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

Traditional oval-shaped rural stone house

Report#	47
Last Updated	
Country	Nepal
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Important

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General Information

Building Type:	Traditional oval-shaped rural stone house
Country:	Nepal
Author(s):	Yogeshwar Krishna Parajuli Jitendra Kumar Bothara Bijay Kumar Upadhyay
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in in Kaski, Syangja, Parbat, and Baglung districts of Central Mid Mountains of the Western Development Region of Nepal (Nepal is divided into five development regions and seventy five districts which are further subdivided into small political units (56 municipalities and some 4000 Village Development Committees). The percentage of this building type in the total stock as well as total population inhibiting this building type is unknown. This type of housing construction is commonly found in rural areas. These buildings are being gradually replaced by more modern building types even in rural areas.
Summary:	This is a typical rural construction concentrated in the central mid-mountain region, particularly in the Kaski, Syangja, Parbat, and Baglung districts. (The country is divided into 75 administrative districts.) These primarily residential buildings are basically loose-fitting, load-bearing structures, constructed of uncoursed rubble stone masonry walls and a timber structure for the floor and roof. Village artisans play a pivotal role in these owner-builtbuildings. Because of the loss of integrity during an event, they are expected to be extremely vulnerable from the effects of an earthquake.
Length of time practiced:	More than 200 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling

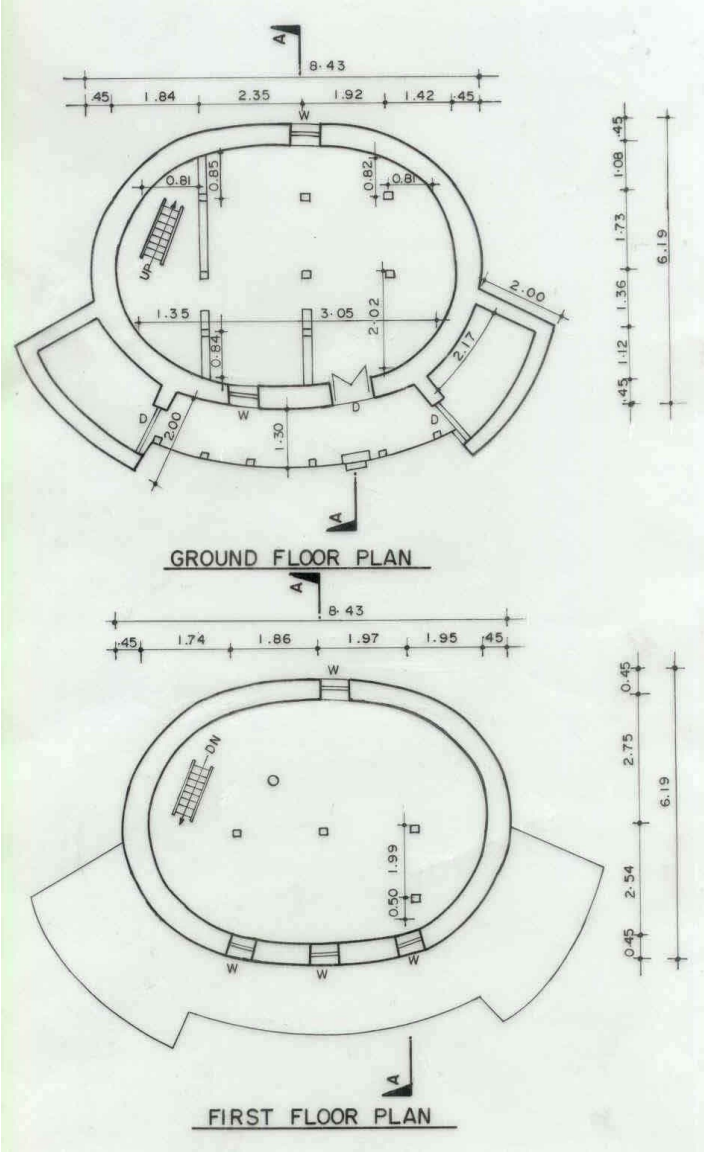
Typical number of stories:	2
Terrain-Flat:	Typically
Terrain-Sloped:	Typically
Comments:	

