# 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
# Load-bearing wall buildings protected with the "sliding belt" base isolation system

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|---|---|
| **Report #** | 76 |
| **Report Date** | 05-06-2002 |
| **Country** | KYRGYZSTAN |
| **Housing Type** | Seismic Protection Systems |
| **Housing Sub-Type** | Precast Concrete Building : Large Panel Precast Walls |
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## Summary


Sliding belt is a base isolation system developed to protect buildings from seismic effects by reducing and limiting the level of seismic forces. The sliding belt system is installed at the base of the building between the foundation and the superstructure. The foundation is usually made

of cast-in-situ concrete and the superstructure is typically a load-bearing wall structure, either a 9-story, large concrete panel system, or a 3-story brick masonry construction. Once the earthquake base shear force exceeds the level of friction force developed in the sliding belt, the building superstructure starts to slide relative to the foundation. The lateral load transferred to the superstructure is expected to be approximately equal to the frictional force that triggers the sliding of the structure. The sliding belt consists of the following elements: (a) sliding supports, including 2-mm-thick stainless steel plates attached to the foundation and 4-mm Teflon (PTFE) plates attached to the superstructure, (b) reinforced rubber restraints for horizontal displacements (horizontal stop), and (c) restraints for vertical displacements (uplift). A typical large panel building with plan dimensions 39.6 m x 10.8 m has 63 sliding supports and 70 horizontal and vertical restraints. The sliding belt scheme was developed in CNIISK Kucherenko (Moscow) around 1975. The first design application in Kyrgyzstan was made in 1982. To date, the system has been applied on over 30 buildings in Bishkek, Kyrgyzstan. All these buildings are residential buildings and are presently occupied. Base-isolated buildings of this type have not yet been exposed to the effects of damaging earthquakes.

# 1. General Information

Buildings of this construction type can be found in Kyrgyzstan. There are about 30 base isolated buildings in Bishkek (Kyrgyzstan). In 1982, two 3-story brick masonry wall buildings were built in the area with high seismicity (9-10 per MSK scale). A residential block (microdistrict) of 9-story concrete large panel buildings protected with seismic isolation belt was built in the period 1983-1990. Several 9-story large panel concrete buildings were built in the center of Bishkek. One of the buildings is also equipped with a dynamic damper. Some buildings with seismic isolation belt were built in Kazakhstan and Russia (Kamchatka). 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 1A: Typical Building

Figure 1B: Typical Building

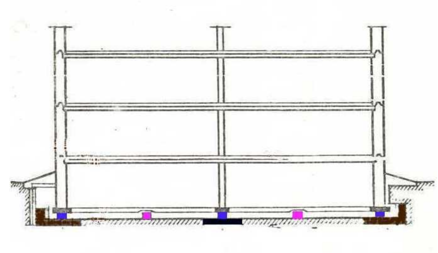

Figure 2: Key Load-Bearing Elements

# 2. Architectural Aspects

## 2.1 Siting

These buildings are typically found in flat 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 of this housing type is rectangular. Wall openings are same as in typical large panel buildings. Usually, for a 3.6m long panel, a window size is 1.82 m (width) X 1.53 m (height); for 2.7 m long panel - window size is 1.24 m (width) X 1.53 m (height). The size of a door is 0.9 m (width) X 2 m (height). The size of a balcony door (together with window) is either 2.25 m or 1.66 m (width) or and 1.9 m (height). Overall window and door areas make up to 20% of the overall wall area. There are 16 windows for a building with 10.8m x 25.2m plan dimensions.

## 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 (with average plan dimensions 10.8 m X 12.6 m).

## 2.4 Modification to Building

Typical patterns of modification include the perforation of walls with door openings and the creation of door opening instead of the window.

