

Addendum on Structural Damages (August 2016)

This addendum to the paper to be published at the 16th World Conference on Earthquake Engineering provides further descriptions on structural damages. **A FINAL REPORT including all updated observations and analyses will be published during the fourth quarter of 2016.**

Authors: G. Franco⁽¹⁾, H. Stone⁽²⁾, B. Ahmed⁽³⁾, S.C. Chian⁽⁴⁾, F. Hughes⁽⁵⁾, N. Jirouskova⁽⁶⁾, S. Kaminski⁽⁷⁾, J. López⁽⁸⁾, N.G. van Drunen⁽⁹⁾, and M. Querembás⁽¹⁰⁾

(1) *Global Head of CAT Risk Research, Guy Carpenter, guillermo.e.franco@guycarp.com*

(2) *Research Engineer, University College London, harriette.stone.13@ucl.ac.uk*

(3) *Ph.D. Candidate, University College London, bayes.ahmed.13@ucl.ac.uk*

(4) *Assistant Professor, National University of Singapore, sc.chian@nus.edu.sg*

(5) *Ph.D. Candidate, Cambridge University, feh22@cam.ac.uk*

(6) *Ph.D. Candidate, Imperial College, n.jirouskova14@imperial.ac.uk*

(7) *Structural Engineer, Arup, sebastian.kaminski@arup.com*

(8) *Structural Engineer, Arup, Jorge.Lopez@arup.com*

(9) *Architect, INBAR, n.g.vandrunen@gmail.com*

(10) *Director of the School of Military Engineering (Ecuador), mquerembas@gmail.com*

All correspondence should be directed to the EEFIT Team Leader Guillermo Franco:
Guillermo.E.Franco@guycarp.com

A.1 Introduction

Four structural engineers travelled to Ecuador with the EEFIT mission, Jorge Lopez and Sebastian Kaminski from Arup, Harriette Stone from University College London, and Guillermo Franco from Guy Carpenter. The team aimed to gather information on the primary reasons for earthquake damage, in addition to surveying the levels of damage to different building typologies throughout the affected area.

This section of the preliminary report will provide initial information on the methodologies used, the typical building typologies in the affected area, the site visits completed, and will then provide initial observations of structural damage and on the initial response. It is important to note that these surveys were conducted over a month after the earthquake, and therefore many of the buildings had already been demolished and the extent of, and reasons for, the damage was not observed.

A.2 Methodology

The team used a number of surveying methods to fit with different objectives for different survey area. These are explained briefly here.

A.2.1 Methodology

The simplest method used was a rapid visual survey which we completed at a slow walking pace. This collected data on the following:

Table 1 – Rapid visual survey data collected

	Data collected	Additional data collected, where possible
1	Photograph of façade	Photographs of specific damage
2	GPS location	Identifying features (e.g. name of property)
3	Main structural material	Roof type, floor type, lateral load resisting system
4	EMS-98 damage grade	Specific notes on damage

The EMS-98 damage descriptions are used throughout when describing damage. Where structural and non-structural damage descriptions did not match, preference was given to the structural damage grade.

If a building appeared to have been demolished, a photo of the site was taken and the GPS location was noted. In some cases, locals were more than happy to offer information on the buildings that previously stood on the sites. This information was recorded and where possible it will be checked for accuracy with existing imagery such as Google street view, Google earth, or photos from other sources.

A.2.2 Detailed visual surveys

Detailed visual surveys were also used to collect more information on structural characteristics and sustained damage of a number of structures. Photos and GPS locations were taken for each structure. These detailed surveys were carried out on a number of key buildings, such as churches, public facilities, hospitals, and high-rise apartment blocks. Internal and external inspections were carried out, and where possible, questions were asked to someone knowledgeable about the building, i.e. the owner, or security guard.

We also performed detailed surveys using Arup’s REDi system, and an extended version of Global Earthquake Model’s inventory capture tool. Both of these survey methods are in the development phase, so feedback will be provided on their usability in the field.

A.3 Building typologies in the affected area

There are a number of different building typologies in the earthquake affected regions, with varying levels of engineering input, quality, and durability. The types described in this section are those observed on the fieldwork mission – others may also exist that were not seen.

