Simple Action For the Environment (SAFE)
Registered under: Niraporth Bangladesh Songstha (Safe Bangladesh Organisation, SBO),
Sundarban Village, PO: Ramdubihat, Upuzila: Sadar Dinajpur.

Housing and Hazards
www.housingandhazards.org

Case study: construction of rammed earth house

13 June 2011

Introduction

This case study documents the construction of a rural house, using rammed earth construction technique, which took place during June 2011. It has been undertaken with support from the Australian High Commission, British Women's Association and Housing and Hazards. It details our participatory approach and provides technical information about our techniques and the associated costs.

SAFE is a small NGO working in the Dinajpur district of Bangladesh to:

Reduce the vulnerability of low income households to environmental hazards such as flooding and strong winds.

We do this through promoting improved and appropriate house building techniques – using cheap, locally available materials, and environmental initiatives such as tree planting. With stronger houses that last longer, households in the long run save time and money and are less vulnerable to environmental hazards.

We aim to increase community self reliance by creating skilled and informed local builders, craftsmen and house owners. We do this through a programme of workshops, construction of demonstration houses and material subsidies.

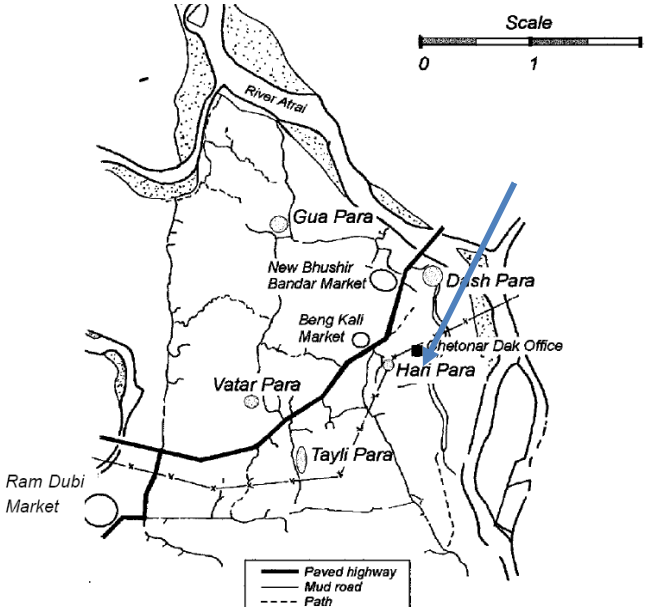
Northern Bangladesh

Participatory Approach

We recognise the importance of participation if our new techniques are going to be accepted and spread within the local population. This house has been built through a partnership between SAFE and the household. Both parties contributed labour and materials in an approximately 50/50 split. This split was agreed at the outset and a simple hand written contact outlining each party's responsibilities was signed.

The size and type of house was decided by the household based on available materials and space requirements.

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



Map of Sundarban Union showing location of demonstration house

Improved Construction Techniques

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

Refer to construction drawings in Appendix A.

Foundation

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

Walls

Vertical and horizontal bamboo reinforcement used.

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

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

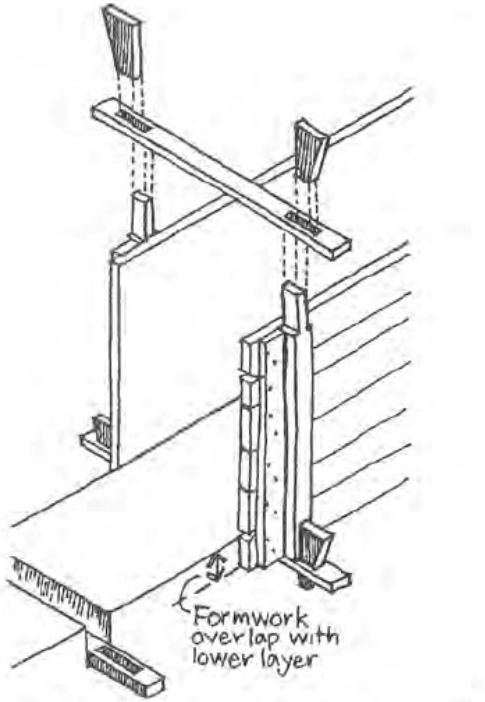
An overhanging layer of bricks has been built into the wall approximately half way up. Any water which comes into contact with the wall above these bricks will drip clear of the lower section of the wall – reducing damage.

