Developing Chiang Mai building inventory for earthquake loss assessments

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1. INTRODUCTION

Earthquakes, though categorized as low-frequency disasters, can unleash substantial devastation, resulting in injuries, fatalities, and structural collapses. This research endeavors to construct a city model for Chiang Mai, with the goal of assessing earthquake-induced impacts and damages. Termed the "Catastrophe Model", this initiative encompasses three primary components. The first phase entails building a comprehensive database and conducting field surveys to gather precise building footprints and detailed structural information. Consequently, exposure maps for Chiang Mai can be formulated. The Catastrophe Model's development will facilitate the preparation of effective incident response plans and risk mitigation measures. It will also enable the creation of web applications for disseminating research results efficiently to users. Furthermore, publication and demonstrations will benefit various stakeholders, including the insurance industry, hospital emergency response planning, and public awareness campaigns in Chiang Mai.

2. METHODOLOGY

The methodology is divided into 3 steps. The initial step of the building data survey involves digitizing the footprint of buildings from high-resolution satellite imagery to obtain building footprints and their positions in a coordinate system. This is conducted in densely populated areas in the municipal district of Chiang Mai province, as shown in Figure 1. Building attributes, including structural systems, construction materials, usage types, the number of floors, and usable floor area were obtained by surveying the area using Google Street View. Second step, to obtain data on buildings crucial for modeling specific areas accurately, a Walking Survey is conducted. This in-depth survey includes information such as Number of floors in the building, Building usage types based on HAZUS building occupancy classes, Types of structures based on FEMA [1, 2](36 types), Number of occupants in the building, Estimated age of the building, Vulnerability parameters, Front and side photos of the building and other information. The last step is the advanced level building survey, which is collected from construction drawings. The Information includes the number of bays in the X and Y directions, along with the length of each bay, The specified dimensions of beams and columns, The identification of the position of brick walls and the type of bricks used, The height of each floor in the building (Typical floor height), Vertical setback, The presence of overhangs and Interior photographs of various building usage types.

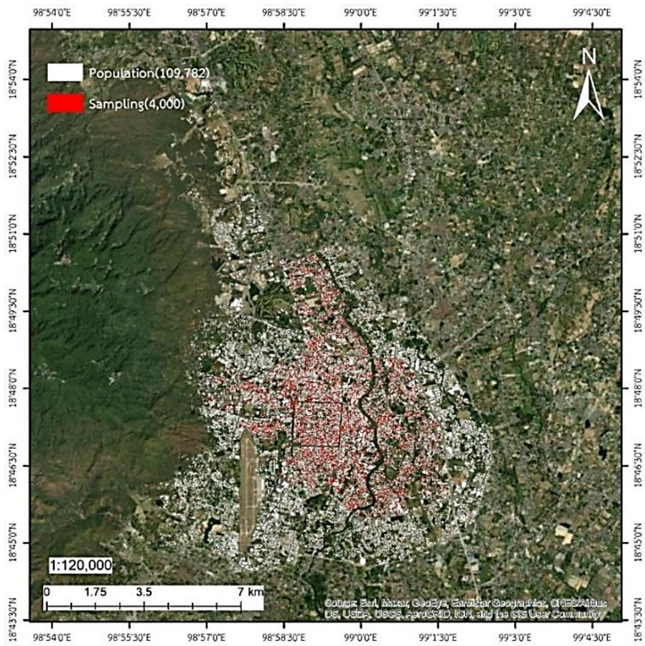

Figure 1. Building footprint for the study area of Chiang Mai and the distribution of sampling surveyed buildings in Chiang Mai

3. RESULTS

For the Basic-GIS survey, the data collection can be done using Google Street View, and the project has successfully surveyed a total of 171,243 buildings as shown in Figure 2, including 109,782 buildings in the Chiang Mai province. The basic level survey is conducted to analyze the collected data statistically, allowing for adjustments to improve the completeness of the Basic GIS data. Currently, our project has successfully surveyed 4,118 sample buildings within the study area. Figure 3 shows that there were 3,101 buildings of Building Type C3 (Concrete Frame with Unreinforced Masonry Infill Walls), which accounted for 75.3% of the total buildings. The most prevalent building usage types were as follows: RES1 (Single Family Dwelling, C3) with 1,638 buildings, accounting for 39.77%, RES3 (Multi Family Dwelling, C3) with 366 buildings, accounting for 8.89%, COM1 (Retail Trade, C3) with 313 buildings, accounting for 7.6%, followed by various other building usage types.

