July 27, 2019 Batanes Post-Earthquake Reconnaissance Report

Itbayat, Batanes

Survey Date: October 1-11, 2019

Report Date: October 31, 2019

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1. Executive Summary

Build Change, with partners Philippine Red Cross, conducted a post-earthquake reconnaissance survey in Itbayat, Batanes following the July 27, 2019 earthquakes. The two consecutive earthquakes happened at 4:16 AM and 7:37 AM with a magnitude of 5.4 and 5.9 respectively. The earthquakes caused major damage to houses in Itbayat, where most traditional unreinforced limestone masonry houses collapsed, and also damaged government buildings such as schools, the town hall and hospital.

The team from Build Change and Philippine Red Cross arrived in Itbayat, Batanes on October 2, 2019 for a weeklong survey. Key findings include:

- Residents were already rebuilding their temporary shelters since financial aid from the government had been released and construction materials were being distributed.
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- The most common house typologies are unreinforced limestone masonry, reinforced concrete and light timber houses.
- Most of the unreinforced limestone masonry houses totally collapsed during the earthquake and a few reinforced concrete houses suffered out of plane failure of gable wall and wall cracks.
- Most of the totally collapsed traditional unreinforced limestone masonry houses were already demolished and cleared when we arrived. Factors that caused the collapse of these houses include the poor quality of material used, age of the house and subjection to numerous tropical storms over the years, which would likely have caused the limestone to erode over time and consequently weakened the walls' ability to withstand an earthquake.
- The most common failure observed was the out of plane failure of wall. These walls do not have ring beams, horizontal bands, vertical bands or buttresses, anchors to the roof, or other types of framing typically used to brace unreinforced masonry wall out-of-plane.

Both government and the private sector are planning to provide financial subsidies to affected residents to build permanent houses. Technical assistance is recommended to help the residents rebuild homes that are earthquake and typhoon-resistant. The government and private sector organizations are encouraged to develop disaster resistant designs for the new houses using materials available in the island (such as limestone) since the cost of materials coming from the mainland is too expensive due to lack of good transport infrastructure.

Homeowner-driven construction (where loans or subsidies are provided directly to homeowners for reconstruction or retrofitting) is recommended, supported by technical assistance to effectively build the capacity of the community in earthquake-resistance construction.

Disaster-resistant design and construction can become a common practice of the community after post-disaster assistance is completed.

2. Background

2.1 Objectives of the Mission

Assist the affected Philippines Red Cross (PRC) Chapter in the following:

1. To raise awareness and promote locally appropriate measures to achieve safe shelter of the affected population.
2. Ensure thematic agendas are being incorporated in the activities conducted.
3. To conduct a case study on Shelter Damage Evaluation

2.2 Key Deliverables/Expected Outcomes

1. Damage Evaluation (Assessment)
   a) To determine the types of structural failures through visual inspection.
   b) To share assumptions on the factors behind these failures based on Build Change's previous experience.
2. Determination of Rehabilitation Actions (Repair of Partially Damaged Houses)
   a) To provide general recommendations applicable to the disaster-resistant rehabilitation of partially damaged houses.
3. Reconstruction Actions (Construction for Totally Damaged Houses)
   a) To provide general recommendations applicable to the disaster-resistant reconstruction of totally damaged houses.
4. Safe Shelter Awareness (SSA) and Build Back Better (BBB)
   i. To conduct SSA and BBB orientation for the PRC Staff and Volunteers (training-of-trainers)

This report will focus on the damage evaluation and determination of rehabilitation and reconstruction action by providing general recommendation that Build Change deemed proper (Items 1 to 3).

2.3 Reconnaissance Survey Team

A team composed of four (4) from Build Change, the Philippine Red Cross and the International Federation of Red Cross (IFRC) went on an 11 days field work to Itbayat, Batanes to conduct the reconnaissance survey and training to the community.

1. Roel Ombao - Project Manager, Build Change
2. Raquel Lagramada - Senior Builder Trainer, Build Change
3. Journel Torres - Philippine Red Cross
4. Rajeev KC - IFRC

2.4 Itbayat, Batanes town information

Itbayat, officially the **Municipality of Itbayat** (Ivatan: *Kavahayan nu Itbayat*; Tagalog: *Bayan ng Itbayat*), is a municipality in the province of Batanes in the Region 2 of the Philippines. According to the 2015 census, it has a population of 2,867 people.

