Building vulnerability and human loss assessment in different earthquake intensity and time: a case study of the University of the Philippines, Los Baños (UPLB) Campus

I Rusydy1,3,4*, D V Faustino-Eslava2, U Muksin3,6, R Gallardo-Zafra5, J J C Aguirre5, N C Bantayan7, L Alam4,8, and S Dakey4,9

1 Geological Engineering Department, Syiah Kuala University, Jl. Syech Abdurrauf No. 7, Banda Aceh, 23111, Indonesia
2 School of Environmental Science and Management, University of the Philippines, Los Baños, Pedro R. Sandoval Ave, Los Baños, Laguna, Philippines
3 Tsunami and Disaster Mitigation Research Center (TDMRC), Syiah Kuala University, Jl. Prof. Dr. Ibrahim Hasan, Gampong Pte, Banda Aceh, 23233, Indonesia
4 PARR Research Fellows at University of Philippines Los Baños, Pedro R. Sandoval Ave, Los Baños, Laguna, Philippines
5 Department of Civil Engineering, University of Philippines Los Baños, Pedro R. Sandoval Ave, Los Baños, Laguna, Philippines
6 Physic Department, Syiah Kuala University, Jl. Syech Abdurrauf No. 7, Banda Aceh, 23111, Indonesia
7 College of Forestry and Natural Resources, University of the Philippines, Los Baños, Pedro R. Sandoval Ave, Los Baños, Laguna, Philippines
8 LESTARI, Universiti Kebangsaan Malaysia (UKM), Kampung Bangi, 43600 Bangi, Selangor, Malaysia
9 Visvesvaraya National Institute of Technology, South Ambazari Road, Nagpur, Maharashatra 440010, India

*email: ibnu@tdmrc.org

Abstract. Study on seismic hazard, building vulnerability and human loss assessment become substantial for building education institutions since the building are used by a lot of students, lecturers, researchers, and guests. The University of the Philippines, Los Baños (UPLB) located in an earthquake prone area. The earthquake could cause structural damage and injury of the UPLB community. We have conducted earthquake assessment in different magnitude and time to predict the possibility of ground shaking, building vulnerability and estimated the number of casualty of the UPLB community. The data preparation in this study includes the earthquake scenario modeling using Intensity Prediction Equations (IPEs) for shallow crustal shaking attenuation to produce intensity map of bedrock and surface. Earthquake model was generated from the segment IV and the segment X of the Valley Fault System (VFS). Building vulnerability of different type of building was calculated using fragility curve of the Philippines building. The population data for each building in various occupancy time, damage ratio, and injury ratio data were used to compute the number of casualties. The result reveals...
that earthquake model from the segment IV and the segment X of the VFS could generate earthquake intensity between 7.6 – 8.1 MMI in the UPLB campus. The 7.7 Mw earthquake (scenario I) from the segment IV could cause 32% - 51% damage of building and 6.5 Mw earthquake (scenario II) occurring in the segment X could cause 18% - 39% structural damage of UPLB buildings. If the earthquake occurs at 2 PM (day-time), it could injure 10.2% - 18.8% for the scenario I and could injure 7.2% - 15.6% of UPLB population in scenario II. The 5 Pm event, predicted will injure 5.1%-9.4% in the scenario I, and 3.6%-7.8% in scenario II. A nighttime event (2 Am) cause injury to students and guests who stay in dormitories. The earthquake is predicted to injure 13 - 66 students and guests in the scenario I and 9 - 47 people in the scenario II. To reduce the number of injuries, the authority of UPLB have to carry out the buildings restoration, set up earthquake early warning system in all dormitories, and evacuation sign board.

1. Introduction

The number of human losses when an earthquake occurred is related to the vulnerability of buildings to earthquakes. Another factor that could increase the number of losses is the number of people living or working in the buildings. Buildings that mostly inhibited by people are university or school buildings therefore it is important to study the vulnerability of buildings at university or schools. In this paper we analyzed the building vulnerability and human loss of the buildings of The University of The Philippines, Los Banos (UPLB) that used by students and faculty members of the university.