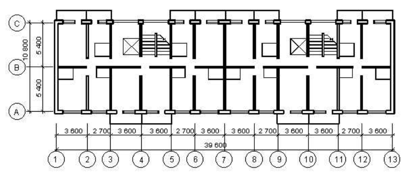


Figure 3: Typical Floor Plan

# 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 | ☐ |
| | | | Concrete block masonry in | |

| | | | | |
|---|---|---|---|---|
| | | 16 | cement mortar | ☐ |
| Structural concrete | 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 | ☐ |
| | | 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) | ☐ |

## 3.2 Gravity Load-Resisting System

The vertical load-resisting system is others (described below). Gravity load-bearing structure is a conventional building construction, either large panel construction or brick masonry construction. Majority of base isolated buildings of this type are large panel concrete buildings with monolithic joints (seria 105). This construction type was described in detail in another contribution from Kyrgyzstan (by S. Uranova and U. Begaliev). Brick masonry buildings are 3-story high and are equipped with the reinforced concrete members and steel mesh, typical for brick masonry construction in the former Soviet Union. It should be noted, however, that the construction of conventional 3-story high brick masonry construction was otherwise not permitted in high seismic zones (intensity 9 to 10 on the MSK scale).

## 3.3 Lateral Load-Resisting System

The lateral load-resisting system is others (described below). Lateral load-resisting system includes the superstructure (e.g. large reinforced concrete panel construction or brick masonry construction) and the foundation. The sliding belt is installed at the base of the building, between the foundation and the superstructure. The sliding belt consists of the following elements: a) sliding supports, including the stainless steel plates attached to the foundation and the Teflon (PTFE) plates attached to the superstructure, b) reinforced rubber restraints for horizontal displacements (horizontal stop), and c) restraints for vertical displacements (uplift). The steel plates are 2 mm thick; the plate width is approximately equal to the foundation width, and the length depends on the size of the Teflon plate located at the center (usually projects by 150 mm on each side). The dimensions of Teflon plates are usually 400 mm x 400 mm for 9-story buildings and 200 mm x 200 mm for 5-story buildings; typical plate thickness is 4 to 6 mm. Horizontal stops consist of rigid reinforced structure with steel plates and a rubber damper. Vertical stops consist of steel anchor bolts. A typical large panel building (plan dimensions 39.6m x10.8 m) is equipped with 63 sliding supports and 70 horizontal and vertical restraints. A gap between rubber damper and sliding support for a 9-story building is usually 50 mm; this means that the horizontal stops will be activated once the building has moved by 50 mm in the horizontal direction. The recommended #seismic gap" ranges from 100 to 120 mm. In buildings constructed in Bishkek 300 mm gap was provided. No special provisions were made for flexible water supply and electrical facilities in the buildings protected with this system. Once the earthquake base shear force exceeds the level of frictional force developed in the sliding belt (approximately equal to 10% of the building weight), the building (superstructure) starts to slide relative to the foundation. The design recommendations state that the frictional coefficient value for Teflon-steel sliding is 0.1 (unless a different value is obtained by the tests). However, it should be noted that once the sliding is initiated, building continues to vibrate and restraints get activated as well. The analysis is based on rather complex formulas based of research studies that have been modified for the design practice. Simplified design calculations are not commonly used in the design of this construction type; comprehensive analysis is deemed required. Seismic design of the superstructure is performed based on the results of the dynamic analysis. The level of seismic forces (seismic demand) is reduced as compared to the conventional buildings by up to 50%. The sliding belt scheme was developed by CNIISK Kucherenko in Moscow around 1975; other institutes in the former Soviet Union also contributed to the development. Late L. S. Kilimnik was the leader in the development of the seismic belt system. The first design applications of seismic belt scheme were made in Bishkek in 1982. Two types of tests, static tests under horizontal loads and dynamic tests of full-scale buildings using the vibration equipment were conducted in 1980. The design recommendations for base isolated buildings of this type were developed based on the results of these tests.

## 3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 50.4 and 50.4 meters, and widths between 10.8 and 10.8 meters. The building is 9 storey high. The typical span of the roofing/flooring system is 2.7 meters. Typical Span: For cross walls: 3.6 m or 2.7 m. For longitudinal walls: 5.4 m. The typical storey height in such buildings is 3 meters. The typical structural wall density is up to 20 %. Total wall area/plan area is about 0.14. Wall density in two principal directions is not equal; in one of the directions wall density is less by 20 to 30% as compared to the other direction.

## 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 | ☐ |

Foundation indude seismo-isolation sliding belt.

