World Housing Encyclopedia Report

Country: Russian Federation

Housing Type: Large concrete block walls with reinforced concrete floors and roof (typical series: 1-306c, 1-307c, 114c)

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1 General Information

1.1 Country
Russian Federation


FIGURE 1: Typical Building

1.3 Housing Type
Large concrete block walls with reinforced concrete floors and roof (typical series: 1-306c, 1-307c, 114c)

1.4 Summary
This is a typical residential construction found both in urban and rural areas. It represents a construction practice followed in the former Soviet Union. Buildings of this type constitute 15 to 30% of the housing stock in seismically prone areas of Russia (Far East, Siberia, Baikal Lake Region, North Caucasus) and CIS states (Central Asia, Armenia, Georgia, etc.). The main load bearing system for lateral and gravity loads consists of concrete block masonry walls and concrete floor slabs. Seismic resistance is relatively good, provided that the welded block wall connections are present and are well constructed.

1.5 Typical Period of Practice for Buildings of This Construction Type

How long has this construction been practiced	
< 25 years	
< 50 years	X
< 75 years	
< 100 years	
< 200 years	
> 200 years	

Is this construction still being practiced?	Yes	No
	X	

Additional Comments: The Soviet Union construction practice followed in the last 50 years.

1.6 Region(s) Where Used
15-30% of the housing stock in seismic zones of Russia (Far East, Siberia, Baikal Lake Region, North Caucasus) and CIS (Central Asia, Armenia, Georgia, etc.).

1.7 Urban vs. Rural Construction

Where is this construction commonly found?	
In urban areas	
In rural areas	
In suburban areas	
Both in rural and urban areas	X

2 Architectural Features

2.1 Openings

Windows: 10-15%;
Doors: 5-8%.

2.2 Siting

	Yes	No
Is this type of construction typically found on flat terrain?	X	
Is this type of construction typically found on sloped terrain? (hilly areas)		X
Is it typical for buildings of this type to have common walls with adjacent buildings?		X

The typical separation distance between buildings is 5 meters

2.3 Building Configuration

In general, all buildings of this type are of a rectangular plan.

2.4 Building Function

What is the main function for buildings of this type?	
Single family house	
Multiple housing units	X
Mixed use (commercial ground floor, residential above)	
Other (explain below)	

Additional Comments: Some buildings of this type (approximately 5% of the total number) are of mixed use. In case of mixed use buildings, commercial ground floor causes a soft storey effect and reduces seismic resistance of a building.

2.5 Means of Escape

Usually there is one exit stair with one main entry in one section of a building. An average section includes 12 housing units in total (i.e. 3 per floor).

2.6 Modification of Buildings

Typical patterns of modification include demolishing of interior walls and the perforation of walls with door openings.

3 Socio-Economic Issues

3.1 Patterns of Occupancy

One family per unit (apartment).

3.2 Number of Housing Units in a Building

48 units in each building.

Additional Comments: Usually there are 12 - 64 units in each building.

3.3 Average Number of Inhabitants in a Building

How many inhabitants reside in a typical building of this construction type?	During the day / business hours	During the evening / night
< 5		
5 to 10		
10-20		
> 20	X	
Other		X

3.4 Number of Bathrooms or Latrines per Housing Unit

Number of Bathrooms: 1
Number of Latrines: 0

Additional Comments: Usually one bathroom per family (unit).

3.5 Economic Level of Inhabitants

Economic Status		House Price/Annual Income (Ratio)
Very poor	X	/
Poor	X	/
Middle Class	X	/
Rich		/

3.6 Typical Sources of Financing

What is the typical source of financing for buildings of this type?	
Owner Financed	
Personal Savings	
Informal Network: friends and relatives	
Small lending institutions/microfinance institutions	
Commercial banks / mortages	
Investment pools	
Combination (explain)	
Government-owned housing	X
Other	

3.7 Ownership

Type of Ownership/Occupancy	
Rent	
Own outright	X
Own with Debt (mortgage or other)	
Units owned individually (condominium)	
Owned by group or pool	
Long-term lease	X
Other	

Additional Comments: Own outright (for unit), Long-term lease (most common)

4 Structural Features

4.1 Lateral Load-Resisting System

Lateral load-resisting system consists of concrete block walls and precast concrete floors. Blocks are joined together by means of welding. In most cases, the floor structure consists of precast concrete hollow-core slabs, combined in horizontal disk by special reinforced monolithic concrete bond beams (web blocks) located at the building perimeter.

