

**A RESEARCH AND LEARNING CENTER FOR LOCAL BUILDING
TECHNOLOGY**

BY

RUBAIYA NASRIN

08308013

SEMINAR II

Department of Architecture

BRAC University

CONTENT

CHAPTER 1: INTRODUCTION

- 1.1 Project brief
- 1.2 Project background
- 1.3 Project Rationale
- 1.4 Objectives
- 1.5 Given program

CHAPTER 2: SITE APPRAISAL

CHAPTER 3: LITERATURE REVIEW

CHAPTER 4: CONTEXTUAL ANALYSIS

- 4.1 Historical Background
- 4.2 Local Architectural Character
- 4.3 Climatic Conditions

CHAPTER 5: CASE STUDY

- 5.1 Example_ International
- 5.2 Example_ Local
- 5.3 Analysis and Findings

CHAPTER 6: PROGRAMME AND DEVELOPMENT

CHAPTER 7: CONCEPTUAL STAGE AND DESIGN DEVELOPMENT

CHAPTER 8: CONCLUSION

CHAPTER 01

1.1 PROJECT BRIEF

Project Name:

A RESEARCH AND LEARNING CENTER FOR LOCAL BUILDING TECHNOLOGY

Function: Research Center, Center for learning and sharing knowledge on rural materials and techniques

Location: Sunderban Village, Dinajpur

Area: 85,000 sft

Client: SAFE

1.2 PROJECT BACKGROUND

"The only form of building improvement programme which has the potential to result in widespread improvements is one which changes the building decisions made by the poor in their own construction projects, designed by themselves"

- Dudley and Haaland (1993), Rural Housing and Affordable Innovation, 1997.

The poor rural people are the ones who need most knowledge about utilizing their local materials and resources in order to be able to make their own building decisions. Such decisions should be encouraged to enhance our local technology.

Technology is referred as "the systematic application of knowledge put to some practical use". So local technology is the technology used for an area by using traditional knowledge, methods and materials. Resources can be defined as something that can be used for support or help. And natural resource is "material source of wealth, such as timber, water, mineral deposit that occur in a natural state and has economic value."

The need to promote local technology with local resources comes from the desire to make long term sustainable development by holding onto our culture. In order to develop sustainable strategies it is important to take account of, and learn from, what local people already know and accomplish.

The idea is to create a center which works on innovation, building technology and artisan development in a rural area. The project would increase community self-reliance by creating skilled local builders, craftsmen and at the same time, interaction between scientific and traditional knowledge would be enhanced.

Architecture plays a decisive role in the development of Bangladesh. The population of Bangladesh was 147 million in 2006 (source: Wikipedia, 2006). About 75 percent of all Bangladeshis live in villages, most of them in earth or bamboo houses. Although these traditional building materials are highly sustainable, people are seeking for materials such as bricks, concrete, and corrugated iron sheets that are supposedly more durable. In terms of the consequences of energy consumption through the production of these materials, such a trend could have severe consequences on the global warming.

Simple strengthening improvements for earth and bamboo construction houses can cost just 5% of the total construction cost. (www.safebangladesh.wordpress.com) By knowing appropriate technology, people can reduce the vulnerabilities caused by natural hazards. The knowledge requires not only the understanding of technology but also of people and places. So the intention of this project is to create architecture by integrating local tradition and local technology to make improved house building techniques and environmental initiatives.

SAFE is an NGO based in the Dinajpur region in the far north west of the country. It has been officially been operating since 2009 with support from Housing and Hazards, (www.housingandhazards.org), an international group of building professionals working to promote affordable hazard resistant housing. SAFE have also implemented projects in partnership with UNDP, Australian High Commission and British Women Association (Dhaka). SAFE's founder, Azit Roy, has been involved in low cost housing projects for over 14 years.

There are two elements which underpin SAFE's activities:

1. Using methods that are appropriate
 2. Communicating these methods in a way which people understand and will remember.
- (www.safebangladesh.wordpress.com)

Local people not only observe their surroundings but also experiment and develop appropriate technologies to fit their own environment. Appropriate building techniques are those which are affordable and use materials which are available and techniques which can easily be learnt.

Knowledge and access to knowledge are not spread evenly through a community or between communities: people have differing objectives, interests, perceptions, beliefs and access to information and resources. Knowledge is generated and transmitted through their interactions within specific social and agro-ecological contexts. So a research and learning center where rural people could assemble together is ideal to spread the knowledge of appropriate technology and encourage the local craftsmen.

The approach is focused on the process rather than the product. That means it is the process, like the involvement of local builders, the teaching methods; these are more important than simply producing a house. This approach will ensure that the ideas and techniques stand a much better chance of spreading to others in the immediate and surrounding community.

1.3 PROJECT RATIONALE

Architecture is a form of art and an architect can be the artist or the person who enhances the need of art in different social levels. This project is chosen on the basis of systematic structure required for rural artisans to develop their skills and spread their knowledge.

Architecture is more significant when one sees the practical use and its positive effects on people, specially people who really need it. That is the sole reason behind choosing this project. Because people living in rural areas are the ones who need knowledge about making their own house, they don't need a designer to build their house. They are people who make home with aspirations and dreams but those dreams get washed away because of lack of knowledge. Whereas they are capable of doing better with traditional materials and methods. So a center for promoting local resources and technology can work like a guidance to rural people to be aware of their own capacity and spread their knowledge to others. Basically, this project is derived from the realization of need to promote architecture in rural sectors, not as an architect but as a social activist to create a greater impact on the rural areas of the country.

1.4 OBJECTIVES

The aims of this project are -

- I) To learn about local technologies which are appropriate for specific site conditions in rural areas. Realizing the potential of the indigenous materials, method and design for the growing needs of today and tomorrow.
- II) To improve the local resources and utilize them in developing rural architecture. The concept of people managing the construction processes would be encouraged.
- III) To explore the possibilities to be more environment-friendly and create a sustainable society.
- IV) To understand the socio-cultural development related to architecture.
- V) To establish a system for educating rural people about local materials and methods which can be developed locally.
- VI) To realize our scope of contribution to promote local technology in rural sectors.

1.5 PROGRAMME

The functional requirements are as follows-

- Office space
 - i) lobby
 - ii) 3 office rooms
 - iii) 1 meeting room
 - iv) 1 waiting room
 - v) 1 information center etc
- Lab
 - i) Material treatment plant for bamboo
 - ii) Research lab
 - iii) Computer lab
- Library
 - i) Material library
 - ii) General library
- Multipurpose hall
(outdoor and indoor)
- Exhibition space
- Classrooms for:
 - i) wooden crafts

- ii) bamboo, cane crafts
- ii) earth construction
- Residential zone for 50 artisans
 - i) dorm (male and female)
 - ii) dining hall (common)
 - iii) kitchen
 - iv)toilet
- Test sites

CHAPTER 02

2.1 SITE APPRAISAL

The existing site for SAFE head office has been chosen as the site for the project. It is situated in Sunderban village, Dinajpur. Sunderban village sits on both sides of the main highway, midway between Dinajpur and Saidpur. The river Atrai forms the eastern boundary of the village.

The selected site for the project has both positive and negative sides, but the opportunities are greater so the center is proposed to build in the Sunderban village near Bengkali Bazar.

Strength:

Visible and easily accessible from main road.

Existing head office for SAFE makes it easy to relate.

The raised land is surrounded by free lands which can be used to extend in future.

Weakness:

The hot-dry climate of the area can make it difficult for the people from other areas to cope up with.

There can be no vehicular access directly to the site as the adjacent road is narrow.

Opportunity:

Highlight local materials like bamboo, earth which are available in the surrounding.

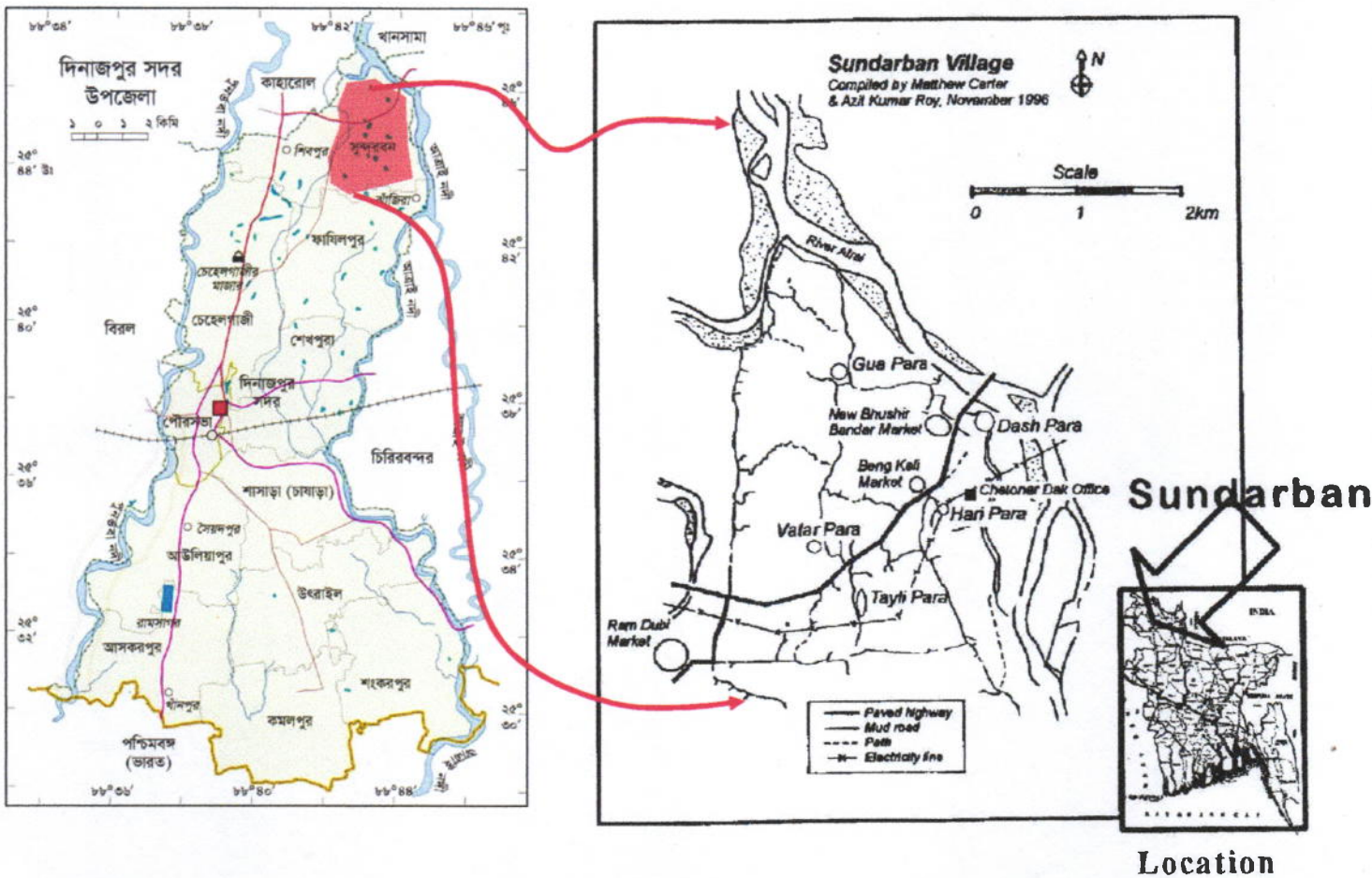
The surrounding landscape can be incorporated and used to enhance the beauty of the project.

Set an example for proper sustainable architecture and system in this area would create a great social impact.

Threat:

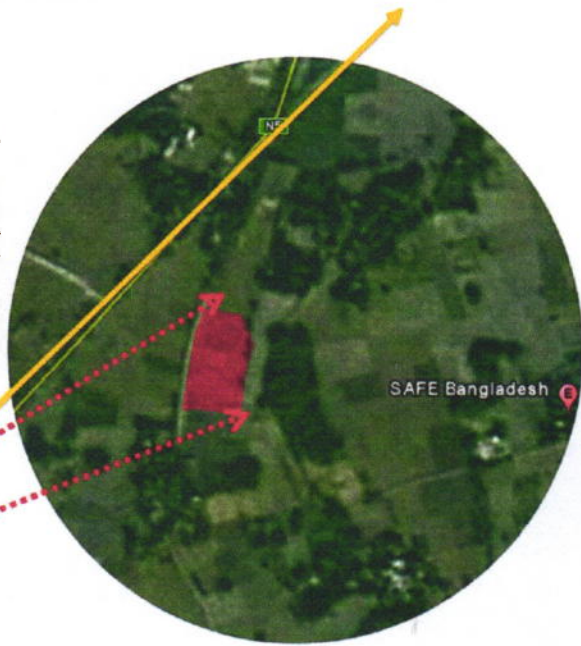
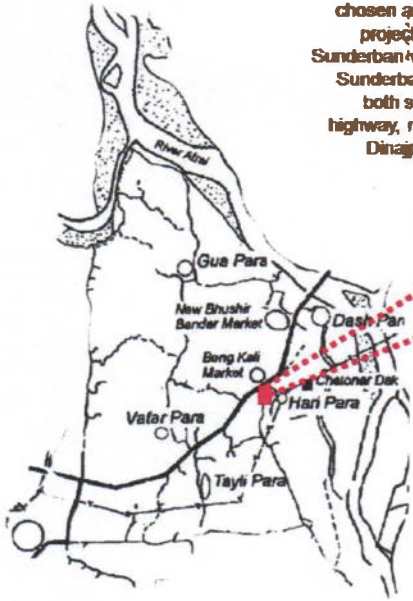
Local environment can be harmed with excess use of local materials and natural resources.

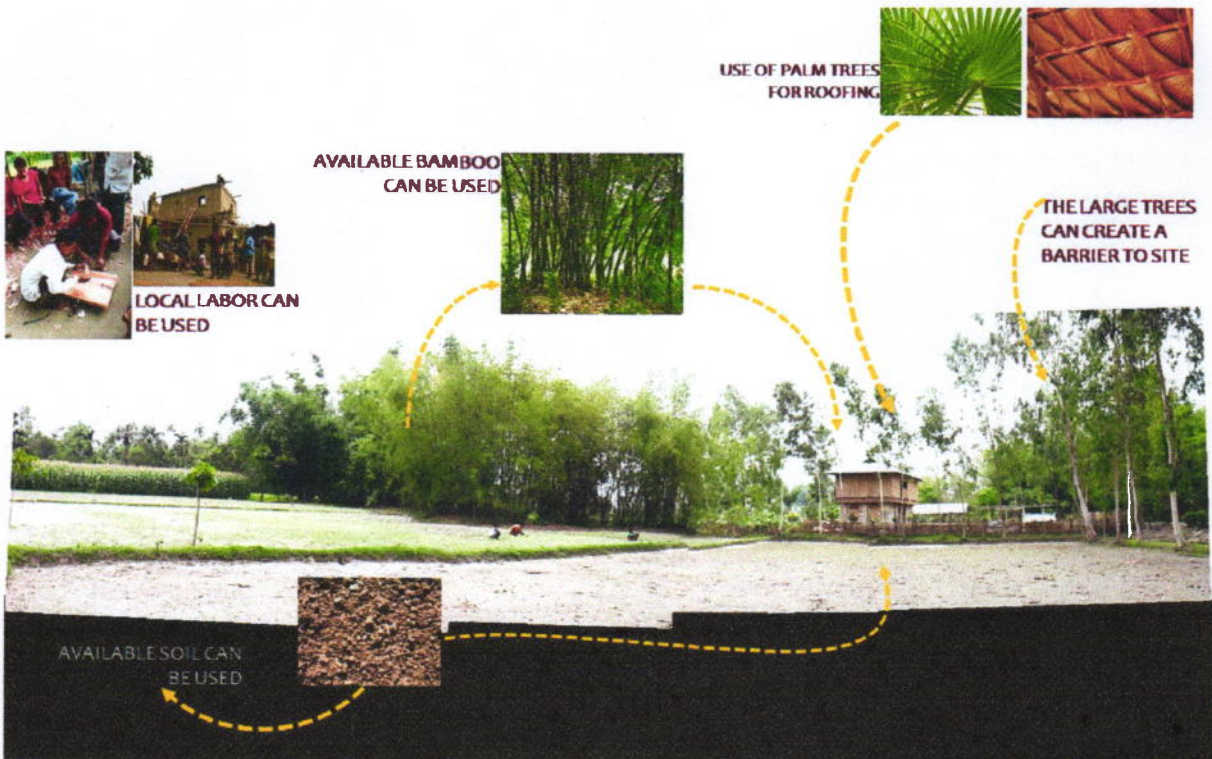
The price of local materials may drive up because of emerging demand.



SITE APPRAISAL

The existing site for SAFE head office has been chosen as the site for the project. It is situated in Sunderban village, Dinajpur. Sunderban village sits on both sides of the main highway, midway between Dinajpur and Saidpur.





GREEN AROUND SITE



SITEPHOTOES



CHAPTER 03: LITERATURE REVIEW

Rural architecture is the informal, functional architecture of structures, often in rural areas built of local materials and designed to meet the needs of the local people. It is estimated that worldwide close to 90% of all building is vernacular, meaning that it is for daily use for ordinary, local people and built by local craftsmen. Vernacular architecture is a term used to categorize methods of construction which use locally available resources and traditions to address local needs. It tends to evolve over time to reflect the environmental, cultural and historical context in which it exists. Frank Lloyd Wright described vernacular architecture as;

"Folk building growing in response to actual needs, fitted into environment by people who knew no better than to fit them with native feeling".

Rural Structures that are being constructed by a group of craftsman without having formal knowledge. These structures evolve through trial and error procedures guided by emotions and family needs. Usually such construction is being conditioned by its immediate environment and economic ability. Use of "Appropriate Technology" is very rare in such cases.

In architectural terms, appropriate technology comprises, two interdependent aspects: techniques and knowledge. "Techniques" include the use of materials, energy, climate control and construction techniques. "Knowledge" is the historical dimension, the theory of settlement development including land use and typologies, socio-cultural needs, contextual considerations, and the creative use of space and form. Implied in the definition is unquestionably also the principle that appropriate technology should benefit economically disadvantaged people, which in Bangladesh constitutes most of its population.

It is frequently documented that Bangladesh is one of the most vulnerable countries to future changes to both our climate and our depletion of natural resources and ecosystem. With a population of over 150million, Bangladesh is one of the most densely populated countries in the world, with approximately 80% of the population living in rural areas. This is leading to a large housing shortage, coupled with increase vulnerability to hazards, there is a great need to build stronger, more resilient rural housing.

A rural Bengali house was traditionally described as a grouping of rectangular huts around a courtyard, with the periphery of this courtyard surrounded either by vegetation, or screen of jute sticks or bamboo. Most houses are non-engineered and built by their owners and usually made

up of indigenous local materials such as bamboo, earth and timber. Corrugated Iron (CI) Sheets are also now common, being introduced by the British during the colonial period (1757-1945), along with brick that has been used for approximately the last 40 years.

As Bangladesh develops, so does its architecture. As *Patterns and Changes of Vernacular Architecture in Bangladesh (2003)* documents, 'in the time of globalization the architecture in rural areas is changing simultaneously...it is assumed that with the changes of building materials, changes in the use pattern of spaces and the additions of new built forms with houses, the architecture in rural areas may lose some aspects of its sustainability.'

"You must start right from the beginning, letting your buildings grow from the daily lives of the people who live in them, shaping the houses to the measure of the peoples songs, weaving the patterns of a village as if on the village looms, mindful of the trees and the crops that will grow there, respectful to the skyline and humble before the seasons. There must be neither faked tradition nor faked modernity, but an architecture that will be the visible and permanent expression of the character of the community. But this would mean nothing less than a whole new architecture." - Hassan Fathy

The Egyptian architect was intellectually stimulated by the art of the pharaonic period and was directly influenced by vernacular architecture. He studied the buildings of the old city of Cairo and Nubia in order to create a national architectural language based on the employment of traditional elements and building techniques. His projects are based on the use of a narrow vocabulary made of morphological and structural elements taken from tradition: parabolic arches, square spaces covered with domes, rectangular rooms or narrow spaces with vaults, courts, balconies wind towers. Fathy recognized that architecture is for human beings. He believed that architecture must be shaped by factors like the wind, sun, nature and the individuality and culture of the people involved. He rejected architecture that was not indigenous rooted in the location and the culture of the area, which in his mind found its truest expression in the vernacular architecture of a society.

Fathy devoted himself to housing the poor in developing nations and deserves study by anyone involved in rural improvement. Fathy worked to create an indigenous environment at a minimal cost, and in so doing to improve the economy and the standard of living in rural areas. Fathy utilized ancient design methods and materials. He integrated a knowledge of the rural Egyptian economic situation with a wide knowledge of ancient architectural and town design techniques. He trained local inhabitants to make their own materials and build their own buildings. Climatic

conditions, public health considerations, and ancient craft skills also affected his design decisions. Based on the structural massing of ancient buildings, Fathy incorporated dense brick walls and traditional courtyard forms to provide passive cooling.

"The one man missing in the building venture was the architect. The owner dealt directly with the men who did the work, and he could see what he was getting. For their part, the craftsmen were free to vary their designs within the limits of tradition and subject to the owner's approval. If an architect had come between owner and craftsmen, he would have produced plans that neither could understand, and, unable to escape from his drawing boards, would have remained quite ignorant that the variations of detail possible in a design make all the difference between a good house and a bad one."

Hassan Fathy demonstrated that it is possible to build for the poor and teaching people to build for themselves. According to him, "We need a system that allows the traditional way of cooperation to work in our society. We must subject technology and science to the economy of the poor and penniless. We must add the aesthetic factor because the cheaper we build the more beauty we should add to respect man."

The necessity of practicing rural architecture has been discovered by the great architects who devoted their knowledge to improve the condition of people who need it most.

"I would rather see a million houses that cost only 500 rupees each, and are only 200 sq. ft. mud and thatch, than one more high rise building, even it were necessary. Unless I had done something for the 20 million homeless, I wouldn't be happy doing a high-rise building."

- Laurence Wilfred Baker

MATERIALS

Architecture does not involve with people only, it has a very strong relation with nature also, specially while choosing materials. "The construction of a house can be seen as process of negotiation between the builder/owner and the environment. The takes from the earth what is needed to build, directly, or indirectly through a processing method. Mud is directly used for construction whereas cement is processed from limestone. Unfortunately the environment has little say in the negotiation. Man takes or often plunders what is he needs from the environment.

The environment may retaliate by upsetting the balance of nature i.e global warming etc. The issue of sustainability is very much related to how direct this negotiation process is." (K.H.Kabir, F.H.Mallik (2005), "Living below the line: Sustainability and the houses of the ultra poor")

We use natural resources by not considering its after effects. Here, K.H.Kabir has emphasized on the relationship between nature and its use and the fact that if we are not aware enough then we might end up hurting the nature. Each building has a relation with the nature, so one must be well aware to make a structure with local materials. Some of the materials are discussed below:

Bamboo

"The bamboo is literally the stuff of life. He builds his house of bamboo; he fertilizes his fields with its ashes; of its stem he makes vessels in which to carry water; with two bits of bamboo he can produce fire; its young and succulent shoots provide a dainty dinner dish; and he weaves his sleeping mat of fine slips thereof. The instrument with which his women weave their cotton are of bamboo. He makes drinking cups of it, and his head at night rests on a bamboo pillow; his forts are built of it; he catches fish, makes baskets and stools, and thatches his house with the help of the bamboo. He smokes from a pipe of bamboo; and from bamboo ashes he obtains potash. Finally, his funeral pyre is lighted with bamboo."

(Lewin, 1869)

Bamboo has played an important role in the traditional rural sector of Bangladesh. It is a prevalent material in the rural areas. Though it can be used for various functions, Its availability, durability, lightweight, tensile character makes it a good building material.

The role of bamboo in house construction has been substantial everywhere of the country where it grows naturally. It has strength, flexibility and versatility and therefore it is a suitable material for practically every part of the house – when treated and used properly. The advantages of using bamboo for construction do not end with technical advantages only. It is very economical because it is a local product and therefore amongst the cheapest building materials. Prices have been increasing lately though due to over extraction from forests and lack of plantations that are well managed. Cultivating bamboo can have very high yields if managed properly. Moreover, bamboo can be used as a substitute for timber in many applications, and compared to the trees used for that timber, bamboo grows substantially faster. One major disadvantage of bamboo is its poor resistance to fungi and bacteria. Without preservative treatment and proper use, the material has a very short life. With the rise of the

more durable brick and concrete, bamboo became inferior to those construction materials and its social status is considered very low. In fact, as soon as they can afford to, people tend to replace their bamboo buildings with masonry or concrete. With new technologies of constructing with bamboo, more durable constructions can be achieved as well as better appearance of the house - making it more socially acceptable. This is very well worth while bearing in mind all the advantages bamboo has as a construction material. Huge development efforts are taking place in Latin America, where different new building systems have been developed for low-income, middle-income as well as high income households. In Bangladesh, where over 70% of housing is made from bamboo, the applications are still very traditional. Shila K. de Vries, (2002), "Bamboo Construction Technology for Housing in Bangladesh", pp 6-7.

The technologies stem from family tradition and bamboo needs replacing every other year or so. Research into the subject of bamboo in Bangladesh has been restricted to botanical issues rather than applications in for example housing.

In order to improve the durability and performance, bamboo are treated with or without the use of chemicals. Treatment is intended to:

- Extend durability and lengthen useful life.
- Capture and delay degradation.
- Preserve dimensional stability and retain strength.
- Impart properties like fire resistance, luster, etc.
- Improve aesthetic qualities

Selection of the treatment method depends on many factors:

- State of bamboo - green or dry
- Form - round bamboo, splits or bamboo products.
- End applications - in ground contact, exposed to atmosphere, undercover, structural/non-structural.
- Scale - quantity to be treated and time available.
- Potential causes of decay - biotic (fungus/insects) and abiotic

Traditional bamboo treatment:

It is cheaper compared to chemical preservative methods, but less effective. It can be done easily in rural areas without special equipment. Therefore such bamboo treatment is needed to be promoted where such practice is declining.

1. Soaking in Water ("Pynol") - Most Common Practice

- The culms should be placed in water for around two weeks.

