World Housing Encyclopedia

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

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HOUSING REPORT
Precast, prestressed concrete frame structure with concrete shear walls

Report #	68
Report Date	05-06-2002
Country	SERBIA
Housing Type	Precast Concrete Building
Housing Sub-Type	Precast Concrete Building : Prestressed moment frame with shear walls
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Summary

This housing type is a prefabricated frame structure, consisting of precast concrete columns and other structural elements, e.g., waffle floor slabs, edge girders, stairs, and wall panels. The frame structure carries the gravity load, while shear walls are the main lateral load-resisting

elements. The main feature of this technology is that the key structural elements are joined together by prestressing in two orthogonal horizontal directions. The technology has been used in Yugoslavia during the last 40 years under the proprietary name, IMS Building System, and it can be found in all major Yugoslav cities, including Belgrade, Novi Sad, Nis, etc., and also in other countries, such as Cuba, the Philippines, and Egypt. To date, around 400,000 housing units (approximately 2.5 million m^2 of the built area) have been constructed using this technology. Design applications include both residential housing and public buildings (e.g., hospitals). Seismic performance of the main IMS structural elements has undergone extensive experimental laboratory tests, and has also been tested in a few major earthquakes. Several buildings of this type sustained the effects of the 1968 Banja Luka earthquake without any damage.

1. General Information

Buildings of this construction type can be found in The technology has been used throughout the former Yugoslavia for building the Post-World War II urban settlements. Over 50% of the apartments in New Belgrade (a part of the country's capital built after the World War II) were built using the IMS technology. It can be also found in the cities of Novi Sad, Nis, Banja Luka, Sarajevo, Tuzla etc. (currently a part of Bosnia and Herzegovina) and in other countries e.g. Cuba, Russia, Georgia, China (where this technology was used for building the sustainable housing). Recent design applications were reported in the Philippines and Egypt.   This type of housing construction is commonly found in urban areas.

This technology has been mainly usedfor medium to high-rise buildings; however, some design applications include single-family row housing units (such as townhouses), as well as schools, hospitals, offices, shopping malls, multi-story garages, etc.

This construction type has been in practice for less than 50 years.

Currently, this type of construction is being built.   This technology has been used for the construction of multi-story residential buildings for more than 40 years.

Figure 1A: Typical building

Figure 1B: IMS Buildings under construction

Figure 1C: A block of buildings constructed using IMS technology

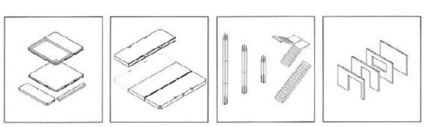


Figure 2A: Key load-bearing elements

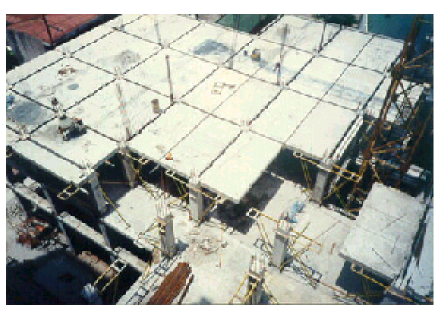


Figure 2B: A building under construction showing main load-bearing elements: columns and slabs

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat, sloped and hilly terrain. They do not share common walls with adjacent buildings. When separated from adjacent buildings, the typical distance from a neighboring building is 0.5 meters.

2.2 Building Configuration

In general, a regular shape. In some cases shear walls are perforated with door or window openings.

2.3 Functional Planning

The main function of this building typology is multi-family housing. Many buildings are mixed-use. This building type has been also used for other types of facilities, including schools, hospitals, hotels, garages etc. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. The means of escape depends on the building type. In single-story buildings, there is an additional door besides the main entrance. There is at least one additional staircase besides the main stairs in multi-story buildings (depending on the Fire Safety Code requirements).

2.4 Modification to Building

It is easy to perform modifications on buildings of this type, considering that the main gravity load bearing system is a concrete frame and majority of the walls are non-load bearing structures (except for the shear walls).

