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Sustainable Green Concrete with a Partial Replacement of Cement and Sand

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Abstract : This paper presents the rapid surge in population and industrialization has resulted in the generation of substantial waste volumes. Large quantities of waste from industrial, commercial, mining, agricultural, and domestic activities are discharged into the soil, either treated or untreated. This discharge has profound effects on soil properties, potentially leading to improvements or degradations in the soil's engineering behavior. The implications are significant, influencing the overall environmental impact of waste disposal practices.

When there is an enhancement in the engineering behavior of soil, it presents an opportunity for the valorization of industrial wastes, offering a triple benefit of safe effluent disposal, utilization as a stabilizer, and generating income. This study explores the advantageous effects of specific agricultural and domestic wastes in geotechnical applications, using them to create a mixture.

The term "Green Concrete" does not signify a green color but rather underscores its environmental sustainability and eco-friendliness. This type of concrete is crafted using eco-friendly waste materials, thereby earning the designation of green concrete. The utilization of agricultural and industrial waste in this context not only addresses waste management concerns but also aligns with environmentally conscious practices, contributing to sustainable and eco-friendly construction solutions.

***Keywords* - Waste Valorization, Soil Engineering Behavior, Environmental Impact, Waste Disposal Practices, Industrial Waste, Agricultural Waste, Domestic Waste, Geotechnical Applications, Green Concrete, Eco-Friendly Construction, Sustainable Practices, Rice Husk Ash, Stone Dust.**

I. INTRODUCTION

The other important characters of concrete than the other materials while its strength, are easy Molded in any forms, an engineered material that can meet almost any desired specification, adaptable, quite incombustible, affordable, and easily obtained. Concrete has the advantage of having outstanding mechanical and physical properties when properly planned and constructed. Concrete is widely employed in modern industrial civilization, with more than 10 billion tonnes produced annually [1]. By 2050, it is expected that the world's population would have exploded from 1.5 to 9 billion people, resulting in increased need for energy, housing, food, and clothes, as well as a rise in demand for concrete, which is expected to climb by 18 billion tonnes annually [2].Unfortunately, the benefits of concrete are inversely proportional to the volume of concrete produced. The concrete industry has left an immense alteration in the environmental appearances during a 100-year period. In addition, CO2 emissions are produced during the manufacturing process, which requires a vast volume of raw materials to make the billions of tonnesof concrete produced each year across the world. The cement industry alone is estimated to be responsible for about 7% of all CO2 generated in the world [3]. Hereafter, the reality shows that every ton production of Portland cement releases nearly one ton of CO2 into the atmosphere. On the other hand, issues such as carbon dioxide emissions and energy consumption, large aggregate consumption, concrete demolition waste, and filler requirements all contribute to the common environmental impact that concrete is not environmentally friendly or appropriate for the needs of sustainable development.

The rapid growth in population and industrialization cause generation of large quantities of wastes. Bulk wastes from industrial, commercial, mining, agricultural, and residential operations are released over the soil, either treated or untreated, creating changes in soil attributes and a better or worsening of soil engineering behaviour. If the engineering behavior of soil improves, there is a value addition to industrial wastes, providing three benefits: safe effluent disposal, use as a stabiliser, and a return on investment.

II. METHOD

A. Green and Sustainable Concrete

With In response to escalating environmental challenges, there is a growing imperative to explore green and sustainable materials as viable alternatives to conventional counterparts across diverse applications. The term "green concrete" is not indicative of its color but rather signifies concrete that incorporates at least one ingredient derived from waste or follows an environmentally benign manufacturing process. Maintaining strength and performance is crucial when integrating waste resources into green concrete. Key determinants of green concrete include manufacturing methods, life cycle sustainability implications, and the extent of cement replacement. While adhering to the principles of reduce, reuse, and recycle, the primary objective of green concrete development is to curtail CO2 emissions, limit the consumption of natural resources, and repurpose waste materials that would otherwise contribute to disposal costs and environmental pollution.

A viable approach to harness waste materials for green concrete development involves utilizing them as partial replacements for cement. Many waste materials, arising from rapid industrialization and urbanization, are generated globally, with disparities in quantity and type across regions. Unfortunately, a significant portion of these waste materials ends up in landfills without proper treatment or re-use, posing a substantial environmental challenge. Solid waste management (SWM) has emerged as a critical concern due to the proliferation of landfill sites, prompting a reevaluation of waste disposal practices in both developing and developed nations.

