AGRO-WASTE AS A LATEST EMERGING BUILDING CONSTRUCTION MATERIAL

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ABSTRACT

India is a country in which Agriculture forms its major industry. According to the results till 2011, India is having a huge and disparate agricultural sector, on an average, approx. 16% of GDP and 10% of earnings from export. Total Land area which is arable in India is 394.6 million acres or 159.7 million hectares, which marks the place as second largest in the world after United States. India falls amongst the major producers of many crops worldwide, that includes cotton, pulses, rice, wheat, ground-nuts, vegetables and fruits. India is also known as country of white revolution, Dairy and Poultry industries has major contribution in agricultural industry. Till then India has the largest number of buffalo and cattle. The agricultural waste is also being utilised in number of ways. Gobar Gas is one of the example of agricultural waste. As an architectural view and construction expert, we should utilise the waste in our sector. We have to explore the available agricultural waste near our region which can be used as a potential building materials for sustainable and eco-friendly environment. Due to many constraints and lack of exposure we are unable to re-utilise agricultural waste as potential material till date. Waste management is also contributes to the problems associated with rural areas in our country. This research paper is an attempt for exploring new horizons for solutions to the above said problems in development of 21st century India. Pros and cons of waste management in rural areas and recycled materials for building construction needs to be discussed to enlighten the building construction experts to bring in fashion, agricultural waste as potential building construction material for better development of nation. Due to many limitations, for the easement and for much practical results the research is much focused on Madhya Pradesh state of India. Important agricultural wastes and its application in building construction is discussed.

INTRODUCTION

The materials and construction technology for low cost housing remain very much bound with the locally available materials. By adopting new appropriate and innovative technologies for utilizing alternative to basic building materials like brick, cement, is an effective, efficient and economic manner. One of the best approaches is to use agriculture waste to meet the growing requirement of the building material. Utilization of agro-industrial wastes assumes a high priority in producing the resources of building materials. Agriculture is the most economic activity of India and other developing countries. There has been a vast expansion in agro-industrial field in recent years which makes the sustainable increase in the volume of agricultural residues of different types. Thus, the current shortages of wood and other building materials for ever rising the housing requirements have created a great interest in these agro-wastes. Groundnut husk, jute fibre, rice husk, rice straw, rice bale, saw dust, and coconut fibre and other fibrous material have been identified as most economically important wastes for building industry. It is estimated that in India nearly 700 million tons of organic waste is generated annually which is either burned or land filled. The large amount of the agro waste generated from the market area has created major environmental problems. Earthworms have ability to convert organic waste into valuable resources containing plant nutrients and organic matter, which are essential for maintaining soil productivity. It also promotes microbial and enzyme activities, in the soil. In the present investigation, the study is carried out on the proper utilization of agriculture waste as a building material.

POTENTIAL FOR AGRO-INDUSTRY IN DEVELOPING COUNTRIES:

The potential for agro-industrial development in the developing countries is largely linked to the relative abundance of agricultural raw materials and low-cost labour in most of them. The most suitable industries in such conditions are indeed those that make relatively intensive use of these abundant raw materials and unskilled labour and relatively less intensive use of presumably scarce capital and skilled labour.

Many of the industries using agricultural raw materials have in fact those characteristics that make them particularly suitable for the circumstances of many developing countries. Where the raw material represents a large proportion of total costs, its ready availability at a reasonable cost can often offset such disadvantages as a lack of infrastructure or skilled labour. Further-more, for many agro-industries, a small plant may be economically efficient, which is another important factor in developing countries where the domestic
market is limited by low purchasing power and sometimes by the small size of the market itself.

PRESENT SCENARIO IN INDIA

Presently in India, about 960 million tons of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tons are organic wastes from agricultural sources; 290 million tons are inorganic waste of industrial and mining sectors and 4.5 million tons are hazardous in nature. Globally 998 tons of agricultural waste is produced in a year. To safeguard the environment, efforts are being made for recycling different wastes and utilize them in value added applications.

