Building Seismic Performance Evaluation Methods for Non- Engineers

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The 2011 Tohoku Earthquake affected people in Tokyo metropolitan area nearly 400 km away from the epicenter. Although no structural damage was observed in most buildings, many people were excessively frightened as the building shaking was often the largest and longest ever experienced by them. In addition to this wide-spread discomfort, business and residential functions were lost in many buildings due to non-structural damage including fallen ceiling panels and toppled furniture. This experience has increased the desire in people to understand the seismic performance of the buildings they live in or own. Until now, seismic safety of buildings has been evaluated by technical indices including structural strength, maximum story drifts and maximum response accelerations. These indices however are highly specialized and for the most part, only understood by structural engineers. In an effort to convey building response in a way that does not require knowledge of structural engineering, Takenaka Corporation proposes two new evaluation methods.

Fig.1 shows the application of one of the proposed evaluation methods to the analytical response of a 7-story steel building subjected to a ground motion record observed in Tokyo during the 2011 Tohoku Earthquake. The method uses previously identified amplitude limits associated with discomfort (Architectural Institute of Japan, 2004), fear and difficulty in evacuation (Takahashi, 2010), along with limits for furniture response (Hamaguchi, 2004). The acceleration response of the building with conventional structure, with supplemental energy dissipation and seismically isolated are shown left to right, respectively. From the maximum spectral ordinate of the analytical response, the following conclusions are reached:

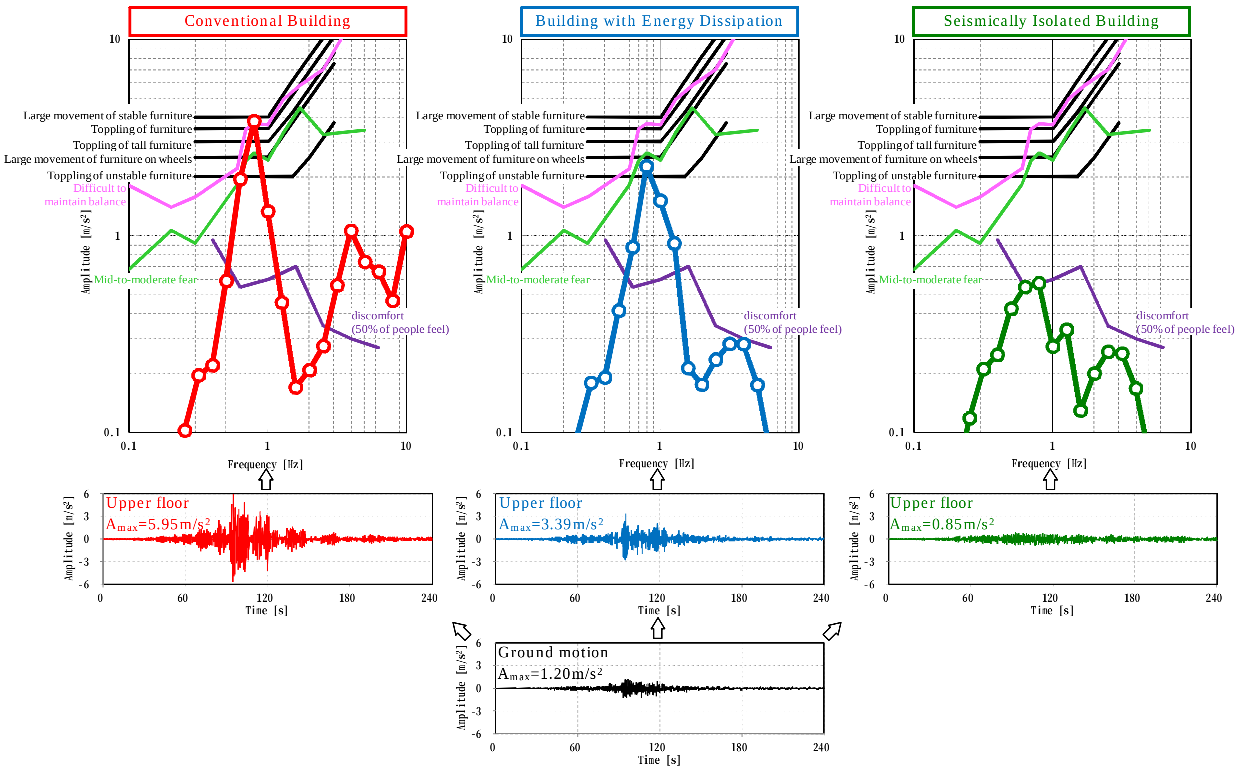

Fig. 1 Spectral evaluation method for seismic performance of buildings

・Conventional building: Almost all furniture topples, people are frightened and some may find difficult to maintain balance and avoid hazards.

・Building with supplemental energy dissipation: People may feel discomfort and unstable furniture may topple.

・Seismically isolated building: People may feel discomfort but there is little chance of furniture toppling.

The second proposed evaluation method is shown in Fig.2. This method is based on the relationship between ground motion input and the response of different building types, not including high-rise buildings. Both the input ground motion and building response are characterized using the seismic intensity scale of the Japan Meteorological Agency (JMA), a scale very familiar to most Japanese, where Seismic Intensity 7 (SI-7) is the largest possible. Similar to the previous method, Fig.2 shows the response of a conventional building, a building with supplemental energy dissipation and a seismically isolated building. The figure allows people to easily understand the difference in expected earthquake response for the different building types and illustrates what may happen to those buildings when subjected to each earthquake intensity level. To illustrate the evaluation method, the expected building responses for the particular buildings analyzed in the previous evaluation method are shown in Fig.2. From the figure it is clearly seen that for the same ground motion intensity, the building response varies significantly depending on the building type.

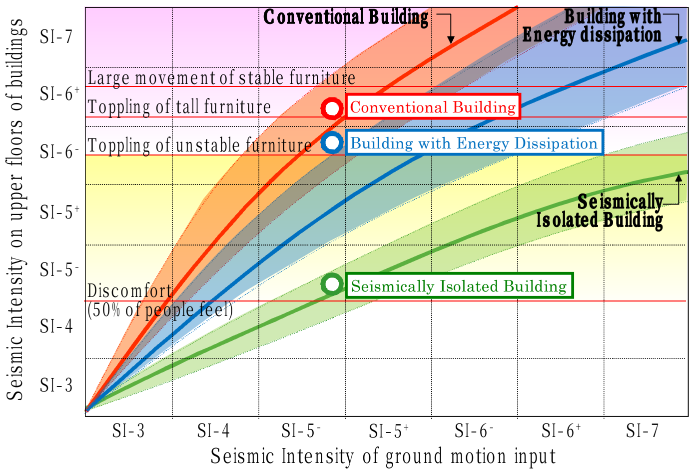

Fig.2 Evaluation method for seismic performance of buildings based on JMA's Seismic Intensity

In addition to providing a general understanding, these two evaluation methods may be utilized in the design stage using results of time-history analysis to help building owners understand how their building would shake or potentially be damaged for different ground motion intensities. This tool will improve the mutual understanding between structural engineers and building owners and aid in the decisions of which safety level their building should be provided.

References

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