World Housing Encyclopedia

an Encyclopedia of Housing Construction in Seismically Active Areas of the World

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HOUSING REPORT
Confined and Internally Reinforced Concrete Block Masonry Building

Report #	161
Report Date	17-12-2011
Country	GUATEMALA
Housing Type	Confined Masonry Building
Housing Sub-Type	Confined Masonry Building with Concrete blocks, tie-columns and beams
Author(s)	Diego Velasquez Jofre, Lars Abrahamczyk, Jochen Schwarz
Reviewer(s)	Jitendra K Bothara, Dominik Lang, Marjorie Greene

Summary

The February 1976 earthquake caused severe damage to housing and buildings in Guatemala. Because many adobe houses were destroyed during the earthquake, there was greater interest in building with reinforced concrete block masonry structures after the event. This building

type can now be found throughout Guatemala. Reinforced concrete block masonry structures are primarily used for family housing, both in cities and in rural Guatemala. The main load-bearing elements are masonry walls with concrete block walls reinforced with vertical and horizontal reinforced concrete elements in addition to internal steel reinforcement bars placed in the hollow cores of the concrete blocks. After the 1976 earthquake several guidelines were published on the construction of masonry block buildings, but the first formal standard/code was established in 2000, the Recommended Structural Standards of Design for the Republic of Guatemala -AGIES. The main parameters for structural design are incorporated in chapter No. 9 Mamposteria Reforzada [1]. Nowadays reinforced concrete block masonry houses are constructed all over the country by governmental institutions for low-income classes. Currently this type of structure is the most widely built in Guatemala [2].

1. General Information

Buildings of this construction type can be found in throughout Guatemala (see Figure 1). This type of housing construction is commonly found in both rural and urban areas. This construction type has been in practice for less than 50 years.

Currently, this type of construction is being built. This construction type has been in practice for more than 30 years.

Figure 1. General view of a single house of this building type. a) Quiché (Northwest of Guatemala) [3], b) Chimaltenango (Center of Guatemala) [4], c) Alta Verapaz (North of Guatemala) [5].

2. Architectural Aspects

2.1 Siting

These buildings are typically found in flat terrain. They share common walls with adjacent buildings. In urban areas typically adjacent buildings have common walls on one or both sides. In rural areas, these buildings are commonly arranged in a row with adjacent walls to neighboring buildings, but stand- alone buildings can also be found (see Figure 2). Due to the limited availability of flat land in Guatemala, these buildings are constructed very dose together When separated from adjacent buildings, the typical distance from a neighboring building is 0.5 to 2 or 3 meters.

2.2 Building Configuration

Typically, the houses have one story and the general shape is square (see Figure 3). The thickness of the walls is generally 0.14 meters. .

2.3 Functional Planning

The main function of this building typology is single-family house. This building typology is mainly used for residential purposes. The typical house showed in Figure 3 consists of 2 bedrooms for 4 or 5 persons, one room destined for living room, dining room and kitchen, and one room destined for the bathroom that indudes a shower. In a typical building of this type, there are no elevators and no fire-protected exit staircases. Generally these houses have one main door, one back door, and three windows (one window in each bedrooms and one in the bathroom).

2.4 Modification to Building

There are no significant structural modifications known. Sometimes small modifications are made, which indudes an elongation of the roof in front of the main entrance of the house, due to the dimate extremes (severe rain or sun).

Figure 2. View of several buildings with adjacent walls to neighboring buildings [6].

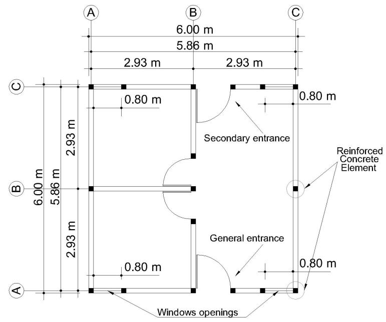

Figure 3. Typical plan view of the one story house.

Figure 4. Small modification to the house [7].