TYPES OF AGRO-WASTE RICE STRAW

Rice straw is produced throughout the world as a by-product of rice cultivation. More than two billion people eat rice as a staple food, and the crop dominates cereal production in many low income countries. The options for disposal of straw are limited and include burning, composting and feeding on-farm. Off-farm, the straw is used for a host of processing activities – livestock feed, compost, pulp, extracts and/or fibres. Rice straw is a valuable ingredient of feed during the second half of the year for many small-scale livestock owners when rotational clover is no longer available.

Building Materials Made From Rice Straw

- Particle board
- Medium density fibre board
- Straw Board
- Thatched roofs
- Cement bonded boards
- Composites

Particle Board

- It uses as a sound absorbing, and for inner walls
- It improves the mechanical strength and water absorption

Medium Density Fibre Board

- It uses as a wall ceiling and furniture
- It improves mechanical strength, water resistance, and cutting tools wear.
Straw Board

- It uses as a for walls and roofing
- It improves the mechanical strength

Cement Bonded Boards

- Straw-fibre cement building blocks are cheap recyclable building material
- It uses for building blocks and ceiling panel
- It improves bond between straw and cement and acidity straw.

Thatched Roofs

- It improves fire hazard and durability

Composites

- It uses has a sound absorbing insulation board in construction
- It improves the bond between the straw and cement

RICE BALE

Straw bale construction has recently gained more confidence to be used as structural elements. A number of laboratory tests worldwide, show this system to be capable of supporting substantial service loads in case of proper baling, stacking, and plastering. In Egypt, growing attention is focused on examining this new trend of construction in order to solve the environmental pollution caused by burning millions of tons of straw every year. Straw bales consist of cheap abundant cellulose fibres packaged into conveniently, sized rigid bundles that are suitable for building. Any conventional building method, if used to build walls of the same thickness as a bale wall, would provide similar levels of performance, but at a much greater financial and environmental cost. Bales work cheaply and sustainably. The most common types of straw are wheat, oats, barley and rice. All of these are commercially farmed in most parts of the world. It is possible to bale and build with almost any fibrous plant stems. These types of straw are considered a waste by product of grain production. Most probably excess straw is burned in the field, contributing seriously to air pollution.
Advantages of Straw Bale

Energy Efficiency
One of the leading reasons to choose straw bales over other building materials is their high level of energy-efficiency. This is due to the exceptional insulating properties of the bales.

Healthy Choice
Straw bales are a healthy choice. They do not contain the paints, chemicals, glues and toxins Combined with clay and lime renders and natural paints or oxides to finish the structure, straw bale walls can breathe and provide a natural, fresh and healthy living environment. The thick walls seal out noise.

Cost Advantage
Straw bale is a low cost material. At best, the bale walls can reduce your overall budget by 5 to 10 %. But you’ll be getting more than twice the insulation value and great aesthetic potential, and savings in energy costs will stay with you for the life of the buildings. Heating costs can be reduced by up to 75% annually compared with modern style housing.

Structural Capabilities
Research has shown that structural load bearing straw bale walls can withstand loads of more than 48,826 kg/m2. In the load-bearing straw bale method, walls of up to 3 stories have been constructed, with infill walls, in post and beam type structures; the straw does not take weight anyway.

Comfort, Creativity & Aesthetics
Straw bale buildings have their own unique feel and character.

The thickness of the walls provides a feel of calm, safety and comfort. Deep window seats, alcoves, niches, and subtle curves are creative features.

Resistance against termites and pests
Walls built with tightly pressed straw bales provide fewer spaces for pests to live in than conventional timber frame houses do. Also, because clean and dry straw has very little nutritional substance, it is unable to support a pest population for long in itself if the render is
well applied, contains no or only very fine cracks and is well maintained, the risk of any pest infestation into your walls is very low. However, normal precautions against termite infestation, as used with any other construction technique, should be followed to protect the vulnerable components of your building from termites.

