Improvement of Contact Algorithm in Motion Analysis Code of Furniture under Seismic Excitation

Sora Yoshimi[1] and Daigoro Isobe[2]

[1]Graduate School of Systems and Information Engineering, University of Tsukuba
1-1-1 Tennodai, Tsukuba-shi, Ibaraki 305-8573, JAPAN
s1920955@s.tsukuba.ac.jp

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

There are some possibilities of overturn or fall of furniture during earthquakes even though the damage to the building is small. This may cause injury to people and obstruct evacuation routes. Therefore, it is necessary to know the overturning behaviors of furniture and to take effective earthquake resistance measures on furniture. However, the overturning behaviors of furniture are greatly influenced by the seismic motion of floors and walls that constitute the building. Hence, it is necessary to consider the motion of buildings simultaneously to obtain more accurate behaviors of furniture. In this research, a finite element analysis code which can simulate the behaviors of furniture in a building under seismic excitation was developed.

The numerical code is based on the adaptively shifted integration (ASI)-Gauss technique [1], which is a finite element scheme that provides higher computational efficiency than the conventional code. Numerical models of building and furniture were constructed with linear Timoshenko beam elements. To realize various contact phenomena during seismic excitations, a contact algorithm based on the sophisticated penalty method used in the previous study [2] was improved and adopted. First modification was done to realize more accurate calculation of contact forces between furniture. Second modification was aimed to consider the effects of rotation of the floors and walls.

First, the improved contact algorithm was verified by using numerical models of two box-shaped furniture piled up on a floor. To verify the normal force, vertical downward force was applied to the top surface of the furniture on the above. Furthermore, to verify the calculated dynamic frictional force, the furniture on the above was subjected to horizontal forces. The numerical results showed more accurate normal forces and dynamic frictional forces acting between the furniture than the previously used algorithm. Next, the motion of furniture placed on the upper floors of a mid-rise reinforced concrete building was simulated using the proposed algorithm.

References

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