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

Unburnt brick wall building with pitched roof (nyumba ya zidina)

Report#	46
Last Updated	
Country	Malawi
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Important

A, Martin & Associates, Inc. or the participant's organizations.

General Information

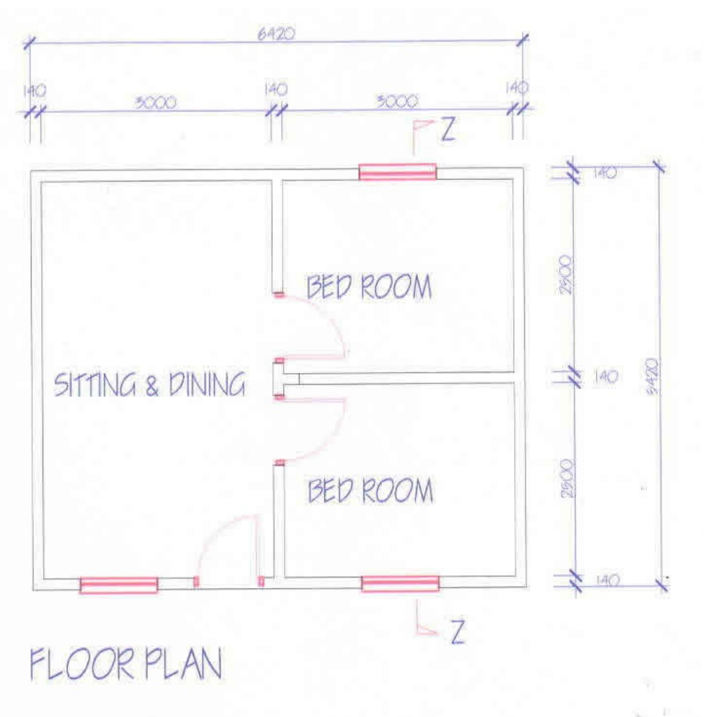
Building Type:	Unburnt brick wall building with pitched roof (nyumba ya zidina)
Country:	Malawi
Author(s):	Sassu, M. Ngoma,I
Last Updated:	
Regions Where Found:	This type of construction is practiced in all three regions of Malawi and in neighbouring countries i.e. Zambia and Tanzania. The percentage of this type of housing is estimated at over 45 %.
Summary:	This type of building is found both in urban and rural areas throughout Malawi. It is a construction type that is gaining popularity at the moment; it is estimated that it constitutes 45% of the country's housing stock. The thatched roof is supported by unburnt mud brick walls built in mud mortar. The walls are built on a stone platform raised above ground for the purpose of protection from floods. These buildings are built without any horizontal and vertical reinforcement. The strength of the building is very low. This type of construction is considered to be very vulnerable to earthquake effects. In the 1989 Salima earthquake (magnitude 6), 9 people died and over 50,000 people were left homeless. Many buildings of this type suffered extensive damage or collapsed.
Length of time practiced:	76-100 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwellingOther
Typical number of stories:	1
Terrain-Flat:	Typically
Terrain-Sloped:	Never
Comments:	This type of housing is also used for commercial rental housing--many people having multiple rooms,

	but it is not built as highr

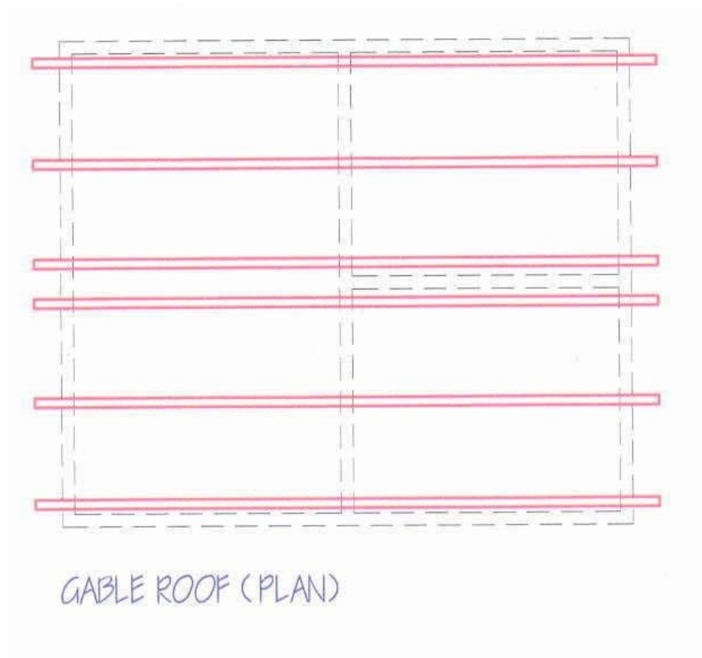
Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	
Typical plan length (meters)	6
Typical plan width (meters)	4
Typical story height (meters)	2.4
Type of Structural System	Masonry: Earthen/Mud/Adobe/Rammed Earth Walls: Adobe block wallsOther
Additional comments on structural system	Lateral load-resisting system: The wall takes the load from the roof and wall elements. The walls are placed on a raised platform as a way of keeping above ground/surface water levels during the rainy season. This platform may be considered as a foundation because it projects outside the wall thickness and is generally constructed of stone. However, the connection between the wall and the raised platform is not structural, so there is no transfer of lateral forces at this point. The connection between the roof and the wall does not provide lateral transfer of forces.Gravity load-bearing system: The roof loads are supported on the timber members which are supported on walls. Generally gable walls are used both internally as room partitions and at the extreme ends of the building.
Gravity load-bearing & lateral load-resisting systems	Other: unreinforced unburnt clay bricks (zidina) in mud mortar
Typical wall densities in direction 1	>20%
Typical wall densities in direction 2	>20%
Additional comments on typical wall densities	About 20 %.
	The number of openings is more than one i.e. could

