Performance of Buildings under the Coming Mid-size Earthquake beneath Tokyo Metropolitan Area

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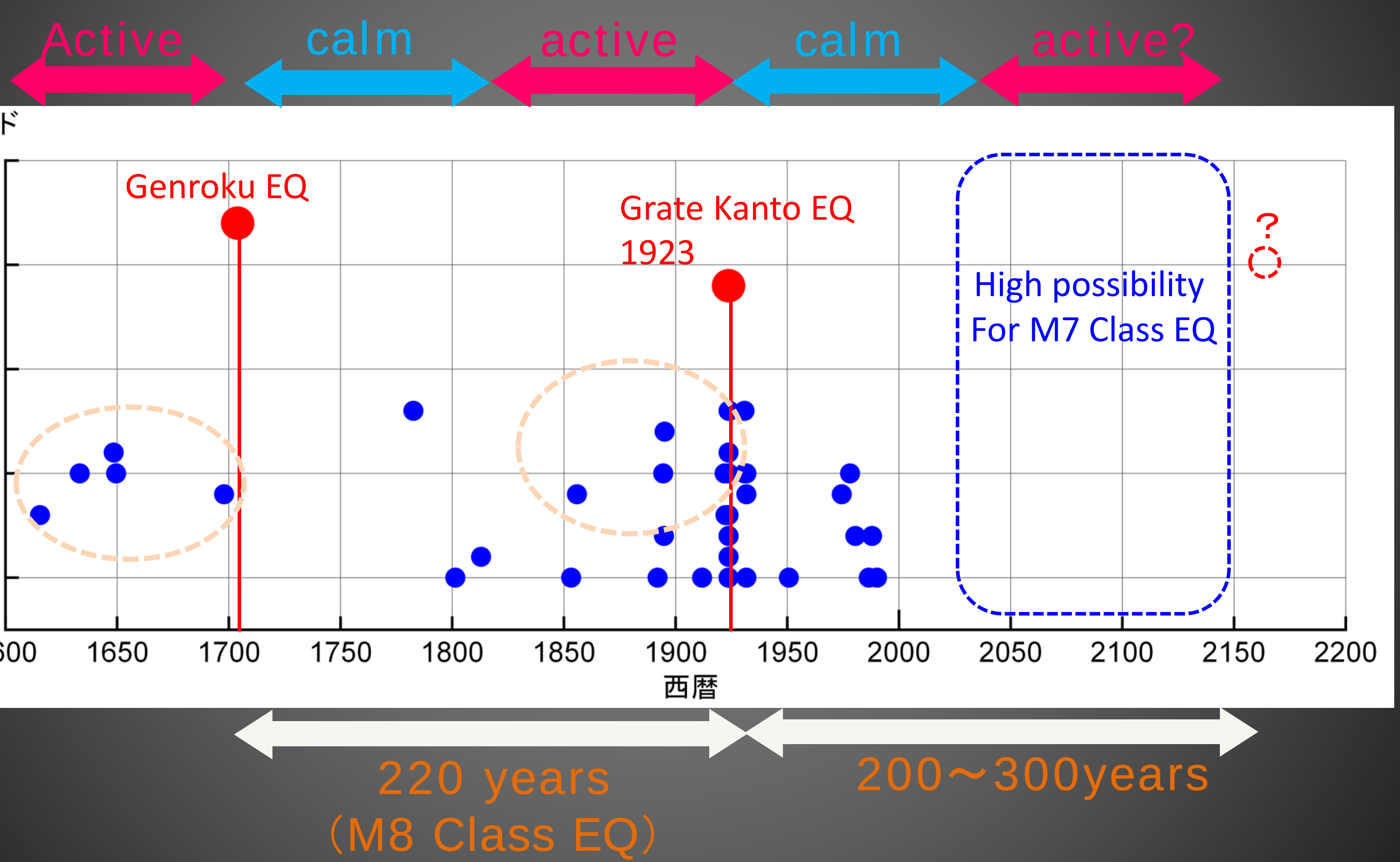
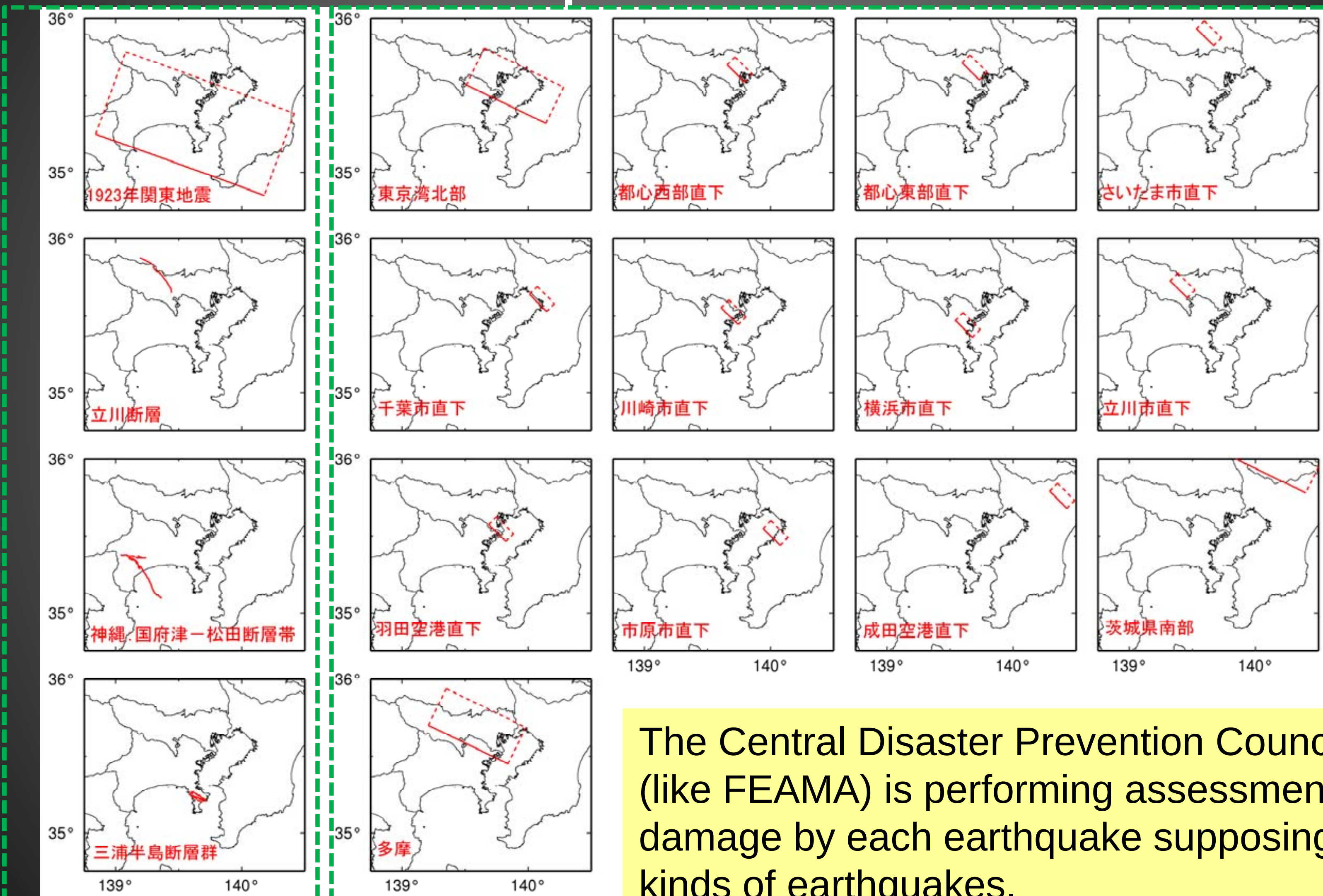
History of Earthquakes around Tokyo



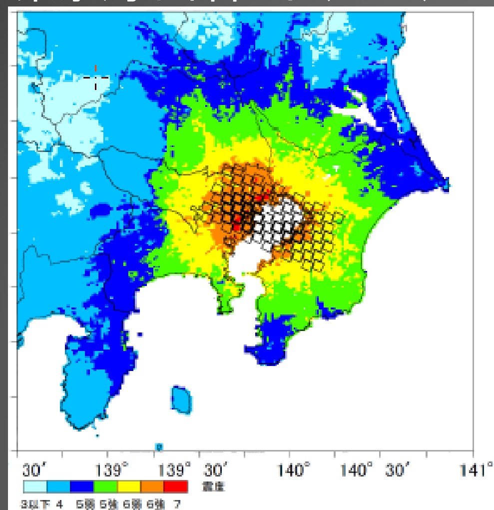
The coming mid-size Tokyo Metro. EQ for disaster prevention（2004）



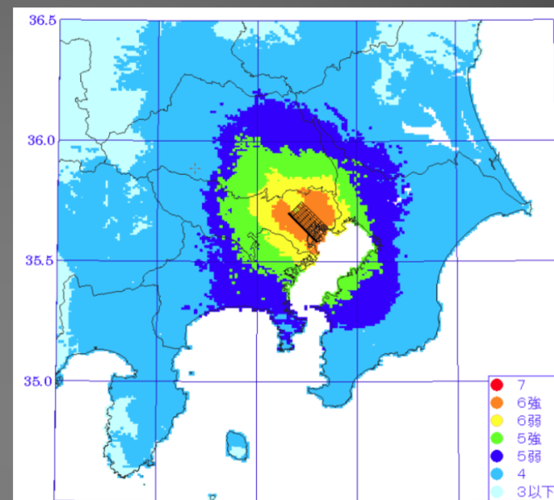
The Central Disaster Prevention Council 2004 (like FEAMA) is performing assessment of damage by each earthquake supposing 18 kinds of earthquakes.

Prediction for EQ. intensity

東京湾北部直下(2012)

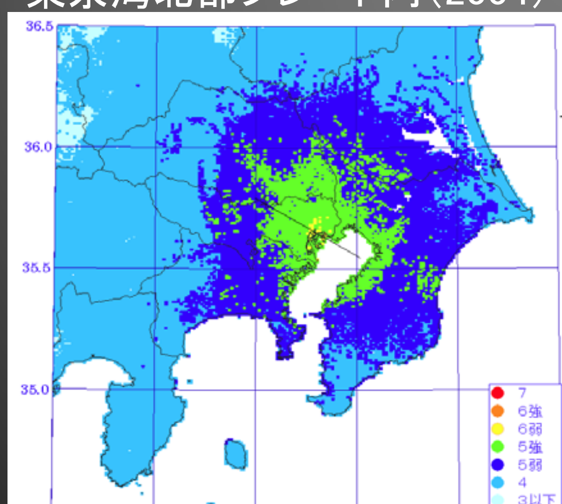


都心東部直下(2004)

