Target performance.

Maximum interstory drift angle $\theta_{\max}$ = 1/100 rad

Building Description:

The ten-story buildings are selected from the JSSI (Japan Society of Seismic Isolation) manual (Refs (1) and (2)). The term of Conventional type and trimmed type are used for the building designed without passive damper devices and with passive damper devices, respectively Figures 1,2 and 3 give the layout configurations of the building. Also, the lists of column and beam size of conventional type and trimmed type are presented in Table 1 and Table 2, respectively.

Building height H = 18 m
Frame natural period (Without damper) T_f = 1.001 s (0.056H)
Initial damping ratio h_0= 0.02

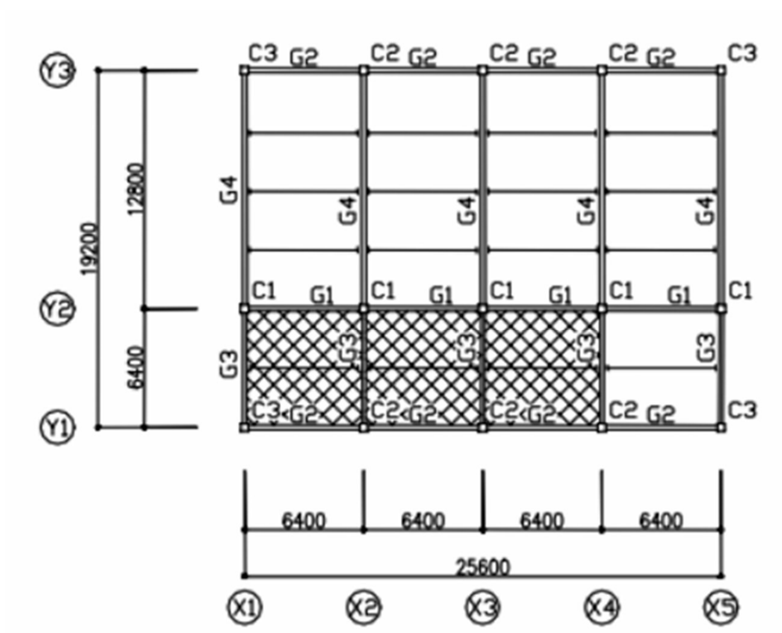
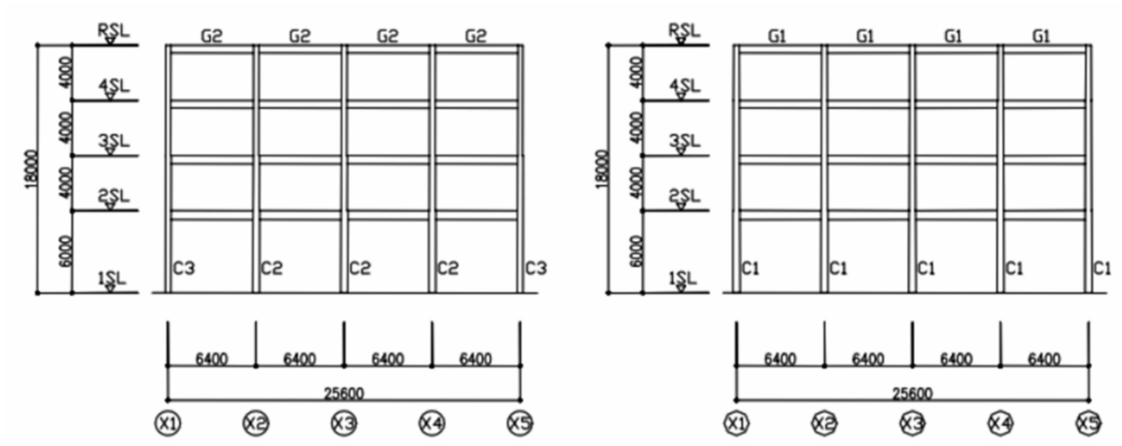