The University of The Philippines, Los Banos (UPLB) has several types of buildings and different use (academic, service, administration, and dormitories) and some of the buildings are more vulnerable than the other buildings when the earthquake occur. The Philippines has a lot of experiences with earthquakes which caused building damages and injured many people in various parts of the country. One of the greatest earthquakes is The 1990 Central Luzon earthquake in the magnitude of 7.6 Ms [1].

In order to estimate the number of injured people due to different magnitudes and time of earthquake occurrences, in this study we produce the seismic hazard map and building damage of the study area. The seismic hazard map was produced from the fault line which is close to study area. The Deterministic Seismic Hazard Analysis (DSHA) method was used generate earthquake model intensity or ground shaking model. Ground shaking is the primary factor that causes building damage compared to liquefaction, landslide, and seismic bearing capacity [2]. DSHA method used in this study is considered to be accurate since the tectonic setting of area is well studied [3]. The second process is to evaluate the building vulnerability based on the seismic performance in MMI (Modified Mercalli Intensity) of each building and fragility curve of different types of structure [4].

Previously in the Philippines, there is numerous study about earthquake assessment including, seismic hazards, damage assessments, simulations/scenarios, and site responds carried out by several researchers. The ground motion simulation technique was developed based on seismic hazard assessment from historical earthquakes and active faults in the Philippines [1]. The study produced the PGA (peak ground acceleration) map of the Philippines in expected event of 475 years recurrence (10% in 50 years) and occasional events of 100 years recurrence (39% in 50 years). The developed PGA map is a macro-zonation map and the acceleration in bedrock [1]. To develop the micro-zonation map, the site coefficient is needed. In Metro Manila, the earthquake damage estimation was conducted based on earthquake scenario and the seismic performance of the building was determined based on expert’s judgment [5]. The building vulnerability calculated from the fragility curve which is varied in the different types of the buildings.

In this study, we develop the seismic hazard map in ground shaking model at the different sources of earthquakes, calculate the building vulnerability based on the fragility curve and estimate of injury number of UPLB communities for various magnitudes of earthquakes and occurrence time. The
occurrence time of earthquakes used in this study is 2 Am for night-time scenario, 2 Pm and 5 Pm for the day-time scenario as suggested by FEMA [6].

2. Tectonic Setting of The Philippines
The Philippines located in one of the most active tectonic setting in Asia. Several numbers of destructive earthquakes have occurred in every part of the country. The Central Luzon earthquake in 1990 with a magnitude of M_s7.6 was the largest seismic event for Philippines people. Earthquakes in the Philippines could occur along the Philippines trench, the Manila trench, the Philippine Fault Zone (PFZ), and the Valley Fault System (VFS).

The Philippine trench, built by subduction of the western edge of the Philippine Plate penetrating beneath the Eurasia plate. This trench is the primary sources of the earthquakes [1]. The very seismically active Philippines trench extends from south of the Mindanao Island to the Luzon Island in the north for a distance of about 1400 [7]. The Manila Trench is a 1200-km long subduction zone between the South China Sea and the Northern Philippines plate which produced several mega earthquakes [8, 9]. Nguyen, et al., [9], developed the scenarios of the earthquakes for tsunami modeling and the seismic event were divided into six fault zones (the earthquake sources), and the worst case is the earthquake with magnitude of Mw 9.3.

