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Rephrasing Existence: Enacting Disaster Resilient Features in the Traditional Houses of Coastal areas of Satkhira, Bangladesh

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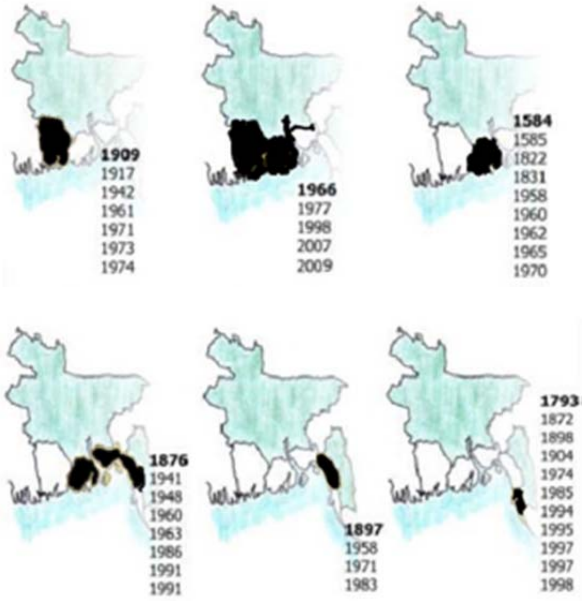
Abstract—*The coastal areas of Bangladesh experienced two of the most devastating cyclones of the last decade, consequently in 2007(Sidr) and in 2009(Aila) that concluded in a devastating aftermath of at least 3786 deaths. More than 2.5 million people were left homeless and the total damage was counted to be of more than 650 million. The massive loss of life is due to the high density of population in the coastal areas, people living in poverty within poorly constructed houses and the extremely low-lying land of the coastal zone. In the name of disaster preparedness, the major response to frequent cyclonic storms has been the establishment of cyclone shelters, which considering the depth of damage forced upon by such calamities, have failed to ensure minimum loss of lives and assets. The reason behind that is, while the cyclone shelters have been proved to be useful they are more of a disaster management solution and thus is useful particularly in the event of a cyclone. But in the case of developing countries like Bangladesh where the coastal areas are highly vulnerable to such cyclonic effects, actions on identifying the point of intervention at micro level becomes paramount. Acknowledging this scenario, it becomes necessary to walk through a more suited approach that will enhance building sustainability during and after cyclones and will minimize the damages in the event of a disaster. An extensive survey was conducted in Satkhira, one of the most disaster prone coastal areas of Bangladesh, to document the architectural, structural and traditional features of the construction of these houses. This paper summarizes the challenges and their probable responses with the aim of making the traditional structures more compatible to cyclonic storms by proposing some vital guidelines for traditional house building in coastal areas of Bangladesh.*

Keywords*: Cyclones, Disaster, Resilient, Bay of Bengal, Adaptation, Traditional house, Local materials, Micro-level housing etc.*

Introduction

Bangladesh, the largest delta on earth is ranked as the world's fifth most disaster prone country. Its topographic and geo-physical location has made it vulnerable to various natural hazards, particularly to extreme climate-induced disasters (UNU–EHS; 2016). A catastrophic tropical cyclone is likely to hit the coastal region of Bangladesh almost every three years. The tropical cyclones cause casualties and damages and sometimes are responsible for cascading disasters (Ahmed; Kelman: 2016). About 33% of Bangladeshi people live on the coastal zones of Bay of Bengal covering 19 districts. Because of illiteracy and lack of ideas on sustainable low-cost technology, these coastal people built their houses by assistance of locally available wood craft and artesian for living somewhat only. Hence, they live with the risk of losing their houses every year due to natural disaster especially cyclone, wind storm, Sidr, Aila etc.