A.3.1 Reinforced concrete structure with masonry infill walls

This is the most common building typology observed in the affected region (Figure 1). It consists of reinforced concrete (RC) columns and slabs (sometimes with beams), with masonry walls forming the façade and internal partition walls. In some cases, reinforcement bars connect the masonry to the concrete structure. The masonry panels tend to be very slender. In reality, the lateral load-resisting system will be a combination of RC frame action and the masonry infill walls. The design and construction of these systems varies greatly in quality, with some frames clearly having been engineered for gravity loads, while the majority are likely to be non-engineered and built by local builders.



Figure 1 – Reinforced concrete structure with masonry infill walls

A.3.2 Quincha/bahareque

Quincha/bahareque is a derivative of wattle-and-daub popular in Latin America (Figure 2). *Quincha* in the areas surveyed typically consists of a timber frame, clad in a matrix of split bamboo, plastered in manure or soil, sometimes with straw or horse hair added for strength. This structural system is primarily used for one or two storey structures, with the floor and roofing system constructed from timber. It is very common to see the ground floor used for retail with an overhang, while the upper floor may be residential or used for storage. Properly constructed and maintained *quincha* has been shown to possess good structural unity and

flexibility, and thus can behave well in earthquake shaking. However, it requires a reasonable standard of construction, detailing and maintenance to avoid deterioration through rot or insect attack. The *quincha* structures observed tended to be quite old, often showing serious signs of rot and insect (especially termite) attack.



Figure 2 – Quincha structure



Figure 3 – Timber frame with masonry infill

A.3.3 Timber frame with and without masonry infill

Timber framed structures were observed in all of the areas surveyed, usually only one and two storeys. The timber frame was often braced, and either contained masonry infill (brick or

concrete block) or had a timber or CGI sheet façade (Figure 3). In some cases this system was combined with quincha or RC frame with masonry infill, with the heavier system on the ground floor and the lighter system on the first floor. Maintenance of these buildings is essential, and many of these structures showed signs of insect attack and rot.

A.3.4 Informal rural housing

Informal housing in rural areas generally uses either timber and/or bamboo for the frame (Figure 4) or RC frames with masonry infill. These systems are completely non-engineered and vary significantly in their ad-hoc stability.



Figure 4 – Informal rural housing

A.3.5 Others

A small proportion of steel, unreinforced masonry, and completely bamboo framed housing was observed, but as these typologies did not make up a significant proportion of the buildings, they have not been presented in detail in this report.

A.3.6 Other observations

It is noted that we did not see any adobe buildings during the surveys conducted.

A.4 Areas covered

A.4.1 Manta

The team started the mission on 28 May by surveying the damage in Manta. Surveys focussed on the restricted zone in the commercial district of Tarqui and in the area surrounding the seismometer station (AMNT). On 5 June, the team returned to Manta to extend surveys in Tarqui.

The team's observations on the structures in Manta are as follows:

- Initial survey of the restricted zone in Tarqui:

- The district of Tarqui was an old commercial district with typical buildings using their ground floors for commercial purposes and their upper floors (if present) for either storage or residential purposes.
- A common observation, with the help of local knowledge, was that the district of Tarqui saw a period of rapid growth that was reflected in their building stock. The buildings had additional stories added and other forms of extensions without consideration of good seismic (or even structural) design practice, or even non-seismic structural design.
- Most of the buildings used RC moment frames as a lateral load-resisting system, with masonry infill present. Some of the frames had flat slabs and others had RC beams.
- Much of the observed earthquake damage was in the non-structural elements, mainly the fired clay brick or concrete block masonry infill walls. The masonry infill walls experienced both in-plane and out-of-plane failures (see Figure 5);
- Broadly, structural damage and failures were caused by soft storeys, shear and flexural failure of concrete columns, and localised damage due to pounding.



Figure 5 – Structural and non-structural damage

- Rapid visual survey of area around the recording station:
 - Around 20 buildings were surveyed.
 - Most of the buildings surveyed were tall (8+ stories) residential and hotel buildings built in the last couple of decades.
 - The lateral load-resisting systems of most of the buildings in this area were reinforced concrete moment frames with masonry infill.
 - Most of the earthquake damage in this area was in the masonry infill walls; very little structural damage in the tall buildings was observed.

- Rapid visual survey of buildings in Tarqui:
 - Around 200 buildings were surveyed.
 - Building types surveyed were primarily RC and timber buildings, with a handful of steel frame and masonry buildings.

