WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Hazard Risk Rapid Assessments of Evacuation Centers at the Municipality of BOAC in the Central Marinduque Fault Line's Vicinity

Charizza D. Montarin[1], Julius V. Del Mundo[2], Dana Marie R. Revilloza[3], Irish Joy P. Regencia[4], Eljohn D. Cipriano[5]

[1]*Faculty, Bachelor of Science in Civil Engineering, College of Engineering, Marinduque State College, Main Campus, Boac, Marinduque, MIMAROPA, Philippines*

[2,3,4,5] *Student, Bachelor of Science in Civil Engineering, College of Engineering, Marinduque State College, Main Campus, Boac, Marinduque, MIMAROPA, Philippines*

Email - chamontarin@gmail.com

DOI: https://doi.org/10.55248/gengpi.4.823.45754

ABSTRACT –

Earthquakes are any sudden shaking of the ground and their impact can be extensive, triggering other hazards and producing great damage to structures, loss of lives, and natural resources. Due to the occurrence of the 7.0 magnitude – Abra earthquake in 2022, DPWH National Building Code and Development Office (NBCDO) issued a memorandum order requiring all building officials and municipal engineers to inspect buildings' vulnerability to seismic activities. It focused on the evacuation centers of barangays located on the Central Marinduque Fault Line's vicinity at the Municipality of Boac. Using the Rapid Visual Screening Method in assessing the 43 evacuation centers, it was reported that the most commonly used facilities as evacuation centers are the barangay halls or multi-purpose halls. Results reveal that there are 38 potentially seismically hazardous buildings that require detailed structural evaluation, three (3) that are seismically safe, and two (2) that need both detailed structural and non-structural evaluation. The study reveals the expected damage level that the buildings may experience once seismic activity occurs. This study also provides an Expected Damage Level Map that would help government officials in locating and consider which buildings need prior attention.

Keywords: *Rapid Visual Screening, Seismic Vulnerability Map, Evacuation Centers, Quantum Geographic Information System, Central Marinduque Fault Line*

I. INTRODUCTION:

In recent years, several moderate to high-intensity seismic activities happened in the country, leading to casualties, deaths, and damages to different structures. On July 27, 2022, a magnitude 7.0 earthquake struck Lagangilang, Abra, in the northern part of the Philippines, with the epicenter being located close to Tayum. The National Disaster Risk Reduction and Management Council pegged the number of affected or displaced individuals at over 500,000, while damage to infrastructure was estimated to have reached over P1.5 billion.

The Central Marinduque Fault Line, which is about 29.4 kilometers long and passes in the southeast direction near Mount Malindig to the northwest part of the province, could trigger a maximum 6.8 magnitude or intensity 7 earthquake, according to Phivolcs associate scientist Dr. Teresito Bacolcol. The recent earthquake that occurred in the province of Abra may provide insight into the potential magnitude of destruction that the Central Marinduque Fault may bring if it moves. Based on the FaultFinder, the Municipality of Boac has the largest number of barangays that the Central Marinduque Fault Line passes through.

Recalling the earthquake that happened on October 20, 2006, in the Province of Marinduque, Phivolcs reported a 5.3-magnitude earthquake with tremors reaching as far as Tagaytay and Quezon City. It was the strongest magnitude earthquake that occurred in the province and sent many residents into panic.

The 7.0-magnitude earthquake that hit the province of Abra and other areas of the country, including Manila, have highlighted the need for more stringent implementation of the National Building Code of the Philippines, its revised implementing rules and regulations, and other issuances, with particular emphasis on the structural integrity of buildings throughout the country, assessment of the damage that may have been sustained as a result thereof, and the prompt and timely implementation of measures to address their vulnerability to seismic hazards or repair any such damage or injury.

In this study, the researchers focused on assessing the seismic vulnerability of evacuation centers using the Rapid Visual Screening method. It is a very useful technique to shortlist the buildings that need detailed vulnerability assessment.

II. METHODOLOGY

PHASE 1: Acquisition of Building Identification Information, Historical Geologic Hazards Data and Soil Type Data

Step 1: Gather building identification information from the Municipal Office of Boac or inquired orally from the building personnel and barangay officials within the study area

Step 2: Gather soil type data and information on geological hazards present on the evacuation center's respective location such as liquefaction, landslides, and surface rupture from the Provincial Planning and Development Office.

↓

PHASE 2: Perform Seismic Vulnerability Assessment of Evacuation Centers

Step 1: Verifying and updating the building identification information

Step 2: Assessing around the building to identify the number of stories and shape on the Data Collection Form

Step 3: Photographing the building

Step 4: Determining and documenting occupancy

Step 5: Reviewing and verifying of the geologic hazards, as identified during the pre-field planning process

Step 6: Identifying adjacency issues, building irregularities, and any potential exterior falling hazards

Step 7: Identifying the building material, gravity load-carrying system, and seismic force-resisting system to identify the FEMA Building Type and circling the Basic Score on the Modified Level 1 Data Collection Form.