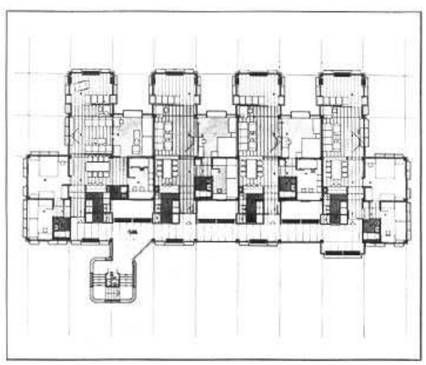


Figure 3: Plan of a typical building

3. Structural Details

3.1 Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	Most appropriate type
	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	☐

Masonry	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	☐
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). The structure consists of the following gravity load-bearing elements: - Columns, continuous for up to three stories; - Floor slabs, supported on 4 columns, and cantilever (balcony) slabs, supported on 2-3 columns; both floor slabs and balcony slabs are waffle slabs; - Edge girders to carry façade loads and different types of stairs. Main structural elements are shown in FIGURE 2A. The gravity load transfer from the floor slabs to the columns is achieved by friction in the joints induced by axial forces developed in the prestressing cables; the joint shear capacity is proportional to the force developed in the cable and to the friction coefficient value. The prestressed cables play a very important role in this type of construction, and therefore it is very important to protect the cables from the corrosion by grouting the cement emulsion into the holes provided in the columns. The elements of the gravity load-bearing structure, i.e., columns, floor slabs, cantilevers and edge girders are joined together by prestressing in two orthogonal directions.

3.3 Lateral Load-Resisting System

The lateral load-resisting system is others (described below). Shear walls are the main structural elements providing lateral resistance in this system. The walls consist of reinforced concrete panels (typically 15 cm thick) enclosed with the two adjacent columns. The columns are provided throughout the building height. As elements of the shear wall, columns carry additional axial load (tension/compression) due to the bending moment. The concrete wall panels are subjected to shear effects. It is very important to ensure the continuity of shear walls in both directions throughout the height of the building. The concrete wall panels are usually cast in-situ. However, in some cases precast panels have been used. Generally, the concrete frame itself is able to sustain the lateral force effects. However, because the structure is too flexible, excessive lateral movements would have detrimental effects on the performance of nonstructural elements, e.g., the façade, partitions, installations. The shear walls therefore have a role in increasing the lateral stiffness of the structure and in limiting lateral deflections to the acceptable level. The main feature of this building type of space frame is the high load-bearing capacity of the prestressed floor-column joints. This capacity is based on the friction developed between these two concrete elements after the prestressing is completed. A number of tests were performed, in which column-slab joint models were subjected to static or quasi-dynamic loading. The tests have revealed that failure occurs in the connected elements (i.e., in the slab) and not in the joint itself. Typical floor-column joints are illustrated in FIGURE 4A.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 40 and 60 meters, and widths between 10 and 15 meters. The building has 5 to 10 storey(s). The typical span of the roofing/flooring system is 6.0 meters. Typical Story Height: Typical story height for the residential buildings is 2.8 m, and 3.2 m for public buildings. Typical Span: The span between the columns can vary from 3.0 m to 12 m, with an increment of 60 cm. The typical storey height in such buildings is 2.9 meters. The typical structural wall density is none. Information on a typical wall density is not available.

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	☑	☑

Precast columns and waffle slabs joined by prestressing cables The floor slabs are considered to be rigid diaphragms and are able to transfer lateral loads to the shear walls. Precast columns and waffle slabs joint by prestressing cables.

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	☐

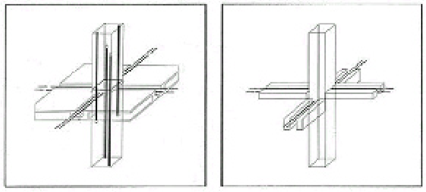
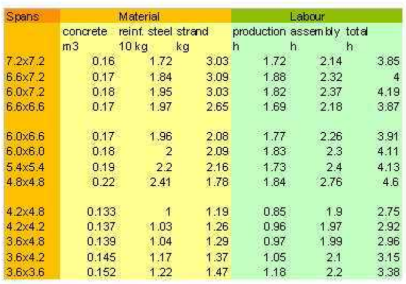


Figure 4A: Details of a typical post-tensional slab-column connection

Figure 4B: Details of a typical post-tensional slab-column connection

Figure 4C: Details of an IMS building under construction showing cantilevered balcony slabs



