06 February 2012
Ms 6.9 Negros Oriental Earthquake

PHIVOLCS QUICK RESPONSE TEAM

Department of Science and Technology
PHILIPPINE INSTITUTE OF VOLCANOLOGY AND SEISMOLOGY
November 2015

DOST
PHIVOLCS

06 FEBRUARY 2012 NEGROS ORIENTAL EARTHQUAKE

Geologic Impacts of the 06 February 2012
Negros Oriental Earthquake in
Negros and Cebu Islands

REPORT OF INVESTIGATION

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DEPARTMENT OF SCIENCE AND TECHNOLOGY
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SUMMARY

The 06 February 2012 earthquake that hit Negros Oriental produced: (1) strong ground shaking, (2) liquefaction, (3) landslides, (4) tsunamis, and (5) ground deformation and coastal uplift. Considerable to severely damaged infrastructures and houses were observed in the municipalities of Ayungon, Tayasan, Jimalalud, La Libertad, and Guihulngan City in the province of Negros Oriental. These towns were also the areas that felt the strongest ground shaking at PHIVOLCS Earthquake Intensity Scale (PEIS) VII-VIII (destructive-very destructive). Local tsunami with wave heights of less than 4-5m impacted Ayungon, Tayasan, Jimalalud, La Libertad, and Guihulngan City. Unusual waves were also observed as far as municipalities of San Jose in the south and Vallehermoso in the north, giving a total length of approximately 100 km of coastline affected by unusual waves related to tsunami in Negros Oriental. Unusual sea waves, minor landslides, small sink holes and slight damages to infrastructures and properties were also reported and documented at Badian, Moalboal, Ronda, and Dumanjug, Cebu. Five portable seismographs were installed as temporary seismic networks to enable accurate aftershocks monitoring.

The 06 February 2012 Negros Oriental Earthquake was generated by a NE-trending blind thrust fault along the eastern region of Negros Island. This fault plane, if projected, would possibly surface east of the Negros Island, most likely offshore, explaining the documented coastal uplift ca. ≤1m and extends for approximately 2 km at Guihulngan coast. It is possible that the uplift may extend further south with almost the same length as the projected possible fault rupture length of 30-40km.

Extensive Information Education Communication (IEC) Campaigns were also conducted in the towns affected to allay the fears of the residents and to explain the aftershock occurrences. An IEC seminar was also organized for local media to explain the basics of earthquake and its hazards, preparedness, and communication protocols followed under the National Disaster Risk Reduction and Management Council (NDRRMC).

Results of the Quick Response Team (QRT) investigation, the detailed mapping, and studies that will be conducted will be included in the earthquake-hazard maps that will be produced for the province of Negros Oriental. These hazard map will greatly aid the province in their disaster risk-reduction plans in the future. In addition, the following general recommendations apply to all areas in Negros and Cebu Islands that may experience yet another large magnitude earthquake capable of generating high intensity shaking in the future:

1. Immediately conduct rapid building/structure safety evaluation by the Building Official's authorized local civil/structural engineers after a locally destructive earthquake so as to promptly inform the occupants of its hazards or safety for use/habitation and to provide appropriate recommendations. Strong aftershocks may cause subsequent collapse of building weakened by the main shock.

2. Immediately evacuate and demolish severely damaged buildings, facilities and houses to prevent further use of these structures and avoid greater risk of local inhabitants to possible future collapse.

3. Relocate communities situated in areas vulnerable to earthquake hazards, such as landslides, ground ruptures and tsunami.

4. Activate and strengthen the Provincial Disaster Risk Reduction and Management Council (PDRRMC) down to the Barangay DRRM Committee with the capacity building for disaster preparedness, response, and rehabilitation.

5. Establish short- and long-term community preparedness plans in preparation for future earthquakes. This would include building of community-based disaster/emergency response units, identifying evacuation sites and routes and other mitigation strategies.

6. Conduct more intensive community-wide earthquake and tsunami information and education campaigns and drills, to raise and sustain awareness and proper response as well as to allay fears and eliminate spread of false information.

7. Strictly implement and conduct quarterly earthquake drills in schools and government institutions.

8. Strictly implement and monitor the National Building Code requirements and its referral codes in the design and construction of public and private facilities/structures to minimize severe structural damage or collapse in future earthquake events.

9. Formally train local masons and carpenters on proper construction practices and use of standard construction materials.

INTRODUCTION

Earthquake Information

On 06 February 2012 at 11:49 a.m. Philippine Standard Time (PST), a strong earthquake with a body-wave magnitude (Mb) of 6.9 shook the Islands of Negros, Cebu, and nearby islands of Western Visayas region. The epicenter was located by the Philippine seismic network at 9.97° N, 123.14° E, which is approximately 5 km northwest of Tayasan, Negros Oriental (Figure 1). The earthquake had a depth of focus of 5-10 km. Based on the hypocenter and focal mechanism solutions by the International Seismic Network (ISN), PHIVOLCS and the United States Geological Survey (USGS), the earthquake was determined to be tectonic in origin, and suggests a dominantly thrust-faulting movement along a NE-SW fault plane (Figure 2). Ensuing aftershocks recorded by PHIVOLCS permanent seismic stations also suggests a NE-SW fault plane and rupture propagation along the eastern coast of Negros Island.

Damage to or collapse of weak structures due to strong ground shaking was expected in view of its location, magnitude, shallow depth and sense of movement. In particular, the earthquake was expected to generate such earthquake-related hazards as tsunami, liquefaction and landslides.

Objectives

Immediately after the earthquake, damages were assessed and reported by the Office of Civil Defense through the local Disaster Risk Reduction and Management Councils (DRRMCs). Based on the extent of damages reported, PHIVOLCS deployed a Quick Response Team (QRT) from its technical staff on field assignment from its Canlaon Volcanological Station to do rapid damage assessment on the day of the earthquake. Another team was deployed on 07 February 2012 from its central office in Quezon City to supplement and further assess the impacts of the 06 February earthquake. As severe impact of the earthquake event was realized, additional team members from the main office were dispatched. The PHIVOLCS QRT visited the provinces of Negros Oriental and Cebu from 07 to 28 February 2012 specifically to:

1. Conduct and facilitate intensive information drive and allay the fears of affected communities in the epicentral region of Negros Oriental province;

2. Conduct damage assessment and intensity survey;

3. Further verify, assess, map and document the impacts of the earthquake, giving particular attention to occurrences of ground rupture, liquefaction, tsunami and landslides in the towns nearest the epicentral region; and

4. Install portable seismographs in and around Negros Oriental for aftershocks monitoring.

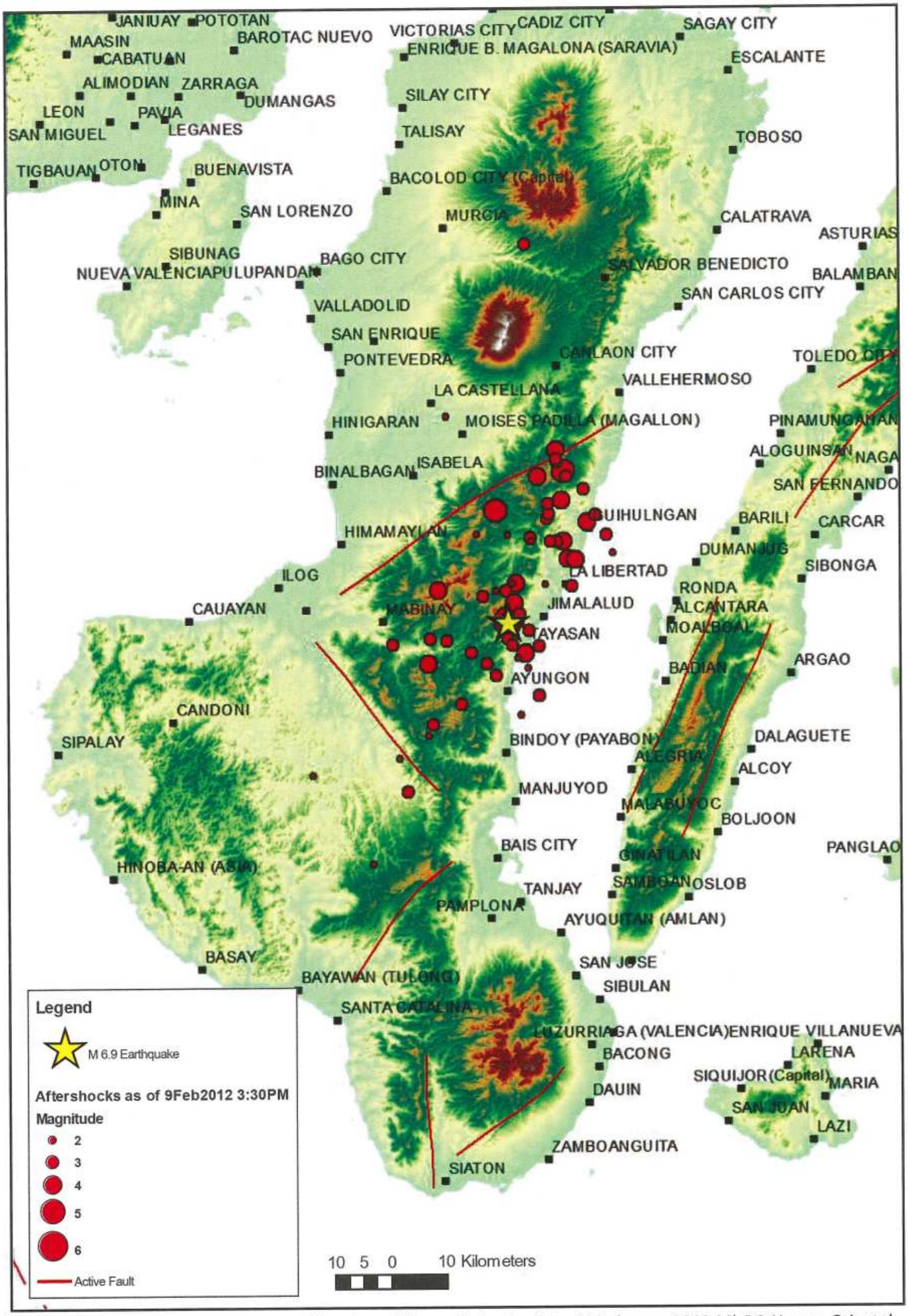


Figure 1. Map showing the epicentral location of the mainshock of the 06 February 2012 Mb6.9 Negros Oriental Eathquake (yellow star) and the aftershocks (red circles) as of 9 February 2012.

