

Performance of Seismically Isolated Buildings due to 2011 Tohoku Earthquake

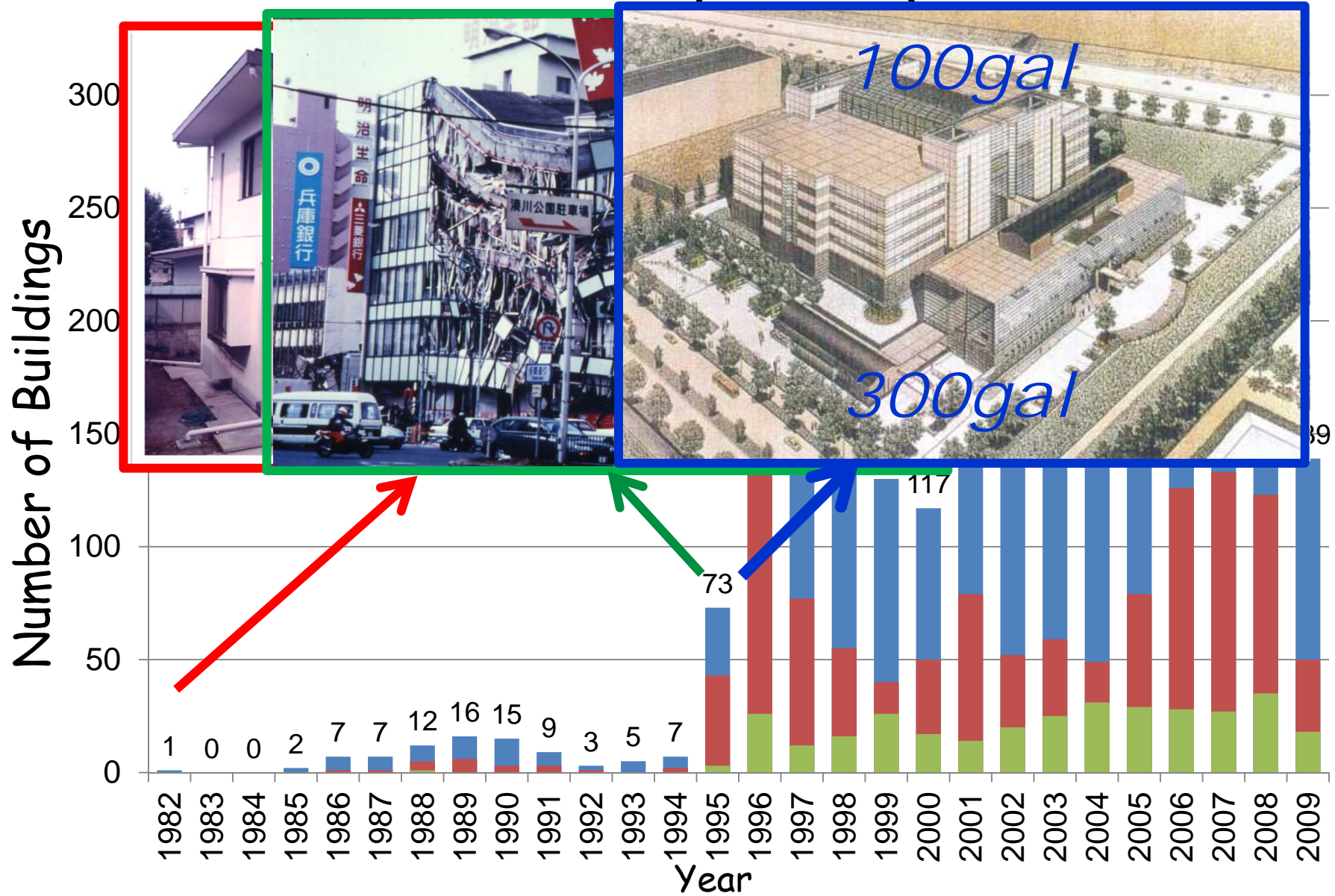
Mineo Takayama
Fukuoka University



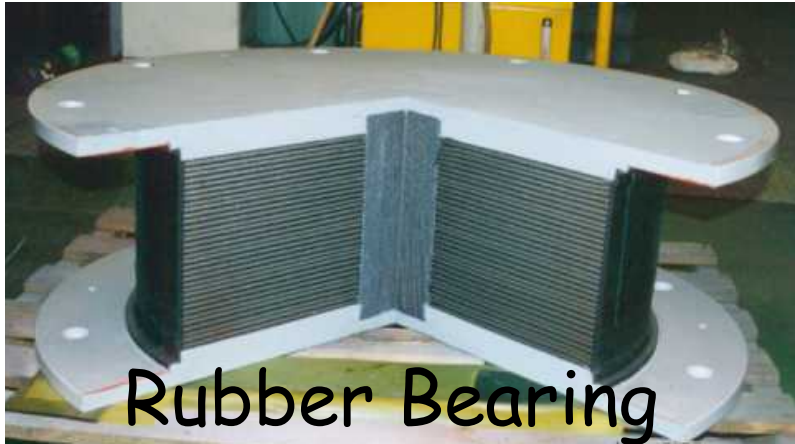
Topics

- Present State of Seismic Isolation in Japan
- Performance of Seismic Isolated Buildings based on Earthquake Records
- Response Analysis Results

