

World Housing Encyclopedia

A Resource on Construction in Earthquake Regions



an initiative of
Earthquake Engineering Research Institute (EERI) and
International Association for Earthquake Engineering (IAEE)

HOUSING REPORT Mud House of Bangladesh

Report#	143
Last Updated	
Country	BANGLADESH
Author(s)	Amrita Das, Mohammad Shariful Islam, Dr. Md. Jahangir Alam, Nusrat Hoque,
Reviewers	Dominik Lang,

Important

This encyclopedia contains information contributed by various earthquake engineering professionals around the world. All opinions, findings, conclusions & recommendations expressed herein are those of the various participants, and do not necessarily reflect the views of the Earthquake Engineering Research Institute, the International

General Information

Building Type:	Mud House of Bangladesh
Country:	BANGLADESH
Author(s):	Amrita Das Mohammad Shariful Islam Dr. Md. Jahangir Alam Nusrat Hoque
Last Updated:	
Regions Where Found:	<p>Buildings of this construction type can be found in villages and suburban areas of the country. Generally, areas of less rainfall dry climate, lateritic soil (rich in minerals, typically red in color) and where the lands are normally above the flood level, are more suitable for the construction of mud houses. This type of housing construction is commonly found in both rural and urban areas. Nowadays in rural and suburban areas, economically stable people try to build semi-permanent houses. Despite of this, the percentage of mud houses is higher in these areas. Locally this type of housing is called a Kutcha. About 74% of the total houses of Bangladesh are Kutcha houses, most of which might be considered as Mud houses. The percentage of Kutcha houses is 46% and 83% for urban and rural areas, respectively. Among mud houses, those of rammed earth type are most common but also mud block wall systems are being used. This type of construction is still being practiced in developing countries like Bangladesh.</p>
Summary:	<p>In Bangladesh, a mud house is one of the traditional housing types that are used by poor families mainly in rural areas as well as in the outskirts of small cities. This building type is typically one or two stories and preferably used for single-family housing. It is more predominant in less flood-prone areas, i.e. in the highlands or in mountainous regions. The masses of these buildings are generally high and their walls are characterized by insignificant strength, particularly against forces that act out-of-plane. This type of building is highly vulnerable to both seismic forces and high</p>

pressures due to flood flow. The main load bearing system consists of mud walls of 1.5 to 3.0 ft thickness, which carry the roof load. Clay tiles, thatch or CI sheets are used as roofing materials. The application of these materials depends on their local availability and the ability of the house owners. There is no monolithic joint between the wall and the roof. For this reason, these buildings behave poorly under any type of lateral load (e.g. earthquake, wind).

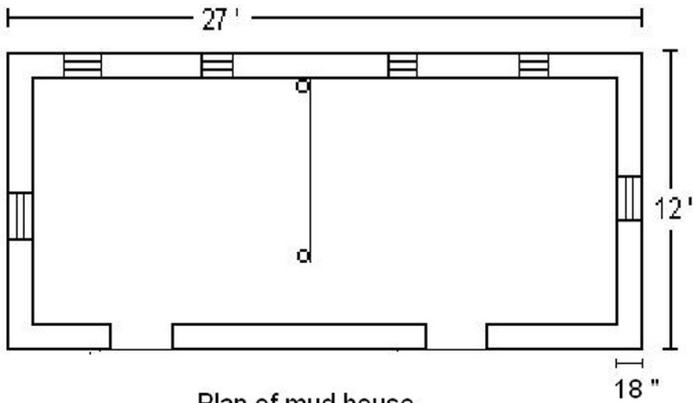
Length of time practiced:	More than 200 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1-2
Terrain-Flat:	Typically
Terrain-Sloped:	Typically
Comments:	In villages this type of construction can be used as a go down or storage house. Though most of the mud houses are used as single-f

Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	The plan shape of this type of construction is generally rectangular with lengths between 20-30 ft and widths between 10-15 ft. The main structural elements are mud walls which carry the load of the roofing.
Typical plan length (meters)	5-10
Typical plan width (meters)	3-5
Typical story height (meters)	1.6-2.5
Type of Structural System	Masonry: Earthen/Mud/Adobe/Rammed Earth Walls: Mud walls
	The vertical load-resisting system is earthen walls. Mud walls carry gravity loads due to the roof weight and transmit them to the ground. Rarely, wooden or concrete block lintels assist in resisting the gravity

