StEER STRUCTURAL EXTREME EVENTS RECONNAISSANCE		**EVENT BRIEFING**	
		Event:	27 July 2022, Philippines, Mw 7.0 Earthquake
		Region:	Asia
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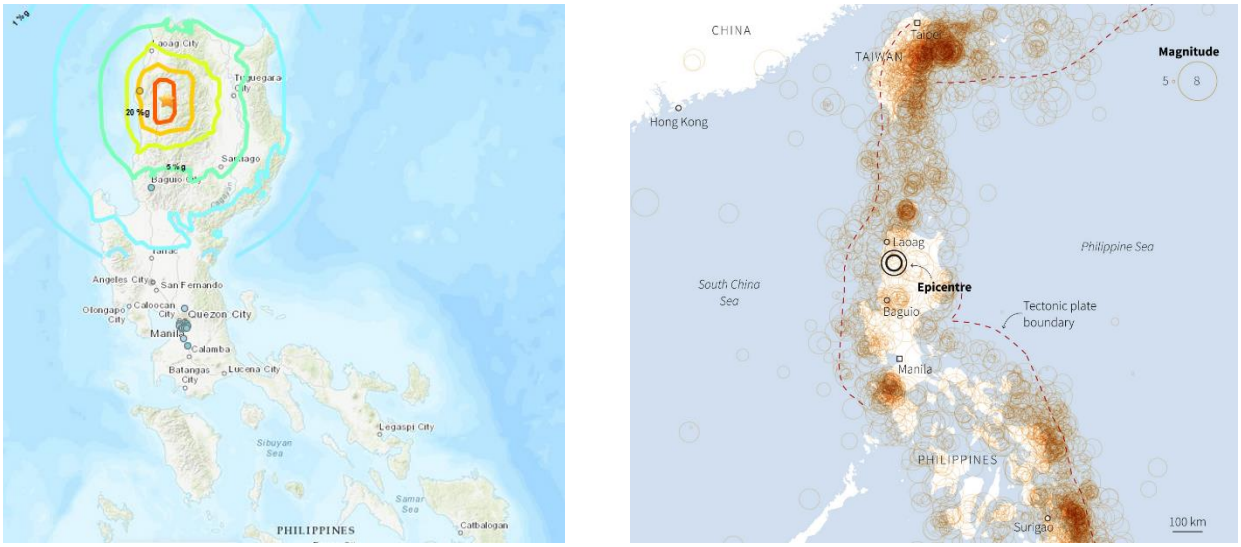
Key Lessons & Recommendations

- ❏ The region where the earthquake occurred has complex tectonics, including reverse, normal, and strike slip faulting. From seismology and Ground Motion (GM) perspectives, this region can be considered as a living laboratory and a great source for GM recordings. Therefore, GM recording stations in this region should be increased to record and document the characteristics of ground shaking in earthquakes due to the different fault mechanisms.
- ❏ This region has high seismicity rates. Since 1970, 11 other earthquakes of magnitude 6.5 or larger have occurred within 250 km of this earthquake event. This historical data should be considered to update magnitude-recurrence relationships of earthquake source models in this region to be used in probabilistic seismic hazard analysis as well as in the response spectra used in design codes.
- ❏ Collapse of non-ductile buildings highlights the fact that economic retrofit measures are needed for the Philippines to improve the performance of the existing building stock as large magnitude earthquakes continue to occur frequently.
- ❏ Damages to centuries old historical structures and churches highlight the need for careful retrofit of these historical structures, while preserving their cultural and historical identity.
- ❏ Patients, some of them in wheelchairs, and medical personnel were evacuated from at least two hospitals in Manila, about 200 miles south of the epicenter, where the ground shaking was low, but were later told to return after engineers found only a few minor cracks on walls. Although this is considered a short time to return to occupancy, this also highlights the need to assure that essential structures, like hospitals, need to remain fully functional without any disruptions to operations, especially in low levels of shaking.