4.2 Gravity Load-Bearing Structure

Same as lateral load-resisting system. The main elements of the load-bearing structure for this construction type are illustrated in Figure 2A: 1- breast block; 2- interfenestral block; 4- lintel member, 6-floor panel, 7-regular block, 8-web block.

4.3 Type of Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	
Masonry	Stone masonry walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	
		2	Massive stone masonry (in lime or cement mortar)	
	Earthen walls	3	Mud walls	
		4	Mud walls with horizontal wood elements	
		5	Adobe block or brick walls	
		6	Rammed earth/Pise construction	
	Unreinforced brick masonry walls	7	Unreinforced brick masonry in mud or lime mortar	
		8	Unreinforced brick masonry in mud or lime mortar with vertical posts	
		9	Unreinforced brick masonry in cement or lime mortar (various floor/roof systems)	
	Confined masonry	10	Confined brick/block masonry with concrete posts/tie columns and beams	
	Concrete block masonry walls	11	Unreinforced in lime or cement mortar (various floor/roof systems)	
		12	Reinforced in cement mortar (various floor/roof systems)	
		13	Large concrete block walls with concrete floors and roofs	X
Concrete	Moment resisting frame	14	Designed for gravity loads only (predating seismic codes i.e. no seismic features)	
		15	Designed with seismic features (various ages)	
		16	Frame with unreinforced masonry infill walls	
		17	Flat slab structure	
		18	Precast frame structure	
		19	Frame with concrete shear walls-dual system	
		20	Precast prestressed frame with shear walls	
	Shear wall structure	21	Walls cast in-situ	
		22	Precast wall panel structure	
Steel	Moment resisting frame	23	With brick masonry partitions	
		24	With cast in-situ concrete walls	
		25	With lightweight partitions	
	Braced frame	26	Concentric	
		27	Eccentric	
Timber	Load-bearing timber frame	28	Thatch	
		29	Post and beam frame	
		30	Walls with bamboo/reed mesh and post (wattle and daub)	
		31	Wooden frame (with or without infill)	
		32	Stud wall frame with plywood/gypsum board sheathing	
		33	Wooden panel or log construction	
Various	Seismic protection systems	34	Building protected with base isolation devices or seismic dampers	
	Other	35		

4.4 Type of Foundation

Type	Description	
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	X
	Mat foundation	
	No foundation	
Deep Foundation	Reinforced concrete bearing piles	
	Reinforced concrete skin friction piles	
	Steel bearing piles	
	Wood piles	
	Steel skin friction piles	
	Cast in place concrete piers	
	Caissons	
Other		

4.5 Type of Floor/Roof System

Material	Description of floor/roof system	Floor	Roof
Masonry	Vaulted		
	Composite masonry and concrete joist		
Structural Concrete	Solid slabs (cast in place or precast)		
	Cast in place waffle slabs		
	Cast in place flat slabs		
	Precast joist system		
	Precast hollow core slabs		
	Precast beams with concrete topping		
	Post-tensioned slabs		
Steel	Composite steel deck with concrete slab		
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 single roof		
	Wood planks or beams that support clay tiles		
	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		
Structural Concrete	Precast hollow core concrete slabs	X	X

4.6 Typical Plan Dimensions
Length: 44 - 44 meters
Width: 44 - 44 meters

4.7 Typical Number of Stories
4

4.8 Typical Story Height
2.8 meters

4.9 Typical Span
6.0 meters

4.10 Typical Wall Density
20-25%

4.11 General Applicability of Answers to Questions in Section 4

This description does not refer to a particular building - it is a generic description of a typical building of this housing type.

