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Exploring New Methods of Construction with Sustainable Materials in Rural Bangladesh

Fawaz Rob

The paper investigates new methods of construction using organic materials in the rural areas of Bangladesh. Instead of using materials with high carbon footprint like CI sheet and kiln fired brick, the new technique implements compressed earth block, jute based tin roof and cured bamboo. This paper through a series of real life examples investigates the possibility of new kind of rural architecture in Bangladesh, which will directly contribute to reducing carbon emission and deforestation.

Field of Research: Architectural Engineering

Introduction

There are over hundred million people inhibiting rural areas of Bangladesh. Historically, people of Bengal have built their houses with natural and sustainable materials like mud, thatch and bamboo. However, the sustainable and vernacular tradition of homesteads went through major transition in the last century and the natural materials have been replaced with non-organic and energy inefficient materials like CI sheet, oven-baked brick and cement. At present over 8000 brick factories produce nearly eight million tons of carbon emission every year. Corrugated iron industry adds another six million tons. Research shows that these materials directly contribute to air pollution, deforestation and depletion of fertile top soil. The paper discusses new methods and materials of constructing rural houses using compressed earth block (CEB), Jute Composite Tin (JCT) and bamboo. A two storied clinic was built using the new methods in the remote area of Bangladesh. Using this clinic as a case study, the paper discusses techniques, research findings and outcome of the construction method.

Intent and Objectives of Applied Research:

The objective of the project was to acquire knowledge in the new construction method and to find out if the new construction method can be socially and economically viable for the rural architecture of Bangladesh. Instead of using kiln fried bricks, the intent was to use CEB and measure its impact. Moreover, Jute Composite Tin (JCT) was used instead of Corrugated Iron sheet to measure the technical and environmental impact. Cured bamboo was used in constructing the second floor to minimize the static load. Also, implementing cross bracing and other construction technique, the longevity and the strength of the building was measured. Finally, the environmental impact of earth, jute and bamboo as construction materials were observed compared to current models.

Fawaz Rob, MA, IDSA, North South University, Dhaka 1206, Bangladesh. fawazrob@northsouth.edu

Figure 1 *A clinic in rural Bangladesh built with Earth, Bamboo and Jute*

CONSTRUCTION APPROACH:

COMPRESSED EARTH BLOCKS (CEB)

A small mobile unit of CEB machine was installed on site to produce the bricks. The machine was locally produced from free source design. The machine produces on an average 500 bricks per day. The main ingredients for the CEB are 5% cement, 40 -50% sand and 50 - 55% earth. Although, the technique for brick production was taken from proven methods of UNHABITAT and GTZ, various experiments were performed to get the most durable and strong CEB. The psi exceeded 1200.

Figure 2: *Brick Machine is used to produce CEB which are 1.5 times bigger than regular bricks.*

TREATED BAMBOO:

The bamboo used in the project was cured thoroughly. The bamboo was submerged in water and a small amount of borax for 21 days and dried in shade for another 7 days. The curing process resists the bamboo from termite infection. Moreover, once the project was finished, a coat of varnish was applied for longevity. The bricks were placed without mortar, but every three feet, 3mm iron rods were placed to hold the bricks. Afterwards mortar slurry was inserted into the aligned holes. The fusion of mortar slurry and iron rods created strong internal columns to bind the whole structure.

Figure 4: Implementing new construction method using CEB and cured bamboo.

JUTE COMPOSITE TIN (JCT):

Using jute, resin and crystalizing agents, Jute composite tins were developed for the roofing material. Jute composite could be molded into any form of tiles. However, since rural masons are trained at making roofs with CI sheets, the same forms were replicated. Countless experiments were done with various proportions of resin and crystalizing agents. Moreover, various kinds of jutes with different thread counts and density were experimented to find out which one produced the strongest JCT. Finally, a superior quality JCT was achieved that is more

strong and durable than regular CI sheet.

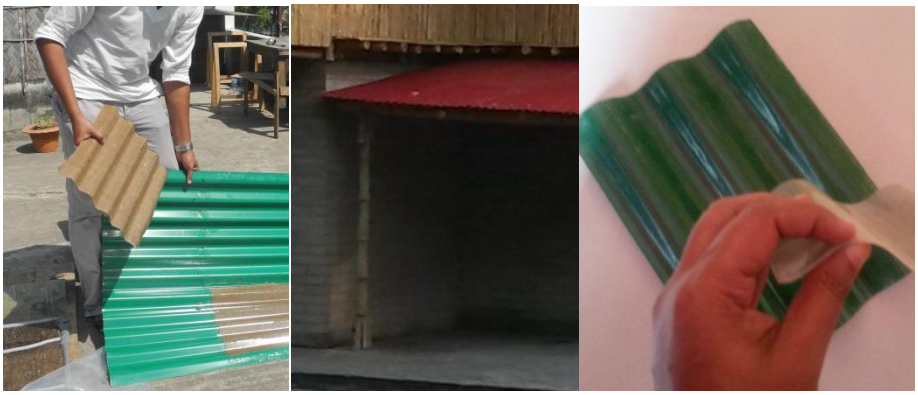

***Figure 3**: Jute Composite Tin (JCT) made from jute, resin and crystalizing agents.*

SOCIAL APPROACH TO NEW CONSTRUCTION METHODS:

