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

Reinforced concrete frame with concrete shear walls - dual system

Report#	59
Last Updated	
Country	SYRIAN ARAB REPUBLIC
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Important

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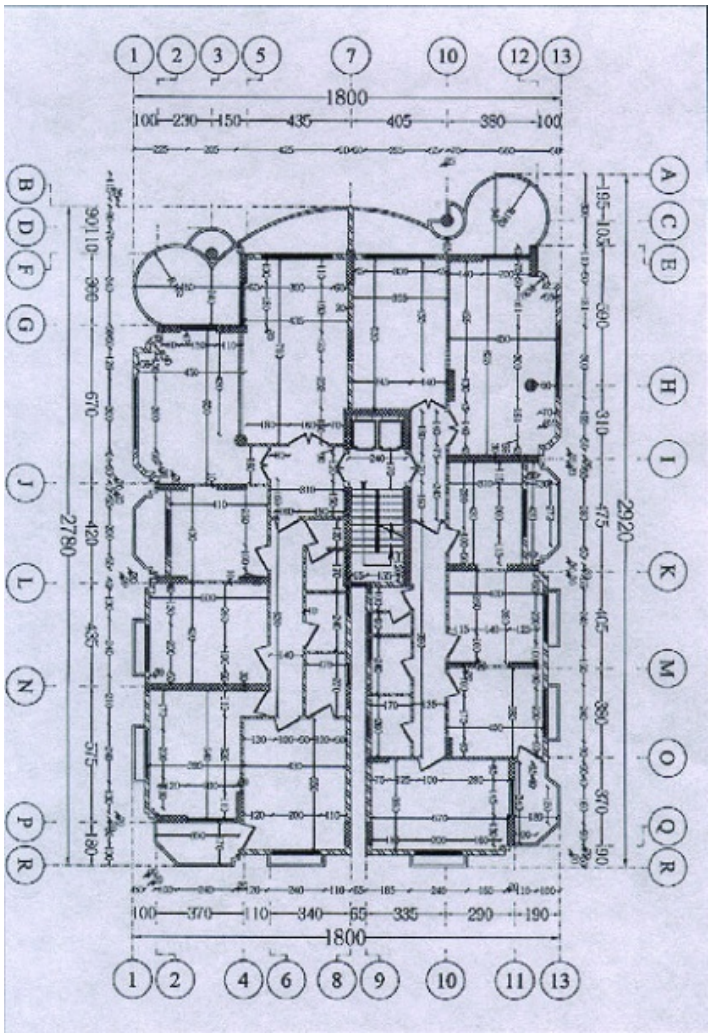
General Information

Building Type:	Reinforced concrete frame with concrete shear walls - dual system
Country:	SYRIAN ARAB REPUBLIC
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, and Hama. This type of housing construction is commonly found in urban areas.
Summary:	These buildings are characterized by a combination of shear walls and frames in both directions. The buildings are multiple housing units found in the main cities of Syria. The shear walls are often part of the elevator and service cores, whereas the frames are arranged in-plane, in conjunction with the walls, to support the floor system. Stiffness and mass distribution are irregular and the majority of buildings may experience soft-story or torsional problems. As a result, these buildings are expected to have only moderate seismic resistance.
Length of time practiced:	Less than 25 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Residential, 20-49 units
Typical number of stories:	6-15
Terrain-Flat:	Typically
Terrain-Sloped:	Typically
Comments:	