There are two on land sources of the earthquakes for the Philippines which are the Philippine Fault Zone (PFZ) and the Valley Fault System (VFS). The Philippine Fault Zone (PFZ) formed because of oblique motion of the Philippines Sea plate relative to the Eurasia plate [10, 11, 12]. PFZ is an active left lateral strike-slip fault system extending 1600-km from the Mindanao to the Luzon Island [12]. The 1990 Central Luzon earthquake was the most destructive earthquake occurred in the PFZ. The Valley Fault System (VFS) is the nearest fault to study area which is around 20-50 km. The VFS is a 130 km right lateral strike-slip fault system beginning from south of Canlubang, Calamba, Laguna to

![Figure 1. The fault system in the Philippines and the study area in the UPLB campus (black rectangle) and the tectonic map of Philippines, modified from [24, 25, 12], digital elevation model dataset is from NASA 2007](figure1.jpg)
the Umiray and the Dingalan Bay in the north in NNE (North North East) of the strike [12]. The VFS is divided into two major fault systems, the East Valley Fault System (EVFS) and the West Valley Fault System (WVFS). The WVFS is divided into four minor segments, and the EVFS is divided into six minor segments (see Figure 1).

The Pittland–Sungay segment IV of the WVFS and the Talim Island segment of the EVFS are the imminent fault to UPLB with the length of about 20 – 30 km and both segments is recognized as the active faults. The magnitude of earthquake along this fault system have been estimated based on empirical relationships among surface displacement, rupture length, and magnitude within a range of 6.1 to 7.5 Mw (empirical relationship based on length) and in the range of 7.4 to 7.7 Mw (empirical relationship based on displacement) [12]. The earthquake estimation of each segment is shown in Table 1.

Table 1. Magnitude estimates in EVFS and WVFS based on length of segments and maximum displacement [12], see Figure 1 for their location.

| Fault Segments         | Length (Km) | Est. Mag. based on length (Mw) | Est. Mag. based on displacement (Mw) |
|------------------------|-------------|---------------------------------|--------------------------------------|
| Segment I (Rodriguez–Taguig) | 45          | 7.0                             | 7.7                                  |
| Segment II (Sucat–Binan)   | 14          | 6.4                             | -                                    |
| Segment III (Binan–Sto. Domingo) | 12      | 6.4                             | 7.6                                  |
| Segment IV (Pittland–Sungay) | 7.5         | 6.1                             | 7.7                                  |
| Segment V (Umiray)        | 35          | 6.9                             | -                                    |
| Segment VI (San Mateo-Rodriguez) | 37      | 6.9                             | 7.4                                  |
| Segment VII (Antipolo)    | 9           | 6.2                             | -                                    |
| Segment VIII (Angono)     | 10          | 6.3                             | -                                    |
| Segment IX (Binangonan)   | 13          | 6.4                             | -                                    |
| Segment X (Talim Island)  | 14.5        | 6.5                             | -                                    |

The sources of the earthquake models were generated from Segment IV and Segment X and ground shaking models were produced in MMI. The ground shaking or intensity models were highly influenced by local geology condition or site coefficient. Different site coefficient has different site respond to the earthquake model and it is also influenced by soil properties or geotechnical condition underlying the buildings [13, 14, 15].

3. Methodology

3.1. Data preparation
In this study, the earthquake model was generated into two scenarios in a precise way and the model refers to the previous study about the seismicity and the tectonic setting [12]. The ground shaking or intensity scenario was developed using the Intensity Prediction Equations (IPEs) for global application.

This new global shaking attenuation was developed for shallow crustal and near earthquake [16]. The building vulnerability or damage ratio estimation in different types of building was calculated based on fragility curve [4]. The fragility curve is a function of the intensity of the earthquake in MMI. The flow chart of this study is shown in Figure 2.
3.2. Earthquake Model

The generated earthquake model depends on the shaking attenuation that is influenced by physical properties of structures and experimental data [16]. Shaking attenuation is an empiric approach to determine ground motion in PGA (peak ground acceleration) or intensity of the earthquake in MMI (Modified Mercalli Intensity). The latest seismological approach employs the intensity values for efficiently communicating seismic hazard and risk information to the public and media [16]. The different tectonic setting has different shaking attenuation and the choice of what shaking attenuation will be applied in the study based on the similarity of tectonic setting and the source of the earthquake. In this study we used the shaking attenuation [16] to produce earthquake model from the segment IV and the segment X. The shaking attenuation particular designed [16] to compute the intensity in the shallow active tectonic crust in the range of magnitude of Mw 5 - 7.9. This shaking attenuation named as the Intensity Prediction Equations (IPEs) for global application.

