Target performance.

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

Building Description:

The twenty-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 = 82 m
Frame natural period (Without damper) T_f = 4.59 s (0.056H)
Initial damping ratio h_0= 0.02

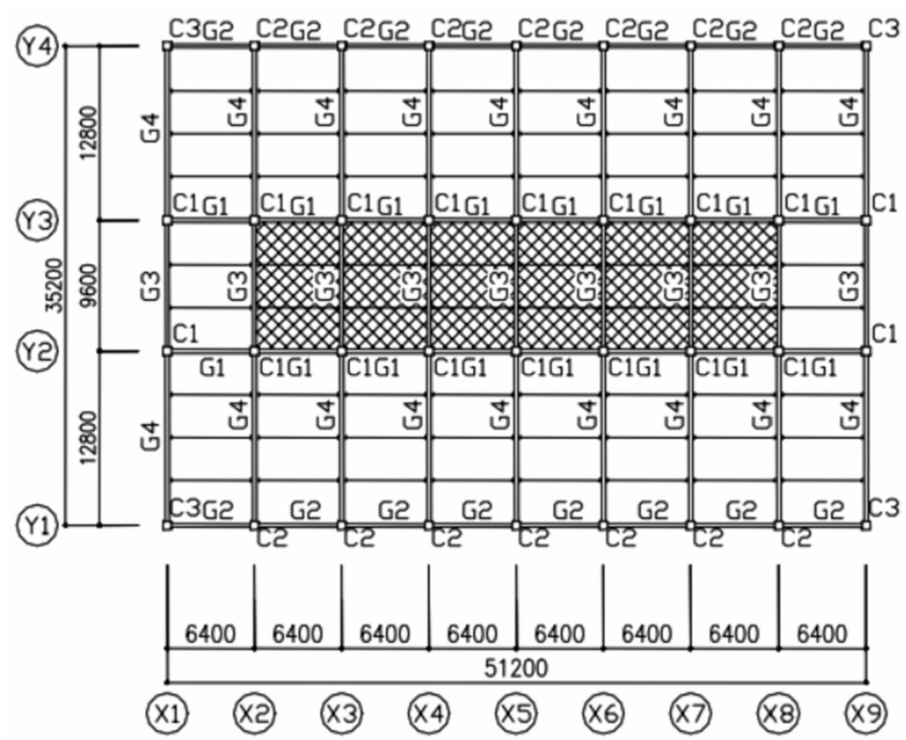
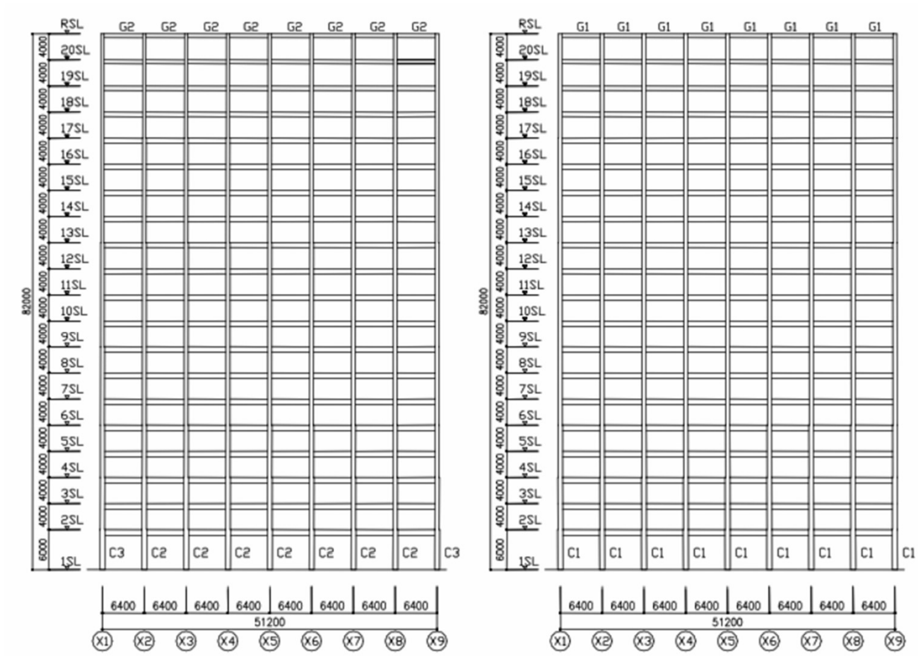
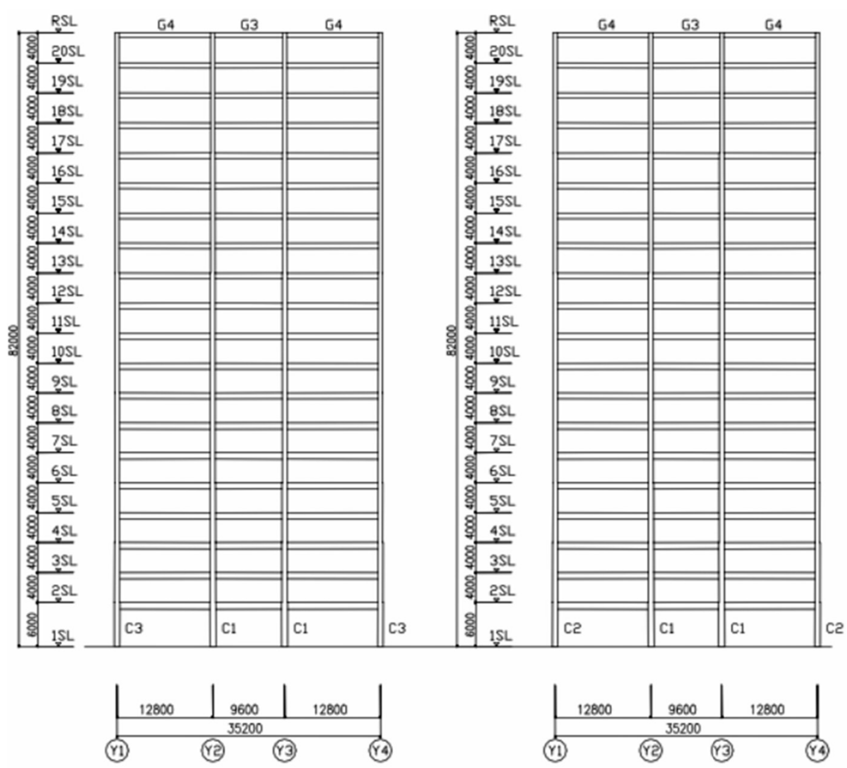