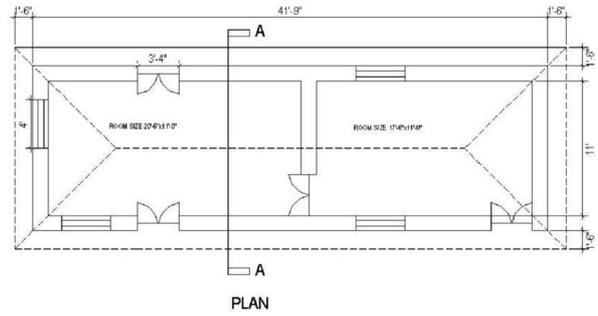
<p>Additional comments on structural system</p>	<p>loads at wall openings. Mudwalls are mostly susceptible to excessive rainfall, which frequently causes the washing away of mud from the wall. The lateral load-resisting system is earthen walls. The dimensions of the mud walls are typically: height 3.0 m, width 4.0 m, thickness 0.50 m. The walls do not have any additional system (such as crown beam or pilasters) to restrain their out-of-plane movement which is one reason why the buildings are so vulnerable during earthquakes. If the walls fail in out-of-plane direction, the roof generally loses its support and collapses. The wall corners (junctions) are very vulnerable parts of the structure. The typical wall thickness varies from 0.3 to 0.6 m.</p>
<p>Gravity load-bearing & lateral load-resisting systems</p>	<p>Mud walls are the main structural elements of this type of construction. They carry both lateral and vertical loads.</p>
<p>Typical wall densities in direction 1</p>	<p>>20%</p>
<p>Typical wall densities in direction 2</p>	<p>>20%</p>
<p>Additional comments on typical wall densities</p>	<p>The typical structural wall density is more than 20 %. Generally wall density varies with the thickness of the wall. For the house of the same dimension mentioned above, wall density will be different if the wall thickness is different.</p>
<p>Wall Openings</p>	<p>Many houses have open verandas at the front with roof supported by posts. The opening area is about 30 percent of the total wall area. The construction of doors can be done in two ways. Either by providing doors with heights equal to the wall height, or by a discontinuous construction of the wall at the location of the opening according to their dimension. The door frames are provided afterwards. In case that doors are provided with height less than the wall height, a wooden plank is provided over the opening with support of 6" on both sides. Afterwards the construction of the wall is continued leaving the opening. In case of the construction of windows, the walls are raised up to window sill level and then the walls are discontinued at the location of the opening. When the walls are raised up to the top level of the window, wooden planks are again placed over the openings with support of 6" on both sides. The remaining wall is constructed as described before.</p>
<p>Is it typical for buildings of this type to have common walls with</p>	<p>Yes</p>

adjacent buildings?	
Modifications of buildings	A typical modification of these buildings consists in the lateral extension. Vertical extension is not very common.
Type of Foundation	Shallow Foundation: Wall or column embedded in soil, without footing Shallow Foundation: No foundation
Additional comments on foundation	In the construction of mud houses no proper foundation is provided. Only the ground is excavated with a width equal to the wall thickness and the wall is then constructed. Generally the wall is embedded to the ground, without footing. The general depth of the embedment is about 0.3-0.5m. As a result no firm connection exists between the building and the ground. Thus the building may fail easily due to severe lateral loading.
Type of Floor System	Other floor system
Additional comments on floor system	The floor generally consists of compacted earthen materials.
Type of Roof System	Roof system, other
Additional comments on roof system	Thatched roof supported on wood purlins; thatched roofs are very commonly seen, but corrugated sheets or tiles supported by wooden purlins can also be used as roofing materials. The roofs are usually inclined to facilitate the drainage of water. Sometimes flat roofs with wood joists are also used. In Bangladesh, bamboo joists are more common. The roofs (and walls) typically have a 10 cm (4 inch) layer of straw. The compacted ground that is used as floor is generally raised 0.5-0.6 m above the existing ground level.
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 2-4 meters. It is not easy to specify the actual length and width of the house. Generally, this depends on the requirements as well as on the economic situation of the inhabitants. Roughly, the ratio of the length and width of the house can be expressed as 3:2 or 2:1. The span width also depends on the number of members that would occupy a single room.



