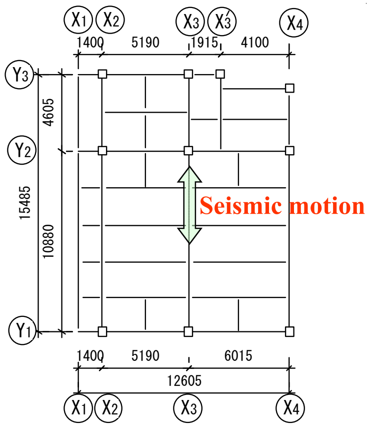
Lesson six

Seismic response analysis of high-damping smart structures using DRAMS

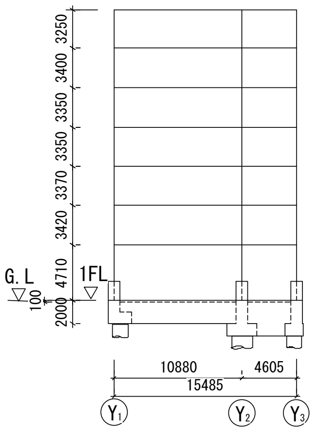
Seven-story steel frame

South elevation East elevation

Analytical model

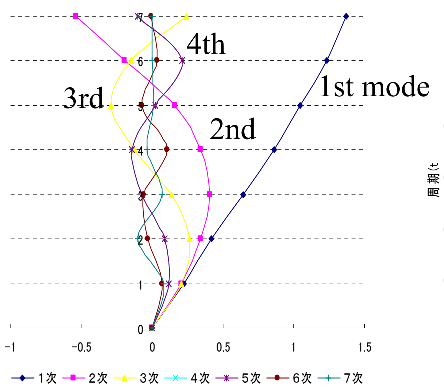


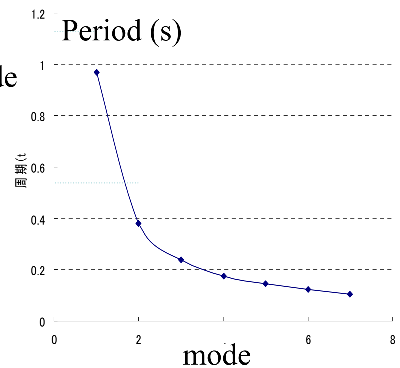
plan of the 2～5 floor frames



elevation of the X3 frame

Natural period and mode shapes（βu）

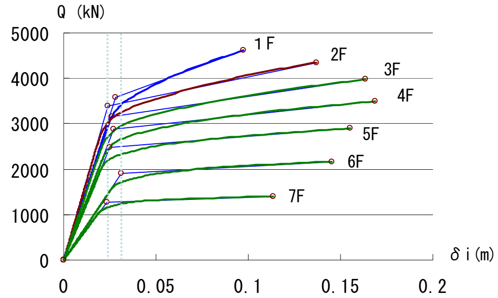




Mechanical properties

Mass and stiffness

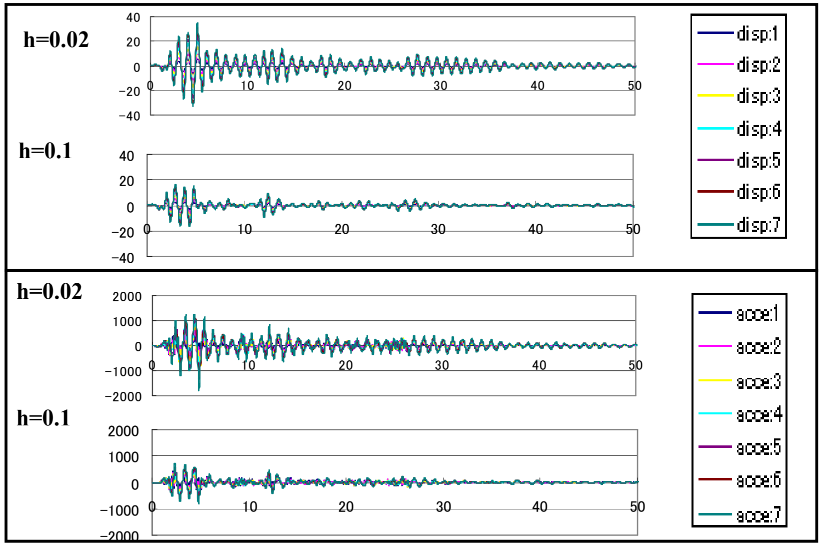
	mi (t)	K1 (kN/m)	K2 (kN/m)	Qy (kN)
1F	151.2	126290	14523.35	3573.40
2F	149.7	140190	8131.02	3394.57
3F	147.9	121660	5596.36	3164.79
4F	146.2	106120	4138.68	2878.38
5F	146.2	98740	3060.94	2477.24
6F	124.8	60760	2126.60	1904.80
7F	141.5	54830	1370.75	1276.78



