Research Paper

Volume : 2 | Issue : 2 | Feb 2013 • ISSN No 2277 - 8179

Engineering

KEYWORDS : agro waste, rice-straw, rice husk, rice bale, bamboo fibre, sugar baggase, resource conservation, sustainable

A Study on Utilization of Agro-Wastes as an Innovative Material in Indian Context

Mr Ankit N. Patel	Student of final year M.E. Construction Engineering and Management, Civil Engineering Department, B.V.M. Engineering College Vallabh vidyanagar-Gujarat-India
Mr Sanjay Salla	Student of final year M.E. Construction Engineering and Management, Civil Engineering Department, B.V.M. Engineering College Vallabh vidyanagar-Gujarat-India
Prof. Jayeshkumar Pitroda	Assistant Professor & Research Scholar, Civil Engineering Department, B.V.M. Engineering College Vallabh vidyanagar-Gujarat-India

ABSTRACT

- Traditionally materials like clay, sand, stone, gravels, cement, brick, block, tiles, distemper, paint, timber and steel are being used as major building components in construction sector. All these materials have been produced from the existing natural resources and will have intrinsic distinctiveness for damaging the environment due to their continuous exploitation. The cost of construction materials is increasing incrementally. It is essential to find functional substitutes for conventional building materials in the construction industry. In view of the importance of saving of energy and conservation of resources, efficient recycling of all these agro wastes is now a global concern requiring extensive R&D work towards exploring newer applications and maximizing use of existing technologies for a sustainable and environmentally sound management. More details on the availability of agro wastes of all kinds from different sources, their present utilization and recycling potentials for safe, sound and substantial development are summarized and discussed in this paper.

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 staw, 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 tonnes 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.

PRODUCTION OF AGRO-WASTE IN INDIA

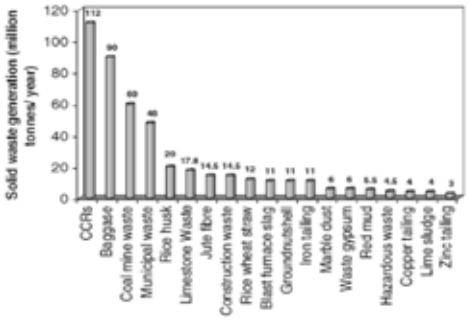

Fig-1 Current Status of solid waste generation in India (million tonnes /year)
Source: http// www.academicjournals.org

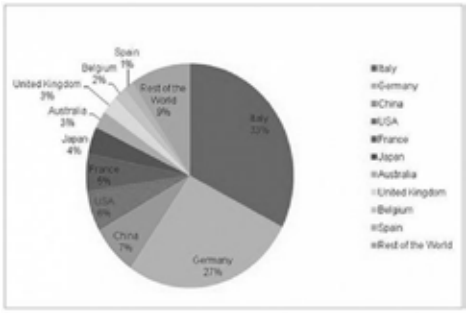

Fig -2 Pie chart of production of Agro-waste in India
Source: http// portlandwiki.org

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. Furthermore, 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.

PRIMARY ENERGY CONSUMPTION IN INDIA

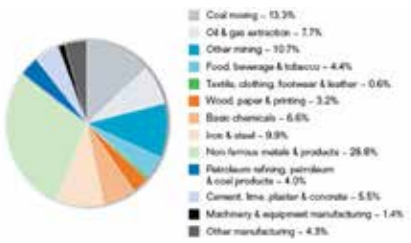

Fig -3 production consumption energy in India
Source: www.garnautreview.org.au

PRESENT SCENARIO IN INDIA

Presently in India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Of this 350 million tonnes are organic wastes from agricultural sources; 290 million tonnes are inorganic waste of industrial and mining sectors and 4.5 million tonnes are hazardous in nature. Globally 998 tonnes 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.