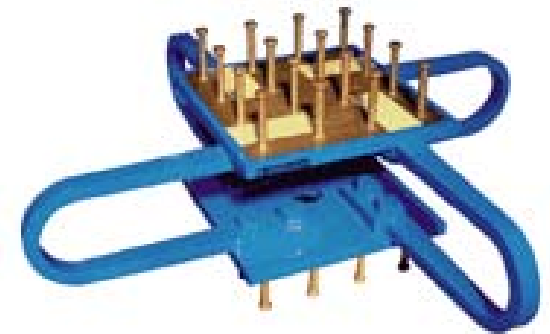
Number of SI buildings in Japan



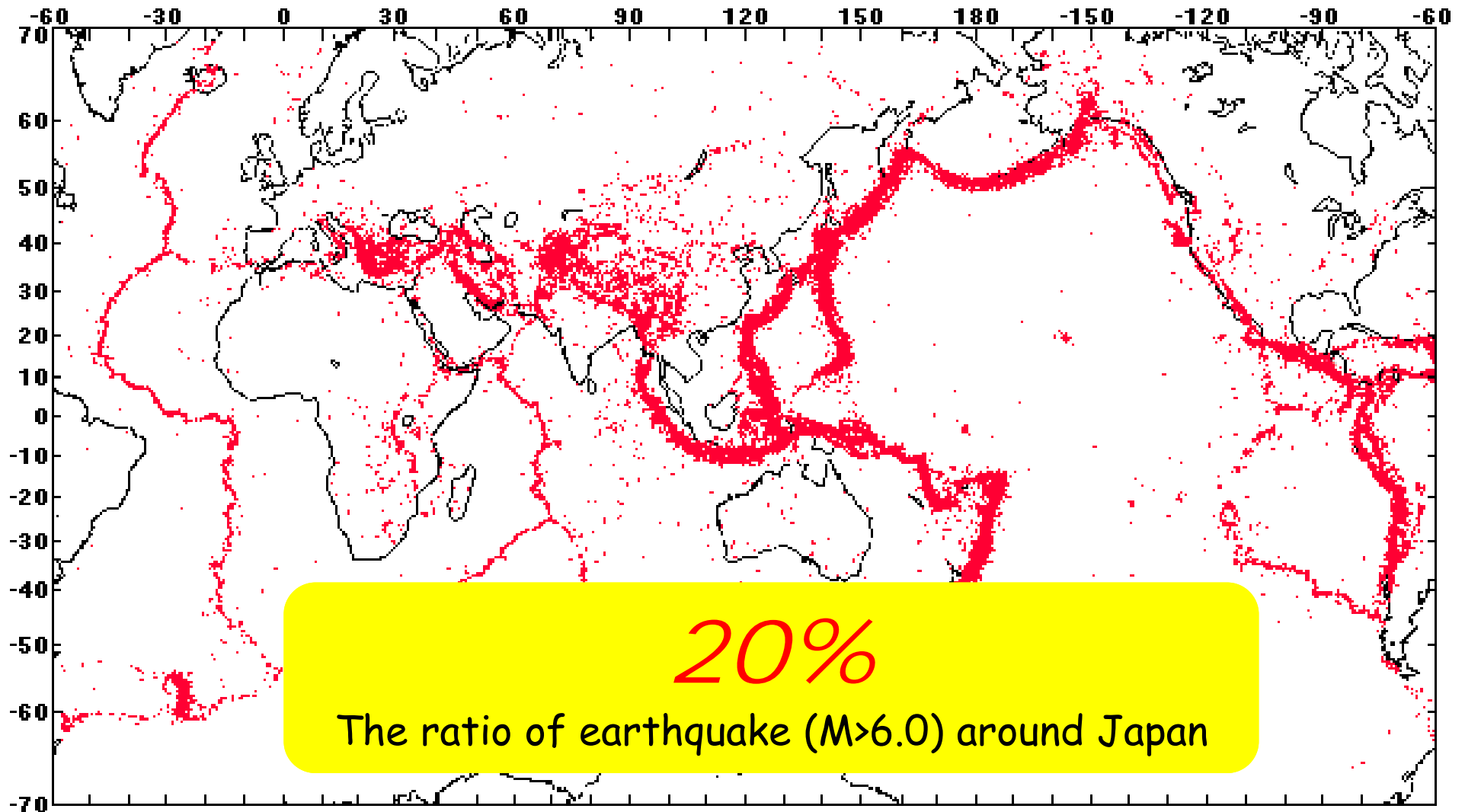
Various Types of Isolator & Damper



Oil Damper
Lead Damper Steel Damper

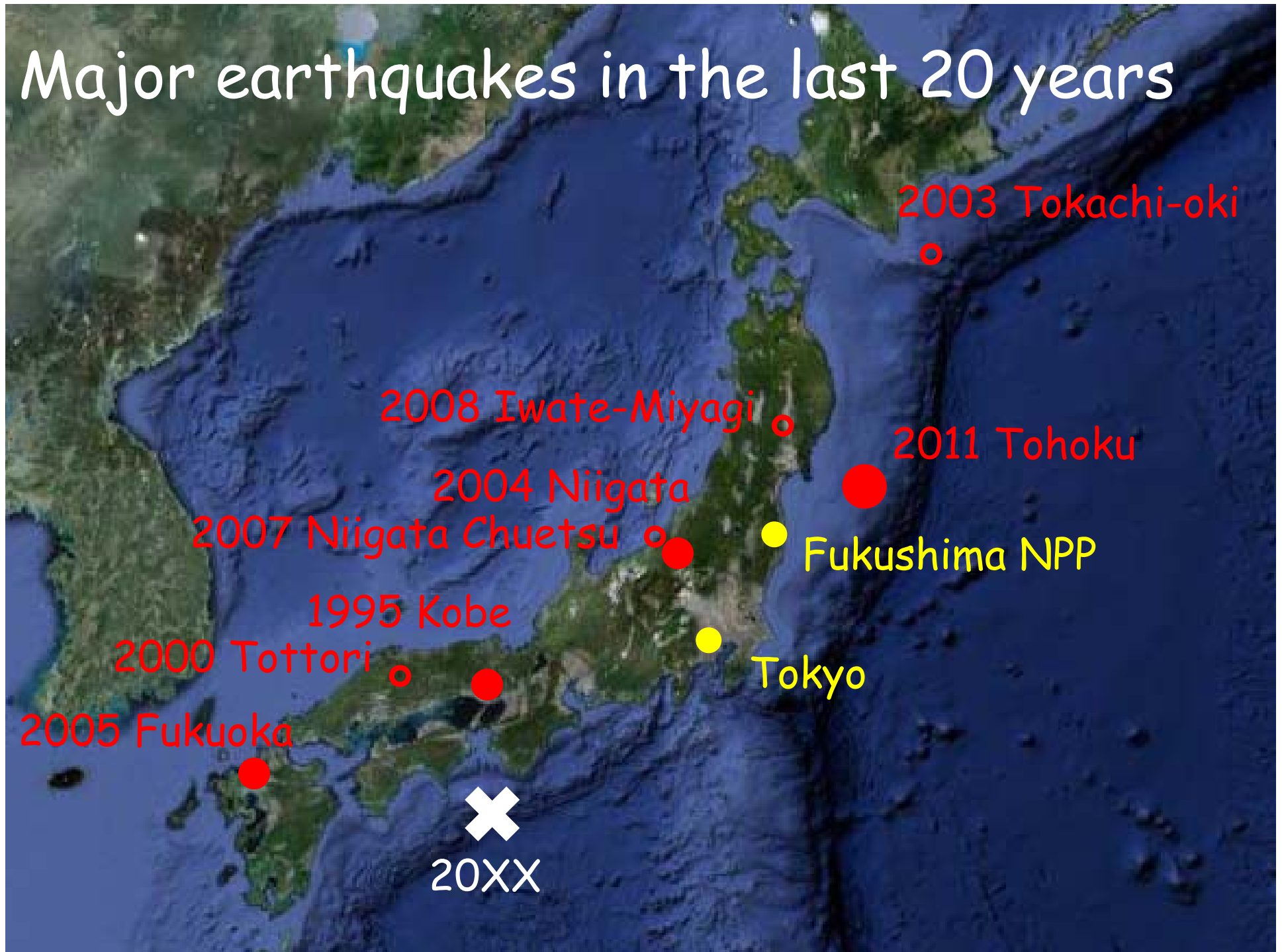


Earthquake Distribution Map in the World



($M > 4.0$, Depth $< 100\text{km}$)