Load-deflection relation of each story

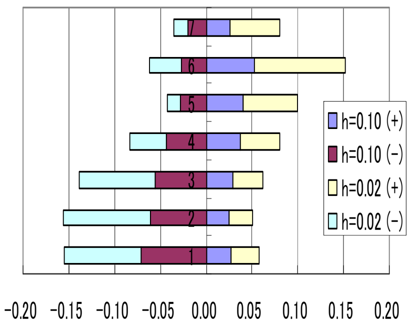
Viscous Damping Effect on Linear Response to Level-2 EL_NS

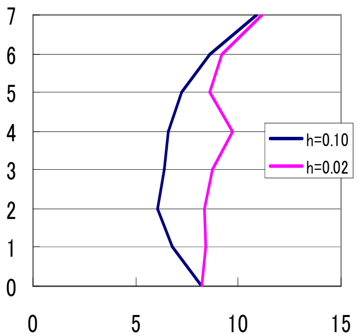
7flndata.txt



Viscous Damping Effect on Bi-linear Response to original Kobe_NS

drams_7F¥7fbldata.txt

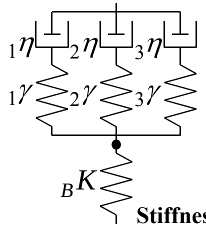




Response control by VED

drams_7F¥7fblvedata.txt

- VED: linear diene elastomer (SDM-2)
- Ground motions: 20 simulated ground motions
  Original El Centro NS
  Original Kobe NS
- Capacity: First story S/d=25m, 50m, 100m, 150m, 200m, . . . , 350m
- arrangement: Proportional to shear distribution when subject to El Centro NS

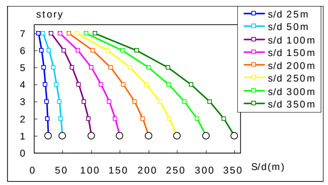


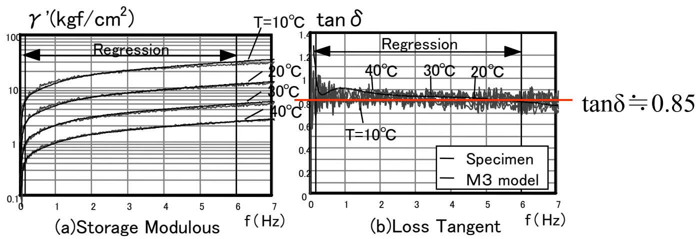
$_{1\sim3}\gamma$: *Rigidity of Maxwell model*

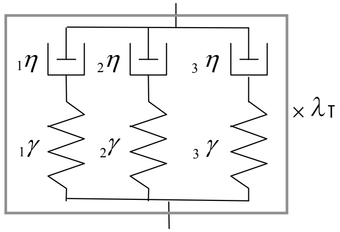
$_{1\sim3}\eta$: *viscosity of Maxwell model*

Stiffness of supporting member

$K_B / K_F = 3.0$







$_1\eta$ =4.2(kgf・s/cm^2)

$_2\eta$ =0.52(kgf・s/cm^2)

$_3\eta$ =0.28(kgf・s/cm^2)

$_1\gamma$ =3.0(kgf/cm^2)

$_2\gamma$ =4.6(kgf/cm^2)