A.4.2 Portoviejo

The team spend 29 and 30 May in Portoviejo. Surveys were conducted in a number of different areas, including the restricted ‘ground zero’ area where the damage was most intense, the commercial areas beyond ground zero, a neighbourhood with localised residential damage, the local university, the old airport building (now the site of a large temporary shelter for displaced families), and the area close to the seismometer station.

The team’s observations are as follows:

- Ground zero commercial area:
 - Around 70 buildings were surveyed using the rapid visual survey technique.
 - Buildings were generally low-to-mid rise 1-4 storey buildings, with some taller structures.
 - Building typologies were mostly RC frame with masonry infill, with some *quincha* and timber frame buildings.
 - Structural damage varied considerably. Most RC buildings over three storeys experienced some level of damage, normally failures in masonry walls, however severe partial collapses were also seen (Figure 6).
 - Most RC buildings less than three storeys experienced minor levels of damage.
 - Many *quincha* and timber buildings experienced heavy levels of damage, caused by severe rot and termite damage.
- Residential neighbourhood:
 - On one street in residential neighbourhood, it was observed that two large four storey RC frame with masonry infill apartment blocks on one side of the street experienced heavy levels of structural damage, whilst opposite, two storey terraced houses experienced little to no damage.
- University campus:
 - A number of large university blocks were inspected.
 - Structures showed varying levels of damage – some had significant short column shear failures, and others only had infill masonry wall damage.
- Area around seismometer station:
 - A rapid visual assessment of 70 buildings was conducted in a residential area close to the seismometer station (APO1). Most of the buildings were between 1-3 storeys and were RC frame with masonry infill houses – very little damage was seen.



Figure 6 – Upper floor soft storey collapse on two floors in Portoviejo



Figure 7 – Site welded steel plates for column strengthening in Portoviejo airport

- Airport building:
 - Column strengthening was seen to the upper floor columns in the airport building (Figure 7). The remedial work consisted of four steel angles placed

one at each corner of the column, with site welded plates anchoring them in place.

- It is assumed that this retrofitting work was proposed to increase the shear capacity of the column.
- The quality of the site welding of the plates was deemed poor.
- In addition, as the concrete columns were not perfectly flat the steel did not bear directly against them; instead a small gap remained.

A.4.3 Bahía de Caráquez

The team spent 31 May and the morning of 4 June in Bahía de Caráquez, first surveying the bridge, and the Hospital Miguel Hilario Alcivar De Bahia De Caraquez, and returning to survey the damage to structures in the town, including a detailed survey of the Edificio Torresol apartment building.

- Los Caras bridge:
 - The bridge is formed of an RC bridge deck supported on a number of piers.
 - The bridge, designed and built by the Ecuadorian Army Corps of Engineers, has triple pendulum dampers to reduce the seismic load on the bridge deck.
 - According to the authorities, the bridge performed very well in the earthquake and aftershocks, with only one of the seismic dampers exceeding capacity due to larger than expected soil effects. This damper will be repaired or replaced and some local soil improvement work will be carried out to protect the bridge in the future.
- Detailed survey of Hospital Miguel Hilario Alcivar De Bahia De Caraquez:
 - The team conducted a REDi damage assessment for the main hospital in Bahía de Caráquez.
 - The building was retrofitted after the 1998 earthquake, through the addition of one RC shear wall per elevation coupled with the columns. The coupled columns were also retrofitted by concrete jacketing. Spalling due to the earthquake was seen at the coupling connection.
 - One survey group had recommended demolition, and another has recommended repair and rehabilitation.
 - Heavy non-structural damage was observed with many internal and external masonry walls failing in- and out-of-plane.
 - Generally, slight to moderate structural damage was observed, with some spalling of concrete on columns.
- Detailed survey of Edificio Torresol:
 - Only the ground floor was inspected by the team.
 - The nine storey apartment block is comprised of RC frame construction with a one-way spanning slabs.
 - Heavy non-structural damage was sustained during the earthquake, with masonry infill wall damage.
 - Some structural damage was observed.
 - Interestingly, the building was undergoing a major strengthening programme, with steel plates add to encase the ground floor columns only completed a few days prior to the 16 April earthquake (Figure 8).
- Rapid visual survey of Bahía de Caraquez town centre:
 - A rapid visual survey was carried out, with data collected for approximately 150 buildings.

- The main town consists of a number of high-rise (8+ storeys) hotels and apartment blocks, with other buildings very similar to those seen elsewhere in the region.