Itbayat is the country's northernmost municipality, located 156 kilometers (97 mi) from the southernmost tip of Taiwan.

In addition to the main island of Itbayat which is the largest in Batanes, the municipality includes the rest of the province's northern islands, all small and mostly uninhabited. These islands are, from south to north: Di'nem Island, Siayan, Misanga, Ah'li, and Mavulis Island, the northernmost island of the Philippine archipelago.

According to the Philippine Statistics Authority, the municipality has a land area of 83.13 square kilometres (32.10 sq mi) constituting 37.96% of the 219.01-square-kilometre- (84.56 sq mi) total area of Batanes.

Itbayat is politically subdivided in 5 barangays (villages).

PSGC	Barangay	Population			±% p.a.	
		2015[3]		2010[8]		
020902006	Raele	16.2%	465	442	▲	0.97%
020902007	San Rafael (*Idiang*)	26.0%	745	789	▼	−1.09%
020902008	Santa Lucia (*Kawxawxasan*)	14.7%	422	478	▼	−2.34%
020902009	Santa Maria (*Marapuy*)	16.1%	463	438	▲	1.06%
020902010	Santa Rosa (*Hiñatu*)	26.9%	772	841	▼	−1.62%
	TOTAL		2,867	2,988	▼	−0.78%

Figure 2.1 Itbayat, Batanes Map and Barangays. Source: Wikipedia.

2.5 Overview of the recent Earthquake

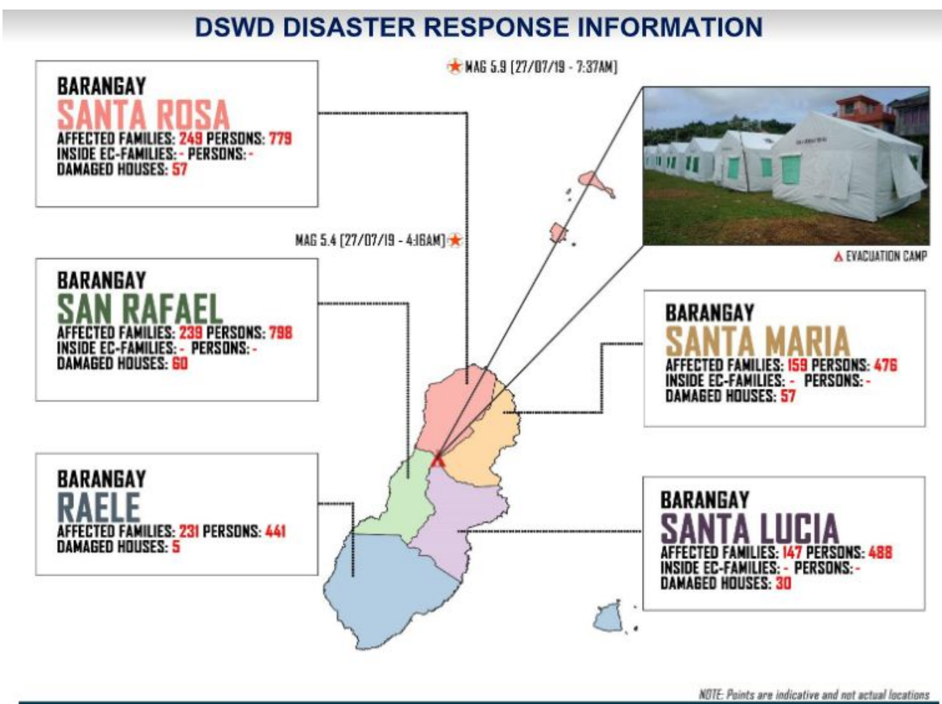
At 4:16 AM on 27 July 2019, Saturday, a Magnitude 5.4 earthquake shook the Batanes Islands. Its epicenter is located 12 kilometers north of Itbayat, Batanes and originated at a depth of 12 kilometers. At 7:37 AM, an earthquake with Magnitude 5.9 occurred 21 kilometers north of Itbayat, Batanes at a depth of 7 kilometers. At 9:24 AM, a Magnitude 5.8 earthquake occurred, located 11 kilometers north of Itbayat, Batanes, with a depth of 11 kilometers. Each event was followed by small-magnitude aftershocks. As of 8:00 PM of 27 July 2019, 104 aftershocks have been recorded by the Department of Science and Technology - Philippine Institute of Volcanology and Seismology (DOST-PHIVOLCS) seismic monitoring network.