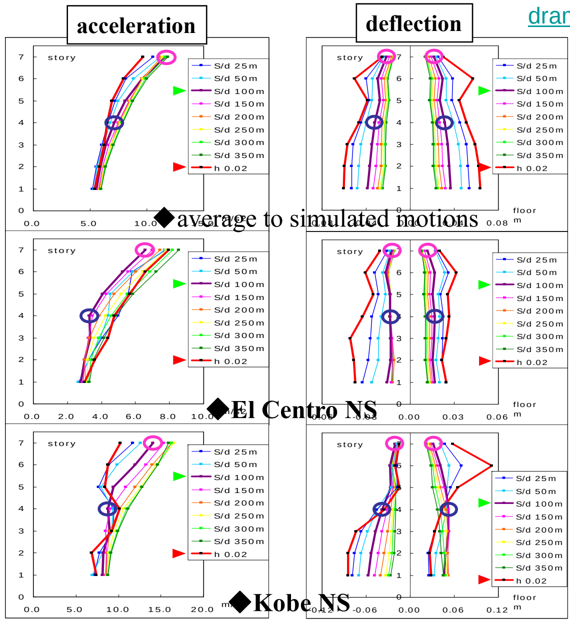
$_3\gamma$ =20.0(kgf/cm^2)

$$\lambda_T = \left(\frac{80}{T+60}\right)^{7.13}$$

Six-Element Model for Dien Elastomer VED

Maximum displacement and acceleration

drams_7F¥7fblvedata.txt



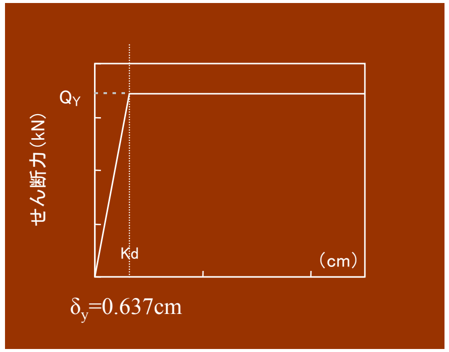
Problems with the temperature-dependent linear VEDs

When the proper amount of VED is used (S/d=100m for the 1st story, the rests are in proportion to shear distribution) displacement could be decreased by about 40% of that with out dampers. But, the maximum acceleration might increase about 20%

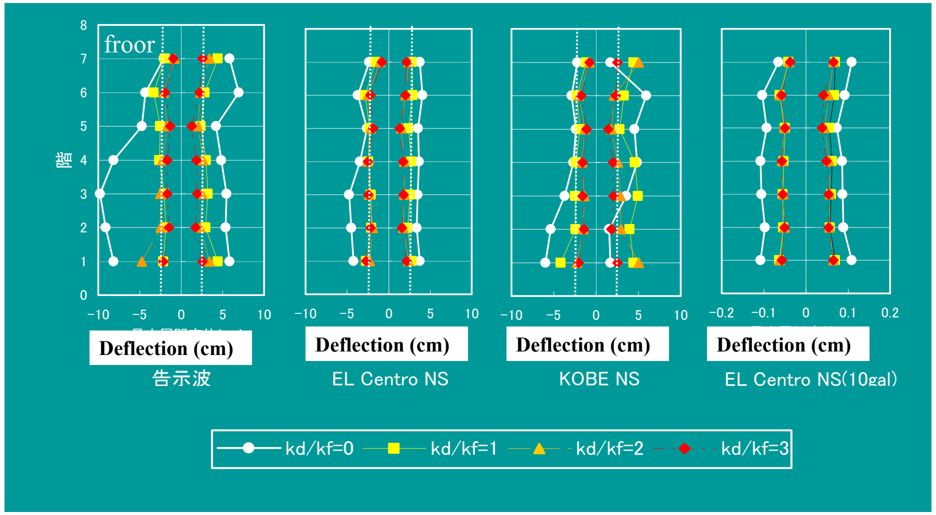
The lower the temperature is, the higher the stiffness of the damper is. Therefore, in extremely low temperatures, acceleration may increase by as much as 50%