The IPEs method was developed using 13,077 earthquakes around the world since 1973 and 1,613 from Asia countries and some of the data taken from the historical earthquake in the Philippines. The intensity of the earthquake in every distance of rupture zone could be determined by:

\[
I \left(M, R_{rup}\right) = c_0 + c_1 M + c_2 \ln R_{rup}^2 + \left[1 + c_3 e^{(M-5)}\right]^2 + S
\]  

(1)

where \(I\) is intensity in MMI, \(M\) is magnitude of the earthquake in Mw, \(R_{rup}\) is the distance to source of the earthquake in Km, \(c_0\) is a coefficient number of 3.950, \(c_1: 0.913\), \(c_2: -1.107\), \(c_3: 0.813\). The site correction \(S\) is related to the site amplification representing the amplification factor of the local soil expressed by:

\[
S = 3.18 \log (F)
\]  

(2)

The earthquake intensity models that are generated from the segment IV and X are the intensity in bedrock without any consideration of site coefficient or site amplification. The site coefficient and the site characteristic of the soil can be determined accurately from shear wave velocity (Vs) and Horizontal Vertical Spectral Ratio (HVSР). However, those parameters also can be estimated from Standard Penetrating Test (SPT), Cone Penetrating Test (CPT), Dilatometer Test (DMT), and Pressure Meter Test (PMT) [13]. In UPLB campus, the Vs data is not available thus we used the N-SPT data and classified it based on the soil classification as suggested by ASCE/SEI 7-10 [17]. In this study we used the previously calculated PGA map for the University of Philippines, Los Banos from Torregosa,
et al [1] and Aguirre [18] in the range between 0.2 to 0.4 g. Based on N-SPT data, the type of soil in UPLB campus is considered as soft soil type E (SE).

Table 2. Site coefficient ($F_a$) for five different soil classifications based on ASCE/SEI 7-10 [17] for PGA map of 0.4 g.

| Site Class | $S_A$ | $S_B$ | $S_C$ | $S_D$ | $S_E$ |
|------------|-------|-------|-------|-------|-------|
| N-SPT      | NA    | NA    | >50   | 15 to 50 | <15   |
| $F_a$      | 0.80  | 1.00  | 1.20  | 1.40  | 1.72  |

3.3. Human Injury Assessment

The UPLB campus is located 16 km from the segment X and 24 km from the segment IV (see Figure 1). The nearest and shallow crustal earthquake could cause the highest impact to the building in terms of damage and casualty [16]. Different type of building has different resistance to ground shaking thus will increase the value of building vulnerability and injury ratio. We refer to fragility curve of the Philippine building in MMI determined previously [4]. The type of building in determination of the fragility curve is similar to that proposed by FEMA [6].

The fragility curve shows the damage ratio or building vulnerability of the structure on a scale of 0 to 1 toward ground shaking [4]. In this study, we used this fragility curve for different types of buildings in the UPLB campus. The main reason we used this fragility curve is because it was developed for buildings in the Philippines (Figure 3).

Figure 3. Fragility Curve of 3 types of buildings in the UPLB campus as a function of intensity in MMI [4]

Valino [19] and Arellano [20] had conducted the building inventory classification of the lower-campus and the upper-campus of the UPLB. They classified 67 buildings in UPLB Lower Campus into two types of building: (1) Low-Rise Concrete moment frame (C1-L) and (2) Medium Rise Concrete Moment Frame (C1-M). We updated the inventory building data from 67 to 145 buildings based on a previous study conducted by Valino [19] and Arellano [20] but we only focused on UPLB lower-campus. The types of buildings in the UPLB lower campus were divided into three type: (1) Low-Rise Concrete moment frame (C1-L), (2) Medium Rise Concrete Moment Frame (C1-M), and (3) Low-Rise Light wood-frame (W1-L). To determine the building vulnerability in different types of buildings
we refer to the fragility curve in Figure (3). Building vulnerability of each building results in different number of casualties because the people is considered to be trapped in collapsed or heavily damaged buildings [21]. There are many equations were used to calculate the casualty ratio. In this study, we used equation (3) which was proposed by Hashemi & Alesheikh [21]. The equation computes the injured ratio separately based on occupancy of the buildings at the earthquake occurrence time, damage ratio or building vulnerability, population of each building, and injury ratio as follows:

