World Housing Encyclopedia

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

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HOUSING REPORT
Reinforced concrete frame buildings without beams (seria KUB).

Report #	39
Report Date	05-06-2002
Country	KYRGYZSTAN
Housing Type	Precast Concrete Building
Housing Sub-Type	Precast Concrete Building : Moment frame
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Summary

Frame buildings without beams were introduced in the last decade of the Soviet Union (period 1980-1989) in some of the Soviet Republics: Kyrgyzstan, Tadjikistan, Caucasian region of Russia etc. This type of precast construction is known as seria KUB. This type of apartment

buildings is usually 5-9 stories high; in some cases these buildings are 12 stories high. The load-bearing structure consists of precast reinforced concrete columns and slabs. Precast column elements are usually two stories high. Typically, column spans are equal to 6m. Precast slab elements are made of solid concrete without ribs, and the dimensions are: 3 m x 3 m X 0.16 m (length X width X thickness). Most buildings of this type have some kind of lateral load resisting elements, such as: cast-in-situ shear walls, or precast shear walls, or shear cross braces etc. All precast structural elements are combined in 3-D moment frame by means of a special joint system. Partitions are made of brick masonry or small concrete block masonry. This building type is considered to be very vulnerable in earthquakes. The seismic resistance of buildings of this type depends on the type of column-to-slab joints. Similar structures were damaged in the 1988 Spitak (Armenia) earthquake.

1. General Information

Buildings of this construction type can be found in Duchanbe (Tadjikistan), Nalchik (Russia), and Almaty (Kazachstan). There are some of these buildings in Bishkek (Kyrgyzstan). This type of housing construction is commonly found in urban areas. This construction type has been in practice for less than 25 years.

Currently, this type of construction is being built. .

Figure 1: Typical Building

Figure 2A: Key Load-Bearing Elements

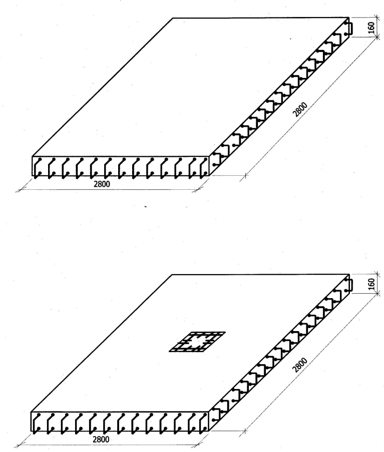

Figure 2B: Precast reinforced concrete slabs; a slab to be joined with a column is perforated with a hole at the center

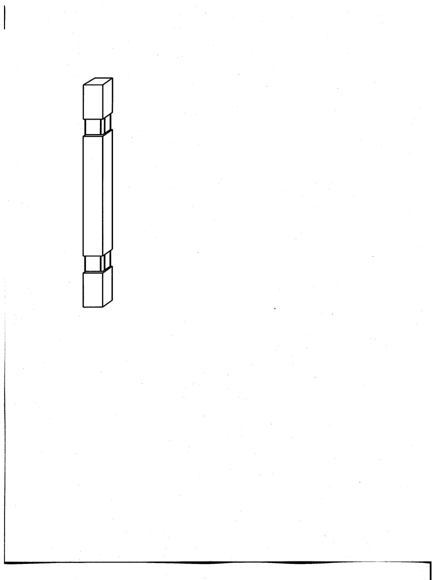

Figure 2C: Precast reinforced concrete column element; column contains grooves at the slab location

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat terrain. They do not share common walls with adjacent buildings. Usually, this is the minimum distance between 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 or square with some modifications at the perimeter. Walls are not the part of load-bearing structure in frame buildings without beams. If lateral load-resisting elements (e.g. shear walls) are present, the overall wall area usually does not exceed 1% of the floor area. These shear elements are solid (without openings), and are usually located between columns inside the building. Typical size of window openings is: 1.2 to 1.5 m (height) X 2 m (width), doors: 2m (height) X 0.9-1 m (width). Overall window area constitutes up to 30 or 40% of the exterior wall area. Less than 10% of the partition walls are perforated by door openings.

2.3 Functional Planning

The main function of this building typology is multi-family housing. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. There is one stair in one building unit. Building unit consists of 2-6 apartments (housing units) at each floor level. Each building contains 1-4 building units.