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

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

Roof

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



Formwork fixing detail (taken from Building with Earth, a handbook – see footnote 1)

Damp-proof course between brick foundation and earth wall

Costs

A cost comparison has been carried out between the rammed earth and brick walled house. It is assumed that the foundations and roof, and other costs such as the door and window

[1] Iftekar, K.A. Handbook on Design and Construction of Housing for Flood-Prone Rural Areas of Bangladesh, ADPC 2005. Available at www.sheltercentre.org

[2] Norton, J. Building with Earth, A Handbook, Practical Action, 1997

frames to be of similar construction and so have been discounted. It is also assumed that the household can provide 3-4 labourers during construction at no cost, however skilled labour for the setting of the rammed earth formwork will be required and is included.

Refer to the cost comparison in Appendix B. The total cost of the rammed earth walls comes Tk12,769 or 28Tk per sqft. The brick wall cost comes to 51Tk/sqft – approx 55% of the cost of using brick wall construction.

For more information contact:

Azit Roy, T: +880 (0)1726 007 343, E: azit_sorkar@yahoo.com
John Arnold, T: +880 (0)1753 858 660 E: johnarnold700@yahoo.co.uk

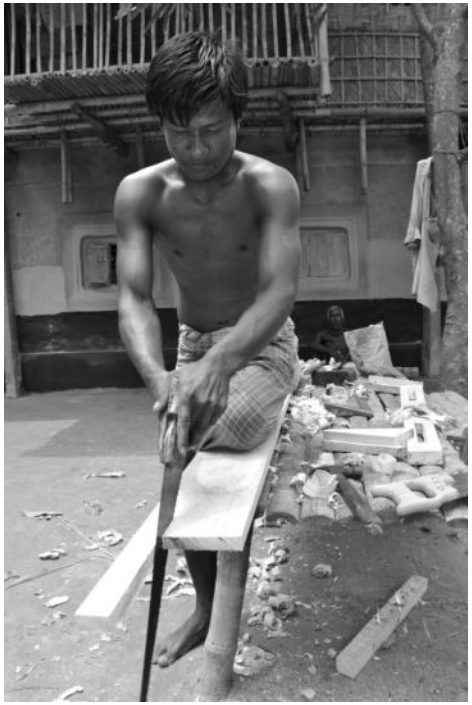
In the UK:

Robert Hodgson (Housing and Hazards), T: +44 (0)1884 821239
R.L.P.Hodgson@exeter.ac.uk