\[
\text{Injured} = \text{Occupancy ratio} \times \text{population} \times \text{damage ratio} \times \text{injury ratio} \tag{3}
\]

At the night-time (2 Am), the occupancy ratio was assumed as 1 for dormitories because at this time all students are sleeping in the dormitories but considered as 0 for offices and classroom building in the UPLB campus. For the day-time (2 Pm) scenario, the occupancy ratio in offices, classroom and dormitories is 1. At 5 pm, most of the class were dismissed, and the staff in the offices would already be out of the office thus the occupancy ratio at this time is predicted of 0.5. The population data of the offices and the classrooms were uncalculated and we had no access to the data. The data of the student population in dormitories was obtained from the authority of dormitories and the Programmatic Environmental Performance Report and Management Plan [22] as shown in Table 3. The avoid the unavailability of population data, we used percentage for the population of all office buildings (instead of number) thus the casualty or injury estimation result is also shown in percentage (%). The worst scenario of the injury ratio refers to Hashemi & Alesheikh [21] which was developed for the Teheran city. Although the injury ratio developed by Hashemi & Alesheikh [21] as shown in Table 4 is considered to be relatively high, but the final result of injury could be adjusted by the damage ratio and the occupancy ratio.

**Table 3.** The student population at dormitories in the UPLB campus. The data was obtained from Programmatic Environmental Performance Report and Management Plan [22] and building authority.

| No. | Dormitories                                | Population | Source of Data         |
|-----|--------------------------------------------|------------|------------------------|
| 1.  | Male Residence Hall                        | 646        | PEPRMP 2014            |
| 2.  | Female Residence Hall                       | 444        | PEPRMP 2014            |
| 3.  | Veterinary Medicine Residence Hall          | 376        | Authority of Dormitory |
| 4.  | New Dormitory                              | 294        | Authority of Dormitory |
| 5.  | ACCI                                       | 90         | PEPRMP 2014            |
| 6.  | SEARCA Residence Hotel                      | 90         | Authority of SEARCA    |
| 7.  | ATI-NTC                                    | 126        | Authority of Dormitory |
| 8.  | International House                         | 124        | PEPRMP 2014            |

**Table 4.** The worse scenario of injury ratio for different type of building proposed by Hashemi & Alesheikh [21]

| No. | Type of Building          | Injury Ratio |
|-----|----------------------------|--------------|
| 1.  | RC Building > 4 stories (C1-M) | 0            |
| 2.  | RC Building < 4 stories (C1-L)   | 0.2          |
| 3.  | Timber Frame Building (W1-L)     | 0.4          |
4. Result

4.1. Earthquake hazard model

This study develops two earthquake model at three different times of events: 2 pm, 5 pm, and 2 am. The earthquake models which were calculated using IPEs equation is shown in Figure 3. This result has no consideration of site coefficient. Equation (2) was used to calculate the site coefficient and used as the input of equation (1) to determine the surface seismic intensity. According to ASCE /SEI 7-10 [17] in Table 2, the type of soil E produces the site coefficient of 1.72. Table 5 shows the total intensity on the surface after calculated by using formula (1) and (2) in two different magnitudes and sources of the earthquakes. The site coefficient of 1.72 was assumed to have the same effect to all buildings in the UPLB campus since the UPLB campus was built on nearly homogenously pyroclastic deposits.

