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 = 42 m
Frame natural period (Without damper) T_f = 2.01 s (0.056H)
Initial damping ratio h_0= 0.02

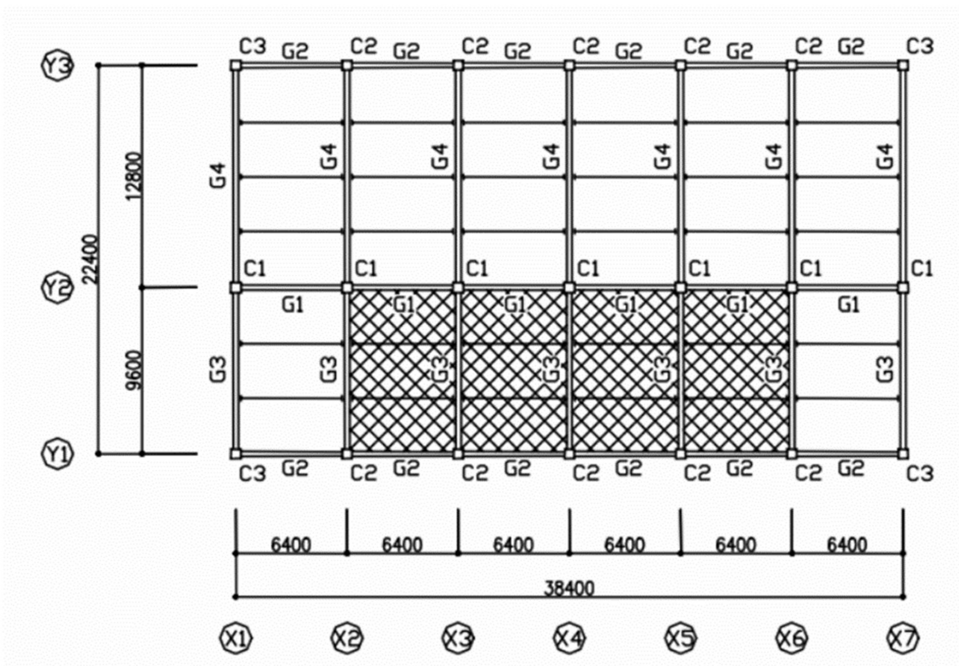
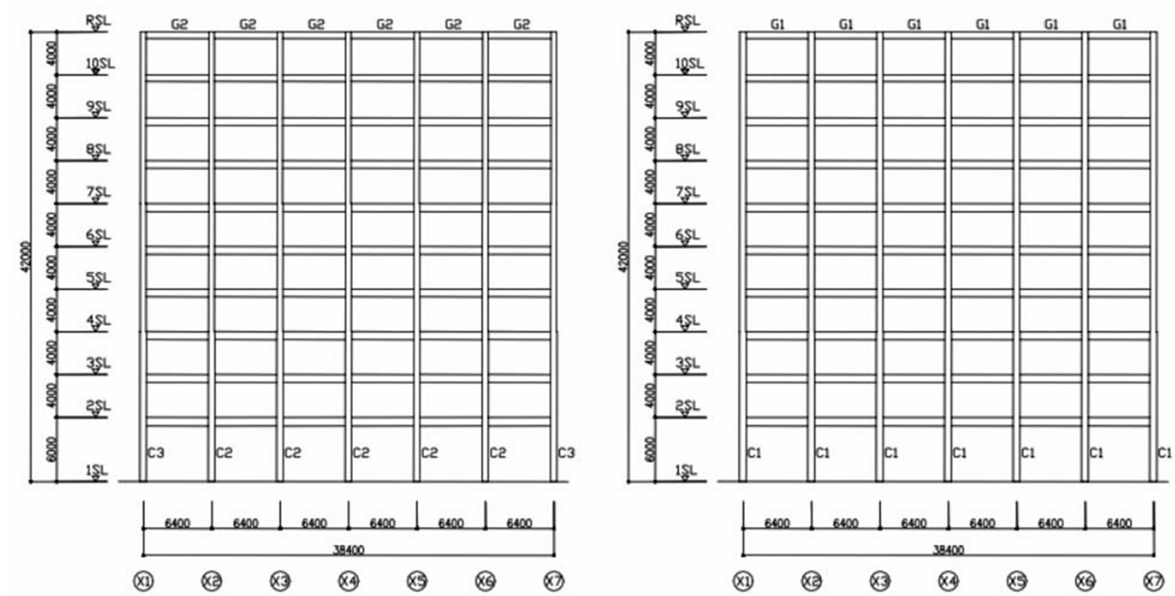


