

# 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)

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## HOUSING REPORT

### Dual precast RC system (IMS5, IMS8, IMS12, IMS18)

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<b>Report#</b>	191
<b>Last Updated</b>	01/26/2016
<b>Country</b>	Cuba
<b>Author(s)</b>	Grisel Morejon Blanco, Kenia Leyva Chang, Dario Candebat Sanchez, Zulima Rivera Alvarez, Yelena Berenguer Heredia, Madelin Villalon Semanat, Dominik H. Lang, Abdelghani Meslem,
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### Important

This encyclopedia contains information contributed by various earthquake engineering professionals around the world. All opinions, findings, conclusions & recommendations

expressed herein are those of the various participants, and do not necessarily reflect the views of the Earthquake Engineering Research Institute, the International Association for Earthquake Engineering, the Engineering Information Foundation, John A, Martin & Associates, Inc. or the participant's organizations.

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## **General Information**

<b>Building Type:</b>	Dual precast RC system (IMS5, IMS8, IMS12, IMS18)
<b>Country:</b>	Cuba
<b>Author(s):</b>	Grisel Morejon Blanco Kenia Leyva Chang Dario Candebat Sanchez Zulima Rivera Alvarez Yelena Berenguer Heredia Madelin Villalon Semanat Dominik H. Lang Abdelghani Meslem
<b>Last Updated:</b>	01/26/2016
<b>Regions Where Found:</b>	Santiago de Cuba
<b>Summary:</b>	Dual precast RC system, formed by a simple modular network of one or two precast slabs and four columns, which are joined by a pre-stressed joint to form a frame structure. This construction type is not widespread. They were built in one time period by the Yugoslavian engineers using Yugoslavian code.
<b>Length of time practiced:</b>	25-60 years
<b>Still Practiced:</b>	Yes
<b>In practice as of:</b>	1985 -1990
<b>Building Occupancy:</b>	Residential, 50+ units
<b>Typical number of stories:</b>	5-18
<b>Terrain-Flat:</b>	
<b>Terrain-Sloped:</b>	
<b>Comments:</b>	

## **Features**

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<b>Plan Shape</b>	Rectangular, solid
<b>Additional comments on plan shape</b>	Number of stories: 5 (IMS5), 8 (IMS8), 12 (IMS12), 18 (IMS18)
<b>Typical plan length (meters)</b>	
<b>Typical plan width (meters)</b>	
<b>Typical story height (meters)</b>	
<b>Type of Structural System</b>	Structural Concrete: Precast Concrete: Prestressed moment frame with shear walls
<b>Additional comments on structural system</b>	Gravity: Precast RC slabs, transferring the gravity loads to the beams and columns and finally to the footings Lateral: Shear walls provide the lateral resistance; these walls are reinforced-concrete panels of 15 cm thickness, confined between two adjacent columns.
<b>Gravity load-bearing &amp; lateral load-resisting systems</b>	Dual precast RC system (RC frames and shear walls that take more than 50% of the lateral load)
<b>Typical wall densities in direction 1</b>	>20%
<b>Typical wall densities in direction 2</b>	>20%
<b>Additional comments on typical wall densities</b>	
<b>Wall Openings</b>	
<b>Is it typical for buildings of this type to have common walls with adjacent buildings?</b>	
<b>Modifications of buildings</b>	
<b>Type of Foundation</b>	Shallow Foundation: Reinforced concrete isolated footing Shallow Foundation: Mat foundation
<b>Additional comments on foundation</b>	Shallow foundation; reinforced-concrete isolated footing is used for buildings of 5 stories, sometimes cast-in-situ; for buildings of 8, 12 and 18 floors foundation mats are used.
<b>Type of Floor System</b>	Precast concrete floor with reinforced concrete topping

**Additional comments on floor system**

Consisting of precast post-tensioned slabs; the beams are formed when the joints between the horizontal elements (slab-slab) are constructed forming the rigid diaphragm.

**Type of Roof System**

Precast concrete roof with reinforced concrete topping

**Additional comments on roof system**

Consisting of precast post-tensioned slabs; the beams are formed when the joints between the horizontal elements (slab-slab) are constructed forming the rigid diaphragm.