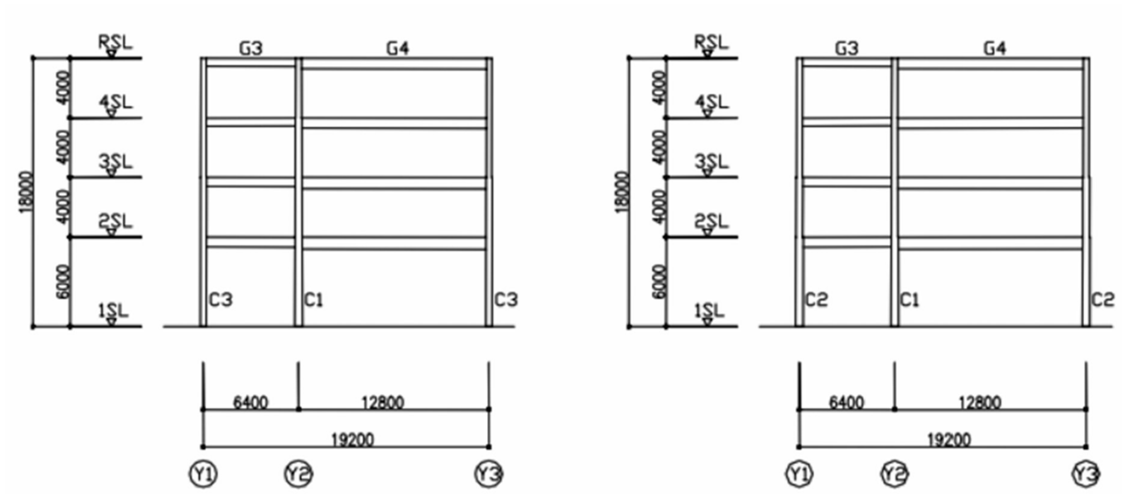
Figure 1. Building plan



a) Y1 and Y7 frame

b) Y2 frame

Figure 2. Longitudinal direction



c) X1 and X5 frame

d) X2 to X4 frame

Figure 2. Transverse direction

Table 1. Box steel column sections.

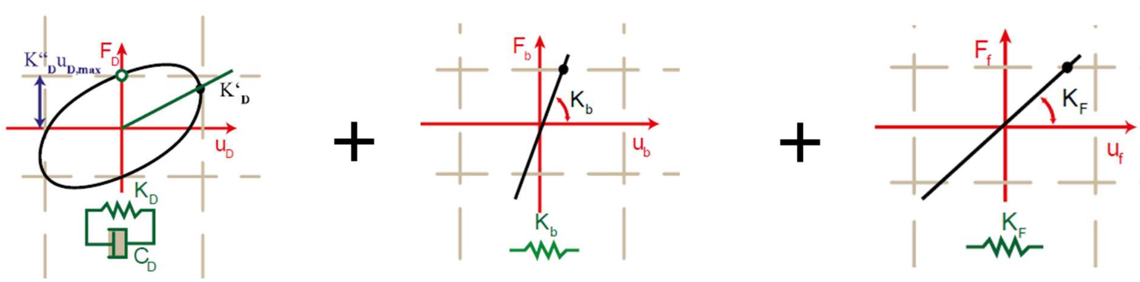
Floor	C1					
	Conventional Type			Trimmed Type		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
4	400	400	16	300	300	19
3	450	450	19	350	350	14
2	450	450	22	350	350	19
1	500	500	22	350	350	25
Floor	**C2**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
4	400	400	16	300	300	12
3	400	400	19	300	300	12
2	450	450	19	300	300	14
1	500	500	19	350	350	14
Floor	**C3**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
4	350	350	16	300	300	9
3	350	350	16	300	300	9
2	400	400	19	300	300	12
1	400	400	19	350	350	12

Table 2. H steel beam sections.

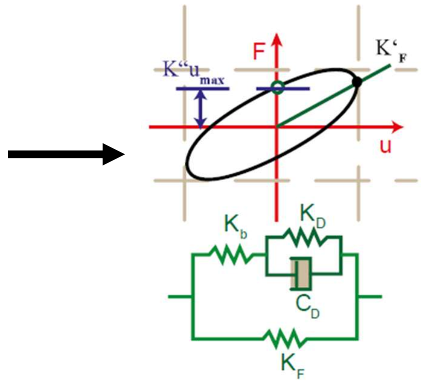
Floor	B1							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	550	200	9	16	300	250	9	22
4	550	250	9	19	350	300	12	28
3	600	250	12	22	400	300	16	28
2	650	250	12	25	450	300	19	28
Floor	B2							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	550	200	9	16	300	200	9	25
4	550	250	9	19	350	200	12	28
3	600	250	12	22	400	200	12	25
2	650	250	12	22	450	200	19	28
Floor	B3							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	550	250	12	22	350	300	9	19
4	550	200	12	22	350	300	12	22
3	600	200	12	25	400	300	12	25
2	650	200	12	25	400	300	16	28
Floor	B4							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	700	300	12	22	400	300	12	19
4	700	250	12	22	400	300	12	22
3	750	250	14	25	400	300	16	22
2	800	250	14	25	450	300	12	22

Viscoelastic Damper:

The force-deformation relationships of the viscoelastic damper, the added system to the frame is presented in Figure 1. Figure 2 represents the layout of the passive control devices. The devices are considered only in the longitudinal direction of the building.



a) Damper **b)** Added Component **C)** Steel Frame



d) System

Figure 1. Force-Deformation Relationship of each component.