- Then they are to be dried for a week (in the shade).
- By leaching, this process eliminates the nutrients (starch) sought after by bamboo borers.
- Does not retard termite infestation.

2. Clump Curing

- Cut bamboo should be stacked vertically for a few weeks after felling, with branches and leaves intact.
- Such bamboo continues to live off its reserves and hence reduces starch content and thereby insect attack.
- Does not hold back termite infestation.

3. Seasoning

- This should be done by drying bamboo in the open, under cover, with as much air movement as possible.
- It can take a couple of months.

Chemical Preservative Treatment Methods:

1. Diffusion Method

Round bamboo, splits and slivers can be treated by keeping them submerged in water-borne preservative solution. The preservative moves into the bamboo due to concentration gradient and the cell sap moves out due to osmotic pressure. The method of diffusion can be varied by increasing the concentration of preservative to reduce treatment time, using two salts to increase fixation and filling the lacuna of the culms with solution by puncturing the nodes to fasten the diffusion process.

Scale: The process is slow, requiring a large number of tanks. It is suitable for treating 50-100 culms a month.

Method

- I. Prepare the water-borne solution of preservative in a tank. A tank with an outlet at the base is required for draining of solution and cleaning.
- II. For round bamboo, puncture the diaphragm with a long rod to improve penetration.
- III. Bundle the material and submerge using sinker load.
- IV. Cover the tank to reduce water loss through evaporation.

- V. Sludge may form after a few days especially in fixed type preservatives. Do not stir to disperse the sludge as this may facilitate deposition of particles on the bamboo surface and hinder penetration.
- VI. Keep the material immersed for 15-20 days for round bamboo, and 7-10 days for splits and slivers. Thin walled culms may require less time.
- VII. Drain and remove the treated material.
- VIII. Stack horizontally to facilitate further diffusion and air dry under cover.
- IX. Check the solution regularly with a hydrometer. Top solution daily to replace uptake.
- X. Clean tank periodically (4 - 8 weeks) depending on use. Remove sludge and mix it with chromic acid solution to retrieve preservatives. Filter in muslin cloth and reuse solution.

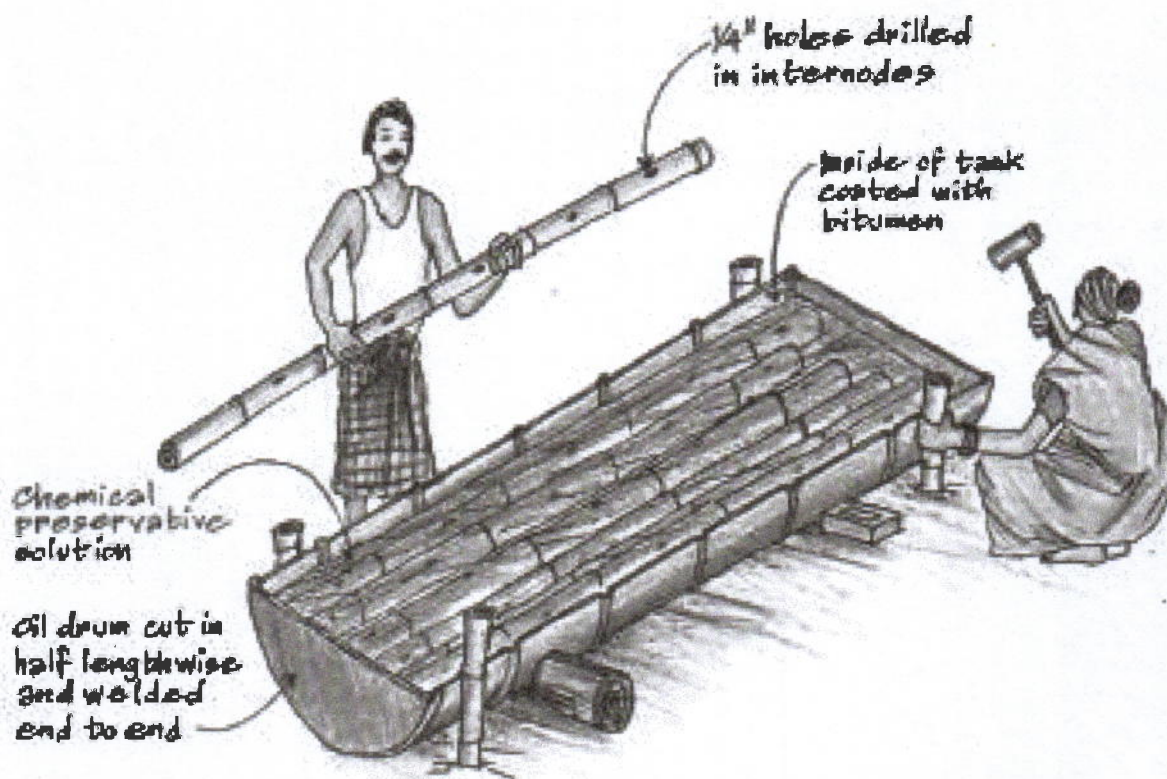
Preservatives

5-8% Boric Borax for indoor use

4-10% CCA for exterior use

3-5% CCB for indoor use

5-12% CCB for exterior use.



Dip Diffusion Method

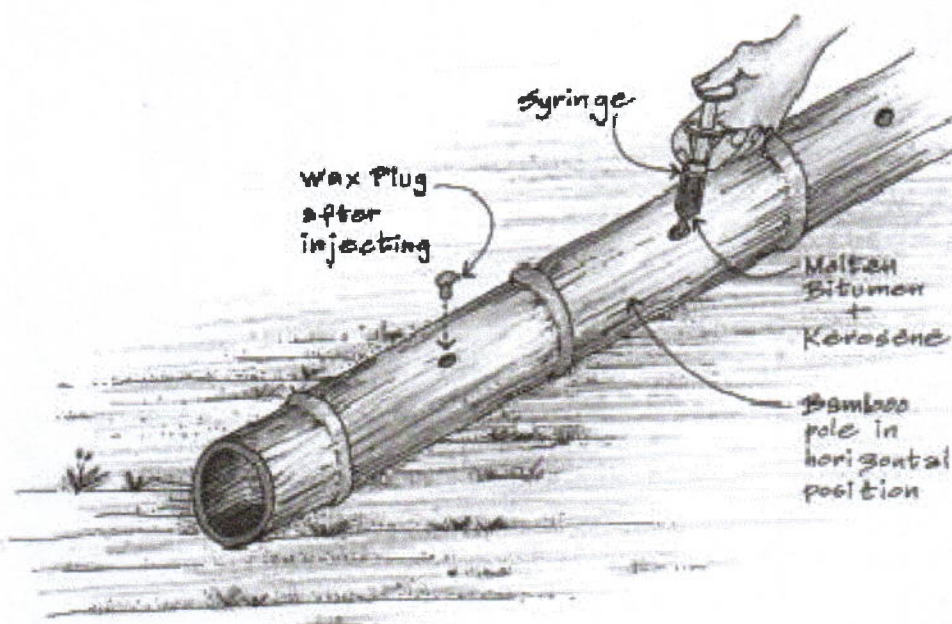
By increasing the solution concentration, soaking time can be reduced considerably. Also, in this way, there will be no contamination of the solution with cell sap and large-scale treatment is possible. This method is not suitable for round bamboo.

- I. Dip material for 10 minutes in high concentration solution (15-20% CCB) or 10% Boric acid: Borax at 50°C - CCB/CCA should never be heated
- II. Remove and stack the material under cover. The material should be packed tightly to minimize gaps in between
- III. Cover the stack with a polyethylene film to prevent drying.
- IV. Store for 10-20 days to allow diffusion.
- V. Air dry

2. Internodal Injection Method

Treatment method applicable for green or dry culms used for making members exposed to occasional wetting, such as bamboo posts.

- I. 6 mm hole should be drilled in each internodes of a whole bamboo culms and 20-50 ml creosote (tar oil/molten bitumen) combined with kerosene/ sump oil/ Mobil/ diesel should be injected with a large syringe.
- II. Paraffin wax (or putty, if available) should be used to plug the holes.
- III. The culms should be rolled 2-3 times a day for 7-10 days to distribute the preservative and complete the treatment.
- IV. preservative and complete the treatment.



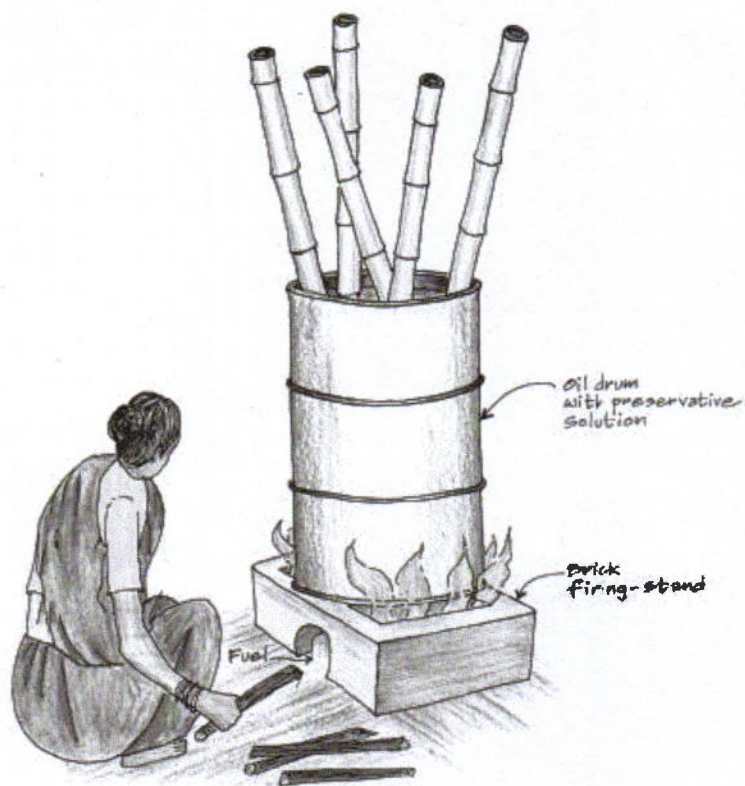
3. Hot and Cold Method

It is based on the principle that on heating, air from the cells will expand and partially escape. During cooling a slight vacuum is created due to contraction of the residual air and causes the entry of preservative into the cell.

Scale: Large quantities can be treated at one time.

Method

- I. For round bamboo - make two holes on opposite walls of each internodes near the node or rupture the nodal diaphragm.
- II. Air dry the material.
- III. An open tank fitted with steam coils or other alternate heating arrangement is required.
- IV. Load culms into tank.
- V. Fill tank with hot oil - creosote oil or mixed with furnace oil (50:50).
- VI. Heat to 900 C and maintain for 2-3 hrs.
- VII. Allow to cool to ambient temperature
- VIII. Drain excess preservative.



Preservatives

Creosote for exterior uses (can be heated to 900 C)

Boric acid-Borax (should be heated to 500 C)

Feasibility of treated bamboo:

Cost of a untreated bamboo house with thatch roof (around 200 square feet) = Tk 5,000

Cost of a treated bamboo house of same dimension = Tk 6,250

Cost increase due to preservative treatment = Tk 1,250

Cost of treatment = 25 % of the cost of untreated house

Service life of conventional untreated bamboo house = 7 years

Minimum expected service life of treated bamboo house = 15 years

That is, 25% increase in cost results in 100% increase in lifespan.

K.Iftekhar Ahmed (2005), "Design and construction of houses of flood prone areas of Bangladesh", chapter-3.

For the past all most four year SAFE has been working closely with a community low cost Bamboo and mud wall house in Dinajpur. SAFE has successfully run Bamboo Cultivation Rural housing workshop in Sundarban, Dinajpur 22 December 2011. Participants teamed up with local house builders, Bamboo cultivator both men and women.

All of participants agree coming season all most 86 decimal land bamboo will be cultivated. Three groups of 7 were set up and each group was given material and asked why need bamboo cultivation. Throughout the workshop the participant were able to express their spatial requirements about bamboo cultivation and a full understanding of this workshop.

In SAFE, bamboo is treated with a solution of boric acid, borax and water. This solution penetrates the bamboo easily, reducing the level of sap in the bamboo and making it less likely to damage by insects. A vertical soak diffusion technique is used. Bamboo is used in various purposes like building material, scaffolding, shuttering, ladders for various construction works, rural bridges and tools. (<http://safebangladesh.wordpress.com>)

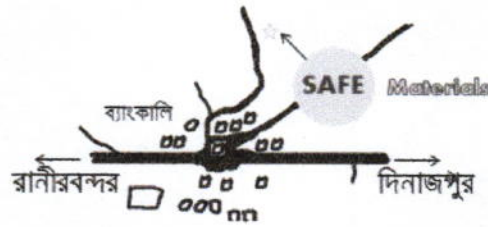
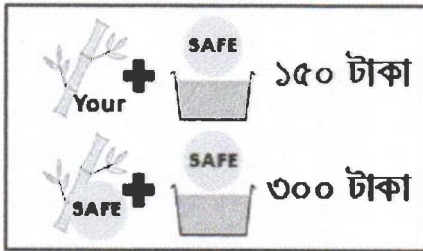
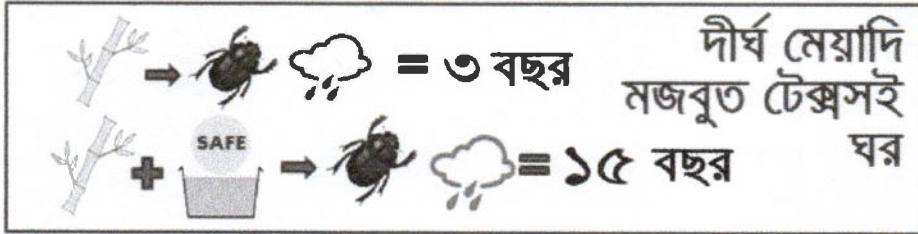
Improvised field testing was carried out to ascertain a reasonable strength value for bolted bamboo connections used in the cross-bracing of informal housing. A single connection strength of 3.9kN was determined (which includes a 0.60 safety factor for variations in materials and construction) provided that the following requirements are met;

- The end distance between the bolt and the end of the cross-bracing member must not be less than 2" (51mm)
- The minimum wall thickness of bamboo to be used as a cross-bracing member is to be 3/4" (19mm)
- The minimum outer diameter of bamboo to be used as a cross-bracing member is to be 2.5" (63mm)

Samuel G Stephens (2012), "Improvised field testing of bolted bamboo connections for use in bracing of informal housing."

SAFE Materials

Treated Bamboo প্রক্রিয়া জাত করন বাঁশ
Mud Blocks মাটির ব্লক
Bondachula বন্ধুচুলা
Sand Cement Tiles সিমেন্ট বালির টালি



Earth

Unfired earth is the most common building material in the world: nearby 1/3 and maybe even half of the world's population lives in buildings made of unfired earth. The remaining 2/3 of the population – maybe 50% – live in the other constructive typologies: in steel and in reinforced concrete houses.

(Maria Rosaria Gargiulo and Immacolata Bergamasco, "The Use of Earth in the Architecture of Hassan Fathy and Fabrizio Carola: Typological and Building Innovations, Building Technology and Static Behaviour.")

For many years earth architecture has held a minor role. It was often linked to poor housing and self-building phenomena and as such it wasn't considered worth being studied in depth. The search for materials at a low environmental impact due to the energetic crisis of the 1970s caused the re-approach of the world of architecture to unfired earth. Since then several research study centers have been created regarding this material.

A Study on the Traditional Housing Technology of Bangladesh (2007) reveals the mud-made housing technology is not only significant from ecological and economical perspective but also from social, cultural, and environmental context of human existence. There is also a huge number of resources supporting the importance of earth construction as a sustainable ecological building material.

There are many ways to use earth. Buildings can be made of raw unbaked earth alone in massive cob walls or in individual mud blocks (also called adobe). Plain earth or earth with a little lime or cement or bitumen can be used in rammed earth walls or compressed earth blocks (CEBs). Or earth can be poured into sandbags and stacked for earthbag walls, in what has been called the cheapest building method on earth.

Earth buildings last well when maintained. Outside walls of raw earth that get rained on should be replastered every few years unless they have special coatings. Siloxane is a new water-repellant that allows unstabilized earth walls to 'breathe' and dry out. It is absorbed into earth or lime plaster, so that it does not wear off quickly.

Raw earth buildings need to be protected from rain and flooding to work well in humid climates. A good roof and a dry base of stone or cement stucco on gravel bags, or concrete are very important. Unstabilized earth construction must be raised 50 cm or more above the ground in rainy areas. A good vapor barrier must be placed between all un-stabilized earth and concrete surfaces. Many people don't realize that raw earth buildings are healthier than concrete in high humidity. They never absorb enough water to let mold grow on them like concrete does. The most dampness they absorb from the air (5- 7% by weight) is not enough to let insects or mold grow (which need between 14 and 20%).⁴⁷ Very humid air is near its dew-point. Every time that damp air warms up just a little more than a building, moisture in it condenses on the slightly cooler surface. Heavy concrete walls in very humid areas become frequently damp from condensation, causing algae or mold growth.

Hassan Fathy tested equally sized buildings in Cairo in 1964. On a March day the temperature varied between 12 and 28 C. A building of 50 cm thick mud block with a vaulted mud block roof only stayed a comfortable 21 to 23 C inside. A similar building of 10 cm thick precast concrete walls and roof became 9 C hotter inside than out. Overall it was within the human comfort temperature range for only 5 hours out of 24. Because the mud block held more heat, it warmed up slowly in the morning, and cooled off slowly at night. It also insulated much better than the concrete, and may have reflected more sunlight. (depending on surface finish)

How common building materials compare at holding heat, insulating, and cost:

<u>Material-thickness</u>	<u>Holds less heat (btu/in/°F)</u>	<u>Reflects Sunlight</u>	<u>Insulates better (R val.)</u>	<u>Costs Less</u>
Solid poured concrete- 15cm	2.7 times better (15)	Smooth: 35%	Insulates the worst (0.5)	Greatly > materials + skilled labor
Fired bricks- rat trap 20 cm	4 times better (10)	Regular dark: 20%	2.8 times better (1.4)	> materials + mason
Hollow conc. block- 20cm	5 times better (8)	Rough stucco: 20%	2.2 times better (1.1)	Standard with mason
CEB- 20cm	2.4 times better (17)	Light: 40%	4.4 times better (2.2)	<materials + mason
Mud block or cob- 40cm	1.2 times better (33)	Light plaster: 40%+	8.8 times better (4.4)	33% materials? + mason
Earth in earthbag- 48 cm	Holds most heat- (40)	Light plaster: 40%+	10 times better (5.3)	Cheapest: site mat'ls + unskilled labor
Light earth in earthbag – 48cm	2.1 or more times better (19)	Light plaster: 40%+	12 + times better (6+)	Cheap: mostly site mat'ls + unskilled labor

Patti Stouter, "Planning Buildings in Warm Humid Regions: Hints for NGOs"

EARTHBAG

Earthbags are a simpler way to build with earth, using the strength of woven fabric bags while the earth dries. Because it is tamped, it has some of the properties of rammed earth without the need for heavy forms. Earth bag is finished with a plaster layer of earth materials and/ or cement or lime.

Earthbag building works well with a greater range of soils than most other earth techniques, between 5% and 30% clay. Earthbags can also be built of sand, gravel, or soil without clay, if they use some bamboo, wood, or steel reinforcement, or have a plaster of cement stucco, techniques which are better in dry regions. It can be reinforced enough to perform well even in high seismic risk regions.



Compressed earth blocks (CEBs)



It uses earth with about 5- 10% clay. They are usually 2.5 times thicker than fired bricks, but they insulate better and moderate humidity better than fired bricks. These smaller blocks require more time for construction. Because CEBs are less expensive than fired brick, and can be produced by

individuals with simple equipment, these blocks are improving living conditions in many countries. In humid regions they must be either stabilized or protected by a substantial roof overhang. CEBs produced with bitumen or cement cost more than raw blocks.

The quality of individual production should be pre-tested before use in exposed areas, because poorly stabilized CEBs can be damaged by absorbing too much moisture. Stabilized CEBs can be coated with cement plaster.

MUD BLOCK

Unbaked mud block (or adobe) is usually built by masons, but is twice as thick as CEB walls. It is inexpensive because it does not require fuel or sophisticated equipment. Because of mud block's historic usage, basic rules of strength for unreinforced construction are well accepted for regions not subject to earthquake hazard. In regions with medium or high risk of earthquakes, some sort of reinforcement may be necessary. Mud block can be used there as infill between concrete posts. Historic structures of mud block have been built up to 8 stories. It is strongest if built of short wall segments that include piers or corners. Windows should be spaced at least 1m from corners, and 1m apart unless a pier is located between windows. Corbelled window openings can be built without lintels.



Mud block requires water resistant mud plaster on exterior walls that must be renewed every few years. Like all raw earth construction, mud block should not be covered with concrete stucco. The concrete retains too much moisture and will decay the mud block. This material is a good choice for interior walls and furnishings, especially in buildings where reduced humidity is needed to preserve materials, like museums, libraries, and computer centers. Mud block walls are easier to clean and still retain much of their humidity-modifying properties if finished with a lime-plaster or tiled surface, or coated with a natural oil finish.

RAMMED EARTH / COB

Solid earth can be rammed or built as cob. These are both difficult to build in wet climates because they dry slowly. Rammed earth walls need large forms to hold the earth in, are waterproof, and strong enough to build in multiple stories. Cob walls are traditional in many parts of Africa. They are built of hand sized loafs of mud, without forms. Since they must be thick to be strong they may receive more condensation than CEBs.

COMPARING EARTH CONSTRUCTION PROCESSES

Construction materials may be chosen because of the availability of related materials, supplies, tools, or skills. This chart may help to evaluate the different strengths and requirements of different construction processes using earth.

	Earthbag	Adobe	Rammed Earth	Cob	CEB
Special curing process? (= delays)	No	Yes	Yes	Yes	Yes
Special soil mix?	No*	Yes	Yes	Yes	Yes
Relatively fast?	Yes	No	No	No	No
Expensive forms?	No	No	Yes	No	No
Expensive tools and equipment?	No	No	Yes	No	Depends on hand vs. power machines
Water required?	No	Yes	Yes	Yes	Usually (minimal)
Work in the rain?	Yes	No	No	Yes	No
Excessive handling of materials?	No	Yes	Yes	Yes	Yes
Owner-builder friendly?	Yes	Yes	No	Yes	Yes
Easy to make curved walls?	Yes	Yes	No	Yes	Yes
Domes?	Yes	Yes	No	Yes	Yes
High R-value?	Yes**	No	No	No	No
Foundation required?	No	Yes	Yes	Yes	Yes
Earthquake/flood resistance?	Excellent	Poor	Fair	Poor	Poor
Plaster required?	Yes	No	No	No	No

Green = Favorable Red = Not Favorable

* Assumes a suitable soil is used (= most soil types)

** Assumes bags are filled with scoria, pumice, etc. (= porous volcanic rock)

Patti Stouter, "Planning Buildings in Warm Humid Regions: Hints for NGOs"

Advantages of earth building:

- low cost of materials
- low energy and transportation costs
- can be built personally by the homeowner
- thermal mass for natural heating by the sun
- maintains a balanced indoor climate without extremes of temperature
- a renewable non-toxic resource which can be readily recycled
- low fire risk, non-combustible
- virtually soundproof
- natural warm texture and colours
- allows expression of personal creativity using traditional crafts and skills
- can be shaped by hand into attractively rounded forms and niches
- variable light quality reflected from moulded and textured surfaces

Disadvantages of earth building:

- time and expense required for soil testing, calculations, and reports
- requires more customized design effort
- design limitations, e.g. wall heights, the size of openings for windows and doors, or necessary roof overhangs to provide weather protection
- construction period longer and also weather-dependent
- higher overall contract cost unless you use your own labor

Any architectural design should take account of the limitations of the building materials and techniques. Earth is a heavy, fairly low-strength material so it is used to make thick walls of limited height. The upper storey, if any, is usually confined to an top story within the roof space. It helps to have a light roof structure, and to keep window and door openings fairly small and away from the corners of the building.

A roughly symmetrical structure will behave more predictably in an earthquake. Small simple buildings can be designed easily. A more adventurous design will require the engineering analysis.

Earth buildings require stable sites which do not flood and which ideally provide some weather protection from the erosive effect of driving rain

Participatory Approach in SAFE

SAFE recognizes the importance of participation in new techniques are going to be accepted and spread within the local population. One house has been built through a partnership between SAFE and the household. Both parties contributed labor and materials in an approximately 50/50 split. This split was agreed at the outset and a simple hand written contact outlining each party's responsibilities was signed. The size and type of house was decided by the household based on



available materials and space requirements.

The house included some new techniques and SAFE made sure that the household and builders understood these fully. As part of this, a 1-day building-for-safety workshop for households in the local area, students and local builders was organized. These workshops included practical demonstration of these new techniques.

Improved Construction Techniques

The house has been built with the household of Udoi and Doiya Rani Roy in Baniar Para, Sundarban village, Dinajpur. The house was built to replace an existing sleeping room which was in poor condition. The house comprises of one room of outside dimensions 17.5ft by 8.5ft. The house is built on brick foundations. The structure is made rammed earth with bamboo reinforcement. The roof is of hipped (*chochala*) construction and made with bamboo frame and corrugated iron (CI) sheet. SAFE has used added several low cost improvements to this traditional house.

Foundation

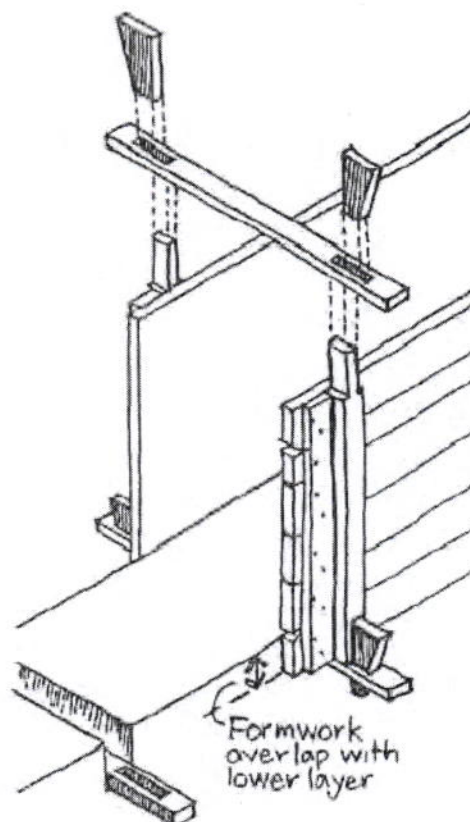
A layer of plastic sheet has been used to provide a damp proof layer between the top of the brick foundation and the mud walls.

