Lesson Three

Smart Passive Dampers

What we have learned about passive damping devices?

- There are already many passive dampers that have large amount of energy absorbing capacity
- Some dampers work only when the ground motion is quite strong.
- Some dampers exhibit energy dissipating capacity at the sacrifice of accumulation of damage
- Some dampers are frequency dependent or temperature dependent

⇒ Smart passive dampers are required

Purpose of Smart Passive Dampers

Not only

1) To minimize maximum displacement

2) To suppress excessive acceleration

but also

3) To minimize damage concentration

4) To minimize residual displacement

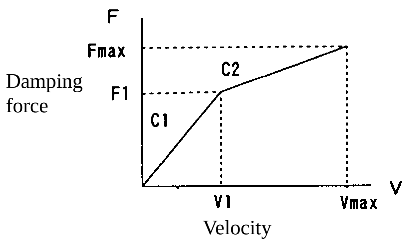
5) To get rid of temperature dependency

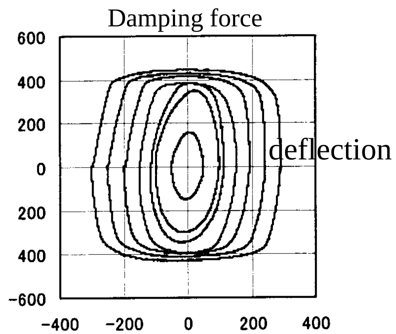
etc.

1) Oil damper with relief valves

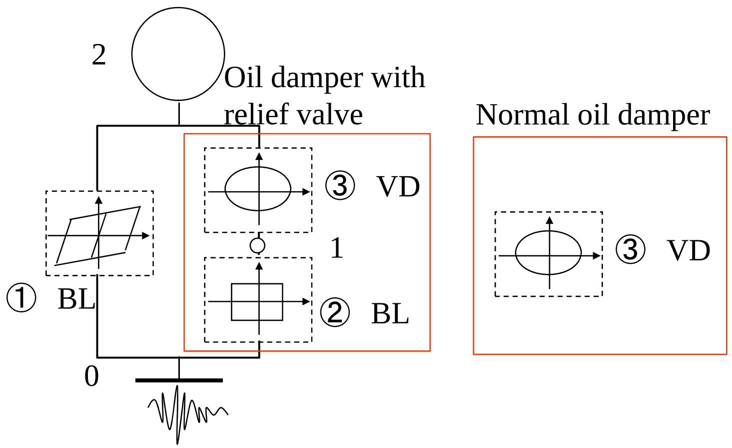
Fmax：最大減衰力　F1：折れ点減衰力
C1：1次減衰係数　C2：2次減衰係数
V1：折れ点速度　Vmax：最大速度

最大減衰力（Fmax）	465　(kN)
限界変形	500　(mm)
最大速度（Vmax）	1200　(mm/s)
折れ点速度（V1）	260　(mm/s)
1次減衰係数（C1）	1500　(kN・s/m)
2次減衰係数（C2）	80　(kN・s/m)

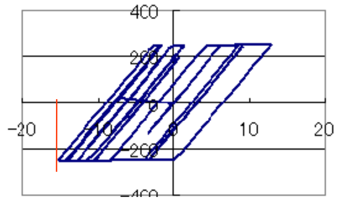




Sample seismic response analysis of an elastic-plastic SDF model with two types of oil damper

