World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

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HOUSING REPORT

Buildings with cast in-situ load-bearing reinforced concrete walls

Report#	40
Last Updated	
Country	Kyrgyzstan
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Important

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General Information

Building Type:	Buildings with cast in-situ load-bearing reinforced concrete walls
Country:	Kyrgyzstan
Author(s):	Svetlana Uranova Ulugbek T. Begaliev Manukovskiy V.
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in Bishkek (Kyrgyzstan) and the other Republics of the former Soviet Union. Many buildings with cast in-situ load-bearing reinforced concrete walls can be found in Moldova. This type of housing construction is commonly found in urban areas.
Summary:	Buildings with cast in-situ load-bearing reinforced concrete walls are widespread in many Republics of the former Soviet Union. There are many such buildings in Kyrgyzstan in areas with design seismicity of 8 and 9 on the MSK scale. The buildings with cast in-situ walls are typically medium- to high-rise buildings (4-18 stories high; often 12-stories high). High-rise buildings of this type (9-18 stories high) have basements. The load-bearing structure consists of cast in-situ reinforced concrete walls and precast reinforced floor slabs. Floor slabs are either flat slab structures, or, less often, hollow-core slabs. Buildings of this type do not have any frame elements (columns or beams). Facade walls are usually made of lightweight (ceramsite) concrete. Buildings of this type are supported by concrete strip or mat foundations. This building type is considered to be earthquake-resistant. Problems are mainly related to the quality of construction.
Length of time practiced:	25-60 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Residential, 50+ units
Typical number of stories:	4-18
Terrain-Flat:	Typically
Terrain-Sloped:	3

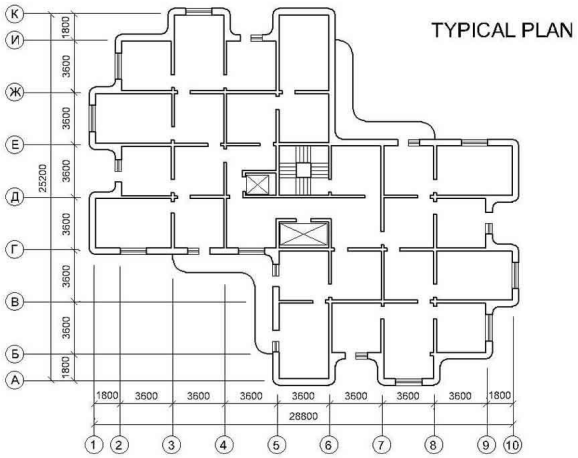
Comments:

Features

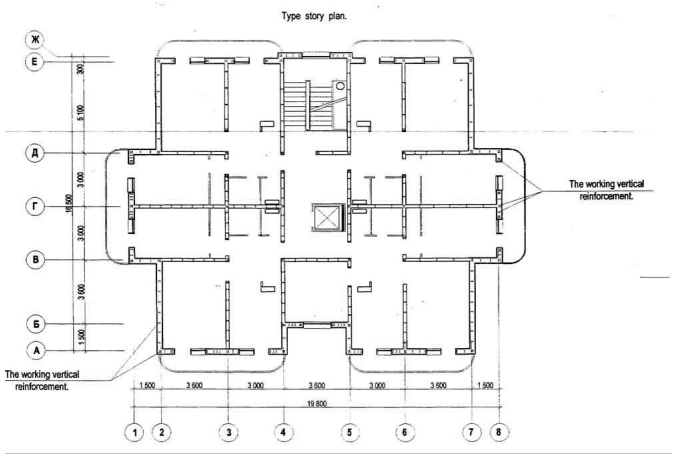
Plan Shape	Square, solidRectangular, solid
Additional comments on plan shape	Typical shape of a building plan for this housing type is rectangular or square; in some cases, the plan consists of two rectangles or squares.
Typical plan length (meters)	26-30
Typical plan width (meters)	12-14
Typical story height (meters)	3
Type of Structural System	Structural Concrete: Precast Concrete: Shear wall structure with walls cast in-situ
Additional comments on structural system	Lateral load-resisting system: The lateral load-resisting system consists of reinforced concrete walls and reinforced concrete slabs. Walls and slabs are joined together in a rigid space (3-D) system. This system works as a uniform (box-type) construction. Floor slabs are either flat slab structures, or, less often, hollow-core slabs. Buildings of this type do not have any frame elements (columns or beams). Thickness of exterior (facade) walls is usually 300-400 mm, and the thickness of interior walls is 160-200 mm. Thickness of flat slabs and hollow-core slabs is 160 mm and 220 mm, respectively. Facade walls are usually made of lightweight (ceramsite) concrete; thickness is variable depending on the thermal insulation requirements. Buildings of this type are supported by concrete strip or mat foundations. Wall reinforcement is based on the Building Code requirements. Vertical reinforcement bars are located close to the door and window openings, as well as at the wall end zones and at the wall intersections. Distributed vertical reinforcement is typically installed throughout the wall length, typically in two layers. In addition, two layers of welded-wire mesh are typically installed close to the exterior wall surfaces. If the walls are perforated with openings, coupling beams (spandrel beams) are designed for bending and shear effects. The reinforcement bars are joined by welding or lap splices. Gravity load-bearing system: Gravity load-bearing structure consists of reinforced concrete walls and slabs.
Gravity load-bearing &	