Step 8: Circling the appropriate seismic performance attribute Score Modifiers on the Modified Level 1 Data Collection Form.

Step 9: Determining the Final Level 1 Score, SL1 (by adjusting the Basic Score from Step 8 with the Score Modifiers identified in Step 9)

Step 10: Completing the summary section at the bottom of the form (i.e., Extent of Review, Other Hazards and Action Required)

↓

PHASE 3: Generation of Expected Damage Level Map and Seismic Vulnerability Map using QGIS

Step 1: Acquiring shapefiles and raster data from PPDO and other external sources.

Step 2: Determining the exact coordinates of the facilities. Tabulating these on excel together with the facilities basic information.

Step 3: Set an appropriate coordinate system.

Step 4: Importing the acquired shapefiles on a new project in QGIS.

Step 5: perform clipping, buffering, extracting and other processes on the different layers to suit the desired information to be included in the map.

Step 6: Create a new layout with desired dimension.

Step 7: Decide which layers to keep.

Step 8: Add labels and arrange the map elements that are on the generated maps.

Step 9: Apply finishing touches on the overall design of the map.

Step 10: Save and export the project as pdf or image, and print on the appropriate size.

↓

PHASE 4: Map Evaluation

III. RESULTS AND DISCUSSIONS

3.1. Distribution of Designated Evacuation Centers

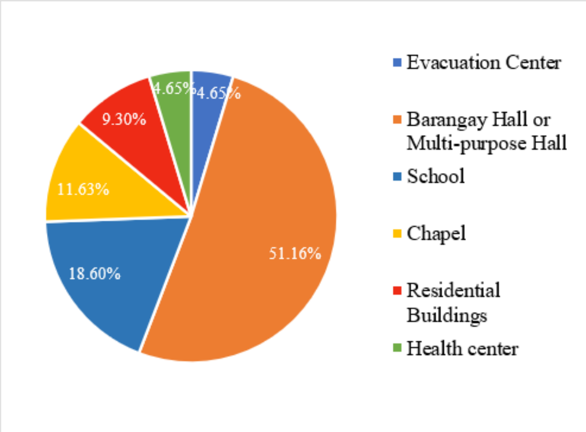


Figure 1: Distribution of Designated Evacuation Centers

Barangay halls or multi-purpose halls are the most commonly used facilities as evacuation centers in twenty-four (24) barangays since those barangays lack evacuation centers, and the barangay hall or multi-purpose hall is the most available and convenient for people to seek shelter once disaster strikes or during emergencies.

Other facilities including School Buildings, Chapels, Residential buildings, and Health Centers are used as designated evacuation centers.

3.2. Building Type

After assessing 43 designated evacuation centers in 24 different barangays, it was found that all of the buildings were of building type C1 or concrete moment-resisting frame. This type of building can be identified if all exposed concrete frames are reinforced concrete.

3.3. Building Irregularities

When it comes to irregularities, specifically moderate vertical irregularities, results suggest that sloping sites and split levels are present in some facilities. On the other hand, the type of severe vertical irregularities present in some facilities includes weak or soft stories, out-of-plane setbacks, and short columns. In terms of plan irregularity, torsion is the most common, followed by beams that do not align with columns and non-parallel systems.

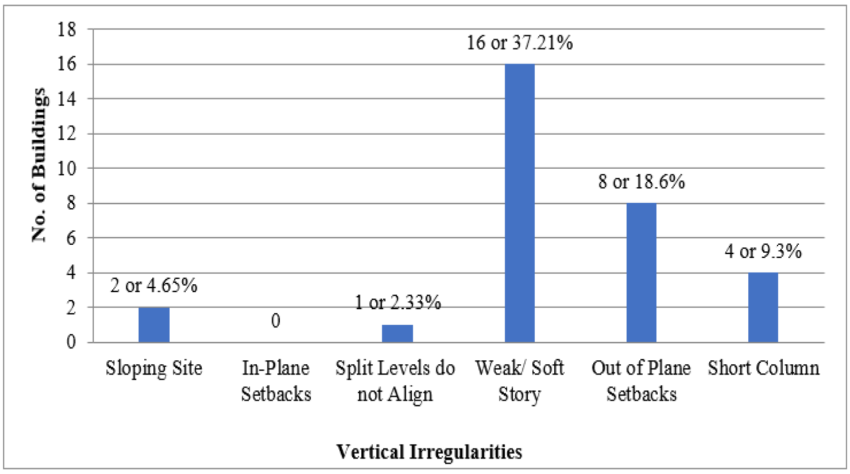


Figure 2: Distribution of Designated Evacuation Centers with Vertical Irregularities