3. Structural Details

3.1 Structural System

Material	Type of Load-Bearing Structure	#	Subtypes	Most appropriate type
Masonry	Stone Masonry Walls	1	Rubble stone (field stone) in mud/lime mortar or without mortar (usually with timber roof)	☐
		2	Dressed stone masonry (in lime/cement mortar)	☐
	Adobe/ Earthen Walls	3	Mud walls	☐
		4	Mud walls with horizontal wood elements	☐
		5	Adobe block walls	☐
		6	Rammed earth/Pise construction	☐
	Unreinforced masonry walls	7	Brick masonry in mud/lime mortar	☐
		8	Brick masonry in mud/lime mortar with vertical posts	☐
		9	Brick masonry in lime/cement mortar	☐
		10	Concrete block masonry in cement mortar	☐
	Confined masonry	11	Clay brick/tile masonry, with wooden posts and beams	☐
		12	Clay brick masonry, with concrete posts/tie columns and beams	☐
		13	Concrete blocks, tie columns and beams	☑
	Reinforced masonry	14	Stone masonry in cement mortar	☐
		15	Clay brick masonry in cement mortar	☐
		16	Concrete block masonry in cement mortar	☐
	Moment resisting frame	17	Flat slab structure	☐
		18	Designed for gravity loads only, with URM infill walls	☐
		19	Designed for seismic effects, with URM infill walls	☐
		20	Designed for seismic effects, with structural infill walls	☐

Structural concrete		21	Dual system – Frame with shear wall	☐
	Structural wall	22	Moment frame with in-situ shear walls	☐
		23	Moment frame with precast shear walls	☐
	Precast concrete	24	Moment frame	☐
		25	Prestressed moment frame with shear walls	☐
		26	Large panel precast walls	☐
		27	Shear wall structure with walls cast-in-situ	☐
		28	Shear wall structure with precast wall panel structure	☐
Steel	Moment-resisting frame	29	With brick masonry partitions	☐
		30	With cast in-situ concrete walls	☐
		31	With lightweight partitions	☐
	Braced frame	32	Concentric connections in all panels	☐
		33	Eccentric connections in a few panels	☐
	Structural wall	34	Bolted plate	☐
		35	Welded plate	☐
Timber	Load-bearing timber frame	36	Thatch	☐
		37	Walls with bamboo/reed mesh and post (Wattle and Daub)	☐
		38	Masonry with horizontal beams/planks at intermediate levels	☐
		39	Post and beam frame (no special connections)	☐
		40	Wood frame (with special connections)	☐
		41	Stud-wall frame with plywood/gypsum board sheathing	☐
		42	Wooden panel walls	☐
Other	Seismic protection systems	43	Building protected with base-isolation systems	☐
		44	Building protected with seismic dampers	☐
	Hybrid systems	45	other (described below)	☐

Walls are made of concrete block masonry. The reinforcement consists of vertical and horizontal elements of reinforced concrete as well as steel reinforcement bars located in the holes of the concrete blocks as it is illustrated in Figure 5.

3.2 Gravity Load-Resisting System

The vertical load-resisting system is reinforced masonry walls. .

3.3 Lateral Load-Resisting System

The lateral load-resisting system is reinforced masonry walls. The main load bearing elements are masonry walls reinforced with vertical and horizontal reinforced concrete elements and also steel reinforcement bars placed in the hollow cores of the concrete blocks.

3.4 Building Dimensions

The typical plan dimensions of these buildings are: lengths between 6 and 10 meters, and widths between 6 and 10 meters. The building is 1 storey high. The typical span of the roofing/flooring system is 6 meters. (see section 2.2 and Figure 3). The typical storey height in such buildings is 3.0 meters. The typical structural wall density is up to 10 %. Total wall area/plan area is 6.5 % in each direction.

3.5 Floor and Roof System

Material	Description of floor/roof system	Most appropriate floor	Most appropriate roof
Masonry	Vaulted	☐	☐
	Composite system of concrete joists and masonry panels	☐	☐
Structural concrete	Solid slabs (cast-in-place)	☐	☐
	Waffle slabs (cast-in-place)	☐	☐
	Flat slabs (cast-in-place)	☐	☐
	Precast joist system	☐	☐
	Hollow core slab (precast)	☐	☐
	Solid slabs (precast)	☐	☐
	Beams and planks (precast) with concrete topping (cast-in-situ)	☐	☐
	Slabs (post-tensioned)	☐	☐
Steel	Composite steel deck with concrete slab (cast-in-situ)	☐	☐
Timber	Rammed earth with ballast and concrete or plaster finishing	☐	☐
	Wood planks or beams with ballast and concrete or plaster finishing	☐	☐
	Thatched roof supported on wood purlins	☐	☐
	Wood shingle roof	☐	☐
	Wood planks or beams that support clay tiles	☐	☐
	Wood planks or beams supporting natural stones slates	☐	☐
	Wood planks or beams that support slate, metal, asbestos-cement or plastic corrugated sheets or tiles	☐	☐
	Wood plank, plywood or manufactured wood panels on joists supported by beams or walls	☐	☐
Other	Described below	☑	☑

