Lesson Four

Seismic Response Control of Wooden Houses

Part one:

a house installed with compressive knee-brace oil dampers

Part two:

a house being placed on the sliding foundation

Part One

Seismic Response Control of Wooden Houses by Compressive Knee-Brace Dampers

Background of Development

In 1995 Kobe earthquake, more than five thousands people were killed under the collapsed wooden houses, which accounts for nearly 80% of the death toll caused by the Quake. So, since then, upgrading seismic safety of new and existing houses became our top priority for another big one.

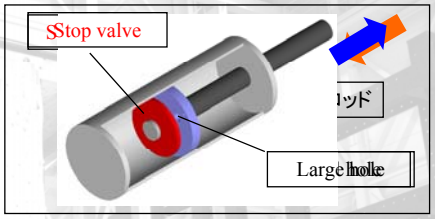
Background of Development (continued)

Many methods to grade up seismic safety of new houses or to strengthen existing houses have been proposed. But mainly due to lack of scientific rationality and cost performance, they have not been widely put into practice.

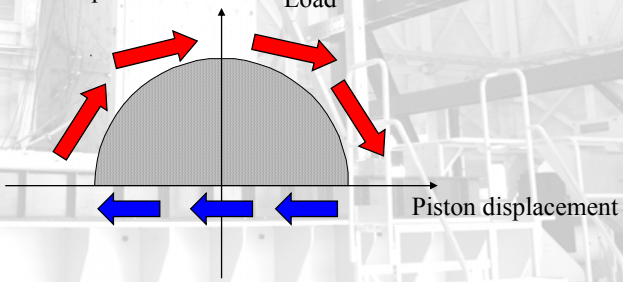
In the case of wooden houses, it often causes trouble to find enough space for installing large scale dampers. It is also difficult to firmly fix the dampers to wood by means of simple metal mountings and screws, especially when they are subject to tension.

We developed a new small oil damper that works only when subject to compression. Since the damper is small, no less than 50 to 100 dampers are required. But, it is already found to be quite easy to install and enough to resist even very strong ground motion.

