RE-THINKING MUD HOUSE: COUNTERING THE GRADUAL SHIFT IN TRADITIONAL VERNACULAR ARCHITECTURAL PRACTICE IN NORTHERN BANGLADESH

DOI: http://dx.doi.org/10.26687/archnet-ijar.v12i2.1530

Nadia Monzur

Keywords

Mud architecture; vernacular architecture; indigenous material; Rammed earth; bamboo; sustainability.

Abstract

The diversified vernacular architecture in rural Bangladesh is the result of a constant and gradual attempt to maintain sustainability and cultural identity by using knowledge of the local environment. However, factors like natural resource scarcity and economic viability of modern construction techniques is evidently causing a rapid change in the rural landscape. A physical and questionnaire survey carried out in the area under study, namely the village Kaligram in Manda upazilla, Naogaon, revealed that, nearly sixty-percent of houses built within the last decade is concrete and brick made with little or no regards to any traditional vernacular features. Investigation of various parameters such as, mud house construction techniques, availability and preference of building materials, socio-economic changes, has revealed that the loss of precious fertile top soil, high maintenance of mud structures added with the availability and affordability of more durable materials, are some of the prime reasoning behind revising the options to brick construction. This research aims to assess the factors causing this gradual shift in the indigenous practices of mud house in the area under study and further extends onto a discussion of an alternate design approach that will exemplify a more durable, low maintenance, energy efficient yet economic building technology while acknowledging the strengths of the contextual indigenous architectural practices under debate.

Nadia Monzur*
Assistant Professor, Department of Architecture, Rajshahi University of Engineering & Technology, Rajshahi- 6204, Bangladesh

*Corresponding Author's email address: nadiamonzur@live.com
INTRODUCTION

Throughout centuries, the portrayal of human endeavor towards developing a tradition and culture specific architecture has been consistent. The growth pattern of pastoral heritage in the history of Bangladesh reads no differently. The traditional vernacular architecture of Bangladesh has evolved through time according to the need of the users and is characterized by factors such as- climate, culture and resources. However, the recent scenario of the rural landscape happens to dictate a wave of change in the age-old traditional vernacular architectural practice.

Housing typology in the villages of Bangladesh is experiencing a significant modification in terms of the use of materials, construction methods and spatial planning. The familiar rural landscape of the northern Bangladesh is no longer boldly characterized by modest mud houses topped by thatched roofs, built around a courtyard with a pond nearby. The folk architectural archetypes of the Bangladeshi villages are gradually being overtaken by a more modern approach to house building technologies that rarely correspond to the knowledge of constructing vernacular structures.

The architects, planners and sociologists who are looking for ideas to initiate sustainable rural development in Bangladesh are raising the question of whether this phenomenon is pointing to the right direction. To investigate this issue, a particular village in the North-West part of Bangladesh was selected as the study area, which features a long history of traditional earthen architecture currently under radicalization, by such mindsets. The field survey taken out across the village reveals that, about 60% structures that have been built in the last decade are all brick and concrete construction.

Identifying the factors contributing to such a trend is a mandatory step in forming an insight towards an appropriate approach to sustainable development in the future. Therefore, after analyzing the root causes against the sustenance of mud architecture in the study area, this paper discusses an alternate design approach featuring earth and bamboo as the main building materials; focusing on a durable, low maintenance, energy efficient and economic building technology that holds a flexible scope for future expansion.

STUDY AREA

Bangladesh is in general a hot and humid country with a prominent monsoon season and a short winter. The Northern region of this delta is particularly characterized by the highest temperatures in the country accompanied by high humidity and a low rainfall rate. The study area is a village named Kaligram, of the district Naogaon located in the Rajshahi division, a historically and culturally significant place in Northern Bangladesh. The village is 15 square kilometers in area and is home to approximately 3000 people.

