The Significance Of Agricultural Wastes In The Construction Sector

Nitin[1]*, Yeshpal[2], Veena Chaudhary[3],

[1*]Author-Research Scholar, Department of Chemistry, Meerut College, Meerut, Utter Pradesh
[2]JRA UPCST Project, Department of Chemistry, Meerut College, Meerut, Utter Pradesh
[3]Professor, Department of Chemistry, Meerut College, Meerut, Utter Pradesh

***Corresponding author:** Nitin
*Author-Research Scholar, Department of Chemistry, Meerut College, Meerut, Utter Pradesh
Email:-nitinkumar371996@gmail.com

Abstract
A variety of problems are now affecting the building business. The two that matter most are the rise in urban population and the decrease in the amount of resources required to make construction supplies. Businesses have also begun to reassess their strategies for producing ecologically friendly construction materials as a consequence of a greater knowledge of climate change. In the development of ecologically friendly construction materials, a variety of agricultural wastes, such as rice husk ash (RHA), sugarcane bagasse ash (SCBA), and bamboo leaf ash (BLA), have shown to be successful alternatives. In this investigation, six distinct agricultural waste-derived construction materials are investigated. The list includes bio-based polymers, building insulation and reinforcement materials, green concrete, particleboard, bricks, and masonry components. The frequency of usage in current building projects should be the primary factor when choosing materials. The goal of this paper is to look at alternative production methods for eco-friendly construction materials since the ones currently in use have negative environmental consequences. The results of the investigation demonstrated that it was successful to produce environmental friendly construction materials from agricultural waste since the completed products satisfied certain building requirements. Using agricultural products in lieu of traditional building materials is advised in order to achieve long-term economic, environmental, and social security.

Keywords: Agricultural waste, Construction materials, and sustainability.

1. Introduction

A short glance at world statistics demonstrates that the human population is still growing. Increasing from 6.8 billion in 2009 to 7.7 billion in 2019 and 9.7 billion in 2050 [1]. Changes in health and mortality rates, which have both increased over time, have a direct impact on population growth. Contrarily, population expansion suggests a higher need for social resources like housing. The housing market's fast rise has put further strain on the construction industry and the manufacturing of conventional goods like cement, steel, aluminum, and wood [2]. According to Guna et al. [3], modern building materials like beton need a lot of thermal and electrical energy, which drives up the cost of construction. Additionally, this kind of production has a greater carbon effect and pollutes the air, land, and water. The Kalkbrenn procedures, according to Wi et al. [4], need temperatures as high as 1450 °C to manufacture concrete and emit around 0.85 tons of CO2 for every completed ton. A further research found that 23.5% of France's GHG emissions come from buildings [5]. The argument put out by Shafigh et al. [6] contends that the building sector is no longer lucrative. This revelation highlights how important it is to do further scientific research in order to create low-cost construction materials that are more sustainable and ecologically beneficial.

The study also reveals how challenging it is for developing countries to handle agricultural wastes including rice straw, cocoa leaves, rye sand, and sugar cane bagasse. For instance, India produced more than 600 metric tons (MT) of agricultural waste [2]. According to Obi, Ugwuishiwu, and Nwakaire [7], the development of farming methods and the increase in agricultural output would result in the creation of more agro-waste materials in this decade. The three most common methods for disposing of this agro-waste are composting, incineration, and landfill disposal, according to Madrid et al. [8]. This process has detrimental environmental effects. Recent research suggests that an effective and practical solution to the issues raised is to produce building materials in part or in whole from agricultural waste and byproducts. Recycling agricultural waste helps to minimize cement and other traditional building material pollution as well as garbage disposal [9]. The strength and resilience of cement blocks that partially replaced the sand with agricultural wastes such sorghum grains, coco leaf litter, rice straw, and coco leaf litter exceeded ASTM standards [10]. Accordingly, Ashour et al.'s [11] study shown that soil may be stabilized with natural wheat and barley straw fibers to produce reinforced bricks with exceptional thermal & static qualities. Buildings composed of sand and soil are healthier for the environment, according to researchers [12]. The good qualities of the materials, such as their low energy emission and high thermal performance, according to the experts, are the cause of this. The study's findings suggest that utilizing agricultural waste to make building materials provides a viable remedy for the lifespan problem while lowering pollution levels and damaging impacts on the surrounding ecology.

An extensive overview of the use of agricultural waste in the manufacture of building materials is provided by this review research. Their advantages and disadvantages as comparison to conventional construction materials are also explored in order to draw attention to possible research gaps for future development. The essay is composed of five parts. The first looks at how environmental preservation may be sustained throughout time in relation to building. The differences of the study are covered in the second chapter. In this part, a number of important review articles on the topic are thoroughly analyzed to determine the necessity for this research. The third attribute pertains to the method by which different environmentally friendly construction materials, such as bricks, green concrete, Styropor, and biodegradable polymers, may be created from different agricultural wastes. The fourth portion of the essay discusses the benefits and drawbacks of utilizing materials. The report's many findings are discussed in the fifth and sixth parts, and the seventh and eighth sections provide a conclusion.

2. The Study's Originality

It took several years and a lot of work to create strong construction materials from agricultural waste. It is common knowledge that many research programs focus on finding solutions to two universal issues. The first step is to advocate for alternative approaches that decrease the impact of the building sector on climate change. One example of this is using agricultural waste, such as sugar cane ash (SBA), in lieu of building materials to prevent the formation of sour gas during manufacturing. The second is the identification of a long-term strategy for managing agricultural waste that emphasizes waste prevention since it is detrimental to the environment and human health. A similar technique is used in this research, which focuses on the same two universal problems.

On the other hand, a careful analysis of the search-term articles reveals a number of significant weaknesses that are addressed in this article. The first is that, in contrast to the exhaustive research that was done, the scope of review articles is limited. Self-compacting concrete [13], masonry blocks [15], and bricks [16] are three materials that scientists are particularly interested in, according to research by Rahman et al. In contrast, this study looks at a range of construction supplies. Bricks and other masonry components, bio-based polymers, green concrete, particleboards, and reinforcing materials for construction are a few examples. Our research provides extra information on the use of agricultural waste in more diversified building sectors as a consequence of not focusing on a restricted number of applications. This makes it simple for the reader to comprehend how different construction materials are created from diverse kinds of agricultural waste. The researcher claims that this is the first article to make an effort to look at how agricultural waste is used to produce a variety of building materials, including bricks, concrete, and reinforcing components.

Insufficient restrictions made it challenging to integrate waste materials into the brickmaking process, according to Rahman et al.'s [16] second observation. The results, however, showed that 10% palm oil fuel ash (POFA) added to fly ash bricks greatly improved them. Fly ash and POFA were also mixed in a 1:1 ratio to get the optimum compressive strength value. This research stresses the absence of standards for compiling results. In contrast to past research, more information is now available on how the ratio of conventional materials to agricultural waste impacts their different qualities [16]. Think about how much agro-waste is needed to make bricks and other masonry components compared to reinforcing and insulation materials and green concrete.

In each of the many review studies, experts have emphasized the benefits of using agro-waste to produce building materials. The use of POFA in making durable concrete, according to Ting et al. [17], reduced production costs and enhanced performance in both fresh and hardened forms. It has been discovered that POFA may increase new concrete's workability or homogeneity, compressive strength, tensile strength, water permeability, and elastic modulus [17]. Rahman et al. [15] obtained similar results. They found that the masonry components' compressive strength and load-bearing capacity were enhanced by adding POFA to the manufacturing process, and that it could satisfy Malaysian Standard MS76:1972. Despite the emphasis on the positives of agro-waste, it has been argued that the researchers are unaware of any drawbacks. This study aims to fill this gap by examining the downsides of agro-waste in the creation of sustainable building materials. This article explores if there are more advantages than disadvantages to utilizing agricultural waste as construction material. Can the concerns that have been discovered be addressed? Additionally, the study aims to determine if various agro-waste-based building materials, including sugarcane bagasse (SBA), rice husk ash (RHA), or POFA, adhere to established building rules and standards. This makes it feasible to research how various recycling materials affect the application of building rules.

Fourthly, it has been noted that few revision studies, such as those by Rahman et al. [13-16] and Ting et al. [17], have focused only on the use of a particular kind of agricultural waste in the creation of durable building materials. The investigation by Ting et al. [17] on the usage of POFA to improve the concrete's material attributes In contrast, Rahman et al. [13] used rice husk argilate (RHA) to make self-compacting concrete. Rahman et al. [14] also used peat oil clinker (POC) to improve the technical properties of peat. In previous research, POFA was also employed to design components [15]. Numerous investigations have shown that some agricultural wastes are utilized to make construction materials. Rahman et al.'s [16] study employs fly ash and POFA to make mixed bricks; there is just one difference. By offering additional details on past studies, new research aims to expand this subject.

use a similar approach. The results of the investigation will address the following question: Does the presence of different agro-waste products affect the overall quality of building materials? What are the advantages and disadvantages of using this strategy?

This research is unusual because it shows how agricultural waste may be blended and utilized in various ratios to produce sustainable building materials in addition to looking at different building materials generated from agricultural waste. It also examines the negative effects of utilising agricultural waste products and points forth potential study topics. Significant research gaps that might be crucial for potential future applications are also noted in the report.

3. The construction sector and environmental toxicity

It is vital to do a quick examination of the construction industry and its impacts on the environment before we look at the many forms of agricultural losses in the manufacturing of building materials. The private and governmental sectors invested around \$11.4 trillion in residential and non-residential development in 2018, according to figures [18]. The sum shows a consistent rise in spending, from \$10,9 billion in 2017 to \$10,5 billion in 2016. In addition, estimates indicate that expenditure will reach \$14 trillion by 2025 [18]. Indirectly, this means that more funds will be allocated for building the built environment, which includes both residential and commercial constructions as well as infrastructure like roads. In actuality, sand and bentonite were used as standard construction materials. The World Bank made similar observations. She also highlights that the building sector is both the world's greatest user of raw resources and the leading cause of climate change [19]. Between 2018 and 2023, the industry will expand by 4.2% yearly, according to the analysis. The value of the market is increased through the development of residential, commercial, and infrastructural developments [19]. The following forecasts are made by PwC in their Global Construction 2030 Report: China, the US, and India would account for around 57% of the global construction market by 2030, which would see an 85% increase to \$15.5 trillion [20].

Two major inferences may be made from these growth numbers. First and foremost, it is projected that as industrial production rises, more raw materials (such sand and cement) would be utilized [18]. Second, a review of the Bank of the World's results reveals that the building and construction sectors are mostly responsible for greenhouse gas emissions. This is the rationale for the expectation that such significant emissions would be seen in the future [19]. According to the UNEP 2018 worldwide Status Report, building development and operation also accounted for up to 40% of worldwide carbon emissions and 36% of energy use in 2017. Willmott Dixon's study on the impact of construction and the built environment [22] ranked the construction industry as one of the least sustainable due to its heavy reliance on non-renewable resources like water (50%), energy (45%–50%), destroying agricultural land (80%), and building materials (60%). The research also identified other environmental pollution estimations that are connected to buildings, including air pollution (23%), climate change (50%), anthropogenic global warming (40%), drinking water contamination (40%), and ozone layer depletion (50%).

