World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

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

HOUSING REPORT

Adobe / Earthen House : Adobe block walls

Report#	137
Last Updated	
Country	Nicaragua
Author(s)	Matthew A. French, ,
Reviewers	Andrew W. Charleson,

Important

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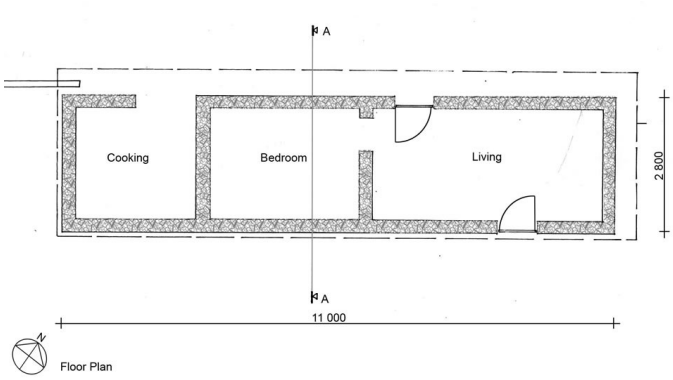
General Information

Building Type:	Adobe / Earthen House : Adobe block walls
Country:	Nicaragua
Author(s):	Matthew A. French
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in Nicaragua, predominantly used near the Honduras border. Towns close to Costa Rica and the Mosquito Coast area have few adobe dwellings due to their geographic location. This type of housing construction is commonly found in rural areas. Sometimes, adobe is used in urban centres, but not extensively.
Summary:	The plan of this adobe building is a simple rectangle with three rooms. Adobe as a material is very weak under seismic loads, which is the main issue which concerns this building type. Also, the roof does not have sufficient eaves to protect the adobe walls, which has resulted in the dislodging of the exterior plaster. This has eroded the walls, further reducing their structural strength. Adobe is commonly used in Nicaragua, as it is both affordable and accessible, but it is being replaced by more 'modern' materials, such as concrete block and red fired brick.
Length of time practiced:	More than 200 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	Currently, this type of construction is being built. Influence from its overdeveloped far northern neighbors has led to a wider

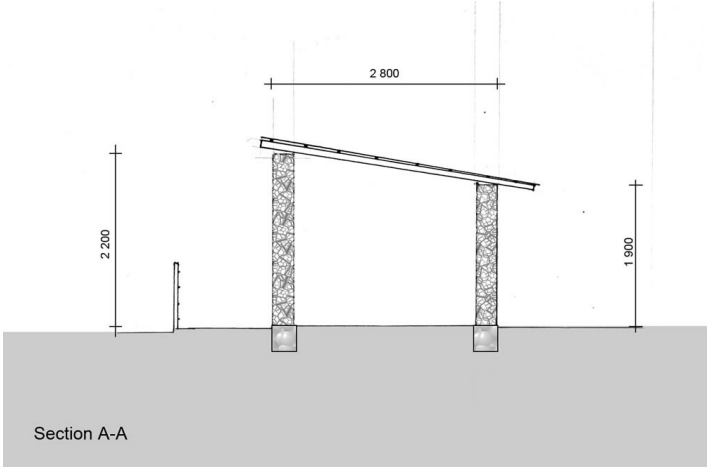
Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	The building is a rectangle, composed of three rooms; two are 'weather-proof' spaces, and the third a semi indoor-outdoor kitchen.
Typical plan length (meters)	4-9
Typical plan width (meters)	2.8-4
Typical story height (meters)	2.2
Type of Structural System	Masonry: Earthen/Mud/Adobe/Rammed Earth Walls: Adobe block walls
Additional comments on structural system	Lateral load-resisting system: Adobe walls are relied on to resist lateral loads. The blocks measure 250mm wide, 300mm long and 100mm deep. Mortar joints average 40mm. It is unlikely the roof will work as a diaphragm due to its flexible nature and lack of connection to the walls. Gravity load-bearing system: The adobe walls resist gravity loads and rest on stone rubble foundations.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	>20%
Typical wall densities in direction 2	>20%
Additional comments on typical wall densities	The typical structural wall density is unknown.
Wall Openings	The building has only one door opening on the road elevation due to the need to screen off the dust and noise. The opposing wall has one doorway and one larger break in the wall to allow access to the cooking area. The internal wall to the bedroom has one door opening. There are no windows.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No

