World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

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

HOUSING REPORT

Confined block masonry house

Report#	1
Last Updated	
Country	Argentina
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Important

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General Information

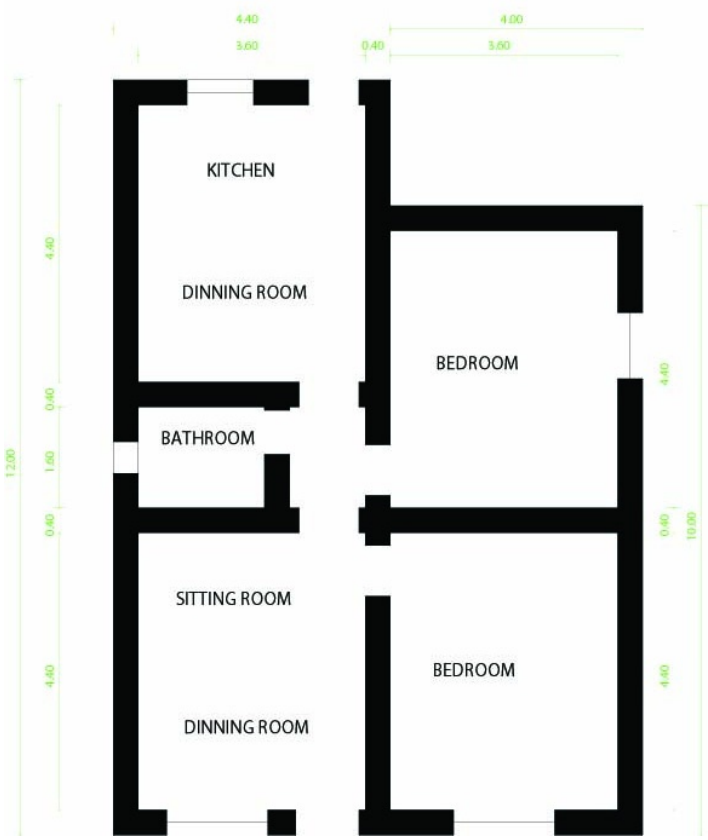
Building Type:	Confined block masonry house
Country:	Argentina
Author(s):	Virginia I Rodriguez Maria I Yacante Sergio Reiloba
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in San Juan Capital City and the surroundings. This type of housing construction is commonly found in urban areas.
Summary:	This is typically a one-or-two-story residential building, of detached or semi-detached construction, generally found in the urban areas of San Juan and Mendoza and less frequently in the rural areas. The walls are made of concrete block masonry with reinforced concrete columns and beams that tie the walls together and provide the strength for the building. One of the main structural deficiencies for this construction type lies in the widely different wall densities in the two orthogonal directions. This deficiency may be eliminated with appropriate architectural design. This construction type is otherwise expected to demonstrate good seismic performance.
Length of time practiced:	25-60 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1 or 2
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	This construction practice has been followed for 30 years.

Features

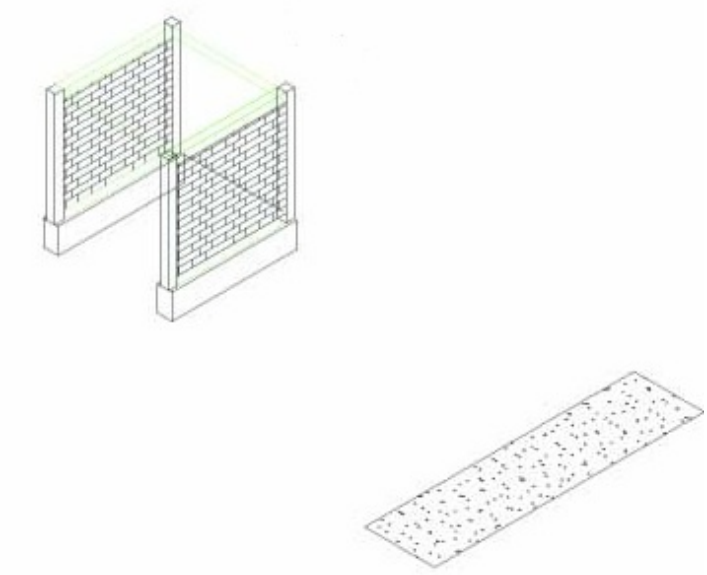
Plan Shape	Rectangular, solid
Additional comments on plan	The typical shape of a building plan for this housing type