5 Evaluation of Seismic Performance and Seismic Vulnerability

5.1 Structural and Architectural Features: Seismic Resistance

Structural/ Architectural Feature	Statement	True	False	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 form the building to the foundation.	X		
Building configuration	The building is regular with regards to both the plan and the elevation.	X		
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.	X		
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.	X		
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.	X		
Wall and frame structures- redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	X		
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: 1) Less than 25 (concrete walls); 2)Less than 30 (reinforced masonry walls); 3) Less than 13 (unreinforced masonry walls).	X		
Foundation- wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	X		
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.	X		
Wall openings	The total width of door and window openings in a wall is: 1) for brick masonry construction in cement mortar: less than 1/2 of the distance between the adjacent cross walls; 2) for adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; 3) for precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	X		
Quality of building materials	Quality of building materials is considered to be adequate per requirements of national codes and standards (an estimate).		X	
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).		X	
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).		X	
Other	Welding connections for the block walls are adequate		X	

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake-Resilient Features	Earthquake Damage Patterns
Wall	-Low cohesion of masonry (<120 kPa) (cohesion equals to tension strength when shear stress=0). -Welded block wall connections are inadequate or absent; -Poor strength of the block walls.		
Frame (columns, beams)			
Roof and floors	Floor slabs cannot be considered as rigid due to poor quality of joints and connections.		

5.3 Seismic Vulnerability Rating

	Vulnerability					
	High (Very Poor Seismic Performance) A	B	Medium C	D	E	Low (Excellent Seismic Performace) F
Seismic Vulnerability Class		<	0	>		

0 - probable value
< - lower bound
> - upper bound

6 Earthquake Damage Patterns

6.1 Past Earthquakes Reported To Affect This Construction

Year	Earthquake Epicenter	Richter magnitude(M)	Maximum Intensity (Indicate Scale e.g. MMI, MSK)
1995	Neftegorsk, Sakhalin Island, Russia		9 (MSK)
1971	Kamchatka, Russia	7.2	7 (MSK)
1959	Kamchatka, Russia	7.8	8(MSK)

Additional Comments: Typical earthquake damage patterns for this construction type are illustrated in Figures 5A to 5G. Figures 5H and 5I illustrate the seismic performance of this construction type in the 1995 Neftegorsk earthquake. At the time of the earthquake, there were 17 five-story large-block residential buildings constructed in the period 1967-1971. These buildings were constructed without any seismic provisions. All 17 buildings collapsed in the earthquake, as illustrated in Figure 5H. Several two-story large-block buildings were also exposed to the Neftegorsk earthquake (see Figure 5I), however these buildings had suffered some damages, e.g. vertical and horizontal cracks between blocks, diagonal cracks in partitions, vertical cracks in the wall connections, partial damage to chimneys, and displacement of entrance canopies. For more information on the Neftegorsk earthquake, refer to Klyachko (1999) and Melentyev (1999).

7 Building Materials and Construction Process

7.1 Description of Building Materials

Structural Element	Building Material	Characteristic Strength	Mix Proportions/ Dimensions	Comments
Wall/foundations	Steel concrete (large-block)	Yield strength = 295 MPa cube compressive strength (15-20 MPa)		
Foundations	concrete	15-20 MPa (cube compressive strength)		
Roof and floors	Slabs - reinforced concrete	30 MPa (cube compressive strength) 295 MPa (Steel yield strength)		
Bond Beam (Web Blocks)	Reinforced concrete	20-30 MPa (cube compressive strength)		

7.2 Does the builder typically live in this construction type, or is it more typically built by developers or for speculation?

Buildings of this type were built by government-owned construction companies.

7.3 Construction Process

All precast structure members and concrete blocks are manufactured in special construction plants. Masonry mortar is produced either in the factory or at the construction site. Lifting crane is used for the erection of the building.

7.4 Design/Construction Expertise

Expertise for design of buildings of this type was available, including the construction quality procedure developed by the author of this contribution.

7.5 Building Codes and Standards

	Yes	No
Is this construction type addressed by codes/standards?	X	

Title of the code or standard: Building Catalog of Typical Housing Projects, seria 1-306c, 1-307c, 1957y.
Year the first code/standard addressing this type of construction issued: 1951
National building code, material codes and seismic codes/standards: Construction in the Seismic Regions. SNiP II-7-81*
When was the most recent code/standard addressing this construction type issued? 1981 (followed by several amendments)

7.6 Role of Engineers and Architects

Design performed by Professional Engineers and Architects.

7.7 Building Permits and Development Control Rules

	Yes	No
Building permits are required	X	
Informal construction		X
Construction authorized per development control rules	X	

7.8 Phasing of Construction

	Yes	No
Construction takes place over time (incrementally)		X
Building originally designed for its final constructed size	X	

7.9 Building Maintenance

Who typically maintains buildings of this type?	
Builder	
Owner(s)	X
Renter(s)	
No one	
Other	

Additional Comments: The maintenance is performed either by the owner (city) or (periodically) by a contractor - a maintenance firm.