Modifications of buildings	A work area has been added at the rear of the building, but this plays no structural part in the main dwelling being reported on here. This area is merely a roof with one wall on the road side.
Type of Foundation	Shallow Foundation: Rubble stone, fieldstone strip footing
Additional comments on foundation	
Type of Floor System	Other floor system
Additional comments on floor system	Compacted earth.
Type of Roof System	Roof system, other
Additional comments on roof system	wood planks or beams that support slate, metal, asbestos-cement or plastic corrugated sheets or tiles
Additional comments section 2	Typical separation distance between buildings: 4 meters



Plan of building



Section A-A

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Adobe	Characteristic Strength- 3-4 MPa standard block strength. Stabilized blocks up to 8 MPa. Final block

		strength depends on mixture consistency when pouring blocks. Mix Proportion/Dimensions- Clay 10%-30%, Silt 0%-20%, Sand 50%-70%, Straw to bind The mix changes with site conditions, material availability and builder preference.
Foundations	Stone and mortar	Mix Proportion/Dimensions: Field stones and mud Foundation types vary widely.
Floors	Compacted earth	Mix Proportion/Dimensions: 5-10% chopped straw to bind earth Relaid/ relevelled as required
Roof	Timber with iron sheeting	Mix Proportion/Dimensions: 100mm X 40mm sawn timber rafters laid on unsawn timber top plate
Other		

Design Process

Who is involved with the design process?	Other
Roles of those involved in the design process	Only local traditional knowledge is used in these constructions. The role of architects is minimal to none.
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	
Expertise of those involved in building process	
	The site is cleared. The mud block ingredients are

Construction process and phasing	mixed and placed in a wet mold. This is compacted and turned out to dry. While the blocks are drying, the site is further prepared. After four weeks, and several rotations of the drying block, the block is ready for final placement. The wall is constructed by simply laying one block on another with mud mortar between until the desired height is reached. The timber roof framing is laid and the corrugated iron material nailed in place. The construction of this type of housing takes place in a single phase. Typically, the building is originally 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	
Process for building code enforcement	

