World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

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

HOUSING REPORT

Precast reinforced concrete frame panel system of seria IIS-04

Report#	66
Last Updated	
Country	Uzbekistan
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Important

A, Martin & Associates, Inc. or the participant’s organizations.

General Information

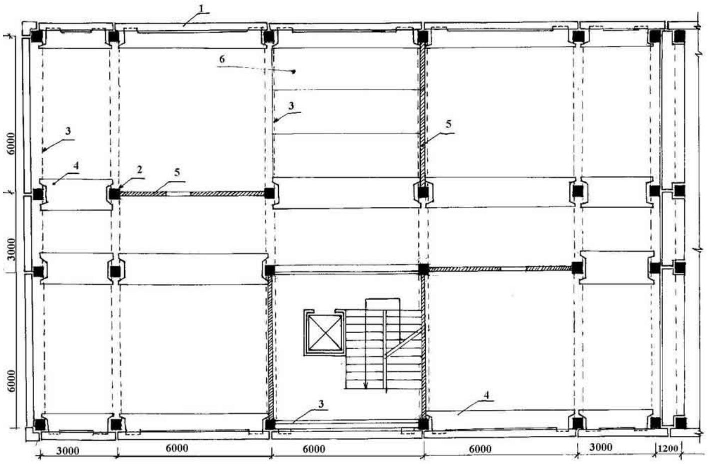
Building Type:	Precast reinforced concrete frame panel system of seria IIS-04
Country:	Uzbekistan
Author(s):	Shamil Khakimov Bakhtiar Nurtaev
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in Tashkent and other cities of Uzbekistan and Central Asia. In Tashkent, this housing type accounts for over 18% of the residential building stock and for over 25% of the public building stock. This type of housing construction is commonly found in urban areas.
Summary:	This housing type is used in the construction of residential and public buildings in many cities throughout Uzbekistan (including the capital city Tashkent) that are located in zones with intensities between 7-9. Residential buildings of this type are generally 9 to 12 stories high, whereas public buildings of the same construction are 1 to 4 stories high. All seismic loadresisting (and also nonstructural) components, e.g., foundations, columns, girders, slabs, staircases, wall panels, etc., are manufactured in specialized plants. The materials are subsequently transported to the building site. The positive features of this construction type are (1) the ability to manufacture all building materials in an industrialized setting, and (2) the gain in efficiency inasmuch as the same building components may be used both for residential and public buildings. The key drawback is that the welded joints cause seismic vulnerability when the building is located in zones of extremely high seismic loads. These joints have shown extremely brittle behavior during earthquakes. Earthquake damage is mainly concentrated in the column joints, or in the column-to-girder joints. In some cases non-bearing walls and exterior wall panels have collapsed.
Length of time practiced:	25-60 years

Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Residential, 50+ units
Typical number of stories:	9-12
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	This traditional construction practice has been followed for over 35 years. The frame panel seria IIS-04 was first used in 1973.

Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	
Typical plan length (meters)	24
Typical plan width (meters)	15
Typical story height (meters)	3
Type of Structural System	Structural Concrete: Precast Concrete: Moment frame
Additional comments on structural system	The vertical load-resisting system is reinforced concrete moment resisting frame. The gravity load-bearing structure consists of reinforced concrete frame, including precast columns and beams and precast floor panels. The lateral load-resisting system is reinforced concrete moment resisting frame. The lateral load-resisting system is reinforced concrete frame, which consists of precast columns and beams and cast in-situ or precast concrete shear walls. Precast frame elements are joined together in the space frame structure. Shear walls may be made of precast panels or cast in-situ elevator cores in the taller buildings of this type (e.g., 12-story buildings). In medium-rise buildings of this type (e.g., 4-5 stories), the entire lateral load-resisting system consists of a RC frame only (i.e., shear walls are not present). Precast floor panels are joined in a rigid diaphragm for the distribution of lateral forces.

Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	4-5%
Typical wall densities in direction 2	4-5%
Additional comments on typical wall densities	The typical structural wall density is up to 5%.
Wall Openings	Usually a rectangular plan. In this housing type, the main load-bearing elements are the columns, beams and joints (a frame structure). Therefore, seismic vulnerability does not depend on the number and size of the openings. The size of the windows and doors ranges from 2.25 m to 4.5 m.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	Minor modifications of interior partition walls may be done by the owners.
Type of Foundation	Shallow Foundation: Reinforced concrete isolated footingShallow Foundation: Reinforced concrete strip footing
Additional comments on foundation	
Type of Floor System	Other floor system
Additional comments on floor system	Structural concrete: Hollow core slab (precast)
Type of Roof System	Roof system, other
Additional comments on roof system	Structural concrete: Hollow core slab (precast)
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 30 meters. Typical Plan Dimensions: Typical plan dimensions: 18x18m, 12x36m, 15x24m Typical Span: The typical span may be either 6 or 3 meters.



Plan of a Typical Building

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Partition Walls: Reinforced concrete Wall panels (vertical diaphragms): Reinforced concrete	Wall panels (vertical diaphragms): 30 MPa (cube compressive strength) Partition Walls: These walls are not lateral load-resisting elements Mix - 1: 1.5: 2.4: 0.45 Dimensions 6000 X 1500 X 250 (mm) Wall panels (vertical diaphragms): Mix- 1: 1.75: 3.21: 0.51 Dimensions 5600 X 140 X 3280 (mm)
Foundations	Reinforced concrete	10-15 MPa (cube compressive strength) Mix- 1: 1,4: 2: 0,49 Dimensions: 1400 X 1400 X 900 (mm)
Floors	Reinforced concrete	30 MPa (cube compressive strength) Mix- 1: 1.75: 3.24: 0.44 Dimensions : 6000 X 220 X 1600 (mm)
Roof	Reinforced concrete	30 MPa (cube compressive strength) Mix- 1: 1.75: 3.24: 0.44 Dimensions : 6000 X 220

		X 1600 (mm)
Other	Column: Reinforced concrete Girder: Reinforced concrete	Column: 40 MPa (cube compressive strength) Girder: 40 MPa (cube compressive strength) Column: 1: 2: 3: 0.5 Cross sectional dimensions: 400 X 400 (mm) X height (3300 -13500 mm) Girder: Mix- 1: 1.4: 2.8: 0.49 Cross-sectional dimensions: 420 X 480 (mm)

Design Process

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

Construction Process

Who typically builds this construction type?	OwnerBuilderOther
Roles of those involved in the building process	A builder may live in this construction type, and his children may attend the schools housed in buildings of this type. Typically, frame panel buildings are constructed by order of the municipality.
Expertise of those involved in building process	
Construction process and phasing	Based on the order of the government, a design agency develops a series of industrialized construction elements. Based on the information provided by the design agency, a concrete plant prepares a set of metal forms for the columns, girders, diaphragms, slabs, wall panels, staircases, etc., corresponding to the requirements of a series. Based on the order of a municipality or other clients, design firms develop designs of individual buildings or typical (standardized) building designs. A concrete plant manufactures and delivers all required building elements to the construction site.

	A construction company erects the building at the construction site. The main pieces of equipment used for the construction are a tower 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.
Construction issues	

Building Codes and Standards

Is this construction type address by codes/standards?	Yes
Applicable codes or standards	The construction is carried out based upon the catalogs of frame panel seria IIS-04 (developed in 1973), and upon the National Building Code of Uzbekistan: "Construction in Earthquake-prone Areas" (KMK.2.01.03-96). National Building Code, Material Codes and Seismic Codes/Standards; National Building Code of Uzbekistan: Construction in Earthquake-prone Areas (KMK.2.01.03-96). The most recent code/standard addressing this construction type issued was 1996.
Process for building code enforcement	Design of buildings using the seria IIS-04 is carried out in accordance with the National Building Code of Uzbekistan: Construction in Earthquake-prone Areas. All designs are reviewed by the State Expert Bureau of the State Committee on Architecture and Construction (SCAC); the revisions are incorporated in the final design (if required). Once the review is completed, the designs are forwarded to the concrete plants and the construction company. The concrete strength is evaluated in the laboratory in the concrete plant, and the reinforcement schedule is checked and compared with the design documents. Periodically (once in six months), the laboratory data are examined by a representative of the State Architecture Construction Control Department (SACC) of SCAC. SCAC also monitors the construction quality at the site. In addition to this, a representative of the design agency or firm also performs a site inspection. The builders should take into account the designer's comments made during the site inspection. Once the construction is complete, a special state expert committee needs to approve the building and to issue the building permit. Use and selection of the typical, standard production of series IIS-04 depend upon load conditions. Engineers and architects cannot change