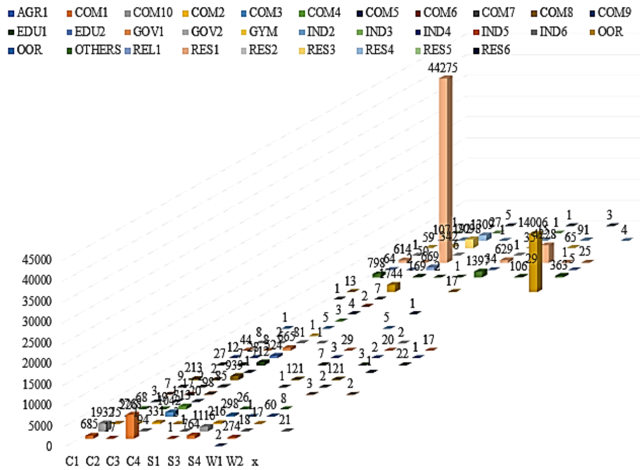

Figure 2. Building structural types and occupancy classes conducted through Google Street view.

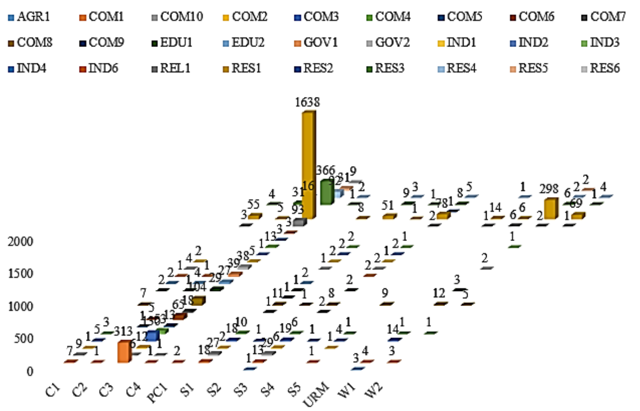

Figure 3. Building structural types and occupancy classes conducted through a walking survey.

There was a total of 988 commercial buildings. Most of these buildings were of the COM1, with 364 buildings, accounting for 36.77% of all the buildings. COM3 had 192 buildings, representing 19.45% of all the buildings, and COM8 consisted of 157 buildings, making up 15.90% of all the buildings. The remaining various other types within the Commercial category accounted for 27.88% of all the buildings (Figure 4).

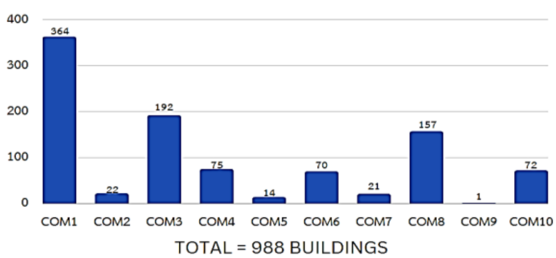

Figure 4. Distribution of the commercial building types

Considering 988 Commercial buildings, there was a total of 311 buildings as Terraced Buildings, accounting for 31.51% of all Commercial buildings. Most of the Terraced Buildings were of type COM1, with 214 buildings out of the 311. Among Terraced Buildings, the highest number of units found was 4 units, totaling 49 buildings. There were 36 buildings with 2 units, and 30 buildings each with 3 and 5 units (Figure 5).

