# BUILDING DAMAGE ANALYSIS FOR FUTURE EARTHQUAKES

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## Introduction

Japan is located in one of the most seismically active regions in the world. The ever increasing cost and casualty of earthquake in the past several decades has warranted commitments and cooperative endeavors by the insurance sector, as well as the emergency management agencies at a national and international level, toward reducing the losses caused by earthquake disasters. Many methods have been proposed to estimate the losses and casualties during the past earthquakes. Since building and lifestyle have been changed by past several years in Japan, a generalize method needs to estimate the losses and casualties of earthquake. This paper describes, a methodology for estimating losses and casualties due to earthquakes in Japan. The methodology is explained as (1) numerical simulation to estimate damage and loss for wooden building; and (2) statistical analysis to estimate the loss and casualty in an area. To estimate the losses and casualties, the relationship between the building damage and losses is investigated. Then modification factors are introduced for other influence factors such as time of occurrence, earthquake scenario and population density of the area. The proposed method can be used to (1) determine the seismic behavior, damage level, economic and human losses for wooden buildings; and (2) estimate approximate economic loss and human casualty of a Japan city for any future earthquakes.

## Earthquake Caused Damage

Earthquake could make damage almost in all the parts of city. Major damage during an earthquake caused mainly due to ground motion, ground failure and tsunamis. In this study the damage caused by ground motion is analysis. Although the earthquake proof design of structure have been improved, housing development on the unstable ground such as the inclined and the reclaimed ground, multistory and overcrowded buildings in the town have suffered during recent earthquakes.

## Building Damage Estimation by Numerical Simulation

3D Distinct Element Method (DEM) has used for the numerical simulation of the collapse process of the buildings [2]. The model behaves as continuous medium before fracture of the springs but after fracture, this model will only encounter contact between member elements. By using DEM, it is possible to follow the track of elements that have separated from the whole assembly.

A Wooden building frame has modeled using DEM and observes its seismic performance for different earthquakes. Based on numerical analysis results and nonlinear mapping the conventional method of damage estimation has been replaced by direct numerical simulation. For given joint strength and earthquake the building damage can be estimate from the energy dissipated at the joints.

The damage state of the building ($D_s$) for given dissipated energy (E) can be expressed in the form of,

$$P[D_S / E] = \Phi\left[\frac{1}{\beta}\ln\left(\frac{E}{E_\alpha}\right)\right]$$

Where,

$D_s$ – Damage state of the building

E – Dissipated energy at the joints during earthquake

$E_\alpha$, $\beta$ – Mean and Standard deviation of dissipated energy respectively

$\Phi$ – Cumulative probationary function

Keywords: Distinct Element Method, Human Casualty, Joint Strength, Numerical Analysis, Peak Ground Acceleration
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## Casualty & Economic Loss Estimation

Although there is many factors influence the human casualties during an earthquake, building collapse is one of the major causes of human casualties. Human death is mainly caused by the building collapse while the human injuries are mainly due to falling objects or overturning of heavy furniture.

Past earthquake history records, even though not fully detailed, shows the number of human deaths has a good agreement with the number of collapsed houses (Fig. 01), and human injuries has good correlation with peak ground acceleration (Fig. 02).

Direct economic loss to buildings based on separate damage and loss estimates for the structural, non-structural components and contents. The repair or replacement cost of each damage state is expressed as a fraction of total replacement cost of the system of interest.

## Conclusions

Numerical modeling and damage estimation for wooden building has explained. Statistical based casualty and economic loss estimation also explained. For prospective earthquakes approximate casualty and economic losses can be estimate using this methodology.

## Acknowledgement

The authors wish to acknowledge to Dr. Masato Abe for his guidance and advice to carry out this study.

## References

1. Applied Technology Council (ATC), 1985. “Earthquake Damage Evaluation Data for California”.
2. Sarwar, M.W., Abe, M., Fujino, Y., 2003. “Seismic Performance of Wooden Houses With Emphasis on Joint Behavior”, *Proceedings of the Second Annual Meeting of Japan Association for Earthquake Engineering,* Keoi University, Yokohama, pp. 122-123

## Tables and Figures

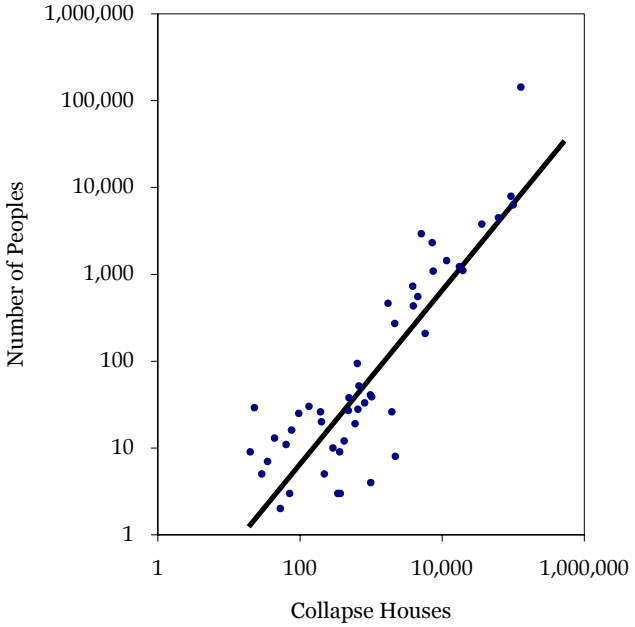


Fig.01 Number of Deaths has good correlation with Collapse houses

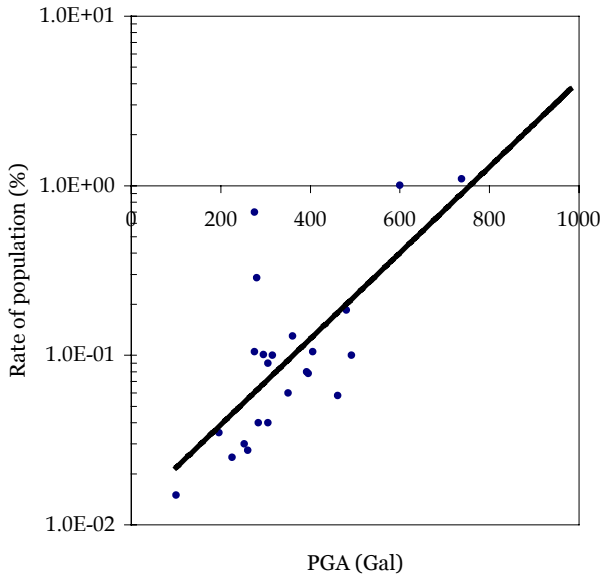


Fig.02 Number of Injuries has good correlation with Peak Ground Acceleration