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

Traditional adobe house

Report#	2
Last Updated	
Country	Argentina
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Important

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General Information

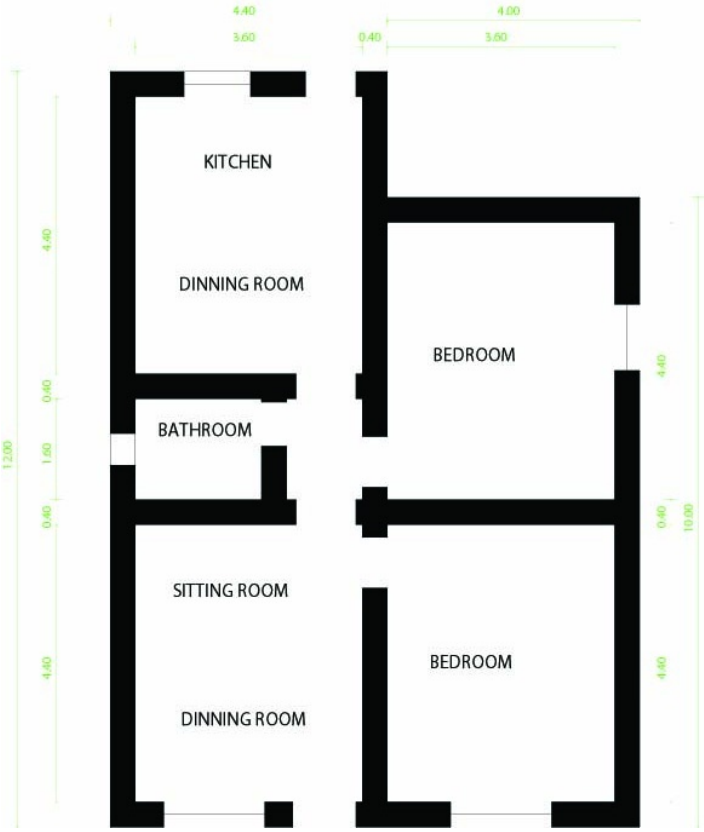
Building Type:	Traditional adobe house
Country:	Argentina
Author(s):	Virginia I Rodriguez Maria I Yacante Sergio Reiloba
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in in the province of San Juan. This type of housing construction is commonly found in rural areas. The building code allows this type of construction only in rural areas. However, as the city has grown, the current urban area now includes adobe block constructions that were built in the past (when the area was rural).
Summary:	This construction type is a single-family house. In general, it is a single-story building, an isolated construction found in the rural areas of San Juan and Mendoza. The traditional adobe block masonry walls are reinforced with foundations and plinth structure, which provide structural strength. A deficiency in this type of construction is that the adobe blocks deteriorate due to prolonged exposure to humidity.
Length of time practiced:	76-100 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Single dwelling
Typical number of stories:	1
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	This is a traditional construction practice that has been practiced in San Juan for many years, but since 1948 it has been pract

