Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 03

Agro bricks

Hello students. So, in our last class we saw two innovative building materials. One was milk paints and other was use of recycled plastics. Today we will see yet another innovative building material that is agro bricks. Now, agro bricks are a noteworthy innovation in sustainable construction. From the focal point of this exploration, we will be looking at classification of their composition of agricultural byproducts and how these bricks present distinctive characteristics that set them apart in the realm of eco-friendly building materials.

This introduction dwells into the classification, emphasizing the diverse range of agro-based components employed in their creation. The discussion extends to the advantages these bricks offer, both in terms of construction feasibility and environmental impact. Environmental benefits take center stage examining how agro-bricks contribute to conservation by minimizing resource intensive practices. However, the exploration acknowledges its limitations.

Moving forward, the applications of agrobricks are explored, showcasing their versatility across various construction contexts. A case study provides practical insights into the real-world application of agrobricks, followed by an illustrative example of a building that successfully integrates this sustainable construction material. Finally, a comprehensive summary ties together the diverse facets of agrobricks offering a holistic overview of their classification, characteristics, benefits and potential in construction practices. Now, agrobricks or biobricks are eco-friendly building blocks that are crafted by repurposing agricultural waste generated after each harvest. In India, around 600 metric tons of waste is estimated to result from agricultural activities.

The types of waste include sugarcane bagasse, wheat and paddy straw, husk, vegetable and food product residues, oil production remnants, jute fiber, groundnut shell, hardwood mill waste, coconut husk, cotton stock and many more. By utilizing these agricultural by-products as a sustainable construction material, agro bricks or bio bricks offer a

promising solution to issues related to land filling, pollution and the escalating costs of traditional building materials. Now, let us classify these agro bricks. The range of agro bricks is distinguished by the specific agricultural waste employed in their production. First, rice husk ash bricks utilize the byproduct of rice milling, which is rice husk ash, thereby promoting the recycling of rice husk waste and contributing to sustainable construction.

Second, we have hempcrete bricks. Hempcrete bricks incorporate hemp fibers from the hemp plant known for their lightweight composition and excellent insulation properties offering a sustainable building solution. Third is date palm fibre bricks. These utilise fibres extracted from date palm trees presenting a sustainable alternative with inherent natural insulating characteristics. Finally, sugarcane bagasse bricks are composed of sugarcane bagasse which is a residue from sugar production contributing to waste reduction and providing an eco-friendly solution for construction needs.

Other types of agro bricks include wheat and paddy straw bricks, vegetable and food product waste bricks, jute fibre bricks, groundnut shell bricks, hardwood mill waste bricks, coconut husk bricks, cotton stock bricks etc. Each type of brick has its unique characteristics, making them suitable for various construction applications while promoting sustainability and reducing the environmental impact of traditional building materials. Let us look at the characteristics of rice husk ash bricks. For rice husk and rice husk ash bricks as depicted in this figure, the density and strength varies significantly with the percentage replacement in a brick. The properties of rice husk ash bricks were analyzed across various parameters by a particular researcher in 2012.

The raw material composition primarily clay was found to consist of silicon dioxide, aluminum dioxide and iron oxide with silicon dioxide contributing to strength. Differential thermal analysis revealed significant points of moisture evaporation and endothermic reaction and a structural change in silicon dioxide during the process. Bulk density was influenced by rice husk and rice husk ash additions with a decrease in bulk density noted with higher rice husk content and a peak at 1.68 g per cm3 for 2% rice husk ash. The compressive strength also showed a decline with increased rice husk content.

Also, water absorption increased with higher rice husk content, while 2% rice husk ash demonstrated peak absorption of 15.2%. Microstructure analysis revealed increased porosity in modified bricks and residues on the surface with rice husk ash addition. Now, let us look at date palm fiber bricks. It is found that the addition of date palm waste presented distinct characteristics on date palm fiber reinforced adobe bricks.

A particular study revealed a significant decrease in dry compressive strength as date

palm waste content increased. Now these bricks showed very good compressive strength and this compressive strength when used in adobe constructions were actually on par with any other material. The mechanical behavior exhibited in stress-strain curves demonstrated a transition from reduced rigidity to increased ductility, with the apparent modulus of elasticity well within acceptable standards. Flexural strength also was well within acceptable standards, signifying enhanced ductility and delayed rupture in terms of thermal properties. Now, the thermal conductivity of these bricks was measured and found to be 0.