As any traditional architecture of a certain region, the vernacular practices in Naogaon is the result of a cumulative knowledge of the local environment. The Deep mud walls on raised plinth, capped by thatched roofs of straw supported by beams of ‘Taal’ or Palm wood briefly describe the distinct characteristics of Mud architecture of rural Bangladesh that has been crafted by numerous generations. Hence, Kaligram village was selected as a starting point of the exploration into the local Mud architecture and causes behind its steady abandonment.
THE AIM AND APPROACH

The Scope

Currently emphasis on sustainable building design technology is considered fundamental to the growing field of contemporary architecture. Practicing architects have a challenging responsibility to design buildings that are environmentally sustainable with the change in the global concern regarding the use of energy and resources (Wines and Jodidio, 2000; Cox, 2009; Friedman, 2012). This new responsibility has prompted a sensible shift in trend from a biased preference of eye-catching, institutionalized building forms to more organic, humble, yet energy-efficient vernacular forms. Additionally, the local forms of construction capitalize on the users’ knowledge of how buildings can be effectively designed to promote cultural conservation and traditional wisdom (Oliver, 2003; Rapoport, 2005).

In a developing country like Bangladesh, the idea of environmentally sustainable development is farfetched unless the potential aspects of locality and context are realized and reconsidered by the practitioners. Looking into and understanding the causes of disappearing traditional building technology can create new opportunities towards developing a scheme that overcomes these limitations and makes way for an era of truly context-based, environmentally conscious, sensible and sustainable building design. The scope of this study, therefore, leads to the following consecutive aspects–

- By studying the root causes behind the ever-changing rural landscape of the village Kaligram, the limitations of mud architecture can be identified in a more specific sense.
- Sequentially this research can be a guideline to identify some of the common fundamental issues behind the gradual disappearance of other types of indigenous practices in the different rural areas of this country.
- Finally, the scope extends to provoking an argument towards the concept of sustainable architectural practices in the context to rural Bangladesh by discussing an alternate design concept proposed for the study area.

By analyzing the findings and their possible counter actions to ensure the continuation of earth architectural practice in Bangladesh, this study specifically aims at focusing on an affordable, durable, construction friendly, sustainable solution featuring Rammed earth and Bamboo as the main building material.

Methodology

This study examines a specific type of mud architecture focusing on its construction methods and limitations. The relevant documentation of the existing condition was structured around a volume of existing as well as collected data through means of literature along with physical, ethnographic, questionnaire surveys and interviews. The physical survey combined with interview sessions helped build up an idea about the mud house construction techniques in the area and the drawbacks of the process. The result of the questionnaire survey was twofold, the first set of which focused on the regular lifestyle of people and how it has changed with time, revealing an interesting insight into the socio-cultural and economic aspect of the research. Whereas the second set of questions focusing on the benefits and demerits of living in a mud house, helped disclose facts about the discontinuing preference of mud houses. In addition to that, case studies on a number of mud construction techniques were taken into consideration to formulate an idea on the current researches ongoing in this aspect. The findings were then analyzed and scrutinized to take an attempt towards solving the research question. Overall, identification of the factors that are contributing to the gradual
shift in the mud architecture practice in the study area, dictated paths to a possible solution that addresses the climatic and contextual factors keeping in mind the ever changing social dynamics.

THE SITE AND FINDINGS

Climate of Naogaon

The village under study is situated in the northwestern parts of Bangladesh. High temperatures and humidity defining a tropical climatic zone in particular characterize this region. The annual maximum and minimum temperature on average is recorded to be 37.8 °C and 11.2 °C consequently. However, recordings have shown that during summer the temperature here can climb up to 40°C or even more. Combined with the humidity and insufficient rainfall, the weather conditions get harsh during these times. In the year 2006, the highest temperature was recorded to be 44°C, whereas in Dhaka, the capital city, the highest temperature reached to 35°C that year. According to the data received, the difference between the maximum and minimum average temperature of summer and winter in Naogaon district was found to be a vast 37°C, which exceeds the average of Dhaka in the same year by 14°C.

