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

Two-story unreinforced brick masonry building with wooden floors

Report#	41
Last Updated	
Country	Kyrgyzstan
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Important

participant’s organizations.

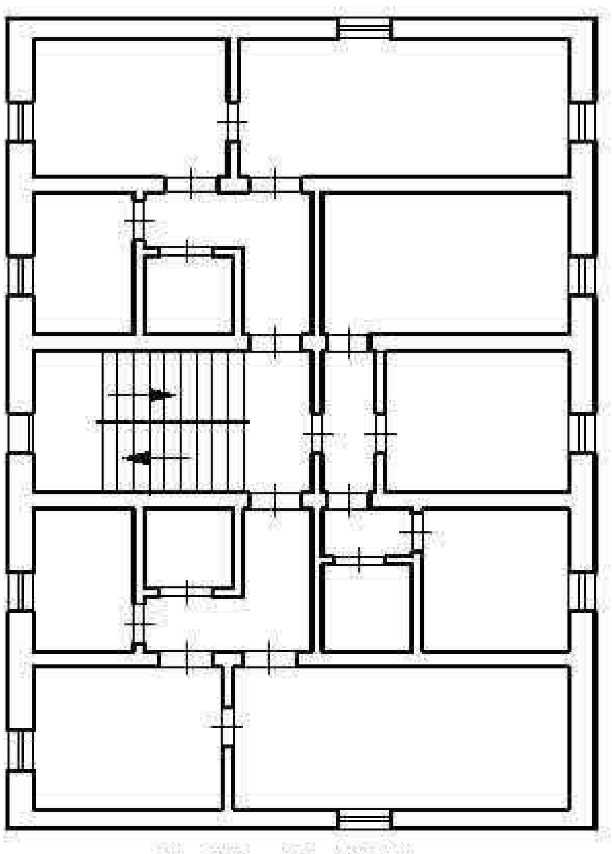
General Information

Building Type:	Two-story unreinforced brick masonry building with wooden floors
Country:	Kyrgyzstan
Author(s):	Svetlana Uranova Ulugbek T. Begaliev
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in the cities throughout Kyrgyzstan. It is estimated that around 5% of residential buildings in Bischkek and 5-7% of buildings in other cities are of this type. This type of housing construction is commonly found in urban areas.
Summary:	This is a non-engineered construction practiced in Kyrgyzstan in the period from 1920 to 1957. The load-bearing structure in buildings of this type consists of unreinforced brick masonry walls and wooden floor beams. Brick masonry walls are usually constructed in mud mortar. Walls are usually perforated with rather large door and window openings. The wall length between the adjacent cross walls is on the order of 9-10 m. Wooden floor elements (beams) are not tied together and they do not behave as diaphragms. Based on performance in past earthquakes, this building type is considered highly vulnerable to seismic effects.
Length of time practiced:	76-100 years
Still Practiced:	No
In practice as of:	
Building Occupancy:	Single dwellingResidential, 10-19 unitsMixed residential/commercial
Typical number of stories:	2
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	

Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	Typical shape of a building plan for this housing type is rectangular.
Typical plan length (meters)	30
Typical plan width (meters)	12
Typical story height (meters)	3.5
Type of Structural System	Masonry: Unreinforced Masonry Walls: Brick masonry in mud/lime mortar
Additional comments on structural system	Gravity load-bearing system: Elements of gravity load-resisting system are the same as lateral load-resisting system. Wooden floor beams also carry gravity loads. The beams are supported by the wall; however, without any special anchorage. Typical beam cross-sectional dimensions are: 70-150 mm width and 150-250 mm depth. Wooden floors typically do not have concrete topping. Details of floor structures and wall-floor connections are illustrated in Figure 4. Lateral load-resisting system: The lateral load-resisting system in buildings of this type consists of unreinforced brick masonry walls. Brick masonry walls are usually constructed in mud mortar. Typical wall thickness ranges from 380 mm to 510 mm. Walls are usually perforated with rather large door and window openings. Window and door lintel beams are made of timber board or steel bars embedded in mortar. Typical lintel details are shown in Figure 5. Wooden floors do not act as diaphragms.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	15-20%
Typical wall densities in direction 2	15-20%
Additional comments on typical wall densities	The typical structural wall density is up to 20 %. Total wall area/plan area is 15%. The range between the ratios of the area of all the walls in each principal direction divided by the total area of the plan is 7-8%.
Wall Openings	Typical size of window openings is 1.2m-1.5m(height) x 1.5-2m (width), and the door openings are: 2m (height)x1m (width). There are 16-20 windows at each floor level in the building. The overall window and door areas constitute around 15% of the overall wall surface area.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
	Modifications in buildings of this type are common e.g.

Modifications of buildings	installation of new doors and windows, new walls and partitions, deletion of doors and windows, demolition of existing load-bearing walls and partitions, construction of new balconies, etc.
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	Timber: wood planks of breams with ballast and concrete or plaster finishing
Type of Roof System	Roof system, other
Additional comments on roof system	Timber: wood shingle roof
Additional comments section 2	Typical separation distance between buildings: minimum 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	Wall: Brick masonry	Wall: Characteristic Strength- Rt<30kPa; brick compressive strength is over 750 MPa, and mortar compressive strength of over 50 MPa. Rt= adhesion between mortar and bricks
Foundations	Stone	
Floors	Wood	Typically pine or aspen wood
Roof	Wood	Typically pine or aspen wood
Other		

Design Process

Who is involved with the design process?	Other
Roles of those involved in the design process	
Expertise of those involved in the design process	