B. Rice Husk Ash (RHA)

Over half of the world's population eats rice as a staple food [11]. Rice is a seed of semi- aquatic grass species. A total of 22 species of rice exist, The only two species that are essential for human consumption are Oryza sativa and Oryza glaberrima. Oryza sativa was first grown and cultivated in South and Southeast Asia between 8,000 to 15,000 years ago, while Oryza glaberrima is believed to be the domesticated version of the wild Oryza barthii species of rice approximately 3,000 years a long time ago in Africa's Niger River floodplains [11]. With the exception of Antarctica, rice is now grown on every continent. Paddy rice is the final result of rice grain harvesting and threshing. Rice paddy production is estimated to be around 600 million tonnes per year [12] and is likely to rise further in the future. Paddy rice yields 25 percent husk, 10% bran and germ, and 65 percent white rice on average [13]. Rice mills create 20% rice husk from every paddy tonne, which is subsequently utilised as fuel in the mill's boiler to generate energy. RHA [14] is formed when about 25% of the rice husk is transformed into solid trash. both Rice Husk and RHA are shown in Figure 1. Being a waste product produced by the rice mills, it has very little to none commercial value, thus is disposed causing health issues to the inhabitants nearby.

Figure 1 . Sample of Rice Husk and Rice Husk Ash

III. RESULT & DISCUSSION

Construction and demolition debris (C&D waste) is a broad term encompassing a variety of waste materials generated by the construction industry, including concrete, glass, brick, metal, wood, and plaster. C&D waste must be processed, mainly by separation, before it can be incorporated into engineering uses. Because C&D waste is a highly heterogeneous material, a comprehensive characterization is difficult to achieve. The processing of demolition debris involves a series of separations and screenings, starting with the larger materials (lumber, concrete) down to the sand and gravel sized material. Upon arrival to the processing facility the incoming material is separated into concrete and non-concrete materials. The no concrete material passes through several screens and conveyors in order to remove harmful materials such as asbestos. The concrete material is crushed and a magnet is used to remove any metal and rebar present. C&D wastes are used in asphalt pavement and base/sub base applications.

The processing and disposal of vast quantities of agricultural and home trash is a major issue all over the world. The need for a big storage area and the safe disposal of agricultural and home wastes without harming the environment are key concerns. As a result, efforts are being made to use these agricultural and domestic wastes in geotechnical engineering applications such as embankment construction, backfill, sub-base and foundation material, and so on. The use of certain agricultural and household wastes also improves the soil's engineering behaviour. As a result, there is a value addition to industrial effluent that serves the three advantages of

- Safe effluent disposal
- Use as a stabiliser
- And return on investment

Green concrete has lowered environmental effect by 30 percent by reducing CO_2 emissions in the concrete industry. They are resistant to heat and fire. The utilization of waste materials such as ceramic wastes and aggregates in concrete recycling increases waste products in the concrete industry by20%

Process

1. Collect Raw material

To produce green concrete, it is crucial to carefully collect and process the raw materials, specifically focusing on environmentally sustainable alternatives. Two key components in the formulation of green concrete are rice husk ash and stone dust.

Rice Husk Ash (RHA):

Collection: The collection process begins with obtaining rice husks, the outer layer of rice grains that is usually considered as agricultural waste. Rice mills or paddy processing units are the primary sources of rice husks.

Processing: The collected rice husks undergo a controlled combustion process to produce rice husk ash. This ash is rich in amorphous silica, making it an excellent pozzolanic material for concrete. as show on figure 2(a)

Stone Dust:

Collection: Stone dust is a by-product of crushing stones for various construction purposes. It is obtained during the process of stone mining or crushing in quarries.

Processing: The collected stone dust is typically sieved to ensure uniform particle size and to remove any impurities. This processed stone dust serves as a supplementary material in concrete production. . as show on figure 2(b)

Proportioning and Mixing:

Once the raw materials are collected and processed, the next step involves determining the appropriate proportions for the concrete mix. This is a critical aspect as it influences the strength, durability, and other properties of the green concrete.

The rice husk ash is usually added as a partial replacement for cement, contributing to the pozzolanic reaction and enhancing the concrete's performance. Stone dust, on the other hand, may be used as a partial replacement for fine aggregates. .as show on figure 2 (c)