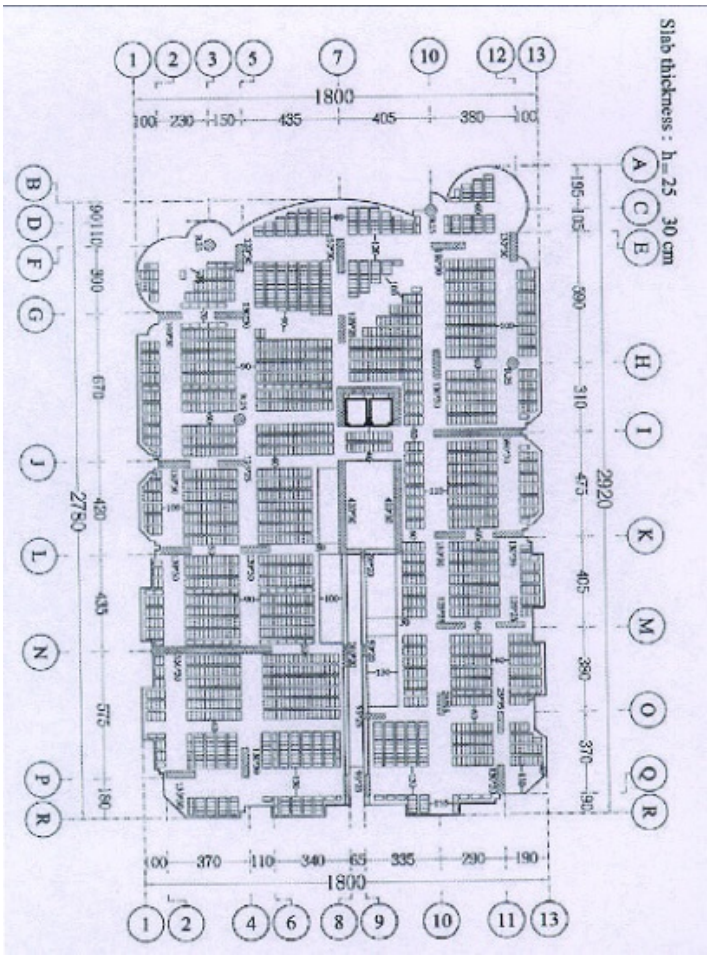
Features

Plan Shape	Rectangular, solid
Additional comments on plan shape	
Typical plan length (meters)	30
Typical plan width (meters)	20
Typical story height (meters)	3.1
Type of Structural System	Structural Concrete: Moment Resisting Frame: Dual system Frame with shear wall
Additional comments on structural system	The vertical and lateral load-resisting system is a dual system. Shear walls and frames (columns, beams) carry gravity loading. We can assume that the shear walls provide adequate strength and stiffness to control lateral displacements.
Gravity load-bearing & lateral load-resisting systems	
Typical wall densities in direction 1	3-4%
Typical wall densities in direction 2	3-4%
Additional comments on typical wall densities	The typical structural wall density is up to 3 %. The ratio between total wall area/plan area is 1 to 3% (for each floor).
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	Buildings of this type haven't a lot of modifications yet.
Type of Foundation	Shallow Foundation: Reinforced concrete isolated footingShallow Foundation: Reinforced concrete strip footingShallow Foundation: Mat foundation
Additional comments on foundation	
Type of Floor System	Other floor system

Additional comments on floor system	waffle slabs (cast-in-place), solid slabs (precast)
Type of Roof System	Roof system, other
Additional comments on roof system	waffle slabs (cast-in-place), solid slabs (precast)
Additional comments section 2	When separated from adjacent buildings, the typical distance from a neighboring building is 10 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	Wall: Concrete	Characteristic strength:1-3/18-25/1-2 Mix

		proportions: 1:2:4
Foundations	Concrete	Characteristic strength:1-3/18-25/1-2 Mix proportions: 1:2:4
Floors	Steel	Characteristic strength:360-420; Deformed bars
Roof	Steel	Characteristic strength:360-420; Deformed bars
Other		Characteristic strength"360-420; Deformed bars

Design Process

Who is involved with the design process?	EngineerArchitect
Roles of those involved in the design process	The designer may visit the construction site, at request.
Expertise of those involved in the design process	The structural engineer will have 5 years of studies and more than 5-10 years of experience.

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	It is built by developers and sold to the people who may live in this construction type.
Expertise of those involved in building process	The construction engineer may have 5 years of studies and less experience than the structure engineer.
Construction process and phasing	The owner of the land will hire an architectural office and structural engineer to design the building. 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. The year the first code/standard addressing this type of construction issued was 1972. The most recent code/standard addressing this construction type issued was 1997.
Process for building code enforcement	The building design must follow the Syrian Code 1995. In case of damage arbitration process may take place at the court of justice. There is compulsory inspection during the construction and good revision of the structural 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	

