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Comparative Analysis of Traditional Building Practice(Wattle and Daub) and CSEB- Alternative Building Technology

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Abstract
Housing is the basic right and need of any people and it must be guaranteed by the government in any nations and also there is great urgency for sustainable intervention in the construction. Affordability is the major parameters for the economic sustainability of any housing process. In context of Nepal, especially in Terai belt, many marginal groups are living in temporary shelters made by bamboo and mud which are not strong and durable enough to resist climatic impacts like wind and rain. Though this bamboo and mud technology in Terai area is a major construction technology and also the vernacular to that particular belt, the low income groups cannot afford for the improvisation of such technology. In the present days among different alternative building materials, CSEB, is one which is being used in the construction sectors and many organizations have been promoting and using such alternative materials both for low and high income groups in Nepal. CSEB has been used in constructing more than 60 residential units in Bhaura and Mateyaria community in Kalaiya, by Lumanti support for shelter.
Therefore, this research aimed to find the different materials and technology which was already there in Bhaura and Mateyaria and the reasons for choosing CSEB as an alternative building materials for these communities. This research was based on post-positivist paradigm with qualitative approach of research followed by different research methods like questionnaire survey, key informant interview, observation, mobile ethnography and focus group discussion. It was concluded that social dimensions of CSEB are better than that of wattle and daub whereas economic and environmental dimensions of wattle and daub have more positive value.

Keywords
Sustainability assessment, Traditional building practices, CSEB alternative building technology, Sustainability parameters

1. Introduction

One of the major issues in the building industry is the sustainability which is broad and complex. Architects, engineers and planners have a chance to introduce the sustainability features in the building industry to minimize the impacts in the environment to create an ecological human settlement [1]. Although, some of the countries also include renewable energy and its application in the category of sustainability, many countries have identified construction sectors as a prioritizing area as it for human well-being. It is already known from the research findings that our building is responsible for more than 40 percent of energy consumption which is not sustainable approach of making our building resilience [2]. So, we need to adopt the new alternative technology that have low embodied energy and also cost effective in a sustainable way. Application of green technology in building construction sectors can help to reduce the ecological load in building and also to create sustainable and resilient settlement. This kind of practice can be seen both in our urban and rural traditional settlement.

In addition to playing a significant part in making a settlement sustainable, the building industry advances any nation's economic standing by raising its GDP. It may also be a crucial component of the national economy. The goal of this sector is to adopt sustainable construction methods, and in order to accomplish this goal, professionals and policymakers are constantly pursuing numerous sustainable agendas. [3].

The main obstacles to creating sustainable housing include a lack of resources, insufficient funding, a shortage caused by a sudden increase in demand, a shortage of qualified labor, a lack of quality control, inefficiency-related waste, a lack of added value

development, and location and quality. One of the key driving forces behind the adoption of new sustainable construction techniques in the construction industry is adherence to standards and laws.[4] . The codes and regulations compliance are one of the major contributing factor in adopting the new methods of sustainability in the construction sector.

2. Background

The housing demands in Nepal had been increased tremendously after 2015 earthquake hits Nepal and different stakeholders and developers have been producing alternative materials like compressed stabilized earth block(CSEB), autoclaved aerated composite block (AAC), expanded polystyrene panel (EPS) panels and sandwich panels to mitigate the aftermath of earthquake. Sustainability approach has been less considered while constructing the housing for the needy people because of which our existence resilient settlement has been losing its vernacular approach.

Local governments are only focused on making other infrastructures like road rather than making housings for low income group. Also socially deprived groups have no financial and political support for the construction of the dwellings. In addition to that, there is a need for rehabilitation of landless, squatter and informal tenure holders for improved housing [5]. It has been observed that many non-governmental organizations have been involved in making and upgrading the settlement of the underprivileged groups. The aim of such organizations was to provide the basic shelters for those groups who are socially excluded and who have no affordability to build their house on their own. Lumanti(NGO) support group for shelter is one of the leading organization that is being actively participating in collaborative and public participation approach to bring changes in the local community through rebuilding settlement[6].

Housing is not only a social indicator but also the basic needs of any human beings. In context of Nepal, construction of house is taken as most essential part of social life. However, substantial percentage of people are still living in a low standard dwelling which have unhealthy environments [5]. Although constitution of Nepal guarantees right to housing for all, many low income, marginal and informal groups are deprived of housing and the reasons being no financial approach. Nepal government had different schemes like Janata Awas Program, to provide housing for all. However, these marginal groups are not within this approach. Different ethnic groups like musahar, chamar, sarki etc in Bhaura and Mateyaria community in Kalaiya have very low grade of life staying in a temporary shelter made of bamboo and mud with very poor sanitation, which has adverse effect on their health. Since their major livelihood activity is agriculture on other's farm, they cannot think of making their own permanent housing. So Lumanti in collaboration with local ward and municipality, also funding from some abroad foundation started to make settlement for these marginalized groups in participatory approach.