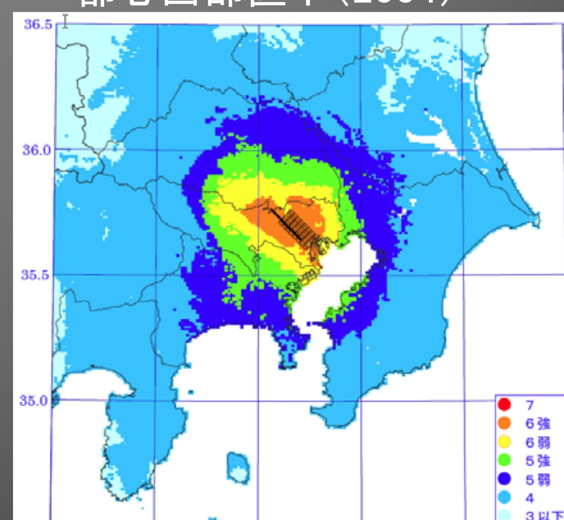


M.S.
- :9
- :8
- :7
- :6

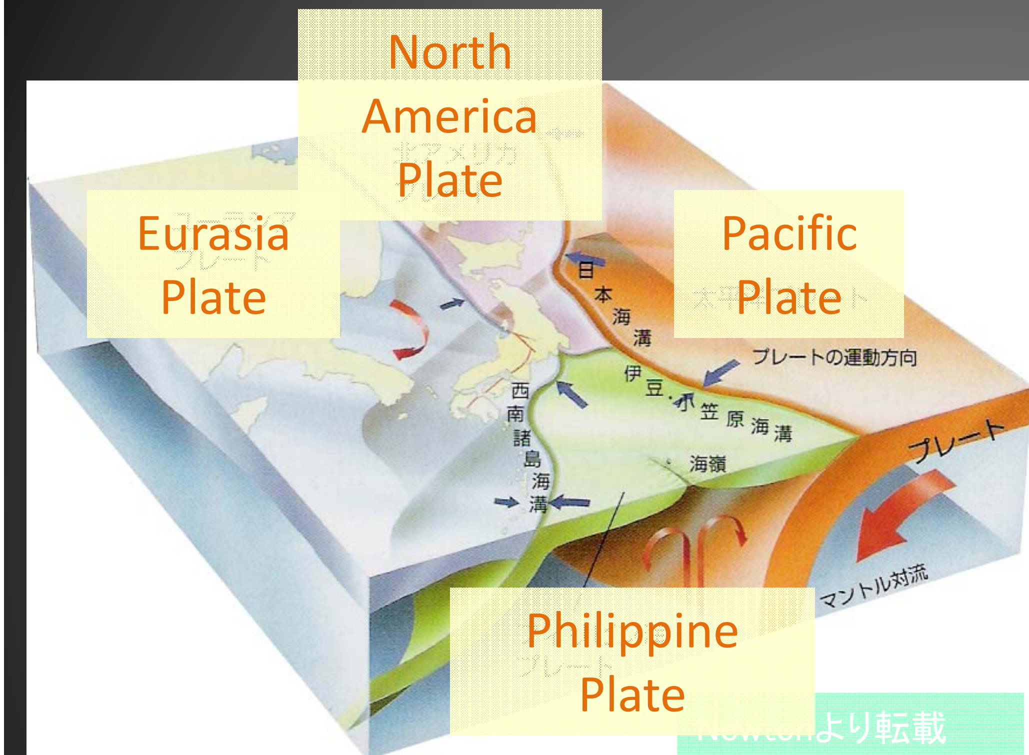
東京湾北部プレート内(2004)

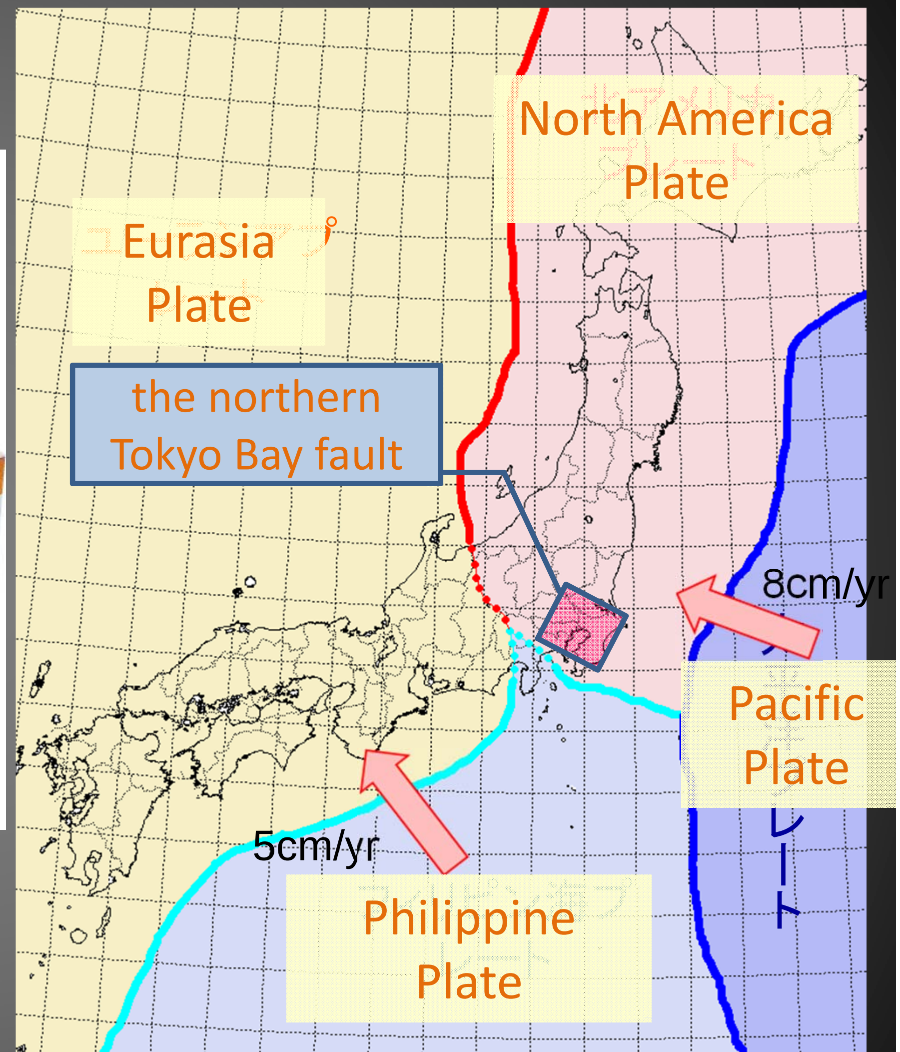


都心西部直下(2004)



Intersection for 3-Plates





関東:3枚のプレート

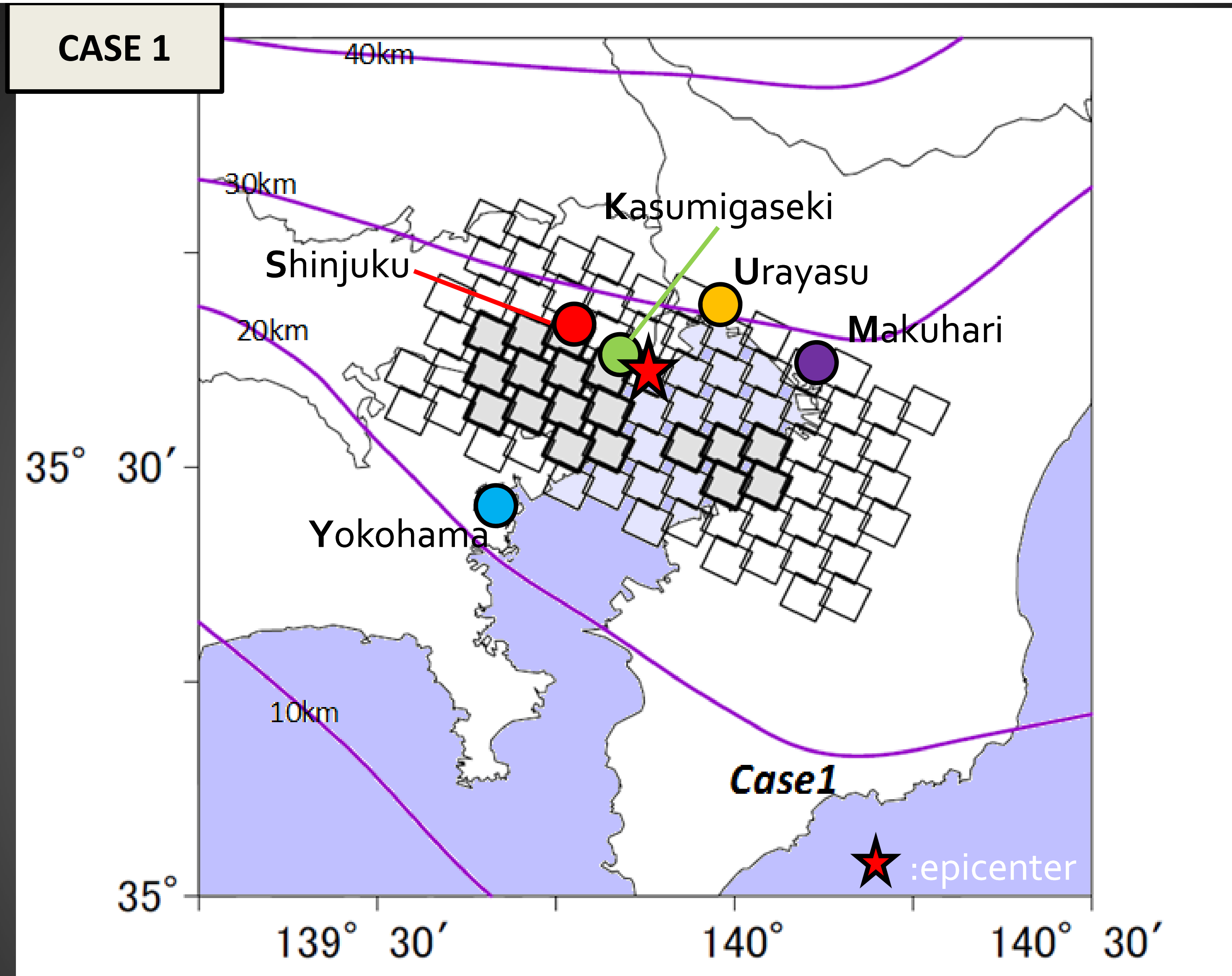
two plates have sunk beneath Tokyo area, the occurring earthquake can consider various types.

Fault model spec.

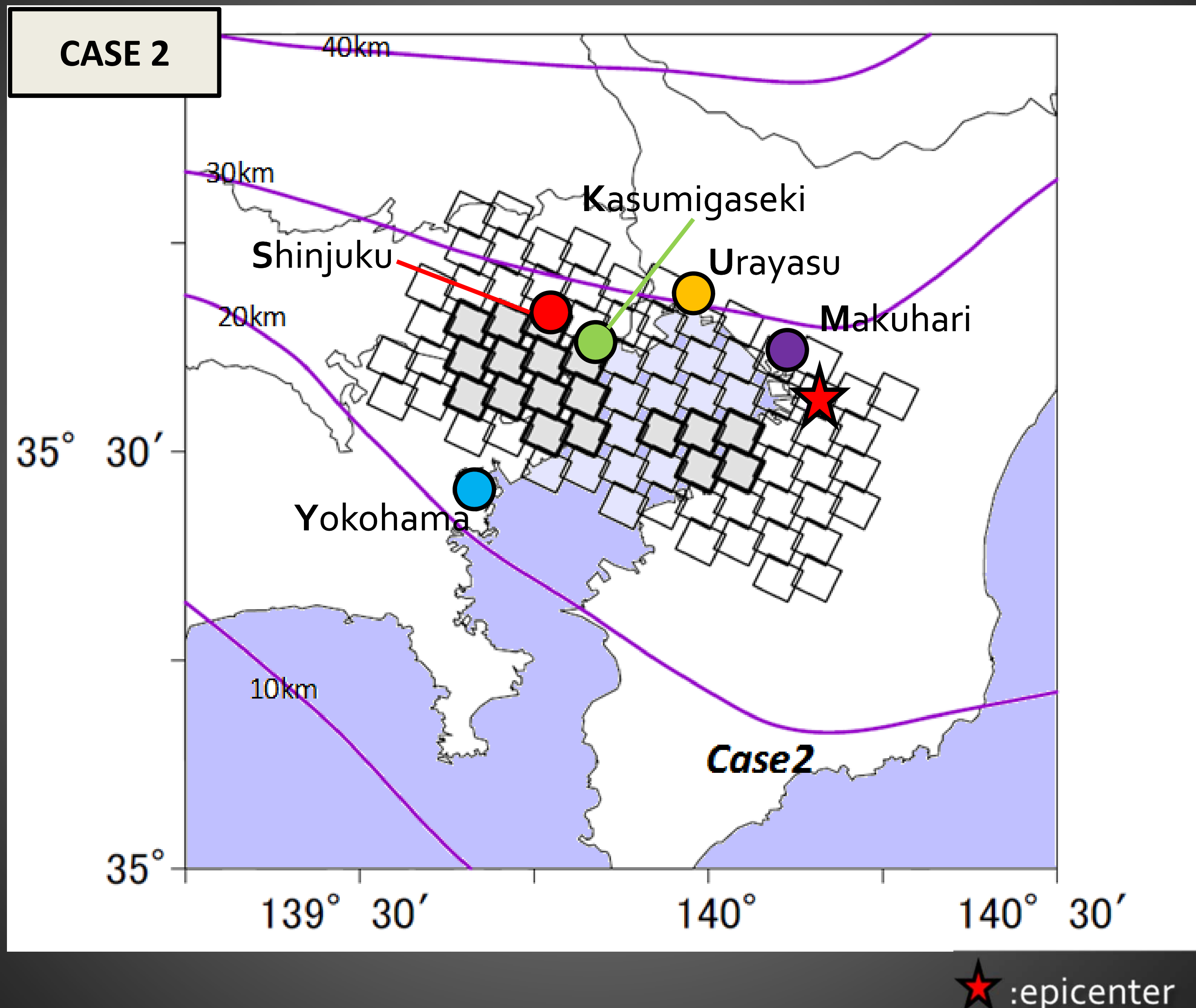
The main specifications of the set-up fault model are shown below.