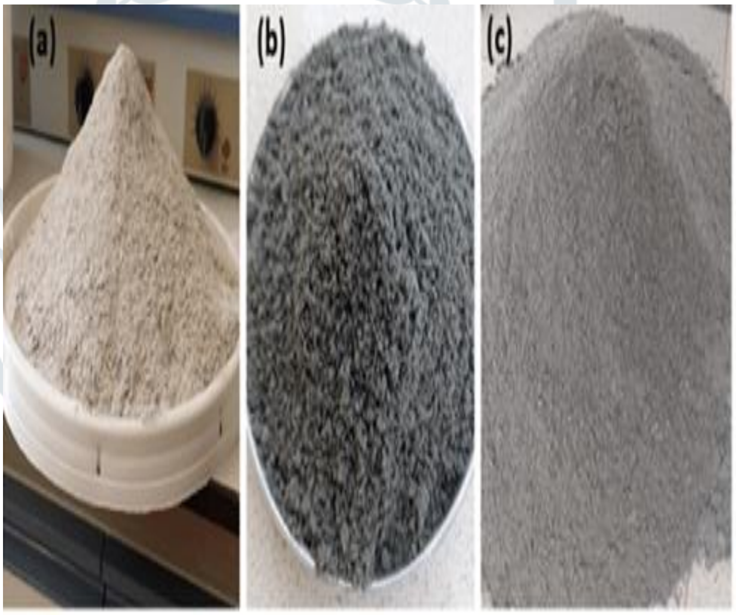


Figure 2: Collected Material(a) Rice husk ash (b) Quarry dust (c) Homogeneous composite mixture

Segregating dust for green concrete involves the careful separation and selection of specific dust materials, such as rice husk ash and stone dust, to be used in the concrete mixture. Here's a step-by-step process for segregating dust for green concrete:

Collection of Raw Materials:

Gather the raw materials, including rice husk ash and stone dust, from their respective sources. Ensure that these materials are obtained sustainably and meet the required quality standards.

Dust Size Classification:

Classify the dust particles based on size. Fine particles of rice husk ash and stone dust are typically preferred for green concrete. This can be achieved using sieves or other size classification methods.

Density Separation:

Consider the density of the dust particles. While both rice husk ash and stone dust are likely to have different densities, ensure that the segregated particles fall within the desired range for green concrete.

Quality Analysis:

Conduct a quality analysis of the segregated dust. Check for impurities, contaminants, or other materials that may affect the performance of the green concrete. This may involve laboratory testing or quality control measures.

Moisture Content Control:

Control the moisture content of the segregated dust. Green concrete often benefits from materials with specific moisture levels. Adjust the moisture content as needed to meet the concrete's requirements.

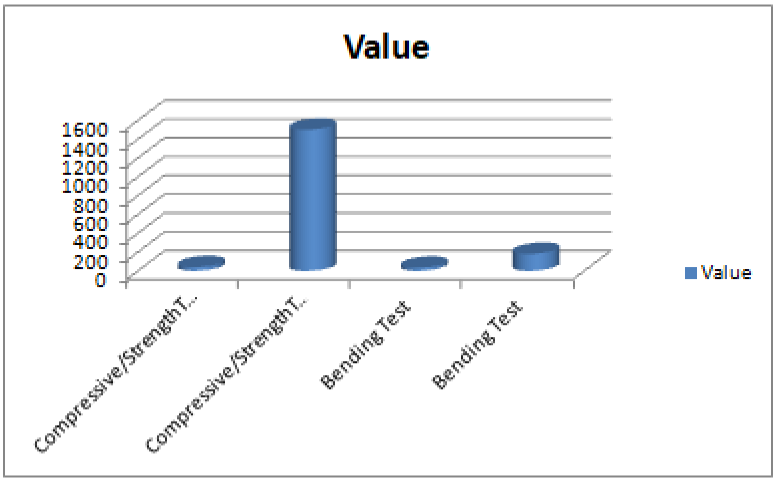
Environmental Impact Consideration:

Evaluate the environmental impact of the segregated dust. Ensure that the chosen materials align with eco-friendly and sustainable construction practices, contributing to the overall "green" nature of the concrete.

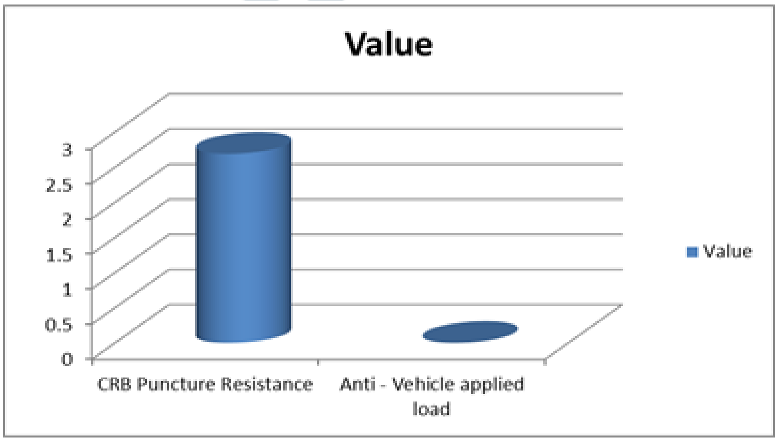
Optimization for Concrete Mix:

Optimize the proportions of rice husk ash and stone dust in the concrete mix. This involves determining the ideal ratio that balances the environmental benefits and structural properties of the green concrete.

