

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

Solid brick masonry house with composite hollow clay tile and concrete joist roof slabs

Report#	70
Last Updated	
Country	Argentina
Author(s)	Virginia I Rodriguez, Maria I Yacante, Sergio Reiloba,
Reviewers	Argimiro C. Gandica ,

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

General Information

Building Type:	Solid brick masonry house with composite hollow clay tile and concrete joist roof slabs
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 Argentina. Nowadays, this housing type represents about 30% of all the houses built in the capital city of the province of San Juan, reaching 70% in certain neighborhoods. This type of housing construction is commonly found in urban areas.
Summary:	This housing type is found in the urban areas of the Province of San Juan. It is a one-story, detached or semi-detached building, mainly used as a single-family house. The strength of this construction type is due to its solid brick walls confined with concrete tie-beams and tie-columns. The roof slabs are of composite concrete and masonry hollow clay tile construction, which form a diaphragm tied to the walls. The deficiency of this type of construction is found in the slabs which suffer serious deterioration due to the effects of humidity. This housing type is expected to have good seismic behaviour.
Length of time practiced:	25-60 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	

Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	
Typical plan length (meters)	11
Typical plan width (meters)	8.5
Typical story height (meters)	2.8
Type of Structural System	Masonry: Confined Masonry: Clay brick masonry with concrete posts/tie columns and beams
Additional comments on structural system	Lateral load-resisting system: Confined solid brick masonry with concrete tie columns and bond beams. Gravity load-bearing system: Confined solid brick masonry with concrete tie columns and bond beams.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	3-4%
Typical wall densities in direction 2	5-10%
Additional comments on typical wall densities	Total wall area/plan area: 0.15 Direction Y: 0.06 Direction X: 0.03
Wall Openings	This housing type has five (5) windows and two (2) doors. It has a main window of about 3.5 m ² , other windows have an area that varies between 1 m ² , and 1.5 m ² . The area of the two doors varies between 1.70 m ² and 2 m ² . All these openings are placed next to or very near the tie columns. 11.20% is the percentage for the overall window and door area as a fraction of the overall wall surface area.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	Typical patterns of modification observed in this housing type is the extension of the dining room up

FOUNDATIONS OF BUILDINGS

to the building line and/or a garage. The most common final plan configuration is the "L" shape.

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 slabs are made of concrete ribs and precast clay joists, with concrete topping cast in-situ. The floor/roof system is considered to be a rigid diaphragm.

Type of Roof System

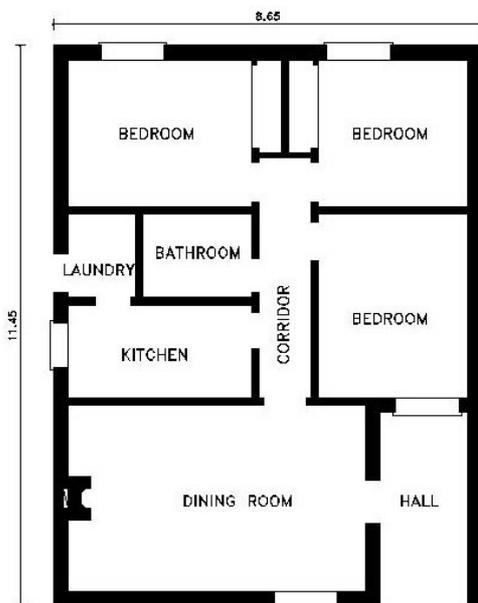
Roof system, other

Additional comments on roof system

The slabs are made of concrete ribs and precast clay joists, with concrete topping cast in-situ. The floor/roof system is considered to be a rigid diaphragm.