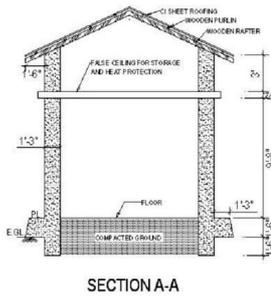
Plan of mud house

Plan of a typical mud house



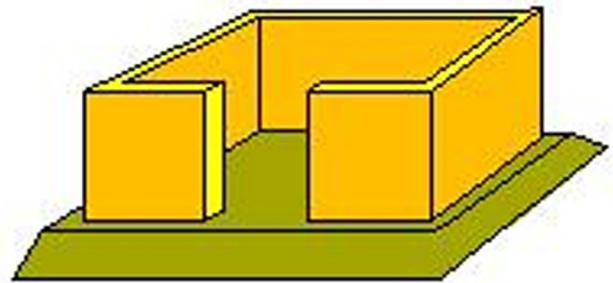
PLAN

Plan of a typical mud house

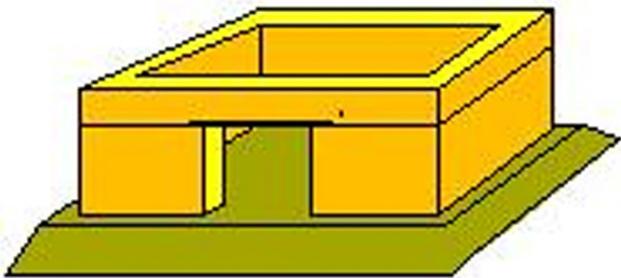


SECTION A-A

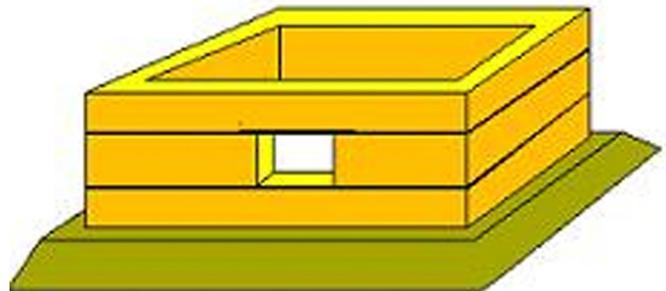
Elevation of the mud house shown in Fig. 5



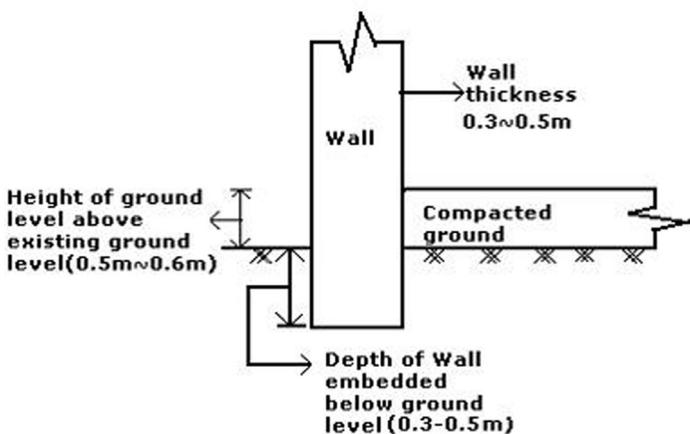
Construction of door with height equal to the wall height



Construction of door with height less than the wall height



Construction of window



Cross-section of wall and

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Mud (i.e.molded soil)is used fortheconstructionof the walls.Bamboo Frames	In unreinforcedmud walls thecompressivestrength of mud isabout 120--140 kPa(Islam andKanungo, 2006).The mix proportion of materials is notspecific. After mixing with water the mud iskept in place for a few days so that thedispersion of clay particles can take place.Afterwards it is used for construction. Themimum thickness of the walls is 1.5 ft.Among the lower income class, owners construct theirhouses themselves. In general, no testing of thematerial strength is done during construction. This issolely based on experience. Irrespective of this, testingfacilities are not available in those areas where thesetypes of constructions are available.
Foundations	Mud (moldedsoil) is usedfor theconstructionof foundation.	The mix proportion of materials is notspecific
Floors	Straw , C.G.ISheet,Bamboo,Golpata (akind of leaffound inMangroveforest).	
Roof	Straw , C.G.ISheet,Bamboo,Golpata (akind of leaffound inMangroveforest).	
Other		

Design Process

Who is involved with the design process?	None of the above
Roles of those involved in the design process	
Expertise of those involved in the design process	

Construction Process

Who typically builds this construction type?	Owner
Roles of those involved in the building process	These buildings are typically built by the owners, whereas the owner is directly involved in the construction process and may also contribute his own labor.
Expertise of those involved in building process	Local unskilled persons and villagers without any technical knowledge construct these buildings. Generally the builders construct their own houses and sometimes they employ skilled labor. Generally, the craftsmanship is poor. There is no special expertise and no formal training of labor. Their seniors trained them.
Construction process and phasing	Soil is excavated about 1.5--2 ft all around the building. In a first step, the wall base up to a height of 2--3 ft is erected out of compacted mud before it is left for one day for hardening. The same procedure is repeated several times in order to raise the wall up to the desired height. Roofing: The roof truss consists either of bamboo or wood. For the construction of the roof, first wooden beams are provided on top of the walls. The longitudinal beams are provided with grooves in equidistant intervals. Then the cross beams are placed at the positions of the grooves. Afterwards, the roof trusses are provided onto the longitudinal beams and fixed to them by nails. It has been observed that the roof trusses are not always provided directly over the cross beams. On top of the roof truss a roof frame is applied and fixed to the trusses by ropes. At the end, cover materials such as CI sheets or straw are provided. The construction of this type of housing takes place incrementally over time. Typically, the building is originally not designed for its final constructed size.
Construction issues	

Building Codes and Standards

Is this construction type address by codes/standards?	No
Applicable codes or standards	This type of construction is an informal construction. There are no guidelines for this type of housing. No prior approval is required.
Process for building code enforcement	This type of construction is very common in rural areas where no strict development authorities are present to observe the construction process of this type of construction.

