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Numerical Examples of Traditional Timber Building using Frame Analysis with Semi-rigid Spring Elements

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SUMMARY

The full-scale vibration tests for Japanese traditional timber building are carried out to clarify the structure-mechanical characteristics of the tradition timber building in order to construct the design method in recent years. In this study, numerical analysis for traditional timber building is shown and the characteristics of the solution are investigated. The factors for the structural behavior of traditional timber building are variously considered. In this study, the three points witch strength of the soil walls, joints in framework, and sliding behavior of the traditional timber building were modeled by frame analysis. In order to analyze these structural elements, the beam element with the semi-rigid spring elements witch has shearing and bending rigidity are formulated. The modeling of the nonlinear characteristic of the tradition timber building was evaluated by semi-rigid spring elements. M-θ relation of the column-beam joints are evaluated based on past experimental result by slip hysteresis characteristic relationship. The nonlinear characteristic of soil walls are considered by rigid-bar and shear spring elements. It has been obtained by the element experimental test that the shearing deformation characteristic of soil walls. In this analysis, the locking deformation of wall is modeled by the rigid body. These hysteresis characteristics are modeled by bi-linear + slip restoring force characteristics. And, the sliding behavior of the traditional timber building between column base and foundation stone is evaluated by shear spring element on the beam element edges based on Coulomb friction characteristics considering the axial force fluctuation. However, the changing of the shearing force for column refloatation is not considered. The test specimen for the experiment is shown in Figure2 and the analytical model is shown in Figure3. 1P model and 2P model are investigated in this study. The numerical examples for the experimental test are shown in this paper and the examined input seismic wave is BCJ-L2 wave (Ground No2 correspondent), and the input maximum acceleration is from 200gal to 400gal. Analytical result and test data are shown in Table1 and Table2. The sliding displacement for 1P model and 2P model are small values in the input acceleration 200gal, so the sliding dose not occurred. The maximum story deformation angle for the 1P model becomes the double of the 2P model one. According to 1P model result, when the sliding does not occurred, the maximum story deformation angle becomes larger. In accordance with the input increases, the sliding displacement tends to increase. When the sliding behavior is generating, the maximum story deformation angle does not increase in proportion to the input acceleration. This tendency was confirmed even in the analysis. In comparison with model considering the fluctuation axial force and not considering model are shown in Figure7, the sliding displacement for non-fluctuation axial force model tend to small sliding displacement.

[Figures, Photos or Tables could be included but not exceeding one A4 page]

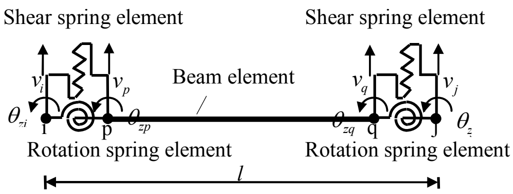

Figure 1 Beam element model

- Test specimen weight: M_1=5.318ton, M_0=0.788ton (Total: M_1+M_0=6.11ton)
- Input seismic wave : BCJ-L2 (Ground No2 correspondent)
- Friction coefficient : μ=0.35
- Damping factor : h=0.02 (Rayleigh damping)
- Analysis increment time : Δt =0.0001sec

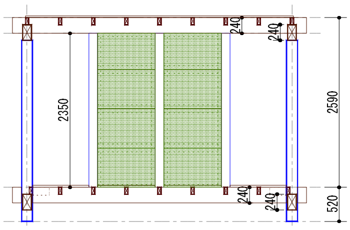

Figure 2 Test specimen

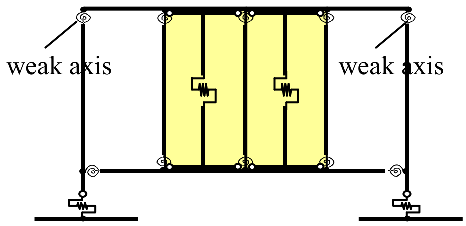

Figure 3 Analytical model

Table1 2P model

Maximum acceleration	Sliding displacement (mm)		Maximum story deformation angle (rad)	
	Analysis	Experiment	Analysis	Experiment
200gal	10	3	0.015	0.008
400gal	150	160	0.030	0.018

Table2 1P model

Maximum acceleration	Sliding displacement (mm)		Maximum story deformation angle (rad)	
	Analysis	Experiment	Analysis	Experiment
200gal	3	3	0.025	0.015
250gal	45	30	0.030	0.024
400gal	200	—	0.040	—

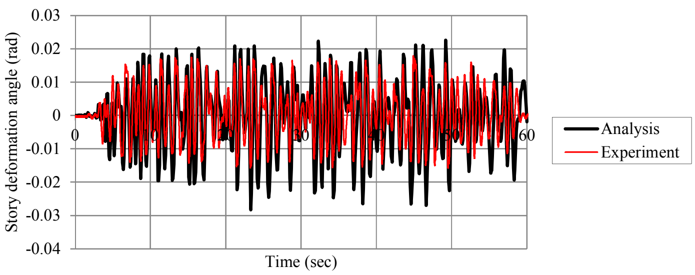

Figure 4 Time history response of story deformation angle for 2P Model (BCJ-L2 wave:400gal)

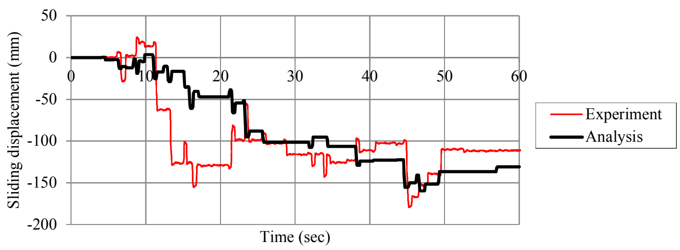

Figure 5 Time history response of sliding displacement for 2P Model (BCJ-L2 wave:400gal)

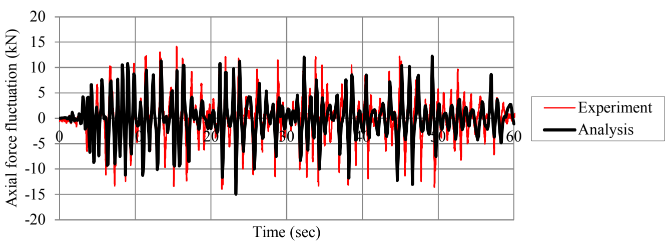

Figure 6 Time history response of axial force fluctuation for 2P Model (BCJ-L2 wave:400gal)

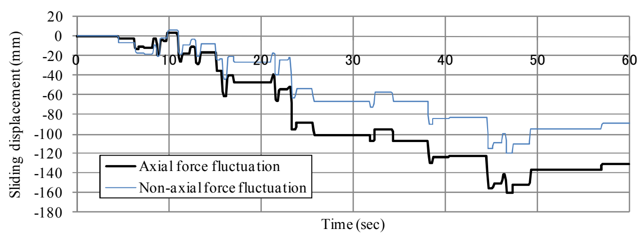

Figure 7 Comparison of sliding displacement for axial force fluctuation model and Non-axial force fluctuation model (BCJ-L2 wave:400gal)