Figure 8 – Steel casing installed around ground floor columns just days before the 16 April 2016 earthquake

A.4.4 Canoa

On 1 June, the team surveyed buildings along the coast from a couple of kilometres south of Canoa towards the town, and then surveyed the main town area in Canoa including the Canoa Bridge, a pedestrian suspension bridge that collapsed due to the earthquake, and a church building. The team also travelled inland from Canoa towards the area of Rio Canoa, which is a series of small settlements along a valley. The team's observations on the structures in Canoa are as follows:

- Survey of buildings along the coast on the way to Canoa:
 - Residential buildings were found to suffer mainly non-structural damage in their masonry infill walls. Structural damage was seen in only one two storey building that suffered partial collapse of an uppermost floor.
 - We spoke to some building owners and construction managers who told us that their buildings were built to US standards as they were intended for US citizens in retirement.
 - The better construction quality was evident, however, similar construction practice with regards to the masonry infill walls for seismic areas was found as in the other places visited.
- Survey of Canoa bridge and buildings in Canoa:
 - The Canoa bridge was a pedestrian suspension bridge that suffered failure of the anchors of both cables at one end of the bridge;

- A walk around survey was performed by the team using the omnidirectional camera which would allow the team to analyse the buildings and the earthquake damage they suffered at a later stage;
- Most of the heavily damaged and collapsed buildings were cleared out by the time the team arrived in Manta. Some damage to buildings that had not been demolished could still be seen, exhibiting mainly non-structural damage.
- Survey of Catholic church in Canoa (Figure 9):
 - Both structural and non-structural damage was observed in a Catholic church in Canoa.
 - Structural damage was found at the top of most of the columns, with most damage being concentrated in the shorter columns. The shorter columns were stiffer, therefore attracted more lateral loads than the taller columns.
 - Reportedly the brick masonry infill walls did not suffer heavy damage, instead they were demolished or dismantled after the earthquake.
- Survey of Rio Canoa:
 - The buildings the team surveyed in Rio Canoa were mainly one and two-storey single family dwellings made of timber frames with either timber panel or masonry infill walls. Most of the damage seen was of the masonry infill walls.



Figure 9 – Structural damage of Church in Canoa.

A.4.5 Jama

Jama is a small rural town with a population of a few thousand. On 1 June the team briefly visited Jama and conducted a rapid visual survey of the town centre.

- Rapid visual survey of town centre:
 - Round 100 buildings were surveyed.
 - Building typologies were generally comprised of timber or RC frame with masonry infill, all general 1-2 storeys.
 - Damage was significant, with many buildings demolished, and many remaining structures showing signs of severe damage.

A.4.6 Pedernales

Pedernales was reported to be one of the most affected towns. The army reported that 402 buildings had been demolished prior to our arrival. Structures were surveyed using a rapid visual survey in the town centre and in the area around the seismometer station (APED). Additionally, detailed surveys were conducted in the cathedral, and the main municipality building, both located on Plaza Central.

- Rapid visual surveys of town centre:
 - Around 200 buildings were surveyed in Pedernales town centre and 100 surveyed around the seismometer station (APED).
 - Building typologies were mostly comprised of low-rise RC or timber masonry infilled buildings.
 - Structural damage was generally light, and moderate and above in some cases, however many of the most damaged buildings had been demolished.
 - Non-structural damage comprised in- and out-of-plane masonry infill wall damage.
- Detailed survey of the cathedral (Figure 10):
 - The cathedral is formed of RC and an architectural steel truss roof.
 - Masonry was used throughout for infill, gable, and external walls.
 - Non-structural damage was heavy, with some significant masonry wall damage, and dislodged heavy ceiling tiles. Roof cladding panels had also fallen during the earthquake.
 - Observed structural damage was light and appeared to be caused by connections to the masonry infill walls.



Figure 10 – Pedernales cathedral on Plaza Central

- Detailed survey of the main municipality building (Figure 11):
 - This building is a 5 storey building of RC frame construction with masonry infill internal and external walls.

- The team surveyed the building internally on level 1 and externally, and observed moderate structural damage, including cracks and spalling of concrete in the top of the columns, and heavy damage to the RC staircase.
- Non-structural damage was heavy with the failure of full wall panels internally and externally.



Figure 11 – The main municipality building in Pedernales

A.4.7 Chamanga

The team visited the coastal village of Chamanga on the morning on 3 June. A visual survey was performed with team members taking photographs and writing down main features of the earthquake damage, but no data was collected by means of a rapid visual survey.

