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Jute Composite and Geotextiles-a Greener Building Solution

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Abstract
This study was undertaken to assess whether jute-based building materials are a viable alternative solution to locally available building materials or not. As Bangladesh is the biggest producer of jute, Jute-based building materials have been chosen to boost our local economy. Firstly, the properties and historical uses of jute, jute composites, and jute geo-textiles have been explored. Then we selected a new technology of jute composite-based tin and jute composite-based tiles was selected and blended with jute geo-textiles technology to form our new solution. A case study of a semi-pucca village home was undertaken and both jute-based building materials and locally available building materials were used separately. Then a comparison was made between these two options from two points of view. One is economy and durability, the other one is environmental sustainability. Local materials might be cheaper, but they are more energy-consuming and less eco-friendly. On the other hand, jute-based products are more durable and by using them, we can be in a win-win situation. As this technology uses jute which is widely produced in our country and it can be demonstrated that we are more environmentally friendly and, as a result, greater compensation can be gained from industrialized nations, which are primarily liable for environmental pollution.

Keywords: *Building material; jute composites; jute geo-textiles; sustainability.*

1 Introduction

In the present world, the use of composites is increasing day by day. Composites can be defined as a select combination of dissimilar materials formed with a specific internal structure and with a specific external shape or form to achieve unique mechanical properties and superior performance characteristics not possible with any of the component materials alone (Sharma et al., 2018). Jute fiber is a promising reinforcement for use in composites because of its low cost, low density, high specific strength and modulus, no health risk, easy availability, renewability, and much lower energy requirement for processing. In recent years, there has been an increasing interest in finding new applications for jute fiber-reinforced composites that are traditionally used for making ropes, bags, Hessians, sacking, mats, and carpets. Amongst these new findings, one of the most exciting is the use of jute composite as housing material (Mohanty and Misra, 1995). The use of jute fibers since the middle of the nineteenth century led to the improvement of its method of cultivation and extraction of fibers followed by the manufacture of fabrics with its yarns. The jute plant has an erect stalk with leaves. It thrives in hot and humid climates, especially in areas where rainfall is in plenty. Jute has coarse natural bast fibers lying in the peripheral layer of its stem (Chandekar et al., 2020).

Jute composite materials consist of jute fibers of high strength and modulus embedded in or bonded to a matrix with distinct interfaces (boundaries) between them. In this form, both fibers and matrix retain their physical and chemical identities, yet they produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, jute fibers are the principal load-carrying member, while the surrounding matrix keeps them in the desired location and orientation, acts as a load transfer medium between them, and protects them from environmental damages due to elevated temperature and humidity.

Jute geotextile (JGT) might be thought of as a feasible competitor to take the place of the bulk of today's common synthetic materials, which pose significant risks to the environment and have a negative impact on eco-congruity. Jute geotextile's uses and useable areas are on the rise, which is a positive sign for sustainable socioeconomic development (Ghosh et al., 2014). It is easy to blend with other natural materials and synthetic fibers. Jute Geotextile is environmentally friendly, designed biodegradable, hydrophobic, anionic, and locally available materials. Besides, it has got high strength and non-hazardous properties. It is also a renewable source of energy as natural biomass. Due to their short life span, JGTs are used as separators, vegetation growing mesh on slopes, or as vertical drains (Kumar et al., 2022).

The idea is to introduce an energy-efficient, low-cost, and sustainable (having superior mechanical properties) housing material named Jutin, which has the exact product appearance as the current corrugated iron sheets but is produced mainly from natural jute fiber. The idea directly contributes to the reduction of the burning of non-renewable

fossil fuels, thus minimizing the consumption of non-renewable energy sources. The idea also reduces the emission of CO_2 by burning significantly less amount of fossil fuel and thus provides ways of mitigating the deleterious effects of Green House Gases. Unlike the corrugated iron sheets manufacturing process, the idea does not use toxic chemical materials like lead, Sulphur, and different types of acids. Similarly, Jute tiles are simply a form of jute composites. It is also comprised of mainly jute fiber and resin. Jute tiles have also got a huge market potential like Jutin. It has excellent mechanical properties to satisfy all needs. The properties are quite similar to Jutin.

The objectives of this thesis are to prepare an estimate of a village home using jute-based materials and locally available materials and then make a comparison between them and find out which option is more viable.

