A Finite Element Approach to Analyze Motion Behaviors of Indoor Non-Structural Components of Buildings

Daigoro Isobe[1*], Masato Katagiri[2], Takashi Fujiwara[2], Toshiki Miura[2]

[1]Division of Engineering Mechanics and Energy
University of Tsukuba
1-1-1 Tennodai, Tsukuba-shi, Ibaraki 305-8573, Japan
isobe@kz.tsukuba.ac.jp

[2]Graduate School
University of Tsukuba
1-1-1 Tennodai, Tsukuba-shi, Ibaraki 305-8573, Japan
{s1420877, s1520916, s1211184}@u.tsukuba.ac.jp

ABSTRACT

The Great East-Japan Earthquake, which occurred on March 11th, 2011, had caused catastrophic disasters along the coast side of East-Japan mainly by a huge tsunami driven by the diastrophism. The earthquake not only damaged structural components of buildings and facilities but also indoor non-structural components of buildings which were located several hundred kilometers away from the epicenter. Indoor non-structural components such as ceilings, doors and furniture, could become fatal obstacles that obstruct people from evacuating or could even injure them. Motion behaviors of these indoor non-structural components have become one of the main targets of recent investigations to reduce number of victims in such events.

Under these circumstances, a finite element code, which can handle motion behaviors of non-structural components of buildings, was developed. The code was developed with a use of an ASI (Adaptively Shifted Integration)-Gauss technique [1][2] which was originally developed to simulate collapse behaviors of buildings. It provides higher computational efficiency than the conventional code in those problems with strong nonlinearities including phenomena such as member fracture and elemental contact.

One of the applications of the numerical code was a ceiling collapse analysis of a gymnasium under seismic excitation. It is very important, nowadays, to know the collapse mechanism of the ceilings since it causes not only the possibility of human injuries, but may disturb the use of the facilities after earthquakes. The behaviors of plaster boards near walls and roof top, which drop occasionally due to detachment of clips and screws, were well simulated.

The behaviors of door frames in a ten-story reinforced concrete (RC) building during seismic excitations were also simulated. According to the simulation, the door frame in lower level had deformed to a critical angle that could likely damage the door and make it difficult for people to evacuate, while the story-drift angle of the building itself had not reached to a critical one.

Another application of the numerical code was a motion analysis of furniture under seismic excitation. A sophisticated penalty method was applied, in this case, to realize the slip and contact motions of furniture with and without casters. The tumbling motions of furniture were well simulated as a whole in spite of different conditions of seismic waves.

References

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