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

Moment resisting frame designed for gravity loads only

Report#	60
Last Updated	
Country	Syria
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Reviewers	Ravi Sinha,

Important

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participant’s organizations.

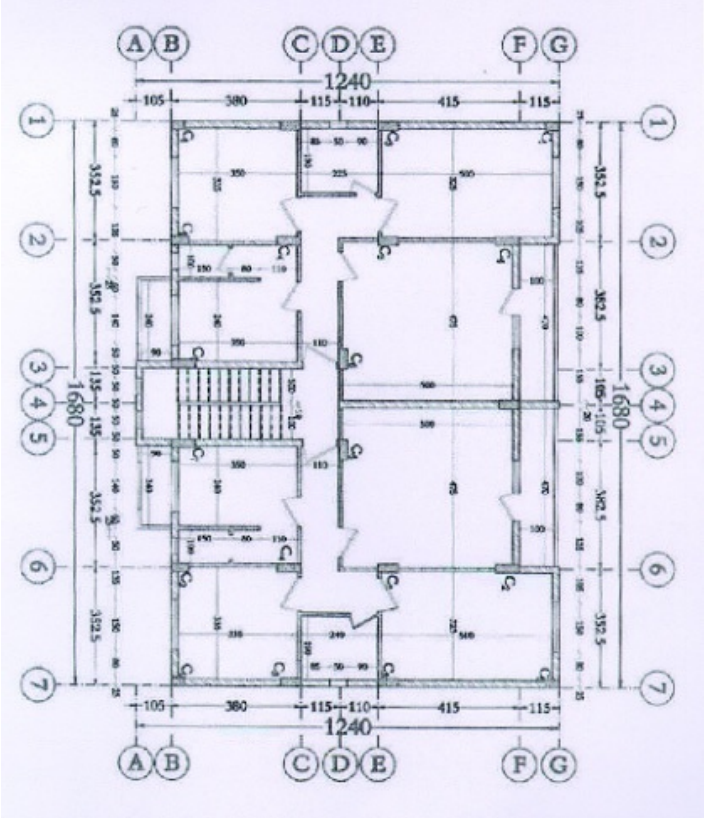
General Information

Building Type:	Moment resisting frame designed for gravity loads only
Country:	Syria
Author(s):	Adel Awad Hwaija Bassam Isreb Talal
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in the main cities of Syria like Damascus, Aleppo, Latakia, Homs, Hama, Deir-ez zor, Idleb, Al-Haskeh, Al-Raka, Al-Sweida, Dara, Tartus, Jableh, Qunitera etc. This type of housing construction is commonly found in urban areas.
Summary:	These buildings are found in the main cities of Syria and represent modern construction practice followed in the last 50 years. The floor system is a two-way reinforced concrete slab, which spans between orthogonal sets of beams that transfer the load to the columns. The frames are designed to carry gravity loads only.
Length of time practiced:	25-60 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Residential, 10-19 units
Typical number of stories:	3-5
Terrain-Flat:	Typically
Terrain-Sloped:	Occasionally
Comments:	Modern construction followed in the last 50 years. There are from 6 to 12 units in each building.

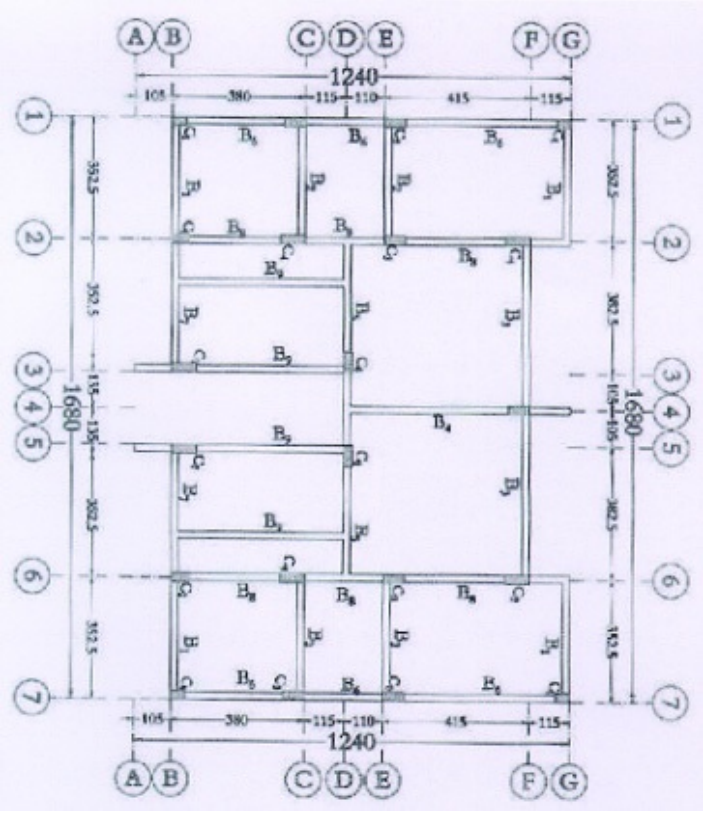
Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	
Typical plan length (meters)	20

