World Housing Encyclopedia Report

Country: Argentina

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

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1 General Information

1.1 Country

Argentina

1.3 Housing Type

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

1.4 Summary

This housing type is found in the urban areas of the Province of San Juan. It is a one-story, detached or semidetached 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 behavior.

FIGURE 1: Typical Building

1.5 Typical Period of Practice for Buildings of This Construction Type

How long has this construction been practiced	
< 25 years	
< 50 years	X
< 75 years	
< 100 years	
< 200 years	
> 200 years	

Is this construction still being practiced?	Yes	No
	X	

1.6 Region(s) Where Used

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.

1.7 Urban vs. Rural Construction

Where is this construction commonly found?	
In urban areas	X
In rural areas	
In suburban areas	
Both in rural and urban areas	

2 Architectural Features

2.1 Openings

This housing type has five (5) windows and two (2) doors. It has a main window of about 3.5 m², other windows have an area that varies between 1 m², and 1.5 m².The area of the two doors varies between 1.70 m² and 2 m².
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.

2.2 Siting

	Yes	No
Is this type of construction typically found on flat terrain?	X	
Is this type of construction typically found on sloped terrain? (hilly areas)		X
Is it typical for buildings of this type to have common walls with adjacent buildings?		X

The typical separation distance between buildings is 3.00 meters

2.3 Building Configuration

The typical shape of a building plan for this housing type is rectangular.

2.4 Building Function

What is the main function for buildings of this type?	
Single family house	X
Multiple housing units	
Mixed use (commercial ground floor, residential above)	
Other (explain below)	

2.5 Means of Escape

There is an additional door on the side wall besides the main entry.

2.6 Modification of Buildings

A typical pattern 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.

3 Socio-Economic Issues

3.1 Patterns of Occupancy

One family

3.2 Number of Housing Units in a Building

1 units in each building.

3.3 Average Number of Inhabitants in a Building

How many inhabitants reside in a typical building of this construction type?	During the day / business hours	During the evening / night
< 5		
5 to 10	X	X
10-20		
> 20		
Other		

3.4 Number of Bathrooms or Latrines per Housing Unit

Number of Bathrooms: 1
Number of Latrines: 0

3.5 Economic Level of Inhabitants

Economic Status		House Price/Annual Income (Ratio)
Very poor		/
Poor		/
Middle Class	X	/
Rich		/

3.6 Typical Sources of Financing

What is the typical source of financing for buildings of this type?	
Owner Financed	
Personal Savings	
Informal Network: friends and relatives	
Small lending institutions/microfinance institutions	
Commercial banks / mortages	X
Investment pools	
Combination (explain)	
Government-owned housing	
Other	

3.7 Ownership

Type of Ownership/Occupancy	
Rent	
Own outright	
Own with Debt (mortgage or other)	X
Units owned individually (condominium)	
Owned by group or pool	
Long-term lease	
Other	

4 Structural Features

4.1 Lateral Load-Resisting System

Confined solid brick masonry with concrete tie columns and bond beams.

4.2 Gravity Load-Bearing Structure

Confined solid brick masonry with concrete tie columns and bond beams.