Major earthquakes in the last 20 years



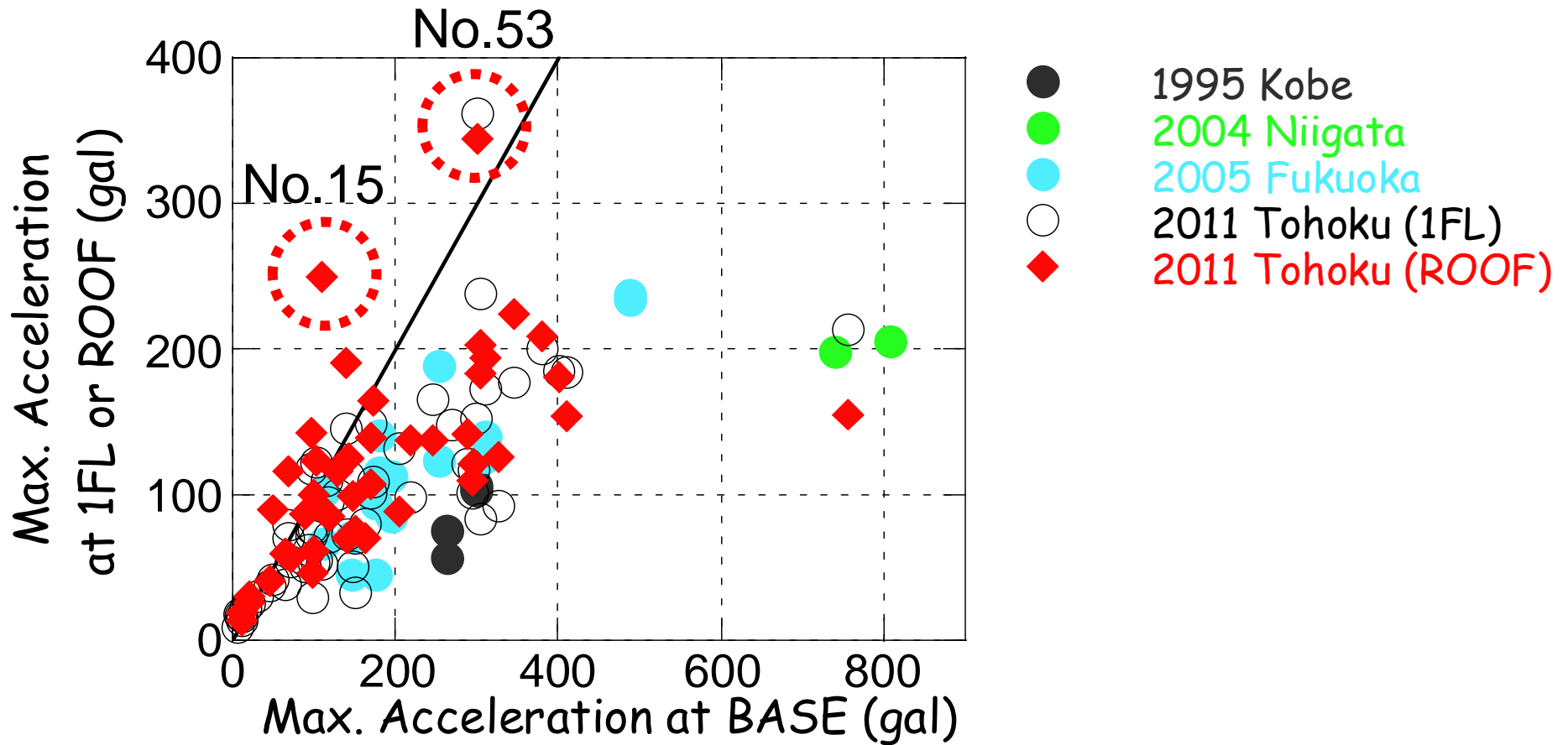
Top 15 of order

No.	Prefecture	Use	Story	No.	Max. Acceleration(gal)			Amplification		No.	Max. Displacement (cm)
					BASE	1FL	ROOF	1FL/BASE	ROOF/BA		
				4	756	213	155			4	24.0
4	Fukushima	Office	2	12	411	184	154	0.282	0.205	12	
12	Fukushima	Office	3	13	402	185	181	0.448	0.375	13	13.9
13	Ibaragi	Apartment	21	20	381	200	209	0.460	0.450	20	18.1
20	Miyagi		6	18	345	177	224	0.525	0.549	18	10.5
18	Miyagi	Office	5	3	327	92	126	0.513	0.649	3	5.9
3	Ibaragi	Office	7	24	311	173	194	0.281	0.385	24	23.0
24	Miyagi	Office	18	2	305	83	183	0.557	0.624		
2	Iwate	Hospital	6	37	305	238	203	0.273	0.599		
37	Ibaragi	Research Lab.	5	6	301	362	344	0.780	0.666		
53	Miyagi	Research Lab.	3	17	299	152					
17	Miyagi		9	8	296	117	121				
8	Ibaragi	Research Lab.	3	6	295	101	110				
6	Ibaragi	Office	6	9	289	121	142				
9	Miyagi	Office	9	10	289	121	142				
10	Miyagi	Office	9								

