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Review on use of sugarcane bagasse ash in concrete

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ABSTRACT –

The construction industry is one of the most energy-intensive sectors globally, and cement production, being a major contributor to carbon emissions, has raised environmental concerns. To mitigate this issue, researchers have turned to alternative materials, one of which is sugarcane bagasse ash (SCBA). SCBA, a by-product of sugarcane processing, has shown potential as a partial replacement for cement in concrete production. This review paper examines various experimental investigations on the compressive strength of concrete when substituting cement with SCBA. The influence of SCBA on the mechanical properties, durability, and sustainability of concrete is discussed, along with the optimum substitution levels and the chemical interactions that affect performance.

Keyword - Sugarcane Bagasse ash (SCBA), concrete, Sustainable development, ecofriendly environment

1.INTRODUCTION :

Cement production is a major contributor to global carbon emissions, accounting for approximately 5-7% of total emissions worldwide. Consequently, there has been growing interest in finding sustainable alternatives to reduce the environmental footprint of cement. Sugarcane bagasse ash (SBA), produced as a waste product during the sugar extraction process, has emerged as a viable alternative material for partial cement substitution in concrete. SBA is rich in silica (SiO_2), making it a promising pozzolanic material, which could enhance concrete properties, particularly compressive strength.
This review paper aims to analyze the impact of SBA on the compressive strength of concrete by synthesizing various experimental studies. The goal is to evaluate the potential benefits and limitations of SBA as a cement substitute and to explore the optimal substitution levels and other influencing factors.

2. Properties of Sugarcane Bagasse Ash (SBA) :

SBA is derived by burning sugarcane bagasse, a fibrous residue left after extracting juice from sugarcane. The physical and chemical properties of SBA vary depending on the burning conditions and processing methods. However, typical characteristics include:

- Chemical Composition: SBA primarily consists of silica (SiO_2), along with small amounts of alumina (Al_2O_3), calcium oxide (CaO), and iron oxide (Fe_2O_3). The pozzolanic properties of SBA are mainly attributed to its high silica content.
- Particle Size and Surface Area: The particle size of SBA is generally finer than that of ordinary Portland cement (OPC), which contributes to its ability to react with lime in the cementitious matrix and improve strength.
- Color: SBA has a light gray or white color, which can be indicative of low carbon content, a desirable property for use in concrete.

2.LITERATURE REVIEW :

R Srinivasan and K. Sathiya demonstrated that blended SCBA-infused concrete had superior performance in terms of compressive, tensile, and flexural strengths when compared to concrete that did not contain carbon black. The researchers came to the conclusion that SCBA can substitute cement up to a maximum of ten percent of the original material. Even further, they arrived at the conclusion that increasing the amount of SCBA would result in a decrease in the density of the concrete, which would then lead to the manufacture of concrete with a lower weight. Compressive quality, split rigidity, flexural strength, and modulus of flexibility at seven years old and 28 days were some of the established solid tests that were used. Additionally, new strength tests such as the compaction factor test and the droop cone test were also adopted.

When compared to concrete that did not contain SCBA, the data indicate that blended concrete that did contain SCBA had significantly higher compressive, tensile, and flexural strengths. The addition of SCBA to plain solid improves its quality under pressure, strain, youthful modulus, and flexure up to 10% of substitution after those quality outcomes decreased, as indicated by the strength test results obtained for concrete cube, cylinder, and prism specimens with partial replacement of SCBA. This improvement follows a decrease in the quality outcomes caused by the addition of SCBA.

According to the findings, SCBA has the potential to replace concrete up to the highest conceivable cutoff point of 10% in a profitable manner. Despite this, a substitution rate of 10% was utilized in order to acquire the greatest possible amount of SCBA content. Because the new concrete is easier to work with when the bond is partially substituted by SCBA, the use of super plasticizer is not as critical as it once was.

A study was conducted by M.Vijaya Sekhar Reddy and I.V.Ramana Reddy in December 2012 to investigate the behavior of High Performance Concrete (HPC), which is the type of concrete that is utilized in the construction industry the most frequently. As an alternative to cement, they utilized metakaolin, fly ash, and silica fume as Supplementary Cementing Materials (SCM). Using the M60 mix design, cubes were cast and cured for a period of ninety days in a solution consisting of 5% hydrochloric acid (with a pH of 2), sodium hydroxide, magnesium sulfate, and sodium sodium sulfate. It was determined by them that the addition of additional cementing elements to concrete resulted in a significant extension of the service life of the structures and a reduction in the heat production during the hydration process. They discovered that the highest percentage of concrete strength loss that happened when fly ash was replaced for concrete was 12.64%, and the lowest percentage of concrete strength loss that occurred was 1.92%.

