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RESPONSE OF INTERIOR OBJECTS TO EARTHQUAKES

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INTRODUCTION: Residents of buildings are subjected to injuries from displacement of surrounding objects (overturning of shelves, falling down of overhead articles, etc.). Material loss due to the damage to the overturned and fallen down objects can also be considerable. To be able to estimate the stability of rigid body assemblies, the response has to be followed from the onset of the excitation. With the response being highly nonlinear and as such, extremely complex to derive analytically, explicit numerical approaches handling a large number of arbitrary shaped bodies and regarding various kinds of boundary conditions may be more convenient to apply. Many researchers have addressed the above problem of rigid bodies on a rigid floor in various ways. Most efforts were expanded upon the study of behavior of a single rigid block on a rigid floor[1 and 2]. Response of two rigid blocks, as a tower, was analytically examined[3], and found rather painstaking and lengthy. The authors seek a numerical approach that is applicable to rather general models and boundary conditions. The Distinct Element Method (DEM) and a contact model (Figure 1) proposed by Cundall[4] seem to be appropriate to the problem at hand.

METHOD: Shaking table tests were conducted to investigate the response of rectangular wooden blocks and block assemblies of various sizes and slenderness to harmonic and earthquake base excitation. The shaking tests were followed by an analytical and a numerical study of response of single blocks and block assemblies. The analytical study was aimed at establishing criteria of the initiation of rocking and of overturning in response to harmonic base motion and was constituted of numerically solving the differential equations of motion of a rigid block on rigid foundation. The numerical study, in the course of which the response of both single blocks and block assemblies was examined, was implemented by means of the DEM. Prior to the DE simulation of actual shaking tests, preliminary analyses were conducted to confirm numerical stability and to evaluate material and damping parameters. The fundamental idea of the authors' work is to confirm applicability of the chosen DE model to testable cases such as single blocks and simple assemblies of blocks, and than forward to numerical analysis of cases that emerge in reality[5].

RESULTS: Recently the authors have been implementing an easy-to-use, interactive 'what will happen if' sort of visual package (Figure 2) that will tell the user what is expectable to become of the interior on a certain floor of a building at a specific site in case of an earthquake. With this new system in use anybody, regardless of qualification, can obtain an idea of the reaction of interior objects to intense ground shaking. The user can freely set the conditions of the simulation. It is possible to specify the floor on which the apartment or office we inquire about is located (Figure 3); the user than shall select one of several historical earthquake motions as input base motion (Figure 4). What is left is only the arranging of the interior itself. Simply by clicking in the screen the user can choose a desired set of interior objects (Figure 5) that will be exposed to the motion of the specified floor computed from the input ground motion. Finally, the computed response of the interior objects is presented in a real-time animation (Figure 6) from which the importance of the problem will be very simple to perceive. The authors believe that this informative system will raise awareness to the importance of positioning of furniture and other sorts of potentially hazardous objects of interiors.

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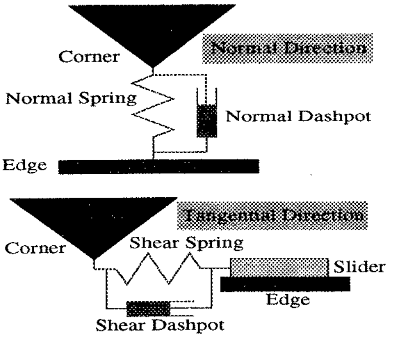

Figure 1. The DEM model.

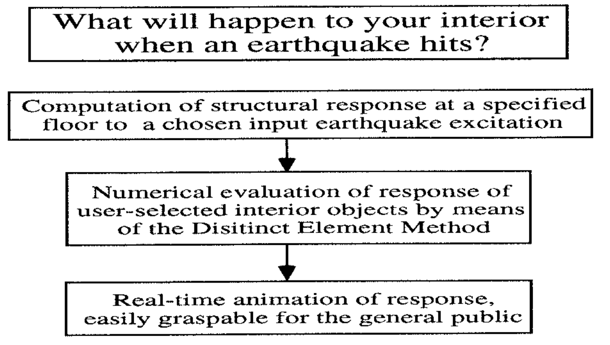

Figure 2. The concept of the system.