4.3 Type of Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	
Masonry	Stone masonry walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	
		2	Massive stone masonry (in lime or cement mortar)	
	Earthen walls	3	Mud walls	
		4	Mud walls with horizontal wood elements	
		5	Adobe block or brick walls	
		6	Rammed earth/Pise construction	
	Unreinforced brick masonry walls	7	Unreinforced brick masonry in mud or lime mortar	
		8	Unreinforced brick masonry in mud or lime mortar with vertical posts	
		9	Unreinforced brick masonry in cement or lime mortar (various floor/roof systems)	
	Confined masonry	10	Confined brick/block masonry with concrete posts/tie columns and beams	X
	Concrete block masonry walls	11	Unreinforced in lime or cement mortar (various floor/roof systems)	
		12	Reinforced in cement mortar (various floor/roof systems)	
		13	Large concrete block walls with concrete floors and roofs	
Concrete	Moment resisting frame	14	Designed for gravity loads only (predating seismic codes i.e. no seismic features)	
		15	Designed with seismic features (various ages)	
		16	Frame with unreinforced masonry infill walls	
		17	Flat slab structure	
		18	Precast frame structure	
		19	Frame with concrete shear walls-dual system	
		20	Precast prestressed frame with shear walls	
	Shear wall structure	21	Walls cast in-situ	
		22	Precast wall panel structure	
Steel	Moment resisting frame	23	With brick masonry partitions	
		24	With cast in-situ concrete walls	
		25	With lightweight partitions	
	Braced frame	26	Concentric	
		27	Eccentric	
Timber	Load-bearing timber frame	28	Thatch	
		29	Post and beam frame	
		30	Walls with bamboo/reed mesh and post (wattle and daub)	
		31	Wooden frame (with or without infill)	
		32	Stud wall frame with plywood/gypsum board sheathing	
		33	Wooden panel or log construction	
Various	Seismic protection systems	34	Building protected with base isolation devices or seismic dampers	
	Other	35		

4.4 Type of Foundation

Type	Description	
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	X
	Mat foundation	
	No foundation	
Deep Foundation	Reinforced concrete bearing piles	
	Reinforced concrete skin friction piles	
	Steel bearing piles	
	Wood piles	
	Steel skin friction piles	
	Cast in place concrete piers	
	Caissons	
Other		

4.5 Type of Floor/Roof System

Material	Description of floor/roof system	Floor	Roof
Masonry	Vaulted		
	Composite masonry and concrete joist		X
Structural Concrete	Solid slabs (cast in place or precast)		
	Cast in place waffle slabs		
	Cast in place flat slabs		
	Precast joist system		
	Precast hollow core slabs		
	Precast beams with concrete topping		
	Post-tensioned slabs		
Steel	Composite steel deck with concrete slab		
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 single roof		
	Wood planks or beams that support clay tiles		
	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			

Additional Comments: 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.

4.6 Typical Plan Dimensions

Length: 11.5 - 11.5 meters
Width: 11.5 - 11.5 meters

4.7 Typical Number of Stories

1

4.8 Typical Story Height

2.80 meters

Additional Comments: 2.80 meters in flat roof buildings and 4.30 meters in gable roof buildings. Sloping roof has 2.80 meters in perimeter walls and 4.30 meters in ridge.

4.9 Typical Span

4.00 meters

4.10 Typical Wall Density

Total wall area/plan area: 0.15
Direction Y: 0.06
Direction X: 0.03

4.11 General Applicability of Answers to Questions in Section 4

The housing type discussed in this example is a typical building.

5 Evaluation of Seismic Performance and Seismic Vulnerability

5.1 Structural and Architectural Features: Seismic Resistance

Structural/ Architectural Feature	Statement	True	False	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 form the building to the foundation.	X		
Building configuration	The building is regular with regards to both the plan and the elevation.	X		
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.	X		
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.	X		
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.	X		
Wall and frame structures- redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	X		
Wall proportions	Height-to-thickness ratio of the shear walls at each floor level is: 1) Less than 25 (concrete walls); 2)Less than 30 (reinforced masonry walls); 3) Less than 13 (unreinforced masonry walls).	X		
Foundation- wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	X		
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.	X		
Wall openings	The total width of door and window openings in a wall is: 1) for brick masonry construction in cement mortar: less than 1/2 of the distance between the adjacent cross walls; 2) for adobe masonry, stone masonry and brick masonry in mud mortar: less than 1/3 of the distance between the adjacent cross walls; 3) for precast concrete wall structures: less than 3/4 of the length of a perimeter wall.	X		
Quality of building materials	Quality of building materials is considered to be adequate per requirements of national codes and standards (an estimate).	X		
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).	X		
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).	X	X	
Other				

Additional Comments: Both kinds of situations are present in this construction type because the slab deteriorates with humidity.

