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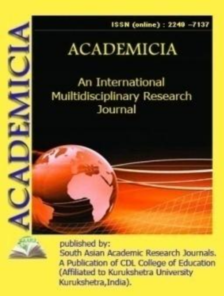

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A STUDY OF GREEN CONCRETE MADE PARTLY FROM AGRICULTURAL WASTE LEFTOVERS

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ABSTRACT

The increasing use of concrete has resulted from the growing demand for building throughout the globe. Conventional concrete-making materials, on the other hand, are not completely environmentally friendly, prompting research into greener concrete alternatives. Extensive study has been done in the past to use agricultural waste materials such as those from palm oil, coconut, sugarcane, and the paddy industry in concrete, and the results show that such resources may be used in concrete. Reusing agricultural waste materials in concrete may decrease reliance on traditional concrete-making resources while also reducing environmental impact, waste conservation, and waste disposal from these industries. A review of the use of developing alternative agricultural waste materials in concrete, such as bamboo, maize, wheat, olive, sisal, seashells, and other materials, is conducted in this article with the goal of evaluating the advantages and drawbacks of utilizing these materials. This study examines the use of agricultural waste materials in concrete in various forms, including partial cement and aggregate substitution, as well as fiber reinforcing. The paper's primary conclusion is that, although the use of agricultural waste materials reduced certain concrete characteristics, effective treatment techniques and waste material selection would allow for the manufacture of *concrete with better performance. The summary and discussion in this article should offer fresh information and expertise on a wider range of agricultural waste materials that may be utilized to make greener and more sustainable concrete.*

KEYWORDS: *Agricultural Waste, Concrete, Fiber Reinforcing, Green Concrete, Soil.*

INTRODUCTION

There is a rising need for greener concrete due to the increased use of concrete in the building sector throughout the globe. The negative environmental effect of concrete-making ingredients such as aggregates and cement is one of the main causes behind this. Excessive use of aggregates depletes these natural resources, and irresponsible quarrying and mining operations to extract these materials may result in environmental problems such as landscape destruction and eco-system disturbance, as well as pollution of water, soil, and air. Furthermore, cement production is an energy-intensive process that, most significantly, results in greenhouse gas emissions[1]. The cement sector alone is thought to be responsible for around 1.8 Gt of CO2 emissions each year, accounting for about 5–7% of total anthropogenic CO2 emissions. According to a life cycle study, the manufacturing of 1 t of cement emits approximately 0.8 t of CO_2. Researchers have looked at the potential of using industrial by-products and waste materials in concrete in an effort to protect the environment via the development of green concrete. Industrial by-products have long been utilized in a variety of applications throughout the globe[2]. While the use of industrial by-products in concrete is well-established, the integration of waste material for concrete production, particularly waste from the agricultural sector, is still very much in the research stage. Agriculture waste is often burned or dumped, resulting in pollution and poisoning of the environment. Recognizing the potential for environmental conservation, research has been carried out throughout the years to re-use agricultural waste from the agriculture sector to make concrete. For example, waste from the palm oil industry, such as waste oil palm shell and palm oil fuel ash, waste from the coconut industry, such as waste coconut shell and coconut fibers, and waste from the paddy industry, such as waste rice husk, are among the most well-known agricultural wastes for concrete production[3]. These agricultural waste products were utilized in concrete production as aggregate, fiber reinforcement, and supplemental cementitious material (SCM).

Alternative agricultural waste materials for concrete, such as those from agriculture (bamboo, banana, maize, wheat, sisal, grass, etc.) and aquaculture farming (oyster, cockle, clam, and periwinkle, for example), have recently become popular. Agricultural farming wastes have often been used as a partial cement replacement material in concrete by researchers. This is due to the fact that plants obtain various minerals and silicates from the earth during their growth process; inorganic materials, particularly silicates, are found to be higher in annually grown plants than in long-lived trees, allowing plant residues to be a potential source of cement replacement material with pozzolanic reactivity[4]. Another frequent use of agricultural wastes is as fiber reinforcement in concrete composites. Natural fibers have the potential to be used since they are: I less expensive, ii) need less industrialization, iii) environmentally benign, and, most significantly, iv) natural fibers are as strong as synthetic fibers. Furthermore, in an attempt to decrease reliance on traditional aggregates such as granite, gravel, and natural mining, some of these agricultural waste materials were used as partial aggregate replacements in concrete in an effort to protect the environment. As a result, the emphasis of this study will be on collecting and analyzing past results obtained when agricultural waste residues (from agriculture and aquaculture farming) were used in concrete[5].