Features

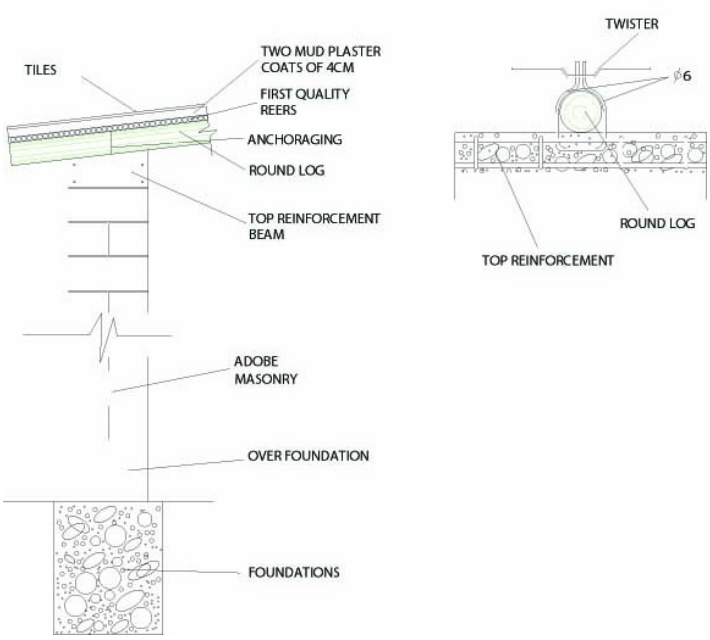
Plan Shape	Rectangular, solid

Additional comments on plan shape	The typical shape of a building plan for this housing type is rectangular.
Typical plan length (meters)	12
Typical plan width (meters)	8.4
Typical story height (meters)	3
Type of Structural System	Masonry: Earthen/Mud/Adobe/Rammed Earth Walls: Mud walls with horizontal wood elements
Additional comments on structural system	The vertical load resisting system is adobe block walls. The earthquake-resistant system consists of adobe block walls of 40 cm thickness, which generally meet the quality standards and architectural requirements (small openings, heights shorter than 3 m). In general, the roofs are light (weight less than 150 kg/sq m). On the upper part of the wall, there is a reinforced concrete bond beam, and on the bottom there are foundations and plinth structure.
Gravity load-bearing & lateral load-resisting systems	40-cm-thick block walls joined using mud mortar.
Typical wall densities in direction 1	10-15%
Typical wall densities in direction 2	15-20%
Additional comments on typical wall densities	The total wall density is 0.215; it is 0.153 in the X-direction and 0.11 in the Y-direction.
Wall Openings	The typical house has approximately seven openings, with an average area of 1.60m2 . These openings are: 5 (five) windows, placed in the middle of the walls, and 2 (two) doors. The doors are placed to one side of the wall. The opening area is about 10.40% of the whole wall area.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	
Type of Foundation	Shallow Foundation: Reinforced concrete strip footing
Additional comments on foundation	Concrete, with a minimum cement of 180 kg/sq m and 30 % of stone. The top of the plinth is 30 cm above the ground level.
Type of Floor System	Other floor system
Additional comments on floor system	
Type of Roof System	Roof system, other

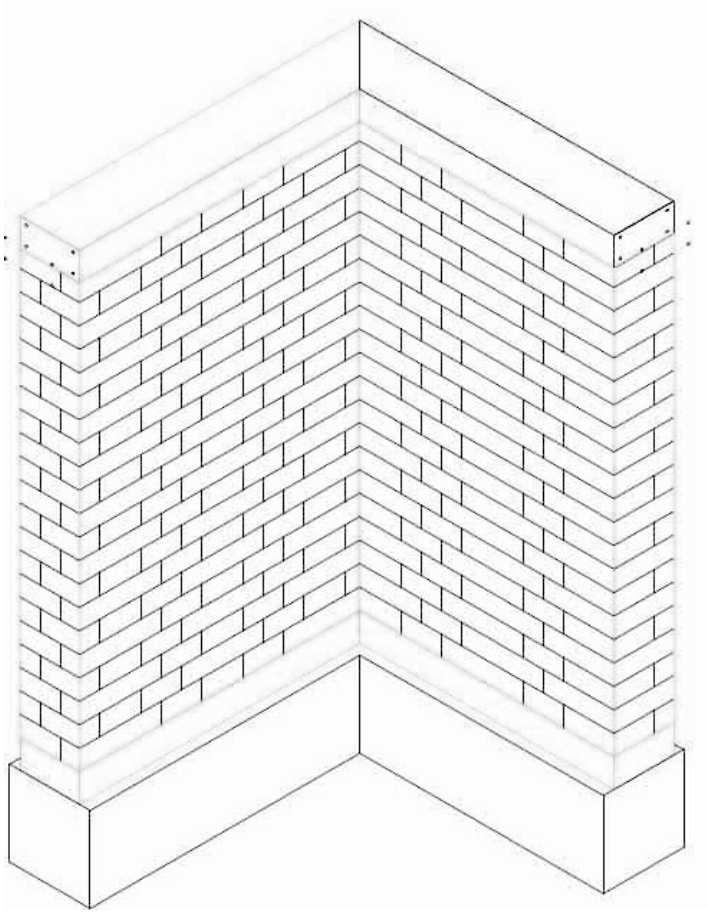
Additional comments on roof system	The roofing system consists of mud and cane roof with exterior finishing of clay tiles supported by round logs. The roof is considered to be a flexible diaphragm with a maximum weight of 150 kg/sq m.
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 5 meters.



