`

CONTEXT-SPECIFIC GREEN HOUSING DESIGNS FOR RURAL MEGHALAYA

Development of sustainable, appropriate and context specific housing designs and construction recommendation refinements for rural housing in Meghalaya

A report

- Harsha Sridhar

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Introduction

In 2014 a report on Sustainable Housing for Rural Meghalaya was submitted to the MoRD with the purpose of creating a Compendium of Sustainable Technologies and to highlight a set of design and construction technology recommendations that are applicable in the distinct zones identified as a result of this exhaustive study.

As part of a Second Phase, an exercise to develop context specific, alternative, green housing designs for construction supported by the Indira Awaas Yojana in the State of Meghalaya was undertaken. A workshop was then designed and conducted in coordination with the State Institute for Rural Development, SiRD, where these prototypes were presented to a cross section of the Govt functionaries dealing with the delivery and coordination of Indira Awaas Yojana scheme in the state of Meghalaya.

This report captures the design prototypes, the construction recommendations and the programme and actionable outcomes of the workshop.

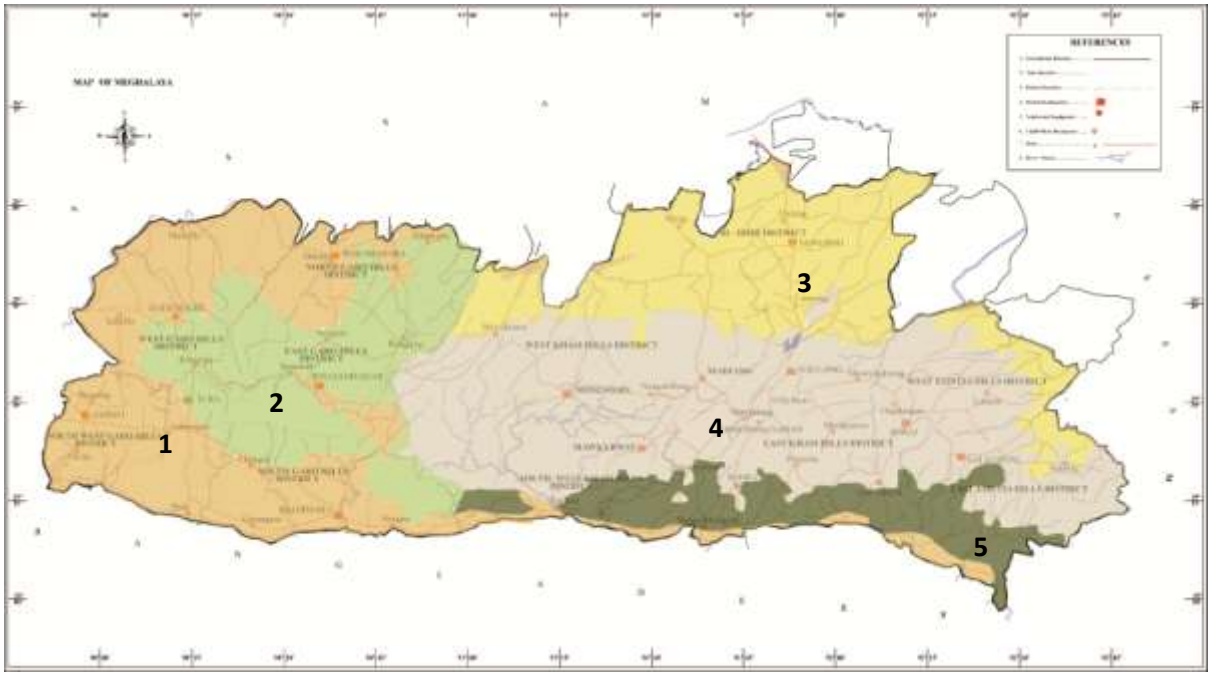
Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Contents

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Housing Zones

Geographic, climatic and resource factors has resulted in a great degree of variation in building types, architectural forms and details, and material use. Five distinct zones that capture this as physical areas that demonstrate and demand specific architectural solutions in the built form have been created. These zones span different districts and blocks; sometimes a single block can have more than one zone.



The zones identified are:

S No	Zones	Geography	Cultural association
1	Western and Southern Plains	Mostly plains and random hillocks,	Primarily Garo, Hajong and Rabha. Some Khasi and Jaintia areas in along the southern fringe too.
2	Western Hills	Hilly areas between 300 and 800 metres elevation in general, but still hot and humid	Predominantly Garo
3	Northern Slopes	Hilly areas on the leeward side with elevations lower than 600 metres in general, predominantly Khasi areas.	Predominantly Bhoi
4	Higher Plateau	Regions above 600 metres in elevation in general.	Khasi and Garo
5	Southern Slopes	Hilly tracts below 600 metres in elevation in general.	Khasi, Jaintia, War, Pnar,

The boundaries of these zones are broad depictions based on the agro-climatic map of the state and can be further refined with a more exhaustive survey on the ground, and with the cooperation of the various Gram Sewaks and Block Development officials.

Construction Technologies and Design Recommendations for each zone

Detailed recommendations for Built form and Construction Technologies for each zone had been developed as per the report on Sustainable Technologies for Rural Housing- Meghalaya. These have also been revised based on the feedback received in the Workshop conducted in Meghalaya on Sustainable Rural Construction Technologies, attended by the Govt functionaries and some representatives from civil society.

Prototype designs have also been created for each of these zones demonstrating what the beneficiary structures could look like with possible extensions and utilities. Each of these prototype designs also demonstrates the use of the recommended construction technologies for each zone. Each prototype design has demonstrates at least two different variations of construction technologies, from foundation to roof, that the beneficiaries could employ.

This design prototypes show how a beneficiary's home can be built with design, usage and construction variations. ***The layouts developed are only suggestive and the beneficiaries are free to plan their home the way they desire.*** It offers ways to build a strong and secure home which is reflective of local traditions and a beneficiary family's functional needs. It is easy to build, using materials and skills available in the village of the beneficiary. This design ensures that there is least damage to the environment with materials used and construction methodology.

Each of these structures has been designed to withstand earthquakes and cyclones. It is proposed that the beneficiaries follow the construction technologies recommended and build themselves a sturdy and beautiful home.

These Housing Prototypes were later revised based on the feedback from the workshop conducted in Shillong on Green Housing Technologies.

In addition Construction details highlighting horizontal and vertical reinforcement in masonry construction, reinforcement around openings and bracing in bamboo construction are also drawn out.

Zone 1

This region is characterised by the earthen plinth structures and a mixture of adobe walled and bamboo mat screen walled structures. The influence of adobe construction in the region is perhaps due to its proximity to the plains of neighbouring Bangladesh and Assam. This region is also home to the Koch, Rabha and Hajong tribes who are known to build walls using adobe.

The adobe walled structures help keep the interiors cool in the sweltering heat that these areas face. There has traditionally been access to bamboo and timber and there are visible skills in bamboo and timber works. Bamboo mat walling also seems to provide respite from the heat in the interiors

Burnt Clay Bricks are very prevalent in the area and possibly amount for the bulk of all the walling in new construction in the area. This is aided by the presence of various brick kilns in this zone, especially towards the North West corner of Garo Hills.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo framework for structures, especially roofing
- Adobe wall erection

RECOMMENDED CONSTRUCTION MATERIAL AND TECHNOLOGY OPTIONS FOR THE REGION

A revised list of recommended construction materials and technologies for the region was prepared. This was revised post the first workshop held with informed feedback from the government officers representing different Blocks in each zone.

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Stone Masonry strip foundation • Option of Isolated footings with large stone pieces and cement soil mixture and raised flooring on plinth beams for flood prone areas.	Loosely collected and shallow quarried boulder rock can be used in the foundation.
2	Plinth	• Stone Masonry plinth • RCC Plinth beams for raised floors in flood prone areas. Flooring support framework in bamboo/timber	

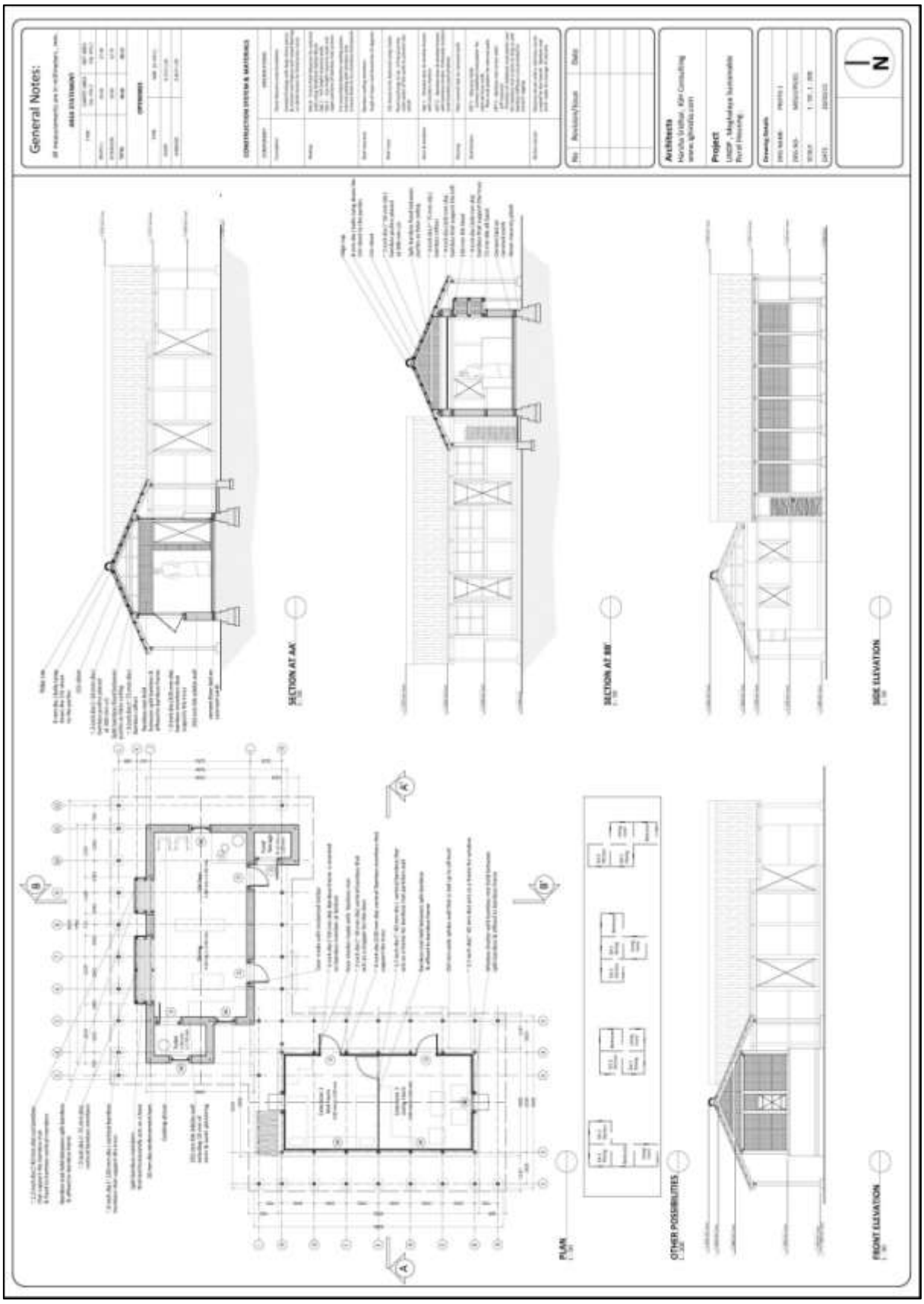
3	Walling	Minimum 8-9 inch thick Masonry for external walls using: • Stabilised Adobe Blocks • Rammed earth walls • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework. Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework Internal walling could also use bamboo mat screens fixed onto a bamboo/timber framework	Vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length and Horizontal reinforcement bands are to be provided at plinth, sill, lintel, and roof level. Additional reinforcement to be provided around all openings.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3 ft feet beyond the outer plane of the walls to prevent rain splash. Lightweight ferrocement/bamboocrete roofing laid over the roofing structure can be explored	
6	Doors and windows	Wooden door and window frames with wooden shutters. Preferably medium sized bamboo jaali windows or small windows in masonry walls.	
7	Flooring	Plain Cement/Rammed earth flooring laid over a back filled plinth. Wooden planks of hardy non-edible betel nut trees laid over a split bamboo framework.	
8	Wall finishes	Masonry Walls • Cement stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls • Bamboo mat screen walls • Can be left exposed • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging.	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

9	Kitchen alcove	Where a kitchen is to be attached, a masonry or bamboo/timber alcove with a chimney can be created for the hearth. A timber and bamboo mat shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

DESIGN PROTOTYPE

The designs are essentially modifications of both the 'Adobe block house' and the 'On ground Rectangular Timber post and beam house', both traditional housing types found in this region. Here are some salient aspects of this prototype:

- These structures can be rectangular in plan with an entry from the longer sides. Extended roofs on two sides of the home are held up by bamboo poles. These could also be used as verandahs with masonry bases.
- We have shown the house to have a gable roof (two sided), but one could also do a hipped roof (four sided).
- Stabilised adobe blocks are used for the walls as they are similar to the unstabilised adobe blocks used locally, and can be made with the current skills in the area. One could build them either as full height or half height walls.
- Protection of the walling areas by providing deep roof overhangs is done.
- The roof is made of CGI sheets supported on a bamboo roofing structure. One could use an under layer tied to the roof of split bamboo to create an air gap which will help keep the home slightly cooler. Alternatively, one could create a loft to store materials or serve as an extra sleeping area.
- The house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage areas.



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

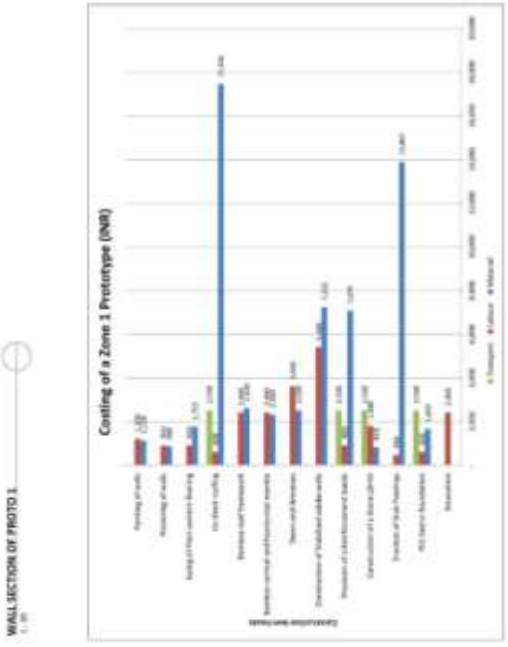
General Notes:

Architects
Harsha Sridhar, IGH Consulting
www.ighindia.com

Project
UNDP - Meghalaya Sustainable Rural Housing

Costing of Prototype for Zone 1

WALL SECTION OF PROTO 1



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Zone 2

This region is characterised by raised bamboo-timber hybrid structures with whole & split bamboo walls, and variants that use timber/bamboo posts with bamboo mat screens for wall. This is also a predominantly Garo region and where the traditional Garo long huts are found. Traditionally, this is not an area known for any masonry construction.

This is an area where very sturdy and ingenious bamboo and timber hybrid structures have been developed over time, some even dating back to over a 115 years, surviving the earthquake of 1857.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo and timber framework for structures– walling, roofing, flooring, etc.
- Rough timber works

RECOMMENDED CONSTRUCTION MATERIAL AND TECHNOLOGY OPTIONS FOR THE REGION

A revised list of recommended construction materials and technologies for the region was prepared. This was revised post the first workshop held with informed feedback from the government officers representing different Blocks in each zone.

S No	Component	Recommended Specifications	Specific comments
1	Foundation	Isolated footings with large stone pieces and cement soil mixture. Alternatively, you could use large stones as stubs.	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor (no masonry plinth) Flooring support framework in bamboo propped up on bamboo columns embedded in the concrete footings	
3	Walling	Option of • Bamboo mat screens held in either timber or bamboo framework. • Close knit framework of Split/whole bamboo assembly with bamboo mats made from flattened bamboo in the rear. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework Internal walling could also use bamboo mat screens fixed onto a bamboo/timber framework	Strong vertical members at corners and short intervals along with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and at all vertical members are to be provided for extra stability.