Based on their findings, Bangar Sayali S. and colleagues came to the conclusion that if some of the cement in concrete was replaced with SCBA, the strength of the concrete could be increased while using less cement. As a matter of fact, they arrived at the conclusion that the most effective application for bagasse ash is cement addition, as opposed to land filling.

The year 2013: Kawade, U.R. As cement continues to gain popularity and be used more frequently, professionals and academics are looking for ecologically friendly alternatives to fasteners that may also assist with waste management. The utilization of garbage from industrial and agricultural settings that is generated by modern methods has been the primary focus of efforts to improve waste reduction. Sugarcane bagasse powder, also known as SCBA, is a stringy waste product that is obtained from the sugar industry on an item-by-item basis. It is considered to be an agricultural waste product. In that stage, the juice is extracted from the sugar stick by employing cinder that was produced by consuming bagasse under conditions that were not under control and at a high temperature. SCBA was synthesized, physically characterized, and partially substituted by weight of bond in concrete in the following proportions: 0%, 10%, 15%, 20%, 25%, and 30%. This study was conducted in order to investigate the characteristics of SCBA. Both the slump cone test for new concrete and the compressive strength of hardened concrete at ages 7, 28, 56, and 90 days are evaluated. Additionally, the slump cone evaluation is performed. According to the findings of the tests, substituting cement for SCBAs can increase the strength of concrete by as much as fifteen percent.

After soaking the cubes in solutions of sulphuric and hydrochloric acids for a period of thirty-two weeks, P. Murthi and V. Siva Kumar conducted an investigation in 2008 to determine the level of resistance that ternary mixed concrete possessed to acid attack. Binary blended concrete was made using 20% class F fly ash, and ternary mixed concrete was made with 20% fly ash and 8% silica fume by weight of cement. Both types of blended concrete were created using the same proportions. After conducting a great deal of research, they arrived at the actual conclusion that the ternary blended concrete was functioning better than both the binary blended concrete and the conventional plain concrete. They found that the mass loss of the M20 PCC specimens at 28 and 90 days was 19.6% and 16.1%, respectively according to their findings. In addition, they observed that it took 32 weeks to reduce the loss of 10% of mass when the substance was submerged in solutions that contained 5% $H2SO4$ and 5% HCl.

Metakaolin was used in place of cement in high-performance concrete that was exposed to hydrochloric acid, and Beulah M., an assistant professor, and Prahallada M., a professor, conducted research on the effects of this substitution. For the purpose of casting the cubes, a variety of water cement ratios (0.3, 0.35, 0.4, and 0.45) were utilized. The compressive strength of the cubes measuring 150 mm by 150 mm by 150 mm was evaluated, as was the percentage of weight loss that occurred in the cubes measuring 100 mm by 100 mm by 100 mm. They were treated in hydrochloric acid at a concentration of 5% for thirty, sixty, and ninety days.

Mr. H.S. Otuoze and his colleagues were the ones who carried out the research investigation titled "Characterization of Sugar Cane Bagasse Ash and Ordinary Portland Cement blends in Concrete." SCBA is produced by burning sugar cane bagasse at temperatures ranging from 600 to 700 degrees Celsius. This is done because the total amount of Sio2, Al2o3, and Fe2o3 is 74.44%. The strength test was conducted using a mix ratio of 1:2:4, and OPC was partially substituted with 0.5 percent, 10 percent, 15 percent, 20 percent, 25 percent, 30 percent, 35 percent, and 40 percent by weight in the concrete. At seven, fourteen, twenty-one, and twenty-eight days of age, the compressive strength values of hardend concrete were measured. In light of the findings of the experiment, it is possible to assert that SCBA is an outstanding pozzolana for the purpose of cementing concrete. Furthermore, it is possible that combining it with OPC in a partial mixture could result in concrete that possesses exceptional strength development and other engineering characteristics. When it comes to reinforced concrete with dense aggregate, the maximum percentage of SCBA that can be used in mixes with OPC is 10%. Higher blends of SCBA with OPC, up to 35%, are permitted for use in bulk or flat concrete. The maximum allowable percentage is 15%.