5.2 Seismic Features

Structural Element	Seismic Deficiency	Earthquake-Resilient Features	Earthquake Damage Patterns
Walls within frames of columns and beams	No deficiency	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.	Diagonal shear cracks in buildings with poor construction quality.
Frame (columns, beams)			
Roof and floors	The structure is frequently rusted because the roof has deficient waterproof insulation		

5.3 Seismic Vulnerability Rating

	Vulnerability					
	High (Very Poor Seismic Performance) A	B	Medium C	D	E	Low (Excellent Seismic Performace) F
Seismic Vulnerability Class			<	0	>	

0 - probable value
< - lower bound
> - upper bound

6 Earthquake Damage Patterns

6.1 Past Earthquakes Reported To Affect This Construction

Year	Earthquake Epicenter	Richter magnitude(M)	Maximum Intensity (Indicate Scale e.g. MMI, MSK)
1977	Caucete	7.4	IX (MMI)

<u>Additional Comments:</u> 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.

7 Building Materials and Construction Process

7.1 Description of Building Materials

Structural Element	Building Material	Characteristic Strength	Mix Proportions/ Dimensions	Comments
Walls	Solid clay brick	2.5 kg/cm² (1) 15 kg/cm² (2)	1:1:5 (cement/lime/sand) Dimensions: 6 X 13 X 27	(1) Resistance to shear strength (2) Resistance to compression
Foundations	Cyclopean concrete	130 kg/cm² (3)	1:3.50:4 (cement/sand/stone) Dimensions according to calculus. Minimum: wall width + 15 cm X 70 cm	(3) Typical resistance
Frame	Reinforced concrete	170 kg/cm² (4) 4200 kg/cm² (5)	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	(4) Typical resistance of concrete (5) Typical resistance of steel
Roof and floors	Clay joist slab	170 kg/cm² (6) 4200 kg/cm² (7)	1:2.5:3.5 (cement/sand/stone) Hollow brick	(6) Typical resistance of concrete (7) Typical resistance of steel

7.2 Does the builder typically live in this construction type, or is it more typically built by developers or for speculation?

The builder usually does not live in this construction type. This type of building is designed and built by professionals.

7.3 Construction Process

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.

7.4 Design/Construction Expertise

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.

7.5 Building Codes and Standards

	Yes	No
Is this construction type addressed by codes/standards?	X	

Title of the code or standard: "Código de la Edificación de la Provincia de San Juan"
Year the first code/standard addressing this type of construction issued: 1951
National building code, material codes and seismic codes/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.
When was the most recent code/standard addressing this construction type issued? 1983

7.6 Role of Engineers and Architects

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.

7.7 Building Permits and Development Control Rules

	Yes	No
Building permits are required	X	
Informal construction		X
Construction authorized per development control rules	X	

7.8 Phasing of Construction

	Yes	No
Construction takes place over time (incrementally)	X	
Building originally designed for its final constructed size	X	

Additional Comments: 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.

7.9 Building Maintenance

Who typically maintains buildings of this type?	
Builder	
Owner(s)	X
Renter(s)	
No one	
Other	

Additional Comments: There is no careful maintenance of the building.

7.10 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 Dirección 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.

7.11 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.

8 Construction Economics

8.1 Unit Construction Cost (estimate)

450 $US/m

8.2 Labor Requirements (estimate)

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.

9 Insurance

9.1 Insurance Issues

	Yes	No
Earthquake insurance for this construction type is typically available		X
Insurance premium discounts or higher coverages are available for seismically strengthened buildings or new buildings built to incorporate seismically resistant features		X

Additional Comments: Insurance does not cover earthquakes, and in fact they make explicit that there is no coverage for catastrophe.

