



BUILDING FAMILIARISATION IN EARTH AND BAMBOO TECHNOLOGIES - TRAINING WORKSHOP FOR IAY BENEFICIARIES



Designing, Coordination and Conducting a Workshop

A report

- Harsha Sridhar



Introduction

This report is to be seen in the context of detailed studies conducted on rural housing in Meghalaya and the report, 'Sustainable Housing Technologies for Rural Meghalaya'. As an extension of this another exercise, 'Development of Context Specific Green Housing Designs for Construction in Meghalaya' was also undertaken. A major outcome of this exercise has been the development of five design prototypes for alternative housing in Meghalaya which were presented during a state consultation for review before independent architects, state government officials, government engineers and Block Development Officers of Meghalaya. Comments from this consultation have been incorporated in the designs and the designs verified for structural soundness by an independent agency.

The designs and the consultative were appreciated by the Government of Meghalaya who wanted to take up appropriate technologies in rural buildings immediately. In order to advocate for the use of appropriate technology, it was decided that GoM would build government buildings in each of the zones through MGNREGS. To kick start this, GoM offered to organise a three-day training workshop on 24-26 March wherein 300 beneficiaries and 30 master trainers would be participating. UNDP was requested to bring in resource persons to present the different designs and give hands-on training to the master trainers and entrepreneurs on different building technologies such as mud block, bamboo, etc. and also develop materials for an exhibition that will be held along side.

This report captures the programme details of this Earth and Bamboo Familiarisation workshop for Beneficiaries conducted in the Meghalaya.



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Scope of Work & Key Deliverables

Scope of work

1. To Design and conduct a workshop for beneficiaries and artisans in the State of Meghalaya on recommended sustainable technologies for the construction of rural houses as part of the IAY programme.
2. To work within the programme a series of hands-on training sessions to familiarise the beneficiaries and artisans in these technologies.
3. To present revised zone-wise design options to the beneficiaries for them to study, validate and recommend changes
4. Compile the workshop outcome to include an actionable plan to take the work forward

Key Deliverables

1. Programme for the 3-day workshop for Beneficiaries and Artisans in Shillong, Meghalaya
2. Defining the Hands-on training sessions on Construction technologies.
3. Identification of experts to conduct the training sessions (in coordination with HUDCO and UNDP).
4. Work out the infrastructure and material requirement for each of these sessions in coordination with the trainers.
5. Preparation of IEC material for the workshop.
 - a. Recommended technologies and their benefits
 - i. Earth technologies- Stabilised Adobe and Soil Cement blocks, Rammed earth walling and flooring, Stone debris blocks, Soil testing and comparisons of strengths
 - ii. Bamboo technologies- Treatment methods, Species identification, sustainable stocks, bamboo verticals, jointing, roofing, walling panels, flooring
 - iii. Zone-wise recommended designs & specifications (revised following the 1st workshop on the 18th and 19th of Feb 2015)- plans, sections, perspectives, virtues of each design, areas and costs
6. Conduct the workshop programme
7. Organise the beneficiaries into groups zone-wise and facilitate their hands-on training.
8. Conduct a design study session for the beneficiaries where they would come up with their recommendations on how they would lay out their house plans and what changes they would effect to the prototypes from a functionality aspect.



Development of the Programme for the Beneficiaries Workshop

The workshop was designed with the primary intent of familiarising the beneficiaries with some of the technologies identified as the part of the sustainable technologies recommended for rural housing in Meghalaya and getting their views.

The workshop format was spread over 3 days starting from the 24th to the 27th of March 2015. As discussed as part of the Action Plan meeting conducted in the presence of the Joint Secretary, MoRD, the Principal Secretary, CnRD, Govt. of Meghalaya, the Director and Deputy Director, SiRD Meghalaya, UNDP and HUDCO and other MoRD representatives, it was decided that about 300 beneficiaries slated to start the building of their houses (or extensions) would be invited for the workshop. To make the most of this opportunity to showcase these technologies adequately, the workshop was primarily designed as day long sessions demonstrating these technologies. Group discussions were incorporated on Day 2 and 3 to have more focussed discussions on the construction technologies and for them to explore the designs of their homes with these construction technologies in mind.

The technologies identified for demonstration were:

EARTH TECHNOLOGIES

1. stabilised adobe block making,
2. Cement Stabilised Earth Block making,
3. Rammed earth walling and flooring,
4. Stone debris block making,

BAMBOO TECHNOLOGIES

1. Treatment of bamboo
2. Various Jointing techniques of bamboo including (using FRP, etc)... With and without power tools
3. Grouting of bamboo in concrete stubs (protection of these bamboo members)
4. Making of Bamboo walling panels using split bamboo (preferably with pre-existing panels as examples).
5. Protection of bamboo members

Two agencies were identified to conduct the training in these Earth and Bamboo technologies, respectively.

- **Gramavidya**, an NGO from Bangalore were identified for Earth technology dissemination and
- **WonderGrass Pvt Ltd**, a bamboo technology enterprise based out of Nagpur and Bangalore were identified for the Bamboo technology dissemination.

As part of the training a list of materials was also generated by the two training groups. The State Institute of Rural Development, Meghalaya took the lead at coordinating the effort behind the mobilisation of all local infrastructure, material and resources needed for the workshop. The SiRD was also the venue for the workshop.

Specific flyers that addressed the beneficiaries directly were prepared zone wise on the Design Recommendations and Recommended Sustainable Construction Technologies. Separately one each on the Earth and Bamboo Technologies were prepared for this workshop.



The Workshop for IAY Beneficiaries, at SiRD, Meghalaya

A 3 day state-level workshop in Meghalaya was conducted on the 24th, 25th and 26th of March 2015 with the participation of up to a maximum of 200 participants, constituted mainly by beneficiaries from across the state accompanied by their block representatives, namely BDOs, Engineers and Gram Sewaks. The workshop was conducted in coordination with the SiRD and was held at the SiRD campus, near Shillong, Meghalaya.

The SiRD had coordinated the invitation and hosting of the various participants for the duration of the workshop.