Rethinking the role of sustainability in the building sector is required due to both the depletion of non-renewable resources and severe pollution. The generation of high levels of carbon monoxide in the finished goods (buildings and infrastructure) as well as the decrease of resources utilized in the construction industry, such as sand and bentonite, must both be avoided. Since then, several programs and research efforts have been launched in an effort to protect the sustainability of the construction industry. How corporations may aid in the execution of international accords is shown in the UNEP's 2018 Global Situation Report [21]. For instance, countries that have ratified the UN Framework Convention on Climate Change (UNCFCC) take part in international negotiations on climate change where Nationally Determined Contributions (NDCs) for improved construction practices are suggested [21]. For instance, Canada's NDCs currently specify that new building must be net-zero and energy-ready. Countries may reduce emissions in the building and construction sectors with help from the Global Alliance for Buildings and Construction (GlobalABC) [21].

On the other hand, modern strategies that promote sustainability in the construction industry are also becoming known thanks to scientific research. Sustainable or ecologically friendly buildings are characterized by the use of technology solutions to help the conservation of water, energy, and materials [23]. Low-energy materials, alternative energy sources, and energy-efficient technology are some of these replacements. According to many experts [10–12], another tactic is to make building materials from agricultural waste. The construction industry's attempts to reduce pollution and the agricultural industry's efforts to find waste management solutions are both aided by the creation of building materials from agricultural waste.

4. Recycling of agricultural waste to produce construction materials:

This section describes the creation of different construction materials from agricultural waste.

Brick as a constructing elements

Bricks have been the most widely used masonry building material from the dawn of time [9]. Combining the fundamental components (such as clay and water), forming and drying the briquets, and burning the briquets to generate the required amount of electricity are the three main steps in the conventional briquet-making process. The main problem with this building technique is how much greenhouse gas emissions it generates. According to Luby et al. [24], frequent burning of bricks in charbroilers results in excessive pollution. Her research into the factors behind the continued use of this technology in Bangladesh was intriguing since she found that customers often choose older bricks produced in these kilns because they are less costly. Kilnbesitzer also employed them since they may provide a high rendite [24].

The substantial depletion of natural resources brought on by the widespread use of non-renewable resources like water and stone in technology [9] is another problem. To solve these issues and improve the carbonization process, which would reduce emission levels, modern kilns should be acquired. The Hoffman kiln (HK) and the vertical shaft brick kiln (VSBK) are two readily available options that have been demonstrated to reduce emission levels by 42% and 29%, respectively, according to Gomes and Hossain [25]. They provide a contrast to the conventional bull's-trench kiln (BTK). Figure 1 below shows a schematic of four VSBKs. China is where the vertical shaft brick kiln (VSBK) technique was developed, according to Daraina et al. [26]. The VSBK has many benefits over clamps and conventional BTK kilns, including cheaper building costs, a compact design, high energy efficiency while burning bricks, and weatherproof nature so it may be used even during rainy seasons. As shown in Figure 2, the VSBK consumes much less energy than the clamp and BTK technologies. The fixed BTK-Entrance Street uses 1.08 Gcal/'000 Brick-Noyaux, whereas the open Entrance Hall uses 0.86 Gcal/'000 Brick-Noyaux, or 0.57 Gcal/'000 Brick-Noyaux.

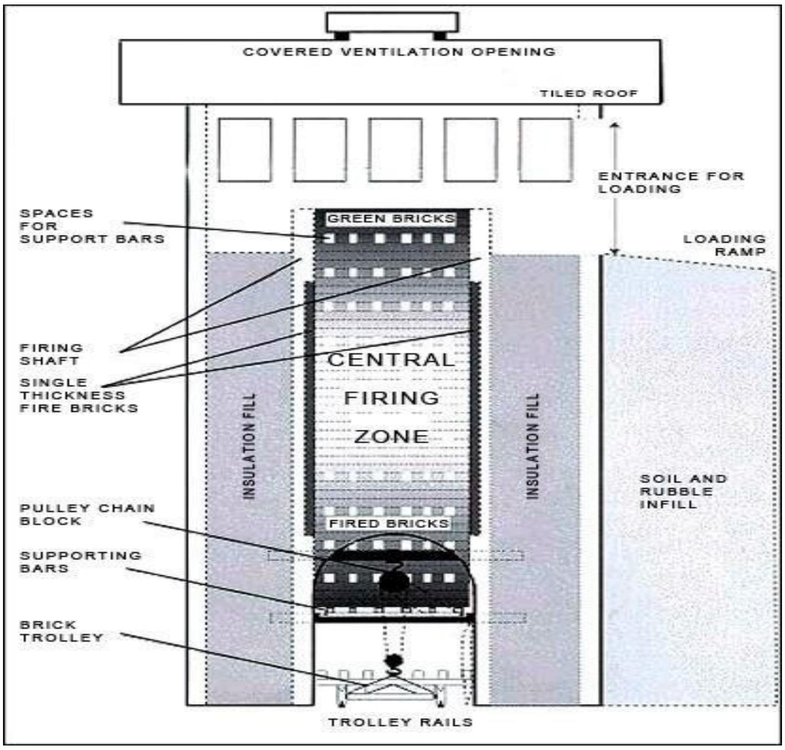

Figure 1. Modern vertical shaft brick kiln [26].

A more effective course of action would be to convert to ecologically friendly brick-making techniques. By providing the briquettes useful qualities and reducing agricultural waste, the approach aids in the solution of the issue of waste management caused by agricultural goods [27]. In Kazmi et al.'s investigation [27], riz and sugarcane were added to an argon mixture (RHA and SBA), each at a rate of 5% to the mass of the stones.

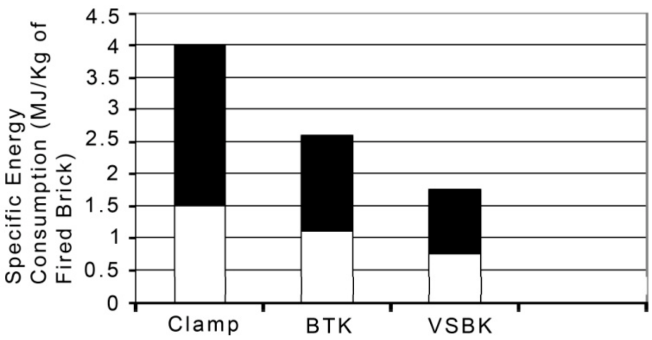

Figure 2 Displays the energy usage for the Bull's Trench Kiln (BTK), Kesselöfen, and VSBK [26].

The results demonstrated that clay-burned bricks' compressive strength and rapture modulus reduced when additional RHA and SBA were applied. In contrast, the bricks' compressive strength and fracture module met both conventional ATSM standards and Pakistani building regulations. Additionally, it was discovered that the newly constructed bricks were inherently lightweight, reducing the structural load on the building. They developed resilience over time, according to further studies, and the RHA and SBA boosted their defenses against invasion. Scanning electron microscope (SEM) study also revealed that the bricks were more porous, which raised the buildings' overall environmental sustainability.

Kizinievic et al. [28] examined the mechanical, porous, and physical properties of clay bricks burned with oat, barley, and middle husks in a separate investigation. A description of made-briketts The brick molding components had three concentrations of oat or barley husks and middlings: 5%, 10%, and 20%. A further hour was spent maintaining temperatures between 900 and 1000 degrees Celsius. According to the study, chaux-solid Briketts with a concentration of five to ten percent were the most ecologically beneficial [28]. A brick's density may be anywhere between 1300 and 1800 kg/m3, its total open porosity could be anywhere between 34% and 49%, its water absorption rate could be anywhere between 14% and 28%, and its compressive strength could be anywhere between 3.3 and 3.7, or 9.5 MPa. A porous structure was created when solid wastes (oat, barley, and middlings) were burnt at 500 °C in the clay body. Comparing the methods used by Kazmi et al. [27] and Kizinievic et al. [28] to use agricultural waste as additives in the manufacturing of clay bricks, it was found that only a small portion of the waste (5%–10%) was used. Other agricultural materials, such as rice and sugar cane [27] and avoine and mango [28] leaves, showed similar features in the bricks, including greater porosity, improved compressive strength, and a higher density.

In a third research, Taurino et al. [29] examined if clay and wine byproducts (WWs), such as reduced wine, grape seed, and stem, might be used to produce light bricks. Similar to earlier testing, the researchers altered the WW concentration and looked at the built-up bricks. The research revealed that the best mechanical and physical qualities were found in bricks made with a wine weight of 5% or less. The Briketts' diameter was decreased by up to 13%, depending on how many WWs were used. As more WW was applied, the briques' flexing power also dropped.

It's noteworthy to note that experts [29] claim that using stones with increased porosity may enhance heat resistance while also making them lighter and more pliable, which may be advantageous for living structures. The results were contrasted with those of previous studies [27, 28], which showed a comparable impact of waste material concentration on the basic characteristics of the bricks. The ideal brick properties were reached at a low concentration (5%). Wine waste materials are used in a different way than more common agricultural products like wheat and rice.

The effects of waste rice husk ash (RHA) addition on the thermal and acoustic properties of burnt clay bricks were further studied by De Silva and Perera [30]. In the study, clay was blended with six different RHA waste concentrations (0%, 2%, 4%, 6%, 8%, and 10%). After undergoing additional processing and being fired in an industrial kiln, the bricks of the following dimensions were tested for compressive strength, thermal conductivity, acoustic performance, chemical composition, particle size distribution, and Atterberg's limits for physical characteristics. According to the research, bricks containing 4% RHA exhibited the best characteristics. They possessed a 19% greater water absorption rate and an increased compressive strength of 3,55 N/mm2, which is 32% higher than that of conventional clay-burned bricks. Comparing the bricks to traditional clay bricks, the internal temperatures were 6 °C and the noise level was 10 dB lower. Comparative analysis was done between the methodologies used by De Silva and Perera [30] and Kazmi et al. [27]. RHA, a byproduct of the production of stone blöcks, was used in both methods. The findings demonstrated that a little amount of solid abfall (5% and 4% RHA, respectively) is adequate to improve the concrete's quality. The results of the two investigations were equivalent and showed that using RHA waste materials improved the compressive strength and porosity of stones for building purposes.

In their study effort, Deraman et al. [31] examined the effects of employing kosofiber (CB) and dried fruit leaves (EFB) as extra fillers on the creation of clay bricks. Based on the physical-mechanical properties of the bricks, such as their compressive strength, thermal conductivity, and water absorption rates, the study used three waste product concentrations: 0%, 5%, and 10%. The findings demonstrated that the boards, when utilized with 5% EFB, complied with ASTM C517 and BS392:1985 thermal conductivity specifications for water absorption and compressive strength. Dadurch,

The results of the research imply that employing blocks could improve the thermal properties of construction walls.
Many research have examined the utilization of various agricultural wastes (not only food waste), including the dust created during the briquette-making process. For instance, Mandal, Verma, and Sinha [32] created insulating bricks by combining various sawdust concentrations with red mud and fly ash (FA). The effects of sawdust mixing, fire temperatures, and FA to RM ratios on the physical properties of the bricks were also examined. Regardless of the fire temperature, the findings revealed that bricks with the greatest maximum force had an FA to RM ratio of 60:40. The results also shown that raising the fire temperature enhanced the porosity and thermal insulation of the bricks, increasing brick strength while decreasing sawdust mixing [32]. At 1100 °C, sand (7.5%) and red brick (40%) were joined to create briketts that met the requirements for type A isolation briquets specified by IS:2042. In a different

investigation, Muoz et al.'s [33] porous structures for creating firestone briquettes were made from grapevine vines. The authors of the research assert that burnt clay bricks (FCB) were manufactured using wood chips from cut grapevine shoots. Finding out how agricultural wastes impacted the size of the particles in briquettes was the study's major objective. There were three dimensions considered: 0 to 1.5 mm, above that, and 0.55 to 1.5 mm. We also looked at the mechanical and thermal properties of the bricks. The maximum compressive strengths and water absorption rates were found in bricks containing fewer than 10% wood chips, but their thermal consistency was lowered by as much as 50%. Given that just a little amount of garbage was required to generate high-quality brique with outstanding compressive levels and water absorption rates, the work of Muoz et al. [33] and Mandal, Verma, and Sinha [32] may be compared. The thermal properties were also enhanced in both circumstances.