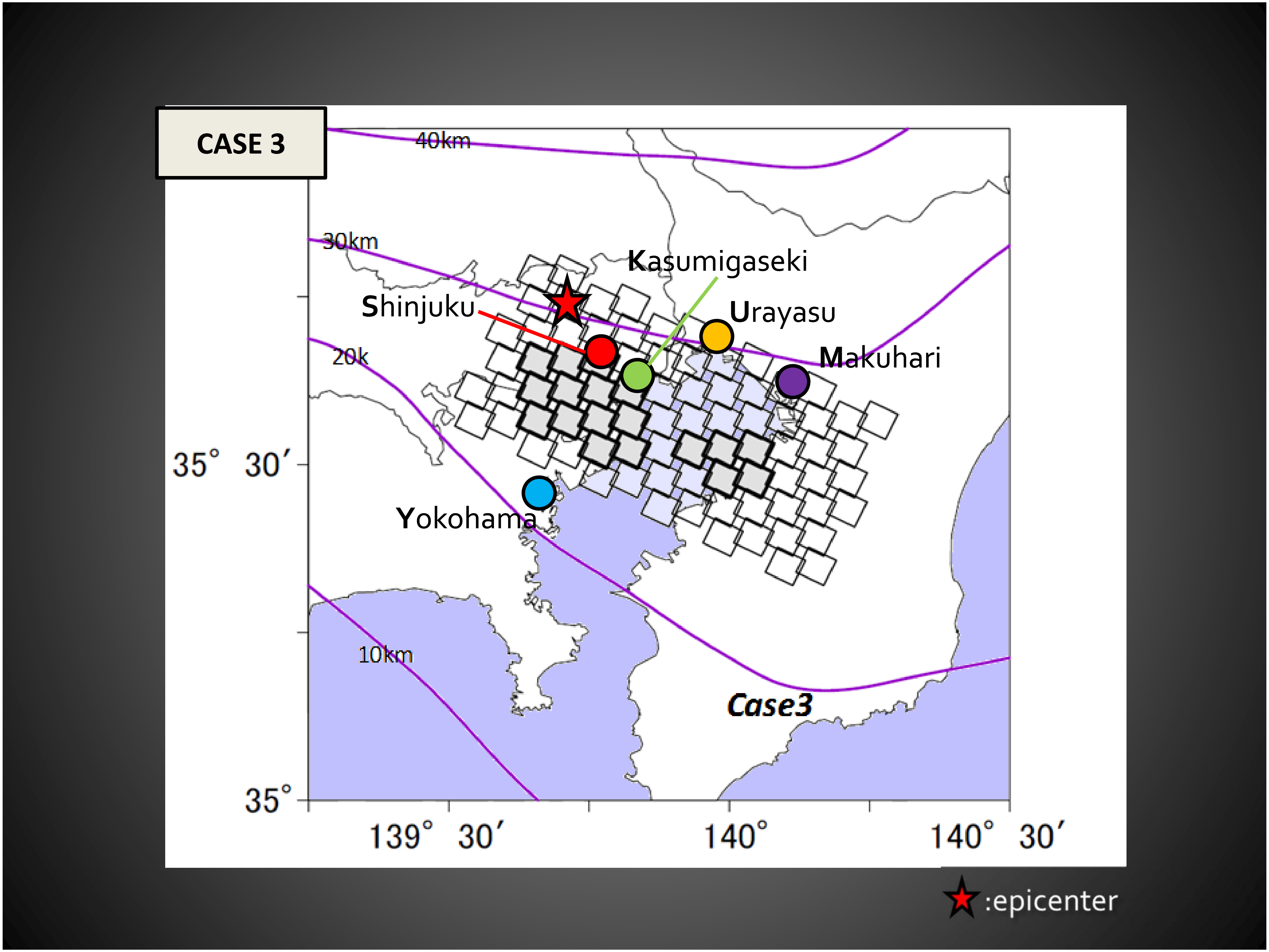
Earthquake size: Mw7.3
Tomographic-layer product: 63 km x 32 km
Strike of a fault: 296 degrees
Inclination of a fault: 23 degrees
Slide angle: 138 degrees
Mean-stress descent: 3MPa
fmax: 6Hz
Rupture-propagation speed: 2.5 km/s

This study has done based on the northern Tokyo Bay earthquake which is expected to have the largest number of victims or the greatest economic impact among 18 scenarios.



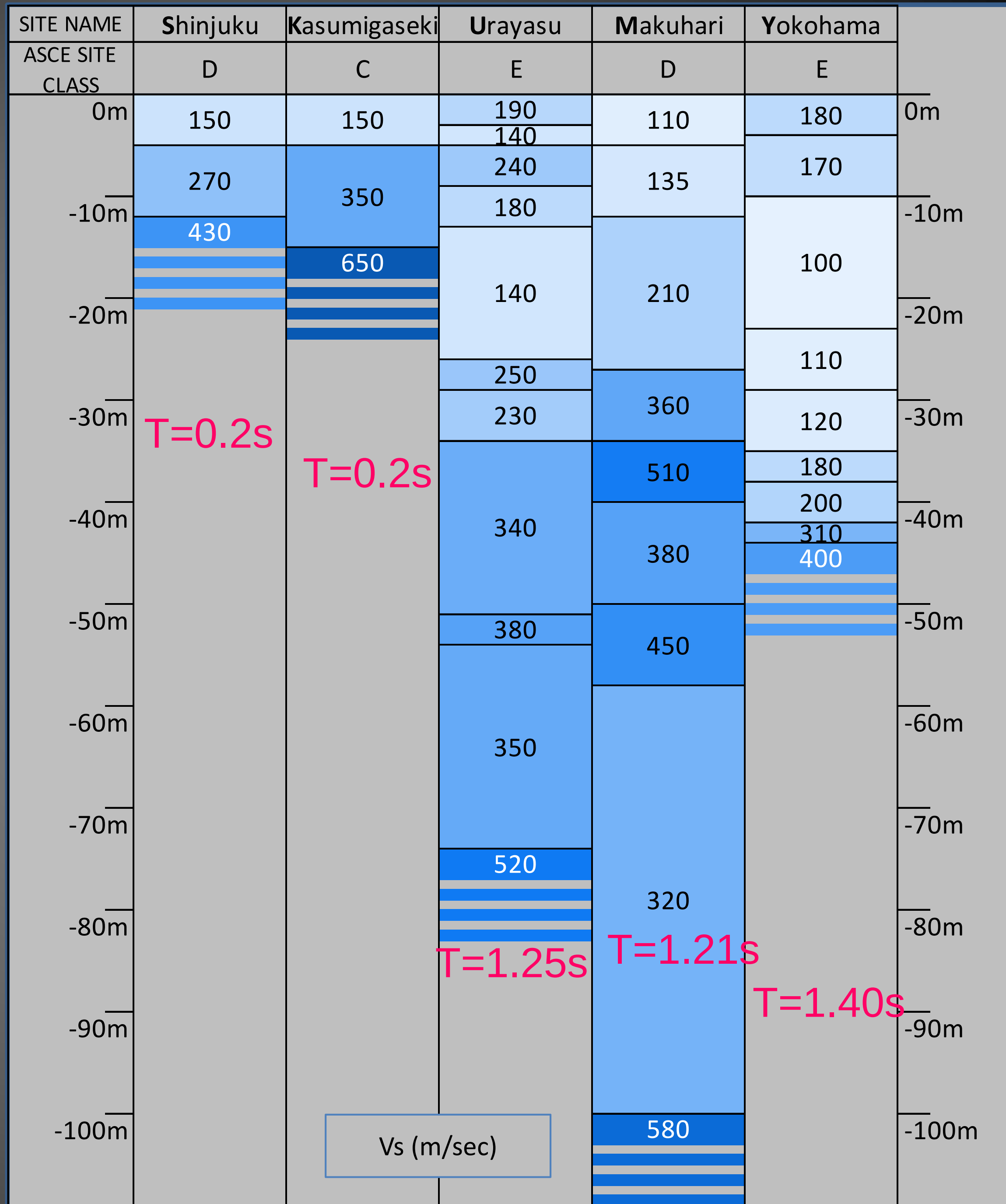
About the rupture starting point, Three different type were considered.
Case-1:from center of the fault, Case-2:from east part of the fault and
Case-3:from west part of the fault


CASE 2
40km
30km
20km
10km
Kasumigaseki
Shinjuku
Urayasu
Makuhari
Yokohama
Case2
35° 30′
35°
139° 30′
140°
140° 30′
:epicenter



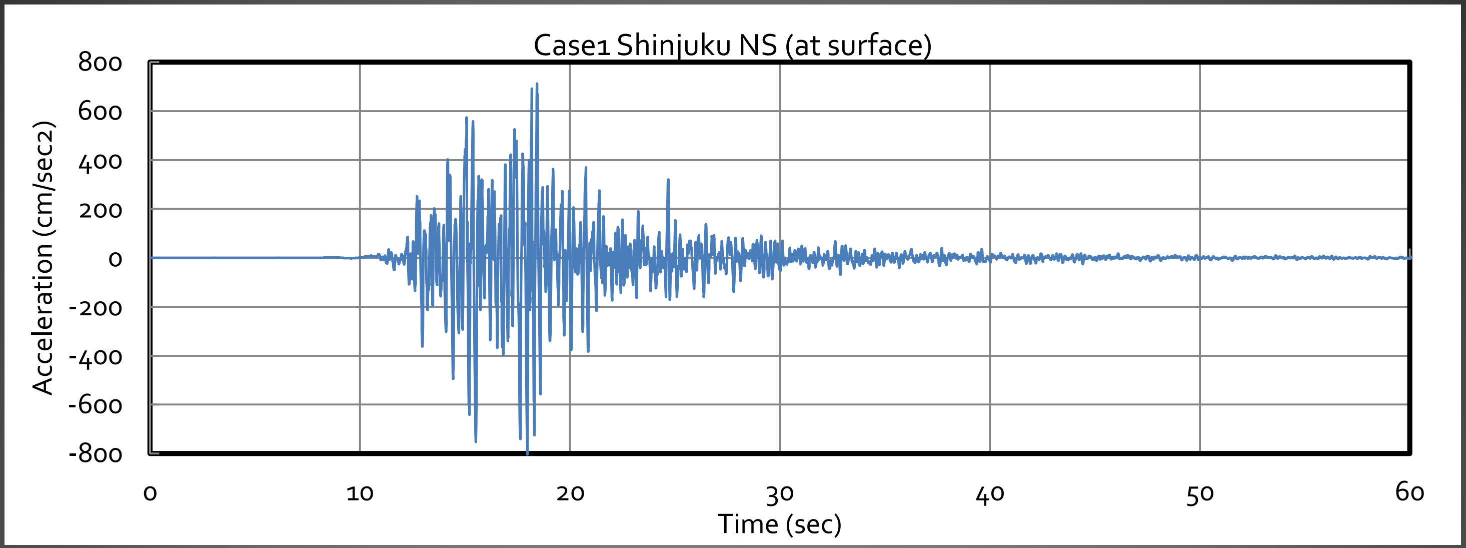
CASE 3
40km
30km
20k
10km
Kasumigaseki
Shinjuku
Urayasu
Makuhari
Yokohama
Case3
35° 30′
35°
139° 30′
140°
140° 30′
:epicenter