AIM OF THE WORKSHOP

At the start of the workshop we had set ourselves a set of key points that form the main aim of this workshop:

1. To introduce and familiarise these identified sustainable construction technologies to the beneficiaries
2. To demonstrate appropriate alternatives to their current construction materials.
3. To highlight the durability, aesthetics and resource/cost effectiveness of these technologies
4. To educate them on the benefits of these technologies
5. To showcase examples of projects, from across the country and beyond, that employ these technologies effectively.
6. To ascertain from them their opinions on these demonstrated technologies

The workshop programme was as follows:

S No	Session	Activity	Duration	Start time	End Time
Day 1- Inauguration and Hands on Training in different Technologies					
1	Session 1	Registration	30 mins	9:30 AM	10:00 AM
		Inauguration of the workshop and introductory remarks by : - Mr T. Lyngwa, Director, SiRD, and - Mr Banteilang S Rumnong, Deputy Director, SiRD	30 mins	10:00 AM	10:30 AM
2	Session 2	Broad Introduction to the workshop and Sustainable Rural Housing for Meghalaya, and introduction to the Housing Zones for Meghalaya by Harsha Sridhar	15 mins	10:30 AM	10:45 AM
BREAK TEA - 15 MINUTES					
3	Session 3	Parallel Technology & hands on training Sessions Earth- Stabilised Adobe block making – Zones 1 & 4 Bamboo- Treatment & Joinery (using thin dia. Bamboos) – Zones 2, 3 & 5	150 mins	11:00 AM	1:30 AM
BREAK FOR LUNCH - 1 HOUR					
5	Session 5	Parallel Technology & hands on training	150 mins	2:30 PM	5:00 PM



		Sessions Earth- Stabilised Adobe block making – Zones 2, 3 & 5 Bamboo- Treatment & Joinery (using thin dia. Bamboos) – Zones 1 & 4			
END OF THE DAY 1					
Day 2- Continuation of Technology Training sessions					
1	Session 1	Brief introduction to the day's programme	5 mins	9:30 AM	9:35 AM
		Presentation on Bamboo Technologies – Examples from across the world and projects of Wondergrass	30 mins	9:35 AM	10:05 AM
		Presentation on Earth & Bamboo Technologies – Examples from across the nation by Pankaj Khanna	30 mins	10:05 AM	10:35 AM
		Presentation on Projects using Earth & Bamboo Technologies – Examples of projects by Initiative for Green Habitats by Harsha Sridhar	20 mins	10:35 AM	11:55 AM
BREAK TEA - 15 MINUTES					
2	Session 2	Parallel Technology & hands on training Sessions Earth- CSEB production & Rammed Earth wall construction – Zones 1 & 4 Bamboo- Treatment & Joinery (using large dia. Bamboos) – Zones 2, 3 & 5	90 mins	11:10 AM	1:30 AM
BREAK FOR LUNCH - 1 HOUR					
3	Session 3	Group wise Discussion with groups on the construction technologies demonstrated - Zones 1 & 2 - Zone 3 - Zones 4 & 5	90 mins	2:30 PM	4:00 PM
END OF DAY 2					
Day 3- Continuation of Technology Training sessions & Study of Zone wise Prototypes and Exercise on imagining their houses by Beneficiaries					
1	Session 1	Brief introduction to the day's programme	5 mins	9:30 AM	9:35 AM
		Presentation on various Earth Technologies – Examples of projects of Gramavidya	40 mins	9:35 AM	10:15 AM
BREAK TEA - 15 MINUTES					
2	Session 2	Parallel Technology & hands on training Sessions Earth- CSEB production & Rammed Earth wall construction – Zones 2, 3 & 5 Bamboo- Treatment & Joinery (using large dia. Bamboos) – Zones 1 & 4	90 mins	10:30 AM	12:00 PM
3	Session 3	Group Sessions with groups from the zones- Beneficiaries to Imagine their homes, with no restriction on utilising only the construction technologies that they have seen during this workshop.	120 mins	12:00 PM	2:00 PM

		- Zones 1 & 2 - Zone 3 - Zones 4 & 5			
BREAK FOR LUNCH - 1 HOUR					
4	Session 4	Closing Session and Concluding remarks from: <ul style="list-style-type: none"> • Mr Akashdeep, Director, CnRD, Govt. of Meghalaya • Mr B S Rumnong, Deputy Director, SiRD, Meghalaya • Mr Suneel Padale, Programme Analyst, UNDP • Mr Harsha Sridhar, UNDP Consultant • Feedback from Block officials, beneficiaries, and trainers • Vote of Thanks 	90 mins	3:00 PM	4:00 PM
END OF DAY 3 AND THE WORKSHOP					

About an average of about 160 participants comprising of beneficiaries and block officials attended the workshop during the three days. Out of this number an average of approximately 120 members represented the beneficiaries. The block officials also assisted in the translation of the lectures, and presentations given by the various session leaders.

The earth technologies were keenly observed and were well appreciated by the participants. The bamboo technologies on the other hand had a slower start with lesser appreciation by the participants. However, by day 2 of the training programme, there was greater participation in the bamboo technologies, from treatment to joinery.

To supplement the training sessions and to showcase successful projects using these earth and bamboo technologies in other parts of the globe and from other parts of India, a few presentations were prepared and shown. Projects showcasing cutting edge bamboo and earth architecture demonstrated the versatility, durability, strength and aesthetic virtues of these technologies. Apart from this an exhibition of posters showcasing noted projects that use these technologies from different parts of India was also prepared and put up. This was done with the assistance of Mr Pankaj Khanna from Delhi and Ms Gayatri Ratnam, GM HUDCO.

The flyers that were prepared for the zone wise Design Recommendations and Recommended Sustainable Construction Technologies and on the Earth and Bamboo Technologies were distributed to the BDOs (and/or other Block representatives) from the respective zones.

During the training sessions many one-to-one discussions were had with beneficiaries and block officials, gauging their views. This provided valuable feedback in the difficulties that the beneficiaries were having with these technologies. This was also conducted as formal discussions during the group sessions in the classrooms on the technologies.

The key recommendations and findings of the group sessions were as follows:

1. Beneficiaries felt that they wanted to see full scale structures to see exactly what the finished buildings using these technologies looked like.
2. Beneficiaries were very interested in the Stabilised Adobe blocks. The greatest interest was from people of Zone 1 (western plains of Garo hills). Some people from Zone 4 and 5 too indicated that they would use this in their houses. Most of them had indicated that they would use this in the construction of their houses
3. Some people from Zones 3, 4 and 5 were also interested in the CSEB production using the Mardhini press. They requested that the machines were made available by the Block offices that can be used by those who wanted to use them.
4. They wanted to know what the mix would be for different types of soil.
5. They also wanted to know what types of Bamboo were to be sourced and grown.
6. Many block officials were keen to have one demo structure in their blocks.
7. The presentation showcasing projects from various parts of the country and the globe proved to be very useful and was well appreciated by the participants. Both beneficiaries and Block officers shared their admiration for the aesthetics achieved and structural properties using these same earth and bamboo technologies. One of the Block officers from Garo Hills was also keen to explore the construction of bridges using bamboo.

Some Pictures of the Workshop



Picture 1 Introduction to the workshop on the first day of the programme.



Picture 2 Introductory remarks to formally start the workshop by Mr T Lyngwa, Director, SiRD



Picture 3 Mr Banteilang S Rumnong, Deputy Director, SiRD, outlining the broad purpose of the workshop as part of the inaugural function.



Picture 4 Presentation by Vaibhav Kaley of Wondergrass Pvt. Ltd on contemporary use of Bamboo technologies- a global and national perspective in addition to the experiences of Wondergrass.