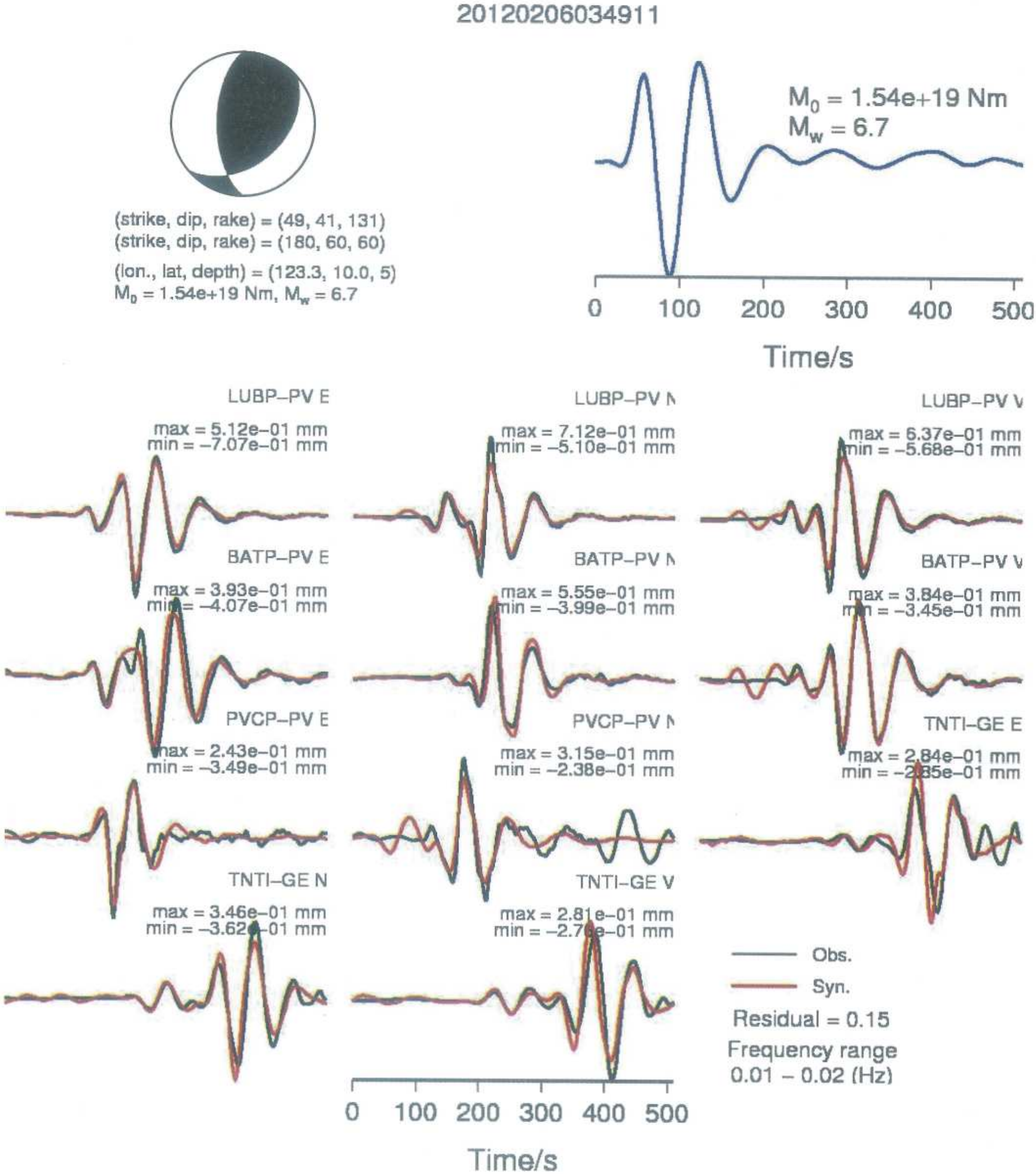


Figure 2. Focal mechanism solution for the earthquake of 06 February 2012 11:49AM in Negros Oriental. Data from the stations of PHIVOLCS-NIED SWIFT Broadband Network (RP-Japan Project) and GFZ Network.

REGIONAL IMPACTS OF THE EARTHQUAKE

Ground-Shaking Intensity Distribution and Aftershocks Monitoring

The earthquake was felt most strongly along the eastern coast of Negros Island. Initial intensity reports showed that the strongest ground shaking was felt at intensity VII using the PHIVOLCS Earthquake Intensity Scale (PEIS) in the municipalities of Tayasan, Vallehermoso, and Guihulngan City (Negros Oriental). There were reports of felt intensities as far as 200 kilometers away from the epicentral area. The reported intensities in other cities and municipalities in Negros Island and surrounding islands are illustrated in Figure 3 and listed in Table 1.

Field investigation revealed that maximum ground shaking intensity of PEIS VIII occurred in the epicentral area covering municipalities of Ayungon, Tayasan, Jimalalud, La Libertad and Guihulngan.

Aftershocks of lesser magnitude followed few minutes after the main shock. The strongest felt aftershock was recorded at 6:10 PM (local time) with a magnitude of Ms 6.2 within 5 km from the epicenter of the mainshock.

Preliminary hypocentral determination and plots of the aftershocks were located within a NE-SW trending rectangular area of approximately 20-30 km distance from the Tayasan epicenter. This suggests a rupture propagation that correlates well with the NE-SW strike of the fault plane. As of 16 February 2012, a total of 1,678 aftershocks was recorded, 102 of these were felt at intensity V or IV within the epicentral region of Ayungon, Tayasan, Jimalalud, La Libertad, and Guihulngan, Negros Oriental.

In the areas of the epicentral region, local residents observed that the aftershocks were always preceded by rumbling sounds from the ground that vary in intensity depending on the size of the event. Vertical shaking is also almost always felt from bigger aftershocks, preceding a horizontal shaking. Sometimes oscillation follows the horizontal shaking.

In order to detect aftershocks that are very local to the Negros Island region and would not be detected by the surrounding PHIVOLCS permanent seismic stations, five temporary portable seismographs were installed (Figure 4, Table 2).

Considering the magnitude of this event, aftershocks will follow for more than one month after the mainshock. Thus, everyone was advised to take precautionary measures especially when entering buildings and houses that suffered minor to severe damages, and when undergoing rescue/retrieval operations in landslide affected areas.

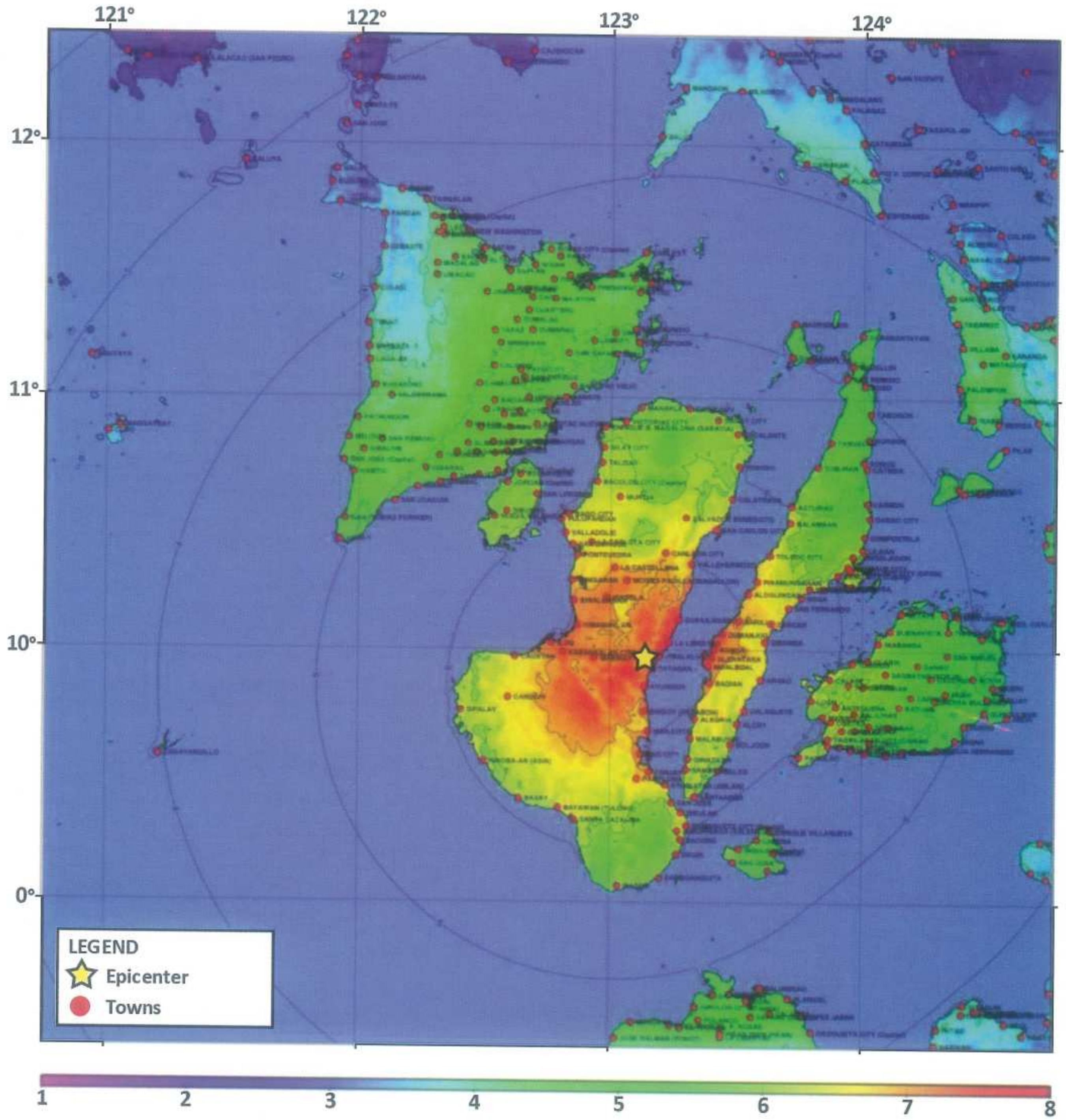


Figure 3. Isoseismal map of the 06 February 2012 Negros Oriental Earthquake (PHIVOLCS-SOEPD, 2012). The epicenter is shown by the yellow star.

Table 1. Reported intensities of the 06 February 2012 Negros Oriental Earthquake in different localities. (PHIVOLCS, 2012) based on PHIVOLCS Earthquake Bulletin

Reported Earthquake Intensity*	Province	City / Municipality
VIII (very destructive)	Negros Oriental	Ayungon, Tayasan, Jimalalud, La Libertad, Guihulngan
VII (destructive)	Negros Oriental	Vallehermoso
VI (very strong)	Negros Oriental	Manjuyod, Tanjay, Dumaguete City
	Negros Occidental	La Carlota City, La Castellana
	Cebu	Argao, Barili, Cebu City, Dalaguete
	Bohol	Clarin
V (strong)	Aklan	Roxas City
	Capiz	Dao, Ivisan
	Iloilo	Iloilo City
	Negros Oriental	Ayungon, Canlaon City
	Negros Occidental	Bacolod City, Binalbagan, Candoni, Hinigaran, Sagay City, San Carlos City
	Guimaras	
	Bohol	Tagbilaran City
IV (moderately strong)	Aklan	Banga, Balete, Batab, Kalibo, Makatao, New Washington, Numancia
	Antique	Anini-y, Pandan, Patnungon, San Jose de Buenavista
	Negros Occidental	Sipalay
	Leyte	Ormoc City
	Iloilo	Santa Barbara
	Zamboanga Del Norte	Dipolog City
III (weak)	Agusan Del Norte	Butuan City
	Albay	Legaspi City
	Misamis Oriental	Cagayan De Oro City
	Leyte	Tacloban City
	Samar	Catbalogan
	Southern Leyte	Saint Bernard
	Masbate	Masbate
II (slightly felt)	Aklan	Malay (Boracay), Malay (Caticlan), Nabas, Lezo
	Sorsogon	Sorsogon City (Cabid-an)
	Eastern Samar	Borongan
	Camiguin	Mambajao
	Bukidnon	Malaybalay
I (scarcely perceptible)	Zamboanga del Sur	Pagadian City

** Intensity based on PHIVOLCS Earthquake Intensity Scale (PEIS)*

Figure 4. Locations of the PHIVOLCS permanent Seismic Stations (pink stars) and QRT temporary seismic stations (blue stars) monitoring the aftershocks of the 06 February 2012 Negros Oriental Earthquake.

Table 2. Temporary seismic monitoring stations installed for aftershocks monitoring of the 06 February 2012 Negros Oriental earthquake.

Station code	Site location	Latitude	Longitude
MNOR	Tirambulo Highland Resort, Mabinay, Negros Oriental	9.6675	122.9655
BDAC	Tropical Garden, Manay-as Lambog, Badian, Cebu	9.8556	123.3793
KNOC	DPWH, Kabankalan, Negros Occidental	10.0061	122.8249
VALH	Mayor Villegas' residence, Vallehermoso, Negros Oriental	10.3418	123.3243
TANO	Tayasan Municipal Hall, Negros Oriental	9.9224	123.1718

Damage to Vertical and Horizontal Infrastructures

The 2012 Negros Oriental Earthquake generated severe ground shaking above intensity VI at the epicentral area along the eastern seaboard of Negros Oriental. In PHIVOLCS Earthquake Intensity Scale (PEIS) of I to X, any intensity higher than VI are considered damaging to man-made structures. Damage to infrastructure, buildings, houses and cottages due to ground shaking were observed along the coastal communities of the Municipalities of Bindoy, Ayungon, Tayasan, Jimalalud, La Libertad, up north to Vallehermoso and of the City of Guihulngan (Figure 5 and 6). As of 13 February 2012, the National Disaster Risk Reduction and Management Ccouncil (NDRRMC) website posted the total cost of damages to roads, bridges and public buildings in Negros Oriental alone at Php346, 459, 000.00 (Figure 7).

In the ravaged City of Guihulngan, a rapid damage assessment was conducted from 15th to 19th February to determine the statistical impact to man-made structures in a certain community at the epicentral area. Specifically selected was the coastal barangay of Tinayunan Beach approximately 2km south of Poblacion with at least 334 households reported to be directly affected. The densely populated coastal section of the barangay (Figure 8) including all houses and structures from Poblacion to Tinayunan Beach boundary to the north towards down south to Tinayunan Bridge and from the National Highway towards the coastlines were rapidly inspected. The total number of man-made structures (public facilities, school buildings, engineered and non-engineered houses, traditional dwellings, cottages, seawall, lighthouse, bridge, road, sewage canal, warehouse, etc.) assessed during the field survey was 270. Results show 60 (22%) of these were either collapsed or partially collapsed while 65 (24%) sustained slight to moderate structural damage and moderate to severe non-structural damage that requires immediate intervention prior to reuse or habitation. One hundred forty five of these structures (54%) however, sustained none to slight structural damage and minor non-structural damage and are deemed safe for re-occupation (Figure 9).