Event Description

On July 27, 2022, at approximately 8:43 am local time, a moment magnitude (Mw) 7.0 earthquake, with a depth of 10.0 km, struck the northern Philippines with coordinates of 17.560°N and 120.801°E (Fig. 1). The earthquake was followed by hundreds of aftershocks (Reuters, 2022). The earthquake resulted in five casualties, damage to buildings and other infrastructure, and disruptions to the community. Objectives of this earthquake briefing are: (1) to provide details of the 27 July 2022 Mw 7.0 Philippines Earthquake, (2) to describe damage to buildings and disruption to the community in terms of fatalities, downtime, and economic losses, and (3) to list key lessons learned from this international event.



(a) (b)

Figure 1. Epicenter of the 27 July 2022, Mw 7.0 earthquake: (a) per USGS (2022) and (b) per Reuters (2022), along with epicenters of earthquakes of magnitude 5 or above.

Hazard Description

The earthquake occurred at a shallow depth of approximately 10 km and was the result of oblique reverse faulting. Initial USGS analysis indicates that the fault for this earthquake was either striking to the north or southwest (USGS, 2022).

The earthquake occurred in the northwestern portion of the island of Luzon, which is a region with complex tectonics (USGS, 2022). Luzon is bounded by subduction zones in the east and west. In the southern part of Luzon, the Philippine Sea plate subducts westward beneath the Sunda plate. In the northern region of Luzon, where the earthquake occurred, the subduction zone location and direction changes, with the Sunda plate subducting eastward beneath the Philippine Sea plate (Figure 2). The earthquake depth, mechanism, and location verify that the earthquake occurred in the Philippine Sea plate above the Sunda plate (USGS, 2022).

The complexity of the plate boundary interactions in this region is also evidenced by the diversity of faulting mechanisms in large earthquakes. Magnitude 7 or greater earthquakes in this region since 1970 have been occurring due to reverse, normal, and strike slip faulting. From seismology and Ground Motion (GM) perspectives, this region can be considered as a living laboratory and a great source for

GM recordings. Therefore, GM recording stations in this region should be increased to record and document the characteristics of ground shaking of earthquakes due to these different fault mechanisms.

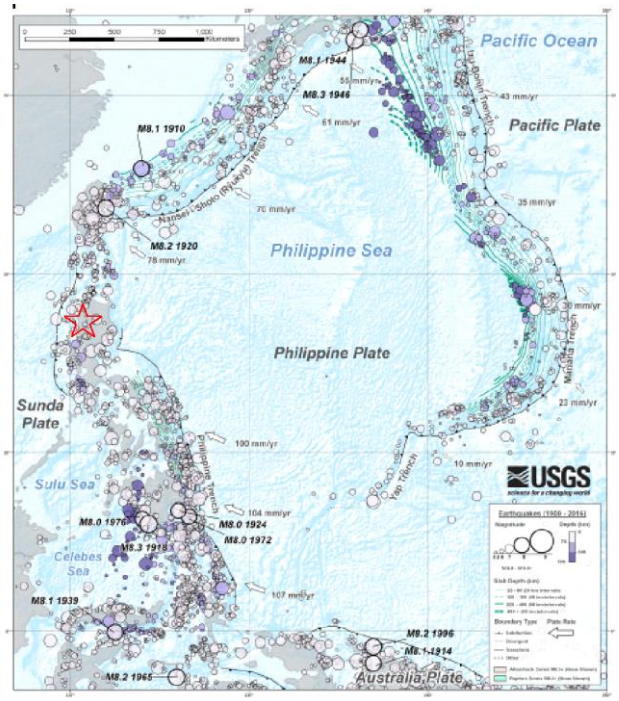


Figure 2. Plate boundaries and complex tectonics near the earthquake epicenter (USGS, 2022).

The interacting active plate boundaries lead to high seismicity rates (USGS, 2022). Since 1970, 11 other earthquakes of magnitude 6.5 or larger have occurred within 250 km of the July 27, 2022 earthquake. The largest of these earthquakes was a magnitude 7.7 strike slip earthquake on July 16, 1990, located approximately 215 km south of this July 27 earthquake. This historical data should be considered to update the recurrence intervals of different magnitude earthquakes (magnitude-recurrence relationships) in this region to be used in probabilistic seismic hazard analysis as well as in the response spectra used in design codes.

