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

Rural mud wall building (nyumba yo mata OR ndiwula)

Report#	43
Last Updated	
Country	Malawi
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Important

participant's organizations.

General Information

Building Type:	Rural mud wall building (nyumba yo mata OR ndiwula)
Country:	Malawi
Author(s):	Sassu, M. Ngoma,I
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in the three regions of Malawi (Northern, Central and Southern region). This housing type represents about 5% of the entire housing stock. This type of housing construction is commonly found in rural areas.
Summary:	This housing construction type is used only for residential purposes. The building technique consists of timber poles as the core or base with a mud smear applied on both sides. The plan is circular (only one floor) and the roof is formed by grass thatch supported on timber poles and cross members. The circular shape of the plan and the light weight of the roof, combined with the wood skeleton or frame, ensure a good seismic response. The seismic vulnerability is increased by poor connections of the wood skeleton and by progressive damage of the natural components.
Length of time practiced:	101-200 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	

Features

Plan Shape	Curved, solid (e.g. circular, elliptical, ovoid)
Additional comments on plan	

Additional comments on plan shape	Mainly circular shape.
Typical plan length (meters)	4
Typical plan width (meters)	4
Typical story height (meters)	2
Type of Structural System	Masonry: Earthen/Mud/Adobe/Rammed Earth Walls: Mud walls
Additional comments on structural system	Lateral load-resisting system: The lateral load-resisting system is timber frame. Timber poles form the inner skeleton of the building. Timber vertical elements, of about 5-7 cm (butt end) with a spacing of approximately 1.5 cm, provide the circular transverse section of the structure; horizontal wooden elements (half part of an element with a diameter of 2-3 cm) connect the vertical ones by way of bark strings. The mud layers give transverse stiffness to the wooden skeleton, completing the connection. Gravity load-bearing system: The roof and the mud smear vertical loads are directly supported by the wooden structure.
Gravity load-bearing & lateral load-resisting systems	Wattle and daub may not fully cover the structural timber elements where wooden poles are used instead of bamboo/reeds mesh.
Typical wall densities in direction 1	10-15%
Typical wall densities in direction 2	10-15%
Additional comments on typical wall densities	The typical structural wall density is up to 20 %. 10 - 13%.
Wall Openings	Windows are not provided in this type of circular housing and there is only one door with a typical size range of (1.50 - 1.70 m) height X (0.60 - 0.80 m) wide. The diameter of the round plan is estimated at about 3 - 4 m. In some cases an additional external ring of about 0.50 m is constructed to keep domestic animals and for extra storage space.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	Periodic restoration of the roof (three-five years) and re-smearing with mud on internal and external surfaces.
Type of Foundation	Shallow Foundation: Wall or column embedded in soil, without footing
Additional comments on foundation	The back fill is tamped (compacted) after all vertical members are placed.

Type of Floor System	Other floor system
Additional comments on floor system	Other: Timber, rammed earth with ballast and concrete or plaster finishing Roof and floor are considered to be flexible diaphragms.
Type of Roof System	Roof system, other
Additional comments on roof system	Other: Timber, thatched roof supported on wood purlins Roof and floor are considered to be flexible diaphragms.
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 3 meters.