The research project titled "Compressive Strength and Microstructure of Sugar Cane Bagasse Ash Concrete" was carried out by Asma Abd Elhameed Hussein and another group of researchers. The purpose of this study is to report on an experimental inquiry that determined whether or not it would be feasible to use Sugar Cane Bagasse Ash (SCBA) as an alternative to cement when producing concrete. The ordinary Portland cement was replaced with a mixture of 0 percent, 5 percent, 10 percent, 15 percent, 25 percent, and 30 percent, respectively, in order to explore the effect that sugar cane bagasse ash has on the workability, compressive strength, and microstructure of the Interfacial Transition Zone (ITZ) of concrete. The findings revealed that the addition of sugar cane bagasse ash to concrete to the extent of up to twenty percent improved the concrete's compressive strength at all ages of concrete; the highest level of compressive strength was attained at a replacement level of five percent SCBA.

Research conducted by Lavanya and colleagues looks into the minimal cement replacement in conservative concrete.

In order to determine whether or not SCBA is suitable for partial replacement of up to thirty percent of cement with a water-to-cement ratio that is inadequate, the tests were carried out in accordance with the requirements established by IS 516-1959 and the recommendations established by the Bureau of Indian Principles (BIS).

With the use of second-pass aggregate, Somna et al. explore the utilization of a pozzolanic material for the purpose of enhancing the mechanical characteristics and roughness of concrete structures. Using ground bagasse ash (GBA), Portland cement was applied to the reverse side of the object in the following proportions: 20, 35, and 50 by file weight. According to the SCBA, the amount of reverse probable coarse aggregate that should be added should not exceed 25 percent of the overall weight. utilizing partial cement substitutes at weight percentages of 0%, 10%, 15%, 20%, 25%, and 30% for compressive strength, Kawade and colleagues computed the influence of utilizing SCBA on concrete. They measured the compressive strength of the concrete. In the event that a small quantity of raw materials with compositions that are comparable may be substituted for the weight of cement in concrete, it is possible that the price of the material can be decreased without impacting the quality of the material. It is important that the configuration be designed in such a way that the cement strength is positively replaced by SCBA up to a maximum of fifteen percent. In January of 2014, J.Sahaya Ruben and Dr.G.Baskar wrote: This research will ultimately analyze the behavioral study of natural fiber in concrete construction, which is the ultimate goal of this initiative. In recent times, there has been a growing interest in the utilization of coir fiber as a sustainable fiber composite material. This interest is mostly attributed to certain mechanical properties that mimic those of artificial fiber. It is necessary to treat the coir fiber with natural latex prior to its application in concrete in order to ensure that it is not impacted by the moisture content that is present in concrete. Within the context of this experimental study that lasted for a period of 28 days, the compressive strength and split tensile strength were evaluated by employing a variety of coir fiber lengths, specifically 20mm, 25mm, and 30mm, respectively, with varying percentages of 0.5%, 0.75 percent, and 1 percent. In the realm of civil engineering, there should be an emphasis placed on the utilization of natural fibers due to the fact that these materials are readily available in the local area. The following is a list of the results obtained from the experiment:

When coir fiber is used in common development, natural contamination elements are reduced, and there is also the possibility of obtaining some adjustments in the material's solid qualities. When coir fiber is used as a component of the bond, it improves the protection of cement against sulfate attack. Additionally, the compressive quality of the cement is improved up to a specific rate. Additionally, the addition of coir fiber prevents the micro fissures that are already present in the concrete during the process.

In 2014, Suhas M. Patil stated: As a result of the requirement for sustainable growth, it is now essential to maximize the utilization of waste from a variety of industries in any and all possible applications. Ashes made from sugarcane bagasse are an example of this type of trash that is readily available and has been demonstrated to possess pozzolanic capabilities. An investigation was carried out in order to provide an explanation for the pozzolanic behavior of bagasse ash that was collected from the indigenous sugar business in Pandharpur. When sugarcane bagasse ash is produced under regulated conditions, the amorphous silica that is present in the ash comes into play. The purpose of this study is to investigate the effect that partially substituting sugarcane bagasse ash for cement has on the compressive strength of concrete, specifically M20 grade concrete. Coir fiber has recently gained favor as a viable fiber composite material due to certain mechanical qualities that distinguish it from synthetic fiber. These properties separate coir fiber from synthetic fiber. Prior to being utilized as a component of the solid, the Coir fiber is treated with normal latex. This ensures that the moisture content of the concrete will not have any impact on the Coir fiber. For the purpose of evaluating the compressive quality and split elasticity of the 28-day trial, a variety of coir fiber lengths, including 20 mm, 25 mm, and 30 mm, were utilized. Each of these lengths was subjected to varying rates of 0.5%, 0.75 %, and 1%. The field of structural design ought to be supported by the provision of support for the utilization of common strands or materials that are easily accessible in the surrounding area. The following is a list of the conclusions from the investigation:

In addition to Satish D. Kene, The majority of the construction work that was done throughout the ancient period of time was accomplished with the assistance of nmudstone from industry. In power plants, fly ash is produced when coal is burned, and rice husk ash is produced when rice husk is burned at a higher temperature in paper plants. Both of these by-products are referred to as ash. Significant efforts are being made all over the world to make use of bye-products and waste materials as supplementary solidifying elements in order to improve the qualities of bond concrete. A few of examples of such materials are rice husk powder (RHA) and fly cinder (FA). RHA is bye-result of paddy industry. Rice husk fiery debris is an exceptionally receptive pozzolanic material delivered by controlled consuming of rice husk. FA is finely separated created by coal-let go control station. Fly cinder has pozzolonic properties like normally happening pozzolonic material.

Gawande Sagar Mukundrao, Dahiphale Shubham Changdeo (2017) To some extent, conventional concrete is to blame for the quantity of carbon dioxide emissions. In order to lower emissions, different kinds of concrete are made using waste materials from industry and agriculture, such as fly ash, rice husk and blast furnace slag, which utilise less energy and have minimal negative environmental effects. Bagasse (plural) Ash produced by the sugar industry after bagasse is burned causes disposal issues. When bagasse ash is disposed of in the open, it can lead to a number of health issues, which has prompted the need for immediate solutions for handling bagasse ash. Bagasse ash was partially substituted with cement for 10%, 20%, 30%, and 40% of the M30 grade of concrete due to its similar pozzolanic qualities to cement. The properties of the concrete, such as workability, compressive strength, split tensile strength, and flexural strength, were also assessed. 10% replacement was found to be the ideal replacement after the aforementioned tests' results were obtained.

Rooj Masood et al., studied the behaviour of mixed fibre reinforced concrete exposed to acids. A mixture 75% glass and 25% steel fibres were used in mixed fibre reinforced concrete and cubes were casted 20 and cured for 30, 60, 90, 120 and 180 days in acids and sodium sulphate. Test specimens were tested for weight loss and denseness of concrete of exposed and unexposed specimens at all the ages and compressive strength at 180 days.

Mr. G. Siva Kumar et al., (2013) had studied on “Preparation of Biocement using Sugarcane bagasse ash and its Hydration behaviour”. In this study they had used as partial Replacement in ordinary Portland Cement (OPC) by 10% weight. Compressive strength of the sample was carried out and reported that the cementious material in sugar cane bagasse ash is responsible for early hydration. Mr. R. Srinivasan et al., has investigated on "Experimental Study on Bagasse Ash in Concrete". They had observed that Sugar Cane bagasse is fibrous waste-Product of sugar refining industry, and causing serious environmental problem which mainly contain aluminium ion and silica. Hear bagasse ash has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 15%, 25% by weight of cement in concrete. Fresh concrete tests like compaction factor test and slump cone test were undertaken, was well as hardened concrete test like compressive strength , split tensile strength, flexural strength and modulus of elasticity at the age of seven and 28 days was don. The results show that the SCBA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without SCBA. It is found that cement could be advantageously replaced with SCBA up to maximum limit of 10%.

Lourdes M. S. Souza et al, had studied on "Hydration Study of Sugar Cane Bagasse Ash and Calcium Hydroxide Pastes of Various Initial C/S Ratio" they had investigated on the reactions between calcium hydroxide (CH) and sugar cane bagasse ash (SCBA).Iyanut Muangtong et al., had investigated on "Effects of Fine Bagasse Ash on the Workability and Compressive Strength of Mortars" They are currently exploited as pozzolanic materials and supplements to improve the compressive strength in terms of microstructures of cement by partly replacement of cement with them. One of their advantages is to decrease CO2 gas emission from decreasing consumption of cement in either mortar or concrete production.

3 . CONCLUSION :

Sugarcane bagasse ash (SBA) shows significant potential as a partial replacement for cement in concrete production. It can improve the compressive strength of concrete, particularly when substituted at optimal levels (typically 10-15%). The pozzolanic reaction between SBA and lime in cement contributes to the strength enhancement, while the filler effect leads to a denser and more durable concrete structure. Despite its potential, challenges such as variability in SBA properties and the need for proper quality control remain. Further research into the standardization of SBA production and its integration into concrete mixes is needed to maximize its benefits.

The adoption of SBA as a sustainable alternative to cement in concrete could help reduce the environmental impact of construction activities and promote the use of agricultural waste products. Future studies should focus on the long-term performance of SBA concrete and the development of standardized guidelines for its use in concrete mixes.

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