**Fire resistance**

Straw bales are tightly packed and covered with a skin of cement render. Fire can’t burn without oxygen, and the dense walls provide a nearly airless environment, so the fire resistance of compacted straw is very good. A test of a plastered wall panel showed a two-hour fire resistance, and an un-plastered bale wall had a 30-minute resistance.

**Moisture effect**

Straw bale walls should not exceed moisture content of 15%. Protecting your bale walls with an appropriate foundation, generous roof overhangs, intact & well maintained guttering, porches and verandas and suitable render materials are the most effective ways to avoid direct rain exposure, splash back and resulting moisture damage to the walls. Well applied, intact, properly maintained and breathable render will also protect the straw bales from moisture damage.

**Maintenance**

Maintenance is possible, and is very easy. Wedges of the bales can be pulled out quite easily. Hazel pins can be cut through if necessary and fresh straw wedges can be packed tightly back to fill the gap.

**RICE HUSK**

To achieve economy in construction, we should also maximize the use of local materials. Some of the important construction trends include use of stabilized soil sub base and bases, particularly lime-soil, soil-cement, lime-fly ash, soil lime-rice husk ash etc. Use of rice husk ash in embankment is also important option which requires due exploration. Use of waste material like Rice husk ash, as substitute road construction material is required, not only for economical consideration but for environmental consideration also.

Rice husk is a major agricultural by product obtained from the food crop of paddy. It contains 16 to 18 % pure silica by weight and on burning the rice husk yields 20-25% ash.
with more than 90% silica. About 35 million tons of paddy is produced in India, which yields more than 7 million tons of rice husk annually. One ton of rice husk, on completion of combustion, produces 200 kg of ash.

**BAMBOO FIBRE**

Bamboo fibre is regenerated cellulose fibre which is produced from raw materials of bamboo pulp. Firstly bamboo pulp is refined from bamboo through a process of hydrolysis-alkalization and multi-phase bleaching. Bamboo pulp is then processed into bamboo fibre. Bamboo has been in wide usage since ancient times as a low cost material for houses, bridges. Recently start appearing in designer homes as flooring, walling and panelling material. Bamboo fibre resembles cotton in its un spun form, a puffball of light, airy fibres. Many companies use extensive bleaching processes to turn bamboo fibre white, although companies producing organic bamboo fabric leave the bamboo fibre unbleached. To make bamboo fibre, bamboo is heavily pulped until it separates into thin component threads of fibre, which can be spun and dyed for weaving into cloth.

**The Production Flow of Natural Original Bamboo Fibre**

Two well known processes exist for producing regenerated bamboo fibre:

1) **Chemical Processing:** Sodium hydroxide (NaOH- also known as caustic soda or lye) is used to ‘cook’ the fibre into a form of regenerated cellulose fibre carbon disulfide is used for hydrolysis alkalization combined with multiphase bleaching. This process produces a fibre also known as bamboo rayon or modal. Chemical processing is the most popular bamboo fibre regeneration process.

2) **Mechanical Processing:** In mechanical transformation, machines are used to crush the woody parts of the bamboo plant; natural enzymes are then used to break the bamboo into a mushy mass at which point the individual fibres are combed out and spun into a yarn. This is similar to the process used to make linen. As such, the end product in this process is also known as bamboo linen. This process is much less popular than chemical, primarily because it is much more labour intensive and costly.

**Advantages of Bamboo Fibres**

- **Strength:** Bamboo is an extremely strong natural fibre on par standard hardwoods when cultivated, harvested and store properly.
• **Flexibility:** Bamboo is highly flexible. During its growth, it may be trained to growth in unconventional shapes. After harvest it may be bent and it is used in arch and other curved shapes.

• **Earthquake Resistance:** It has a great capacity for shock absorption. Which makes it particularly using in earthquake prone areas.