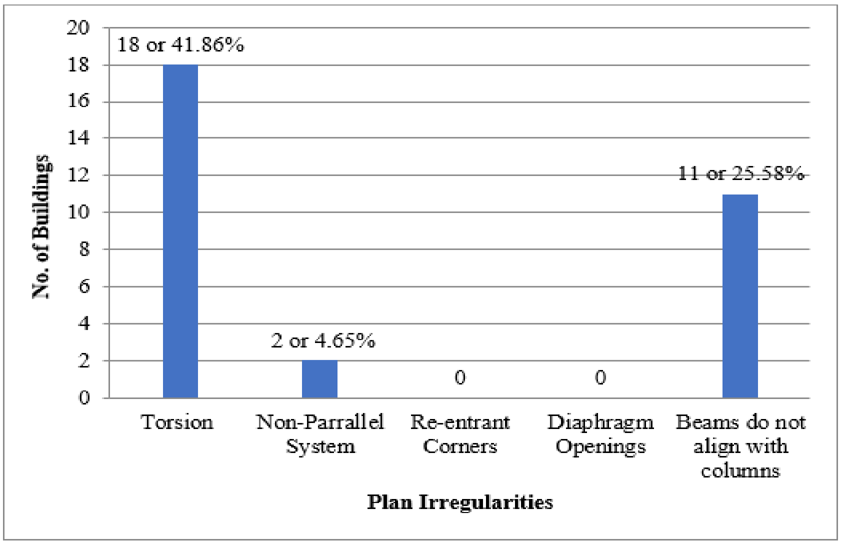


Figure 3: Distribution of Designated Evacuation Centers with Plan Irregularities

3.4. Pre-Code and Post Benchmark

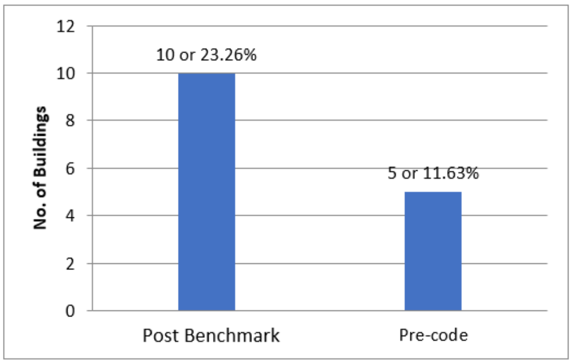


Figure 4: Distribution of Designated Evacuation Centers in which Pre-code and Post Benchmark Year Applies

In addition, Pre-Code was applied to five (5) buildings since these buildings were built before the adoption of codes, or before the year 1972. A post-benchmark was applied to ten (10) buildings since they were built after 2015 or after the adoption of substantially improved codes.

3.5. Non-Structural Hazard

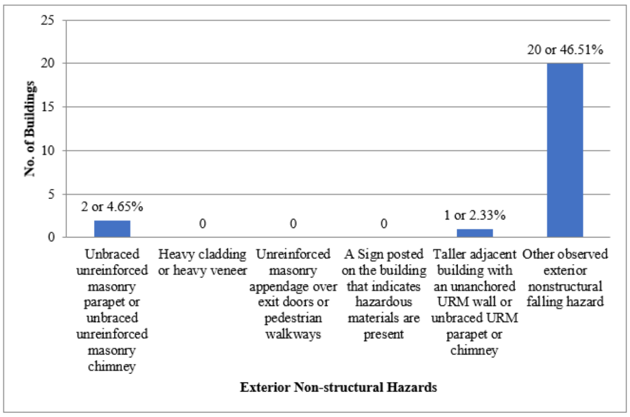


Figure 5: Distribution of Designated Evacuation Centers with Exterior Non-structural Hazard

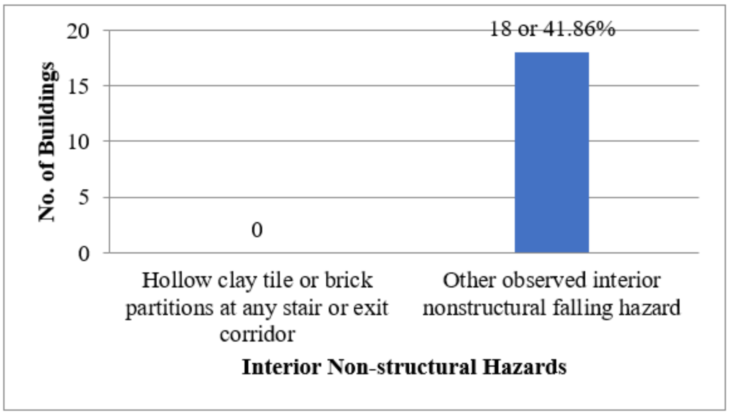


Figure 6: Distribution of Designated Evacuation Centers with Interior Non-structural Hazards

With regards to the non-structural hazards, the most prevalent is the observed presence of trees near the location of the structures, as these would constitute exterior falling hazards in an earthquake. There is also an unbraced unreinforced masonry parapet and a taller adjacent building with an unanchored URM wall or unbraced URM parapet. On the other hand, several designated evacuation centers were observed to have glass walls and windows, unsupported cabinets, TVs, bookshelves, desktop, and countertop equipment, and deteriorating wood trusses and ceilings in close proximity to evacuees that would still put the occupants at risk. Such hazards are existing non-structural hazards that require mitigation, but a detailed evaluation is not necessary.