Table 1: Maximum and minimum temperature comparison in Naogaon and Dhaka (Source: Bangladesh Meteorological Department, 2006).

<table>
<thead>
<tr>
<th>Year</th>
<th>Season</th>
<th>Maximum Temperature</th>
<th>Year</th>
<th>Season</th>
<th>Minimum Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>December</td>
<td>6.1°C(min)</td>
<td>2005</td>
<td>December</td>
<td>13°C(min)</td>
</tr>
<tr>
<td>2006</td>
<td>April</td>
<td>44°C(max)</td>
<td>2006</td>
<td>April</td>
<td>35°C(max)</td>
</tr>
<tr>
<td>2007</td>
<td>December</td>
<td>7°C(min)</td>
<td>2007</td>
<td>December</td>
<td>12°C(min)</td>
</tr>
</tbody>
</table>

Difference between min and max average temperature of summer and winter
37°C

As for humidity, during the monsoon season from June- August, the air contains highest humidity up to 96%. During the summer, the humidity drops to an average of 60% in March-April.

Table 2: Maximum and minimum average humidity comparison in Naogaon and Dhaka (Source: Bangladesh Meteorological Department, 2006).

<table>
<thead>
<tr>
<th>Airflow</th>
<th>Month</th>
<th>Season</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monsoon airflow</td>
<td>June-July</td>
<td>Rainy</td>
<td>84- 96%</td>
</tr>
<tr>
<td>Low temperature and pressure</td>
<td>January- February</td>
<td>Winter</td>
<td>67- 70%</td>
</tr>
<tr>
<td>High temperature and pressure</td>
<td>March- April</td>
<td>Summer</td>
<td>55-60%</td>
</tr>
</tbody>
</table>
Collective precipitation data of this region reveals that intensive rainfalls occur through monsoon season starting from June and continues until September in most years. The time between October to April features low precipitation. Owing to these longer periods of less than average rainfall, and the underground water being extensively used for irrigation purpose, the area is distinguished as a drought prone zone.

**Soil condition**

Naogaon District, considered as the breadbasket of Bangladesh occupies an area of about 3,435.67 square kilometers, about 80% of which is under cultivation. The soil of the area is fertile, inorganic clay called Loam. It can range from Clay loam to sandy loam. It is calcareous and moderately acidic to neutral in nature with a soil pH range of 5.5 to 7.5. Loam is a type of Clayey Soil, sticky and soft when wet, hard when it is dry. According to collected data, the sub-soil features multiple strata of soil with ground water level of 7.6- 9.8 m from the surface. This type of soil is suitable for growing paddy and different types of fruits. Owing to the composition of soil, it is also suitable for building mud houses.

**The Village of Kaligram**

**The Land and the Water**

An extensive field survey reveals that the basic layout of the village Kaligram features rural houses grouped together adjoining a pond or any other water sources. Commercial infrastructures such as local shops are mostly found near the junction of highways. Usually the roads and streets direct the settlement pattern of the houses and generally, these groups of houses are surrounded by paddy fields and Mango Garden.

In order to understand the spatial layout of the site more acutely, a cartographic survey of the study area was carried out along with the physical survey. This survey exposed an atypical growth of water bodies that seemed to be not only unplanned but also unfit to the regime of the settlement pattern in a village. This village having an area of 15 square kilometers has a greater than typical number of small to large scale ponds scattered across it.

The water table data further explains the formation of these ponds, some of which only have a depth of 3- 4m. Although the ground water table in this region is found to be as low as 7.8 meters, these water levels fluctuate depending on the precipitation pattern. According to some of the local home owners, after the monsoon season when the ground water reservoirs get recharged, excavating at a depth of even 3m eventually produces an unwanted waterbody. Fig 1 and 2 are satellite images of Kaligram where along with the settlements, the waterbodies have been highlighted to accentuate this scenario.