Source: **Major Cyclones of Bangladesh**; (Rethinking Innovations for Affordable Housing in Disaster Prone Areas of Bangladesh; Dr. Khandaker Shabbir Ahmed, Professor, BUET)

In 1991, these people in coastal area faced a deadly cyclone of wind speed of up to 250km/hr which caused 138,000 deaths and rendered 10 million people homeless in addition to the loss of billions of money and severe sufferings. Then category-1 cyclone 'Sidr' devastated the coastal region

of Bangladesh on 15th November 2007. The cyclone battered vast areas of Khulna, Barisal, and Chittagong divisions with a wind speed of almost 250 km per hour with giant waves up to 30ft high (MoFDM, 2008). Again 'Aila', category 1 cyclone, hit South-Western coastal region of Bangladesh on 25th of May 2009. The cyclone took shape on 23rd May and dissipated on 25th May, 2009. Sustained wind speed of the Cyclone Aila was about 65-75 mph and thus it is defined as the category-1 cyclone (74 mph is the lowest threshold for Cat-1 hurricane). The tidal surge height of about 10-13m dropped on the region washing away a huge number of households, lives, livestock, crops and all other resources of the affected region. The whole incident occurred within a very short time, and people became homeless leaving their assets in the households. Even though Aila was a weak category cyclone by the definition, its economic devastation outweighs the impacts of Super cyclone 'Sidr' and brought in long-term sufferings for the south-western people of Bangladesh.

Source: GoB Upazila-wise 'Aila' Damage Assessment Form

Indigenous communities while living in the coastal areas for centuries having close contact with nature, it is assumed that they have developed an indigenous perception and prediction strategy for cyclones and, there by possess effective survival strategies (Hassan, 2000; Hossain, 2001). Unfortunately, it's true that Bangladesh National Building Code-93 (BNBC-93) doesn't provide any provision for wind resistant design for above mentioned non-engineered housing. Hence the phenomenon of losing house in disaster is incessant. To minimize the loss of houses and economy in coastal zone of this delta, the aim is to investigate the present housing condition in southern part of Bangladesh to develop and establish a sustainable, cost effective, comprehensive, safe and economical design concept by scrutinizing some highly vulnerable cyclone-affected villages located in the southwest coastal districts of Bangladesh so that people under poverty can build structurally robust houses to resist high speed wind within their affordable limit.

Selection of the Study Area

A comprehensive study was undertaken in some villages of Shyamnagar, Satkhira coastal belt to see resources dependencies on the mangrove forest of Sundarbans in order to frame out a system for sustainable resource management and to identify the available and affordable resources that could be spent while building sustainable climate resistant houses by using indigenous knowledge shaped by modern technology and in line with urban design principles.

There were three main predefined priorities: (a) Indigenous communities (b) Coastal region; and (c) Impact of the "Sidr" and "Aila". Keeping these in context, on the basis of secondary information Shyamnagar upazila of Satkhira district was selected for intensive in-depth investigation.

Methods and Approaches

The study mostly relied upon qualitative data and information. In order to achieve the objectives of the study, data have been collected from both primary and secondary sources. Primary data have been collected through field visits which are mostly qualitative. Secondary data are obtained from reports, journals, research papers, and book. Information on relevant issues is collected from websites available on the internet.

Relevant information on the concerned issue has been collected through in-depth, key informant interviews and group discussions with the local people were also carried out. Primary data and information collected through questionnaire have been summarized and analyzed for the purpose of the study.

This article contributes to an understanding of the social dynamics following cyclone disasters in coastal area of Bangladesh by addressing the following three research questions:

a) How did the communities perceive indigenous technology of house design on pre-event cyclonic disasters?
b) What were the activities (post-event) undertaken by the affected communities at homestead level to recover from the cyclone disasters?
c) What changes took place at individual build form level?

It covers the indigenous methods adopted by the people in the coastal community to recover from the losses, and the changes on the overall transformations in house design as well as livelihood pattern and lifestyle at the community level.