	any construction details (joints, connections) in the existing series, which is approved by the government. Only the agency that has developed the series is able to change the details.

Building Permits and Development Control Rules

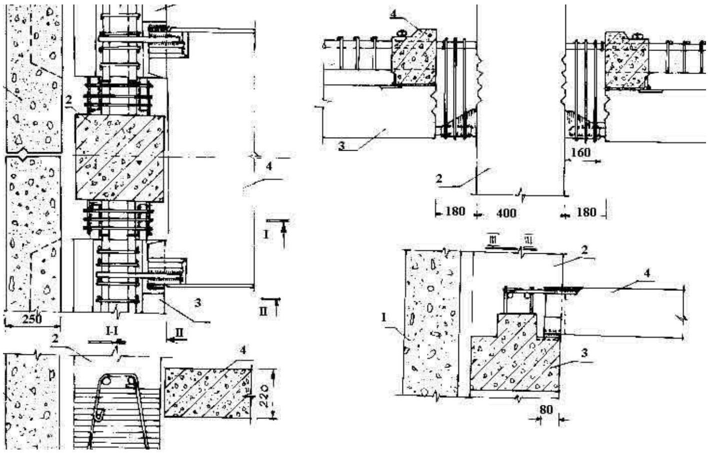
Are building permits required?	Yes
Is this typically informal construction?	No
Is this construction typically authorized as per development control rules?	Yes
Additional comments on building permits and development control rules	

Building Maintenance and Condition

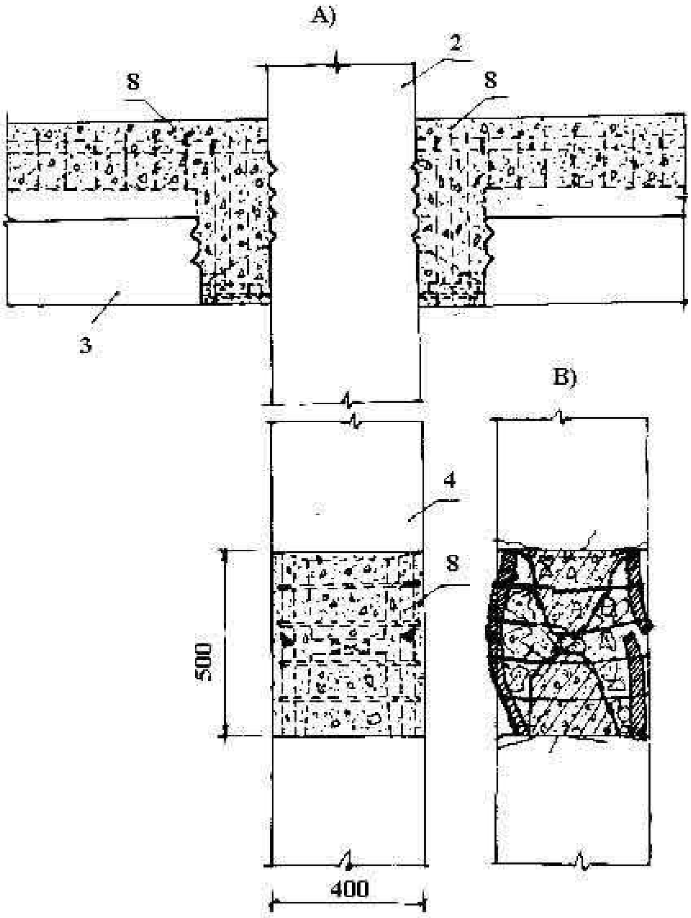
Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)Renter(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	33000 sum/m# (110 US$/m#).
Labor requirements	A 12-story residential building with 48 housing units and with plan dimensions18x18 m may be erected by 10 workers in 10 months.
Additional comments section 3	



