World Housing Encyclopedia

an Encyclopedia of Housing Construction in Seismically Active Areas of the World

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

HOUSING REPORT
Houses with mud walls and thatch roofs

Report #	42
Report Date	05-06-2002
Country	KYRGYZSTAN
Housing Type	Adobe / Earthen House
Housing Sub-Type	Adobe / Earthen House : Mud walls
Author(s)	Svetlana Uranova, Ulugbek T. Begaliev
Reviewer(s)	Svetlana N. Brzev

Summary

This building type is widespread in the rural areas of Kyrgyzstan, and also in some urban areas. It is a non-engineered construction. Due to its low cost, it is mainly used by poor people. Various building materials are used for this type of construction, e.g., clay and straw for the walls, wood for the roof structure, and stone for the foundations. In order to achieve adequate flexibility or plasticity, a small amount of clay is mixed with water. Straw is added to achieve

an improved consistency. Small panel boards are used as formwork for casting mud walls. The walls are cast in lifts; a new lift is cast after the previous one has set. Windows and doors have wood lintels. Floors are made out of wood planks. Buildings of this type do not have any earthquake-resistant features and are considered to be highly vulnerable to seismic effects.

1. General Information

Buildings of this construction type can be found in all regions of Kyrgyzstan. This type of housing construction is commonly found in both rural and urban areas. This construction type has been in practice for less than 200 years.

Currently, this type of construction is being built. .

Figure 1: Typical Building

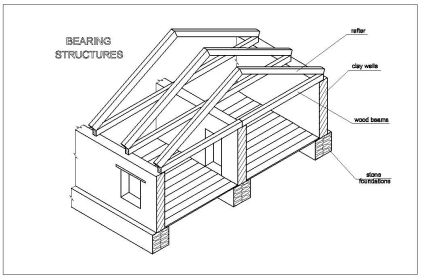

Figure 2: Key Load-Bearing Elements

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat, sloped and hilly terrain. They do not share common walls with adjacent buildings. When separated from adjacent buildings, the typical distance from a neighboring building is 10 meters.

2.2 Building Configuration

Typical shape of a building plan for this housing type is rectangular. Typical size of windows: 1.2 m (height) X 1-1.2 m (width), doors: 2 m (height) X 1 m (width). There are 5-6 windows in a building. Overall window and door areas account for around 12-15% of the overall wall surface area.

2.3 Functional Planning

The main function of this building typology is single-family house. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. Buildings of this type have only one door, i.e. there is only one means of escape (except for the windows).

2.4 Modification to Building

There are lots of modifications in the buildings of this type. The modifications are more common in urban than in rural areas. Typical modifications indude installation of new door openings, deleting the existing window openings and expansion (addition of rooms).

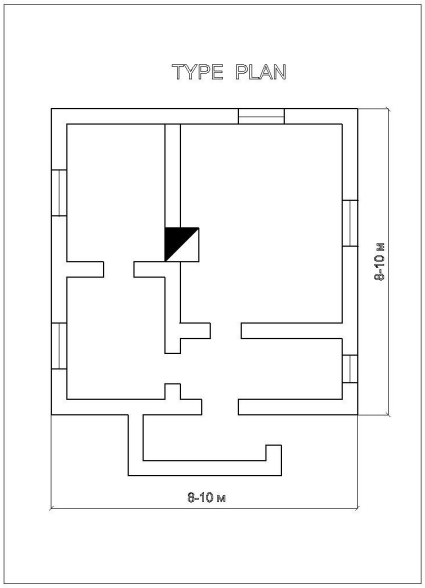

Figure 3: Plan of a Typical Building

3. Structural Details

3.1 Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	Most appropriate type
Masonry	Stone Masonry Walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	☐
		2	Dressed stone masonry (in lime/cement mortar)	☐
	Adobe/ Earthen Walls	3	Mud walls	☑
		4	Mud walls with horizontal wood elements	☐
		5	Adobe block walls	☐
		6	Rammed earth/Pise construction	☐
	Unreinforced masonry walls	7	Brick masonry in mud/lime mortar	☐
		8	Brick masonry in mud/lime mortar with vertical posts	☐
		9	Brick masonry in lime/cement mortar	☐
		10	Concrete block masonry in cement mortar	☐
	Confined masonry	11	Clay brick/tile masonry, with wooden posts and beams	☐
		12	Clay brick masonry, with concrete posts/tie columns and beams	☐
		13	Concrete blocks, tie columns and beams	☐
	Reinforced masonry	14	Stone masonry in cement mortar	☐
		15	Clay brick masonry in cement mortar	☐
		16	Concrete block masonry in cement mortar	☐
		17	Flat slab structure	☐
			Designed for gravity loads	