After asking about the usage and management of these waterbodies, a farmer who has been living in the village for 28 years expressed that there are a number of ponds that have not been used since they have been excavated. The area has always had sufficient number of waterbodies according to the needs of the household or farming purposes of the community. But as the population grew and more mud huts were erected, the number of ponds increased through years for them to be treated as a left over water reservoir. Some of these pond are as small as 5 square meter in area, and are insufficient to be used in any of the household needs as they dry out during the summer.

Moreover, these waterbodies are a result of permanent sacrifice of precious cultivable top soil that has been dug up to be used as building material. This had become a one way path
for the local people who wanted to continue living in the village until they opted for a more current option.

![Figure 1.2: Settlement and Land use pattern of Kaligram (Source: Wikimapia, 2014).](image)

**The Mud House**

As in any form of indigenous culture, in the case of the traditional Bangladeshi built environment, the user is simultaneously the designer, builder, landscape specialist, artist and artisan. The folk architecture of the village Kaligram represents the classic indigenous mud architecture practice that has been part of Bangladeshi heritage for more than 200 years.

A traditional mud house in Kaligram has a typical U or L shaped layout with a courtyard at the centre. According to a report on Mud houses of Bangladesh published in 2007 (Housing Report), the construction does not include a proper foundation; instead, the ground is excavated with a width equal to the wall thickness before the wall is erected. Commonly, the wall is embedded to the ground, without any footing and general depth of this embedment is about 0.3-0.5m. As a result, no firm connection exists between the building and the ground. Thus, the building may fail easily due to severe lateral loading. Either the plinth of the house is of raised mud platform or in some cases, it is made of plastered brick.

The thick walls that envelop the living space are made by using mud as the prime material. In some cases, cow-dung or dry leaves and straw are mixed with the mud as reinforcing materials. The mud houses in Kaligram features mud walls of depths ranging from a minimum of 2 feet to even 4 feet in some structures, which is necessary for it to act as a load bearing wall. This thickness not only provides the mud walls sufficient strength to act as a structural element, also combined with the pitched straw roofing; it provides superior insulation from the great temperatures in the summer and the harsh cold in the winter.

The ceiling is made by placing ‘Chatai’ (sheets made of bamboo strips) over the beams and then mud is laid on it. After completion, it is sometimes colored or covered by sealer to achieve moisture resistance. Roofing is completed by using thatched roof of straw or CI sheets or in some cases mud tiles, which are placed over a triangular framework of bamboo or wood.
The structural system consists of a column and beam frame of either ‘Taal’ (Palm), ‘Neem’ (Azadirecta) or ‘Koroi’ (Albizzia spp.), Bamboo or Mango tree. Sometimes precast concrete columns of 4-10 inches diameter are used to support the overhanging wooden veranda. In the two story mud huts, the beams underneath the first floor is extended up to 1 meter outside the exterior wall which act as a supports for the shading devices made of the same roofing material.

Though most of the mud houses are built for single-families, they are in many cases extended longitudinally to accommodate a growing family where vertical extension is typically limited to two stories. Besides the living area, the attic space above the ceiling is used to store seasonal and yearly harvests.

**Deviation from tradition**

As time progresses the effortless and spontaneous attitude of being guided by nature no longer seems to be sufficient for the rural people. The village of Kaligram is following no separate path to this, as it is becoming a village now more recognized by its brick and concrete structures than the distinguishable heavy walled mud houses. Zahangir Alam Shah, owner of a benevolent local farmer welfare organization, explains that easy access to information combined with availability of formerly absent technologies and building materials, is influencing the people of Kaligram to think about alternative options to Mud houses.

The current method of Brick and Concrete based construction starts with making a better foundation using ratttrap bond and sand. According to necessity, the walls are either load bearing with a thickness of 10 inch or a concrete column beam network is constructed as the structural frame. Sill and lintels of concrete mix hold the wooden door and window frames in places. The structure is then capped off by CI sheets. The field survey taken out across the
village reveals that about 60% structures that have been built within the last decade are all brick and concrete construction.