Earthquake level.

Japan Building Centre simulated earthquake wave BCJ-L2 wave (original wave) The displacement response spectrum value $S_d(T_f, h_0)$ = 23.10 cm, Pseudo velocity spectrum value $S_v(T_f, h_0)$ = 138 cm/s

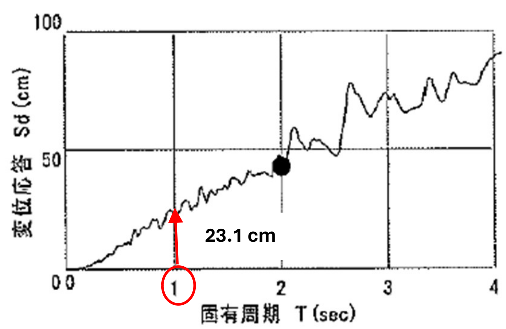


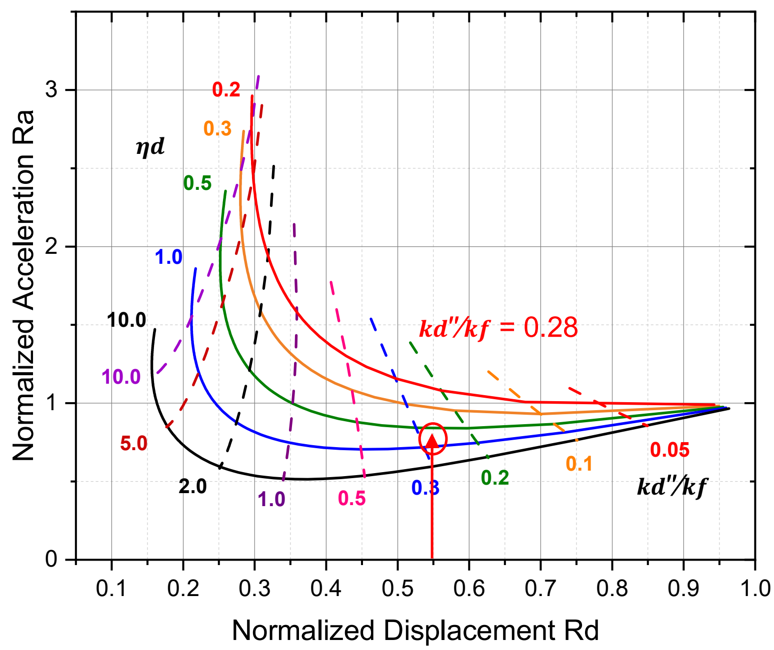
Figure 1. Response spectrum (BCJ-L2 original wave)

Performance curves of structure with VE damper.

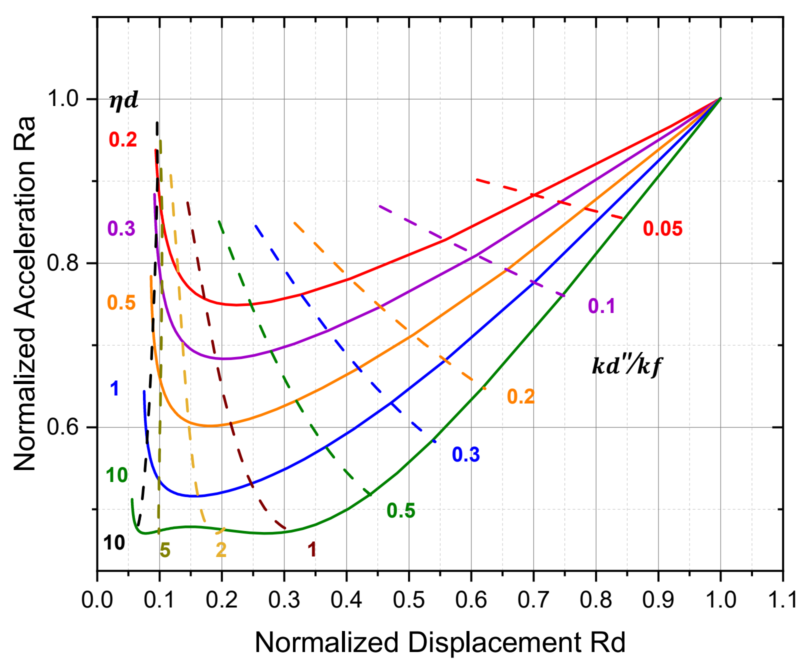
When the natural period of the building is in the short, medium, and long period regions, it is assumed that the pseudo acceleration spectrum is Spa is constant and the pseudo velocity spectrum is constant respectively, the damping performance curves for these two cases are shown in Figure 1. Since the 10-story building can be considered as medium to long period structure, the performance curve with Spv constant will be used.