Closer inspection revealed that most of the severely damaged structures were either old traditional masonry-wood houses or under-reinforced masonry/concrete structure that utilized beach sand and gravel as aggregates (Figure 10).

Figure 5. Left: Two-storey reinforced concrete collapse due to ground shaking. Right: A traditional house that swayed to the direction of the shaking.

Figure 6. Wooden post failure due to severe shaking.

Figure 7. Above: Ruptured concrete of a national highway section. Right: Span collapse of Martilo Bridge at La Libertad Municipality.

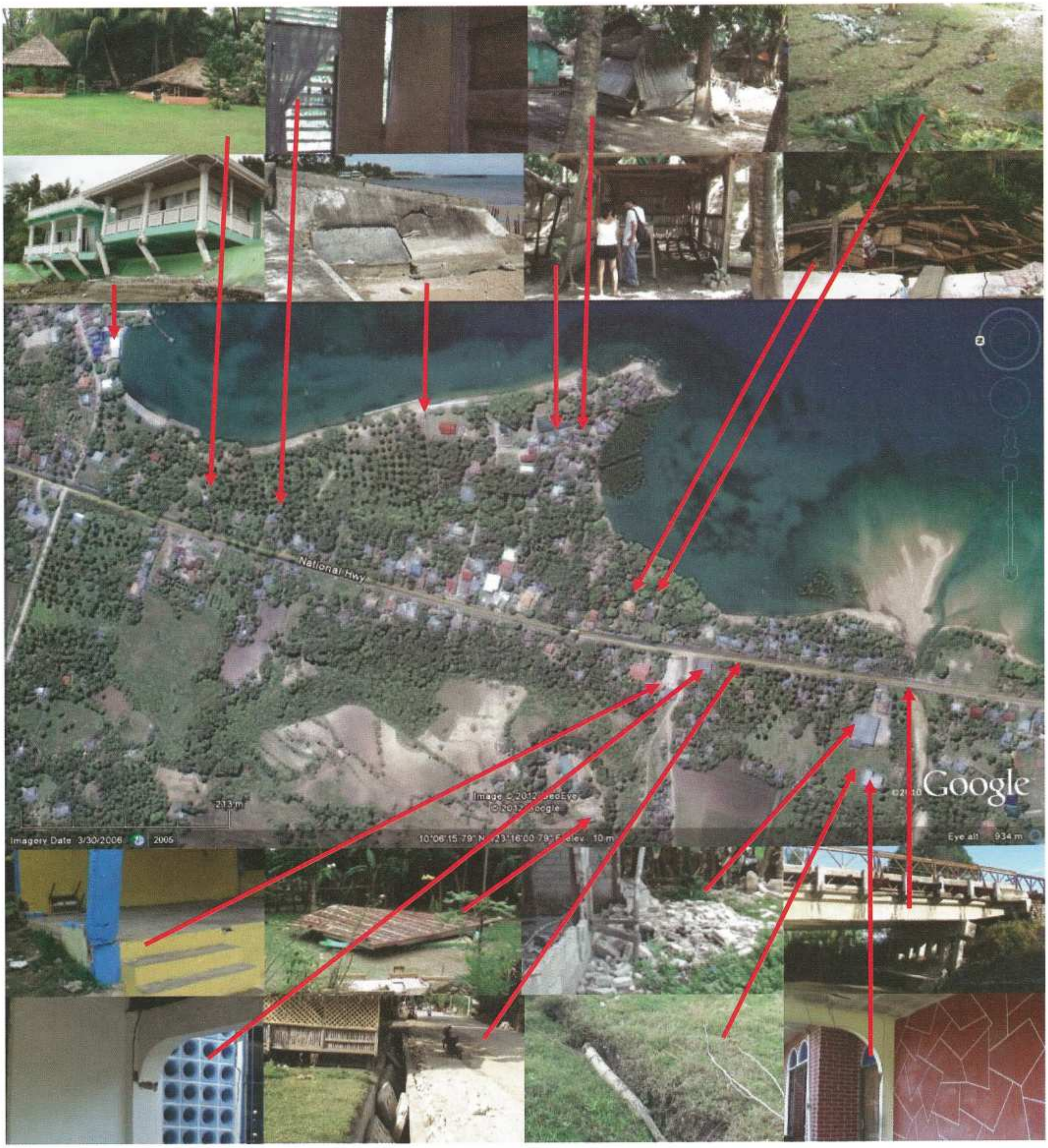


Figure 8. Photos show the damaged man-made structures due to strong ground-shaking inspected at Brgy. Tinayunan Beach, Guihulngan City. Their exact location is shown in the Google image map.

9 A. Foundation of the lighthouse with no significant damage

9 B. A single-storey residential building with adjoining open garage.

9 C. Single-room reinforced-concrete cottage

9 D. Reinforced-concrete Barangay Day Care Center

9 E. Single wooden post open cottages

9 F. Outhouse made of light materials

9 G.Two-storey bamboo and nipa resthouse

9 H. Irregular two-storey reinforced concrete residential building

Figure 9. Photos of some structures in Barangay Tinayunan Beach, Guihulngan City that sustained none to slight structural damage.

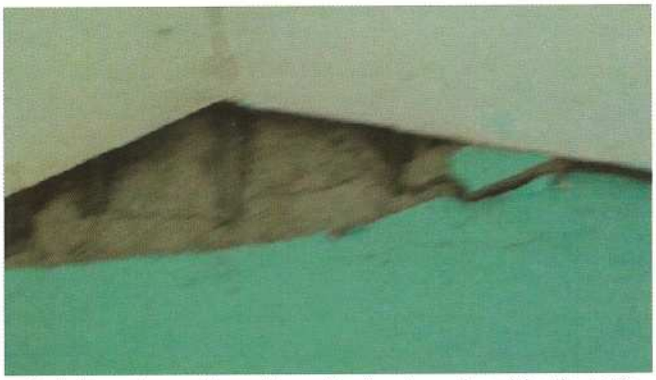
10 A. Inadequate connections at wood-masonry joints

10 B. Rupture at concrete pedestal-wooden post connection

10 C. Column plaster normally spalled by high-intensity shaking

10 D. Typical column-wall joint failure due to insufficient dowelling

10 E. Concrete slab cracks lacking adequate reinforcements and anchorage



10 F. Hazard posed by gable walls already weakened by the main shock

10 G. Corrosive effect on re-bars of beach sand and gravel aggregates

10 H. Inadequate quality and quantity of re-bars and concrete mix

Figure 10. Typical damage details amongst the damaged structures in Bgy. Tinayunan Beach, Guihulngan City.

Discussion

The 2012 Negros Oriental Earthquake exposed the structural vulnerability of all man-made structures close to the epicentral area. For economic reasons, people are normally inclined to build houses and facilities within their budget or preferably less with only minor consideration on the structural soundness against a rare long duration and high intensity earthquake. This high intensity earthquake which was never before experienced by the residents in their lifetime vigorously shook the City of Guihulngan for more than 20 seconds, and the Municipality of Ayungon for more than 10 seconds forcing all its residents and building occupants to run out and stay in the open. It caused moderate to severe lateral spreading and ground settlement close to rivers and coastlines in the epicentral area triggering severe damage to collapse of structures such as houses, roads and bridges built over it.

At Barangay Tinayunan Beach, structures of all sorts were impacted with differing severity. With owners and builders having no inkling of a high intensity earthquake occurrence, most old traditional houses and dwelling places made of either light materials or of a combination of masonry and wood obviously were not fitted for severe shaking. Some were observed out-of-plumb after the earthquake generally leaning towards the predominant direction of the horizontal ground shaking while others were either partially or totally collapsed. The onsets of those failures were found to be in many cases at joints and on timber posts-concrete pedestal connection. On the collapsed reinforced concrete structures, noted were the severe corrosion and thinning of the newly exposed longitudinal reinforcing bars and the fewer than expected lateral ties for the column support (Figure 10 G, H). The ruptured and shattered concrete materials exposed spherically-shaped course aggregates and yellowish fine aggregates strikingly similar to sand and gravel found along the beaches (Figure 10G). Collapsed walls revealed undersized and corroded re-bars with little anchorage to the supporting columns and more beach aggregates. A set of toppled piles of concrete hollow blocks (CHB) found in the area were made up of aggregates seemingly taken from the beaches (Figure 11A). Yawning cracks and fissures at wall-wall, wall-timber post, wall-column, and floor-wall joint connections exhibited insufficient size and spacing of dowels and re-bars to hold the members together during the earthquake. Some CHB walls with recently exposed section manifested poorly mixed and poorly compacted mortar fillers essential for bonding and strength (Figure 11B).

The heavy-roofed barangay community stage sustained shear failure at the base of its slender reinforced-concrete columns and at column-beam joints (Figure 8). It was immediately cordoned-off for safety against possible total collapse in the ensuing aftershocks. The old masonry-wood Chapel along the National Highway sustained moderate to severe damage to its walls and main entrance posing imminent hazard to parishioners. The hillside school stage of the Filomena T. Aranas Memorial Elementary School totally collapsed while five of the schools' buildings sustained slight to moderate structural damage and moderate to severe non-structural damage requiring immediate solutions prior to use as it poses risks to students in the aftershocks and in any future intense earthquake. The damages to roads and to a section of the open pit sewage canal were mainly due to moderate to severe lateral spreading and fissuring.

The damage to Tinayunan Bridge (Km Post) (Figure 8) was mainly due to a combination of shear in the longitudinal direction of the bridge parallel to the shoreline and lateral spreading on both sides of the river. The row of column supports in the north-east end were all sheared at the base and collapsed towards the north-east abutment while the other row of column supports in the south-west end on the other side of the river collapsed towards the south-west abutment. Both abutments were severely damaged by pounding and lateral spreading. The nearby river dike on the south-west end was ruptured at many points along its length while plenty of fissures and uneven ground settlement were found on the approach and fringes of the north-east end of the bridge. These observations at Tinayunan Bridge attest to an intensity of ground shaking not less than PEIS VII.

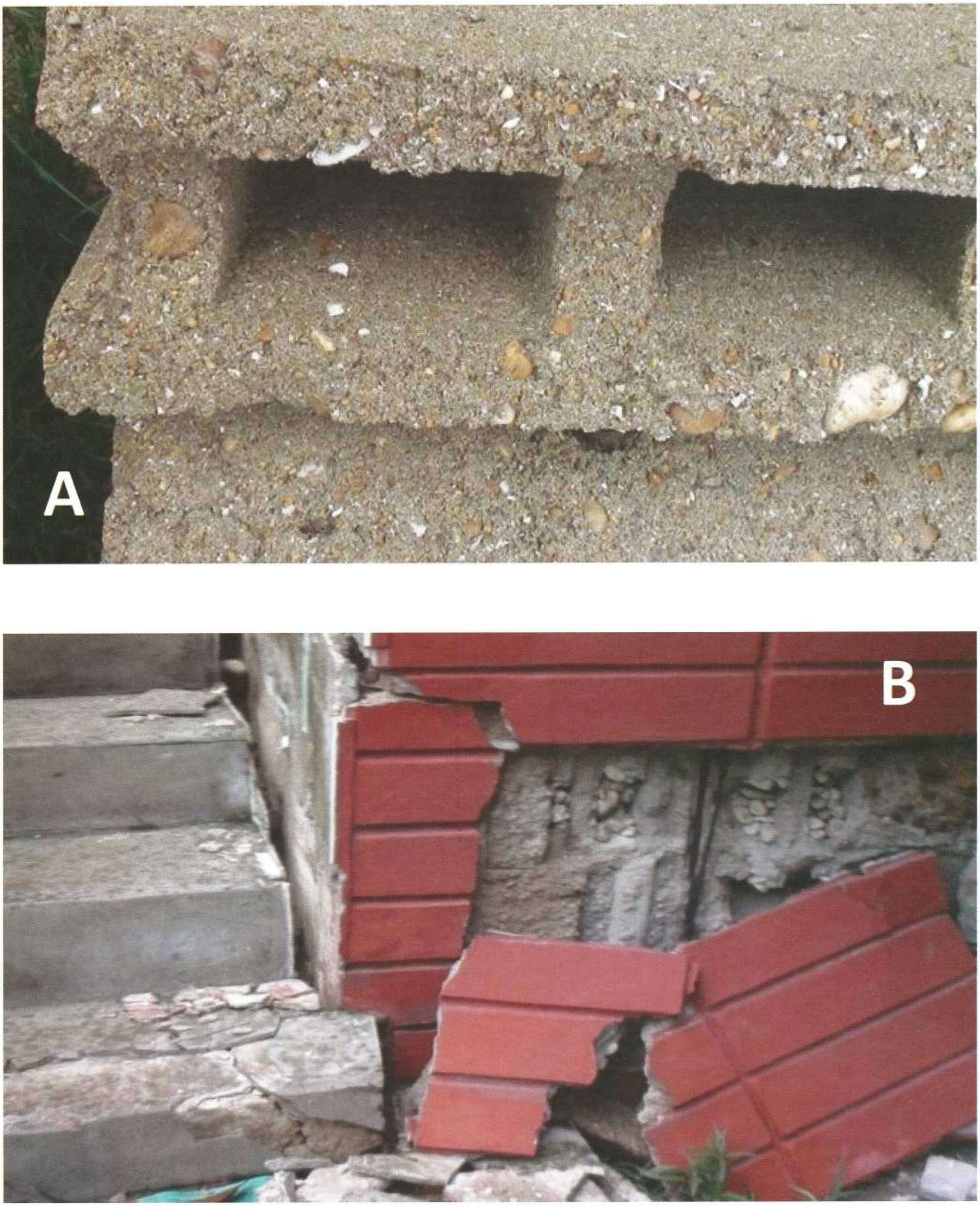


Figure 11. A. Aggregates used for CHB taken from beaches. B. CHB wall showing mortar fillers lacking cement paste for bonding.