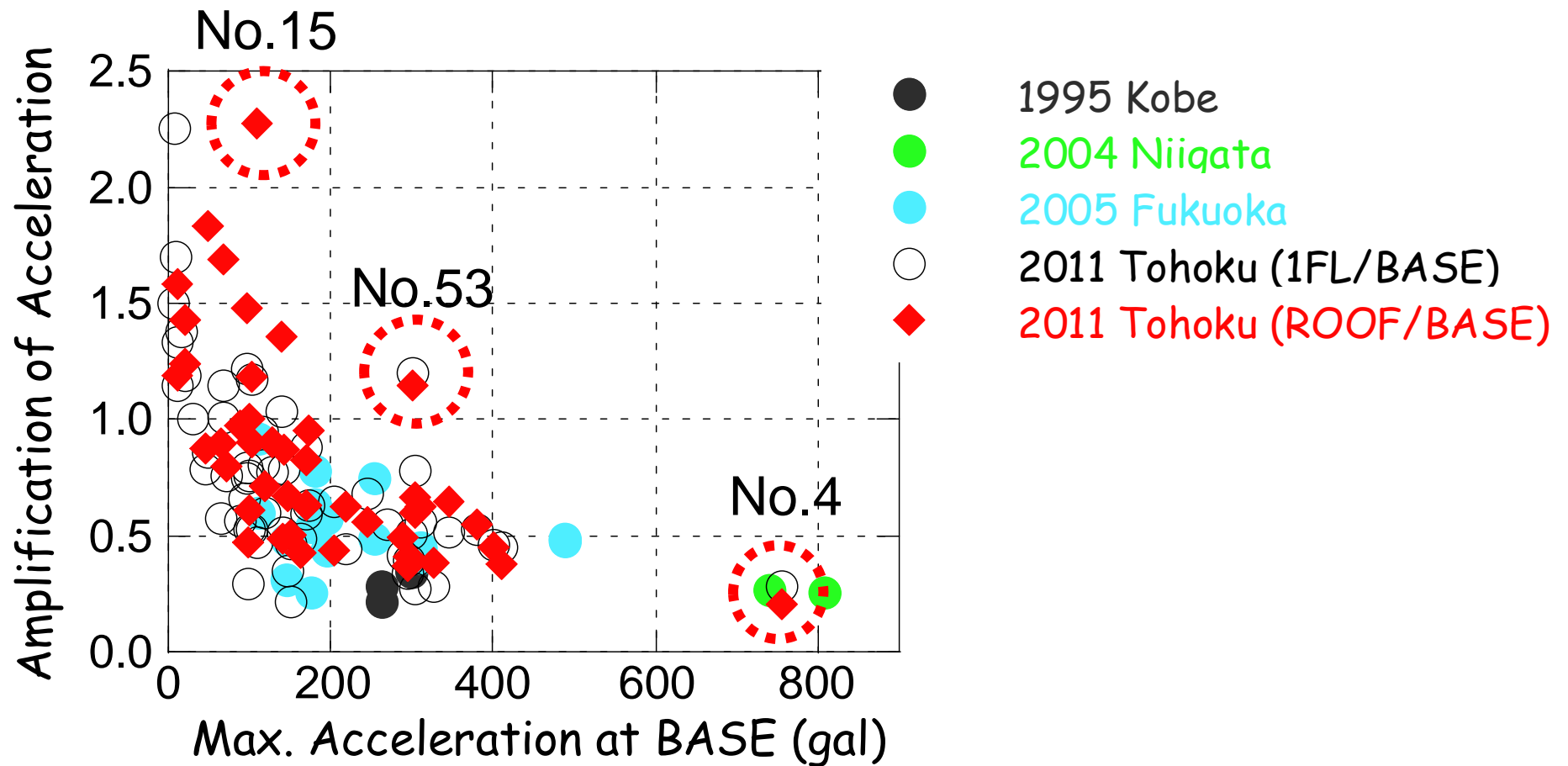
Top 15 of order

No.	Prefecture	Use	Story	No.	Max. Acceleration(gal)			Amplification	
					BASE	1FL	ROOF	1FL/BASE	ROOF/BA
				1	RB+VD	151	33		
1	Tokyo	Office	2	2	NRB+LRB+SLB+SD	305	83	0.219	0.599
2	Iwate	Hospital	6	3	NRB+LRB+SD	327	92	0.273	0.599
3	Ibaragi	Office	7	4	NRB+LRB+SD	327	92	0.281	0.385
4	Fukushima	Office	2	5	NRB+LRB+SLB+OIL	756	213	0.282	0.205
5	Tokyo	School	26	6	NRB+OIL	98	29	0.296	0.469
6	Ibaragi	Office	6	7	NRB+SLB+OIL	295	101	0.341	0.373
7	Kanagawa	School	7	8	HDR	147	51	0.347	0.672
8	Ibaragi	Research Lab.	3	9	NRB+SD+LD	296	117	0.395	0.409
9	Miyagi	Office	9	10	HDR+OIL	289	121	0.419	0.491
10	Miyagi	Office	9	11	NRB+LRB	289	121	0.419	0.491
11	Chiba	Office	8	12	NRB+HDR	219	98	0.445	0.626
12	Fukushima	Office	3	13	LRB+SLB+OIL	411	184	0.448	0.375
13	Ibaragi	Apartment	21	14	NRB+SLB+SD+LD	402	185	0.460	0.450
14	Chiba	Apartment	3	15	NRB+VD	150	70	0.467	0.503
15	Tokyo	Research Lab.	2		HDR	110	52	0.473	2.273

Observed Acceleration of Seismic Isolated Buildings



Amplification Factor of Observed Acceleration of Seismic Isolated Buildings



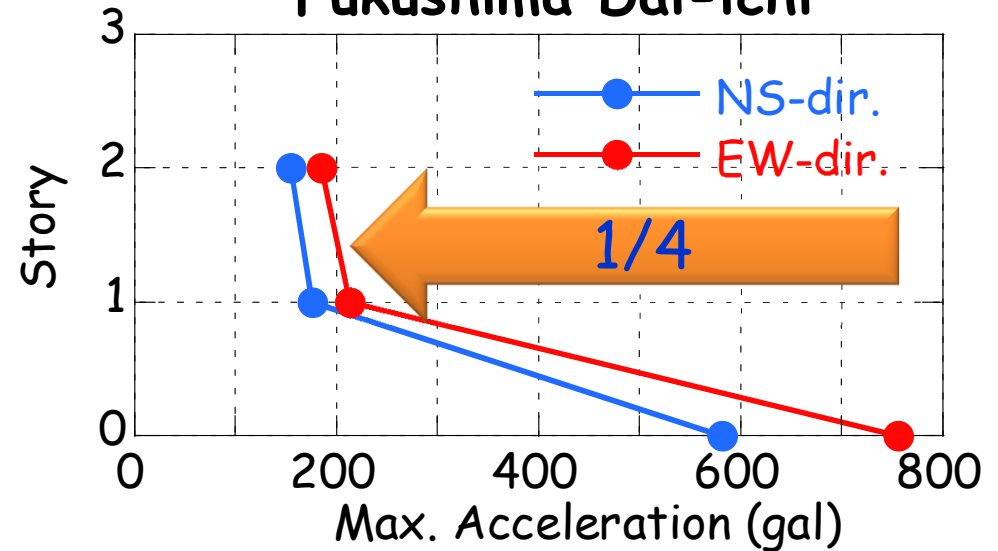
Seismic Isolated Building at Fukushima Dai-ichi & Dai-ni NPP