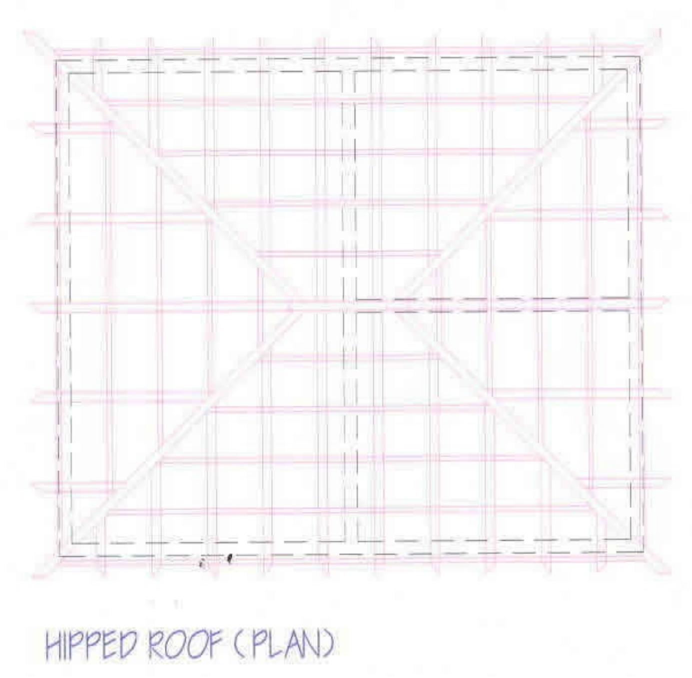
Wall Openings	be two doors and two to three windows depending on the size of the building. 8% estimated as overall window and door areas as a fraction of the overall surface area.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	Some extensions have been made. In some cases the roofing material has been changed.
Type of Foundation	Other Foundation
Additional comments on foundation	Other:Stone raised wall is built to support wall and for rainwater clearance i.e. to avoid water touching the walls.
Type of Floor System	Other floor system
Additional comments on floor system	The floor is made up of rammed earth with mud smear finish or cement floor screed.
Type of Roof System	Roof system, other
Additional comments on roof system	Other: Timber, thatched roof supported on wood purlins; sometimes iron sheets are used.
Additional comments section 2	Typical separation distance between buildings: 2-3 m