lateral load-resisting systems	
Typical wall densities in direction 1	10-15%
Typical wall densities in direction 2	10-15%
Additional comments on typical wall densities	The total wall density in both directions is on the order of 15%. Wall density in one direction amounts to approx. 70-80% of the wall density in the other direction i.e. walls are rather uniformly distributed in the two principal directions.
Wall Openings	Typical window opening size is 1.3m (height)x1.8m (width), door openings: 2m (height)x1m (width). Overall window and door areas constitute up to 20% of the wall area. There are 20 to 25 windows in a building with plan dimensions of 28x26m.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	Typical patterns of modification include the perforation of walls with door openings. This has been a very serious problem in Kyrgyzstan since 1992. There has been a trend of people purchasing apartments at a low cost and using them as shops. As a result of these modifications, the number of door openings on the exterior load-bearing walls has increased; fragments of the walls have been removed and apertures on the lower stories have been made. Modifications of this type have resulted in increased seismic vulnerability for buildings of this type. In an attempt to regulate this process in Kyrgyzstan, an annex to the Building Code has been developed, under the title #Change of the building function of some space of the existing apartment buildings# (SNiP 31-01-95). It is interesting to note that in Uzbekistan, modifications in the apartment buildings of this type are prohibited at the ground floor level.
Type of Foundation	Shallow Foundation: Reinforced concrete strip footingShallow Foundation: Mat foundation
Additional comments on foundation	
Type of Floor System	Other floor system
Additional comments on floor system	Floor and roof slabs are of precast construction (either hollow core slabs or solid slabs).
Type of Roof System	Roof system, other

Additional comments on roof system	Floor and roof slabs are of precast construction (either hollow core slabs or solid slabs).
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 20 meters.



Plan of a Typical Building



Plan of a Typical Building

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Wall: Reinforced concrete	Wall: Characteristic Strength-30-35 MPa (cube compressive strength) 390 MPa (steel yield strength) Mix Proportion/Dimensions-variable, depending on the type of ingredients in the mix
Foundations	Reinforced concrete	Characteristic Strength: 10-15 MPa (cube compressive strength) 295 MPa (Steel yield strength) Mix Proportion/Dimensions: variable, depending on the type of ingredients in the mix
Floors	Reinforced concrete	Characteristic Strength: 30-35 MPa (cube compressive strength) 390 MPa (steel yield strength) Mix Proportion/Dimensions:

		variable, depending on the type of ingredients in the mix
Roof	Reinforced concrete	Characteristic Strength: 30-35 MPa (cube compressive strength) 390 MPa (steel yield strength) Mix Proportion/Dimensions: variable, depending on the type of ingredients in the mix
Other		

Design Process

Who is involved with the design process?	EngineerArchitectOther
Roles of those involved in the design process	Designs were prepared by specialized design institutes with expertise in this construction practice. Design for this construction type was done completely by engineers and architects. Engineers played a leading role at each stage of construction.
Expertise of those involved in the design process	Expertise related to the design and construction of this building type according to the building regulations of Kyrgyzstan was available.

Construction Process

Who typically builds this construction type?	BuilderOther
Roles of those involved in the building process	Construction is performed by builders. Design (construction) documents are developed in the design institutes.
Expertise of those involved in building process	Expertise related to the design and construction of this building type according to the building regulations of Kyrgyzstan was available.
Construction process and phasing	Specialized construction companies fabricate precast concrete elements and perform casting of concrete in-situ. Precast elements are made at the factory. Main construction equipment includes crane, welding equipment and concrete mixers. This building is not typically constructed incrementally and is designed for its final constructed size.
Construction issues	Poor quality of construction and inadequate concrete strength.