Modern methods for producing green concrete

Concrete and bricks are both extensively used building materials. Cement, fine aggregate, and coarse aggregate are a few of the natural ingredients needed to build concrete, according to Prusty et al. [34]. To cope with the strain on non-renewable natural resources and the expanding demand for housing, research has been done on the use of alternative agro-waste materials to create concrete.

First, Modani and Vyawahare [35] looked into the effects of adding untreated sugarcane bagasse ash (SCBA) in ratios of 0, 1, 2, 3, and 4% to fine aggregate in concrete. The superplasticizer concentration was kept constant at 0.8%, while the water-to-cement ratio was kept constant at 0.40. After a typical laboratory cure, cast concrete samples were examined for tensile strength, compressive strength, and sorptivity over the course of seven and a half days. According to the results, specimens with a 10% SCBA replacement performed better when measuring compressive force than specimens with a 0% SCBA replacement. When SCBA was raised further, both the properties and compressive strength of fresh concrete decreased. Pozzolan characteristics have given SCBA-containing mixes increased strength over time.

Further research also revealed that increasing the SCBA-Niveau decreased resistance and response capabilities. The study's results show that SCBA may be used to produce betons rather than aggregate, which has important economic ramifications. Around 10 million tons of sugarcane are processed in India as waste, according to Prusty et al. [29], who have previously brought attention to the problem. They will be easier to transport and utilize as construction materials as a consequence. The process of turning cane sugar into bagasse and then back into cane sugar bagasse is shown in Figure 3.

Figure 3. Processes to produce sugarcane bagasse ash [34].

Rao and Prabath also looked at the effects of using cement instead of bagasse ash in the proportions of 0, 5, 10, 15, and 25% for making concrete [36]. After the particles had successfully passed through a 90-meter filter and had a specific surface area of 4716 cm2/gm, the bagasse hopper was originally set up. After that, argile was used to replace the necessary amounts of Portland cement. The percentage of the control mixture was kept at 378 kg/m3, and the cement-to-water ratio was held constant at 0.42. The concrete's compressive, split tensile, and flexural strengths were also tested at 7, 21, and 90 days after curing. After 90 days, concrete mixes containing 10% bagasse had the best results, including increased compressive and flexural strengths [36]. Figure 4 below displays the outcomes of compression strength tests conducted on different blends at 7, 28, and 90 days. The strength of the compressive combination was evaluated during intervals of seven, eighteen, and ninety days [36].

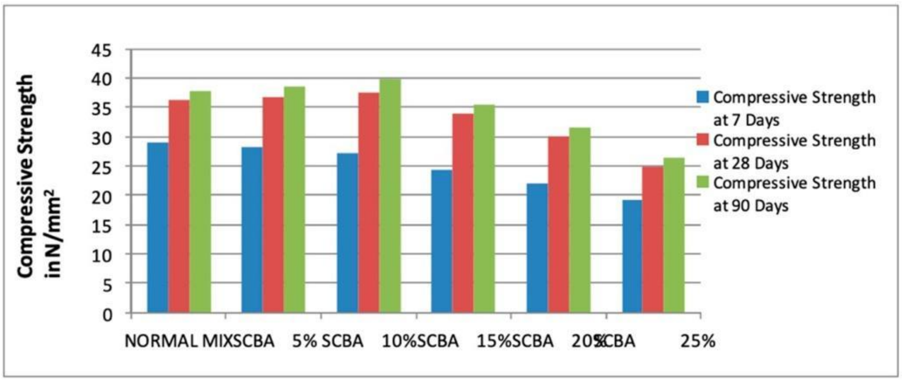

Figure 4. Compressive strength for the concrete mixes after 7, 28, and 90 days [36].

The findings also shown that over the course of seven days, as the ratio increased, the compressive strength of the SCBA mixes gradually decreased. The compressive force gradually reduced as the SCBA ratio increased, reaching 10% on the 28th day. Visit this page to compare and contrast SCBA users Modani and Vyawahare [35] with Rao and Prabath [36]. The best bricks were made with a 10% SCBA ratio, which is a considerable difference between the two tests and suggests that just a modest quantity of agricultural waste was necessary to make high-quality concrete. But there were a lot of variations. First, it was found that Modani and Vyawahare [35] substituted SCBA with a volume of fine aggregate in concrete whereas Rao and Prabath [36] replaced SCBA with a volume of cement. In contrast to Modani and Vyawahare [35], who only properly cured the concrete for 7 and 28 days, it was found that Rao and Prabath [36] correctly did so for both 7 and 28 days. These two instances show how SCBA may be used in lieu of cement and fine aggregate. The price of making concrete out of agricultural waste has dramatically increased as a result. The findings of Rao and Prabath [36], which demonstrate that curing for 90 days produced better results than 28 days, are equally important for those in the construction business who use this information.

In a different research, Rodier et al. [37] examined how the pozzolanic characteristics and hydration of cement paste were affected by the addition of bambou-argillite (BLA) and cane-sugar-argillite (SCBA). Electrical conductivity experiments were used to examine the pozzolanic activity of binary and tertiary stone mixtures. The pozzolanic reaction between the calcium hydroxide solution and the stones was measured using a diffusion kinetics model. Additionally, X-ray diffraction, isothermal calorimetry, and thermal gravimetry investigations were carried out to determine how ash influenced the hydration of various cementitious pastes. In comparison to BLA-Mixtures and SCBA-Mixtures, the findings demonstrated that SCBA-Mixtures without extra components had reduced pozzolanic activity [37]. It was found that the Kontrollmortar's compressive strength was lower than that of the binary and ternary mortars because it lacked these advances. The results of the research validated Rao and Prabath's [36] suggestion to replace SCBA with 10% of the mass of BLA and cement, which allowed the cement to display its best qualities. However, when BLA was added to the SCBA, the compressive force of the mortise substantially changed. This suggests that using more than one kind of agro-waste material in place of cement improves the end product's quality when producing green concrete. Additionally, Rodier et al. [37] discovered that using agro-industrial ashes in lieu of traditional cement resulted in a reduction in the energy needed to produce 1 tonne of binder.

Akram et al. investigated sugarcane bagasse ash (SCBA) as a viscosity-modifying component in self-compacting concrete [38]. The researcher's assertion that self-compacting concrete does not need vibrators when it is compacted has been noted by several industry experts. However, its use and acceptance are limited because of its higher delivery cost than that of regular cement. The research examined the relative costs and efficiency of using sugarcane bagasse ash (SCBA) as a component to modify the viscosity of self-compacting concrete. The amount of superplasticizer, the water-binder ratio, and the amount of bagasse ash were all considered while managing flowability. Cement and water were added in the same amounts. After 28 days, the self-compacting concrete containing bagasse ash had compressive strengths comparable to the control concrete. Despite both having a greater compressive strength of 34 MPa, the analysis also showed that the total prices of the components in the particular beton combinations were 35.63% cheaper than those of the control betons [38]. The work is noteworthy because it shows that agricultural waste may be used to make self-compacting concrete instead of the conventional ternary and binary combinations.

The creation of green benton from other agricultural wastes, such banana peels, has been studied by other researchers. For example, Kimeng et al. [39] investigated the possibility of using groundnut shells in place of fine aggregate while light concrete panels were being constructed in Nigeria. In 63 different concrete samples, groundnut shell substitutes for cement were used. The proportions for each were 0, 1, 2, 5, 10, 30, 50, and 60%. Compression tests and density evaluations were carried out after 7, 4, and 28 days. When just edrusschalen was used as the aggregate, the findings revealed that the density of the blocks was 830 kg/m3, but when sand aggregates were also utilized, the density rose to 2160 kg/m3. In accordance with further study, the compressive strength of shells ranged from 0 to 100% between 5,83 N/mm2 and 0,9 N/mm2, 8,07 N/mm2 and 0,5 N/mm2, and 10 N/mm2 and 0,6 N/mm.

From 0.47% to 2.04%, the rate of moisture absorption has similarly risen. Additionally, the statistics indicated that changing the aggregates from 30 to 70% led to excellent results. Although earth-nue panels have been successfully used to construct free-standing barriers, their inadequate compressive strength makes them unsuitable for structural purposes [39]. The study's results point to the possibility of a cost advantage in producing concrete from pine needles as opposed to aggregates, especially considering how difficult it is to remove leftover pine needles from Nigeria. The selling of groundnuts and groundnut shells as recycled goods may be advantageous to farmers.

150 × 150 meter-long betons plates were utilized for the research by Sada et al. [40] to examine the usage of river sand in lieu of fine aggregate (agrégats) during the production of concrete in Nigeria.

Replacement values of 0, 5, 15, 25, 50, and 75% were used to make 150 mm. After 28 days, the compressive strength, density, and slump of the concrete mixes were evaluated. According to the findings, at a replacement level of 5%, there was a maximum compressive force of 40.59 N/mm2 and a dilute of 2533.33 kg/m3. However, when the percentage of groundnut shells approached 5%, the compressive strength and density of the concrete slabs decreased. For instance, the concrete dams had a density of 1854,81 kg/m3 at 75% replacement and a compressive force of 7,56 N/mm2. In contrast to Kimeng et al. [39], who also employed pinzets as a replacement for aggregate while constructing green benton, Sada et al. [40] demonstrate the capacity of pinzetten to build lightweight concrete. The fluctuation in compressive force according to the quantity of sandkörners is shown in Figure 5.

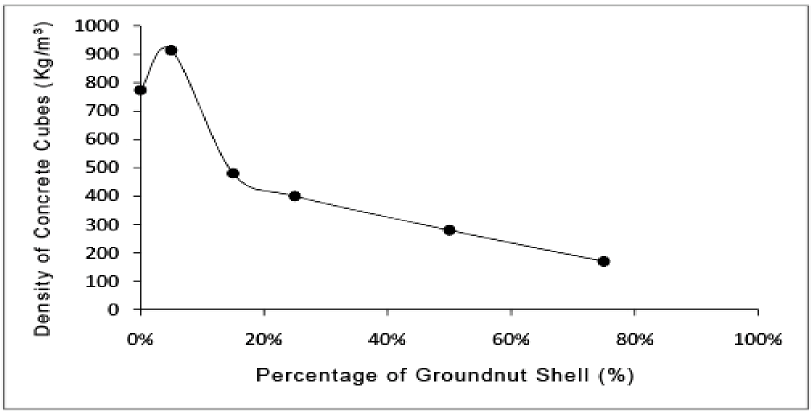

Figure 5.The variety of compressive force has an impact on the percentages of groundnut shells [40].

Insulation Materials for Buildings

Agricultural wastes were also employed as building materials for isolation. According to Liu et al. [41], the use of biomass, such as agricultural, industrial, and forest waste, in the thermal insulation of buildings has recently attracted more attention. Other agricultural byproducts, according to the study, were also used for heat dissipation. Hemp, straw, coconut, wood, and flax were more often used materials [41] despite the fact that sisal, reed, grass, and pineapple were seldom used. An examination of the thermal properties of contemporary biomass is shown in Figure 6.

