World Housing Encyclopedia

A Resource on Construction in Earthquake Regions

an initiative of
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International Association for Earthquake Engineering (IAEE)

HOUSING REPORT

Reinforced concrete frame building with timber roof

Report#	44
Last Updated	
Country	Malaysia
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Important

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General Information

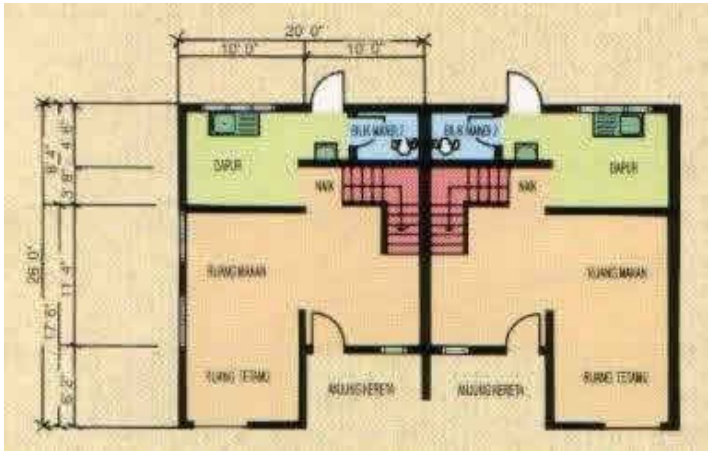
Building Type:	Reinforced concrete frame building with timber roof
Country:	Malaysia
Author(s):	Dr. Azlan Adnan Tuan Norhayati Tuan Chik Bahiah Baharudin
Last Updated:	
Regions Where Found:	Buildings of this construction type can be found in almost all parts of Malaysia. This type of housing construction iscommonly found in both rural and urban areas. About 30-40% are located in semi-urban areas.
Summary:	This housing type is commonly used for family housing and it is found in urban areas of Malaysia.Columns and beams are of reinforced concrete to provide structural strengths. Roof consists oftimber trusses. These houses are designed according to the British Code BS 8110 without seismicdesign considerations.
Length of time practiced:	25-60 years
Still Practiced:	Yes
In practice as of:	
Building Occupancy:	Residential, 10-19 units
Typical number of stories:	2
Terrain-Flat:	Typically
Terrain-Sloped:	3
Comments:	

Features

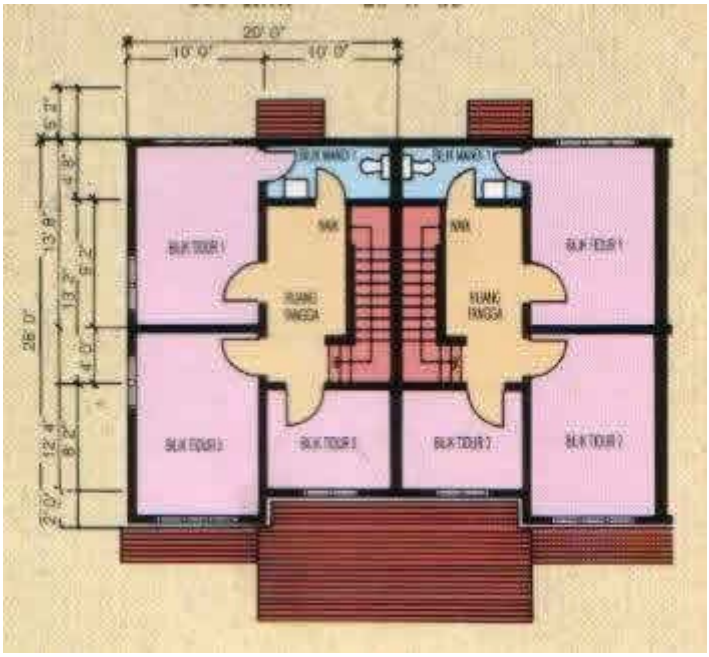
Plan Shape	Rectangular, solid
Additional comments on	The typical shape of a building plan for this housing

