ABSTRACTS (PH D THESIS)

Response control and seismic design method by applying oil damper for timber structure

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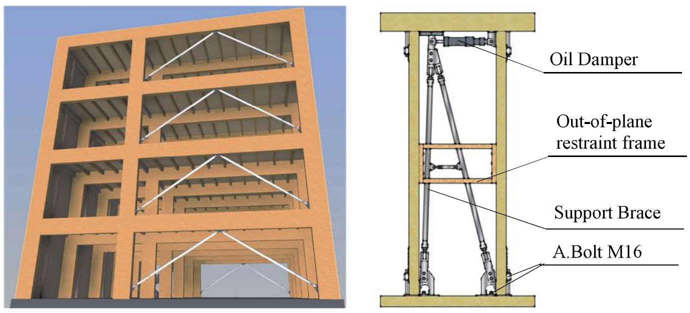
1. Abstract

Over the past few years, many earthquakes have been encountered in Japan, so high earthquake resistance for the buildings are required. Furthermore, the construction of high-rise timber structures in the world is progressing toward a sustainable society. For nations that have many earthquakes like Japan vibration control structure with high energy absorption performance is expected to be applied for high-rise timber buildings. The purpose of this research is to make clear the applicability of oil dampers for timber structures by full-scale shaking table tests, and to provide the basic concept for constructing a seismic design method considering dampers.

In this paper, for the purpose of proposing a seismic design method considering dampers, we conducted a full-scale shaking table test, proposed an analytical model including a design method, and verified the validity. The content of 6 Chapters are shown below.



a)Target timber building image b)Tested Damping wall
Figure 1. Target timber building and Tested Damping wall

Chapter 1 is an introduction and explanations of the background and purpose of this research.

Chapter 2 is an explanation about the full-scale shaking table test of two-story wooden structure test piece with an oil damper.

Chapter 3 is a proposal of a time history response analysis model for wooden house with an oil damper, and explanation of a seismic design method considering dampers for wooden house.

Chapter 4 is an explanation of a full-scale shaking table test of a semi-rigid timber frame structure with an oil damper.

Chapter 5 is a proposal of ,a vibration damping design method based on the calculation of the limit strength of the semi-rigid timber frame structure with an oil damper, and the verification by numerical experiments and shaking table tests.

Chapter 6 is the conclusion of this research.

2. Shaking table tests of two story wood house with oil damper

In this chapter, we conducted a shaking table test of a full-scale two-story test piece in order to quantitatively understand the effectiveness of the oil damper in a wooden house. The oil damper unit test and the dynamic wall test of the damping wall with oil damper were conducted, and useful data were obtained to analyze the effect of the oil damper in the shaking table test. In the shaking table test, a test piece with an oil damper and a test piece using general structural plywood were manufactured, and vibrations of earthquake were continuously input. Then, the response deformation and energy absorption were compared to quantitatively confirm the reduction effect of the response due to the oil damper.

As a result, compared with general structural plywood, the maximum response deformation of the damping test piece with oil damper is reduced by about 69 to 25%. Furthermore, it became clear of the energy absorption rate that the damper are increasing with each repetition of the vibration, and even with repeated large earthquakes the oil damper is not damaged and effective for earthquake resistance.

3. Analytical simulation of displacement response for two-story wood house with oil damper shear wall and design value for wood shear wall with damper

In this chapter, the numerical calculation method of nonlinear Maxwell model, which is a series combination of non-linear damper support springs specific to timber and bilinear type oil damper is presented, and shaking table test from Chapter 2 is simulated by time history response analysis using this method.

As a result of the simulation, it was confirmed that not only the maximum response deformation but also the differences of structural behavior in each phase can be precisely reproduced. Next, using this analysis method, the safety of damping wall evaluation method "Equivalent evaluation of shear wall strength" used for seismic retrofitting of Japanese wooden houses was verified. As a result, it was shown that this is mostly valid and safe.

4. Shaking table test of semi-rigid timber frame structure with oil damper

Due to Non-residential timber buildings do not have enough shear walls to keep large and many openings, semi-rigid timber frame were developed and increased. However, semi-rigid timber frame structure is relatively soft. This chapter presents seismic performance of semi-rigid timber frame structure with damper through full-size shaking table tests. We compared response deformations during moderate and severe ground motions among only frame, frame with oil damper and frame with shear wall to verify the damping effect of oil damper.

As a result, the maximum response deformation of "Semi-rigid timber only frame" was 1/106rad for Taft (25 kine) in the middle earthquake and 1/45rad for BSL (80%) in the big earthquake. Although "Semi-rigid timber only frame" has about 2.5 times the actual performance as compared with general performance, it was confirmed that the response deformation may become large depending on the seismic wave. Then, the maximum response deformation of "Semi-rigid timber frame with oil damper" was the smallest for any of seismic wave compared to the other test pieces. Furthermore, it was confirmed that damage to the main structure can be suppressed by damping because the natural frequency almost not changed.

5. Seismic design method based on spectrum capacity procedure for timber semi-rigid frame with oil damper

This chapter is about equivalent linearization method based on calculation of response and limit strength for SDOF model of timber structure with oil damper by assuming slip type resilience characteristic of main frame. By integrating many literatures, the evaluation of oil damper effects in vibration control design by extended limit strength calculation method is shown. By comparing with numerical analysis and full scale shaking table tests the accuracy has been verified. In particular, complying to previous research etc., refer to what current calculation of response and limit strength can do to evaluate the effect of oil damper on ”Japanese seismic Isolation Building Design Standards”, by replacing Maxwell model with equivalent Voigt Model, the extended method is considered and shown.

As a result, it was confirmed that the tendency of overall seismic response can be predicted by the proposed evaluation method. Furthermore, it was confirmed that the accuracy of evaluation was improved by adding the evaluation based on the existing literature.

6. Conclusion

In this paper, full-scale shaking table test shows the effectiveness of applying an oil damper to a timber structure. Then, the possibility of considering oil dampers based on the current seismic design method was shown.