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	

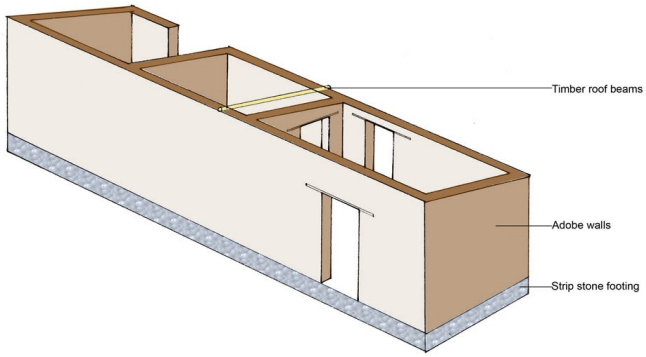
Building Maintenance and Condition

Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)No one

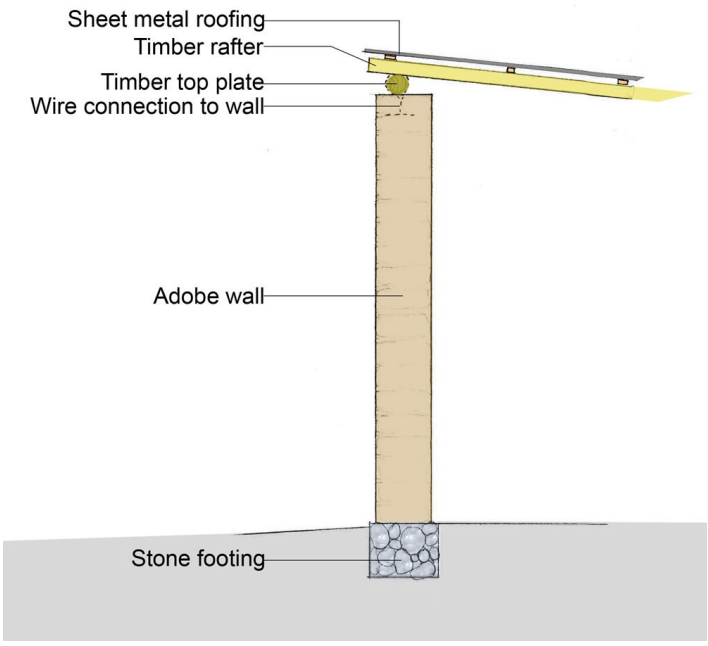
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	US $ 20/m2.
Labor requirements	Typically, adobe dwellings of this size take between 1-3 months to construct. The bricks alone must be left to dry for 3-4 weeks in the sun. As there several people on site - family, friends, and community helpers - adobe is a relatively quick and informal construction method for Nicaragua.
Additional comments section 3	



Load bearing structure.



Wall section of loadbearing elements

View from the road. The exterior plaster on the left side has fallen off due to the lack of eaves.

Roof and wall connection.

Timber roof framing and plastered wall.

Socio-Economic Issues

Patterns of occupancy	The house is occupied by one family. It is used as a base from which the mother and daughter make food to sell on local buses as their source of income. During the evening, the whole family is present.
Number of inhabitants in a typical building of this construction type during the day	<5
Number of inhabitants in a typical building of this construction type during the evening/night	<5

Additional comments on number of inhabitants	
Economic level of inhabitants	Very low-income class (very poor)
Additional comments on economic level of inhabitants	House Price/Annual Income (Ratio) 1:1 or better
Typical Source of Financing	Owner financedPersonal savingsInformal network: friends or relatives
Additional comments on financing	
Type of Ownership	RentOwn outrightOwn with debt (mortgage or other)
Additional comments on ownership	
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 incorporate seismically resistant features?	No
Additional comments on premium discounts	
Additional comments section 4	

Earthquakes

Past Earthquakes in the country which affected buildings of this type

Year	Earthquake Epicenter
1972	12.400N
1985	11.725N

2004	11.424N
2005	11.198N

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	Wall: The walls will crack in shear from lateral in-plane loads, or will fall in or out due to face-loads. In both cases, roof collapse may follow due to loss of wall support. Roof: The roof collapses due to lack of wall support and poor connections.
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 ½ of the distance between the adjacent cross walls; For adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; For precast concrete wall structures: less than 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 intensity expected in this area.	N/A
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);	TRUE
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	FALSE

	each diaphragm level with metal anchors or straps.	
Wall Openings		TRUE
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 considered to be good (per local construction standards).	FALSE
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

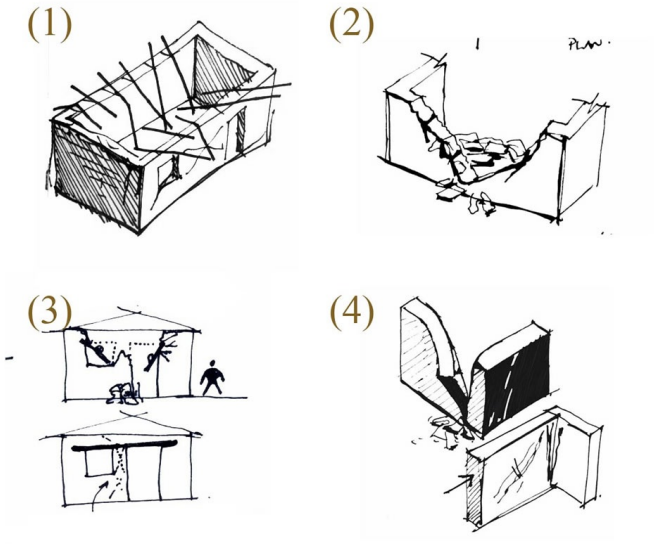
Additional comments on structural and architectural features for seismic resistance	
Vertical irregularities typically found in this construction type	No irregularities
Horizontal irregularities typically found in this construction type	No irregularities
Seismic deficiency in walls	The adobe walls have limited tension resistance under seismic loads.
Earthquake-resilient features in walls	
Seismic deficiency in frames	
Earthquake-resilient	