- Survey of village:
 - The village of Chamanga is mainly a low-income fishermen village. The mangroves once formed the coast line in Chamanga, but some of this area has been reclaimed for construction.
 - It was observed that there was a concentration of heavy damage in the buildings that were founded on the reclaimed areas along the coastline, with ground settlements suspected.
 - Some buildings are located just offshored, with timber and concrete piles used for foundations placed 1-1.5m deep (Figure 12). It is believed that there was no engineering behind any of those buildings.



Figure 12 – Buildings built near-shore in Chamanga founded on timber and concrete piles manually placed down to about 1-1.5m deep. The piles seen were previously used for one to three storey buildings.

A.5 Initial observations on reasons for structural failures

The following are initial observations on possible most significant reasons for the structural failures seen.

A.5.1 RC frame with masonry infill

Weak & Soft storeys

This failure occurs when a floor is weaker in strength or less stiff than the adjacent storeys, resulting in damage concentration at this floor level, which can exceed the capacity and result in collapse of that floor (Figure 6). This form of collapse was seen in a number of buildings: interestingly weak or soft storey failures were rarely observed at ground floor level, but instead at an upper level (e.g. Figure 6).

Inadequate masonry infill design and construction

The masonry used to infill frames to provide facades and partition walls was inadequate in a number of areas (Figure 13):

1. The connections between the columns and the masonry were often insufficient – in many buildings no reinforcement bars existed connecting the two. This lack of a proper connection at the column interface can lead to the walls failing out-of-plane.
2. Where reinforcement bars did exist connecting the columns to the masonry, the masonry was often too thin and the mortar too poor quality to enable the bars to properly bond to the masonry.
3. The aspect ratio of the panels was in nearly all cases too large for the thickness of the masonry, which means that the masonry is unable to arch under out-of-plane load, nor able to be stable under in-plane load, and can fail/buckle out-of-plane.
4. Where the designated lateral load-resisting system is a moment frame, the masonry should be decoupled from the frame through the introduction of a ‘soft’ joint on three sides of the masonry panel (typically 10-40mm thick), filled with a compressible material.

Inadequate masonry design and detailing was observed in many buildings that had infill masonry walls.



Figure 13 – Inadequate masonry infill wall design and construction

Short columns

This failure occurs when partial height walls are constructed against columns. This construction promotes a brittle shear failure mode prior to a ductile flexural mode (Figure 14). This failure mode was seen in a number of buildings.



Figure 14 – Short columns at a school in Pedernales

Inadequate design and detailing for shear

In seismic areas, the shear links within RC elements need special detailing. In particular, shear links need to be closely spaced, the two ends of the loop need to return into the column by an angle greater than 135 degrees, and the length of the returns need to be sufficient. This detailing ensures that the shear capacity of the concrete is as designed, helps to reduce buckling of the longitudinal bars and helps to confine the concrete in the core. In many RC buildings surveyed some or all of these detailing requirements were not present.



Figure 15 – Inadequate design and detailing for shear

Inadequate design and detailing of RC moment frames

RC moment frames in seismic areas require several key considerations to ensure they behave safely in an earthquake:

- Sufficient overall moment and shear capacity.
- A columns flexural strength should exceed that in the beams, such that flexural failure occurs first in the beams.
- Columns and beams stronger in shear than in flexure, such that a ductile flexural failure mode occurs before a brittle shear failure mode.
- Adequate detailing of the reinforcement in all elements.

Damaged RC structures observed generally failed some or all of these requirements.

Insufficient cover to rebar

Sufficient cover to reinforcement is required to protect the reinforcement against corrosion. In coastal outdoor environments, the environment is more aggressive and the requirements for cover increase. In many columns the cover was very low (0-20mm), which caused corrosion to the steel. For comparison, for this region UK codes generally require around 50mm cover for good quality concrete in a coastal environment.

Inadequate laps and corrosion to reinforcement bars

A number of buildings experienced upper floor soft storeys without a clear change in stiffness or strength. It is known that the reinforcement bars come in set lengths, and when placed for construction the top of the bars were often observed to rise just above the second floor. It is common to build just two storeys initially and leave extra reinforcement exposed, ready for an additional floor in the future (Figure 17).