Structural concrete	Moment resisting frame	18	only, with URM infill walls	☐
		19	Designed for seismic effects, with URM infill walls	☐
		20	Designed for seismic effects, with structural infill walls	☐
		21	Dual system – Frame with shear wall	☐
	Structural wall	22	Moment frame with in-situ shear walls	☐
		23	Moment frame with precast shear walls	☐
	Precast concrete	24	Moment frame	☐
		25	Prestressed moment frame with shear walls	☐
		26	Large panel precast walls	☐
		27	Shear wall structure with walls cast-in-situ	☐
		28	Shear wall structure with precast wall panel structure	☐
Steel	Moment-resisting frame	29	With brick masonry partitions	☐
		30	With cast in-situ concrete walls	☐
		31	With lightweight partitions	☐
	Braced frame	32	Concentric connections in all panels	☐
		33	Eccentric connections in a few panels	☐
	Structural wall	34	Bolted plate	☐
		35	Welded plate	☐
Timber	Load-bearing timber frame	36	Thatch	☐
		37	Walls with bamboo/reed mesh and post (Wattle and Daub)	☐
		38	Masonry with horizontal beams/planks at intermediate levels	☐
		39	Post and beam frame (no special connections)	☐
		40	Wood frame (with special connections)	☐
		41	Stud-wall frame with plywood/gypsum board sheathing	☐
		42	Wooden panel walls	☐
Other	Seismic protection systems	43	Building protected with base-isolation systems	☐
		44	Building protected with seismic dampers	☐
	Hybrid systems	45	other (described below)	☐

There are several subtypes related to this structural system: adobe block walls, cast-in-place mud walls, and cast-in-place mud walls with timber elements (sinch).

3.2 Gravity Load-Resisting System

The vertical load-resisting system is earthen walls. Gravity load-bearing system for building of this type consists of day walls and wood roof and floor structures.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is earthen walls. Lateral load-resisting system for building of this type consists of day

walls and wood roof and floor structures.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 10 and 10 meters, and widths between 10 and 10 meters. The building is 1 storey high. The typical span of the roofing/flooring system is 5 meters. Typical Span: Typical span may be 3-5 meters. The typical storey height in such buildings is 3 meters. The typical structural wall density is none. Total wall area/plan area is 0.2. Wall density in each principal direction is on the order of 8-10%.

3.5 Floor and Roof System

Material	Description of floor/roof system	Most appropriate floor	Most appropriate roof
Masonry	Vaulted	☐	☐
	Composite system of concrete joists and masonry panels	☐	☐
Structural concrete	Solid slabs (cast-in-place)	☐	☐
	Waffle slabs (cast-in-place)	☐	☐
	Flat slabs (cast-in-place)	☐	☐
	Precast joist system	☐	☐
	Hollow core slab (precast)	☐	☐
	Solid slabs (precast)	☐	☐
	Beams and planks (precast) with concrete topping (cast-in-situ)	☐	☐
	Slabs (post-tensioned)	☐	☐
Steel	Composite steel deck with concrete slab (cast-in-situ)	☐	☐
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	☐	☐
	Wood shingle roof	☐	☑
	Wood planks or beams that support clay tiles	☐	☐
	Wood planks or beams supporting natural stones slates	☐	☐
	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	Described below	☐	☑

3.6 Foundation

Type	Description	Most appropriate type
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	☐
	Steel skin friction piles	☐
	Wood piles	☐
	Cast-in-place concrete piers	☐
	Caissons	☐
Other	Described below	☐

NA.

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

Figure 4B: Illustration of Key Seismic Features

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 1 housing unit(s). 1 units in each building. The number of inhabitants in a building during the day or business hours is less than 5. The number of inhabitants during the evening and night is 5-10.

4.2 Patterns of Occupancy

Typically, one family per building.

4.3 Economic Level of Inhabitants

Income class	Most appropriate type
a) very low-income class (very poor)	☑
b) low-income class (poor)	☑
c) middle-income class	☐
d) high-income class (rich)	☐

Ratio of housing unit price to annual income	Most appropriate type
5:1 or worse	☐
4:1	☐

3:1	☐
1:1 or better	☑

What is a typical source of financing for buildings of this type?	Most appropriate type
Owner financed	☐
Personal savings	☑
Informal network: friends and relatives	☐
Small lending institutions / micro-finance institutions	☐
Commercial banks/mortgages	☐
Employers	☐
Investment pools	☐
Government-owned housing	☐
Combination (explain below)	☐
other (explain below)	☐

In each housing unit, there are no bathroom(s) without toilet(s), no toilet(s) only and no bathroom(s) induding toilet(s).

Usually latrines is located outside house. .

4.4 Ownership

The type of ownership or occupancy is outright ownership.