No.4

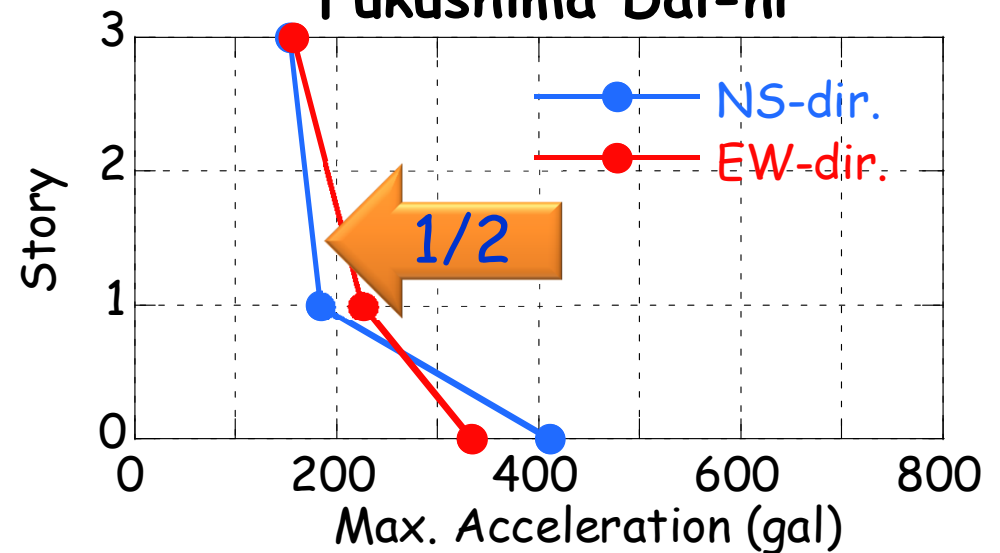


No.12

Fukushima Dai-ichi



Fukushima Dai-ni



No.13

Condominium Building at Mito City

RC / 21 Story

Height : 68.9m

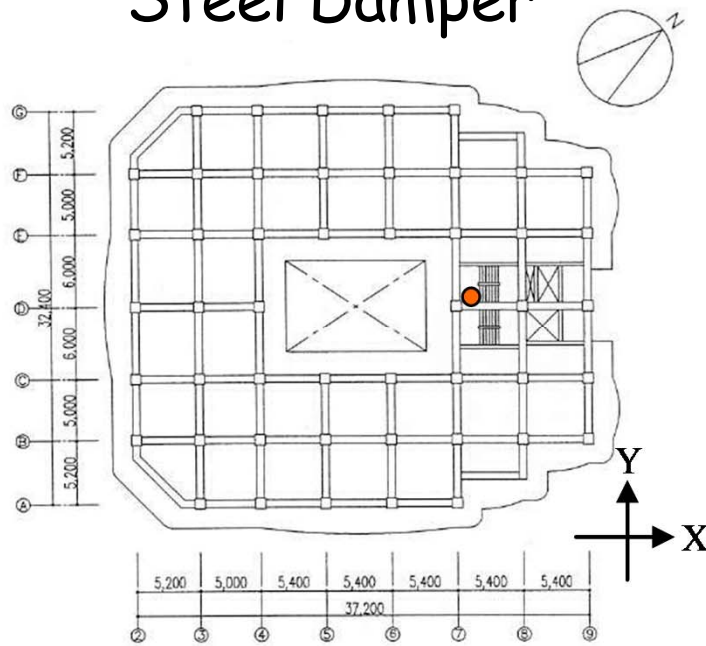
Isolation system :