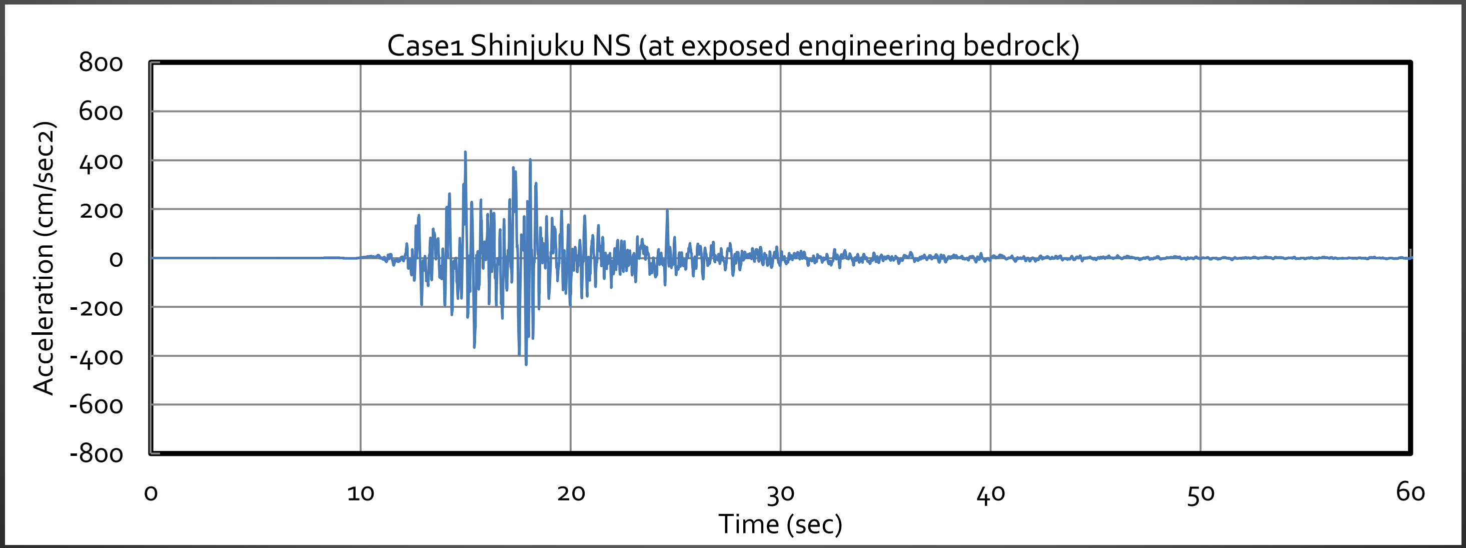
Site Spec.



SITE NAME
Shinjuku
Kasumigaseki
Urayasu
Makuhari
Yokohama
ASCE SITE CLASS
D
C
E
D
E
0m
-10m
-20m
-30m
-40m
-50m
-60m
-70m
-80m
-90m
-100m
150
270
430
150
350
650
190
140
240
180
140
250
230
340
380
350
520
110
135
210
360
510
380
450
320
580
180
170
100
110
120
180
200
310
400
T=0.2s
T=0.2s
T=1.25s
T=1.21s
T=1.40s
Vs (m/sec)

Example of Acceleration on the ground level & at the level of the seismic bedrock at SITE-S





1）Comparison of ACC. Response spectra (h=5%)

on bed-rock (Vs>400m/s） for 5-site

- depend on Case-1,2,3
- including design-earthquake force

2) Comparison of ACC. Response spectra (h=5%)

on the ground level

- h=5% & 20%

3) Comparison of VELOCITY Response spectra (h=5%)

- bed-rock & on the ground level

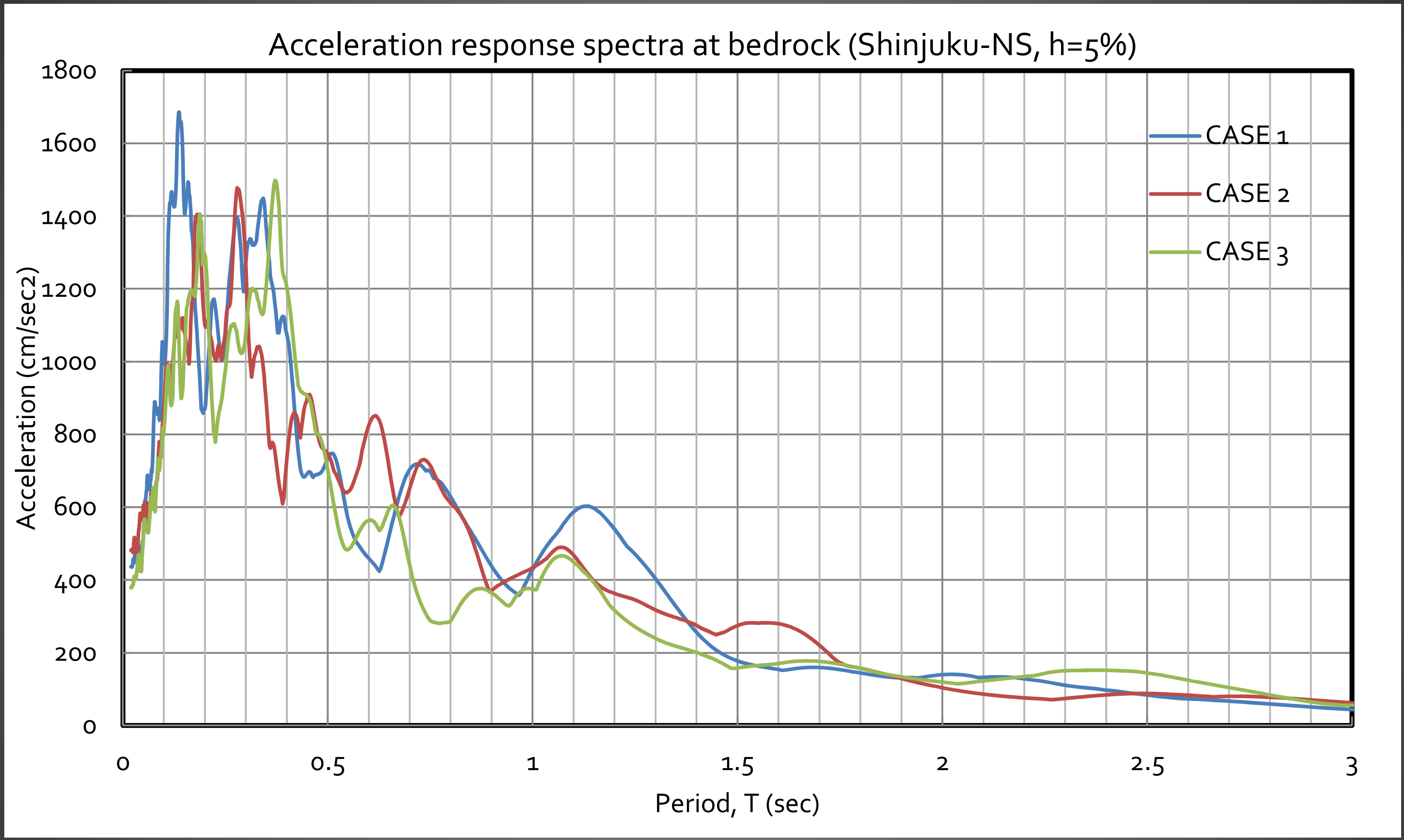
4) Responses of 15 sample buildings

by results of non-linear time history analysis

with the effect of dissipation damping for 5-site

Response spectra for Acceleration on bedrock h=5%

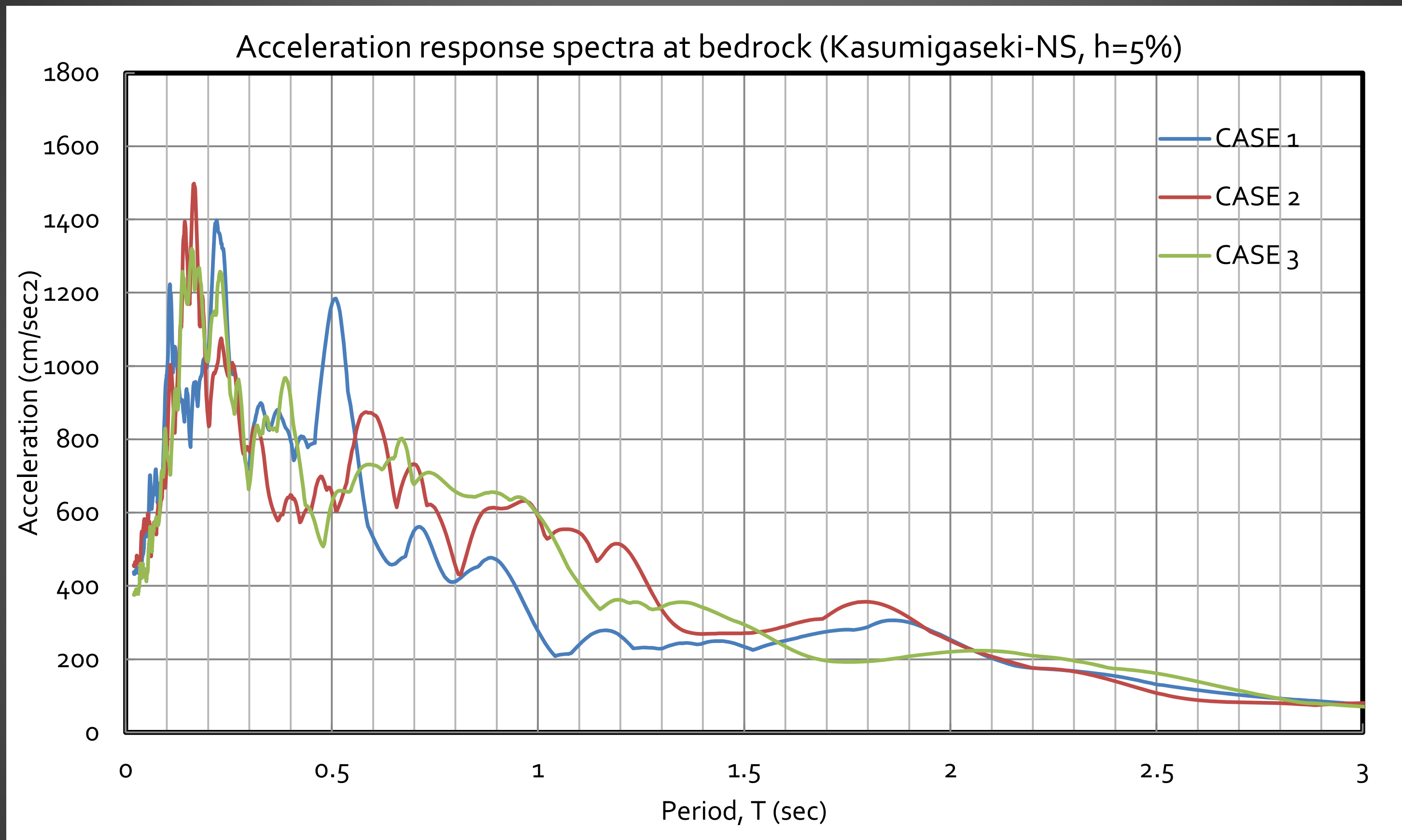
SITE-S（SHINJUKU)



Basically there are not so much differences for CASE-1,2,3.
Response for period of 1~1.5 exceed in CASE-1.