Typical plan width (meters)	16
Typical story height (meters)	3
Type of Structural System	Structural Concrete: Moment Resisting Frame: Designed for gravity loads only, with URM infill walls
Additional comments on structural system	Frames (columns, beams) carry gravity loading. We can assume that the frames (columns + beams) provide a partial strength and stiffness to control lateral displacements due to moderate earthquakes.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	10-15%
Typical wall densities in direction 2	10-15%
Additional comments on typical wall densities	The typical structural wall density is up to 20 %. Total wall area/plan area (for each floor) 10% to 15%.
Wall Openings	Area of openings /walls surface area = 20% for inner walls and 40% for outer walls.
Is it typical for buildings of this type to have common walls with adjacent buildings?	No
Modifications of buildings	There aren't a lot of modifications in this buildings yet.
Type of Foundation	Shallow Foundation: Reinforced concrete isolated footing
Additional comments on foundation	
Type of Floor System	Other floor system
Additional comments on floor system	Structural Concrete: cast in place solid slabs
Type of Roof System	Roof system, other
Additional comments on roof system	Structural Concrete: cast in place solid slabs
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is several meters. Typical Plan Dimensions: Length varies from 12 to 20 meters, width varies from 12 to 16 meters. Typical Story Height: Story height ranges from 2.85 to 3.1 meters.



Plan of a Typical Building



Plan of a Typical Building

Building Materials and Construction Process

Description of Building Materials

Structural Element	Building Material (s)	Comment (s)
Wall/Frame	Frame: Steel	Frame: Characteristic Strength- 360-420 Deformed bars
Foundations	Concrete	Mix Proportion: 1:2:4
Floors	Steel	Characteristic Strength: 360-420 Deformed bars
Roof	Steel	Characteristic Strength: 360-420 Deformed bars
Other		

Design Process

Who is involved with the design process?	EngineerArchitect
Roles of those involved in the design process	The owner of the land will hire an architect and a structural engineer to design the building.

Expertise of those involved in the design process	A structural engineer will have 5 years of education and more 5-10 years of experience. A construction engineer may have 5 years of education and less experience than the structural engineer. The designer may visit the construction site, at request.

Construction Process

Who typically builds this construction type?	Contractor
Roles of those involved in the building process	It is built by developers and sold to the people who live in this construction type.
Expertise of those involved in building process	A structural engineer will have 5 years of education and more 5-10 years of experience. A construction engineer may have 5 years of education and less experience than the structural engineer. The designer may visit the construction site, at request.
Construction process and phasing	For construction, they will use modern equipment. The construction of this type of housing takes place in a single phase. 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	Starting from 1997, the seismic design for buildings is mandatory as a law: Syrian code for earthquake resistant building (1995). Prior to 1997, seismic design was not applicable but the normal Syrian building code is used from 1972.
Process for building code enforcement	The building design must follow the 1995 Syrian code. In case of damage arbitration process may take place at the court of justice.