Plan of typical building



Critical structural details



Key load-bearing elements

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Wall: Adobe blocks/ Reinforced concrete Frame: Reinforced concrete	Wall- Characteristic Strength: 3 Kg/sq cm - 10 Kg/sq cm Mix Proportion/Dimensions: Clay soil and thatch Joined with mud (1) resistance to compression (2) resistance to deflection Frame- Characteristic Strength: 200 kg/ cm22400 kg/ cm2 Mix Proportion/Dimensions: 1:3:3 (cement-sand-gravel) Top reinforced concrete beam as wide as the wall (3) resistance of concrete to compression (4) resistance of steel to tension Frame- Characteristic Strength:200 Kg/sq cm-2400 Kg/sq cm Mix Proportion/Dimensions: 1:3:3 (cement-sand-gravel) Top

		reinforced concrete beam is as wide as the wall. High resistance of concrete to compression, and of steel to tension.
Foundations	Concrete with stone	Characteristic Strength: 150 kg/ cm2 Mix Proportion/Dimensions: 1:3:5 & 3 (cement # sand # pebble and stone) Minimum 180 Kg/sq cm, 30% stone
Floors		
Roof	Round logs with cane and mud roof	Round log d=16 cm, every 60 cm Roof maximum weight: 150 kg/ m2
Other		

Design Process

Who is involved with the design process?	Other
Roles of those involved in the design process	In the beginning, this type of construction was designed and built by engineers and general builders, but later the same construction began to be made by the owners.
Expertise of those involved in the design process	

Construction Process

Who typically builds this construction type?	OwnerOther
Roles of those involved in the building process	When this construction was first used, the builder did not live in this construction type. However, later on it was built by the owners themselves; in general, owners of this type of construction are people without any chances of building their houses with other building materials (due to their high cost).
Expertise of those involved in building process	This construction began to be practiced after the 1944 earthquake, as an alternative to improve the seismic behavior of the traditional adobe block construction. The design of adobe construction was largely based on the local building experience related to this kind of construction. This experience and the new information gained after the earthquake helped in improving the adobe construction practice. This construction proved to be an economic solution as the local material and skills were used and the traditional construction practice was followed.

Construction process and phasing	The owner of the house usually carries out the construction. It begins with the manufacturing of adobe, the filling in of foundations and plinth construction. After that, the adobe block masonry is built, caring that the blocks are perfectly joined. Then, the frame of the top reinforcement concrete beam is made, and the iron bars are placed to fasten the round logs of the roof. The frame is filled in with concrete. The round logs are placed and fastened every 60 cm. After that a 5cm-wide coat of cane and mud is placed. This coat is later made waterproof with asphalt, finishing the process with the placement of Spanish tiles. The tools and equipment typically used are: wheelbarrows, grub hoe, and matrix for the manufacturing of adobe blocks; spatulas, shovels, hoes, baskets, saws, pliers, levels, cement mixers, etc., are used in the whole process. This type of construction is generally designed for its final constructed size, but 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	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 construction process is controlled by the corresponding state authorities.

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?	No
Additional comments on building permits and development control rules	This construction is subject to regulations and the approval of plans.

Building Maintenance and Condition

Typical problems associated with this type of construction	

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 given the low economic levels of the owners there is generally little or no maintenance and over time the construction deteriorates.

Construction Economics

Unit construction cost	Unit construction cost per m2 of built-up area is approximately US$ 137.
Labor requirements	The typical amount and skill-level of labour employed in the construction of a typical building of this type of housing is 380 man-days (assuming 8 working hours/day). Experience is required in the selection of the land. Knowledge is necessary about the adequate mix proportions to manufacture the adobe blocks, and about foundations, plinth structure, top reinforcement beam, and round log. The tools needed in this construction type are not many: shovels, baskets, hoes, pliers, spatulas, etc.
Additional comments section 3	

