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 Masonry Building with Concrete blocks, tie-columns and beams

Report#	27
Last Updated	
Country	Iran
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Important

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General Information

Building Type:	Confined Masonry Building with Concrete blocks, tie-columns and beams
Country:	Iran
Author(s):	Behrokh Hosseini Hashemi Faramarz Alemi Mohsen Ghafory Ashtiany
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in rural areas of Iran. The percentage of this housing type in those regions is almost 10%. This type of housing construction is commonly found in rural areas.
Summary:	This is a typical confined brick masonry housing construction common in rural areas of Iran. This building type is often used as a single-family house. Brick masonry shear walls confined with concrete tie columns and beams provide earthquake resistance in both directions. This building type is expected to have 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
Terrain-Flat:	Typically
Terrain-Sloped:	Typically
Comments:	These buildings are typically found in flat, sloped and hilly terrain. They do not share common walls with adjacent buildings. T

Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	The typical shape of a building plan for this housing type is rectangular. To view outside the building, typically a window opening is built in external walls. These windows almost take 40% of the external walls areas. The other wall has one or two doors. The door sizes are typically 90 X 210 (cm). The overall window and door areas are about 25% of the overall wall surface area.
Typical plan length (meters)	5
Typical plan width (meters)	9
Typical story height (meters)	3
Type of Structural System	Masonry: Confined Masonry: Concrete blocks, tie columns and beams
Additional comments on structural system	The vertical load-resisting system is confined masonry wall system. Gravity loads sustain by bearing masonry brick walls. The lateral load-resisting system is confined masonry wall system. In both directions of the buildings lateral load-resisting system are provided by masonry brick shear walls which are confined with concrete tie column and beams.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	15-20%
Typical wall densities in direction 2	15-20%
Additional comments on typical wall densities	The typical structural wall density is up to 20 %. Total wall area/plan area (for each floor) 0.2.
Wall Openings	To view outside the building, typically a window opening is built in external walls. These windows almost take 40% of the external walls areas. The other wall has one or two doors. The door sizes are typically 90 X 210 (cm). The overall window and door areas are about 25% of the overall wall surface area.
Is it typical for buildings of this type to have	No

common walls with adjacent buildings?	NO
Modifications of buildings	This type of construction does not have many modifications.
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 floor/ and roof are considered to be a rigid diaphragm.
Type of Roof System	Roof system, other
Additional comments on roof system	The floor/ and roof are considered to be a rigid diaphragm.
Additional comments section 2	The main function of this building typology is single-family house. In a typical building of this type, there are no elevators and 1-2 fire-protected exit staircases. Building of this type can have as the one main entry so the two doors. Buildings of this type in some places are located close together and in other places are scattered When separated from adjacent buildings, the typical distance from a neighboring building is 5 meters.

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Clay brick masonry. / Steel bars.	Clay brick masonry: 150 Kg/sq cm 10 Kg/sq cm characteristic strength, 1:6 / 55 X 110 X 220 (mm) mix proportions/dimensions Steel bars: 3000 Kg/sq cm characteristic strength
Foundations	Concrete.	210 Kg/sq cm characteristic strength, 1:2:4 mix proportions
Floors	Wood	
Roof	Wood	

Other		

Design Process

Who is involved with the design process?	EngineerArchitect
Roles of those involved in the design process	For design of building, engineers and architectures are both involved. However, during the construction process they do not spend any time to visit the site.
Expertise of those involved in the design process	As far as the design concern, engineers do their job properly. But the main problem is the construction of this type of buildings in rural areas, due to lack of skilled worker.

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	It is typically built by developers and the builders does not necessary live in this building type.
Expertise of those involved in building process	The main problem is the construction of this type of buildings in rural areas, due to lack of skilled worker.
Construction process and phasing	Typically developers build these types of constructions. Process starts with the foundations and then bearing walls. Process continues by adding the concrete tie columns and then tie beams then placing of wood beams and finally putting the finishing on the hole building. The construction of this type of housing takes place incrementally over time. Typically, the building is originally designed for its final constructed size.
Construction issues	

Building Codes and Standards

Is this construction type address by codes/standards?	Yes
Applicable codes or standards	The first official issue about this type of building was in 1987. The Iranian Code of Practice for Seismic Resistant Design of Buildings (Standard 2800) addressed this type of construction. Iranian Code of Practice for Seismic Resistant Design of Building, 1st Edition- 1987 and 2nd Edition-1999 Iranian National Building Code, Part: 8, Reinforced and unreinforced

	masonry buildings. The year the first code/standard addressing this type of construction issued was 1987. Iranian Code of Practice for Seismic Resistant Design of Building, 1st Edition- 1987 and 2nd Edition-1999.
Process for building code enforcement	The building department of municipalities approves the design and holds the designer responsible for the projects. For those constructions, which are supported by government's fund, there is a proper control during construction. But for the others, there is not any control.