**Additional comments section 2**





## **Building Materials and Construction Process**

### **Description of Building Materials**

<b>Structural Element</b>	<b>Building Material (s)</b>	<b>Comment (s)</b>
Wall/Frame		
Foundations		
Floors		
Roof		
Other		

### **Design Process**

<b>Who is involved with the design process?</b>	Owner
<b>Roles of those involved in the design process</b>	
<b>Expertise of those</b>	

**involved in the design process**

## **Construction Process**

**Who typically builds this construction type?**

Other

**Roles of those involved in the building process**

**Expertise of those involved in building process**

**Construction process and phasing**

**Construction issues**

## **Building Codes and Standards**

**Is this construction type address by codes/standards?**

Yes

**Applicable codes or standards**

Yugoslavian code

**Process for building code enforcement**

## **Building Permits and Development Control Rules**

**Are building permits required?**

**Is this typically informal construction?**

**Is this construction typically authorized as per development control rules?**

**Additional comments on building permits and development control rules**

## **Building Maintenance and Condition**

<b>Typical problems associated with this type of construction</b>	
<b>Who typically maintains buildings of this type?</b>	Other
<b>Additional comments on maintenance and building condition</b>	

### **Construction Economics**

<b>Unit construction cost</b>	IMS5 and IMS8: 50 CUC/m2 IMS12 and IMS: 80 CUC/m2
<b>Labor requirements</b>	
<b>Additional comments section 3</b>	

### **Socio-Economic Issues**

<b>Patterns of occupancy</b>	
<b>Number of inhabitants in a typical building of this construction type during the day</b>	>20
<b>Number of inhabitants in a typical building of this construction type during the evening/night</b>	>20
<b>Additional comments on number of inhabitants</b>	
<b>Economic level of inhabitants</b>	Middle-income class High-income class (rich)
<b>Additional comments on economic level of inhabitants</b>	
<b>Typical Source of Financing</b>	Other
<b>Additional comments on financing</b>	
<b>Type of Ownership</b>	Other

**Additional comments on ownership**

**Is earthquake insurance for this construction type typically available?**

No

**What does earthquake insurance typically cover/cost**

**Are premium discounts or higher coverages available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features?**

**Additional comments on premium discounts**

**Additional comments section 4**

## **Earthquakes**

**Past Earthquakes in the country which affected buildings of this type**

<b>Year</b>	<b>Earthquake Epicenter</b>

## **Past Earthquakes**

**Damage patterns observed in past earthquakes for this construction type**

There are no reports of damage from past earthquakes for this type of buildings (also not from former Yugoslavia or other countries where this constructive system can be found).

**Additional comments on earthquake damage patterns**

## 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  $\frac{1}{2}$  of the distance between the adjacent cross walls; For adobe masonry, stone masonry and brick masonry in mud mortar: less than  $\frac{1}{3}$  of the distance between the adjacent cross walls; For precast concrete wall structures: less than  $\frac{3}{4}$  of the length of a perimeter wall.

<b>Structural/Architectural Feature</b>	<b>Statement</b>	<b>Seismic Resistance</b>
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-Vertical	The building is regular with regards to the elevation. (Specify in 5.4.1)	
Building Configuration-Horizontal	The building is regular with regards to the plan. (Specify in 5.4.2)	
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 doveled 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		
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 a 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).

## Building Irregularities

<p><b>Additional comments on structural and architectural features for seismic resistance</b></p>	
<p><b>Vertical irregularities typically found in this construction type</b></p>	<p>Other</p>
<p><b>Horizontal irregularities typically found in this construction type</b></p>	<p>Other</p>
<p><b>Seismic deficiency in walls</b></p>	<p>The columns are designed to resist axial loads only; column joints are carried out in areas of greater bending moments; the reinforcement detailing do not comply with the requirements for areas of high seismic hazard; In fact, the construction joints and details were designed considering regions of low-moderate seismicity (Yugoslavia) while the buildings are located in high seismic regions. Previous studies addressing the vulnerability of IMS18 showed that failures by axial load with flexure of shear walls on the first floors can occur, also drifts are expected to be greater than the provided limits as per the Cuban code; it was also found that the main reason for failure of this typology is the corrosion of the steel reinforcement due to water leakages.</p>
<p><b>Earthquake-resilient features in walls</b></p>	
<p><b>Seismic deficiency in frames</b></p>	
<p><b>Earthquake-resilient features in frame</b></p>	
<p><b>Seismic deficiency in roof and floors</b></p>	
<p><b>Earthquake resilient features in roof and floors</b></p>	
<p><b>Seismic deficiency in</b></p>	

**Seismic deficiency in foundation**

Unknown deficiencies

**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		

## Retrofit Information

### Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening

**Additional comments on seismic strengthening provisions**

**Has seismic strengthening described in the above table been performed?**

**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**

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