Research Article

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Waste Materials as a Supplementary Building Material for Low Cost Housing

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ABSTRACT

This paper presents the approach to minimise the cost of house especially in rural area which shares about 69% of total population. In India, agriculture contribute is about sixteen percent (16.11%) of total GDP .At present cost of construction is increasing day by day due to hiking material price and non-availability of manpower (Skilled and Unskilled). In rural sector per capita income is quite low then that of urban area. In rural areas to provide shelter being basic need is a great challenge both at economic and engineering level. To develop means for affordable housing especially in rural areas is need of the day and to be focused at all the relevant levels. This work is on various materials which are easily available in rural area in the form of waste materials like Earth, Bamboo, Straw, Fibers, Rice Husk, Fly ash, PVC, etc. which is easily available and much cheaper then that of replaced construction materials, also Use of these materials will save the environment.

Keywords: Earth, Bamboo, Straw, Fibers, Fly ash, PVC, Rice Husk, Sustainability, Rural, Development,

1. INTRODUCTION

Indian population expanding by 1.2% every year, to provide a shelter to all has long been a problem for government. To provide the economical houses is a major concern to the government as 23.6% of the country's population leaves below the International poverty line which is $1.90per day (World_Bank). Majority of Indians are living in a congested houses for their housing need. India is an Agricultural based country and industrial developing country which produces large amount of by-product in the form of waste but after some processing these waste can be utilized as a replacement for the conventional building material which can reduce the overall cost of housing and also conserve the environment.

In India, burning agricultural waste, such as stalks, leaves and husk, continues to be the easiest and inexpensive way to eliminate the volume of combustible waste material. Open air burning of biomass produces 40% of carbon dioxide, 32% of carbon monoxide (CO),20% of particulate matter (PM), and 50% of polycyclic aromatic hydrocarbons (PAHs) released into the environment. It is frequent practice and dangerous for a public health. Commission for Environmental Cooperation.

Cement plants are a significant source of sulphur dioxide, nitrogen oxide and carbon monoxide which cause environmental impacts such as ground-level ozone, acid rain, global warming lung diseases, cardiovascular disease, effect on central nervous system etc.

The use of natural materials like earth, straw, bamboo, Coir, Jute, sisal etc. is an old practice in India. These materials are easily available locally and easy workable which also reduces the cost. Also industrial wastes like PVC, fly ash and rice husk possess pozzolanic properties which can act as excellent substitute material. This paper approach to bring together the studies of these materials keeping in mind their availability, affordability and workability.

2. LOW COST SUPPLEMENTARY CONSTRUCTION MATERIALS

These are the material which are easily available and cheaper than that of conventional construction materials. These materials can classified into Natural and Manmade products.

2.1 Natural Supplementary Materials and Methodology

2.1.1 Earth

Earth is the oldest and most used construction material. But its widespread use is hindered due to the limitations like Seepage, Erosion due to water, Termites and insects attack, High maintenance requirement etc. but now a days these problems are overcome by using Compressed Earth block, Bitumen cutback plaster, dagga-cement Plaster.

i) Compressed Earth Block

It is also known as pressed earth block. It is simply compressed soil at high pressure typically around 3,000 psi (https://goo.gl/9D0rwp) is applied in compression and the original soil volume reduces by about half. Compressed earth block is generally mechanically pressed to form a block out of an appropriate mix of non-expansive inorganic subsoil. In the tropical environments, polycarbonate varnish is required to avoid the erosion due to wet weather. These CEB is a good replacement for conventional kiln burnt brick.

ii) Bitumen Cutback Plaster

Bitumen cutback plasteris developed by Central Building Research Institute, India. This plaster is used to cover mud wall and protect it from rain. It is economical and effective which cost Rs. 25/m^2 (CSIR, https://goo.gl/8tZhmq).This plaster is prepared by mixing hot bitumen and kerosene in a 5:1 ratio, and then combining one part of that mixture with 20 parts of fermented soil and wheat straw. Water is added and the whole mixed together thoroughly. This type of plaster is applied in two layers, first directly applied on wall and second coat after complete drying of first layer. Another coat of mud-cowdung slurry (gobri) with cutback is appied on drying of second layer.

iii) Dagga-cement Plaster

It is found that Dagga cementis another proprietary plaster. In which a mix of two parts sand to one part clayey soil to 0.2 part cement by volume is used which gives more durability. This produces a good weather-resistant plastering mix (https://goo.gl/KPqp2l, wikipedia.org/wiki/sisal).