Fig-4 Agro Waste -Rice Straw
Source: http/en.wikipedia.org//rice straw

Building Materials Made From Rice Straw

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

Particle Board

Fig-5 Particle Board
Source:http//www.biomassandbioenergy.nl/filesrices-trawKeijser

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

Medium Density Fibre Board

Fig-6 Medium Density Fibre Board
Source:http//www.biomassandbioenergy.nl/filesrices-trawKeijser

- It uses as a wall celling and furniture
- It improves mechanical strength, water resistance, and cutting tools wear

Straw Board

Fig-7 Straw Board
Source:http//www.biomassandbioenergy.nl/filesrices-trawKeijser

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

Cement Bonded Boards

Fig-8 Cement Bonded Boards
Source:http//www.biomassandbioenergy.nl/filesrices-trawKeijser

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

Volume : 2 | Issue : 2 | Feb 2013 • ISSN No 2277 - 8179

Thatched Roofs

Fig-9 Thatched Roofs
Source:http//www.biomassandbioenergy.nl/filesricestrawKeijser

- It improves fire hazard and durability

Composites

Fig-10 Composites
Source:http//www.biomassandbioenergy.nl/filesricestrawKeijser

- 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.

Fig-11 Agro Waste - Rice Bale
Source: http/en.wikipedia.org

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.

Fig-12 Straw bale wall can withstand great loads. Wall up to 3 stories can be constructed
Source: http//www.urbanharmony.org

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 unplastered 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 ton of paddy is produced in India, which yields more than7 million ton of rice husk annually. One ton of rice husk, on completion of combustion, produces 200 kg of ash.

Fig-13 Agro Waste - Rice Husk
Source: http/en.wikipedia.org

Chemical Properties of Rice Husk Ash

TABLE-1
CHEMICAL COMPOSITION OF RICE HUSK ASH (IN %)

Constituents	Weight % Rice Husk Ash
Silicon dioxide (Si02)	87.2
Aluminum oxide (Al2O3)	0.15
Ferric Oxide (Fe2O3)	0.16
Calcium Oxide (CaO)	0.55
Magnesium Oxide (MgO)	0.35
Sodium Oxide (Na2O)	1.12
Potassium Oxide (k2O)	3.68
Phosphorous Oxide (P2O5)	0.50
Titanium Oxide (TiO)	0.01
Sulphur Oxide (SO3)	0.24
Carbon (C)	5.91
Loss on ignition	8.55

Source: http// Building Materials and Technology Promotion Council (BMTPC)

Physical Properties of Rice Husk Ash

TABLE-2
PHYSICAL PROPERTIES OF RICE HUSK ASH

Sr. No.	Name	Physical Properties
1	Density	2.06
2	Average particle size	5.85 to 6.86
3	Specific surface area	32.4 to 112.1
4	Minerology	Non-crystalline
5	Shape and texture	Irregular, Cellular

Source: http// Building Materials and Technology Promotion Council (BMTPC)

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 time as a low cost material for houses, bridges. Recently start appearing in designer homes as flooring, walling and panelling material.

Bamboo fiber resembles cotton in its unspun form, a puffball of light, airy fibers. Many companies use extensive bleaching processes to turn bamboo fiber white, although companies producing organic bamboo fabric leave the bamboo fiber unbleached. To make bamboo fiber, bamboo is heavily pulped until it separates into thin component threads of fiber, which can be spun and dyed for weaving into cloth.

Fig-14 Agro Waste - Bamboo Fibre
Source: http/en.wikipedia.org

The Production Flow of Natural Original Bamboo Fiber

Two well know processes exist for producing regenerated bamboo fiber:

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

Volume : 2 | Issue : 2 | Feb 2013 • ISSN No 2277 - 8179

- **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 fiber 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 fibers and is second only to cotton in amount produced and variety of uses. Jute fibers 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.

