Earthquake Research Institute,
The University of Tokyo

November, 2018

Division of Disaster Mitigation Science: Koichi Kusunoki

Is your home safe to occupy after an earthquake? Development of a rapid seismic performance evaluation system with inexpensive sensors

After a catastrophic earthquake, the levels of damages of buildings have to be evaluated in order to prevent loss of lives caused by damages or collapses of buildings due to aftershocks. Kobe earthquake revealed that most people preferred to evacuate from their homes in fear of damages, even though the damage levels were not severe. Quick inspection of damaged buildings can be a potential solution to evaluate the damage level, and help the residents to overcome their fear. Damage levels of shelters, such as school buildings, need to be quickly evaluated to decide whether those can be used as shelters. However, visual inspection of each individual building is time consuming. Further, Tohoku earthquake revealed that safety of high-rise buildings also needed to be evaluated even though the damages did not appear to be severe. This extends the downtime of high-rise buildings since visual inspection of each structural component takes long time. Development of a quick damage evaluation system is indispensable to surmount these problems.

The author has developed a rapid residual seismic capacity evaluation system [1, 2, 3, 4, 5]. The developed system measures absolute accelerations at each floor with accelerometers, and the displacements are derived from the measured accelerations with a double integral technique. The validity of the proposed method has been confirmed with experiments involving instrumented existing buildings and shaking table tests.

To continuously evaluate the serviceability of a building, it is necessary to evaluate not only the level of damage of structural elements, but also that of non-structural elements. A new project is just launched to develop a new system for detecting damages of non-structural members, such as ceiling system and tile finishing using video cameras. In order to validate this new system, a shaking table test with full-scale 3-story reinforced concrete structure which includes non-structural members will be conducted in 2020.

1.Kusunoki, K. and Teshigawara, M. (2004): Development of Real-Time Residual Seismic Capacity Evaluation System –Integral Method and Shaking Table Test with Plain Steel Frame-, the 13th world conference on earthquake engineering, CD-Rom.

2.Kusunoki, K., Elgamal, A., Teshigawara, M. and Conte, J. P. (2008): Evaluation of structural condition using Wavelet transforms, the 14th World Conference on Earthquake Engineering, CD-Rom

3.Kusunoki, K. and Teshigawara, M. (2003): A New Acceleration Integration Method to Develop A Real-Time Residual Seismic Capacity Evaluation System, Journal of Structural And Construction Engineering, No.569, 119-126 (in Japanese)

4.Kusunoki, K., Tasai, A. Teshigawara, M. (2012): Development of Building Monitoring System to Evaluate Residual Seismic Capacity after an Earthquake, the 15th World Conference on Earthquake Engineering, Digital

5.Kusunoki, K. (2016): Damage Evaluation of A Base-Isolated Building With Measured AccelerationsDuring Tohoku Earthquake, the 16th World Conference on Earthquake Engineering, Digital

Figure 1: Green, Yellow, and Red tags for current Japanese rapid inspection, which is based on visual inspection by engineers.

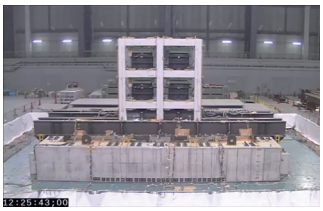

Figure 3: The system was evaluated with a large scale shaking table test. The specimen has a pile foundation to reproduce more realistic condition.

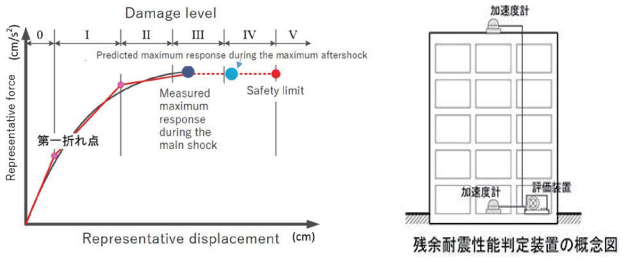

Figure 2: The building is instrumented with a few inexpensive sensors, which are connected to a computer. When an earthquake occurs, the system automatically derives the performance curve, which is the relationship between the restoring force and deformation. Based on the performance curve, the system estimates the damages during the main shock, and predicts the damages due to the largest possible aftershock.