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?	No
Additional comments on building permits and development control rules	

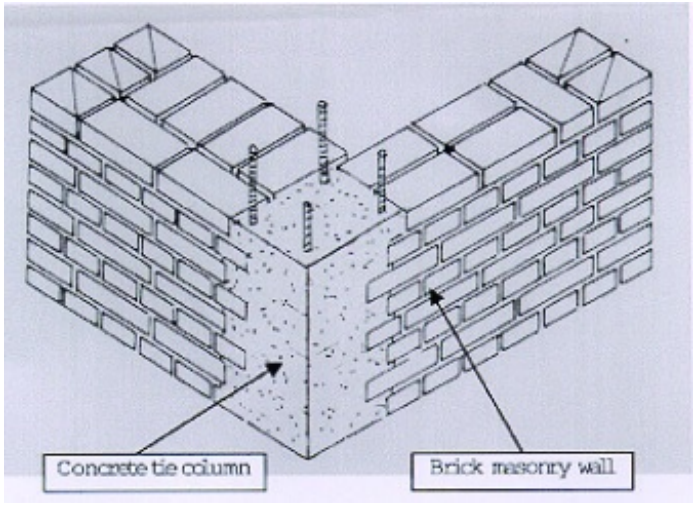
Building Maintenance and Condition

Typical problems associated with this type of construction	
Who typically maintains buildings of this type?	Owner(s)Renter(s)
Additional comments on maintenance and building condition	

Construction Economics

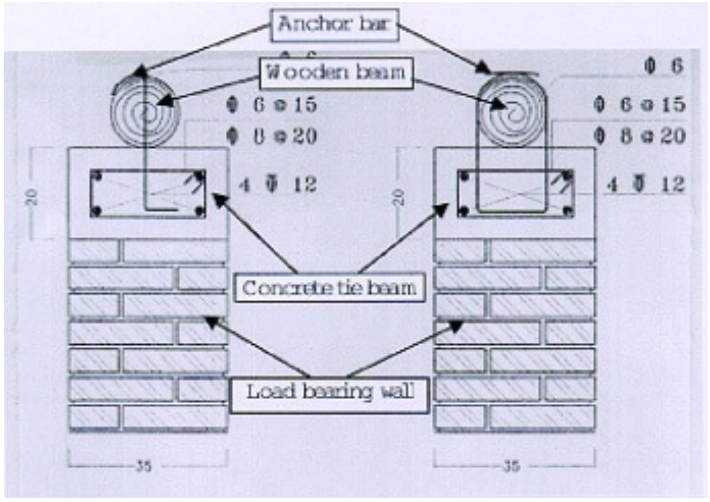
Unit construction cost	A unit construction may cost 500,000 Rials/sq m (250 $US/sq m).
Labor requirements	For a typical one story building needs about 30 to 40 days to complete the load bearing structure.
Additional comments	

section 3	

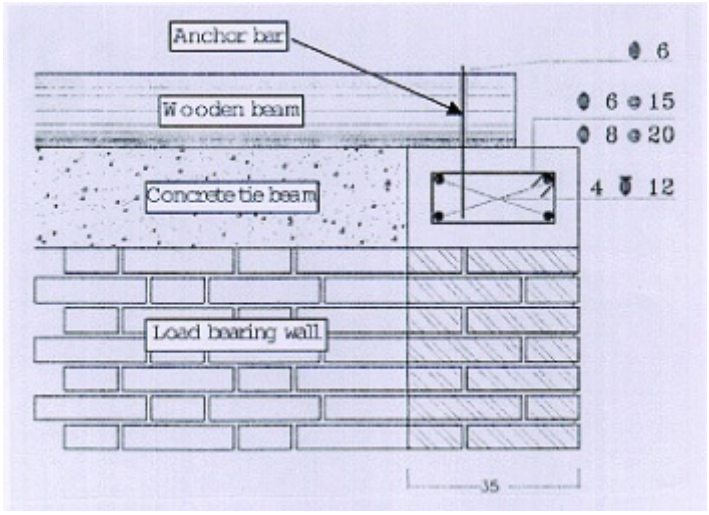


Critical Structural Details: Concrete tie column

An Illustration of Key Seismic Deficiencies: lack of Connection Between Wooden Beam and Concrete Tie Beam and Poor Quality of Materials