Understanding the typical behaviors of such waste elements in concrete, such as their advantages and downsides, may serve as a foundation for the creation of an environmentally friendly concrete that includes agricultural waste materials. Agriculture farming is a significant worldwide business since the majority of produced agricultural goods are used to feed people all over the globe[6]. China, India, the United States, Brazil, and Nigeria are among the world's top producers of agricultural goods such as cereals, vegetables, and fruits. However, there are many waste elements left behind after harvesting and consumption of agricultural goods, such as leaf, straw, stalk, and ash. The majority of these agricultural wastes are dumped in the environment, with little effort made to recycle them. Researchers have recently started to use these wastes as a partial substitute for traditional concrete-making ingredients and have discovered some intriguing results. While the use of farm wastes in concrete, such as those from the palm oil, coconut, sugarcane, and paddy industries, has long been recorded, this section examines new research on other agriculture leftovers, such as those from bamboo, wheat, olive, and other agricultural sectors.

Bamboo is the world's fastest-growing and highest-yielding natural resource and building material. Bamboo has been recognized as a potential option for building material by experts during the past two decades owing to its favorable mechanical characteristics, high flexibility, and cheap cost. Bamboo has been proven to be suitable for structural elements such as beams, columns, and slabs. Bamboo output is estimated to be about 20 million tons per year worldwide, mostly in Asia and Latin America, resulting in a large quantity of agricultural waste from the bamboo industry[7]. These agricultural wastes are often burnt in open landfills, polluting the environment. While bamboo is often used as reinforcement, the re-use of waste products such as bamboo leaf ash and fiber in concrete is gaining popularity in recent years. WSA's potential as an SCM in concrete was shown by a 25 percent improvement in mortar compressive strength when WSA was used at a 20 percent cement replacement level. On the other hand, it was discovered that when 8% WSA was applied, the compressive strength required 180 days to achieve the compressive strength of control concrete without WSA, which was ascribed to the delayed pozzolanic response. In the presence of up to 16 percent WSA, however, concrete's 28-day flexural strength was shown to be enhanced. Because concrete durability is so important, researchers also looked at the durability characteristics of concrete that utilized WSA as a partial cement substitute. When concrete was exposed to a sodium sulphate solution, WSA substitution up to 24 percent increased compressive strength, while WSA replacement up to 8 percent improved performance of concrete subjected to a magnesium sulphate solution. WSA-blended concrete had greater freeze-thaw resistance than control concrete, and increasing the WSA replacement amount from 5% to 15% improved the freeze-thaw resistance of the concrete.

Furthermore, as compared to control concrete without WSA, the resistance of WSA-blended concrete to alkali-silica reaction degradation was higher, and increasing WSA concentration to 15% resulted in better resistance to alkali-silica reaction. WSA's anti-alkali-silica degradation effects were shown to be stronger in concrete mixtures with a lower water-to-binder (w/b) ratio[8]. The pozzolanic reaction and filler effect of WSA, which refined the capillary pores within the cement matrix, were ascribed to the increased durability of concrete containing WSA against freeze-thaw and alkali-silica reaction. WSA may potentially be used as a partial substitute for fine aggregate in concrete, according to the researchers. The workability of new concrete was decreased when WSA was utilized as a partial replacement by up to 10.9 percent owing to the greater fineness of WSA, which increased the water demand to wet the surface of the WSA particles. Furthermore, in the presence of WSA at a fine aggregate replacement level of 10.9 percent, the setting time of new concrete was extended by up to 92 percent. The use of up to 10.9 percent WSA increased the compressive, tensile, and flexural strengths of autoclaved concrete by up to 87 percent, 67 percent, and 71 percent, respectively, when combined with limestone fine aggregate. The compressive strength of WSA concrete (up to 6% fine aggregate replacement) was greater than that of control concrete after 28 days, despite the fact that the 7-day compressive strength was comparable. Based on the studied durability characteristics of WSA concrete, using WSA as a partial fine aggregate replacement of up to 6% resulted in outstanding concrete durability[9].