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

4	Roof structure	Bamboo/timber roofing members. Preferably a hipped roof.	Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain Cement flooring laid over a split bamboo framework. • Wooden planks of hardy non-edible betel nut trees laid over a split bamboo framework. • Bamboo mat flooring over the bamboo framework • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework	
8	Wall finishes	• Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. • Keeping the walling exposed, as long as there is adequate rain protection from the roof overhang	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry or bamboo/timber alcove with a chimney can be created for the hearth. A timber and bamboo mat shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

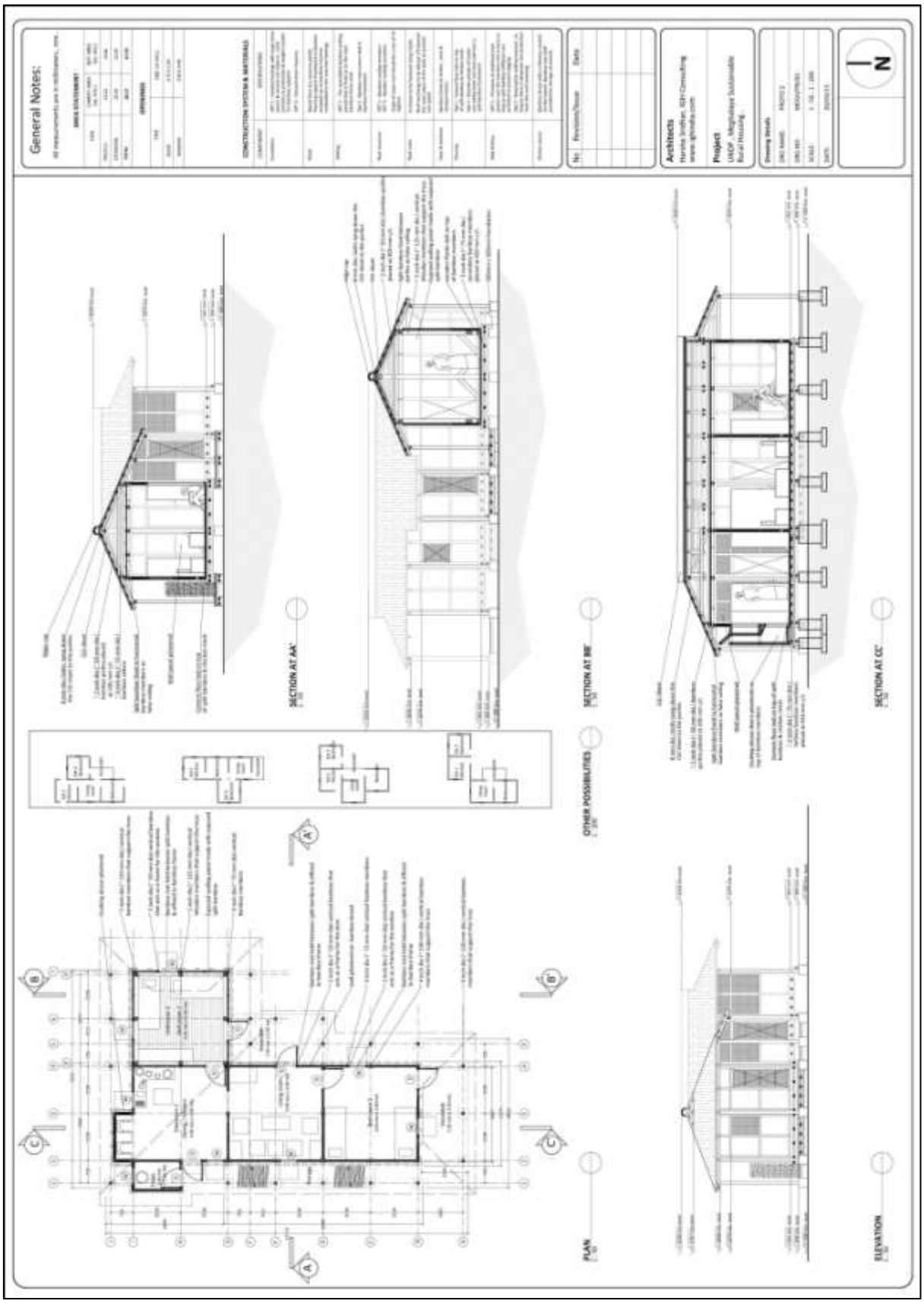
DESIGN PROTOTYPE

The design takes cues from both the 'Garo Long house' and the 'On ground Rectangular Timber post and beam house', both traditional housing types found in the region. Here are some salient aspects of this prototype:

- The house is a rectangular structure and linear in the arrangement of the interior spaces. The Living room is in the centre as in traditional Garo houses. Space for storage can be provided under the roof overhangs on the side. Verandahs to be provided in both the short sides.
- In this prototype we have demonstrated a raised bamboo flooring structure which is in-turn supported on short stub columns. A cement floor over a tightly laid split bamboo-chicken mesh framework (on the flooring supports) is shown as an option, or, and as an alternative, we have shown a betel nut wood flooring in the extension.

- Bamboo panels made with split bamboo in bamboo frames between the main vertical members form the walling. These are plastered with a soil-cement plaster and protected from the rain by providing deep roof overhangs which are supported using external bamboo posts that are embedded in the ground.
- We have shown the house to have a hipped roof (four sided), which fares well in strong cyclonic winds. The roof cover is CGI sheets supported on a bamboo roofing structure. One could use an under layer tied to the roof of split bamboo to create an air gap which will help keep their home slightly cooler.
- This house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage.

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

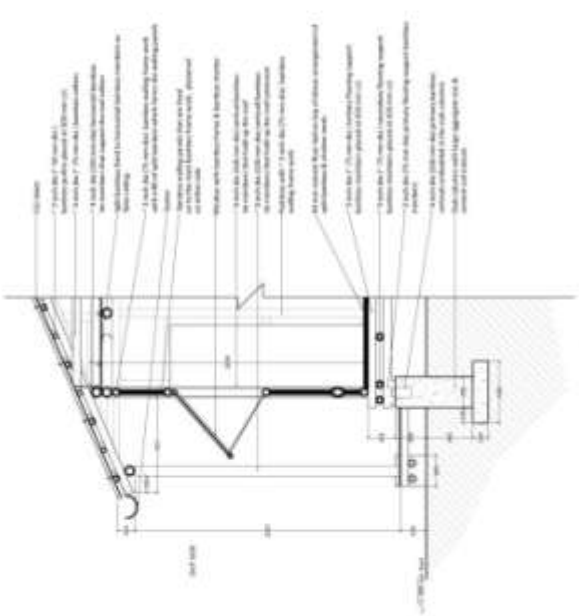
General Notes:

Architects
Harsha Sridhar, IGH Consulting
www.ighindia.com

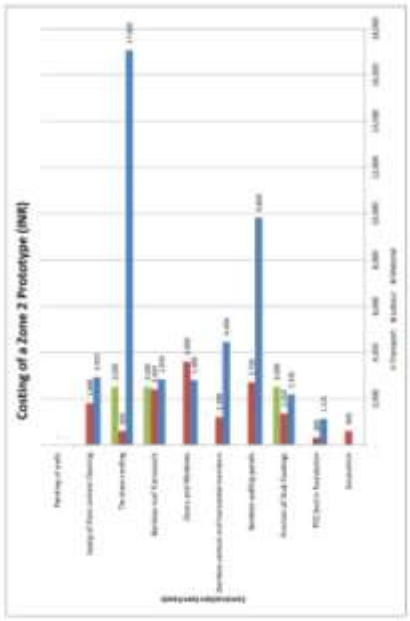
Project
UNDP - Meghalaya Sustainable Rural Housing

Costing of Prototype for Zone 2

S.No.	Item	Unit	Material			Labour			Transport	Total Amount
			Qty	Rate	Cost	Qty	Rate	Cost		
1	Foundation:									
	Earth work excavation in ordinary soil and stacking the excavated soil nearby	cum	4.0			4	125	500		500
2	PCC bed for concrete footings									
	Concrete 1:3:6	cum	0.5			1	150	150		150
	Bamboo	pcs	10	20	200					200
	Aggregate	cum	0.3							0
	Sand	cum	0.3							0
3	Stone soling bed for footings	Sqm	16			2	150	300	1,440	1,740
	Stone	cum	3.2							0
	Sand	cum	0.3							0
4	Bamboo reinforcement, Stitch/Tied with GI wire									
	Bamboo	nos	30.0	20	600	2	150	300		900
	GI wire	kg	1.5	80	120					120
5	Plastering of earth on plinth	sqm	3.0			1	150	150		150
	Earth	cum	0.9							0
	Water	ltrs	300							0
6	Making and erecting the earthen wall (Rammed Earth Wall)	cum	4.1			1	150	150		150
	Earth	cum	4.1							0
7	Bamboo reinforcement in the Rammed Earth Wall									
	Bamboo	nos	45.0	20	900	4	150	600		1,500
	GI wire	kg	1.5	80	120					120
8	Making and erecting the Bamboo roof									
	Bamboo	nos	45.0	20	900	4	150	600		1,500
	GI wire	kg	1.5	80	120					120
	Jute rope	kg	1.5	100	150					150
9	Making and erecting the Bamboo roof									
	Bamboo	nos	45.0	20	900	4	150	600		1,500
	GI wire	kg	1.5	80	120					120
	Jute rope	kg	1.5	100	150					150
10	Thatching with Thatch grass									
	Thatch grass	Nos	300	10	3,000	2	150	300	2,160	5,460
	Bamboo	nos	10	20	200					200
	Jute rope	kg	1.5	100	150					150
11	Plastering of mud mortar on bamboo mat walls, Mud coating on the roof									
	Earth	cum	2.1			4	150	600		600
	Bamboo mesh	nos	30.0	5	150					150
	Sand	cum	0.3							0
	Water	ltrs	200							0
12	Making of windows and doors									
	Bamboo	nos	10.0	20	200	2	150	300		500
	GI wire	kg	1.5	80	120					120
	Cost of plinth beam									14,000
	Cost of Wall Beam								1,800	17,800
	Cost of Roof Beam									49,870



WALL SECTION OF PROTO 2
1:10



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Zone 3

This region is characterised by raised Assam type houses and variants that use timber/bamboo posts with bamboo ikra walling. This is also a region occupied by Khasi, Bhoi and Jaintia villages. Traditionally, this is not an area known for any masonry construction.

However, by the sheer proximity to most to the main Guwahati-Shillong-Jowai highways, a lot of transformation to the building stock has taken place, with evidence of concrete block work, and some brick work (along main arterial roads). Bamboo and timber skill-sets are still abundant, with a number of houses being built entirely in Bamboo.

The mud/lime plastered wall surfaces of the Assam style and traditional bamboo structures in this region offer great respite from chill winds. A thatch roof offers great comfort in winter as against a CGI sheet roof in this zone.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo and timber framework for structures– walling, roofing, flooring, etc.
- Carpentry

RECOMMENDED CONSTRUCTION MATERIAL AND TECHNOLOGY OPTIONS FOR THE REGION

A revised list of recommended construction materials and technologies for the region was prepared. This was revised post the first workshop held with informed feedback from the government officers representing different Blocks in each zone.

S No	Component	Recommended Specifications	Specific comments
1	Foundation	Isolated footings with large stone pieces and cement soil mixture	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor (no masonry plinth) • Entire Flooring support framework in bamboo propped up on bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber	

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

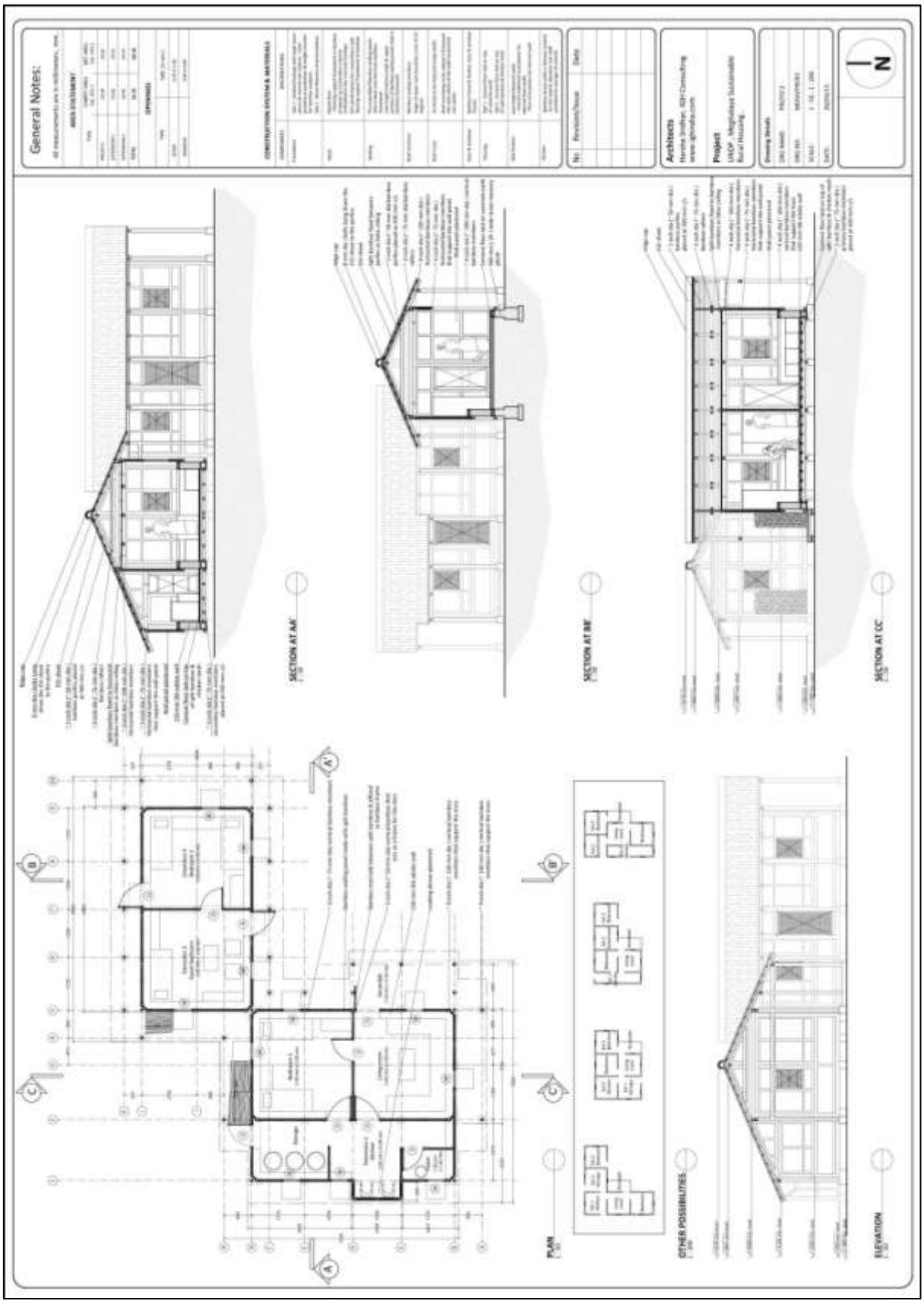
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on the outside and inside. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework.	Strong vertical bamboos at corners and short intervals with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and all vertical members. Masonry walls- vertical reinforcement in corners and every 1-1.2 metres of wall length. Horizontal tie reinforcement bands at plinth, sill and lintel levels.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be boarded up.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window shutters and frames • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain Cement flooring laid over a split bamboo framework. • Bamboo mat flooring over the bamboo framework • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework	
8	Wall finishes	Ikra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. • Low height Masonry Walls • Cement stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