Structure of the Damper



Inside structure of the damper



In compression

In tension

Mechanical Properties of the Damper

■Specifications

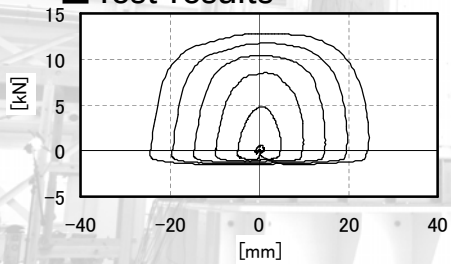
・length：305mm ・weight: ≒6N

・Stroke:±30mm）

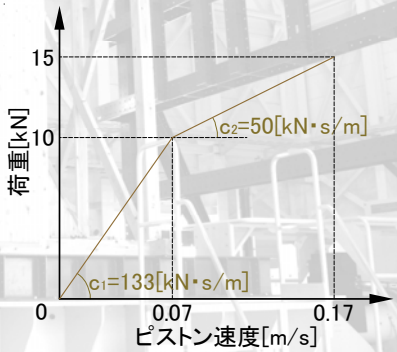
・Max.resisatnace:≒15kN

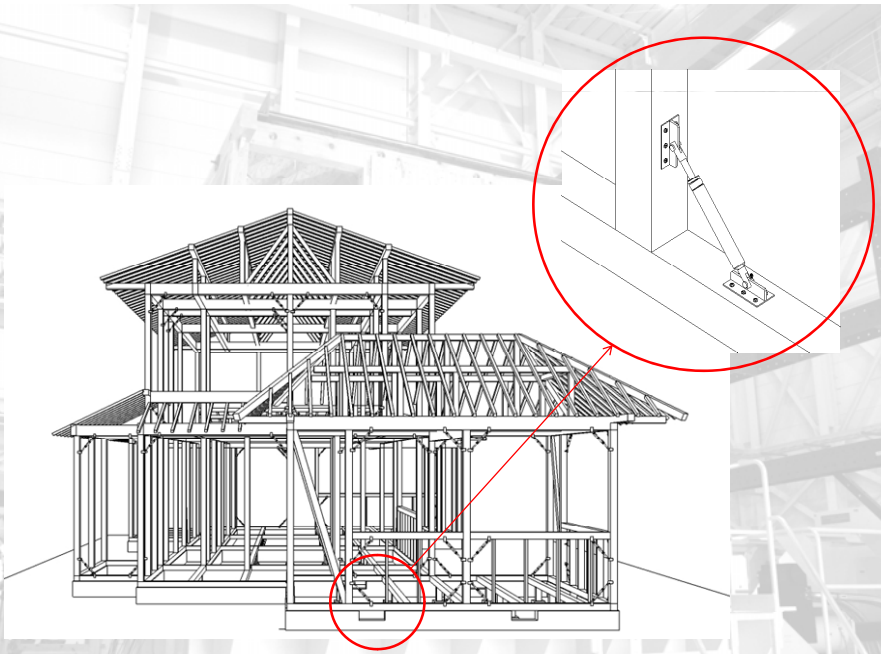
external appearance of the Damper

■Test results



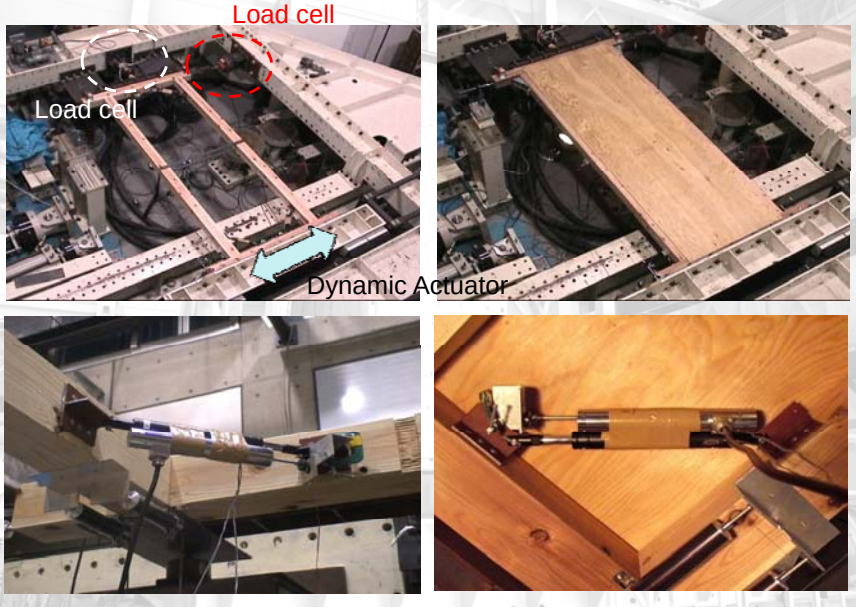
Load-deflection relations



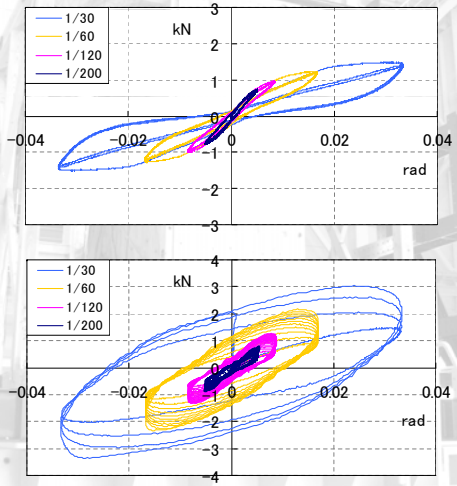


Experimental study to confirm the damping capacity of the wooden frame with the dampers

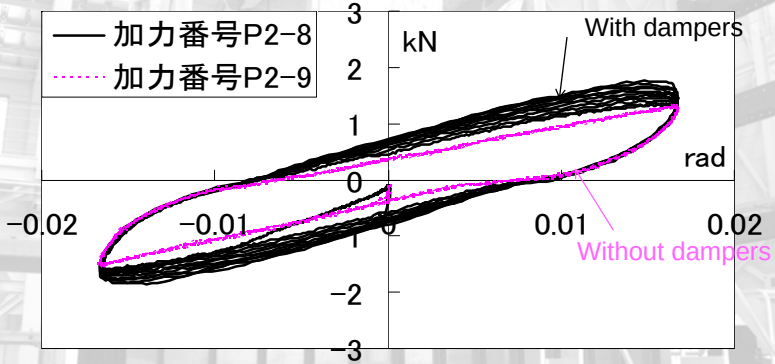
Full Scale Dynamic Loading Test



Test results (Frame Model)