2.1.2 Straw

The dried stems from harvested small grains produces straw. As India ranks second worldwide in farm output so the waste output is also high. Straw is considered as an environmental problem as its burning causes breathing problems. In India there is a lots of scope for straw in construction sector. The majority of small grain grown in India is wheat and rice. Rice straw has the highest opaline silica content (20 %) in combination with a large amount of phenyl propanoid structural polymer called lignin, this abundant agricultural waste has all of the properties one could ever expected of some of the best insulating material. Straw bales have a low embodied energy. Sunlight was the main energy source for growing plant which means that very little energy was used to manufacture the product. The only energy needed to make a straw bale is in the bailing process and the transportation to the worksite. Other insulation materials, such as fiberglass requires much amount of energy to produces. Straw bale hoe can least over 100 year if maintained properly .Straw bales are 100% biodegradable so when the time comes straw bales can be plowed back into earth.

The following are the some construction alternatives constructed with straws and straw bales

i) Thatched Roofing

It is locally available and effective roofing alter-native. One of the advantage of thatched roof is stability to the temperature of the roof. Because of their size and mass they are slow to warm up and cool down (https://goo.gl/nDGAKP,buildingwithawareness.com). In places where temperature variation is high this can be a great advantage. By treating it with copper Sulphate solution, its life can be extended by reducing the effect of bio-degradability. Additional layer of treatment on the surface by using phosphorylated spray or CNSL oil imparts water proofing, fire resistance, termite and insects proofing and enhance weathering resistance (Chowdhury and Roy, 2013).

ii) Straw panel

It is revealed that Straw panels is used for wall of low-rise buildings and as a partition wall of high-rise buildings. It is lightweight (33kg/m2) hollow panels which is made of 70% of straw,35%-50% of gypsum product and 10%-20% of wood product and glass fiber as a reinforcing materials.The properties of this product is - Dry Shrinkage ≤0.8 mm/m, Sound Insulation ≥ 40db and Water Absorption 22% (ICM, Beijing).

iii) Roof Insulation

In a conventional Roof structure straw bales may be insulated, taking advantage of its high insulation values and good acoustic properties (https://goo.gl/nDGAKP,buildingwithawareness.com).

2.1.3 Bamboo (Bambuseae)

Bamboo is an eco-friendly, highly renewable source of material. India is the second largest producer of bamboo after china. These two countries together have more than half of the total bamboo resources worldwide.

As a grass, bamboo grows much faster than wood. Moso bamboo is the primary species which is used in field of construction which can grow up to 119 cm in 24 hours and 24 m high in 40 to 50 days. It takes about 3–5 years for bamboo to reach full maturity (Sharma et al. 2014).136 species of bamboo is found in India. Fifty-eight species of bamboo belonging to 10 genera are distributed in northeastern states. Bamboos are called poor man's timber because they found in grate abundance. Bamboos have extraordinary strength,hardness and lightness it is available in range of sizes and they achieve their maturity in short period of time. Bamboo can be used in different form in the construction to cut the cost because it is every much easily available and satisfy all the requirement to cut the cost of house

The following are the some construction alternatives constructed with bamboo

i) Bamboo Board

Bamboo board is made by lining thin strips of bamboo parallel to one another and heat pressing them together. They are generally made of three or more layers thick for stability. Bamboo board comes in different grades, which are determined by when the bamboo is harvested, the age of the plant, and the amount of rain among other environmental factors which affect the hardness. The multilayer design make it more durable, strong give more resistance to wraping than other conventional board. These board can be used for Partition wall, Flooring, kitchen top, doors and windows etc.

ii) Bamboo flooring

Bamboo has been used as an alternative of flooring because of its characteristic similarity to other hardwoods. A Bamboo flooring is typically made by slicing mature bamboo poles into strips. These poles are crosscut to length and then sliced into strips depending on the width desired and by using adhesive and nails it is fixed on the floor.

iii) Bamboo Walls

The most extensive use of bamboo in construction is for the walls and partitions walls. Bamboo wall frame requires an infill between framing members to protect against rain, wind and animals, to offer privacy and to provide plane bracing to ensure overall stability of structure.

iv) Bamboo Roofing

The simplest form consists of a bamboo purlin and beams, supported on perimeter posts. Halved culms are laid convex side down, edge-to-edge,spanning from the ridge to the eaves. A second layer, convex side up, is then laid to cover the joints. Another way is use of bamboo corrugated sheet coated with resin can used as roof alternativeBamboo Corrugated Roofing Sheet is best suitable for roofs (Rinku and Vidya, 2009).