0738 watts per meter Kelvin. The formulated earth blocks displayed a linear decrease in thermal conductivity resulting in a notable 49 percent improvement in thermal insulation. The specific heat also exhibited an increase of 4%, but declined beyond 4% influenced by porosity. This comprehensive analysis highlights the multifaceted impact of date palm fiber inclusion on the mechanical and thermal characteristics of adobe bricks. We have already seen hempcrete in detail, but hempcrete as part of agro bricks we will quickly have a recapitulate.

Hempcrete bricks composed of inner fibers of the hemp plant, lime based binder and water offers a unique set of characteristics. These bricks are known for their excellent insulation properties, lightweight nature, facilitating easy construction and the ability to sequester carbon during hemp growth. Their natural breathability regulates moisture and prevents mold, making them a healthy choice for indoor environments. Hempcrete bricks are non-toxic and inherently fire resistant due to lime mineralization. Additionally, their production relies on fast growing hemp making them a renewable and sustainable resource.

With resistance to pests and rot, hempcrete bricks ensure long lasting durability in various construction applications. Let us now look at sugarcane bagasse ash bricks. Now, the study on sugarcane bagasse ash SCBA bricks revealed significant findings on its characteristics. Water absorption demonstrates a slight increase with higher sugarcane bagasse ash content.

It ranged from 13.1% to 22.7% with minimal adverse effects at 2.5% and 5% sugarcane bagasse ash. Their apparent porosity rose notably reaching 30.12% at 900 degree centigrade with 7.

5% of sugarcane bagasse ash indicating a correlation between higher sugarcane bagasse ash content and increased porosity due to combustion during firing. Their bulk density exhibited a decrease alongside rising bhagase ash content, reflecting open porosity resulting from the ash combustion with values ranging point 1.47 to 1.95 g per centimetre

cube. Compressive strength also increased with higher firing temperatures.

The surface texture of sugarcane bagasse ash containing bricks revealed visible pores aligning with water absorption, porosity and density trends. Bricks fired at elevated temperatures of 1100 degree centigrade displayed a reddish brown color indicative of denser and stronger properties. These findings underscore the intricate interplay of sugarcane bagasse ash content firing conditions and resulting physical and mechanical characteristics in brick production. Let us now look at the advantages. Now, agro bricks harnessed from agriculture waste bring forth a range of compelling advantages in the realm of sustainable construction.

Firstly, their commitment to waste utilization stands out as these bricks repurpose agricultural byproducts such as rice husk ash and sugarcane bagasse. This not only reduces the burden on landfills but transforms these residues into valuable construction materials contributing to efficient waste management. Additionally, the energy efficiency of certain agro bricks exemplified by varieties like hempcrete bricks lies in their exceptional insulation properties. This characteristic regulates indoor temperature, lessening the dependence on conventional heating or cooling system and consequently diminishing overall energy consumption. Moreover, the cost effectiveness of agro-bricks varies with regional contexts.

Leveraging local available agricultural waste minimizes transportation costs, making construction more economically viable and accessible. Beyond economic considerations, the demand for agro-bricks plays a crucial role in the promotion of sustainable agriculture by creating a market for agricultural residues. This not only provides an additional revenue stream for farmers but also encourages the adoption of sustainable agricultural practices. Furthermore, agro-bricks spur innovative construction solutions by driving the development of new eco-friendly building materials that align with evolving environmental standards. Lastly, they contribute to community development by fostering local industries, generating employment opportunities and enhancing economic self-sufficiency.

In essence, agro-bricks emerge as a multifaceted solution interwining environmental stewardship, economic viability and community well-being in the construction landscape. Let us look at the environmental benefits in specifics. Agro bricks offer significant environmental benefits by mitigating the reliance on conventional burnt clay bricks known for resource intensive extraction and processing. The production of agro bricks stands out for its lower energy consumption and reduced greenhouse gas emissions compared to conventional brick manufacturing, contributing to a diminished overall carbon footprint. Utilizing agricultural waste aligns with sustainable practices, tapping

into renewable resources that are replenished through regular crop cycles.

Additionally, certain agro bricks are designed to be biodegradable, offering a sustainable solution that minimizes environmental impact at the end of their life cycle. This environmentally conscious approach marks a positive stride towards conservation and sustainable building practices. Let us also look at the limitations. Now, while agro or biobricks have notable advantages, they also come with certain limitations that need to be considered. Firstly, their durability may not match that of traditional bricks, particularly in challenging weather conditions.