TSUNAMI

Tsunami is a series of waves that is commonly generated when a significant displacement occurs under water due to faulting with large vertical component, underwater landslides, underwater volcanic eruption and rarely due to meteorite impact in the sea. Based on historical earthquake and tsunami data, a destructive widespread tsunami threat does not exist. However, due to its magnitude and epicentral proximity from the coast, generation of local tsunami is possible and may be destructive along coasts 100 km from the epicenter. Thus, PHIVOLCS raised Tsunami Alert Level 2 to prevent people from approaching the beach. Tsunami Alert Level 2 recommends people to be on alert for unusual waves, to stay away from the beach, but there is no need for massive evacuation. The alert level was cancelled after 2.5 hours as per Standard Operating Procedures considering arrival period and extended observation period.

In general, there is practically not enough lead time to warn for a locally-generated tsunami. The first wave may arrive in as short as 3-5 minutes. Considering this scenario, the three natural signs of a possible occurrence would serve as the primary warning mechanism instead.

Sea retreat and unusually high waves along the east coast of Negros Oriental was reported. The QRT verified the reports by conducting interviews and coastal field surveys in Negros Oriental and the southwest coast of Cebu (Figure 12). Based on the documentation, the tsunami hit approximately 100-km of the eastern shoreline of Negros Oriental from San Jose to Vallehermoso, and approximately 35-km of the southwest shoreline of Cebu from Badian to Barili.

Areas hardest hit was Barangays Martilo, Pisong, and Magtalisay in La Libertad, Negros Oriental where the tsunami wave height reached as high as 5 meters. Notably, witnesses observed two waves coming from north and south directions. Run-up was said to have impacted the shoreline, destroying some houses and small boats. In Tayasan, four houses made of wood and nipa materials were swept away by the 4-m waves after experiencing ground subsidence. No casualty due to tsunami was reported.

The tsunami arrival time that hit the coastal areas could not be exactly identified as the answers of the respondents varied. A few seconds after the mainshock, most respondents saw the seawater receding at about 300 meters. Majority of the residents quickly fled to the higher grounds as soon as they observed the water recession. Throughout the interviews, it was noted that most coastal residents stayed overnight on the mountains for fear that another tsunami would arrive. An eyewitness in Guihulngan said that in less than two minutes the tsunami was observed. In Vallehermoso, one personnel of a beach resort noticed the arrival of the tsunami in less than two minutes. Generally, witness accounts of the tsunami arrival time are between 2 to 5 minutes after the earthquake, coinciding with the low tide level on that day. Some witnesses described hearing loud booming sound from the sea while others heard sounds similar to blowing wind. Others described the waves having a white foamy top and bluish to brownish mid- to bottom section.

Tsunami debris were observed in many places. High water marks on walls of houses and fences, scoured tree barks and eroded beach face and berm deposits, knocked down trees, preferred side of damages on walls and sand deposits were some of the evidence of tsunami inundation (Figure 13). Wave heights were reconstructed based from interviews, high water marks on walls, and traces of seaweeds, sands or scours on branches or barks of trees (Figure 13 D). A north-northwest preferred alignment of knocked down trees and damaged side of walls of houses was observed in Sitio Looc, Bgy. Martilo, La Libertad.

Figure 12. Tsunami wave height distribution along the coasts of Negros Oriental (left) and Cebu (right) Provinces.
** Yellow line: Inundation Area - area flooded with water by the tsunami*
** Red line: observed tsunami waveheight*

Figure 13. Debris left by the local tsunami that hit the eastern coast of central Negros Island. A. High water marks and sand deposit in a house at Sitio Looc, Bgy. Martilo, La Libertad. B. Abraded bark of a tree at its southeast side. C. Eroded beach face and berm deposit and damaged fishing boat. D. Wave height of 5 m from sea level during time of survey reconstructed from this tree at Sitio Looc, Bgy. Martilo, La Libertad.

This indicates the possible wave direction in that area. Sitio Looc is characterized by a relatively steeply inclined coast and the inundation measured is approximately 50 m. On coasts with relatively flat morphology, inundation reached as far as 200 m inland and run-ups measured were between 1-3 meters. Measurements were mainly based from witness accounts and some preserved high water marks.

In the west coast of Cebu, the tsunami destroyed several fishing boats and transported cobble to boulder-sized coral fragments 20 m inland (Figure 14). The maximum wave height that impacted the west coast of Cebu is 3 m, particularly at Brgy. Zaragosa, Badian and Bgy. Saavedra, Moalboal. The farthest inundation distance of approximately 150 m was documented at Brgy. Japitan, Barili. Table 3 lists the documented and measured wave heights, inundation, and other observations noted related to the tsunami impact.

Figure 14. Tsunami impact along the west coast of Cebu Island. A. Overturned and damaged fishing boat at Badian, Cebu. Photo taken few hours after the impact, courtesy of Engr. Nellas of Badian-MPDC. B. Tsunami debris including sea weeds strewn amongst the mangroves show the approximate wave height. About 2.2 m of wave height was measured at Barangay Poblacion West, Moalboal. C and D. Cobble- to boulder-sized coral fragments that was transported as far as 20 m inland by the tsunami.

Table 3. Documented tsunami wave heights and inundation related to the 06 February 2012 Negros Oriental earthquake. GPS coordinates are in WGS84 projection. Wave heights from sea level, uncorrected for the low sea level.

Location (Brgy., Municipality	Observation Point Latitude N/ Longitude E	Tsunami Height (meters)	Inundation (meters)	Damage	Remarks
NEGROS ORIENTAL					
Brgy. Bantayan, Dumaguete City		~0.5	15-20		Wave reached the sea wall
Brgy. Hilocon, San Jose	approx. 9°25"26'N /123°14"13.5'E	1	10-20		Wave did not went beyond the storm berm
Brgy. Okiot, Bais City		0.5			
Brgy. Tampocon II, Ayungon	9.853420°N/ 123.144830°E	2	400		Entered Tampucon River, went beyond Tampucon II Bridge.
Brgy. Matu-og, Tayasan	9.91048123.15708	4	50	4 houses washed away by the wave	
Brgy. Palaslan, Tayasan	9.91952N/ 123.16798E	2	10 - 30		2nd wave was the strongest
Brgy. Poblacion, Tayasan	9.92090N/ 123.17100E	1.5	10		Observed tsunami less than 2 minutes after the shaking
Brgy. Sta Cruz, Tayasan	9.94803N/ 123.18218E	0.5	10		3 waves were noticed. 2nd wave was the strongest
Brgy. Banga, Tayasan	9.902634N/ 123.14997E				
Brgy. Cabulotan, Tayasan	9.92892N/ 123.17902E	1	12		
Brgy. South Poblacion, Jimalalud	9.97962N/ 123.20149E	1	10		Observed 3 waves but without much force
Brgy. Polopantao, Jimalalud	9.98699N/ 123.20605E	1	~10m		
Brgy. Crossing Ipil, South Poblacion, Jimalalud	9.97184N/ 123.19763E	2	-		Observed two waves from south and north direction
Brgy. North Poblacion, La Libertad	10.03298N/ 123.23597E	4	200		
Sitio Looc, Brgy. Martilo, La Libertad	10.04716N/ 123.23991E	5	50	Houses and beach cottages partially to totally damaged; fishing boats transported and damaged	Observed two waves coming from opposite directions; Tree trunks abraded; banana trees knocked down; Beach erosion
Sitio Habag, Brgy. Martilo, La Libertad	10.05267N/123.2445 1E	4	50-100	1 house built of light material was totally damaged	
Brgy. Martilo, La Libertad	10.05518N/ 123.24765E	4			
Brgy Pisong, La Libertad	10.06175N/ 123.24844E	3	150-200		Elementary school inundated
Brgy. McKinley, Guihulngan	10.08339N/ 123.25894E	1.5	15-30		2 waves observed, 2nd wave is higher

Table 3. Cont'd…

Location (Bgy., Municipality	Observation Point Latitude N/ Longitude E	Tsunami Height (meters)	Inundation (meters)	Damage	Remarks
Brgy. Poblacion, Guihulngan	10.11605N/ 123.27031E	1			Observed wall type of wave did not overtopped sea wall
Brgy Calamba, Guihulngan	10.16222N/ 123.28053E	0.4			Oscillation type of wave without much force
Brgy Bolado, Guihulngan	10.19033N/ 123.29146E	0.3			Oscillation type of wave without much force
Brgy. Basak, Guihulngan	10.22011N/ 123.30450E	1	50		Observed 3 to 4 waves without much force
Brgy. Hilaitan, Guihulngan	10.25352N/ 123.32504E	0.3			No observed recession of water
Brgy. Poblacion, Vallehermosa	10.33414N/ 123.32808E	0.5	15		
CEBU					
Brgy Saragoza, Badian	9.88403N/ 123.38345E	3			No receding of water
Brgy Saragoza, Badian	9.88598N/ 123.38374E			Houses of light materials damaged, some collapsed;several fishing boats smashed onshore and destroyed	Rise in water level first then after few seconds the water receded; Concrete post abraded; sea wall (riprap) damaged
Brgy. Saavedra, Moalboal	9.98462N/ 123.36880E	3	20		The tsunami transported rocks, coral fragments (cobble to boulder-sized) and fish inland for a distance of 20 meters
Brgy. Poblacion West, Moalboal	9.93816N/ 123.3880E	2.2	100		amounts of sand distributed on the leaves and around the mangrove area
Alcantara	9.97057N/ 123.40236E	-	-		
Ronda	10.00061N/ 123.40904E	-			
Brgy. Poblacion, Ronda	10.0029N/ 123.40755E	2.5	10		
Brgy. Looc, Dumanjug	10.05938N/ 123.43234E	1.6	22	Damaged small fishing boats	
Brgy. Tangil, Dumanjug	10.06852N/ 123.44704E	1			
Brgy. Japitan, Barili	10.12458N/ 123.49201E	1.9	150		

LIQUEFACTION

Initial reports of the impacts of the earthquake by the local DRRMCs documented severe liquefaction in the coastal areas and alluvial plains of the epicentral region in Negros Oriental. These lowland areas have been previously identified as susceptible to liquefaction (Figure 15) during the occurrence of large magnitude earthquakes. Generally, deposits susceptible to liquefaction are composed of loose, fine-grained, well-sorted, water-saturated young sedimentary deposits. The phenomenon typically occurs in fluvial, backswamp, deltaic, and beach environments characterized by relatively unconsolidated, water-saturated, moderately sorted, fine-grained sand deposits (PHIVOLCS, 1994).