The earthquake in scenario I occur along the segment IV (Pittland–Sungay) with magnitude of Mw 7.7 and the earthquake in scenario II occur along the segment X (the Talim Island) with magnitude of 6.5 Mw. The scenario I is the worst scenario for UPLB campus because it is possible to produce the intensity of about 8.1 on the surface. It is noted that the intensity of 8 able to destroy masonry building type B [23]. The Masonry building (type B) was built with excellent workmanship and mortar; reinforced, but was not designed for lateral forces resistance. The intensity in scenario II have similarity of destructive to the Masonry building type B.

![Figure 4](image-url)  

**Figure 4.** Predicted intensity of the $R_{rup}$ using IPEs for Mw 7.1 and Mw 6.5 earthquakes and without consideration of site coefficient.

| Earthquake Scenario | Magnitude $(M)$ | Distance $(R_{rup})$ | Intensity at Bedrock | $S$ | Intensity at Surface |
|---------------------|----------------|---------------------|----------------------|-----|----------------------|
| I                   | 7.7 Mw         | 24 Km               | 7.3                  | 0.82| 8.1                  |

**Table 5.** Earthquake scenarios and ground shaking respond in bedrock and surface.
Earthquake Scenario | Magnitude (M) | Distance (Rrup) | Intensity at Bedrock S | Intensity at Surface |
--- | --- | --- | --- | --- |
II | 6.5 Mw | 16 Km | 6.8 | 0.82 | 7.6 |

4.2. Building Vulnerability

Using the fragility curve in Figure 3, we were able to calculate the damage ratio in a different types of buildings which depend on the surface intensity as shown in Table 5. The magnitude of Mw 7.7 in the scenario I tear the building in a ratio range of 0.32-0.51. This ratio mean, around 32% to 51% of the UPLB buildings in Lower-campus was estimated to be destroyed due to Mw 7.7 earthquake from the segment IV of the Valley Fault System (VFS). This earthquake damages around 51% of the Low-Rise Concrete moment frame (C1-L) building, 47% of the building types of Low-Rise Light wood-frame (W1-L) and 32% of the building types of Medium Rise Concrete Moment Frame (C1-M) as shown in Table 6.

**Table 6.** Damage ratio in a different type of building and scenarios.

| Type of building | Number of Buildings | Damage Percent (%) |
|---|---|---|
| | | Scenario I | Scenario II |
| C1-M | 17 | 32 | 18 |
| C1-L | 126 | 51 | 36 |
| W1-L | 12 | 47 | 39 |

The building with Low-Rise Concrete Moment Frame (C1-L) is the most vulnerable building in UPLB lower-campus where 87% of total building in UPLB lower-campus is C1-L. An earthquake with magnitude of Mw 7.7 from the segment IV is worst scenario. The earthquake could damage 51% of almost all building in the UPLB lower-campus. Most of C1-L buildings in the UPBL campus are old buildings and constructed before 1977 and between 1978 and 2000 [19]. Therefore, it is necessary to revitalize the buildings in the UPBL campus. The damage ratio of C1-L and W1-L types of buildings in scenario II are considered to be lower than that of scenario I.

4.3. Human Casualty Analysis

The first step in human casualty analysis is to determine precise number of population, damage ratio, and intensity of the earthquake model. In the case of intensity map, without any detailed knowledge of how the building responds to the ground shaking at different periods, this method could potentially add more uncertainty to loss estimation [16]. In this study at the first stage, we develop the intensity map model using IPEs equation, the population in the building, and damage ratio as precise as possible. The human casualty analysis caused by two earthquake scenarios was applied into three times: 2 pm, 5 pm and 2 am as suggested by FEMA [6].

4.3.1. Daytime (2 Pm) Earthquake Event

Daytime at 2 pm is a busiest time during a day and at this particular time many students are in classrooms and administrative staff are in their office. The number casualty is calculated by using equation (3). The result shown in Table 7 describes that if the students and staffs have no adequate access to evacuation zone, around 10.2% students or officers will be injured in C1-L buildings, 0% in C1-M building, and 18.8% in W1-L buildings for scenario I. For scenario II, the intensity of earthquake is predicted of 7.6 MMI and it would affect to 7.2% injuries in C1-L buildings, 0% in C1-M buildings, and 15.6% in W1-L buildings.