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	In general, this is a non-engineered construction (constructed without qualified technical expertise). Usually an engineer managed the construction of this type.
Expertise of those involved in building process	
Construction process and phasing	Construction of this type was practised many years ago. Usually an engineer managed the construction; however, construction workers did not have any construction-related experience. In some cases, buildings of this type had been constructed without a proper design documentation. This building is not typically constructed incrementally and is not 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

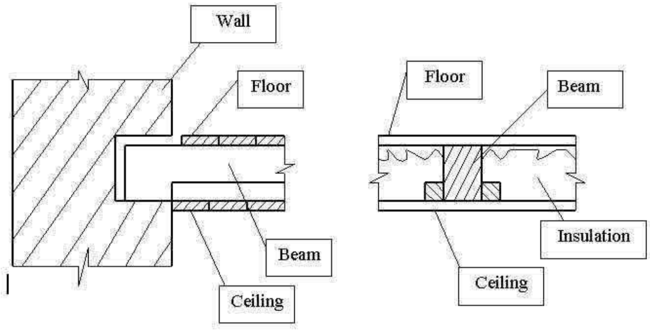
Are building permits required?	No
Is this typically informal construction?	Yes
Is this construction typically authorized as per development control rules?	No
Additional comments on building permits and development control rules	

Building Maintenance and Condition

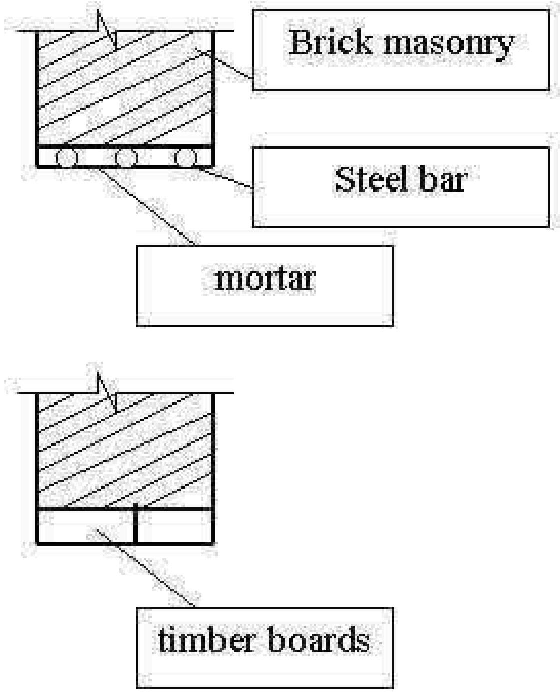
Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	Cost of load-bearing structure is on the order of 100 US$/sq m.
Labor requirements	10 people need to work for 12-24 months in order to build a building of this type.
Additional comments section 3	



Critical Structural Details - wall and floor connection details



Cross-section through door lintels

Socio-Economic Issues

Patterns of occupancy	There are 2-4 housing units per building unit at each floor level. Usually there are 8 - 16 units in each building. One family occupies one housing unit. In general, between 8 to 16 families occupy one building of this type.
Number of inhabitants in a typical building of this construction type during the day	10-20
Number of inhabitants in a typical building of this construction type during the evening/night	>20
Additional comments on number of inhabitants	
Economic level of inhabitants	Low-income class (poor)Middle-income class
Additional comments on economic level of inhabitants	70% poor and 30% middle class inhabitants occupy buildings of this type. Ratio of housing unit price to annual income: 5:1 or worse
Typical Source of Financing	Personal savings
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
1992	Suusamir, Kyrgyzstan
1986	Kairakuum, Tadjikistan
1988	Spitak, Armenia

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	The epicenter of the Suusamir earthquake was in the hilly area (mountains). Maximum earthquake intensity (based on the 12-point intensity scale) was 9. Buildings of this type affected by the earthquake were away from the epicenter, located in the region with intensity 6-7 on the same 12-point intensity scale. In the Kairakum earthquake, intensity reported in the cities (where this type of

	construction is found) was 6-7. Most buildings of this type suffered various extent of damage to masonry walls. Buildings of this type were also damaged in the 1988 Spitak, Armenia earthquake (see Figure 6).
Additional comments on earthquake damage patterns	Overall damage patterns observed in past earthquakes for this type of construction included damage to the walls or complete collapse of buildings; the extent of damage depends on the direction of seismic waves, earthquake intensity, and pier dimensions. Wall failure was due to in-plane or out-of-plane shear, more often as a result of out-of-plane shear.

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	FALSE

	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.	FALSE
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 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	FALSE

	generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).

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	- Brick masonry walls have poor shear, tension and compression resistance, and steel reinforcement is generally not provided; - Window and door lintels are made of timber boards or steel bars; - Walls are usually perforated with rather large door and wind
Earthquake-resilient features in walls	
Seismic deficiency in frames	
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	Wood beams are not joined in the rigid diaphragm
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	-|			

A Photograph Illustrating Typical Earthquake Damage (1988 Armenia earthquake, source: EERI Annotated slide collection)

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening

Additional comments on seismic strengthening provisions	Seismic strengthening is not considered feasible for buildings of this type. If strengthening were to be implemented, there would be a need to install new floors, provide jacketing of the walls (on both faces) etc. This is considered to be expensive and therefore the buildings of this type, if severely damaged in an earthquake, are replaced with new buildings. In case of minor damage (e.g. cracks developed in the walls), these cracks are repaired without strengthening.
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	N/A

damages?	
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?	N/A
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	N/A
Additional comments section 6	

References

Seismic Hazard and Building Vulnerability in Post-Soviet Central Asia Republics. Nato Series.Netherland.

Buildings and Construction Design in Seismic Regions. Handbook.Bishkek.1996.

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