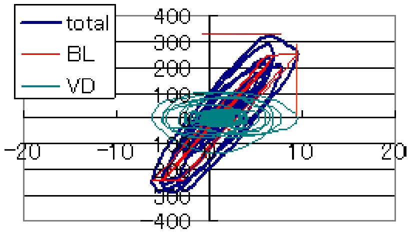


Seismic response of a SDOF elastic-plastic model with/without oil damper



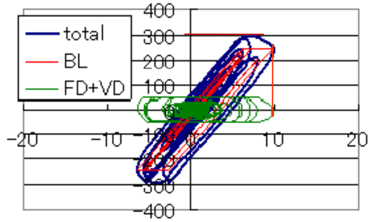
drams_1F¥1fbldata.txt

drams_1F¥1fbl.xls



drams_1F¥1fblvddata.txt

drams_1F¥1fblvd.xls

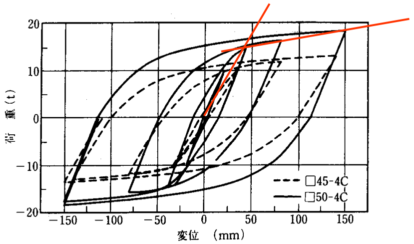


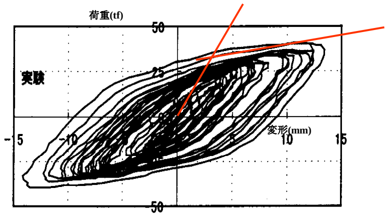
drams_1F¥1fblvdfddata.txt

drams_1F¥1fblvdfd.xls

2) Steel U-plate damper with guide rollers

- Back ground of the development -





Conventional steel damper

1)To accommodate large displacement, it does not work if the displacement is small

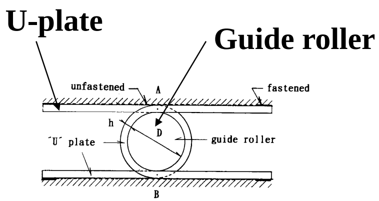
2)To be effective for small displacement, it can not accommodate large displacement

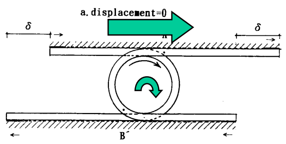
3)Second stiffness is relatively large compared to initial one

2) Steel U-plate damper with guide rollers

Characteristics:

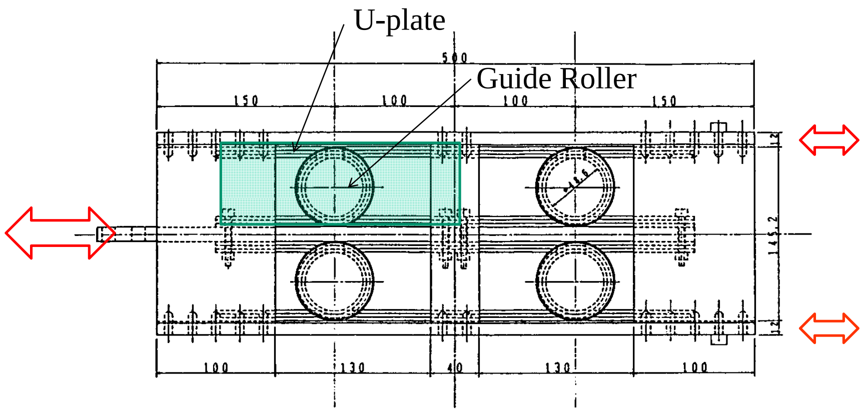
Effective even for small displacement, can accommodate large displacement, second stiffness is almost zero



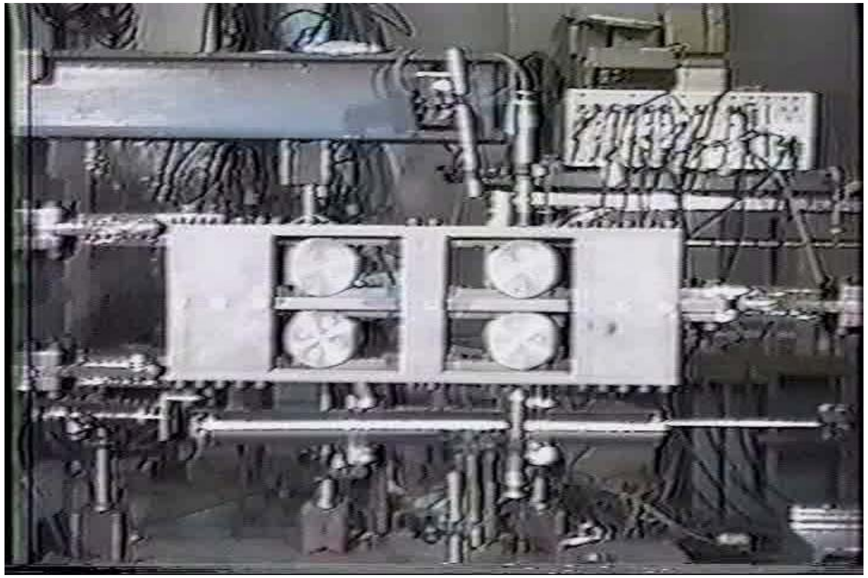


a. basic unit

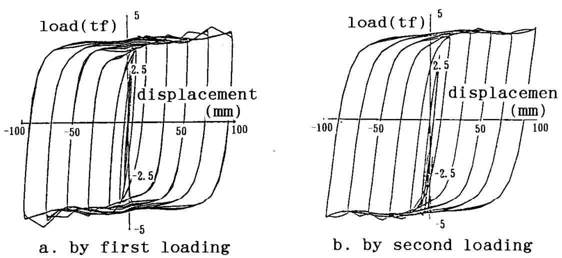
Experimental model of U-Plate Damper with Guide Roller