To use the performance curve, it is necessary to know the damper loss coefficient. Material will be selected from those listed in Manual Appendix A3 Technical Data Sheet (pp448-467), we will proceed with the acrylic viscoelastic damper, until obtaining the value of T_{eq}, the frame period 2.01 seconds is substituted to get $\boldsymbol{\eta_d}$**=0.95**, At the reference temperature of 20^0c , a=$5.6x10^{-5}$, b=2.10, and $\alpha = 0.558$

The second parameter in the performance curve is the target displacement reduction factor R_d which is obtained by θ_{max} / θ_f where $\theta_f = Sd/H_{eff}$ so $\boldsymbol{R_d} = \mathbf{0.55.}$ the location of passive damper devices is shown in Figure 1.



a) Constant velocity response



b) Constant acceleration response

Figure 1. Performance curve of damping structure with viscoelastic

Parameters of viscoelastic damper in each story.

Table 3. Parameters of each damper in each story

Floor	W	H	Elastic Stiffness Kf	Added system Stiffness Kb	Damping factor c	Damper Stiffness Kd
	KN	mm	KN/mm	KN/mm	KNS/mm	KN/mm
4	4894.0	4000	627.0	217.90	0.934	0.864
3	3669.0	4000	729.0	253.40	1.086	7.03
2	3691.0	4000	910.0	316.30	1.356	7.39
1	3762.0	6000	562.0	263.90	1.131	12.60

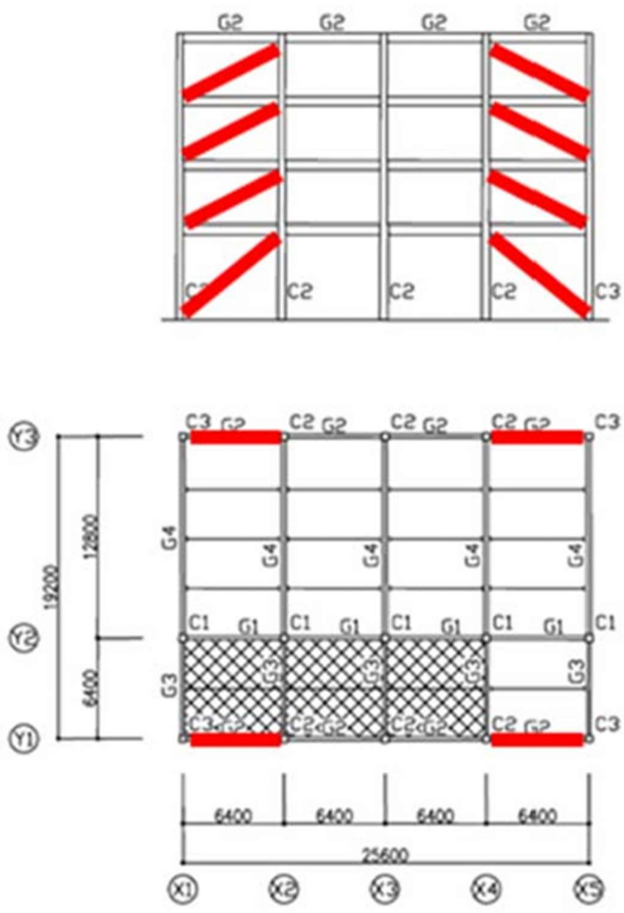


Figure 1. Location of passive control devices

Reference.

[1] Manual of Design and Construction of Passive Control Structure, the Japan Society of Seismic Isolation, 2013.11 (in Japanese) http://www.jssi.or.jp

[2] Details of 4, 10, and 20-story theme structure used for Passive Control Design Examples, Eiichi SEKIYA, Hiroshige MORI, Toshiyuki OHBUCHI, Keisuke YOSHIE, Hiroshi HARA, Fumiko ARIMA, Yuri TAKEUCHI, Yoshihito SAITO, Masato ISHII, and Kazuhiko KASAI, Symposium on Passive Control Structure, Tokyo Institute of Technology (in Japanese)