CSH (calcium silicate hydrate) which is a composite compound that improves strength, durability and the appearance of concrete.

Fig : 2 Ground granulated blast furnace slag

2) Properties Of RHA

Chemical composition of RHA

TABLE I

Chemical composition of RHA

Mineral	RHA
Silicon Dioxide	87.95%
Aluminium oxide	0.26%
Iron oxide	0.20%
Calcium oxide	0.3- 2.26%
Magnesium oxide	0.2- 0.6%
Sodium oxide	0.8%
Potassium oxide	2.15- 2.30%

3) Advantages of RHA

a) Its high silica content makes it useful for strengthening building materials.
b) It resists moisture penetration.
c) RHA is a good insulator.
d) Water proofing and rehabilitation.
e) Concreting the foundation.
f) It's renewable.

4) Properties of GGBS: The typical chemical composition of GGBS are given in below table.

TABLE III

Mineral	GGBS
CaO	30-50%
SiO2	28-40%
Al2O3	8-24%
MgO	1-18%
S	0.8
MnO	0.3

5) Advantages of GGBS

a) Good workability which helps in better placing and compaction.
b) High resistance to chloride ingress (see factsheet) thus reducing the risk of steel reinforcement corrosion.
c) High resistance to attack by sulphates and other chemicals .
d) Considerable sustainability benefits.
e) Minimizes the risk of damaging internal reactions such as Alkali Silica Reaction and Delayed Ettringite Formation.

II. LITERATURE REVIEW

1) *Maria:* Eldho Geopolymer concrete technology is a promising technology for the construction industry. Replacing the conventional resource consuming Portland cement with supplementary cementitious material can reduce the carbondioxide emission as well as energy consumption. It serves as an effective way of disposing industrial wastes that found difficult to be handled in past. Rice husk ash, an agricultural biomass which is rich in silica can be used as an effective source material. In the present study M30 grade GGBS and rice husk ash based geopolymer concrete is developed. Rice husk ash of varying percentage of 5 and 15% is considered to study its effect on mechanical and durability properties. 6 M sodium hydroxide is used. Ratio of sodium hydroxide to sodium silicate used is 1:2. Ambient curing of 28 days is done. The result is compared with OPC concrete specimen to evaluate the performance of geopolymer concrete.
2) *Ankur Mehta:* The paper presents the utilization of industrial by-products such as ground granulated blast furnace slag (GGBS) and rice husk ash (RHA) for the development of sustainable geopolymer concrete. GGBS-based geopolymer concrete mixture was prepared and the effect of adding RHA as partial replacement of GGBS, on compressive strength, split tensile strength, chloride permeability and sorptivity were investigated up to the age of 90 days. In addition, SEM, EDS and XRD tests were also performed to observe the microstructure. The results indicate the development of geopolymer concrete using GGBS and RHA with high 3-day compressive strength of approximately 60 MPa, which can replace the conventional cement concrete and thus reduce carbon dioxide emissions. Also, the increase in compressive and split tensile strength, and reduction in chloride permeability and sorptivity was observed with the inclusion of RHA up to 15% at all ages. Beyond this optimum content of 15%, RHA inclusion showed negative results. In addition, the results of microstructure analysis showed more compact and dense micrograph of geopolymer concrete with 15% RHA, due to the coexistence of polymerization products with the additional calcium based hydration products.
3) *R. Prasanna Venkatesan:* This paper presents an experimental study on the strength and durability properties of Geopolymer concrete prepared using Ground Granulated Blast Furnace Slag (GGBS) and Black Rice Husk Ash (BRHA). The Geopolymer concrete was prepared with GGBS as the primary binder instead of cement and BRHA was replaced with GGBS at various proportions such as 10%, 20% and 30%. The effect of curing temperature on the compressive strength of Geopolymer concrete was studied in addition to the flexural and split tensile strengths. Studies on the durability performance under Sorptivity, Rapid Chloride Permeability Test and Accelerated corrosion were also made. The test results show that the strength of Geopolymer concrete increases with increase in curing temperature. Addition of BRHA in Geopolymer concrete beyond 10% retards the strength development yet the strengths are well above the target for up to 20% replacement levels. At the same time, addition of BRHA significantly improves the durability with reduced sorptivity and chloride permeability when compared to the control concrete. Higher corrosion initiation and delayed cracking time were observed up to 20% BRHA replacement in Geopolymer concrete.
4) *Sundeep Inti:* Research for complete OPC free concrete is still evolving and there is a need for developing alternative binding agents which are environmentally friendly. One such alternative is identified to be geopolymer which often consists of fly ash, sodium silicate, and sodium or potassium hydroxide (NaOH or KOH). Since, many coal based power plants in US have been retiring due to thrust towards cleaner energy production and this may lead to scarcity of flyash in future. Hence the objective of this study is to incorporate other Pozzolanic materials in geopolymer concrete. In line with objective two Pozzolanic materials granulated blast furnace slag (GGBS) and rice husk ash (RHA) were used to replace flyash in geopolymer concrete. Tests are performed on compressive strength of geopolymer concrete by varying percentages of RHA and GGBS. Results indicated that complete replacement of flyash in geololymer concrete with RHA and GGBS is not feasible. As geopolymerization needs specific amount alumina, RHA and GGBS have minimal amount which is adversely affecting the strength. Nevertheless GGBS up to 50% can be used as replacement of flyash to attain compressive strength around 2000 psi and 5-10% of RHA can be used to achieve similar strength. In addition micro-characterization of geopolymers was performed using scanning electron microscope and X-ray diffraction. These techniques helped in understanding the characteristics of binder formation around the sand particles which is affecting the strength.
5) *Shaswat Kumar Das:* Concrete is the most versatile, durable and reliable construction material on the planet. But sustainability becomes the major concern as the conventional concrete is not eco-friendly due the large carbon footprint of Ordinary Portland Cement (OPC) industries. Efforts are needed to develop an eco-friendly material with minimal environmental damage. A concrete with complete replacement of OPC by pozzolanic materials like fly-ash, Rice Husk Ash (RHA), Ground Granulated Blast-furnace Slag (GGBS) etc. having a polymeric binder is called Geopolymer concrete (GPC). In Geopolymer concrete, most of the research work has been focused on fly ash based binders. However, the RHA has the potential to be used as a