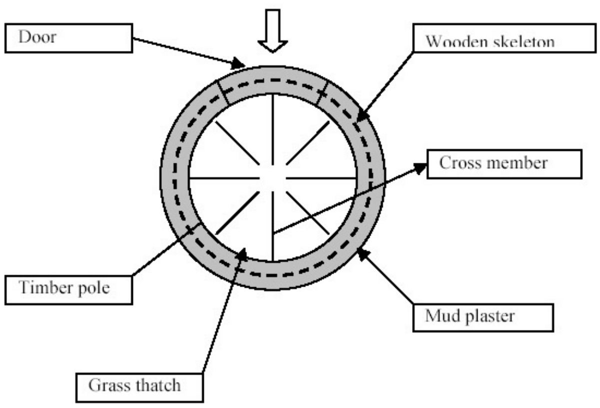
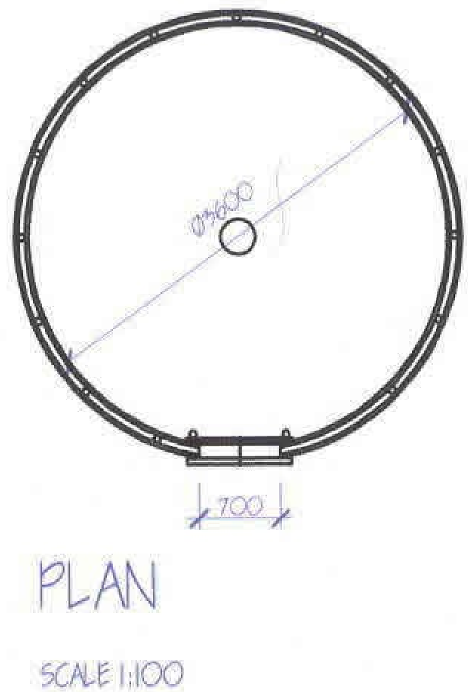
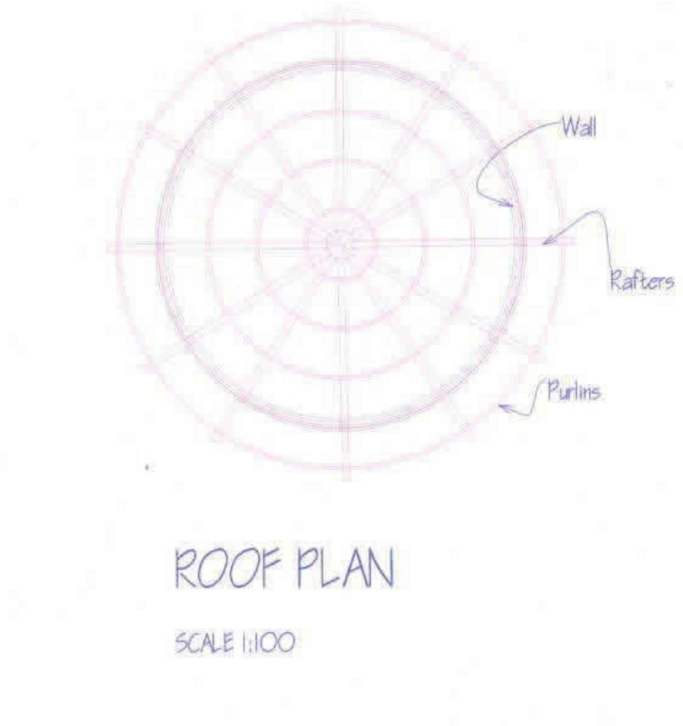


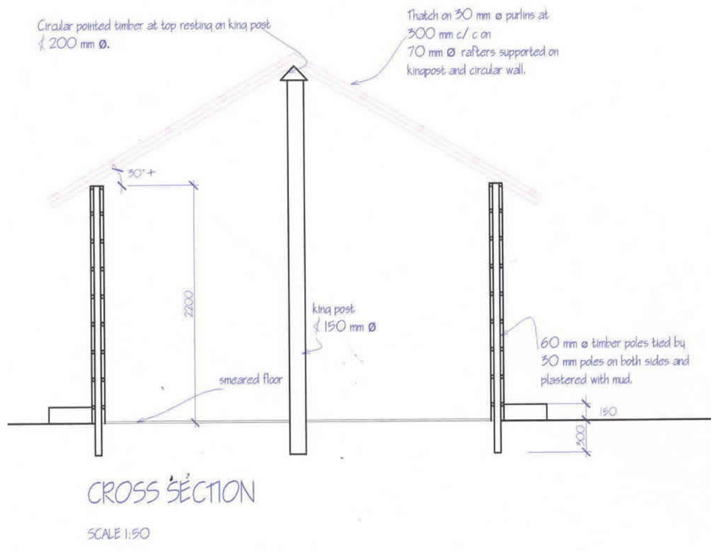
Fig.3: Plan of a typical building

Plan of a typical building



Plan of a typical building





Typical cross section

Typical roof plan

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Timber/mud	
Foundations		
Floors	Rammed earth	
Roof	Timber	
Other	Timber	

Design Process

Who is involved with the design process?	OtherNone of the above
Roles of those involved in the design process	
Expertise of those involved in the design process	The level of expertise is good as it is a practice communally executed which ensures all the necessary skills and knowledge.