Picture 5 A presentation on the other examples and experiences of buildings made using earth and bamboo technologies from across the country, by Pankaj Khanna.



Picture 6 The Earth technology demonstration yard. Mounds of sifted earth and sand are seen in the foreground.



Picture 7 Mixing lime into the water that will be used in the soil and cement mix for block making.



Picture 8. Mixing of the soil cement mix using the lime water.



Picture 9 Pugging of the soil mix which will be used to make the stabilised adobe blocks. Demonstrated by the team from Gramavidya.



Picture 10 Filling the mix into the mould



Picture 11 The block is then emitted from the mould by overturning it on a flat surface. This is then left for one day, before it is lifted and stacked for curing.



Picture 12 Mixing of the earth, sand and cement mix for CSEB and rammed earth production



Picture 13 Compressed Earth Stabilised Blocks made from the Mardhini press



Picture 14. Making CSEB blocks using the Mardhini press. The mould is being prepared. One can see the sifted sand, and soil in the vicinity.



Picture 16 Beneficiaries understanding the Mardhini CSEB press



Picture 15 Rammed Earth Production being demonstrated.



Picture 17 Selecting the appropriate bamboo for construction.



Picture 18 A session on the preparation of the Borax chemical solution used for the treatment of the bamboos.



Picture 19 The sorted bamboos being sized for fabrication



Picture 20 Making of various sturdy bamboo joints of various kinds using hemp, cotton rope, bolts, etc were demonstrated.



Picture 21 Assembling a bamboo member that can be used for as a column or as a beam.



Picture 22 Bamboo Joinery being demonstrated



Picture 23 Some traditional bamboo woven ware being demonstrated by the beneficiaries



Picture 24 Bamboo columns and beam forming a portal. Small dia. Bamboos (approx 40 mm) were used for this.



Picture 25 Bamboo walling panels assembled using large dia. Members for the main vertical and horizontal members and smaller dia. Members for the walling panel secondary members and split bamboo used for the walling weave.



Picture 26 Exhibition prepared by Pankaj Khanna and supported by HUDCO, examples of noteworthy projects using sustainable technologies like earth and bamboo.



Picture 27 Classroom based sessions to discuss the apprehensions of the participants on these technologies, and to inform them of the benefits of using these technologies.



Picture 28 Additional sessions on imagining their homes in the context of the three days of hands-on training and the recommended design methods was also conducted zone-wise.



Picture 29 As part of the concluding session Block officials from each zone and a few beneficiaries shared their impressions on the workshop and the earth and bamboo technologies that they had seen over the past few days.



Picture 30. The Mr Subhash Chandra Basu representing the Gramavidya team summing up his experiences as a trainer (earth technologies) in this workshop.



Actionable outcomes and way forward

A number of action points were identified as a result of the workshop. All these points were discussed by a group of the following members:

1. Mr Banteilang, Rumnong, Deputy Director, SiRD, Meghalaya
2. Mr Suneel Padale, Programme Analyst, UNDP
3. Mr Harsha Sridhar, Consultant, UNDP

THE ACTION POINTS

1. Emphasis was laid on the building of 5 demonstration structures in each zone as decided as an action point at the end of the previous workshop for Govt officials, held in Shillong on the 18th and 19th of February 2015. These structures would be built as community structures or block offices under NREGS.
 - a. Each structure would be live full scale applications of the identified earth and bamboo technologies
 - b. Each structure would involve a far more intensive hands-on training of select artisans with an entrepreneurial bent of mind. This training would be engineered to impart full skills on these technologies to these artisans.
 - c. The artisans trained in the construction of these five demonstration structures could then build subsequent structures that may be commissioned in the respective blocks of their zones using these technologies.
2. Setting of bamboo treatment centres in different parts of the state. These centres would be developed as SHGs managing sourcing of correct bamboo species, sorting, and treatment. These centres could then be expanded to certain up the chain aspects like managing bamboo plantations growing specific species that are conducive to construction and down end aspects like the production of specific prefabricated bamboo elements like walling panels, columns, roofing trusses, doors & windows, etc. As a start, bamboo treatment centres could be a part of the five demonstration structures to be built as the next phase of this sustainable construction technology transfer.
3. Enabling of Block offices to become custodians of this effort of transfer and adoption of sustainable construction technologies for each zone. This would involve:
 - a. Training of block officers in the recommended sustainable construction technologies for their zones. This training would also train the block officials in the seismic resistant features that have been recommended as part of technology recommendations and demonstrated in the design prototypes. This training should enable the block officers to assist the beneficiaries in their choice of technology application etc.
 - b. Setting up simple soil testing centres at the block level.
 - c. Build a local resource bank for sourcing material locally. They could provide assistance on the species of bamboo to use and where once could source them. This could also extend to assisting the beneficiaries in sourcing of power tools for bamboo works,
 - d. Provide backward integration to assist the beneficiaries, and/or village council groups to source block making apparatus, like the Mardhini press, rammed earth moulds etc.
 - e. Provide supply chains to the block offices for the procurement of chemicals for bamboo treatment (Ex. Boric acid, Borax), general purpose resin, hardener and activator (also

called Catalyst) & hemp needed for making sturdy, immobile joints and preservative coatings for bamboo. (cashew shell oil, etc).

- f. The Block offices could be enabled in providing access to hardware like J-bolts that have to be used for tying down the corrugated roofing sheets down to the bamboo/timber roofing members.
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Annexure

Flyers prepared for the workshop capturing zone-wise design and construction technology recommendations, and on earth and bamboo technologies

of the walls to prevent rain splash.

Lightweight ferrocement/bamboocrete roofing laid over the roofing structure can be explored.

Doors and Windows

Wooden door and window frames with wooden shutters. Preferably medium sized bamboo jaali windows, or small windows in masonry walls.

Flooring

Plain Cement flooring laid over a back filled plinth. Alternatively, a rammed earth floor could be explored.

Wooden planks of hardy non-edible betel nut trees laid over a split bamboo framework.

Wall Finishes

Masonry Walls

- Cement stabilised mud plaster for external faces walls.
- Plain mud plaster for internal walls

Bamboo mat screen walls

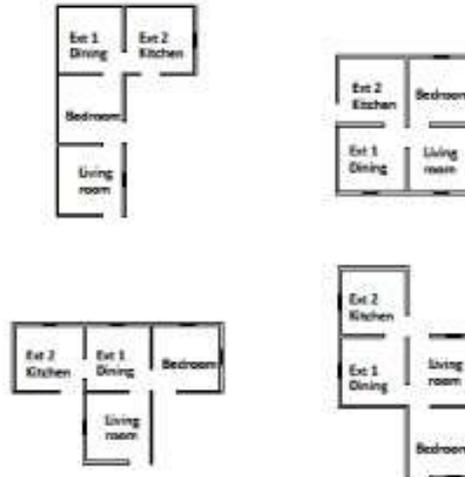
- Can be left exposed
- Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging.