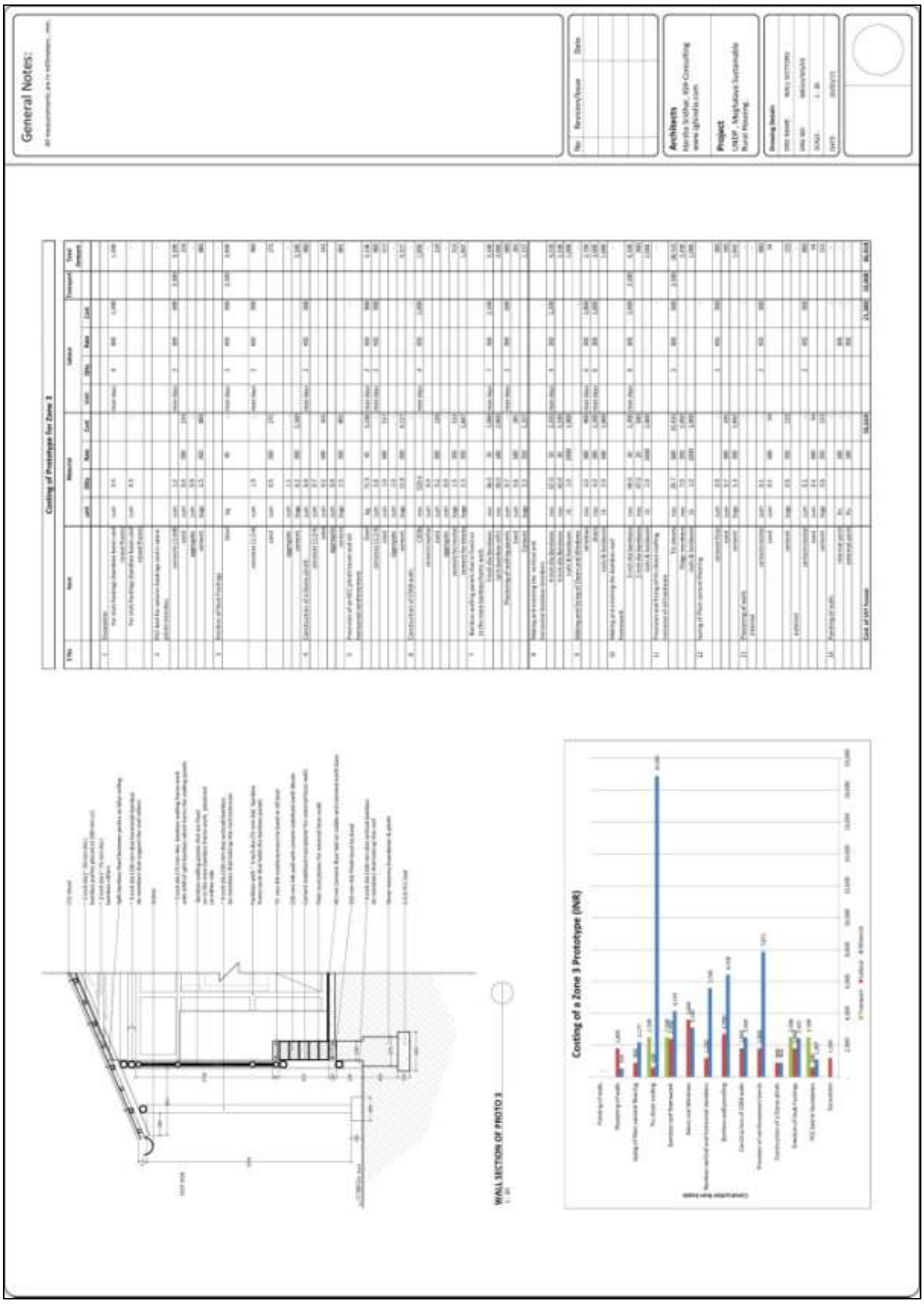
DESIGN PROTOTYPE

The design is a hybrid of sorts melding the traits from the Assam style houses and Bamboo post and beam houses, both housing types found in this region. Here are some salient aspects of this prototype:

- The house is a rectangular structure and linear in the arrangement of the interior spaces. Space for storage can be provided under the roof overhangs on the side. Verandahs to be provided in both the short sides.
- In this prototype we have shown both a raised bamboo flooring structure which is in-turn supported on short stub columns and a masonry plinth variant in the extension structure. A cement floor over a tightly laid split bamboo-chicken mesh framework (on the flooring supports) is shown as an option, and as a variation we have shown a cement floor on a back-filled plinth.
- Stabilised Soil Blocks form a low height walling till sill height. Bamboo panels made with split bamboo in bamboo frames between the main vertical members form the walling above sill height. These are plastered with a soil-cement plaster and protected from the rain by providing deep roof overhangs which are supported using external bamboo posts.
- We have shown the house to have a gable roof (two sided). The roof is made of CGI sheets supported on a bamboo roofing structure. Alternatively, one could create a loft to store materials or serve as an extra sleeping area.
- This house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage.



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Zone 4

This region occupies the higher elevations of the state forming the Meghalaya Plateau is characterised by raised Assam type houses and is home to the Traditional Khasi and Jaintia Huts. These traditional structures and their variants in this region predominantly see the use of timber posts with wooden panel and bamboo ikra walling. This region receives amongst the highest rainfall in the state, specially towards the south, and also sees some of the strongest cyclonic activity. This is also a region occupied mainly by Khasi and Jaintia villages. One also sees traditional stone masonry in this region. All-timber houses are also common.

Large diameter and high wall thickness Bamboo does not grow well in this region. Most of the bamboo and thatch in this region is brought up from lower altitude areas. The Khasi hut which is the iconic traditional structure is solely found in this zone. This structure is perhaps a great example of a cyclone resistant roof form, and a seismically secure structure. The structures of this region also strive to keep the occupants inside comfortable and insulated from the cold.

The Main skills recorded in this zone are:

- Carpentry
- Stone masonry
- Bamboo mat making & bamboo framework

RECOMMENDED CONSTRUCTION MATERIAL AND TECHNOLOGY OPTIONS FOR THE REGION

A revised list of recommended construction materials and technologies for the region was prepared. This was revised post the first workshop held with informed feedback from the government officers representing different Blocks in each zone.

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Isolated footings with large stone pieces and cement soil mixture • · Strip foundation with stone masonry with drainage gutter provided all around the house.	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor • Entire Flooring support framework in timber/bamboo propped up on timber/bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber • Stone Masonry plinth with earth backfilling	

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

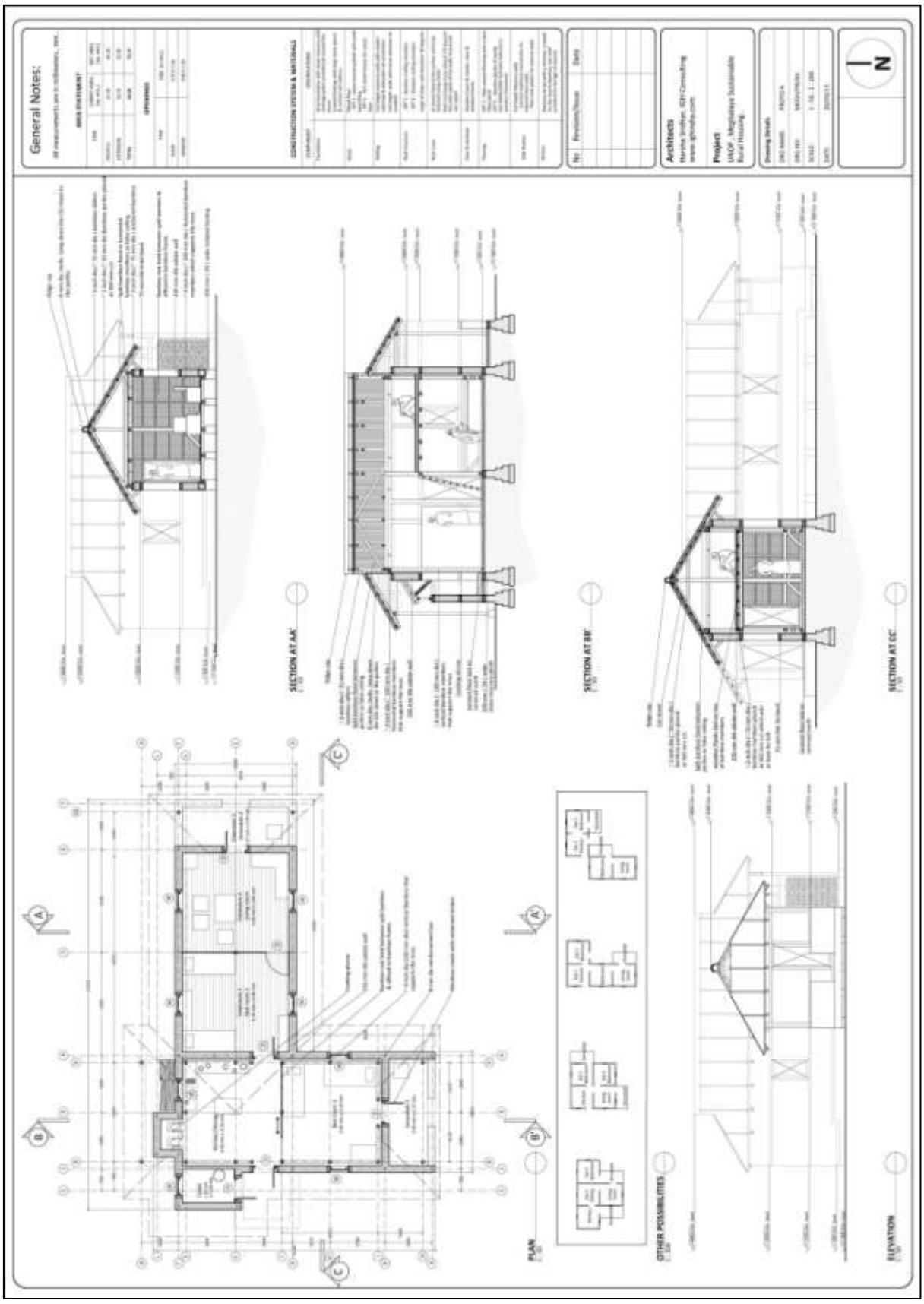
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on the outside and inside. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. This could also be made as bamboocrete panels. • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework. • Full height masonry walls with smaller openings and adequate rain protection.	Vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length. Horizontal tie reinforcement bands have to be provided at plinth, sill and lintel levels where applicable.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 30°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Lightweight ferrocement roofing can be explored. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be boarded up.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters • Wooden door and window frames with wooden shutters • Preferably small sized windows.	
7	Flooring	• Plain cement flooring over a backfilled plinth • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework • Timber Plank flooring over Timber under-structure.	
8	Wall finishes	Ikra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. • Low height Masonry Walls • Stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

DESIGN PROTOTYPE

The design borrows heavily from certain aspects of the Khasi Oval Hut, the iconic traditional housing type of this region, without taking the obvious oval plan form. Here are some salient aspects of this prototype:

- The house is a rectangular structure preferably laid out in the SW-NW direction. Verandahs to be provided in both the short sides.
- In this prototype we have shown a raised structure on plinth beams which are in turn supported on short stub columns and a masonry plinth variant in the extension structure. A cement floor over a back-filled plinth is shown as an option, and as a variation we have shown a timber plank floor supported on stub columns.
- The walls are full height Cement Stabilised block masonry. Reinforcement bands run at plinth, sill, lintel and roof springing point levels.
- The roof is essentially a gable roof form with 30° slopes, to ensure greater resistance to strong winds which this zone experiences, especially in the pre-monsoon months of March and April. Taking inspiration from other traditional structures across the state, an additional set of bamboo members are provided above the CGI roofing sheets and tied down with the rafters below, securing the sheets from getting dislodged due to gale force winds. One could create a loft to store materials or serve as an extra sleeping area.
- This house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage.



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

General Notes:

All measurements are in millimeters, mm.

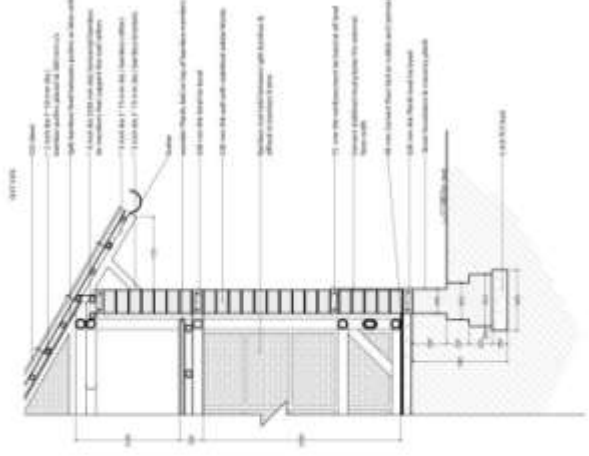
Architects
Harsha Sridhar, IGH Consulting
www.ighindia.com

Project
UNDP, Meghalaya Sustainable Rural Housing

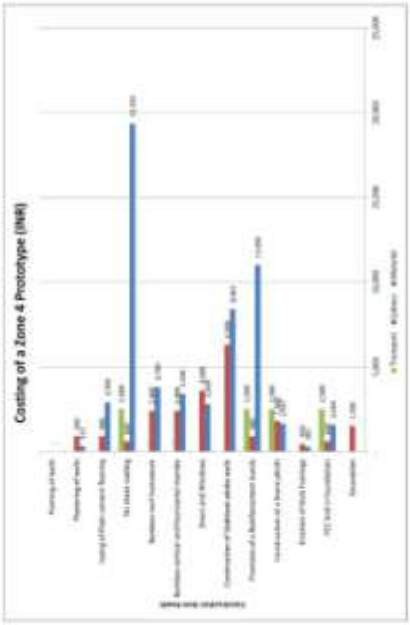
Drawing Details
DRG NAME: WALL SECTIONS
DRG NO: WS/01/01/01
SCALE: 1 : 20
DATE: 2020/2/5

Costing of Prototype for Zone 4

S.No	Item	Unit	Volume	Rate	Cost	Labour			Transport	Total Amount
						Unit	Qty	Rate		
1	Excavation									
	Trench excavation	cum	13.5	300	4,050	man days	9	450	1,350	5,400
	Pit excavation	cum	4.9	300	1,485	man days	3	450	495	1,980
2	Stone work in foundation									
	Stone work in CM 1:6	cum	1.7	5,500	9,350	man days	9	450	3,150	12,500
	Plinth filling	cum	5.1	300	1,530	man days	1	450	450	1,980
	Backfilling	cum	3.2	300	960	man days	1	450	450	1,410
3	Masonry in Superstructure									
	Stone masonry in CM 1:6	cum	9.2	5,500	50,600	man days	46	450	15,750	66,350
	Lintel band	cum	4.2	5,500	23,100	man days	9	450	2,700	25,800
	Gable wall	cum	4.2	5,500	23,100	man days	9	450	2,700	25,800
	Reinforcement	kg	81	70	5,670					5,670
4	Construction of a Gable grade									
	masonry in CM 1:6	cum	1.3	5,500	7,150	man days	9	450	2,250	9,400
	plaster	sqm	8.4	300	2,520	man days	1	450	450	2,970
	RCC Band	cum	0.6	6,500	3,900	man days	1	450	450	4,350
	Reinforcement	kg	50	70	3,500					3,500
5	Construction of a Gable grade and laying of reinforced grade									
	masonry in CM 1:6	cum	1.3	5,500	7,150	man days	9	450	2,250	9,400
	plaster	sqm	8.4	300	2,520	man days	1	450	450	2,970
	RCC Band	cum	0.6	6,500	3,900	man days	1	450	450	4,350
	Reinforcement	kg	50	70	3,500					3,500
6	Construction of Reinforced window sunshade									
	RCC	cum	0.6	6,500	3,900	man days	4	450	1,800	5,700
	Reinforcement	kg	50	70	3,500					3,500
	Shuttering	sqm	3.2	300	960	man days	1	450	450	1,410
	Plastering of Reinforced window sunshade	sqm	3.2	300	960	man days	1	450	450	1,410
	Painting of Reinforced window sunshade	sqm	3.2	300	960	man days	1	450	450	1,410
7	Plastering and Painting of Plinth (Internal and External)									
	Plastering	sqm	37.7	300	11,310	man days	46	450	20,700	32,010
	Painting	sqm	37.7	300	11,310	man days	46	450	20,700	32,010
8	Plastering and painting of the window and ventilator openings (Internal and External)									
	Plastering	sqm	20.5	300	6,150	man days	46	450	20,700	26,850
	Painting	sqm	20.5	300	6,150	man days	46	450	20,700	26,850
9	Plastering and painting of the wall (Internal and External)									
	Plastering	sqm	81	300	24,300	man days	46	450	20,700	45,000
	Painting	sqm	81	300	24,300	man days	46	450	20,700	45,000
10	Provision of fire retardant coating on the external surfaces of all timbers									
	Fire retardant coating	sqm	25.7	300	7,710	man days	4	450	1,800	9,510
	Wood preservative	sqm	8.7	300	2,610	man days	1	450	450	3,060
	Polish	sqm	8.7	300	2,610	man days	1	450	450	3,060
11	Laying of floor screed									
	Laying of earth	cum	1.3	300	390	man days	1	450	450	840
	Screed	sqm	4.9	300	1,470	man days	1	450	450	1,920
	Tiles	sqm	4.9	300	1,470					1,470
12	Painting of roof									
	Painting	sqm	37.7	300	11,310	man days	46	450	20,700	32,010
13	Fencing									
	Fencing	sqm				man days	46	450		
14	Miscellaneous									
	Miscellaneous	sqm	4.9	300	1,470	man days	1	450	450	1,920
	Sub Total of Estimate								21,600	22,500
										87,810



WALL SECTION OF PROTO 4
1 : 20



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Zone 5

This region occupies the lower elevations of the Meghalaya Plateau and sees very high rainfall. It is also amongst the most humid areas as well and is a bamboo and betel nut growing region. Traditionally, this region sees the use of timber and bamboo posts with wooden panel and bamboo ikra and bamboo mat walling. This too is a region occupied mainly by Khasi and Jaintia villages. Traditionally, masonry is not common in this belt.