3.6. Other Hazards Identified

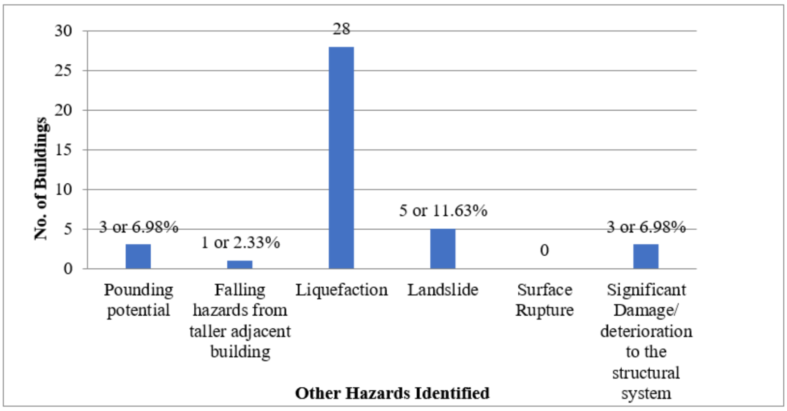


Figure 7: Distribution of Designated Evacuation Centers with Other Hazards Identified

Some facilities have been found to be at risk in terms of other identified hazards, which include pounding potential and falling hazards from taller adjacent buildings. In terms of geologic hazards, landslides were found at the building sites of five (5) evacuation centers. In addition, there are three (3) of the designated evacuation centers that have significant damage or deterioration to structural systems.

The result also revealed that forty (40) structures are identified as potentially seismically hazardous, and the three (3) remaining structures were found to have acceptable seismic performance.

3.7. Expected Damage Level of 43 designated Evacuation Centers as a function of RVS Score

The expected damage levels as a function of the RVS score were also determined based on the RVS results. It shows that there are three (3) structures that have final scores greater than 3, which indicates that these structures may have a probability of Grade 1 damage, which is negligible to slight damage. There are also three (3) structures that have final scores greater than 2.0 but less than or equal to 3.0 that may have a very high probability of Grade 1 damage and a high probability of Grade 2 damage, which may experience negligible, slight, or moderate damage. In addition, nineteen (19) structures have scores greater than 0.7 but less than or equal to 2.0, which may experience moderate damage to substantial to heavy damage; only one (1) structure has a score greater than 0.30 but less than or equal to 0.70, indicating a very high probability of Grade 3 damage and a high probability of Grade 4 damage, and may have substantial to heavy damage to very heavy damage; and seventeen (17) structures have scores equal to 0.30, indicating a very high probability of Grade 4 damage and a high probability of Grade 5 damage, which may result in destruction.

Upon completing the Rapid Visual Screening procedure, results were analyzed, and final scores for forty-three (43) designated evacuation centers were calculated.

It shows that there are three (3) structures, or 6.98% of the total structures, with final scores greater than 3. It indicates that these structures may have a probability of Grade 1 damage, which is negligible to slight damage (no structural damage, slight non-structural damage) such as fine cracks in plaster over frame members or in walls at the base, and in partitions and infills.

The expected damage level maps of all facilities are shown in Figures 9 to 14.

IV. CONCLUSIONS AND RECOMMENDATIONS

By employing Rapid Visual Screening as a method of seismic vulnerability assessment, it was discovered that 40 out of 43 evacuation centers are considered potentially seismically hazardous, of which 38 buildings required detailed structural evaluation and two (2) buildings needed both detailed structural and non-structural evaluation. However, three (3) buildings were found to have acceptable seismic performance, which does not require either detailed structural or non-structural evaluation.

From the results, it was concluded that there are more structures that require further or more detailed analysis than those with acceptable seismic performance, based on the observation that the majority of the buildings are old and were constructed before significantly improved building codes were adopted and enforced by local authorities, which result in a score below the cut-off.

In terms of expected damage to the structures, negligible to slight damage is expected to occur in three (3) structures, and there are also three (3) structures that are negligible to slight damage or moderate damage. Moreover, nineteen (19) structures may experience moderate damage to substantial to heavy damage, and only one (1) of the total designated and evaluated evacuation centers may experience substantial to heavy damage to very heavy damage. On the other hand, seventeen (17) structures, or 39.53, have a high possibility of experiencing very heavy damage or may result in destruction. It could be concluded from these findings that the majority of the structures are expected to suffer from heavy damage and, in the worst case, destruction during severe ground shaking associated with earthquakes of magnitude ranging from 5.0 to 6.9, or Intensity VIII, as suggested from the data used in the probabilistic seismic hazard and risk assessment in the generated spectral acceleration map of the Philippines (2021).

The result of the research project evaluation indicates that the expected damage level maps could be used as a baseline for extensive seismic vulnerability assessments of the buildings, as the result reveals that the maps passed the criteria by which they were considered moderately acceptable. The results from the RVS procedure can be utilized by concerned agencies, government officials, and building and municipal engineers in considering which structures need prior attention.

