FRAGILITY OF LOW-RISE RC MOMENT FRAMES IN NORTHERN THAILAND: OBSERVATION FORM THE 2025 MANDALAY EARTHQUAKE

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1. INTRODUCTION

Reinforced concrete (RC) frames with masonry infill walls constitute a significant portion of the building stock, particularly for low- to medium-rise structures across Asia and many other regions worldwide. Following the 2025 Mandalay Earthquake, northern Thailand experienced moderate ground shaking. Despite the relatively low seismic intensity, several low-rise buildings in major urban centers, such as Chiang Mai, sustained noticeable damage. To evaluate the seismic vulnerability of this building class, representative low-rise RC frame structures were modeled and analyzed under varying levels of ground motion intensity. Field survey data of observed damage were integrated with analytical results to develop fragility curves, providing quantitative estimates of the seismic vulnerability of low-rise RC frames in northern Thailand.

2. DAMAGE OBSERVATION

Following the earthquake on April 28, 2025, the Earthquake Research Center of Thailand coordinated with local engineers and Chiang Mai municipality to document damage observed in 241 buildings in the affected area [1]. The survey covered buildings ranging from 1 to 32 stories in height and included various building types, such as schools, residential buildings, and government offices. The observed damage was classified into four categories: 1) Immediate Occupancy; 2) Slight Damage (with continued operation); 3) Moderate Damage (with partial continued operation); and 4) Severe Damage (no access permitted)

For the purpose of this study, data from buildings between 1 and 6 stories were used to represent low-rise buildings in the area. The majority of the damage occurred in infill walls, with only minor structural damage observed in a few exceptional cases. This limited structural damage is likely due to the relatively low level of ground shaking. Field observations were compared with existing experimental results for reinforced concrete (RC) frames with infill walls. Based on this comparison, story drift values were estimated for each documented damage state. These results are summarized in Table 1. Figure 1 provides examples of damage corresponding to each documented damage state.

Table 1. Observed damage for buildings between 1-6 stories in Chiang Mai from 2025 Mandalay Earthquake [1]

Damage State	No. of Buildings	Estimated Story Drift (%)
Immediate Occupancy	109	0-0.25
Slight Damage	24	0.25-0.5
Moderate Damage	3	> 0.5
Severe Damage	1	N/A
Grand Total	**137**	

Slight Damage

Moderate Damage and Severe Damage

Fig. 1. Observed damage and classification (Source: Chaing Mai Municipality) [1].

3. CASE STUDY BUILDINGS

In this study, the fragility of representative buildings was evaluated and compared with the observed damage. In total, 7 buildings were used as representatives of low-rise RC buildings in northern Thailand. These included regular and irregular 2-story school buildings, regular and irregular 3-story office buildings, regular and irregular 4-story apartment buildings, and a 4-story commercial building. Structural models were created to represent the RC frames and the infilled wall [2]. Fig. 3 shows the example structures used in this study. The irregularity of the structures lies mainly in the way the strong infill walls are distributed within the building.

Fragility analysis of the selected representative buildings was carried out using the Multiple Strip Analysis (MSA) Method [3]. Nonlinear dynamic analyses were carried out at 4 different ground motion intensity levels using 20 ground motions at each level. The results in terms of the story drifts from all the buildings were compiled into fragility curves. The curves were generated to obtain the probability of reaching different drift limit states. Fig.3 shows the fragility curves from analysis and the results from field survey.

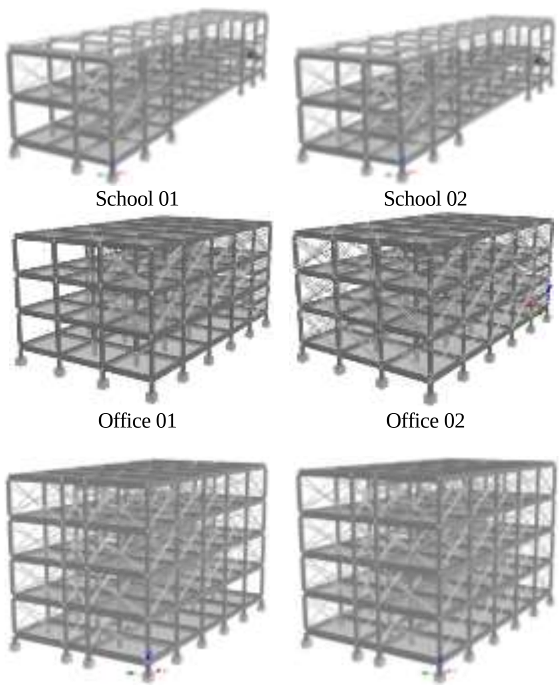

Fig. 2. Example Computer Models of Low-Rise RC Buildings

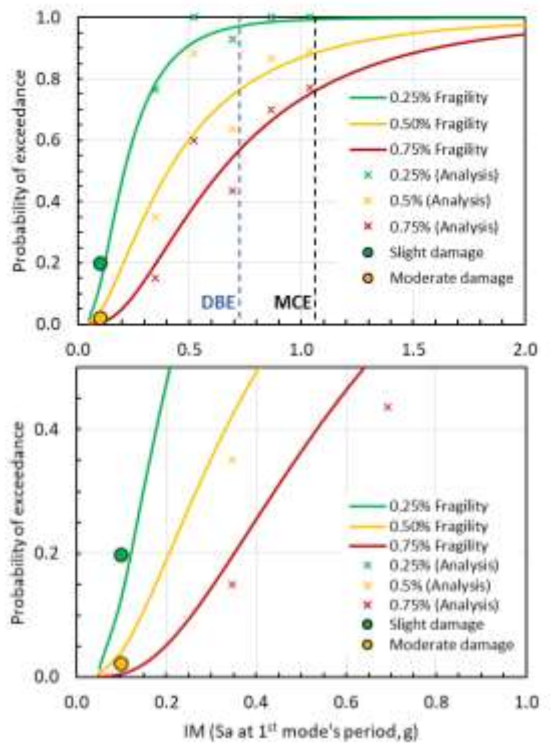

Fig.3. Fragility curves from analysis and observed damage from building survey.

4. CONCLUSIONS

In this study, fragility curves for representative low-rise RC buildings were derived from both nonlinear time history analyses and observed post-earthquake damage, and subsequently compared. The damage observations served as a basis for calibrating the analytical fragility curves, enhancing their reliability. The fragility curves indicate a high likelihood of significant damage to a large proportion of low-rise buildings—exceeding 50%—under design-basis earthquake ground motions. These findings highlight the seismic vulnerability of low-rise building stock in northern Thailand.

5. REFERENCE

[1] Earthquake Research Center of Thailand (2025) Earthquake Damage Survey Database.

[2] Srechai, J., Leelataviwat, S., Wararuksajja, W, and Limkatanyu, S., (2022) "Multi-strut and empirical formula-based macro modeling for masonry" Engineering Structures, 266, 114559.

[3] Baker, W., (2015). Efficient Analytical Fragility Function Fitting Using Dynamic Structural Analysis, Earthquake Spectra, Vol. 31, No. 1, 579–599.