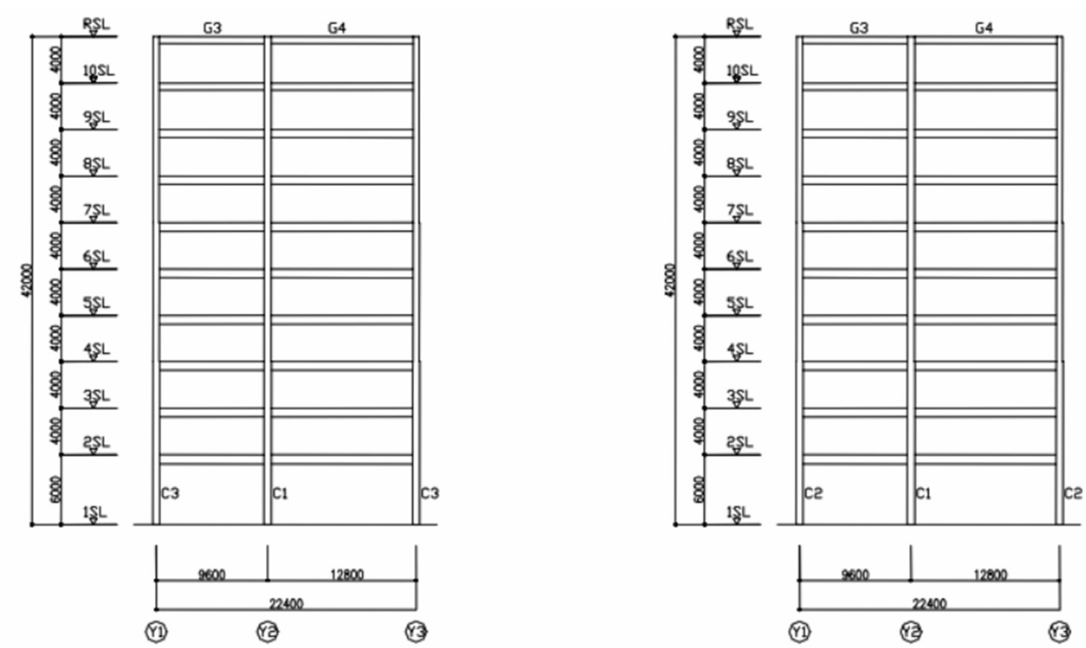
Figure 1. Building plan



b) X1 and X7 frame

a) X2 to X6 frame

Figure 2. Longitudinal direction



d) Y1 and Y3 frame

c) Y2 frame

Figure 2. Transverse direction

Table 1. Box steel column sections.

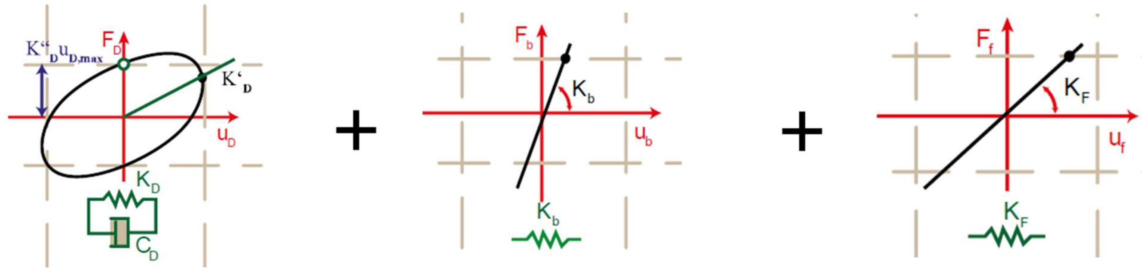
Floor	C1					
	Conventional Type			Trimmed Type		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
9-10	550	550	22	350	350	25
8	550	550	22	400	400	25
7	550	550	22	400	400	28
5-6	600	600	28	450	450	25
4	600	600	28	450	450	28
3	650	650	28	500	500	28
2	650	650	28	500	500	28
1	650	650	28	500	500	36
Floor	**C2**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
9-10	500	500	22	350	350	25
8	500	500	22	350	350	25
7	500	500	22	350	350	28
5-6	550	550	25	400	400	25
4	550	550	25	400	400	25
3	600	600	25	450	450	25
2	600	600	25	450	450	25
1	600	600	28	450	450	36
Floor	**C3**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
9-10	500	500	19	350	350	16
8	500	500	19	350	350	16
7	500	500	19	350	350	16
5-6	550	550	22	400	400	19
4	550	550	22	400	400	19
3	600	600	22	450	450	19
2	600	600	22	450	450	19
1	600	600	25	450	450	28