Agro-waste	Application	Density ρ (kg/m^3)	Thermal conductivity λ (W/mK)	Specific heat c (J/kgK)
Hemp	Lime/Concrete	220-1000	0.06-0.542	300-1340
	Panel/Loose-fill	5-1280	0.033-0.138	1600-1700
Straw	Lime/Concrete/Plaster	1123.89-2000	0.2261-1.35	1209.63-1821.19
	Panel/Brick	41.4-1690	0.038-0.32	900
Olive	Panel/Brick	970-1880	0.0841-0.76	-
	Lime/Concrete	1147.94-2127	1	-

Figure 6. Depicts the thermo-physical properties of biomass residues [41].

Figure 6's depiction of the thermal characteristics of overrests, including their conductivity, heat capacity, and thermal diffusivity, has ignited the majority of study interest in this field. Your density is what follows.

Others, like compressive strength and liquid absorption, have been taken into account while others, like radioactivity and pH, have not. Numerous manufacturing methods were used, according to the research, although the mixing of multiple ingredients with a binder was the most common one [41]. In other instances, the manufacturing of new liquid materials, such as kartons from sour milk, was made possible by employing agricultural waste in its natural condition.

The investigations by Benfratello [42] largely examined the amount of extra cement, the mixture's granulometry, as well as the thermal properties of isolation panels built of cement and concrete. The results of the investigation showed the extraordinary mechanical toughness and isolating properties of the biocomposites. It was less dense than traditional concrete and could only be used in areas with lower pressures, such as green roofs on existing buildings.

The thermal and mechanical properties of lime-hemp concrete blocks were also looked at in a previous work by Elfordy et al. [43]. In addition to the density of the blocks, mechanical properties including flexural strength, hardness, and compression strength were evaluated. The results showed that the mortar density had a direct correlation with the variance in the blocks' mechanical and thermal permeability. The discrepancy between Benfratello [42] and Elfordy et al. led to the astounding finding that hemp is an outstanding biomaterial for structural and thermal isolation. Die Le [43]. Further research by Elfordy et al. [43] has shown that an increase in density improves compressive force, resistance, and stiffness. As a result, it is important to balance the mechanical benefits of the created components with the achievement of a suitable thermal isolation. The results back up Liu et al.'s claim that chanvre was often used in construction materials as a thermal isolator. Straw has also been frequently used in the manufacture of building thermal insulation materials in addition to hemp. Rojas et al. examined the use of natural fibers derived from maize and wheat husk as an alternative to petrochemical isolation materials in their investigation. Die Le [44]. The thermal conductivity and dichte of the composites were investigated using the Taguchi Method. An L-9 orthogonal array was used to analyze the four control variables of boiling time, fiber length, mixing time, and NaOH concentration. The Taguchi Method employs a certain set of orthogonal arrays and suggests a small number of tests that provide the greatest details about the many factors that influence the outcomes [45]. Furthermore, the compressive and flexural strengths of the composites were evaluated and compared with those of polystyrene insulating blocks. The results showed that there was

significant heat transmission between the blocks. They were mechanically equal to expanded polystyrene blocks, including flexural stress, but their electrical values were only 0,046 and 0,047 W/mK. Positive results have significant economic ramifications since natural fibers are widely available and abundant in developing nations like Chile. Building material manufacture requires less energy and is less costly than the production of petroleum-based goods.
Straw and wheat fibers might be combined to make lightweight composites that could be used to isolate structures, according to research by Belayachi et al. [46] In contrast to Rojas et al. [44], the comparison of treated and untreated materials was used to assess the impact of treatment on component flammability and thermal degradation during a fire. Throughout the research, the fibers were mixed with either gypsum plastic or lime. They were also treated with boiling water and linseed oil to reduce the amount of water absorption and improve the compatibility and adhesion of the binder.
The impregnated composites were tested for flammability every 10 seconds, 5 minutes, 10 minutes, and 60 minutes after soaking. Temperature measurements have been made using infrared cameras before, during, and after exposure to flames. A further analysis of the results of the soot emissions of various substances treated and untreated with fire is shown in Figure 7.

Composites and designation	Flame Height (cm) after 20 s removal burner for 15 s of exposure	Droplets Yes/No	Flame Height (cm) after 60 s removal burner for 30 s of exposure	Droplets Yes/No
Wheat-Plaster-Non treated (W-P-NT)	8.5	No	13.4	Yes
Wheat-Plaster-Boiled water (W-P-BW)	9.1	No	10.5	No
Wheat-Plaster-Linseed oil (W-P-LO)	6.1	No	10.2	No
Wheat - lime - Non Treated (W-L-NT)	7.9	No	8.6	No
Wheat-Lime-Boiled Water (W-L-BW)	6.7	No	8.1	No
Wheat-Lime-Linseed Oil (W-P-LO)	5.7	No	7.2	No
Barley-Plaster-Non Treated (B-P-NT)	13.1	Yes	14.2	Yes
Barley-Plaster-Boiled Water (B-P-BW)	7.5	No	9.3	No
Barley-Plaster-Linseed Oil (B-P-LO)	4.5	No	6.7	No
Barley-Lime Non Treated (B-L-NT)	8.2	No	8.5	No
Barley-Lime-Boiled Water (B-L-BW)	6.3	No	9.3	No
Barley-Lime-Linseed Oil (B-L-LO)	3.4	No	4.1	No

Figure 7. After 15 to 30 seconds of exposure to the ground, the flames began to spread [46].

The findings show that linseed oil successfully inhibits flame spread and the subsequent degradation of composite materials [46]. A further research showed that composites made of barley behaved in a way that was more susceptible to fire than composites made of wheat. Further processing may enhance the thermal characteristics of natural fibers, including flammability and thermal degradation, according to studies. This is why these insights might be useful for real-world applications like constructing isolation. Wang et al. [47] conducted a separate experiment into the thermal and mechanical properties of composites made from rice straws, a magnesium cement adhesive, and a foaming agent. Similar treatment was given to the combinations as it was to Belayachi, Hoxha, and Ismail [46]. Linseed oil was substituted with the alkali NaOH. Stroh's properties and connection to the matrix were also examined.
The results showed that after 150 minutes of mixing the paja with 3% NaOH, the mechanical parameters of the combined system had reached their maximum value. The novel material provided thermal insulation, was non-flammable, and lighter than earlier composites. The work is noteworthy because it lends credence to Belayachi et al.'s results [46], which claim that composite materials manufactured from agricultural wastes like rice, maize, or beans may benefit from treatment to enhance their mechanical and thermal characteristics.
Additional researchers looked at what happened when they mixed beton and paja with additional agrochemicals. When it comes to thermal insulation panels, Bakatovich and Gaspar [48] looked into the usage of sphagnum moss as a facer. The research used liquid glass glue to create various rye straw, reed, and moss-based compositions for thermal insulation boards. The calculations' physical properties, such as compressive and flexural strength, and thermal conductivity were rigorously investigated. The results demonstrated the greatest performance of the amorphous panels made of musk and flax fiber. The thermal conductivity was positive at 0.044 A and 0.046 W/mK, and the density varied from 156 to 190 kg/m3.
In addition to achieving a compression strength of 0.20 to 0.21 MPa, drying did not result in any shrinking. Sair et al. [49] expressed similar views as well.
A gypsum matrix has been combined with two natural fibers (cardboard and cork flakes) to make ecological composites. The results showed that adding the two combinations to gipso-Bau material improved aislamization. The total compression capacity of the mixture was also improved by the paper fiber [49]. In a second investigation, Wang et al. [50] looked into the mechanical and thermodynamic characteristics of the Mastixgummi-enhanced trigo/konjac

glucomannan-based aerogel. To improve the aerogel's physical properties, including the distribution of pore size and mechanical force, tigo and cebada were added. The results demonstrated that the inclusion of trigo and cebada boosted the mixes' mechanical strength while reducing the size of the aerogel pores. The improved aerogel combination also showed outstanding thermal stability with a compression modulus of 67,5 kPa, an elasticity of 0,27, and a low thermal conductivity of about 0.046 Wm-1K-1.

The results imply that by using additional agricultural products such cardboard, henna, and mush, the separation materials may be further enhanced. This implies that a variety of choices are open to building professionals for enhancing the longevity of thermal insulation materials. By adding more agrodechets to the composites as well as by applying alkali treatments like NaOH or linseed oil, these characteristics are in some ways improved.

Materials for construction Stability

The analysis revealed that while making construction materials for reinforcement, land economic rights are also used. The results from the previous section, which showed that the construction materials made from agricultural rights were lightweight, must be underlined before going on to discuss their use. For instance, Taurino et al. [29] shown that mixing stone with agricultural waste from wine and pomegranate seeds might result in the production of lightweight bricks.

The fact that cement panels composed of river rock twigs as a replacement for aggregate cannot be employed in big projects because to their poor compressive strength was also addressed in Kimeng et al. [39]. According to Belayachi et al. [46], the building materials made from cebada and maz fibers were naturally lightweight. The emphasis of attention is thus on research that shows how diverse agrochemical rights are used in reinforcing applications.

First off, Pacheco-Torgal and Jalali [51] have shown that the resistance and other qualities of concrete materials have increased due to the use of plant fibers as reinforcement. Figure 8 shows reinforced vegetal fiber horned forms using bamb bars.

Figure 8 Concrete beams reinforced with bamboo rebars: (**a**) finished reinforcement, (**b**) the setup [51].

It has also been shown that a variety of plant fibers, including bamb, hemp, sisal, coco, and cocoa, are efficient in strengthening cement-based structures. The substance that resembles cement in Figure 12 has reinforcing that bears the Bamb brand.

As Sharda et al. [52] shown, fiber proved to be an excellent replacement for steel bars when concrete strengthening was required. The researchers assumed that fibers prolonged the life of concrete materials based on test results for permeability, carbonation depth, and freeze-thaw resistance. Sharda et al. [52] stressed the need of doing the fibrose refuerzo thoroughly and with the required expertise. The utilization of Rohreismehl (RH) and Green Nadelmoss (GNS) in the synthesis of hybrid biopolymers (PP) based on green architecture was investigated by Guna et al. [3]. Experiments were then conducted to determine the effect of the amount of reinforcement on a variety of properties, including sound absorption, fire resistance, thermal insulation, water stability, and mechanical characteristics. The results showed that the reinforced compositions have flexional and resilient strength. The 20/60/20 GNS/RH/PP relationship has maximum values of 37,6 MPa and 15,6 MPa, respectively.

Additionally noticed were a thermal conductivity range of 0.156 to 0.270 W/mK and a maximum sound absorption value of 0.48. The characteristics of the composites may then be compared with those of other biocomposite materials. A graph illustrating the creation of composites is presented in Figure 9.

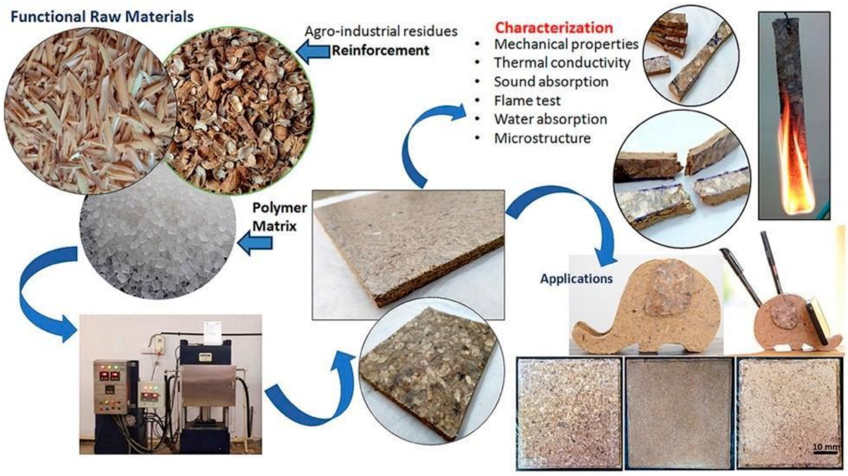

Figure 9 The development of a polipropileno hybrid formed from rice leaves and almond stalks [3].