Walls Vertical and horizontal bamboo reinforcement used.

Formwork fixing detail

Walls are made used rammed earth with cement stabilized mud, a techniques which make the wall much stronger and more resistant to water. The mud was mixed with 5% cement^{1,2} (refer to footnotes for more information on this technique). Cement stabilized earth was used only for the bottom 6ft (bottom two layers) of the wall – above this, protection from rain is given by the roof overhang.

The forms were constructed on site of dimensions 6'8" x 3' with made using 1.5" thk timber boards.



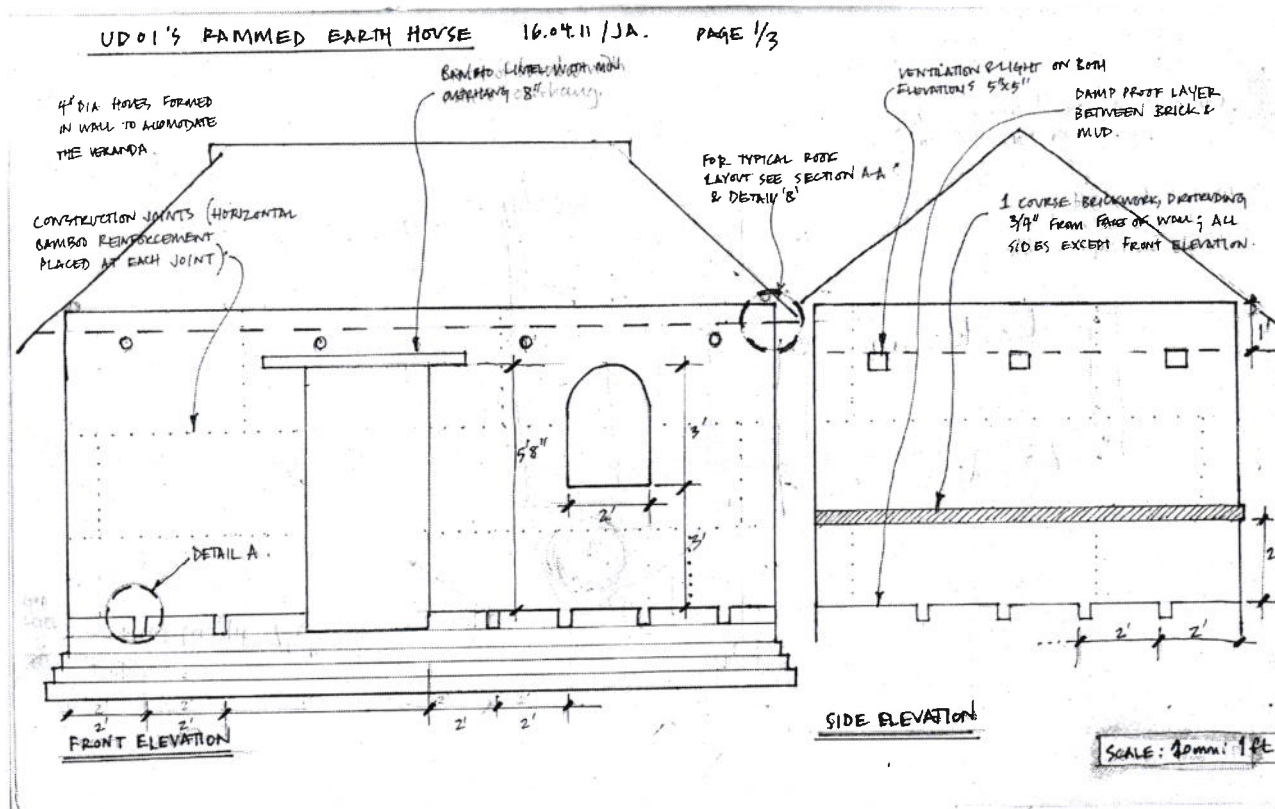
An overhanging layer of bricks has been built into the wall approximately half way up. Any water which comes into contact with the wall above these bricks will drip clear of the lower section of the wall – reducing damage.

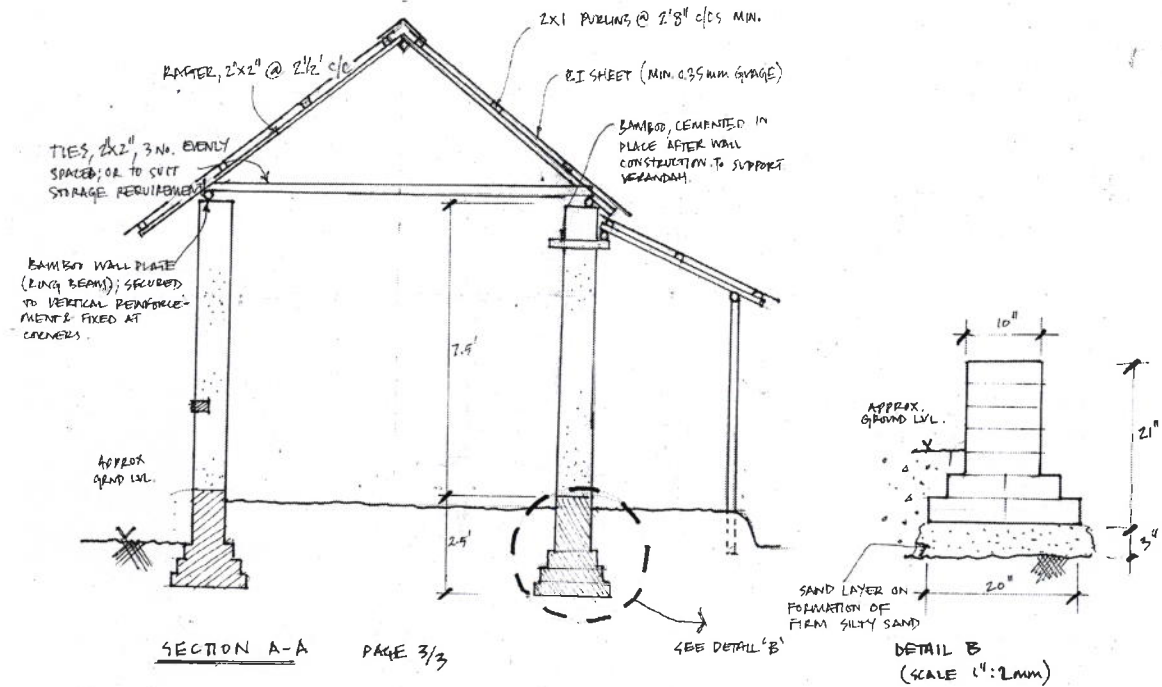
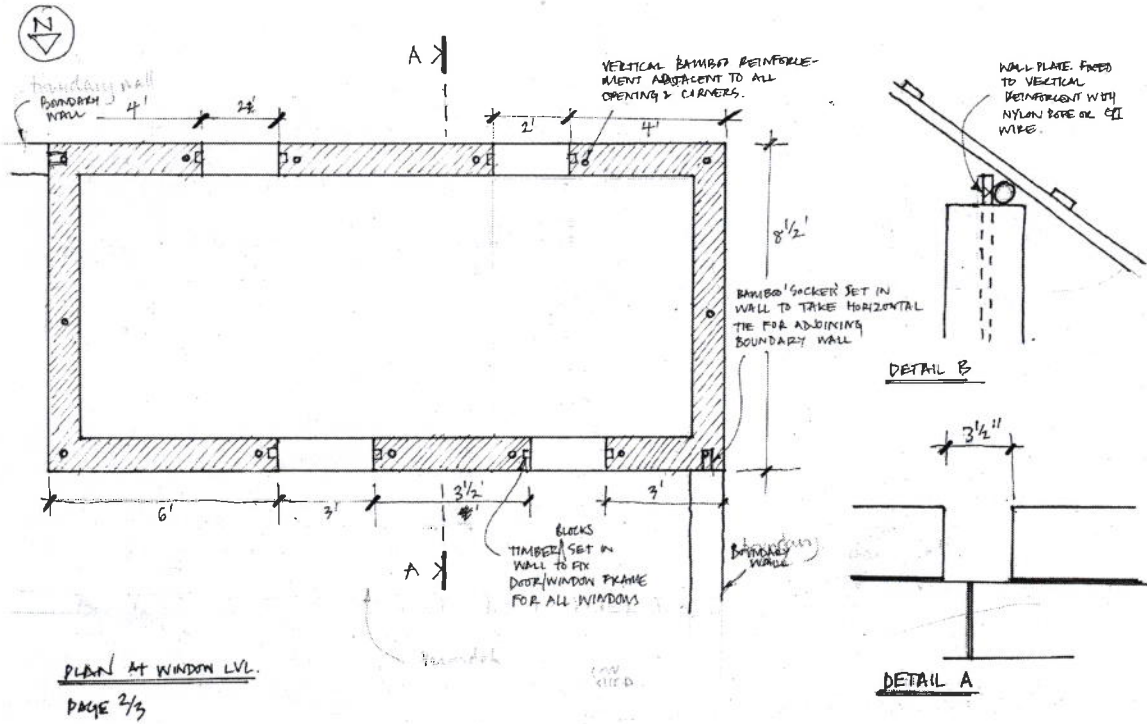
Ventilation – 3 windows and ventilation holes have been used to provide adequate ventilation within the house.

A bamboo ring beam has been constructed at the top of the walls fixed to the vertical reinforcement.

Roof

The roof is secured to the walls using the bamboo vertical reinforcement. Overhang of approx 2" is given to give adequate protection from rain. Nylon rope has been used over jute rope for its longevity.





CHAPTER 04: CONTEXTUAL ANALYSIS

4.1 HISTORICAL BACKGROUND

Although Dinajpur does not suffer from the severe storms that affect the coastal region of the country, localized flooding does often occur and strong winds in September and October regularly cause damage to houses. Dinajpur also lies in the highest earthquake risk zone in Bangladesh. Dinajpur's economy depends largely on agriculture, the area being famous for its rice. Approximately 40% of its population are landless laborers. It also has a large Hindu population, over 20% according to the 2001 census.

The client, SAFE provides services in the rural area of Sundarban in Dinajpur, focusing on a relatively small geographical area consisting of around 500 households in total. It has a recent history of successful workshops and other programs.

1. Building for Safety workshops:

There are 2 day long workshops with up to 20 people from the local community and local builders encouraging both men and women to participate. The workshops include practical sessions eg. mud wall building, but also sessions on softer subjects such as house maintenance and the longer term financial benefits of certain techniques. The aim is to hold one workshop during the construction of each demonstration house.

2. Construction of demonstration houses: Together with the household and local builders, design and plan of the construction and selection of appropriate techniques is done. There are options that suit the house-owner's wants and needs, and are in line with what the owner would have originally paid, costing between 10-20% extra. SAFE subsidizes approximately 50% of the cost of the house.

3. Provide material support and advice to householders using our techniques: SAFE provide follow up visits to communities to reinforce the messages from workshops and encourage their use in future building works. Subject to funding we will subsidize the additional costs of construction work using our BfS techniques for low income households (households that own less than ½ acre of land).

4. Construction of community centre: SAFE aims to construct a local community centre in partnership with the local community. The community has participated in the planning of the project, which will be managed by community committee and who will donate land and labor for

the construction. The centre will be used as a pre-school for 25 pupils, and to hold events - weddings, funerals, public meetings.

The design will promote sustainable materials and construction techniques in line with our existing approach.

5. Partnership with learning organizations: SAFE has partnerships with BRAC University, Housing and Hazards, Exeter University (UK) and RedR-UK to offer opportunities for students and professionals to participate in the our workshops and construction of demonstration houses.

6. Tree planting: The trees provide future protection from wind and will prevent soil erosion and SAFE includes small workshops to demonstrate this. The team use selected indigenous species of trees and work with communities to select the type of tree and carry out the planting – often using trees that will later bear fruit or have medicinal uses. Since 2008 SAFE has successfully planted approximately 1000 trees in partnership with the local government. Depending on funds we will aim to plant 700 trees in summer 2011.

7. Income generating activities: SAFE pursue the development of private construction work whose profits will subsidize its activities.

4.2 LOCAL ARCHITECTURAL CHARACTER

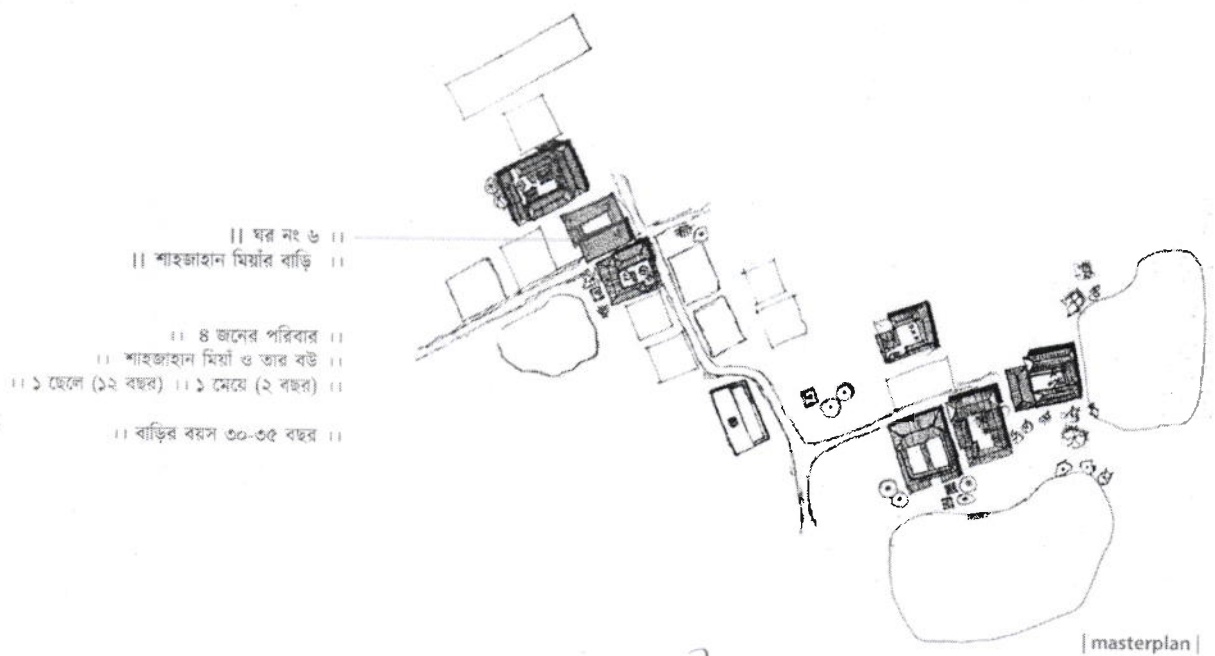
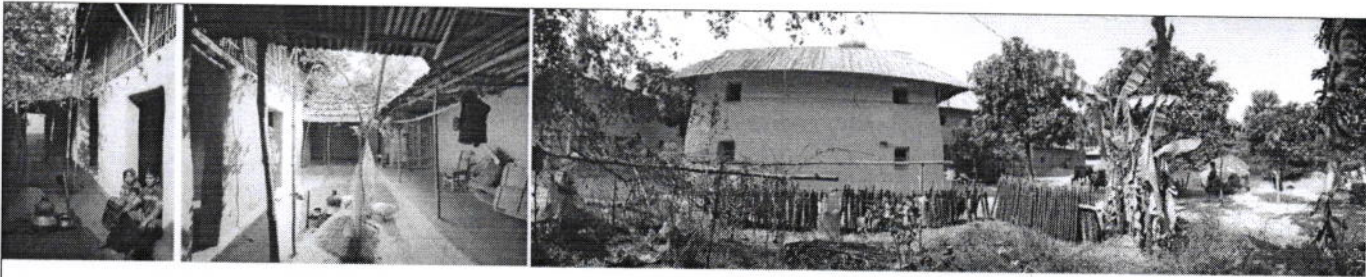
Traditional Houses represent the heritage of a country and also reflects traditional forms and values, fundamental to the culture of the people of that country. It possesses distinct characteristics as regards planning, use of materials and location.

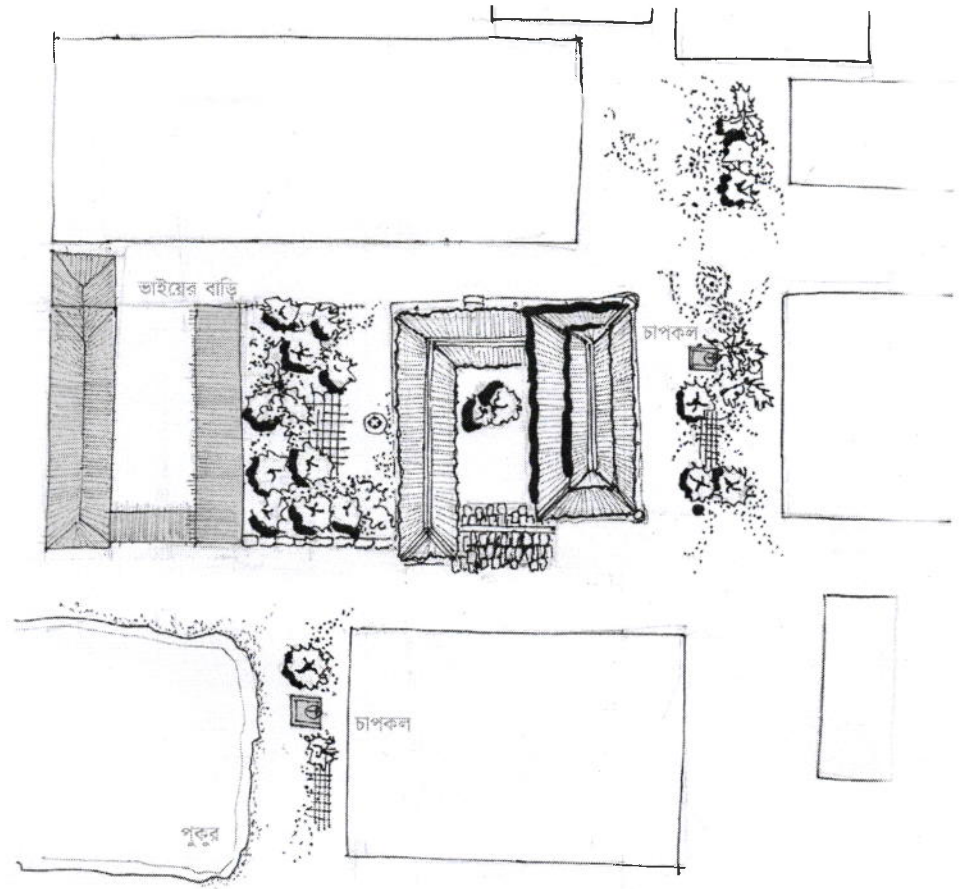
As rural Bangladesh housing typologies vary from region to region depending on available materials, the choice of the construction approach is dependent on the owners particular circumstances and preference. It is completely reasonable that two adjacent houses can be made of completely different materials. The choice of materials available is largely cost driven. Kutcha materials such as earth and bamboo construction being the most affordable, semi-pucca or pucca brick and timber are more expensive, although these materials hold more cultural prestige and deemed as much more durable.

Available materials used in Dinajpur: bamboo, CI(Corrugated Iron) sheet, Thatch, Clay tiles

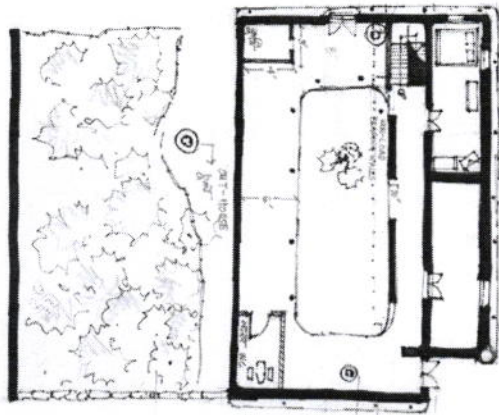
The only buildings seen nearby are the farmers' houses, which have mud walls and straw-thatched roofs. The building materials are available within the villages. Bamboo is used extensively – as structural members (fastened with jute ropes/string), or flattened for wall panelling, or simply woven together to act as screens.

Study of a household in Tanore (Collected from 4th year student project by Badru Ahmed and Imtiaz Hossain)

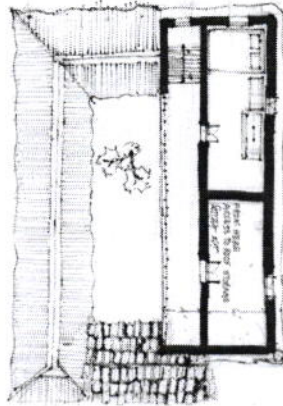




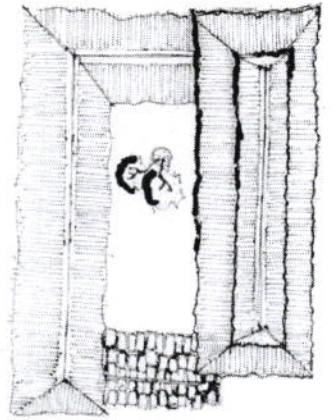
an | খর নং ৬ | শাহজাহান মিয়া'র বাড়ি |



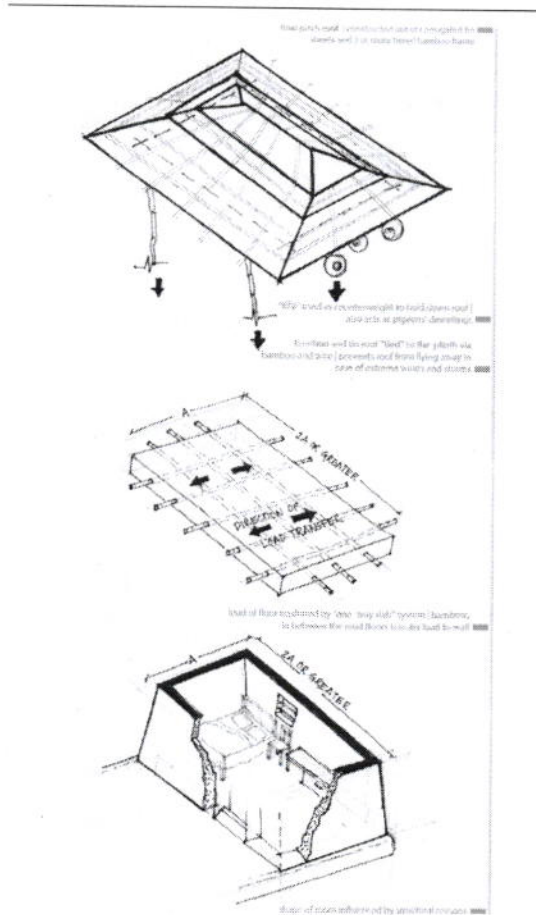
| plan | ground floor |



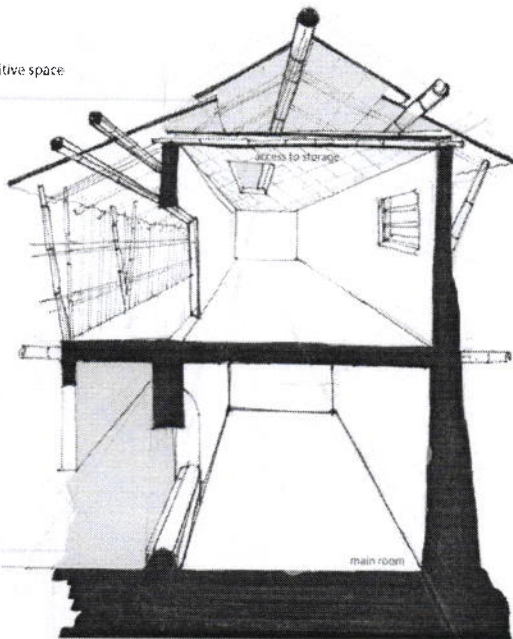
| plan | first floor |



| plan | roof level |



storage space on triangular positive space
formed by pitch roof



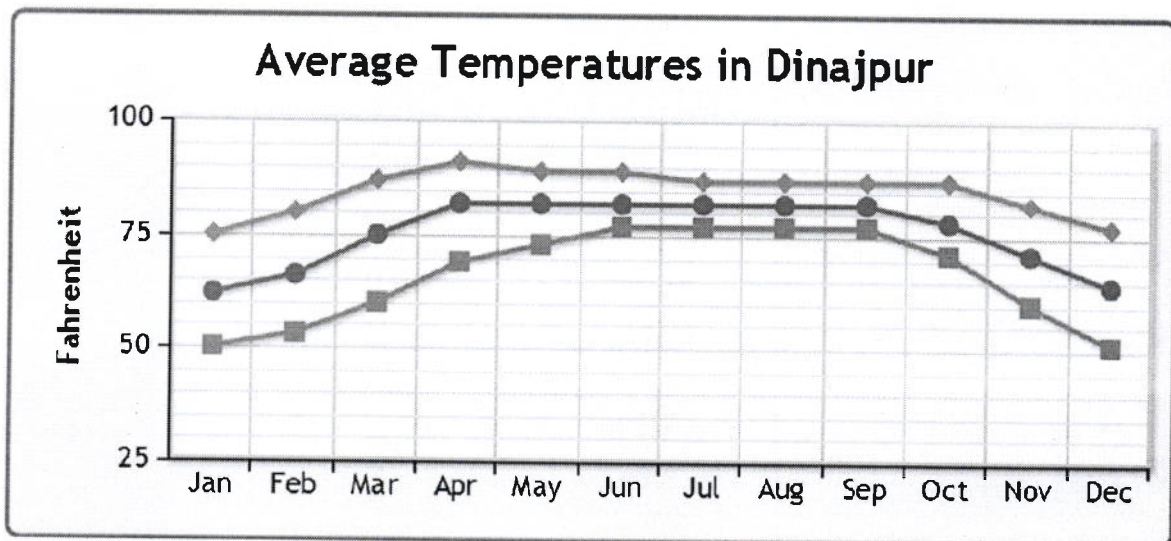
4.3 CLIMATIC CONDITION

Dinajpur district experiences extremes of weather. There are three main seasons in Dinajpur. They are summer, monsoon and winter season. Summers are extremely hot and humid. Winters season experiences cold weather conditions.