7.10 Process for Building Code Enforcement

The process consists of issuing permits for the design and construction, including the architectural permits and urban planning/municipal permits. Designers need to have license to practice and are responsible to follow the building codes. Building inspection is performed and the permit is issued.

7.11 Typical Problems Associated with this Type of Construction

Absence of welded block wall connections in the pre-1975 construction.

8 Construction Economics

8.1 Unit Construction Cost (estimate)

250-350 $US/m² (official rate).

8.2 Labor Requirements (estimate)

It takes about 34 man-months to build a 4-story building of this type with plan dimensions 12 m X 42 m.

9 Insurance

9.1 Insurance Issues

	Yes	No
Earthquake insurance for this construction type is typically available	X	
Insurance premium discounts or higher coverages are available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features		X

Additional Comments: The insurance is available as a part of the usual property insurance.

9.2 If earthquake insurance is available, what does this insurance typically cover/cost?

About 3-5% of the total estimated property value.

10 Seismic Strengthening Technologies

10.1 Description of Seismic Strengthening Provisions

Type of intervention	Structural Deficiency	Description of seismic strengthening provision used
Retrofit (Strengthening)	Inadequate seismic resistance of masonry walls	The method of exterior frame
	Inadequate seismic resistance of masonry walls	Vertical post-tensioning (see Figure 6A, 6B and 6C)
	Inadequate seismic resistance of masonry walls	The method of upper damping storey

Additional Comments: The recommended seismic strengthening techniques are: THE METHOD OF EXTERIOR FRAME (MEF) # Goal: To increase lateral seismic stability of the building with load-bearing masonry or large-block concrete walls. # Concept: The system of precast or "cast-in-situ" concrete buttresses (counterforts) (1) tied to the longitudinal exterior wall. # Application: This method has been used successfully for seismic strengthening of the buildings with longitudinal bearing walls and deficient seismic resistance both as self-contained strengthening system and as a combination with PTS (for stringer walls) or with SIS (for extended masonry buildings with widely spaced lateral inner walls). # Description: The MEF is performed by constructing special concrete buttresses (counterforts) tied to the longitudinal load-bearing walls at the building ends and other locations as required. In order to ensure a uniform seismic performance of the existing structure strengthened with the buttresses, the buttresses are tied to the existing walls by means of the dowels and anchors. This solution does not require to tie the pairs of buttresses (counterforts) together at each floor level. Instead, it is adequate to install a prestressed tie to connect the buttresses (counterforts) at the roof level. STRENGTHENING OF BUILDINGS USING THE POST-TENSIONING SYSTEM (PTS) # Goal: To increase seismic resistance of load bearing masonry buildings. # Concept: Reduction in the principal tensile stresses induced by seismic loads to allowable levels. # Description and sequence of operations: Drilling of the vertical holes is carried out by means of special equipment; the amount of opening (10) is not less than one for each partition. The wire cables (2) are pulled through each opening (10). Cables are anchored at the basement level and then post-tensioned up to 1600 KN. A special cement-based grout (1) is injected into the holes and the cables are subsequently anchored at the roof level. Post-tensioning of walls prevents the formation of cracks in an earthquake and results in the increased seismic resistance of the individual walls and the building as a whole. # Equipment: For drilling: "GEARMEC" (Sweden); for post-tensioning: IMS system (Yugoslavia). THE METHOD OF UPPER DAMPING STOREY (UDS) # Goal: To develop a big mass damper for the self-damping of buildings under seismic impact. # Idea: To achieve a flexible structure with stiffness and mass capable of reducing the seismic demand to a permissible level. # Application: Masonry or block buildings with deficient seismic resistance D=2.0 (MSK scale). A highly effective and fast application for 4- to 5-story residential masonry and large-block houses with D=1.0-1.5. The superstructure can be constructed as a "cold" garret or as additional floor (duplex apartment).

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

Yes. Some buildings of this type have been strengthened using the above described methodology.

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

Some work was done as a mitigation effort (strengthening of undamaged existing buildings), and in some cases earthquake-damaged buildings were strengthened.