General Development Perspective

It is realized that most of the houses damaged or collapsed either due to poor construction practices or inability of the victim to construct a relatively safe structure. The GoB has to detail out a comprehensive rehabilitation strategy, on which shelter construction and livelihood restoration are major challenges. Some guidelines were worked out that were specifically framed for the reconstruction of houses considering multi hazard perspective for the coastal communities which were affected by cyclones in coastal districts of Sundarbans. These guidelines will also be helpful for the construction of houses in other districts apart from the coastal districts, which are prone to cyclones. The entire coastline being vulnerable to multi hazard destruction, the initiatives to be implemented needs to be replicated at national and international level through medium of experience sharing forums, best practices and learning techniques.

Now the greatest challenges and opportunities identified are:

- To ensure incorporation of disaster resistant features in all the shelters.
- Skill up-gradation of construction workers.
- Sourcing indigenous building materials, technology and design.
- Bridging the gap in technology know-how, transfer of technology, dissemination, setting and maintaining of quality control system.
- Bringing together key stakeholders for building better habitat.
- Mainstreaming disaster resistant features and cost optimization through appropriate technology promotion in all state sponsored housing scheme and private and public buildings.

Existing Housing Condition

Particulars	Materials
Roof Construction	Bamboo, woods Golpata / Tally Corrugated iron (CI) sheet
Wall Construction	Bamboo, woods, Goran sita Golpata CI sheet Mud/ Brick/ concrete
Floor Construction	Mud Brick/ Concrete

Rephrasing a Micro-Climatic House

Tree plantation and orchard in the backyard:

A well thought out plan of plantation helps to reduce the impact of both cyclone and tidal surge. Tree plantation should be undertaken by involving participation of local people in order to select species of trees such as Accacia (Shishu) and location of plants. In this area 48% of the houses are south facing and the 39% face towards the east, giving a total sum of 87% housing units that are oriented to south and east directions because of nor-western storm and cyclone (Nahiduzzaman, Kh; 2007). Most of the orchards/gardens are located in the rear side of housing units which offer primary protection from any intensity of storms. Such indigenous technique of house construction has been established because

of the fact that it takes advantages from nature by, on one hand, setting up the facades of the houses into opposite direction of cyclone and, on the other, planting trees on the rear side of house. Tree planting programs on Killas and embankments should be extended to settlements throughout the risk prone areas and planting materials should be made available for this purpose. (Lewis & Krisholm; 1995)

Spatial Setting

Orchard, water body and agricultural land are parts of housing and it is interesting to observe how they are being spatially distributed to protect households from natural calamities. A typical pattern is shown in the figure to give an idea of indigenous knowledge on house units in relation to their surroundings. Most of the residential units are oriented towards south and east direction and most of the orchards are located behind the housing unit. This spatial setting is due the fact that the villagers are frequently affected by the Nor-western storms (as come from north-western side), which occurs 2-5 times in a year, especially in the Bengali months of Baishakh-Jaistha (April-May).

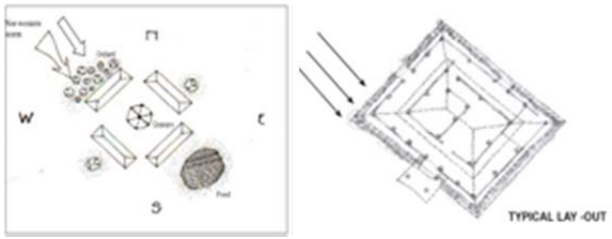


Figure: A typical pattern of house units in relation to their surroundings. (Huq, 1995).

Lay-out and orientation of traditional houses, in most cases, locate the house in a manner so that the shorter face of the house is towards the windward direction of the cyclone. A very important feature of these recommendations is that they are based on people's perception & their identification of problem & possible solutions.