**Table 7.** The percentage of injury in different type of building at 2 Pm of earthquake event
### Table 8. The percentage of injury in different type of building at 5 Pm of earthquake event

| Type of building | Injury in Percent (%) |
|------------------|-----------------------|
|                  | Scenario I | Scenario II |
| C1-M             | 0          | 0           |
| C1-L             | 10.2       | 7.2         |
| W1-L             | 18.8       | 15.6        |

### 4.3.2. Daytime (5 Pm) Earthquake Event

At 5 pm, the students are mostly outside the building and most of the staff about to going out from the office. At this time period, a half of students stay in dormitories and half of staff are working in the office or the occupancy ratio is 0.5. If an earthquake occurs at this time, the estimated injuries would be 5.1% of population in C1-L building, 0% of population of C1-M building and 9.4% of population in W1-L building for scenario I. For scenario II, the percentage population will injure are 3.6% in C1-L building, 0% in C1-M building and 7.8% in W1-L building. The detailed estimation of injuries is shown in Table 8.

### 4.3.3. Nighttime (2 Am) Earthquake Event

If earthquake occur at 2 am, all student are expected to stay in dormitories and none of students are in the office. In this time scenario, we are able to calculate the number of injury since the population data of residences is available as shown in Table 3. The occupancy ratio at 2 am is 1 for all residences and 0 for offices. There are 8 residential accommodated by the students and guests of the UPLB. In all two scenarios of the earthquakes, the Male Residence Hall is highly vulnerable and we estimate the number of injuries of 66 students in scenario I, and 47 students in scenario II. SEARCA Residence Hotel and New Dormitory is less vulnerable. The number of injured people in UPLB at night-time event is shown in Table 9.

### Table 9. The number of injury at university residential at 2 Am of earthquake event

| No. | Dormitories                     | Type of Building | Peak Population | Number of Injury in different scenarios |
|-----|---------------------------------|------------------|-----------------|----------------------------------------|
| 1.  | Man Residence Hall              | C1-L             | 646             | 66 47                                  |
| 2.  | Women Residence Hall            | C1-L             | 444             | 45 32                                  |
| 3.  | Veterinary Medicine Residence Hall | C1-L             | 376             | 38 27                                  |
| 4.  | New Dormitory                   | C1-M             | 294             | 0 0                                    |
| 5.  | ACCI                            | C1-L             | 90              | 9 6                                    |
| 6.  | SEARCA Residence Hotel          | C1-M             | 90              | 0 0                                    |
5. Conclusion
This study has successfully built earthquake model and predicted the worst scenario for UPLB communities during a different time when an earthquake occurred. Earthquake shaking model in MMI was developed using global applicable macro-seismic Intensity Prediction Equations (IPEs). Even though it is a global shaking attenuation, but the equation was purposed for a shallow crustal earthquake or inland earthquake. In this study, the earthquake model was produced along the Valley Fault System (VFS) which is a shallow crustal earthquake.

The UPLB campus has different types of buildings and all buildings in the UPLB campus are divided into three types: C1-L, C1-M and W1-L. Different type of building and ground shaking will respond in various damage ratios. In a worst scenario in scenario I, 126 of C1-L buildings have 51% of damage and cause 10.2% population injury at day-time. The earthquake occurring at night-time (2 Am) is expected to injure 184 students and guests in worst scenario. To avoid this condition, the authority of UPLB have to conduct the restoration of the buildings and set up earthquake early warning system all dormitories, evacuation sign board and road.

In future, some suggestions have to put on top to improve this study in the UPLB in particular and the Laguna province in general. The respond of the building toward the ground shaking depends on the site coefficient of soil beneath the building. The site coefficient plays a crucial factor in ground shaking intensity and has to be determined carefully. To improve the result of this study, the GIS analysis is recommended to be performed in future to determine the distribution of damage building.

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