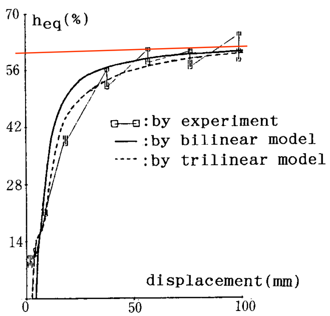


Elevation(unit:mm)



Load-deflection Relation





Load-deflection Relation

equivalent damping factor

3) Origin Restoring Friction Damper to Prevent Residual Displacement

- Back ground of the development -

Friction Damper

Passive, Low Cost, Maintenance Free

Friction Damper

Advantages

- Passive
- Law Cost
- Maintenance Free
- Ample Damping Capacity
- Simple
- Durable

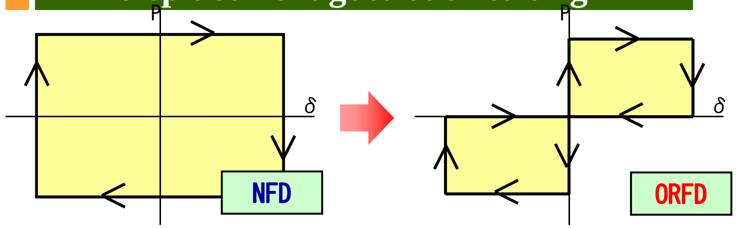
Disadvantage

Residual displacement even in linear system

New Friction Damper to suppress Residual Displacement

NFD and ORFD

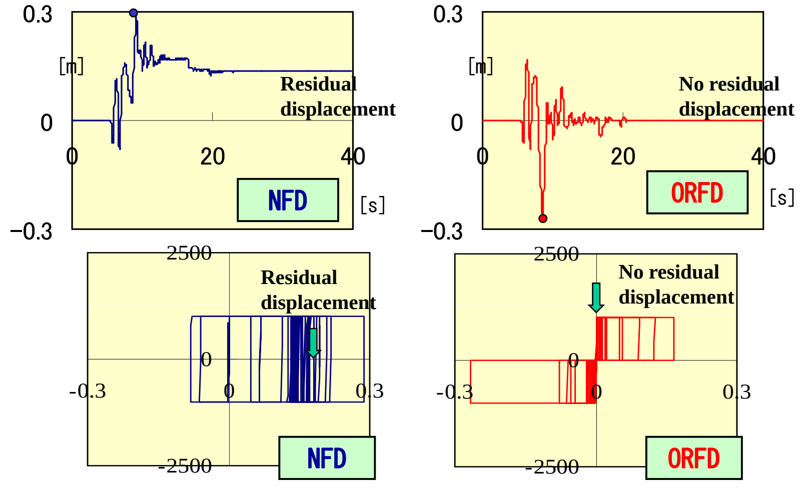
to make the resistance zero when the displacement goes back to origin



Normal FRD — **Origin Restoring FRD**

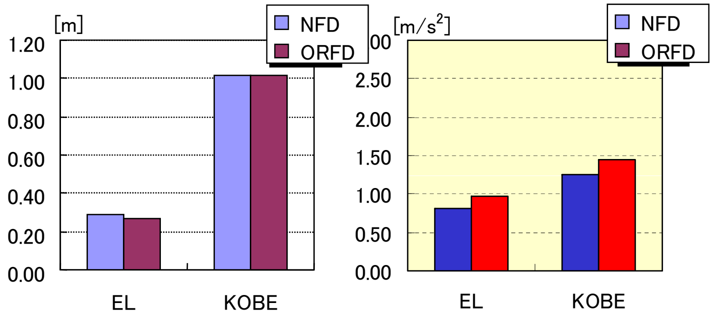
h_{eq} of ORFD = ½ (h_{eq} of NFD)