features in frame	
Seismic deficiency in roof and floors	The roof is poorly connected to the walls, and these poor connections ensure that it can not be counted on to act as a rigid diaphragm for the transfer of loads.
Earthquake resilient features in roof and floors	The roofing material is lightweight, so the risk of injury from roof collapse is minimized.
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	o					



(1) Typically the roof collapses inwards due to reduced wall support and poor connections. The probability of this damage pattern

occurring is increased when heavy roofing materials such as earth are used. (2) Wall collapse under face loads is a common ea

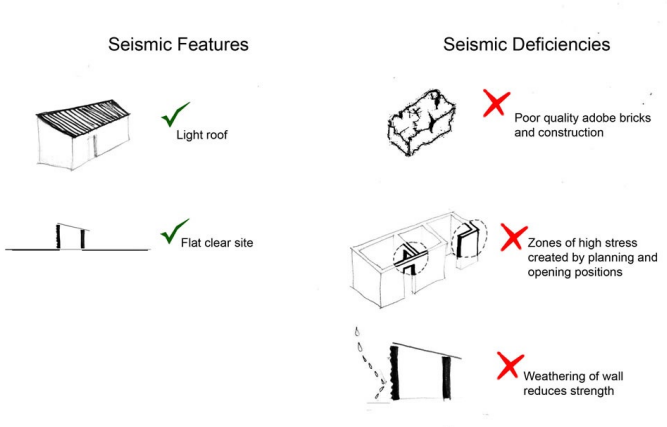
Retrofit Information

Description of Seismic Strengthening Provisions

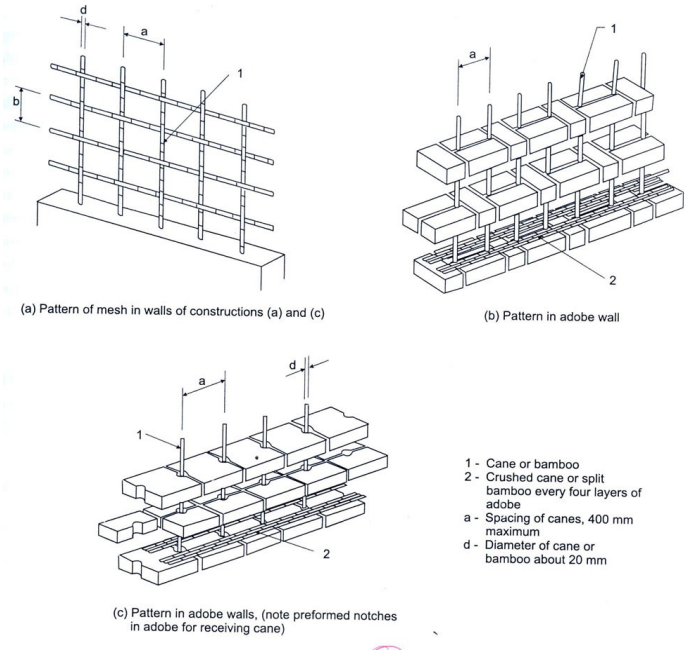
Structural Deficiency	Seismic Strengthening
Walls	1. Bamboo: Several researchers have been involved with using internal horizontal and vertical bamboo, in a fashion similar to reinforced concrete masonry walls. 2. Timber ring beam: This helps to hold the walls together and facilitate transfer of loads from the roof to the walls. 3. 'Improved Adobe' has long been promoted to make adobe buildings more robust under seismic activity. The 'system' does not utilise another material, but focuses on the design and planning of adobe buildings by limiting opening sizes, plan dimensions, wall lengths and heights, and roof weight
Roof	Adequate connections to a top timber or concrete ring beam and stronger connections in the framing itself will help the roof act as a diaphragm. Galvanized sheet metal is now common and helps reduces high loads. For thermal and aesthetic reasons, how ever, clay tile continues to be used.

