World Housing Encyclopedia Report

Country: Malawi

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

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1 General Information

1.1 Country
Malawi

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

FIGURE 1: Typical Building

1.4 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.

1.5 Typical Period of Practice for Buildings of This Construction Type

How long has this construction been practiced	
< 25 years	
< 50 years	
< 75 years	
< 100 years	X
< 200 years	
> 200 years	

Is this construction still being practiced?	Yes	No
	X	

1.6 Region(s) Where Used
This type of construction is practiced in all three regions of Malawi and in neighboring countries i.e. Zambia and Tanzania. The percentage of this type of housing is estimated at over 45 %.

1.7 Urban vs. Rural Construction

Where is this construction commonly found?	
In urban areas	
In rural areas	
In suburban areas	
Both in rural and urban areas	X

2 Architectural Features

2.1 Openings

The number of openings is more than one i.e. could 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.

2.2 Siting

	Yes	No
Is this type of construction typically found on flat terrain?	X	
Is this type of construction typically found on sloped terrain? (hilly areas)		X
Is it typical for buildings of this type to have common walls with adjacent buildings?		X

The typical separation distance between buildings is 2 meters

2.3 Building Configuration

Rectangular

2.4 Building Function

What is the main function for buildings of this type?	
Single family house	X
Multiple housing units	
Mixed use (commercial ground floor, residential above)	
Other (explain below)	

Additional Comments: This type of housing is also used for commercial rental housing--many people having multiple rooms, but it is not built as high-rise buildings.

2.5 Means of Escape

None unless it is two door openings type building. Windows are generally too small.

2.6 Modification of Buildings

Some extensions have been made. In some cases the roofing material has been changed.

3 Socio-Economic Issues

3.1 Patterns of Occupancy

Generally single family occupies one house.

3.2 Number of Housing Units in a Building

1 units in each building.

Additional Comments: Housing units can be many if made for commercial purposes. In this case the house is built as a block.

3.3 Average Number of Inhabitants in a Building

How many inhabitants reside in a typical building of this construction type?	During the day / business hours	During the evening / night
< 5	X	X
5 to 10		X
10-20		
> 20		
Other		

3.4 Number of Bathrooms or Latrines per Housing Unit

Number of Bathrooms: 1
Number of Latrines: 1

Additional Comments: Bathrooms and toilets are externally provided and are not joined to the housing unit.

3.5 Economic Level of Inhabitants

Economic Status		House Price/Annual Income (Ratio)
Very poor	X	/
Poor	X	/
Middle Class	X	/
Rich		/

Additional Comments: Very poor: no rate, no salary (subsistence farmers). Poor: less than 30 US$ salary.

3.6 Typical Sources of Financing

What is the typical source of financing for buildings of this type?	
Owner Financed	X
Personal Savings	X
Informal Network: friends and relatives	X
Small lending institutions/microfinance institutions	X
Commercial banks / mortages	
Investment pools	
Combination (explain)	
Government-owned housing	
Other	

3.7 Ownership

Type of Ownership/Occupancy	
Rent	X
Own outright	X
Own with Debt (mortgage or other)	
Units owned individually (condominium)	
Owned by group or pool	
Long-term lease	
Other	

4 Structural Features

4.1 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.

4.2 Gravity Load-Bearing Structure

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.

4.3 Type of Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	
Masonry	Stone masonry walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	
		2	Massive stone masonry (in lime or cement mortar)	
	Earthen walls	3	Mud walls	
		4	Mud walls with horizontal wood elements	
		5	Adobe block or brick walls	X
		6	Rammed earth/Pise construction	
	Unreinforced brick masonry walls	7	Unreinforced brick masonry in mud or lime mortar	
		8	Unreinforced brick masonry in mud or lime mortar with vertical posts	
		9	Unreinforced brick masonry in cement or lime mortar (various floor/roof systems)	
	Confined masonry	10	Confined brick/block masonry with concrete posts/tie columns and beams	
	Concrete block masonry walls	11	Unreinforced in lime or cement mortar (various floor/roof systems)	
		12	Reinforced in cement mortar (various floor/roof systems)	
		13	Large concrete block walls with concrete floors and roofs	
Concrete	Moment resisting frame	14	Designed for gravity loads only (predating seismic codes i.e. no seismic features)	
		15	Designed with seismic features (various ages)	
		16	Frame with unreinforced masonry infill walls	
		17	Flat slab structure	
		18	Precast frame structure	
		19	Frame with concrete shear walls-dual system	
		20	Precast prestressed frame with shear walls	
	Shear wall structure	21	Walls cast in-situ	
		22	Precast wall panel structure	
Steel	Moment resisting frame	23	With brick masonry partitions	
		24	With cast in-situ concrete walls	
		25	With lightweight partitions	
	Braced frame	26	Concentric	
		27	Eccentric	
Timber	Load-bearing timber frame	28	Thatch	
		29	Post and beam frame	
		30	Walls with bamboo/reed mesh and post (wattle and daub)	
		31	Wooden frame (with or without infill)	
		32	Stud wall frame with plywood/gypsum board sheathing	
		33	Wooden panel or log construction	
Various	Seismic protection systems	34	Building protected with base isolation devices or seismic dampers	
	Other	35		