Some of the best bamboo works come from this region, where perhaps some of the best bamboo grows. Some exquisite bamboo works, bamboo mat making and basket making are skills of this region. This is also a region from where thatch is sourced. The traditional Jaintia Hut is also from this region, a low roof form with a drooping front canopy. Earthen floors and rough stone plinths are also visible in this region.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo framework
- Carpentry, with additional skills in fashioning palm wood for flooring and reapers.

RECOMMENDED CONSTRUCTION MATERIAL AND TECHNOLOGY OPTIONS FOR THE REGION

A revised list of recommended construction materials and technologies for the region was prepared. This was revised post the first workshop held with informed feedback from the government officers representing different Blocks in each zone.

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Isolated footings with large stone pieces and cement soil mixture • Strip foundation with stone masonry, but with drainage gutters provided around the house.	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor • Entire Flooring support framework in timber/bamboo propped up on timber/bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber • Stone Masonry plinth with earth backfilling	

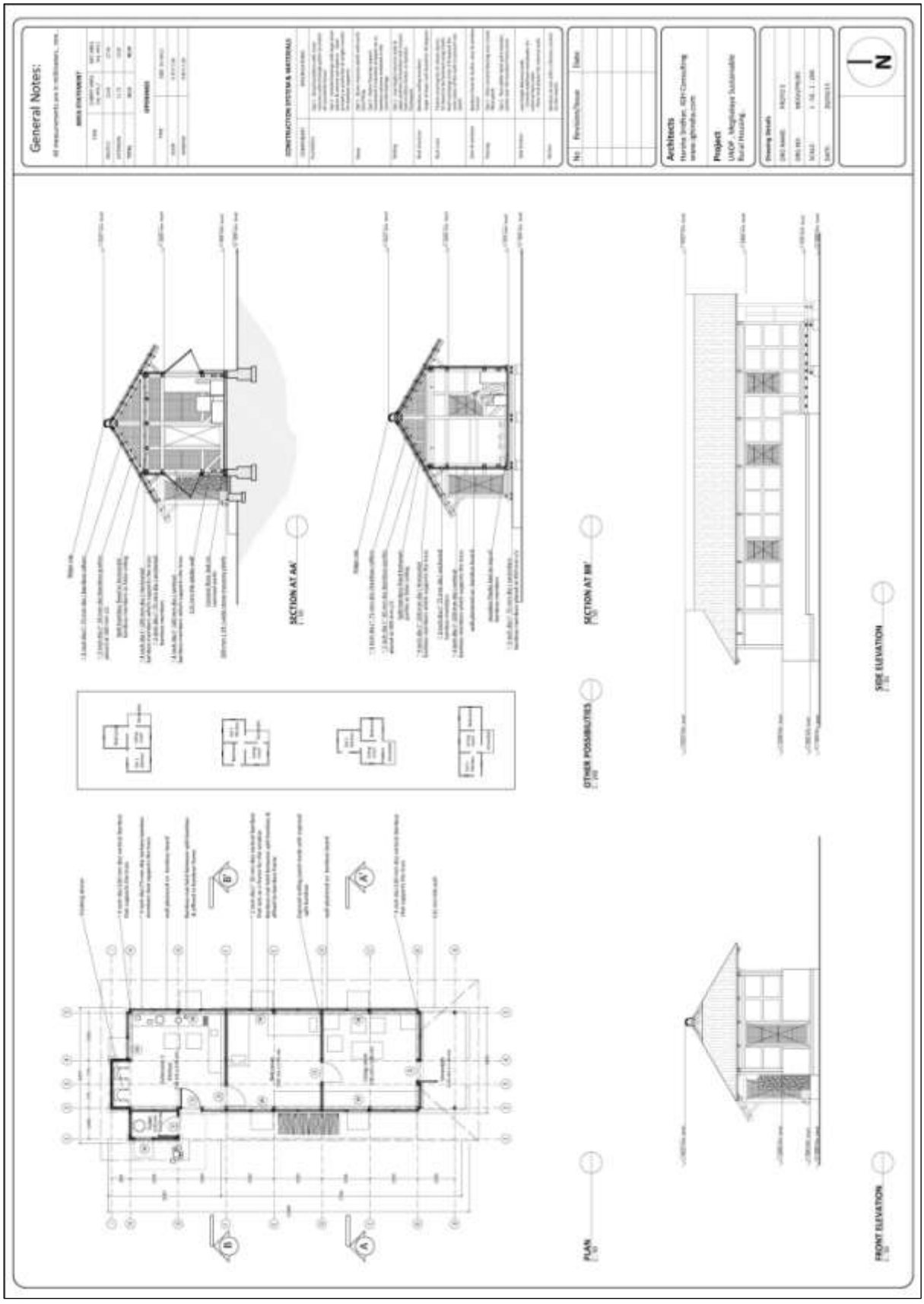
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on both faces. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. This could also be made as bamboocrete panels. • Bamboo mat screens supported against a timber/bamboo framework for external and internal walls • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework.	Strong vertical members at corners and short intervals along with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and at all vertical members. Masonry walls- vertical reinforcement in all corners and every 1-1.2 metres of wall length. Horizontal tie reinforcement bands at plinth, sill and lintel levels
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be minimum 30°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Lightweight ferrocement roofing can be explored. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be boarded up.	Extra vertical supports can be added to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain cement flooring over a backfilled plinth • Plain Cement flooring laid over a split bamboo framework. • Bamboo mat flooring or Close stacked split bamboo flooring fixed over a tight bamboo flooring framework • Non edible betel palm wooden planks over the bamboo framework.	
8	Wall finishes	Ikra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. • Low height Masonry Walls • Stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

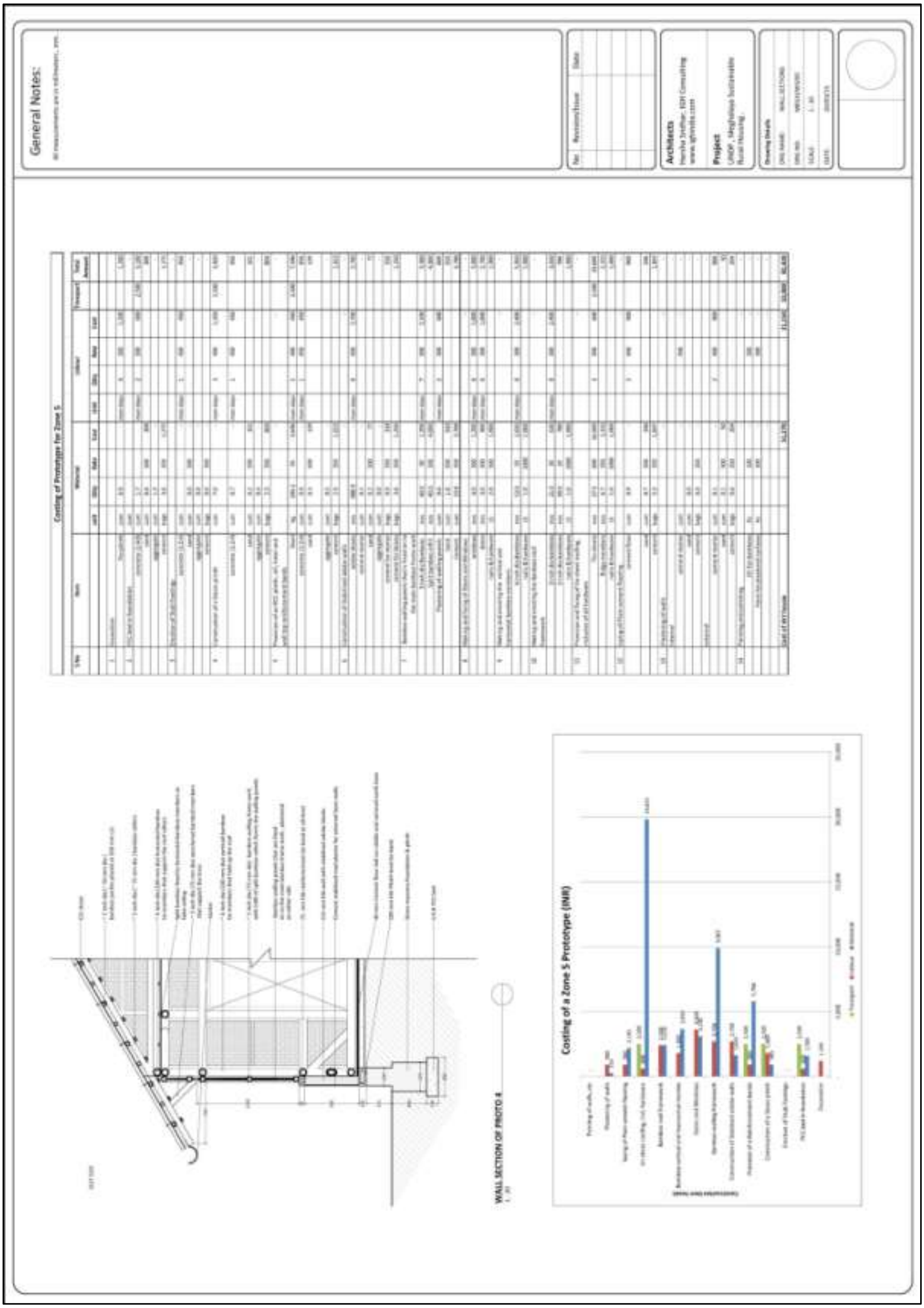
DESIGN PROTOTYPE

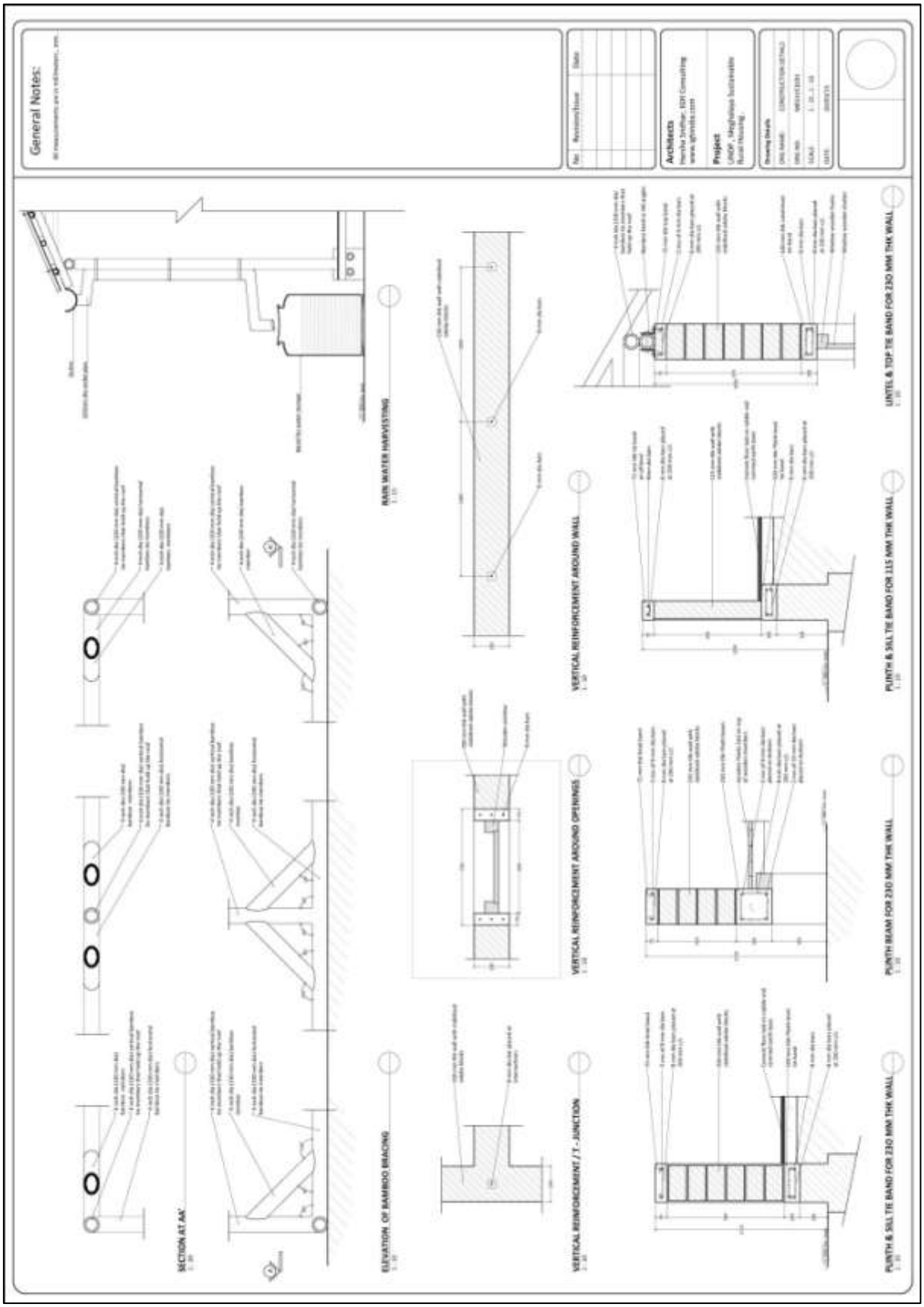
The design reflects the strong bamboo architecture of this zone and takes some inspiration from Jaintia Huts. Here are some salient aspects of this prototype:

- The house is a rectangular structure preferably laid out in the SW-NW direction. Verandahs are to be provided in both a short and a long side.
- Both a masonry plinth and raised bamboo flooring framework has been used in this structure and its extension. The main unit has a cement floor, while the extension sees the use of a palm wood (*thlu*) floor.
- Low walls till sill height are provided on the outer faces. A bamboo structure is housed within this. Cross bracing of every vertical support is done to provide greater stability to the structure. The entire structure is tied at various levels with horizontal bamboo members.
- Modular bamboo wall panels with split bamboo held within a bamboo framework and plastered from both sides form the walling surface above sill level. The rear has a simple bamboo mat held between split bamboos.
- Here too the roof has slopes of 30° and is a hipped roof towards the entry and has a gable end to the rear. Bamboo brackets support the weight of a deeper overhang. You could use an under ceiling layer tied to the roof of split bamboo to create an air gap to keep your home slightly cooler, or create a loft to store materials or serve as an extra sleeping area.
- This house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage.