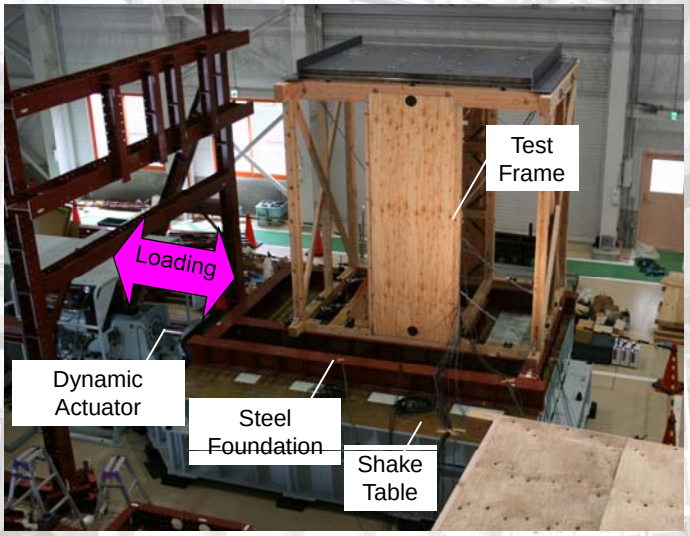


Test results (Walled Frame))

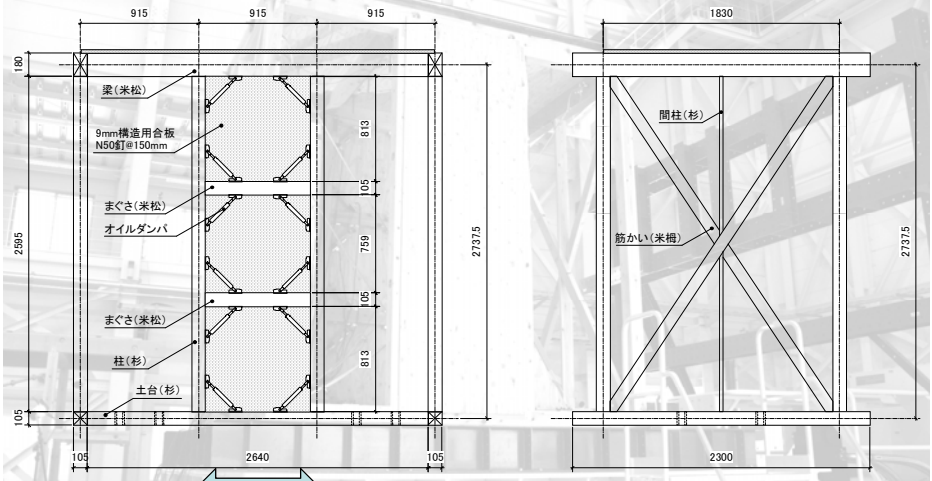


Shake Table Test of Full Scale Wooden House

■ General View of Shake Table System



Elevations of Test Frame

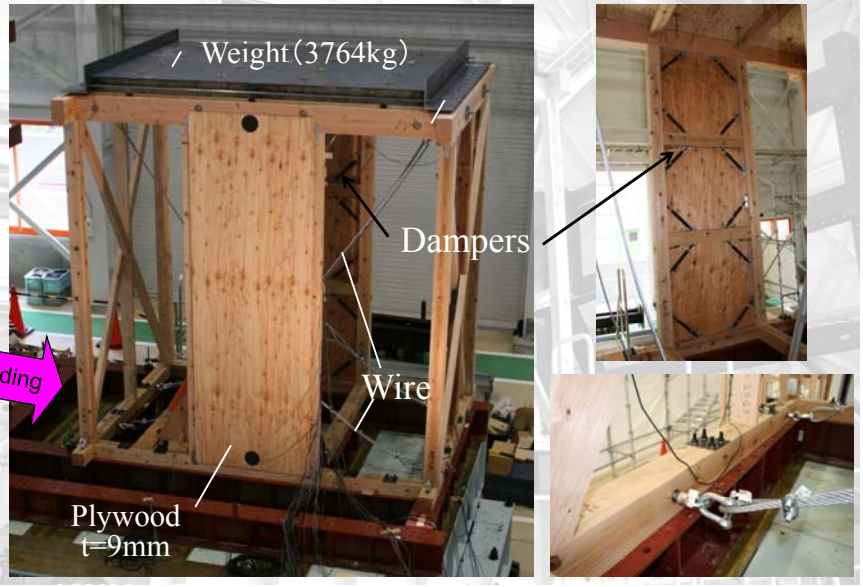


Loading Direction

Perpendicular to Loading Direction

■ Details of Test Frame

Seismicity Grade=1.0　　Number of Dampers：24 pieces



■ Shaking Test Schedule

(1) Test of the frame with dampers

- Stationary white noise 0.1~10Hz　max. acc. =60gal
- 1995 JMA Kobe NS　10%→30%→60%→60%