plan shape	type is rectangular shape.
Typical plan length (meters)	6
Typical plan width (meters)	20
Typical story height (meters)	4-Mar
Type of Structural System	Structural Concrete: Moment Resisting Frame: Designed for gravity loads only, with URM infill walls
Additional comments on structural system	The lateral load-resisting system is reinforced concrete moment resisting frame. Columns and walls give stiffness tothe structure, which controls the lateral drift. The common size of columns is 600 mm X 600 mm and for walls are150 mm thickness.The vertical load-resisting system is reinforced concrete structural walls (with frame). The roofs are designed totransmit gravity loads to the slabs, beams, and columns. The walls are from the non-load bearing wall system. Allexternal walls and partition walls are 9-inch brick walls. Internal partitions are timber framing.
Gravity load-bearing & lateral load-resisting systems	Structural Concrete: Moment resisting frame, designed for gravity loads only (predating seismic codes i.e. no seismic features)
Typical wall densities in direction 1	1-2%
Typical wall densities in direction 2	1-2%
Additional comments on typical wall densities	The typical structural walldensity is up to 5 %. 2% (1% -5%).
Wall Openings	A typical house has approximately several windows, with average size of 2.4 sq. m.
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 isolated footingShallow Foundation: Mat foundation
Additional comments on foundation	The typical separation distance between buildings is 10 meters or more.

Type of Floor System	Other floor system
Additional comments on floor system	Structural concrete: cast in place and precast solid slabs. Floor/roof are considered to behave as rigid diaphragms.
Type of Roof System	Roof system, other
Additional comments on roof system	Timber: thatched roof supported on wood purlins. Floor/roof are considered to behave as rigid diaphragms.
Additional comments section 2	When separated from adjacentbuildings, 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	Concrete	Characteristic Strength: 24 kN/m^3 -30kN/m^3Grade 25-30Mix Proportion/Dimensions: 1:2:4 (cement: fine aggregate: course aggregate)
Foundations	Concrete	Characteristic Strength: 24

		kN/m^3 -30kN/m^3Grade 25-30Mix Proportion/Dimensions: 1:2:4 (cement: fine aggregate: course aggregate)
Floors	Concrete	Characteristic Strength: 24 kN/m^3 -30kN/m^3Grade 25-30Mix Proportion/Dimensions: 1:2:4 (cement: fine aggregate: course aggregate)
Roof	Concrete	Characteristic Strength: 24 kN/m^3 -30kN/m^3Grade 25-30Mix Proportion/Dimensions: 1:2:4 (cement: fine aggregate: course aggregate)
Other		

Design Process

Who is involved with the design process?	EngineerArchitect
Roles of those involved in the design process	Engineers are in charge of the structural design and the construction process. Architects are in charge of the architectural design.
Expertise of those involved in the design process	Engineers and architects have experience in design and construction process. This is one of the most typicalconstructions in Malaysia, so there are good capable professionals with experience on this kind ofbuilding.

Construction Process

Who typically builds this construction type?	Other
Roles of those involved in the building process	It is more typically built by developers or for speculation.
Expertise of those involved in building process	
	Developers normally build structures of this type.

Construction process and phasing	Process start with the foundation of the building, then columns and brick walls are built, finally beams and roofs are made at the time to get a monolithic structure. The tools typically used in this type of construction, are hammers,nails, construction wire, etc. and the equipment used include concrete vibrator, concrete mixer and others. To start the construction of the building one needs to get a construction license. Municipal authorities are in charge of giving this license to the builder companies.Each housing project must have four kinds of technical drawings: structural drawings, architectural drawings, water installation drawings and electric installation drawings. Municipal authorities need to approve this technical information in order to get construction license.Construction typically takes place over time, buildings are originally designed for a specific number of stories. However, it is commonly found that owners decide to build additional stories some years later of the end of the original construction.
Construction issues	

Building Codes and Standards

Is this construction type address by codes/standards?	Yes
Applicable codes or standards	BS 8110 (British Standard). The year thefirst code/standard addressing this type of construction issued was 1980's. The BS 8110 code also includes nationalbuilding codes, specifications for materials and seismic standards.
Process for building code enforcement	Municipal authorities just approve the design of the building. Typically, the owner hires aparticular supervisor for construction of the building.