In case of this study area, it is recommended that the houses near to the coastal areas should be built at least 4 m above the mean sea level. The generalized assumption is that the dwellings located in higher grounds are less likely to be affected by storm surges (Dasgupta, Laplante; 2009) After analyzing the DEM, it was found that the average elevation of the dwellings is only 3.5 m (Mallick, Vogt; 2015). This makes the houses highly vulnerable to cyclones and storm surges. In the study area it was observed that, before the occurrence of the cyclone event, most of the houses were already in a (physically) vulnerable situation.

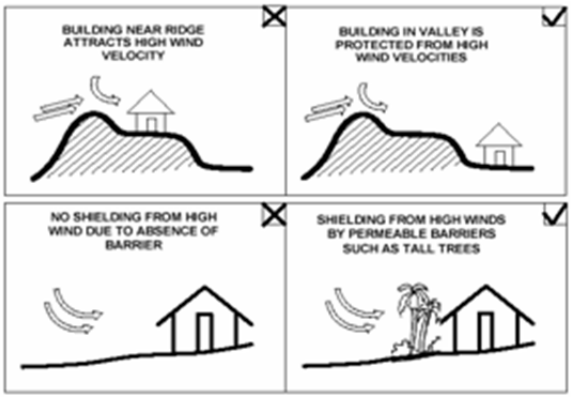
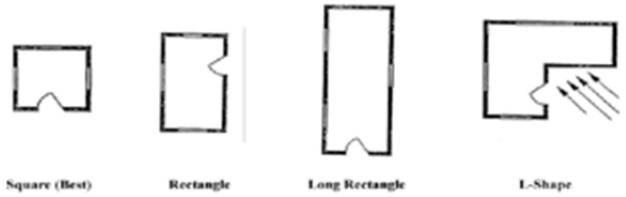


Fig: The area behind a mound or a hillock or casuarinas plantation should be preferred to provide natural shielding (Santhakumar, 2005).

In regions close to the coast, a site above the likely inundation level should be chosen. In case of non-availability of high level natural ground, construction should be done on stilts with no masonry or cross bracings up to maximum surge level. Or they should be constructed on raised earthen mounds to avoid flooding/inundation but knee bracing may be used. (Agarwal, DRMP-UNDP; 20117)

Form Orientation

The best shape for planning is a square or a rectangle for wind resistance. The traditional houses in these areas are mostly rectangular with length and width ratio within 2:1. It may be mentioned here that length to width ratio up to 3:1 is recommended for cyclone resistant houses (Huq; 1995). The rectangle is better than the L-shaped plan.



This is not to say that all buildings must be square. But it is to say that one must be aware of the implications of design decisions and take appropriate action to counter negative features. The best shape to resist high winds is a square. If other shapes are desired, efforts should be made to strengthen the corners. If longer shapes are used, they must be designed to withstand the forces of the wind. Most houses are rectangular and the best layout is when the length is not more than three (3) times the width.

Fig: In case of construction of group of buildings, a cluster arrangement can be followed in preference to row type (Agarwal, DRMP-UNDP; 20117)

Plan Layout

The typical house plan consists of a "ghar'' and "pashchati/ veranda". In many houses the pashchati runs on all four sides of the "ghar''. There are houses with "pashchati" on 2 or 3 sides of the "ghar''. Whether the "pashchati" is on 2 or 3 sides of the "ghar", it is invariably facing the windward direction.

Cyclonic storms and high winds are the most obvious factors shaping the development of the form of these houses. In order to reduce the high pressure on the internal surfaces of the wall these houses are built with only one opening on the "pashchati". The pashchati wall works as a barrier and reduces water penetration into the ghar during high wind accompanied by rain.