Wall cross-section showing a concrete tie beam ad roof-to-wall connection



Wall side view showing a concrete tie beam and roof-to-wall connection

Socio-Economic Issues

Patterns of occupancy	One family usually occupies each house.
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	Roughly an Iranian family has 4~6 members.
Economic level of inhabitants	Very low-income class (very poor)
Additional comments on economic level of inhabitants	For Poor Class the Housing Price Unit is 5000 and the Annual Income is 1000. Ratio of housing unit price to annual income: 5:1 or worse
Typical Source of Financing	Owner financedPersonal savingsCommercial banks/mortgages
Additional comments on financing	
Type of Ownership	Own outrightOwn 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

1990	Manjil

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	
Additional comments on earthquake damage patterns	

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 integrity, i.e. shape and form, during an earthquake of intensity expected in this area.	N/A
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.	FALSE
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	FALSE

	each diaphragm level with metal anchors or 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).	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	Unequal stiffness distribution.
Earthquake-resilient features in walls	
Seismic deficiency in frames	Poor quality of workmanship and materials.
Earthquake-resilient	

features in frame	
Seismic deficiency in roof and floors	Lack of proper connection between roof and masonry shear walls They are not perfectly rigid diaphragm.
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	-|		

Damage caused by the absence of concrete posts (1990 Manjil earthquake)

Damage due to large opening, absence of masonry shear wall and short column behavior in concrete post (1990 Manjil earthquake)

Damage in the wall panel (1990 Manjil earthquake)

Collapse due to heavy roof (1990 Manjil earthquake)

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	Seismic Strengthening
Shear wall	Add new shear wall
Tie beams	Increasing the size of the existing tie beams and adding new tie beams for added new walls
Roof	Proper connections of the wood beams to the tie beams (existing and new construction).
New Construction	Roof: Proper connections of the wood beams to the tie beams.

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?	
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	

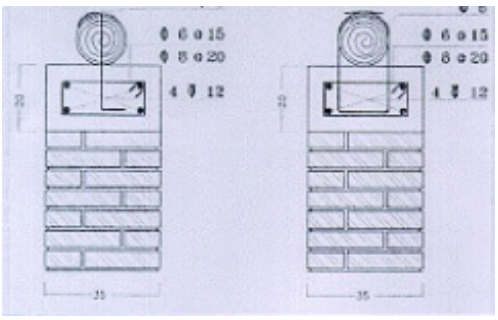
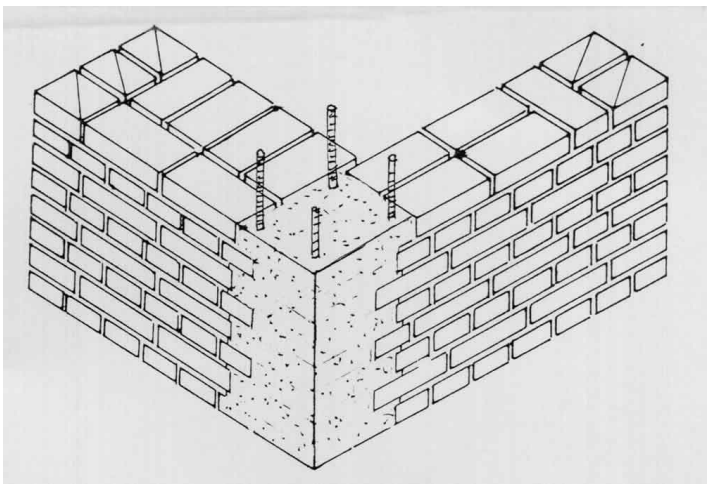


Illustration of Seismic Strengthening Techniques



Seismic Strengthening: Addition of a new concrete post

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