Building Permits and Development Control Rules

Are building permits required?	No
Is this typically informal construction?	Yes
Is this construction typically authorized as per development control rules?	No
Additional comments on building permits and development control rules	This type of construction is very common in rural areas where no strict development authorities are present to observe the construction process of this type of construction.

Building Maintenance and Condition

Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	BDTK 50 per square feet.
Labor requirements	It takes about 60 days for 2-3 persons (120-180 person days) to complete the construction.

**Additional comments
section 3**



A building with thatch roof supported by wooden purlins in Muktagacha, Mymensingh (Asrafur Aslam, 2006; Firoza Akter, 2007)



Mud house with straw roof



CI sheet roof supported by wooden purlins (Firoza Akter, 2007)



Two-story mud house (Firoza Akter, 2007)



Mud house with corrugated galvanized iron sheet roof



Too many openings provided in onewall (Firoza Akter, 2007)

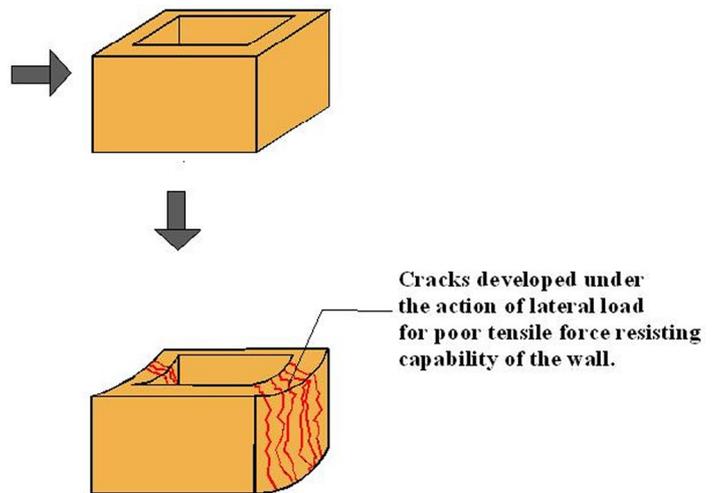
Two-storied mud house



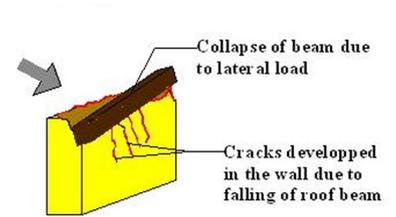
A building with tile roof supported by wooden purlins in Pahartoli, Raozan, Chittagong (Rebeka Ahsan, 2006; Firoza Akter, 2007)



Mud house with flat roof supported by bamboo joists



Cracking pattern of mud wall due to lateral load



Existing feature of wall and beam connection

Effect of roof load on the wall (RebekaAhsan, 2007)



Existing feature of roof truss located above the opening



Earthen wall without reinforcement in Hathazari Chittagong (Iftekhar, 2007)

Socio-Economic Issues

<p>Patterns of occupancy</p>	<p>One family possibly with a married son and his wife typically occupies one house. In rural areas, one family has at least 5--8 members. Each building typically has 1 housing unit(s). There might be two units if a combined family live in the house.</p>
<p>Number of inhabitants in a typical building of this construction type during the day</p>	<p><5</p>

Number of inhabitants in a typical building of this construction type during the evening/night	5-10
Additional comments on number of inhabitants	All family members return from their work back home at night. Consequently the number of occupants during night will be more than 5 people.
Economic level of inhabitants	Very low-income class (very poor)Low-income class (poor)Middle-income class
Additional comments on economic level of inhabitants	Most of the middle class families that were originally coming from the villages but that have moved into the cities, still stay in their mud houses when they come to their villages. They even renovate it at least once a year. Generally, the very poor people who live from hand to mouth, cannot engage themselves in any meaningful income generating labor and so they sometimes must live in houses with leaky roofs (even in winter and heavy monsoon). The gross national income of Bangladeshi people is 394 US-\$/year. The construction costs of such mud buildings is about 1000--1500US-\$ for a building of 1000 square feet. Ratio of housing unit price to annual income: 3:1
Typical Source of Financing	Owner financedPersonal savingsInformal network: friends or relativesSmall lending institutions/microfinance institutions
Additional comments on financing	Nowadays, Grameen Bank is the world renowned micro-finance institution, which lends money to the people as per their requirements under some easier terms and conditions. They help the poor people to become independent by loaning money for their development.
Type of Ownership	Own outright
Additional comments on ownership	Generally the occupants are the owner of the house. Renting a house is not very common.
Is earthquake insurance for this construction type typically available?	No
What does earthquake insurance typically cover/cost	
Are premium discounts or higher coverages available for seismically strengthened buildings or new buildings built to	No

incorporate seismically resistant features?	
Additional comments on premium discounts	
Additional comments section 4	Even today, people in Bangladesh are not aware about earthquake risk.