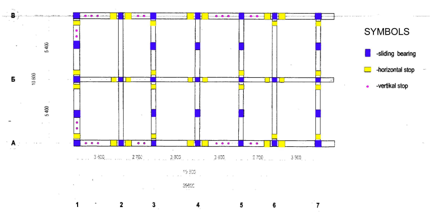


Figure 3A: Ground Floor Plan Showing Locations of Base Isolation Devices

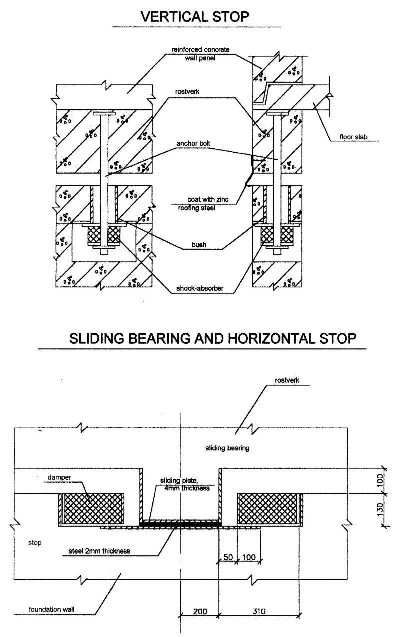


Figure 4: Critical Structural Details - Base Isolation Devices

# 4. Socio-Economic Aspects

## 4.1 Number of Housing Units and Inhabitants

Each building typically has 51-100 housing unit(s). 60 units in each building. Typical range from 32 - 64 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

In general, in a building of this type there are 3 - 4 housing units per building unit ("Block-Section"). One family occupies one housing unit. Depending on the size of the building (number of stories), 32 to 64 families occupy one 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) | ☐ |

50% poor, and 50% 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) | ☐ |

Until 1990 (the breakdown of the Soviet Union), the 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. In each housing unit, there are no 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) | ☐ |

These buildings were constructed at the time of the former Soviet Union and the construction was sponsored by the Government. However, at the present time all apartments are owned by the residents.

## 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:<br><br>Less than 25 (concrete walls);<br><br>Less than 30 (reinforced masonry walls);<br><br>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:<br><br>For brick masonry construction in cement mortar : less than ½ of the distance between the adjacent cross walls;<br><br>For adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls;<br><br>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 | Application to large panel construction - Panel joints; quality of construction, especially welding of reinforcing bars from the adjacent panels and filling the gaps between the panels with concrete is not satisfactory in some cases. | Due to a large number and uniform distribution of panel joints existing in one building, deficient construction of some joints does not have a major impact on the overall seismic resistance in the building as a whole. | Damage of bearing structures of upper floors less then in similar buildings without Seismic protection system |
| Roof and floors | is within the panel joints; quality of construction, especially welding of reinforcing bars from the adjacent panels and filling the gaps between the panels with concrete is not satisfactory in some cases. | include a large number and uniform distribution of panel joints existing in one building, deficient construction of some joints does not have a major impact on the overall seismic resistance in the building as a whole. | |
| | | The sliding belt is efficient in reducing the level of seismic forces in the building | |

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| | | | |
| | | | |

### 5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *E: LOW VULNERABILITY (i.e., very good seismic performance)*, the lower bound (i.e., the worst possible) is D: MEDIUM-LOW VULNERABILITY (i.e., good seismic performance), and the upper bound (i.e., the best possible) is *F: VERY LOW VULNERABILITY (i.e., excellent 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 |
|---|---|---|---|

This building type was tested by special vibration equipment that applied loads equal to design seismic loads.

# 6. Construction

### 6.1 Building Materials

| Structural element | Building material | Characteristic strength | Mix proportions/dimensions | Comments |
|---|---|---|---|---|
| Walls | Reinforced concrete | Concrete: 30-35 MPa ( cube compressive strength) Steel: 390 MPa (steel yield strength) | | |
| Foundation | Reinforced concrete | Concrete: 10-15 MPa (cube compressive strength) Steel: 295 MPa (Steel yield strength) | | |
| Frames (beams & columns) | | | | |
| Roof and floor(s) | Reinforced concrete | Concrete: 30-35 MPa (cube compressive strength) Steel: 390 MPa (Steel yield strength) | | |

### 6.2 Builder

Anyone can live in buildings of this construction type.