EARTHQUAKE PREDICTION RESEARCH CENTER : AKIHITO NISHIYAMA

LONG-TERM SEISMIC ACTIVITY DATABASE BASED ON HISTORICAL DIARIES WIDELY DISTRIBUTED IN JAPAN

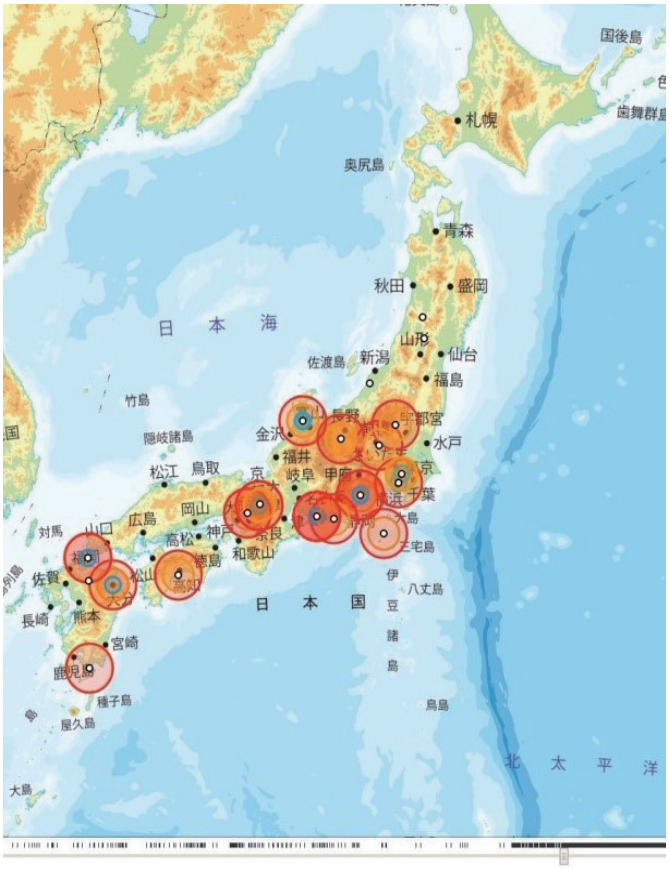

Fig.1: Aiming at the comprehensive understanding of historical earthquake activities, the present database covers not only damaging mainshocks but also the smaller foreshocks or aftershocks. Spatio-temporal distribution map of felt earthquakes related to the Ansei Nankai Earthquake (December 24, 1854).

Japan is exposed to frequent disaster risks of earthquakes. Descriptions on these natural disasters can be found in a large amount of historical diaries that were written by officials of local governments before the middle of AD 19C. These historical diaries were often used as official records of local governments and contain descriptions about natural phenomena such as daily weather, earthquake ground shaking or volcanic smoke. As the historical earthquake records, the historical diaries have several good points:

1. Since the description was made on the same day as the earthquake occurred, it is highly credible.

2. The places where the diaries were written can be precisely specified.

3. Since the same person kept the diary for several decades, continuous and stable information can be obtained.

4. In Kinki district, especially around the ancient capitals, Kyoto and Nara, the historical diaries have been existing from the ancient and medieval (AD 10-16C) eras providing the continuous records of about 900 years. From the modern times (AD 17-19C), the historical diaries can be found nationwide.

In this research, we are developing a historical earthquake database based on the historical diaries. The database contains not only damaging events but also small felt earthquakes, and also provides the daily information on the existence and absence of earthquakes. This novel database is expected to help the better understanding of long-term characteristics of the earthquake activities in Japan

In the future, we plan to increase the variety of historical diaries and improve the spatial density of the database. By combining the present historical analysis with earthquake researches based on modern instrument observations, we aim to elucidate the long-term nationwide earthquake activities in Japan from the historical era to the present day.

***The Collaborative Research Organization for Historical Materials on Earthquakes and Volcanoes*:**
Historical data is essential for long-term forecasts of future seismic and volcanic hazards. To develop a scientific database that can provide long-term information about seismic and volcanic activities in Japan, The Collaborative Research Organization for Historical Materials on Earthquakes and Volcanoes has been established as a collaboration between the Earthquake Research Institute and the Historiographical Institute at the University of Tokyo.