Note: Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

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)



Drawing 3: Plan variations that show other possible arrangements for you to lay out your home.

Note: Contact your Block Office to get detailed drawings and information about the prototype for your zone.

This effort for the Community and Rural Development Department, Government of Meghalaya is supported by the Housing and Urban Development Corporation..



COMMUNITY & RURAL DEVELOPMENT DEPARTMENT
Government of Meghalaya

GREEN RURAL HOUSING FOR MEGHALAYA

Sustainable Rural Housing Design and Construction
Technologies as part of the Indira Awaas Yojana, Govt of India

ZONE 1

Western Plains of Garo Hills and along the southern edge
(mostly plains and random hillocks)



This prototype shows how your home can be built with design, usage and construction variations. **These layouts are only suggestive and you are free to plan your home the way you desire.** It offers ways to build a strong and secure home which is reflective of your traditions and your functional needs. It is easy to build, using materials and skills available in your village. This design ensures that there is least damage to your environment with materials used and construction methodology.

Each of these structures have been designed to withstand earthquakes and cyclones. We propose that you follow the construction technologies recommended and build yourself a sturdy and beautiful home.



Highlights of the Design

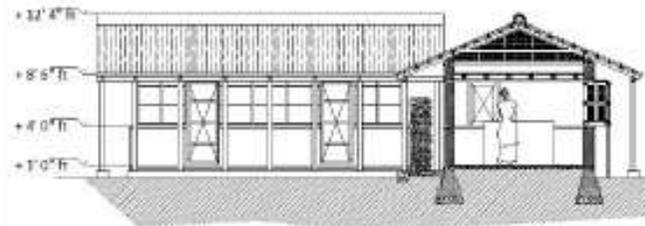
The designs are essentially modifications of both the 'Adobe block house' and the 'On ground Rectangular Timber post and beam house', both traditional housing types found in your region. Here are some salient aspects of this prototype:

- These structures can be rectangular in plan with an entry from the longer sides. Extended roofs on two sides of your 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 you 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. You could build them either as full height or half height walls.
- Protection of the walling areas by providing deep roof overhangs is done.



Drawing 1: Plan of the House and extension

- The roof is made of CGI sheets supported on a bamboo roofing structure. You could use an under layer tied to the roof of split bamboo to create an air gap which will help keep your home slightly cooler. Alternatively, you 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.



Drawing 2: Section through the House and extension

Recommendations for Construction components and materials, with options

Foundation

- Stone Masonry strip foundation (Loosely collected and shallow quarried boulder rock can be used in the foundation)
- Option of Isolated footings with large stone pieces and cement soil mixture and raised flooring on plinth beams for flood prone areas.

Plinth

- Stone Masonry plinth
- RCC Plinth beams for raised floors in flood prone areas. Flooring support framework in bamboo/timber

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

Note: Vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length. Horizontal reinforcement bands have to be provided at plinth, sill, lintel, and roof level. Additional reinforcement to be provided around all openings.

Roof Structure

Bamboo/timber roofing members (Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°).

Roof Cover

GI Roofing Sheets to be fastened onto roofing structure using J-bolts.

Roof overhangs to be at least 3 ft feet beyond the outer plane

Doors and Windows

- Bamboo door and window frames and shutters
- Wooden door and window frames with wooden shutters
- Small to medium sized windows.

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

Wall Finishes

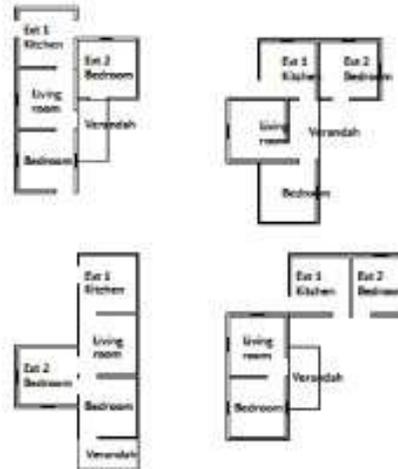
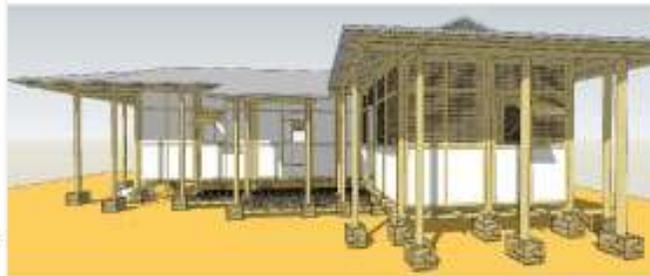
- Provision of stabilised mud plaster over the bamboo mat screens as long as split bamboo stiffeners are provided to prevent sagging.
- Keeping the walling exposed, as long as there is adequate rain protection from the roof overhang

Note: Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

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)



Drawing 3: Plan variations that show other possible arrangements for you to lay out your home.

Note: Contact your Block Office to get detailed drawings and information about the prototype for your zone.

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GREEN RURAL HOUSING FOR MEGHALAYA

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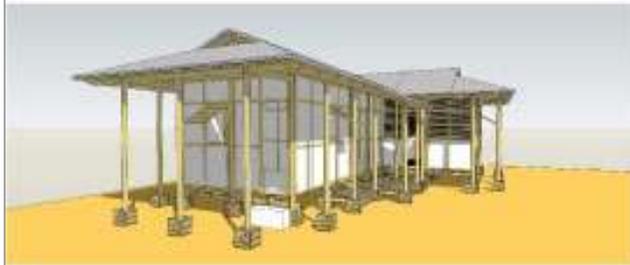
ZONE 2

Western Hills of Garo Hills
(Hilly areas)



This prototype shows how your home can be built with design, usage and construction variations. *These layouts are only suggestive and you are free to plan your home the way you desire.* It offers ways to build a strong and secure home which is reflective of your traditions and your functional needs. It is easy to build, using materials and skills available in your village. This design ensures that there is least damage to your environment with materials used and construction methodology.

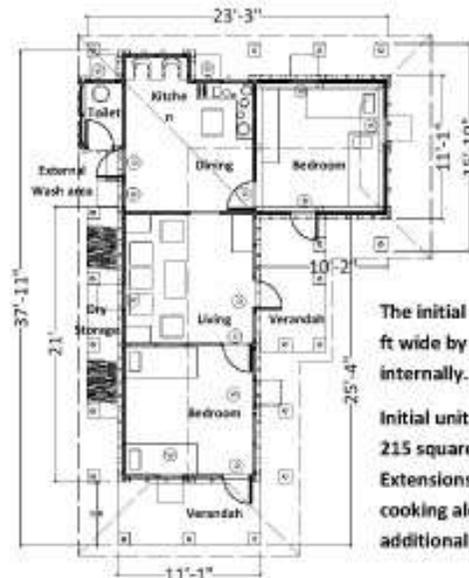
Each of these structures have been designed to withstand earthquakes and cyclones. We propose that you follow the construction technologies recommended and build yourself a sturdy and beautiful home.