Comparison of Displacement Response



Response to 1995 KOBE Earthquake

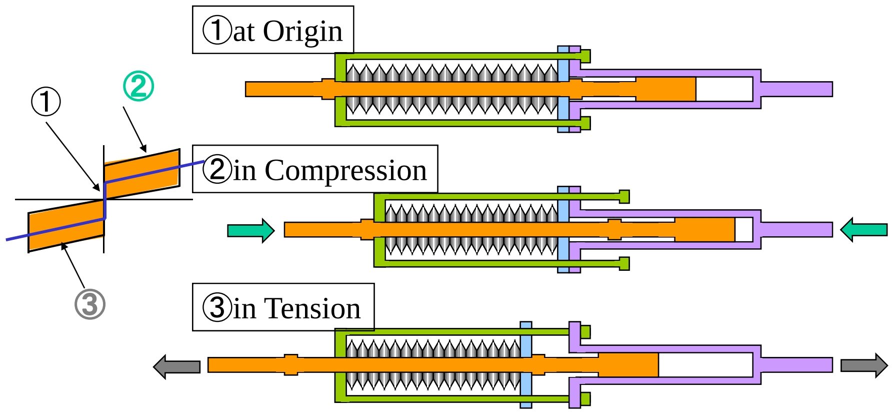
Comparison of Maximum Displacement & Acceleration



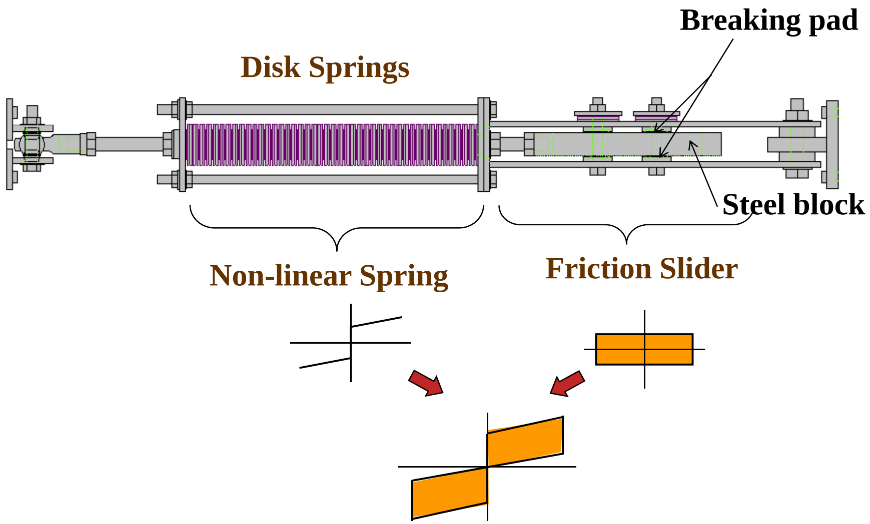
Max. Displacement **Max. Acceleration**

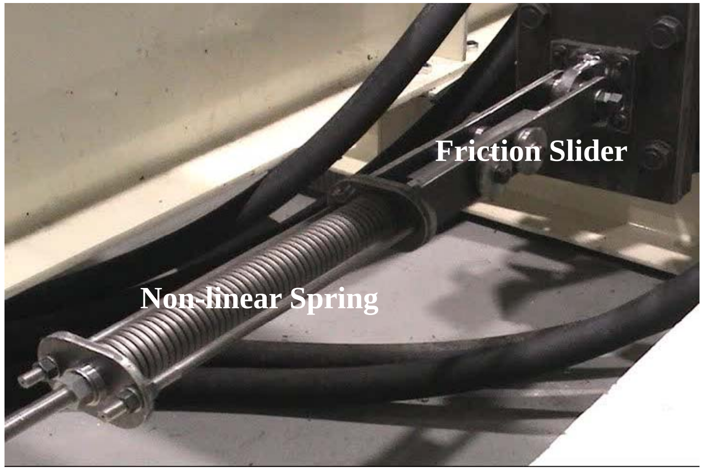
ORFD is useful for such building systems as base-isolated building and low-rise houses, because the former must tolerate large displacement and the latter must allow for large post yield displacement.