REASONING THE TRANSFORMATION

Use of earth suffers from certain drawbacks (Heathcote, 1995; Guettala et al., 2006; Ren and Kagi, 1995) such as less durability and low compressive strength of which low durability has been seen as a very prominent factor affecting the use of earth. A questionnaire survey taken among approximately 150 villagers helped to pinpoint some of the prime reasons behind this shift in mud architectural practice. According to the findings throughout this study, the causes behind the deviation from tradition in terms of building material and technology can be written off into a three-fold synopsis.

Socio-economic aspects

Owing to the social dynamics of the rural development, easy access to information and knowledge sharing has led people free from their tradition bound thoughts. Many people from the recent generations of the rural families that used to live in the village are gradually withdrawing their roots from the village to explore their opportunities in the city or elsewhere. The families that used to grow as a joint family are now becoming fragmented nuclear families with their separate households. Therefore, the need to expand the household is becoming obsolete. Moreover, the new generations are opting for a more convenient and permanent built form.

The traditional mud houses in the North might be a symbol of an age-old tradition, but the idea of it remains constrained to the lower income people of the society. According to research, despite having a long and acceptable history in architecture, many associate earth use with poverty and under-development (CRATERRE, 1979). If a family can upgrade to a semi-pucca brick house, it is considered as an achievement on their part and a symbol of solvency compared to their previous state. The availability and affordability of materials such as brick, cement, sand etc. has strengthened this trend furthermore.

Construction and Maintenance

The construction technique of the mud house can be time consuming and laborious. It takes about 60 days for 2-3 persons (120-180 person days) to complete the construction (Housing Report, 2007). Whereas the brick house construction may take less than half of that time, with the same number of labors. Collection of mud itself can be a very laborious task and a number of things can go wrong such as finding the right type of soil. A brick and concrete construction does not require these additional efforts. Adding to that, the maintenance of a mud house can be a critical job. The mud walls suffer from extended shrinkage cracks, which weaken the walls. Too much moisture can erode away the mud walls. Sometimes, the mud walls are covered with protective coating of animal dung that serves as a wearing surface. This layer requires continued maintenance and sometimes renewal almost every year.

Another menacing problem in mud houses is the occasional attack of rodents that burrows into the thick mud walls making it weak and prone to collapse. Above all, water is the main harmful element in the lifespan of a mud house. Studies also show that adobe has poor mechanical properties in terms of compressive strength and durability in addition to poor resistance to moisture and water attack (Degirmenci, 2008). Therefore, it limits the use of mud constructions to a less flood prone area with lower precipitation rate. Altogether, these
drawbacks have led people to the conception that mud houses are inferior to brick construction.

Environment and Resources

As stated previously, the field study has disclosed that the excavation of mud from any area in the village has fuelled the loss of precious top soil replacing the excavated area of land with an unwanted water body. In essence, this has caused the villagers to lose the utility of parts of the land they own. In these parts of the country, 80% of the area is cultivable land with a nutrient-rich fertile soil. Therefore, allowing this land to be replaced by unnecessary ponds is under serious argument. Adding to that, another issue with this type of construction is the use of wood to construct the beams and the frame below the roof. According to 90% of the villagers who took part in the questionnaire survey, the number of trees has visibly gone down through the years because they were used in construction of the mud houses and this has become a genuine concern among them.

HARBORING THE HOPE

Without doubt, Bangladeshi architecture has experienced a number of transformations and importation of certain outside concepts, yet certain attitudes deep within the psyche of the people have remained unchanged. New elements of experience, knowledge, value, will and behavior have simply been absorbed into the individual subconscious within the constraints of collective conditions (Saif-Ul-Haque, 1994). Passive environmental systems require considerations in the early design stages, initial decisions about orientation, form, and materiality, which cost nothing, yet lead to increased sustainability (Yousuf, 2011).