Spans	Material			Labour		
	concrete m3	reinf. steel 10 kg	strand kg	production h	assembly h	total h
7.2x7.2	0.16	1.72	3.03	1.72	2.14	3.85
6.6x7.2	0.17	1.84	3.09	1.88	2.32	4
6.0x7.2	0.18	1.95	3.03	1.82	2.37	4.19
6.6x6.6	0.17	1.97	2.65	1.69	2.18	3.87
6.0x6.6	0.17	1.96	2.08	1.77	2.26	3.91
6.0x6.0	0.18	2	2.09	1.83	2.3	4.11
5.4x5.4	0.19	2.2	2.16	1.73	2.4	4.13
4.8x4.8	0.22	2.41	1.78	1.84	2.76	4.6
4.2x4.8	0.133	1	1.19	0.85	1.9	2.75
4.2x4.2	0.137	1.03	1.26	0.96	1.97	2.92
3.6x4.8	0.139	1.04	1.29	0.97	1.99	2.96
3.6x4.2	0.145	1.17	1.37	1.05	2.1	3.15
3.6x3.6	0.152	1.22	1.47	1.18	2.2	3.38

Figure 5: IMS building under construction showing columns under construction

Figure 6: A medium-rise residential building under construction

Figure 7: A building under construction, showing columns at the top floor erected in the vertical position

Figure 8: An Illustration of column erection

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 51-100 housing unit(s). Up to 100 units in each building. It varies from one housing unit per building (case of a family house) to 40 or even 200 units in the condominium buildings. 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. The average number of inhabitants depends on the building function (i.e. is it a single- or multi-family housing).

4.2 Patterns of Occupancy

Typically, a single family occupies one housing unit.

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)	☐

In the last 10 years, the economic situation in Yugoslavia has been very bad. The average net salary is less than 50 $ US per month. However in spite of the extremely poor economic situation new construction is carried out per the latest Euro Code requirements. Economic Level: For Middle Class the ratio of Housing Price Unit to their Annual Income is 30:1 For Poor Class the ratio of Housing Price Unit to their Annual Income is 50:1.

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)	☐

At the present time, it is not possible to obtain a mortgage due to the current socio-political-economic situation in Yugoslavia. In each housing unit, there are 1 bathroom(s) without toilet(s), 1 toilet(s) only and no bathroom(s) including toilet(s).

The majority of apartment units have two or three bedrooms, with one bathroom, or one bathroom with a separate WC. .

4.4 Ownership

The type of ownership or occupancy is individual ownership and ownership by a group or pool of persons.

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	Shear walls may be under-reinforced and might suffer damage in a major earthquake; however, the damage can be repaired by injecting the cracks with cement or with an epoxy emulsion.	Shear walls do not have any function in the gravity load-carrying system and therefore any damage to these elements would not affect the gravity load-bearing capacity of the structure in an earthquake.	There are no reports of earthquake damage to buildings of this construction type.
Frame (columns, beams)		During an earthquake, columns adjacent to the shear walls are subjected to axial tension and to compression forces induced by the bending effects in the shear walls.	
Roof and floors		Roof and floor elements are reinforced concrete waffle slab designed to carry gravity loads. However, these elements also act as rigid diaphragms in the seismic load transfer.	
Column-slab joint		Prestressed floor-column joints are characterized by a very high load-bearing capacity. This capacity is based on the friction developed between these two concrete elements due to prestressing. A number of tests were performed, in which column-slab joint models were subjected to static or quasi-dynamic loading. The tests have shown that the failure occurs in the connected elements (i.e., the slab) and not in the joint itself.	

A reinforced concrete frame without shear walls is capable of sustaining lateral force effects without failure, however very large lateral deformations (drift) would be expected in such case.s The role of shear walls is to add rigidity to a system and control lateral deformations. Buildings of this type are usually located in urban centers and pounding effects are also a concern. For that reason, design of shear walls, including their number and distribution, needs to be carefully performed.

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 E: LOW VULNERABILITY (i.e., very 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
1969	Banja Luka, Bosnia	6.4	VIII (MMI)
1977	Vrancea, Romania	7.2	
1979	Montenegro	7.2	IX (MCS)
		5.7	

1980	Kopaonik		

There was no reported damage to the buildings in the past earthquakes in Yugoslavia. In other countries, where this technology has been used, e.g. Cuba, Georgia and the Philippines, buildings of this type were subjected to strong earthquakes also without any reported damage.

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Concrete, Reinforcing steel	Concrete- minimum C 40 (40 MPa cube compressive strength) Steel- minimum A 40 (400 MPa yield strength)	Minimum 3 fractions of gravel and 400 kg/m³ of cement	C 40 (concrete) and A 40 (steel) is based on the Eurocode. Quality control is mandatory.
Foundation	Concrete and reinforcing steel	Minimum C 40 Minimum A 40	Minimum 3 fractions of gravel and 400 kg/m³ of cement	Quality control is mandatory.
Frames (beams & columns)	Concrete and reinforcing steel	Minimum C 40 Minimum A 40	Minimum 3 fractions of gravel and 400 kg/m³ of cement	Quality control is mandatory.
Roof and floor(s)	Concrete and reinforcing steel	Minimum C 40 Minimum A 40	Minimum 3 fractions of gravel and 400 kg/m³ of cement	Quality control is mandatory.