Identification and documentation of the liquefaction-affected areas on a 1:50,000 scale map also served to check and allow for corrections of the Regional Liquefaction Susceptibility Map. Liquefaction was manifested as small to widespread sand boils, lateral spreading, ground settlement or subsidence, ground fissuring, buckling and to a limited extent, ground undulations. Observed sand boils in the deltaic and mangrove area of Ayungon were relatively small, forming small mounds ranging from 0.5 to 1.5 m in diameter. Most sand boils observed in Negros Oriental occur as linear mounds of sand aligned along earthquake-induced ground fissures e.g. Bgy. Solongon, La Libertad (Figure 16). Widespread sand boils were observed in Bgy. Bateria, Guihulngan City, consisting of greenish-gray fine sands (Figure 17). The sand boils in residential areas caused minor damages like ground settlement resulting to cracks on floors, pavements and walls or tilted houses. Residents who witnessed their formation were alarmed in fear of a new volcano formation. Sand fountains, according to witnesses, reached heights of 0.5 meter depositing fine- to coarse-sand.

Lateral spreading was very apparent along the coastal part of National Highway and some barangay roads producing fissures parallel to them. Fissures along the stretch of the highway in Jimalalud and Guihulngan extend approximately 250 to 500 meters and are up to half meter wide and 2 meters deep (Figure 18 A and B). The most extreme lateral spread combined with ground undulation and subsidence occurred along the approach of Tuway Bridge, affecting ~100 m stretch of the road with terrace-like fissures as high as 1.3 m and opening as wide as 1 m, and subsidence as large as >3m (Figure 19). Along banks of small creeks and rivers, fissures and terrace-like ground-failure damaged concrete river dikes and fences along the banks. Lateral spread along a road in Bgy. Taluyong, La Libertad, situated between a creek and irrigation canal, has an opening of 70 cm. Witnesses reported the breaching of the irrigation canal diverting the water to flow across the concrete road towards the creek. Many bridges also suffered from loss of bearing capacity caused by ground settlement and lateral spreading. Bridge footings tilted, abutments and road approaches were fractured and settled. Two bridges, the Pangaloan Bridge and Martilo Bridge (Figure 20), suffered from span collapse and were rendered temporarily impassable for days, isolating the towns of Jimalalud, La Libertad, and Guihulngan and caused starvation and fear among the residents. Buckling of the roads and residential areas were also very evident in the towns of La Libertad and Guihulngan. Measured vertical displacements of buckled roads range from 15 to 59 cm.

Ground undulations were likewise preserved in areas where there are buildings, paved roads, and other structures (Figure 21). The wavelength measured from the undulated section of the highway in Bgy. McKinley, Guihulngan City is approximately 10 m, with amplitude of 21 cm. Photos from the aerial survey also showed liquefaction among dug-out fishponds in Ayungon Poblacion, showing fresh, light brownish sediments filling some ponds, which are

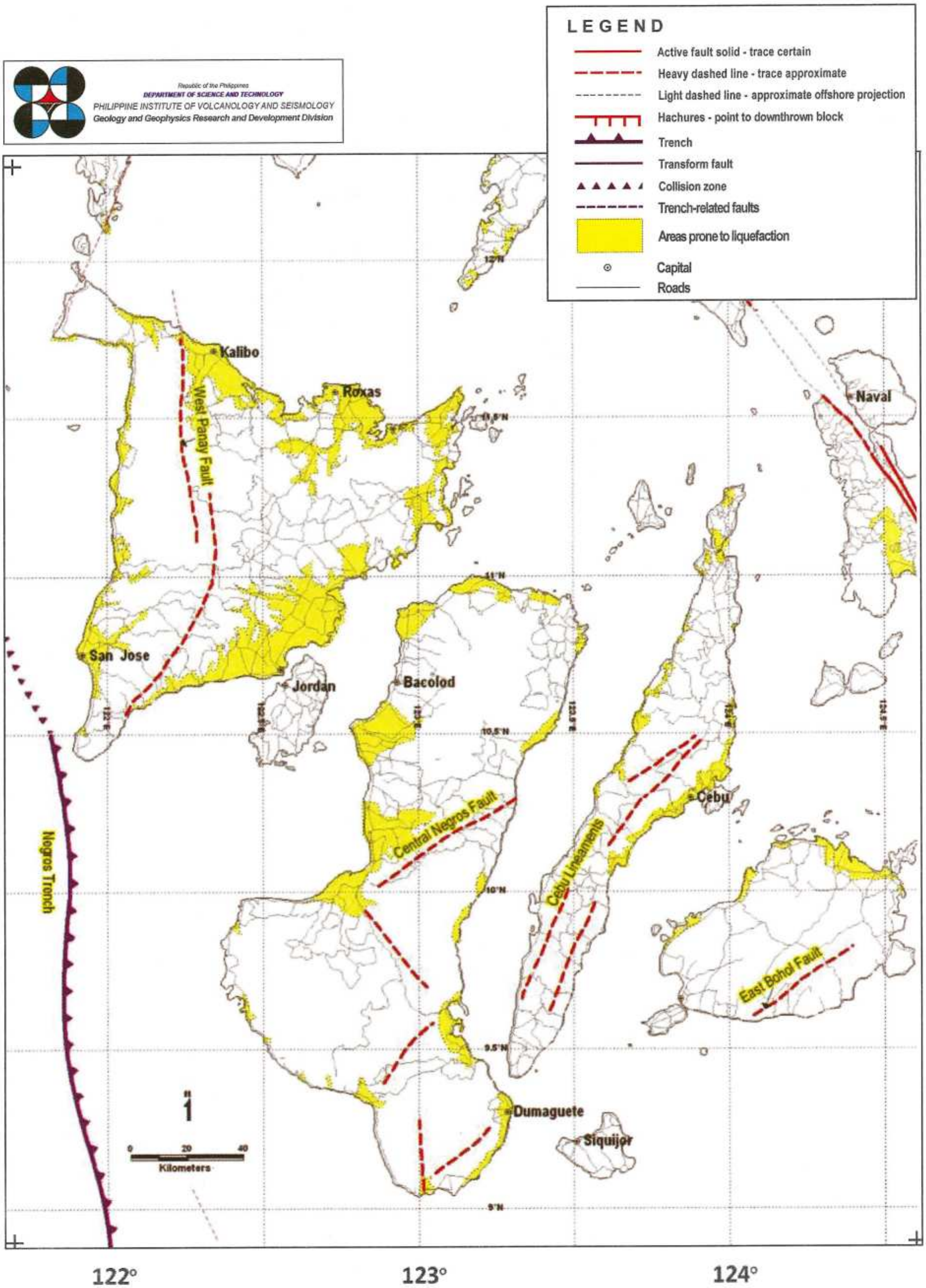


Figure 15. Active faults and liquefaction susceptibility map of Western and Central Visayas Region.

Figure 16. Sand boils in Bgy. Solongon, La Libertad aligned along a ground fissure were a common occurrence.

Figure 17. Widespread sandboil in Bgy. Bateria, Guihulngan City.

Figure 18. Intermittent lateral spreading affected 250-500 m stretch of the National Highway in Negros Oriental. A. Fissures parallel to a segment of the highway just north of Jimalalud Bridge were as deep as 2 m, and B. Step-like fissures and undulation along the highway in Guihulngan City Poblacion.

Figure 19. Broken and dislocated asphalt road near the section of Tuway Bridge in Guihulngan City due to lateral spreading, undulation and ground subsidence.

Figure 20. Loss of bearing capacity due to lateral spreading along river banks resulted to span collapse of some bridges like Pangaloan Bridge in Jimalalud. This rendered some bridges to be temporarily impassable for days.

are probably due to sand boils. There were also reports in some areas of water in wells and pumps turning murky or brownish for 1-2 days after the earthquake possibly reflecting the response of groundwater to ground shaking.

Local subsidence was observed in the coastal barangay of Matuog in Tayasan compounded by tsunami impact, drowning some coconut trees and sweeping away 4 nipa houses. Other fissures and damage to roads and houses were found to be related to failure of loose but relatively dry gravelly earth-fill used in construction due to ground shaking. Such failure is different from liquefaction, which involves excess pore-water pressure in usually sandy material.

Figure 21. Ground undulation exhibited on one of the school buildings of Ayungon Elementary School.

EARTHQUAKE-INDUCED LANDSLIDES AND ROCKSLIDES

Landslides are slope failures commonly triggered by intense rainfall that saturates the soil inducing high pore-water pressure that eventually weakens its shear strength causing the slope to fail. In some cases, strong earthquake can cause the ground to shake severely; the shear stress produced by strong vibration may exceed the shear strength of the slope (especially on slopes with low factor of safety) producing slope failure.

The 2012 Negros Oriental earthquake induced at least four major deep seated rotational landslides (Figure 22) with deformation area ranging from 10 to 50 hectares. Likewise, several small shallow translational landslides and rock fall were triggered in several areas of La Libertad, Guihulngan and Vallehermoso and Bindoy. All landslides occur along the area composed of coralline to sandy friable limestone and calcareous sedimentary sequences.

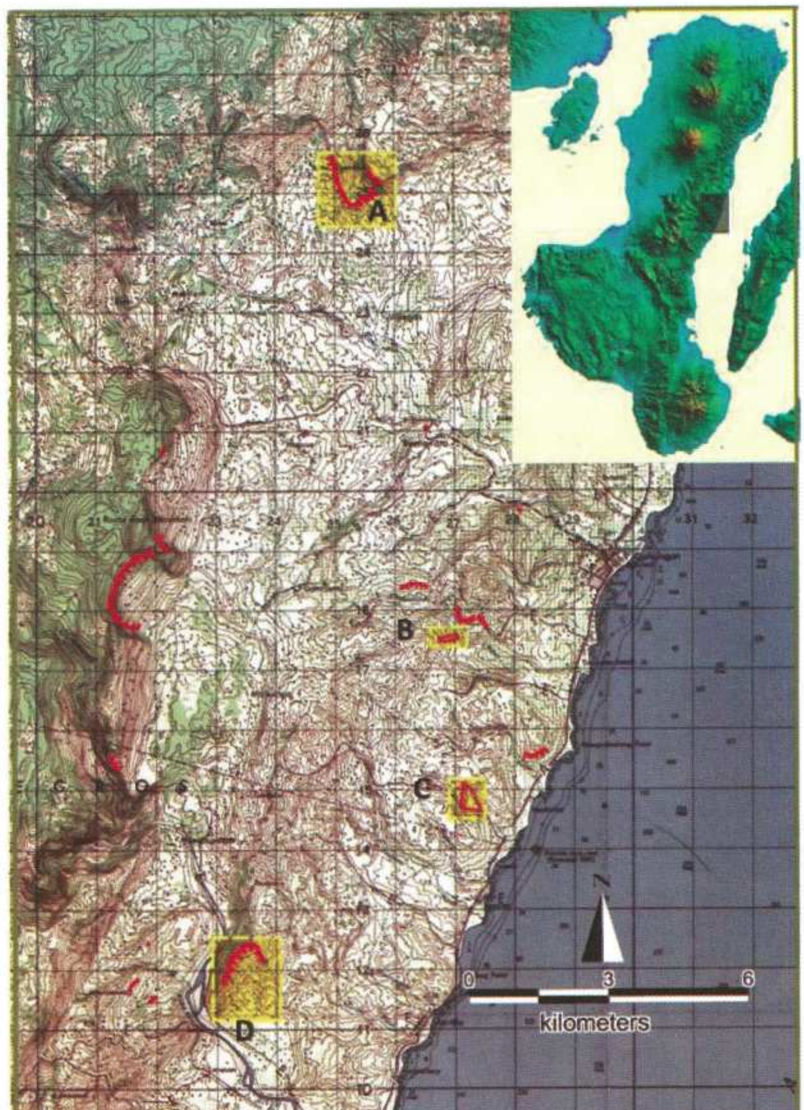


Figure 22. Distribution of earthquake-induced landslides (red symbol) in the municipalities of La Libertad, Guihulngan and Valehermoso. Yellow boxes are the location of major landslides.

Figure 22 shows the distribution of earthquake-induced landslides in Negros Oriental. Red lines shows the location of the landslide crown, while areas with yellow boxes shows the 4 major deep seated rotational landslides (Block A to D). Many rockfall occurred in many areas and the most notable is the Razorback Ridge (Figure 23). Major landslides observed are shown in Figures 24 to 27.

Around 70 people died due to burial by the landslides in two separate areas. The two sites are Solongon, La Libertad and Planas, Guihulngan (Figure 24). Based on interview, landslide occurred almost simultaneously with the strong earthquake and a strong up and down movement was also experienced. Most of the fatalities were believed buried several meters below the ground since retrieval operations accounted only very few victims.