2.4 Modification to Building

Usually, modifications are made in non-load-bearing elements e.g. exterior and interior walls.

PLAN

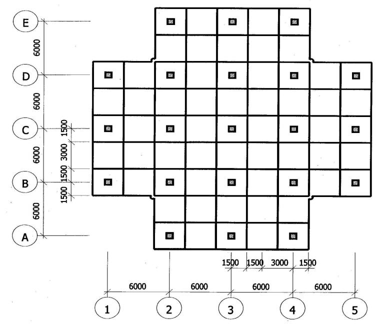

Figure 3: Plan of a Typical Building

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	☐
	Moment resisting frame	17	Flat slab structure	☐
		18	Designed for gravity loads only, with URM infill walls	☐
		19	Designed for seismic effects, with URM infill walls	☐
			Designed for seismic effects,	

		20	with structural infill walls	☐
		21	Dual system – Frame with shear wall	☐
Structural concrete	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)	☐

Shear walls usually do not exist in buildings of this type.

3.2 Gravity Load-Resisting System

The vertical load-resisting system is reinforced concrete moment resisting frame. Gravity load-bearing structure consists of reinforced concrete columns and slabs (same elements as in lateral load-resisting system).

3.3 Lateral Load-Resisting System

The lateral load-resisting system is reinforced concrete moment resisting frame. Lateral load-resisting system consists of reinforced concrete columns and slabs. In addition to this, most buildings of this type have some kind of lateral load resisting elements, such as: cast-in-situ shear walls, or precast shear walls, or shear cross braces etc. In case lateral load-resisting elements (shear walls etc.) are not present, lateral load path depends on the ability of slab-column connections to transfer moments. In case of poorly constructed connections this is not possible and in such cases completeness of lateral load path is questionable. However, properly constructed slab-column joints are capable to transfer moment as shown by several full-scale vibration tests on buildings of this type performed in Kyrgyz Republic. Precast column elements are usually two-story high. Typically, column spans are equal to 6 m. A typical precast column element is shown on FIGURE 2C. Precast slab elements are made of solid concrete without ribs, and the dimensions are: 3 m X 3m X 0.16 m (length X width X thickness). A typical precast slab element is shown on FIGURE 2B. All precast structural elements are combined in a space frame system by means of special joints. The assembly of precast concrete elements is shown on FIGURE 2A and FIGURE 5. Precast concrete floor slabs are lifted from the ground up to the final elevation. Longitudinal steel bars-dowels have been projected from the adjacent slabs and subsequently welded. Transverse reinforcement bars are installed in-situ. Gaps in the connections are filled with concrete at the site. Details of the slab-column connection are shown on FIGURE 4.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 24 and 60 meters, and widths between 18 and 24 meters. The building has 5 to 12 storey(s). The typical span of the roofing/flooring system is 6 meters. Typical Number of Stories: 9. The typical storey height in such buildings is 3 meters. The typical structural wall density is none. Walls are not load-bearing structures. If present, shear elements constitute less than 1% of the floor area in a building.

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	☐

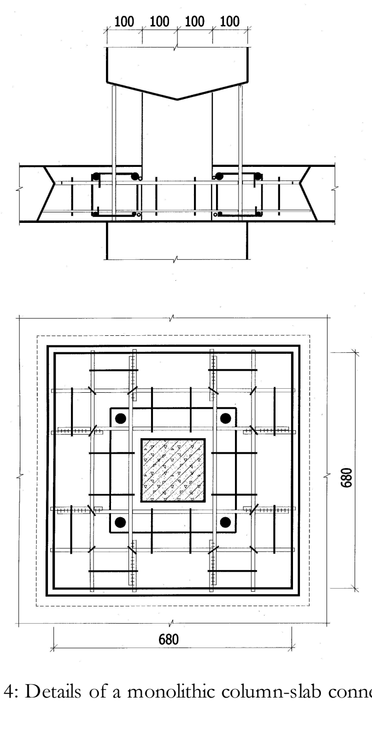

Figure 4: Details of a monolithic column-slab connection


Figure 5:Building under construction

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 21-50 housing unit(s). 36 units in each building. Ranges from 10 to 120, commonly equal to 36. The number of inhabitants in a building during the day or business hours is more than 20. The number of inhabitants during the evening and night is more than 20.