GM data from recording stations is not available at the time of writing this briefing. However, according to the USGS ShakeMap, ground shaking near the epicentral region reached large levels of shaking at Peak Ground Acceleration (PGA) of 0.5g (Figure 3).

Landslides and rockslides occurred as another direct physical effect of the earthquake (Figure 4; NPR, 2022). These rockslides blocked the roads and hampered the efforts to assess damage in certain locations (Reuters, 2022).

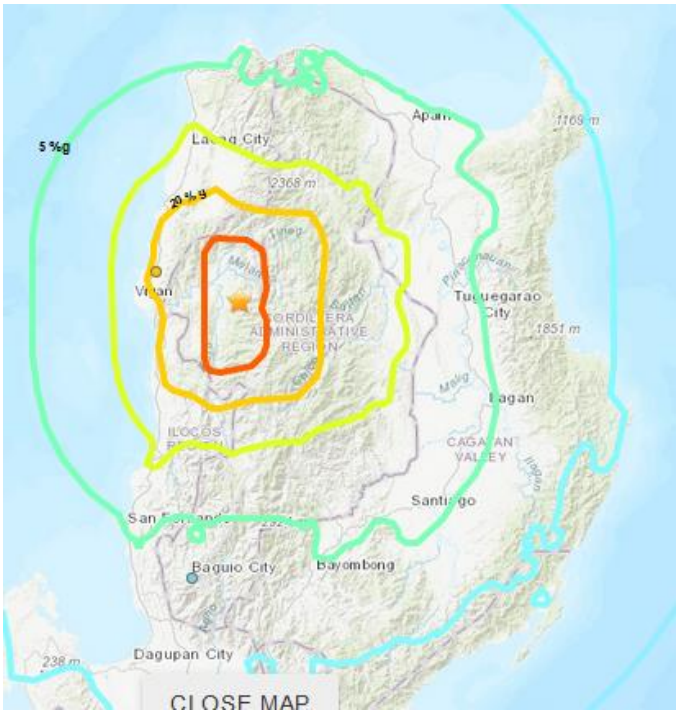


Figure 3. USGS ShakeMap ground shaking estimates (USGS, 2022).

Figure 4. Earthquake rockslides resulting in road blockages (NPR, 2022).

Damage to Structures

Buildings were damaged across northern Luzon, including more than 400 residential structures, dozens of schools, several hospitals, and historical buildings (CNN, 2022; NTV America, 2022; ABCNews,

2022). Similar to previous earthquakes in the Philippines (Günay et al., 2019, 2020), there were collapses among nonductile reinforced concrete buildings (Figures 5 and 6). The mixed soft[1] and weak[2] stories of the partially collapsed building due to shop and window openings can be observed in Figure 5. It is noted that since calculations are not made for strength and stiffness, we are not distinguishing between soft and weak story irregularities. The upper stories of this building remained intact with collapse occurring at the weak/soft first story only. Intact columns of the collapsed building in Figure 6 can be observed, indicating potential non-ductile beam-column joint failures, leading to this collapse. This highlights the need for economic retrofit measures of the entire building system to properly preserve the load path of these buildings in the Philippines (and other earthquake-vulnerable developing countries) to improve the performance of the existing building stock as large magnitude earthquakes continue to occur frequently as described above in the Hazard Description section.

In this earthquake, historical structures were also damaged, including the Bell Tower in Bantay, Ilocos Sur and a 16th-century Cathedral in Vigan, Ilocos Sur (Figures 7 and 8). This damage highlights the need for careful retrofit of historical structures, while preserving their cultural and historical identity.

Other than buildings, several bridges and roads were damaged in Luzon (Figure 9; CNN, 2022). The Department of Public Works and Highways (DPWH) reported that road closures were due to blocked roads by landslides and rockslides, soil collapse, and damaged bridges with damaged and settled approaches (GMA News, 2022).