Figure 1. Building plan



b) Y1 and Y4 frame **a)** Y2 and Y3 frame

Figure 2. Longitudinal direction



d) X1 and X9 frame **c)** X2 - X8 frame

Figure 2. Transverse direction

Table 1. Box steel column sections.

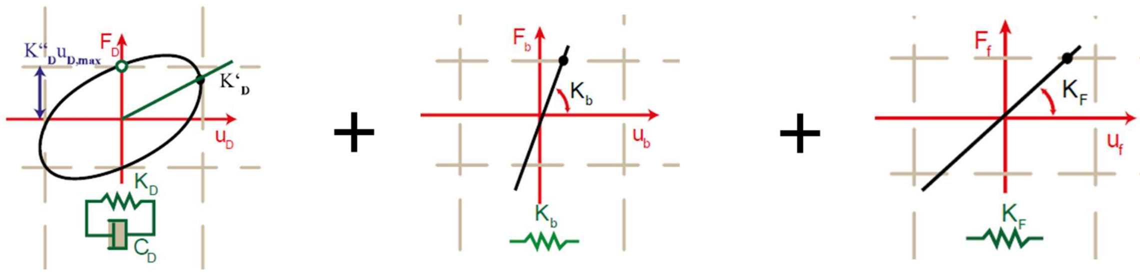
Floor	C1					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
17-20	550	550	25	350	350	28
13-16	600	600	28	400	400	32
9-12	650	650	28	450	450	36
6-8	650	650	32	450	450	40
4-5	700	700	32	500	500	40
2-3	750	750	36	500	500	45
1	800	800	36	550	550	55
Floor	**C2**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
17-20	500	500	22	350	350	25
13-16	550	550	25	350	350	32
9-12	600	600	28	400	400	32
6-8	600	600	28	400	400	36
4-5	650	650	28	450	450	36
2-3	700	700	36	450	450	45
1	750	750	36	500	500	50
Floor	**C3**					
	Conventional Type			**Trimmed Type**		
	H (mm)	**B** (mm)	**t** (mm)	**H** (mm)	**B** (mm)	**t** (mm)
17-20	500	500	19	300	300	25
13-16	500	500	19	300	300	25
9-12	550	550	22	350	350	25
6-8	600	600	25	400	400	28
4-5	650	650	28	450	450	32
2-3	700	700	32	450	450	36
1	750	750	32	500	500	36