Hassan et al. [53] looked at the mechanical and morphological characteristics of carbonized maize stalk, which is used to improve polyester composites in the creation of environmentally friendly composites. A total of 5%, 10%, 15%, and 20% of carbonized maize stalk ash particles (MSAps) were applied. Composite samples were analyzed to see how the varied ratios impacted the samples. According to the findings, the mixes' higher compressive, tensile, and tensional forces were inversely correlated with an increase in the number of Mazezucker particles. However, the force of the strike gradually faded. According to the research, matrix polymer blends used in both the construction and automotive industries may benefit from the addition of MSAps.

Due of the weak tensile and bending strengths of geopolymer composites, Natali et al. [54] investigated the use of fiber. As a result, they hardened and keramized. The findings also demonstrated that both organic and inorganic variables boosted geopolitical players' flexibility. The geopolitical community has also seen an increase in resistance [54]. Santos et al. [55] looked into the strengthening effects of adding PLA- and pine-based natural fibers to a polymeric matrix in three different amounts: 5%, 7,5%, and 10%. The morphological and thermodynamic properties of the Faser were also examined. The results showed that composites with more natural fibers were more flexible than composites with fewer fibers.

Yang et al. [56] also examined the use of waste tire composites reinforced with rice straw as composite building materials. In the research, panels composed of composite materials and panels made of wood particles were constructed as two distinct kinds of panel aislamization plates. The panel aislamization panels were made from a mixture of rice and agricultural lignocellulosic fiber particles with weight indices of 10/90, 20/80, and 30/70. As a composite adhesive, polyurethane Gummi adhesive was used. The findings show that when compared to placards made of wood, composite placards reinforced with arroz display improved water absorption, impermeable qualities, and growth potential. Composite panels have superior acoustic, anticorrosive, anti-estuarine, and electrical insulating properties compared to wood panels. The study, which also explored how composite boards may successfully replace insulating boards and other flexible building elements, corroborated this idea. This is as a result of its superior impact resistance, reasonable cost, and ease of customisation.

A study of the halluzinations reveals two important halluzinations. First, agricultural waste products, such as bamb in cement applications, may be employed in reinforcing applications in their natural forms. Second, as they may be processed or utilized as chemical admixtures in reinforcing biocomposites, it was advised that the materials made from agrowaste be treated before being used for reinforcement applications. However, the coincidence of multiple research revealed that the new construction materials had amazing properties that were equal to those of other conventional building materials.

Other researchers investigated the use of natural fibers to reinforce other construction components, such as blocks. For instance, Binici et al. [57] investigated the outcomes of reinforcing hormigon using both natural fibers like paja and synthetic fibers like poliester. The findings demonstrated that the natural fiber blocks met the demands for compressive strength and thermal permeability established by Turkish and ASTM standards. Basalt stone was also utilized to lessen the heat conductivity of the fiber-reinforced blocks. However, when compared to the two reinforced arcilla blocks that used paja rather than fibers, the reinforced plastic arcilla blocks had a greater compressive strength. However, concrete buildings performed worse than mud-brick homes when it came to regulating the temperature inside a house in the winter and the summer. A model home made of fiber-reinforced mud bricks is shown in Figure 10.

Figure 10 The model home was constructed using mud blocks that had fiber reinforcement [57].

The feasibility of substituting composites of reinforced polymers for conventional wood components was examined by Saxena et al. [58]. When compared to conventional products like wood, particleboards, and medium density fiber (MDF), composites made with natural fiber or industrial wastes, such as red mud and fly ash, achieved superior mechanical properties and were also resistant to fire, abrasive wear, chemical attack, and water absorption. Plant fiber and plastic waste, which have benefits over traditional wood in terms of technology, energy efficiency, and economics, may eventually replace it, said the researchers. Additionally, the outcomes have provided engineers the chance to look at the hitherto ignored usage of widely available land economic rights during the manufacturing of construction materials [58].

Particleboards

Particleboards are made by compressing wood chips, sawdust, or shavings and fusing them together with synthetic glue. They are sometimes referred to as chipboards or particleboards. Agricultural rights are also used in place of traditional timber products like lija and sierra harin to improve the quality of the end product. For example, Bhaduri and Mojumder [59] looked into using the Khimp plant, an arbuscular tree that is often found in Rajastan's desert, to make high-density laminates (60 cm x 60 cm x 1.3 cm), using different resins of urea and phenolformaldehyde as binders. Pictured in Figure 15 is the Khimp plant.

In order to assess how the adhesive affected the mechanical and physical characteristics of the paper board, the concentrations of UF and PF ranged from 10% to 20%. After that, conventional methods were used to assess the plates' mechanical properties, including tension and pressure, stiffness, and flexibility mechanisms, as well as their physical properties, including density, moisture content, energy levels, and ability to store water. The results showed that the plates built from UF- and PF-resins satisfied with the BIS Standards set for plates formed from extremely dense particle materials for general use in terms of their physical and mechanical qualities. The fact that PF-resin plates outperformed UF-resin plates in terms of their physical and mechanical properties, however, was a remarkable finding. The economic benefit of the research came from the successful substitution of plastic for wood as a raw material for particle plates without having a negative impact on the environment in the dry area. The study is unique, however, in that it places a focus on the utilization of desert plants, such the Khimp tree, in the manufacture of building materials.

In a separate study, scientists investigated the possibility of making high-density plastic plates using wood rather than agriculturally derived materials. For instance, Das et al. [60] shown how particleboards for various purposes may be made from agricultural waste from jute sticks. After protein extraction, Das and Chanda carried out more study on the use of sugar beet leaf waste in particleboard production [61]. The research used a number of adhesion methods, including in situ condensation of formaldehyde and urea without the use of resin, phenol- and formaldehyde-resins, and urea- and formaldehyde-resins. Then, it was looked at how several tables' physical properties, such as their moisture content, water absorption, density, and elongation or elongation values, performed.

Similar calculations were made using BIS standards for mechanical properties including pressure and traction. The results showed that Cebada particle table properties were equivalent to those of traditional lignocellulosic materials such bagasse, jutewood, and jutepasta [61]. Additionally, the results were wildly inconsistent due to the use of different adhesive resins. In particular, the plates created using the in-situ condensation of formaldehyde and urea without resin saw lower performance than the plates created using UF- and PF-resins. However, the study found that particle panels made from uva bay leftovers complied with BIS rules for typical uses including construction, painting, and interior partitions. The physical and mechanical characteristics of sample plates made using different fiducial processes are compared in Figure 11.

Material	Binder	Moisture content (%)	Density (kg/m³)	Water Absorption value (%) After 24 h soaking	After 2 h soaking	Thickness swelling (%)	Impact strength (kgf/cm)	Tensile strength (N/mm²)
Sugarbeet	UF resin	9.30	612.46	22.67	61.44	3.17	2.5	0.98
Leaf fibre	PF resin	12.29	652.68	50.27	60.41	4.03	3.5	0.84
Residues	*In situ* condensation	17.07	564.27	41.57	79.50	5.47	2.0	0.51
Cotton stalk[14]	UF resin	3-6	570- 720	29-72	57-100	—	—	0.6 - 2.7
Coconut pith[16]	UF resin	10.2	668.5	5.3	13.6	4.8	__	0.15
Jute stick[12,15]	UF resin	10	407	39.5	51.7	9.5	1.5-2.9	0.5 - 0.9
IS speci-fications[11]	__	5-15	500-900	25	50	10	—	0.8

Figure 11. Physicomechanical features of different particleboards [61]

In order to create particle labeling plates, Rosario et al.'s research [62] also looked at algal leaflets. The quality of particle tables consisting of one single decker and three algodon leaf deckels was examined in relation to three various reizgehalt levels (8%, 10%, and 12%), as well as three different table weight densities (400 kg/cm3, 500 kg/cm3, and 600 kg/cm3). Since even the thickest table (600 kg/cm3) met all of the PHILSA mechanical requirements for resin content, the results showed that only the density of the tables had a very noticeable effect on their quality. However, only three-capacity particle plates with a density of 600 kg/cm3 and a resin content of 10% or 12%, respectively, were able to meet the PHILSA standards for dimensional stability. Additional implications showed that the top three caps were Single-cape plaques were 8% resin and had the same density as particle matter plaques, which were 10% resin and had a density of 600 kg/cm3.

The physical and mechanical properties of three-layer particleboards composed of wood and covered with varying percentages of cotton stalks and unprocessed Paulownia-Holz particles were studied in a second investigation by Khanjanzadeh et al. [63]. The ratios of the two components when using urea-formaldehyde resin were 30, 50, and 70%. The findings demonstrated that the mechanical properties of the tablons were greatly enhanced by the addition of Caucho and Paulownia wood. The materials' resistance to moisture, however, decreased when more coco fiber and paulownia wood particles were included. At levels between 50% and 70%, the compositions obtained exceptional mechanical characteristics. Both Rosario et al. [62] and Khanjanzadeh et al. [63] used cotton stalks to make particleboard, and their investigations show numerous similarities and differences. Both researchers employed urea-formaldehyde as a glue and produced findings that were equivalent since the plates complied with the requirements. The use of paulownia wood particles to further improve the mechanical and physical properties of particulate-dispensing plates was shown by Khanjanzadeh et al. [63], which is a substantial difference. As a consequence, the proposal to combine several agro-pecuary rights to raise the standard of the planks was made.

Further investigation is required to back up this assertion. In order to make plaques formed of particle-containing material for this investigation, the researchers need mix numerous agro-plant rights. Fiorelli et al. [64] investigated the thermodynamic, physical, mechanical, and microstructural characteristics of panels made from sections of many caps using a mix of cane sugar and amazonian plant fibers, such as jute and curaua, for their exterior caps. Röntgendiffraction measurements were used to confirm that the plattendensity remained at 550 kg/m3. Additionally, the mechanical and physical features of the tablones were evaluated using Brazilian standards, ABNT NBR 14,810:2013. Thermal conductivity was also measured in accordance with ISO 8301:1999 guidelines. The findings demonstrated that the mechanical qualities of particulate matter plates employing a mezclador with plant fibers were better to those of particulate matter plates using just cane sugar. The heat conductivity of the different boards was also found to be equal, demonstrating that the presence of vegetable fibers had no impact on this specific property.

In a study that looked at the resilience and characteristics of the force resistance of particle display trays based on EPS and wood deflection, Akinyemi et al. [65] found a similar observation. On the placards, the research used two different dosages of EPS resin and two different sizes of wood particles as an adhesive. Following that, the fracture and elastic moduli (MOR and MOE) were assessed. The results demonstrated a decline in the soil's capacity to absorb water.

Once the EPS intake rose, the group carried on. The best performance was discovered before the tables were submerged in water for a long period of time, however. The research suggests that waste wood and EPS might be used to create composite wood panels that can withstand hot temperatures.