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

Yes.

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

Strengthening is done in a similar way as new construction. The construction is done by the contractor.

Engineers manage each stage of construction.

10.6 What has been the performance of retrofitted buildings of this type in subsequent earthquakes?

Information not available.

11 References

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Recommendations for Preventive Aseismic Strengthening of Buildings, CENDR, 1993.

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Melentyev, A. Lessons of the 1995 Sakhalin and 1994 Kuril Islands Earthquakes. Seismic Hazard and Building Vulnerability in Post-Soviet Central Asian Republics (Stephanie A. King, Vitaly I. Khalturin and Brian E. Tucker-Editors), NATO ASI Series 2. Environment - Vol.52, Klywer Academic Publishers, The Netherlands, 1999.

12 Contributors

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Webpage			

13 Figures

FIGURE 1: Typical Building

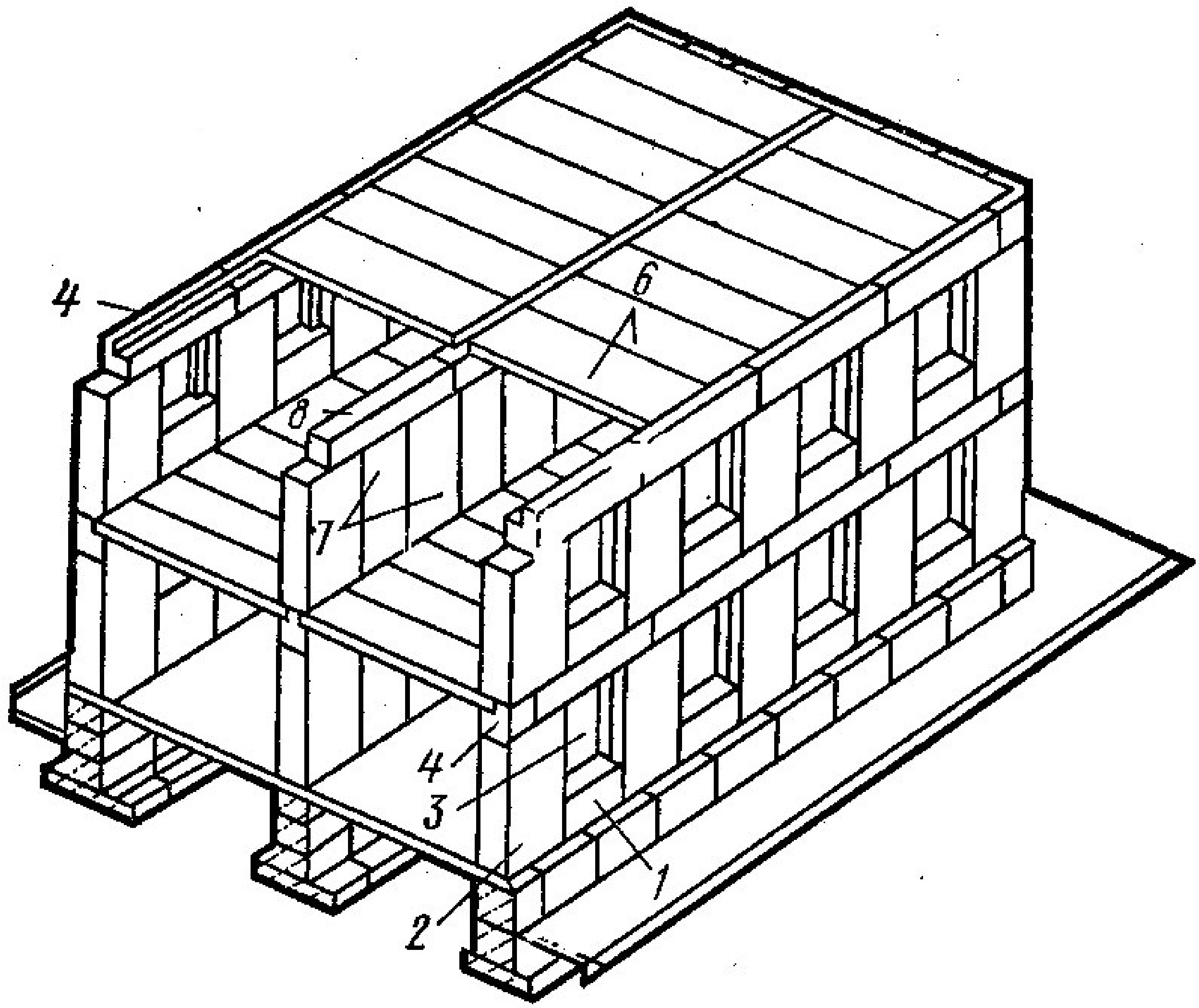

FIGURE 2A: Key Load-Bearing Elements

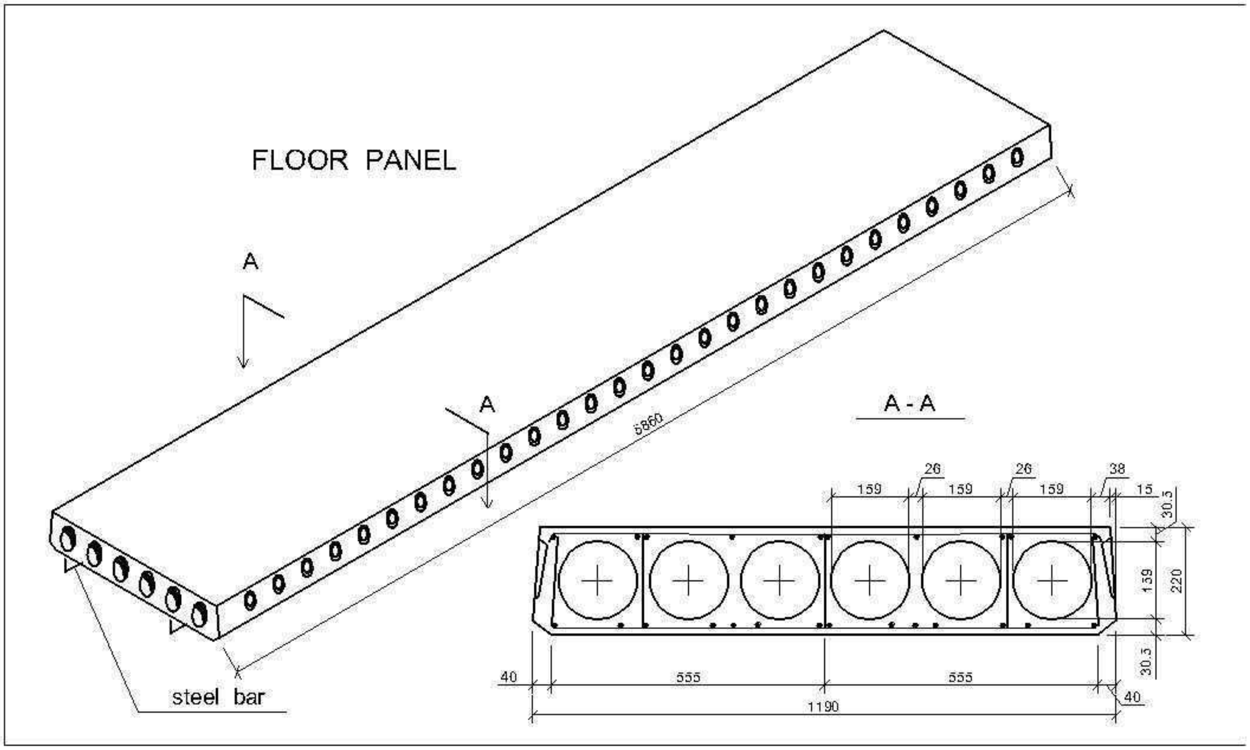

FIGURE 2B: Precast Hollow-Core Reinforced Concrete Floor Slab (Credit: U. Begaliev and S. Uranova)