One of the notable case of slope failure was a roadside rockslides in Brgy. Dampa, Guihulngan, where a large limestone block measuring ca. 1 m in diameter rolled and smashed into a hut along the way (Figure 28). Several other large, shallow to deep-seated landslides were found along river valleys. These were mostly failures in deep soil or highly weathered rocks along the steep walls of the V-shaped river valleys. None, however, was large enough to cause temporary damming of the river channel.

Figure 23. Landslide viewed from the east at Brgy. Saavedra, Moalboal, Cebu

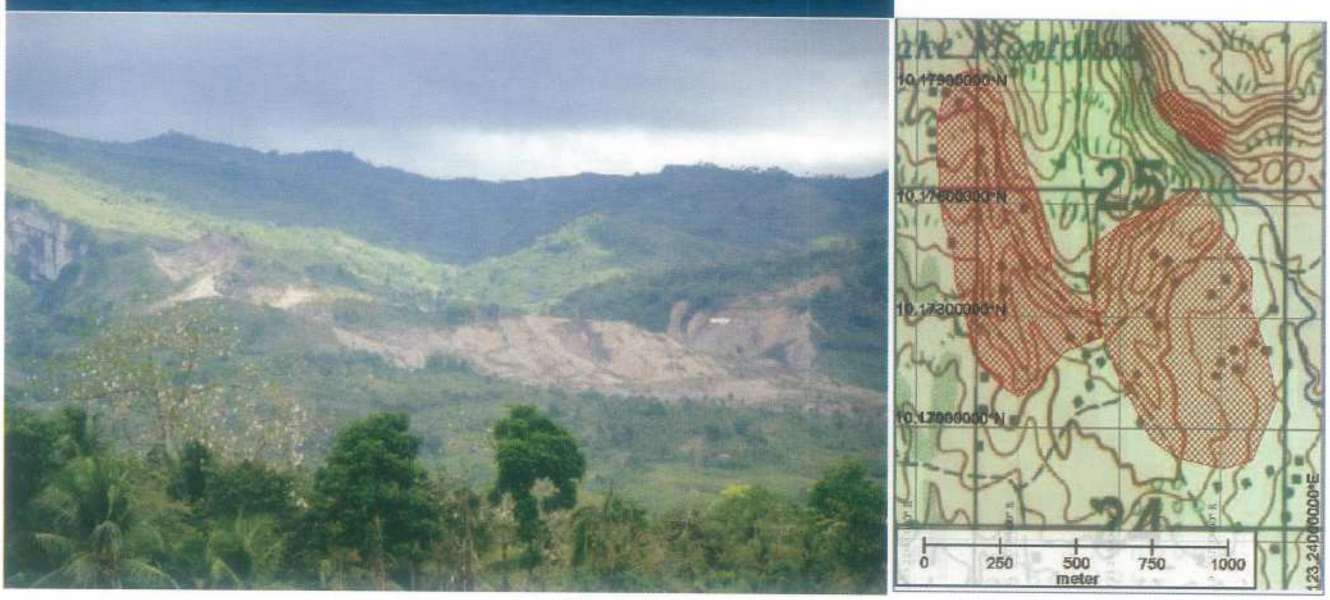


Figure 24. Landslide in Brgy. Planas, Guihulngan City. Around 40 were reported dead. Landslide area covers around 50 hectares (see Figure 22 Block A for location).

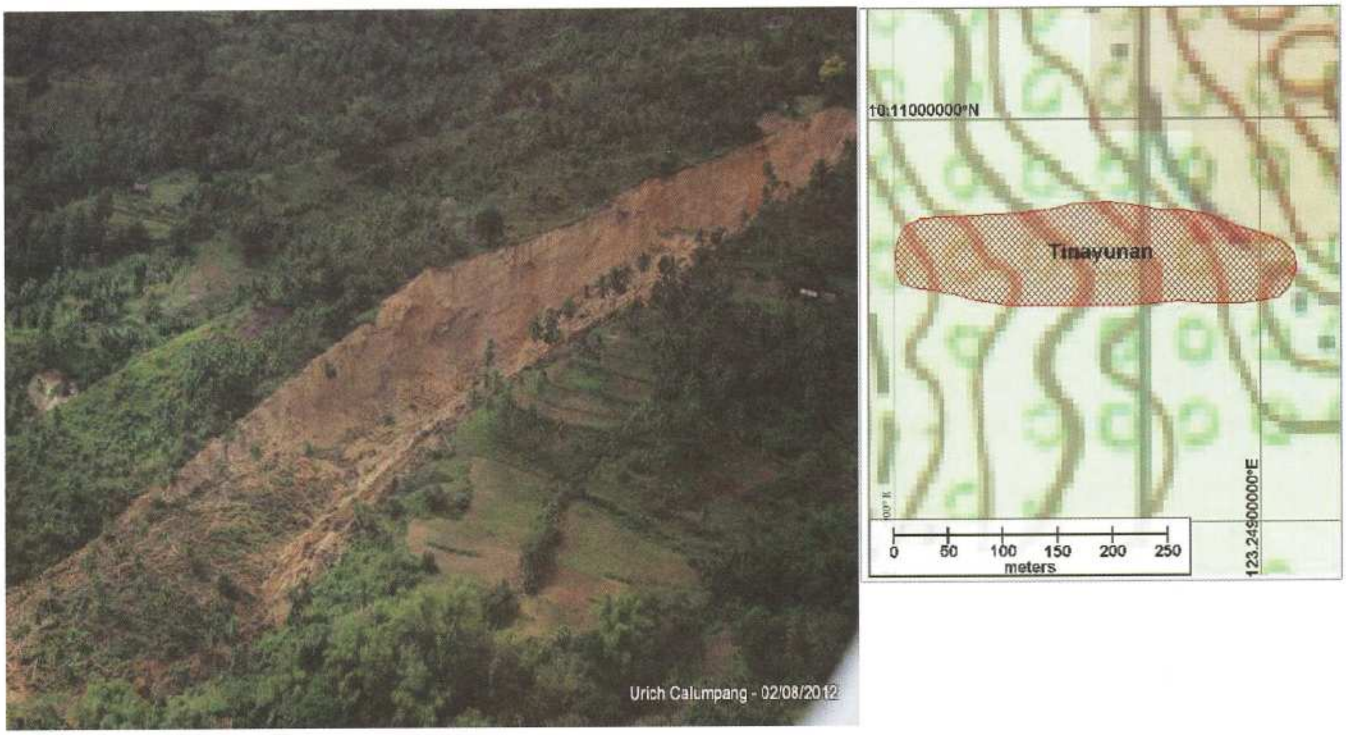


Figure 25. Landslide in Brgy. Tinayunan, Guihulngan City. Landslide area is composed of coralline limestone to calcareous sandstone. No reported casualty in this landslide (see Figure 22 Block B for location).

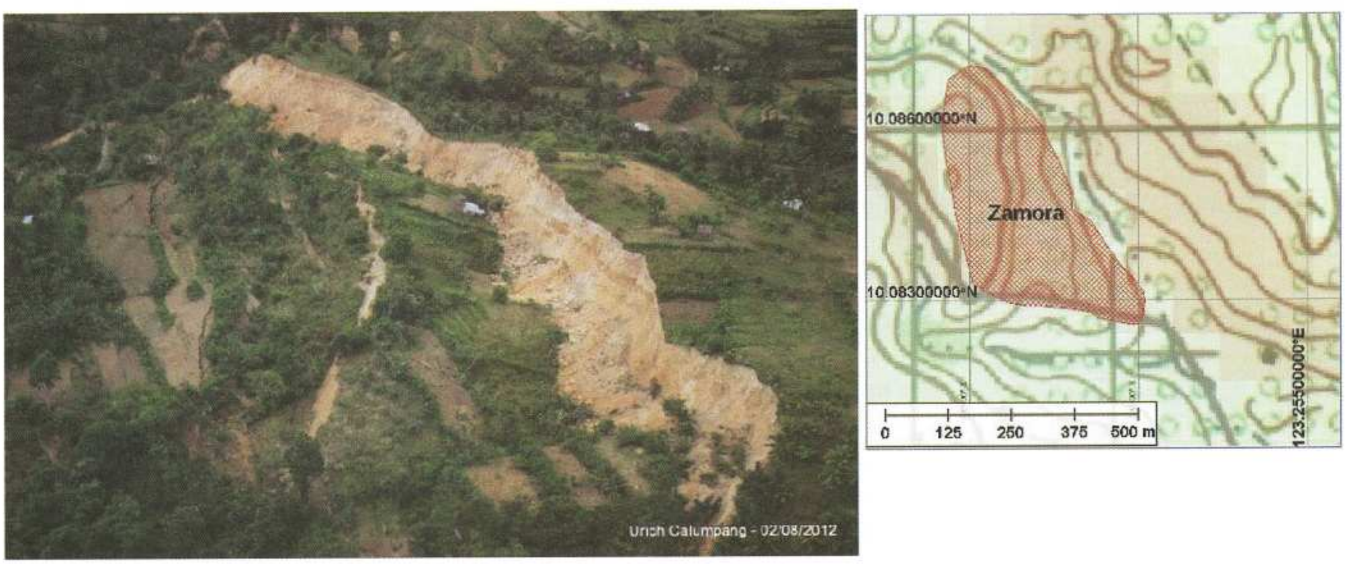


Figure 26. Brgy. Zamora, Guihulngan City rotational landslide (10.08484191° N, 123.24971459° E). Approximately 10 hectares of land was deformed causing rotational movement on the upper part (see Figure 22 Block C for location).

Figure 27. Barangay Solongon, La Libertad landslide (10.05770099° N, 123.21576893° E). About 40 people reportedly died in this area (see Figure 22 Block D for location)..

Figure 28. A large limestone block, ca. 1 m in diameter, from a rockslide in Brgy. Dampa, Guihulngan City rolled and smashed into a hut along the way.

OTHER GROUND DEFORMATIONS AND COASTAL UPLIFT

Considering the earthquake's magnitude of Mb 6.9, if surface rupturing is present, the possible length would approximately be 30-50 km (Wells and Coppersmith, 1994). However, during the aerial survey three days after the event, no coseismic surface rupture was observed at the suspected areas where it was initially projected. Instead, ground deformations such as buckling in houses and roads and notable coastal emergence were observed in Guihulngan City.

Coastal uplift and deformation were observed in the barangays of McKinley and Tinayunan Beach in Guihulngan City. At least four concrete houses along the beach were damaged and tilted higher than the surrounding surfaces (Figure 29). One resident, Sgt. Emmanuel Mendoza described that his house was "uplifted" or raised after being "pushed in" from the sea. He further indicated that there was no steep beach face before the earthquake but simply a gentle beach face composed of calcareous sand. After the shaking, they immediately noticed the "growth" of beach with the appearance of the mounds or new steep berms ca. 1.3 to 2 m high, visible from the shoreline and extending for approximately 100 m (Figure 30 & 31). The new steep berms were observed to have exposed a vertical face of gray sandstone unit. The highway adjacent to or in front of their houses showed evidence of ground undulation with wave axis perpendicular to the highway (either E-W or NNW). The wavelength was measured at ~10m and amplitude is ~21cm (Figure 32). The buckling and tilting of the houses are oriented parallel to the shoreline (NE-SW). The team also noted buckling or compressional features in other houses located inland or west of the highway, and their long axes trends N50°-60°E. Witnesses further claimed that the high tide levels after the 06 February earthquake event is lower than before. These are further verified by new high tide indicators such as the new berms and wrack zones forming at a relatively lower elevation or farther out into the shorelines than before.

Figure 29. Four houses fronting the beach in Bgy. McKinley, Guihulngan City that were damaged and tilted due to buckling and uplift along the coast.

Figure 30. Approximately 1.3 – 2m of gray sandstone under calcareous sand units were uplifted and exposed creating steep beach face or berms in Bgy. McKinley, Guihulngan City.

Figure 31. Section of the Bgy. McKinley coast with observed emergence of sandstone and calcareous sand units. Photo taken 11 February 2012, ca. 1430H (local time).

Figure 32. Ground undulation exhibited in a section of the highway adjacent to the uplifted beach in Bgy. McKinley, Guihulngan City. Wave axis is perpendicular to the highway (either E-W or NNW). The wavelength was measured at ~10m and amplitude is ~21cm.