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com


General Notes:
Costing of Prototype for Zone 5
WALL SECTION OF PROTO 4
Costing of a Zone 5 Prototype (INR)
Architects
Project



Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Meghalaya Workshop for Government Officials- Project Directors, BDOs, Engineers, Gram Sewaks

As part of a review, feedback and validation process from State Stakeholders a workshop was designed and conducted at Shillong. A 2 day state-level workshop in Meghalaya was conducted on the 18th and 19th of February 2015 with the participation of all the stakeholders, namely, the State rural department and other concerned government agencies, R &D (Research and Development) bodies and local experts and facilitators. Representatives from all zones were invited to participate in the workshop. The workshop was conducted in coordination with the SiRD and was held at the Shillong Convention Centre, Shillong, Meghalaya.

Mr Sadanandan, Joint Secretary, Ministry of Rural Development, Government of India, accompanied by Mr Rakesh Kumar and Ms Anushree Raha from the MoRD attended the workshop. The participants from the state included Mr H N Kumar, Principal Secretary CnRD, Mr Lyngwa, Director SiRD, Mr Banteilang Rumnong, Deputy Director SiRD, Project Directors, Block Development Officers, Assistant & Junior engineers, Gram Sewaks, and SiRD officials amongst others. Ms Shashi Sudhir and Mr Suneel Padale, Programme Analysts from the UNDP and Ms Gayatri Ratnam from HUDCO also attended the workshop representing the programme partners of this exercise. Resource persons working on similar studies on IAY housing in other states, and experts in earth and bamboo technologies were also invited to the workshop.

The workshop was inaugurated by the Honourable Minister, Mr Prestone Tynsong, Community and Rural Development Department.

The workshop set out to achieve the following goals:

1. Present the study done on Sustainable Rural Housing Technologies
2. Introduce the Design Prototypes developed for each zone.
3. Get experts on earth and bamboo technologies to present their work
4. Get feedback from the participants on
    a. The design of the 5 housing prototypes, in terms of layout, spaces, functions.
    b. The construction technologies and specifications recommended for each zone
    c. The costs projected and rates applied.

The workshop programme was as follows:

S No	Session	Activity	Duration	Start time	End Time
Day 1- Group Exercises					
1	Session 1	**Registration**	30 mins	9:30 AM	10:00 AM
		Inauguration	30 mins	10:00 AM	10:30 AM
BREAK TEA - 15 MINUTES					
2	Session 2	**Broad Introduction to the workshop and Presentation on Sustainable Rural Housing for Meghalaya by Harsha Sridhar**	30 mins	10:30 AM	11:00 AM
BREAK TEA - 15 MINUTES					
3	Session 3	**Presentation on Alternate Technology for Rural Housing by Pramod of Gramavidya**	30 mins	11:15 AM	11:45 AM

4	Session 4	**Study of the prototypes in terms of functionality and coming up with recommendations and suggestions for improvement**	60 mins	11:45 AM	12:45 PM
		Sharing of group findings and recommendations	15 mins	12:45 PM	1:00 PM
BREAK FOR LUNCH - 1 HOUR					
5	Session 5	**Study of the prototypes in construction methods and coming up with recommendations and suggestions to these construction technologies and specifications**	60 mins	2:00 PM	3:00 PM
		Sharing of group findings and recommendations	15 mins	3:00 PM	3:15 PM
BREAK TEA - 15 MINUTES					
6	Session 6	**Study of the prototypes in terms of costs and recommendations for reduction. Study of sanitation, water harvesting, drainage and other aspects around the house**	60 mins	3:30 PM	4:30 PM
		Sharing of group findings and recommendations	15 mins	4:30 PM	4:45 PM
END OF THE DAY 1					
Day 2- Presentations					
1	Session 1	**Brief introduction to the day's programme**	15 mins	9:30 AM	9:45 AM
		Compilation of findings by each group	60 mins	9:45 AM	11:00 AM
		Parallel session on Action Points and way forward (closed group)	60 mins	9:45 AM	11:00 AM
BREAK TEA - 15 MINUTES					
2	Session 2	**Presentation on Engineered Bamboo Houses by Rabi Mukhopadhyay**	90 mins	11:15 AM	12:45 AM
BREAK FOR LUNCH - 1 HOUR					
3	Session 3	**Presentations of findings by the 5 groups**	60 mins	2:00 PM	3:00 PM
BREAK FOR TEA - 15 MINUTES					
4	Session 4	**Presentation on the Gujarat Experience by Romkesh Patel, People in Centre**	45 mins	3:15 PM	4:00 PM
BREAK FOR TEA - 15 MINUTES					
5	Session 5	**Closing comments- by Joint Secretary & Principal Secretary**	30 mins	4:15 PM	4:30 PM
		Valedictory speech by Mr Akashdeep, Director, CnRD	15 mins	4:30 PM	5:00 PM
6	Session 6	**Film on the rural housing conundrum through the voice of rural folk.**	50 mins	5:00 PM	5:50 PM
7	Session 7	**Wrap up Meeting on Action Points and way forward (closed group)**			
END OF DAY 2 AND THE WORKSHOP					

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

About 120 participants in all attended the workshop during both days. For the Group sessions, participants were divided into 5 groups, each representing the zones that they belonged to.

Posters and models for each zone was prepared and put up as part of an exhibition that also served as the backdrop for the group discussions.

The workshop saw the technologies being keenly scrutinised and debated by the participants. Nearly all the technologies were accepted, subject to feedback from beneficiaries. The key recommendations and findings of the group sessions were as follows:

Design

1. Incorporation of Washing and bathing areas in all the designs. The designs had considered them as separate structures not attached to the houses and therefore not shown them.
2. The incorporation of a split bamboo under-layer for the CGI roofing to provide some respite from the cold/heat.
3. The incorporation of a loft to accommodate extra sleeping space for large households. This recommendation was from representatives of Zones 1 and 4.
4. There were suggestions on provision of doors to access external areas where water and other storage could be located.
5. Cooking alcoves were requested by nearly all zones. These were already provided.

Construction Technologies

1. Only one specification that involved thatch as an insulating under-layer for roofing was discouraged due to poor availability and due to heightened decay due to moisture build-up.
2. Large sized stone for stub footings to support raised floors were suggested to be added to the recommended options in Zone 2, due to greater availability.
3. Stone, where available, was suggested to be added to the recommended options as a masonry material in Zone 4.
4. It was also suggested that micro-concrete tiles over a bamboo/timber roofing under-structure could be tried out in areas not affected by cyclonic winds.

Costs of construction

1. Nearly all the groups studied the figures and revised the figures, based on some revised rates of material and labour, to range from Rs 80,000 to a maximum of Rs 1.10 Lakhs.
2. It was mentioned that costs of labour for excavation taken as Rs 150 was to be revised to Rs 300.
3. Cost of sand, which was not specified, was also incorporated.

Some pictures of the workshop

Picture 1 The exhibition of posters and models in the discussion hall.

Picture 2 The Group discussion hall with the posters and models forming the backdrop

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Picture 3 Posters and Model for Zone 1

Picture 4 Posters and Model for Zone 2

Picture 5 Posters and Model for Zone 3

Picture 6 Posters and Model for Zone 4

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Picture 7 Posters and Model for Zone 5

Picture 8 A participant's view of the proceedings in the main presentations hall.

Picture 9 Honourable Minister, Mr Prestone Tynsong, CnRD, Meghalaya and Mr Sadanandan, Joint Secretary MoRD visiting the exhibition.

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Picture 10 During the presentation sessions.

Picture 11 Deliberations on the pros and cons of the recommendations by the members of Zone 3, during the Group discussions

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Picture 12 Another group belonging to Zone 4 discussing the prototype of their zone.

Picture 13 Members of Zone 5 discussing the nuances of costs, technology and design pertaining to their zone.

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Actionable outcomes and way forward

A number of action points where identified as a result of the workshop. All these points where discussed threadbare by a closed group of the following members on the second day of the workshop:

1. Mr Sadanandan, Joint Secretary, MoRD
2. Mr Rakesh Kumar, Deputy Secretary (Rural Housing), MoRD
3. Mr Anusree Raha, Assistant Director, MoRD
4. Mr H N Kumar, Principal Secretary, CnRD, Meghalaya
5. Mr Lyngwa, Director, SiRD, Meghalaya
6. Mr Banteilang, Rumnong, Deputy Director, SiRD, Meghalaya
7. Ms Shashi Sudhir, Programme Analyst, UNDP
8. Mr Suneel Padale, Programme Analyst, UNDP
9. Ms Gayatri Ratnam, General Manager, HUDCO,
10. Mr Harsha Sridhar, Consultant, UNDP

Picture 14 The meeting to identify and highlight the action points held on the second day of the workshop.

Picture 15 Another picture of the group discussing the action points.

THE ACTION POINTS

1. A workshop for beneficiaries would be conducted on the 24th to 27th of March 2015 to get their views and suggestions on the recommended technologies for the various zones.
    a. This workshop would involve hands-on training on earth and bamboo technologies through specialist trainers who would be identified and brought in by the UNDP.
    b. The workshop would be conducted with a target of about 300 beneficiaries representing all the zones identified for the state.
    c. The workshop, participation of beneficiaries and all local arrangements would be coordinated by the SiRD.
    d. The UNDP would be coordinate the invitation of trainers, and other resource persons and support their costs.
    e. It was also discussed that the State government would undertake the translation and printing of zone wise IEC material developed specifically for the beneficiaries by the UNDP and associated resource persons.
2. It was also decided that five demonstration structures would be built using the technologies accepted in both the February and March workshops. These Structures would be built as public structures (community centres, Block offices, etc) under NREGS and would be used structures that would see a great foot-fall from the people of that zone.
    a. The State Government of Meghalaya would identify 5 suitable locations for these demonstration structures. One of the recommended locations was in Nongbah Myrdom where the MRLTC was being set up by the CnRD, Govt. of Meghalaya.

b. It was decided that these five structures would be developed with great emphasis on design and would demonstrate clearly the construction technologies identified for the respective zones.
c. It was recommended that the design work would be coordinated through the UNDP for this specific exercise.
d. It was also discussed that the construction of these demonstration structures could also be used for the training of local artisans and entrepreneurs who might be interested in these technologies.

3. Other aspects relating to the special recommendations made in the report on Sustainable Housing for Rural Meghalaya were discussed.
    a. On the aspect of managed plantations at the village level, it was suggested that one could employ a current scheme related to setting up and maintaining social forestry patches in villages that was set up by the State Forest Department.
    b. On the inclusion of toilets with every IAY home, it was mentioned that it was possible to do so by clubbing the construction of the IAY house with an existing scheme for toilet construction in every home as part the Swachha Bharat Abhiyaan.
    c. On the increasing of the fund available for IAY house construction by the State of Meghalaya, it was mentioned that no further enhancement was possible. However, some funds for each home could be allocated from NREGS.
    d. On Artisan training, it was discussed that apart from the training during the construction of the demonstration structures, the State Government could support specific training activities of both block level engineers and identified engineers.
    e. On adoption of new technologies, it was discussed that the State Government could fund the setting up of specific bamboo curing facilities and procurement of block making equipment.

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

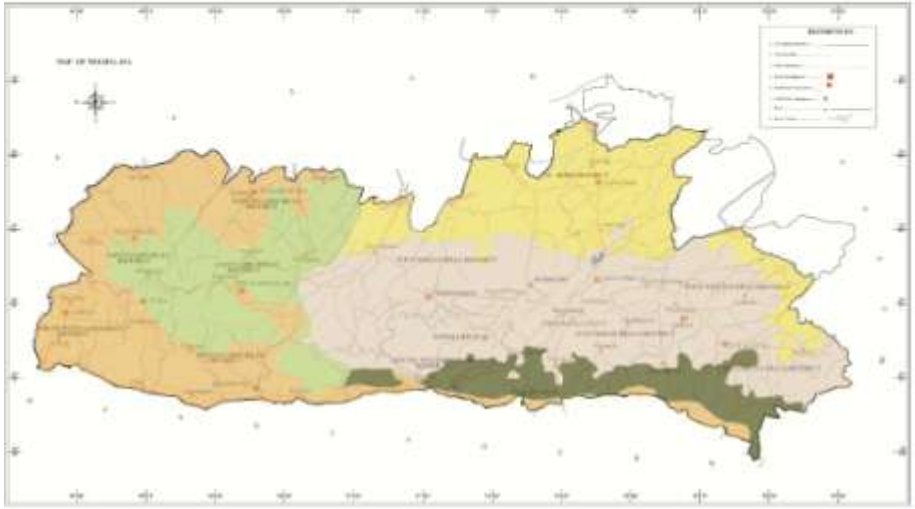
ANNEXURE

POSTERS PREPARED FOR THE WORKSHOP

Harsha Sridhar
Registered Address: No. 14, Anugraha Meadows, Horamavu Agara Rd, Voddarapalya, Bangalore-560043
Email: harsha@ighindia.com Web: www.ighindia.com

Zoning

From the study it was possible to identify 5 distinct zones within the state. The boundaries can be further refined with a more exhaustive survey on the ground, and with the cooperation of the various Gram Sevaks and Block Development officials.



S No	Zones	Geography	Cultural association
1	Western Plains	Mostly plains and random hillocks,	Garo, Hajong and Rabha
2	Western Hills	Hilly areas between 300 and 800 metres elevation in general, but still hot and humid	Predominantly Garo
3	Northern Slopes	Hilly areas on the leeward side with elevations lower than 600 metres in general, predominantly Khasi areas.	Predominantly Bhoi
4	Higher Plateau	Regions above 600 metres in elevation in general.	Khasi and Garo
5	Southern Slopes	Hilly tracts below 600 metres in elevation in general.	Khasi, Jaintia, War, Pnar,

A set of key principles have been formed to guide the housing programme recommendations:

- Development of technologies that exploit the existing skills of each micro region
- Utilisation of materials that can be sustainably sourced from within the village limits
- Fully make use of and nurture the existing skills of each micro region, and provide for employment opportunities that would help boost the rural economy.
- Ensure minimal dependence on materials from outside the village limits.
- Improve on their current construction to improve their quality of lives and reduce recurring maintenance of their structures.
- Employment of sound seismic engineering features as a minimal requirement for all structures built as part the programme.

Summary of construction technologies recommended

Area of application	Specifications and construction technologies across all zones
Foundation	• Isolated footings with large stone pieces and cement soil mixture • Strip Foundation with stone masonry
Plinth	• Raised Floor – Entire Flooring support framework in timber/bamboo propped up on timber/bamboo columns embedded in the concrete footings – RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber • Stone Masonry plinth with earth backfilling
Walling	• Bamboo/Timber framework with infill panels made of split/whole bamboo • Panels provided with a Stabilised Mud plaster on the outside and inside • Bamboo/Timber framework with infill panels made of split/whole bamboo • Panels provided with a Stabilised Mud plaster only on the outside, leaving the inside exposed • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. • Pre assembled bamboocrete panels • Bamboo mat screens supported against a timber/bamboo framework for external and internal walls • Locally made Bamboo particle board / Rice husk particle boards for internal wall partitions • Low height masonry walls using stabilised soil blocks and upper portions of bamboo mat screens held in either timber or bamboo framework • Full height masonry walls using wither stabilised soil blocks or rammed earth walls • Masonry walls using stabilised adobe blocks.
Roofing	• Bamboo/timber roofing members
Roofing cover	• Thatch covering with GI Sheets above • Lightweight ferrocement roofing supported on bamboo/timber structure can be explored • Light weight bamboocrete roofing supported on bamboo/timber structure can also be explored • Ferrocement and bamboocrete roofing laid over thatch layer and plastered over.
Doors and Windows	• Bamboo frame and shutters for doors and windows • Wooden frame and shutters for door and windows • Bamboo Particle board/ Rice husk particle board/ bamboo mat board for door/window shutters
Flooring	• Plain cement flooring over a backfilled plinth • Plain Cement flooring laid over a split bamboo framework • Bamboo mat flooring over the bamboo framework • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework • Precast Bamboocrete panels laid over bamboo/timber flooring framework • Precast ferrocement panels laid over bamboo/timber flooring framework • Non edible betel palm wood (thlu) planks over the bamboo framework
Walling finishes	• Ikra walling – Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging • Low height Masonry Walls – Cement stabilised mud plaster for external faces walls – Plain mud plaster for internal walls

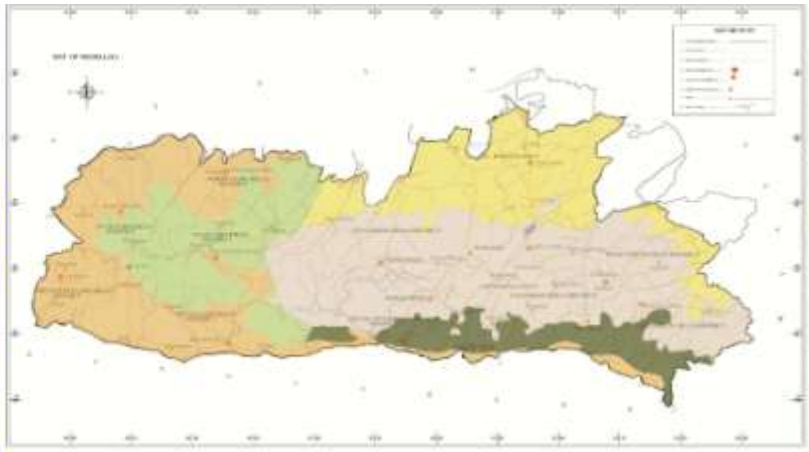
Recommendation for capacity building and improvement of construction

To create sustainable habitats that can be seen as worthy alternatives by the rural masses, it is important to create conditions that would enable these technologies and building traditions to thrive.