Basic Mechanism of the ORFD

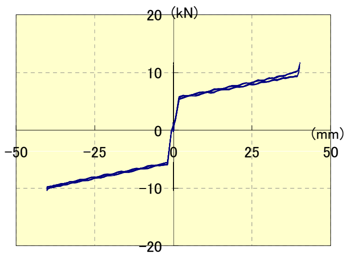


A Real ORFD (Test Piece)

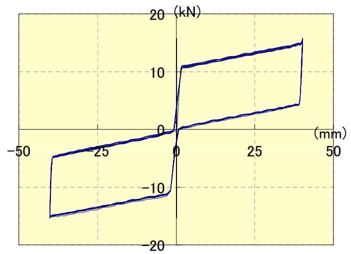




Hysteretic Loops of ORFD

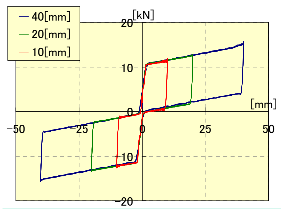


No Friction

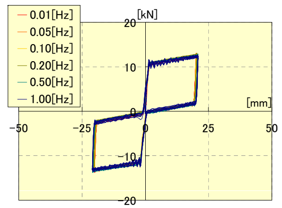


Friction Working

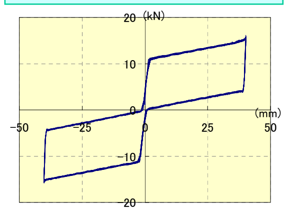
Dependence on Amplitude, Frequency, Longterm Loading, Friction Material



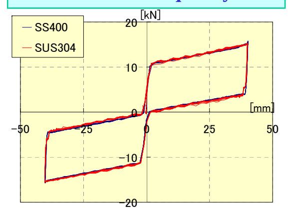
Effect of Amplitude



Effect of Frequency



Effect of Long Term Continuous Loading



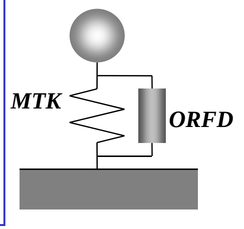
Effect of Friction Surface

Steel & Stainless

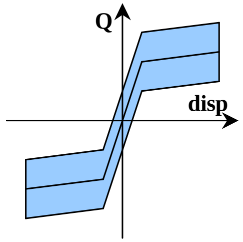
Seismic Strengthening of RC Building with ORFD

Mechanical properties of unstrengthened model

T = 0.5s
W = 9800kN
Q_y = 2940kN (= 0.3W)
h = 2%



a. SDOF RC model

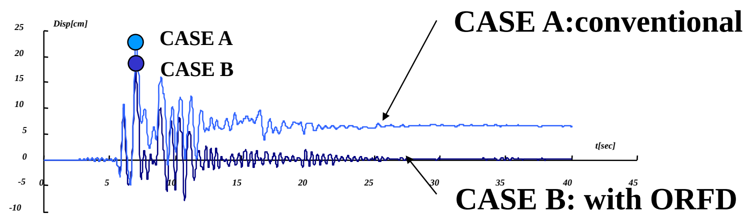


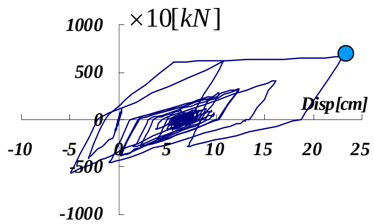
b. ORFD

Two cases of strengthening

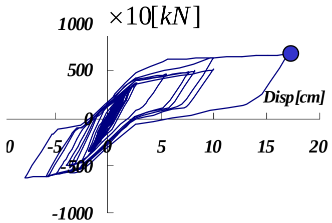
CASE A: the strength and stiffness are doubled following the conventional method of strengthening
CASE B: ORFD is installed to make the total strength and stiffness be the same as in the CASE A

Comparison of Seismic Response





CASE A:conventional



CASE B: with ORFD

4) Origin-Restoring Oil Damper (OROD)

(to upgrade seismic safety and daily comfortness)

Origin-Restoring Oil Damper (OROD)

(to upgrade seismic safety and daily comfort ness)

(stroke=±50mm、 max. f=150kN)