Earthquakes

Past Earthquakes in the country which affected buildings of this type

Year	Earthquake Epicenter
1997	N-E-N of Chittagong
2003	SW of Daluchari, Rangamati, Chittagong
2003	Barkal
1997	Jaintapur
1997	Bangladesh-Myanmar border

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	<p>Bangladesh has a long history of devastating earthquakes that have affected earthen buildings. Fortunately, the number of casualties caused by these earthquakes are not so significant. Recently, on July 26, 2003 (local time 5:18 am), a moderate earthquake occurred in the Chittagong hill tracts near the Bangladesh-India border causing minor structural damage, 3 fatalities and 25 injuries. The earthquake had a magnitude of 5.6 and was felt at many places in southeastern Bangladesh. Two women were killed when a mud house collapsed in the town of Rangamati. Five of the injured persons came from Rangamati district where the roof of the Aymyachhara Health complex collapsed in the town of Barkol. The Union Parishad building collapsed in Barkol. Several buildings including a school were damaged in the town of Rangamati. Five acres of land near the school reportedly caved in. Throughout the region nearly 500 buildings were damaged. In the earthquake in 1997, a five storied building at Hamzarbag was seriously damaged and</p>
--	---

many people died. Cracks also formed in many weak structures.

Additional comments on earthquake damage patterns

Structural and Architectural Features for Seismic Resistance

The main reference publication used in developing the statements used in this table is FEMA 310 "Handbook for the Seismic Evaluation of Buildings-A Pre-standard", Federal Emergency Management Agency, Washington, D.C., 1998.

The total width of door and window openings in a wall is: For brick masonry construction in cement mortar : less than $\frac{1}{2}$ of the distance between the adjacent cross walls; For adobe masonry, stone masonry and brick masonry in mud mortar: less than $\frac{1}{3}$ of the distance between the adjacent cross walls; For precast concrete wall structures: less than $\frac{3}{4}$ of the length of a perimeter wall.

Structural/Architectural Feature	Statement	Seismic Resistance
Lateral load path	The structure contains a complete load path for seismic force effects from any horizontal direction that serves to transfer inertial forces from the building to the foundation.	FALSE
Building Configuration-Vertical	The building is regular with regards to the elevation. (Specify in 5.4.1)	TRUE
Building Configuration-Horizontal	The building is regular with regards to the plan. (Specify in 5.4.2)	TRUE
Roof Construction	The roof diaphragm is considered to be rigid and it is expected that the roof structure will maintain its integrity, i.e. shape and form, during an earthquake of intensity expected in this area.	FALSE
Floor Construction	The floor diaphragm(s) are considered to be rigid and it is expected that the floor structure(s) will maintain its integrity during an earthquake of	FALSE

	intensity expected in this area.	
Foundation Performance	There is no evidence of excessive foundation movement (e.g. settlement) that would affect the integrity or performance of the structure in an earthquake.	TRUE
Wall and Frame Structures-Redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	TRUE
Wall Proportions	Height-to-thickness ratio of the shear walls at each floor level is: Less than 25 (concrete walls); Less than 30 (reinforced masonry walls); Less than 13 (unreinforced masonry walls);	N/A
Foundation-Wall Connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	FALSE
Wall-Roof Connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.	FALSE
Wall Openings		N/A
Quality of Building Materials	Quality of building materials is considered to be adequate per the requirements of national codes and standards (an estimate).	FALSE
Quality of Workmanship	Quality of workmanship (based on visual inspection of a few typical buildings) is	FALSE

	considered to be good (per local construction standards).	
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).	FALSE

Building Irregularities

Additional comments on structural and architectural features for seismic resistance	
Vertical irregularities typically found in this construction type	Other
Horizontal irregularities typically found in this construction type	Other
Seismic deficiency in walls	1. Very poor lateral resistance. 2. No seismic bands at lintel level provided. 3. The proportions of openings are not favorable. Openings are arranged too close to wall corners. Distances between wall corners and openings are not according to code specifications. Earthquake Damage Patterns: Partially or complete collapse of walls.
Earthquake-resilient features in walls	The provisions of bamboo posts at the inner and outer sides of the walls at regular intervals.
Seismic deficiency in frames	Improper connection between longitudinal and transversal beams. Earthquake Damage Patterns: Separation of the transversal beams from the longitudinal beams.
Earthquake-resilient features in frame	Wooden bracings should be provided at each corner where longitudinal and transversal beams are joined together.
Seismic deficiency in roof and floors	1. The single roofing elements are not interconnected. 2. The roofing truss is not fully anchored to the walls. 3. Poor maintenance makes the roof truss more vulnerable to damage. 4. Roof does not provide rigid diaphragm action. Earthquake Damage Patterns: Collapse of roof. Again cracks are formed in the walls above

openings.