Response spectra for Acceleration on bedrock h=5%

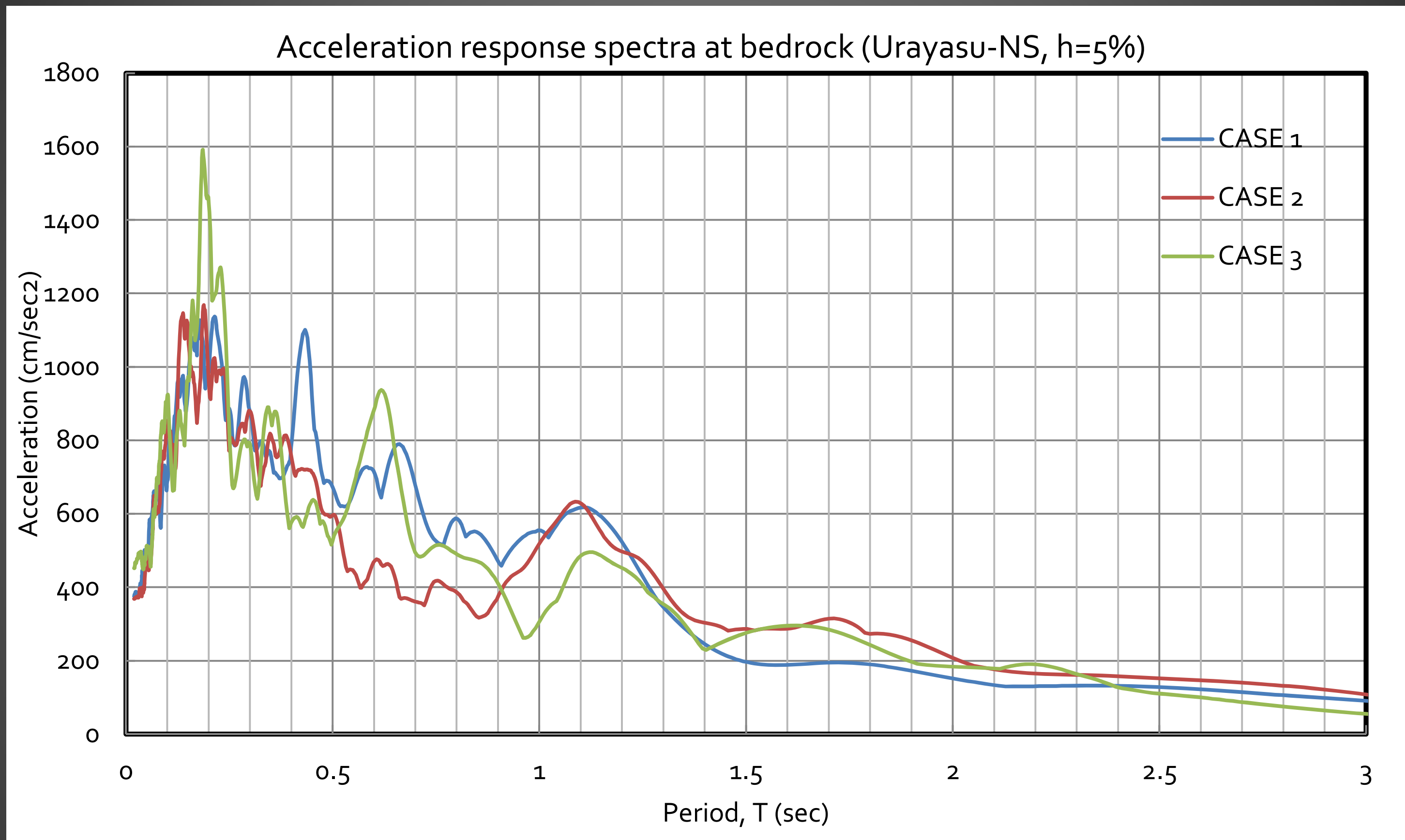
SITE-K（KASUMIGASEKI)



Basically there are not so much differences for CASE-1,2,3.
Response for period of 1~1.5 exceed in CASE-2 than CASE-1.

Response spectra for Acceleration on bedrock h=5%

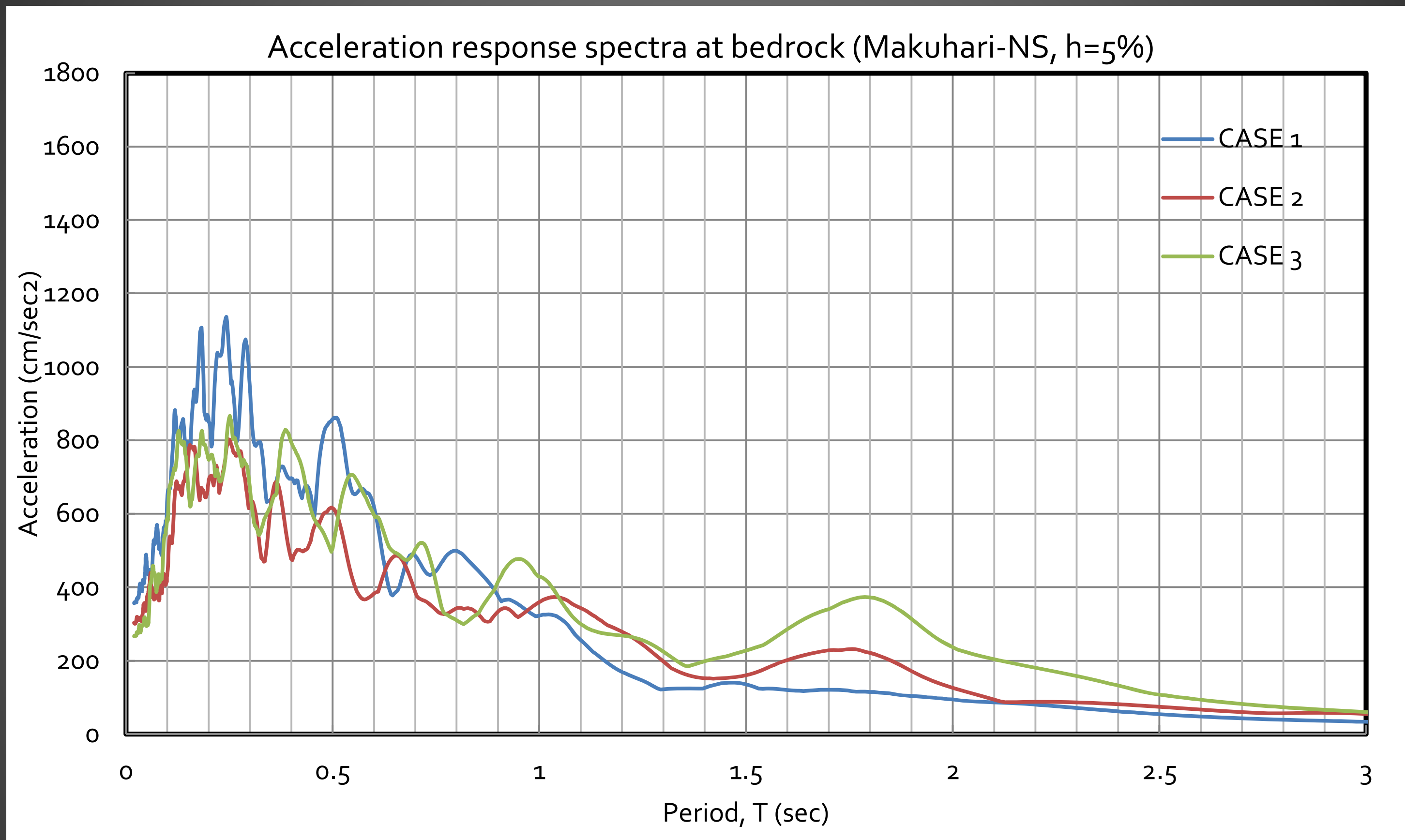
SITE-U（URAYASU)



Response for period of 0.5~1.5 exceed in CASE-1,3 than CASE-2.

Response spectra for Acceleration on bedrock h=5%

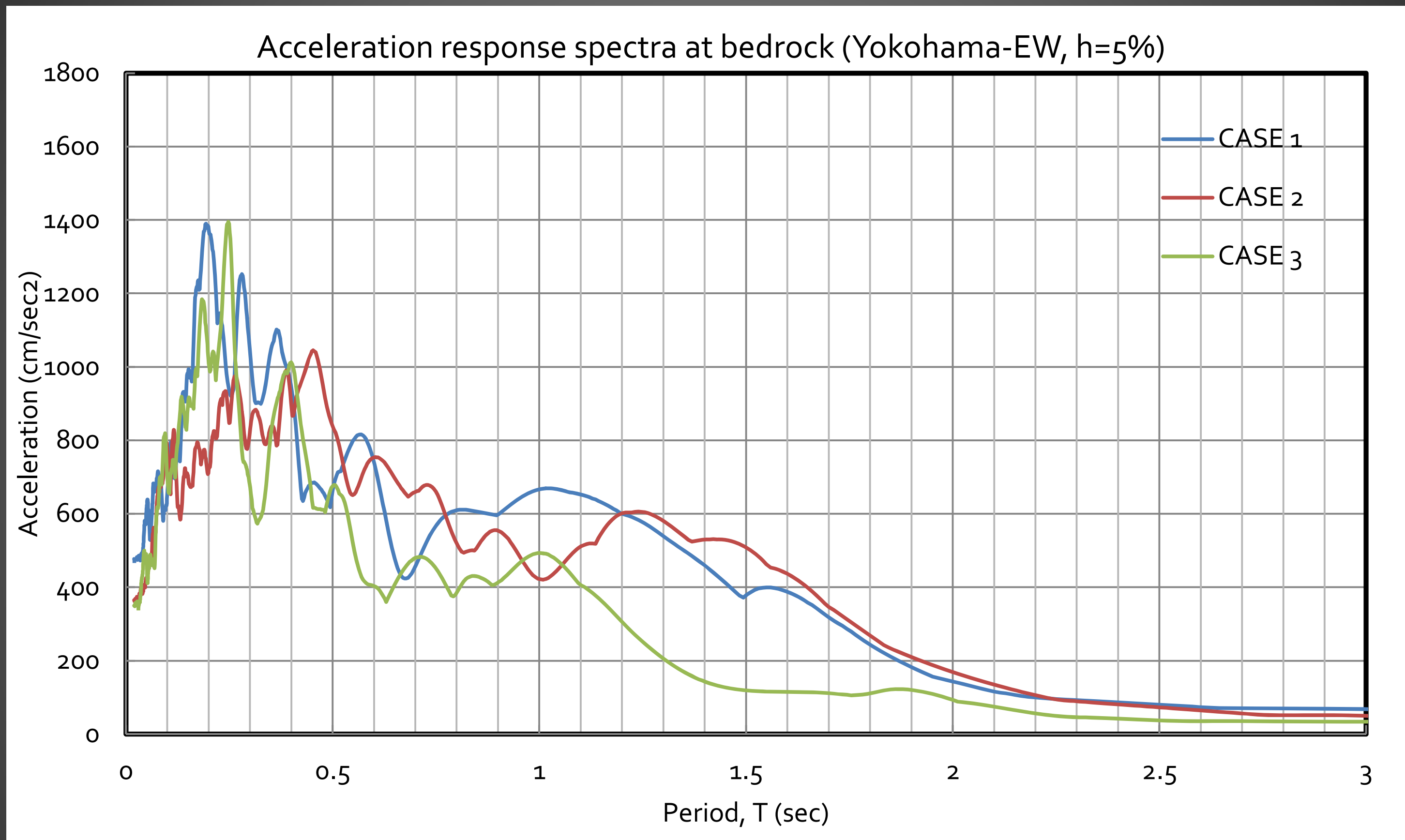
SITE-M（MAKUHARI)



Response for period of 1.0~2.0 exceed in CASE-2,3 than CASE-1.