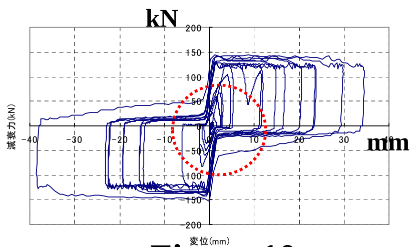
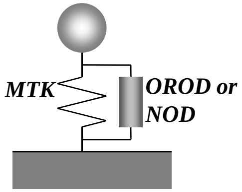
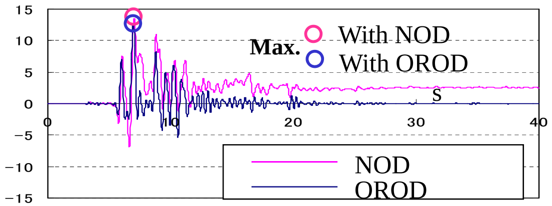


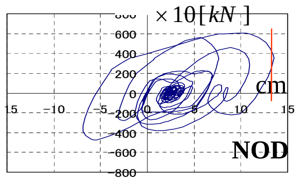
Figure 10

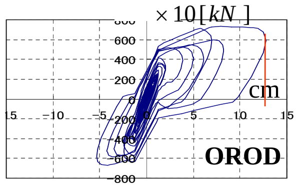
Comparison of Seismic Response



a. SDOF RC model







Conclusions

●Passive origin-restoring dampers can be realized quite simply either as friction dampers or as oil dampers.
●Origin-restoring dampers is capable of keeping the seismic displacement almost symmetric as to the origin.
● Developed origin-restoring dampers are quite effective, especially for those buildings in which relatively large displacement is expected.
●The advantage of the OROD to the ORFD can be regarded as the former being effective even for minor excitations.

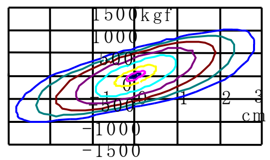
5) Hybrid Damper of
VED and LYPSD

VED :Visco-Elastic Damper

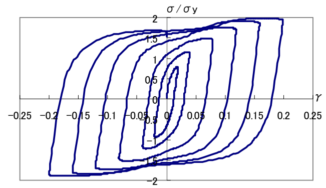
LYPSD: Low Yield Point Steel Damper

Properties of
Individual Dapmer

VED
1)Temperature dependent
2)Linear
3)Effective from very small
shear strain



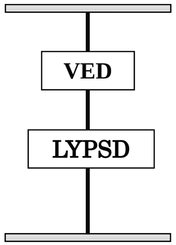
LYPSD
1)Temperature independent
2)Limit in strength
3)Only effective for large
shear strain



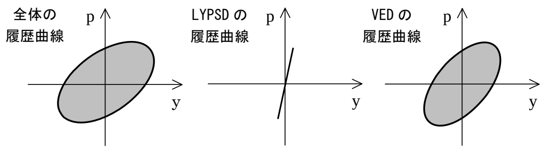
Basic Idea of the System

1) To evade occurrence of excessive stress regardless of the temperature

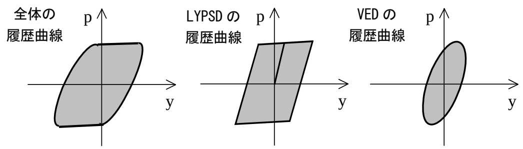
2) To be effective for minor to major excitations