NRB

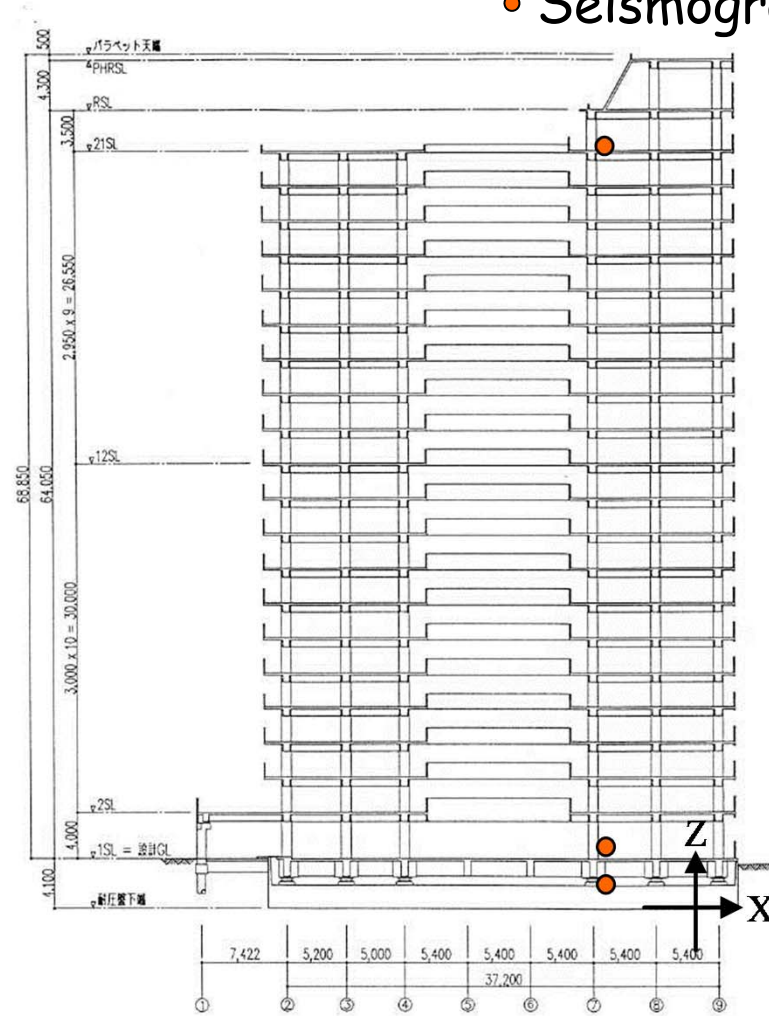
Lead Damper

Steel Damper

• Seismograph



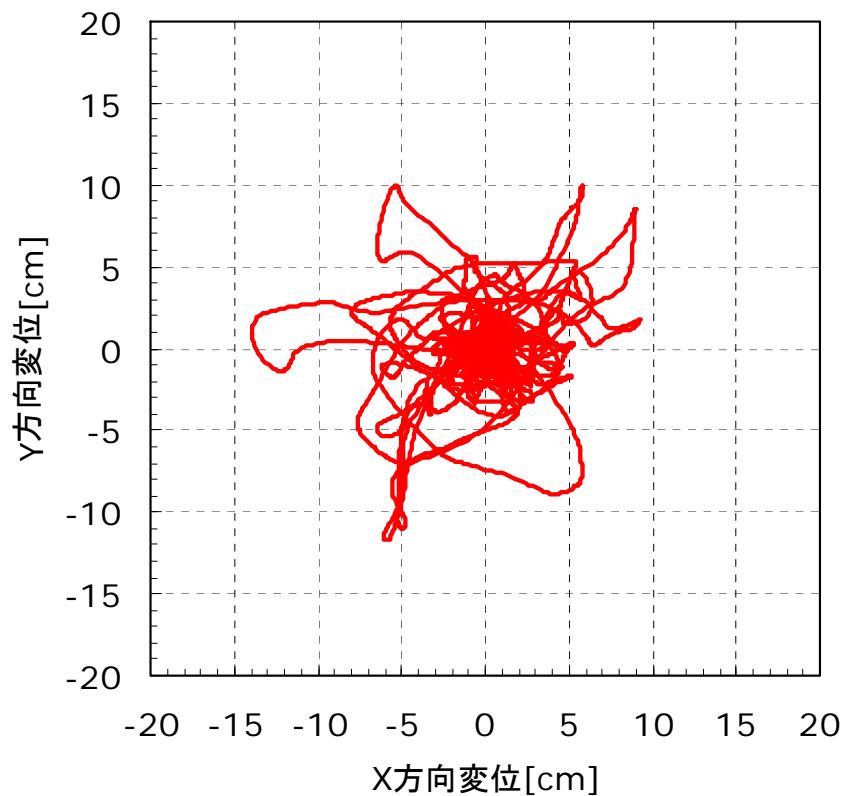
PLAN



SECTION

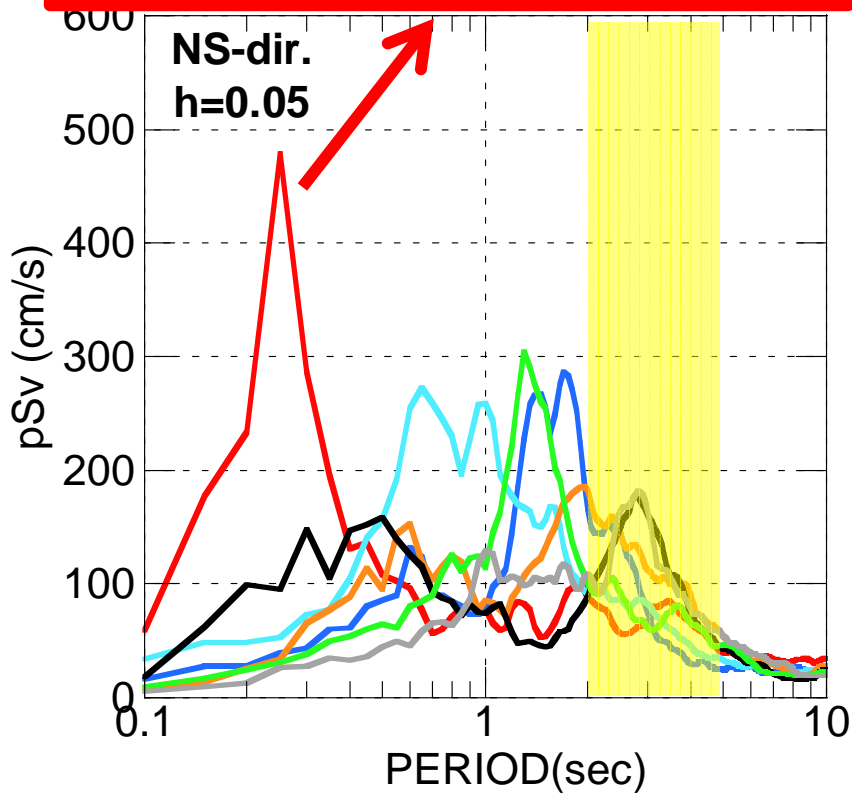
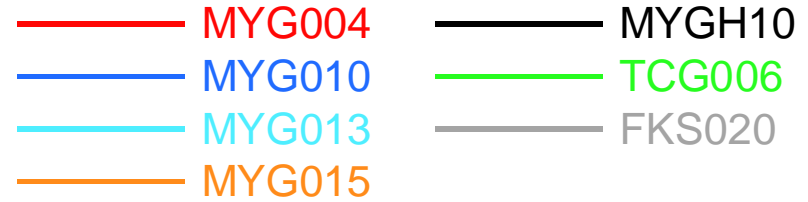
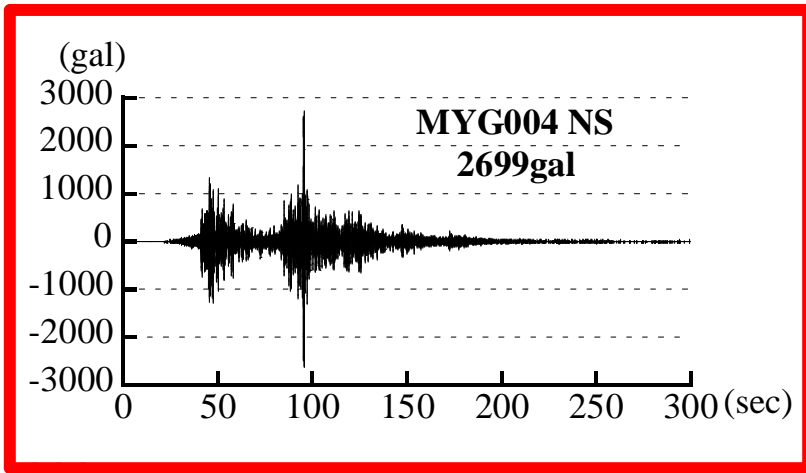
Max. Acceleration (gal)