Table 2. H steel beam sections.

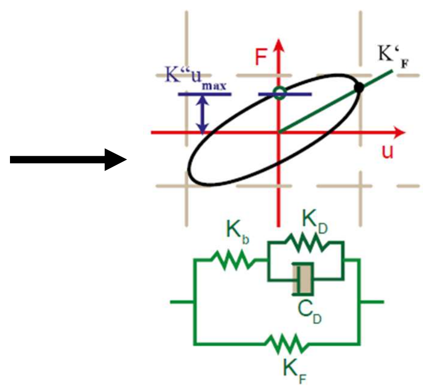
Floor	B1							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	600	300	12	22	450	200	9	16
10	600	300	12	22	450	300	9	16
9	700	300	12	22	500	300	12	19
8	700	300	12	22	500	350	12	19
7	750	300	16	25	500	350	12	22
6	750	300	16	25	500	350	12	22
5	750	300	16	28	500	350	16	25
4	750	300	16	28	500	350	16	28
3	750	300	16	28	500	350	16	28
2	800	300	16	32	500	350	16	32
Floor	B2							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	600	250	12	22	450	200	9	12
10	600	250	12	22	450	200	12	19
9	700	250	12	22	500	300	9	16
8	700	250	12	22	500	300	12	19
7	750	250	14	25	500	300	12	22
6	750	250	14	25	500	300	12	22
5	750	250	16	28	500	300	16	25
4	750	250	16	28	500	300	16	25
3	750	250	16	28	500	300	16	25
2	800	300	16	28	500	300	16	28
Floor	B3							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	600	300	14	25	450	300	16	28
10	600	300	14	25	450	300	12	19
9	700	300	14	25	500	300	12	25
8	700	300	14	25	500	300	12	25
7	750	300	16	28	500	350	12	25
6	750	300	16	28	500	350	16	28
5	750	350	16	28	500	350	16	28
4	750	350	16	28	500	350	16	32
3	750	350	16	28	500	350	16	32
2	800	300	16	32	500	350	16	36
Floor	B4							
	Conventional Type				Trimmed Type			
	H (mm)	B (mm)	t1 (mm)	t2 (mm)	H (mm)	B (mm)	t1 (mm)	t2 (mm)
R	600	300	14	32	450	350	16	32
10	600	300	14	32	450	300	16	28
9	700	300	16	32	500	300	16	32
8	700	300	16	32	500	300	16	32
7	750	300	16	32	500	350	16	32
6	750	300	16	32	500	350	16	32
5	750	350	16	32	500	350	16	36
4	750	350	16	32	500	350	16	36
3	750	350	16	32	500	350	16	36
2	800	300	16	32	500	350	16	36

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 $S_d(T_f, h_0)$ = 44.20 cm, Pseudo velocity spectrum value $S_v(T_f, h_0)$ = 138 cm/s