Summer season is typically from early March to Late May. Summer experience high humidity. Temperatures in summer vary from a minimum of 32°C to a maximum of 40°C. Humidity may rise up to 80 % in May. May is the hottest month of the year.

Monsoon season is from June to September. August receives the most amount of rainfall and humidity is also high during this period. Temperatures fall towards the end of the monsoon season.

Winter season starts in late November and goes on till February. The winters are extremely cold and temperatures can fall rapidly in January. December and January are usually the coldest month of the year. Temperatures range from a minimum of 10°C and rise up to a maximum of 20°C. (<http://www.latestworldweather.com/destinations/asia/bangladesh/dinajpur.html>)



(www.weatherbase.com)

The challenge is to make a structure with natural ventilation and lighting considering this situation. Ultimately, the center itself will be a shining example for sustainable architecture.

CHAPTER 05: CASE STUDY

5.1 EXAMPLES_ INTERNATIONAL

Hunnarshala Foundation, India

We can see shining example of such craftsmen based local research center in our neighborhood countries like, India. It is named Hunnarshala Foundation, situated in Kutch, Gujrat.

Hunnarshala Foundation (HSF) was formed in response to the earthquake in Kutch in 2001. This organization facilitates self-sustaining housing for the poor, favor artisans' involvement in mainstreaming



buildings and promotes local eco-friendly and cost-effective materials and technologies like earth, bamboo and sewerage recycling. HSF has worked in disaster rehabilitation in India, Iran, Indonesia and Afghanistan. The HSF approach particularly focuses on empowering communities and their artisans by mainstreaming their sustainable knowledge systems, positioning artisans to be in charge of the technical success of the programs and ensuring a decentralized community driven process. They provide technical guidelines and training to engineers and artisans as well as inputs for policy making for the government. The HSF approaches in their work is to see:

- I. how people are empowered to shape their own habitats;
- II. how habitat solutions can become more environment friendly, sustainable and disaster safe; and
- III. how local artisanal knowledge and skills can deliver high quality products.

(www.hunnar.org)

Main activities:

- **Green technologies:**

Hunnarshala uses a design vocabulary based on traditional features like courtyards, verandahs, and other features for passive solar cooling to respond to climatic needs. The materials and technologies promoted and used by the foundation includes lime, earth, thatch, country tiles along with roof water harvesting, and decentralised waste water recycling.

HSF works with stabilised and non-stabilised mud blocks, rammed earth, wattle & daub and adobe. HSF is making efforts to use these green approaches and technologies at large scale such as mass housing and city level.

Hunnarshala collaborates with its sister organisations to get inputs particularly on water, renewable energy, bio-diversity, etc.

- **Community driven housing:**

HSF helps people get together, develop their own relevant solutions and articulate their plan of actions. The people achieve this not as individuals but as a community. This is also a process of empowerment and results in habitats that nourish and enrich lives of its inhabitants. This process of housing through collective decision-making and efficient management results in speedier construction, and caters better to individual and community needs.

- **Strengthening artisans:**

Amalgamating technology with cultural needs, local artisans have developed habitat design and technologies that are time-tested for safety and use environmental resources in a sustainable way.

However, new knowledge creation in scientific and design institutions has disregarded this traditional knowledge base. New knowledge systems have created specializations, where artisans have been relegated only to skilled labor and the prerogative of providing the design and artistic content is controlled by new educated elite. This has resulted in lack of validation of traditional sciences and its inability to keep pace with fast changing needs of modern times.

Hunnarshala is exploring:

- validation of the science of local artisans' knowledge;
- redesigning products using their knowledge and skills for the contemporary needs;

- documenting their knowledge base in its cultural and environmental context;
- identifying the master artisans to link them to market through their projects.
- Through this process, Hunnarshala hopes that an indigenous vocabulary of architecture would emerge giving expression to local culture

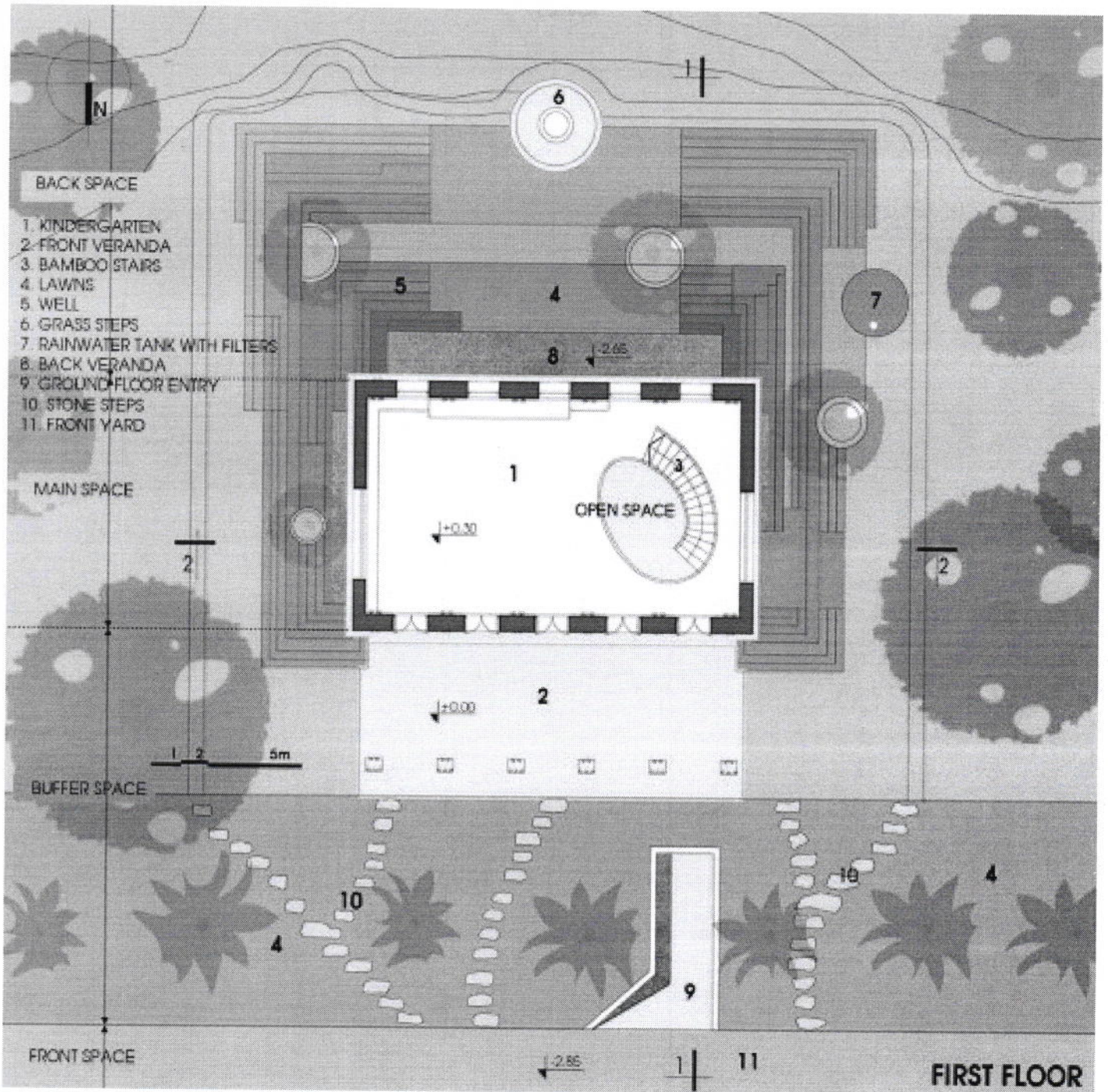
Suoi Re Village Community House, Vietnam

Located in Suoi Re, Luong Son, in the Hoa Binh province, the community house was erected against a picturesque scene, leaning against mountains and facing an incredible valley. Contextually aware of its surroundings, as well as the architectural typology of the Kinh and Muong people of the area, the interior of the structure is strikingly modern by comparison.

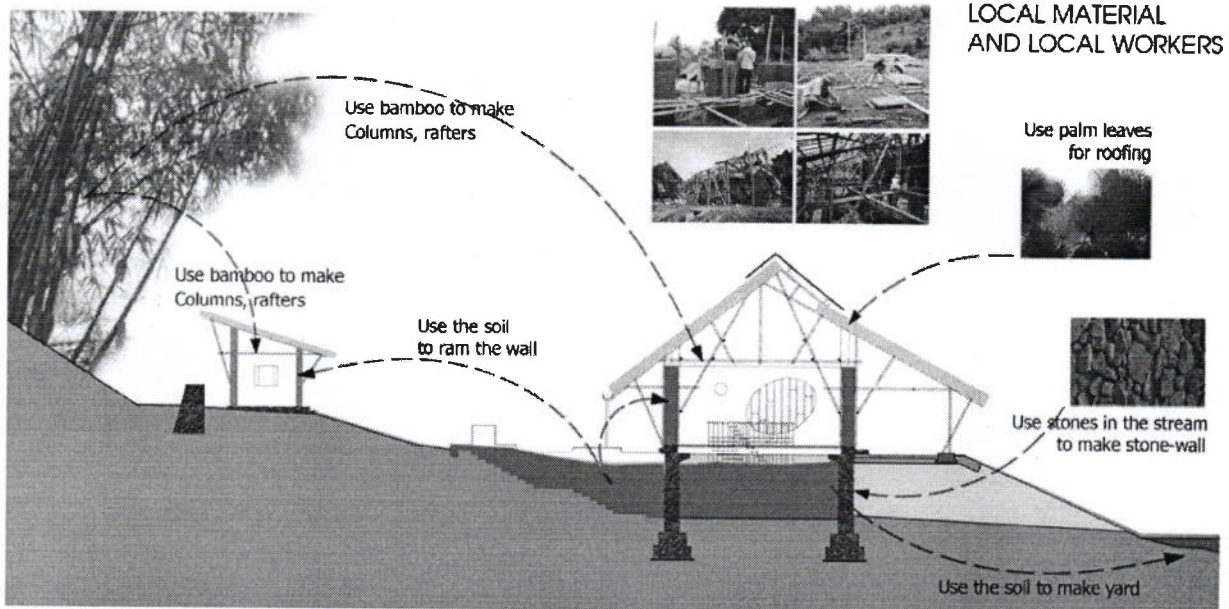
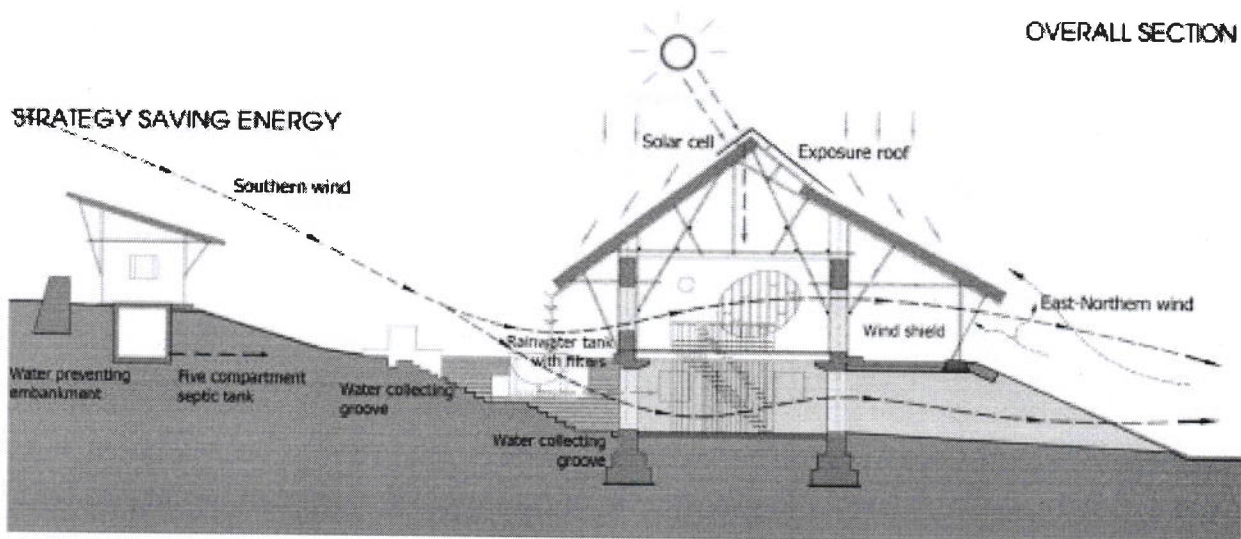


The idea of having a convection wind tunnel, the ellipsoid open space, the grass steps, slopes taper, exposure roof make all those connect with the front and the back, the interior and the exterior, the upstairs and the downstairs, creating a continuous chain of open space.





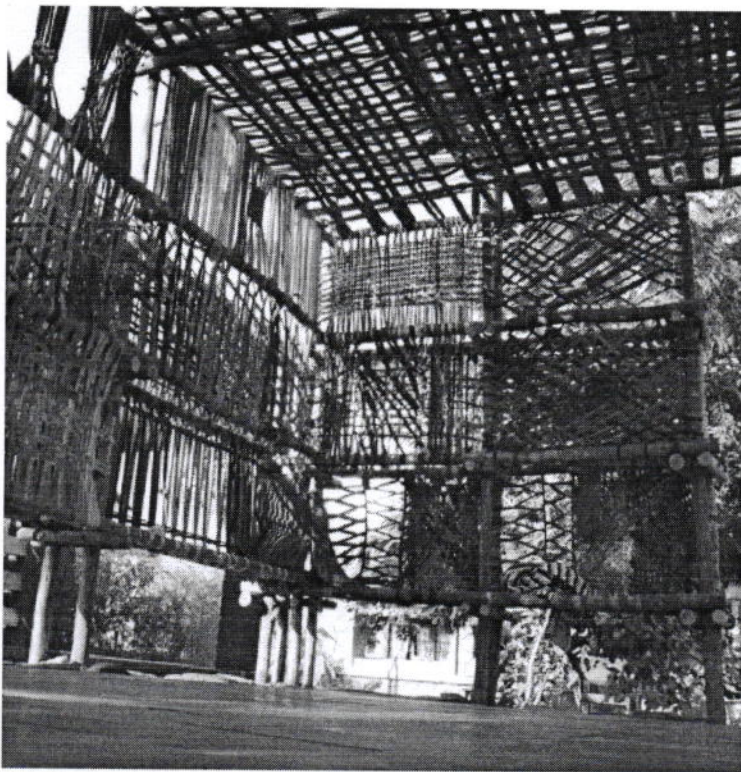
OVERALL SECTION



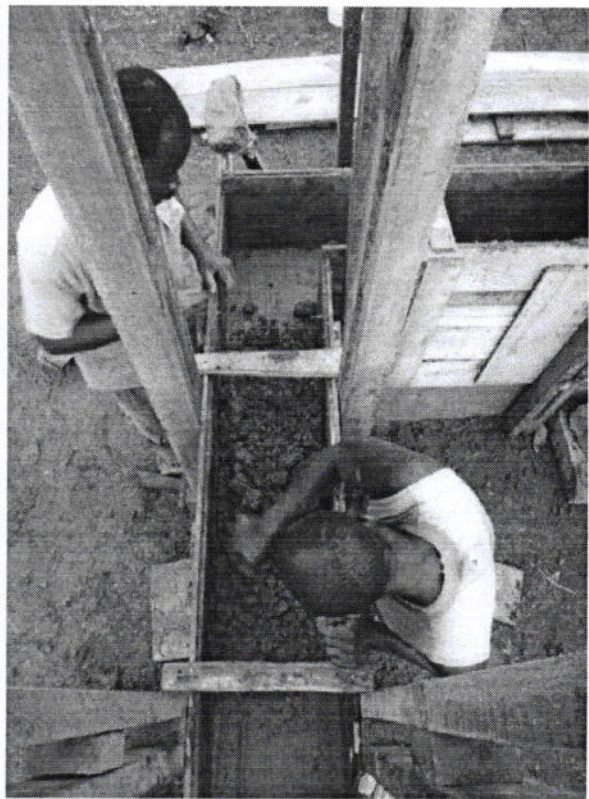
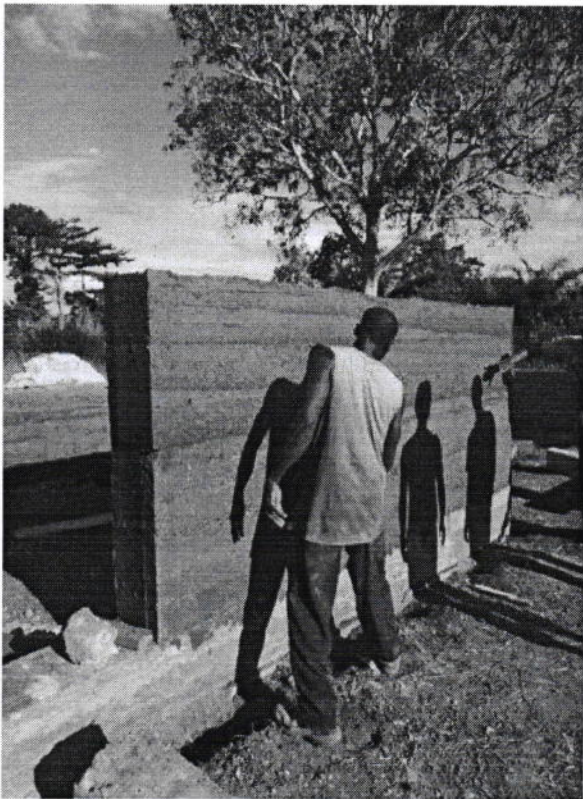
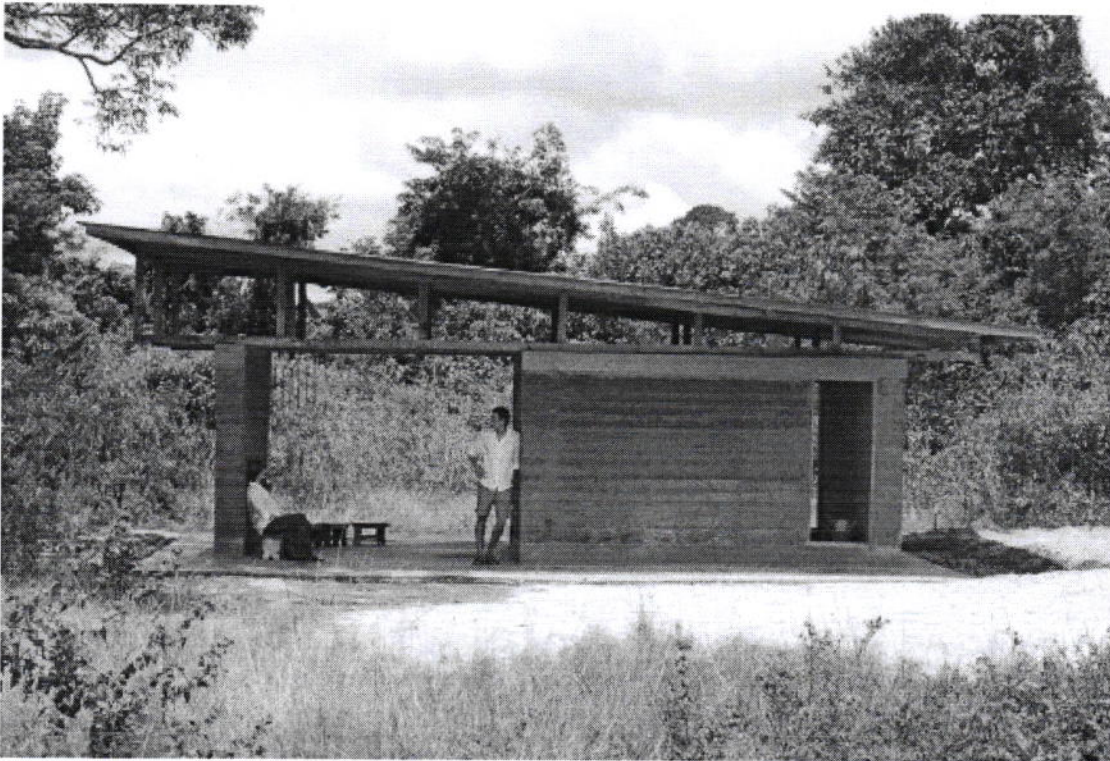
The overall space is organized in a chain, where the front space is an open courtyard, the main living space lies at the center and consists of connecting two floors. Upstairs one can find a teaching area, library and meeting areas. Overall, open space and programmatic flexibility were the focal points in determining the layout of the floor plan.

Built simply and economically with local materials, the ground floor was constructed with smoother stone, while bamboo doors cover passageways, and a bamboo ceiling warms the space. A rammed-soil wall with heavy stones supports the structure, and the bamboo roof frame has been adorned with dense palm leaves, providing protection from above.

Some more examples



Children's corner, Center for rural knowledge, Halwad, Gujrat by SABA



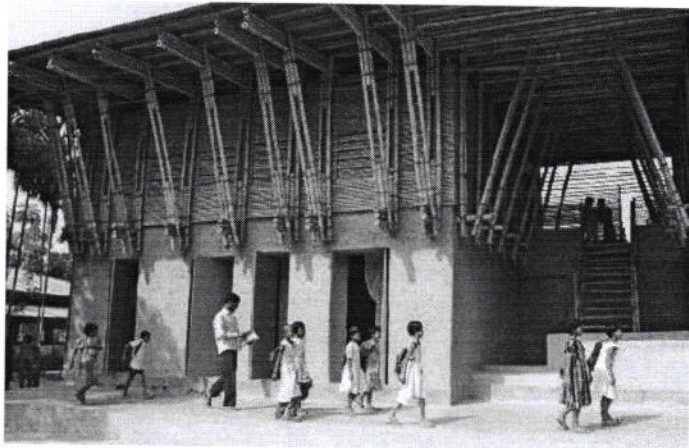
A project for re-inventing the African Mud hut

5.2 EXAMPLES_ LOCAL

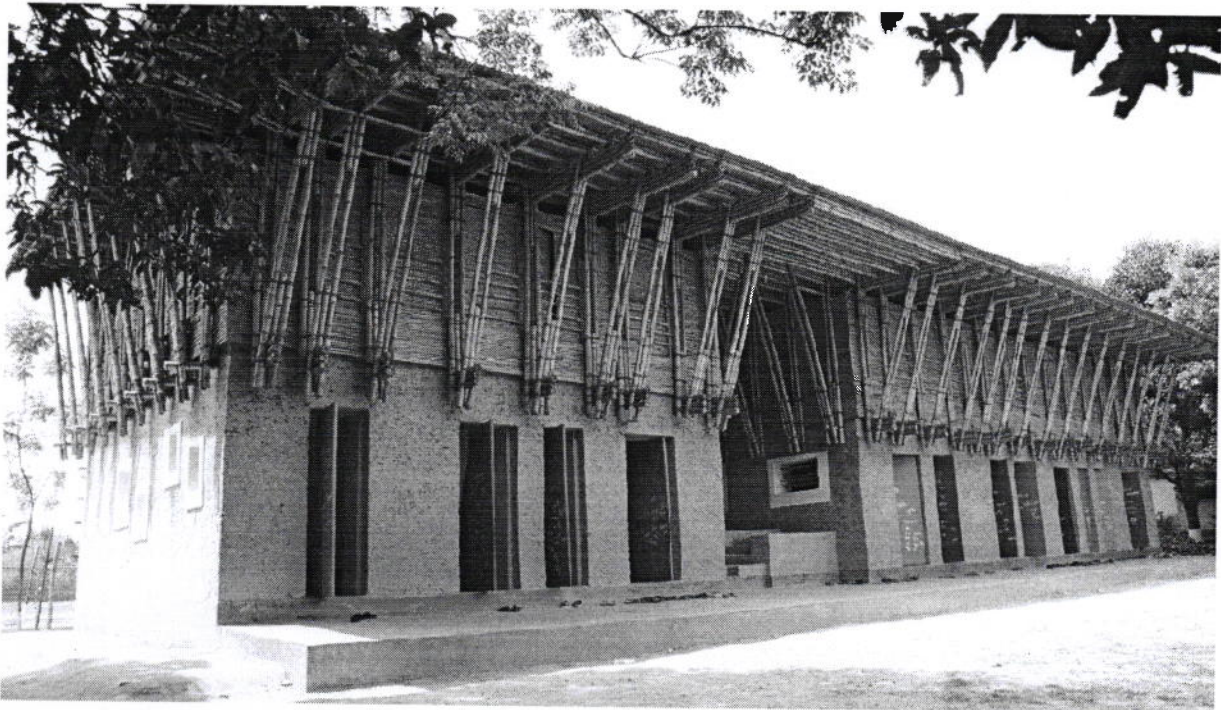
There is a bright example of utilizing local materials in a school in Rudrapur in Dinajpur.

METI – Handmade School in Rudrapur.

The project was conceptualized and designed by Architect Anna Heringer.



The local NGO Dipshikha has basically taken this great endeavor with the intention is to give the rural population perspectives and to help people learn about power of local materials. Part of this is a special school concept that instills in the children self-confidence and independence with the aim of strengthening their sense of identity.