Additional comments section 2

Typical separation distance between buildings: 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	Wall: Solid clay brick Frame: Reinforced concrete	Wall: Characteristic Strength- 2.5 kg/cm.sq. Resistance to shear strength 15 kg/cm.sq. Resistance to compression Mix Proportion/Dimensions- 1:1:5 (cement/lime/sand)Dimensions: 6 x 13 x 27 Frame: Characteristic Strength- 170 kg/cm.sq. Typical resistance of concrete 4200 kg/cm.sq. Typical resistance of steel Mix Proportion/Dimensions- 1:2.5:3.5 (cement/sand/stone) Columns: 0.20 x 0.20 m 0.13 x 0.20 m 0.13 x 0.13 m Beams: 0.27 x 0.35 m 0.12 x 0.35 m
Foundations	Cyclopean concrete	Characteristic Strength: 130 kg/cm.sq Typical resistance Mix Proportion/Dimensions: 1:3.50:4 (cement/sand/stone) Dimensions according to calculus. Minimum: wall width + 15 cm x 70 cm
Floors	Clay joist slab	Characteristic Strength: 170 kg/cm.sq. Typical resistance of concrete 4200 kg/cm.sq. Typical resistance of steel Mix Proportion/Dimensions: 1:2.5:3.5 (cement/sand/stone) Hollow brick
Roof	Clay joist slab	Characteristic Strength: 170 kg/cm.sq. Typical resistance of concrete 4200 kg/cm.sq. Typical resistance of steel Mix Proportion/Dimensions: 1:2.5:3.5 (cement/sand/stone) Hollow brick
Other		

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 and they are sometimes responsible for the construction process of this housing type. Engineers work in structural design and sometimes in the

construction process too.

Expertise of those involved in the design process

This construction type was most prevalent between 1950 and 1970. Nowadays it is rarely built. Architects and engineers involved in the design and construction process acquired a good level of expertise since the reconstruction of the city of San Juan after the earthquake of 1944.

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. This type of building is designed and built by professionals.

Expertise of those involved in building process

Construction process and phasing

This construction type is built by a construction company. The construction process begins with the digging and filling of the foundations. Then the frame of low reinforcement concrete beam and the columns are placed, later the beams are filled; the masonry is erected and the columns are filled. Finally, the frames of the top reinforcement beams are placed and the slab is built to fill with concrete all the structure at once. This construction process does not need many tools. The tools and equipment typically used are: shovels, hoes, baskets, pliers, levels, cement mixers, etc. This building is typically constructed incrementally. This construction type is designed for its final constructed size, but it is usually extended. The extensions are generally built without the participation of an architect or an engineer.

Construction issues

Building Codes and Standards

Is this construction type address by codes/standards?

Yes

"Codigo de la Edificacion de la Provincia de San Juan" The first code/standard addressing this type of construction was issued 1951; the most recent code/standard addressing this construction was issued 1983. Applicable national building code,

Applicable codes or standards

material codes and seismic code/standards: "Normas Argentinas para Construcciones Sismorresistentes" (INPRES-CIRSOC 103 Rules - 1983)The seismic code: "Normas Argentinas para Construcciones Sismorresistentes" (Reglamento INPRES-CIRSOC 103) first issued in November 1983, and nowadays in current use, allows the construction of ribbing slabs. The most recent code/standard addressing this construction type issued was 1983.

Process for building code enforcement

The process of application of the Building Code is -in general- appropriate. In the province of San Juan there is an official entity called Direccion de Planeamiento y Desarrollo Urbano (Planning and Urban Development Secretary) which examines and approves the projects (the functional design and the structural calculus). This office also examines the foundations and the structure (plinth, columns, beams, slabs) that must be in accordance with the previously approved project.

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

Humidity damages the slabs made of clay blocks. This kind of slab generally last for 50 years.

Who typically maintains buildings of this type?

Owner(s)

Additional comments on maintenance and building condition

There is no careful maintenance of the building.

Construction Economics

Unit construction cost

450 \$US/m.sq.

Labor requirements

This construction type requires the approval of the architectural plans, the structural plans, and the sanitary installations plans by the provincial authorities; it also needs the electrical installation plans and the building permit given by the municipal authority. Nowadays, the gas installation plans are examined and approved by a private entity. This type of construction needs about 3 or 4 months to complete the construction.