Building Codes and Standards

Is this construction type address by codes/standards?	Yes
Applicable codes or standards	SNiP II-7-81. Building in Seismic Regions. Design code. The first and most recent code/standard addressing this type of construction was issued 1981.
Process for building code enforcement	Building permit is issued if design documents have been approved by State Experts. The State Experts check for compliance of design documents with pertinent Building Codes. According to the building bylaw, a building cannot be used without the formal approval.

Building Permits and Development Control Rules

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

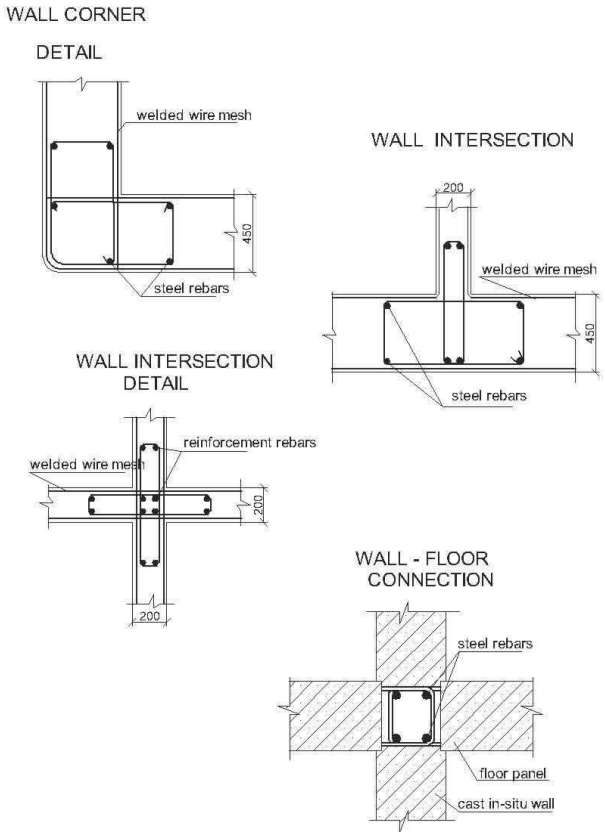
Building Maintenance and Condition

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

Construction Economics

Unit construction cost	For load-bearing structure only: about 150 US$/sq m.
Labor requirements	It would take 10 to 18 months for a team of 15 workers to construct a load-bearing structure for a building of this type.

Additional comments section 3	



Wall Details

Socio-Economic Issues

Patterns of occupancy	Each floor in a building has 4-8 housing units. One family occupies one housing unit. Depending on the number of stories, 20 to 90 families occupy one building.
Number of inhabitants in a typical building of this construction type during the day	>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	60% poor and 40% 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 savingsInformal network: friends or relatives
Additional comments on financing	Until 1990 (the breakdown of the Soviet Union), the main source of financing for buildings of this type had been provided by the Government. At the present time, all new and existing apartment buildings are privately owned.
Type of Ownership	RentOwn outrightUnits owned individually (condominium)
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	Buildings of this type have not been subjected to the effects of damaging earthquakes in Kyrgyzstan as of yet. However, many existing buildings of this type in Kichinev, Moldova, were exposed to an earthquake of intensity 8 on the MSK scale. Many of these 12-story buildings suffered damage in piers at the lower stories due to the poor quality of concrete construction.
Additional comments on earthquake damage patterns	The most common type of damage includes concrete crushing and spalling at the locations of construction joints, as well as the inclined diagonal cracks in the wall piers (due to the shear failure). Severe damage and collapse is not expected.

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	TRUE

	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.	TRUE
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.	TRUE
Wall-Roof Connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.	TRUE
Wall Openings		TRUE
Quality of Building Materials	Quality of building	FALSE

	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 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).	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	Poor quality of concrete, especially at the location of construction joints; the "as constructed" reinforcement locations do not match with the design locations; inadequate length of lap splices in steel rebars; inadequate confinement in highly stressed areas.
Earthquake-resilient features in walls	The load-bearing structure (consisting of walls and slabs) represents a rigid box system favorable for resisting lateral load effects.
Seismic deficiency in frames	
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	

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
Poor quality of concrete (especially at the lower part of the building); poor quality of construction joints	Reinforced concrete jacketing, shotcreting

Additional comments on seismic strengthening provisions	
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 damages?	N/A
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 Buildings Vulnerability in Post-Soviet Central Asia Republics. Edited by Stephanie A. King, Vitaly I. Khalturin and Brian E. Tucker. Kluwer Academic Publishers, P.O. Box 17, 3300 AA Dordrecht, The Netherlands. (Proceeding of the NATO Advanced Research Workshop on Earthquake Risk Management Strategies for Post-Soviet Central Asian Republics. Almaty, Kazakhstan, 22-25 October 1996)

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

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