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 and internally-reinforced concrete block masonry

Report#	207
Last Updated	03/20/2020
Country	Jamaica
Author(s)	Kemmar Webber, Lars Abrahamczyk,
Reviewers	Svetlana Brzev,

Important

This encyclopedia contains information contributed by various earthquake engineering professionals around the world. All opinions, findings, conclusions & recommendations expressed herein are those of the various participants, and do not necessarily reflect the views of the Earthquake Engineering Research Institute, the International Association for Earthquake Engineering, the Engineering Information Foundation, John

A, Martin & Associates, Inc. or the participant’s organizations.

General Information

Building Type:	Confined and internally-reinforced concrete block masonry
Indigenous Building Type:	Concrete Block House
Country:	Jamaica
Author(s):	Kemmar Webber Lars Abrahamczyk
Last Updated:	03/20/2020
Regions Where Found:	This type of house is found in the capital Kingston and all over the island. Confined reinforced-concrete masonry represents approximately 53.6% of the structures in Kingston.
Summary:	Since the 1907 earthquake in Jamaica which destroyed many brick and timber-framed structures, residents have chosen to adopt the confined reinforced-concrete masonry building technology. These buildings are for both single- and multi-family use. The concrete masonry blocks confined with horizontal belt beams and vertical concrete columns (stiffeners) are the main lateral load and gravity load-bearing system. The concrete blocks are reinforced with horizontal and vertical steel rebars and are filled with 10MPa concrete. The International Building Code (IBC) is generally used as the structural design provision in Jamaica. The seismic performance is highly dependent on the quality of construction. However, in many cases, the recommended strength of the concrete blocks by the Bureau of Standards Jamaica (BSJ) is not achieved.
Length of time practiced:	76-100 years
Building Occupancy:	Single dwellingResidential, 2 unitsResidential, 3-4 units
Typical number of stories:	1
Comments:	These buildings became popular in the early 1900s. These buildings are typically detached housing units.

Features

Plan Shape	Square, solidRectangular, solid
Additional comments on plan shape	These buildings are usually rectangular in plan with lengths between 16 and 24 meters and widths between 8 and 12 meters. Set-backs are not common.
Type of Structural System	Masonry: Confined Masonry: Concrete blocks, tie columns and beams
Additional comments on structural system	Typically, 150 mm thick masonry concrete blocks are used for the walls. The confinement typically consist of stiffeners/columns at 3 m centers and the reinforcements are typically of 12 mm diameter @ 400 mm c/c vertically and of 10 mm diameter @ 600 mm c/c horizontally (see stiffener details).
Gravity load-bearing	The gravity load-bearing system is represented by the masonry walls.
Lateral load-resisting systems	The lateral load-bearing system is represented by the masonry walls. The stiffeners/columns confine the masonry and force it to work together. The stiffeners are typically 150 mm x 300 mm and are placed at 3 m on centers.
Infill wall material	
Type of Foundation	Shallow Foundation: Reinforced concrete strip footing
Additional comments on foundation	The foundation system typically consists of cast-in-place concrete strip footing under both internal and external block walls. The width of the strip footing is normally three times the width of the wall. For this type of structure, the compressive concrete strength specification for footings is 20 MPa @ 28 days.
Type of Floor System	Cast-in-place beamless reinforced concrete floor
Additional comments on floor system	150 mm thick reinforced-concrete floor slabs are applied if the building is constructed with more than one storey. The slabs are reinforced with a layer of 12 mm bars @ 300 mm on center in both directions and top bars over walls for negative moments. A belt beam is used to connect the slab/roof to the wall.
Type of Roof System	Wooden structure with light roof covering
	The slope of a wooden framed roof in this building

Additional comments on roof system	type is typically from 20 to 30 degree which and is in most cases gable shaped but may also be hipped or flat. The wooden frame of the gable roof system consists of 2" x 4" rafters and 1" x 3" purlins which support galvanized zinc or clay tiles. These wooden framing roofing have a lifetime of about 30 years as a result of the deterioration of the timber. This type of roofing also often suffers damage and in some cases is even destroyed during hurricanes. On the other hand, this lightweight roofing creates a smaller base shear than heavier systems during earthquake and may be beneficial in this case.

Building Materials and Construction Process

Is this construction type addressed by codes/standards	No
Applicable codes or standards	
Unit construction cost	This type of structure typically cost approximately JM$ 130,000 (US$ 1045/sqm).
Day	1
Night	3
Economic level of inhabitants	Middle-income class
Additional comments on economic level of inhabitants	Majority of the population uses this housing type and from statistical data, 70% of the population in Jamaica lives in reinforced concrete or block wall masonry structures. The residents are generally from the middle class.

Earthquakes

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.

Past Earthquakes

Is earthquake insurance for this construction type	Yes

typically available	
Damage patterns observed in past earthquakes for this construction type	Earthquakes that affected these types of structures include those of March 1957, January 1993, and June 2005 in Jamaica. During the earthquake of January 1993 (Magnitude 5.4), many structures of this type suffered from some degree of cracking ranging from hairline to gaping cracks. "However these un-engineered buildings fared well particularly in the epicentral area" (Ahmad, 1993).
Seismic deficiency in seismic systems	Many of these structures are constructed with weak concrete and inadequate lateral reinforcement. Additionally, the strength of the concrete blocks usually does not comply with the minimum recommended standard by the Bureau of Standards Jamaica (BSJ).
Seismic deficiency in foundation	No record of the performance of the foundation is made during former earthquake events. On firm soil or rock, the seismic performance is expected to be good.

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	-|		

References

"However these un-engineered buildings fared well particularly in the epicentral area" Ahmad, 1993.

"Some of them suffered because of weak concrete and inadequate lateral reinforcement" Ahmad, 1993.

Authors

Name	**Title**	**Affiliation**	**Location**	**Email**
Kemmar	Mr.	National	Jamaica	kemmarwebber@nwa.gov.jm

Webber		Works Agency		
Lars Abrahamczyk	Dr.-Ing.	Bauhaus-University Weimar, Earthquake Damage Analysis Center	Weimar, Germany	lars.abrahamczyk@uni-weimar.de

Reviewers

Name	Title	Affiliation	Location	Email
Svetlana Brzev	Adjunct Professor	University of British Columbia	Canada	sbrzev@mail.ubc.ca