Due to the denser pore structure of the concrete system when the WSA filled the pores in the concrete system, the sulphate resistance, resistance to water penetration, and abrasion resistance were all improved when the WSA was applied. When concrete was exposed to heat cycling, the WSA concrete showed a smaller decrease in compressive strength than control concrete, indicating a superior reaction to thermal cycling, particularly when the WSA fine aggregate replacement level was raised to 15%. In the presence of WSA, fractures induced by thermal cycling appeared considerably later in the concrete, and the greater electrical resistivity of the WSA-blended concrete explained the concrete's improved resistance to raised temperature. The use of wheat straw as a concrete fiber reinforcement and the performance of wheat straw fiber were compared to hemp fiber[10].

DISCUSSION ON GREEN CONCREATE

When OWA was used as a partial cement substitute, the strength characteristics of concrete were generally decreased, according to numerous studies. The increase in capillary holes in the OWA-containing mortar was ascribed to this. The residual compressive strength of concrete with up to 22 percent OWA was enhanced at higher temperatures of up to 600 C when compared to concrete without OWA. This was bolstered by the fact that the OWA-blended concrete had a lower electrical charge, indicating less fractures and damage when exposed to high temperatures. The enhanced performance of concrete mixed with OWA at higher temperatures was due to the OWA's pozzolanic reaction and filler action, according to the authors. However, because of the lower vapor pressure generated up in the concrete, the existence of a larger number of pores in the OWA concrete may contribute to better fire resistant performance. When OWA was employed as a filler in self-compacting concrete instead of conventional filler, the compressive strength achieved by the former was slightly greater. Sisal fibers were shown to provide greater flexural strength as well as toughness and ductility to concrete, similar to typical fiber reinforced concretes. The composite showed strain hardening behavior and numerous fracture development under tensile when sisal fibres were employed at 10% volume fraction in cement composite. The performance of the concrete when exposed to impact force was also enhanced, such as impact energy, fracture resistance, and failure pattern, owing to the ductility and toughness given in concrete by the inclusion of sisal fibres. The impact energy and ultimate fracture resistance of concrete containing sisal fibres may be increased by up to 6 and 5 times, respectively, when compared to concrete without fibres, according to the results.

Despite the benefits of using sisal fibers, one of the main drawbacks of using this fiber in cement-based concrete is its durability. Untreated sisal fibres linked in cement matrix were shown to deteriorate and become more brittle over time as a result of alkaline attack and fibremineralization, as described. As a consequence, the resultant cement composite would have problems with durability. The compressive and tensile strengths of the resultant cement composite were clearly reduced in the experiment carried out utilizing corroded sisal fibres that were subjected to different media. Recognizing this, researchers have tried to enhance the endurance of such fibers using two methods: I coating the fibres before usage, and ii) using SCM to reduce the alkalinity of cement mortar. Thermal treatment and sodium carbonate ($Na2CO3$) treatment techniques were used on the sisal fibres, and the resultant sisal fibre reinforced concretes were shown to be more durable. The increased endurance of the thermally treated sisal fibres was attributed to better crystallinity, which guaranteed greater mechanical strength of the sisal fibres. When sisal fibres were soaked in $Na2CO3$, calcium carbonate sediments filled in the pits and holes on the surface of the fibres, protecting the interior from alkaline assault during the cement hydration process, resulting in increased concrete durability. The fibre composite including pre-treated sisal fibre with silica fume slurry performed similarly to the control fibre composite having untreated sisal fibre in another study on sisal fibre treatment. While adding silica fume to the sisal fibre mortar increased its durability, using ground granulated blast furnace slag (GGBS) as a partial cement substitute did not decrease the composite's brittleness. Also, when silica fume was employed as a partial cement substitute, the drying shrinkage of sisal fibre mortar was reduced at later ages, while using GGBS resulted in a 9 percent increase in the drying shrinkage value. When met kaolin and calcined waste crushed clay brick were employed as partial cement replacement, there was a substantial increase in the flexural strength (approximately 4 times) and toughness (about 40 times) of sisal fibre composites exposed to hot-water immersion. When shown, the positive impact of cement replacement material on improving the durability of sisal fibre composites was mostly attributable to a decrease in fibre mineralization as the alkalinity in the cement matrix was decreased.