At Bgy. Tinayunan Beach, approximately 2 km north of Bgy. McKinley, the beach area have noticeably widened, specifically when we are conducting our investigations or passing by the coastal community during low tide levels (ca. 12:00 nn). Additionally, the mangroves are completely stranded during low tide levels or too exposed above water even during high tide levels (Figure 33). Local residents claimed that more than a week after the earthquake, the sea level during high tide does not reach its older level before the earthquake or reaches a relatively lower elevation than before. Similarly, they observed that a patch of intertidal modern reef not too far from the coast (ca.50-80m) becomes totally exposed above the low tide levels compared to their observations prior to the earthquake. The team measured the relative change in the high tide level before and after the earthquake, based from sea wall tide marks, mangrove root exposure and estimated height of the modern coral patch to be between 0.7-1m.

The apparent widened beach and stranded mangroves in Bgy. Tinayunan Beach and the buckled houses, uplifted patches of coastlines and modern reef, and formation of steep berms and beach face in Bgy. McKinley are all indications of co-seismic uplift. No co-seismic rupture has yet been identified and the vertical deformations observed in other places in Guihulngan are probably part of the deformation zone. The regional coastal uplift stretches for approximately 2 km within the Guihulngan coast.

Other patches of the Negros eastern coastline show possible coseismic uplift and subsidence based on photos of the coast from the aerial survey but this has not yet been confirmed as of writing. Witness reports received after the QRT investigation mentioned observed subsidence or a higher relative-sea-level after the earthquake offshore of Tayasan based on the depth of the modern coral reef.

Figure 33. The mangroves that are completely stranded during low tide levels or still a little exposed above water even during high tide levels at Bgy. Tinayunan Beach, Guihulngan City. Photo taken 17 February 2012, ca. 1320H (local time).

Remaining Hazards

The recurrence of the landslides in the mountains and along steep and deep gulleys in Negros Oriental and Cebu provinces is considered a certainty given the presence of thick, loose and less cohesive sediments and fractured, slightly weathered bedded sedimentary rock units comprising the mountains and the valley walls. This could be triggered by excessive precipitation or another strong ground shaking from nearby earthquake generators (e.g. Negros Trench, Central Negros Fault, Southern Negros Fault, etc.). Landslides occurring along narrow, V-shaped river channels bounded by steep and tall valley walls such as the one in Bgy. Tinayunan may likely result in the blockage of the river. This will lead to flash flooding when the impounded water in the river reaches some critical level and breaches the temporary landslide dam. Eventually, this may pose threat to communities on the flood plain that may be affected.

INFORMATION, EDUCATION AND DISSEMINATION CAMPAIGNS

PHIVOLCS information education and communication (IEC) activities were conducted in Ayungon, Tayasan, Jimalalud, La Libertad and Guihulngan, Negros Oriental and parts of Cebu Island - Badian, Barili, Dumanjug and Ronda. These activities were part of the QRT to brief the people in the affected areas about the recent earthquake and what to expect from the said event. Through the information drive the agency gave update to the people specifically, on basic information about earthquakes and earthquake hazards, aftershocks, tsunami basic information, Tsunami Alert Levels, PHIVOLCS Earthquake Intensity Scale (PEIS) and earthquake preparedness measures.

Local Officials and Residents

The IEC activities consisted of lectures and debriefing of the officials of the Local Government and residents. Most of these lectures were held outside municipal buildings, parks, evacuation areas and on the streets where people gathered to hear news about the event and were waiting for the relief. Information materials such as the PEIS, Earthquake Preparedness Guide (pocketsize) and Tsunami (flyer) were distributed to the people (Figure 34). Using the Primer on the 6 February 2012 Earthquake at Negros Oriental that was immediately prepared the day after the event, to give a brief background about what happened (Figure 35), the QRT was able to share correct information to the people to relieve their fears on the earthquakes aftershocks and tsunami (Figures 36-39).

Upon the arrival in the affected five municipalities, the QRT noticed significant number of people staying in open grounds due to fear of dwelling inside their houses or any establishment with a roof. Most residents feared that they will experience the same ground shaking effect as to the main shock. Some other residents who stayed at the evacuation areas have severely damaged or totally collapsed houses. Lack of knowledge on earthquake and emergency preparedness among communities on such events was very evident. However, during the minor tsunami event after the main shock, most of the people observed the unusual sea level change and immediately moved higher grounds. Many cited the March 2011 Japan Earthquake for this.

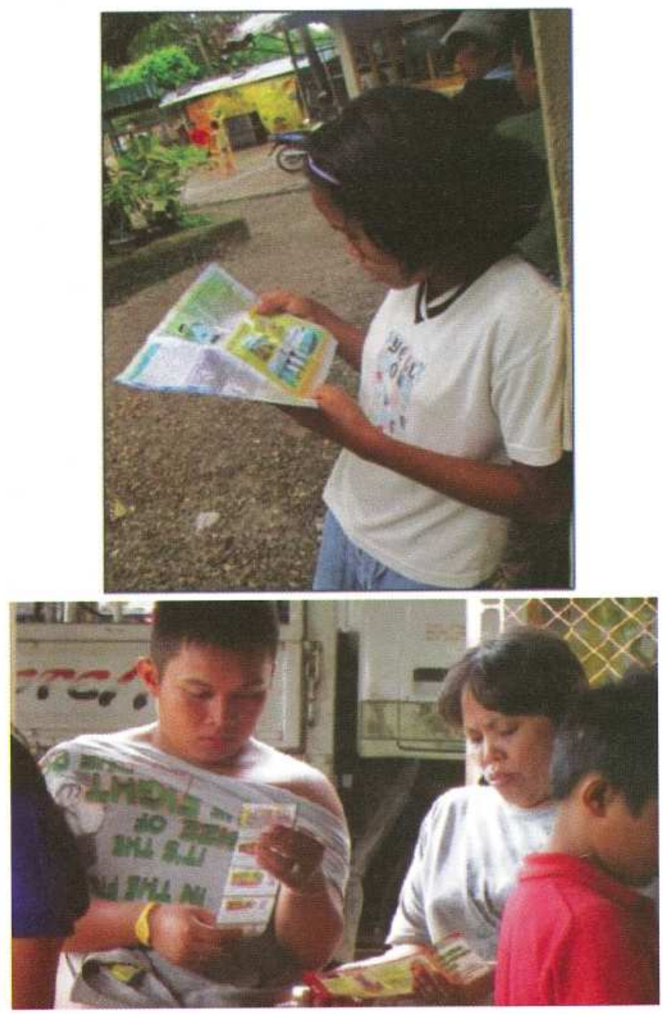


Figure 34. Residents of the affected areas receive PHIVOLCS information materials. It was expected that the materials will be useful source of information about earthquake and tsunami preparedness, and how to use the PEIS.

PRIMER ON THE 6 FEBRUARY 2012 MAGNITUDE 6.9 EARTHQUAKE AT NEGROS ORIENTAL

Department of Science and Technology
Philippine Institute of Volcanology and Seismology (PHIVOLCS)
6 February 2012

What is happening at Negros Oriental, Cebu and nearby islands?

At 11:49 AM on 6 February 2012, a moderate size earthquake of magnitude 6.9 shook Negros, Cebu and nearby islands. Aftershocks of lesser magnitude followed a few minutes after the main shock. 23 hours later, 896 aftershocks have been recorded by the PHIVOLCS seismic monitoring network.

The main shock and ensuing aftershocks have epicenters on the eastern coast of Negros Oriental, near the municipality of Tayasan. It is a shallow earthquake, with focal depth of 10 kilometers. Although there are identified active faults in the island, such as the Central Negros Fault, further investigation needs to be done to determine the fault responsible for this earthquake.

Intensity reports showed that municipalities of Tayasan, Vallehermoso, Guihulngan and Dumaguete City (Negros Oriental) felt the strongest ground shaking at PEIS[1] VII (destructive ground shaking). Furthermore, the surrounding areas of La Carlota City and La Castellana (Negros Occidental), Tanjay and Manjud (Negros Oriental), Argao, Dalaguete, Barili, Cebu City (Cebu) and Clarin (Bohol) felt the ground shaking at PEIS VI (very strong ground shaking). There were reports of felt intensities as far as 200 kilometers away from the epicentral area. The strong ground shaking, especially in the epicentral area, caused damage to or collapse of weak structures, liquefaction in low-lying soft grounds, and landslide in steep slopes. There were also reported sea disturbance in some coastal areas.

Moderate-magnitude[2] earthquakes have also affected Negros Island in the past!

On 5 May 1925, a magnitude 6.8 earthquake occurred at Southern Negros. The towns of Bais, Tanjay, Tolong and Siaton felt the strongest intensity of ground shaking at PEIS VI to VII. There were report of damaged buildings in Bais and Siaton, while in Dumaguete, landslides along ridges and fissures along rivers and mangrove areas.

Why do earthquakes occur at Negros and Cebu Islands?

Negros and Cebu islands are located in a seismically active area in the Philippines. Instrumental monitoring of earthquakes for the past century has detected many small to large-magnitude earthquakes in Negros Island generated by the Negros-Sulu Trench. The Negros-Sulu Trench is an earthquake generator located offshore west of the island, roughly parallel to the Philippine archipelago along its length, but veers very close to land at the southern tip of Panay Island. Another earthquake generator that affects the islands is the Philippine Fault Zone, segments of which pass through the islands of Masbate, Leyte and Eastern Mindanao, and which have also been the locus of small to large-magnitude earthquakes. Other active faults on the islands are the Central Negros Fault and Cebu Lineaments. Seismicity for these structures are low.

Can these present earthquakes indicate volcanic activity from Kanlaon Volcano?

No. The origin of the main shock and aftershocks are clearly tectonic. However, there are also known volcanic activities, such as those of Pinatubo Volcano, which some scientists suggested were influenced by an earlier large-magnitude earthquake. PHIVOLCS is closely monitoring the situation.

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[1]PEIS – PHIVOLCS Earthquake Intensity Scale
[2]Small magnitude less than 4.9; moderate magnitude 5 to 6.9; large magnitude 7 and above
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Figure 35. The Primer served as guide during lectures with LGUs and residents.

Figure 36. IEC activities in Tayasan with the LGU and communities.

Figure 37. a.) LGU of Ayungon meet with PHIVOLCS QRT to know more about earthquake preparedness measures and b.) IEC with communities of Tampocon 2, Ayungon.

Figure 38. IEC at the evacuation area of North Poblacion, Jimalalud.

Figure 39. IEC at Solonggon Barangay Hall, La Libertad (served as landslide victims evacuation area).

These remarks led the QRT to conduct a massive information drive to assist the people in the community in initiating moves to get back to their normal living. The QRT also facilitated information dissemination to the respective LGUs which they found to be in need of help in responding to people's needs of right information. It is obvious that most of these LGUs have no preparedness program on earthquake or any geologic hazards. They listened in full attention and interest and has seen the importance of understanding the hazards of earthquake, tsunami and being prepared (Figures 40-42).

In Cebu, the QRT made focus on conducting surveys, and IECs for LGUs toward better understanding of the event and what actions to take during such event. The importance of understanding the "tsunami alert levels" was given emphasis during discussions at the LGU level.

Figure 40. Public announcement at Guihulngan evacuation sites, streets, subdivision and public market (Police personnel assisted the QRT for the information dissemination)

Figure 41. Coastal community in Japitan, Barili

Figure 42. Residents of Tangil, Dumanjug

The areas covered of IEC:

Province	Brgy/Municipality	Estimated number attendees	Team
Negros Oriental	Bais (LGU)	10	Ground Rupture Team
	San Jose (LGU)	10	Ground Rupture Team
	Ayungon (LGU)	25+	Tsunami, Ground Rupture, Documentation and IEC Team
	Tayasan (LGUs and residents)	100+	QRT
	Jimalalud (Evacuation area Poblacion)	50	Documentation and IEC Team
	La Libertad (Solongon, Public Market, South and North , Poblacion, San Jose, Magtalisay, Martilo and Maragundong	180	Documentation and IEC Team
	Guihulngan (Poblacion Evacuation areas , Tinayunan and Planas)	400	Documentation and IEC Team
Cebu	Badian (Coastal residents of Barangay Zaragosa)		Tsunami and Documentation Team
	Dumanjug (Coastal residents of Barangay Tangil)		Tsunami and Documentation Team
	Moalboal (LGU)		Tsunami and Documentation Team
	Ronda (LGU)		Tsunami and Documentation Team

Some of the frequently asked (FAQs) questions during the information drive:

Community-level

1. Bakit nagkalindol?
2. May lindol pa ba?
3. Kailan hihinto ang lindol? O Gaano pa ba katagal ang mga lindol?
4. May pareho pa bang lakas na pwedeng mangyari pa?
5. Nasaan ang fault?
6. Lulubog ba o mawawala na ba sa mapa ang Guihulngan?
7. Ang mga bitak-bitak ba ay ang faultline?
8. Bakit sa Tayasan ang epicenter? Ano ba ang ibig sabihin nito?
9. May bulkan ba sa ilalim ng dagat?
10. Bakit may mga putik na lumalabas?
11. Ang mga crack ba sa sahig ay delikado o mapanganib?
12. Kailan matatapos ang tsunami?
13. Ang aftershocks ba ay delikado o mapanganib?
14. Paano namin malalaman na pwede na uli bumalik sa aming bahay?
15. Bakit hindi na-detect ng PHIVOLCS ang lindol?