It is of course always a challenge to introduce a new method in the market, regardless of how good it is. Strong mindset about existing construction methods are hard to alter and new materials often fail to gain trust. Moreover, people do not want to take risks with their savings in new and unproven things. However, cost is a big factor in the rural areas of Bangladesh. People are attracted to cheaper yet better material. Once we finished constructing a 10' x 20' house with CEB in less than two weeks and in much cheaper price, high interest was generated among the villagers. The newly designed house built with earth, bamboo and jute looked more attractive and was much comfortable than a ci sheet house. In economy of scale, once the CEB and JCT will be mass produced, the cost of the house will also come down significantly.

COMPARATIVE STUDY OF CONSTRUCTION METHODS IN RURAL AREA

	CI Sheet House	Small Brick House	Earth – Jute House
Compared on a 10feet x 20 feet model.			
Cost (100taka = 1Euro)	200,000 – 300,000 taka	500,000 – 1,000,000 taka	150,000 – 200,000 taka
Materials	CI Sheet, Iron, Wood, Cement	Kiln fried brick, cement, iron rods, concrete, wood, etc.	Earth blocks, cement, Jute Composite Tin, bamboo
Insulation	Very minimal insulation	High insulation	High insulation
Construction time	4 to 6 weeks	6 to 12 weeks	2 to 4 weeks
Comfort level	Low	Low to medium	Medium to high.

RESEARCH FINDINGS

Jute Composite Tin (JCT) was superior to Corrugated Iron (CI) Sheet in almost all the test. JCT is more durable than CI and GP sheets. Because of the properties of jute and resin, much higher heat insulation was achieved. The JCT is rust proof and contains no toxic materials like lead or sulfur. Since there is no iron involved it is completely saline water resistant. Sound proofing is higher and it has very low thermal expansion

	Corrugated Iron Sheet (CI SHEET)	Jute Composite Tin (JCT)
Cost (100 taka = 1 EURO)	5000 – 20000 taka per baan	10,000 taka per baan (*1 baan = 180 sq. feet)
Saline resistance	Subject to corrosion	Corrosion proof
Toxic material	Lead, Sulfur, Galvanizing material, corrosive iron etc.	Resin.
Heat required to produce 1 baan	600 – 700 degrees F.	No heat required.
Insulation and comfort level	Very low.	High

Compressed Earth Blocks (CEB) has been around for a long time and many researches have been done to show its superior quality over regular kiln fired bricks. In this particular project, we concentrated on environmental impact, insulation and usability.

The table shows the comfort index of users inside the building compared to the existing brick cement houses. Y axis represents air temperature while X axis represents hours during the day.

	Regular Kiln fired Bricks	**Compressed Earth Blocks**
Cost (100 taka = 1 EURO)	7 – 10 taka per piece	5-7 taka per piece (based on 1000 bricks per day)
Water resistant:	Yes	Yes
Environmental impact:	8 million tons of carbon emission in Bangladesh every year	Very minimal. CEB's are made with 5% cement stabilization, therefore carbon emission of cement should be considered
Heat required to produce 1000 bricks	1000 – 1500 degrees F	No heat required.
Mortar requirement :	Mortar cement is required for laying bricks and wall plastering	Mortar is only required to make internal columns
RCC Columns requirement:	Columns required every 10 – 15 feet for brick filling	No columns required. Walls are load bearing and internal columns are inserted through the bricks.

Cured bamboo was used instead of regular bamboo to extend the longevity of the building. If the cured bamboo is not found locally, it can be cured with minimal effort. The cost of curing needs to be added with the individual bamboo cost. The selected findings are given below.

	Regular bamboo	**Cured bamboo**
Cost (100 taka = 1 EURO)	100-150 taka per piece	170-200 taka per piece
Termite resistance	No termite resistance.	Termite resistance.
Availability	Widely available	Not widely available.
Processing time	Can be used directly after cutting	Need to cure for at least 3-4 weeks
Longevity	3- 10 years depending on annual perspiration.	20 – 50 years depending on maintenance

INFERENCES AND CONCLUSION

This particular type of material and construction techniques has a huge potential in rural Bangladesh. Furthermore, carbon emission is significantly reduced in the new method, resulting in a very positive environmental impact. Since the labor cost is cheap in Bangladesh, Compressed Earth Blocks (CEB) can be produced in large scale and in much more cost effective ways. As a result, the price of house will be significantly lower and more for the rural people. The CEB machine requires investment at the beginning. However, this also has potential to create local entrepreneurs. Moreover once the new methods enter mainstream construction, more masons and entrepreneurs will be interested to build with these bricks. Jute Composite Tin on the other hand will have rather big challenge to penetrate the market because of its high price. However, since it is rust proof and once the economies of scale will be achieved in mass production, it will have a significant advantage in the coastal areas where corrosion of regular CI sheet is a major problem.

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