Generally the floor in this type of building is a solid reinforced concrete slab (cast-in-place), without any other finishes. The roof is mainly metallic. The main structure of the roof is a steel C profile and the area elements are galvanized thin plates coupled to the C profiles by screws. Sometimes the main structure of the roof is constructed with wooden beams with area elements that are galvanized thin plates. The second option is less used, mainly because of the deterioration of the wood beams due to decay, fungi and insects.

3.6 Foundation

Type	Description	Most appropriate type
Shallow foundation	Wall or column embedded in soil, without footing	☐
	Rubble stone, fieldstone isolated footing	☐
	Rubble stone, fieldstone strip footing	☐
	Reinforced-concrete isolated footing	☐
	Reinforced-concrete strip footing	☑

	Mat foundation	☐
	No foundation	☐
Deep foundation	Reinforced-concrete bearing piles	☐
	Reinforced-concrete skin friction piles	☐
	Steel bearing piles	☐
	Steel skin friction piles	☐
	Wood piles	☐
	Cast-in-place concrete piers	☐
	Caissons	☐
Other	Described below	☐

The foundation is a reinforced concrete strip footing. After the cast-in-place footing, two rows of concrete blocks and finally a reinforced concrete beam are generally set on it to reach the floor level. The reinforcement of this reinforced concrete beam is linked with the reinforcement of the vertical elements of the main structure.

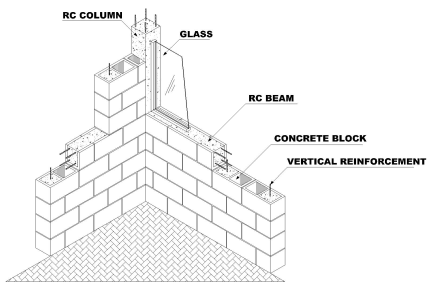

Figure 5. 3D view of the construction system.

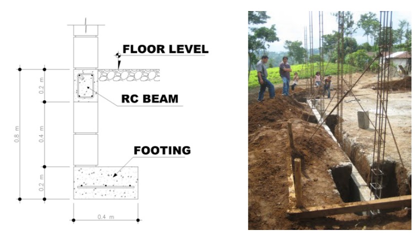

Figure 6. Foundation system. a) Elevation view, b) General view [8].

4. Socio-Economic Aspects

4.1 Number of Housing Units and Inhabitants

Each building typically has 1 housing unit(s). The number of inhabitants in a building during the day or business hours is less than 5. The number of inhabitants during the evening and night is 5-10.

4.2 Patterns of Occupancy

Typically one family (father, mother and two, three or four children) occupies one housing unit. The main function of the building is residential housing.

4.3 Economic Level of Inhabitants

Income class	Most appropriate type
a) very low-income class (very poor)	☐
b) low-income class (poor)	☑
c) middle-income class	☐
d) high-income class (rich)	☐

Ratio of housing unit price to annual income	Most appropriate type
5:1 or worse	☑
4:1	☐
3:1	☐
1:1 or better	☐

What is a typical source of financing for buildings of this type?	Most appropriate type
Owner financed	☐
Personal savings	☐
Informal network: friends and relatives	☐
Small lending institutions / micro-finance institutions	☐
Commercial banks/mortgages	☐
Employers	☐
Investment pools	☐
Government-owned housing	☐
Combination (explain below)	☑
other (explain below)	☐

Generally, the source of financing is a combination of subsidy and the resources of the owner. The government provides a subsidy of 75% of the total cost of the housing, and the owner has to pay the remaining 25%, which can be paid over time. In each housing unit, there are no bathroom(s) without toilet(s), no toilet(s) only and 1 bathroom(s) including toilet(s).

4.4 Ownership

The type of ownership or occupancy is ownership with debt (mortgage or other).