Max. vel.≒50kine

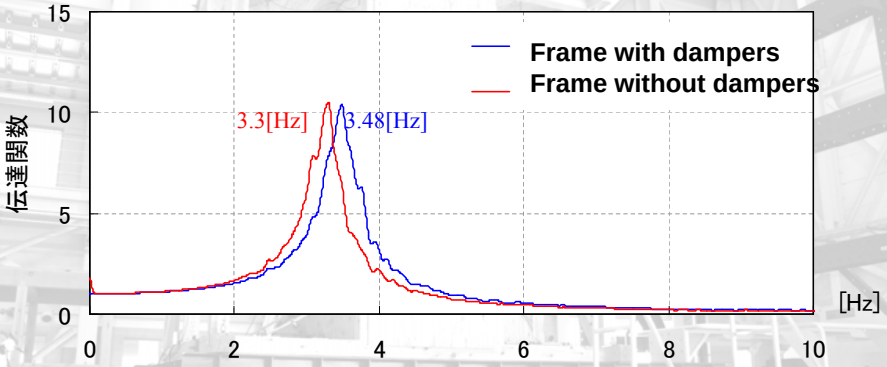
Replacement of plywood and confirmation of strengthening metals

(2) Test of the frame without dampers

- Stationary white noise 0.1~10Hz　max. acc. =60gal
- 1995 JMA Kobe NS　10%→30%→60%

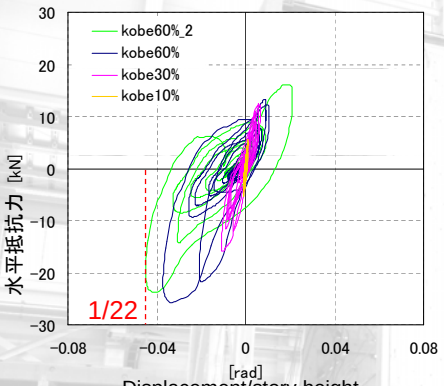
Test Results

■ Transmission Function



Each Frame has almost the same natural frequency

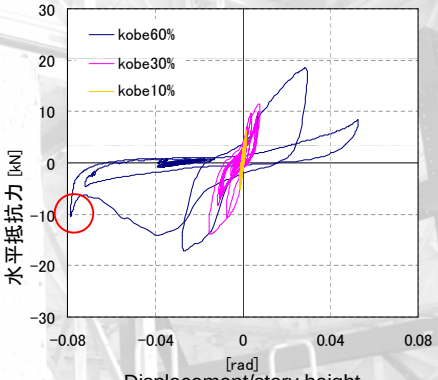
Load-deflection relations obtained in the Test



Displacement/story height

with dampers

damper

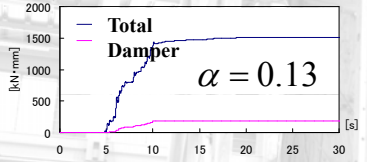


Displacement/story height

without dampers

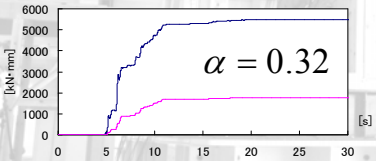
➡ Oil dampers really worked to prevent the frame from collapse even when the frame is subject to the same strong ground motion twice.