• **Light Weight:** Bamboo is extremely light weight. Consequently building with bamboo can be accomplished faster with sample tools than building with other materials. Cranes and other heavy machinery are rarely required.

• **Cost Effective:** Economically especially in areas where it is cultivated and readily available. Transportation cost is much lesser.

**Disadvantages of Bamboo Fibres**

• **Jointing Techniques:** Although many traditional joint type exist, their structural efficiency is low. Considerable research has been directed at the development of more effective methods.

• **Flammability:** Bamboo structures are not fire-resistant, and the cost of treatment where available is very high.

• **Lack of Design Guidance and Codification:** The engineering design of bamboo structures has not yet been fully addressed. There is little or no data containing specification of bamboo.

**JUTE FIBRE**

Jute is long soft, shiny plant fibre that can be spun into course, strong threads. It is produced from plants in the genus Corchorus, which see for botanical information and other uses. Jute is one of the cheapest natural fibres and is second only to cotton in amount produced and variety of uses. Jute fibres are composed primarily of the plant materials cellulose and lignin. Jute is the second most important vegetable fibre after cotton; not only for cultivation, but also for various uses. Jute is used chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth. The fibres are also woven into curtains, chair coverings, carpets, area rugs, hessian cloth, and backing for linoleum.

The fibres are used alone or blended with other types of fibres to make twine and rope. Jute butts, the coarse ends of the plants, are used to make inexpensive cloth. Conversely, very fine threads of jute can be separated out and made into imitation silk. As jute fibres are also being used to make pulp and paper, and with increasing concern over
forest destruction for the wood pulp used to make most paper, the importance of jute for this purpose may increase. Jute has a long history of use in the sackings, carpets, wrapping fabrics (cotton bale), and construction fabric manufacturing industry.

**SUGARCANE BAGGASE**

The sugarcane biases consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of biases (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. Sugar is extracted from sugar cane. Bagasse is the main by-product Biases is burned to produce energy and steam for power one source stated that sugarcane biases ash is thought of as a solid waste that is non-biodegradable. There are other uses of biases ash Partial cement replacement in concrete

**APPLICATIONS OF AGRO WASTE AS BUILDING MATERIAL**

<table>
<thead>
<tr>
<th>Item</th>
<th>Source</th>
<th>Application In Building Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice Husk</td>
<td>Rice mills</td>
<td>As a fibrous building panels brick acid proof cement and rice husk ash as concrete additive and as a building materials and products</td>
</tr>
<tr>
<td>Banana leaves / stalk</td>
<td>Banana plants</td>
<td>In manufacture of building boards, fire resistance board</td>
</tr>
<tr>
<td>Coconut husk</td>
<td>Core fiber industry</td>
<td>As a building boards, roofing sheets Insulation boards, building panel, coir fiber reinforced composite, cement bonded</td>
</tr>
<tr>
<td>Groundnut shell</td>
<td>Groundnut oil mills</td>
<td>As a building panels, building blocks, particle boards</td>
</tr>
<tr>
<td>Jute fiber</td>
<td>Jute industry</td>
<td>As a chip boards, roofing Sheets, door shutters etc. using polymer binders</td>
</tr>
<tr>
<td>Rice / wheat straw</td>
<td>Agricultural Farm</td>
<td>As a roofing units and wall panels</td>
</tr>
<tr>
<td>Saw mill waste</td>
<td>Saw mills</td>
<td>As a cement bonded blocks, particle boards, insulation boards</td>
</tr>
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CONCLUSION

In this study describes briefly the utilization, applications of agro-wastes in construction industry. Agriculture is the most important economic activity of India and so in other developing countries. There has been a rapidly increase in the agro industrial field in last two decades which has caused substantial increases in the volume of agricultural residues of different types. In current shortage of wood and other building materials for ever rising increased housing requirements have created great interest in those agro-wastes. These agro waste materials reduced building cost. Utilization of agricultural wastes helps in environmental prevention and prevention of agriculture land.

REFERENCES

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