Earthquake resilient features in roof and floors

Roof rafters should be placed over the solid wall not over openings.

Seismic deficiency in foundation

Earthquake-resilient features in foundation

Seismic Vulnerability Rating

For information about how seismic vulnerability ratings were selected see the [Seismic Vulnerability Guidelines](#)

	High vulnerability		Medium vulnerability		Low vulnerability	
	A	B	C	D	E	F
Seismic vulnerability class	-	-				



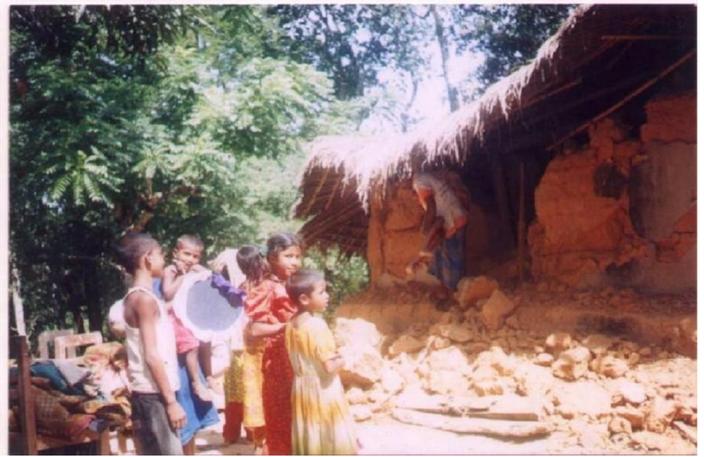
Collapse of mud house due to the 2003 Barkal earthquake (EERC, CUET)



Typical earthquake damage: cracking of walls due to the 2003 Barkal earthquake



Typical damage at a mud house in Hathaazari, Chittagong (Iftexhar, 2007)



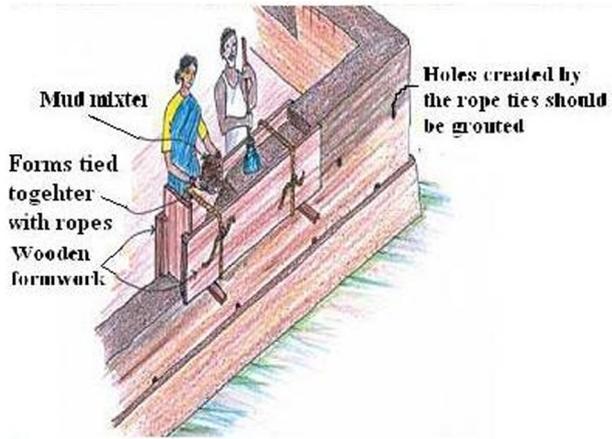
Damaged at a mud house after Barkal earthquake

Retrofit Information

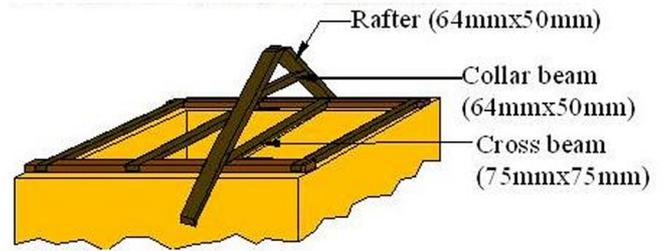
Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
<p>Walls are not strong enough because of low compaction and absence of horizontal force resisting element.</p>	<p>1. In order to increase the horizontal load-resisting capacity of the walls, bamboo can be used as a bracing material at the inner and outer sides of the walls. 2. A mesh of bamboo can reinforce the walls. Tying the vertical bamboo splints with the horizontal splints using wire would create a bamboo mesh that would be tied to the collar beam. 3. Jute mat cover with the help of bamboo slices can be used to resist the horizontal load.</p>
<p>Walls are not strong enough because of low compaction and absence of horizontal force-resisting element.</p>	<p>New Construction: 1. In order to increase the horizontal load-resisting capacity of the walls, bamboo can be used as a bracing material at the inner and outer sides of the walls. 2. A mesh of bamboo can reinforce the walls. Tying the vertical bamboo splints with the horizontal splints using wire would create a bamboo mesh that would be tied to the collar beam. 3. Jute mat cover with the help of bamboo slices can be used to resist the horizontal load.</p>
<p>Lack of preventive measures against flood damage at plinths and walls. Consequently, during rain and flood soil particles of the wall can absorb water easily and become weak over time.</p>	<p>New Construction: In order to increase horizontal load-carrying capacity of the walls bamboo can be used as a bracing materials at the inner and outer sides of the walls.</p>