REFERENCES

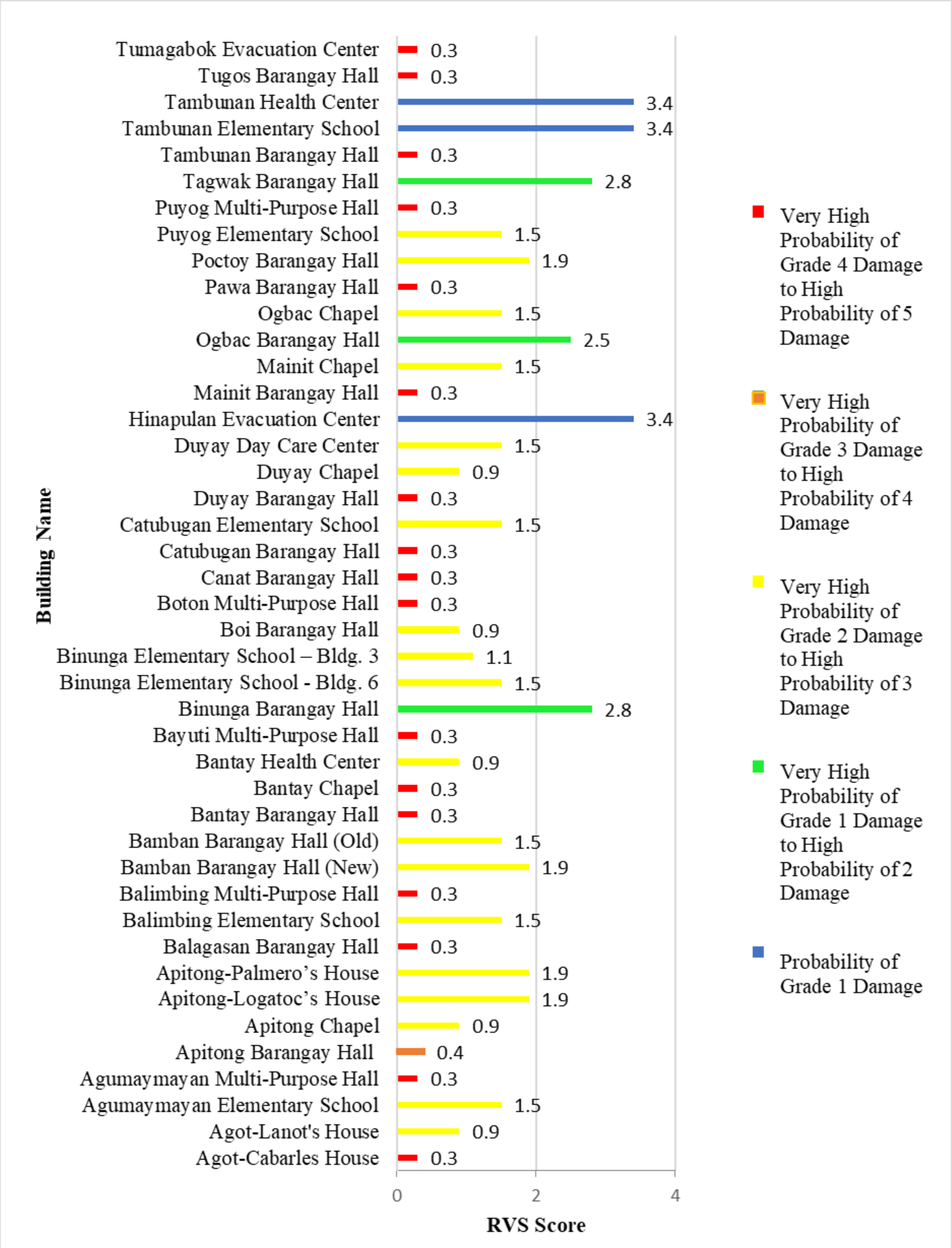
[1] Clemente, S.J., & Concha N., 2020. Assessment of Seismic Vulnerability of Public Schools in Metro Manila within 5 Km from the West Valley Fault Line using Rapid Visual Survey. Retrieved on January 16, 2023 from https://www.researchgate.net/publication/351645107

[2] Department of Science and Technology – Philippine Institute of Volcanology and Seismology, (2021). DOST-PHIVOLCS Releases Spectral Acceleration Maps for Seismic Resilient Design of Buildings. Retrieved on December 8, 2022, from https://www.phivolcs.dost.gov.ph/index.php/news/11550-dost-phivolcs-releases-spectral-acceleration-maps-for-seismic-resilient-design-of-buildings

[3] FEMA, (2015). Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Third Edition. Retrieved on August 10, 2022, from https://unhabitat.org/sites/default/files/2020/01/31_guideline-for-rapid-visual-screening-of- buildings-for-potential-seismic-hazards.pdf

[4] Flores, H., (2018). The Philippine Star. Strong Earthquake hits Marinduque. Retrieved on December 8, 2022 from https://www.philstar.com/nation/2018/02/27/1791612/strong-quake-hits-Marinduque