Hybrid in series

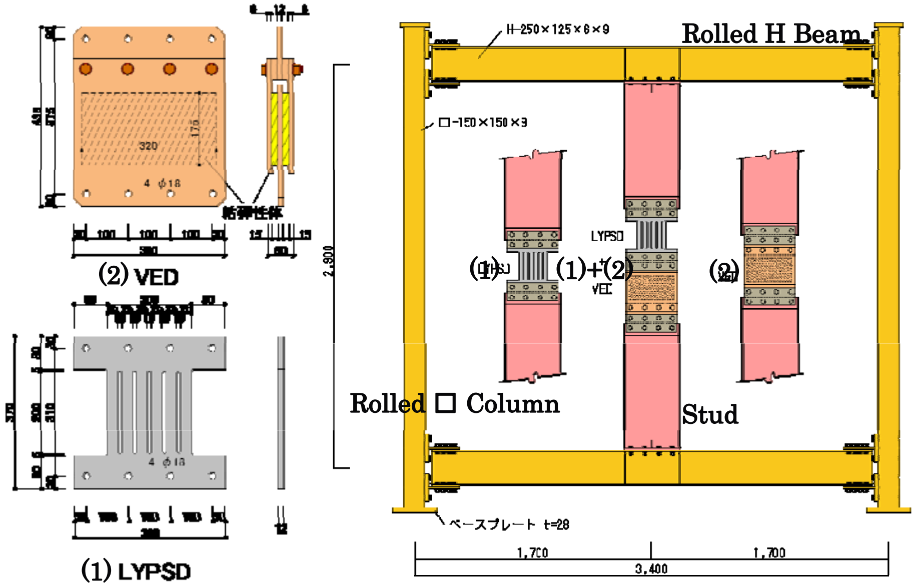


Hysteresis loops when temperature is high

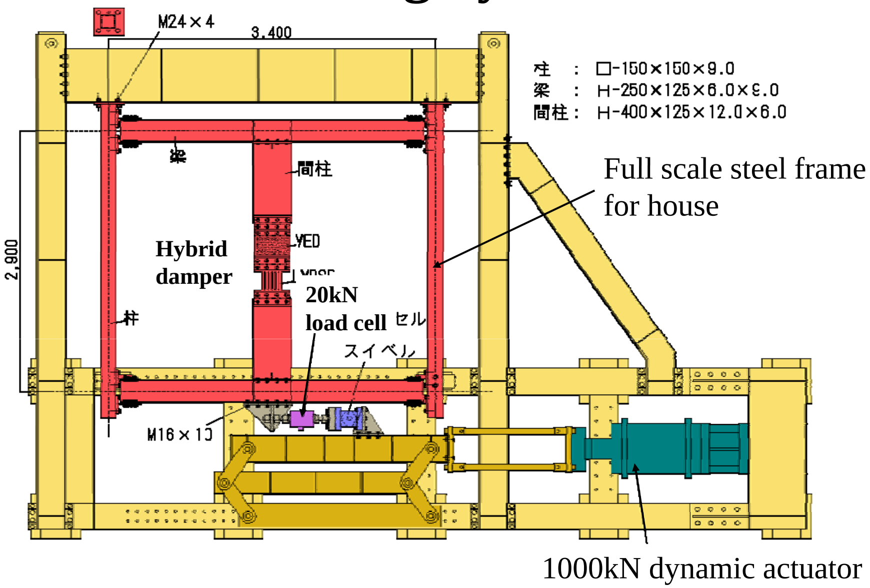


Hysteresis loops when temperature is low

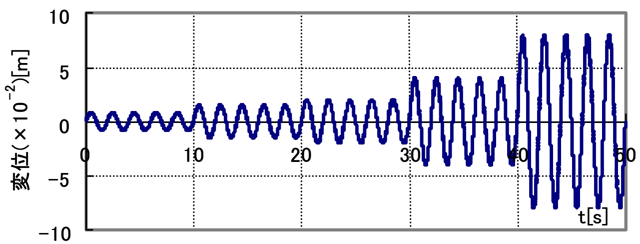
Test Frame and Dampers



Loading System

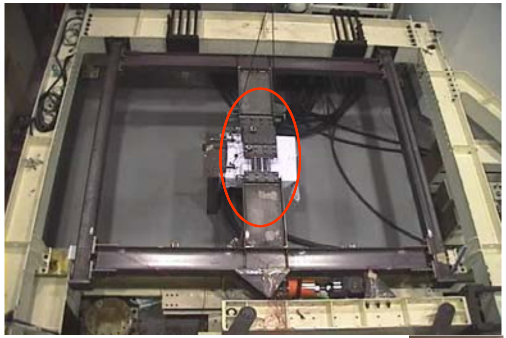


Input Displacement



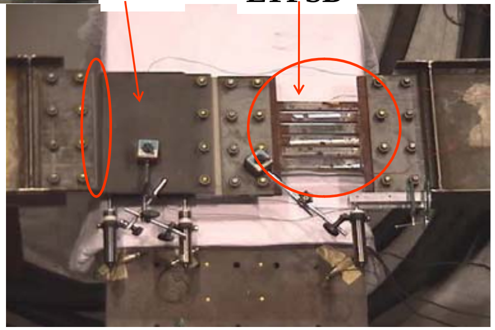
Input Displacement

For a VED alone and a Hybrid damper, test was Performed at the temperature of 21℃ and 28℃