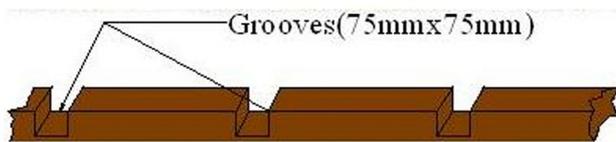
Large openings	New Construction: Lintels must be provided above the openings. The length of the windows should not be more than 3 ft and not more than 1/3 of the total length of the wall.
Poor connection between the roofing materials and the walls. The rafters are not tightly connected to the wall tops so that they easily lose support during earthquake action.	New Construction: To reduce the movements at the longitudinal direction of the walls bracing can be provided between the upper and the lower longitudinal pair. The movement at the cross (transverse) direction can be reduced by providing bracings between two upper longitudinal pairs and the cross pair (see Figure 28).
Additional comments on seismic strengthening provisions	The suggested retrofit provisions are not complex and can be done by local masons and available laborers.
Has seismic strengthening described in the above table been performed?	This has not yet started in Bangladesh in real practice. Strengthening is applied in experimental studies at BUET.
Was the work done as a mitigation effort on an undamaged building or as a repair following earthquake damages?	Even smaller earthquake shaking may damage mud buildings to a greater extent. Dilapidated dwellings are generally replaced by houses made of straw (jhupri) or brick (unreinforced masonry). Consequently, the techniques previously described may be implemented on undamaged buildings in the near future. However, the application of these techniques in order to repair existing earthquake-damaged buildings will be impractical.
Was the construction inspected in the same manner as new construction?	Not applicable.
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	Owner. Neither architects nor engineers were involved in the strengthening process.
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	Not applicable.
Additional comments section 6	



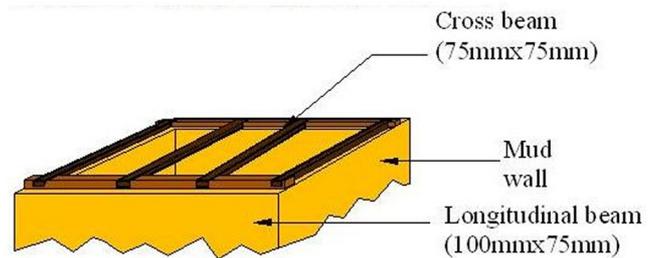
Construction of wall (Ahmed, 2005)