The Magnitude 5.4 earthquake generated ground shaking felt at PHIVOLCS Earthquake Intensity Scale (PEIS) VI (Very Strong) in Itbayat, Batanes. Intensity III (Weak) was also felt in Basco and Sabtang, Batanes.

The larger Magnitude 5.9 earthquake generated stronger ground shaking felt at Intensity VII (Destructive) in Itbayat, Batanes, Intensity V (Strong) in Basco, Ivana, Mahatao, Batanes, and Intensity IV (Moderately Strong) in Sabtang and Uyugan, Batanes. Both ground shaking events resulted in casualties and damages to buildings and infrastructure near the epicentral area.

Prior to the moderate-sized earthquakes on July 27, earthquakes with magnitudes ranging from 4.2 to 4.8 occurred from July 22 to 26, 2019. The maximum reported ground shaking intensity was IV.

According to data from Department of Social Welfare and Development (DSWD) and Philippine Red Cross (PRC) Batanes Chapter there are a total of 207 damaged houses. With 180 houses totally damaged and 27 partially damaged.



GRAND TOTAL	AFFECTED			INSIDE EVACUATION CENTER		OUTSIDE EVACUATION CENTER		DAMAGED HOUSES	ASSISTANCE PROVIDED
	BRGY. AFFECTED	FAMILIES	PERSONS	FAMILIES	PERSONS	FAMILIES	PERSONS		
	5	1,025	2,982	-	-	35	103	209	PHP 15,666,541.80

Source: DRMB-DROMIC GIS Specialists

Figure 2.2 DSWD Disaster Response Information

2.6 Seismic Hazard

The nearest fault line to Itbayat, Batanes is located 104.3 km south of the Island.