4.4 Type of Foundation

Type	Description	
Shallow Foundation	Wall or column embedded in soil, without footing	
	Rubble stone (fieldstone) isolated footing	
	Rubble stone (fieldstone) strip footing	
	Reinforced concrete isolated footing	
	Reinforced concrete strip footing	
	Mat foundation	
	No foundation	
Deep Foundation	Reinforced concrete bearing piles	
	Reinforced concrete skin friction piles	
	Steel bearing piles	
	Wood piles	
	Steel skin friction piles	
	Cast in place concrete piers	
	Caissons	
Other	Stone raised wall is built to support wall and for rainwater clearance	X

4.5 Type of Floor/Roof System

Material	Description of floor/roof system	Floor	Roof
Masonry	Vaulted		
	Composite masonry and concrete joist		
Structural Concrete	Solid slabs (cast in place or precast)		
	Cast in place waffle slabs		
	Cast in place flat slabs		
	Precast joist system		
	Precast hollow core slabs		
	Precast beams with concrete topping		
	Post-tensioned slabs		
Steel	Composite steel deck with concrete slab		
Timber	Rammed earth with ballast and concrete or plaster finishing		
	Wood planks or beams with ballast and concrete or plaster finishing		
	Thatched roof supported on wood purlins		X
	Wood single roof		
	Wood planks or beams that support clay tiles		
	Wood planks or beams that support slate, metal asbestos-cement or plastic corrugated sheets or tiles		
	Wood plank, plywood or manufactured wood panels on joists supported by beams or walls		
Other	Sometimes iron sheets are used.		X

Additional Comments: The floor is made up of rammed earth with mud smear finish.

4.6 Typical Plan Dimensions

Length: 6 - 6 meters
Width: 6 - 6 meters
Additional Comments: Dimensions can vary.

4.7 Typical Number of Stories

1

4.8 Typical Story Height

2.4 meters

4.9 Typical Span

3 meters

Additional Comments: Span varies from 2 to 3 meters

4.10 Typical Wall Density

About 20 %.

4.11 General Applicability of Answers to Questions in Section 4

80 - 90 %

5 Evaluation of Seismic Performance and Seismic Vulnerability

5.1 Structural and Architectural Features: Seismic Resistance

Structural/ Architectural Feature	Statement	True	False	N/A
Lateral load path	The structure contains a complete load path for seismic force effects from any horizontal direction that serves to transfer inertial forces form the building to the foundation.		X	
Building configuration	The building is regular with regards to both the plan and the elevation.	X		
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.		X	
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.		X	
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.			X
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	X		
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: 1) Less than 25 (concrete walls); 2)Less than 30 (reinforced masonry walls); 3) Less than 13 (unreinforced masonry walls).	X		
Foundation- wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.		X	
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.		X	
Wall openings	The total width of door and window openings in a wall is: 1) for brick masonry construction in cement mortar: less than 1/2 of the distance between the adjacent cross walls; 2) for adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; 3) for precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	X		
Quality of building materials	Quality of building materials is considered to be adequate per requirements of national codes and standards (an estimate).		X	
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).		X	
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).			X
Other				

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake-Resilient Features	Earthquake Damage Patterns
Wall	Poor lateral resistance, weak timber lintels.	Gable construction	
Frame (columns, beams)			
Roof and floors	Roofing timber embedded in wall	Light roof system	

Additional Comments: The construction practice is not based on engineering expertise. The tying of the wall girder to the roofing structure contributes somehow to the seismic resistance.