[5] Liashenko, D., Belenok, V., Spitsa, R., Paviyuk, D., & Boiko, O., (2020). Landslide GIS modelling with QGIS software. Retrieved on August 10, 2022 from https://www.earthdoc.org/content/papers/10.3997/2214-4609.202056069


Building Name
Tumagabok Evacuation Center 0.3
Tugos Barangay Hall 0.3
Tambunan Health Center 3.4
Tambunan Elementary School 3.4
Tambunan Barangay Hall 0.3
Tagwak Barangay Hall 2.8
Puyog Multi-Purpose Hall 0.3
Puyog Elementary School 1.5
Poctoy Barangay Hall 1.9
Pawa Barangay Hall 0.3
Ogbac Chapel 1.5
Ogbac Barangay Hall 2.5
Mainit Chapel 1.5
Mainit Barangay Hall 0.3
Hinapulan Evacuation Center 3.4
Duyay Day Care Center 1.5
Duyay Chapel 0.9
Duyay Barangay Hall 0.3
Catubugan Elementary School 1.5
Catubugan Barangay Hall 0.3
Canat Barangay Hall 0.3
Boton Multi-Purpose Hall 0.3
Boi Barangay Hall 0.9
Binunga Elementary School – Bldg. 3 1.1
Binunga Elementary School - Bldg. 6 1.5
Binunga Barangay Hall 2.8
Bayuti Multi-Purpose Hall 0.3
Bantay Health Center 0.9
Bantay Chapel 0.3
Bantay Barangay Hall 0.3
Bamban Barangay Hall (Old) 1.5
Bamban Barangay Hall (New) 1.9
Balimbing Multi-Purpose Hall 0.3
Balimbing Elementary School 1.5
Balagasan Barangay Hall 0.3
Apitong-Palmero's House 1.9
Apitong-Logatoc's House 1.9
Apitong Chapel 0.9
Apitong Barangay Hall 0.4
Agumaymayan Multi-Purpose Hall 0.3
Agumaymayan Elementary School 1.5
Agot-Lanot's House 0.9
Agot-Cabarles House 0.3
0
2
4
RVS Score
Very High Probability of Grade 4 Damage to High Probability of 5 Damage
Very High Probability of Grade 3 Damage to High Probability of 4 Damage
Very High Probability of Grade 2 Damage to High Probability of 3 Damage
Very High Probability of Grade 1 Damage to High Probability of 2 Damage
Probability of Grade 1 Damage