2.1.4 Fiber Cement Composites

Considerable effort has been taken worldwide to utilize the local natural and industrial waste material as a supplementary material in the construction industry in the various way like mixing it with concrete or mixing it with adhesive material to make board for various furniture and essentials for houses. These materials in mixing with concrete improves the properties of concrete as well as the use of these material leads to the proper disposal of waste which also reduces the loss due to improper disposal and harmful effects on the environment.

A) Bagasse

Bagasse is a fibrous material which is obtain from sugarcane after crushing and extracting juice from it. Since it is a by-product of the sugarcane industry, the quantity of by-product is almost equal to the amount produces. So the large amount of these waste is utilised as a fuel to operate the sugar mills which is very harmful to the environment and the remains dumped but these waste can be a good replacement for the construction materials.

Some ongoing products are

i) Bagasse-Cement Boards and Panels

The developed product is eco-friendly and the process utilizes sugar cane bagasse and ordinary Portland cement. The properties of this boards passes the requirements of general purposes high density board which can be utilised for furniture, partition wall, door-window etc. it is also a cost effective replacement for the conventional hardwood.

ii) Bagasse-PVC Boards

This building board uses sugarcane bagasse and PVC as a binding material. PVC is the most widely used resin in making different articles for building applications like doors, electrical fixtures, sanitary items etc.

B) Jute and Coir

Jute is a long, soft, shiny vegetable fiber. The word 'jute' is probably arises from an Oriya word jhuta or jota(https://goo.gl/crInpO,https://en.wikipedia.org/wiki/Jute_cultivation). Jute is one of the most affordable natural fibres and is second only to cotton in amount produced. Almost eighty five percentage of the world's jute cultivated in the Ganges Delta. Production of jute is mainly concentrated in West Bengal, Orissa, Bihar,

Assam, Meghalaya and Andhra Pradesh. West Bengal, Bihar, Assam and Orissa accounts for 98.41% of total area under jute cultivations and 98.45% total raw jute production in India (http://coirboard.gov.in). Coir or coconut fibre, is a natural fibreextracted from the husk of coconut·India accounts for more than two-thirds of the world production of coir and coir products. So as India is a leading producer of jute and coir, so they can be a best solution for low cost housing.

The following are the some alternatives for the construction

i) Coir-CNSL Board

The coir- cashew nut shell liquid (CNSL) board is an alternative for a hardwood which can be used as a door, windows, furniture, packaging, Flooring. It is a single layer flat pressed Medium Density Fibre Board. It has low water absorption and very less change in dimensiondue to water absorption, and easily workable as normal hard wood board.

ii) Coir-CNSL Thermal Insulation Board:

This is a composite material, made by coconut fibre as a reinforcing material and cashew nut shell liquid as the natural binder. Due to Low density it is suitable for moderate temperature insulation.

iii) Coconut and Wooden Chips Roofing Sheet

Coconut fibre and wooden chips are soaked in water for two hours and then the water is drained off. Later these are mixed with cement and laid over a corrugated mould and kept under pressure for 8 to 10 hours. After demoulding, these are cured and dried before use.The addition of coconutfibres significantly improved many of the engineering properties of the concrete, notably torsion, toughness and tensile strength.The ability to resist cracking and spalling were also enhanced. However, the addition of fibres adversely affected the compressive strength, due to difficulties in compaction which consequently led to increase of voids. Despite its excellent properties, coconut fibre as an enhancement of concrete is unlikely to replace steel for the vast majority of structures.

iv) Jute Coir Composites

Jute coir composites provides an alternative for wood which is economical and easily available. . It involves the production of coir boards with oriented jute as face veneer filled with coir and waste rubber wood.

c) Sisal

Sisal it's botanical name is Agave sisalana (https://goo.gl/KPqp2l, wikipedia.org/wiki/sisal). This Fibres have been used to toughen bricks and pottery since the very beginning of civilization. Now it is used in concrete as a fibre reinforcement material to improve the mechanical properties of the concrete.

2.2 Industrial Waste as Supplementary Materials

It is the waste product obtained from industries as a by-product. These waste generally Hazardous to health and create more problems to environment due to dumping of these by-product. Like- Fly ash, PVC, Ferro-Cement, Rice husk ash etc.