Floor structure for loft storage + bamboo ring beam

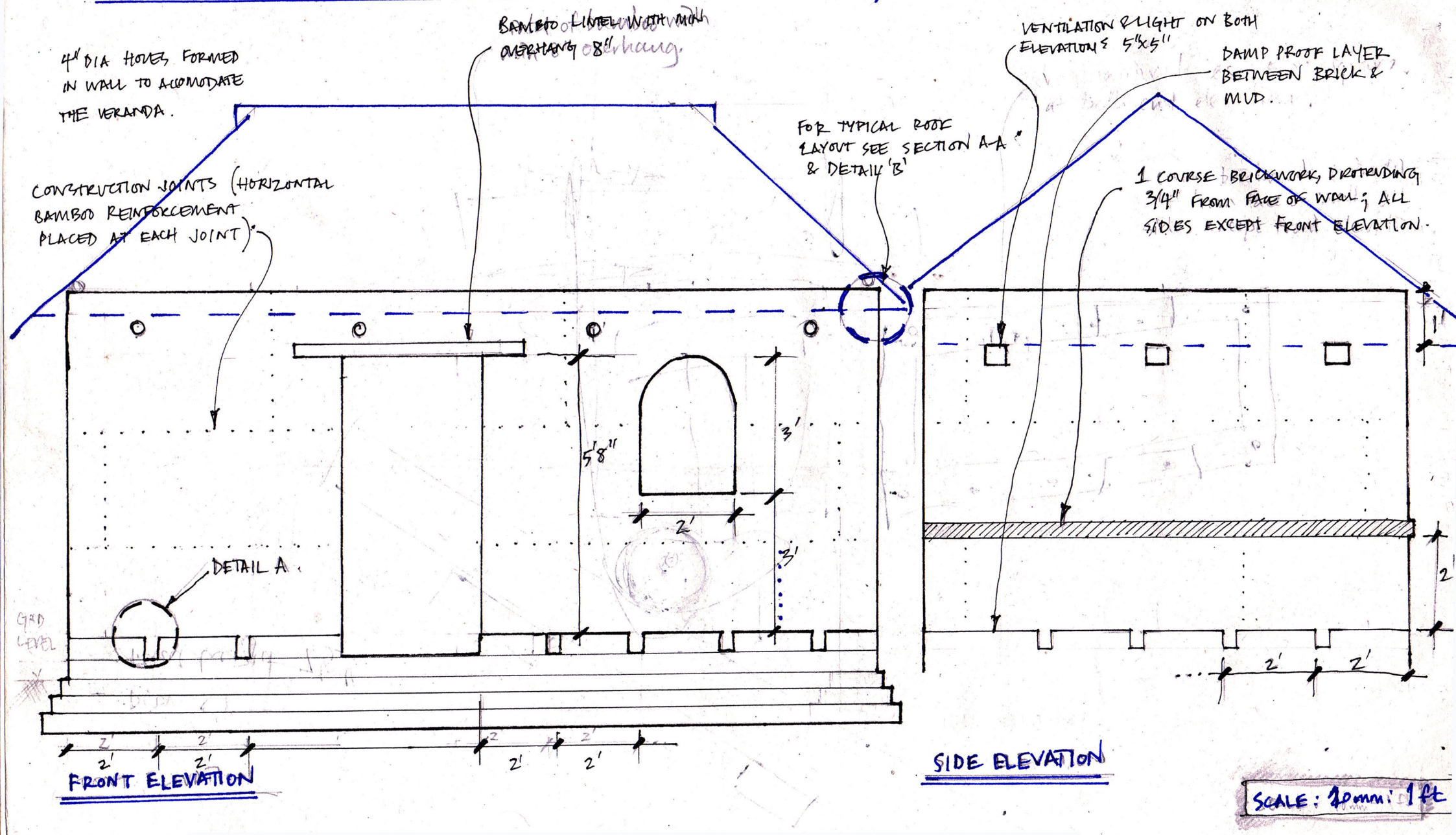
Arched windows formed using bricks