Table 2. H steel beam sections.

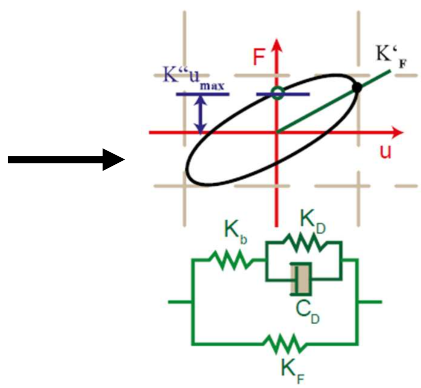
Floor	B1							
	Conventional Type				Trimmed Type			
	H (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)	**H** (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)
20-R	600	300	14	25	450	250	9	19
18-19	700	300	14	22	450	250	12	25
15-17	750	300	16	25	500	250	16	32
12-14	750	300	16	32	500	300	16	32
9-11	800	300	16	32	500	300	16	36
6-8	850	300	16	32	550	300	16	32
3-5	850	300	16	32	550	300	16	32
2	900	300	19	32	600	300	16	32
Floor	**B2**							
	Conventional Type				Trimmed Type			
	H (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)	**H** (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)
20-R	600	250	12	22	450	200	9	19
18-19	700	300	14	22	450	250	9	19
15-17	750	300	16	25	500	250	9	19
12-14	750	300	16	32	500	250	12	22
9-11	800	300	16	25	500	250	12	25
6-8	850	250	16	25	550	250	12	25
3-5	850	300	16	25	550	250	16	28
2	900	300	19	25	600	250	16	32
Floor	**B3**							
	Conventional Type				Trimmed Type			
	H (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)	**H** (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)
20-R	600	300	14	25	450	300	12	25
18-19	700	300	14	28	450	300	12	25
15-17	750	350	16	28	500	300	16	28
12-14	750	350	16	28	500	300	16	36
9-11	800	300	16	32	500	350	16	36
6-8	850	250	16	32	550	350	16	36
3-5	850	300	16	32	550	350	16	36
2	900	300	19	32	600	350	16	40
Floor	**B4**							
	Conventional Type				Trimmed Type			
	H (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)	**H** (mm)	**B** (mm)	**t1** (mm)	**t2** (mm)
20-R	600	300	14	32	450	300	16	36
18-19	700	350	16	32	450	300	16	36
15-17	750	350	16	36	500	350	16	32
12-14	750	350	16	36	500	300	16	36
9-11	750	300	16	32	500	350	16	36
6-8	800	300	16	32	550	350	16	36
3-5	850	300	16	32	550	350	16	36
2	900	300	19	32	600	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 $S_d(T_f, h_0)$ = 101.62 cm.