Type of ownership or occupancy?	Most appropriate type
Renting	☐
outright ownership	☐
Ownership with debt (mortgage or other)	☑
Individual ownership	☐
Ownership by a group or pool of persons	☐
Long-term lease	☐
other (explain below)	☐

The 25% of the total cost of the building, which has to be provided by the inhabitants, can be paid in installments due to financial hardship.

5. Seismic Vulnerability

5.1 Structural and Architectural Features

Structural/ Architectural	Statement	Most appropriate type

Feature		Yes	No	N/A
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.	☑	☐	☐
Building Configuration	The building is regular with regards to both the plan and the elevation.	☑	☐	☐
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.	☐	☑	☐
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.	☑	☐	☐
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.	☑	☐	☐
Wall and frame structures-redundancy	The number of lines of walls or frames in each principal direction is greater than or equal to 2.	☑	☐	☐
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);	☑	☐	☐
Foundation-wall connection	Vertical load-bearing elements (columns, walls) are attached to the foundations; concrete columns and walls are doweled into the foundation.	☑	☐	☐
Wall-roof connections	Exterior walls are anchored for out-of-plane seismic effects at each diaphragm level with metal anchors or straps	☐	☐	☑
Wall openings	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.	☐	☐	☑
Quality of building materials	Quality of building materials is considered to be adequate per the requirements of national codes and standards (an estimate).	☑	☐	☐
Quality of workmanship	Quality of workmanship (based on visual inspection of few typical buildings) is considered to be good (per local construction standards).	☑	☐	☐
Maintenance	Buildings of this type are generally well maintained and there are no visible signs of deterioration of building elements (concrete, steel, timber)	☐	☑	☐
Additional Comments				

5.2 Seismic Features

Structural	Seismic Deficiency	Earthquake Resilient	Earthquake Damage Patterns

Element		Features	
Walls	In buildings without the vertical reinforcement in the masonry blocks walls (some cases) the necessary ductility is not reached.		Sometimes diagonal shear cracks can appear.
Frame (columns, beams)			
Roof	The roof is too flexible and insufficiently connected to the walls to enable it to work as a rigid diaphragm.	The roof is light-weight minimizing risk of injury.	Roof failure due to insufficient support length of the structural roof elements.
Floors			

5.3 Overall Seismic Vulnerability Rating

The overall rating of the seismic vulnerability of the housing type is *D: MEDIUM-LOW VULNERABILITY (i.e., good seismic performance)*, the lower bound (i.e., the worst possible) is C: MEDIUM VULNERABILITY (i.e., moderate seismic performance), and the upper bound (i.e., the best possible) is *E: LOW VULNERABILITY (i.e., very good seismic performance)*.

Vulnerability	high	medium-high	medium	medium-low	low	very low
	very poor	poor	moderate	good	very good	excellent
Vulnerability Class	A	B	C	D	E	F
	☐	☐	☑	☐	☑	☐

5.4 History of Past Earthquakes

Date	Epicenter, region	Magnitude	Max. Intensity
1976	15.32°N, 89.10°W Motagua Fault	7.5	9 (MMI)
1988	13.881°N, 90.450°W San Vicente Pacaya	6.0	6 (MMI)
1998	14.374°N, 91.473°W Santo Domingo Suchitepéquez	6.6	6 (MMI)
2007	13.623°N, 90.797°W 115 km southwest of Guatemala City	6.7	
2009	14.58°N, 91.08°W South of Patzún	6.2	

Guatemala is a seismically active area, primarily affected by the interaction between the North American Plate, the Caribbean Plate and the Coco Plate. The principal seismic sources coincide with the plates: the subduction zone between the Coco Plate and the Caribbean Plate, the big fault systems of the Polochic-Motagua, and the fault systems in the interior of the Caribbean Plate: the line of the Volcanic Arc and the region of grabens between the fault of Motagua and the Volcanic Arc. Historically, each of these systems of faults has produced destructive earthquakes. In the twentieth century 18 events occurred, which generated intensities greater or equal to VII according to the Modified Mercalli scale (MMI) in Guatemala. The following table lists (also illustrated in Figure 7) the strongest events since the 1976 earthquake, which was a major contributor to the adoption of this building type. Comments to vulnerability rating: The assignment of the vulnerability follows the European Macroseismic Scale EMS-1998 [9] where a classification of this building type into class D is suggested with a scatter from class C and E. However it is important to mention that the vulnerability rating is assigned assuming an excellent quality of the construction materials. If the housing is built with deficient materials or poor quality workmanship (produced without quality control) the vulnerability will be higher.