Due to evaporation of water and the formation of drying cracks at later ages, the compressive strength of DPF reinforced concrete that was air-cured was lower than that of water-cured concrete. In terms of the flexural characteristics of DPF reinforced concrete, it was found that the initial crack strength of the fibre reinforced concrete was lower than that of the control concrete, despite increased ductility. However, increasing the fiber content beyond 2% would have a negative impact on the initial crack strength and ductility of the resultant fibre reinforced concrete. Furthermore, it was discovered in the same study that a dry, hot climate had a negative impact on the flexural performance of DPF reinforced concrete, which was ascribed to fast evaporation of water, which resulted in the formation of voids and micro-cracks. When OS was combined with cement paste, there was no substantial reaction, thus the OS simply served as a filler. According to studies, the workability of the OS deteriorated by up to 30% when it was employed as a partial fine aggregate substitute. The increase in water adsorption in the presence of OS caused the slump to decrease, resulting in a more viscous concrete. The unevenly flat OS particle has a worse workability, and the mixing friction has increased. When the aggregate replacement level was raised to 50%, however, the slump worsened, which was ascribed to a lack of coherence between the cement paste and the OS, as described by. The air content of the concrete containing OS was observed to rise due to the porous nature and uneven grading of OS.

In terms of compressive strength, most studies observed a reduction in concrete's 28-d compressive strength as fine aggregate replacement levels with OS increased. However, the 28-d compressive strength of concrete with and without OS was found to be fairly comparable. Nonetheless, as the age of the concrete grew in the research, the strength growth of the OS concrete was lower, eventually culminating in a lower compressive strength of OS concrete compared to the control concrete beyond 56 days. The stress concentration in the weaker OS aggregate was blamed for the OS concrete's poorer strength development. Most agricultural waste materials, especially those from the agriculture industry, are used as SCM because they contain a significant quantity of silica after being burned at high temperatures, such as banana leaf ash, bamboo leaf ash, wheat straw ash, elephant grass ash, and corn cob ash. The high silica concentration in these ashes allows for pozzolanic reactivity, which is advantageous to concrete's later age strength development. Furthermore, by selecting the best burning temperature and grinding the farmed agriculture waste, a better grade pozzolanic material with a higher silica content is produced. The temperatures at which the fire was lit. In general, the use of these agricultural farming waste as SCM would decrease the workability of concrete owing to the porous nature and fineness of the SCM; the strength of the concrete at an early age would also be reduced, if not comparable to the control concrete, as shown in the summary in Table 8. However, owing to the pozzolanic reaction of these SCM, conversion of Ca(OH)2 to extra calcium silicate hydrate (CSH) may occur, and the resultant concrete's later-age compressive strength may surpass that of the control concrete. The enhanced durability characteristics found in earlier studies were also attributable to the pore refinement effect caused by the pozzolanic reaction of the agricultural farming waste as SCM. When aquaculture farming waste, such as seashells, was used as a partial cement replacement, however, there was little improvement because the majority of the ash was CaCO3, and unlike agriculture farming wastes, seashells do not have pozzolanic behavior.In contrast to using agriculture farming waste as a partial cement replacement, when used in powder form as fine ag Due to the fineness of the material, its usage often resulted in decreased workability as a consequence of increased water consumption.

On the other hand, when aquaculture farming waste, such as OS, was utilized as a partial fine aggregate replacement in aggregate form, the strength characteristics were reduced. This was ascribed to the waste aggregates' lower aggregate strength as well as their form. However, owing to the substantially varied nature of the OS employed in various studies, there are conflicting findings on the impact of durability behavior. Several agricultural wastes, such as corn cob, OS, and PS, were tested as coarse aggregate replacements, and the concrete characteristics were all decreased in the presence of these materials, mainly due to the lower intrinsic strength of the materials as aggregate. However, one of the main flaws is the durability of the fibers in the cement matrix, since the fibers may be vulnerable to alkali attack, which occurs during the cement hydration process and may cause increasing brittleness and deterioration over time. However, the long-term durability of natural fibers in concrete may be enhanced with suitable pre-treatments such as heat treatment and the use of SCM to partly substitute cement.

CONCLUSION AND IMPLICATION

In summary, this article outlined the possible use of a range of alternative agricultural wastes from both agriculture and aquaculture in concrete, including cement replacement, aggregate replacement, and fiber reinforcing. Although the use of agricultural waste materials may reduce certain concrete characteristics (such as workability and strength), based on the summarized results in this study, the dose may be controlled to obtain acceptable concrete performance. Furthermore, these materials may be integrated into concrete for better mechanical and durability performance provided appropriate treatment (such as pre-treatment and burning) and material selection is carried out. As a result, the manufacturing of a more sustainable and green concrete may be accomplished, resulting in waste reduction and decreased negative environmental effect. This would result in more environmentally friendly building for the construction industry and a cleaner environment for society to live in.

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