source material in Geopolymer concrete as the RHA is a pozzolanic material containing about 85-90% of silicon dioxide (SiO_2). This paper briefly reviews the work carried out by various researchers & scientists on RHA based Geopolymer concrete as well as focuses on sustainable utilization and potential benefits of using RHA in the field of Geopolymer concrete.

6) *Yamini J. Patel:* Rice Husk Ash (RHA) is an agricultural waste and plentifully accessible in rice-producing countries such as India. Use of RHA is achieving broader awareness because of its considerable impact on the mechanical and microstructural properties of concrete based on OPC as well as geopolymer binders. This paper presents the effect of RHA on the Fresh and Mechanical properties of Self Compacting Geopolymer Concrete (SCGC) blended by Ground Granulated Blast Furnace Slag (GGBFS). The SCGC was developed using GGBFS as the primary binder and GGBFS was replaced with 5%, 15% and 25% of RHA. The workability of fresh SCGC was assessed by slump flow, V-funnel, L-Box and J-Ring test methods as per EFNARC guidelines. Mechanical properties such as compressive strength, split tensile strength and flexural strength at 3, 7, and 28 days was tested. The results show that replacement of GGBFS with RHA results in loss of workability. The optimum replacement level of the RHA is 5% which results in 2.81% decrease in slump flow value but increases 3.02% compressive strength compare to results of 100% GGBFS SCGC mix. From SEM images, 5% RHA mix shows dense microstructure.

III.CONCLUSIONS

A. The primary focus of this investigation has been to experimentally evaluate the durability of fly ash based geopolymer concrete in the marine environment,
B. The dosage of super plasticizer had to be increased along with RHA fineness and contain to maintain the desire workability.
C. All kinds of pozzolanic material are efficient in reducing the permeability of concrete far below the control one.
D. As the GGBS contain increase the water/binder ratio also decrease for the same workability and thus the GGBS has positive effect on the workability.
E. Split tensile strength and flexural strength also decrease with the increase in percentage of GGBS at early age but it increase with increase in percentage of GGBS at latter ages.
F. Heat of hydration is slower in case of GGBS cement, which lowers the risk shrinkage cracking. And make this cement more favorable in high temperature construction areas.
G. Reuse of slag helps to protect the environment from pollution(reduce Co2emission)
H. The best proportion of GGBS and rise husk is partially replaced with cement in various percentages of 5%,10%, 20%, 30%.
I. It provides a mature and cost-effective solution to many problems where hazardous residues must be treated and stored under critical environmental conditions.
J. The employment of RHA in cement and concrete has gained considerable importance because of the requirements of environmental safety and more durable construction in the future.
K. The use of RHA as partial replacement of cement in mortar and concrete has been extensively investigated in recent years.
L. RHA blended concrete can improve the workability of concrete compared to OPC.