Most of the communities in the city have inadequate basic services like improved water and sanitation facilities, health services, improved housing conditions and enough livelihood opportunities which has resulted in a higher number of youth being attracted for foreign employment in the gulf countries. People from the low-income families in the city either work as agricultural labor or depend upon daily wages.

These families, on the other hand, do not have access to commercial banks and financial institutions for housing loans as they are considered by these financial institutions "non-credit worthy". They are often denied access to credit and are left with no option but to live in poor conditions. In contrast, the city government, towards the development of the city infrastructures were more focused on road and drainage construction only without any specific programs regarding financing and improving the housing condition for low income families in their development plans. With years of collaboration with Lumanti and Communities, Kalaiya Municipality has gradually started to invest in improving the housing conditions of the marginalized families.

This research will mainly focus on assessing the housing projects done by Lumanti a non-profit making organization through the perspective of sustainability. Recently completed projects at Bhaura, Kalaiya and on-going project in Mateyaria are chosen to assess the sustainability as per Lumanti organization fellowship program. This research will analyze and compare the traditional building practices in that specific community with new building technology like compressed stabilized earth block (CSEB).

3. Research objectives

The main objective of this research is to assess the sustainability of traditional building practices and alternative building technology like CSEB in Bhaura and Mateyaria community using the established indicators of sustainable development. To support this main objective other specific objectives are created which are as follows:

- To explore different building practices in the community.
- To compare and analyze traditional building practices and CSEB technology.

4. Research questions

Below are the list of questions.

- What are the different materials and technology used in traditional building practices in local community?
- What are the issues and challenges of traditional building practices to go for alternative technology -CSEB?
- Is CSEB technology more sustainable than traditional building practices?

5. Literature study

5.1 Wattle and daub

Wattle and daub is a method of building walls that involves weaving horizontal twigs and branches into vertical wooden stakes, or wattles, before covering the entire structure in mud or clay. One of the earliest techniques for building weatherproof structures is this one. The remains of circular homes built in this manner, with the staves being driven into the earth, have been found at Iron Age sites in England.

The wattles are set into holes bored in a horizontal timber above and fitted into a groove in a corresponding timber below when this technique is used as filling-in for a timber-framed structure. The staves are then plastered with clay and woven with twigs. This is a common way to finish half-timbered homes from medieval Europe. The wattle and daub method of constructing interior walls, which was popular before the invention of plasterboard and Sheetrock, is more recently developed using standardized materials[7].

When compared to stone and burnt clay brick masonry constructions, it is determined that the wattle and daub construction system is the most suitable housing solution in terms of sustainability[8].

5.2 Compressed stabilized earth block

A compressed stabilized earth block (CSEB), also known as a pressed earth block or a compressed soil block, is a building material made primarily from damp soil compressed at high pressure to form blocks. Although, clay is the main component along with some portion of cement and other admixtures, CSEB block can also be made from cement and stone dust because of which it has become one of the most common sustainable building materials in the present days[9].

It is a resource- and money-efficient substance which has 10.7 times less embodied energy than country fired brick and it also produces 12.5 times fewer carbon emissions than wood-fired brick [10].It will unquestionably be affordable to produce locally, using a natural resource and semi-skilled labor, nearly without transportation! More or less depending on the situation and one's knowledge.

Compressed Stabilized Earth Brick (CSEB) is the process of stabilization of blocks with a chemical binder such as Portland cement and consists of soil, sand and 10 percent cement in ideal earth bricks. The mixture is compressed in a machine and a compacted brick with high density is obtained. The next process is stacking and curing for 28 days. The soil compresses ads to the high density and strength so the precise composition of the soil should be around 50 percent sand, 20percent clay, 15percent gravel and 15 percent silt. The soil is tested first and then sand, gravel is added with the consideration in obtaining this ratio as the exact proportion of soil is hard to achieve. This way by improving the exact composition of soil we can achieve the same brick strength in any structures [11].

6. Methodology

This research research was based on qualitative approach that utilizes in-depth interview as a major data collection tool and was also based on exploratory approach where theories are generated based on the discovery and exploration. The research was based on post-positivist paradigm where there can be multiple realities and these realities are objective.

Post-positivism is selected because this paradigm focuses on investigating the phenomena objectively with the help of quantitative and qualitative data.