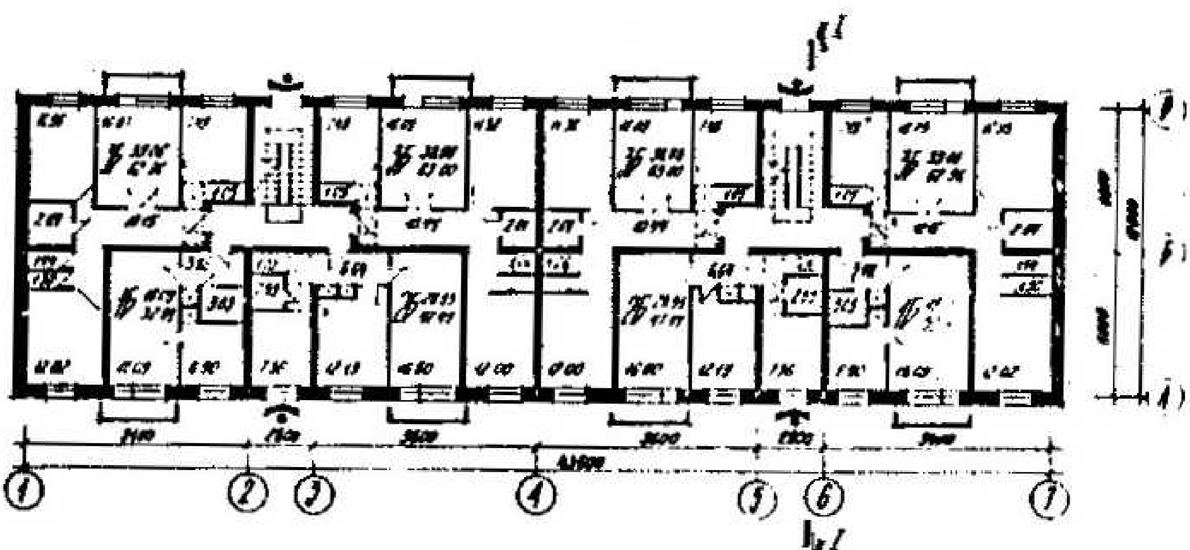

FIGURE 3: Plan of a Typical Building

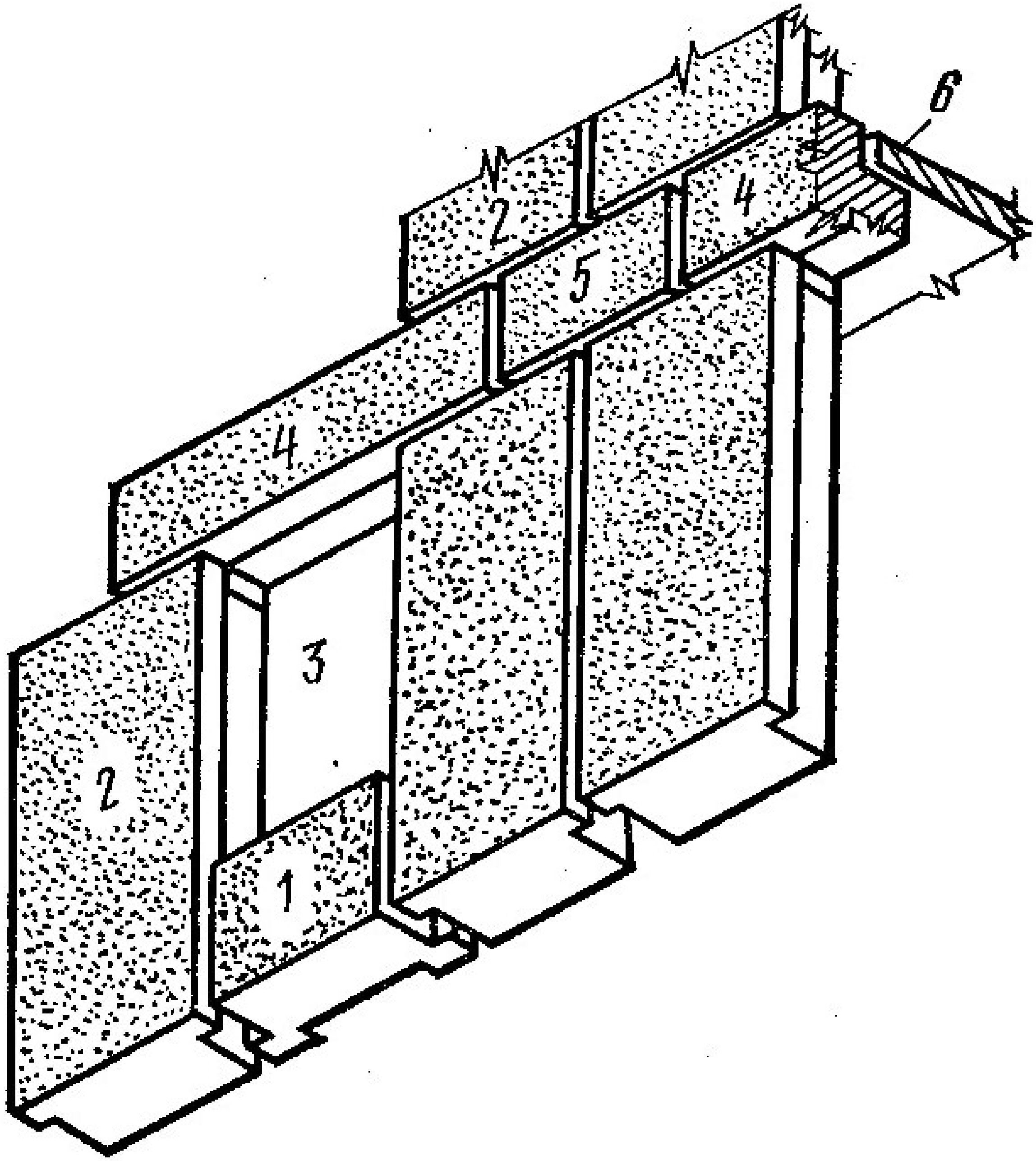

FIGURE 4: Critical Structural Details

FIGURE 5A: Typical Earthquake Damage to the exterior longitudinal walls

FIGURE 5B: Typical Earthquake Damage - A View of the Damaged Building

FIGURE 5C: Typical Earthquake Damage- Shearing of Blocks at the Joint Locations

FIGURE 5D: Typical Earthquake Damage - Shearing of Blocks at the Ground Floor Level

FIGURE 5E: Typical Earthquake damage - Interior View of Damages

FIGURE 5F: Typical Earthquake Damage at the Wall Corner

