Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT59-06 Room:104 Time:May 20 15:30-15:45

Quantification of Collapse Margin to Respond to ”Beyond Scenario Earthquakes”

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The 2011 March 11 Tohoku Earthquake caused the most serious damage to the land and society in the modern history of Japan. The earthquake brought about serious damage, both physical and social, and left us with a variety of lessons. Earthquake engineering faces many challenges of research to comply with those lessons and build the environment that is safer and more secure. Among those, the following two themes, namely, (1) Response to earthquakes beyond what is considered in structural design and (2) Continuing business and prompt recovery, are considered to be most urgent for research and development. To carry out research to this end, those themes must be translated into specific engineering research subjects, and they are identified as: (A) Quantification of collapse margin of buildings and (B) Monitoring and prompt condition assessment of buildings. The first research subject, i.e. ”quantification of collapse margin” is most relevant to the first theme, i.e., ”response to earthquakes beyond design load”. For many plausible reasons, it is impractical that the design earthquake load is increased to the level of a very low-probability, huge earthquake event. Then, how should we compromise? A practical solution is to quantify the reserve capacity of the structure from the level corresponding to the design earthquake load to the level of ”collapse” at which people may lose their life. With such quantitative information at hand, we can argue in a sensible manner what would occur if the building were hit by an earthquake that is twice as large as the design earthquake load and we can also estimate the consequences of such an extreme event.

Suppose we accept the importance of quantification of collapse, are we equipped with means that can do so? The answer depends on the capacity of our numerical simulation technologies to trace the collapse of structures. Numerous efforts have been underway to this end, and various high-fidelity, advanced numerical simulation codes have been made available. However, the accuracy of collapse simulation has not yet been calibrated, and the utmost reason is the lack of ”actual, realistic data on structural collapse”. To resolve this issue, a comprehensive, five-year research program has been launched since last year. The program is named ”Special Project for Reducing Vulnerability in Urban Mega Earthquake Disasters” with the subtitle of: ”Maintenance and Recovery of Functionality in Urban Infrastructures”. In the project, large-scale tests on a steel high-rise building structure and a RC mid-rise building structure are being planned, and these structures are to be shaken to collapse. The project has a strong component of advanced numerical simulation in which the test data will be utilized as the benchmark data for the calibration of accuracies expected in the simulation. The paper introduces the outline and background of the new project, together with some preliminary outcomes.

Keywords: beyond scenario earthquake, collapse margin, large-scale shaking table test, numerical simulation