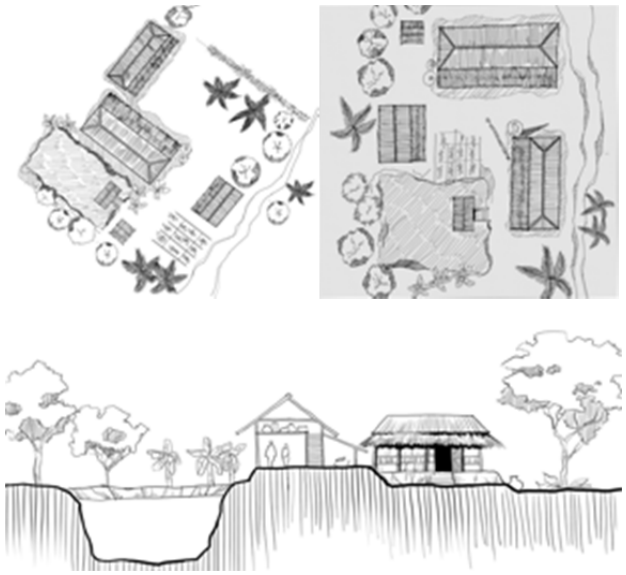


Figure: Proposed Single-family House

Figure: Proposed Multi-family House

Plinth

Extreme care and attention is usually given to construction of the raised floor or plinth which is often the only remaining trace of a build-form after cyclone or flood. This can be constructed in excess of a meter in height and thus protect the rest of the structure in cyclone prone areas.

Improved plinth construction measures include better integration of the frame post and should be surrounded by brick masonry work (if possible). Improvement should be done to the flood resistance of plinths in areas of sandy soils.

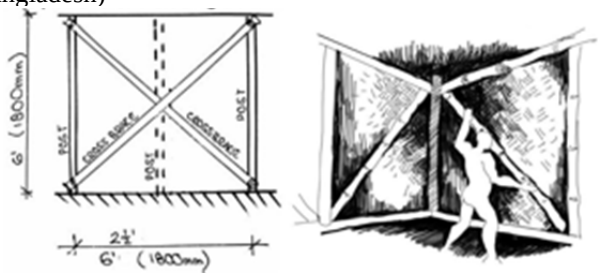
Frame

This is usually done using Talla species of bamboo or wooden posts (sundari/ goran), possibly with jute poles or goran-sita for lighter members. Frame elements are commonly lashed together with jute rope.

Proposed improvements are:

- Treatment of bamboo against insect attack;
- Treatment of poles against rot in the ground;
- Better anchoring of poles into the ground;
- Inclusion of cross bracing:

Source: Guidelines for better building with bamboo (SAFE Bangladesh)



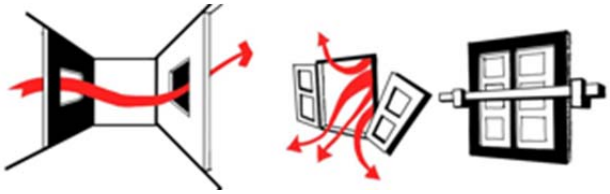
- Sustituting nylone rope or galvanised wire binding for jute rope.

Wall and Openings

Walls are typically made with panels of split and woven bamboo, goran-sita, woven golpata or similar materials or CGI sheets. Sometimes wall panels are covered with mud paste. These panels commence within the mud plinth.

Proposed improvements are:

- Place the door in the center of the wall;
- Wall panels should be modular and easily removable if needed for easy transferibility in disaster times;
- Add a small window in the rear wall;
- To limit the areas of window openings in relation to walls.



- Openings should be framed by vertical posts and appropriate horizontal sections.
- Shutters should be hung along the top frame of window openings.
- Factory finished metal sections of appropriate specifications may be used.
- Glazing in windows should be avoided unless the sections are small.
- Louvre shutters should be designed with special hardware to block the wind inside during cyclone.

Roofing

The traditional houses have hip roof over the 'ghar' and a very low roof over the 'pashchati' which is separated from the hip roof. Magnitude of the wind load on the structure influences the shape of the roof experiment and case studies have shown that houses with hip roofs have the best resistance capacity.