1. **Curing and treatment of bamboo**- To improve its shelf life
2. **Managed plantations**- To maintain a sustainable stock of organic material
3. **Community participation**- To economise building construction costs
4. **Artisan training**- To create a base of quality of crafts persons, and to provide alternative means of income for local people
5. **Interdepartmental learning and coordination of various state and non-state departments**- To build synergies and avoid duplication of effort
6. **Incentivising traditional building and innovation using traditional skills**- To popularise local traditional heritage and knowhow
7. **Creation of rural information and influence centres**- To provide easy access to and facilitate spread of these sustainable technologies across the state
8. **Communication**- To drive home the importance and benefits of the sustainability agenda and to provide true info on the impacts of modern day construction

Traditional Structures

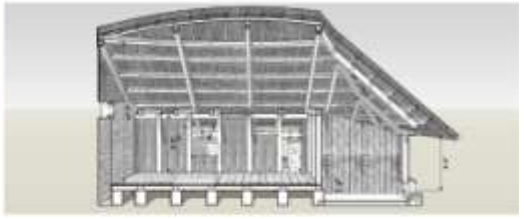
A number of variations in what can be considered traditional housing exist. They vary in size, form, plan layout, and material usage, ranging from bamboo, to wood to wood-bamboo hybrid constructions. Subtle variations to the manner and method of construction are observed when the geography changes drastically. These are rapidly vanishing and the primary reason for their existence is the economic status of their occupants, and their inability therefore to build anything else. This has almost become the exclusive preserve of the poorest. In all the cases, the construction was undertaken by the owner and their families. While there is variety amongst these traditional house types, all of them are single storeyed.



1. Khasi Oval House

Occurrence- Higher Plateau

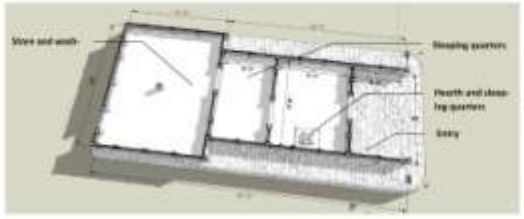
External walls of stone masonry, timber structural members supporting a raised timber floor and upturned boat curved roof form with bamboo structural members and thatch cover. A slightly oval plan form towards the entry and a flat plane wall towards the rear Hierarchy of public and private spaces..



2. Traditional Jaintia House

Some portions of the Meghalayan plateau in Jaintia Hills, Southern slopes of Meghalayan plateau

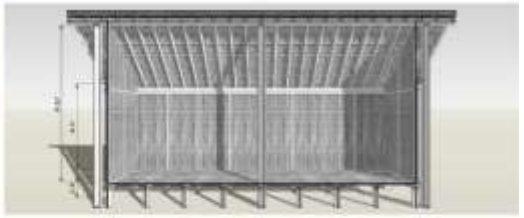
Earthen floor on a rudimentary plinth, Timber and Bamboo structural members, External bamboo mat, with and without plaster, A Double roof with bamboo structural members and thatch cover; lower roof towards the front section of the house and the higher roof form continuing till the rear of the house. Rectangular in form with a Hierarchy of public and private spaces.



3. Rectangular Timber and Bamboo House

Southern slopes of the Meghalayan plateau in both Jaintia and Khasi Hills, North-ern Hills descending towards Assam, Eastern Hills descending towards Assam

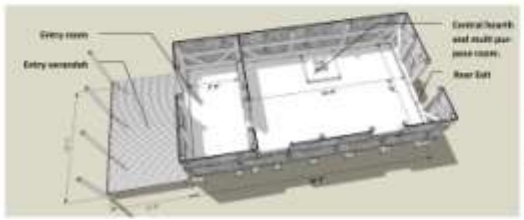
Main timber vertical structural supports along the ridge line, supporting a simple gable roof. Mixture of timber and bamboo towards the roof springing points. Elevated bamboo mat floor, supported on bamboo members. Small diameter and split bamboo plastered with unstabilised mud plaster, forming the external walls. Simple rectangular in form with or without an internal partition bamboo mat screen wall. Bamboo roofing members supporting a thatch roof.



4. Raised Rough Cut Timber post and beam house

Southern slopes of the Meghalayan plateau of the Khasi Hills

External walls of stone masonry, timber structural members supporting a raised timber floor and upturned boat curved roof form with bamboo structural members and thatch cover. A slightly oval plan form towards the entry and a flat plane wall towards the rear Hierarchy of public and private spaces..



Traditional Structures

5. Bamboo Post and Beam House

Southern slopes of the Meghalayan plateau in centre and West Hills. Northern hills descending towards Assam, Eastern Hills descending towards Assam

Bamboo poles driven into the ground, supporting a raised floor with bamboo mat flooring, Bamboo mat wall screens, with or without unstabilised mud plaster, Bamboo roofing members, supporting a thatch roof. L-shaped with a hierarchy of public and private spaces.

6. All Timber House (similar to Assam Type)

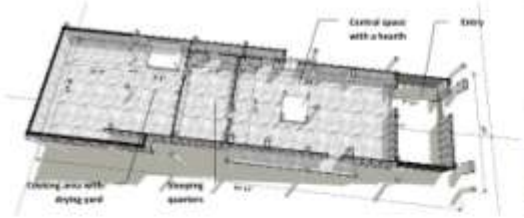
Higher Meghalayan plateau

Timber post and beam structures, made with cut wood sections, with wooden flooring beams supporting an elevated wooden plank floor. Internal and external Walls with wooden planks fixed onto a wooden framework as infill walls. Wooden roofing members, supporting a GI sheet roof. Most of these structures are provided with a verandah.

7. Garo Long House

Hilly tracts of Garo Hills. Not seen in the plains

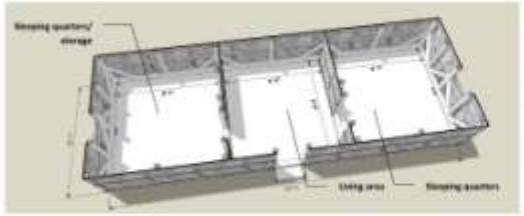
Timber and Bamboo structure, with tree trunk sections used to form the main structural members. Structural bamboo external walls forming a rigid external plane. Array of timber posts driven into the ground form the supports for flooring members made of bamboo that hold up an elevated bamboo mat floor. Thatch roof supported over bamboo purlins and rafters resting on wooden beams forming the ridge member and edge beams at the roof springing point. Rectangular plan form with a hierarchy of public and private spaces.



8. On Ground Timber Post and Beam House

Hilly tracts of central and eastern Garo Hills Northern, Western and Southern Garo Hills. A similar structure is also found in the south eastern parts of Jaintia Hills.

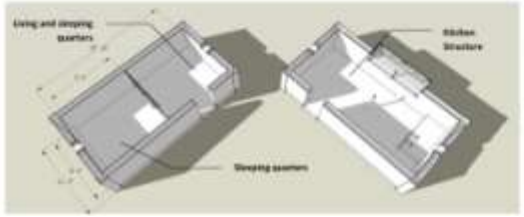
Rectangular timber post and beam structure, with large wooden plinth beams and diagonal bracing of vertical members, with bamboo roofing members, with woven bamboo mat walls left unplastered. Earthen plinth, with or without a plain cement floor. Usually rectangular in form with a minimum of three internal divisions. Mostly, without a verandah.



9. Adobe Block House

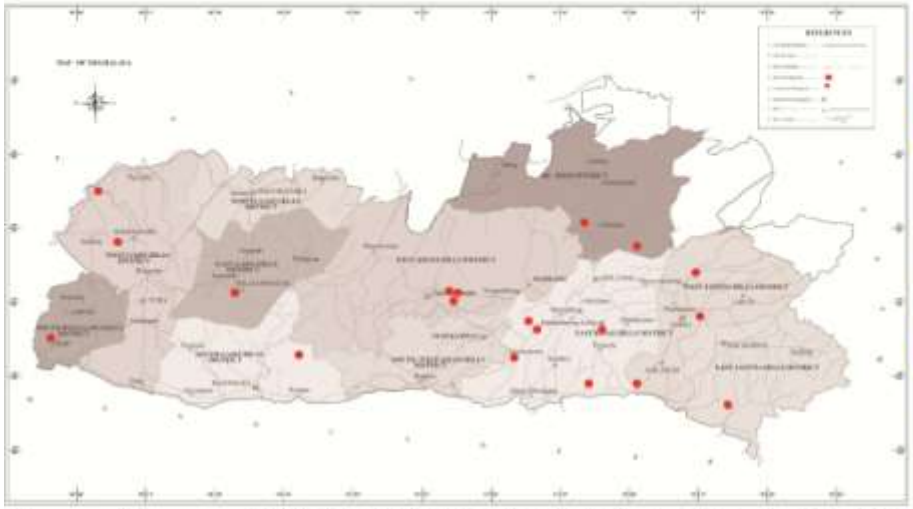
Lower plains of Garo Hills to the south, southwest, west, northwest and north

1 foot thick Walls made of un stabilised adobe blocks made using wooden moulds, plastered using unstabilised mud plaster slightly raised earthen plinth, Bamboo roofing structure with thatch covering, Mostly, without a verandah.



Case Studies

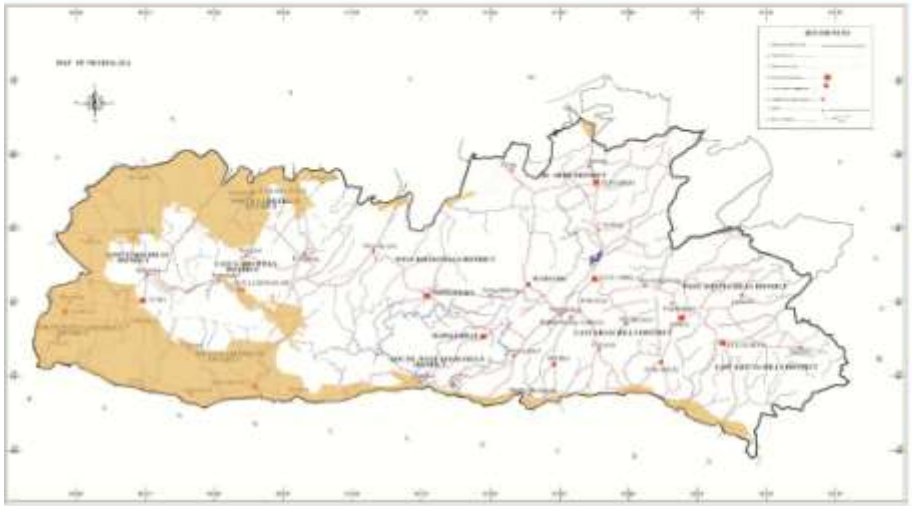
35 Case Studies were conducted over 17 different locations that covered the different geographies of the state and covered the regions of all the major ethnic groups.



S No	Site	Altitude (metres)	Annual Rainfall (mm)	Avg. Temp	Agro climatic category	District	Village	Case Studies
1	Northern hills descending to the Brahmaputra valley in Assam.	600 to 900	1,000 to 2,500	21-22°C	Mild, Moisture	Ri Bhoi	Nongbah Myrdom	1, 2
2	North Eastern hills just a bit lower than the Shillong Plateau	900 to 1,350	2,500 to 3,500	19-20°C	Cold, Wet	Ri Bhoi	Pynthor, Umroi Mynsaim	3, 4, 5, 6
3	Southern low lying Hills, near the Bangladesh plains	150 to 300	8,000 to 10,000	23-25°C	Hot, Wet	West Jaintia Hills	Sohkha. Lamin	7, 8
4	Southern low lying Hills, near the Bangladesh plains	150 to 300	8,000 to 10,000	23-25°C	Hot, Wet	East Khasi Hills	Mawlynnong, East	9, 10, 11
5	East of centre portion of the Meghalayan Plateau	1,350 to 1,800	6,000 to 8,000	16-18°C	Between Cold, Extremely wet and Mild, Wet	East Khasi Hills	Lankyrdem	12, 13
6	South Western portion of the Meghalayan Plateau	1,350 to 1,800	6,000 to 8,000	16-18°C	Cold, Wet to Extremely wet	East Khasi Hills	Tyrsad, Pyndeumdiri	14, 15
7	South Western portion of the Meghalayan Plateau	600 to 900	above 10,0000	16-18°C	Cold, Extremely wet	East Khasi Hills	Mawsynram	16
8	Western portion of the Meghalayan Plateau	1,350 to 1,800	3,000 to 6,000	16-18°C	Cold, Wet	West Khasi Hills	Mankasa, Nongkasen, Tiehsaw	17, 18, 19, 20
9	North of Eastern Hills	800 to 1,350	3,000 to 4,000	19-20°C	Cold, Wet	West Jaintia Hills	Norbang	21
10	Centre of Eastern Hills	1,350 to 1,850	6,000 to 8,000	19-20°C	Cold, Wet	West Jaintia Hills	Iolong	22, 23, 24
11	South Eastern Hills	300 to 800	8,000 to 10,000	21-22°C	Between Mild, Extremely wet and Hot, Wet	East Jaintia Hills	Umlong	25
12	Western Plains	0 to 150	1,000 to 2,000	23-25°C	Hot, Humid	West Garo Hills	Phulbari	26, 27,
13	South Western fringe	0 to 150	2,000 to 3,000	23-25°C	Hot, Humid	South west Garo Hills	Diglipie	28
14	Centre of Western Hills	150 to 300	2,000 to 3,000	21-22°C	Mild, Humid	West Garo Hills	Sadolpara	29, 30
15	Southern hills	300 to 600	3,000 to 5,000	21-22°C	Between Hot, Humid and Mild, Humid	South east Garo Hills	Chimtap	31
16	Southern hills	300 to 600	3,000 to 5,000	23-25°C	Between Hot, Humid and Mild, Humid	South Garo Hills	Gasbari	33
17	Hills to the east of Meghalaya plateau	150 to 300	2,000 to 3,000	23-25°C	Between Hot, Humid and Mild, Humid	East Garo Hills	Bolkinggre	34, 35

ZONE 1

Zones	Geography	Cultural association
Western Plains and Southern fringes	Mostly plains and random hillocks,	Garo, Hajong and Rabha



Structures in the region

This region is characterised by the earthen plinth structures and a mixture of adobe walled and bamboo mat screen walled structures. The influence of adobe construction in the region is perhaps due to its proximity to the plains of neighbouring Bangladesh and Assam. This region is also home to the Koch, Rabha and Hajong tribes who are known to build walls using adobe.