Critical Structural Details



An Illustration of Key Seismic Features and/or Deficiencies

Socio-Economic Issues

Patterns of occupancy	It depends on the size of the multi-story building. Typically, over 60 families live in a 12-story building. Each building typically has 60 housing unit(s).
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	Ratio of housing unit price to annual income: 5:1 or

economic level of inhabitants	worse Economic Level: For Middle Class the Housing Price Unit is 5000 and the Annual Income is 720.
Typical Source of Financing	Commercial banks/mortgagesGovernment-owned housing
Additional comments on financing	
Type of Ownership	RentOwn outright
Additional comments on ownership	Almost 90% of the buildings are privately owned and 10% are rented from the local government.
Is earthquake insurance for this construction type typically available?	Yes
What does earthquake insurance typically cover/cost	The insurance covers approximately 30% of the construction cost.
Are premium discounts or higher coverages available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features?	Yes
Additional comments on premium discounts	
Additional comments section 4	

Earthquakes

Past Earthquakes in the country which affected buildings of this type

Year	Earthquake Epicenter
1984	Gazli
1988	Spitak (Armenia)

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	Buildings of this type were damaged during the 1988 Spitak earthquake, as illustrated in Figures 6 and 7.
Additional comments on earthquake damage patterns	Due to poor quality of wall-column and wall-beam joints, the walls may experience serious damage in an earthquake. Damage to beam-column joints Damage of horizontal panel joints and the subsequent loss of rigid diaphragm behavior Failure of precast diaphragm-to-frame connections.

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 the roof structure will maintain its integrity, i.e. shape and form, during an earthquake of	TRUE

	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.	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.	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 materials is considered	FALSE

	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	Precast floor panels are constructed w ith special grooves and steel dow els projected on all four sides for achieving the cast in-situ joint. This type of floor structure subjected to lateral loads w as tested in the lab. The roof diaphragm is considered to be rigid provided that the quality of construction is adequate.
Vertical irregularities typically found in this construction type	Other
Horizontal irregularities typically found in this construction type	Other
Seismic deficiency in walls	Exterior and interior partition walls are non-load-bearing (i.e., they carry their own weight only).
Earthquake-resilient features in walls	
Seismic deficiency in frames	The most vulnerable parts of a frame are beam-column joints; these welded joints are located in the area of extremely high loads. As a result of the welding, steel reinforcement bars may have loose ductility. Also, the concrete poured in these joints is often poorly vibrated.
Earthquake-resilient features in frame	

Seismic deficiency in roof and floors	The joints between the precast slabs (grouted in-situ) are sometimes not properly filled with grout and may lose their strength in an earthquake.
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	-|		

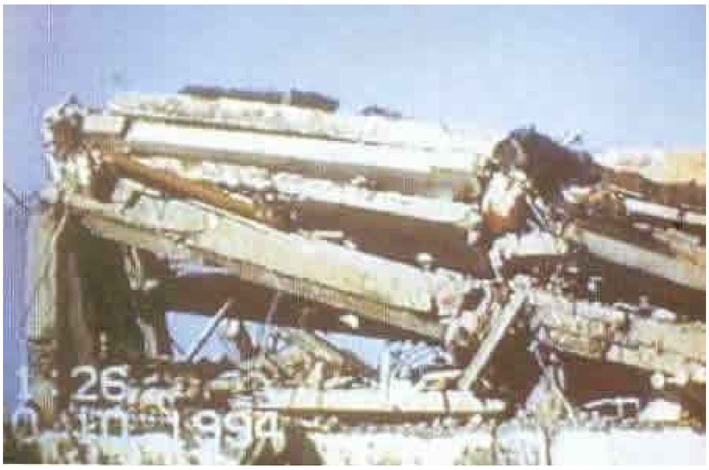
Building Damage in Leninakan (1988 Spitak, Armenia Earthquake)