Additional comments section 3

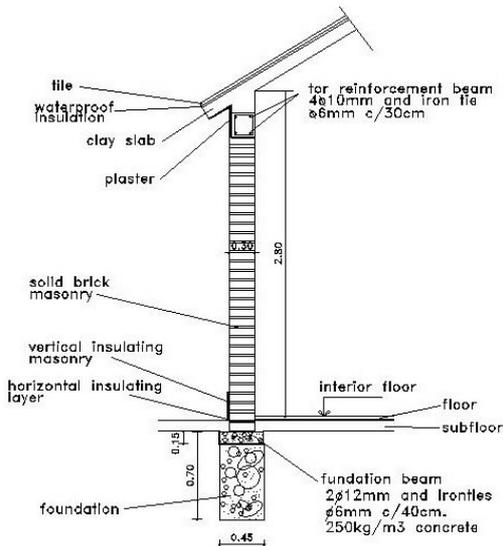
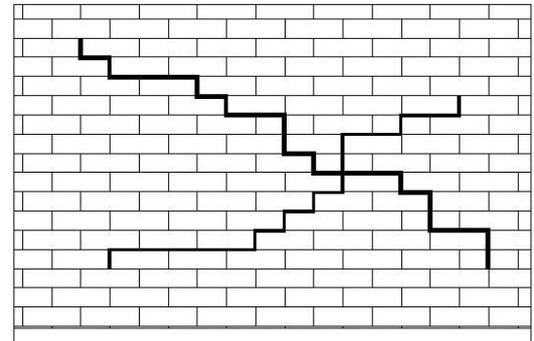


Figure 5:
TYPICAL DAMAGE
SAN ANDRES CROSS



Critical Structural Details (e.g. wall section, foundations, roof-wall connections, etc.)

An Illustration of Key Seismic Features and/or Deficiencies

Socio-Economic Issues

Patterns of occupancy

One family.

Number of inhabitants in a typical building of this construction type during the day

5-10

Number of inhabitants in a typical building of this

5-10

construction type during the evening/night	5-10
Additional comments on number of inhabitants	
Economic level of inhabitants	Middle-income class
Additional comments on economic level of inhabitants	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	Insurance does not cover earthquakes, and in fact they make explicit that there is no coverage for catastrophe.
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 Province, located 100 kilometers from the epicenter and the intensity was between VI and VII per the MMI scale. The buildings of this construction type suffered minor damages.
Additional comments on earthquake damage patterns	Diagonal shear cracks in buildings with poor construction quality.

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.

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	TRUE

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.	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.	TRUE
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 doveled 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	TRUE

straps.

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).	TRUE

Building Irregularities

Additional comments on structural and architectural features for seismic resistance	For maintenance, both kinds of situations (true and false) are present in this construction type because the slab deteriorates with humidity.
Vertical irregularities typically found in this construction type	Other
Horizontal irregularities typically found in this construction type	Other
Seismic deficiency in walls	No deficiency
Earthquake-resilient features in walls	The required wall resistance necessary in the area is 0.02 in accordance with INPRES-CIRSOC 103. The common densities of this construction type in a normal direction at the front is 0.06; and in a parallel direction at the front 0.03. They generally offer a high resistance capacity, even under the present standards.

Seismic deficiency in

frames

Earthquake-resilient features in frame

Seismic deficiency in roof and floors

The structure is frequently rusted because the roof has deficient waterproof insulation.

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	-	

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?

No

Was the work done as a mitigation effort on an

undamaged building or as a repair following earthquake damages?	N/A
Was the construction inspected in the same manner as new construction?	N/A
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	N/A
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	N/A
Additional comments section 6	

References

Interrelations Between Architectural Design and Structural Design in High Seismic Risk Areas Universidad Nacional de San Juan, San Juan, Argentina 1989

Interrelations Between Architectural Design and Urban Design in High Seismic Risk Areas Universidad Nacional de San Juan, Argentina 1994

The 1951 Building Code of the Province of San Juan

Argentinean Standards for Earthquake Resistant Constructions (INPRES-CIRSOC 103 Rules) 1993

Authors

Name	Title	Affiliation	Location	Email
Virginia I Rodriguez	Architect	Professor - Researcher	B# UDAP III Manzana "E" Monoblock 1 Piso 1# 5432 Rivadavia - San Juan - Argentina	deskjet@sinectis.com.ar

Maria I Yacante	Architect	Researcher	Av. Rawson 1068 (s) 5400 San Juan - Argentina
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Sergio Reiloba	Architect	Researcher	Napoleon Borini 4955(o) 5400 San Juan - Argentina	cereiloba@mixmail.com
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Reviewers

Name	Title	Affiliation	Location	Email
Argimiro C. Gandica	Professor	University of the Andes	Merida 5101, VENEZUELA	argimirocastillo@icnet.com.ve