Location	Horizontal	Vertical
Base	314	402
1F	113	185
RF	149	181

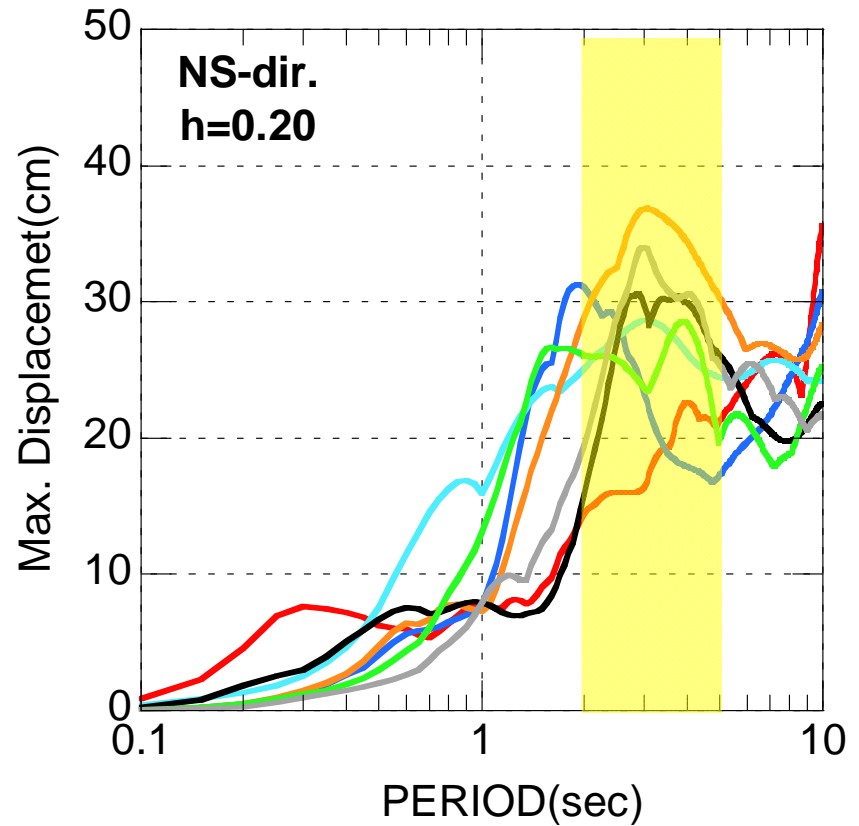


Max.
Displacement
15cm

tra of 2011 Tohoku ake Records



Velocity Spectrum

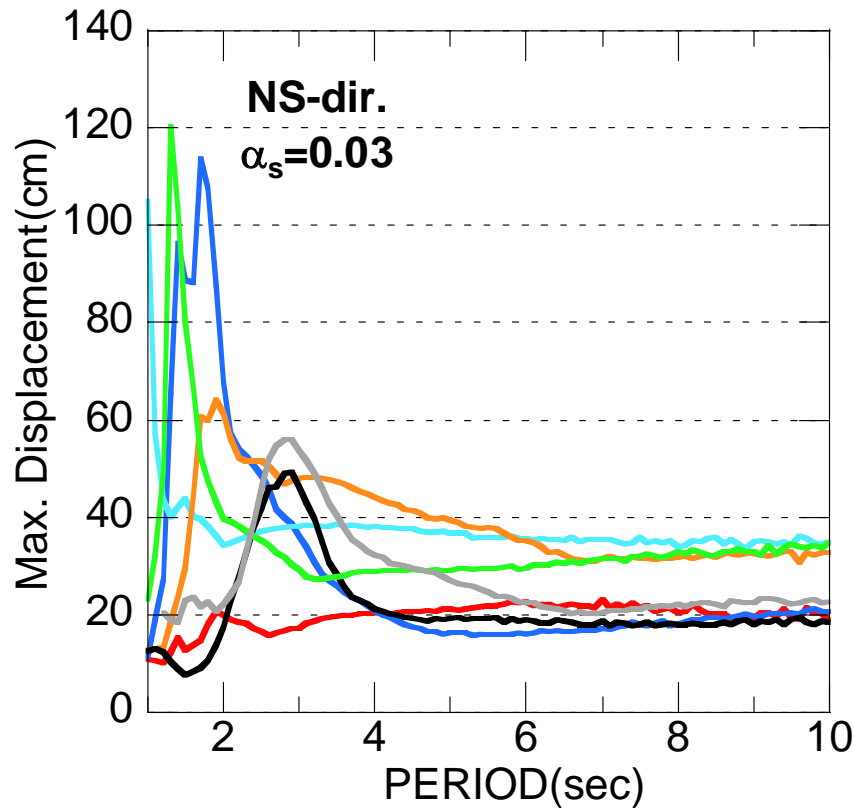


Displacement Spectrum

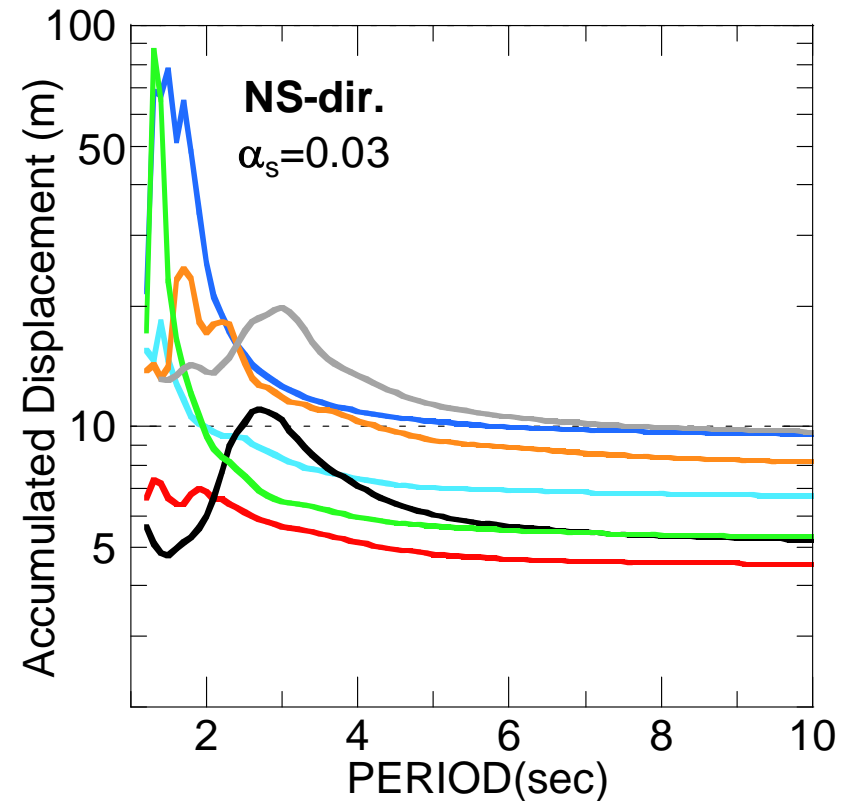
Max. Response of Seismic Isolated Structure with Bi-Linear System