Ratio of absorbed energy to total input energy

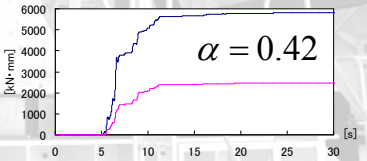


JMA Kobe 30%

$$\alpha = \frac{\text{Absorbed energy in damper}}{\text{Total input energy}}$$

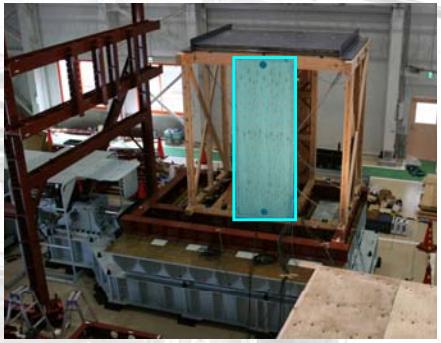


JMA Kobe 60%

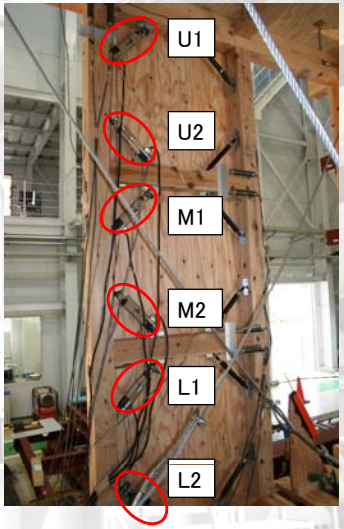


JMA Kobe 60%_2nd

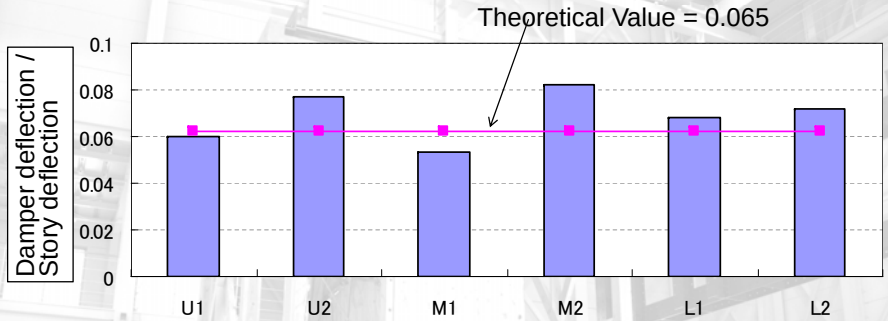
Story deflection vs. damper deflection



Whole view of the frame



Arrangement of instruments →

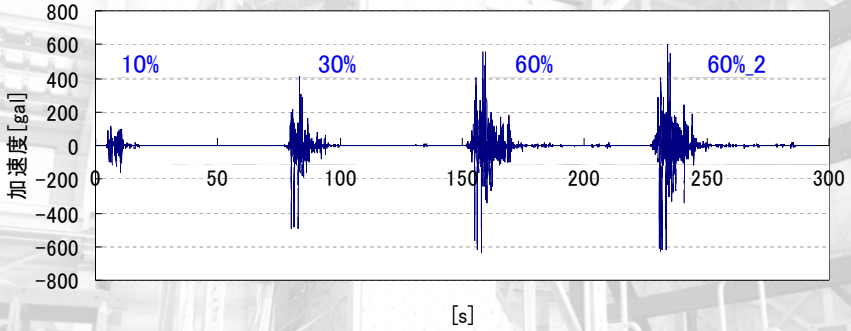


Theoretical vs. Measured

※maximum story deflection angle is 1/27[rad]

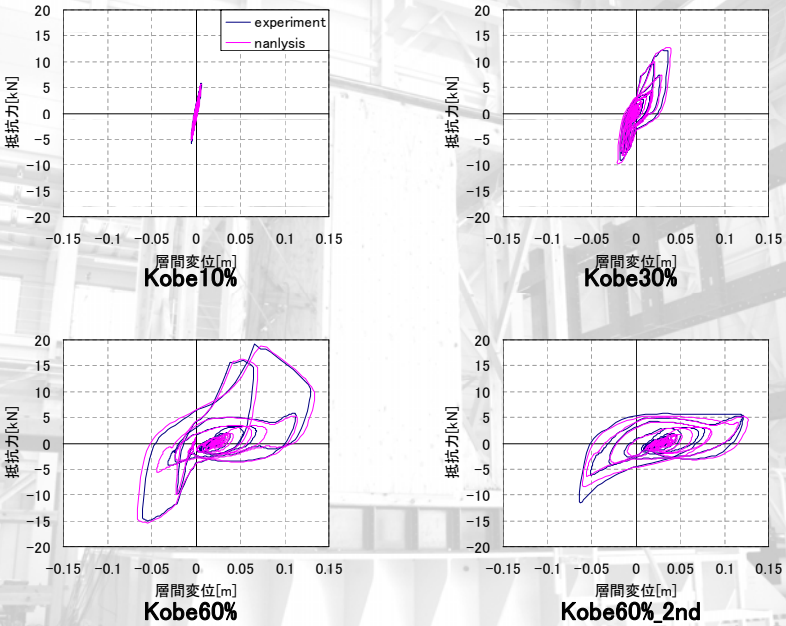
➡ **Story deflection and damper deflection have a one-to-one correspondence on average**

Analytical Results



JMA Kobe (NS) Acceleration time history measured on the shake table

Load-deflection relations



Conclusions

Wooden houses, which are so designed as to be consistent with the minimum seismic safety requirement may collapse when it is subject to normally strong ground motion.

Installment of proper amount of oil dampers really works to prevent the houses from collapsing even when subject to the same level strong ground motion several times.

End of Lesson Four

Part One