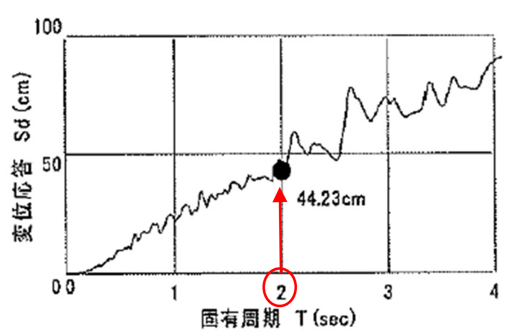


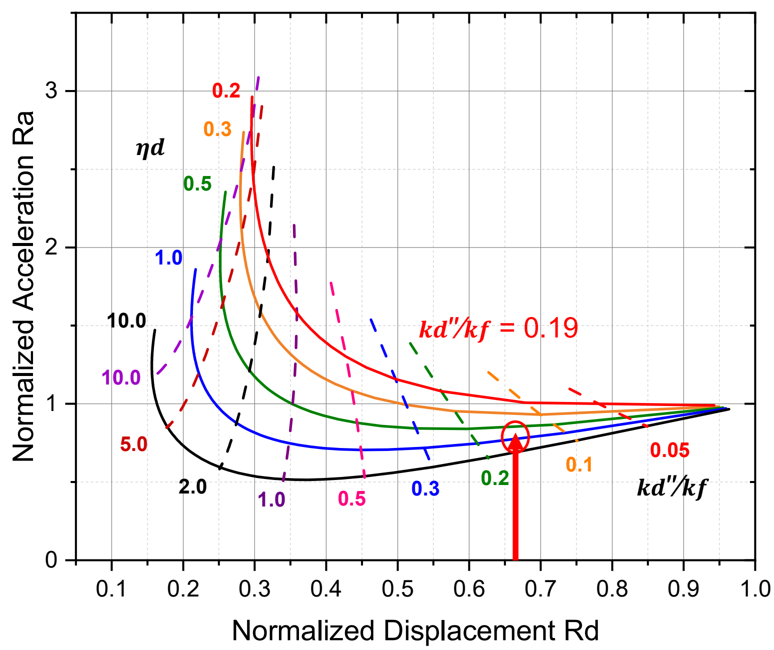
Figure 1. Response spectrum (BCJ-L2 original wave)

Performance curves of structure with VE damper.

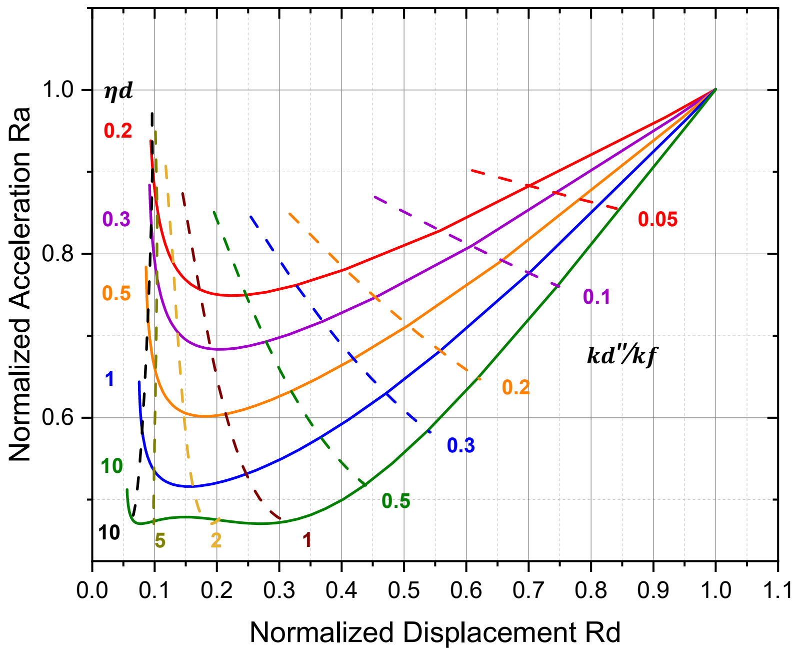
When the natural period of the building is in the short, medium, and long period regions, it is assumed that the pseudo acceleration spectrum is Spa is constant and the pseudo velocity spectrum is constant respectively, the damping performance curves for these two cases are shown in Figure 1. Since the 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 $\boldsymbol{\eta_d}$**=0.86**, At the reference temperature of $20^0 c$, 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 $\theta_{max} \,/\, \theta_f$ where $\theta_f = Sd/H_{eff}$ so $\boldsymbol{R_d = 0.665.}$ 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**
10	8579.0	4000	158.6	------	-----	-----
9	6465.0	4000	189.1	417.4	1.81	7.40
8	6431.0	4000	220.3	510.5	2.21	10.8
7	6470.0	4000	244.8	567.3	2.46	16.0
6	6539.0	4000	291.8	676.3	2.93	14.3
5	6567.0	4000	306.2	709.6	3.08	18.8
4	6622.0	4000	328.2	760.6	3.30	20.2
3	6664.0	4000	383.0	887.6	3.80	12.2
2	6680.0	4000	383.5	888.9	3.80	15.7
1	6859.0	6000	280.0	876.8	3.80	8.50