shape	is rectangular.
Typical plan length (meters)	10
Typical plan width (meters)	6.5
Typical story height (meters)	3.3
Type of Structural System	Other
Additional comments on structural system	The vertical load-resisting system is confined masonry wall system. It consists of concrete block masonry walls with reinforced concrete beams and columns. In some cases, concrete beams and columns are provided without the masonry walls, in which case this system behaves as a frame; this depends on the architectural design. The lateral load-resisting system is confined masonry wall system. It consists of concrete block masonry walls with reinforced concrete beams and columns.
Gravity load-bearing & lateral load-resisting systems	Masonry: Clay/concrete: confined brick/block masonry with concrete posts/tie columns and beams
Typical wall densities in direction 1	1-2%
Typical wall densities in direction 2	5-10%
Additional comments on typical wall densities	The typical structural wall density is up to 10 %. The total wall density is 0.116; it is 0.03 in the X-direction, and 0.08 in the Y-direction.
Wall Openings	The typical house has approximately seven openings, with an average area of 2.50 m2. The position of the openings differs from building to building, however generally there is a front door and a back or side door. There are windows in the family room, in every bedroom and the bathroom. The opening area is about 13% of the overall wall area.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	This building type hasn't many modifications else.
Type of Foundation	Shallow Foundation: Reinforced concrete strip footing
Additional comments on foundation	
Type of Floor System	Other floor system
Additional comments on floor system	The flooring system is a nervure slab made of concrete with hollow clay blocks and fill-in elements.
Type of Roof System	Roof system, other

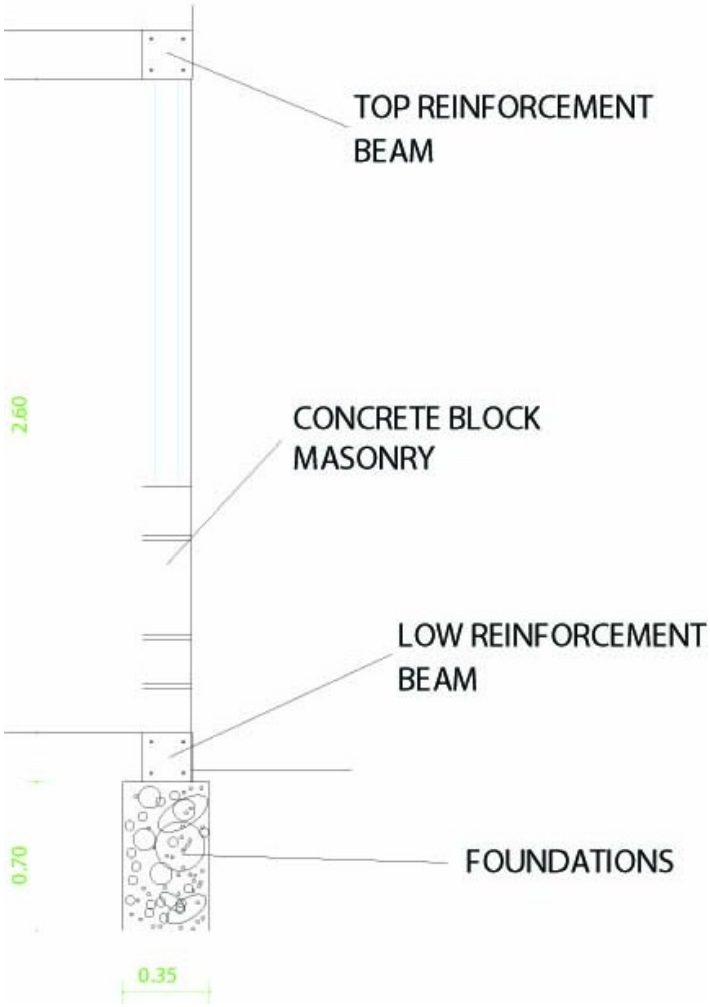
Additional comments on roof system	The roofing system is nervure slab made of concrete with hollow clay blocks and fill-in elements. It is considered to be a rigid diaphragm.
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 5 meters.