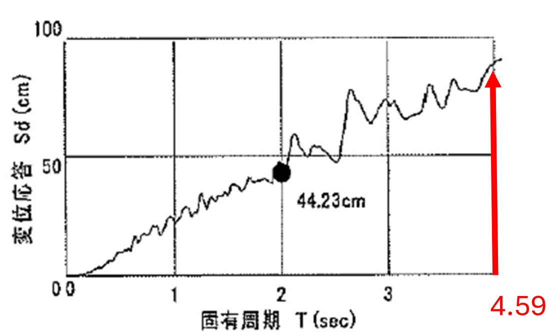


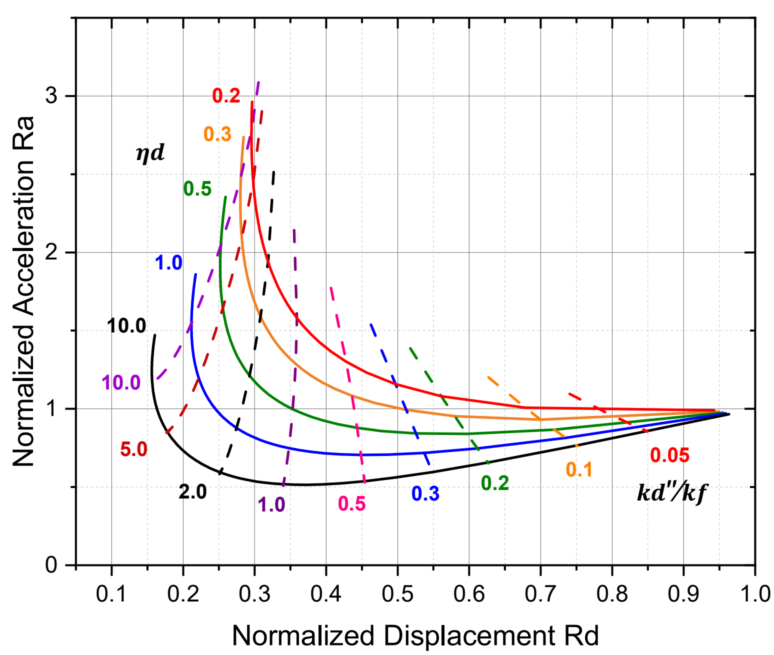
Figure 1. Response spectrum (BCJ-L2 original wave)

Performance curves of structure with VE damper.

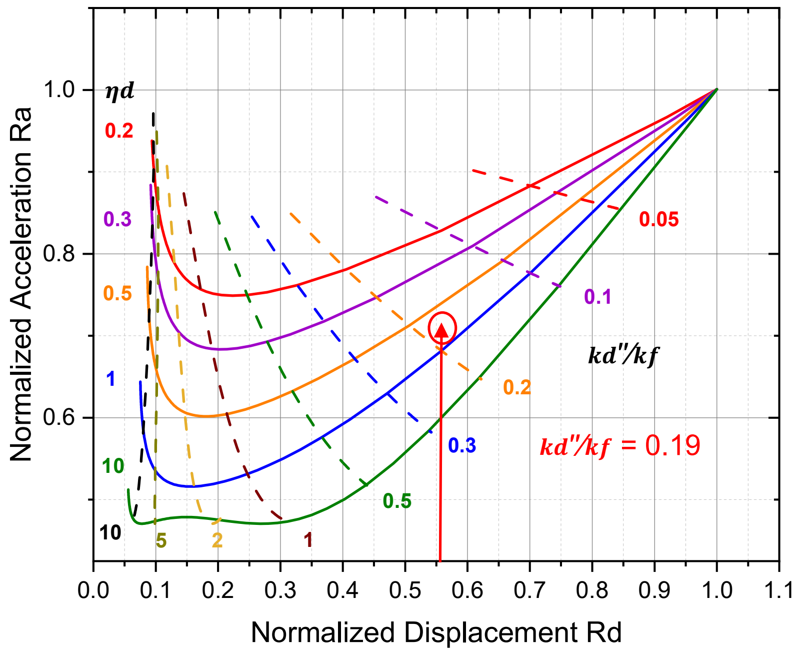
When the natural period of the building is in the short, medium, and long period regions, it is assumed that the pseudo acceleration spectrum is Spa is constant and the pseudo velocity spectrum is constant respectively, the damping performance curves for these two cases are shown in Figure 1. Since the 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 $\boldsymbol{\eta_d}$**=0.74**, 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 $\boldsymbol{R_d = 0.564.}$ 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**
20	18459.8	4000	2789	------	-----	-----
19	13945.1	4000	2929	509.1426	5.350777	7.834956
18	14104.7	4000	3125	543.2129	5.708835	20.08056
17	14104.7	4000	3428	595.8828	6.262364	28.72711
16	14309.7	4000	4439	771.623	8.109286	23.61702
15	14360.5	4000	4530	787.4414	8.275527	33.81614
14	14360.5	4000	4733	822.7285	8.646373	41.00833
13	14448.4	4000	4913	854.0176	8.975202	47.74587
12	14492.8	4000	5992	1041.578	10.94635	37.60979
11	14537.3	4000	6139	1067.131	11.21489	43.28457
10	14405.2	4000	6306	1096.16	11.51997	47.73792
9	14405.2	4000	6381	1109.197	11.65698	53.07273
8	14434.2	4000	6947	1207.584	12.69097	48.92697
7	14454.4	4000	7291	1267.381	13.3194	48.02336
6	14454.4	4000	7367	1280.592	13.45824	51.1878
5	14491.3	4000	8549	1486.057	15.61755	33.94347
4	14569.1	4000	8759	1522.561	16.00118	33.3533
3	14672.5	4000	9308	1617.992	17.00411	26.04432
2	14775.8	4000	9742	1693,434	17.79695	20.10445
1	15222	6000	8429	------	------	------