Different research approaches like semi structured interviews and questionnaire survey were conducted for the study. The targeted respondents were local inhabitants, social mobilizer and project engineer. Questions were asked and discussed in a focus group meeting to know the real scenario of newly built settlement and undergoing settlement and also to examine the relevance of the replacement of traditional building practices with CSEB. The participants were also selected by their willingness to share their experiences and opinions regarding the housing procedure. The respondents were asked to write both subjective and objective answers for the given question.

Observation and mobile ethnography were also done to understand and get inferences from the current scenario built structures using such materials. Observation helped to analyze the application of these materials in different scope of the buildings. Focus group discussion was also conducted to know the holistic approach and participatory approach in the projects.

6.1 Selection of Case Study Area

The main reason for selecting this area was because of the adoption of new materials like CSEB instead of wattle and daub which is the vernacular methods of housing construction mainly in Terai. So, this case was both interesting and challenging to resettle and convince these people for the adoption of new technology which might be the social issue as well. Among various housing projects, these were the recent projects, one was recently completed and other was under construction. So, the study of Bhaura community housing and the findings from this community will help to improvise the techniques in Mateyaria community.

6.2 Selection of sustainability parameters

In depth literature study was done to find the list of sustainability indicators. Most of the indicators were based on UN indicators of sustainable development guidelines and methods. The number of random indicators were categorized as per social, economic and environment aspects. Many such general frameworks have been developed and tested at regional, national and international level [12]. The list of dimensions, indicators and parameter indicators are listed in Table 1. [h!]

Table 1: Development of sustainability parameters indicators

Dimensions	Indicator Parameters	Key Performance Indicators
Social	Form and scale	Variation in planning, use of spaces, typology, observation of existing shelter
	Thermal comfort	U-value of material, self-experience of the users, insulating techniques, roofing materials and methods
	Safety and security	Size of openings, durability of materials, animal attack, flooding, climatic factors like rain and wind
	Acoustic comfort	User's experience
	Gender inclusion and labor	Male and female participation in the construction, issues and challenges for women in decision making
	Traditional architectural considerations	Observation and mobile ethnography
	Public participation	Participation of people from other communities
Environment	consumption of resources	Sources of materials, quantity of materials
	Waste generation	Quantity of waste generated during the construction
	Recycle and reuse	Literature study, database, examples.
	Embodied energy	Calculations or earlier research based data
	Emissions	Earlier research based data, literature study
Economic	Affordability	Source of income, involvement in economic activities, job opportunities
	Cost	Calculations and database analysis
	Repair and maintenance	Source of income, involvement in economic activities, job opportunities, skill and training on construction
	Construction time	User's experience and personal knowledge
	Roofing technology	Materials and method exploration

7. Major findings and analysis

7.1 Traditional building practices

Five different typology of building practices were observed during the study. The typology one was mud plastered two story with different materials like bamboo as rafter and purlin on the roof. The roof has cement tiles. Balcony has a sleeping space with brick masonry as main load bearing wall.

The typology two was also two story with brick wall on the ground floor and timber planking on the first floor. Timber as a rafter and purlin and clay tiles as a roofing materials.

Typology three was wattle and daub construction in

Figure 1: Typical traditional house in Kalaiya- Typology-1

Figure 2: Typical traditional house in Kalaiya- Typology-2

a timber framing plastered with mud. Clay tiles on the roof was supported by bamboo. This typology performs better both in winter and summer seasons.

The fourth typology was a mix of RCC framed structure and bamboo and mud as a main wall with thatched roof. People prefer this modules because of durability of the RCC frame structure. They can repair and maintain their residence just by replacing thatch and clay in the wall.

Lastly, typology five was two story U-shape residence with mix of wattle and daub in the ground whereas timber planking on the first floor. The roof has clay tiles with timber as rafter. These typologies have bigger living spaces and costlier than other types.

Figure 3: Typical traditional house in Kalaiya-Typology-3

Figure 4: Typical traditional house in Kalaiya-Typology-4

Figure 5: Typical traditional house in Kalaiya-Typology-5

7.2 Comparative analysis of traditional building practices & alternative technology-CSEB

The major parameters taken for the comparison are presented in Table 2.