Building Damage in Leninakan (1988 Spitak, Armenia Earthquake)

Building Damage (1988 Spitak, Armenia Earthquake)

Building Damage (1988 Spitak, Armenia Earthquake) Source: Klyachko 1999

Building Damage (1994 Shikotansk, Russia Earthquake) Source: Klyachko 1999



Building Damage (1994 Shikotansk, Russia Earthquake) Source: Klyachko 1999

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
Beam-column joints	Reinforcing of joints with steel plates
Frame (column)	Installation of additional (external) steel ties (straps)

Additional comments on seismic strengthening provisions	Seismic strengthening of a building in Tashkent is illustrated in Figures 12 and 13.
Has seismic strengthening described in the above table been performed?	Yes. Seismic strengthening was performed on some buildings in Tashkent.
Was the work done as a mitigation effort on an undamaged building or as a repair following earthquake damages?	
Was the construction inspected in the same manner as new construction?	
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	
Additional comments section 6	

Illustration of Seismic Strengthening Techniques

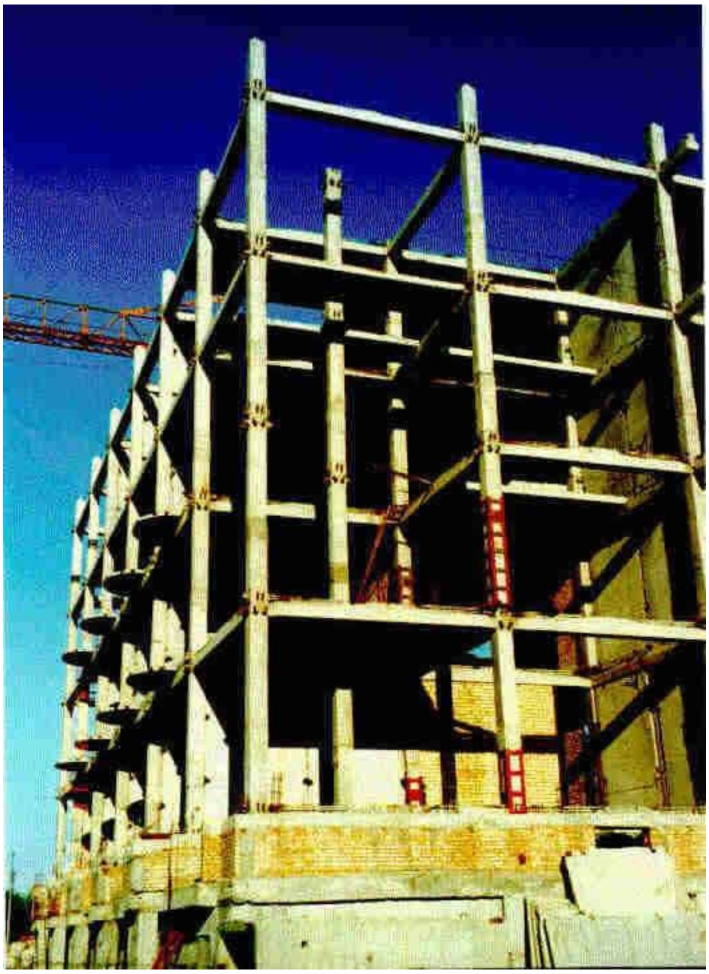


Illustration of Seismic Strengthening Techniques

References

1. Construction in Earthquake-prone Areas National Building Code of Uzbekistan, KMK 2.01.03-96 1996

2. Concrete and Reinforced Concrete - Design Codes and Standards

3. Construction Catalog: seria IIS-04.16

4. Earthquakes and Us Klyachko,M.A Intergraf, Saint Peterburg, Russia (in Russian) 1999

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