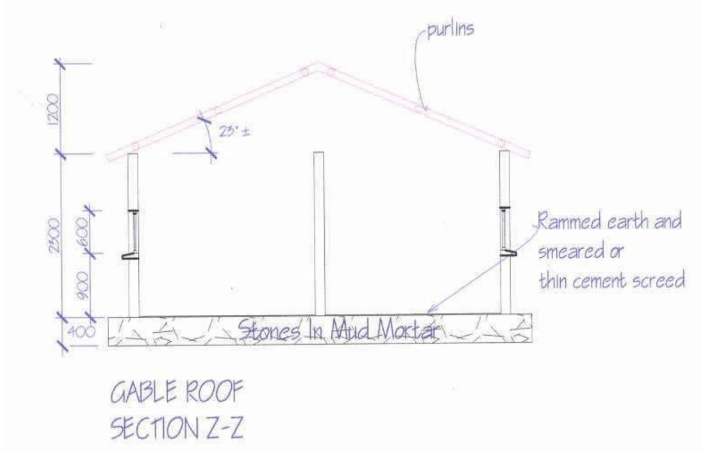
Typical floor plan



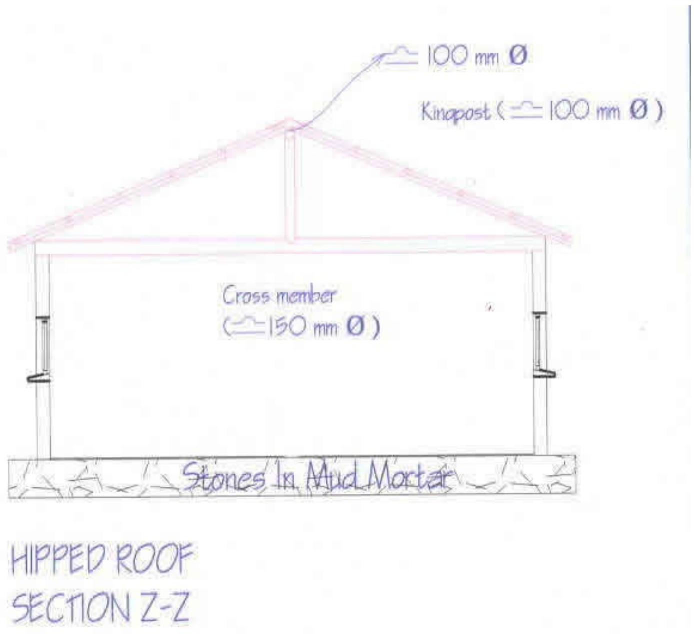
Gable roof (plan)



Hipped roof (plan)



Gable roof (section view)



Hipped roof (section view)

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	wall: unburnt soil blockframe: timber	Mix: mud mortar
Foundations	(no foundation, but wall is	This works to level the

	rested/placed on a raised platform of stones)	start of the wall construction in sloping ground
Floors	1. rammed earth2. cement screed	No structural strength is provided but adds floor resistance to wear and provides easy care.
Roof	timber	No calculations are made to determine member size or spacing.
Other		

Design Process

Who is involved with the design process?	Owner
Roles of those involved in the design process	Owner decides what type of building to build.Masons/bricklayers set out the building plan on the ground marking corners and door openings.No engineers or architects are involved in the design/construction of this housing type. The practice is looked down upon hence less attractive to the professionals.
Expertise of those involved in the design process	Generally the masons/bricklayers are not trained at any school but learn on the job although some may have been trained at trade school. The level of skill is reasonably good. These masons/bricklayers are not covered by design standards which makes it very difficult to talk of expertise.

Construction Process

Who typically builds this construction type?	OwnerMason
Roles of those involved in the building process	The mason/bricklayer lives in this type of construction. First the owner hires brick moulders to mould the bricks. The bricks are dried as a curing process. the mason then marks the ground to peg corners and openings. Mud mortar pit is selected and then building starts. The mason/bricklayer lays the bricks with others bring the mortar until roof level.The carpenter comes in at this stage to make the roof and fix doors and windows to complete the construction.No engineers or architects are involved in the design/construction of this housing type. The practice is looked down upon hence less attractive to the professionals.

Expertise of those involved in building process	Generally the masons/bricklayers are not trained at any school but learn on the job although some may have been trained at trade school. The level of skill is reasonably good. These buildings are not covered by design standards which makes it very difficult to talk of expertise.
Construction process and phasing	The house is constructed by masons/bricklayers. General knowledge is used during construction.FOUNDATION: The ground is levelled. Stone wall 0.4m wide is built along the wall perimeter from ground level in mud mortar to a height of 0.4m. WALL CONSTRUCTION: The dry clay/mud blocks form the masonry units with mud mortar as the joining medium. The procedure is like any masonry wall construction. The mortar thickness is 10mm - 15 mm. At the roofing level of the wall, a wall plate is introduced which is generally of timber poles.ROOFING: Grass thatch or iron sheets supported by timber purlins (generally poles) which run over the gable walls. Truss construction is also used. This building is not typically constructed incrementally and is designed for its final constructed size.
Construction issues	The building is not built to resist seismic forces and so is not specifically strengthened.

Building Codes and Standards

Is this construction type address by codes/standards?	No
Applicable codes or standards	N/A
Process for building code enforcement	N/A

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	Malawi does not have National Building Regulations. Building Regulations are generally applicable in cities. Moves are underway to enact National Building Regulations.Guidelines for building in disaster prone areas were developed and are currently being reviewed.

Building Maintenance and Condition

Typical problems associated with this type of construction	There is no materials quality control and not even construction inspection. There are no written plans for such buildings. There are no permit application procedures. People can occupy buildings before completion. There is a lot of waste of materials. A lot of pits can be seen which affects the environment as people dig into the soil next to the building.
Who typically maintains buildings of this type?	Owner(s)
Additional comments on maintenance and building condition	Owner here means that person to move the process of maintenance upon assessing condition of the building. The actual work is done by masons/bricklayers.