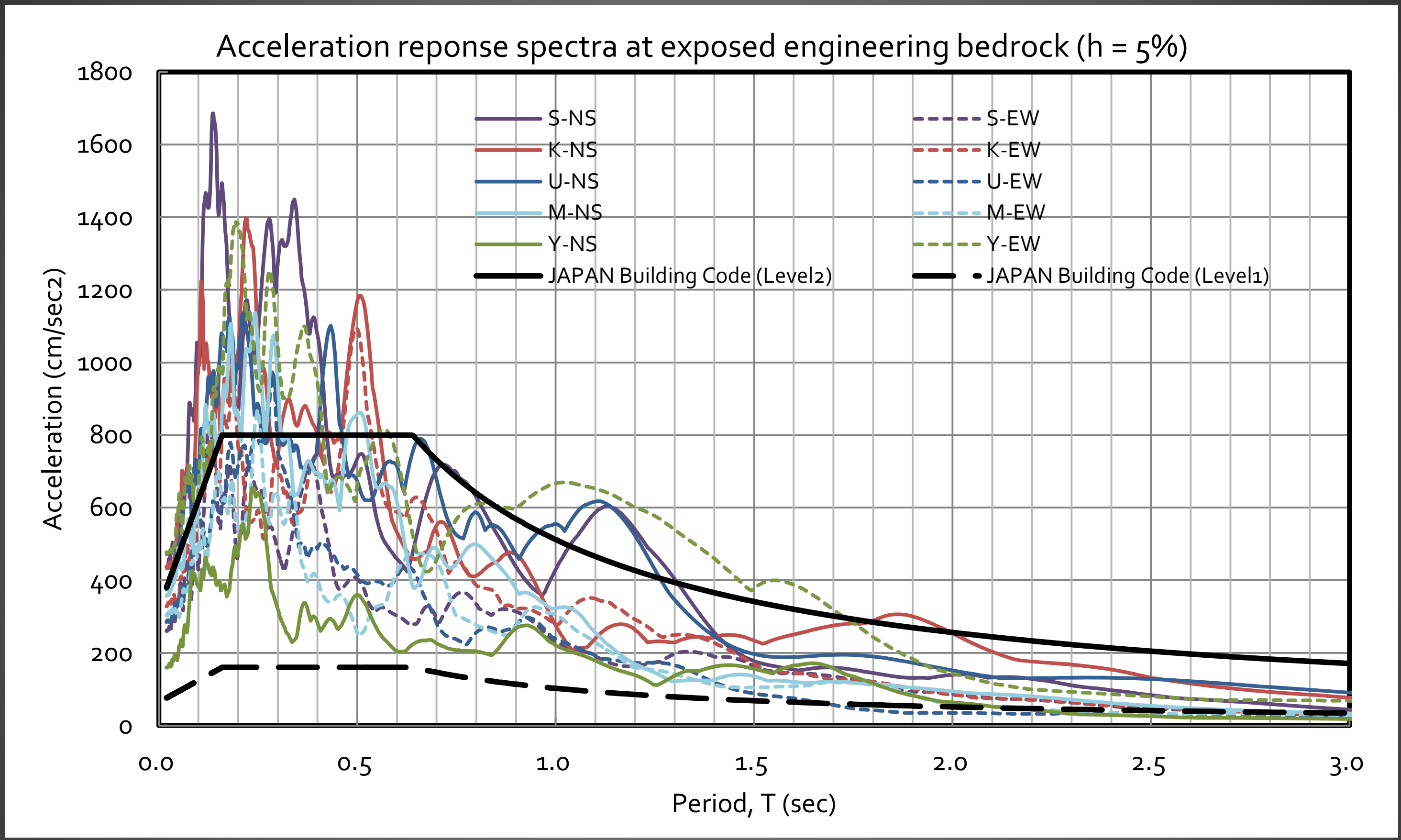
Response spectra for Acceleration on bedrock h=5%

SITE-Y（YOKOHAMA)



Response for period of 1.0~2.0 exceed in CASE-1,2 than CASE-3.

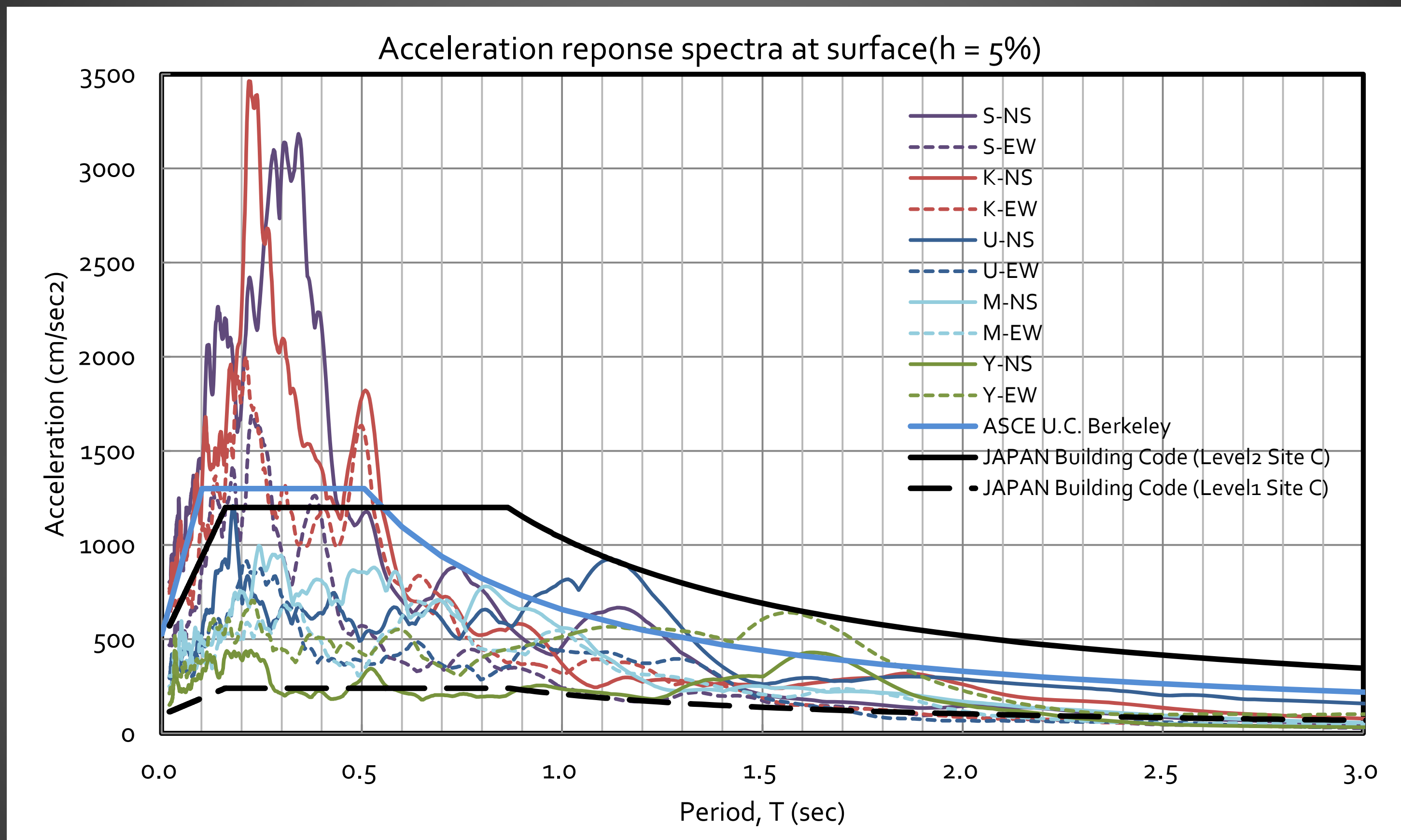
Response spectra for Acceleration on the bedrock level h=5%



Response for period of 1.0~1.5 exceed in SITE-Y than others.