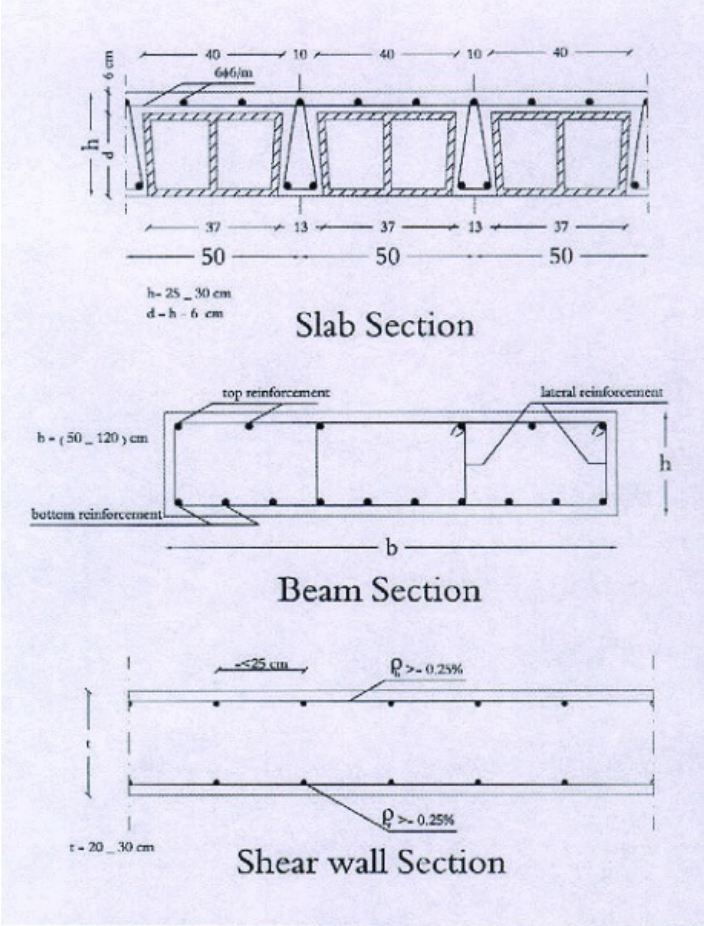
Building Maintenance and Condition

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	

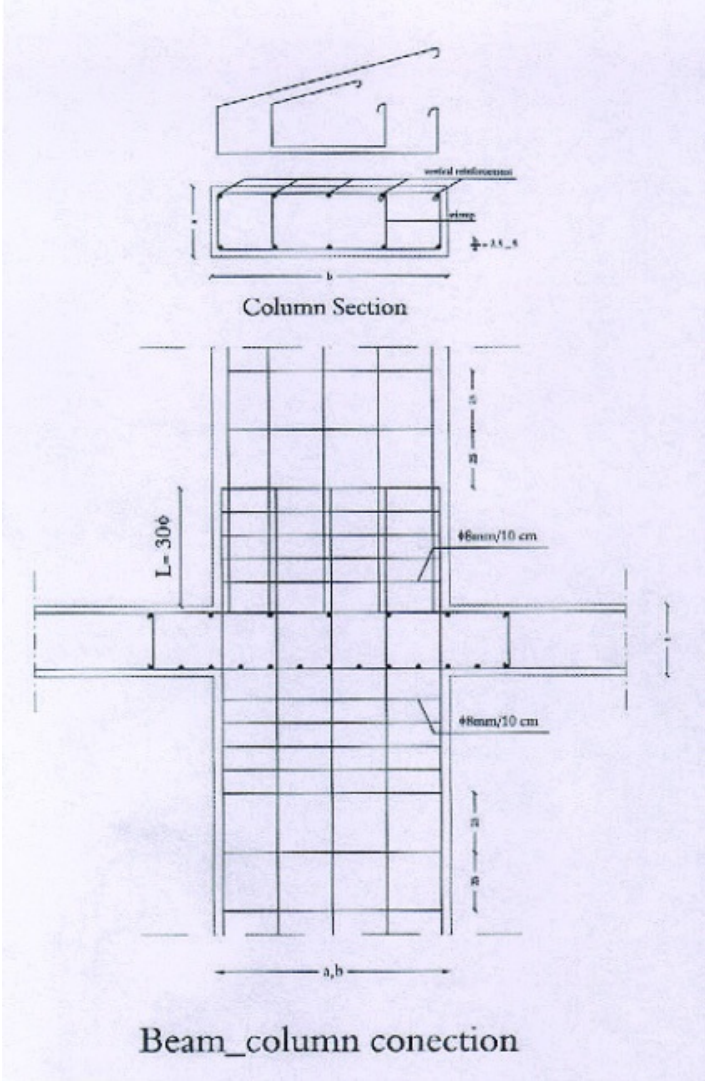
Construction Economics

	A unit construction may cost 170-300 USD/m# (USD

Unit construction cost	A unit construction may cost 170-300 USD/m# (USD =50 Syrian pound (SP), on market rate).
Labor requirements	One floor per month.
Additional comments section 3	



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



Critical Structural Details

Socio-Economic Issues

Patterns of occupancy	Each building typically has 21-50 housing unit(s). 45 units in each building. One family typically occupies one unit.
Number of inhabitants in a typical building of this construction type during	>20

the day	
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	Middle-income classHigh-income class (rich)
Additional comments on economic level of inhabitants	Ratio of housing unit price to annual income: 4:1 Notes: 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. Additional comments: GNP per capita, in 1997, was $1120. GDP per capita, in 1996, was $1288. Economic Level: For Middle Class the Housing Unit Price is 25000 and the Annual Income is 6000. For Rich Class the Housing Unit Price is 40000 and the Annual Income is 15000.
Typical Source of Financing	Owner financedPersonal savingsCommercial banks/mortgages
Additional comments on financing	
Type of Ownership	RentOwn outrightOwn with debt (mortgage or other)Long-term leaseOther
Additional comments on ownership	Other: Ownership by heritage.
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
1796	Lattakia
1822	Aleppo/Al-jaziereh
1827	Harem/ Aleppo

Past Earthquakes

Damage patterns observed in past earthquakes for this construction type	Data about earthquakes taken from (Ambraseys, 1983), starting from 18th Century up to date. But estimation of values (Magnitude M and Maximum Intensity MMI) were made by us depending on our findings and experience. Most of the building destroyed were of adobe and stone masonry particularly in urban regions.
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)	FALSE
Building Configuration-Horizontal	The building is regular with regards to the plan. (Specify in 5.4.2)	FALSE
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 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	No flexural tension reinforcement; and no confinement at the wall ends.
Earthquake-resilient features in walls	
Seismic deficiency in frames	No special transverse reinforcement at the critical region (joints).
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	Weak connection between roof, floors and walls; and no lintel beams.
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**

Additional comments on seismic strengthening provisions	Seismic strengthening has not been done in Syria so far.
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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