Factors like moisture, humidity and exposure to elements can impact their long-term resilience. Secondly, standardization in the production process of agro bricks may be lacking, leading to variations in strength and composition. This not only poses challenges in meeting consistent building standards, but also affects their availability. Thirdly, the biodegradability of agro-bricks while being advantageous may limit their use in application where long-term stability is crucial. Lastly, the perception and acceptance of agro-bricks in the construction industry might face resistance due to established practices and perceptions centered around traditional materials.

To ensure widespread adoption, addressing these concerns requires overcoming skepticism and actively promoting awareness about the benefits of agro-bricks. Let us now look at the application of agrobricks. Apart from the broad spectrum of uses of agricultural waste as shown in this figure, agro or biobricks find diverse applications within the construction sector. It is suitable for residential and commercial construction. These bricks offer an eco-friendly alternative for walls, partitions and flooring.

These are particularly effective in insulation with varieties like hempcrete bricks contributing to energy efficient buildings. Their application extends to low rise structures, non load bearing walls and decorative elements, presenting a sustainable option for bungalows, cottages and artistic installations. Embracing the principles of green building, agro bricks play a role in achieving certifications such as LEED. Moreover, they contribute to community development by being employed in educational facilities, healthcare buildings and community infrastructure projects. Additionally, these bricks serve as experimental materials in research and development projects showcasing their potential for innovative and sustainable construction practices.

As awareness grows and technology advances, the applications of agro-bricks continue to evolve offering a promising solution for environmentally conscious building practices. Let us now look at a case study of a building using Bagasse bricks. Now sugarcane is the world's largest crop, annually yielding nearly 2 billion tons accompanied by 600 million

tons of fibrous bagasse. Sugarcane is a groundbreaking biomaterial and it emerges from the collaboration between architecture studio Grimshaw and the University of East London in the year 2023. Formulated by combining bagasse with mineral binders, sugarcrete stands as a promising replacement for traditional bricks, potentially mitigating 1.

08 billion tons of carbon dioxide equivalent, which is also equivalent to 3% of its global production. Offering a low-cost, low-carbon alternative, sugarcrete is characterized by its lightweight nature, being 4 times lighter than conventional bricks and a reduced carbon footprint of 15 to 20%. With insulating properties and fire resistance, Sugarcrete finds versatile applications in load-bearing walls, structural floors, roof slabs and insulation panels showcasing its potential as a sustainable and innovative construction material. Let us now look at another building example. In Kamogawa, Japan, Six Lines Studio has designed a climate responsive small residential structure spanning just 9 square meters. The architecture incorporates overhangs to shield from sun and rain while courtyards facilitate cross ventilation ensuring a comfortable living environment.

The residence operates off-grid, leveraging solar power, borehole water and waste filtration for sustainable and cost-effective functionality. Notably, the construction prioritizes sustainability by utilizing rice husk bricks, timber, locally sourced sea salt poles and bricks from nearby kilns fired with rice husk. Now to summarize, agro bricks including those made from date palm fibers, hemp crate and sugarcane bagasse offer environmentally friendly alternative in construction. These bricks contribute to conservation by minimizing resource intensive processes, exhibit unique properties such as thermal insulation, lightweight construction and carbon sequestration. The use of agricultural waste like date palm waste and sugarcane bagasse support sustainability by relying on renewable sources.

While agro-bricks present environmentally friendly alternatives, potential limitations may include challenges in widespread adoption due to the need for adaptation in construction practices and variations in performance based on specific agricultural waste sources and regional availability. Additionally, the development of innovative biomaterials like sugarcrete utilizing sugarcane by-product bagasse, it demonstrates low-cost, low-carbon construction possibilities with an interlocking design for ease of assembly and disassembly. Overall, these agro-bricks showcase a promising direction for eco-friendly and sustainable building practices. Building case study shows the use of agro-bricks as a material for internal walling. Overall, agro bricks such as those which incorporate rice husk, sugarcane bagasse and date palm fibres offer sustainable building solutions with reduced environmental impact, improved thermal properties and diverse applications.

Yet, they face challenges in widespread adoption and performance variations- all of it to mitigate is in our hands. With this, we stop this class on agro bricks and we will continue the next class with yet another topic. Thank you.