In many cases, the amount of reinforcement sticking out may not be sufficient for a proper reinforcement lap, which would lead to a weak and brittle connection. In addition, the reinforcement bars are often left out for many years and so can experience surface corrosion, which can weaken their bond to the new concrete once poured. The combination of these

could lead to floors which are weaker when they line up with the inadequate column laps (Figure 17).



Figure 16 – Insufficient cover to rebar



Figure 17 – Exposed reinforcement with possible inadequate lap lengths for future construction, and an upper storey soft storey failure

Poor quality concrete

The concrete used for the frames was observed to be of low quality in some areas, likely for a number of reasons:

- Inadequate mix design – some concrete clearly had too much or too little coarse aggregate (Figure 18).
- Excess water – with informal construction, it is common to add excess water to the mix, which weakens the concrete.
- Poor compaction – some concrete clearly had not been properly compacted and voids was evident at the bottom of pours.

- Use of sea sand – this was mentioned by a number of local engineers however cannot be verified visually as it requires laboratory testing.



Figure 18 – Poor quality concrete

A.5.2 Buildings using timber or bamboo

Rot and damage due to insects

The majority of the damaged timber or bamboo buildings showed evidence of severe damage due to rot, termites or beetles, or a combination (Figure 19). This is due to:

- A lack of appropriate prior treatment of the materials.
- Inadequate selection of durable timbers.
- Inadequate design leading to large areas of the walls fully exposed to the elements.
- A general lack of maintenance, including replacing damaged elements and painting.
- The encasing of timber or bamboo within concrete as a connection to the foundation.



Figure 19 – Rot and damage due to insects

A.6 Initial comments on structural engineering and the response

- Tagging system and demolition process:
 - It was observed that the ‘traffic light’ tagging system used in the affected areas varies in interpretation in the different cities and towns. For instance, ‘red’ in one area was understood by some to signify demolition needed; whereas in other areas it meant ‘do not enter’ as it was deemed a life hazard. Additionally, it was observed that within individual towns, assessors and those responsible for demolition did not appear to have agreed a consensus on the meaning of red tags. With such rapid moving demolition post-event, it is widely reported that buildings that could have been repaired and retrofitted were demolished unnecessarily.
 - We also observed that in some cases people may have inadvertently assumed that “green” means the structure was safe against future earthquakes, as opposed to just being “safe due to not having experienced significant damage during the previous earthquake”.
- Demolition
 - Buildings with ‘red’ and ‘yellow’ tags are being demolished. In smaller towns like Canoa and Chamanga the demolition process appeared to have almost finished
 - The team found that in some of the smaller and lower-income areas such as Chamanga and Rio Canoa, the building owners are carrying out their own demolition and reconstruction process. We found in Chamanga that people were demolishing the concrete slabs and beams, and leaving the existing reinforcement mesh for pouring new concrete to be able keep using their buildings. It is likely that these works are being carried out without any engineering advice. In Rio Canoa people are adding vertical timber posts to ‘improve’ or enhance their buildings; the lateral resistance is not being considered as much as needed.
- Primary issues with the structures observed:

- The main issue with the structures observed is considered to be a fundamental lack of design for lateral loads – both wind and seismic. The structural system most commonly used – RC frame with masonry infill – is a hybrid between an RC frame and confined masonry, yet not detailed for either.
- Indiscriminate growth and extensions of buildings has made this situation worse, by increasing the loads on the buildings below without the buildings necessarily being designed for them, nor for a robust connection between them.
- The use of masonry infill walls inadequately designed and poorly connected to the frames has directly caused structural failures by causing damage to the frame, directly killed people due to falling masonry and likely indirectly killed people by blocking escape routes.
- Inadequate maintenance of the older timber and bamboo structures.
- Preliminary opinions:
 - Engineers and architects in the region would benefit from a broader understanding of good practice seismic design criteria and detailing.
 - Improved enforcement of building codes and better construction control would greatly benefit the region by ensuring the quality of both the design and construction of buildings.
 - The code would benefit from more conservative requirements for cover to reinforcement for concrete, and better masonry infill walls detailing requirements.
 - Builders (*albaniles* and *maestros*) would benefit from training on:
 - Better reinforcement detailing, notably detailing of shear links and lapping of reinforcement.
 - Better installation of masonry infill, notably laying bricks horizontally not vertically, better bed joints, better seismic connections between masonry and concrete.
 - The population would benefit from a reminder of the importance of house maintenance, especially if the house uses timber or bamboo.