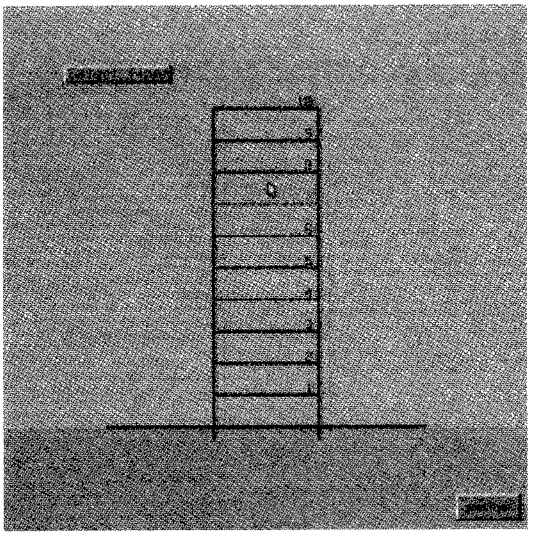

Figure 3. Selecting floor.

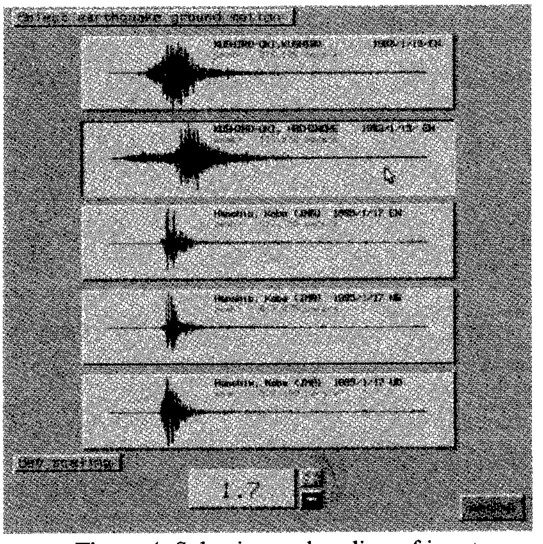

Figure 4. Selecting and scaling of input earthquake ground motion.

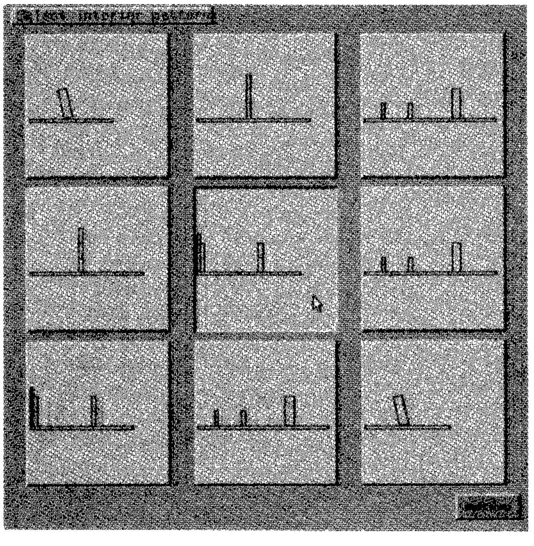

Figure 5. Choosing interior.

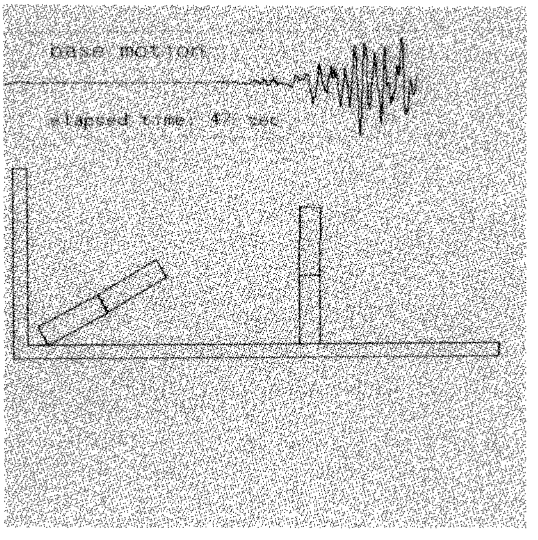

Figure 6. Real-time animation of response.