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Experimental and Analytical Study on Sliding Behavior of Traditional Timber Building under Strong Earthquakes

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SUMMARY

In many of traditional timber buildings in Japan, columns are just placed and not fastened on their foundations. Such timber buildings have possibilities of sliding under strong earthquakes. The behaviors of sliding, rotating due to free column from foundations are not made clear yet. In evaluating the seismic safety of the timber building, it is essential to make clear seismic behaviors including sliding and rotating. In this paper, a response analysis method of traditional timber buildings is presented by considering sliding and rotating. The effects of impact between columns and foundations are also taken into account. Considering horizontal and vertical response, two-dimensional equations of motion are formulated. Sliding obeys Coulomb friction law, and both sliding during shear deforming response and during rotating response are considered. Rotation of structure is initiated when the reaction force from the foundation becomes zero at the bottom of one-side column. Figures 1 and 2 show the analysis model and its restoring force characteristics on the shear deformation. Analytical parameters are determined by the testing results.

In order to confirm the validity of the proposed method, the results of numerical analysis are compared with the results of shaking table tests. Testing specimen are two types of timber frame: a lower and a higher one (Photo. 1, 2). First, the analytical results for sliding response of a lower and rigid wooden frame model without shear deforming and rotating under horizontal excitation show good agreement with the results of shaking table tests (Fig. 3, 4).

Next, the sliding behavior of a higher timber frame model is considered. The analytical results for shear deforming and sliding responses agree well with the testing results in several cases (Fig. 5). In other cases, however, the simulated sliding displacement does not agree with the testing results even if we tuned up the friction coefficient of analysis model (Fig. 6). Figure 7 shows the instantaneous sliding displacements in the same tests of Fig. 6. In the instants when the specimen slides to the plus direction, the analytical results show good agreement. However, in the instant when the specimen slides to the minus direction, the analytical results do not coincide. It is supposed that the friction coefficient of the testing specimen varied depending on the sliding direction.

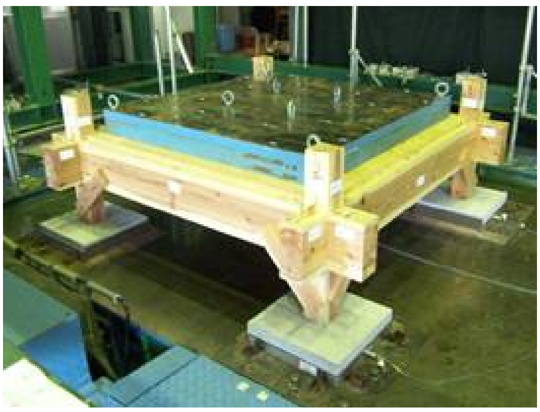

Photo. 1 Lower and rigid specimen.

Photo. 2 Higher timber frame specimen.

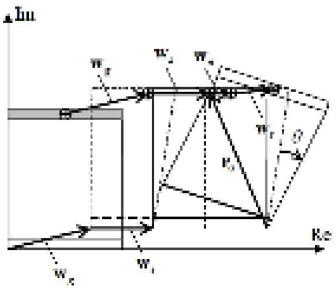

Fig. 1 Analysis model.

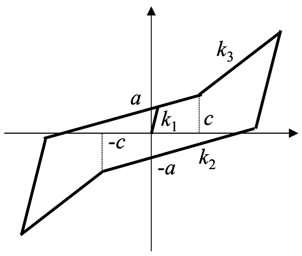

Fig. 2 Restoring characteristics

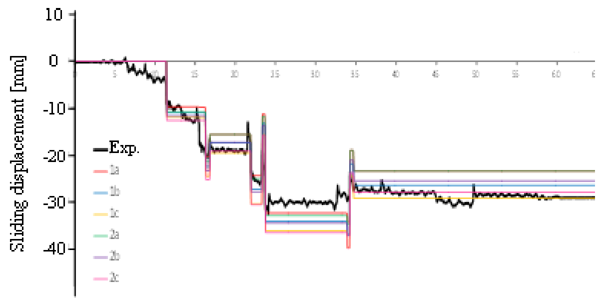

Fig. 5 Comparison of sliding displacements of the higher specimen under BCJ-L2 wave 350cm/s^2.

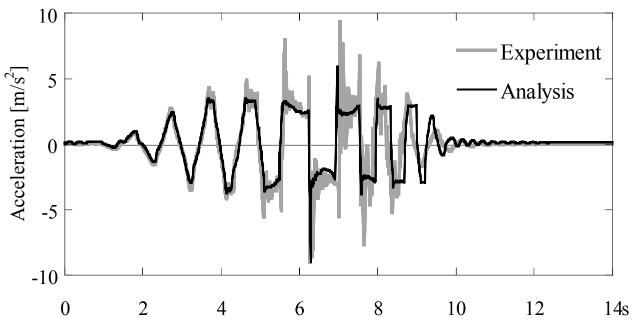

Fig. 3 Comparison of response accelerations of the lower specimen under sin wave 1Hz 250cm/s^2.

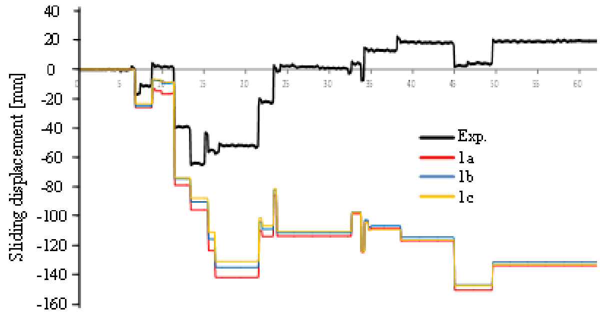

Fig. 6 Comparison of sliding displacements of the higher specimen under BCJ-L2 wave 400cm/s^2.

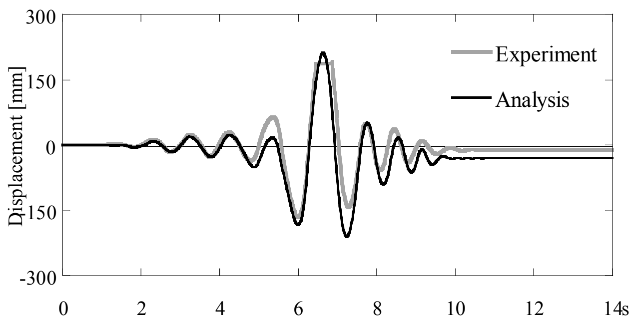

Fig. 4 Comparison of sliding displacements of the lower specimen under sin wave 1Hz 250cm/s^2.

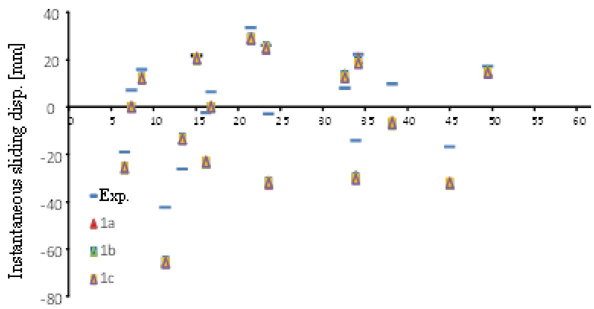

Fig. 7 Comparison of instantaneous sliding