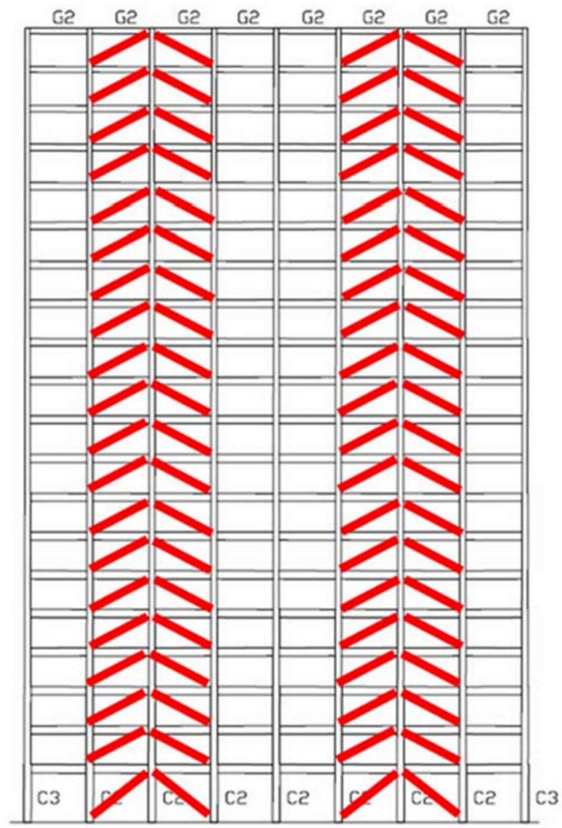


Figure 1. Location of passive control devices

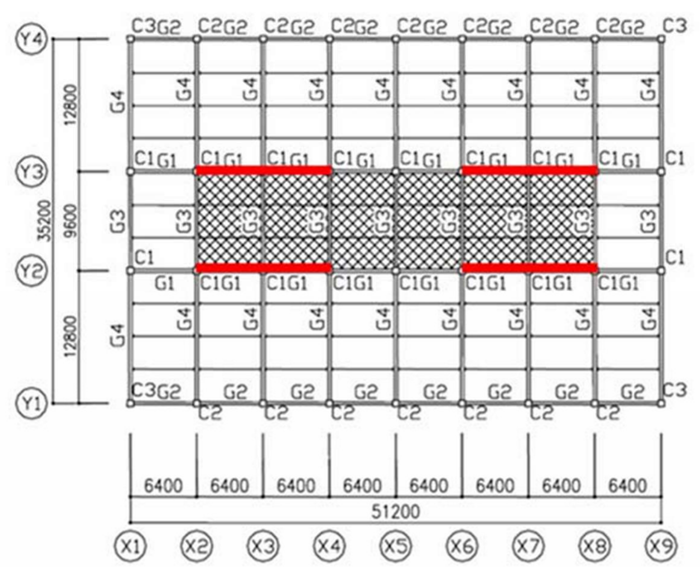


Figure 1. Layout of passive control devices

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)