### 6.3 Construction Process, Problems and Phasing

Construction is performed by builders. Designs are developed in the design institutes. Specialized construction companies make precast concrete elements and perform casting of concrete in-situ. Precast elements are fabricated at the plants. In case of precast foundation and superstructure construction, steel and Teflon plates are installed at the plant. Horizontal restraints (rubber dampers) and vertical restraints are installed at the site. The main construction equipment is the same as in the case of conventional concrete construction and it 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

The expertise required for the design and construction of this type is available. Building designs were prepared by design institutes. The academic background of the designers is the same as for conventional construction. It is not required to have designers with high academic degrees e.g. M.Sc. and Ph.D. on the team. Construction of base isolated buildings and the approval of the designs were controlled by research institutes (State Experts) like any other new construction performed in accordance with the Building Code requirements. Design of buildings of this construction type was done completely by engineers and architects. Researchers also participated in the development of design documentation. 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. SNiP II-7-81. Building in Seismic Regions. Design code. CNIISK. Recommendations for Design of Buildings with Seismic Isolation Belt and Dynamic Vibration Dampers, Moscow, 1984. 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 National building code, material codes and seismic codes/standards: SNiP II-7-81. Building in Seismic Regions. Design code. CNIISK. Recommendations for Design of Buildings with Seismic Isolation Belt and Dynamic Vibration Dampers, Moscow, 1984. 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 (including the seismic belt) the cost is about 230 US$/m². For a similar prefabricated concrete panel building (seria 105) without a seismic belt the construction cost would be 50-200 US$/m². Therefore, the increase in unit cost due to the installation of seismic belt is in the range from 15 to 50 %. It would take from 8 to10 months for a team of 15 workers to construct a load-bearing structure.

## 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

## 8.2 Seismic Strengthening Adopted

Has seismic strengthening described in the above table been performed in design and construction practice, and if so, to what extent?

No. Buildings of this type are already strengthened by means of seismic belt.

Was the work done as a mitigation effort on an undamaged building, or as repair following an earthquake?

N/A.

## 8.3 Construction and Performance of Seismic Strengthening

Was the construction inspected in the same manner as the new construction?

N/A.

Who performed the construction seismic retrofit measures: a contractor, or owner/user? Was an architect or engineer involved?

N/A.

What was the performance of retrofitted buildings of this type in subsequent earthquakes?

N/A.

# Reference(s)


1. Recommendations for Design of Buildings with Seismic Isolation Belt and Dynamic Vibration Dampers
   CNIISK, Moscow 1984

2. Seismic Hazard and Buildings Vulnerability in Post-Soviet Central Asia Republics
   King,S.A., Khalturin,V.I. and Tucker,B.E.
   Proceedings of the NATO Advanced Research Workshop on Earthquake Risk Management Strategies for Post-Soviet Central Asian Republics, Almaty, Kazakhstan, Kluwer Academic Publishers, Dordrecht, Netherlands 1999

3. Building and Construction Design in Seismic Regions-Handbook
   Uranova,S.K., and Imanbekov,S.T.
   Kyrgyz NIIP Stroitelstva, Building Ministry Kyrgyz Republic, Bishkek, Kyrgyz Republic (in Russian) 1996

4. Seismoisolation in Russia and former USSR Countries: Recent Developments
   Eisenberg, J.
   Proceedings of the International Post-SMiRt Conference Seminar, Cheju, Korea, Korea Earthquake Engineering Research Center, Seoul, Korea, Vol.1, p. 99-115 1999

5. Applications of Seismic Isolation in the USSR

Eisenberg, J.
Proceedings of the Tenth World Conference on Earthquake Engineering, Balkema, Rotterdam, Vol.4, p. 2039-2044 1992

6. Operating Experience in Designing and Construction of the System of Special Seismic Isolation of Buildings and Constructions in the former Russia
Eisenberg,J. and Bealiev,V.S.
Proceedings of the Eleventh World Conference on Earthquake Engineering, Pergamon, Elsevier Science Ltd., Oxford, England, Disc 1, Paper No. 263 1996

7. Experimental Buildings with Seismic Protection in Petropavlovsk-Kamchatskiy (in Russian)

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