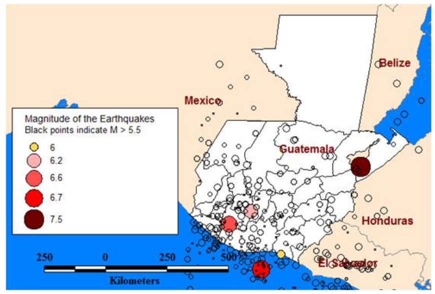

Figure 7. Location and magnitudes of the listed earthquakes [10]. (Map was created with Mapinfo© Professional 10.0.)

6. Construction

6.1 Building Materials

Structural element	Building material	Characteristic strength	Mix proportions/dimensions	Comments
Walls	Concrete blocks	35 kg/cm2	14 x 19 x 39 centimeters	12.5 units per m2
Foundation	Reinforced concrete (RC)	Concrete: 280 kg/cm2 Steel: 4200 kg/cm2	Concrete: generally 1:2:3 (cement:sand:gravel)	
Frames (beams & columns)	Reinforced concrete (RC)	Concrete: 280 kg/cm2 Steel: 4200 kg/cm2	Concrete: generally 1:2:3 (cement:sand:gravel)	
Roof and floor(s)	Floor: RC Roof: Galvanized thin plates	Concrete: 280 kg/cm2 Steel: 4200 kg/cm2 Galvanized plate: 2300 kg/cm2	Concrete: generally 1:2:3 (cement:sand:gravel) Galvanized plate: 0.60 x 1.25 meters	

6.2 Builder

The government hires construction companies to construct the buildings. This building type is rarely constructed as a private building or by a private owner. (See section 4.3).

6.3 Construction Process, Problems and Phasing

The construction process begins with the preparation of the terrain, in which the masons excavate for the footing. After the cast-in-place footing is complete, as illustrated in Figure 6, the process of wall construction begins. Generally after four or five rows of concrete blocks, a reinforced beam is placed. At the same time, the vertical reinforcement and the columns in the corners are constructed. After the reinforced concrete beam has set, the spaces for the windows and the doors are made, and the same process of wall construction is repeated. This time only 2 or 3 rows of concrete blocks are laid. After the concrete has set the steel roof structure is installed. Once the roof structural work is completed, roofing sheet area elements are screwed on it. Then a reinforced on-grade floor slab is constructed. The final step is the installation of the windows and doors. Due to the simplicity of these buildings, the construction process is relatively short. The masons are skilled or semi-skilled. The following equipment is commonly used: concrete mixer, trucks for transporting the construction materials, and of course all the necessary tools for the masons. The construction of this type of housing takes place in a single phase. Typically, the building is originally designed for its final constructed size.

6.4 Design and Construction Expertise

Due to the fact that the construction of these types of buildings involves several governmental institutions, the design, planning and supervision is provided by civil engineers and/or architects, (employed by the government institutions) with 6 years of education and typically 5 years of experience. The construction engineer (who, in the case of these buildings, works for a private company) may have also 6 years of education and also more or less 5 years of experience. The masons involved in the construction are usually skilled and semi-skilled professionals.

6.5 Building Codes and Standards

This construction type is addressed by the codes/standards of the country. This construction type is addressed by the code Recommended Structural Standards of Design for the Republic of Guatemala (AGIES) of the country.
Specifically for this kind of building chapter 9 is used: AGIES NR-9: 2000 Mamposteria Reforzada.

6.6 Building Permits and Development Control Rules

This type of construction is a non-engineered, and authorized as per development control rules. Building permits are required to build this housing type.

6.7 Building Maintenance

Typically, the building of this housing type is maintained by Owner(s). However, as a direct consequence of the difficult economic situation of many of the inhabitants of this construction type, the buildings are seldom maintained.

6.8 Construction Economics

The average cost of this type of housing is 750 Qtz Quetzales/m² (around 100 to 110 US dollars/m²). When the building is designed for its final size and engineers and/or architects participate in the construction, it is possible to construct one unit in one and a half or two months average.