Response control by steel damper

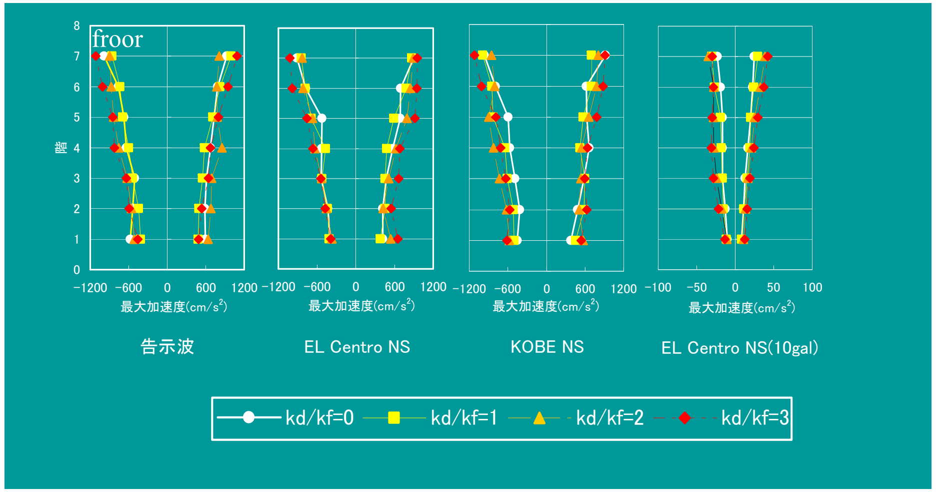
drams_7F¥7fblbldata.txt



Bi-linear load-deflection relation of the steel panel damper



Effect of the ratio of the damper's stiffness to that of the frame on maximum deflection



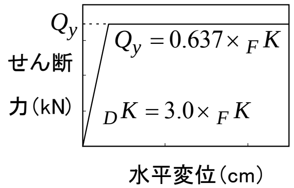
Effect of the ratio of the damper's stiffness to that of the frame on maximum acceleration

Problem with the steel damper

When the stiffness of the damper is set to be nearly the stiffness of the main frame, the maximum displacement can be decreased without excessive increase in acceleration response. However, When the intensity of the ground motion is quite low, there will be no damping effect at all.

Response control by hybrid damper

- Input ground motions：El Centro NS，Kobe NS，simulated
- Mechanical model of the damper:
  both a VED represented by 6 element model and LYPSD by a
  BL model are connected in series by means of small mass
- LYPSD：Kd/Kf=3.0
  yield displacement =0.637 cm
- VED(SDM2)：S/d of the 1st story is 100m

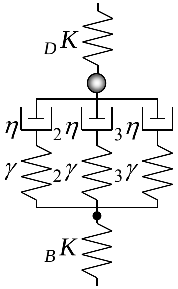


${}_{1\sim3}\gamma$: Rigidity of Maxwell model

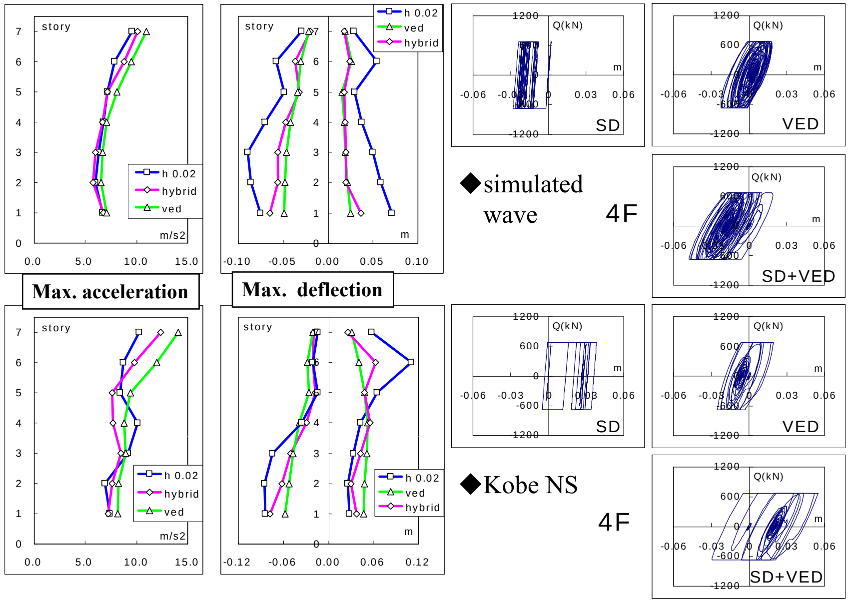
${}_{1\sim3}\eta$: viscosity of Maxwell model