The adobe walled structures help keep the interiors cool in the sweltering heat that these areas face. There has traditionally been access to bamboo and timber and there are visible skills in bamboo and timber works. Bamboo mat walling also seems to provide respite from the heat in the interiors

Burnt Clay Bricks are very prevalent in the area and possibly amount for the bulk of all the walling in new construction in the area. This is aided by the presence of various brick kilns in this zone, especially towards the North West corner of Garo Hills.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo framework for structures, especially roofing
- Adobe wall erection

ZONE 1

Recommendations for Built Form

Zones	Plan Layout	Plinth/Floor	Roof Profile
Western Plains	These structures can be rectangular in plan with an entry from the longer sides. Verandahs are optional.	The structure can be on the ground, with only structures in flood plains to have raised floors on stilts.	A gable or hipped roof can be adopted for these areas.

Recommendations for Construction systems and materials

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Stone Masonry strip foundation • Option of isolated footings with large stone pieces and cement soil mixture and raised flooring on plinth beams for flood prone areas.	Loosely collected and shallow quarried boulder rock can be used in the foundation.
2	Plinth	• Stone Masonry plinth • RCC Plinth beams for raised floors in flood prone areas. Flooring support framework in bamboo/timber	
3	Walling	Minimum 8-9 inch thick Masonry for external walls using: • Stabilised Adobe Blocks • Rammed earth walls • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework. Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework Internal walling could also use bamboo mat screens fixed onto a bamboo/timber framework	Vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length and Horizontal reinforcement bands are to be provided at plinth, sill, lintel, and roof level. Additional reinforcement to be provided around all openings.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3 ft feet beyond the outer plane of the walls to prevent rain splash. Lightweight ferrocement/bamboocrete roofing laid over the roofing structure can be explored	
6	Doors and windows	Wooden door and window frames with wooden shutters. Preferably medium sized bamboo jaali windows, or small windows in masonry walls.	
7	Flooring	Plain Cement/Rammed earth flooring laid over a back filled plinth. Wooden planks of hardy non edible betel nut trees laid over a split bamboo framework.	
8	Wall finishes	Masonry Walls • Cement stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls Bamboo mat screen walls • Can be left exposed • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging.	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry or bamboo/timber alcove with a chimney can be created for the hearth. A timber and bamboo mat shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

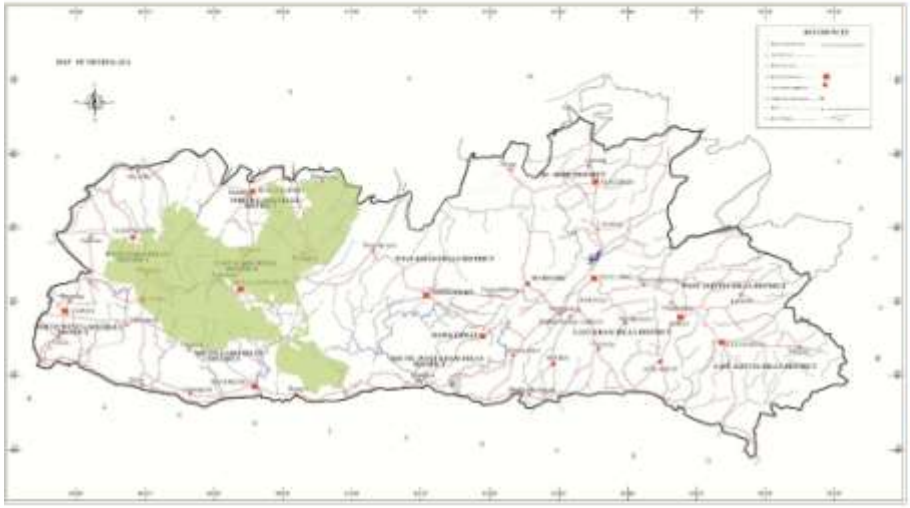
Highlights of the prototype

The designs are essentially modifications of both the 'Adobe block house' and the 'On ground Rectangular Timber post and beam house". Here are some salient aspects of this prototype:

- Stabilised adobe blocks are used as they are similar to the unstabilised adobe blocks used locally, and can be made with the current skills in the area.
- Protection of the walling areas by providing deep roof overhands is done.
- The extended roofs are supported using external bamboo posts that are embedded in the ground.
- The roof is a double layer of thatch and CGI sheets. The thatch provides insulation and would keep the insides cool in hot days, and the CGI sheets would help in protecting the thatch, increasing its life.

ZONE 2

Zones	Geography	Cultural association
Western Hills	Hilly areas between 300 and 800 metres elevation in general, but still hot and humid	Predominantly Garo



Structures in the region

This region is characterised by raised bamboo-timber hybrid structures with whole & split bamboo walls, and variants that use timber/bamboo posts with bamboo mat screens for wall. This is also a predominantly Garo region and where the traditional Garo long huts are found. Traditionally, this is not an area known for any masonry construction.

This is an area where very sturdy and ingenious bamboo and timber hybrid structures have been developed over time, some even dating back to over a 115 years, surviving the earthquake of 1857.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo and timber framework for structures– walling, roofing, flooring, etc.
- Rough timber works

ZONE 2

Recommendations for Built Form

Zones	Plan Layout	Plinth/Floor	Roof Profile
Western Hills	Rectangular structures and linear in the arrangement of their interior spaces. The entry can be from the shorter side. Space for storage should be provided under the roof overhangs on the side. Verandahs to be provided in both the short sides.	It is recommended that the floor is elevated on stilts.	A gable or hipped roof can be adopted for these regions.

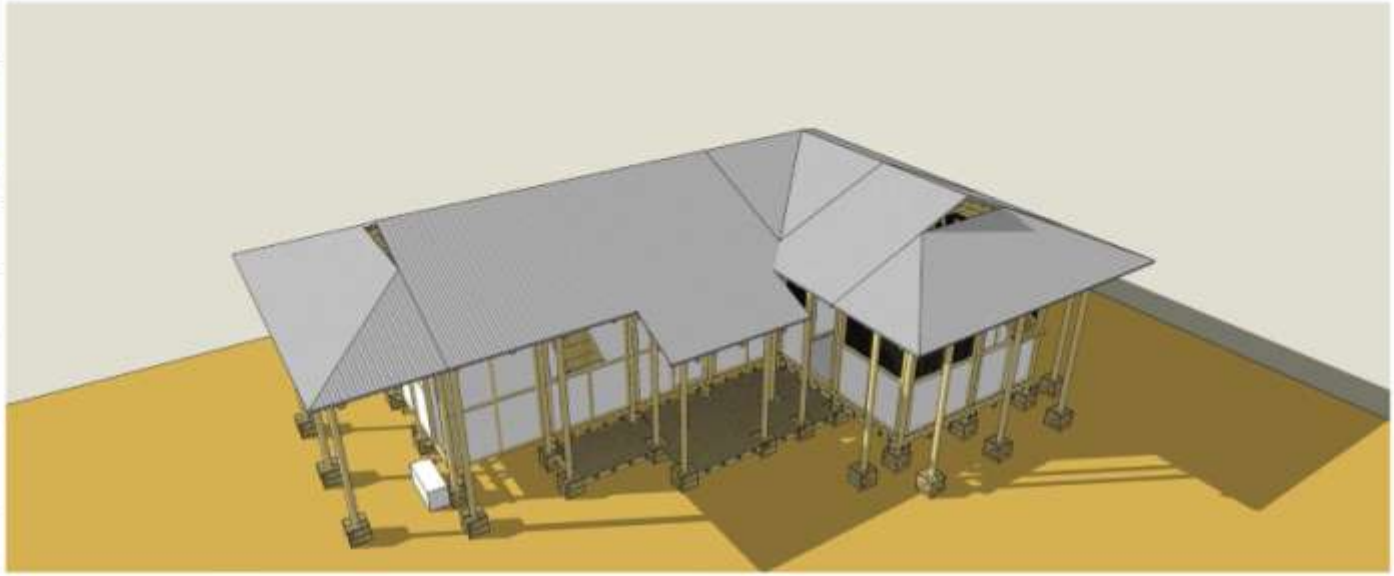
Recommendations for Construction systems and materials

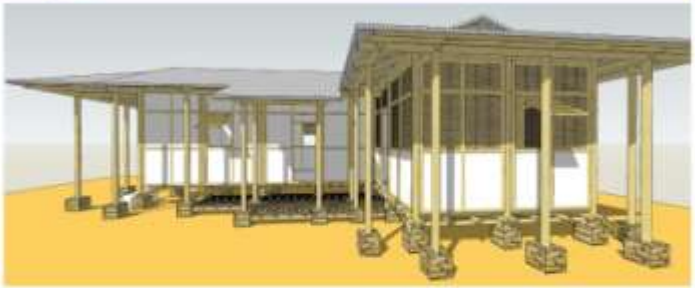
S No	Component	Recommended Specifications	Specific comments
1	Foundation	Isolated footings with large stone pieces and cement soil mixture. Alternatively, you could use large stones as stubs.	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor (no masonry plinth) Flooring support framework in bamboo propped up on bamboo columns embedded in the concrete footings	
3	Walling	Option of • Bamboo mat screens held in either timber or bamboo framework. • Close knit framework of Split/whole bamboo assembly with bamboo mats made from flattened bamboo in the rear. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework Internal walling could also use bamboo mat screens fixed onto a bamboo/timber framework	Strong vertical members at corners and short intervals along with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and at all vertical members are to be provided for extra stability
4	Roof structure	Bamboo/timber roofing members. Preferably a hipped roof.	Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters. • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain Cement flooring laid over a split bamboo framework. • Wooden planks of hardy non-edible betel nut trees laid over a split bamboo framework. • Bamboo mat flooring over the bamboo framework • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework	
8	Wall Finishes	• Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. • Keeping the walling exposed, as long as there is adequate rain protection from the roof overhang	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry or bamboo/timber alcove with a chimney can be created for the hearth. A timber and bamboo mat shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

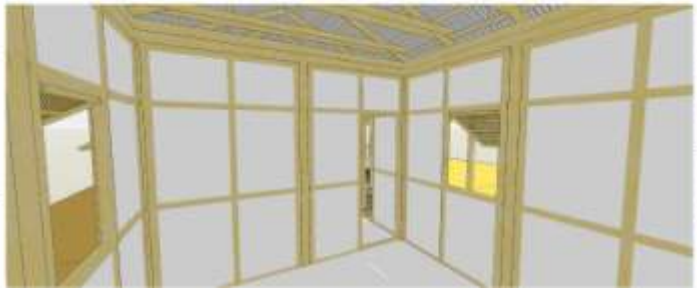
Highlights of the prototype

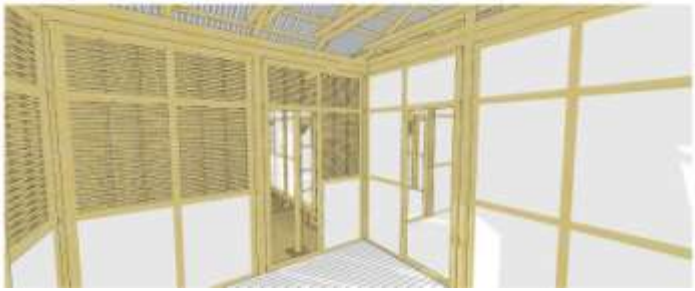
The design takes cues from both the 'Garo Long house' and the 'On ground Rectangular Timber post and beam house'. Here are some salient aspects of this prototype:

- In this prototype we have demonstrated a raised bamboo flooring structure which is in-turn supported on short stub columns.
- A cement floor over a tightly laid split bamboo-chicken mesh framework (on the flooring supports) is shown as an option, or, and as an alternative, we have shown a betel nut wood flooring in the extension.
- Bamboo panels made with split bamboo in bamboo frames between the main vertical members form the walling. These are plastered with a soil-cement plaster and protected from the rain by providing deep roof overhangs which are supported using external bamboo posts .
- The roof is a double layer of thatch and CGI sheets. The thatch provides insulation and would keep the insides cool in hot days, and the CFI sheets would help in protecting the thatch, increasing its life.



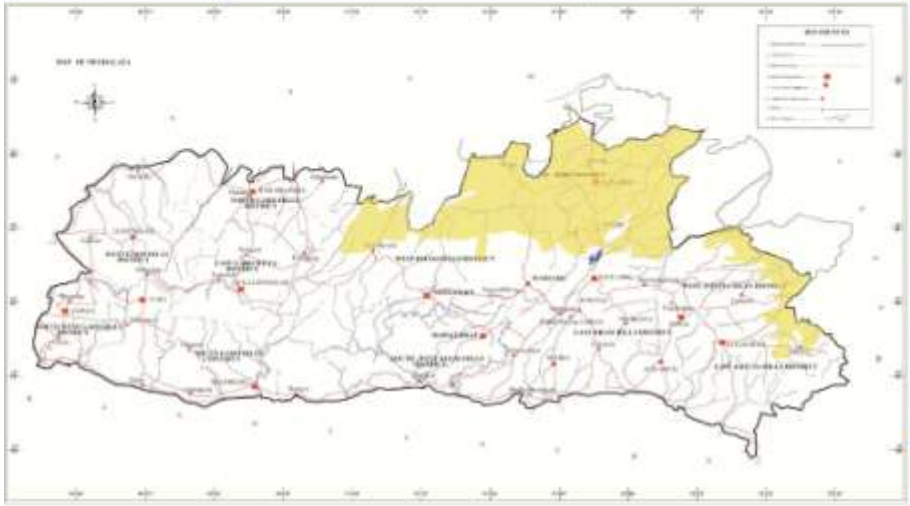






ZONE 3

Zones	Geography	Cultural association
Northern Slopes	Hilly areas on the leeward side with elevations lower than 600 metres in general.	Predominantly Bhoi, some Khasi and Jaintia



Structures in the region

This region is characterised by raised Assam type houses and variants that use timber/bamboo posts with bamboo ikra walling. This is also a region occupied by Khasi, Bhoi and Jaintia villages. Traditionally, this is not an area known for any masonry construction.

However, by the sheer proximity to most to the main Gowahati-Shillong-Jowai highways, a lot of transformation to the building stock has taken place, with evidence of concrete block work, and some brick work (along main arterial roads). Bamboo and timber skill-sets are still abundant, with a number of houses being built entirely in Bamboo.

The mud/lime plastered wall surfaces of the Assam style and traditional bamboo structures in this region offer great respite from chill winds. A thatch roof offers great comfort in winter as against a CGI sheet roof in this zone.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo and timber framework for structures– walling, roofing, flooring, etc.
- Carpentry

ZONE 3

Recommendations for Built Form

Zones	Plan Layout	Plinth/Floor	Roof Profile
Northern Slopes	Rectangular structures. Verandahs to be provided along the long side of the structures.	Either high on ground plinths or elevated floors on stilts	A gable or hipped roof can be adopted for these regions.