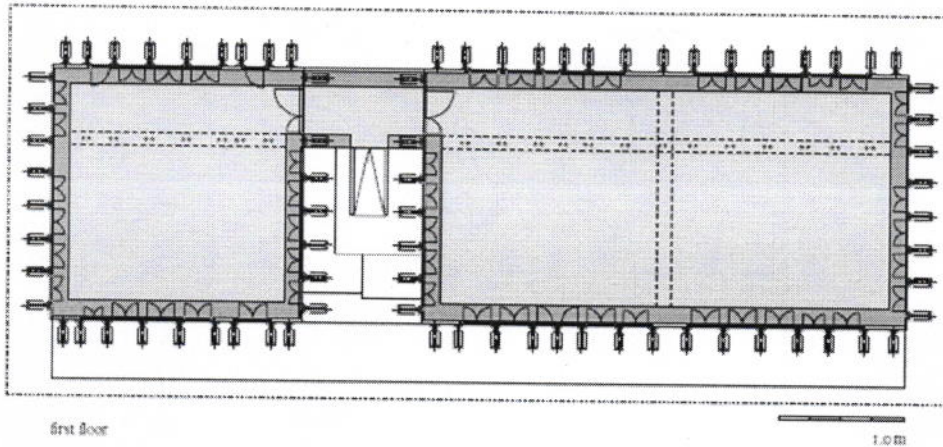
Local traditional building materials have been combined with learned construction knowledge to produce a building that is not only sustainable but also a much-needed facility for the village children. With the encouragement of the client the architect took up the challenge of using local materials to explore a new building dynamics in the design of a mud-wall

construction. The project provides the classrooms which were required by the client as well as additional spaces for children to interact and be creative, which were not asked for. The classrooms at the ground floor are enclosed by a mud wall, with apertures and doorways strategically positioned to allow light and wind penetration. The classrooms on the first floor have walls of slatted bamboo that allow diffused light into the space as well as natural ventilation.

Traditional mud walls are formed with very wet loam. Here, an adapted technique called 'Wellerbau' was used. The wet loam is mixed with straw and applied to the wall in layers, each around 50–70 centimeters high.

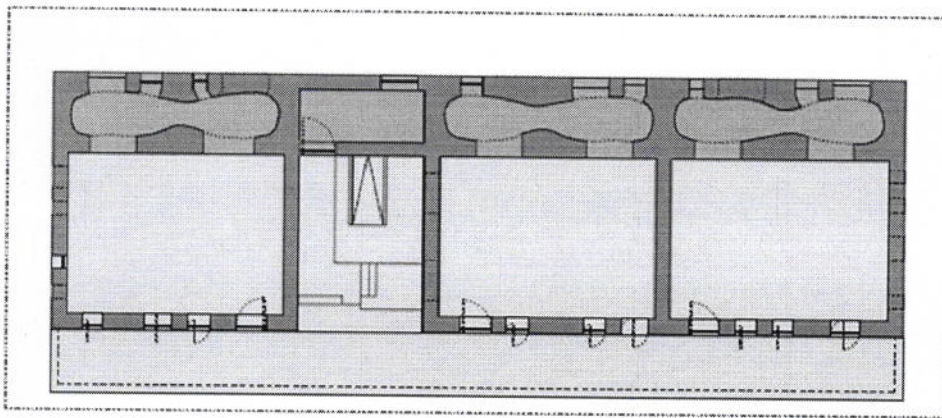
After drying for a couple of days the sides of the walls are trimmed with a sharp spade to obtain a regular flat surface. After a second drying period, a further layer can be added on top. The earth in this region is well suited to such construction and the stability of the mixture was improved by adding rice, straw and jute (cows and water buffalos did the work of treading in the mixture). A further vital technical improvement on traditional house construction was the introduction of a damp-proof course and a brick foundation. The ceiling as well as the first floor is constructed mainly from bamboo, which is widely used by the locals for scaffolding, bridges and other structural components. In many instances, bamboo is better than other comparable materials such as wood or steel. It is light in weight and exhibits a high elasticity and tensile resistance, which makes it appropriate for seismic zones. Bamboo is fast-growing, comparatively low in cost, contributes to the aeration of other building elements, and is easy to handle and maintain. From an ecological point of view, it is also totally recyclable. Three layers of bamboo sticks, bamboo boards and an earth filling make up the surface of the floor. The upper walls and roof are a frame construction using four layers of joined bamboo sticks and vertical and diagonal bamboo poles. Steel pins are fixed with nylon lashing (a variation on the traditional jute ropes) from the junction of the sticks. The walls are covered with slats of bamboo that allow diffused light as well as natural ventilation.

floor plans



first floor

1.0m

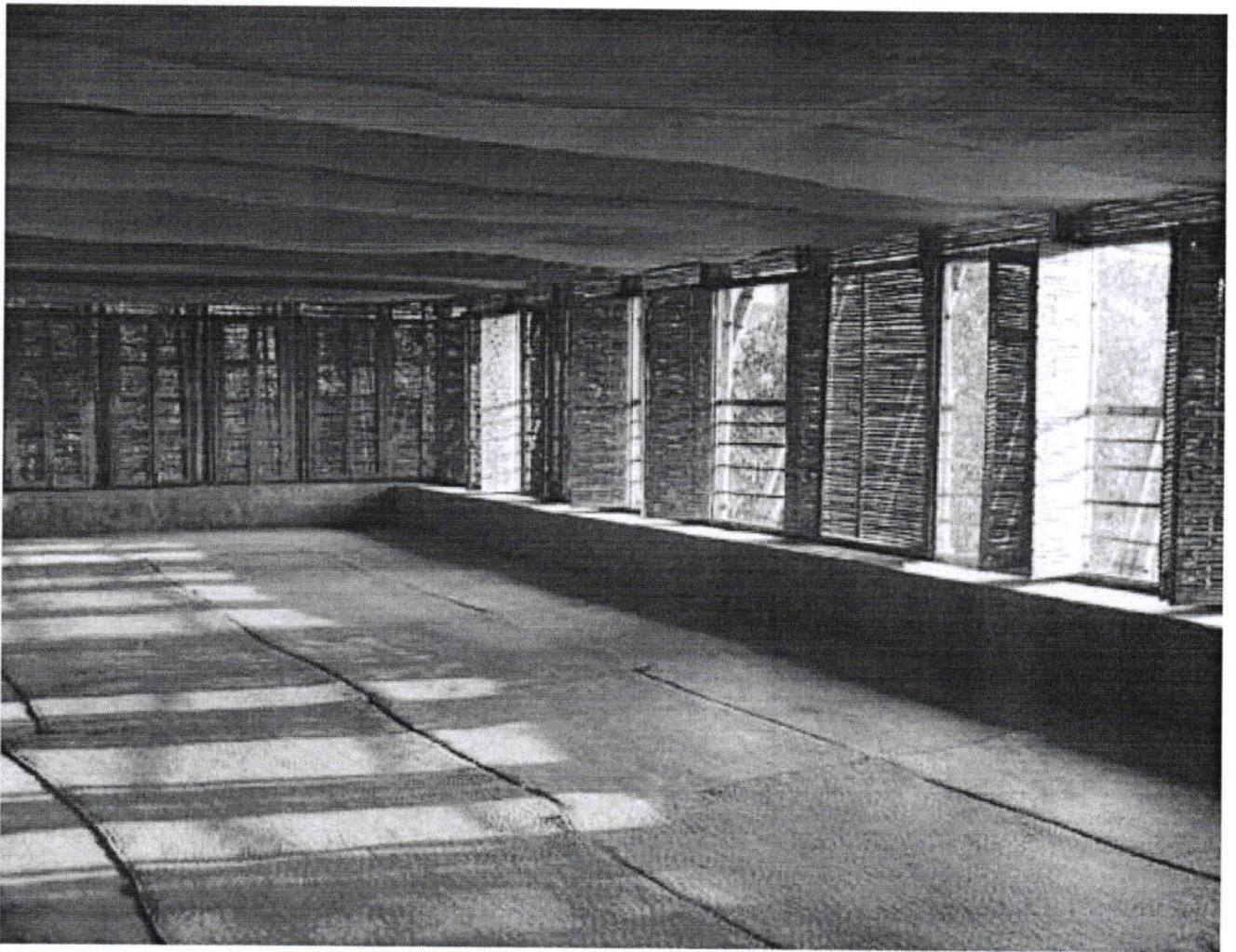
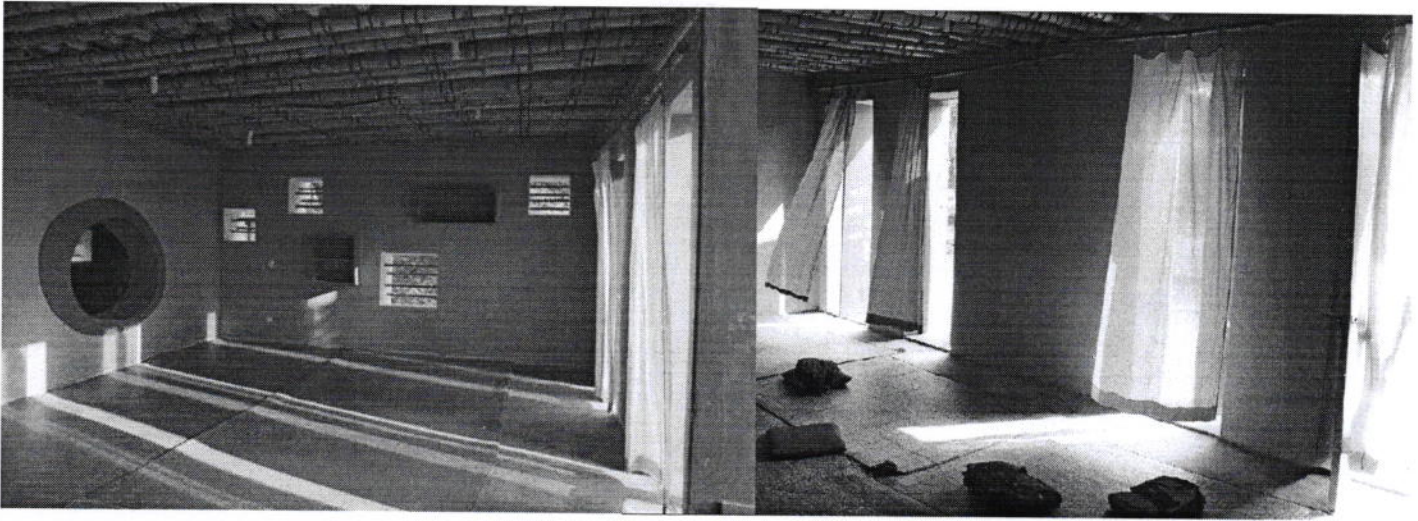


ground floor

1.0m

"This joyous and elegant two-storey primary school in rural Bangladesh has emerged from a deep understanding of local materials and a heart-felt connection to the local community. Its innovation lies in the adaptation of traditional methods and materials of construction to create light-filled celebratory spaces as well as informal spaces for children. Earthbound materials such as loam and straw are combined with lighter elements like bamboo sticks and nylon lashing to shape a built form that addresses sustainability in construction in an exemplary manner. The design solution may not be replicable in other parts of the Islamic world, as local conditions vary, but the approach – which allows new design solutions to emerge from an in-depth knowledge of the local context and ways of building - clearly provides a fresh and hopeful model for sustainable building globally. The final result of this heroic volunteer effort is a building that creates beautiful, meaningful and humane collective spaces for, so enriching the lives of the children it serves." learning

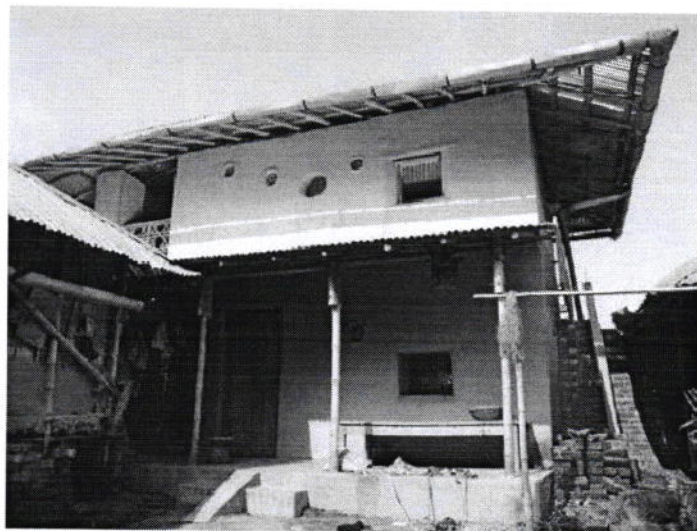
(Jury of The Aga Khan Award for Architecture 10th Circle) (www.anna-heringer.com)



Residence in Dinajpur

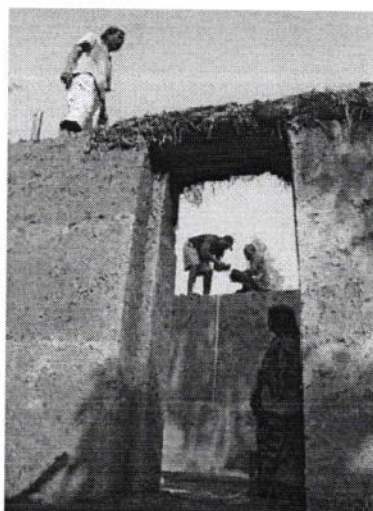
Located in the midst of the rural setting, a two-storey mud-house is part of the extension project of hand-made Meti-school, Rudrapur, Bangladesh. The three hand-built houses were the result of a hands-on workshop for students and young architects conducted in a rural area of Bangladesh. The team included local laborers, students from BRAC University University of LINZ, Austria, and Architect Anna Heringer as the project leader.

The challenge for the pilot project on rural housing was to improve the living conditions in the rural areas while maintaining the existing level of sustainability as well as to meet the needs and dreams of the people.



Three families dismantled their old homes in full trust that we will build a house they'd feel proud of and would serve their needs. And so it began: Design, planning, building, site supervision, communication with clients and villagers, trial and error method.

Every day, neighbors and strangers gathered around the sites, gave comments and started discussions. The most 'popular' site was at Rahini's house that was just beside the main road, next to the market. Fifty, sixty and sometimes more curious visitors who wanted to know why they build in mud, and what was it that they were adding to the new house special.



"A house made of earth will never be as attractive as a brick building to the villagers. Even when it is cheaper," says Mahbub Islam, who has been involved in rural development work in Bangladesh for more than 20 years. They did a lot of experiments to improve the foundation; introduced a damp-proof course; and made the walls stronger through a reinforcement with straw. But most of all, they tried to focus on creating a perfect indoor climate through coconut fiber insulation, glass windows and lots of openings for cross ventilation and a good design. No one can convince someone with rational arguments about sustainability, but it could be done with a comfortable building that one can be very proud of.

A good design doesn't need more money; it only needs creativity, some reflection, and a little bit more intelligence maybe. Because this is not a matter of being poor or rich. Sometimes even limitations can be the best inspiration to stimulate creativity.

"The intention was to create an inter-cultural exchange with the expectation that the young architects will be able to carry their knowledge and skills to other regions of Bangladesh and the trained labor will be able to use their skills to build other modern mud houses in the region"- Anna Heringer.

5.3 ANALYSIS AND FINDINGS

Hunnarshala Foundation fundamentally works,

- To facilitate housing and basic services for the urban poor and develop governance and planning tools to create sustainable communities in our towns, promoting dignity for all citizens.
- To promote eco-friendly, cost-effective, low cost building materials and infrastructure that utilizes locally appropriate inputs and aesthetics.
- To work with and further the interests of building artisans and their craft through training, assistance, and capacity building, and to bring them into the mainstream of construction.
- In post-disaster situations, support government, NGOs, and affected communities with mechanisms that enable owner/community led reconstruction approaches.

After studying Hunnarshala foundation, its objectives and practical implementation of those aims have been inspirational to establish a local research center in our country where people could assemble together to share knowledge. The collective way in which this organization works, has benefited the local people as well as has contributed for sustainable environment. So we can also establish such a center which would add to the development of our local materials and give a platform for local artisans to practice and share their knowledge on local resources.

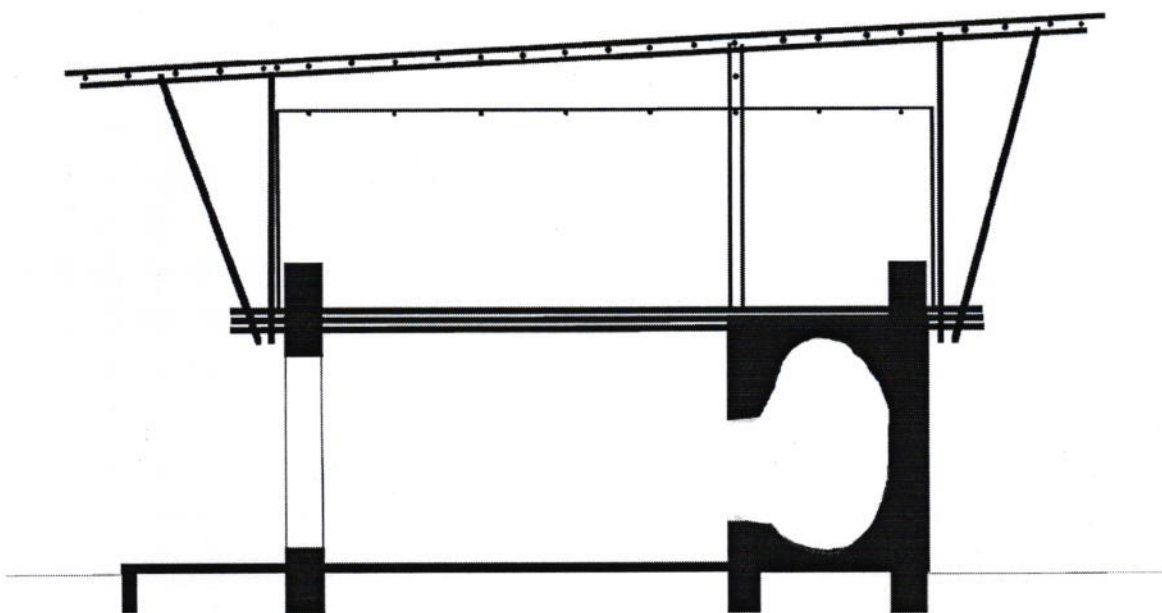
Like Hunnarshala foundation, we need a research center with focused research goals and objectives. This organization is a living example of utilizing the power of local people's knowledge.

The distinctive features of Rudrapur school are:

Massing: In the rural vernacular setting the solidness of the design appears unique.

Materials: mud load-bearing wall with bamboo framing.

Articulation of facades: Rhythmically spaced vertical bamboo trusses are juxtaposed with horizontal bamboo slats to create a powerful imagery. The intricate decorative effect of the trusses is accentuated by the play of sunlight. The horizontal slatted window frames are camouflaged as part of the wall.

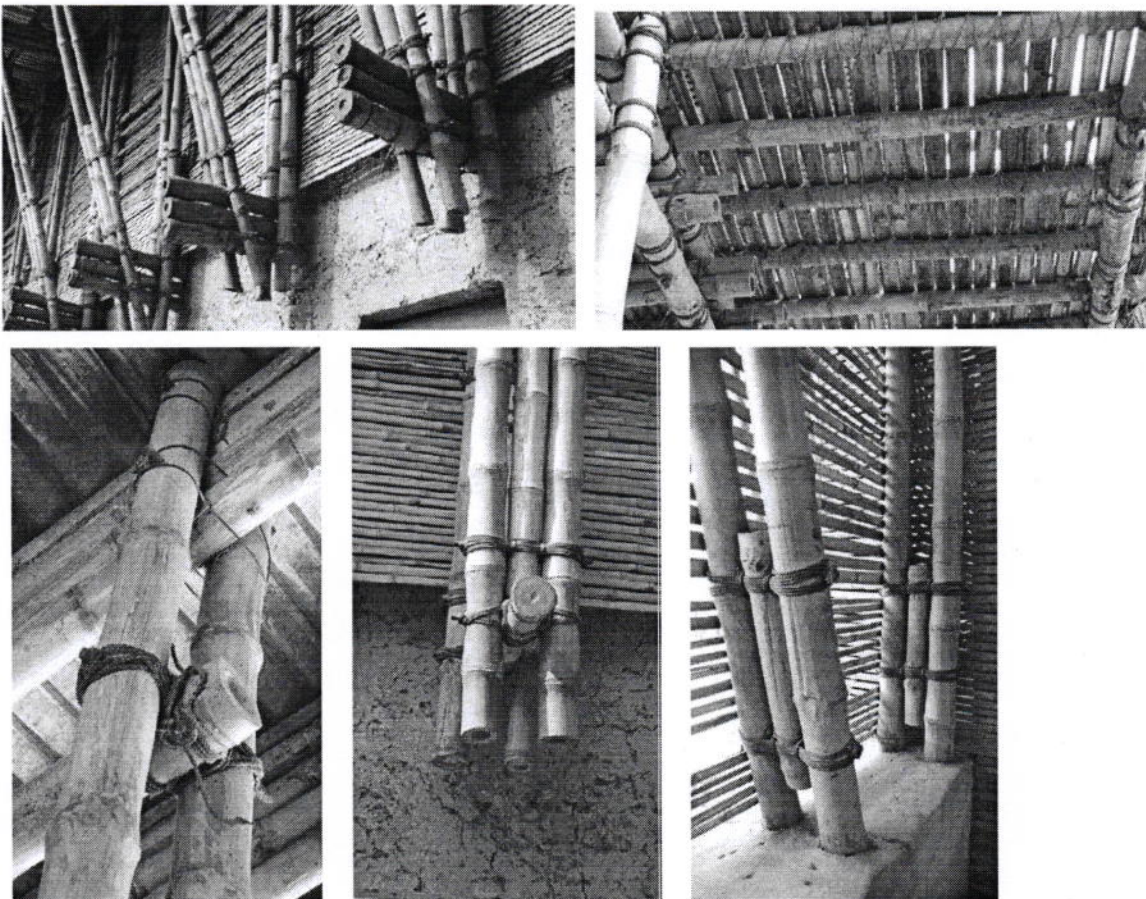


Structure: The structure is made of a brick foundation which supports the mud wall on the ground floor supporting the bamboo frame on the first floor and is covered with a zinc coated iron sheet roof.

Passive Systems: The 'caves' located on the west side of the building help absorb the sun's heat during the afternoon, doors and windows are placed on all four walls at the ground floor for better air circulation. Bamboo material on the first floor allows for filtered day light and an increased air flow. The metal roof has been lifted above first floor ceiling to help allow hot air to escape.

Bamboo connections:

The bamboo frame for the first floor of the school was constructed on the ground and then lifted into place. The joints were secured with steel pins and nylon lashing.



The school shows that there is immense possibility of using our local materials and create a successful contextual architecture. Though there were foreign technician team involved in the

construction process, some local people were also a part of it. The people who worked in this project, learnt about their own surrounding better and the people living in surrounding area were highly influenced by this project. According to one of the loam worker,

"It was good to do tests and experiments together before starting the real construction, so we could understand it although we did not know the language. And everybody learnt a lot from each other. I learned how to build strong walls, how to use measurement tools and the foreigners learnt, that the best mixing machines are water buffalos."

(www.anna-heringer.com)

This project is highly inspirational to use local materials in our local context. If we can produce these materials, we should be able to utilize them to the fullest. The school, as a representative public building, has drawn many visitors and created a positive image for earth construction. So this positive image can be expanded through a center where people could actually learn about materials and the processes being used. Such a center would encourage more people to come up with innovative ideas to use our local materials.

The Local Experiment

The houses for the three peasant families follow the pattern of the traditional homestead—functions like kitchen or sanitary units are still in external buildings.





Thus, the new model is rooted in the traditional and current lifestyles of the peasant families with sensitive but crucial improvements in terms of comfort, safety, durability and a clearly defined space. Local materials like earth, bamboo, straw and coconut fibre were used as major construction materials.

An optimized indoor climate (insulation with coconut fibre and earth as thermal mass; glass windows to prevent the cold wind from entering during winter) assures a high level of comfort. In contrast with the traditional houses, which very often have no windows, these new houses have lots of openings for cross ventilation and natural lightening.

Durability is ensured due to an improved building technique. The first floor brings in a totally new experience of being 'uplifted', enabling the residents to enjoy privacy and a view. The remaining land will be used for gardening, as a means to overcome the present severe food crisis.

The hope for the future is that this new understanding of local capacity and identity would motivate building design that is orientated towards exploiting what's locally available; an architecture that has a fresh and unique language as well as a strong self-confidence by being self-sufficient, which is an important basis of sustainable development.

Six strategies to influence sustainable development in Bangladesh (by Anna Herringer)

- Vertical expansion: two-storey houses. If all these millions of Bangladeshis who still live in rural areas are going to build two storeys instead of one storey, it would set free a huge capacity of land. This could be an effective action against brain drain. Where skyscrapers in cities need a lot of energy for construction and grey energy due to the need for more steel and cement, such two-storey buildings can be easily built with local materials.

- Combine low technology with high technology in a reasonable way with the ultimate goal to be selfsufficient.
- Low-cost local materials with a labor intensive construction can support the local economy. The building sector's economic profit will not flow into external markets—it stays in the region where it becomes a crucial source of income generation.
- The choice of a building material is more than just a rational decision. It is also a matter of prestige, identification, Zeitgeist and culture. Sustainable construction with local materials will not stand a chance to play an important part in future architectural developments if we don't respond to the emotional aspects as well. The challenge is to meet the needs and dreams of the people in an economically reasonable, ecological, social and aesthetic way, along with the appropriate techniques.
- Use beauty and comfort as teasers with sustainability as an underlying concept.