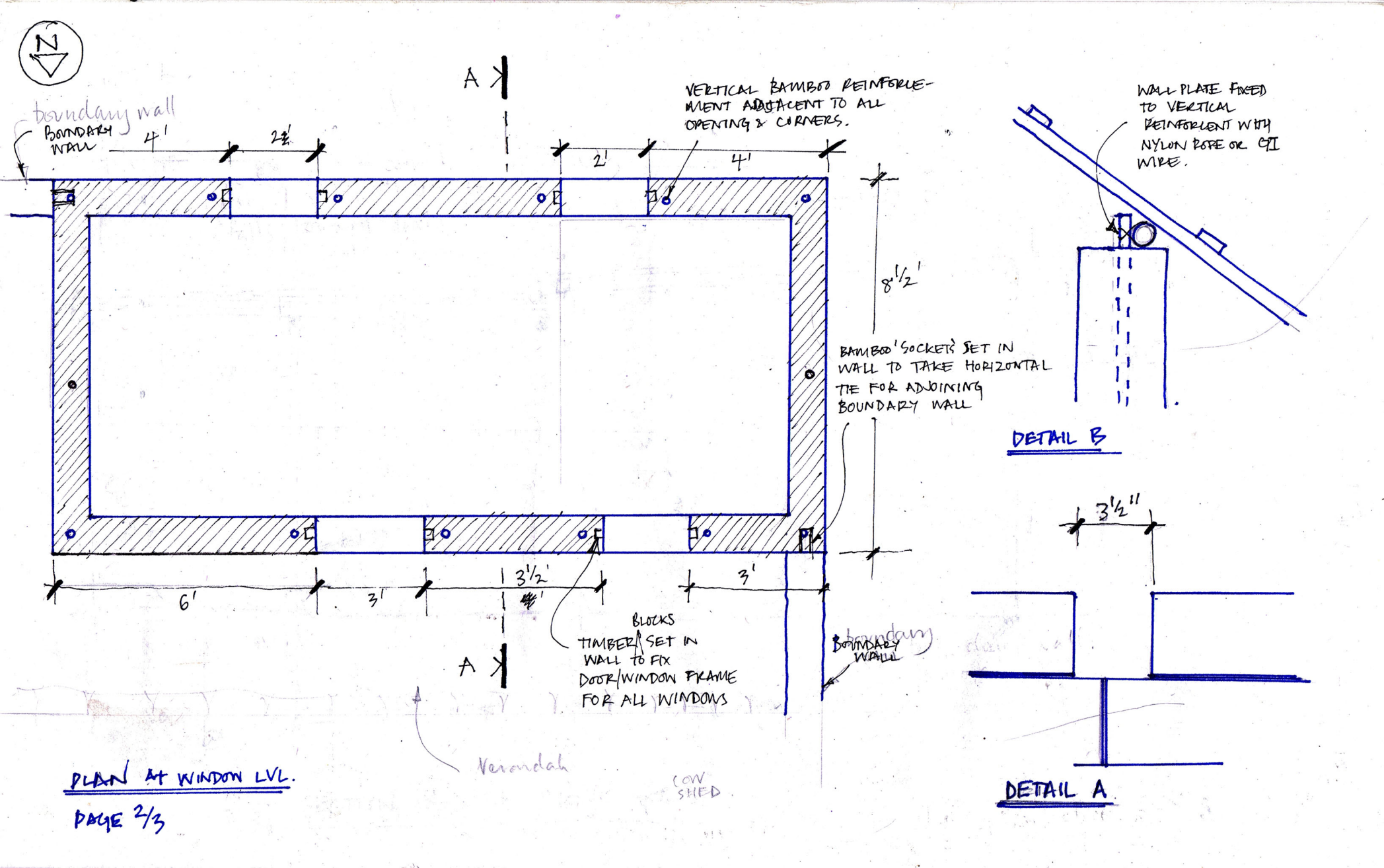
Single layer of protruding bricks provide extra protection to erosion from rain water.