Highlights of the Design

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 your 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



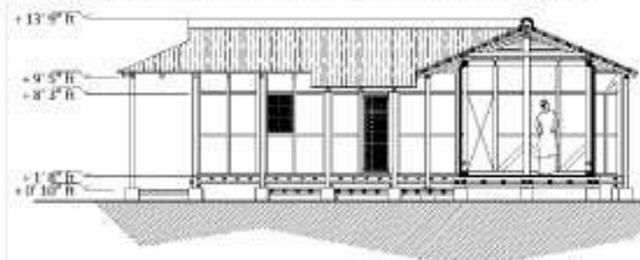
The initial unit is about 10 ft wide by about 20 ft long internally.

Initial unit area is about 215 square feet. Extensions, toilet and cooking alcoves are additional

Drawing 1: Plan of the House and extension

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 are CGI sheets supported on a bamboo roofing structure. You could use an under layer tied to the roof of split bamboo to create an air gap which will help keep your home slightly cooler.
- This house has also been provided with an attached toilet, a cooking alcove, utensils/clothes washing area and storage.



Drawing 2: Section through the House and extension

Recommendations for Construction components and materials, with options

Foundation

- Isolated footings with large stone pieces and cement soil mixture. Alternatively, you could use large stones as stubs.

Plinth

Raised Floor (no masonry plinth)

Flooring support framework in bamboo propped up on bamboo columns embedded in the concrete footings

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

Note: Strong vertical members are to be provided 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.

Roof Structure

Bamboo/timber roofing members (Preferably a hipped roof. Angle of the sloped roof should be a minimum of 23°).

Roof Cover

GI Roofing Sheets to be fastened onto roofing structure using J-bolts.

Roof overhangs to be at least 3 to 4 feet beyond the outer plane of the walls to prevent rain splash.

Additional vertical supports can be provided to support the extended roof.

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.

Doors and Windows

- Bamboo door and window shutters and frames
- Wooden door and window frames with wooden shutters
- Small to medium sized windows.

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

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

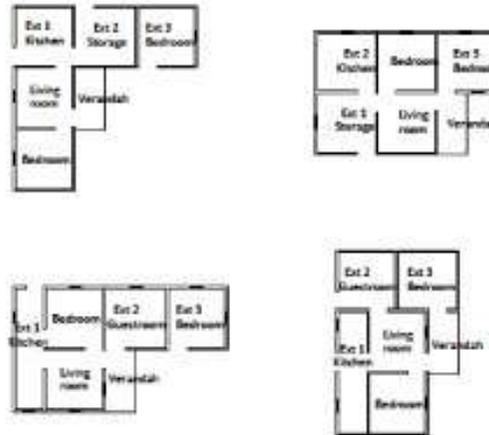
- Cement stabilised mud plaster for external faces walls.
Plain mud plaster for internal walls

Note: Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

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)



Drawing 3: Plan variations that show other possible arrangements for you to lay out your home.

Note: Contact your Block Office to get detailed drawings and information about the prototype for your zone.

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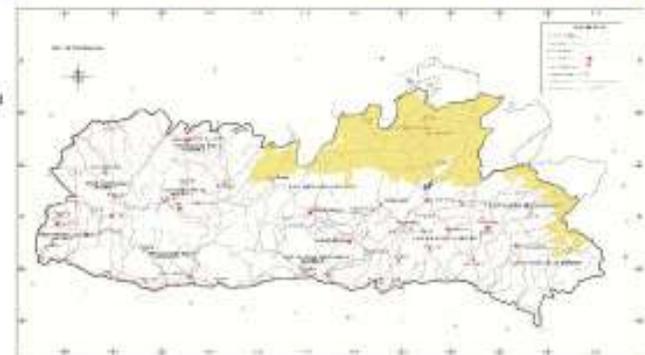
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Government of Meghalaya

GREEN RURAL HOUSING FOR MEGHALAYA

Sustainable Rural Housing Design and Construction
Technologies as part of the Indira Awaas Yojana, Govt of India

ZONE 3

Northern Slopes (Ribhoi and parts of West Khasi and Jaintia Hills)
(Hilly areas lower than 600 m in altitude sloping to the North)



This prototype shows how your home can be built with design, usage and construction variations. **These layouts are only suggestive and you are free to plan your home the way you desire.** It offers ways to build a strong and secure home which is reflective of your traditions and your functional needs. It is easy to build, using materials and skills available in your village. This design ensures that there is least damage to your environment with materials used and construction methodology.

Each of these structures have been designed to withstand earthquakes and cyclones. We propose that you follow the construction technologies recommended and build yourself a sturdy and beautiful home.



Highlights of the Design

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 your 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. Veranda's 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.



Drawing 1: Plan of the House and extension

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, you 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.



Drawing 2: Section through the House and extension

Recommendations for Construction components and materials, with options

Foundation

Isolated footings with large stone pieces and cement soil mixture.

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

Walling

Option of

- 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.

Note: Strong vertical members are to be provided 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. In masonry walls, 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.

Roof Structure

Bamboo/timber roofing members (You could also build a hipped roof. Angle of the sloped roof should be a minimum of 23°).

Roof Cover

GI Roofing Sheets to be fastened onto roofing structure using J-

bolts.

Lightweight ferrocement roofing can be explored.
Roof overhangs to be at least 3 to 4 feet beyond the outer plane of the walls to prevent rain splash.
Gaps between roof and wall to be boarded up.

Doors and Windows

- Bamboo door and window frames and shutters
- Wooden door and window frames with wooden shutters
- Preferably small sized windows.

Flooring

- Plain Cement flooring laid over a back filled plinth.
- Close stacked split bamboo flooring fixed over a tight bamboo flooring framework
- Timber Plank flooring over Timber under-structure.

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.

Masonry Walls

- Cement stabilised mud plaster for external faces walls.

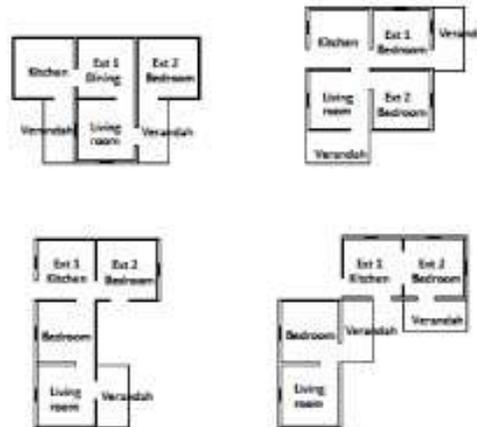
Plain mud plaster for internal walls

Note: Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

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)



Drawing 3: Plan variations that show other possible arrangements for you to lay out your home.

