

Development of “E.Mamoru-kun” to call for evacuation of people inside buildings in megaquakes

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1. Background and Objectives

Japan is an earthquake-prone country where more than 20% of the world's earthquakes of magnitude 6 or greater are concentrated [1]. Large earthquakes, for example, have caused a large number of deaths and injuries. In terms of the percentage of deaths, 83.3% of people died in the Great Hanshin-Awaji Earthquake, 76.0% in the Kumamoto Earthquake, and 90.5% in the Noto Peninsula Earthquake due to collapsed buildings, which is a high percentage [2].

Therefore, we thought that human casualties could be reduced if people could correctly judge whether it was safer to be inside or outside a building at the time of an earthquake and take appropriate evacuation actions. Therefore, we aim to reduce the number of deaths and injuries caused by collapsed buildings by creating “E. Mamoru-kun,” a device that measures earthquake shaking, comprehensively considers the magnitude of the shaking and the sturdiness of the building, and calls for evacuation (Figure 1).

2. Research Methodology

The research was conducted in the following steps: building a house model that can be used for repeated earthquake simulation experiments, building a seismic intensity meter to measure acceleration, conducting earthquake simulation experiments, and collecting data.

The model of the house was a 40-year-old wooden house built using conventional construction methods, and was one-twentieth the size of the actual house based on its floor plan. After considering the advantages and disadvantages of using magnets for the connections, we decided to use magnets for the connections because they are easier to handle as a model (Figures 2, 3, 4, and 5).

The seismic intensity meter we built uses an accelerometer (ADXL355) and a Raspberry Pi to calculate the measured seismic intensity, maximum acceleration, and Fourier spectrum in real time (Figures 6, 7, and 8).

The purpose of the simulated earthquake experiment is to clarify the characteristics of shaking that can cause damage to wooden houses. The model and the seismic intensity meter are placed on the same board, and shaking is manually applied to the house model while watching the data from the seismic intensity meter to determine the acceleration, period, and seconds (Figure 9).

3. Results

The results are summarized in Table 1. The model's behavior changed from “the first floor tilted to the left and right” to “the second floor shook greatly” at a point where the effect of the shaking on the model changed significantly. Therefore, it is expected that more reliable information can be obtained by conducting detailed experiments in that area. This may be related to the fact that previous studies have shown that the magnitude of the shaking affected by the height of the building differs.

4. Discussion

It was found that the collapse of a building is caused by the displacement of sway between the first and second floors.

In addition, visual inspection of a completely collapsed building revealed that the first floor was crushed while the second floor remained intact in many cases, suggesting that when a two-story wooden house

collapses, it may be safer to be on the second floor than on the first floor (Figure 10).

In this experiment, the house model and the seismic intensity meter were fixed to the same board, so when the house model collapsed, the pillars, beams, and roof impacted the board, possibly causing the values to be larger than those generated by hand-controlled shaking. We would like to improve the experiment by using data from the seismic intensity meter up to just before the collapse of the model.

5. Future Prospects

The method of generating shaking should be mechanized instead of manual, and the period and acceleration should be set to the values that were set in the experiment so that the experiment can be conducted accurately and reproducibly. E.Mamoru-kun will be made and installed on the wall of the first floor of the house for demonstration tests. The future prospect is to actually utilize the system in evacuation activities.

6. References

[1] “Japan's Land Vulnerable to Disasters,” Disaster Prevention Information, Cabinet Office, Government of Japan:

<https://www.bousai.go.jp/kaigirep/hakusho/h18/bousai2006/html/honmon/hm01010101.htm>

[2] Tokiwa System, “Explanation of the Ratio of Causes of Death in Major Earthquakes,”

<https://www.tokiwa-system.com/column/column-298/>

Keywords: Earthquake, Device that call for evacuation, Seismic intensity meter, Simulated earthquake experiment



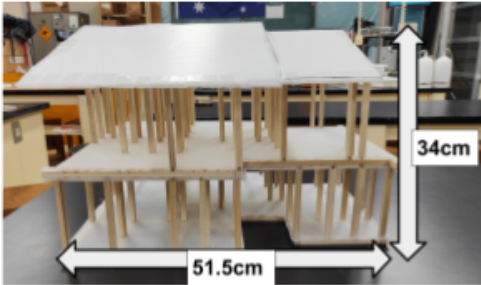
(図1) E.まもるくんの仕組み
(Fig1) How E.Mamoru-kun works



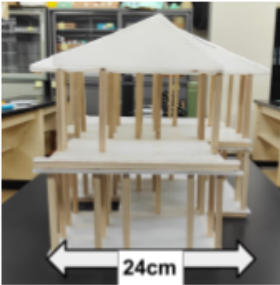
(図2) 柱の底面
(Fig2) Bottom of column



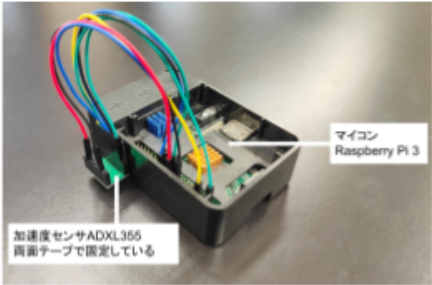
(図3) 柱と梁の接続部
(Fig3) Connection between column and beam



(図4) 模型の長辺は51.5cm、高さは34cm
(Fig4) The long side of the model is 51.5 cm
Height is 34 cm



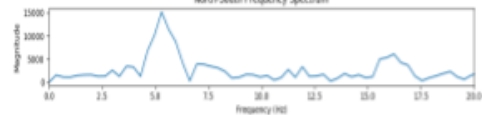
(図5) 模型の短辺は24cm
(Fig5) Model of short side is 24 cm



(図6) 作製した震度計
(Fig6) Seismic intensity meter produced



(図7) 計測震度・加速度の表示
(Figure 7) Display of measured seismic intensity and acceleration



(図8) フーリエスペクトルの表示
縦軸: 揺れの強度、横軸: 周波数(Hz)
(Fig8) Display of Fourier spectrum
Vertical axis: intensity of shaking, Horizontal axis: frequency (Hz)



(図9) 模擬地震実験の様子
(Fig9) Simulated earthquake experiment

	計測震度	震度階級	最大加速度	周期	模型の様子
1	4.7以下	5弱以下	-	-	影響なし
2	-	-	400gal未満	-	
3	5.0以上	5強以上	-	-	一階部分が左右に傾く
4	-	-	400gal以上	-	
5	5.3以上	5強以上	-	-	二階部分が大きく揺れる
6	-	-	2000gal以上	-	
7	5.4	5強	2416gal	-	全壊
8	5.8	6弱	2760gal	-	

(表1) 模擬地震実験の結果
(Table 1) Results of simulated earthquake experiments



(図10) 倒壊した住宅模型 (Fig10) Collapsed house model