FIGURE 5G: Typical Earthquake Damage- Shearing Failure of Blocks at the Joint Locations

FIGURE 5H: Collapse of Five-Story Large-Block Masonry Buildings (1995 Neftegorsk earthquake)-Source: Klyachko (1999)

FIGURE 5I: Two-Story Large-Block Masonry Buildings Did Not Suffer Major Damage in the 1995 Neftegorsk Earthquake (Source: Klyachko, 1999)

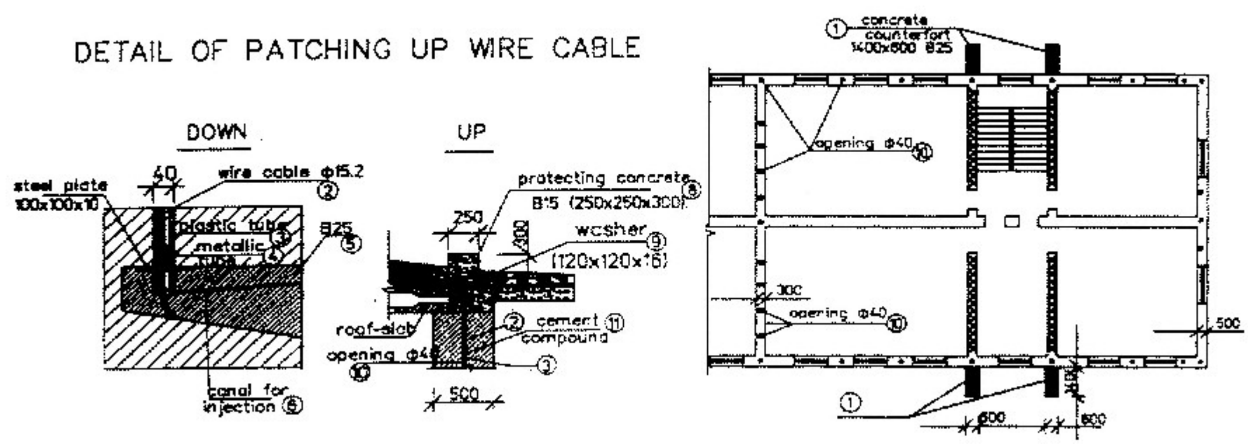

FIGURE 6A: Illustration of Seismic Strengthening Techniques

FIGURE 6B: Seismic Strengthening: Application of Post-Tensioning System

FIGURE 6C: A building Strengthened using Post-Tensioning System