Socio-Economic Issues

Patterns of occupancy	In general, there is a single family in a 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	Very low-income class (very poor)
Additional comments on economic level of inhabitants	House Price/Annual Income (ratio): 5:1 or worse 1. Below are the general guidelines related to the economic status of the inhabitants: Very Poor= lowest 10% of the population (per GDP), Poor= lowest 30% of the population, Middle Class= from the lowest 30% up to the top 20% of the population, Rich= top 20% of the population. Values are variable: the adobe blocks may be manufactured by the owner of the house and the masonry may also be made by the owner; canes grow on

	the banks of the water channels in the area. All this results in a notable reduction of the overall construction cost. Economic Level: For Poor Class the Housing Price Unit is 12,000 and the Annual Income is 7,200.
Typical Source of Financing	Combination
Additional comments on financing	In the #50s, a part of the cost was paid by the government, in the form of a non-repayable contribution or grant, and the rest of the money was financed by a bank. Nowadays, the construction is completely owner financed; the owners are doing the construction by themselves.
Type of Ownership	Own with debt (mortgage or other)
Additional comments on ownership	The information in this chart reflects the period after the 1944 earthquake. After 1960, houses of this construction type were built directly by the owners, without any kind of external financing.
Is earthquake insurance for this construction type typically available?	No
What does earthquake insurance typically cover/cost	Insurance policies for buildings make it explicit that disasters are not covered.
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 100 km to the east of San Juan Capital city

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	In general, during the 1977 earthquake, the adobe block construction built in Caucete using the standards of 1948, suffered moderate damage (economically repairable); those built in the capital city of San Juan, under the same standards, were not damaged at all. Traditional adobe block houses, built without any kind of earthquake-resistant requirements, were seriously damaged during the same earthquake.
Additional comments on earthquake damage patterns	In the Capital city of San Juan, located at approximately 100 km distance from the epicenter, the intensity was between VII MMI and VIII MMI . It is important to mention that a wide area of about 1000 km2 experienced liquefaction.

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.	FALSE
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	FALSE

	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 doweled into the foundation.	FALSE
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		FALSE
Quality of Building Materials	Quality of building materials is considered to be adequate per the requirements of national codes and standards (an estimate).	FALSE

Quality of Workmanship	Quality of workmanship (based on visual inspection of a few typical buildings) is considered to be good (per local construction standards).	FALSE
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).	FALSE

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	The resistance of adobe masonry in this construction type is weakened by the following factors: 1. The openings- due to the following factors:a) the big size of the two windows (1.60 m2) in the main face of the construction. b) The position of the doors in the angles formed by the meeting of walls. c) The great percentage of opening surface (31%) in the front and back walls. 2- The vulnerability of the adobe due to humidity
Earthquake-resilient features in walls	
Seismic deficiency in frames	No buttresses provided at the wall intersections.
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	The roof is flexible.
Earthquake resilient features in roof and floors	
Seismic deficiency in foundation	
Earthquake-resilient features	

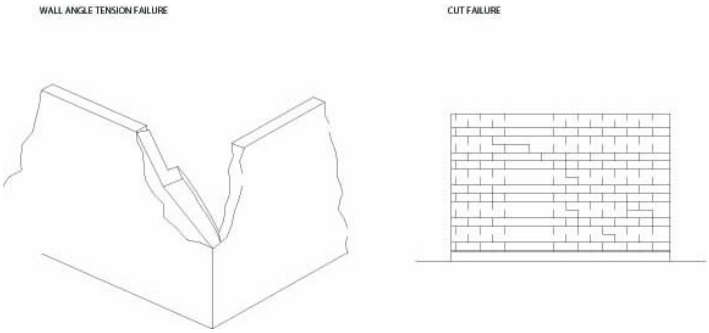
in foundation	

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



An illustration of key seismic features and/or deficiencies

Photograph illustrating typical earthquake damage

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening

Additional comments on seismic strengthening provisions	This type of construction has emerged as a proposal to strengthen the traditional adobe block construction which had an unsatisfactory performance during the 1944 earthquake. This construction has been built in San Juan under the Adobe Construction Regulations of 1948, however it is only allowed in rural areas. During the 1977 Caucete earthquake, this construction has a satisfactory performance so no seismic strengthening has been done since that time. It should be noted that some traditional adobe construction (not following the 1948 Regulations) is still being practiced in rural areas.
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	

References

Adobe Construction Regulations

The 1951 Building Code of the Province of San Juan

Adobe Block Housing in Dry Areas Hugo Giuliani and Jose Herrera Cano

1991 National Survey on Population and Housing (INDEC) N18

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

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