6.2 Builder

In a typical situation, developers build this type of construction. In some cases, developers also live in the buildings of this construction type. Note that, until few years ago, developers were generally government-owned construction companies.

6.3 Construction Process, Problems and Phasing

All structural elements are prefabricated in the plant using steel templates. For smaller size projects, the prefabrication can be carried out at the construction site. The erection is simple and fast, and it is carried out using erection equipment (cranes, etc.). Temporary support to the structural elements needs to be provided before permanent connection by prestressing is achieved. Before the prestressing is carried out, the space between the columns and horizontal elements (floor slabs, cantilever and edge girders) is filled with cement mortar (in order to enable transfer of axial forces). After the prestressing is completed, the holes in the columns are grouted with cement grout and the space between the adjacent floor slabs, cantilevers, or edge girders, is filled with concrete. In this way, the cables are protected from corrosion. Erection of concrete columns is shown in FIGURE 8.Examples of buildings of this type under construction are shown in FIGURE 2B , FIGURE 5, FIGURE 6 and FIGURE 7. 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

Architects and engineers have a role in preparing a design for each building of this construction type. There is no typical (generic) building design, and therefore it is necessary to prepare a separate design for each new building. Cooperation between the architects and engineers is very important and leads to more cost-effective design.

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. The buildings of this construction type are designed in compliance with the Yugoslav National Building Code and related standards. The year the first code/standard addressing this type of construction issued was 1964. Yugoslav National Building Code1987 (based mainly on the Euro Code). The most recent code/standard addressing this construction type issued was 1987. Title of the code or standard: The buildings of this construction type are designed in compliance with the Yugoslav National Building Code and related standards. Year the first code/standard addressing this type of construction issued: 1964 National building code, material codes and seismic codes/standards: Yugoslav National Building Code1987 (based mainly on the Euro Code) When was the most recent code/standard addressing this construction type issued? 1987.

Yugoslavia is located in the Balkan Peninsula, an area considered among the most seismically prone regions in Europe. However, until the catastrophic 1963 Skopje (Macedonia) earthquake, there were no seismic codes or regulations in the country. In 1964, the Preliminary National Building Code (including the seismic provisions) was issued. Since then, several editions of the building code have been issued and the code is generally being enforced.

6.6 Building Permits and Development Control Rules

This type of construction is an engineered, and authorized as per development control rules.

All new buildings need to get a building permit, which is issued if the design has been done properly and is based on the National Building Code. Building permits are required to build this housing type.

6.7 Building Maintenance

Typically, the building of this housing type is maintained by Owner(s). In the cities, government companies are in charge of the maintenance for the buildings of this type.

6.8 Construction Economics

The unit cost depends on the building function. In general, for the apartment buildings of this type the unit cost of structure only is on the order of US$ 50-60 per m². However, as this is a prefabricated construction, there needs to be a certain level of annual production (around 20,000-30,000 m²) is needed in order to achieve cost-effective construction. A table summarizing material and labor requirements per hour is shown on FIGURE 7. Note that the requirements are a function of floor-slab dimensions (first column to the left). A small number of trained staff is required for the fabrication and assembly of this construction type. The majority of labor can be local, without any special training.

Figure 9: A high-rise building under construction

Figure 10: Material and labor consumption per hour as a function of floor slab dimensions

7. Insurance

Earthquake insurance for this construction type is typically available. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is available. The annual insurance rate is 0.45% of the building's value, increased by 15% for earthquake risk.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

The prestressed prefabricated concrete frame structure is an inherently earthquake-resistant system and hence seismic strengthening is not required.

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?

There are no reports of seismic strengthening performed on buildings of this construction type.

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

Not applicable.

8.3 Construction and Performance of Seismic Strengthening

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

Not applicable.

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

Not applicable.

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

Not applicable.

Reference(s)

1. Certificate on the Testing of the Standardized Floor Slabs made of Prestressed Concrete, System IMS-Zezelj
   Institute IMS, Belgrade

2. Certificate of IMS Structural System of Fire Resistance
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3. Certificato d`Idonentia delle Structure Realizzate Secondo il Sistema IMS
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