Bio-Based plastics

The last mentioned construction material was plastic made from bioderivatives obtained via agricultural rights. First, Ashori and Nourbakhsh [66] investigated whether agriculturally produced materials, such as maze, bagasse, and uva, might be used as reinforcement for thermoplastic production in lieu of wood fibers. The research examined the effects of the two-step adjusting agents Eastman G-3003 and G-3216 on the thermoplasts' mechanical properties. The number of utilized binders was 0, 1, 5, and 2.5%, but the amount of used fillers was equal to one step per penny (30%). The results showed that, in comparison to the unmodified experimental pieces, the experimental pieces with one of the two adhesive materials exhibited enhanced tension, flexibility, and influence properties. Additionally, it was shown that the acoplador improved the connectivity of the interface. Due to the G-3003's high melt viscosity, composites treated with it performed better than those treated with G-1303. Additionally, it was found that research using bagasse fiber had better results because of the fiber's inherent chemical properties.

Leceta et al. [67] also looked at the impacts of biodegradable films made from marine and agricultural resources. Examples of agricultural products that are used include agar made from algae, chitosan made from crab shells, and soy protein, a byproduct of the soy industry. The least detrimental to the environment are biodegradable films manufactured from agricultural and marine waste. Lambert and Wagner [68] also looked at the production of bioplastics from a similar aspect in their review study, with a focus on the environment. However, the researchers discovered that the addition of vitamins and microalgae had an impact on the structural composition of the pollutants and, therefore, on their capacity to assemble and disintegrate [68].

Bioplastics outperform traditional plastics made from combustible fuel in terms of energy efficiency, carbon dioxide emissions, and petroleum use, according to Ashok et al. [69]. In terms of their utility, the researchers have shown that bioplastiken are less helpful. In order to further enhance the properties of bioplastics, such as resistance, impact strength, and biodegradability, it was suggested that rice be included in their production. In a different study, Gonçalves de Moura et al. [70] used a green chemical method to generate natural molecules such plant cellulose. Since the recovered celulosa displayed robust thermomechanical and biodegradable characteristics, the researchers were able to develop new functional polymers for containers. The goal of the research was to show that using agricultural rights to produce novel cellulose-based polymers that might be used in food preparation is viable [70]. Utilizing agrochemical wastes to create biodegradable polymers enhances both their mechanical properties, such as impact strength, and their biodegradability, which reduces the problem of environmental contamination. An in-depth examination of the three research [69–71] demonstrates this. Additionally, Chiellini et al. [72] provided a variety of methods for producing combinations and products that are environmentally advantageous. Polyvinyl alcohol (PVA), which can be generated readily from water or other solutions and extracted using injection molding and blast extrusion, was the synthetic chemical used in the study endeavor. In addition to harina of trigo and gelatin, other natural deodorants were also used, including pepitas of abeto (AP), maze fibers (CF), harina of trigo (WF), harina of trigo (WS), and pepitas of amarillo (OP). The exercise of agrarian rights produces

Biodegradable materials and their alternatives have improved the morphological and mechanical characteristics of completed goods, making them more biodegradable and ecologically friendly.

5. The benefits and drawbacks of building materials derived from agricultural rights

As was previously said, careful examination of the different construction materials derived from agricultural waste has shown both benefits and drawbacks. This section discusses the benefits and drawbacks of using landowner rights in the manufacture of construction materials.

Advantages of using agricultural rights to produce construction materials

Two sorts of advantages may be made by exploiting landowner rights to produce construction materials. First, recycling land-based rights that may otherwise be harmful to the environment has benefits. When the building is done, using these materials will have advantages. Traditional disposal methods including burning, composting, and quema cause environmental problems that may be resolved by recycling agricultural rights in industrial operations [8]. This benefits the first group significantly. The research discovered that certain agricultural techniques generated a lot of rights, making it difficult to acquire and manage rights sensibly. Only 600 metric tons (MT) or so of India's land-based commercial assets were destroyed [2, 73-75]. This is because efforts to eliminate rights demand more financial resources to maintain since recycling rights reduces the quantity of material waste. The use of agricultural rights as an alternative to traditional building materials like hormigon and argillite is another advantage that directly improves the environment. This shows that less non-renewable resources are needed to increase output. The environment benefits when building materials are produced with less energy.

There were several advantages for the second group, according to the research. First and foremost, when producing blocks and other materials for masonry work, landowner rights were used to make quality blocks that correspond to set construction requirements. Kazmi et al. [27] demonstrated the use of cane sugar bagasse (SBA) and rice hoja azcar (RHA). By adding 5% RHA and SBA to the clay weight, the bricks were able to meet both Pakistani building standards and the ATSM standard criteria. Additionally, Taurino et al. [29] shown how clay and wine wastes (WWs), including reduced wine, grape seeds, and grape stems, may be used to make lightweight bricks. Studies show that land economic rights may provide the construction materials required to satisfy building criteria.

According to some scholars, the use of land rights has enabled the production of high-quality, cost-effective construction materials, much as the use of green building materials. Akram et al. [38] show how cane sugar (SCBA) can be employed to change the viscosity of the self-klebending body in their analytical investigation. Due to the rising expense of utilizing vibrotometers to monitor compaction operations, this has a substantial influence on the economy.

Hemp and other agricultural wastes were utilized as adaptants, as shown by the biocomposites' extraordinary mechanical resistance and adaptability [42]. This really meant that those who lived in rural dwellings made of agricultural waste had extremely insecure lives. This clarifies how isolating materials promote social and economic sustainability. The efficacy and robustness of reinforced materials, however, significantly increased with availability to agrochemicals. For instance, Pacheco-Torgal and Jalali [51] demonstrated that the inclusion of plant fibers as reinforcement improved the resistivity and other properties of cement-based composites. Using coal tar particles enhances their elastic, compressive, and other mechanical properties, as has been shown in several investigations include the tracing module for the composer. This is one advantage of using more advanced construction materials and various agricultural goods. It has been shown that using agricultural rights to make biodegradable paper and plastic provides a number of long-term economic and environmental advantages. Alternatives, like the tree from the Khimp plant, produced materials that surpassed BIS standards and were of outstanding quality [59]. As a consequence, less wood products are used, lessening the environmental damage while simultaneously generating income from the utilization of these commodities. Biodegradable plastics used less energy, produced less carbon dioxide, and used less petroleum than traditional plastics produced using fossil fuels [69]. Additionally, the fact that they decompose has boosted environmental sustainability.

The stability of the economy, the environment, and society are three major benefits of the different building materials based on agricultural rights, it is legitimate to claim. Since they utilized less energy to create, they needed fewer materials and funds. The adoption of energy-efficient materials would safeguard the environment similarly to isolation. While working in top-notch settings, the occupants of the different buildings may enjoy beautiful and comfortable living arrangements.

The drawbacks of producing construction materials utilizing property rights

Using landowner rights to produce construction materials has several disadvantages in addition to its numerous advantages. However, only a few of them have been implemented, with the main one being the lightness of building materials made possible by agriculturally derived rights. Blocks and stones' low bulk renders them unsuitable for certain building tasks, which is a severe drawback. For instance, stone, canela with sugar stone, rice stone (RHA), and stone-made bricks could only be used if the required construction costs were small, according to Kazmi et al. [27]. When construction materials were utilized, similar hallucinations were found. Since hemp and lime concrete is lighter than regular concrete, Benfratello [42] contends that it should only be utilized in situations where there are little stresses on the buildings, such as green roof covers on existing structures. Despite the fact that certain construction materials, like bricks, are lightweight, agricultural deductions have allowed for more sophisticated usage, such reinforcing applications. As a result, it is false to assert that construction materials derived from agricultural rights are only appropriate for simple uses like techos [42] or other shoddy components [27]. Sharda et al. [52] state that studies on carbonation depth, permeability, and freeze-thaw resistance were utilized to justify the use of fibers as an effective substitute for aluminum-coated bars in applications for reinforcing hormigon. The researchers also suggested that facers could enhance the beton's haltability. In a another investigation, Natali et al. [54] shown that strengthening and adaptability of geopolitical composites were boosted by the addition of reinforcement formed of organic or inorganic elements. A few research have shown the value and toughness of construction materials derived from agriculture. As a result, their flaws also have an impact on the applications they are employed in. For instance, while agrodechets may only be used for light purposes, the materials would not be appropriate if the intention was to use them to manufacture briquets. But mixing natural fibers with cement would also increase the products' robustness.

The significance of the high level of expertise required for manufacturing was a further point raised. It is essential to take care and make sure that the process of re-creating natural fibers in concrete can be carried out, according to Sharda et al. [53]. Furthermore, it is challenging to get highly skilled workers who can create materials. When experienced labor is both affordable and readily available, construction projects go forward more quickly. to circumstances when more expensive labor sources must be used. A third disadvantage may be the need for several pre-processes before the agro-waste might be used in actual construction projects. For instance, alkali (NaOH) treatment was necessary for composites made from rice straws, as illustrated in Figure 7, before they could be mixed with an adhesive and a foaming agent [47]. Similar to this, Belayachi et al. [46] had also shown that a number of pre-processes were necessary to create composites made of wheat and barley straw fibers for building insulation, including mixing with lime or gypsum plaster and treating the straws with boiled water or linseed oil to reduce water absorption while enhancing the compatibility and adhesion of the binder. Although it may be argued that the pre-process treatments were required for experimental purposes, their expense and duration make them unattractive in large-scale applications.

There were additional challenges and shortcomings in the development of sustainable construction materials. When bricks were originally made by mixing earth-based components, shaping, drying, and fire in kilns, it was first discovered that conventional processes were easier to put into effect. The researchers discovered that making sustainable bricks was more challenging, particularly since they lacked guidelines on how to blend agro-waste with conventional materials. For instance, in order to construct sustainable clay bricks by including oat and barley husk middlings, Kiziniević et al. [28] were required to generate three different concentrations—5%, 10%, and 20%—and compare the results. Similar to De Silva and Perera [30], in order to make clay bricks by adding rice husk ash (RHA), the agro-wastes had to be combined in a variety of concentrations: 0%, 2%, 4%, 6%, 8%, and 10%. Similar outcomes were seen by Modani and Vyawahare [35] when they made green concrete by substituting volumetric quantities of fine concrete aggregate for untreated sugarcane bagasse ash in ratios of 0%, 10%, 20%, 30%, and 40%. Hassan et al. [53] employed carbonized maize stalk ash particles (MSAps) in polyester composite reinforcement in four distinct ratios: 5%, 10%, 15%, and 20%. According to the inquiry, there were no guidelines to assist in the development of a variety of sustainable construction materials, thus different concentration ratios were used to combine them. This unequivocally shows the necessity for more research to investigate and establish the ideal ratios to use when incorporating different types of agro-waste. However, it subtly suggests that more study is still needed on the real-world uses for building materials derived from agricultural waste. This will result in higher costs and a longer period of time before the ideal ratios can be determined. Another industrial challenge is the pre-processing activities necessary for certain agro-wastes before they might be blended with conventional materials. In order to minimize water absorption while enhancing the compatibility and adhesion of the binder, Belayachi et al. [46] combined wheat and barley straw fibers that had been treated with boiling water and linseed oil. The result was light-weight composites for building insulation. Wang et al. [47] also employed alkali (NaOH) to treat the agricultural waste before combining it with magnesium cement adhesive, a foaming agent, and rice straws to make composites. In a manner similar to this, the researchers could also be seen igniting various types of solid waste, including peanut, rice, and barley husks, to create ash that could be combined with conventional materials to create brick and other masonry components. The research also showed that further sieving of the ash before adding it to clay bricks was necessary. For the steps used to create SCBA, where the solid waste was burned to make ash, see Figure 3. Producing sustainable building materials will eventually demand more resources to pay for the required pre-processing, such as chemical treatment and burning solid waste to make sufficient ash. This is because of the pre-processing activities. In other instances, however, the researchers used the agro-waste straight without any extra processing. For instance, Pacheco-Torgal and Jalali [51] strengthened cement-based structures using plant fibers.