2 Materials and Method

In this study, Jute-based materials and locally available materials will be compared based on a semi-pucca village home project which has two rooms with a floor area of 30×21 sft. It has a pond in front of the rooms with a plan area of 30×25 sft. The height of the room is 10 ft and which is pucca up to 3 ft above the floor. Tin shedding will be used above 4 ft in height. The interior face of the pucca wall and the floor will be covered with tiles. The depth of the pond is 7 ft, and the side slope is 1V:1H. It has a small road beside the pond with a 6 ft top width and a side slope is 1V:1H. The slope of the road and the slope of the pond will be stabilized with geotextile.

2.1 Project Drawing Details

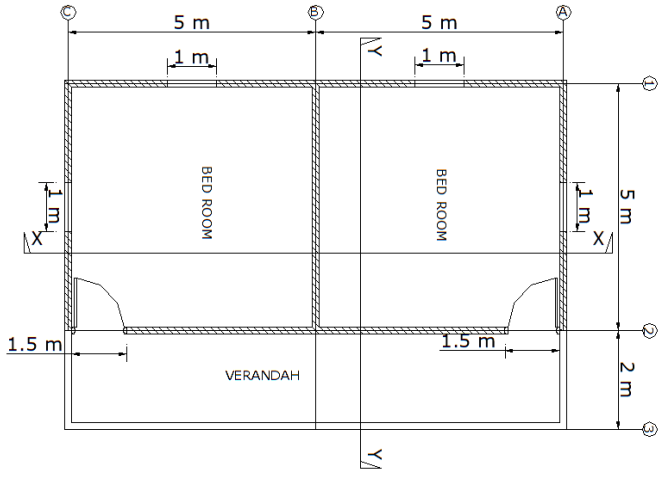

Figure 1. Plan view of the project (Home).