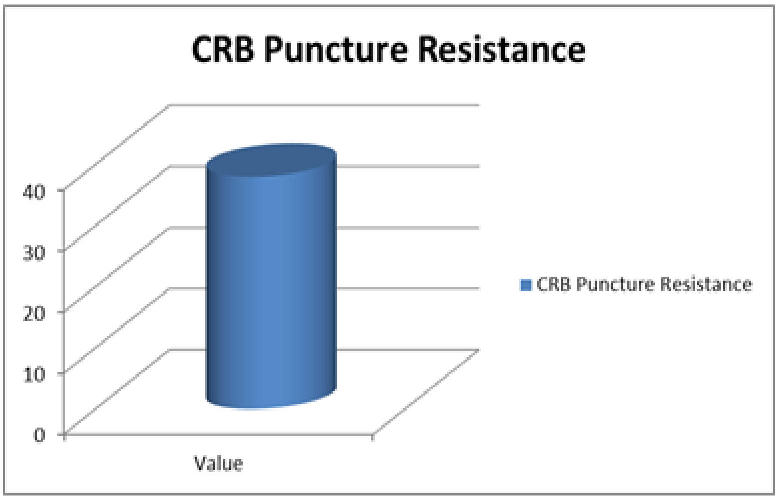
Figure 3 Green Concrete Design



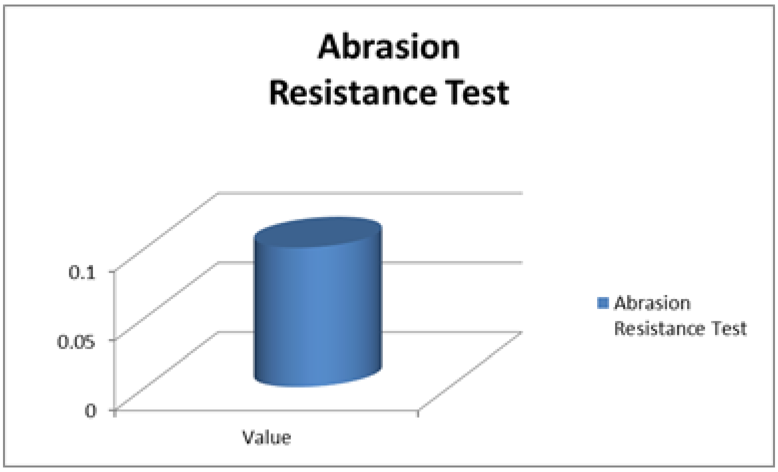
(a)The value of the Compressive Strength Test is 40mpa The value of Strength Test is 1500 mpa The value of Bending Test is 34 MPa. The value of the Bending Test 180mpa



(b)The value of CRB Puncture Resistance test is 2.69KN and the value of Anti - Vehicle applied load test is 30-160KN



(c)The value of CRB Puncture Resistance test is 38mm.



(d) The value of Abrasion Resistance Test is 0.10 g/cm2

Figure 4. Different graph for testing value

IV. CONCLUSION

This paper has focused on the development of sustainable green concrete by partially replacing cement and sand with industrial by-products, namely Fly Ash (FA), Rice Husk Ash (RHA), and Stone Dust (SD), in varying proportions. The aim is to create a cost-effective and environmentally friendly concrete utilizing these studied by-products as substitutes for traditional materials. Through systematic experimentation with different combinations of FA, RHA, and SD, our study investigates the impact on concrete performance, particularly in terms of strength. Despite the introduction of FA, RHA, and SD showing marginal decreases in strength, the overall outcomes highlight the potential of green concrete in reducing carbon dioxide emissions and optimizing the utilization of non-biodegradable industrial wastes.

Binding Action of FA and RHA:

The binding action of FA is significantly superior to RHA, although both exhibit similar results when no treatment is applied to the concrete mix.

Effectiveness of SD Replacement:

The use of SD as a replacement for natural sands in concrete is highly effective, leading to improved mechanical properties and a reduction in water absorption capacity by enhancing matrix density.

Improved Durability:

The reduction in the water absorption capacity of the FA, RHA-, and SD-based concrete indicates an enhancement in durability.

Optimal Replacement Proportions:

Approximately 20% of ordinary materials in concrete can be replaced by the studied by-products (FA, RHA, and SD) without significantly compromising strength properties. However, an excess amount may have adverse effects.

The optimal combination identified in this study involves a 5% weight replacement of FA, a 5% weight replacement of RHA for cement, and a 10% weight replacement of SD for natural sands. This combination achieves the desired strength properties without compromising the overall strength of the concrete

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