CHAPTER 06: PROGRAMME AND DEVELOPMENT

Number of participants and instructors for different subjects:

SUBJECT	SUBDIVISION	NUMBER OF PARTICIPANTS	NUMBER OF INSTRUCTORS	NUMBER OF ASSISTANTS
BAMBOO CONSTRUCTION	i) BAMBOO TREATMENTS	30	2	1
	ii) BAMBOO CONNECTIONS-BRACING			
	iii) PRACTICAL STUDIO			
EARTH CONSTRUCTION	i) INTRODUCTION TO VARIOUS TYPES OF EARTH CONSTRUCTION	30	2	1
	ii) PRACTICAL STUDIO			
WOOD WORKSHOP	i) THEORY	30	2	1
	ii) PRACTICAL STUDIO			
METAL WORKSHOP	i) THEORY	30	2	1
	ii) PRACTICAL STUDIO			
TOTAL		120	8	4

AREA FOR CLASSROOM/STUDIO

SUBJECT	SPACE REQUIRED PER PERSON (SQ- FT)		NO. OF USERS	NO. OF ROOMS		TOTAL AREA FOR PARTICIPANTS (SQ-FT)		STORE ROOM AREA (SQ-FT)	AREA REQUIRED (SQ-FT)
	LECTURE ROOM	WORKING STUDIO		LECTURE ROOM	WORKING STUDIO	LECTURE ROOM	WORKING STUDIO		
BAMBOO CONSTRUCTION	20	50	30	1	1	600	1500	150	2250
EARTH CONSTRUCTION	20	50	30	1	1	600	1500	100	2200
WOOD WORKSHOP	20	50	30	1	1	600	1500	150	2250
METAL WORKSHOP	20	50	30	1	1	600	1500	100	2200
SUB TOTAL									8900
CIRCULATION (30%)									2670
TOTAL AREA (SQ-FT)									11,570

AREA FOR LAB

SPACE	SPACE REQUIRED PER PERSON (SQ- FT)	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED (SQ-FT)
COMPUTER LAB	10		30	2	600
RESEARCH LAB	50		15	1	750
MATERIAL TREATMENT PLANT		2000		3	6000
SUB TOTAL					7350
CIRCULATION (30%)					2205
TOTAL AREA (SQ-FT)					9555

GENERAL LIBRARY				
SPACE	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED(SQ- FT)
LOBBY AND RECEPTION	150			200
CHECK AREA AND LOCKER				200
READING AREA		150	1	1500
BOOK STACK	0.1 SQ-FT/BOOK	20,000 BOOKS		2000
LIBRARIAN'S ROOM	100	2	2	200
AUDIO-VISUAL SECTION			1	800
COPY SECTION			1	200
STORE			1	400
TOTAL FOR GENERAL LIBRARY				5500
MATERIAL LIBRARY				
DISPLAY			1	500
STUDY AREA	400		4	1600
LIBRARIAN'S ROOM	100	1	1	100
STORE			1	400
TOTAL FOR GENERAL LIBRARY				2600
TOILET			1	80
OFFICE PARTICIPANTS	160		2	320
SUB TOTAL				8500
CIRCULATION (30%)				2550
TOTAL AREA (SQ-FT)				11,050

COMMON AREA					
SPACE	SPACE REQUIRED PER PERSON (SQ- FT)	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED (SQ-FT)
EXHIBITION TEMPORARY					2500
PERMANENT					7500
MULTI-PURPOSE HALL	10		200	1	2000
INSTRUCTOR'S COMMON ROOM	20		12	1	240
MEETING ROOM				1	500
INSTRUCTOR'S TOILET		160		2	320
PARTICIPANT'S TOILET		320		2	640
PRAYER SPACE		500		2	1000
MEDICAL AND HEALTH UNIT				1	200
SUB TOTAL					14,900
CIRCULATION (30%)					4470
TOTAL AREA (SQ-FT)					19,370

AREA FOR ADMINISTRATIVE SECTION					
SPACE	SPACE REQUIRED PER PERSON (SQ- FT)	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED (SQ-FT)
RECEPTION					100
WAITING ROOM	15		20		300
DIRECTOR'S ROOM		300	2	2	600
REGISTER'S ROOM			1		250
ACCOUNTS OFFICE	80		4		320
GENERAL OFFICE ROOM	80		6		480
CONFERENCE ROOM	20		15	1	300
TOILET		160		2	320
SUB TOTAL					2670
CIRCULATION (30%)					801
TOTAL AREA (SQ-FT)					3471

AREA FOR RESEARCH SECTION

SPACE	SPACE REQUIRED PER PERSON (SQ- FT)	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED (SQ- FT)
RECEPTION					100
INFORMATION CENTER				1	300
GENERAL OFFICE ROOM	80		15		1200
CONFERENCE ROOM	20		15	1	300
TOILET		160		2	320
SUB TOTAL					2220
CIRCULATION (30%)					666
TOTAL AREA (SQ-FT)					2886

AREA FOR DORMITORY

SPACE	SPACE REQUIRED PER PERSON (SQ- FT)	SPACE REQUIRED PER ROOM (SQ- FT)	NO. OF USERS	NO. OF ROOMS	AREA REQUIRED (SQ- FT)
PARTICIPANTS DORM	100	200	80	40	8000
			40	20	4000
TOILET		320		2	640
INSTRUCTORS DORM	100		8		800
			4		400
TOILET		160		2	320
STAFF DORM	60		10		600
RESEARCHER DORM	120		15		1800
TOILET		100		2	200
KITCHEN				1	1000
DINING	10		120	2	1200
WASH					200
SUB TOTAL					19,160
CIRCULATION (30%)					5748
TOTAL AREA (SQ-FT)					24,908

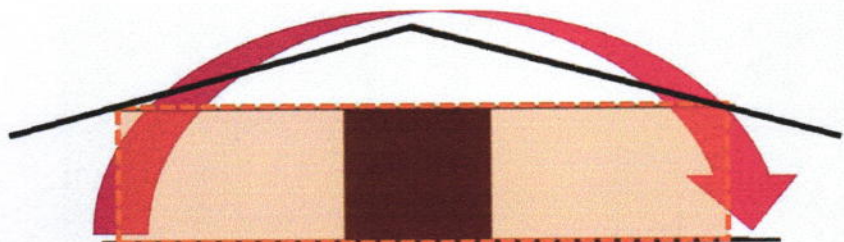
GRAND TOTAL	
AREA FOR-	SQ-FT
CLASSROOM/STUDIO	11,570
LAB	9,555
LIBRARY	11,050
ADMINISTRATIVE SECTION	3,471
RESEARCH SECTION	2886
DORMITORY	24,908
COMMON SPACE	19,370
TOTAL	82,810



CHAPTER 07: CONCEPTUAL STAGE AND DESIGN DEVELOPMENT

PROGRAMMATICALLY REQUIRE:-

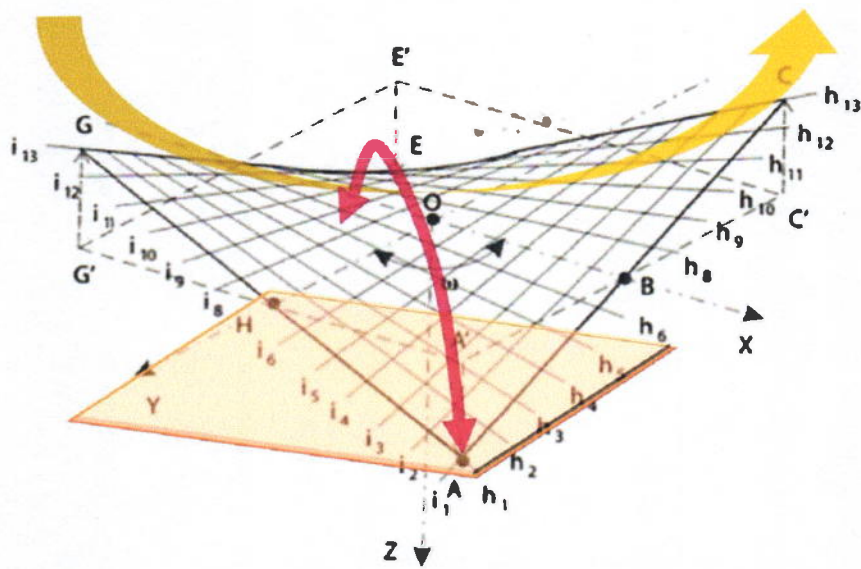
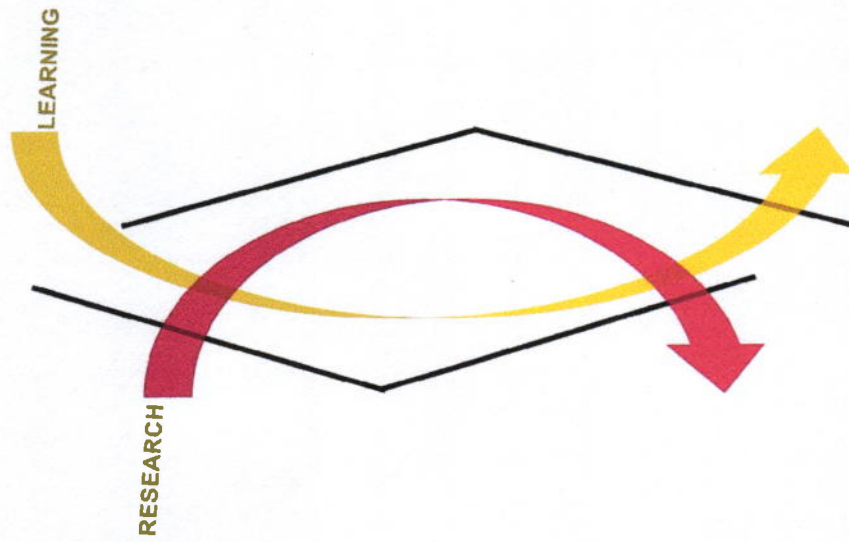
BIG SPAN OPEN SPACES FOR LEARNING ABOUT LOCAL MATERIALS
MIXTURE OF SHADED, SEMI-OPEN AND OPEN SPACES FOR RESEARCH



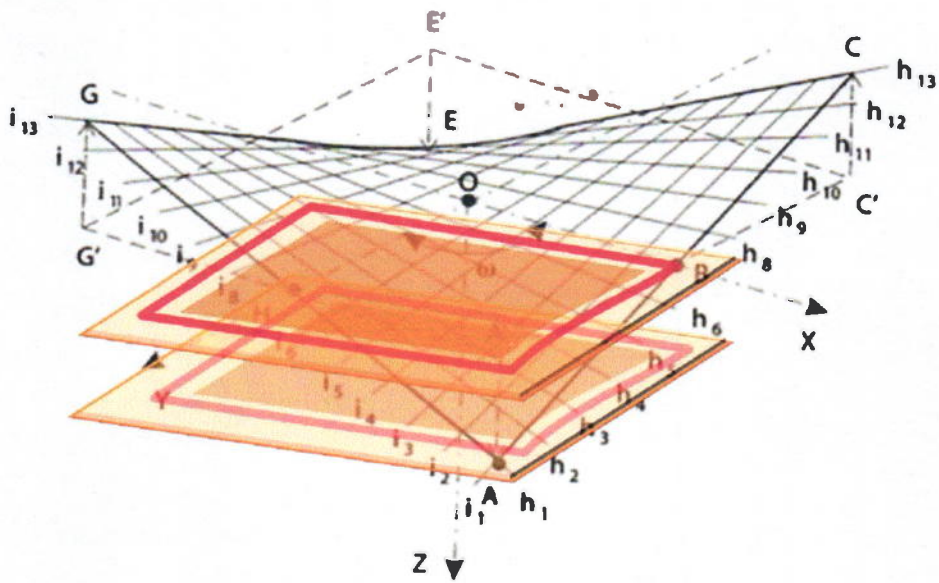
MINIMISE THE ENCLOSED INTERNAL AREA
MAXIMISE THE COVERED OUTDOOR AREA



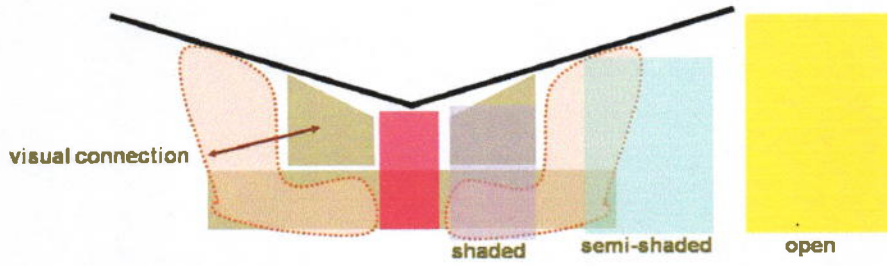
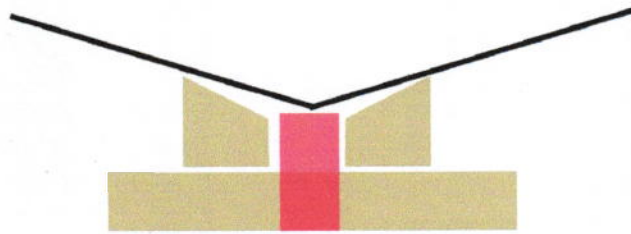
MINIMISE THE STRUCTURAL NODES
MAXIMISE USABLE AREA WITH CANTILIVER



DERIVING THE FORM-HYPERBOLIC PARABOLOID



DERIVING THE FORM- HYPERBOLIC PARABOLOID



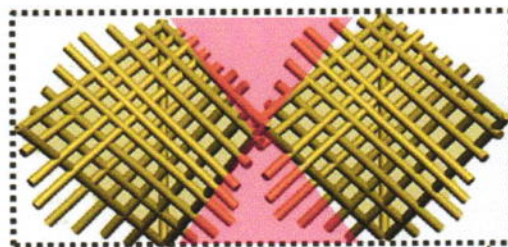
DERIVING THE FORM- HYPERBOLIC PARABOLOID

TYPES OF THE FORM AND SPACES- HYPERBOLIC PARABOLOID

Equilateral Triangle **HORIZONTAL CONNECTION**

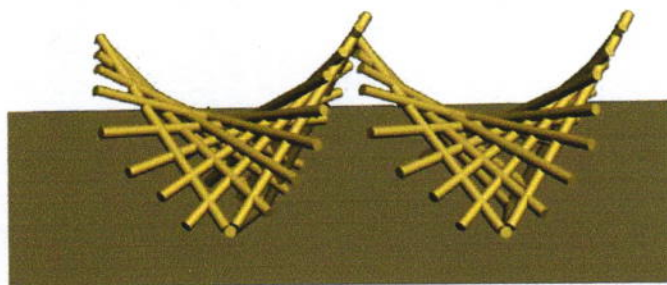


-has three equal sides



plan

**OPEN SPACES IN BETWEEN
4 EQUAL OPENINGS**



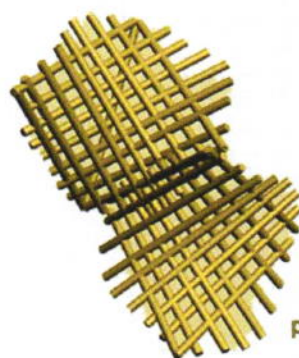
elevation



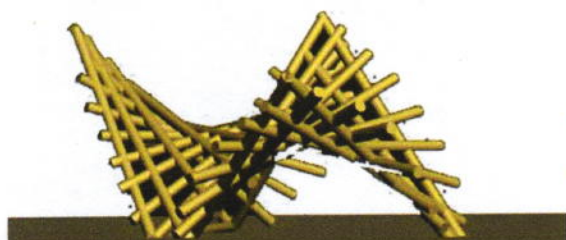
perspective

**CONNECTION WITH
SAME ANGLE**

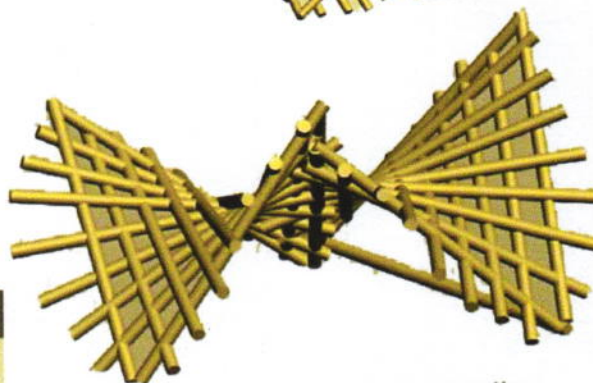
**1 BIG OPENING
2 SMALLER OPENINGS**



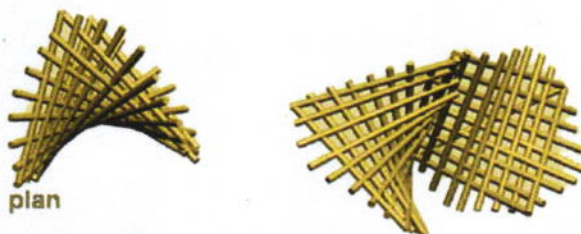
plan



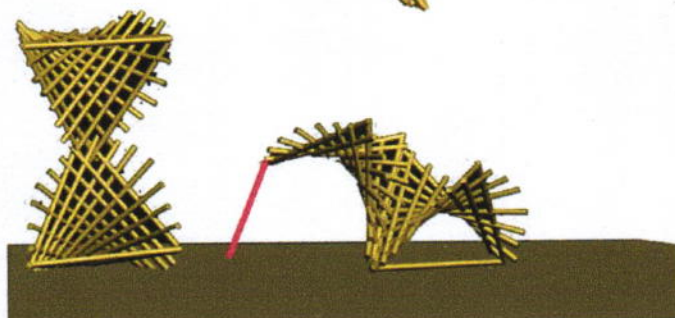
elevation



perspective



plan

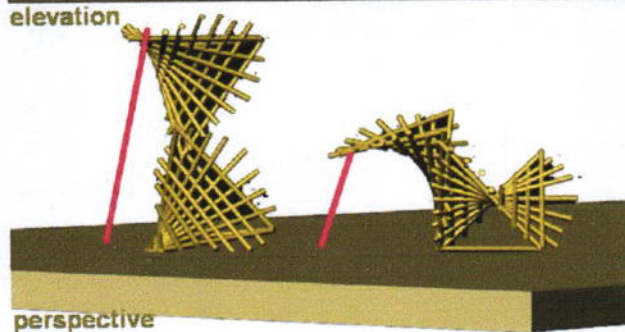


elevation

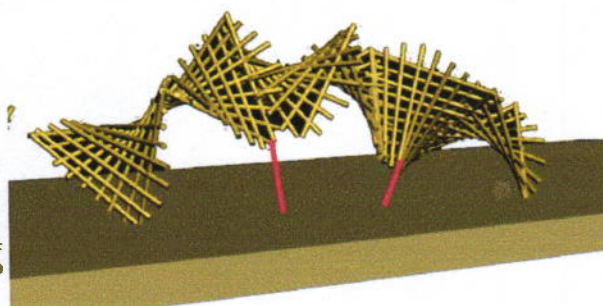
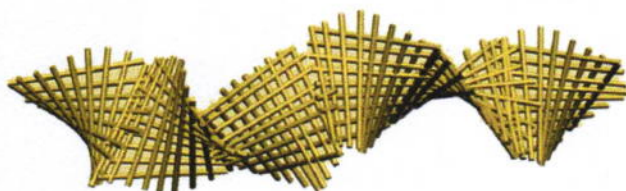
VERTICAL CONNECTION

**COVER LESS AREA
NEED EXTRA SUPPORT**

**OPENING WITH GREATER
HEIGHT**



perspective

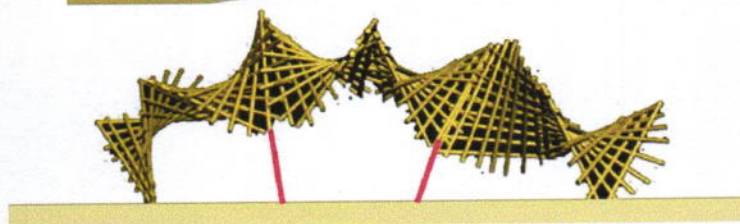


LINEAR CONNECTION

**MIXTURE
HORIZONTAL
VERTICAL**

**OF
AND**

**VARIATION OF HEIGHT
SUPPORT NEEDED**



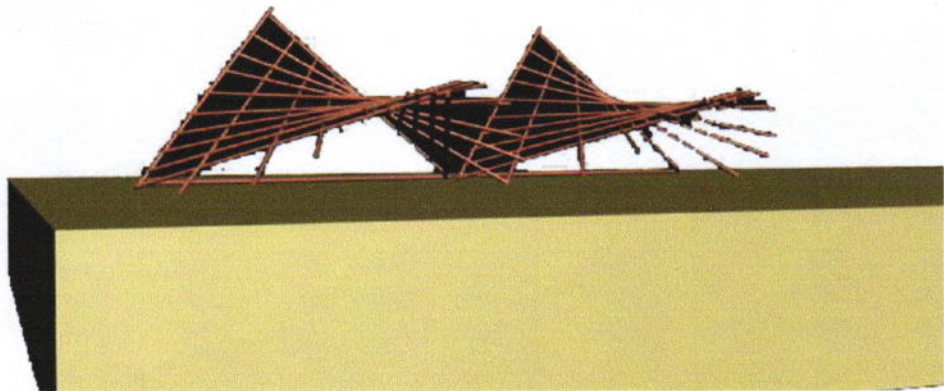
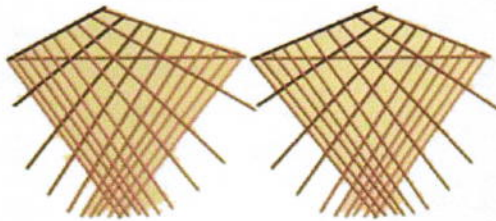
Right Triangle **HORIZONTAL CONNECTION**



-has one right angle

LESS HEIGHT ACHIEVED THAN EQUILATERAL POLYHEDRA

1 SMALL OPENING AND ANOTHER BIGGER OPENING

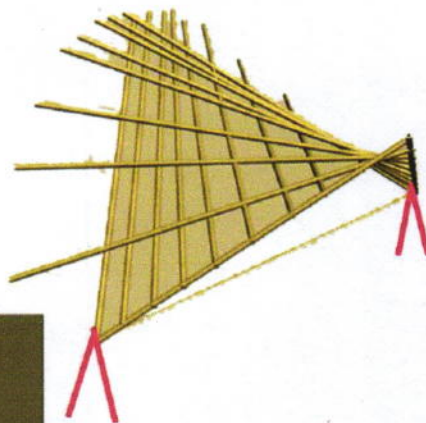
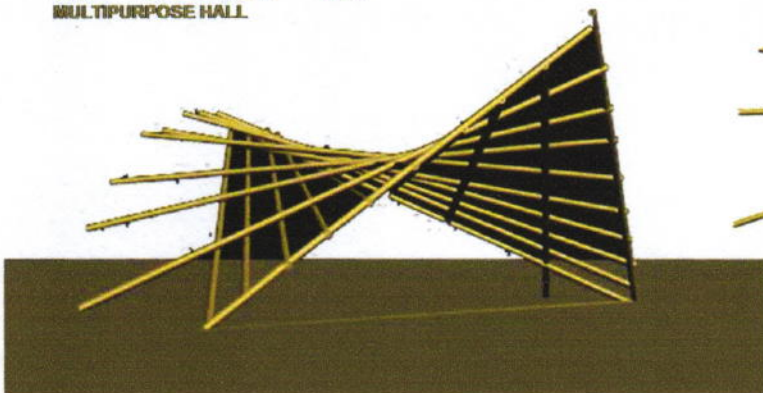
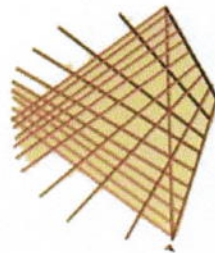


Right Triangle



-has one right angle

COVERS MORE AREA INDIVIDUALLY HEIGHT CAN BE ACHIEVED BY SUPPORT CAN BE USED FOR MULTIPURPOSE HALL

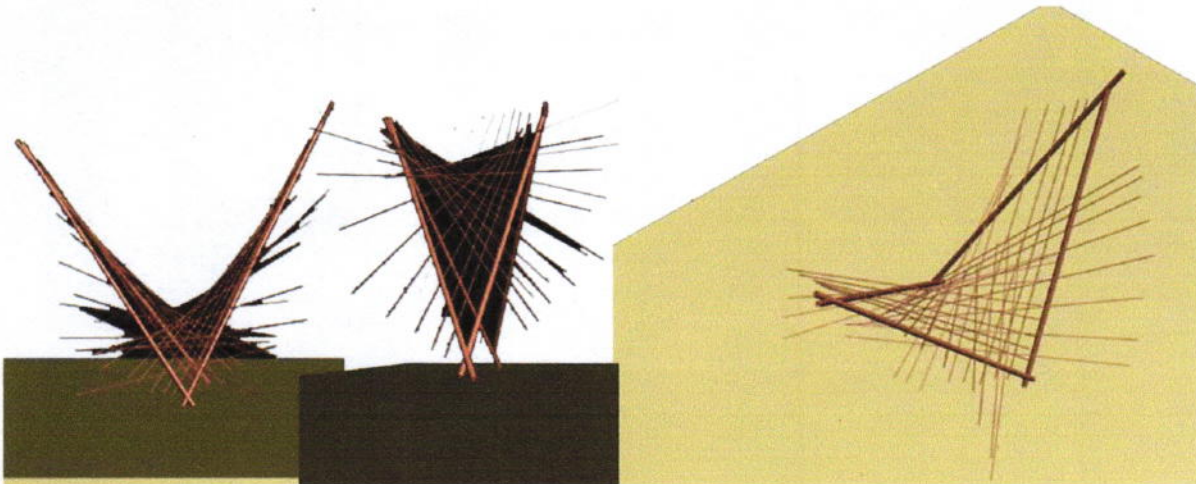
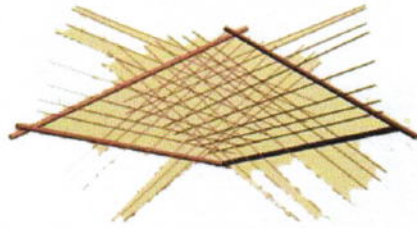


Isosceles Triangle



-has two equal sides

ACHIEVE GREATER HEIGHT ON OPENINGS
SUITABLE FOR ENTRY/EDGE



Obtuse Triangle **HORIZONTAL CONNECTION**

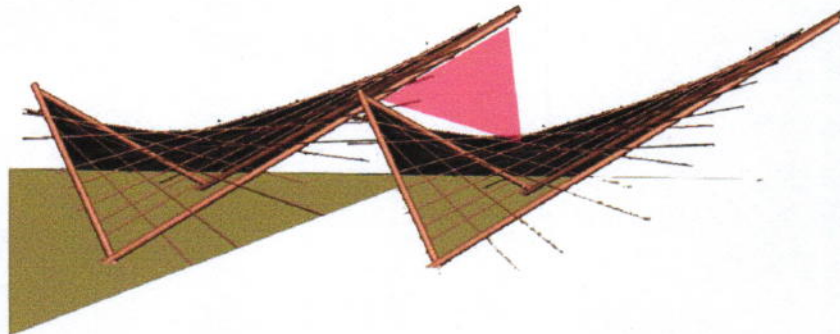
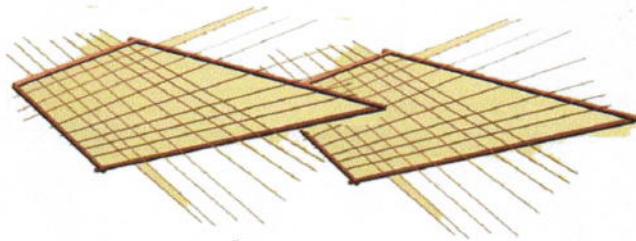