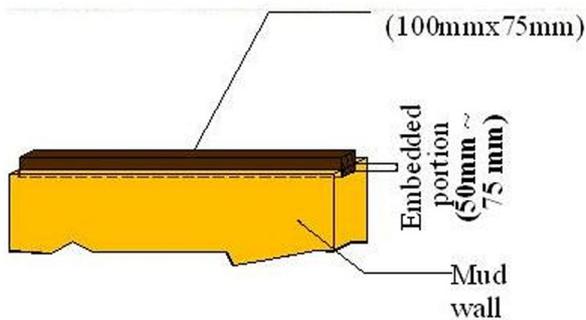
Fixing of roof truss resting on beam



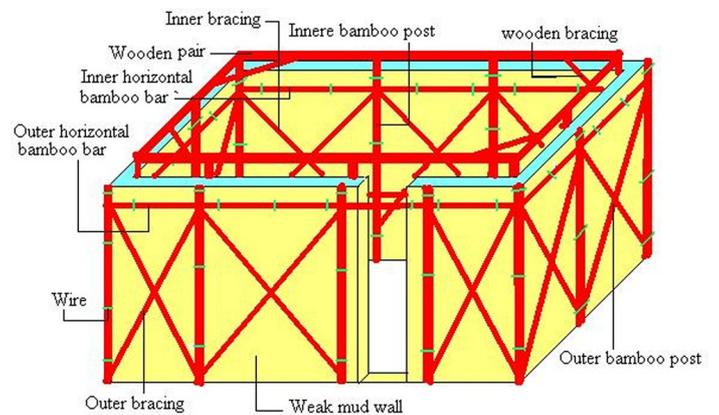
Grooves made into the longitudinal beam



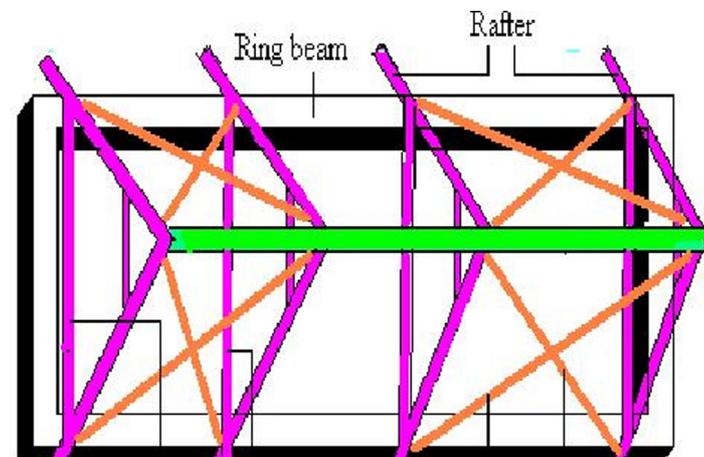
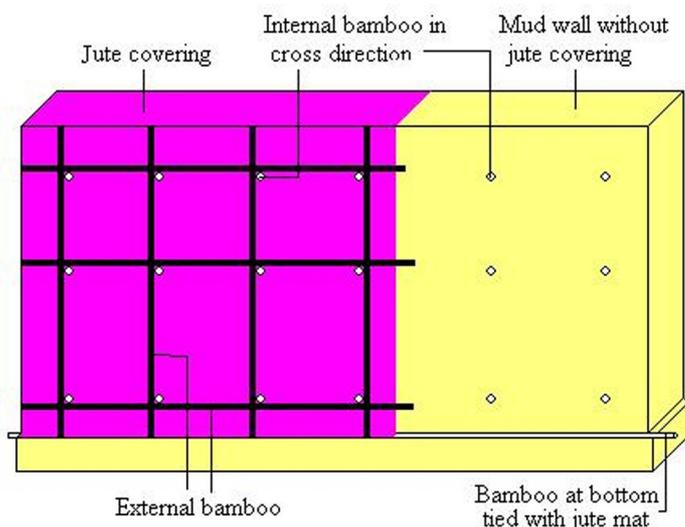
Placing of crossbeam over the longitudinal beam



Placing of longitudinal beam over the wall

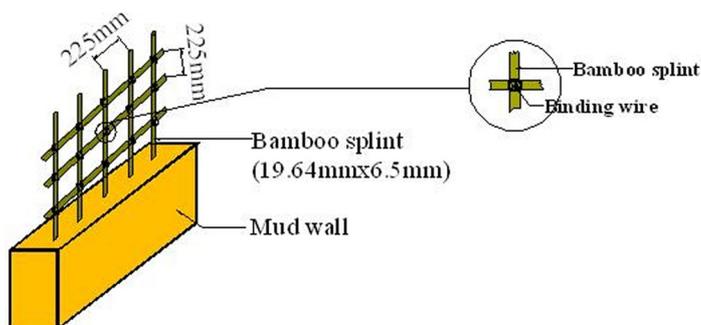


Bracing with bamboo inside and outside the wall



Modification of roof truss

Jute mat covering the mud wall using bamboo slices



Use of bamboo mesh to reinforce the wall

References

Rural Houses at Earthquake Risk in Bangladesh Asraful Alam Bachelor Thesis 2006

Guidelines for Earthquake-Resistant Non-Engineered Building Construction Firoza Akter and Rebeka Ahsan Bachelor Thesis 2007

Rural Mud Houses with Pitched Roof of India Amit Kumar World Housing Encyclopedia 2002 (Report no. 23)

Vivienda de Adobe (Adobe House) of El Salvador Manuel A. Lopez M., Julian Bommer, and Gilda Benavidez World Housing Encyclopedia 2002 (Report no. 14)

Earthquake Resistant Construction of Adobe Buildings: A Tutorial Marcial Blondet, Gladys Villa Garcia M., and Svetlana Brzev EERI/IAEE World Housing Encyclopedia 2003 (Tutorial)

Use of Waste Materials to Improve the Seismic Resistance of Adobe M.S. Islam and M. Kanungo Proceedings of the Pan American Conference on Soil Mechanics and Geotechnical Engineering, Venezuela 2007 (Paper no. 248)

Bangladesh Bureau of Statistics Government of Bangladesh (<http://www.bbs.gov.bd/>)

2003

World Bank Statistics on BangladeshThe World
Bank(<http://www.worldbank.org/bangladesh>) 2004

Authors

Name	Title	Affiliation	Location	Email
Amrita Das	Lecturer	Civil Engineering Department, Southern University, Chittagong	Chittagong 4349, BANGLADESH	amrita_cuet@yahoo.com
Mohammad Shariful Islam	Associate Professor	Department of Civil Engineering, Bangladesh University of Engineering & Technology	Dhaka 1000, BANGLADESH	mshariful@yahoo.com
Dr. Md. Jahangir Alam	Professor	Earthquake Engineering Research Center, Chittagong University of Engineering & Technology	Chittagong 4349, BANGLADESH	amrita_cuet@yahoo.com
Nusrat Hoque	Lecturer	Civil Engineering Department (CUET)	Chittagong University of Engineering & Technology, Chittagong 4349, BANGLADESH	nusrat_hoque@yahoo.com

Reviewers

Name	Title	Affiliation	Location	Email
Dominik Lang	Dr./Researcher	NORSAR	Kjeller 2027, NORWAY	dominik@norsar.no