7. Insurance

Earthquake insurance for this construction type is typically unavailable. For seismically strengthened existing buildings or new buildings incorporating seismically resilient features, an insurance premium discount or more complete coverage is unavailable.

8. Strengthening

8.1 Description of Seismic Strengthening Provisions

Strengthening of Existing Construction :

Seismic Deficiency	Description of Seismic Strengthening provisions used
Lack of appropriate reinforcement	Up to now, no systems are adopted.

8.2 Seismic Strengthening Adopted

Has seismic strengthening described in the above table been performed in design and construction practice, and if so, to what extent?
When new construction follows the design, no strengthening scheme is needed.

Was the work done as a mitigation effort on an undamaged building, or as repair following an earthquake?

The work has been done as a mitigation effort, in response to the poor performance of buildings in the 1976 earthquake.

8.3 Construction and Performance of Seismic Strengthening

Was the construction inspected in the same manner as the new construction?
Yes. This kind of building requires inspection from the private company constructing it and also from the government institution.

Who performed the construction seismic retrofit measures: a contractor, or owner/user? Was an architect or engineer involved?
Contractors hired by the governmental institutions. Engineers and/or architects were involved.

What was the performance of retrofitted buildings of this type in subsequent earthquakes?
There have been no major earthquakes after the strengthening, but the performance in past moderate earthquakes was acceptable.

Reference(s)

1. Recommended Structural Standards of Design for the Republic of Guatemala. Chapter number 9: MAMPOSTERÍA REFORZADA, Guatemala
   AGIES
2. Encuesta Nacional de Condiciones de Vida - ENCOVI 2006 -, Guatemala
   Instituto Nacional De Estadistica (INE)
3. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://www.foguavi.gob.gt/WXFoguavi/2011-Proyecto-Abril-Quiche-4421.html
4. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://www.foguavi.gob.gt/WXFoguavi/2011-Proyecto-Abril-Varios-6663.html
5. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://www.foguavi.gob.gt/WXFoguavi/2011-Proyecto-Abril-AltaVerapaz%20-%204539.html
6. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://www.foguavi.gob.gt/WXFoguavi/2011-Mayo-14-Visita_Cuilapa.html
7. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://www.foguavi.gob.gt/WXFoguavi/2011-Proyecto-Abril-San%20Marcos-2718.html
8. Fondo Guatemalteco Para la Vivienda Foguavi [online]
   Ministerio de Communicaciones, Infraestructura Y Vivienda
   http://chuchosenlacalle.blogspot.com/2011/06/making-progress.html
9. European Macroseismic Scale 1998
   Grünthal, G. (ed.), Musson, R., Schwarz, J., Stucchi, M.
   Cahiers de Centre Européen de Géodynamique et de Seismologie 1998 15
10. Earthquake Catalogue of Guatemala: CA_H1522_Mw35
    Coordinadora Nacional para la Reducción de Desastres (CONRED)

11. Vulnerabilidad de viviendas construidas con mampostería reforzada en Guatemala
Francisco Javier Quiñónez de la Cruz
Centro de Investigaciones de Ingeniería -CII-, Universidad de San Carlos de Guatemala -USAC- 1996

Author(s)

1. Diego Velasquez Jofre
Civil Engineer/Masters -NHRE- student , Bauhaus Universität Weimar
Marienstr. 13B, Weimar 99421, GERMANY
Email:diego.velasquez.jofre@uni-weimar.de

2. Lars Abrahamczyk
Dipl.-Ing., Earthquake Damage Analysis Center -EDAC-, Bauhaus-University Weimar
Marienstr. 13B, Weimar 99421, GERMANY
Email:lars.abrahamczyk@uni-weimar.de

3. Jochen Schwarz
Dr.-Ing., Earthquake Damage Analysis Center -EDAC-, Bauhaus-University Weimar
Marienstr. 13B, Weimar 99421, GERMANY
Email:jochen.schwarz@uni-weimar.de

Reviewer(s)

1. Jitendra K Bothara
Senior Seismic Engineer
, Beca Carter Hollings & Ferner
, NEW ZEALAND
Email:jitendra.bothara@gmail.com FAX: 64-4-496 2536

2. Dominik Lang
Dr.-Ing.
, NORSAR
Kjeller 2027, NORWAY
Email:dominik@norsar.no FAX: +47-63818719

3. Marjorie Greene
, USA

Email:greene.marjorie@gmail.com