Plan of a typical building



Key load-bearing elements



Critical structural details

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Hollow concrete block	Compressive strength of the blocks varies from 2-50 kg/sq cm. The mix proportion used in making the mortars is 1:1:5 (cement-lime-sand). Wall thickness varies from 0.20 to 0.40 m. The walls have good resistance to compression and shear strength.
Foundations	Concrete	Compressive strength of the concrete used is 210 kg/sq cm. The mix proportion used in making the concrete is 1:3:5 (cement-sand- pebble). The foundation under columns is of size 0.60 m x

		0.25 m. The foundation has average resistance to compression.
Floors		
Roof	The roof is made of reinforced concrete hollow clay blocks.	The compressive strength of the concrete used is 210 - 420 kg/sq. cm. The mix proportion used in making the concrete is 1:2:4 (cement-sand-pebble).
Other	Beams and columns used for confining the masonry walls are made of reinforced concrete.	The compressive strength of the concrete used is 210 - 420 kg/sq. cm. The mix proportion used in making the concrete is 1:2:4 (cement-sand-pebble). The size of columns is 0.20 m x 0.20 m and that of beams is 0.20 m x 0.15 m.

Design Process

Who is involved with the design process?	EngineerArchitect
Roles of those involved in the design process	Architects are in charge of the architectural design of the building and sometimes, the construction process. Engineers are in charge of the structural design and of the construction process in general.
Expertise of those involved in the design process	The professionals involved in the design and construction process -architects and engineers- have a good level of expertise and great experience in this type of construction, typical in San Juan.

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	The builder usually does not live in this construction type. It is designed and built by professionals and used in housing plans developed and financed by the state.
Expertise of those involved in building process	
	The construction process is usually carried out by a construction company. It begins with the filling in of foundations, the assembling of the bottom reinforced concrete beams and columns and the casting of these beams. Then the block masonry walls are being built and the concrete columns are being cast. Subsequently, the

Construction process and phasing	top reinforced concrete beams are assembled and the slab concrete is poured. The tools and equipment typically used are. spatulas, shovels, hoes, baskets, saws, pliers, levels, cement mixers, etc. This type of construction is generally designed for its final constructed size, but usually the final size is fulfilled in a later stage, as an extension of the original construction. Sometimes the owner also builds additional parts, generally without any professional input.
Construction issues	

Building Codes and Standards

Is this construction type address by codes/standards?	Yes
Applicable codes or standards	Yes, the 1951 Building Code of the Province of San Juan, Earthquake-proof Norms Concar 70, Argentinean Earthquake-proof Norms 80 and 1990 INPRES CIRSOC Norms.
Process for building code enforcement	The provincial authorities approve the design and controls the construction process. To start the process of construction it is necessary to have the approval of the general and structure plans, the electrical wiring plans, plumbing, and gas plans. This approval is provided by the Provincial Authorities. A construction license provided by the Municipal Authorities is also required.

Building Permits and Development Control Rules

Are building permits required?	Yes
Is this typically informal construction?	Yes
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	The only problems associated with this type of construction are the considerable dispersion in the quality of the concrete blocks used and the common lack of maintenance in this type of construction. The quality of the blocks is controlled by means of standardized trials.
Who typically maintains buildings of this type?	Owner(s)

Additional comments on maintenance and building condition	Usually, it is the owner who maintains the building, but little or no maintenance is done.