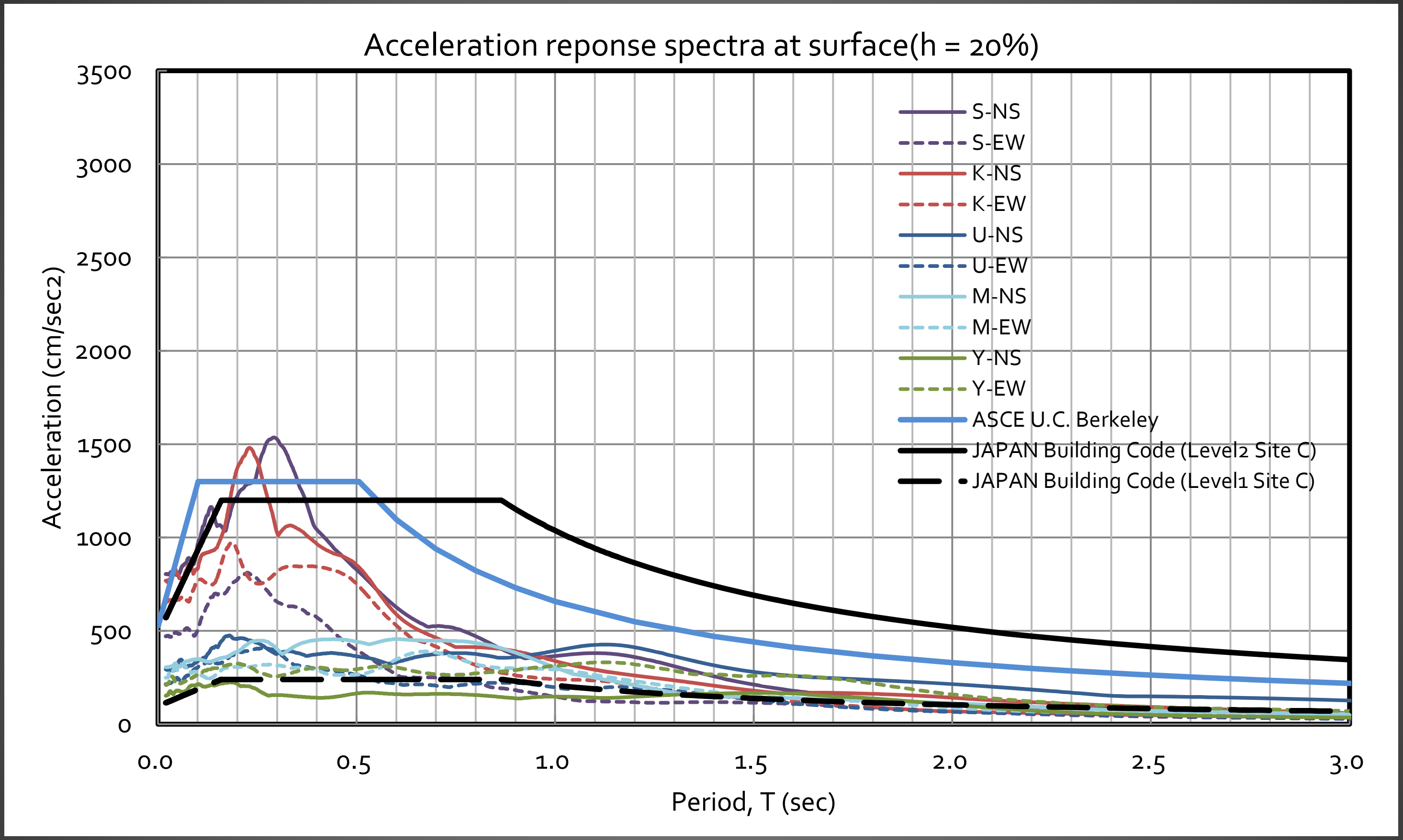
工学的基盤 加速度応答スペクトル 5%減衰

Response spectra for Acceleration on the ground level h=5%



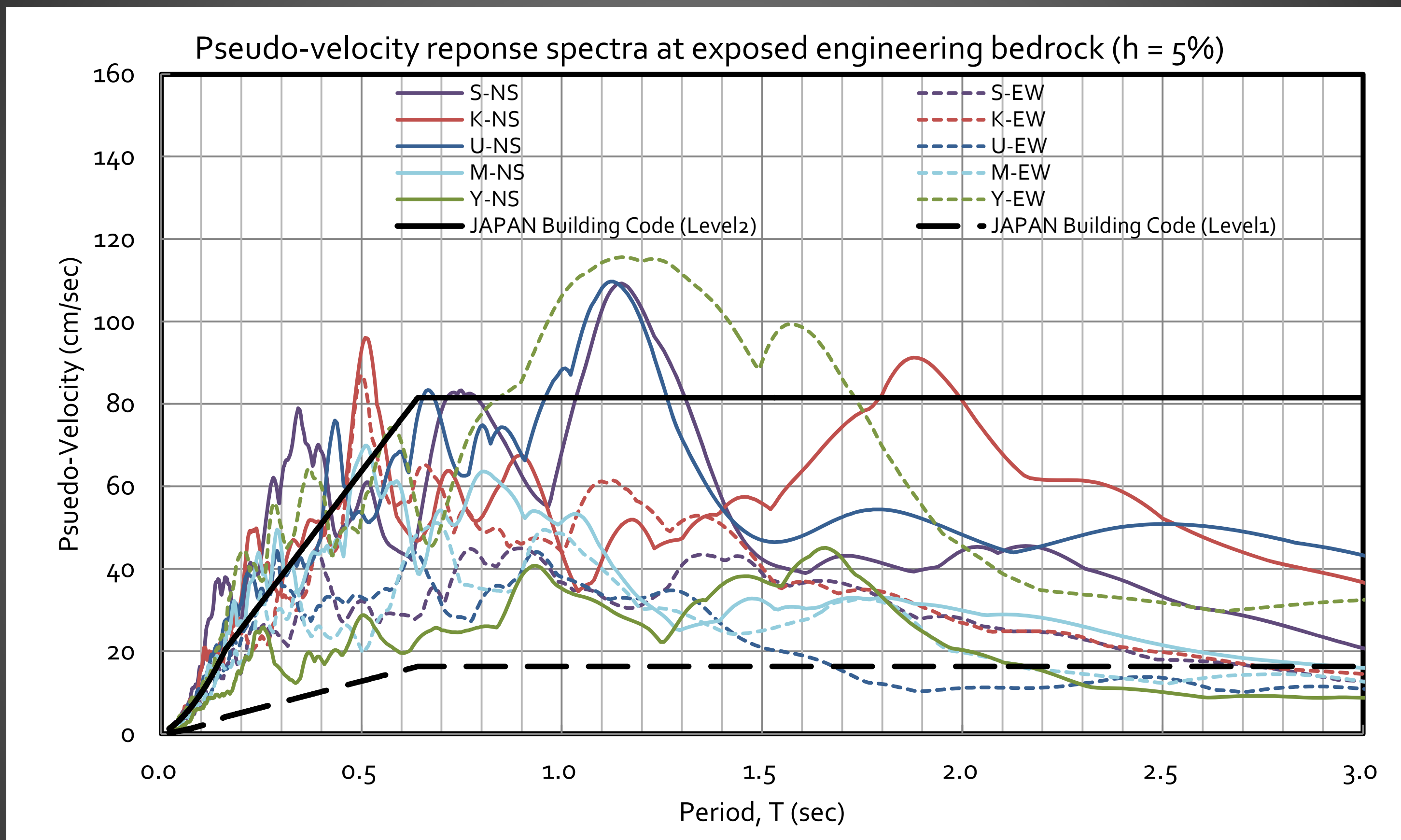
Response for period of 0~0.5 exceed in SITE-S,K than others.
For period of 1.0~2.0, SITE-U,Y than others.

Response spectra for Acceleration on the ground level h=20%



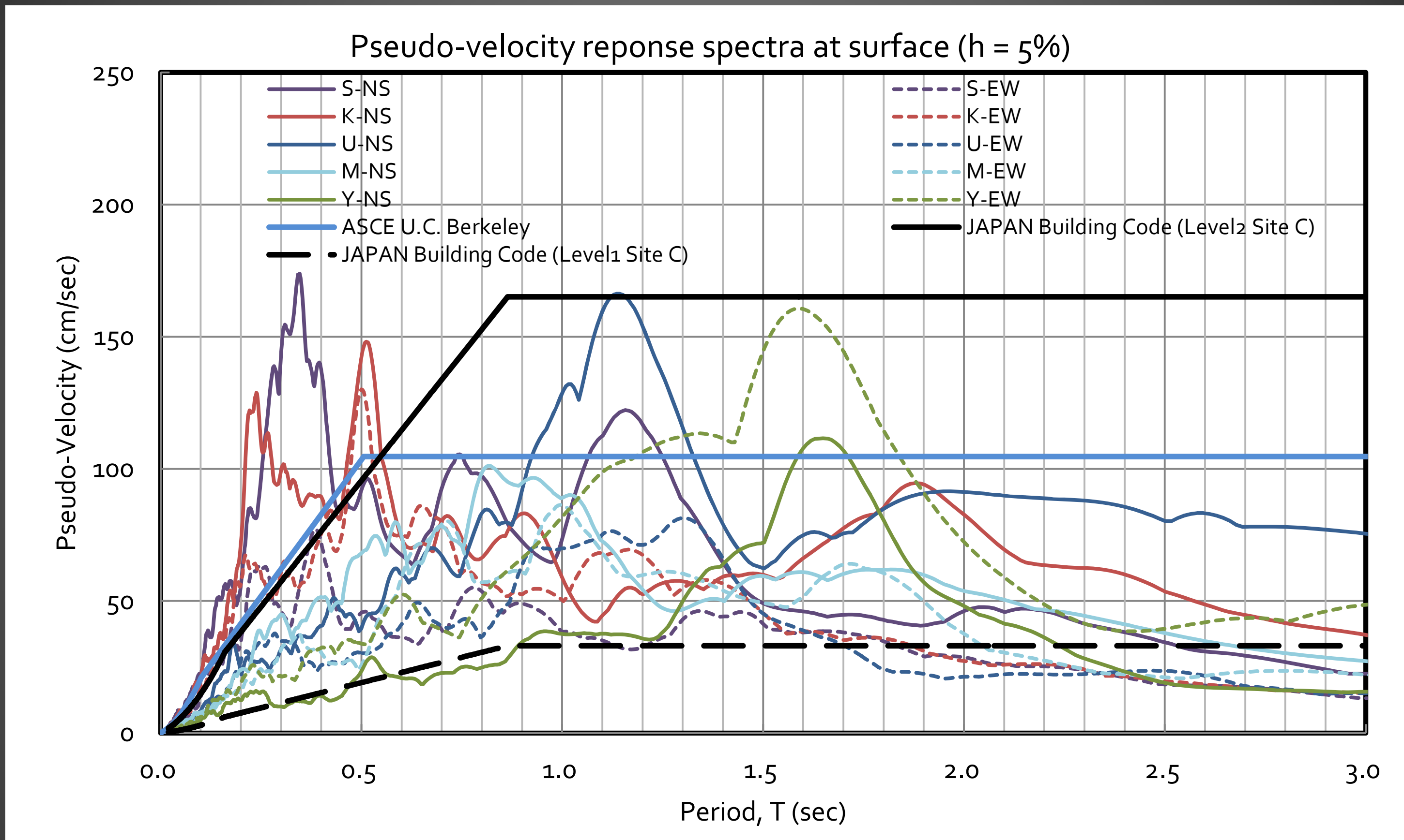
Taking into consideration about dissipation damping, The response of buildings will not so large.