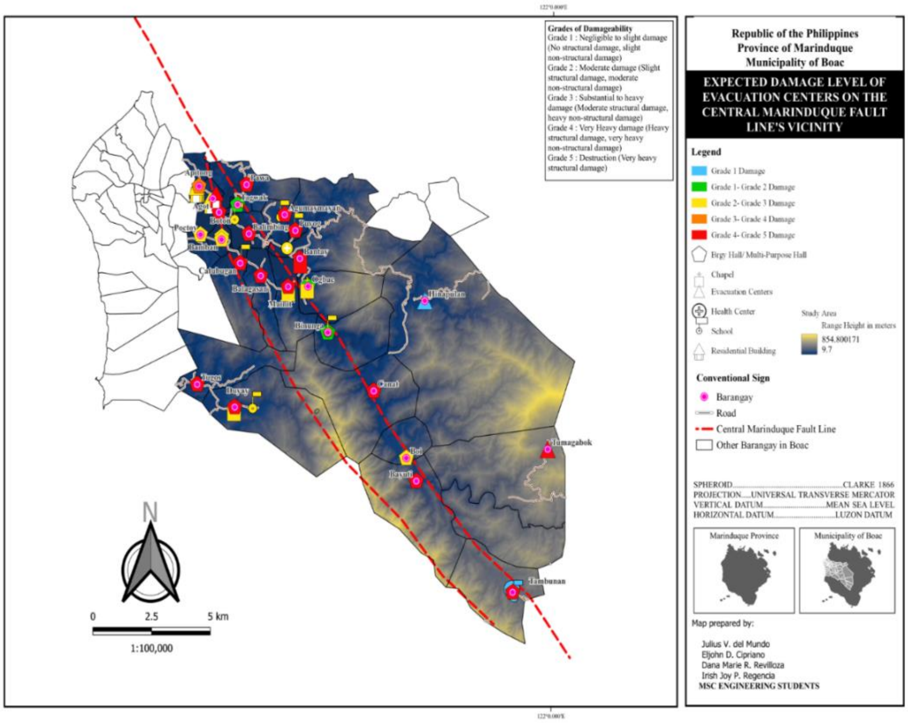


***Figure 9.** Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac*

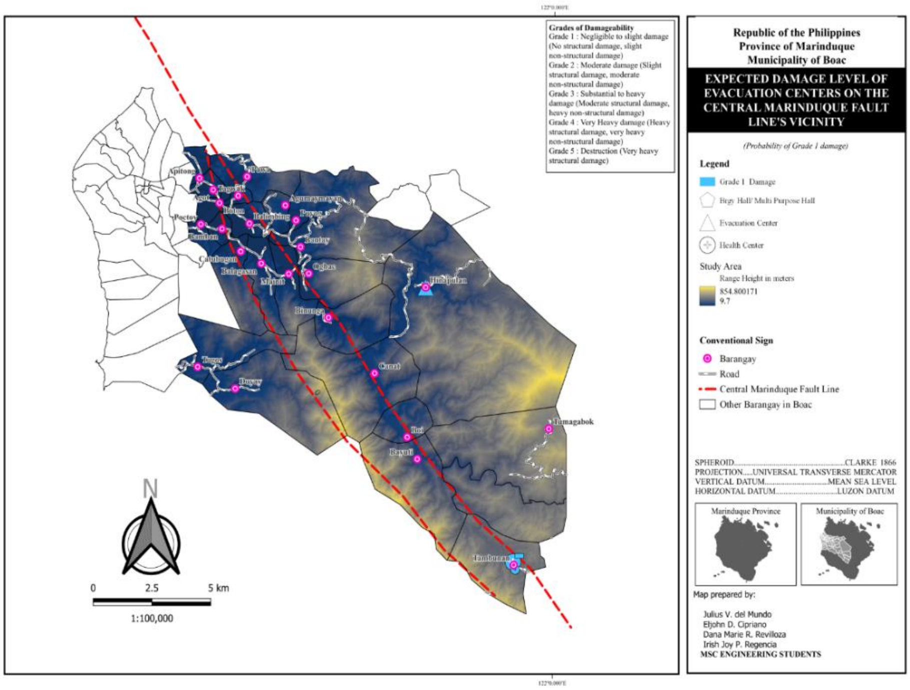


Figure 10. *Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac with Probability of Grade 1 Damage*

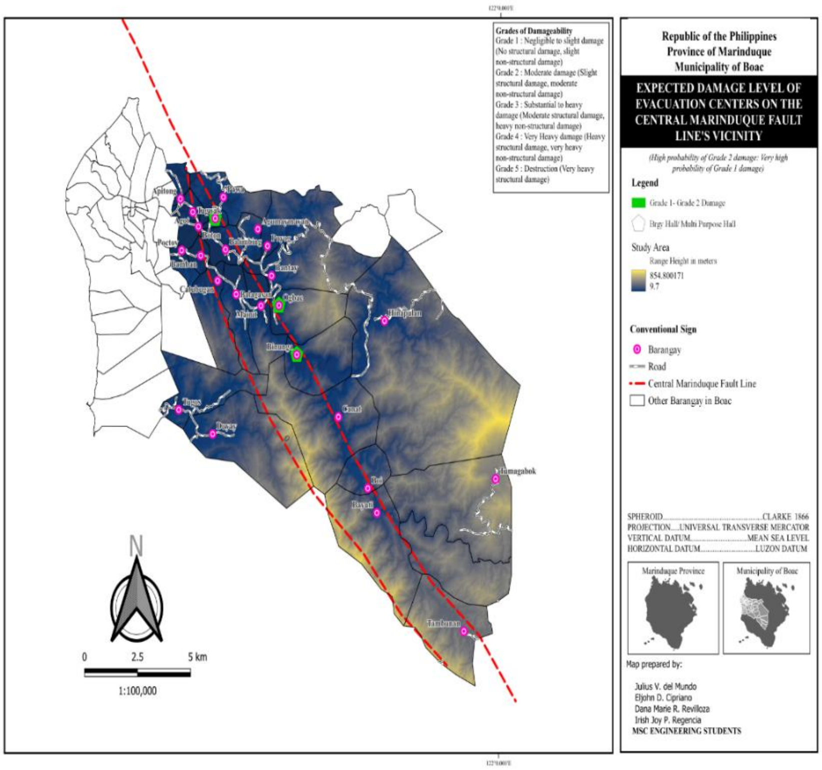


Figure 11. *Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac with Very High Probability of Grade 1 Damage to High Probability of Grade2 Damage*