Features

Plan Shape	Other
Additional comments on plan shape	Building plan is oval in shape.
Typical plan length (meters)	10
Typical plan width (meters)	8
Typical story height (meters)	2.2
Type of Structural System	Masonry: Stone Masonry Walls: Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)
Additional comments on structural system	The vertical load-resisting system is stone masonry walls. The gravity loads of the main building are carried by load bearing walls. Floor and roof are constructed of timber, which transfers their loads to the walls (typical thickness 450 mm - 600 mm), which carries the load to the foundation. These walls are carried by a strip foundation of uncoursed rubble stone masonry. The veranda (annex to the main building) is a lean-to structure to main building, which is supported by timber posts at one end. These posts are generally supported by an above-ground stone pedestal (no anchorage between stone and post). No rigid connection is made between column and beam being supported. The lateral load-resisting system is stone masonry walls. The load bearing walls carry the lateral loads. The masonry walls thus act as shear walls. The building has only a perimeter wall, which encloses the building space and also carries the loads. The roof and floor are loose fit timber structures, which act as flexible diaphragm and are not able to transfer the lateral load to wall piers according to their stiffness.
	Length varies from 8 to 10 meters. Width varies

Gravity load-bearing & lateral load-resisting systems	from 6 to 8 meters. Typical story height is 2 - 2.2 meters. Span between the supports of floor and walls ranges from 1.5 to 2 meters usually. The building is oval shaped and there does not exist any internal walls for separating internal space, so the concept of span is not applicable.
Typical wall densities in direction 1	>20%
Typical wall densities in direction 2	>20%
Additional comments on typical wall densities	Total wall density (total plan area of wall/ total plinth area) is around 25%.
Wall Openings	Typically three to four openings are provided in each story, one for door and rest for windows in main building. Front facade has more openings than the back. Openings are limited in size. Openings constitute some 15-20% of total wall length. Spacing between openings is generally more than twice the length of opening.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	There aren't modifications of bearing structures in these buildings usually.
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	Wood planks (or fire wood) and joists covered with thick mud overlay. Floor and roof structures are loose-fit elements, as if one component is stacked over the other (without any nailing). These therefore behave as flexible diaphragm. In past earthquakes such floors were just scattered due to shaking.
Type of Roof System	Roof system, other
Additional comments on roof system	Timber: thatched roof supported on wood purlins; wood shingle roof Floor and roof structures are loose-fit elements, as if one component is stacked over the other (without any nailing). These therefore behave as flexible diaphragm. In past

	earthquakes such floors were just scattered due to shaking.
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 10 meters.



Plan of a Typical Building

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Rubble stone	Characteristic Strength: Not known/ Not relevant for strength Mix Proportion/Dimensions:

		Irregular boulders (size 200-300mm or less) Slates, lime stone, quartzite
Foundations	Mud	Characteristic Strength: Very low compressive strength and no tensile strength Used for mortar
Floors	Timber/ bamboo	Characteristic Strength: Not known Difficult to define because of selected use of multiple species.
Roof	Timber/ bamboo	Characteristic Strength: Not known Difficult to define because of selected use of multiple species.
Other	Soft and hard wood	Characteristic Strength: Not known Mix proportions/dimensions: Depending on structural value of the member Hard wood used for members of high structural value (e.g. Columns, principal beams) where as softwood used for members with relatively low structural value (e.g.. Joists, purlins)

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	Engineers /architects / technicians are not involved in this construction type.

Construction Process

Who typically builds this construction type?	OwnerOther
Roles of those involved in the building process	Builders/ owners live in this construction type (house owner himself is part of construction team).
	The artisans are without any formal training. The

Expertise of those involved in building process	construction know-how is transferred from generation to generation or the people learn the process on site in a very informal way. The head mason s skilled but the level of know-how varies from person to person. No standard or minimum requirement exists for head or any other mason. The rest of the working team is composed of semi or unskilled personnel.
Construction process and phasing	The walls are constructed in a random uncoursed manner by using irregular stones bound with mud mortar. The stones are collected from quarries, riverbed or field, sometimes partially dressed. Space between interior and exterior wythes is filled with small stones and mud. The joists and rafters are just placed on walls without any anchorage or connection. These buildings are owner-built where village artisans play pivotal role. Simple tools such as chisels, hammers, saw etc are used for construction. 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?	Yes
Applicable codes or standards	NBC203 : Guidelines for Earthquake Resistant Building Construction: Low Strength Masonry (Draft)
Process for building code enforcement	There is no process for Building Code enforcement in rural areas (Village Development Committee areas) of Nepal.