5.3 Seismic Vulnerability Rating

	Vulnerability					
	High (Very Poor Seismic Performance) A	B	Medium C	D	E	Low (Excellent Seismic Performace) F
Seismic Vulnerability Class	0					

0 - probable value
< - lower bound
> - upper bound

6 Earthquake Damage Patterns

6.1 Past Earthquakes Reported To Affect This Construction

Year	Earthquake Epicenter	Richter magnitude(M)	Maximum Intensity (Indicate Scale e.g. MMI, MSK)
1989	Salima	6	MMI VIII
1967	Thambani in Mwanza	5.4	
1966	Mwanza	5.3	
1957	Champira	5	MMI VIII

Additional Comments: 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.

7 Building Materials and Construction Process

7.1 Description of Building Materials

Structural Element	Building Material	Characteristic Strength	Mix Proportions/ Dimensions	Comments
Walls	unburnt soil block	N/A	mud mortar	soil blocks laid in mud mortar
Foundations	(no foundation, but wall is rested/placed on a raised platform of stones)	N/A		stone rubble construction in mud mortar
Frame	timber	N/A		
Roof	timber			
Floor	1. rammed earth 2. cement screed			cement screed is laid on rammed earth

7.2 Does the builder typically live in this construction type, or is it more typically built by developers or for speculation?

The builder lives in this type of construction.

7.3 Construction Process

The house is constructed by builders. General knowledge is used during construction.
FOUNDATION: The ground is leveled. Stone wall 0.4 m wide is built along the wall perimeter from ground level in mud mortar to a height of 0.4 m.
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 10 mm - 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.

7.4 Design/Construction Expertise

Generally the builders 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.

7.5 Building Codes and Standards

	Yes	No
Is this construction type addressed by codes/standards?		X

7.6 Role of Engineers and Architects

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.

7.7 Building Permits and Development Control Rules

	Yes	No
Building permits are required		X
Informal construction	X	
Construction authorized per development control rules		X

Additional Comments: Malawi does not have National Building Regulations. Building Regulations are generally applicable in cities. Moves are underway to enact National Building Regulations.

7.8 Phasing of Construction

	Yes	No
Construction takes place over time (incrementally)		X
Building originally designed for its final constructed size	X	

7.9 Building Maintenance

Who typically maintains buildings of this type?	
Builder	X
Owner(s)	
Renter(s)	
No one	
Other	

7.10 Process for Building Code Enforcement

N/A

7.11 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.

8 Construction Economics

8.1 Unit Construction Cost (estimate)

There are no established/fixed ways of building so that it is difficult to arrive at the unit construction cost.

8.2 Labor Requirements (estimate)

As in 8.1, labor requirements vary considerably from one-man operation to group work.

9 Insurance

9.1 Insurance Issues

	Yes	No
Earthquake insurance for this construction type is typically available		X
Insurance premium discounts or higher coverages are available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features		X

9.2 If earthquake insurance is available, what does this insurance typically cover/cost?

N/A

10 Seismic Strengthening Technologies

10.1 Description of Seismic Strengthening Provisions

Type of intervention	Structural Deficiency	Description of seismic strengthening provision used
Retrofit (Strengthening)	Low level of connection between base of wall and foundation	Truss-wall connection at ground-wall contact
New Construction	Weak connections between roof and walls	Rebuilding of roof
	Weak level of shear strength of mortar	Rebuilding of damaged wall

Additional Comments: 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.

10.2 Has seismic strengthening described in the above table been performed in design practice, and if so, to what extent?

N/A

10.3 Was the work done as a mitigation effort on an undamaged building, or as repair following earthquake damage?

N/A

10.4 Was the construction inspected in the same manner as new construction?

N/A

10.5 Who performed the construction: a contractor, or owner/user? Was an architect or engineer involved?

Mainly the owner.

10.6 What has been the performance of retrofitted buildings of this type in subsequent earthquakes?

N/A

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FIGURE 1: Typical Building

FIGURE 2: Key Load-Bearing Elements

FIGURE 3A: Critical Structural Details

FIGURE 3B: Critical Structural Details

FIGURE 4: An Illustration of Key Seismic Features and/or Deficiencies