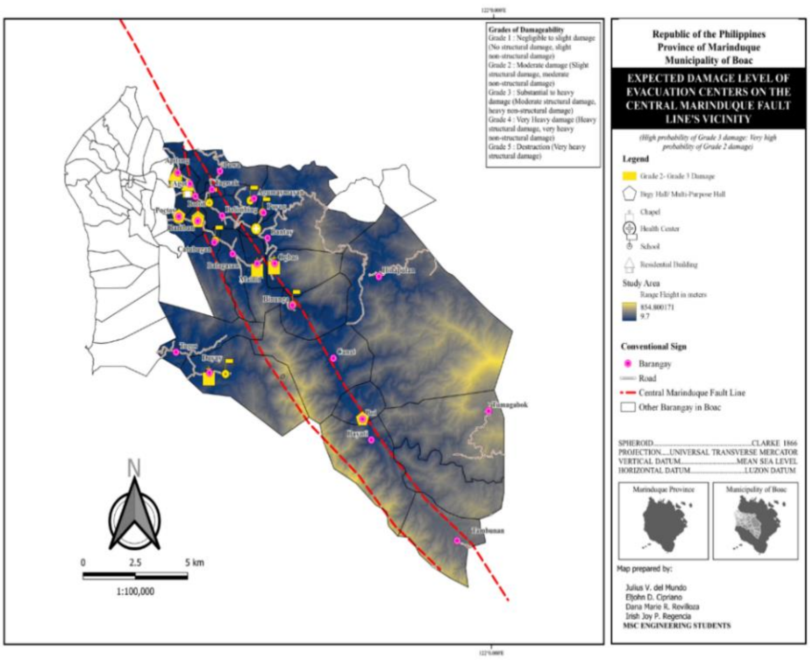


Figure 12. *Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac with Very High Probability of Grade 2 Damage to High Probability of Grade 3 Damage*

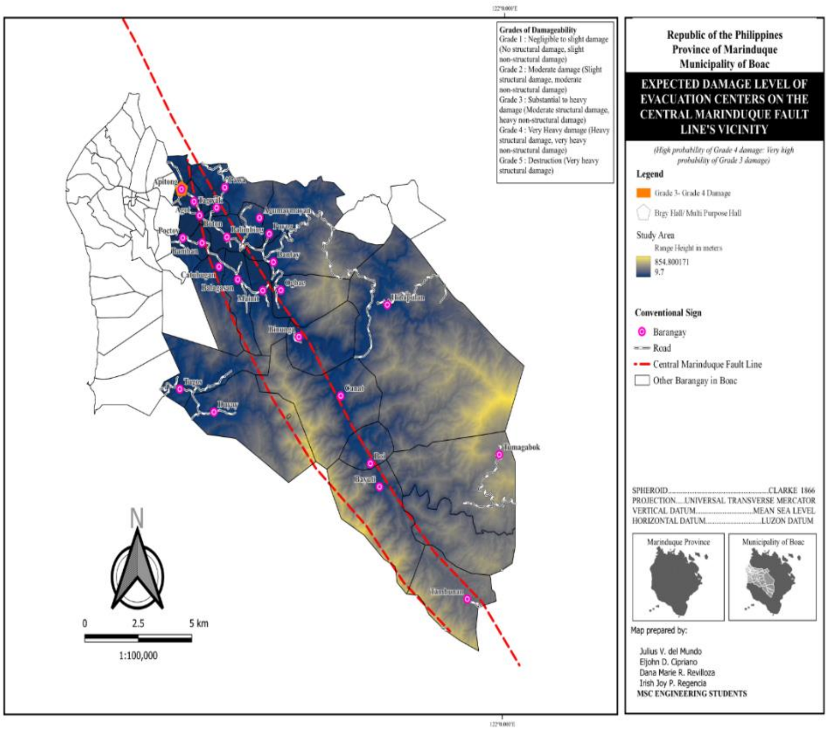


Figure 13. *Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac with Very High Probability of Grade 3 Damage to High Probability of Grade 4 Damage*

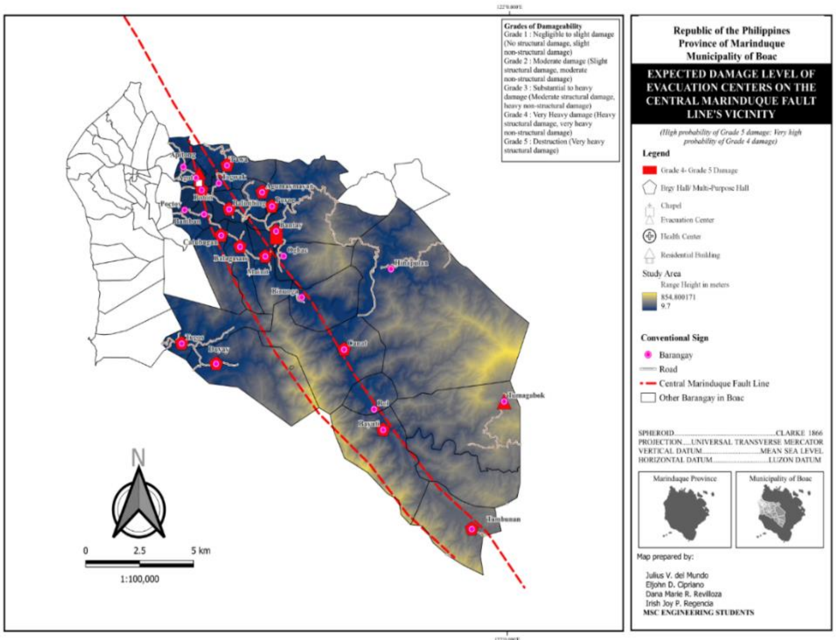


Figure 14. *Expected Damage Level Map of Evacuation Centers on the Central Marinduque Fault Line's Vicinity at the Municipality of Boac with Very High Probability of Grade 4 Damage to High Probability of Grade 5 Damage*