2.2.1 Fly Ash

Fly ash is a by-product obtained from industries where coal or lignite is burnt like thermal power plant, steel, sugar, fertilizer industries etc. The Fly Ash is a class of artificial pozzolans, and generally comes in the category of non-conventional building material (Harison *et al*. 2013). Fly ash now a days used in manufacturing of Bricks and blocks and as a replacement for Fine aggregates and cement in concrete.

2.2.2 PVC

PVC is a by-product of the plastic industries. As a non-degradable material it is very harmful for the environment. PVC plays vital role in construction industries as electrical and sanitary items. It is also used a binding material with different fibres. Pure PVC board is a good and economical replacement for the wood ply board. PVC board have long life and does not affected by water and termites, no any additional treatment is required. Fire resistance is also same as the normal wooden ply board.

2.2.3 Ferro-Cement

Ferrocement can be classified as a thin walled high strength cement based composite material. It is made of cement mortar reinforced with layers of wire mesh which is closely bound together to create stiff structure unit with high performance, light structure and strength. The only disadvantage of the Ferro-cement is its high rate of shrinkage and creep when using rich mortar. It can be used for Precast unites, water tank,roof etc.

2.2.4 Rice Husk Ash

India is one of the world's largest producers of white rice contributing about 20% of world's total rice production. During milling of Paddy about 22-25 % of the weight is collected as a husk (https://goo.gl/fVO48Z , Ricehuskash.com/details.htm). The husk contains about 75% organic volatile matter and 25% of the weight of this husk is converted into Ash during the burning in Plants and mills as a fuel, which is known as rice husk ash. It contains about 85% to 90% amorphous silica. About 20 million tonnes of RHA is produced annually which cause

grate environment threat causing damage to the land, air and soil on which it is dumped. So it is used as an alternative building material is used like Sandcreate block and admixture.

3. SUMMARY & CONCLUSION

In this study, alternative construction materials and methodology were studied and following conclusios were drawn

1. According to the potential discussed materials and methods to be used as a replacement component of the conventional one.
2. All the materials discussed are easily available in rural India and result in reduced the cost of construction.
3. Aapproximately 30% of the total cost of construction consist of Transportation cost.Accordingly materialsshould be chosen which may easily beavailable in the region.
4. Utilisation of Agriculture waste will give extra earning to farmers.
5. Utilisation of Agriculture waste will reduce the emissions of hazardous gases and save the environment.
6. Utilisation of Natural binder material reduce the consumption of cement which cure environment from emitting more than 500,000 tons per year of sulphur dioxide, nitrogen oxide, and carbon monoxide.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

Chowdhury Swaptik, RoySangeeta, “Prospects of Low Cost Housing in India,Geomaterials”, 2013, 3, 60-65 http://dx.doi.org/10.4236/gm.2013.32008 Published Online April 2013 (http://www.scirp.org/journal/gm)

CSIR http://www.csir.res.in/EXTERNAL/HEADS/achievements/Rural/tech/detail.asp?g=2&s=7&t=1

Coir Board, http://coirboard.gov.in/

Commission for Environmental Cooperation, Fact sheet,Burning Agricultural Waste: A Source of Dioxins, 2014.

Harison, Alvin , Srivastava, Vikas , Gupta, Chandra Bhan, Fly Ash as Supplementary Cementious Material in Portland Pozzolana Cement Concrete, IJETT, 6(3), (2013).

https://goo.gl/KPqp2l, wikipedia.org/wiki/sisal.

https://goo.gl/fVO48Z , Ricehuskash.com/details.htm

https://goo.gl/crInpO,https://en.wikipedia.org/wiki / Jute_cultivation

https://goo.gl/nDGAKP,buildingwithawareness.com/earth-plaster-for-straw-bale-homes/

https://goo.gl/bVAQuX,en.wikipedia.org/wiki/Earthen_plaster

https://goo.gl/9D0rwp,en.wikipedia.org/wiki/Compressed_earth_block

ICM, Beijing, Environment friendly Building Material Technologies for Low Cost Housing, P.R.China.

Sharma, P., Dhanwantri, K. and Mehta, S., Bamboo as a building material, *Int. J. Civil Eng. Res.*, 5(3), 249-254(2014).

Taur, Rinku and Devi Tvidya, Low cost housing, International Conference on ‘Advances in Civil Structural and Geotechnical Engineering (ACSGE-2009)’, 25-27, 2009, BITS, Pilani, India.

World_Bank https://goo.gl/KJdAChhttp://www.worldbank.org/en/topic/poverty/brief/global-poverty-line-faq