4.2 Patterns of Occupancy

Each floor in a building unit consists of 2-6 housing units. One family occupies one housing unit. Depending on the number of building units and stories in a building, number of families occupying one building ranges from 10 to 120; with a common occupancy of 36 to 40 families 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)	☐

It is estimated that 60% poor inhabitants and 40% middle class inhabitants occupy buildings of this type.

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 1 bathroom(s) without toilet(s), no toilet(s) only and 1 bathroom(s) including toilet(s).

4.4 Ownership

The type of ownership or occupancy is renting, outright ownership and individual 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	Walls are generally partitions (i.e. non load-bearing structures). Poor quality of walls and their joints with columns and floors.		Complete or partial damage.
Frame (columns, beams)	Poor quality of joints.		
Roof and floors	Roof and floor slabs are load-bearing structures. The most deficient part is slab-column joint.		Collapse of floors, damage of joint areas.

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *B: MEDIUM-HIGH VULNERABILITY (i.e., 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 *C: MEDIUM VULNERABILITY (i.e., moderate 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**
1988	Spitak, Armenia	7.5	IX

Buildings of this type (seria KUB) were not exposed to a major earthquake as yet. However, buildings with a similar load-bearing structure (seria 111) had experienced severe damage or collapse in the 1988 Spitak (Armenia) earthquake. The main cause was considered to be damage and failure of column-slabs joints. The difference between the seria KUB and seria 111 is in the floor slab construction. Seria KUB consists of the smaller floor panels that are joined together in the erected position (see FIGURE 2A). Floor slabs in the seria 111 were large panels cast on the ground and then lifted and erected to the final position. It is expected that these two construction types would experience similar earthquake damage.

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Brick and gasconcrete masonry.	Non bearing structure		
Foundation	Reinforced concrete.	10-15 MPa (cube compressive strength).		
Frames (beams & columns)				
Roof and floor(s)	Reinforced concrete.	30-35 MPa (cube compressive strength).		

6.2 Builder

Anyone can live in buildings of this construction type.

6.3 Construction Process, Problems and Phasing

The construction process is performed by builders. Design institutes develop design documentation. A construction company fabricates precast elements and performs the assembly. Precast elements can be made either at the factory (plant) or at the building site. The main construction equipment includes crane, welding equipment and concrete mixers. The construction of this type of housing takes place in a single phase. Typically, the building is originally designed for its final constructed size.

6.4 Design and Construction Expertise

Expertise related to design and construction of this type according to the legal system of Kyrgyzstan was available. Designs for buildings of this type were prepared by specialized design institutes with expertise in this type of construction. Design for this construction type was done completely by engineers and architects. Engineers played a leading role in each stage of construction.

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. SNiP II-7-81. Building in Seismic Regions. Design code. The year the first code/standard addressing this type of construction issued was 1981. The most recent code/standard addressing this construction type issued was 1981. Title of the code or standard: SNiP II-7-81. Building in Seismic Regions. Design code. Year the first code/standard addressing this type of construction issued: 1981 When was the most recent code/standard addressing this construction type issued? 1981.

Building permit will be given if the design documents have been approved by the State Experts. State Experts check the compliance of design documents with the pertinent Building Codes. According to the building bylaws, building cannot be used without the formal approval by a special committee. The committee gives the approval if design documents are complete and the construction has been carried out in compliance with the Building Codes.

6.6 Building Permits and Development Control Rules

This type of construction is an engineered, and authorized as per development control rules. Building permits are required to build this housing type.

6.7 Building Maintenance

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

6.8 Construction Economics

For load-bearing structure only (without finishes) about 120 US$/m². It would take between 10 and 15 months for a team of 10 workers to build load-bearing structure for a building of this type.

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

Strengthening of Existing Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Column-slab joint	Steel and reinforced concrete cantilever.

Strengthening of New Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Column-slab joint	Improved design solutions for column-slab joint.
Floor slabs	Construction of ribbed slabs. Increased slab thickness.

8.2 Seismic Strengthening Adopted

8.3 Construction and Performance of Seismic Strengthening

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