9.2 If earthquake insurance is available, what does this insurance typically cover/cost?

10 Seismic Strengthening Technologies

10.1 Description of Seismic Strengthening Provisions

Type of intervention	Structural Deficiency	Description of seismic strengthening provision used

10.2 Has seismic strengthening described in the above table been performed in design practice, and if so, to what extent?

No.

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

N/A

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

N/A

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

N/A

10.6 What has been the performance of retrofitted buildings of this type in subsequent earthquakes?

N/A

11 References

Project: Interrelations Between Architectural Design and Structural Design in High Seismic Risk Areas. Unversidad Nacional de San Juan, 1989 - San Juan - Argentina.

Project: Interrelations Between Architectural Design and Urban Design in High Seismic Risk Areas. Universidad Nacional se San Juan, 1994 - San Juan - Argentina.

The 1951 Building Code of the Province of San Juan

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

12 Contributors

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13 Figures

FIGURE 1: Typical Building

Figure 2:

Perspective Drawing Showing
key Load-Bearing Elements

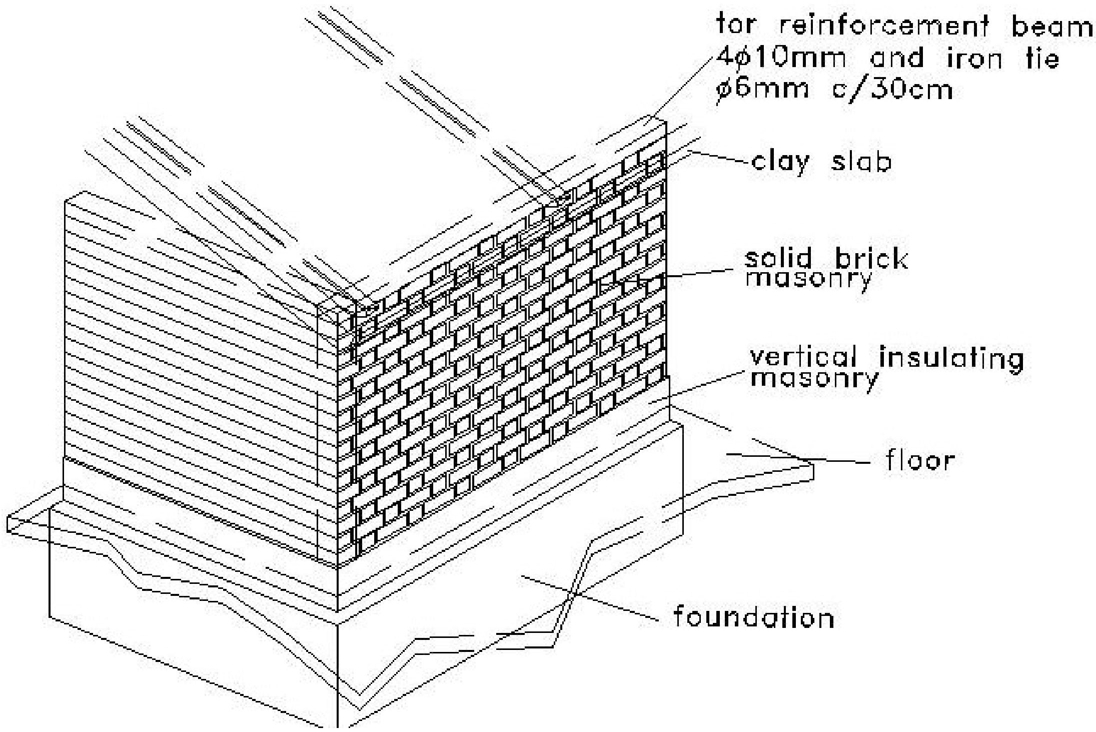

FIGURE 2: Key Load-Bearing Elements

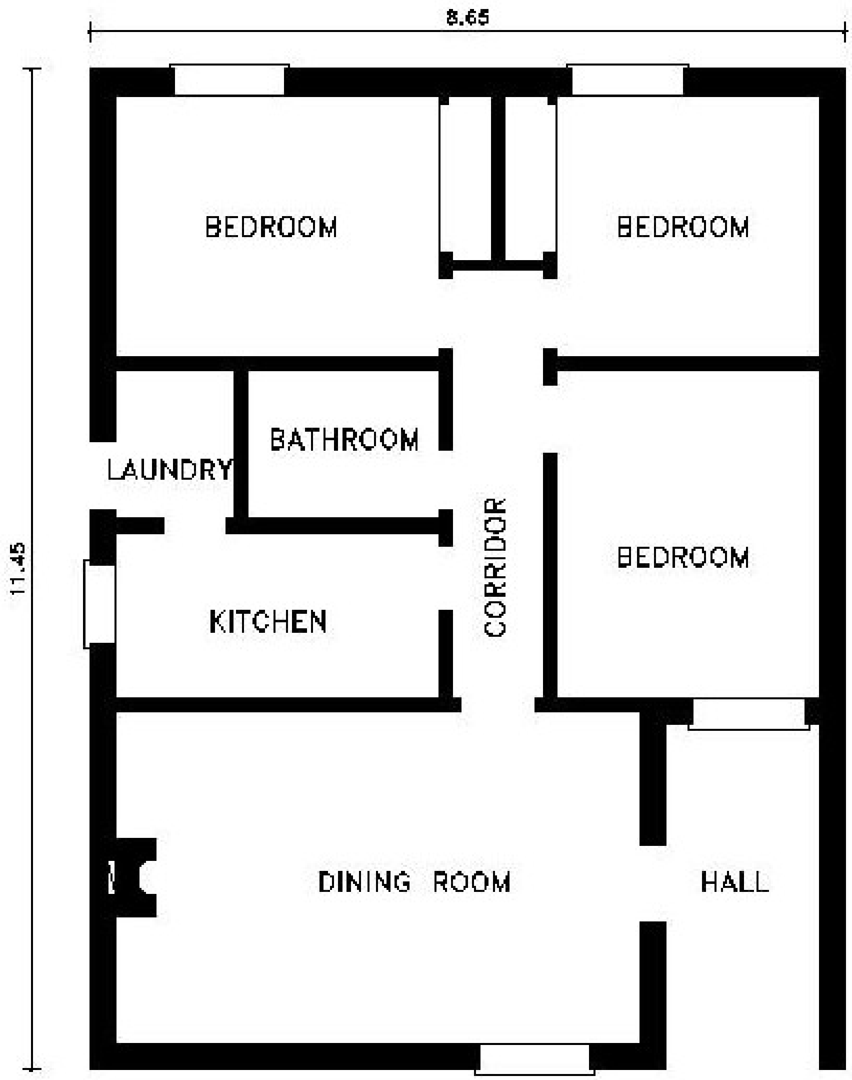

FIGURE 3: Plan of a Typical Building

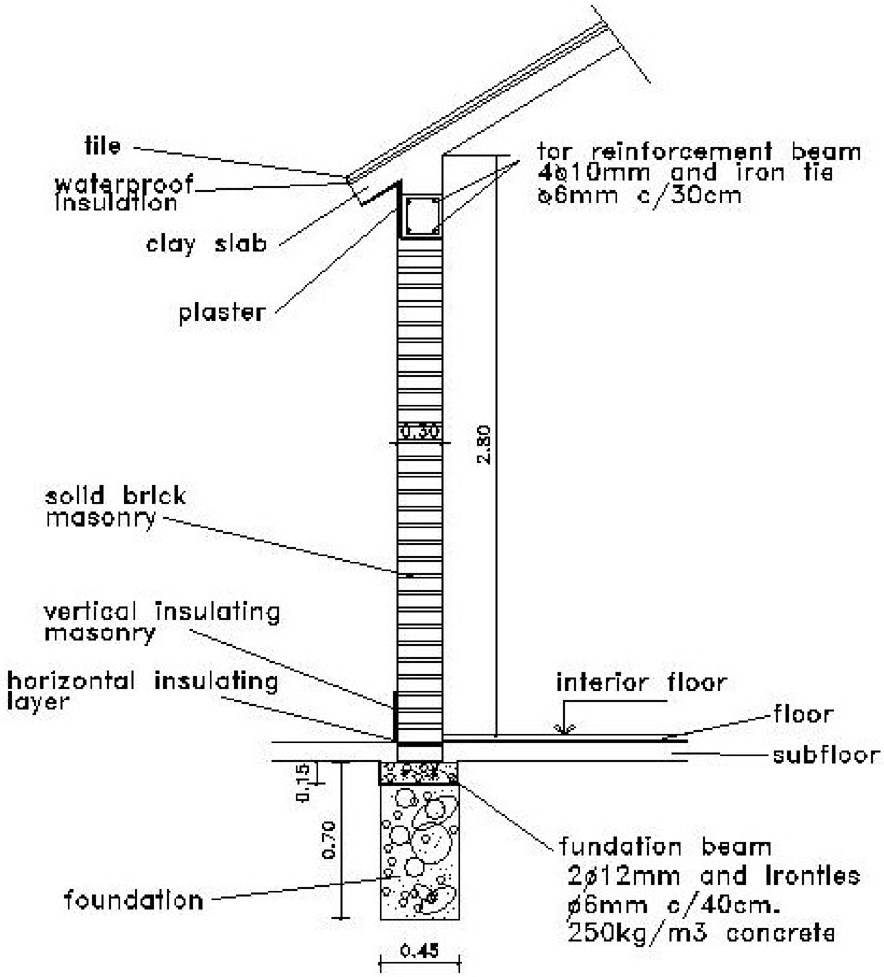

FIGURE 4: Critical Structural Details (e.g. wall section, foundations, roof-wall connections, etc.)

Figure 5:
TYPICAL DAMAGE
SAN ANDRES CROSS

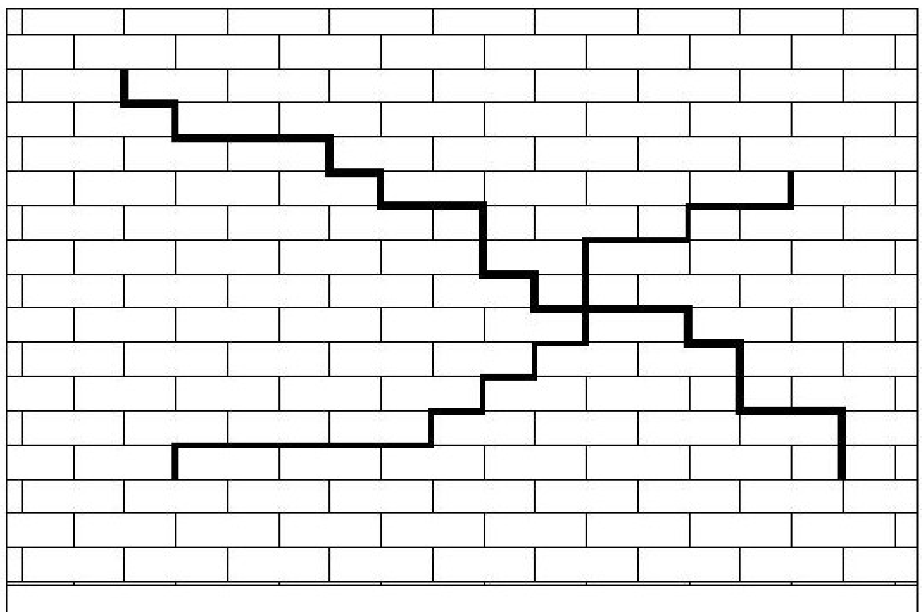

FIGURE 5: An Illustration of Key Seismic Features and/or Deficiencies