$K_F / K_D = 3.0$

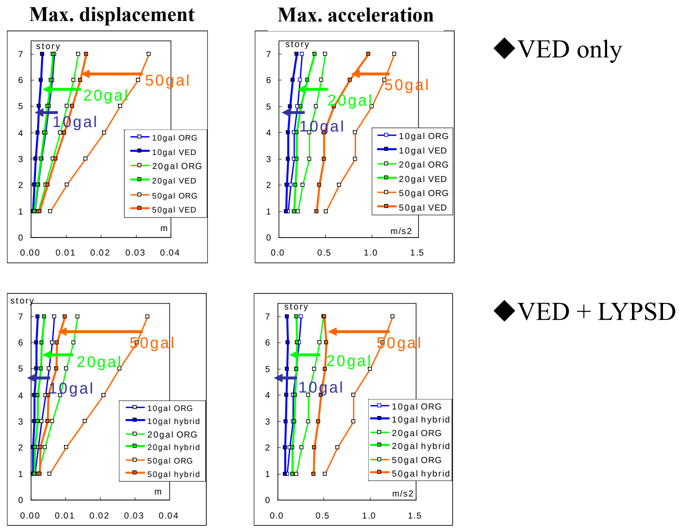
Stiffness of the damper



Comparison of the maximum response



Response to minor ground motion



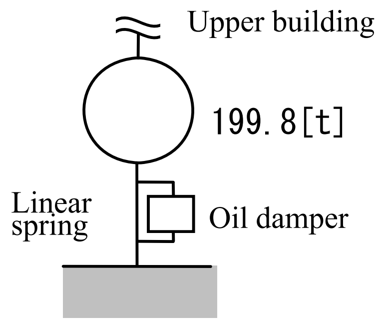
Ground motion:　El Centro NS:10, 20, 50gal

Effect of using the hybrid damper

■For strong ground motions, the maximum displacement will be a bit larger than those expected in the case there's VED only. That additional displacement corresponds to the deflection of the steel damper. However, the maximum acceleration could not be much larger than the case with no dampers.

■For minor ground motions, the maximum response will be almost the same as those that there is VED only.

Comparison with the base-isolation



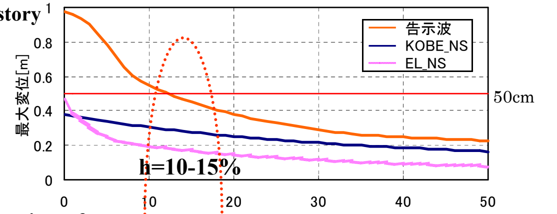
Base-isolated model

Base-isolated natural period is set to be about 3.0 second.

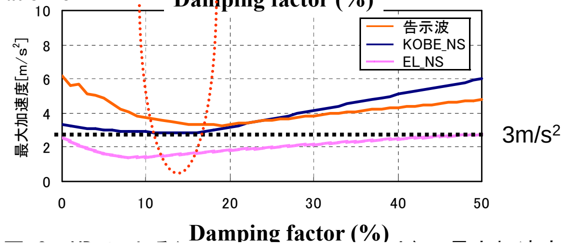
drams_7F¥7fblbidata.txt

Effect of the damping capacity in the base-isolated story

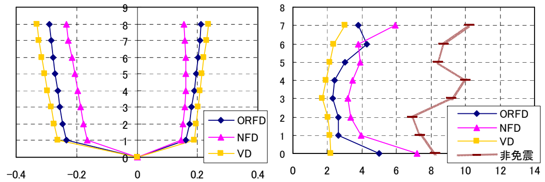
Maximum displacement of the base-isolated story



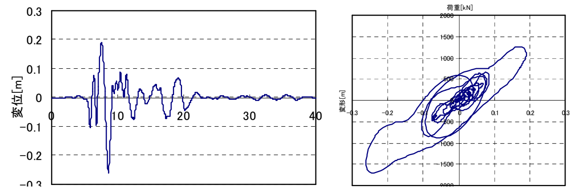
Maximum acceleration of the top floor



Maximum response of base-isolated building with optimum viscous damping subject to the original Kobe NS Ground motion



Max. displacement(m) Max. acceleration(m/s^2)



Displacement time history Load-deflection relation

Response of the base-isolated story

END of Lesson six