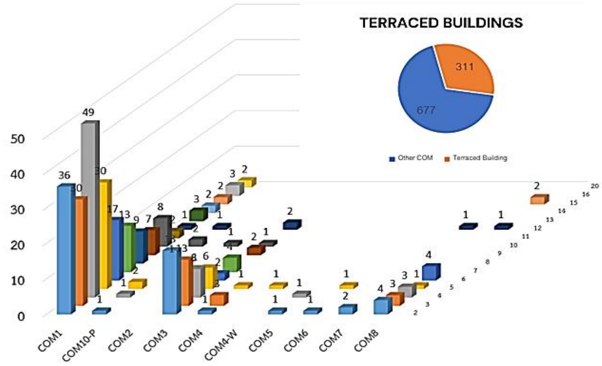

Figure 5. Distribution of the Terraced building types

Terraced Buildings, or row houses, can be classified into a total of 934 units. The majority of these units are of type COM1, with 416 units, accounting for 44.54% of all units. COM3 units make up 272 units, which is 29.12% of the total units, while COM8 units comprise 153 units, equivalent to 16.38% of all units. The remaining unit types within the Commercial category account for 9.96% of all units.

Besides, among all 2,818 Residential buildings, 210 buildings are categorized as Parking, Warehouse, or Space types, accounting for 7.14% of all buildings. These include 178 Parking buildings, 10 Warehouse buildings, and 22 Space buildings. Also, a total of 988 Commercial buildings, 117 buildings fall into the categories of Parking, Warehouse, or Space, representing 11.65% of all buildings. This comprises 87 Parking buildings, 22 Warehouse buildings, and 8 Space.

Table 1. Weighted average of the number of building occupants during the daytime and nighttime per 100 square meters of building area

Occupancy classes	Number of building occupants (day)	Number of building occupants (Night)
RES1	0.887 ± 0.126	1.468 ± 0.167
RES3A	2.107 ± 0.173	3.582 ± 0.338
RES3B	1.137 ± 0.173	2.178 ± 0.245
RES3C	1.389 ± 0.205	2.502 ± 0.300
RES3D	2.028 ± 0.210	3.371 ± 0.295
RES3E	1.721 ± 0.197	3.180 ± 0.338
RES3F	1.622 ± 0.173	2.468 ± 0.182
RES4	1.343 ± 0.182	2.107 ± 0.272
COM1	1.63 ± 0.241	0.444 ± 0.176
COM2	0.91 ± 0.063	0.069 ± 0.11
COM3	2.11 ± 0.371	0.338 ± 0.237
COM4	1.900 ± 0.247	0.408 ± 0.195

Regarding the number of occupants during the day and night, Table 1 shows the weighted average of the number of building occupants during the day and night per 100 square meters of building area. The weighted average of the number of occupants in RES1 is 0.887 ± 0.126 during the daytime and 1.468 ± 0.167 at night. Furthermore, the averages for COM1 are 1.63 ± 0.241 during the day and 0.444 ± 0.176 at night, while the averages for COM3 are 2.11 ± 0.371 during the day and 0.338 ± 0.237 at night.

4. CONCLUSIONS

In this study, we focus on creation of database for the city of Chiang Mai or an Exposure Map using high-resolution satellite imagery to obtain Building Footprints for all buildings in densely populated areas, and to conduct a Walking Survey to gather detailed building information. Currently, our project has successfully surveyed 4,118 sample buildings out of a total of 109,728 within the study area. Analysis of the survey data reveals that the most prevalent structural type in Chiang Mai is C3, comprising 3,101 buildings, constituting 75.30% of the total. These are further segmented by occupancy class: RES1 with 1,638 buildings, RES3 with 366 buildings, COM1 with 313 buildings, and various others. In addition, the weighted number of occupants per daytime and nighttime were presented. Furthermore, to develop fragility curves, 123 and 138 building designs were collected from Mae Hia and Chiang Mai Municipality, respectively. The advanced-level survey focuses on identifying vulnerability parameters of buildings to assess their vulnerability. This information is used to develop fragility functions for representative buildings of different types. Consequently, exposure maps for Chiang Mai can be formulated. The Catastrophe Model's development will facilitate the preparation of effective incident response plans and risk mitigation measures. Furthermore, publication and demonstrations will benefit various stakeholders, including the insurance industry, hospital emergency response planning, and public awareness campaigns in Chiang Mai.

5. REFERENCE

[1] F. E. M. A. (FEMA), *Multi-hazard Loss Estimation Methodology Hazus®–MH 2.1 Technical Manual*. 2013.
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