LGU

1. Ano ibig sabihin ng tsunami alert levels?
2. Nakita na ba ang blind fault?
3. Bakit malakas pa din ang aftershocks?
4. Bakita masmalaki damages sa Guihulngan kumpara sa Tayasan?
5. Ano ang gagawin o solusyon sa mga “liki” o tension cracks sa mga bundok?
6. Ano ang epekto ng lindol sa Lake Balinsasayaw?

Orientation for Members of the Media

The QRT together with Department of Science and Technology (DOST)- Provincial Science and Technology Center (PSTC) Negros Oriental organized a half-day orientation for media practitioners on 16 February 2012 at the DOST Office, Dumaguete City. The orientation aimed to increase better understanding of media practitioners about earthquakes, tsunami and other geologic hazards in order for them to disseminate accurate information to the public. Among the topics discussed by the PHIVOLCS speakers are Volcanoes and Volcanic Hazards, Earthquake and Earthquake Hazards, The Earthquake Story, Earthquake Preparedness Guide, and Preliminary Update on the February 6, 2012 Magnitude 6.9 Negros Oriental Earthquake (Figure 43 and 44). The lecture and forum was attended by 31 media persons of local televisions, radio stations and newspapers, and representatives from Provincial Disaster Risk Reduction and Management Council (PDRRMC), Local Disaster Risk Reduction and Management Office (LDRRMO), Public Information Office, Philippine Information Agency, and students from Negros Oriental State University Geology Department and Silliman University College of Mass Communication's TV Production class.

Before the QRT left the site, a 24 x 34 size poster prepared for the Provincial Government, DOST-PSTC, PHIVOLCS Sibulan Seismic Station and LGUs of Negros Oriental. The poster gives summary information and update about the event (Figure 45).

Findings

- Lack of knowledge among officials and residents about earthquake, tsunami (tsunami alert levels) and preparedness measures.

- Lack of earthquake preparedness program specifically from the Provincial, LGU to community level.

- On a positive note, most of the people living in the coastal areas evacuated to higher ground when they observed the unusual sea level change for fear of experiencing the tsunami event in Japan. However, as an extreme case, some communities stayed for 3 days on the high ground because they are not aware of how long the unusual wave will last in the area. This implies again, lack of understanding and knowledge about tsunami, and proper response depending on the situation and alert levels. Most of the residents opted to stay at the evacuation areas because of severely damaged or totally collapsed houses. Also, many residents feared the aftershocks which might cause similar ground shaking effects as to the main shock (and further damage the houses and buildings).

Recommendations

In coordination with the Office of Civil Defense and the Provincial Government Negros Oriental, activities that would strengthen the capacity of the local government on earthquake and tsunami awareness and preparedness should be planned and programmed. Some suggested activities include roll out of the RA 10121, aggressive information drive, capacity building activities targeting different sectors.

Figure 43. The speaker give updates the media of Negros Oriental on the 6 February 2012 Earthquake.

Figure 44. PHIVOLCS speaker discuss the 3D model of Negros Island in relation to the earthquake event of 06 February 2012.

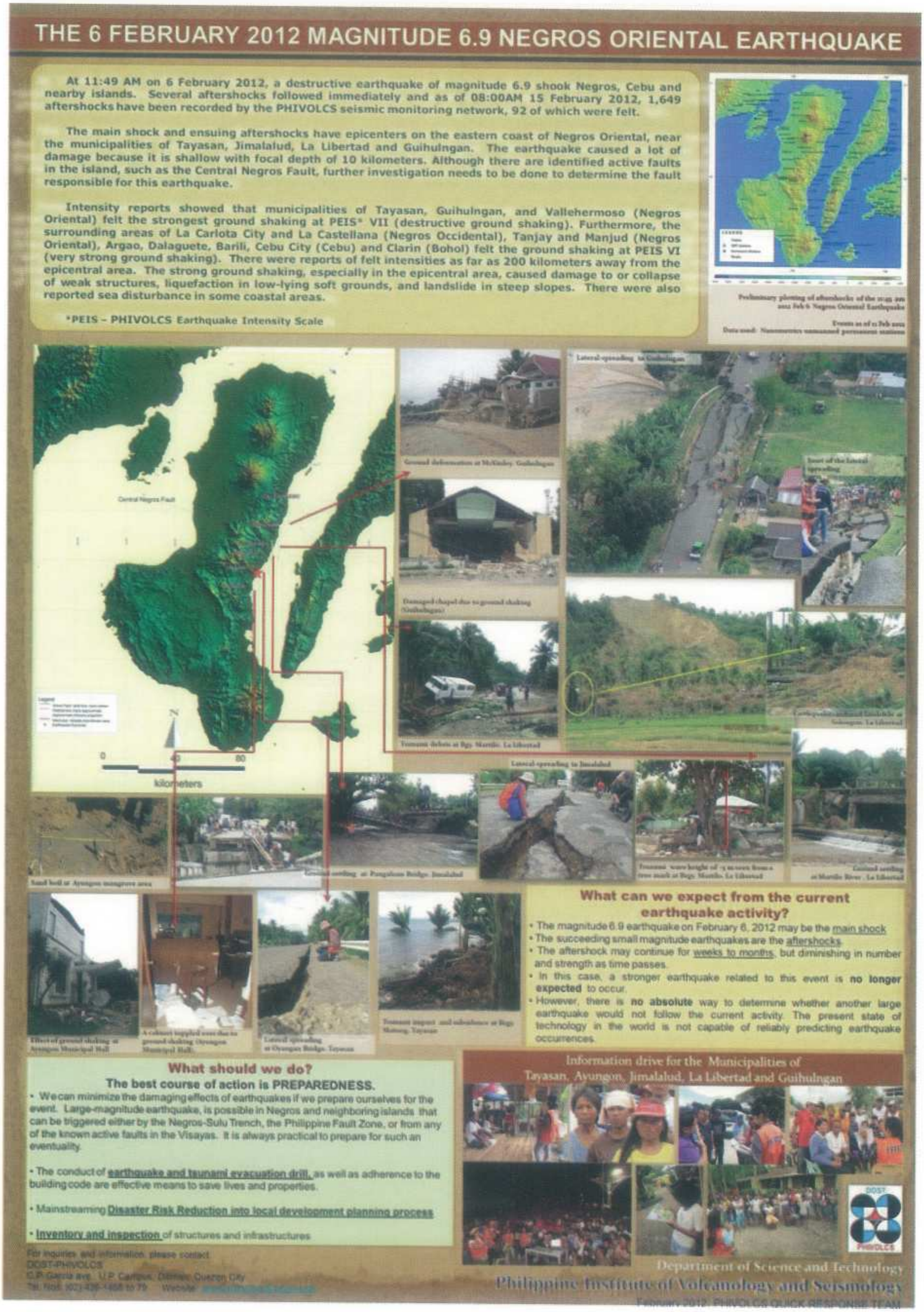

Figure 45. The poster of the 6 February 2012 Magnitude 6.9 Negros Oriental Earthquake.

CONCLUSIONS AND RECOMMENDATIONS

The 06 February 2012 Negros Oriental Earthquake was generated by a NE-trending blind thrust fault along the eastern region of Negros Island. The focal mechanism solutions of the main shock point to a hypocentral source along a NW-dipping thrust fault at 10 km depth which translates to a fault plane surfacing east of Negros Island, most likely offshore. This would explain the documented coastal uplift (ca. ≤1m) indicated by new steep beach faces or berms, exposed patches of intertidal modern coral reefs and completely stranded mangroves during low tide levels. The length of the documented coastal uplift is approximately 2 km at Guihulngan coast. It is highly possible that a small amount of coastal uplift (ca. <1m) may have occurred farther south of Guihulngan, extending for almost the same length equal to the projected possible length of the fault rupture of ca. 30-40km. Review of the aerial survey photos and additional survey is needed to verify this.

The Negros Oriental earthquake also caused widespread liquefaction, tsunami and landslides, as well as severe to moderate infrastructural and building damage in Negros Oriental and Cebu. The maximum ground shaking intensity of PEIS VIII was concentrated in the epicentral region covering the Municipalities of Ayungon, Tayasan, Jimalalud, La Libertad, and Guihulngan City. Aftershocks were also observed to cluster in this region and are expected to last for at least a month after the event. Most severe impact of ground shaking and infrastructural and building damage occurred in Guihulngan City and La Libertad Municipality, and severely in epicentral Tayasan, Ayungon, and Jimalalud Municipalities. Severe damages from ground shaking such as total to partial collapse of structures, fissures on floors and walls were generally observed on non-engineered houses, buildings, and facilities. Other building and infrastructural damages are due to translation from landslide movement or related to deformations from liquefaction and failure of loose gravelly materials. The initial damage of the main shock to some houses and facilities was worsened by the impact of the local tsunami and lead to total collapse of some of the structures. Detailed mapping of the geologic impacts shall be undertaken especially the landslide-prone areas. The results of which will be included in the earthquake-related-hazards map for the Province of Negros Oriental.

For an area prone to destructive earthquakes, the structural safety of buildings, public facilities and of all sorts of houses should be given careful consideration commencing at the design phase. Use of deleterious aggregates in construction practice should be discouraged to avoid corrosion to re-bars, concrete bond loss and ductility reduction of structural members. On the flipside, the use of crushed gravel for better bonding with the concrete paste should be encouraged in lieu of commonly-used smooth and rounded coarse aggregates. Existing structures that were slightly and moderately damaged during the earthquake must be structurally reinforced and retrofitted. Bracing of wooden structural members and jacketing of masonry walls with plaster on wire mesh could be some of the less expensive solution.

The following general recommendations apply to all areas in Negros and Cebu Islands that may experience yet another large magnitude earthquake capable of generating long duration and high intensity shaking in the future:

1. Conduct rapid building/structure safety evaluation by the Building Official's authorized local civil/structural engineers immediately after a locally destructive earthquake so as to promptly inform the occupants of its hazards or safety for use/habitation and to provide appropriate recommendations.

2. Immediately evacuate and demolish severely damaged buildings, facilities and houses to prevent further use of these structures and avoid greater risk of local inhabitants to possible future collapse.

3. Relocate communities situated in areas highly vulnerable to landslide and tsunami.

4. Activate and strengthen the Provincial Disaster Risk Reduction and Management Council (PDRRMC) down to the Barangay DRRMC with the capacity building for disaster preparedness, response, and rehabilitation.

5. Establish short- and long-term community preparedness plans in preparation for future earthquake events.

6. Conduct more intensive community-wide earthquake and tsunami information and education campaigns and drills, if possible, to raise and sustain awareness and proper response as well as to allay fears and eliminate spread of false information.

7. Strictly implement and conduct regular earthquake drills in schools and government institutions.

8. Strictly implement and monitor the National Building Code requirements and its referral codes in the design and construction of public and private facilities/structures to minimize severe structural damage or collapse in future earthquake events.

9. Formally train local masons and carpenters on proper construction practices.

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PHIVOLCS Quick Response Team (QRT)

Arturo Daag
Ma. Isabel Abigania
Mabelline Cahulogan
Florenette Garcia
Robinson Jorgio
Enrico Mangao
Baby Jane Punongbayan
Melcario Pagtalunan
Ruben Lamela
Princess Dianne Decierdo
Ma. Antonia Bornas
Ma. Carmencita Arpa
Vilma Hernandez
Melchor Lasala
Arnaldo Melosantos
Henremagne Peñarubia
Danikko Rivera
Lucille Rose Del Monte
Joan Beliran

Layout and Cover Design
Angelito De Guzman

Reviews and Proofreading
Jeffrey S. Perez
Joan C. Salcedo

Technical Advisers
Renato U. Solidum, Jr.
Ma. Mylene Martinez-Villegas

Contact Address:

Department of Science and Technology
PHILIPPINE INSTITUTE OF VOLCANOLOGY AND SEISMOLOGY
C.P. Garcia Avenue, U.P. Campus Diliman, Quezon City
Philippines 1101

Tel. Nos. (+63-2) 426-1468
Telefax No. (+63-2) 927-4524

http//www.phivolcs.dost.gov.ph