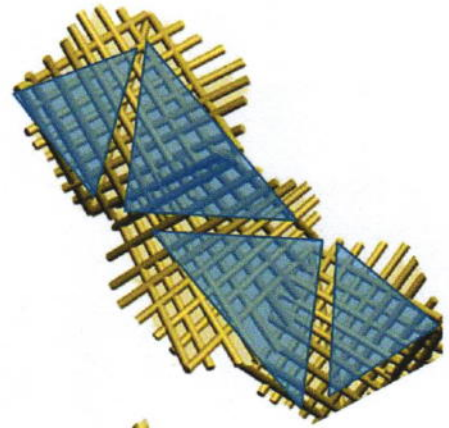
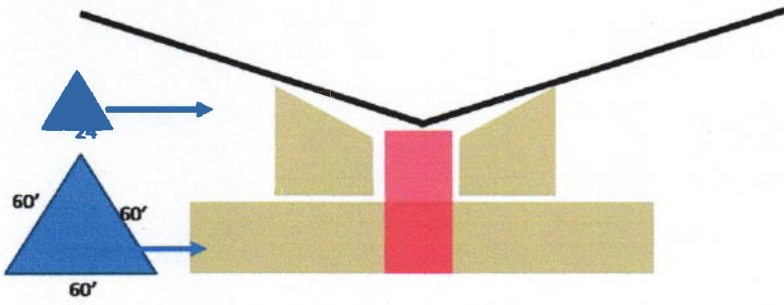
-has one angle >90 degrees

INTERLOCKING UNUSABLE SPACE

BIGGER CANTILEVER ACHIEVED IN ONE SIDE

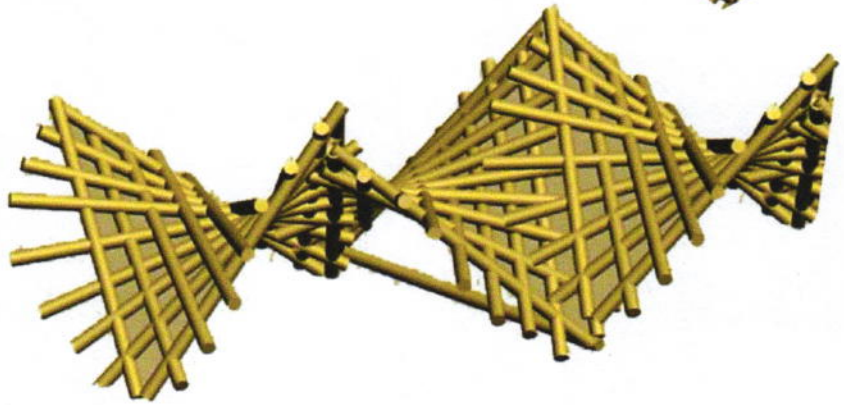
1 SMALL OPENING AND ANOTHER BIGGER OPENING





3 connecting equilateral hyperbolic polyhedra each of 60' can accumulate the classrooms

Studio in ground floor- can get required shaded, semi-open and open area with big height
Lecture room in upper level- can get proper shading

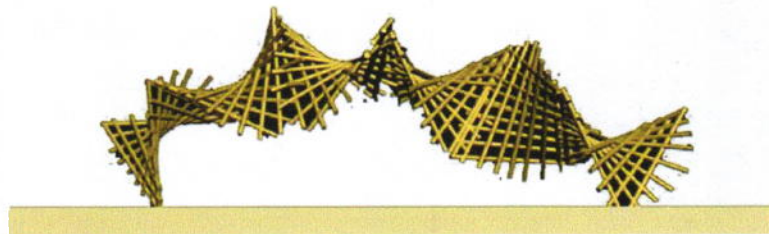
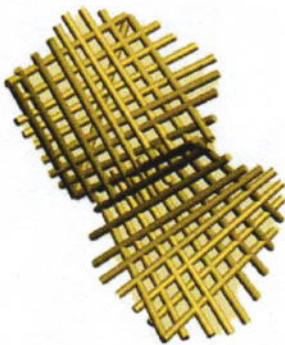
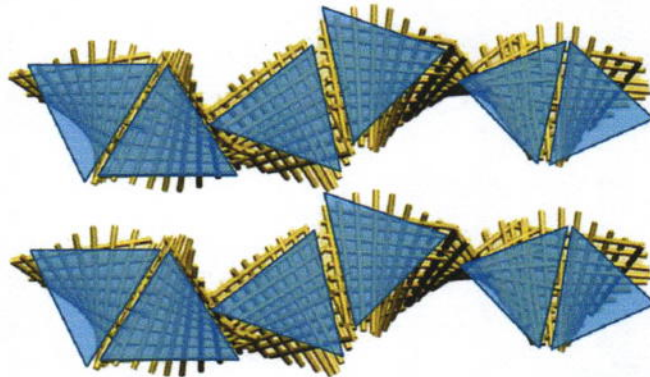


For dorm

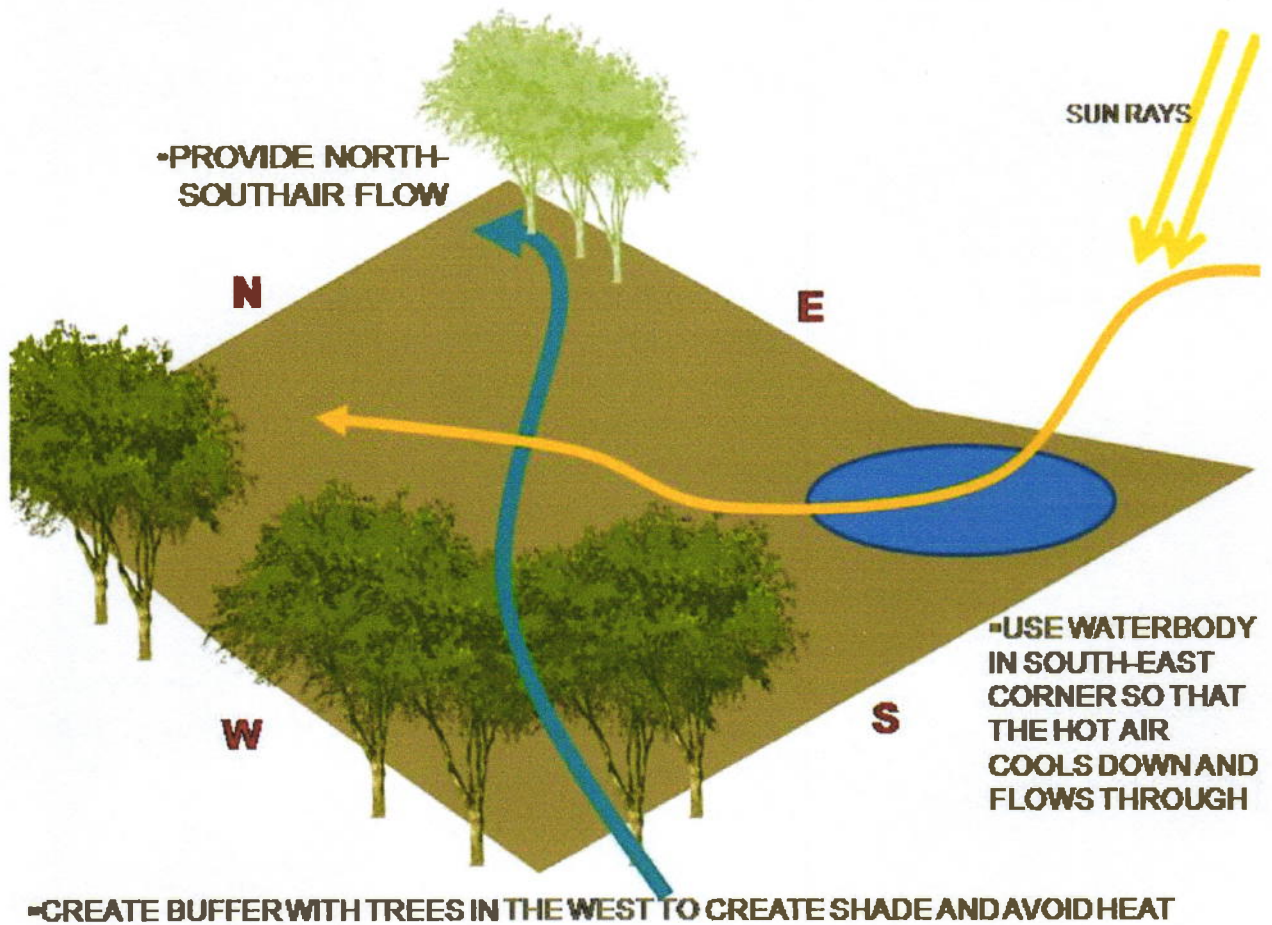
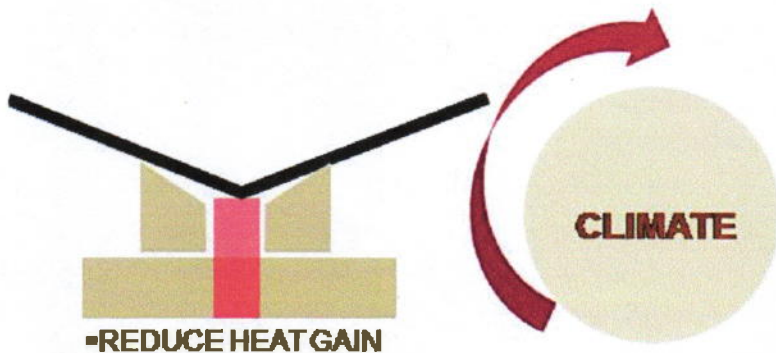
accommodation facility= 16000 sft
Other facility= 4000 sft