Appendix A – construction drawings

UD01's RAMMED EARTH HOUSE 16.04.11 / JA. PAGE 1/3





PLAN AT WINDOW LVL.

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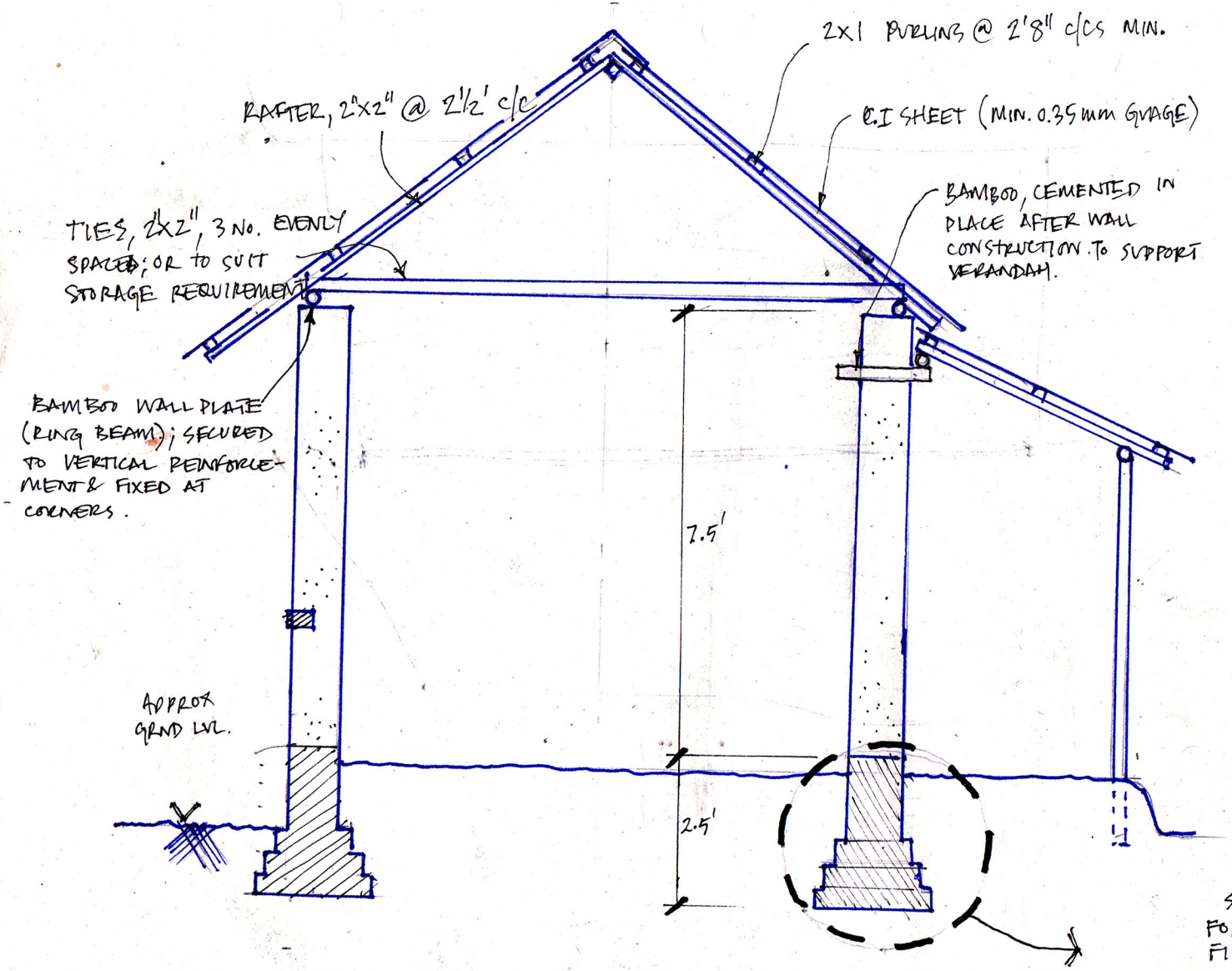
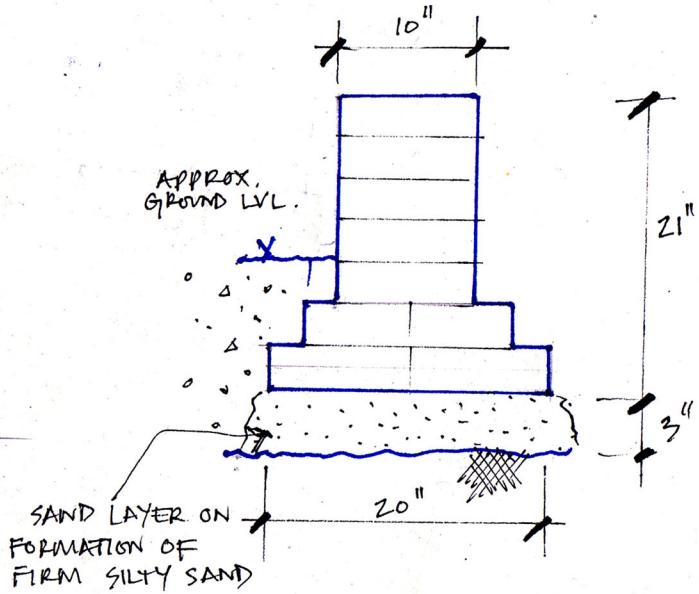


SECTION A-A



DETAIL B
(SCALE 1":2mm)

Appendix B – Cost comparison of cement stabilised rammed earth against brick wall

Budget cost for standard brick/cement wall

Assumptions
Foundations are assumed to be same as mud block wall and are not included
RC lintel is added for stability
Plaster for one side is included
Lowest quality bricks used

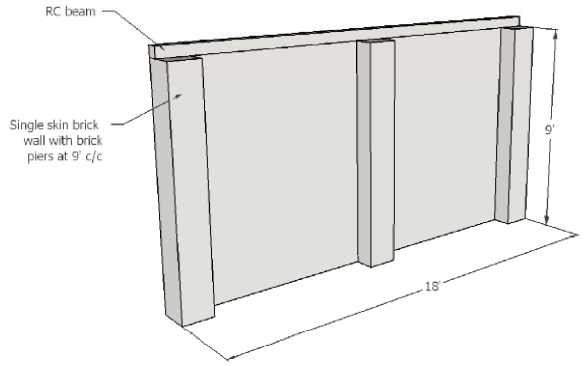
Brick size
Standard brick size = 25 x 7.5 x 12cms
incl mortar joint = 26 x 8.5 x 13cms
Convert