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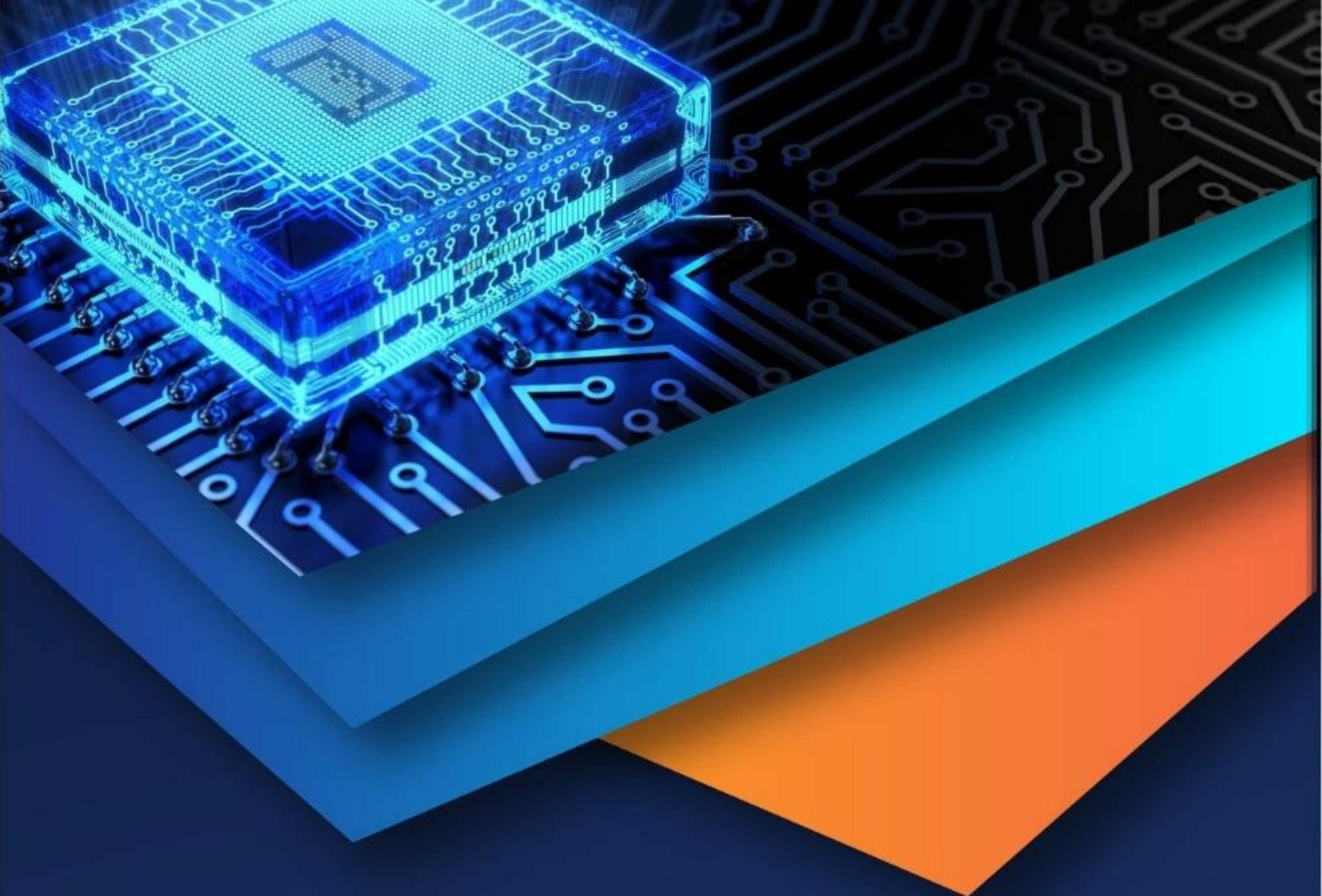

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