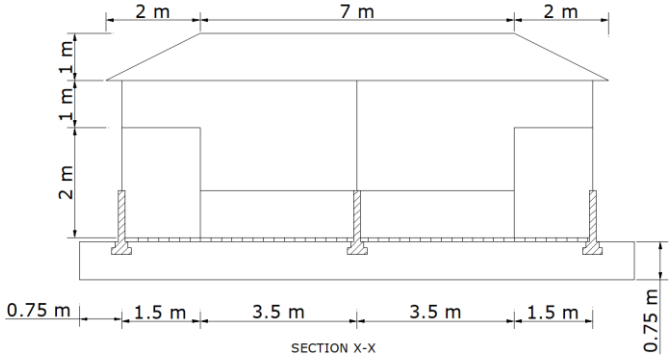

Figure 2. Section X-X of the home

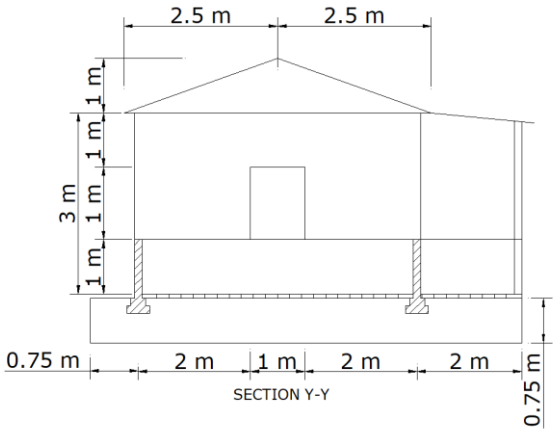

Figure 3. Section Y-Y of the home

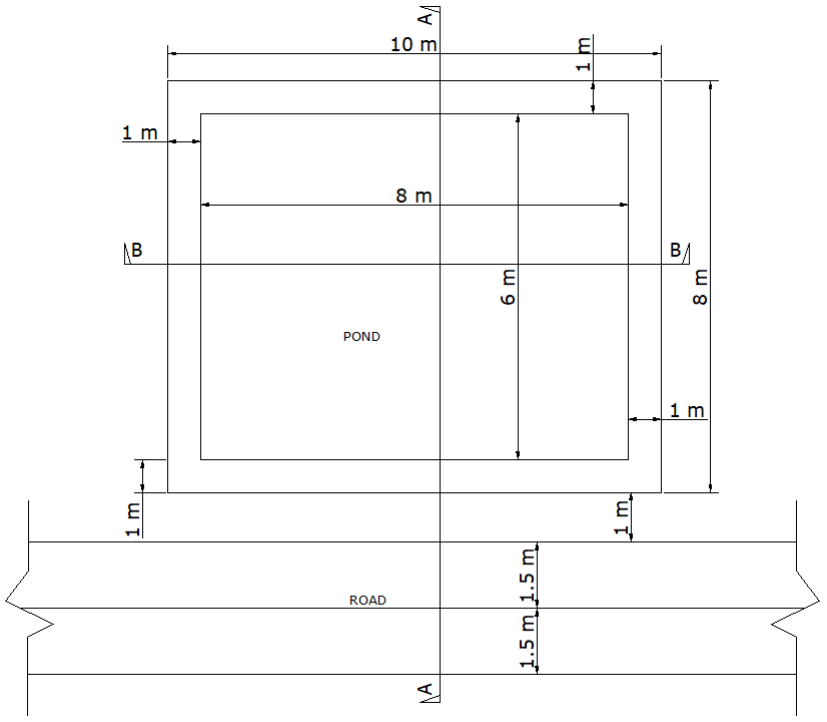

Figure 4. Plan view of the project (Pond).

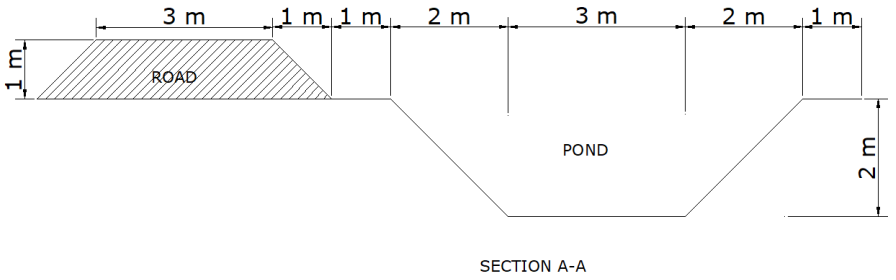

Figure 5. Section A-A of the Pond

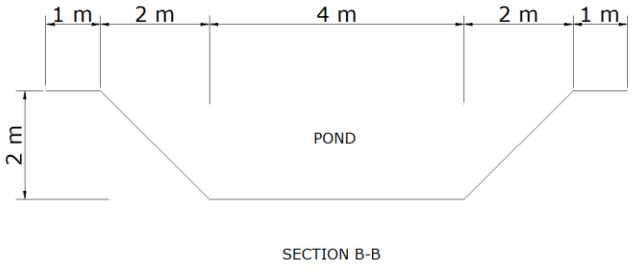

Figure 6. Section B-B of the Pond

A detailed drawing of the home and the pond has been shown on Figure 1-6. Based on the dimensions, an cost estimation and feasibility study has been made for building a village home using jute-based materials and locally available materials.

2.2 Project Estimation

Estimation sheet of the rooms
Surface Area of Roof
Total Area of Both Short Side = 2 (1/2*Base*Height) = 5*2.24= 11.2 m^2
Total Area of Both Long Side = 2 [1/2*(Base +Top) *Height] = (7+11) *2.69 = 48.42 m^2
Total Area of Veranda = Length*Width = 10.5*2.3 = 24.15 m^2
Total Surface Area of Roof = (11.2+48.42+24.15) = 83.77 m^2

Surface Area of Walls Above Windows Bottom Level
= Length*Height- Area of (Doors+ Windows) = 35*2-(6+4) = 60 m^2

Area of Floor Finish and Tiles = Area of (Room 1+ Room 2 + Veranda)
= 2(5*5) + (10*2) = 70 m^2

Area of Floor Brick Flat Soling = Area of (Room 1+ Room 2 + Veranda)
= 2(5*5) + (10*2) = 70 m^2
Single Brick Surface Area = 0.032 m^2
Number of Brick = 70/0.032 = 2187

The volume of the Side Wall = Volume Above Floor Finish + Volume Below Floor Finish
= 32*1*0.127+ 35*0.23*0.127 = 5.1 m^3
Single Brick Volume = 0.0025 m^3
Number of Brick = 5.1/0.0025 = 2040

Estimation sheet of cut and fill.
Volume of pond = 51 m^3 (cut)
Fill for road = ½*(base+ top) *height*length =1/2*(5+3)*1*10 = 40 m^3
Fill for house = length*width*height=8.5*10.5*0.75=67 m^3
Total Amount of Fill = 40+67= 107 m^3

Estimation sheet of the surface area of pond and road slopes
Total surface area of road slope= 2*length*√(depth^2+slope width^2) =2*10*√(12+12)= 28.3 m^2
Total surface area of pond slope=2*length*√(depth^2+slope width^2)= 2* (6+5)* √(22+22)=62.62 m^2