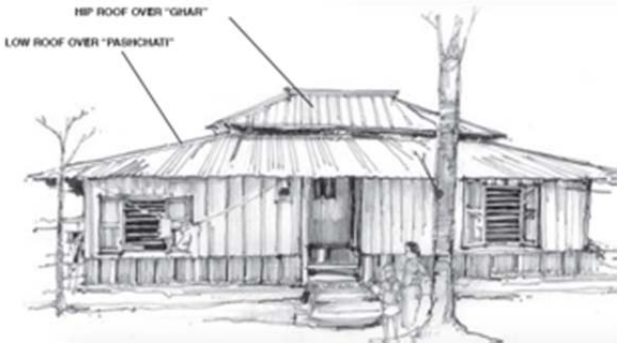


Fig: Use of Hip roof over 'Ghar' and low roof over 'Pashchati'.
(Bashirul Huq; Battling the Strom: 1999).

The roof is usually either thatched or laid with burnt mud tally or CGI sheet. During a cyclone, a large pressure builds up under the overhang, and the pressure added to the suction on the upper roof may pry the roof away from walls and vertical support. These problems have been solved by traditional builders by keeping a minimum roof overhang in most houses, and by having a separation between roof over the 'pashchati' and the main roof of the 'ghar'. (Bashirul Huq; Battling the Strom: 1999).

Other proposed improvements are:

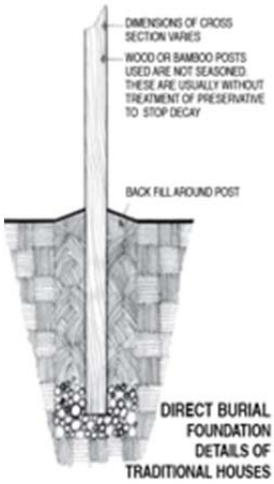
- Incresing the pitches of roofs to 30 to 40 degrees;
- Encouraging the use of hipped roofs;
- Tying down the thatch strongly;
- More frequent, improved fixing for cgi sheets;
- Methods for the parmanent or temporary tying down of entire roofs (eg. On receipt of cyclone warnings)
- Fixing of purlins to rafters should be strengthened with metal straps or bolts with washer at ridges and eaves.
- Purlins and slats should be well seasoned and pressure treated with preservative.

Figure: Tying down the bamboo rafter with earth (author).

- Roof can be strengthened by tying down the bamboo rafter with earth.

Structural Footing & Details

Wood, bamboo and pre-cast concrete posts are used for support of the houses in the areas of our survey and study. The weakest point identified in our survey in the traditional construction methods and techniques is anchorage of vertical supports to foundation system. This weakness is the main reason for strong winds to lift up the entire houses or blow it down. The typical foundation method used in the traditional houses is the direct burial of posts into the soil.



Recommendations and Guidelines

- Bamboo should be selected on the basis of appearance and strength having an average diameter of 125 mm. Bamboo should be treated with appropriate preservative.
- Recommended section of sawn lumber- 120x120m.
- Recommended average diameter of log- 150mm.

- Lumber should be well seasoned and treated with preservative.
- Foundation in accordance with the details in Pre-cast concrete posts should be fabricated with quality control of materials and proper shuttering, fastener, ties, etc.
- Should be embedded in the post at the time of fabrication. Keep provisions for ledges in the pre-cast concrete post.

The illustrated details are typical and not for constructing a particular house.

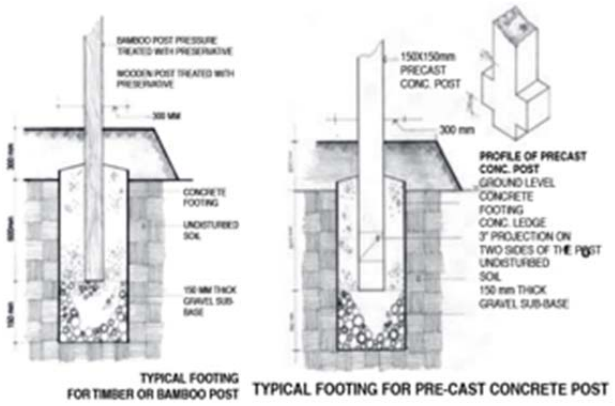


Figure: Bamboo/timber and Concrete footing detail (Bashirul Huq, 1999)