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	

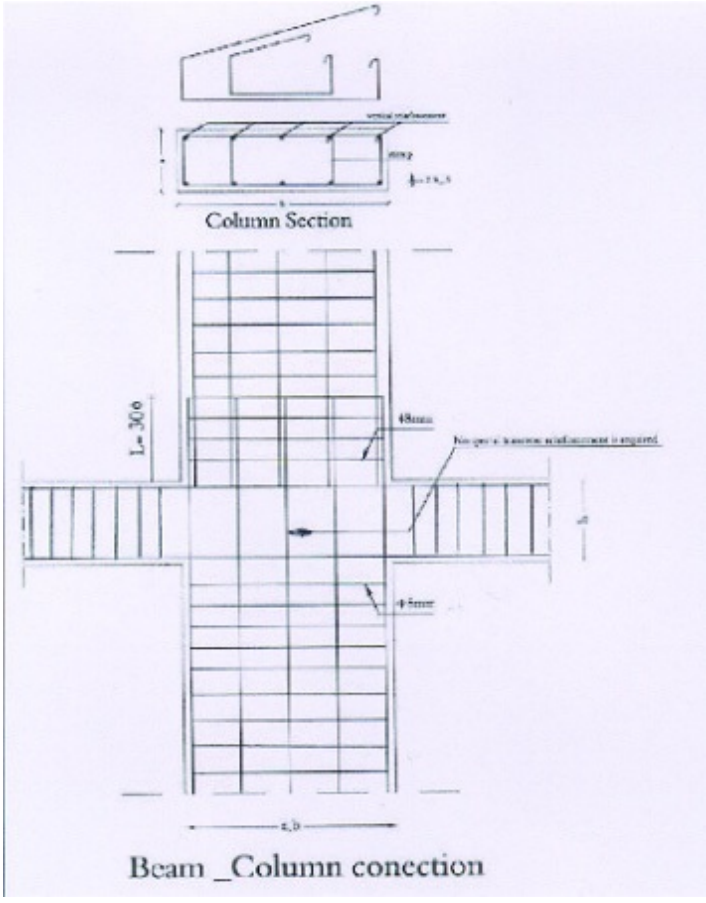
development control rules

Building Maintenance and Condition

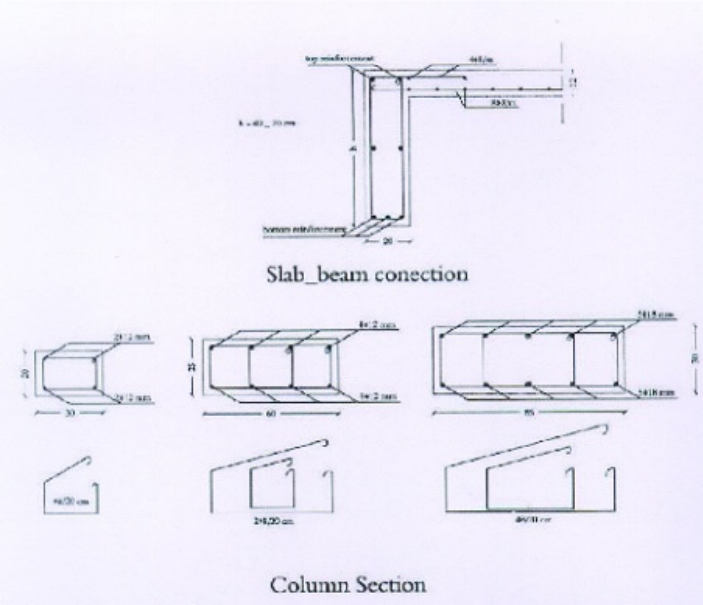
Typical problems associated with this type of construction	The main problems are associated with the construction process e.g. mixing and transportation of concrete, and construction joints.
Who typically maintains buildings of this type?	Owner(s)Renter(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	A unit construction may cost 100-200 USD/m# (USD =50 Syrian pound (SP), on market rate).
Labor requirements	One floor per month.
Additional comments section 3	



Critical Structural Details



Critical Structural Details

Socio-Economic Issues

Patterns of occupancy	One family typically occupies one apartment. Each building typically has 10-20 housing unit(s). 12 units in each building.
Number of inhabitants in a typical building of this construction type during the day	10-20
Number of inhabitants in a typical building of this construction type during the evening/night	>20
Additional comments on number of inhabitants	
Economic level of inhabitants	Low-income class (poor)Middle-income class
Additional comments on economic level of inhabitants	GNP per capita, in 1997, was $1120 ; GDP per capita, in 1996, was $1288. Economic Level: For Poor Class the Housing Price Unit is 10000 and the Annual Income is 2500. For Middle Class the Housing Price Unit is 15000 and the Annual Income is 6000. Ratio of housing unit price to annual income: 4:1
Typical Source of Financing	Owner financedPersonal savingsCommercial banks/mortgagesGovernment-owned housing
Additional comments on financing	
Type of Ownership	RentOwn outrightOwn with debt (mortgage or other)Long-term leaseOther
Additional comments on ownership	Ownership by heritage is also found.
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
1719	Aleppo
1759	Damascus
1759	Damascus/Lattakia
1796	Lattakia
1822	Aleppo/Al-jaziereh
1822	Harem/ Aleppo

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	Data about the earthquakes, starting from 18th century up to date, were taken from Ambraseys (1983). However, we have developed the estimate of the magnitude (M) and the maximum MMI intensity based on our findings and experience. Most of the buildings destroyed in the past earthquakes were of adobe and stone masonry, particularly in the urban areas.
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.	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);	N/A

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 straps.	N/A
Wall Openings		N/A
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	
Earthquake-resilient features in walls	

Seismic deficiency in frames	Weak connections between the secondary and primary beams. No special transverse reinforcement at the critical region (joints).
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	
Earthquake resilient features in roof and floors	
Seismic deficiency in foundation	Reinforced concrete isolated footing without compression/tension ties.
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	Seismic strengthening has generally not been performed in Syria.
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	

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