Figure 5. Collapsed soft/weak story building (CNN, 2022; CNNPhilippines, 2022; Twitter, 2022a).

[1]Irregularity due to significant difference between the stiffness of the stories of a building.
[2]Irregularity due to significant difference between the strength of the stories of a building.

Figure 6. Collapsed reinforced concrete buildings in La Trinidad, Benguet (Reuters, 2022).

Figure 7. Damage to the Bell Tower in Bantay, Ilocos Sur (Twitter, 2022b; Dawn, 2022).

Figure 8. Damage to the 16th-century Cathedral in Vigan, Ilocos Sur (NTV America, 2022).

Figure 9. Damaged roads due to ground shaking and blocked by landslides (GMA News, 2022).

Community Impacts

At least five people died,130 others were injured, and more than 21,000 people have been impacted by this earthquake (CNN, 2022). There were power, water, and communication outages after this earthquake (Reuters, 2022). Impacted people were not only those near the epicenter, but also included distant locations. Patients, some of them in wheelchairs, and medical personnel were evacuated from at least two hospitals in Manila, about 200 miles south of the epicenter, where the ground shaking was low, but were later told to return after engineers found only a few minor cracks on walls (CNN, 2022). Although this is considered a short time to return to occupancy, this also highlights the need to assure that essential structures, like hospitals, need to remain fully functional without any disruptions to operations, especially in low levels of shaking.

USGS PAGER tool estimates of fatalities and economic losses are shown in Figure 10, with fatalities between 1 and 10, and 10 and 100, each estimated with a probability of 38%. PAGER estimated the economic losses to be between $10 million and $100 million with a probability of 39% and between $100 million and $1,000 million with a probability of 26%. It is noted that the Philippines National Disaster Risk Reduction Management Center reported $687 million losses due to this earthquake (CNN, 2022).

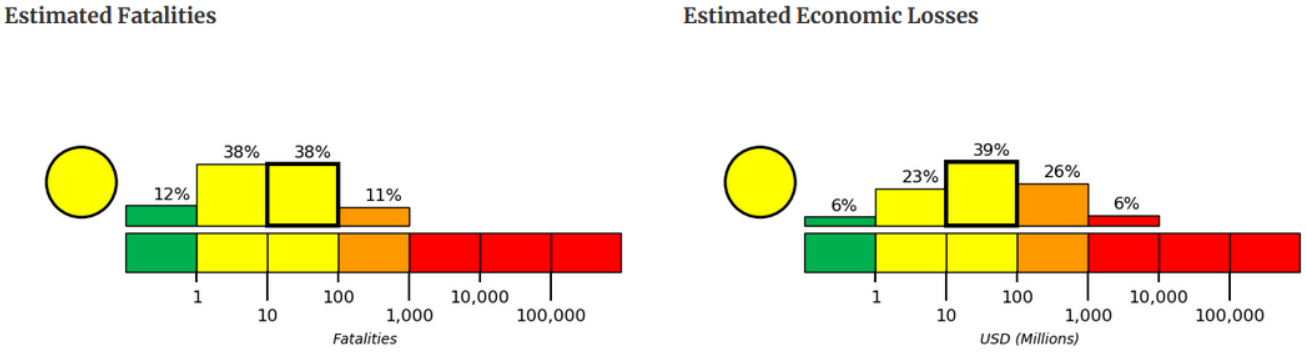


Figure 10. USGS PAGER loss estimates (USGS, 2022).

StEER Response Strategy

At present, StEER has assigned this event a Level 1 (virtual) response; based upon the information assembled in this briefing, StEER does not deem it necessary to form a Virtual Assessment Structural Team (VAST) or Field Assessment Structural Team (FAST) in response to this event. Information provided herein is based on various websites, news channels, and USGS. It does not include detailed field investigations. StEER will continue to monitor the event and, if necessary, will activate a Virtual Assessment Structural Team (VAST) to collect and process additional public data relating to this earthquake in support of a Preliminary Virtual Reconnaissance Report (PVRR).

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