Here, 1 linear mass with 6 equilateral saddle polyhedra = 9000 sft

For other facilities= 2 equilateral saddle polyhedra= 4000 sft

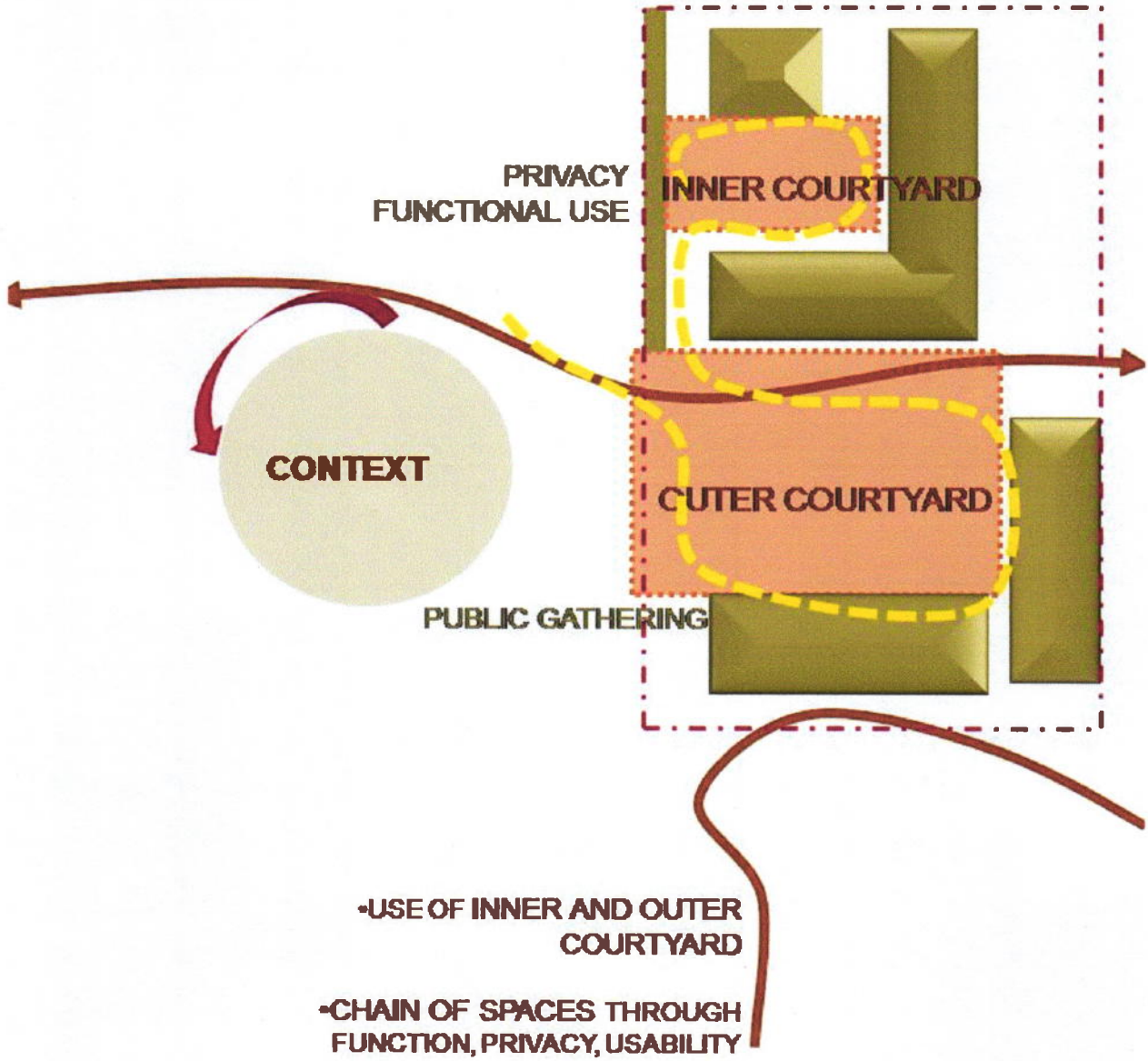


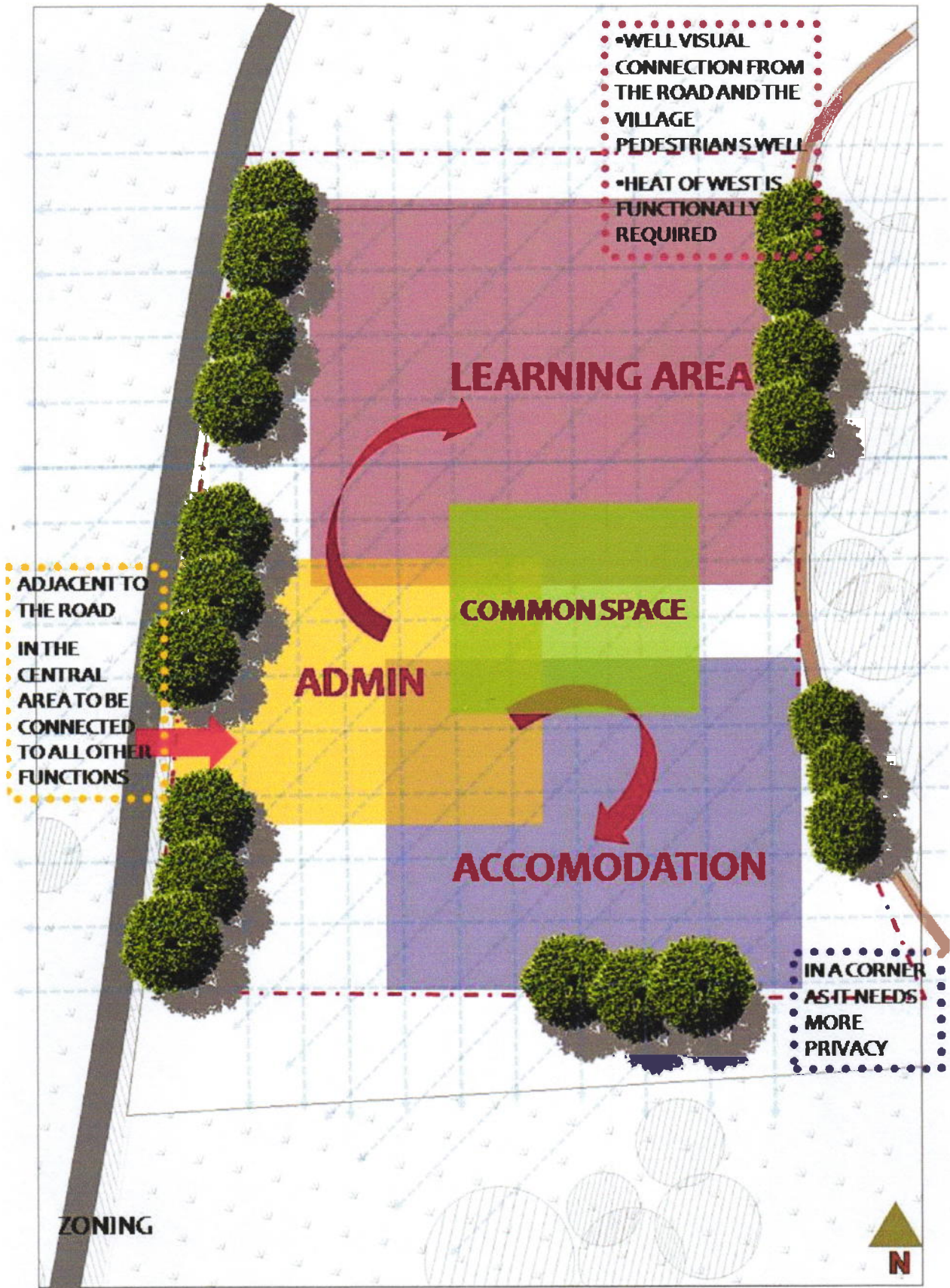
MASTERPLAN STUDY CONSIDERATION



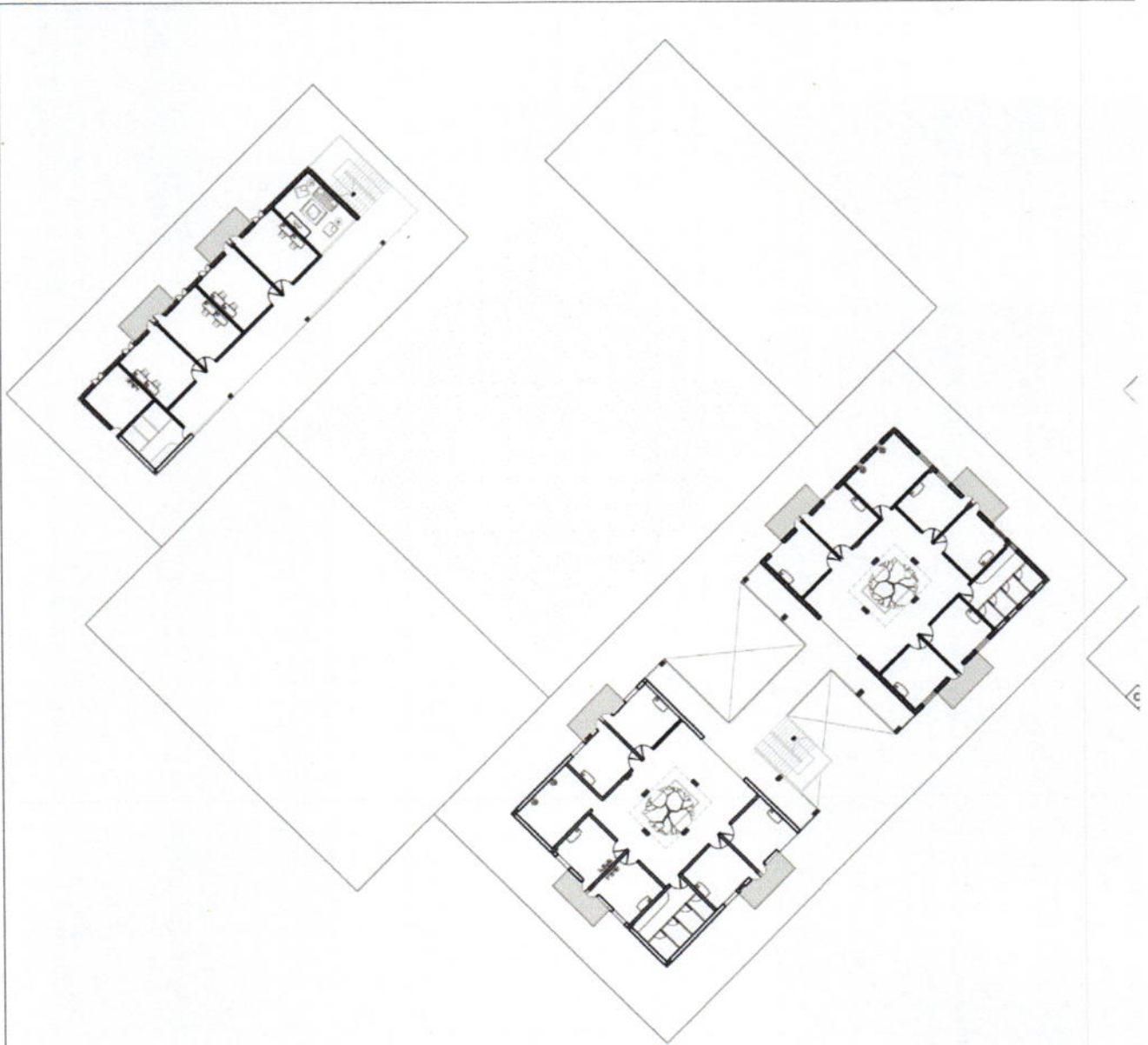
MASTERPLAN STUDY CONSIDERATION

INNER COURTYARD

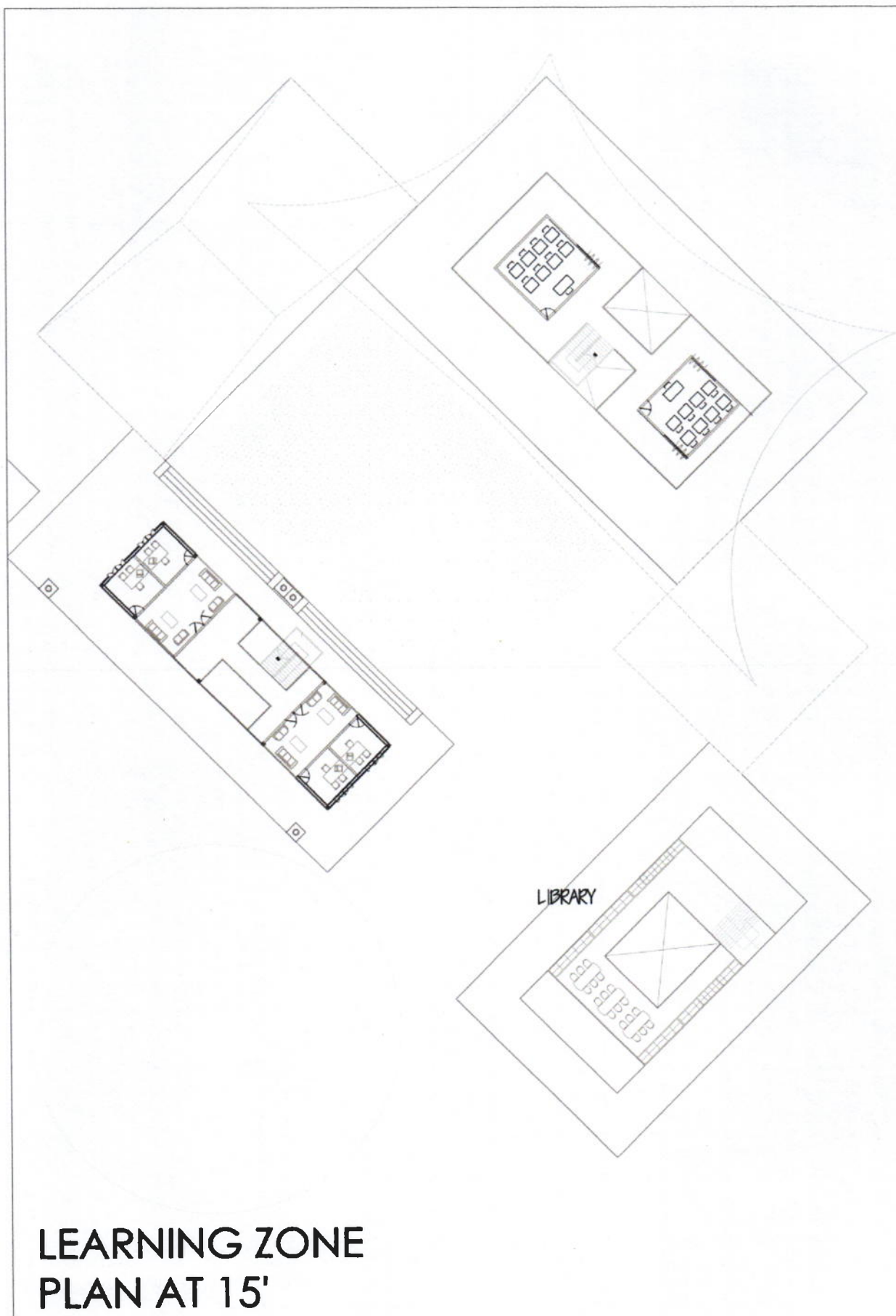




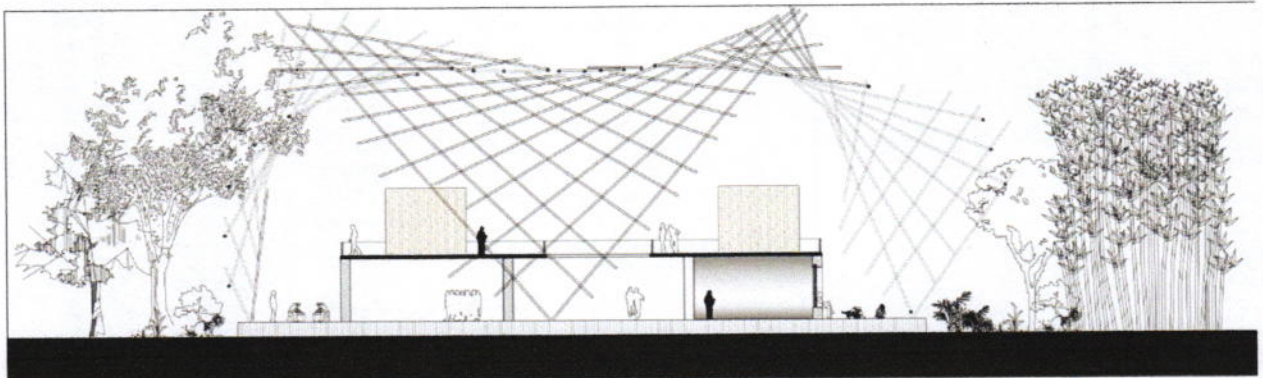




**ACCOMMODATION ZONE
PLAN AT 15'**

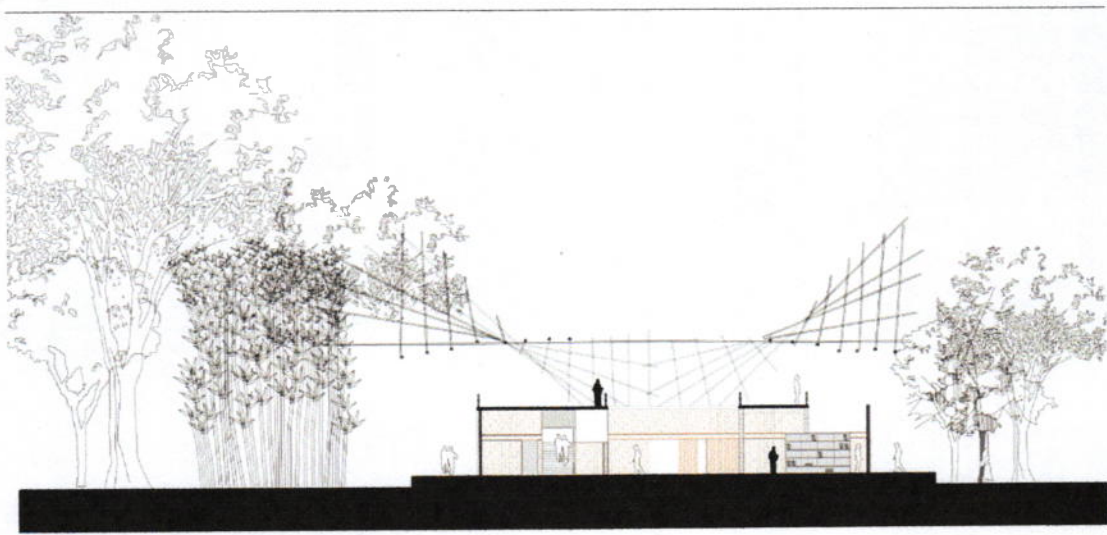
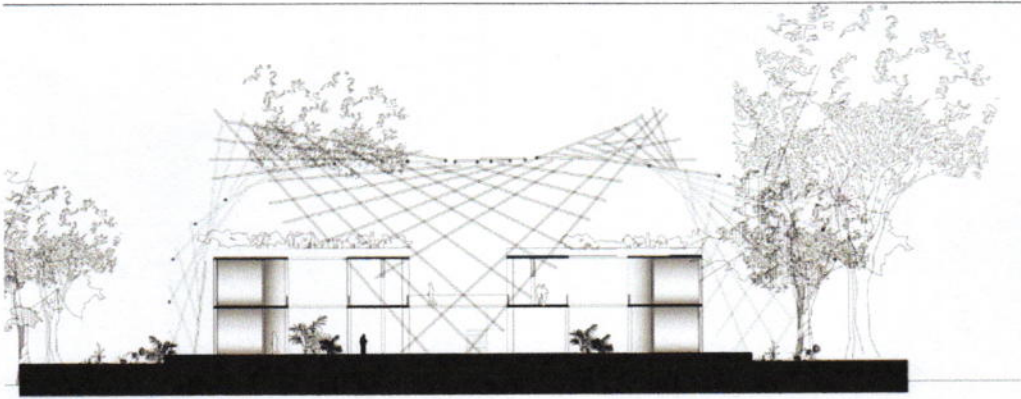


**LEARNING ZONE
PLAN AT 15'**

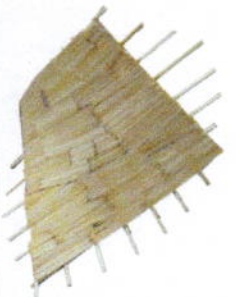


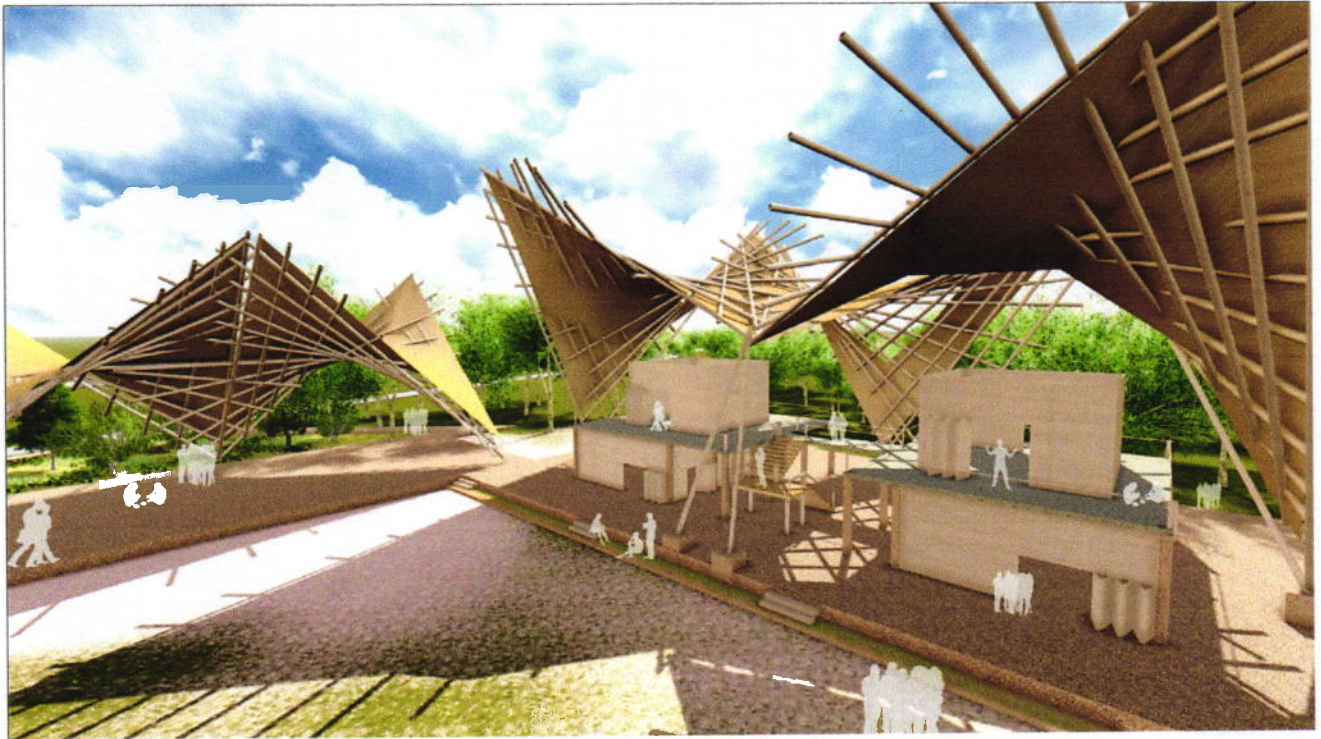
SECTION

ROOF STRUCTURE LAYERS

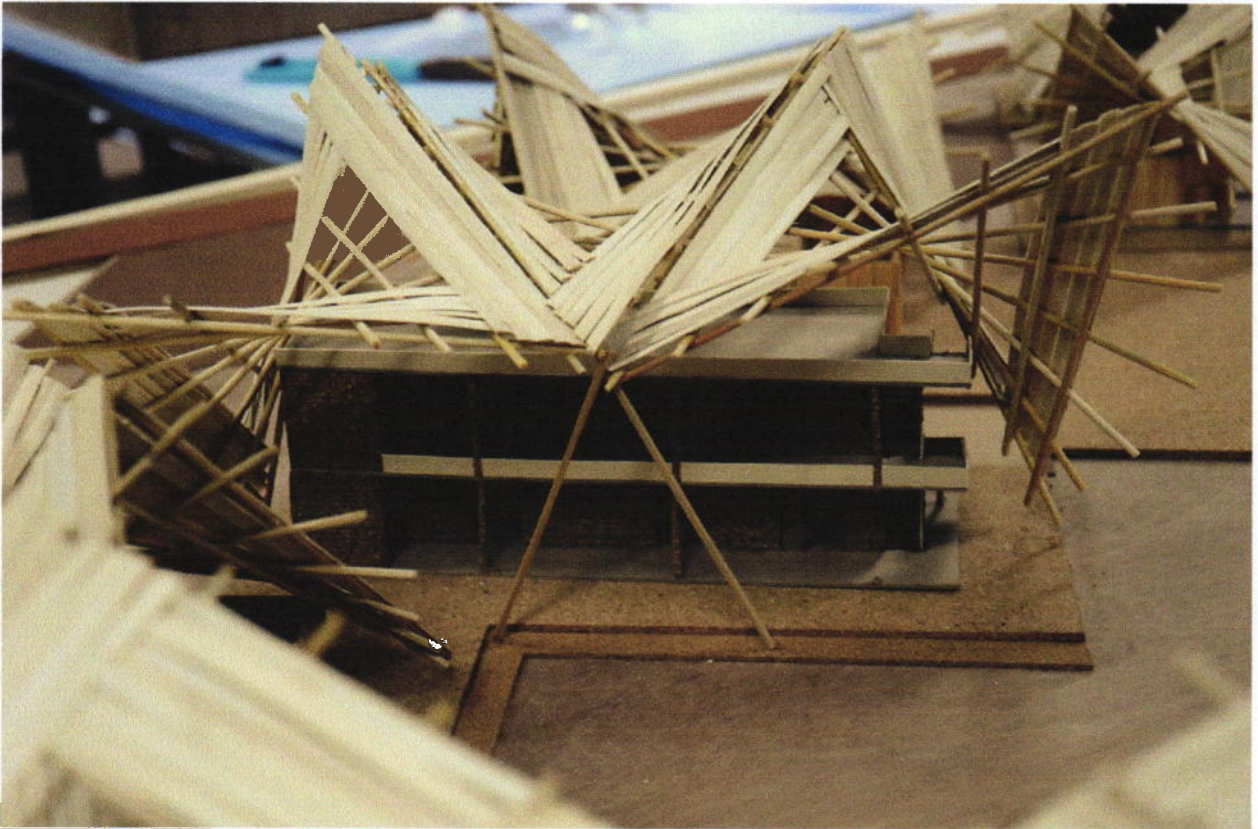
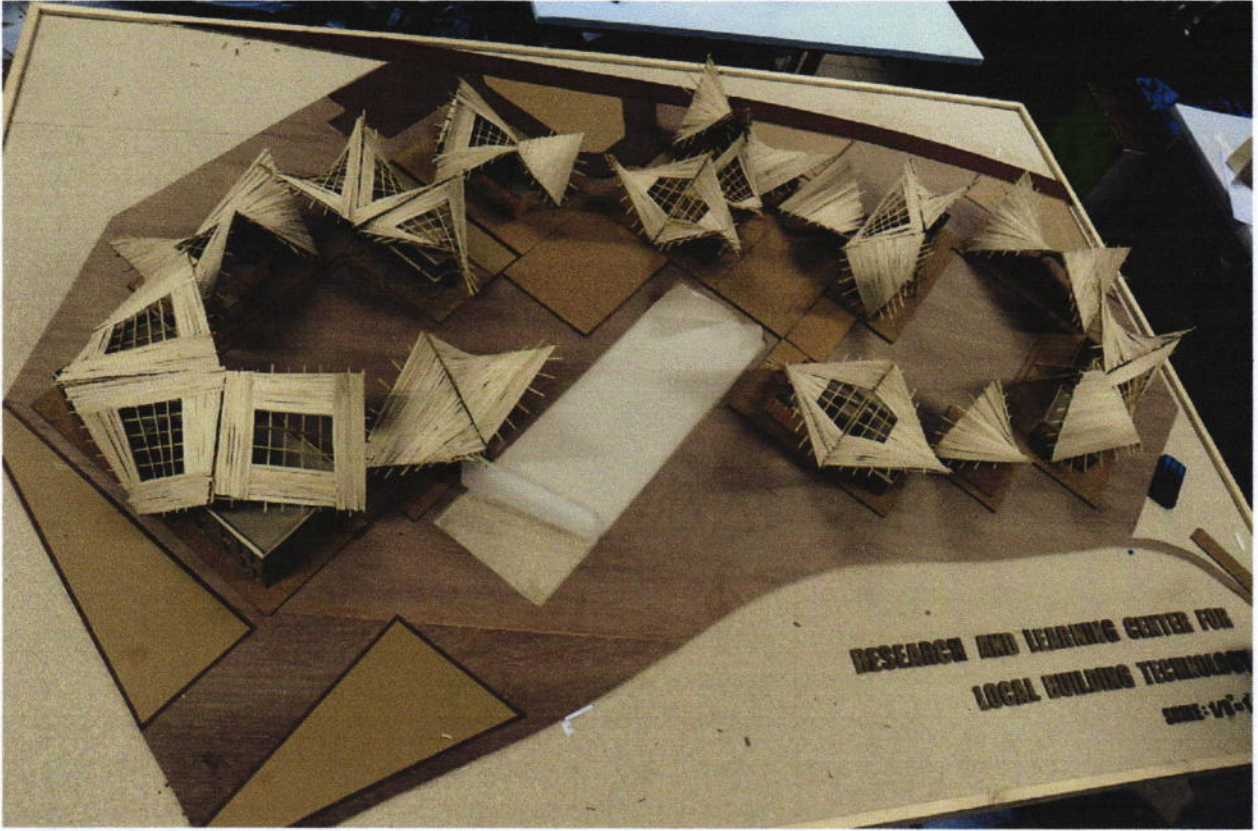


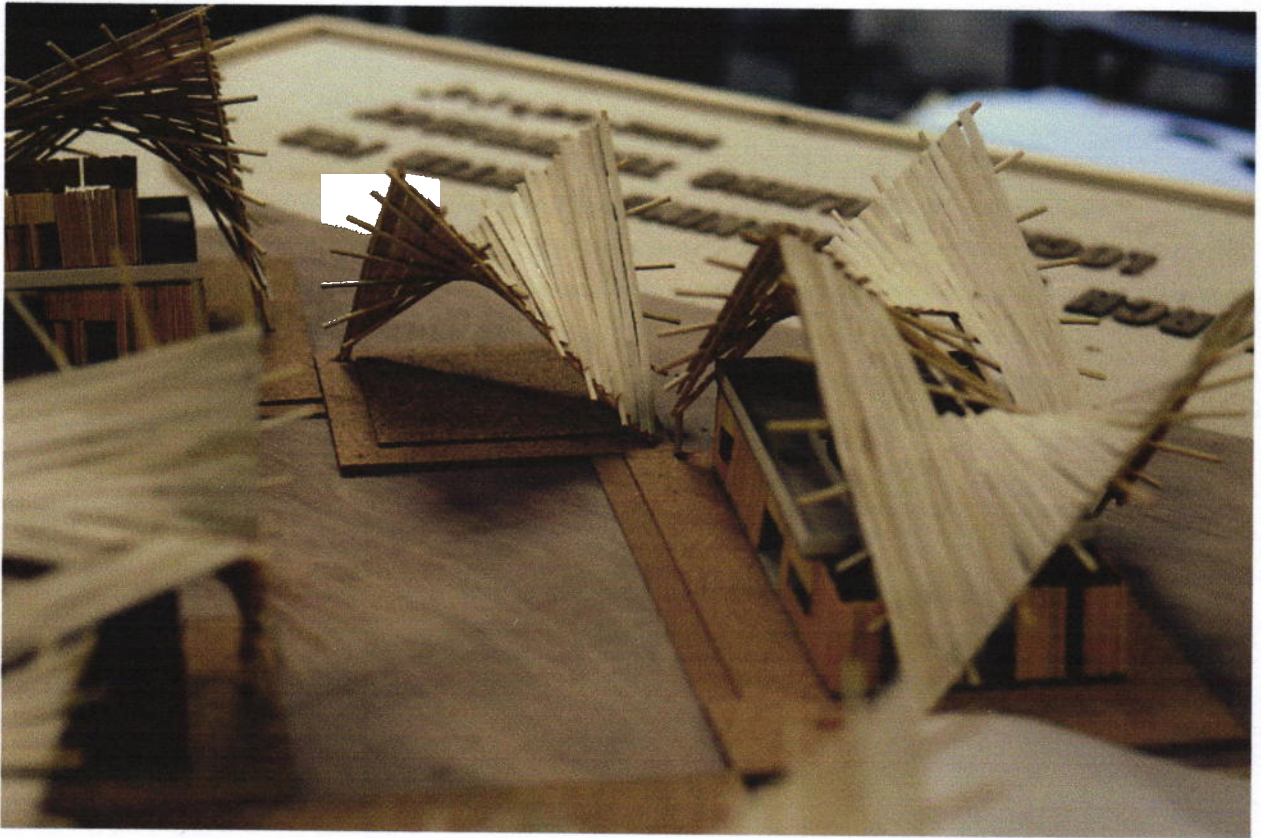
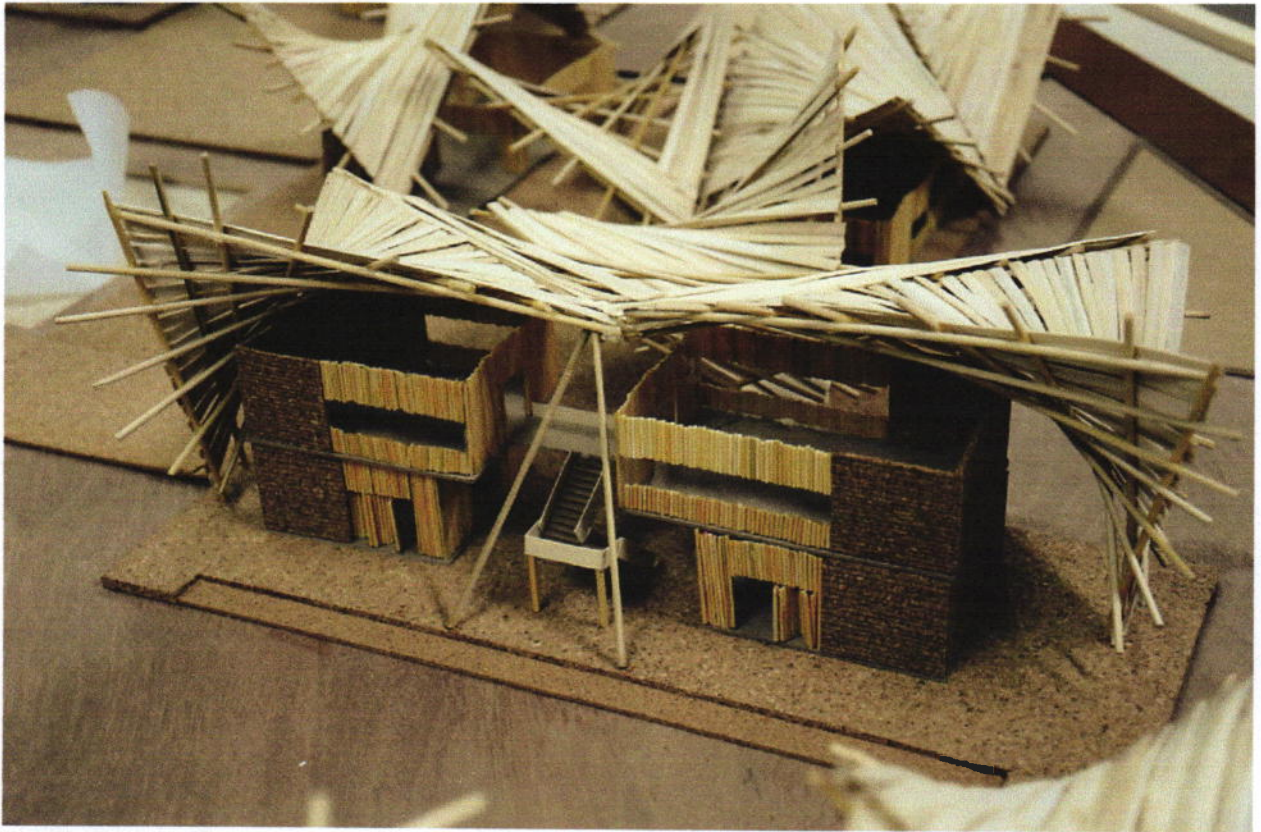
UT







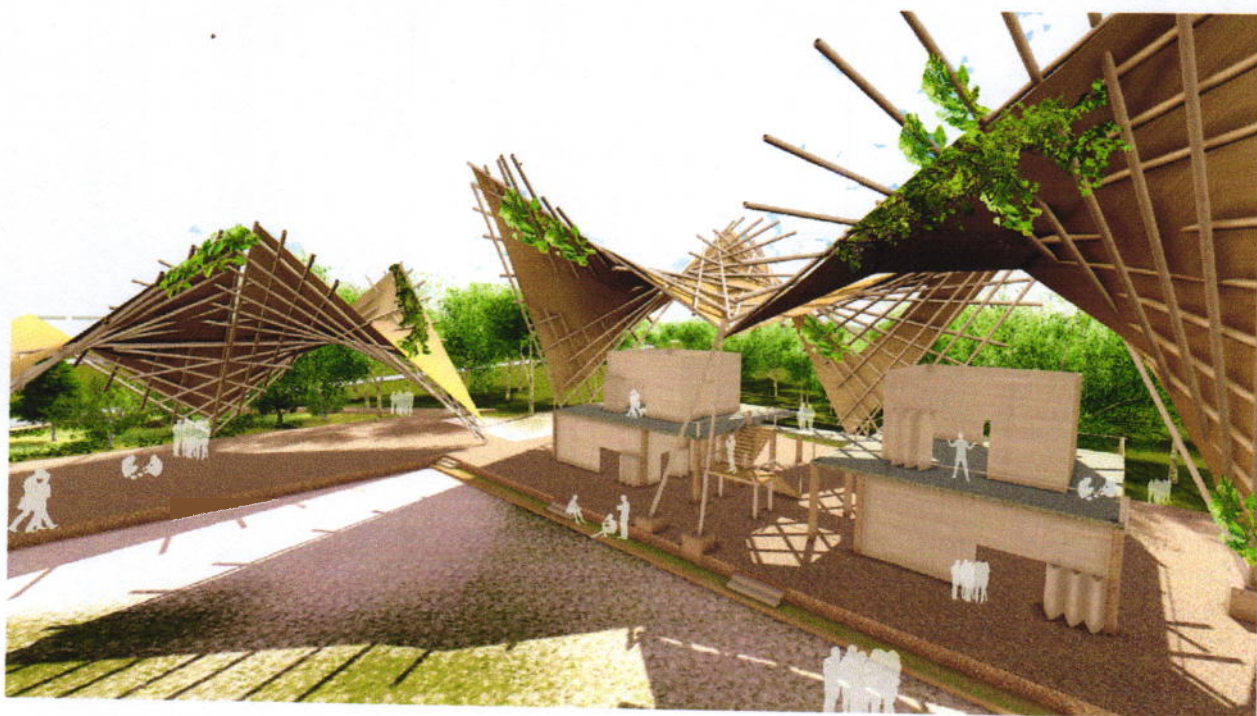




CHAPTER 08: CONCLUSION

The approach of designing this institute is focused on the process rather than the product. It is designed to celebrate the vast possibilities of bamboo structure and inspire general people. If not the shape of the structure, but people will eventually learn small joinery techniques and apply them in their needs. So this approach will ensure that the ideas and techniques stand a much better chance of spreading to others in the immediate and surrounding community.

In short, the research and learning center for local building technology celebrates the authenticity local materials and inspires to explore with local building technology for a green future in Bangladesh. ✓



REFERENCE

www.safebangladesh.wordpress.com

www.housingandhazards.org

www.anna-heringer.com

www.latestworldweather.com

www.weatherbase.com

www.hunnar.org

www.archdaily.com/suoi-re-village-community-house

www.ruralhousingnetwork.in/organization/hunnarshala

<http://www.earthbuilding.org.nz>

M. Carter (1997), "Rural Housing and Affordable Innovation: Implementing building for safety in Dinajpr district. northern Bangladesh", pp 1-6.

R.L.P. Hodgson, M.L. Carter (1996), "Vernacular buildings in Sunderban, Dinajpur district: Implementing building for safety", pp 79-85.

Steele, J, (1997), "An architecture for the people: The Complete Works of Hassan Fathy"

Shila K. de Vries, (2002), "Bamboo Construction Technology for Housing in Bangladesh"

Samuel G Stephens (2012), "Improved field testing of bolted bamboo connections for use in bracing of informal housing."

National Mission on Bamboo Application, (2006), "Training Manual: Preservation on Bamboo."

Maria Rosaria Gargiulo and Immacolata Bergamasco, "The Use of Earth in the Architecture of Hassan Fathy and Fabrizio Carola: Typological and Building Innovations, Building Technology and Static Behaviour."

Fathy, Hassan, "*Natural Energy and Vernacular Architecture: Principles and Examples with Reference to Hot Arid Climates*", UNU, 1986.

Ahmed I (2005), "Design and construction of houses of flood prone areas of Bangladesh"

Patti Stouter (2010), "Planning Buildings in Warm Humid Regions: Hints for NGOs"

Research project for the Department of International Development Bangladesh, (2011),
"Affordable Housing in a Changing Environment: Bangladesh"

Jimmy C.S.Lim, (2007), "Hand Made School, Rudrapur, Bangladesh"

Hasan D (1985), "A Study of Traditional House form in Rural Bangladesh", Unpublished M.Arch
dissertation, Dept of Architecture, BUET Dhaka.

H. Warburton, A. Martin, "Local people's knowledge in natural resources research."

K.H.Kabir, Fuad.H.Mallik (2005), "Living below the line: Sustainability and the houses of the ultra
poor"