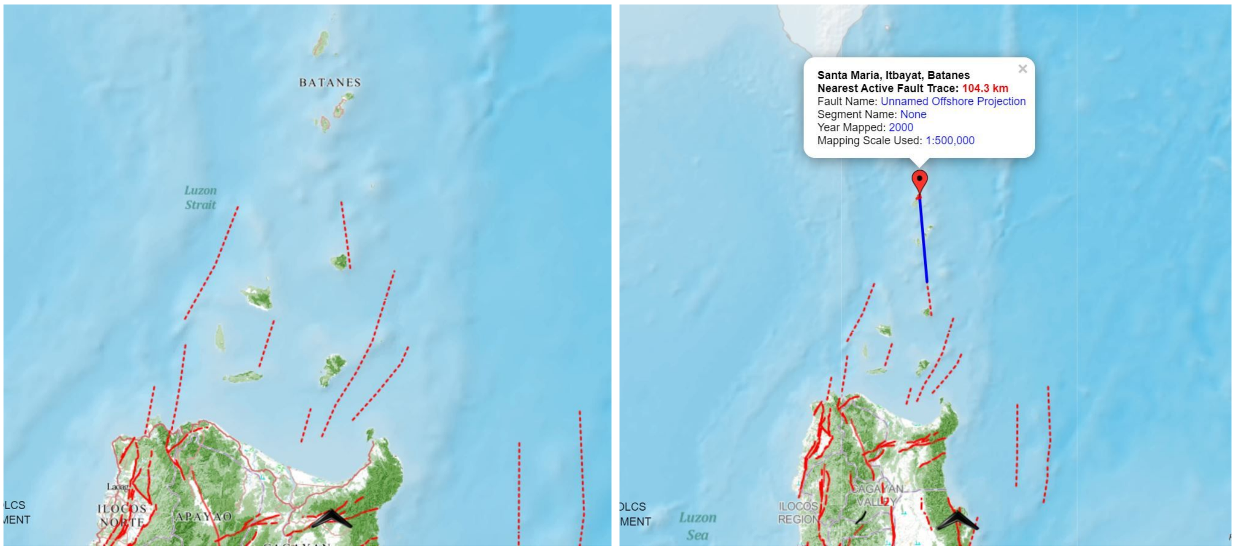


Figure 2.3 Nearest Fault line to Itbayat. Source: PHIVOLCS Fault Finder

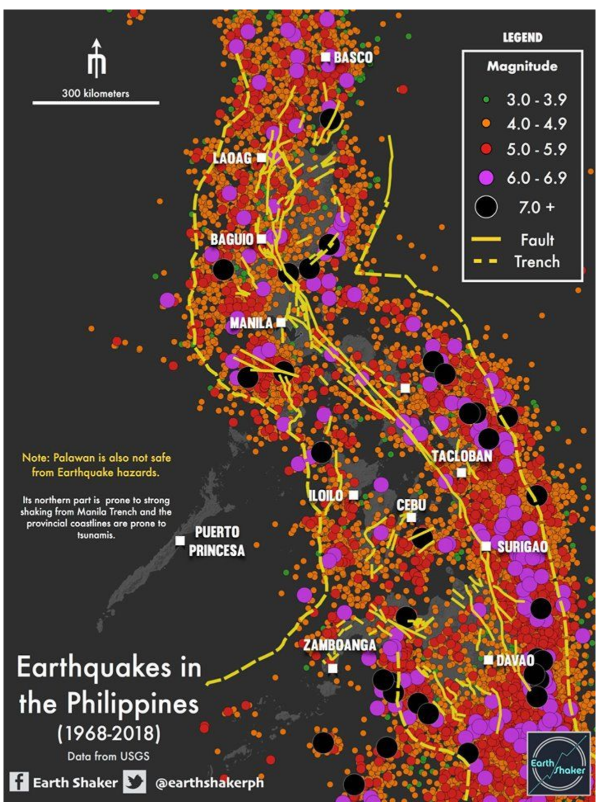


Figure 2.4 Earthquake in the Philippines (1968-2018) Source: Earth Shaker Facebook page

3. Field Observation

On October 2, 2019, the reconnaissance team arrived in Itbayat, Batanes and started with coordination with the PRC Batanes Chapter and officials of different barangays in Itbayat. The team started the house-to-house visits with Barangay Santa Lucia on October 3, 2019. Most of the houses are built near a slope because the topography is predominantly mountainous terrain.

Most of the damaged houses located in the town centers of the 4 barangays were already demolished and cleared when we arrived. The homeowners had all received cash assistance from the government amounting to Php 60,000.00 and were already starting to build their temporary shelters. Also, the construction materials from the Office of Civil Defense had been being distributed to the residents. They were comprised of CGI sheets, GI Pipe and Lumber. The design for the temporary shelters were provided by the government for the residents to follow.

Most of the traditional houses located on the 4 barangays were totally damaged and mostly all demolished. Only Barangay Raele, which is located 9 km from Itbayat proper, had traditional houses still standing. The residents there said that they had experienced lesser intense ground motions during the earthquake, though there were still major cracks present in the walls of several buildings. The buildings with major cracks are classified as off-limits by the DPWH Engineers and are no longer used by their owners.

Overall, the reinforced concrete houses built in Itbayat performed well in the earthquake with most having only minor cracks on the walls. A few houses had collapsed gable walls.

Construction materials are expensive on the island, more than double compared to the prices for materials on the main island of Luzon. For example, the cement in Batanes costs Php 550 to 600 per 40kg bag, compared to Php 225 in the main island. The cost of aggregate and sand is Php 6,000 - 7,000 per truck load (approx. 3 cu.m).26

No.	Item	Unit	Price in Itbayat (Php)	Price in Metro Manila (Php)	% Difference compared to Manila prices
1	Cement	bag	530	225	136
2	10mm def steel bar, 6m	pc	270	157	72
3	12mm def steel bar, 6m	pc	285	230	24
4	Sand/gravel	truck load	6500	1600	306

5	Nails	kg	110	70	57
6	Tie wire	kg	120	70	71
7	CGI, 10ft	pc	1,100	500	120

The team visited and interviewed 59 houses and homeowners from the 5 Barangays of Itbayat: Santa Lucia, San Rafael, Santa Rosa, Santa Maria and Raele.