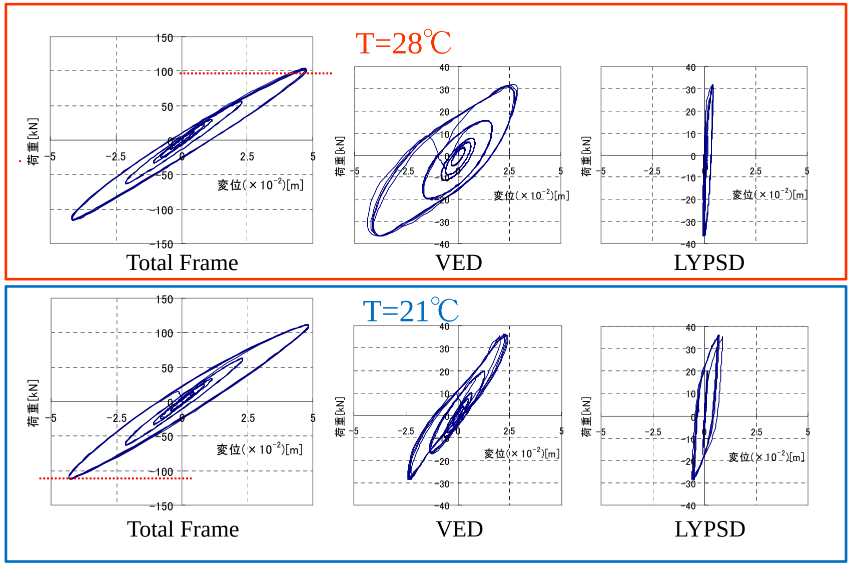


VED+LYPSD

VED LYPSD



Load-deflection relation of the frame with hybrid damper

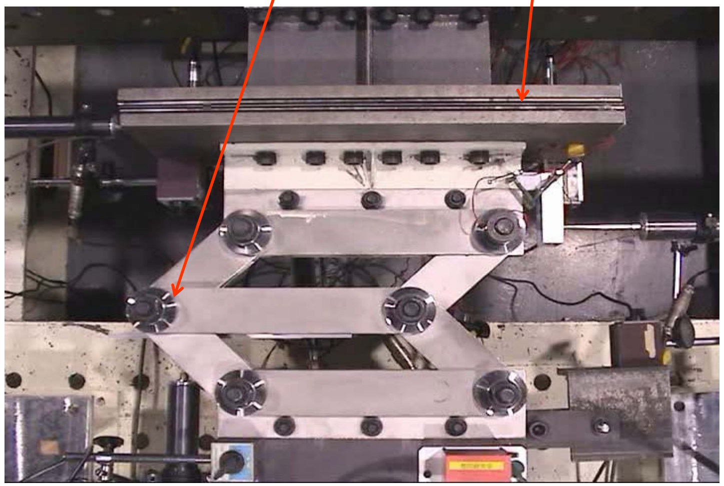


CONCLUSIONS

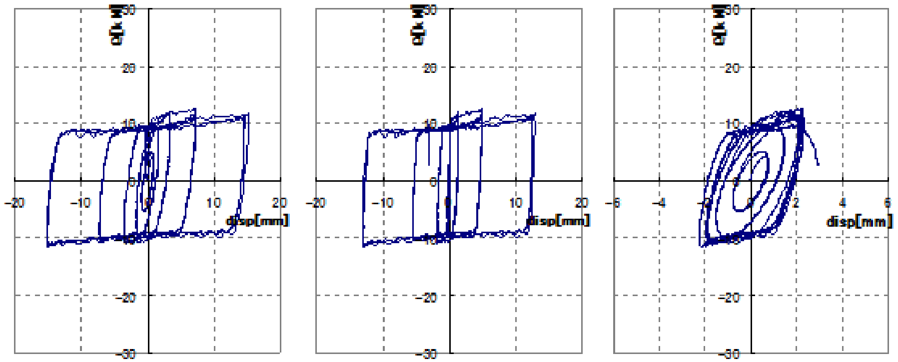
Hybrid damper of a VED and a LYPSD in series is confirmed to be very effective to make use of the ample damping capacity of both dampers regardless of the temperature conditions and the level of input excitations

We can use FRD instead of LYPSD

Hybrid damper FRD - VED



Load-Deflection Relations



(a) Total (b) FRD (c) VED

CONCLUSIONS

Smart passive dampers or hybrid dampers can be effectively used

not only

- 1) To minimize maximum displacement
- 2) To suppress excessive acceleration

but also

- 3) To minimize damage concentration
- 4) To minimize residual displacement
- 5) To get rid of temperature dependency