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
	The building by-laws, building permit process and

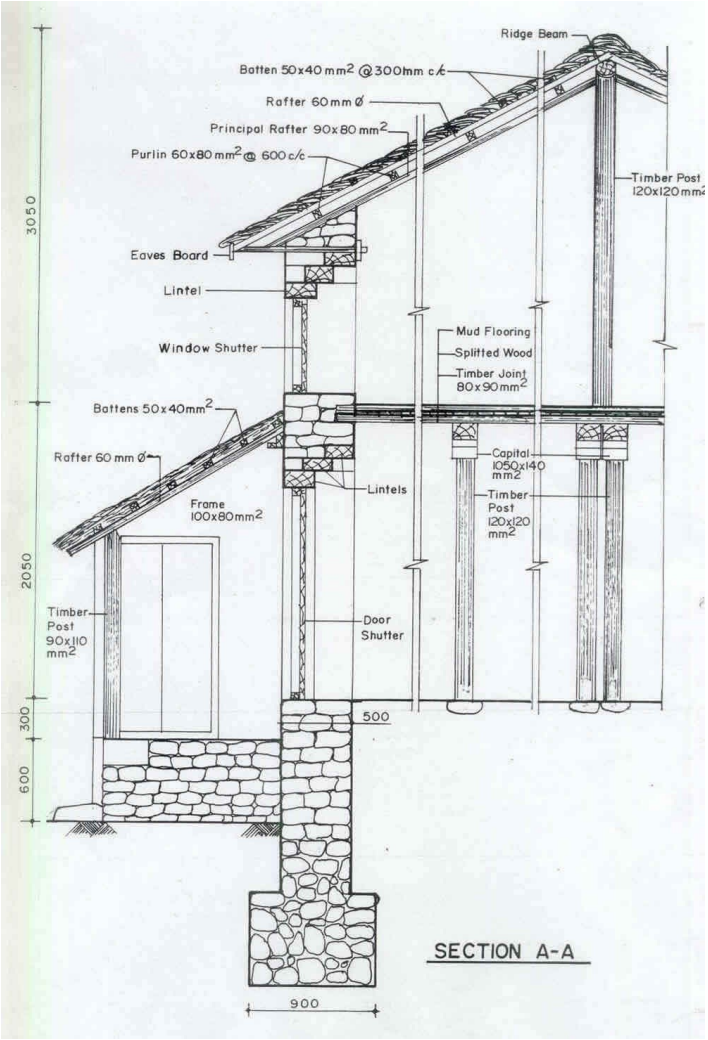
Additional comments on building permits and development control rules	building construction controlling monitoring mechanisms only exists in municipalities and not in Village Development Committee (local authority at village level- rural areas). This is basically a rural house type where the building permit process does not exist. If this type of housing were to be constructed in a municipality, it would have to pass through the formal process (but the process does not require approval of structural drawings for this size of building). Present bylaws or regulation do not prohibit the construction of this type of building in municipal areas.

Building Maintenance and Condition

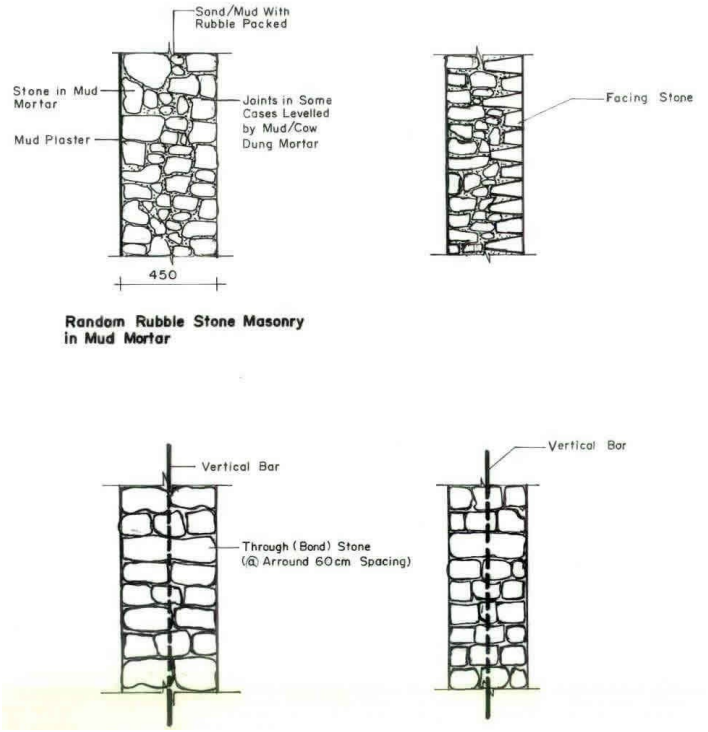
Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	Cash flow in such construction is very minimal so it is difficult to price the building cost.
Labor requirements	120 # 150 man-days (excluding effort required for collection of construction materials).
Additional comments section 3	