This indicates that no further processing is necessary for any agriculturally based construction materials.

Discussion

In this review, the researcher looked at the many ways that agro-waste may be used to make green construction materials. In this regard, six different materials were looked at: bio-based plastics, building reinforcement materials, green concrete, brick/masonry components, and particleboards. On the basis of the evaluation of the numerous publications, a number of intriguing findings are provided. First, since agrowaste is porous and has a low compressive strength compared to other brick/masonry materials, its bricks are naturally light in weight. Although increasing the ratio of agro-waste would have prevented the lightweight nature, the optimal performance of the bricks was only discovered at low ratio percentages. For instance, De Silva and Perera [30] showed that excellent bricks could only be produced at 4% RHA ratios, in contrast to Kazmi et al. [27] who identified a 5% RHA ratio as the best percentage for the bricks. High-quality bricks were created by Rao and Prabath [36] and Modani and Vyawahare [35] using 10% sugarcane bagasse ash (SCBA) ratios, demonstrating the role that agrowaste plays in the production of green concrete at low ratios.

It has also been shown that using a variety of agro-waste in the manufacturing of construction materials improves the performance and quality of the finished goods. Paulownia wood particles, for instance, may be added to particleboards to further enhance their mechanical and physical properties, as shown by Khanjanzadeh et al. [63]. Similar to this, Fiorelli et al. [64] showed that particleboards with a vegetable fiber admixture had superior mechanical properties than those containing just sugarcane bagasse. When it comes to the production of green concrete, Rodier et al. [37] discovered that cement pastes made from ternary mixtures of bamboo leaf ash (BLA) and sugarcane bagasse ash (SCBA) showed greater pozzolanic activity than the binary mixture of SCBA alone. Additionally, Fiorelli et al. [64] showed that multi-layer particleboards constructed from a blend of sugarcane bagasse and Amazonian vegetable fibers like jute and curaua had better mechanical properties than those prepared from only sugarcane bagasse.

Similar to this, Binici et al. [57] shown that adding natural fibers to mud bricks strengthened them and improved their compressive strength and heat conductivity, fulfilling ASTM and Turkish standards requirements. As opposed to mud bricks reinforced just with natural fibers, like straw, or without any reinforcement at all, the researchers discovered that mud bricks reinforced with plastics had greater compressive strengths. The findings point to a research need in understanding what makes agrowaste-based construction materials' characteristics and performance improve after including a number of agrowaste components.

The sustainability requirements that agrowaste-based construction materials must meet are the subject of a third important conclusion. First of all, it is crucial to stress that the majority of research discovered that construction materials made using agro-waste products satisfied the building standards. Deraman et al. [31] used clay bricks as an example and showed that using empty fruit bunch (EFB) and coconut fiber (CB) at 5% concentrations as an additive poring agent resulted in bricks that adhered to BS392:1985 in terms of water absorption and compressive strength as well as the ASTM C517 thermal conductivity standard. The IS:2042-specified Type A insulation bricks parameters were reportedly met by insulation bricks produced by combining sawdust (7.5%) and red mud (40%) at 1100 °C. Furthermore, Binici et al. [57] showed that the ASTM and Turkish requirements for heat conductivity and compressive strength could be met by mud bricks reinforced with natural fibers. The findings instantly suggest that agro-waste-based goods are commercially feasible since they use cheap manufacturing inputs (agro-waste) and maintain the criteria of high quality. Another assertion stated is that the construction materials meet environmental sustainability criteria since they provide an alternative to non-renewable building materials like cement and sand aggregates, which helps save natural resources. Additionally, one may claim that the structure. Social sustainability standards are met by materials that provide construction-related jobs for the neighborhood by repurposing agricultural waste.

This study also reveals other areas that require more investigation. First, it became evident that certain construction materials required small amounts of agro-waste components as additives. For instance, it has been shown that agro-waste concentrations between 4 and 10 percent may produce bricks and green concrete of excellent quality. Particleboard manufacturing had similar outcomes. These findings indicate a knowledge gap that has to be addressed in order to fully comprehend why larger agrowaste concentrations do not improve quality or performance whereas lower concentrations provide the greatest results. Second, as was previously said, further research is needed to determine why employing various forms of agro-waste increased the quality of the construction materials. Third, additional research is still required to identify the many issues that arise in the years after adoption, despite clear evidence that agro-waste-based materials are compatible with the standards for building quality now in place. Empirical study is required to ascertain the materials' long-term performance and their interactions with the environment, including weather, climatic conditions, and human use.

Conclusions

The review research looked on the usage of agricultural waste to produce environmentally friendly building materials. The production of different building materials with natural organic waste from agricultural processes, including rice husks, groundnut shells, and sugarcane bagasse, among others, improved their overall physical, mechanical, and thermal properties. This also increased the sustainability of the materials by lowering costs and fostering environmental preservation. A careful analysis of several research investigations proved this. The results also showed that employing agro-waste-derived construction materials had greater durability advantages.

References

1. Worldometers.info, World Population Clock: 7.7 Billion People (2019)—Worldometers, Worldometers.info. 2019. Available online: https://www.worldometers.info/world-population/ (accessed on 20 November 2019).
2. Madurwar, M.; Ralegaonkar, R.; Mandavgane, S. Application of agro-waste for sustainable construction materials: A review. *Constr. Build. Mater.* 2013, *38*, 872–878. [CrossRef]
3. Guna, V.; Ilangovan, M.; Hassan Rather, M.; Giridharan, B.V.; Prajwal, B.; Vamshi Krishna, K.; Venkatesh, K.; Reddy, N. Groundnut shell/rice husk agro-waste reinforced polypropylene hybrid biocomposites. *J. Build. Eng.* 2019, *27*, 100991. [CrossRef]
4. Wi, K.; Lee, H.; Lim, S.; Song, H.; Hussin, M.; Ismail, M. Use of an agricultural by-product, nano sized Palm Oil Fuel Ash as a supplementary cementitious material. *Constr. Build. Mater.* 2018, *183*, 139–149. [CrossRef]
5. Chabriac, P.; Gourdon, E.; Gle, P.; Fabbri, A.; Lenormand, H. Agricultural by-products for building insulation: Acoustical characterization and modeling to predict micro-structural parameters. *Constr. Build. Mater.* 2016, *112*, 158–167. [CrossRef]
6. Shafigh, P.; Mahmud, H.; Jumaat, M.; Zargar, M. Agricultural wastes as aggregate in concrete mixtures – A review. *Constr. Build. Mater.* 2014, *53*, 110–117. [CrossRef]
7. Obi, F.; Ugwuishiwu, B.; Nwakaire, J. Agricultural Waste Concept, Generation, Utilization and Management. *Niger. J. Technol.* 2016, *35*, 957. [CrossRef]
8. Madrid, M.; Orbe, A.; Rojí, E.; Cuadrado, J. The effects of by-products incorporated in low-strength concrete for concrete masonry units. *Constr. Build. Mater.* 2017, *153*, 117–128. [CrossRef]
9. Figaredo, A.; Dhanya, M. Development of Sustainable Brick Materials Incorporating Agro-Wastes: An Overview. *Int. Res. J. Eng. Technol. (IRJET)* 2018, *5*, 721–726.
10. Sathiparan, N.; De Zoysa, H. The effects of using agricultural waste as partial substitute for sand in cement blocks. *J. Build. Eng.* 2018, *19*, 216–227. [CrossRef]
11. Ashour, T.; Korjenic, A.; Korjenic, S.; Wu, W. Thermal conductivity of unfired earth bricks reinforced by agricultural wastes with cement and gypsum. *Energy Build.* 2015, *104*, 139–146. [CrossRef]
12. Chaussinand, A.; Scartezzini, J.; Nik, V. Straw bale: A Waste from Agriculture, a New Construction Material for Sustainable Buildings. *Energy Procedia* 2015, *78*, 297–302. [CrossRef]
13. Rahman, M.; Muntohar, A.; Pakrashi, V.; Nagaratnam, B.; Sujan, D. Self-compacting concrete from uncontrolled burning of rice husk and blended fine aggregate. *Mater. Des.* 2014, *55*, 410–415. [CrossRef]
14. Rahman, M.; Leblouba, M.; Pakrashi, V. Improvement of Engineering Properties of Peat with Palm Oil Clinker. *Pertanika J. Sci. Technol.* 2014, *22*, 627–636.
15. Rahman, M.; Boon, A.; Muntohar, A.; Hashem Tanim, M.; Pakrashi, V. Performance of masonry blocks incorporating Palm Oil Fuel Ash. *J. Clean. Prod.* 2014, *78*, 195–201. [CrossRef]
16. Rahman, M.E.; Ong, P.J.; Nabinejad, O.; Islam, S.; Khandoker, N.A.N.; Pakrashi, V.; Shorowordi, K.M. Utilization of Blended Waste Materials in Bricks. *Technologies* 2018, *6*, 20. [CrossRef]
17. Ting, T.; Ting, M.; Rahman, M.; Pakrashi, V. Palm Oil Fuel Ash: Innovative Potential Applications as Sustainable Materials in Concrete. *Ref. Modul. Mater. Sci. Mater. Eng.* 2019.
18. Statista, Construction Industry Spending Globally 2025 | Statista, Statista. 2019. Available online: https://www.statista.com/statistics/788128/construction-spending-worldwide/ (accessed on 20 November 2019).
19. World Bank. *Construction Industry Value Chain*; World Bank: Washington, DC, USA, 2018.
20. PwC. *Global Construction 2030: A Global Forecast for the Construction Industry to 2030*; PwC: London, UK, 2019; Available online: https://www.pwc.com/vn/en/industries/engineering-and-construction/pwc-global-construction-2030.html (accessed on 20 November 2019).
21. UNEP. *2018 Global Status Report Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector*; UNEP: Nairobi, Kenya, 2018.

