# 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

**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 Association for Earthquake

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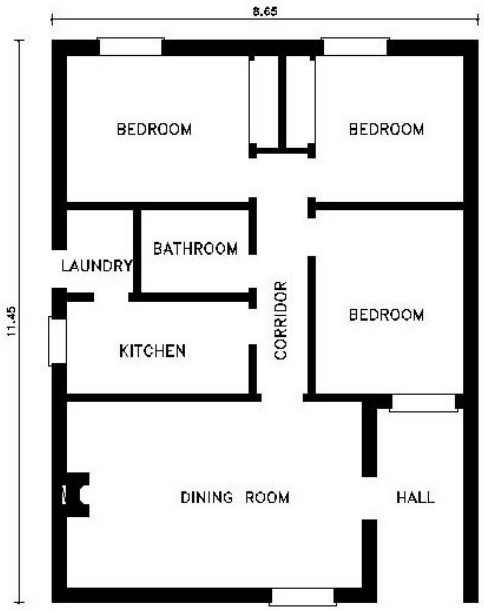
## General Information

| | |
|---|---|
| **Building Type:** | Solid brick masonry house with composite hollow clay tile and concrete joist roof slabs |
| **Country:** | Argentina |
| **Author(s):** | Virginia I Rodriguez<br>Maria I Yacante<br>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#, other windows have an area that varies between 1 m#, and 1.5 m#. The area of the two doors varies between 1.70 m# and 2 m#. 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 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** | The slabs are made of concrete ribs and precast clay |

| | |
|---|---|
| **Additional comments on roof system** | 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

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|---|---|
| **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 |
| **Applicable codes or standards** | "C#digo de la Edificacion de la Provincia de San Juan" The first code/standard addressing this type of construction was issued1951; the most recent code/standard addressing this construction was issued 1983. Applicable national building code, 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

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|---|---|
| **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

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|---|---|
| **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** | |

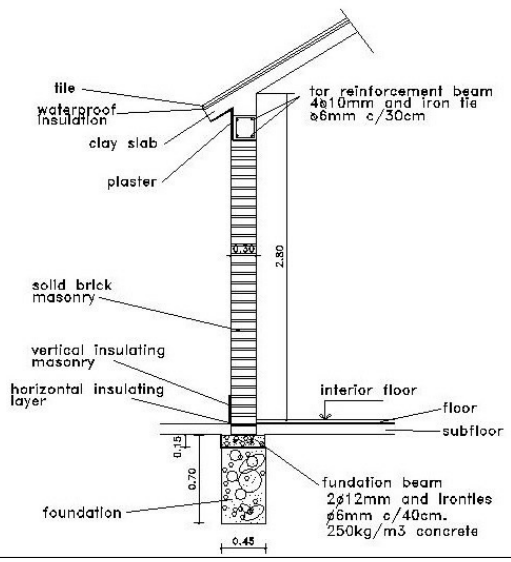
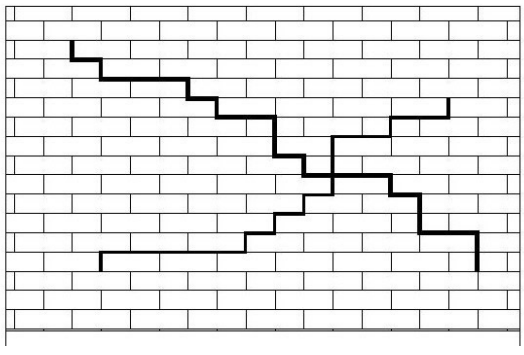



Figure 5:
TYPICAL DAMAGE
SAN ANDRES CROSS



***An Illustration of Key Seismic Features***

| *Critical Structural Details (e.g. wall section, foundations, roof-wall connections, etc.)* | *An Illustration of Key Seismic Features and/or Deficiencies* |
|---|---|

## Socio-Economic Issues

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|---|---|
| **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 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 |
| | |
| | |
| | |
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### 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 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. | TRUE |

| | | |
|---|---|---|
| | (Specify in 5.4.1) | |
| 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 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 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 | 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 |
|---|---|
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|---|---|
| **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 Unversidad Nacional de San Juan, San Juan, Argentina 1989

Interrelations Between Architectural Design and Urban Design in High Seismic Risk Areas Universidad Nacional se 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


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