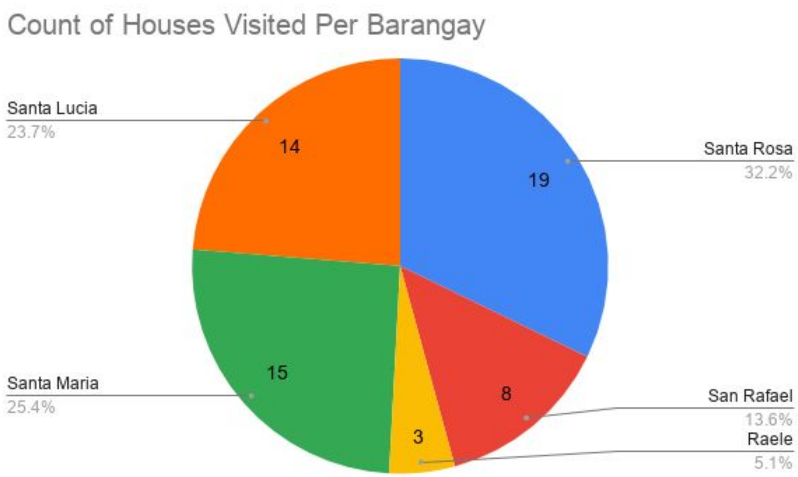


Figure 3.1 Count of Houses Visited per Barangay

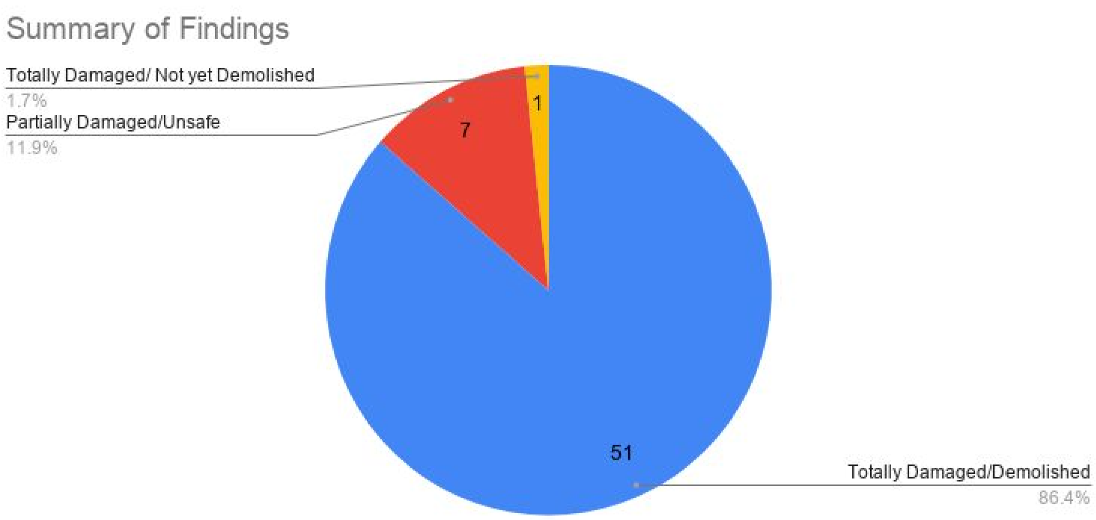


Figure 3.2 Summary of Findings

3.1 Typical House typologies in Itbayat

1. Traditional Unreinforced Limestone Masonry Houses - These buildings are made up of limestone with lime mortar, wood and thatch. These heavy stone walls covered with thick thatched roofs are not found anywhere else in the Philippines. They have been designed to withstand monsoon rains and severe typhoons that normally passes through the region annually. Typical traditional houses are made up of two buildings, the main house and the kitchen. The house is regular rectangular shape with walls ranging from 5 to 10m in length. The stone walls are normally 600mm to 1000mm thick. The roof framing is made of timber material with cogon grass thatching or Corrugated Galvanized Iron (CGI) sheets as roof cover.

Figure 3.3 Typical Traditional Unreinforced Limestone Masonry House

2. Reinforced Concrete Houses - These buildings are normally made with a mix of cement and "local aggregate/sand", which is made of crushed limestone. The mixed is 1 cement to 6-7 parts of crushed limestone by volume. Most reinforced concrete (RC) walls are constructed with cast-in-place concrete rather than concrete hollow block (CHB) that is the normal practice in the main islands of the Philippines.

Figure 3.4 Typical Reinforced Concrete House

3. Timber houses - These buildings are normally with timber frames for walls and roofs. The roofing sheets and wall panels are typically either Corrugated Galvanized Iron (CGI) sheets or cogon grass thatching.

Figure 3.5 Typical Timber House

3.2 Barangay Santa Lucia

Figure 3.6

One Story house with concrete columns and concrete walls. Minor cracks developed in the walls and in the connection between the walls and columns. Concrete mix used is made up of cement and crushed limestone with an 1:7 ratio.