$\alpha_s = 0.03$

- MYG004
- MYGH10
- MYG010
- TCG006
- MYG013
- FKS020
- MYG015



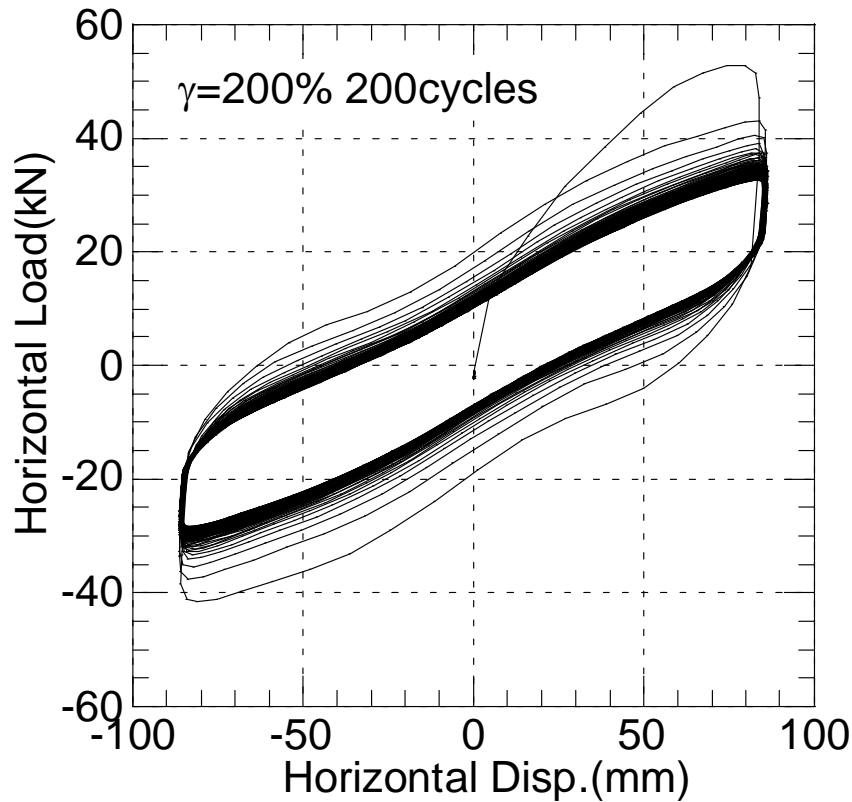
Max. Displacement



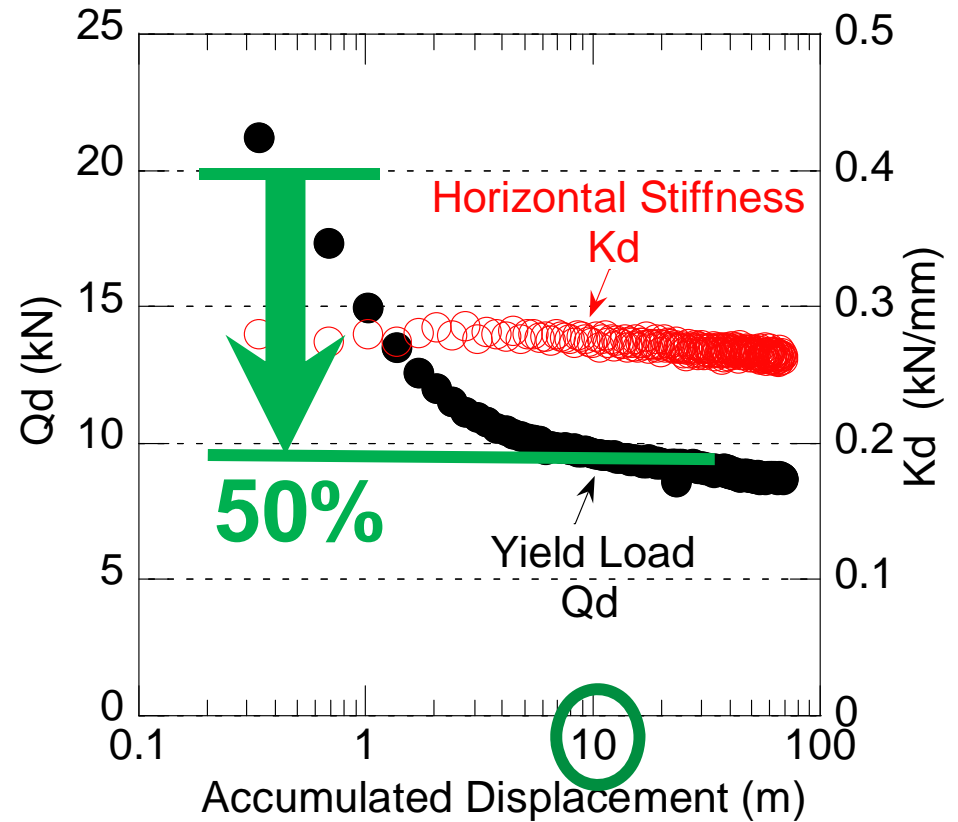
Accumulated Displacement

Restoring Force Characteristics of LRB by the 200 cyclic tests

Diameter of Specimen : 225mm

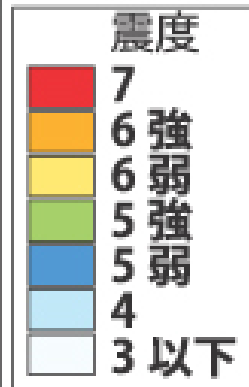


Hysteresis Loop

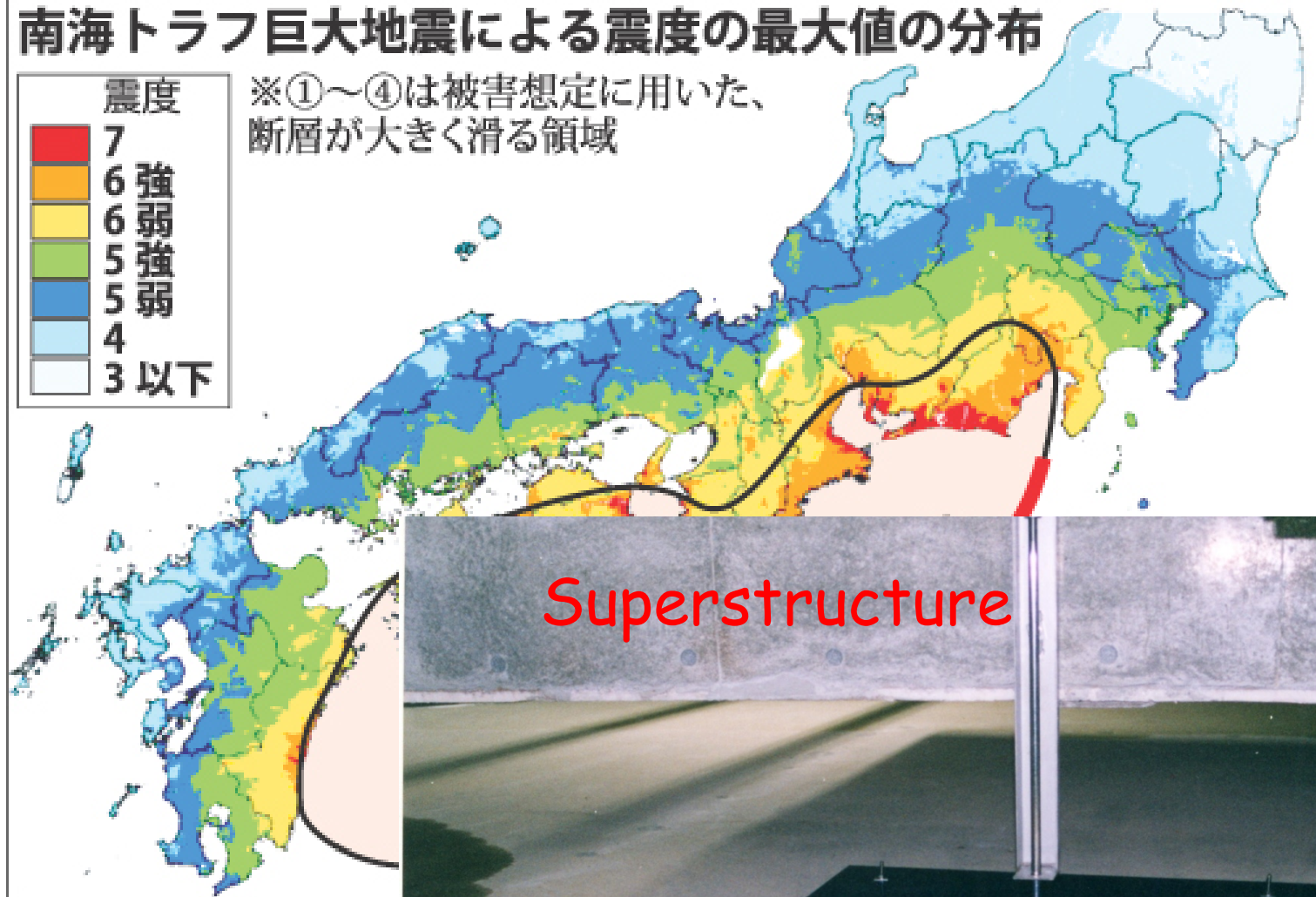


Yield Load & Stiffness

南海トラフ巨大地震による震度の最大値の分布



※①～④は被害想定に用いた、断層が大きく滑る領域



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- In the near future, a major earthquake is predicted in the Kanto region, which will be a challenge for the structure with a basement and large deformation.



Thank you for your attention



"Disaster will attack when you have forgotten"