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	Builder lives in this construction type. It is communally built.
Expertise of those involved in building process	
Construction process and phasing	This type of construction is completed by a group/communally. Timber poles are cut to the same length, holes (0.3 m) to receive the poles dug in the ground, poles are placed in the holes but not firmly back filled, the horizontal members are tied to the poles, and the embedded poles are firmly fixed in the ground ensuring that the poles are vertical. The mud is now placed/smeared on both sides of the pole walls. The tools used are axe, hoe and buckets. In regards to the roof, a central pole (0.2-0.3 m diameter) is placed at centre (embedded 0.3 m in the ground) to receive horizontal members 0.03 m diameter acting as purlins placed at 0.3 m centres top and bottom and tied by bark strings. The pitch is not less than 20 degrees. The grass depth is about 0.025 m forming a thatch. The grass is supported on the timber skeleton by three rows of timber placed at the eaves level, mid-way and top tied by bark strings. Poles 0.15 m diameter and spaced 0.6 m apart support eaves projections. These poles are placed about 0.7 m from the wall forming a verandah or khonde. The verandah/khonde is raised 0.15 m above ground level to protect wall from surface or rain water. This building is not typically constructed incrementally and is 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	Low comfort; no facilities; necessity of periodic rebuilding of the roof.
Who typically maintains buildings of this type?	Owner(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	Not possible to estimate because of communal nature of construction.
Labor requirements	In general, 7 to 10 days are required to complete the construction. This includes the cutting of timber poles , digging of holes, placing of poles in the holes, tieing the horizontal members (connecting the vertical poles with transverse thin wooden branches), smearing/application of mud on both sides of poles wall, roofing, and flooring.
Additional comments section 3	

Socio-Economic Issues

Patterns of occupancy	Generally, a single family occupies a single dwelling
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	
Economic level of inhabitants	Very low-income class (very poor)Low-income class (poor)

Additional comments on economic level of inhabitants	These houses are communal buildings and haven't price. 50% (very poor - less than 50US$/per year) - 50% (poor - less than 100US$/per year). It is difficult to estimate. (From the web page - CIA-The world factbook- the GPD per capita is USD900.00, 2000 est.) http://www.odci.gov/cia/publications/factbook/geos/mi.html#Econ Ratio of housing unit price to annual income: 1:1 or better
Typical Source of Financing	Informal network: friends or relatives
Additional comments on financing	
Type of Ownership	Own outright
Additional comments on ownership	
Is earthquake insurance for this construction type typically available?	No
What does earthquake insurance typically cover/cost	This type of construction is not covered in insurance issues.
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
1957	Champira
1966	Mwanza
1967	Thambani in Mwanza
1989	Salima

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	In 1973 another earthquake hit Livingstonia measuring 5.1 on the Richter magnitude. The 1989 Salima earthquake was the worst in Malawi. It is reported that 9 people lost their lives and over 50,000 people were left homeless. Rural mud wall buildings performed reasonably well. Geologists forecast more intense earthquakes in Malawi.
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.	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.	N/A
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		FALSE
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	TRUE

	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	No structural bond between mud and timber core
Earthquake-resilient features in walls	Well tied vertical and horizontal members light structure
Seismic deficiency in frames	
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	Wall/roof connection weak. Floor is non- structural - it is made of rammed earth.
Earthquake resilient features in roof and floors	Roof with strong mesh structure.
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		

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
Wall/roof connection is weak	Periodic rebuilding of the roof
Mud not properly connected with timber core	Periodic replastering of the surfaces
Floor is not structural	Nossible relative settlements

Additional comments on seismic strengthening provisions	
Has seismic strengthening described in the above table been performed?	Yes
Was the work done as a mitigation effort on an undamaged building or as a repair following earthquake damages?	The work prevents environmental damages, including damage from earthquakes
Was the construction inspected in the same manner as new construction?	Yes
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	The owner
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	N/A: the damaged buildings has been rebuilt
Additional comments section 6	

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