Additional comments on seismic strengthening provisions	The bamboo strengthening scheme is not used in Nicaragua, but is presented here as an option for making Nicaragua buildings safer.
Has seismic strengthening described in the above table been performed?	Bamboo: Yes, it has been implemented in Peru with successful structural results, but unsuccessful local adoption of the concept. The system has not been used in Nicaragua. Timber ring beam: These are common now but often limited finances ensure they are out of reach for many in Nicaragua. 'Improved Adobe': Some principles are used, such as small openings and walls, but others are not evident, such as buttresses.
Was the work done as a	

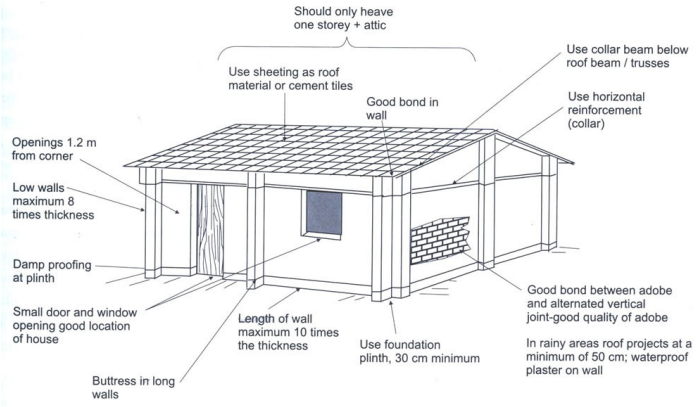
mitigation effort on an undamaged building or as a repair following earthquake damages?	All work done was only as part of the mitigation efforts.
Was the construction inspected in the same manner as new construction?	
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	Technical assistance was used in the Bamboo implementation. Timber ring beams are often incorporated in new constructions by the occupants.
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	The bamboo system and timber ring beams have proven structurally successful in earthquakes.
Additional comments section 6	



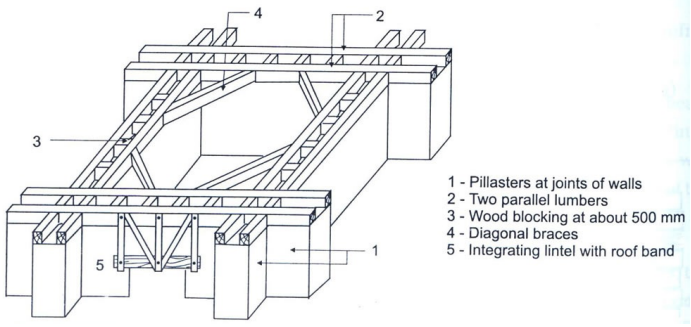
Seismic features and deficiencies in this building.



Bamboo reinforcing system for adobe buildings. IAEE Guidelines, 2004, p73.



'Improved adobe' suggestions. IAEE Guidelines 2004, p.75.



Timber ring beam and lintel support. IAEE Guidelines 2004, p.72.

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Authors

Name	Title	Affiliation	Location	Email
Matthew A. French		Architecture, Victoria University of Wellington	15 Landcross Street, Wellington 4001, NEW ZEALAND	emailformatthew@hotmail.com

Reviewers

Name	Title	Affiliation	Location	Email
Andrew W. Charleson	Associate Professor	School of Architecture, Victoria University of Wellington	Wellington 6001, NEW ZEALAND	andrew.charleson@vuw.ac.nz