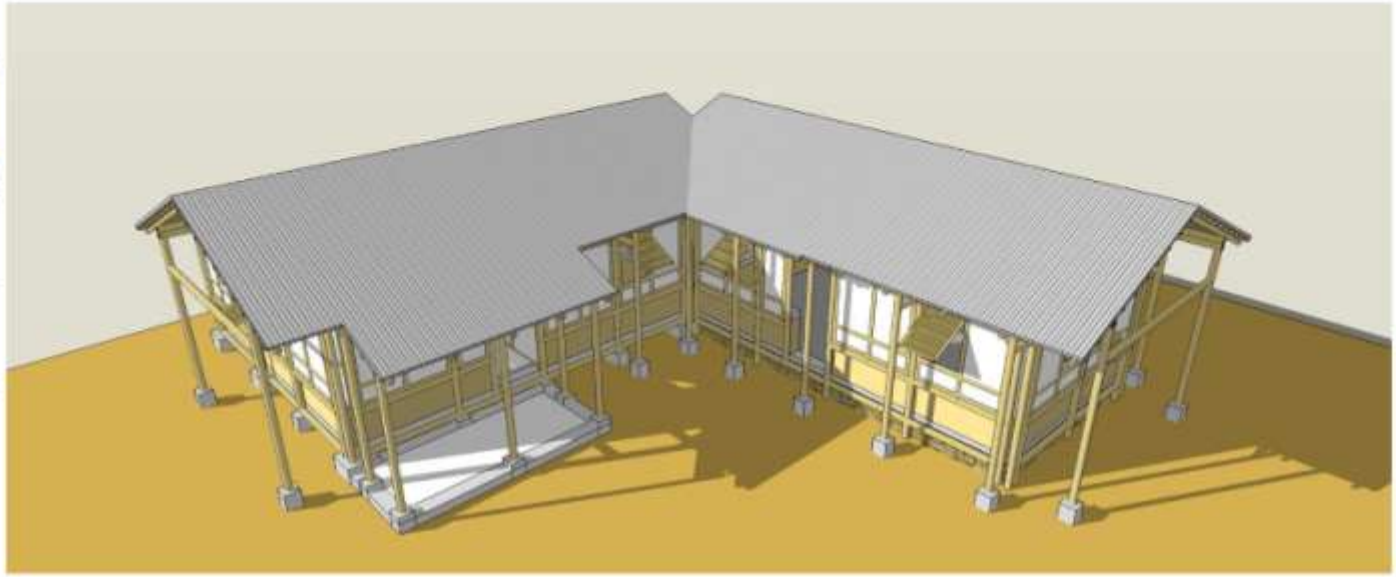
Recommendations for Construction systems and materials

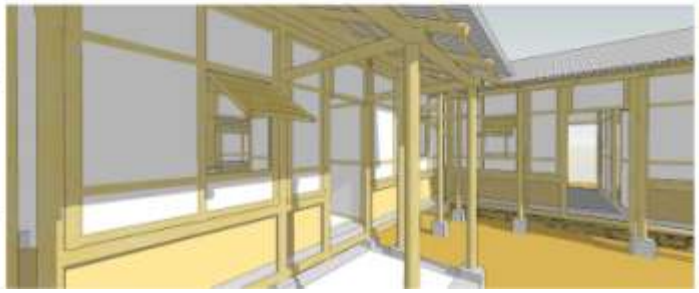
S No	Component	Recommended Specifications	Specific comments
1	Foundation	Isolated footings with large stone pieces and cement soil mixture	Used primarily as protection and weight transfer for bamboo/timber supports
2	Plinth	Raised Floor (no masonry plinth) • Entire Flooring support framework in bamboo propped up on bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber	
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on the outside and inside. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework.	Strong vertical bamboos at corners and short intervals with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and all vertical members. Masonry walls vertical reinforcement in corners and every 1-1.2 metres of wall length. Horizontal tie reinforcement bands at plinth, sill and lintel levels.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Roof overhangs to be at least 3 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be bounded up.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window shutters and frames • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain Cement flooring laid over a split bamboo framework. • Bamboo mat flooring over the bamboo framework • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework	
8	Wall finishes	Ikra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. Low height Masonry Walls • Cement stabilised mud plaster for external faces walls. • Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

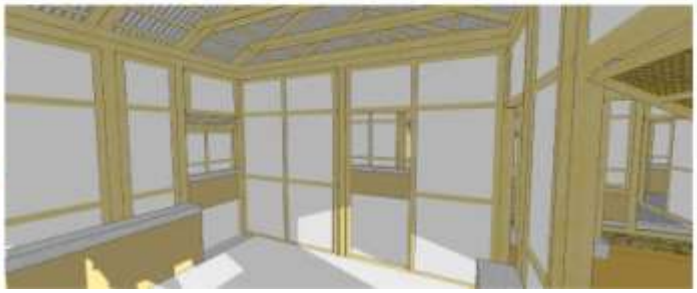
Highlights of the prototype

The designs is a hybrid of sorts melding the traits from the Assam style houses and Bamboo post and beam houses. Here are some salient aspects of this prototype:

- In this prototype we have demonstrated both a raised bamboo flooring structure which is in-turn supported on short stub columns and a masonry plinth variant in the extension structure.
- A cement floor over a tightly laid split bamboo-chicken mesh framework (on the flooring supports) is shown as an option, and as a variation we have shown a cement floor on a back-filled plinth..
- Stabilised Soil Blocks form a low height walling till sill height. Bamboo panels made with split bamboo in bamboo frames between the main vertical members form the walling above sill height. These are plastered with a soil-cement plaster and protected from the rain by providing deep roof overhangs which are supported using external bamboo posts .
- The roof is a double layer of thatch and CGI sheets. The thatch provides insulation and would keep the insides cool in hot days, and the CGI sheets would help in protecting the thatch, increasing its life.

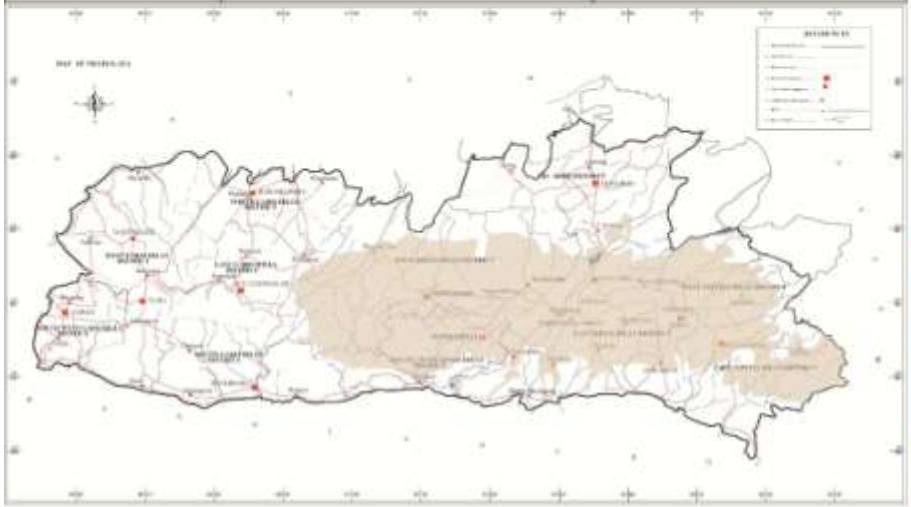






ZONE 4

Zones	Geography	Cultural association
Higher Plateau	Regions above 600 metres in elevation in general.	Khasi and Garo



Structures in the region

This region occupies the higher elevations of the state forming the Meghalaya Plateau. is characterised by raised Assam type houses and is home to the Traditional Khasi and Jaintia Huts. These traditional structures and their variants in this region predominantly see the use of timber posts with wooden panel and bamboo ikra walling. This region receives amongst the highest rainfall in the state, specially towards the south, and also sees some of the strongest cyclonic activity. This is also a region occupied mainly by Khasi and Jaintia villages. One also sees traditional stone masonry in this region. All-timber houses are also common.

Large diameter and high wall thickness Bamboo does not grow well in this region. Most of the bamboo and thatch in this region is brought up from lower altitude areas. The Khasi hut which is the iconic traditional structure is solely found in this zone. This structure is perhaps a great example of a cyclone resistant roof form, and a seismically secure structure. The structures of this region also strive to keep the occupants inside comfortable and insulated from the cold.

The Main skills recorded in this zone are:

- Carpentry
- Stone masonry
- Bamboo mat making & bamboo framework

ZONE 4

Recommendations for Built Form

Zones	Plan Layout	Plinth/Floor	Roof Profile
Higher Plateau	Rectangular structures preferably oriented in the SW-NE direction. Verandahs to be provided, preferably on the short entry side.	Raised floors on stilts	Preferably shell roofs or Hipped roofs with low springing points.

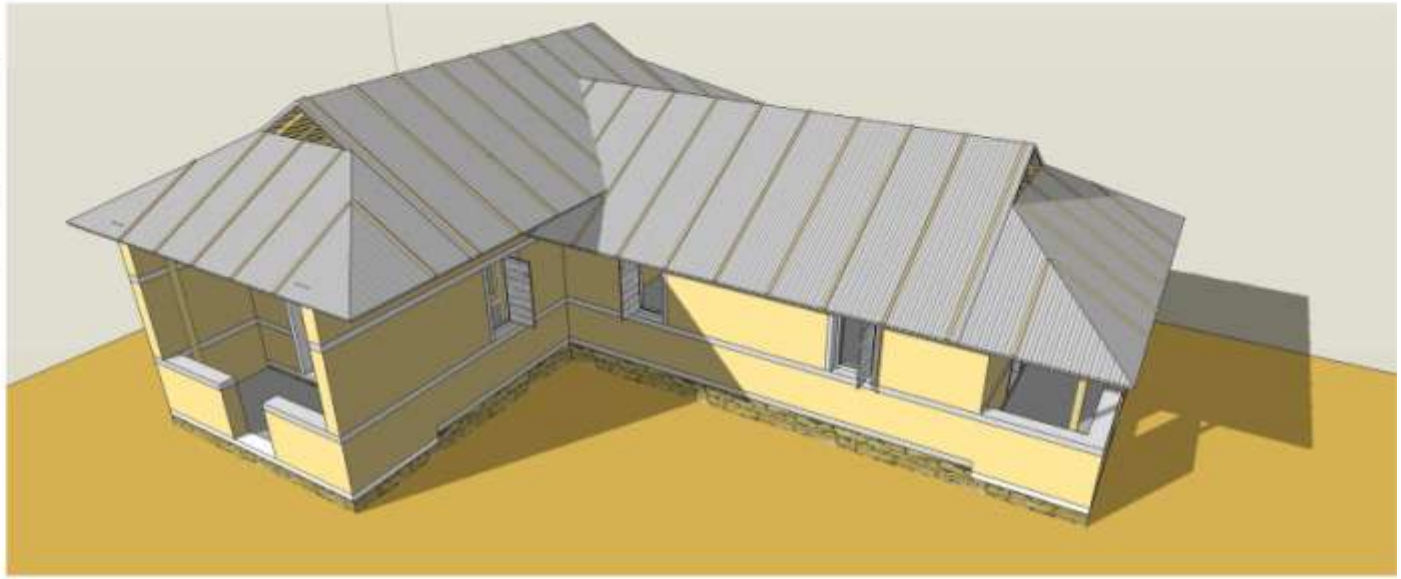
Recommendations for Construction systems and materials

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Isolated footings with large stone pieces and cement soil mixture • Strip foundation with stone masonry with drainage gutter provided all around the house.	Used primarily as protection and weight transfer for bamboo/ timber supports
2	Plinth	Raised Floor • Entire Flooring support framework in timber/ bamboo propped up on timber/bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber Stone Masonry plinth with earth backfilling	
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on the outside and inside. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. This could also be made as bamboocrete panels. • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework. • Full height masonry walls with smaller openings and adequate rain protection.	Vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length. Horizontal tie reinforcement bands have to be provided at plinth, sill and lintel levels where applicable.
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be a minimum of 30°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Lightweight ferrocement roofing can be explored. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be boarded up.	Additional vertical supports can be provided to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters • Wooden door and window frames with wooden shutters • Preferably small sized windows.	
7	Flooring	• Plain cement flooring over a backfilled plinth • Close stacked split bamboo flooring fixed over a tight bamboo flooring framework • Timber Plank flooring over Timber under-structure.	
8	Wall finishes	Ikra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. Low height Masonry Walls • Stabilised mud plaster for external faces walls. Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

Highlights of the prototype

The designs borrows heavily from certain aspects of the Khasi Oval Hut, without taking the obvious oval plan form. Here are some salient aspects of this prototype:

- The walls are full height Cement Stabilised block masonry. The Roof is independently supported on a bamboo framework which is on the inside of this structure, protected from the elements.
- Reinforcement bands run at plinth, sill, lintel and roof springing point levels.
- The roof is essentially a gable roof form with 30° slopes, to ensure greater resistance to strong winds which this zone experiences, especially in the pre-monsoon months of March and April. Taking inspiration from other traditional structures across the state, an additional set of bamboo members are provided above the CGI roofing sheets and tied down with the rafters below, securing the sheets from getting dislodged due to gale force winds.



ZONE 5

Zones	Geography	Cultural association
Southern Slopes	Hilly tracts below 600 metres in elevation in general.	Khasi, Jaintia, War, Pnar,

Structures in the region

This region occupies the lower elevations of the Meghalaya Plateau and sees very high rainfall. It is also amongst the most humid areas as well and is a bamboo and betel nut growing region. Traditionally, this region sees the use of timber and bamboo posts with wooden panel and bamboo ikra and bamboo mat walling. This too is a region occupied mainly by Khasi and Jaintia villages. Traditionally, masonry is not common in this belt.

Some of the best bamboo works come from this region, where perhaps some of the best bamboo grows. Some exquisite bamboo works, bamboo mat making and basket making are skills of this region This is also a region from where thatch is sourced. The traditional Jaintia Hut is also from this region, a low roof form with a drooping front canopy. Earthen floors and rough stone plinths are also visible in this region.

The Main skills recorded in this zone are:

- Bamboo mat making
- Bamboo framework
- Carpentry, with additional skills in fashioning palm wood for flooring and reapers.

ZONE 5

Recommendations for Built Form

Zones	Plan Layout	Plinth/Floor	Roof Profile
Southern Slopes	Rectangular structures	High on-ground plinths or raised floors on stilts.	Hipped roofs with low springing points.

Recommendations for Construction systems and materials

S No	Component	Recommended Specifications	Specific comments
1	Foundation	• Isolated footings with large stone pieces and cement soil mixture • Strip foundation with stone masonry, but with drainage gutters provided around the house.	Used primarily as protection and weight transfer for bamboo/ timber supports
2	Plinth	Raised Floor • Entire Flooring support framework in timber/ bamboo propped up on timber/bamboo columns embedded in the concrete footings • RCC Plinth beams for raised floors with Flooring support framework in bamboo/timber Stone Masonry plinth with earth backfilling	
3	Walling	• Bamboo/Timber framework with infill panels made of Split/whole bamboo. Panels provided with a Stabilised Mud plaster on both faces. • Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. This could also be made as bamboocrete panels. • Bamboo mat screens supported against a timber/bamboo framework for external and internal walls • Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework.	Strong vertical members at corners and short intervals along with horizontal tie members at plinth, sill, lintel and roof levels. Diagonal tie members at corners and at all vertical members. Masonry walls- vertical reinforcement in all corners and every 1-1.2 metres of wall length. Horizontal tie reinforcement bands at plinth, sill and lintel levels
4	Roof structure	Bamboo/timber roofing members	Preferably a hipped roof. Angle of the sloped roof should be minimum 30°.
5	Roof Cover	GI Sheets to be fastened using J-bolts. Lightweight ferrocement roofing can be explored. Roof overhangs to be at least 3-4 feet beyond the outer plane of the walls to prevent rain splash. Gaps between roof and wall to be boarded up.	Extra vertical supports can be added to support the extended roof.
6	Doors and windows	• Bamboo door and window frames and shutters • Wooden door and window frames with wooden shutters • Small to medium sized windows.	
7	Flooring	• Plain cement flooring over a backfilled plinth • Plain Cement flooring laid over a split bamboo framework. • Bamboo mat flooring or Close stacked split bamboo flooring fixed over a tight bamboo flooring framework • Non edible betel palm wooden planks over the bamboo framework.	
8	Wall finishes	Ibra walling • Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging. Low height Masonry Walls • Stabilised mud plaster for external faces walls. Plain mud plaster for internal walls	Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.
9	Kitchen alcove	Where a kitchen is to be attached, a masonry alcove and smokeless chimney can be created for the hearth. A timber/bamboo shelf can be made for storage of utensils.	The hearth has to have adequate stabilised mud plaster.

Highlights of the prototype

The design of this prototype borrows from the strong bamboo architecture of this zone and takes some inspiration from Jaintia Huts

- Low walls till sill height are provided on the outer faces. A bamboo structure is housed within this . Cross bracing of every vertical support is done to provide greater stability to the structure. The entire structure is tied at various levels with horizontal bamboo members.
- Both a masonry plinth and raised bamboo flooring framework has been used in this structure and its extension. The main unit has a cement floor, while the extension sees the use of a palm wood (thíu) floor.
- Here too the roof has slopes of 30° and is a hipped roof towards the entry and has a gable end to the rear. Bamboo brackets support the weight of a deeper overhang.
- Modular bamboo wall panels with split bamboo held within a bamboo framework and plastered from both sides form the walling surface above sill level. The rear has a simple bamboo mat held between split bamboos.