Note: Contact your Block Office to get detailed drawings and information about the prototype for your zone.

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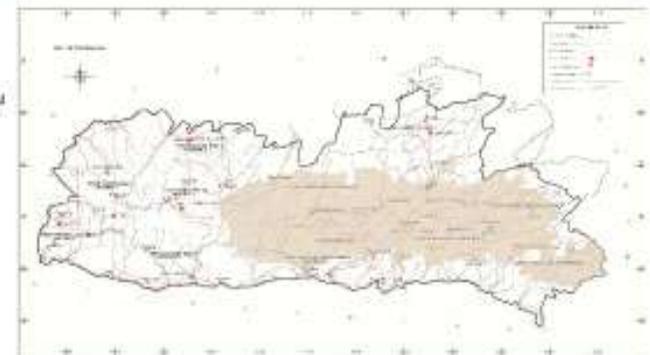
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ZONE 4

Higher Meghalayan Plateau (East & West Khasi and Jaintia Hills)
(Hilly areas above 600 m in altitude)



This prototype shows how your home can be built with design, usage and construction variations. **These layouts are only suggestive and you are free to plan your home the way you desire.** It offers ways to build a strong and secure home which is reflective of your traditions and your functional needs. It is easy to build, using materials and skills available in your village. This design ensures that there is least damage to your environment with materials used and construction methodology.

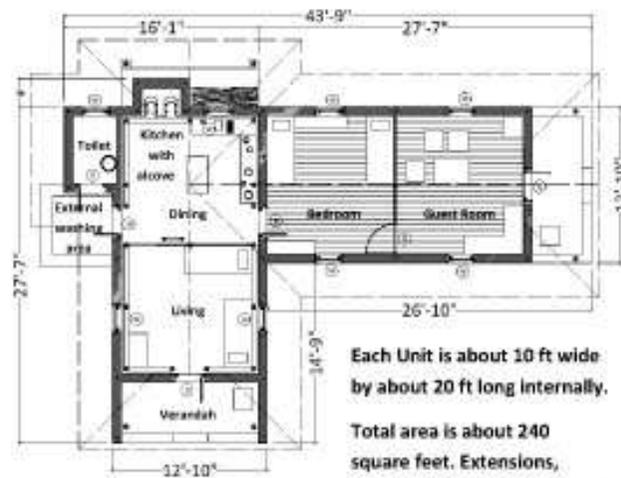
Each of these structures have been designed to withstand earthquakes and cyclones. We propose that you follow the construction technologies recommended and build yourself a sturdy and beautiful home.



Highlights of the Design

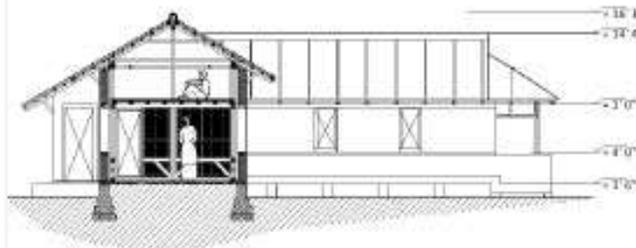
The design borrows heavily from certain aspects of the Khasi Oval Hut, the iconic traditional housing type of your region, without taking the obvious oval plan form. Here are some salient aspects of this prototype:

- 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.



Drawing 1: Plan of the House and extension

- 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. You 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.



Drawing 2: Section through the House and extension

Recommendations for Construction components and materials, with options

Foundation

- Isolated footings with large stone pieces and cement soil mix.
- Strip foundation with stone masonry with drainage gutter provided all around the house.

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.
- 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.

Note: 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.

Roof Structure

Bamboo/timber roofing members (Preferably a hipped roof. Angle of the sloped roof should be a minimum of 30°).

Roof Cover

GI Roofing Sheets to be fastened onto roofing structure using J-

Angle of the sloped roof should be a minimum of 30°).

Roof Cover

GI Roofing Sheets to be fastened to the roof using J-bolts.
Lightweight ferrocement roofing can be explored.
Roof overhangs to be at least 3 to 4 feet beyond the outer plane of the walls to prevent rain splash.
Gaps between roof and wall to be boarded up.

Doors and Windows

- Bamboo door and window frames and shutters
- Wooden door and window frames with wooden shutters
- Small to medium sized windows.

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 over the bamboo framework
- Non edible betel palm wooden planks over the bamboo framework.

Wall Finishes

Ikra walling

- Provision of stabilised mud plaster over the bamboo mat screens with split bamboo stiffeners

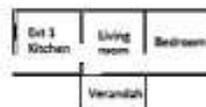
Low height Masonry Walls

- Cement stabilised mud plaster for external faces walls.
Plain mud plaster for internal walls

Note: Cow dung plaster can be used as an alternative for internal plaster where cow dung is available.

Kitchen Alcove

Where a kitchen is to be attached, a masonry or bamboo/ timber alcove with a chimney can be created for the hearth.



Drawing 3: Plan variations that show other possible arrangements for you to lay out your home.

Note: Contact your Block Office to get detailed drawings and information about the prototype for your zone.

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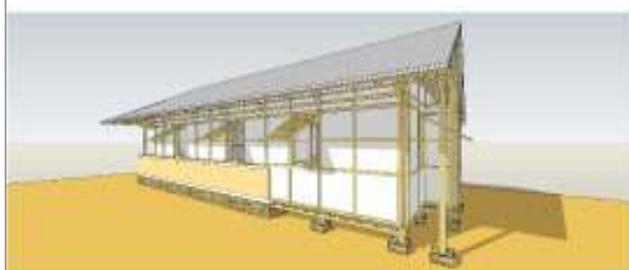
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ZONE 5

Southern Slopes (East & West Khasi and Jaintia Hills)
(Hilly areas below 600 m in altitude sloping towards the south)



This prototype shows how your home can be built with design, usage and construction variations. **These layouts are only suggestive and you are free to plan your home the way you desire.** It offers ways to build a strong and secure home which is reflective of your traditions and your functional needs. It is easy to build, using materials and skills available in your village. This design ensures that there is least damage to your environment with materials used and construction methodology.

Each of these structures have been designed to withstand earthquakes and cyclones. We propose that you follow the construction technologies recommended and build yourself a sturdy and beautiful home.



Highlights of the Design

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



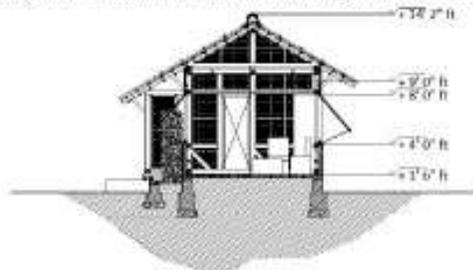
Each Unit is about 10 ft wide by about 20 ft long internally.

Total area is about 225 square feet. Extensions, toilet and cooking alcoves are additional.

Drawing 1: Plan of the House and extension

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.