Fig-15 Agro Waste - Jute Fibre
Source: http/en.wikipedia.org

SUGARCANE BAGGASE

The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (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 Bagasse is burned to produce energy and steam for power one source stated that sugarcane bagasse ash is thought of as a solid waste that is non-biodegradable. There are other uses of bagasse ash Partial cement replacement in concrete

Fig-16 Agro Waste- Sugarcane Baggase
Source: http/en.wikipedia.org//rice straw

APPLICATIONS OF AGRO WASTE AS BUILDING MATERIAL

TABLE-3
APPLICATIONS OF AGRO WASTE AS BUILDING MATERIAL

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

Source: http// Building Materials and Technology Promotion Council (BMTPC)

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.

REFERENCE

[1] Akmal, T., Recycling Rice-Straw for the manufacure of construction brick, in Arabic. 2005. | [2] Shyam, M., Agro-residue-based renewable energy technologies for rural development. Energy for Sustainable Development, 2002. 6(2): p. 37-42. | [3] Building Materials from Agro Industrial Wastes Dr. Manjit Singh, Scientist 'G' & Head, Environmental S & T & Clay Products Divisions,Central Building Research Institute, Roorkee. | [4] Scientist 'G' & Head, Environmental S & T & Clay Products Divisions, Central Building Research Institute, Roorkee | [5] Robinson G (2007). Changes in construction waste management'. Waste Manage. World p. 43-49. | [6] National Energy Administration (NEA) (1993). 'A pre-investment study for fuel production from agricultural wastes for power generation and household consumption', Khartoum: Sudan. | [7] Anaerobic digestion of municipal solid waste and agricultural waste and the effect of co-digestion with dairy cow manure Maritza Macias-Corral, Zohrab Samani,, Adrian Hanson, Geoffrey Smith, Paul Funk, Hui Yu, John Longworth. | [8] Rahman, M.A., Properties of clay-sand-rice husk ash mixed bricks. International Journal of Cement Composites and Lightweight Concrete, 1987. 9(2): p. 105-108. | [9] Mansour, A., J. Srebric, and B.J. Burley, Development of Straw-cement Composite Sustainable Building Material for Low-cost Housing in Egypt. Journal of Applied Sciences Research, 2007. 3(11): p. 1571-1580. | [10] Shyam, M., Agro-residue-based renewable energy technologies for rural development. Energy for Sustainable Development, 2002. 6(2): p. 37-42. | [11] U. C. Jindal. Poor, "Development and testing of bamboo-fiber reinforced plastic composites", J Composite Mater, 1986, vol. 20, pp. 19–29 | [12] M. N. M. Yusoff, A. A. Kadir, A. H. Mohamed, "Utilization of bamboo for pulp and paper and medium density fiber board" (Proceedings style)" National Bamboo Seminar, Kuala Lumpur, Malaysia | [13] Al-Khalaf M. N. and Yousif H. A., Use of Rice Husk Ash in Concrete, The International Journal of Cement Composites and Lightweight Concrete, 6(4), p. 241-248 | [14] Michael K. O., Rice Husk as stabilizing agents in Clay Bricks, Higher National Diploma Project, Department of Civil Engineering, Federal Polytechnic Bida, Nigeria, 1994 | [15] Britany Radake "Sugar Cane Baggase Ash Waste" Brazil June 2012 | [16] C. B. Sisman*, E. Gezer And I. Kocaman "Effect Of Organic Waste (Rice Husk) On The Concrete Properties For Farm Buildings" Bulgarian Journal Of Agricultural Science 17 (No 1) 2011 | [17] Edwin R.P. Keijesers Agrotechnology And Food Science Group "Sustainable Building Materials From Rice Straw" | [18] Gihan L. Garas, Mostafa E. Allam, Hala M. El Kady And Ayman H. El Alfy. "Compressibility of Single Un-Rendered Rice Straw Bales: Characterstics Of Bales Used In Building Materials" ARPN Journal Of Engineering And Applied Science Vol 4 NO 5, July 2009 |