Construction Economics

Unit construction cost	Unit construction cost per m2 of built-up area is approx. US$ 250. This price includes the entire needs of the construction.
Labor requirements	To start the process of construction it is necessary to have the approval of the general and structure plans, the electrical wiring plans, plumbing, and gas plans. This approval is provided by the Provincial Authorities. A construction license provided by the Municipal Authorities is also required. This type of building will need approx. 4 months to complete the construction. This type of building will need approx. 4 months to complete the construction. Workmen must satisfy minimum requirements like some expertise in the making of concrete, bond-beams, tie-columns, slabs cement mortars, and joists as well as in the construction of block masonry walls.
Additional comments section 3	

Socio-Economic Issues

Patterns of occupancy	A single family per housing unit.
Number of inhabitants in a typical building of this construction type during the day	<5
Number of inhabitants in a typical building of this construction type during the evening/night	<5
Additional comments on number of inhabitants	
Economic level of inhabitants	Middle-income class
Additional comments on economic level of inhabitants	Below are general guidelines related to the economic status of the inhabitants: Very Poor are lowest 10% of the population (per GDP), Poor from lowest 30% of the population, Middle Class from the lowest 30% up to the top 20% of the population, and Rich from top 20% of the population. For the Middle class, the price of the Housing Unit is 18,000 and their annual Income is 20,000. Ratio of

	housing unit price to annual income: 1:1 or better
Typical Source of Financing	Commercial banks/mortgages
Additional comments on financing	
Type of Ownership	Own with debt (mortgage or 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?	No
Additional comments on premium discounts	
Additional comments section 4	

Earthquakes

Past Earthquakes in the country which affected buildings of this type

Year	Earthquake Epicenter
1977	Caucete

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	In the Capital city of San Juan, located about 100 km from the epicenter, the intensity was between VII and VIII. The buildings of this construction type sustained the

construction type	earthquake without serious damage.
Additional comments on earthquake damage patterns	During the earthquake of 1977 in Caucete, in the capital city of San Juan, located about 100 km from the epicenter, the intensity was between VII and VIII. The buildings of this construction type sustained no serious damage.

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 intensity expected in this area.	TRUE
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	TRUE

	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.	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 to be adequate per the requirements of national codes and standards (an estimate).	TRUE
Quality of Workmanship	Quality of workmanship (based on visual inspection of a few typical buildings) is considered to be good (per local construction standards).	TRUE
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).	N/A

Building Irregularities

Additional comments on structural and architectural features for seismic resistance	
Vertical irregularities typically found in this construction type	Other
Horizontal irregularities typically found in this construction type	Other
Seismic deficiency in walls	In general, this type of building has no seismic deficiencies, except when the construction is not controlled by an official organization.
Earthquake-resilient features in walls	
Seismic deficiency in frames	Generally without seismic deficiencies.
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	No seismic deficiencies.
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	-|

Photograph illustrating typical earthquake damage

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
Wall	Increase the width of some walls. This has a low increase in the construction cost and a high likelihood of enhancing seismic stability. It is relatively simple to perform.

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	

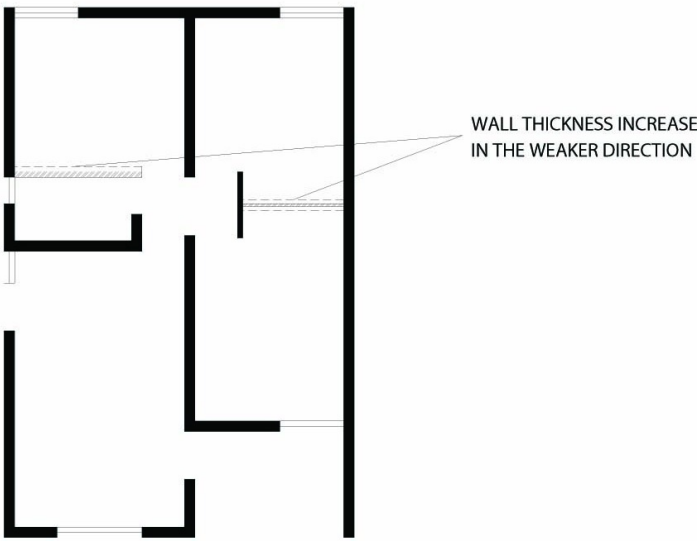


Illustration of seismic strengthening techniques

References

The 1951 Building Code of the Province of San Juan

Inter-relations between Architectural Design and Structural Design in High Seismic Risk Areas : Building Level - San Juan San Juan, Argentina 1989

Earthquake-proof Norms Concar 70

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