Construction Economics

Unit construction cost	There are no established/fixed ways of building so that it is difficult to arrive at the unit construction cost.The unit cost is estimated as K1,000.00/m2 (US$2.23/m2).
Labor requirements	Labour requirements vary considerably from one-man operation to group work. The construction requires a minimum of 3 and 1/2 weeks to complete building the walls for a 6m by 4m plan with internal partitions for a single bricklayers with 3 helpers.
Additional comments section 3	There is no organized arrangement for building these structures as a result the period for construction and building rates are not standardized.

Critical structural details

An illustration of key seismic featuresand/or deficiencies

Socio-Economic Issues

Patterns of occupancy	Generally single family occupies one house.
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	5-10
Additional comments on number of inhabitants	These buildings are not built for day activities and so during the day people spend time outdoors on verandars/khonde or under the trees.
Economic level of inhabitants	Very low-income class (very poor)Low-income class (poor)Middle-income class

Additional comments on economic level of inhabitants	Very poor: no rate, no salary (subsistence farmings). Poor: less than 30 US$ salary.
Typical Source of Financing	Owner financedPersonal savingsInformal network: friends or relativesSmall lending institutions/microfinance institutions
Additional comments on financing	Financing is sometimes from relatives with higher income.
Type of Ownership	RentOwn outright
Additional comments on ownership	In urban areas, these type of houses are rented out by owners.
Is earthquake insurance for this construction type typically available?	No
What does earthquake insurance typically cover/cost	N/A
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	N/A
Additional comments section 4	Housing units can be many if made for commercial purposes. In this case the house is built as a block i.e. single units.

Earthquakes

Past Earthquakes in the country which affected buildings of this type

Year	Earthquake Epicenter
1957	Champira
1966	Mwanza
1967	Thambani in Mwanza
1989	Salima

2009	Karonga

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	In 1973 another earthquake hit Livingstonia measuring 5.1 on the Richter scale. The 1989 Salima earthquake was the worst in Malawi. It is reported that 9 people died and over 50,000 people were left homeless. These types of buildings suffered a lot of damage, including collapse. Geologists forecast more intense earthquakes could occur in Malawi.The 2009 earthquake resulted in 4 people dead, 300 people injured and 2000 households affected.
Additional comments on earthquake damage patterns	The mud mortar did not provide any resistance and so the line of crack followed the mortar line from ground level to top.

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-	The building is regular	TRUE

Horizontal	with regards to the plan. (Specify in 5.4.2)	
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.	FALSE
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.	N/A
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	FALSE

	anchored for out-of-plane seismic effects at 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).	N/A

Building Irregularities

Additional comments on structural and architectural features for seismic resistance	The structural resistance is poor because the building is not designed to resist seismic forces.
Vertical irregularities typically found in this construction type	Other
Horizontal irregularities typically found in this construction type	Other
Seismic deficiency in walls	Poor lateral resistance of adobe bricksMortar does not provide lateral continuityWeak timber lintels.Simple connection between roof members and walls
Earthquake-resilient features in walls	Gable construction. Use of light roofing materials can reduce weight on the walls.

Seismic deficiency in frames	N/A
Earthquake-resilient features in frame	N/A
Seismic deficiency in roof and floors	Roofing timber embedded in wall.Floors are structurally built and so are passive.
Earthquake resilient features in roof and floors	Light roof structural system
Seismic deficiency in foundation	The building has no foundation as it founded on ground level.
Earthquake-resilient features in foundation	N/A

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					

House partial collapse after the Karonga earthquake

Karonga earthquake damaged house

Karonga earthquake damaged house

Karonga earthquake damaged house

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
Low level of connection between base of wall and foundation	Use timber members at specified spacing to connect to roof members through a wallplate type arrangement.
(New Construction):Weak connections between roof and walls	Rebuilding of roof
(New Construction):Weak level of shear strength of mortar	Rebuilding of damaged wall

Additional comments on seismic strengthening provisions	The practice is generally to build a new building when one shows weaknesses. The only lesson taken into account is that of strengthening weak areas in new construction. These are at truss-wall connection at ground-wall contact.
Has seismic strengthening described in the above table been performed?	N/A
Was the work done as a mitigation effort on an undamaged building or as a repair following earthquake damages?	N/A

Was the construction inspected in the same manner as new construction?	N/A
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	Mainly the owner. Architects and engineers are not involved.
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	N/A
Additional comments section 6	The 2009 Karonga earthquake provided opportunity to do retrofit but could not assess performance since no other earthquake took place thereafter.

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