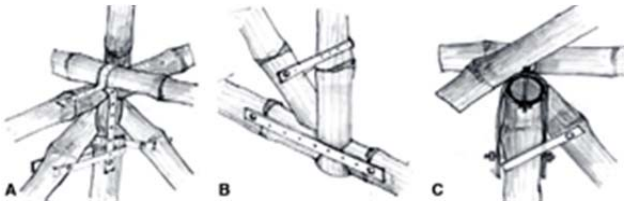


Figure: Bamboo/ wood jointing detail (Bashirul Huq; 1999)

Promulgating Improved Construction

Traditional construction is undertaken by self-builders, possibly with help from neighbours and friends. This artisanal buildings is an aspect of local knowledge and is not in the pureview of construction professionals. Therefore, ways must be found to reach self-builders using methods more appropriate for the target population than conventional sources of information on construction technology. (Lewis & Krisholm; 1995)

Methods for technical improvement should be considered in their cultural, social, economic and practical contexts, including, for example:

- Traing programs for NGOs engaged for housing construction, repair and loan programs so that their activities could be accompanied by the promulgation of improved traditional construction techniques;
- Promulgation by Government or NGOs would be through community groups and community development activities;
- Additional public information programs should be mounted to spread information through newspaper, local news sheets and social medias;
- Demonstration projects with technical assistance in the field.

These activities would require guidelines, leaflets and notices in Bangla with graphic illustrations for distribution as public information programs in advance of each cyclonic seasons.

A series of participatory demonstration projects should be mounted to show the importance of house siting, juxtaposition and form along with how various materials should be selected, treated, joined and maintained.

Proposed Moduler Prototype

We have analyzed the economic feasibility of the inhabitants of study areas and proposed some new module with respect to the cost of existing house typologies and income of different group of people and the resistibility of the built-form.

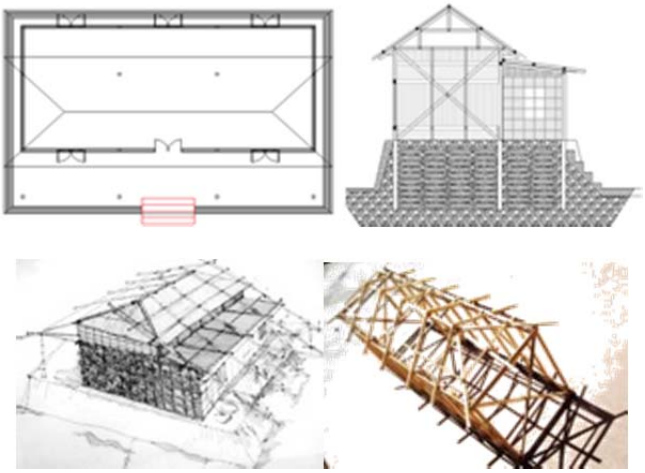
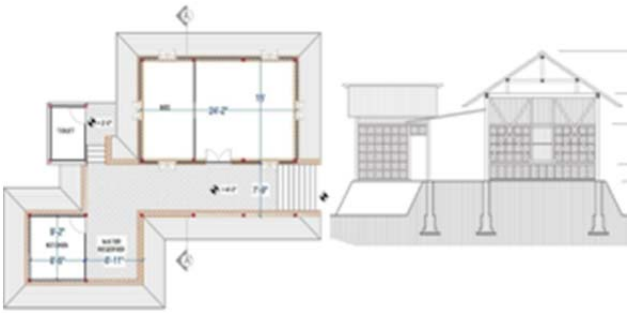