Figure 3.7 Two story concrete house with walls made up of concrete (not CHB). Gable wall and concrete gutters collapsed on both sides during the earthquake and cracks developed in the walls and columns.

Figure 3.8 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake.

Figure 3.10 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

Figure 3.9 One story concrete house with walls made up of concrete (not CHB). Concrete mix used was made up of cement and crushed limestone with an 1:7 ratio. Cracks developed in all the walls, especially near openings. The house is visibly out of plumb.

3.3 Barangay San Rafael

Figure 3.11 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick.The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

Figure 3.12 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

Figure 3.13 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

Figure 3.14 One story traditional unreinforced limestone masonry house with concrete house extension. The traditional stone house collapsed and the concrete house extension was severely damaged due to the force induced by the stone house. The RC house extension is out of plumb with major cracks and separations of the wall-columns and wall-beams. The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

Figure 3.15 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowner has already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

3.4 Barangay Raele

Figure 3.16 One-story unreinforced limestone masonry house. The stone wall suffered major cracks especially near wall openings and on wall corners. Most of the stone houses did not totally collapse in Raele as residents said they experienced less earthquake intensity compared to other barangays. Raele is 9km away from the town center. This house is tagged as Unsafe by the government engineers and awaiting either retrofit or demolition.

Figure 3.17 One-story unreinforced limestone masonry house (Kitchen - photos 1&2, Main House - photos 3-7). The stone wall suffered major cracks especially near wall openings and on wall corners. Most of the stone houses did not totally collapse in Raele as residents said they experienced less earthquake intensity compared to other barangays. Raele is 9km away from the town center. This house is tagged as Unsafe by the government engineers and awaiting either retrofit or demolition.

3.5 Barangay Santa Rosa

Figure 3.18 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowners have already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

3.5 Barangay Santa Maria

Figure 3.19 One story traditional unreinforced limestone masonry house. Already demolished, according to homeowner the house totally collapsed during the earthquake. The wall was approximately around 700mm thick. The homeowners have already received materials for their temporary shelter and is preparing to start with construction. Materials include CGI sheets, lumber and 100mm diameter GI Pipe for the columns.

4. Damage Mechanism of Unreinforced Limestone Masonry and Reinforced Concrete Houses

4.1 Damage Due to Poor Quality Material and Age of the Houses

Houses built with limestone walls bonded with lime mortar can only be found in the province of Batanes and is not typical construction practice in any other part of the Philippines. This type of wall material lacks formal studies or tests on its mechanical properties as a building material. However, limestone is known to be a porous material and that can easily erode when drenched in rainwater. It can also easily break apart or be crushed. This type of material has often exhibited poor earthquake performance.

The crushed limestone, often called by the locals as “local sand and gravel”, is being used as an alternative to black sand and gravel because these materials are not available on the island and are too expensive for locals to buy from the neighboring islands. The common concrete mix used by the locals in construction is 1 bag of cement is to 6 to 7 parts of “local sand and gravel”. The team was unable to get testing data for the mixed concrete to determine its approximate strength. However, studies have shown that limestone aggregate can be used successfully in concrete mix designs (Aquino, 2010; Wang, 2018).

Most of the houses visited by the team were built between 1900 and 1990. Most of them are more than 50 years old and have been subjected to numerous tropical storms over the years, which would likely have caused the limestone to erode over time and consequently weakened the walls ability to withstand an earthquake.

4.2 Out of Plane Failure

The most common damaged observed was the out of plane failure of the walls, especially walls for unreinforced limestone masonry houses and some reinforced concrete gable walls. Noticeably, almost all traditional stone masonry houses have heavy walls on the perimeter or outer walls only with no interior perpendicular walls. These walls also do not have ring beams, horizontal bands, vertical bands or buttresses, anchors to the roof, or other types of framing typically used to brace unreinforced masonry walls out-of-plane. The lack of these elements typically results in out of plane failures like what was observed in Batanes.

At some of the reinforced concrete houses, there were gable walls that collapsed out-of-plane. This is a common failure seen whenever heavy gable walls are not braced to the roof or the walls below.

Figure 4.1 Two story house with out of plane failure of gable wall.