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

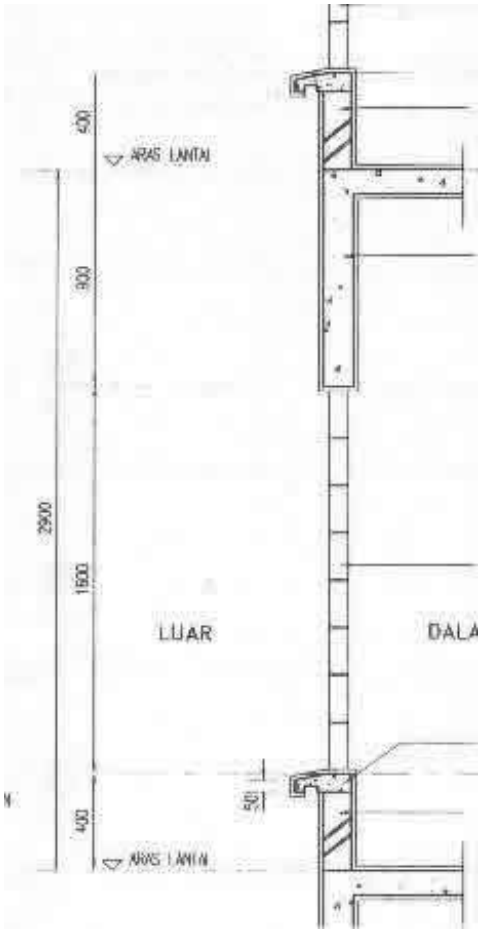
Additional comments on building permits and development control rules	

Building Maintenance and Condition

Typical problems associated with this type of construction	There are no typical problems associated with this type of construction.
Who typically maintains buildings of this type?	BuilderOwner(s)Renter(s)
Additional comments on maintenance and building condition	

Construction Economics

Unit construction cost	Unit construction cost is approximately 13.3 US$/sq. m.
Labor requirements	This type of building needs about 12 months or more to complete the construction. However, thetime required does not depend on the architectural characteristics of the building.
Additional comments section 3	



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

Socio-Economic Issues

Patterns of occupancy	One family occupies a single apartment or housing unit.Each building typically has more than 10 housing unit(s). These housing unites are usually clustered.
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	10-May
Additional comments on number of inhabitants	
Economic level of inhabitants	Low-income class (poor)Middle-income classHigh-income class (rich)

Additional comments on economic level of inhabitants	Ratio of housing unit price to annual income: 5:1 or worse The house price indicated is just for one tenement. Economic Level: For Poor Class the Housing Price Unit is 6250and the Annual Income is 2100. For Middle Class the Housing Price Unit is 25000 and the Annual Income is 4500 ForRich Class the Housing Price Unit is 30000 and the Annual Income is 4600.
Typical Source of Financing	Owner financedPersonal savingsCommercial banks/mortgagesGovernment-owned housingOther
Additional comments on financing	Other: Government loan.
Type of Ownership	RentOwn outrightOwn with debt (mortgage or other)Units owned individually (condominium)
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
1991	Labuan, Sabah
1996	Penang

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	TRUE

	the roof structure will maintain its 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.	TRUE
Wall-Roof Connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps.	FALSE

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).	TRUE
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber).	TRUE

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	Wall is not designed to sustain the seismic forces
Earthquake-resilient features in walls	
Seismic deficiency in frames	Seems sufficient due to the design method
Earthquake-resilient features in frame	
Seismic deficiency in roof and floors	Have adequate rigidity.

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	-|	

A Photograph Illustrating Typical Earthquake Damage in the Labuan, Sabah (M5.8) of 26 May 1991

Typical Earthquake Damage (Penang (M6.0) earthquake of 10October 1996

Retrofit Information

Description of Seismic Strengthening Provisions

Structural Deficiency	**Seismic Strengthening**
Roof	Timber

Columns	Shear steel reinforcement

Additional comments on seismic strengthening provisions	
Has seismic strengthening described in the above table been performed?	Yes.
Was the work done as a mitigation effort on an undamaged building or as a repair following earthquake damages?	Yes.
Was the construction inspected in the same manner as new construction?	Yes.
Who performed the construction: a contractor or owner/user? Was an architect or engineer involved?	A contractor performed the construction and also an engineer was involved.
What has been the performance of retrofitted buildings of this type in subsequent earthquakes?	
Additional comments section 6	

References

BS 8110 - British Standard

Structural Terrace Plan And Brochures of Residential Area.

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