25	9.8 in	26	10.2 in	
7.5	3.0 in	8.5	3.3 in	
12	4.7 in	13	5.1 in	

Volume of 1 brick without mortar course 0.079 cuft
Volume of 1 brick with mortar course 0.10 cuft

Cement
Cost of cement - 50kg bag 360 Tk
Convert to volume @1500 kg/m3 0.033223 m3
convert to cuft @1m3 = 35.32cuft 1.172757 cuft per 50kg bag

Labour
Skilled eg. mason 200 Tk/day
Labourer 120 Tk/day



Size of Wall
Plan area 10.63 sqft
Volume of wall 95.63 cuft

Calculate no. bricks
Brick volume incl. mortar joint from above 0.10 cuft
Total bricks 942 no.
Cost of bricks @ Tk5/brick 4712 Tk

Mortar
Sand - 1 trailer at Tk400/ load 100 Tk

Use rule of thumb 0.3m3 mortar per 1000 bricks
Volume of mortar 0.28 m3
Convert to cuft @ 1m3 = 35.32cuft 10.0 cuft
Volume of cement @ 1:4 2.0 cuft
No. bags cement 1.7 no.
Cost of cement (using rate above) 613 Tk

Labour - laying bricks
say 3 days for mason (Tk200/day) and labourer (Tk120/d 960 Tk

Plaster
Cement - say 1.5 bags @ 360/bag 540 Tk
Sand (use load from before) 100 Tk
Labour - say 1 mason, 1 labourer for 2 days 690 Tk

Lintel
MS Reinforcement, 8kg @ Tk44/kg 352 Tk
Tying wire 70 Tk
Cement - say 1 bag @Tk360/bag 360 Tk
Brick chips (80 no. bricks @ Tk4/brick) 320 Tk
Sand 100 Tk
Labour - say 1 mason, 1 labourer for 1 day 320 Tk

Total cost **8278 Tk**

Total wall length 18 ft
Wall height 9 ft
Area 162 sqft
Cost per sqft. 51 Tk/sqft

Cost of Rammed Earth Technique

Unstabilised mud

Assumptions
Assume house size of 8.5ft x 17.5ft with 9ft high walls
Shuttering cost not included
Scoffolding cost not included
Assume construction in 3' layers
Assume that in 3 days, 2 men will construct 1 layer
Use 1 skilled labour and 1 labourer
Household is required to prepare and carry earth and assisst with ramming - 2/3 people for duration of construction
Earth is assumed to be avaialble locally with no transport costs.
Any minor repair/finishing to be done by household

Labour		
Skilled	200	Tk/day
Labourer	120	Tk/day
Total daily cost of labour	320	Tk
No. of layers	3	no.
No. of days for construction*	11	days
*Assume 2 extra days as work slows on top layer and to construct windows.		
Total labour cost	3520	Tk
Bamboo for reinforcement	1500	Tk
Cost of consumerbles eg. rope for shutters	500	Tk
Total cost	**5520**	**Tk**

Unit cost		
Total lenth of wall	50	ft
Heigth of wall	9	ft
Area of wall	450	sqft
Cost per ft of wall	12	Tk/ft

Extra cost of cement stabilisation

Assumptions
Only bottom 2 layers are stabilised as top layer will be protected by roof overhang
Wall is 10" thick
1-2 extra labourers required during construction - assume 1 is paid @120Tk/day and one is provided by household

Cement cost		
volume of walls =	250	cuft.
assume compaction of	1.5	
volume of earth	375	cuft.
volume of cement @ 5%	18.75	cuft.
volume of 50kg bag cement	1.17	cuft/bag
total cement required	16	bags
Cost per bag	370	Tk
Total cost of cement	5929	Tk
Extra labour		
No. days of construction	11	days
Labour cost	1320	Tk
Total cost	**7249**	**Tk**

Unit cost		
Total lenth of wall	50	ft
Heith of wall	9	ft
Area of wall	450	sqft
Cost per ft of wall	16	Tk/ft

Total cost - rammed earth + stabilisation	**12769**	**Tk**
Unit Cost		
Total lenth of wall	50	ft
Height of wall	9	ft
Area of wall	450	sqft
Cost per ft of wall	28	Tk/sqft