Table 1. Estimation Summary

Total Amount of Cut(m^3)	**51**	
Total Amount of Fill(m^3)	**107**	
Total Earthwork(m^3)	**56**	**(Fill)**
Total Surface Area for Geotextile Stabilization(m^2)	**90.92**	
Total Surface Area for Jutin(m^2)	**143.77**	
Total Surface Area for Tiles(m^2)	**70**	
Total Number of Bricks	**4127**	
cost of bricks@8000taka/1000	**33016**	

3 Result and Discussion

Estimation of summary and cost analysis have been shown in Table 1 and 2 respectively. Table 2 will be used to make a comparison between the jute-based materials and locally available materials.

Table 2. Total Cost Analysis

	Surface Area(m^2)	Unit Price of Jute Materials (Taka/m^2)	Total Cost of Jute Material (Taka)	Unit Price of Local Materials (Taka/m^2)	Total Cost of Local Material (Taka)
Tin	143.77	900	129393	450	64696
Tiles	70	900	63000	550	38500
Geotextile	90.92	50	4546	100	9092

From the cost analysis, it can be seen that jute-based materials price is higher than locally available materials. But from durability study, it is far more economical than locally available materials. Jute-based materials like Jutin or jute tiles last for 50 years whereas local materials like CGI sheets last for only 5 to 7 years. Hence, jute materials are a more viable option.

3.1 Comparative Study of Physical Properties and Environmental Point of View

A comparative study has been done on jute-based materials and locally available materials to show the viability based on physical properties and eco-friendliness. Table 3 shows the comparison between JUTIN and CGI Sheets. In Table 4, a comparison between Jute Tiles and Ceramic Tiles has been made.

Table 3. JUTIN and CGI Sheets comparison

Theme of comparison	JUTIN	CGI Sheets
Temperature Requirements During Production Process	158°c	1652°c
Power Consumption During Production	Negligible	Huge
CO2 Emission	Negligible	Huge
Durability	50 Years	5-7 Years
Corrosion	Does Not Occur	Occurs
Scope for Manual Production	Possible	Not Possible
Salinity and Sulfide Resistance	Resistant	Susceptible
Presence of Toxic Metallic Substance	Free from Toxic Metals	Toxic Metals Like Zn and Pb are Present
Sound Absorbance	Absorbs Sound	Reflects Sound
Thermal Conductivity	Negligible	Much More
Recyclability	Partially Recyclable	Recyclable
Scrape Value	None	Present

The thermal conductivity of JUTIN is 2000 times less than CGI sheet and it is more than 50 years durable. Besides, it is corrosion-free, non-biodegradable, ultraviolet ray resistant, salinity and sulfide resistant, free from toxic metallic substances, and sound proof compared to CGI sheets. All of these properties make JUTIN an ideal building material and more effective than CGI sheets.

Table 4. Jute Tiles and Ceramic Tiles comparison

Theme of comparison	Jute Tiles	Ceramic Tiles
Pressure Requirements During Production Process	Negligible Pressure Required Only to Give a Shape	Huge Pressure Required
Temperature Requirements During Production Process	70°c	1090°c
Dusting During Manufacturing Process	No Dusting	Occurs
Eco-friendly	More	Less

Table 5. Jute Geotextiles and Synthetic Geotextiles comparison

Theme of comparison	Jute Geotextiles	Synthetic Geotextiles
Cost	less	More
Biodegradability	biodegradable	Non-biodegradable
Environment friendly	environment friendly	not environment friendly

After all these comparisons it can be clearly seen that Jute-based materials are a far better option than locally available materials.

4 Conclusion

The aim of this study was to estimate the cost of a village home using jute-based materials and locally available materials and then make a comparison between them. From this comparison, the most viable option has been selected. It has been found that Jute based Solution is preferred because of its physical properties such as enhanced durability, good sound and heat absorbency, corrosion resistance, biodegradability, applicability in salinity-prone areas, free from any toxic substances, and partially reusable capabilities. These Jute based materials are also superior from the environmental point of view because of having these properties. These items consume far less energy during production and local people can produce all the items if the government helps. Besides, these items are also more economical and cost-effective than locally available materials in the long run. Now, practical field implication is needed to get an idea about construction-related problems and practical performance monitoring is needed to check the feasibility of this study.

Acknowledgment

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