Table 2: Comparative Analysis

Parameters	Traditional building practices	alternative technology-CSEB
Thermal comfort	• Density of wattle and daub - 400-2000kg/m3 • Thermal conductivity value:- 0.17-1.2 W/m K • surface temperature- thatch 26C • Transmittance value:- 0.45-2.64 W/m2K (Cuitiño-Rosales et al., 2020) • As per users- good thermal performance	• Density of CSEB :- 1625-2200 kg/m3 • Thermal conductivity :- 0.79-0.93 W/m K • Surface temperature-CGI 60.9C • Transmittance value:- 1.53-2.84 W/m2K ((Cuitiño-Rosales et al., 2020) • Not resided yet in winter- summer was hot- no insulation-CGI in roof
Safety and security	• Problematic- insufficient interior space- sleeps outside on the street- no doors. • vulnerable to wind, rain and mouse	• Secured and safe- durability of CSEB- extended interior spaces. • resist rain and wind
Traditional architecture	• Vernacular approach of tropical climate • Organic architecture	• No essence of traditional architecture- absence of bamboo, timber as a base for roofing works- • Absence of thatch and clay tiles on roof.
Affordability	• Dwelling with thatch roof is affordable • More than 60 percent of them cannot afford cement and clay tiles on roof • Cannot afford more than two rooms dwelling	• 13 percent of total cost from occupants • Paid by daily wage basis • Cannot afford CSEB dwelling individually
Costing of the dwelling	• Total approximate cost= 42000-50000	• Floor area of 250 square foot cost= 3 lakhs including roofing
Repair and maintenance	• Replacing thatch and plastering the wall= 10-15 thousands per year	• Replacing CGI sheet and sometimes metal member of roof • Approximate cost= 6-8 thousands
Roofing material and technology	• Thatch roof costs around 10-15 thousand	• Bamboo truss and CGI sheet= 45,000 • Metal truss and CGI sheet= 60,000
Recycle and reuse	• Thatch decomposes- no recycle and reuse • Less amount of bamboo truss can be reused	• Can be recycled to convert to the dust • Compressive strength of recycled CSEBs is higher than that of ordinary CSEBs
Embodied energy	• No manufacture energy	• Initial embodied energy per M3 =572.6MJ/m3
Carbon emissions (Kg of Co2) per M3	• Natural soil, natural grass, natural bamboo	• 51.5 Kg/ m3 [4]
Indoor environment	• Risk of moisture- unpleasant gases- fungus • Risk of insects-rat-snake • Risk on occupant's health	• No molds and fungus- less chance of risk of insects- rats and snake.

Table 3: Recommendations based on analysis

Parameters	Traditional building practices	Alternative technology-CSEB
Thermal comfort	• Addition of door shutter in the openings. • Provision of small window for ventilation • Increase the thickness of wattle and daub by the addition of insulating sheet and timber planking	• Removal of CGI sheet and replace with thatch or clay tile • Insulation of thatch below CGI sheet. • Use of timber planking on first floor.
Safety-security	• Treated bamboo can be used for strength and durability • Raising plinth level to prevent flow of rain water • Openings should be closed with durable door shutter • Mud plaster can be made more durable by adding some rice husk and animal dung • Linseed oil can also be added but that is not economic for these groups • Wall of wattle is more durable than that of thatched wall	Provision of wall ties, earthquake resistant
Traditional architecture	No recommendations	• Thatch roof, roof with clay tiles are recommended • Timber door and windows are suggested
Costing of the dwelling	• Repair cost can be minimized by the use of treated bamboo	• Cost of CSEB dwelling can be minimized by using bamboo and mud in the flooring • Metal truss can be replaced with bamboo truss that reduces the cost of roof by 50 percent • In-situ production of CSEB can reduce the cost of construction and transportation

8. Conclusion

Brick, bamboo, timber, mud, thatch, clay tiles and cement tiles are major building materials. Clay tiles and thatch are becoming obsolete because of readily availability of CGI sheet and transportation and also fast construction. People who can afford modern technology has already moved to RCC technology. Marginal groups are still staying in temporary shelter of wattle and daub construction which are not safe and secured.

The main issues with temporary shelter are non-durability, insecurity, limited space and threat of rain and wind. Also thermal comfort was not achieved due to unsealed openings. The challenge for traditional construction was improvising wattle and daub construction technology and also reducing repair and maintenance cost. Social dimensions (safety and security, durability, acoustic comfort) of CSEB technology were found to be more efficient than that of traditional wattle and daub.

CSEB technology hard to afford by that particular group. CSEB technology cost about 7 times more than that of wattle and daub for same size of dwelling. Repair and maintenance cost for CSEB technology is about 3 times less than that of wattle and daub. Thermal performance of wattle and daub are better than CSEB technology in the present scenario. (“As per occupants- stakeholders”).

Carbon emission and embodied energy of wattle and daub can be ignored in comparison of CSEB. Both wattle and daub and CSEB technology are environmental friendly, but CGI roofing in CSEB has degraded the performance of CSEB walls. CSEB technology consumes more energy and resource. Social sustainability makes sense in CSEB, present wattle and daub construction are economically sustainable for short term, (improvisation in technology can make it last longer) wattle and daub construction is good indicator of environmental sustainability.

9. Recommendations

The recommendations based on the findings during the research period are presented in Table 3.

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