Earth is the oldest building material most commonly used for making shelter (Dethier, 1986) and nearly 30% of total population of world still resides in mud houses (Coffman et al., 1990). Given the advantages of thermal comfort (Taylor and Luther, 2004); heat and sound insulation (Binici et al., 2009; Binici et al., 2005, 2007; Acosta et al., 2010); availability of local material; local employment criteria (Morel et al., 2001); minimal impact on environment (John et al., 2005); and easy repair and maintenance of adobe structures (Turanli and Erdogan, 1996), earth has remained a frequently used building and construction material throughout time.

The local mud house of Kaligram may be under question given the previously mentioned issues surrounding it, yet the rural people explicitly noted the fact that mud houses were far more comfortable in the summer and winter season when the temperature outside was harsh. Especially during the hot-humid summer combined with the daily dosage of load shading, the burnt brick houses with CI roofs do not prove to be nearly as comfortable as the mud houses. Therefore, when they were asked, if there could be a way for them to build a house that would minimize the issues that led them to restrict their mud house preferences, the people of Kaligram were curious to know whether there could be any such solution.

RETHINKING THE MUD HOUSE

A Rammed Earth and Bamboo House

Rammed Earth consists of walls made from moist, sandy soil, or stabilized soil, which is tamped into form work. According to USC (2007), properly constructed rammed earth walls are unaffected by rain, wind, fire or termites. Load Bearing Rammed earth walls are generally
18 to 24 inches thick and Non-Load Bearing Rammed earth walls are generally 10-14 inches thick. Rammed earth compressive strength is approximately 300psi. Bamboo, another widely popular indigenous material, has high tensile strength and because of its micro fibrous properties, it is flexible in character.

Because rammed earth structures use locally available materials, they typically have low embodied energy and generate very little waste. The soils used are typically subsoil low in clay, between 5% and 15% typically with the topsoil retained for agricultural use. Ideally, the soil removed in order to prepare the building foundation can be used, further reducing cost and energy used for transportation. Rammed earth buildings reduce the need for lumber up to 50% because the formwork used is removable and can be continually reused. Rammed earth can effectively control humidity where unclad walls containing clay are exposed to an internal space. Humidity is held between 40% and 60%, which is the ideal humidity range for asthma sufferers and the storage of susceptible items, such as crops (Olusola Oladapo Makinde, 2012).

The revised concept therefore interprets a structure that, while minimizing the use of mud and being durable and low maintenance compared to a traditional mud house, also provides the user with a comfortable indoor space by utilizing the insulation properties of mud walls, eventually combining their knowledge of local materials with newer, environment conscious techniques that reduces the use of resource, energy consumption. Considering the situation of the study area, the idea is to introduce a design alternative that-

- addresses the socio-cultural dynamic of the rural life style and allows a more flexible option for the future expansion of the household;
- promotes a structure that combines the thermal property of mud and structural strength of Bamboo in the form of Rammed earth structure with multiple Bamboo culm column-beam frame while reducing resource consumption.

**The Layout**

Considering the growing need of accommodation in a typical rural family, the design of the house must have a scope for future expansion. In the case of a traditional U shaped house layout (Figure 8), future expansion often becomes incompatible to the transforming family structures in the rural and suburban areas. Newer generations prefer a household for a nuclear family to live in where they can share the some common space (toilet, crop storage) with the rest of the family but at the same time, which allows them to maintain a separate household of their own. In most cases they move out of their family house to a more compact and durable structure or in some cases the mud houses are taken down and are replaced by brick houses.
To compensate this scenario, an option can be proposed that allows a more sustainable mud construction with a flexible future expansion opportunity. If the separate household blocks are arranged in a more linear manner with a smaller courtyard serving as the junction point; when future expansion is required, more blocks could be added perpendicular to the existing ones as shown in Figure 8.

This flexible layout will firstly, accommodate the growing family and provide an interconnected household that will be a better alternate than moving to a completely separate household. Secondly, it will allow the expansions to be built using the same building materials but with better structural stability and durability.