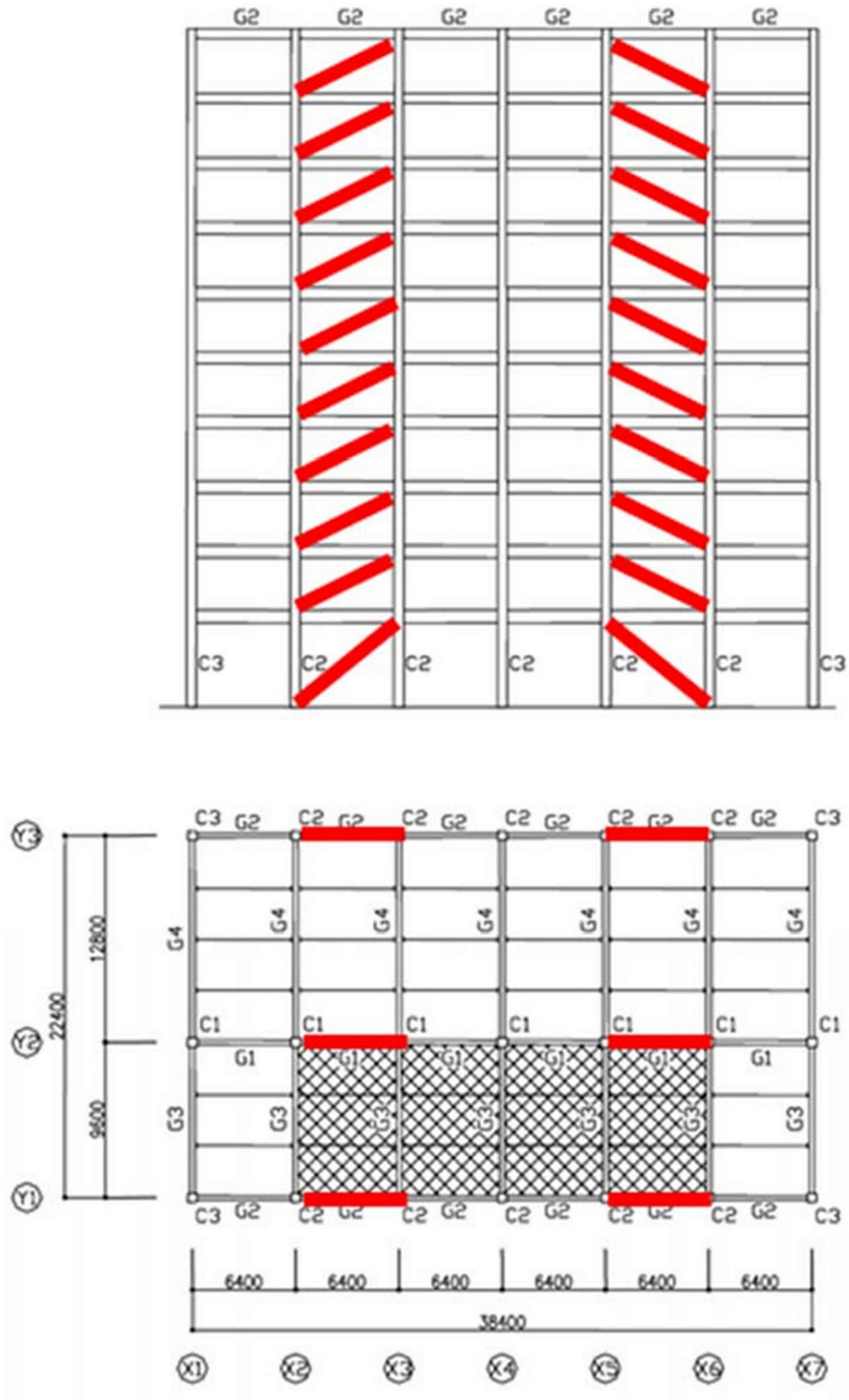


Figure 1. Layout of passive control devices

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)