Drawing 2: Section through the House and extension

Recommendations for Construction components and materials, with options

Foundation

- Isolated footings with large stone pieces and cement soil mix.
- Strip foundation with stone masonry with drainage gutter provided all around the house.

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.
- Pre-assembled Bamboo walling panels that can be fixed onto the main bamboo framework. This could also be made as bambooconcrete panels. Bamboo mat screens supported against a timber/bamboo framework for internal walls
- Low height masonry walls and upper portions of bamboo mat screens held in either timber or bamboo framework.

Note: Strong vertical members are to be provided 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. In masonry walls, vertical reinforcement has to be provided in all corners and at every 1-1.2 metres of wall length. Horizontal tie reinforcement bands has to be provided at plinth, sill and lintel levels

Roof Structure

Bamboo/timber roofing members (Preferably a hipped roof.



This mould can be manufactured by a local fabricator in your nearest town. The rammers can be made in mild steel as well as in wood.

Benefits of these technologies

There are numerous benefits of using these technologies. Here are a few:

1. The main material, soil, used in making these blocks is found all around you and is easy to source.
2. The method of manufacture is simple, and can be constructed by you and other people from your village.
3. The costs of construction can be kept very low. The cost of the Stabilised Adobe moulds is very cheap and can be made any local fabricator.
4. All of these masonry blocks can be left exposed and look good that way. This way you can further save on plaster and paint cost. (A simple pointing (cement grouting of the mortar joints will take make these joints water tight)
5. These are engineered technologies and are far stronger than the locally made concrete blocks or bricks that are available around you. All you have to ensure is that you follow the right methods and recommended mix of soil and cement and you can get a very strong and sturdy walling material with relative ease.

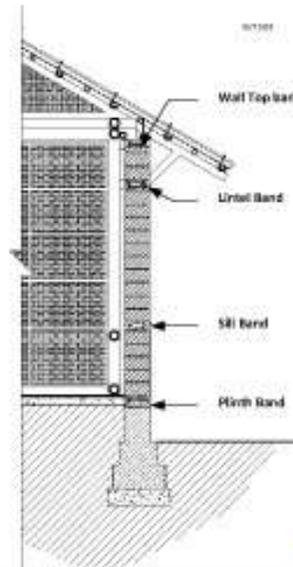
Seismic features in all walls

Meghalaya is a high risk zone for earthquakes and has witnessed devastating earthquakes in its history. It is therefore necessary to follow certain seismic features in all walls:

1. Horizontal tie concrete bands with reinforcement steel have to be provided at plinth level, sill level (below window), lintel level (above door/window) and at top of wall level. In raised floors, a plinth beam would take the

place of the plinth tie band.

2. The plinth tie band has to be anchored into the plinth at corners and at junctions by inserting a tie rod from the plinth band into the plinth.
3. Vertical reinforcement rods have to be provided at all corners, wall junctions and at 4 feet intervals along the wall. This can be done by creating cavities in the blocks during their making.
4. Reinforcement bands have to be provided around all openings.



Rammed Earth flooring

A simple and cost-effective alternative to a cement floor, the rammed earth floor uses the sieved earth from around your home, with a mix of about 7 to 9 % of cement (and lime where available) and water. Nearly 4 inches of this mix is poured over the a backfilled earth plinth and then rammed down using metal or wooden rammers. This is done till we achieve an even rammed earth floor. Once done, the surface is trowelled to achieve a smooth finish. This floor is then set aside and cured for 21 days.

Note: Contact your Block Office to get detailed information about these technologies for your home.

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EARTH TECHNOLOGIES

Engineered systems that are elegant, efficient, resilient and cost-effective



Earth has been used in construction for over 2000 years. In fact there are buildings from those times made of earth that are still standing and in use. In recent years, ways of improving the quality, strength and durability of earth based construction have been devised.

Walling blocks made with earth, using simple and scientifically enhanced methods, and with additives like lime and cement can compete with the best. Such blocks are structurally strong and aesthetically pleasing.

What is even more interesting is that all these earth based technologies can be employed by you, right there in your village. They do not require special skills to be sourced from elsewhere. All you need is earth, which can be sourced from in and around your home, lime and cement and a few simple tools/moulds. Some of these have already been tried and tested right within Meghalaya

Stabilised Adobe



This technology is perhaps the simplest to employ and requires the least investment to produce very good quality blocks. The process of manufacture is in fact very similar to the initial steps of

making burnt clay bricks, that you get in NW Garo Hills, Assam and towards Slichar. The primary difference is the addition of around 7% to 9% cement and a slurry of lime (where available) in the soil mix. Sand or clayey earth may be added depending on the composition of the soil from your site. You need about 2 or 3 moulds, for making the blocks, which are very simple and

economical to make. Just 3 people could work to make these blocks, and the production of blocks could be anywhere from 300 to about 600 blocks per day. The soil cement and lime water



(prepared the day before) is mixed together and then 'pugged' by pressing down on the mix using your feet. Once properly pugged, you take about two handfuls of the mix in your hand and roll it into a ball. This is then smashed into the mould, which is set aside. The mould is filled and smoothed out. The mould is then lifted to a smooth platform and overturned to eject the finished block. This is set aside for two days before it can be lifted and stacked for curing (for 21 days).

Blocks for both internal partition and external walls can be made using this method.

Cement Stabilised Earth Blocks



This is another simple technology where the block making involves compression of the cement soil mix in a manually operated machine. The machine, also known as the Mardhini Press, has been developed by the Indian Institute of Science, Bangalore. The machine is very easy to operate and is entirely manual. A minimum of 4 people are needed to make blocks, and one can produce up to

600 to 800 blocks per day.

Between 7 to 9% cement and a slurry of lime (where available) is added to a sieved soil mix along with water. Sand or clayey earth may be added depending on the composition of the soil from your site. This mix is then filled into a block making machine. Once filled to the brim, the lid is brought down and the block compressed by pulling down on a long lever. This action, compresses the contents of the block. The lever is then pushed back up ejecting the compressed block. This can then be lifted and placed aside for a day. The next day, the block can then be



stacked for curing (for 21 days).

A number of inserts are also available which can be placed in the mould to get corner roundings, half blocks for internal partition walls and hollow cores to pass reinforcement through.

You could encourage your Village Council to invest in one of these machines. That way many families can share the same machine to make blocks at a nominal cost.