Critical Structural Details



An Illustration of Key Seismic Features and/or Deficiencies

Socio-Economic Issues

Patterns of occupancy	Single/multiple families both live in a single 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	
Economic level of inhabitants	Low-income class (poor)Middle-income class
Additional comments on	A pricing system does not exist because of informal

economic level of inhabitants	housing production mechanism. Ratio of housing unit price to annual income: 1:1 or better
Typical Source of Financing	Owner financedPersonal savingsInformal 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	
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

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	No medium or major earthquakes observed in the area to date in known history (oral or written) so the performance of these buildings in a real earthquake is largely unknown. But buildings with similar construction materials and technology (but with different plan shape) have performed extremely poorly in past earthquakes.
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.	TRUE
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.	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 each diaphragm level with metal anchors or straps.	FALSE
Wall Openings		TRUE
Quality of Building Materials	Quality of building materials is considered to be adequate per the requirements of national	FALSE

	codes and standards (an estimate).	
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).	TRUE

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	#NAME?
Earthquake-resilient features in walls	
Seismic deficiency in frames	#NAME?
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	-Flexible. -No interconnection between different structural elements. -No connection between walls and floor/ roof (in general). - Heavy floor
Earthquake resilient features in roof and floors	

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
Roof/ floor	Enhancement of integrity, anchorage with walls, bracing
Walls	Insertion of bond stones, bandages at different levels, splint at critical sections
Timber Frame	Bracing of frame (knee bracing, diagonal bracing) to strengthen beam-column connection, anchorage of column to foundation
(New Construction): Walls	Use of cement mortar, use of bond stones, bands at different levels , vertical bars at critical sections
(New Construction):Timber Frame	Knee or diagonal bracing of beam-column joints, connection of column to foundation

Additional comments on seismic strengthening provisions	
Has seismic strengthening described in the above table been performed?	
Was the work done as a	

mitigation effort on an undamaged building or as a repair following earthquake damages?	
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?	
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	
Additional comments section 6	

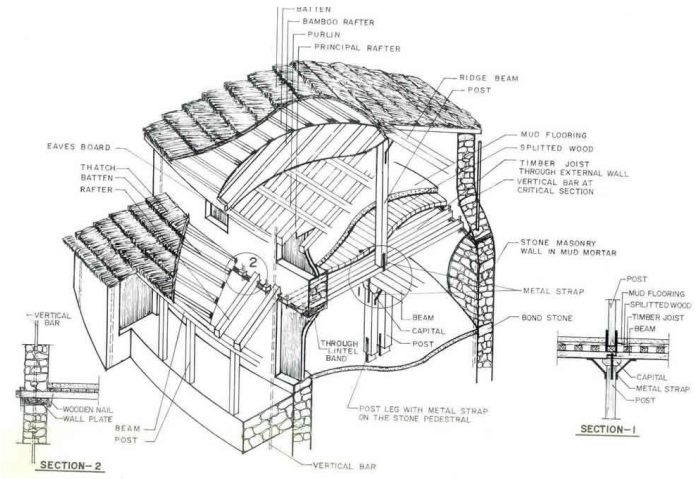


Illustration of Seismic Strengthening Techniques

References

Appendix-A: Prototype Building inventory; the Development of Alternative Building Materials and Technologies for Nepal UNDP/UNCHS (Habitat) Sub-project Nep 88/054/21.03, His Majesty's Government of Nepal, Ministry of House and Physical Planning 1994

NBC 203 Guidelines for Earthquake Resistant Building Construction: Low Strength

Masonry UNDP/UNCHS (Habitat) Sub-project Nep 88/054/21.03, His Majesty's Government of Nepal, Ministry of House and Physical Planning 1994

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