5. Conclusions and Recommendations

It is clear that the residents of Itbayat have traditionally constructed their homes for typhoons/cyclones because they use heavy stone masonry walls that have performed well during strong winds. Also, the builders in Itbayat have adopted good construction practices for constructing their roofs using lessons learned from previous strong typhoons. However, the same unreinforced limestone masonry houses that have strong resistance to typhoons also have weak resistance to strong earthquakes. Almost all houses close to the earthquake epicenter that were constructed of unreinforced limestone masonry totally collapsed, while those in barangays further from the epicenter remained standing but suffered major cracks in the walls that have made the houses unsafe to occupy.

Recommendations for Partially Damaged Houses

1. The unreinforced limestone masonry houses that are still standing but with cracks should be further evaluated by a qualified Structural Engineer in order to determine if it is still possible to repair and strengthen for the next earthquake. The houses where this is not possible should be demolished and cleared as they pose a hazard to people living adjacent to those houses.
2. Reinforced concrete houses visited show cracks near wall openings and column-wall connections. We are recommending that reinforced concrete houses that are partially damaged undergo further evaluation of a qualified Structural Engineer.
3. Walls are normally made up of concrete with cement and crushed limestone with 1:6-7 ratio as gathered during the interview with builders in the community. It is recommended

that testing of samples be performed to determine the compressive strength of this mix and the appropriate ratio of cement to aggregate.

4. The cost of construction materials should be considered when specifying repairs and/or strengthening interventions as prices are considerably higher than the mainland due to poor transportation and infrastructure.

Recommendation on Reconstruction of Collapsed Unreinforced Limestone Masonry Houses

1. The majority of the 59 homeowners surveyed still want to rebuild their houses using stone walls, assuming that they would receive financial support from the government or the private sector and provided that they would be given technical assistance for a disaster-resilient design. There is also a desire to use stone masonry because it is the most readily available material on the island and in order to preserve the heritage houses on the island that have been a tourist attraction and part of the island's culture and history. Thus, the government agencies and private sector entities that are involved in the reconstruction should evaluate and test the use of limestone. Further, the use of common building materials for seismic-resistant construction such as deformed steel reinforcing bars, cement and good quality aggregate should also be considered.
2. Houses could be reconstructed using reinforced concrete shear walls or confined masonry walls with reinforced concrete tie-beams and columns. New building structures should be designed and constructed in compliance with the latest National Structural Code of the Philippines (NSCP 2015) .
3. Due to the high prices of crushed coarse sand/aggregates from the mainland, residents are using crushed limestone that is available in the island as concrete aggregate. It is recommended that testing of samples be performed to determine the appropriate ratio of cement to this type of aggregate. The cost of construction materials should also be considered when specifying new construction as prices are considerably higher than the mainland due to poor transportation and infrastructure.
4. Due to the mountainous terrain of the town, it is important to recommend to residents not to build on top or at the base of hillsides. The guidelines discussed in the Build Change Philippines Design and Construction guidelines can be used as a reference for determining the proper setbacks from hillsides.

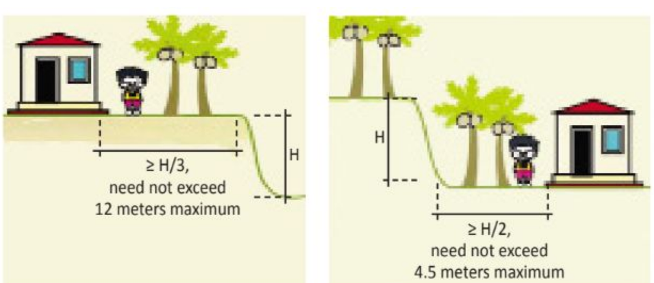


Figure 5.1 Determining proper setbacks from hillsides

It is recommended that the affected areas be supported with subsidies for retrofitting or reconstruction. Technical assistance is recommended to help the communities rebuild homes that are earthquake and typhoon-resistant or to implement technical retrofitting instead of repair. Builders and foremen should receive training in disaster-resistant construction to bolster their current skills and enable them to build better quality, safer homes. Technical assistance should build the understanding of disaster-resistant construction practices for homeowners and builders in both reconstruction of destroyed homes and strengthening of damaged homes. Homeowner-driven construction (where loans or subsidies are provided directly to homeowners for reconstruction or retrofitting) supported by technical assistance effectively builds the capacity of the community in earthquake-resistance construction. Disaster-resistant design and construction can become a common practice of the community after post-disaster assistance is completed.

6. References

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