

Shaking Table Tests on Cluttered Levels of Typical Medicine Shelves and Contents Subjected to Earthquakes

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1. Introduction

Cluttered situation due to overturned and fallen objects is a frequently observed phenomenon after earthquakes. This study investigates quantitatively the cluttered situation due to typical medicine contents of pharmacies in hospitals by shaking table tests.

2. Test specimens, setup and loading program

The test specimens included three conventional types of shelves used in pharmacies, as shown in Fig. 1. The breadth and height of the shelf are the test parameters. Totally five, three and one specimens are prepared for the three types, respectively. In the tests, medicine packages and bottles infilled with sand bags to have proper weights were placed in the shelves following the same method in pharmacies. The specimen was placed against a RC wall, constructed on the shaking table. After each excitation, motions of the shelf and cluttered situations were recorded.

The input excitations included sinusoidal excitations and earthquake motions. As for sinusoidal excitations, the input frequencies were the likely range of equivalent frequency of earthquakes; the amplitude was increased until the specimen overturned. Besides, earthquake motions were also input. The aim is to investigate how to apply the results of sinusoidal excitation for evaluating the cluttered situations under real earthquakes.

3. Test results

For input of sinusoidal excitations, the results are summarized as follows.

(1) **Stock shelf:** A predominant characteristic was

that objects placed in the shelf began to drop from the lower rows, while those in the upper rows hardly dropped out (Fig. 2). The cluttered situation occurred when the acceleration reached 400 gal, about the value of μg (μ : friction coefficient, g : gravitational acceleration). The cluttered distance was influenced simultaneously by acceleration and velocity. With the same ratio of breadth to height of the shelf, the cluttered distance was not influenced by the shelf breadth perpendicular to the overturning direction. Differences in the shelf height of 150, 180 and 210 cm did not influence the cluttered distance.

(2) **Tablet medicine shelf:** The characteristic that objects dropped from the lower rows was the same as observed in the stock shelf. The cluttered situation occurred at 250 gal, less than the value of μg . The reason is that the placed bottles, different from the packages placed in the stock shelf, were prone to overturn and roll out at a smaller acceleration before sliding. The cluttered distance was influenced by acceleration and velocity simultaneously.

(3) **Powder medicine shelf:** Due to response amplification of the top shelf, falling of bottles occurred at 200~250 gal, less than the value of μg . The falling ratio showed a high correlation with the multiplication of acceleration and velocity.

For input of earthquake motions, the predicted critical accelerations dividing different cluttered levels are calculated as 1.75 times those obtained from the input of sinusoidal excitations. Good agreement was observed between the predicted and test results.



Stock shelf Tablet med. shelf Powder med. shelf

Fig. 1 Three types of medicine shelves



Fig. 2 Objects placed in stock shelf began to drop from the lower rows