Fig: Proposed Build form (Module-1)



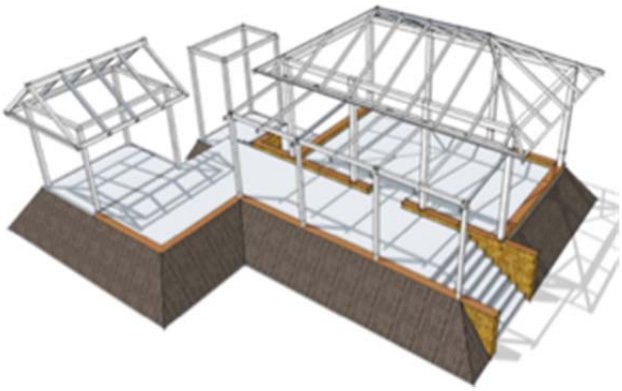


Fig: Proposed Build form (Module-2)

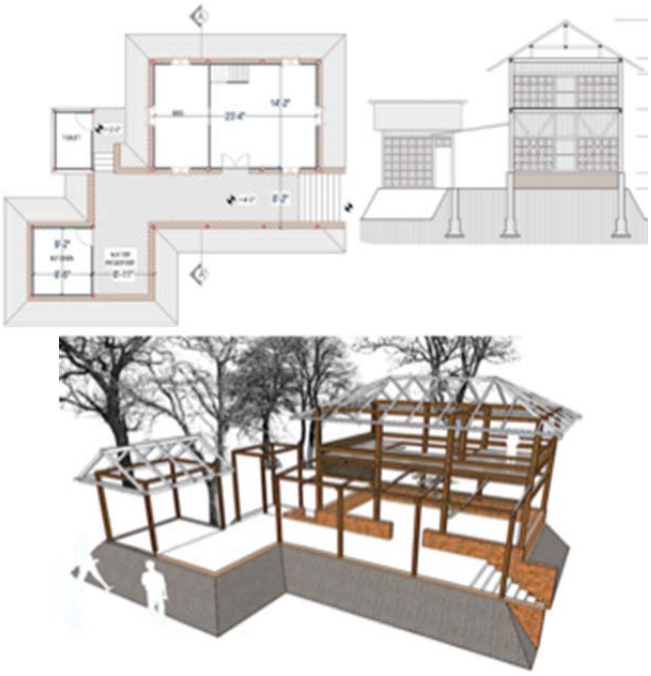


Fig: Proposed Duplex type Build form (Module-3)

Conclusion

It is important to note that traditional houses can only be cyclone resistant with a comprehensive approach for the implementation of all the recommendations in the guidelines for cyclone-resistant houses. The critical aspects of the recommendations are:

- solving the social, cultural, economic and environmental problems of domestic housing. Such programs should be:
  a) inclusive of both kutcha and pucca materials and methods,
  b) repeated annually or designed to be continuous.
- Technology input for improving and enhancing the durability of building material such as bamboo, goran-sita, wood golpata, mud etc.
- Careful consideration of the recommendations outlined in construction techniques, structural components and details.
- Use of tie and bracing can be applied for construction of non-engineered houses in coastal zone of Bangladesh.
- Improved techniques for the fixing of corrugated galvanized iron roof sheets are required urgently.

In short, the cyclone resistant house is feasible with the simultaneous implementation of a community approved plan of tree plantation, preservative treatment of all components of building materials and following recommendations for technology input in construction techniques and structural components and details.

Points for Further Study

- The relationship between dwelling maintenance and cyclone damage needs to be addressed through training and information programs;
- Roof construction must take into account as well as its significance as shelter in times of flooding;
- Post-cyclone field surveys of the modes of structural failure of ‘kutcha’ construction is required;
- Long-term programs are needed for effective promulgation, demonstration and absorption.

It may be emphasized that good quality of design and construction is the single factor ensuring safety as well as durability in the cyclone hazard prone areas.

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