The North- South oriented blocks will be the living space and the newer East West oriented blocks will work as the utility areas such as kitchen, toilets, storage spaces etc. As newer blocks are added to existing ones, they will create more courtyards grouping the households together.

The Structure

In majority of rural areas in Bangladesh, houses are built with bamboo as the primary load bearing elements of the structure. However, these bamboos are usually placed close together so the footing acts as a combined one to stabilize the structure. After studying some of the examples, it is observed that single bamboo culms of 4”- 6”diameters are placed at a distance of no more than 4’ (center to center). Marking that as a standard of the load bearing capacity of a single bamboo, a multiple culm bamboo column is suggested, that can support larger spans.

The combination can range according to the necessity and the bonding pattern of the bamboos can vary according to the design as well. As long as the bamboos are seasoned and the rope ties are done with good craftsmanship, the column will act as a single unit (Figure 9,11).
Historically foundations were often absent in earth structures, with walls built directly onto bearing soil or very shallow footings or slabs. This was due to an apparent resilience of earth walls not found in more conventional materials, which reduced the importance of foundations.

In the proposed structure, the foundation suggested for a two-storied building can be of a minimum 3 feet depending on the soil condition. In addition, the method will be somewhat similar to that of a brick wall. While starting with a sand compaction the rammed earth wall will be joined in a rattrap bond with sand and water. A 25% cement and brick chips mixture over a 3" CC layer can form the ground floor finish over bare top soil (Figure 10). The exterior walls having the thermal mass can be as thick as 18"-24" and can facilitate time lag cooling. A 12" thick rammed earth wall can provide up to 12 hours of time lag cooling. As for the partition walls, thickness should be a minimum of 12" if no more. In addition, this will require less soil usage during construction.
The main categories of binders used for earth construction are (Standards Australia, 2002; Houben & Guillaud 1994; SAZS 724:2001, 2001) Portland cement, lime, bitumen, natural fiber and chemical solutions such as silicates. There are various advantages when using cement as a stabilizer. Soil samples gain strength from both the formation of a cement gel matrix that binds together the soil particles and the bonding of the surface-active particles, like clay, within the soil (Crowley, 1997). High levels of cement stabilization improve the surface coating and reduce erosion (Walker, 2000) while increasing the cement has a considerable influence in improving the resistance of soils vulnerable to frost attack (Bryan, 1988).

Drawing on a comparison between same size (12’x 24’) of a traditional and a Bamboo and Rammed earth structure, it is calculated that-

- A traditional mud house requires 1120cft of soil (adding 15% cow-dung/ fibers). Maintenance requires more soil over time.
- A Rammed earth house requires 930cft of soil (7.5% sand + 25% gravel)

Therefore, this type of design can save up to approximately 56% soil than a traditional mud house which can be pivotal in saving precious top soil in the study area as well as other places where mud architecture is restricted due to constraints on mud usage.

As roofing material, bamboo shingles or mud tiles can be a better option than CI sheets, as they will minimize heat buildup indoors. Bamboo shingle roof construction is simple, cost effective, and durable if the bamboos are treated beforehand with a solution of boric acid and borax powder solution (ratio 1:1.5). Moreover, undeniably besides structural strength and insulation properties, rammed earth construction also has a great aesthetic appeal, which the designer can use to their advantage.

**CONCLUSION**

The fact that architectural practice does not serve the majority of rural populace is a common concern not only in Bangladesh but also in most developing countries with vast rural demography. Present study has revealed that, even though once the rural landscape of Bangladesh was dominated by distinct mud houses, a wind of change has been set in motion that depicts an ultimate extinction of mud house somewhere in the future, due to several undeniable factors at play. Introduction of the aforementioned Rammed earth and Bamboo structure can not only validate the concept and virtues of mud house but also open up new avenues towards more research oriented, context based technologies required to secure a resilient future for the rural housing typology in Bangladesh. Therefore, the researchers need to bring themselves to the same plane of perception on sustainability as these rural people in order to fabricate a better future for the nation.

**REFERENCES**