Rammed Earth Walling



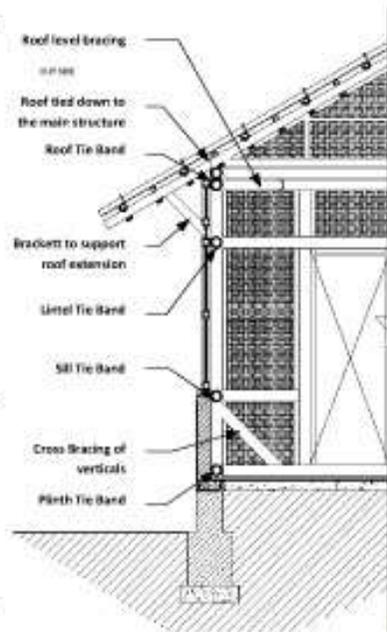
The soil mix in this technology and the mixing is pretty similar to that of the Cement Stabilised Earth Blocks. In this method of construction, large blocks are erected directly onto the areas where you intend to

build walls. Mild Steel moulds (plywood formwork can also be used), ranging from 2 ft to 4 ft in length, 9 inches in width and 1 ft high, are placed onto the plinth beam/tie-band in alignment with the intended wall. The soil mix is filled into the mould, 4 inches at a time, and rammed down using metal or wooden rammers.

The process is repeated till the mould is filled. Once done, the mould is removed and the walls are brushed using a sponge. This creates a smooth surface texture, which is the final finish. The mould is then moved to the next slot and the process is repeated.



also beneficial to connect the horizontal members at the corners with diagonal cross braces at the roof level.



- The roof has to be tied well to the walling framework. The CGI sheets above have to be fixed to the bamboo purlins only using J- Bolts (this is also to be followed when using a timber roof).
- Ensuring that the bamboo members are well protected from too much sun or rain by providing proper and adequate roof overhangs will extend the life of the bamboo structure.

Bamboo walling panels



Bamboo walling panels can be made in two ways.

One using a grid of split bamboo with a spacing of about 4 to 5 inches, fixed between the vertical members. This grid has to be anchored firmly to the verticals, using long nails driven into the verticals, at regular intervals. A chicken mesh is then spread over this grid and a cement/soil plaster is applied over this on both the inside

and outside. Openings can be left where windows/doors have to be made and the frames of these openings can be integrated into the walling grid. You can either choose to paint this surface or not.

The other method is to create the infill between the main verticals and horizontals using a tightly spaced woven split bamboo grid. Such a wall construction is quite common in Meghalaya. A cement/soil plaster can be applied on both the inside and outside. You could add a layer of chicken mesh over the split bamboo panels for better adherence of the plaster. These panels can also be pre-fabricated.

In both cases, the bamboo grids for the wall paneling should be firm enough to take the cement plaster on two sides. Rough plaster is applied as a first coat, before the final finish coat.



Bamboo plantations

We encourage you to speak to your village council to grow bamboo to provide for a regular stock for construction related activity and to avoid recurring costs of purchasing bamboo. Species of the kinds needed for main structural members to those suited for wall paneling infill and for the preparation of bamboo mats, doors and windows can be grown. Since Bamboo is fast growing it will take just 4 years for you to make your village sustainable in its bamboo needs.

Note: Contact your Block Office to get detailed information about these technologies for your home.

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BAMBOO TECHNOLOGIES

Engineered systems that are elegant, efficient, resilient and cost-effective



Bamboo construction is perhaps the oldest building system known to man. This material has given rise to many a building culture all across the world. Meghalaya has a bamboo construction heritage spanning over 4000 years. In recent years, a lot of work has been done on the engineering properties of bamboo. New treatment methods can enhance the life of a bamboo structure from a few years to over 30 years.

Bamboo has a tensile property that is greater than steel and structures built with bamboo can be considered as best suited to earthquake prone zones.

What is even more interesting is that the skills to build a strong and sturdy bamboo home is available right there in your village. All you need are a few simple tools, the right bamboo and some materials to tie the structure.

Some wonderful structures using these bamboo technologies have already been built right within Meghalaya.

The right Bamboo to build with

While a number of bamboos grow in Meghalaya, not many of them are good for all construction uses. There are many that are good for mat making, there are others that are good for split bamboo panels, and yet others that are suitable for poles, horizontal ties and roofing members.

There are a few species that grow in Meghalaya that can be used for construction — Bambusa Balcoa, Bambusa Nutans, Dendrocalamus hookeri, Dendrocalamus hamiltonii and Melocanna bambusoides are a few. You can speak to your local Block Office to understand more about these bamboos that you can use for construction.

In essence, a good Bamboo for construction is generally over 16



ft in length and relatively straight, with a diameter of about 4 inches and nearly 2/3rds of this diameter forming the walls of the bamboo. A good bamboo is also one that is cut at an age of between 3 to 5 years,



depending on the species. Most Bamboos attain their maturity and are sturdy enough by this time.

Bamboos should also be harvested in the dry season as it is during this period that the bamboos

have the least moisture content. They are also least prone to fungus attach if harvested during these months. When cut, the bamboos are not to be kept exposed to direct sun and rain. Also, only the straight portions of the bamboo is to be used, discarding the irregular ends.

Treated Bamboo

It is very important to use only treated bamboo for construction. Such bamboos have a much longer lifespan and when used properly they can prolong the life of your home to over 30 years. Bamboo treatment methods vary. These methods prevent the invasion of pests and also may involve the removal of the nourishment in the bamboo that attract the insects.

The most prominent methods are:

Immersion – Small holes are drilled in the bamboos in the internodes and they are soaked in a long and shallow tank in a solution of Boric Acid and Borax for a period of 3 days, and then stored in the shade to dry.

Pressure Impregnation (or Boucherie method) – A solution (made with boric acid/borax) is applied with pressure at one end of the basal end of a freshly cut bamboo. This drives out the starchy sap and replaces it with the preservative solution. This method uses cylinder filled with the preservative solution, a motorized or manual hand



pump, pressure nozzles, valves to regulate the solution flow, pressure regulator and outlet nozzles fitted to the bamboos. The process takes about 30 minutes and about 6 to 7 bamboos can be treated in one



hour. Beyond these methods, other methods like commercial smoking kilns, and heating have also been used for bamboo treatment.

Bamboo Structures and joinery

It is important that a bamboo structure is built keeping certain aspects in mind. This will ensure stronger and more resilient structures.

1. You need to anchor the main verticals of the structure properly. The bamboo verticals have to be grouted into the ground in lean concrete footings. A coating of either FRP (Fibre reinforced Polymer) or bitumen can also be applied on the bottom portion of these columns. This will ensure that neither termites nor moisture would affect the main structural supports.
2. 4 inch dia erect bamboos have to be selected for the main verticals. It is important to keep a spacing of not more than 4 feet between the main vertical supports, and they have to be provided in all corners and junctions.
3. Horizontal ties, using similar 4 inch dia bamboos have to be provided at plinth, sill, lintel and at the springing point of the roof.
4. Joints have to be firm and rigid. They could be done either as joints held together using bolts and nuts, or, by using encasing the joint in a FRP.
5. Cross bracing is to be provided for all main vertical and horizontal members to provide extra rigidity to the structure. This is done by introducing diagonal members connecting the vertical to the adjacent horizontal member. This is to be done at all corners and wall intersections. It is