22. Willmott, D. *The Impacts of Construction and the Built Environment*; Willmott Dixon: London, UK, 2010.
23. Yılmaz, M.; Bakıs¸, A. Sustainability in Construction Sector. *Procedia Soc. Behav. Sci.* 2015, *195*, 2253–2262. [CrossRef]
24. Luby, S.; Biswas, D.; Gurley, E.; Hossain, I. Why highly polluting methods are used to manufacture bricks in Bangladesh. *Energy Sustain. Dev.* 2015, *28*, 68–74. [CrossRef]
25. Gomes, E.; Hossain, I. Transition from traditional brick manufacturing to more sustainable practices. *Energy Sustain. Dev.* 2003, *7*, 66–76. [CrossRef]
26. Daraina, K.; Rahmanb, A.; Ahsanc, A.; Islamd, A.; Yusuf, B. Brick Manufacturing Practice in Bangladesh: A Review of Energy Efficacy and Air Pollution Scenarios. *J. Hydrol. Environ. Res.* 2019, *1*, 60–69.
27. Kazmi, S.; Abbas, S.; Munir, M.; Khitab, A. Exploratory study on the effect of waste rice husk and sugarcane bagasse ashes in burnt clay bricks. *J. Build. Eng.* 2016, *7*, 372–378. [CrossRef]
28. Kizinievicˇ, O.; Kizinievicˇ, V.; Pundiene, I.; Molotokas, D. Eco-friendly fired clay brick manufactured with agricultural solid waste. *Arch. Civ. Mech. Eng.* 2018, *18*, 1156–1165. [CrossRef]
29. Taurino, R.; Ferretti, D.; Cattani, L.; Bozzoli, F.; Bondioli, F. Lightweight clay bricks manufactured by using locally available wine industry waste. *J. Build. Eng.* 2019, *26*, 100892. [CrossRef]
30. De Silva, G.; Perera, B. Effect of waste rice husk ash (RHA) on structural, thermal and acoustic properties of fired clay bricks. *J. Build. Eng.* 2018, *18*, 252–259. [CrossRef]
31. Deraman, R.; Abdullah, A.; Shahidan, S.; Nagapan, S.; Hamzah, M. The Potential of Agricultural Waste as Pore Forming Agents in Production of Low Thermal Clay Brick. In *Sustainable Construction and Building Technology*; Abas, N., Abd Salam, N., Shahidan, S., Eds.; Penerbit UTHM: Parit Raja, Malaysia, 2017.
32. Mandal, A.; Verma, H.; Sinha, O. Utilization of aluminum plant's waste for production of insulation bricks.*J. Clean. Prod.* 2017, *162*, 949–957. [CrossRef]
33. Muñoz, P.; Mendívil, M.; Letelier, V.; Morales, M. Thermal and mechanical properties of fired clay bricks made by using grapevine shoots as pore forming agent. Influence of particle size and percentage of replacement. *Constr. Build. Mater.* 2019, *224*, 639–658.
34. Prusty, J.; Patro, S.; Basarkar, S. Concrete using agro-waste as fine aggregate for sustainable built environment—A review. *Int. J. Sustain. Built Environ.* 2016, *5*, 312–333. [CrossRef]
35. Modani, P.; Vyawahare, M. Utilization of Bagasse Ash as a Partial Replacement of Fine Aggregate in Concrete. *Procedia Eng.* 2013, *51*, 25–29. [CrossRef]
36. Rao, M.; Prabath, N. Green Concrete using Agro Industrial Waste (Sugarcane Bagasse ASH). *Int. J. Soft Comput. Eng. (IJSCE)* 2015, *5*, 86–92.
37. Rodier, L.; Villar-Cociña, E.; Ballesteros, J.; Junior, H. Potential use of sugarcane bagasse and bamboo leaf ashes for elaboration of green cementitious materials. *J. Clean. Prod.* 2019, *231*, 54–63. [CrossRef]
38. Akram, T.; Memon, S.; Obaid, H. Production of low-cost self-compacting concrete using bagasse ash. *Constr. Build. Mater.* 2019, *23*, 703–712. [CrossRef]
39. Kimeng, H.; Ekundayo, O.; Sani, M.; Frederick, K. Feasibility study of the use of Groundnut Shells as Fine Aggregates in Light weight Concrete Construction. *Int. J. Adv. Res. Eng.* 2015, *1*, 13. [CrossRef]
40. Sada, B.; Amartey, Y.; Bako, S. An Investigation into the Use of Groundnut as Fine Aggregate Replacement. *Niger. J. Technol.* 2013, *32*, 54–60.
41. Liu, L.; Li, H.; Lazzaretto, A.; Manente, G.; Tong, G.; Liu, Q.; Li, N. The development history and prospects of biomass-based insulation materials for buildings. *Renew. Sustain. Energy Rev.* 2017, *69*, 912–932. [CrossRef]
42. Benfratello, S.; Capitano, C.; Peri, G.; Rizzo, G.; Scaccianoce, G.; Sorrentino, G. Thermal and structural properties of a hemp–lime biocomposite. *Constr. Build. Mater.* 2013, *48*, 745–754. [CrossRef]
43. Elfordy, S.; Lucas, F.; Tancret, F.; Scudeller, Y.; Goudet, L. Mechanical and thermal properties of lime and hemp concrete ("hempcrete") manufactured by a projection process. *Constr. Build. Mater.* 2008, *22*, 2116–2123. [CrossRef]
44. Rojas, C.; Cea, M.; Iriarte, A.; Valdés, G.; Navia, R.; Cárdenas-R, J.P. Thermal insulation materials based on agricultural residual wheat straw and corn husk biomass, for application in sustainable buildings. *Sustain. Mater. Technol.* 2019, *20*, e00102. [CrossRef]
45. Gaitonde, V.; Karnik, S.; Davim, J. Multiple performance optimization in drilling using Taguchi method with utility and modified utility concepts. *Mater. Form. Mach.* 2015, 99–115.
46. Belayachi, N.; Hoxha, D.; Ismail, B. Impact of fiber treatment on the fire reaction and thermal degradation of building insulation straw composite. *Energy Procedia* 2017, *139*, 544–549. [CrossRef]
47. Wang, J.; Zuo, Y.; Xiao, J.; Li, P.; Wu, Y. Construction of compatible interface of straw/magnesia lightweight materials by alkali treatment. *Constr. Build. Mater.* 2019, *228*, 116712. [CrossRef]
48. Bakatovich, A.; Gaspar, F. Composite material for thermal insulation based on moss raw material. *Constr. Build. Mater.* 2019, *228*, 116699. [CrossRef]
49. Sair, S.; Mandili, B.; Taqi, M.; El Bouari, A. Development of a new eco-friendly composite material based on gypsum reinforced with a mixture of cork fibre and cardboard waste for building thermal insulation. *Compos. Commun.* 2019, *16*, 20–24. [CrossRef]
50. Wang, Y.; Wu, K.; Xiao, M.; Riffat, S.; Su, Y.; Jiang, F. Thermal conductivity, structure and mechanical properties of konjac glucomannan/starch-based aerogel strengthened by wheat straw. *Carbohydr. Polym.* 2018,

197, 284–291. [CrossRef] [PubMed]
51. Pacheco-Torgal, F.; Jalali, S. Cementitious building materials reinforced with vegetable fibres: A review.*Constr. Build. Mater.* 2011, *25*, 575–581. [CrossRef]
52. Sharda, S.; Singh, M.; Singh, S. A review on Properties of Fiber Reinforced Cement-based materials. *Iosr. J. Mech. Civ. Eng. (IOSR-JMCE)* 2016, *13*, 104–112. [CrossRef]
53. Hassan, S.; Oghenevweta, J.; Aigbodion, V. Morphological and mechanical properties of carbonized waste maize stalk as reinforcement for eco-composites. *Compos. Part B Eng.* 2012, *43*, 2230–2236. [CrossRef]
54. Natali, A.; Manzi, S.; Bignozzi, M. Novel fiber-reinforced composite materials based on sustainable geopolymer matrix. *Procedia Eng.* 2011, *21*, 1124–1131. [CrossRef]
55. Santos, N.; Silva, M.; Alves, J. Reinforcement of a biopolymer matrix by lignocellulosic agro-waste. *Procedia Eng.* 2017, *200*, 422–427. [CrossRef]
56. Yang, H.; Kim, D.; Lee, Y.; Kim, H.; Jeon, J.; Kang, C. Possibility of using waste tire composites reinforced with rice straw as construction materials. *Bioresour. Technol.* 2014, *95*, 61–65. [CrossRef]
57. Binici, H.; Aksogan, O.; Bodur, M.; Akca, E.; Kapur, S. Thermal isolation and mechanical properties of fibre reinforced mud bricks as wall materials. *Constr. Build. Mater.* 2007, *21*, 901–906. [CrossRef]
58. Saxena, M.; Morchhale, R.; Asokan, P.; Prasad, B. Plant Fiber—Industrial Waste Reinforced Polymer Composites as a Potential Wood Substitute Material. *J. Compos. Mater.* 2008, *42*, 367–384. [CrossRef]
59. Bhaduri, S.; Mojumder, P. Medium density particle board from Khimp Plant. *Nat. Prod. Radiance* 2008, *7*, 106–110.
60. Das, R.; Day, A.; Pandey, S. Particle boards from jute stick. *Biol. Wastes* 1987, *20*, 309–313.
61. Das, S.; Chanda, S. Particle Board from Leaf Fibre Residues of Sugarbeet. *J. Sci. Ind. Res.* 2000, *59*, 306–308.
62. Rosario, D.; Rosario, J.; Cruz, M. Particleboard production from cotton stalks. *Sustain. Energy Technol. Assess.* 1998, *23*, 54.
63. Khanjanzadeh, H.; Bahmani, A.; Rafighi, A.; Tabarsa, T. Utilization of bio-waste cotton (Gossypium hirsutum L.) stalks and underutilized paulownia (paulownia fortunie) in wood-based composite particleboard. *Afr. J. Biotechnol.* 2012, *11*, 8045–8050. [CrossRef]
64. Fiorelli, J.; Galo, R.; Castro Junior, S.; Belini, U.; Lasso, P.; Savastano, H. Multilayer Particleboard Produced with Agroindustrial Waste and Amazonia Vegetable Fibres. *Waste Biomass Valorization* 2017, *9*, 1151–1161. [CrossRef]
65. Akinyemi, B.; Okonkwo, C.; Alhassan, E.; Ajiboye, M. Durability and strength properties of particle boards from polystyrene–wood wastes. *J. Mater. Cycles Waste Manag.* 2019, *21*, 1541–1549. [CrossRef]
66. Ashori, A.; Nourbakhsh, A. Bio-based composites from waste agricultural residues. *Waste Manag.* 2010, *30*, 680–684. [CrossRef]
67. Leceta, I.; Etxabide, A.; Cabezudo, S.; De la Caba, K.; Guerrero, P. Bio-based films prepared with by-products and wastes: Environmental assessment. *J. Clean. Prod.* 2014, *64*, 218–227. [CrossRef]
68. Lambert, S.; Wagner, M. Environmental performance of bio-based and biodegradable plastics: The road ahead. *Chem. Soc. Rev.* 2017, *46*, 6855–6871. [CrossRef] [PubMed]
69. Ashok, A.; Abhijith, R.; Rejeesh, C. Material characterization of starch derived bio degradable plastics and its mechanical property estimation. *Mater. Today Proc.* 2018, *5*, 2163–2170. [CrossRef]
70. Gonçalves de Moura, I.; Vasconcelos de Sá, A.; Lemos Machado Abreu, A.; Alves Machado, A. Bioplastics from agro-wastes for food packaging applications. *Food Packag.* 2017, 223–263.
71. Maraveas, C. Environmental Sustainability of Greenhouse Covering Materials. *Sustainability* 2019, *11*, 6129. [CrossRef]
72. Chiellini, E.; Cinelli, P.; Chiellini, F.; Imam, S. Environmentally Degradable Bio-Based Polymeric Blends and Composites. *Macromol. Biosci.* 2004, *4*, 218–231. [CrossRef]
73. Nazia Tarannum, Deepak Kumar, Nitin Kumar; β-Cyclodextrin-Based Nanocomposite Derivatives: State of the Art in Synthesis, Characterization and Application in Molecular Recognition; First published: 09 June 2022; https://doi.org/10.1002/slct.202200140.
74. Veena Chaudhary*1, Yeshpal2 and Nitin3; Bio-Polymer Based Slow Release / Control Release Fertilizer 2023/9/13; Research Journal of Agricultural Sciences; Vol.14, Issue 05 (Sep-Oct 2023) Pages 1; © 2023, Centre for Advanced Research in Agricultural Sciences.
75. Veena Chaudhary*, Yeshpal, Nitin and Ashish Tomar; A CONCEPTUAL REVIEW ON CONTROLLED RELEASE FERTILIZER; *Int. J. Agricult. Stat. Sci.* Vol. 19, No. 1, pp. ..., 2023; DocID: https://connectjournals.com/03899.2023.19.