Type of ownership or occupancy?	Most appropriate type
Renting	☐
outright ownership	☑
Ownership with debt (mortgage or other)	☐
Individual ownership	☐
Ownership by a group or pool of persons	☐
Long-term lease	☐
other (explain below)	☐

5. Seismic Vulnerability

5.1 Structural and Architectural Features

Structural/ Architectural Feature	Statement	Most appropriate type		
		Yes	No	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 from the building to the foundation.	☐	☑	☐

Building Configuration	The building is regular with regards to both the plan and the elevation.	☐	☑	☐
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.	☐	☑	☐
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.	☐	☑	☐
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.	☐	☑	☐
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	☑	☐	☐
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);	☑	☐	☐
Foundation-wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	☐	☑	☐
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps	☐	☑	☐
Wall openings	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.	☑	☐	☐
Quality of building materials	Quality of building materials is considered to be adequate per the requirements of national codes and standards (an estimate).	☐	☑	☐
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per 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)	☐	☑	☐
Additional Comments				

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake Resilient Features	Earthquake Damage Patterns
Wall	Wall material (clay) is characterized with low compressive and shear strength.		Damage or collapse of walls due to in-plane and out-of-plane seismic effects, collapse of buildings.
Frame (columns, beams)	Not applicable		

Roof and floors	Wood beams are not joined together in the horizontal diaphragm.		

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *A: HIGH VULNERABILITY (i.e., very poor seismic performance)*, the lower bound (i.e., the worst possible) is A: HIGH VULNERABILITY (i.e., very poor seismic performance), and the upper bound (i.e., the best possible) is *A: HIGH VULNERABILITY (i.e., very poor seismic performance)*.

Vulnerability	high	medium-high	medium	medium-low	low	very low
	very poor	poor	moderate	good	very good	excellent
Vulnerability Class	A	B	C	D	E	F
	☑	☐	☐	☐	☐	☐

5.4 History of Past Earthquakes

Date	Epicenter, region	Magnitude	Max. Intensity
1986	Kairakuum, Kyrgyz Republic/Tajikistan border	6.8	7
1992	Suusamir, Kyrgyz Republic	7.4	9

Most buildings suffered damages to walls or total collapse.

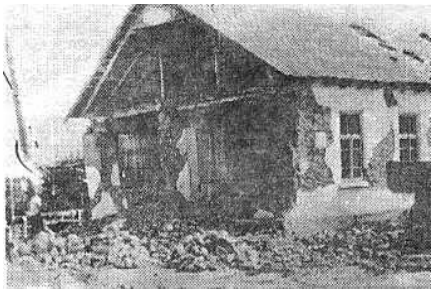

Figure 5: A Photograph Illustrating Typical Earthquake Damage

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Clay.			
Foundation	Stone.			
Frames (beams & columns)				
Roof and floor(s)	Wood.			

6.2 Builder

Buildings of this type are usually constructed by owners.

6.3 Construction Process, Problems and Phasing

Buildings are constructed by owners without any engineered building technique. The construction of this type of housing takes place incrementally over time. Typically, the building is originally not designed for its final constructed size.

6.4 Design and Construction Expertise

Buildings of this type are constructed by unskilled persons. This is a traditional type of construction which had been practiced before the introduction of building codes. As this is a non-engineered construction, current building codes do not address this type of construction.

6.5 Building Codes and Standards

This construction type is not addressed by the codes/standards of the country. The most recent code/standard addressing this construction type issued was Construction standards do not address this type of construction.

6.6 Building Permits and Development Control Rules

This type of construction is a non-engineered, and not authorized as per development control rules. Building permits are not required to build this housing type.

6.7 Building Maintenance

Typically, the building of this housing type is maintained by Owner(s).

6.8 Construction Economics

Load-bearing structure only approximately 10-15 US$/m^2. In order to construct one building of this type, 4-5 persons need to work for 3-4 months.

7. Insurance

Earthquake insurance for this construction type is typically unavailable. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is unavailable.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

Seismic strengthening is not economically feasible. It is more cost-effective to reconstruct buildings of this type rather than strengthen them to resist earthquake effects.

8.2 Seismic Strengthening Adopted

8.3 Construction and Performance of Seismic Strengthening

Reference(s)

1. Seismic Hazard and Buildings Vulnerability in Post-Soviet Central Asia Republics
   Eds. King,S.A., Khalturin,V.I., and Tucker,B.E.
   Proceeding of the NATO Advanced Research Workshop on Earthquake Risk Management Strategies for Post-Soviet Central Asian Republics, Almaty, Kazakhstan, 22-25 October 1996, Kluwer Academic Publishers, P.O. Box 17, 3300 AA Dordrecht, The Netherlands 1996

2. Building and Construction Design in Seismic Regions - Handbook
   Eds. Uranova,S.K., and Imanbekov,S.T
   KyrgyzNIIPStroitelstva, Building Ministry Kyrgyz Republic, Bishkek 1996

Author(s)

1. Svetlana Uranova
   Head of the Laboratory, KRSU
   Kievskai 44, Bishkek 720000, KYRGYZSTAN
   Email:uransv@yahoo.com FAX: 996-3312-282859

2. Ulugbek T. Begaliev
   Head of Department, KNIIPC
   Vost Prom Zone Cholponatisky 2, Bishkek 720571, KYRGYZSTAN
   Email:utbegaliev@yahoo.com

Reviewer(s)

1. Svetlana N. Brzev
   Instructor
   Civil and Structural Engineering Technology, British Columbia Institute of Technology
   Burnaby BC V5G 3H2, CANADA
   Email:sbrzev@bcit.ca FAX: (604) 432-8973