Response spectra for velocity on the bedrock level h=5%



工学的基盤 疑似速度応答スペクトル 5%減衰

Response spectra for velocity on the ground level h=5%



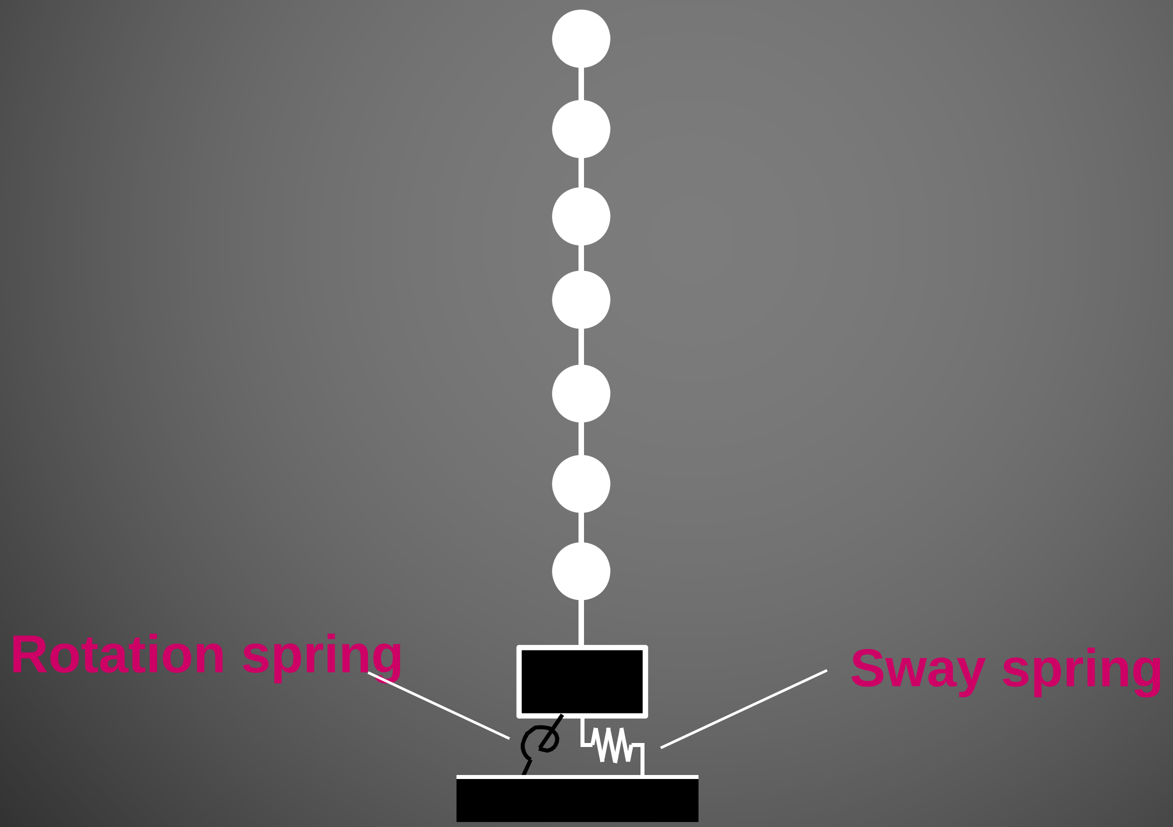
地表面　疑似速度応答スペクトル　5%減衰

15 sample buildings

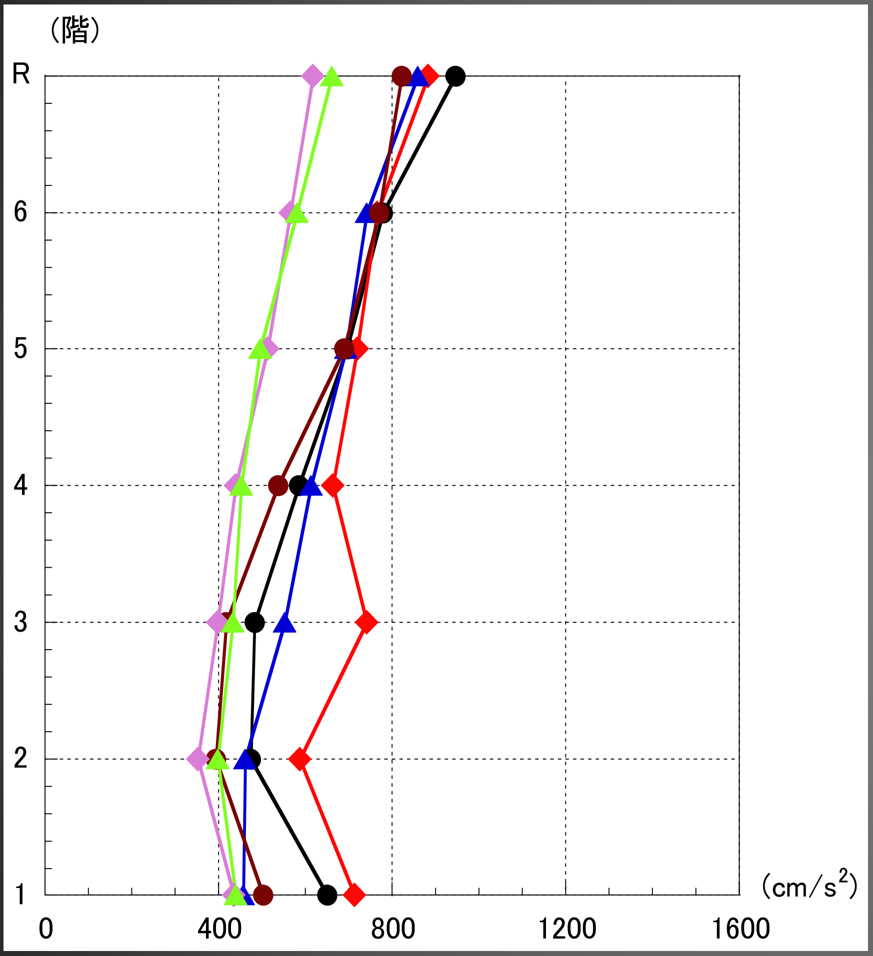
		Story			Height	Length	Width
		Basement	Ground	Rooftop	(m)	(m)	(m)
HIGH-RISE	Steel 1	4	35	3	163.0	61.6	51.6
	Steel 2	3	31	1	139.9	70.5	45.7
	RC	—	30	—	93.1	31.8	27.6
	Base Isolation	1	42	2	144.1	39.5	39.5
MIDDLE-RISE	Steel 1	—	10	1	40.3	32.6	20.2
	Steel 2	1	14	1	58.0	32.0	18.6
	RC	—	15	—	43.9	45.0	14.0
	SRC	1	9	2	30.5	31.5	23.5
	Base Isolation	1	8	1	29.9	72.3	29.9
LOW-RISE	Steel 1	—	5	1	20.5	33.6	20.2
	RC 1	1	6	1	20.2	18.4	13.5
	RC 2	1	2	—	10.3	18.8	13.8
	SRC	1	5	1	19.9	36.0	27.0
	Base Isolation 1	—	4	1	12.3	24.8	14.0
	Base Isolation 2	2	3	—	9.5	32.9	30.8

non-linear time history analysis

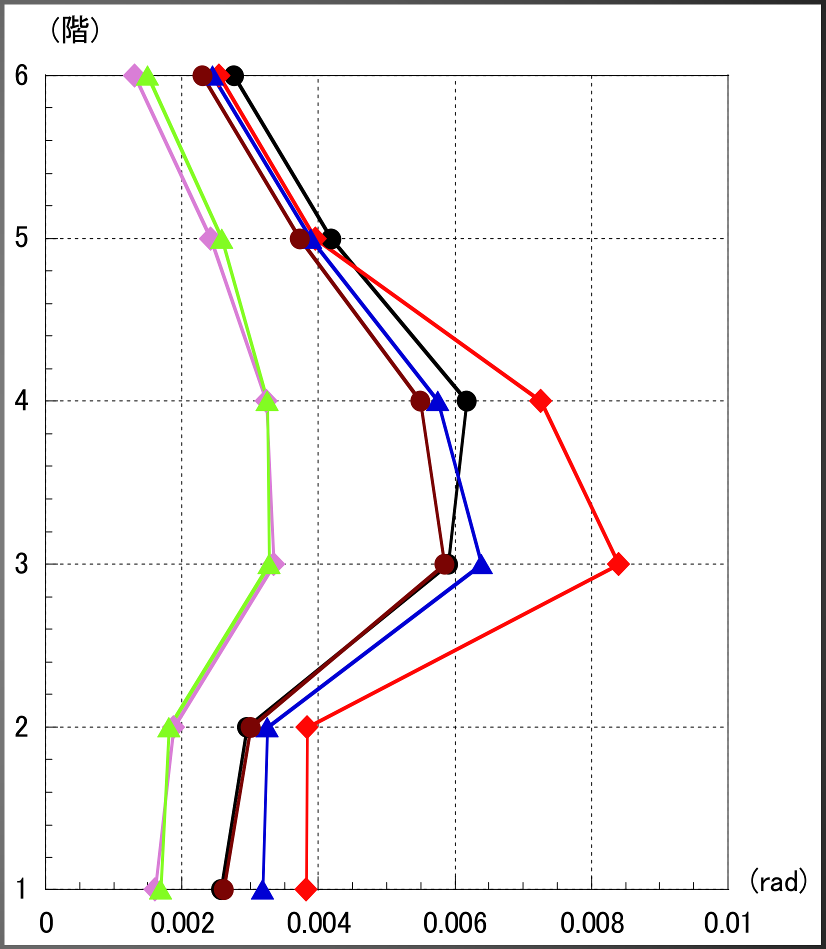
with the effect of dissipation damping for 5-site



Response of 6F-RC (at site-K) T1=0.4

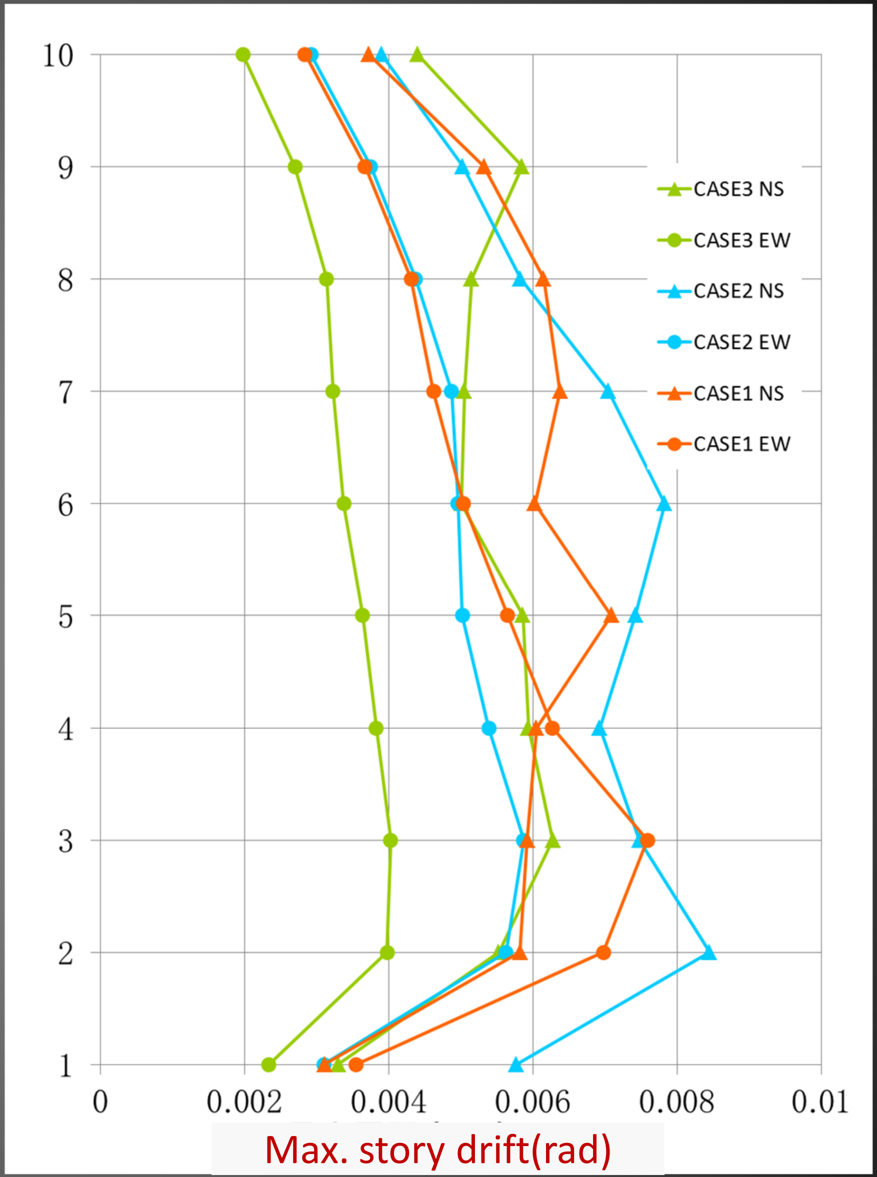


Max. Acceleration(cm/S2)

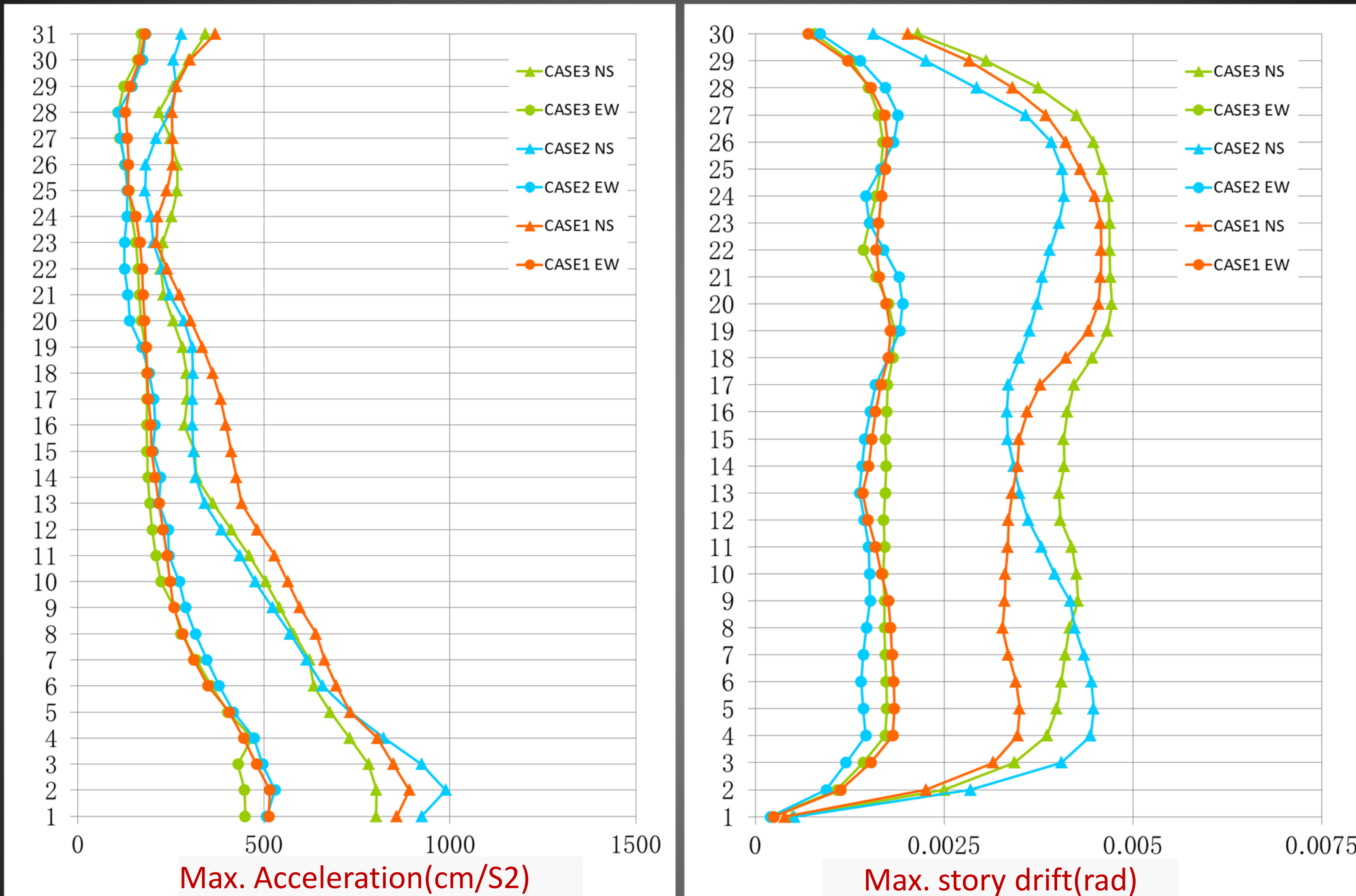


Max. story drift(rad)

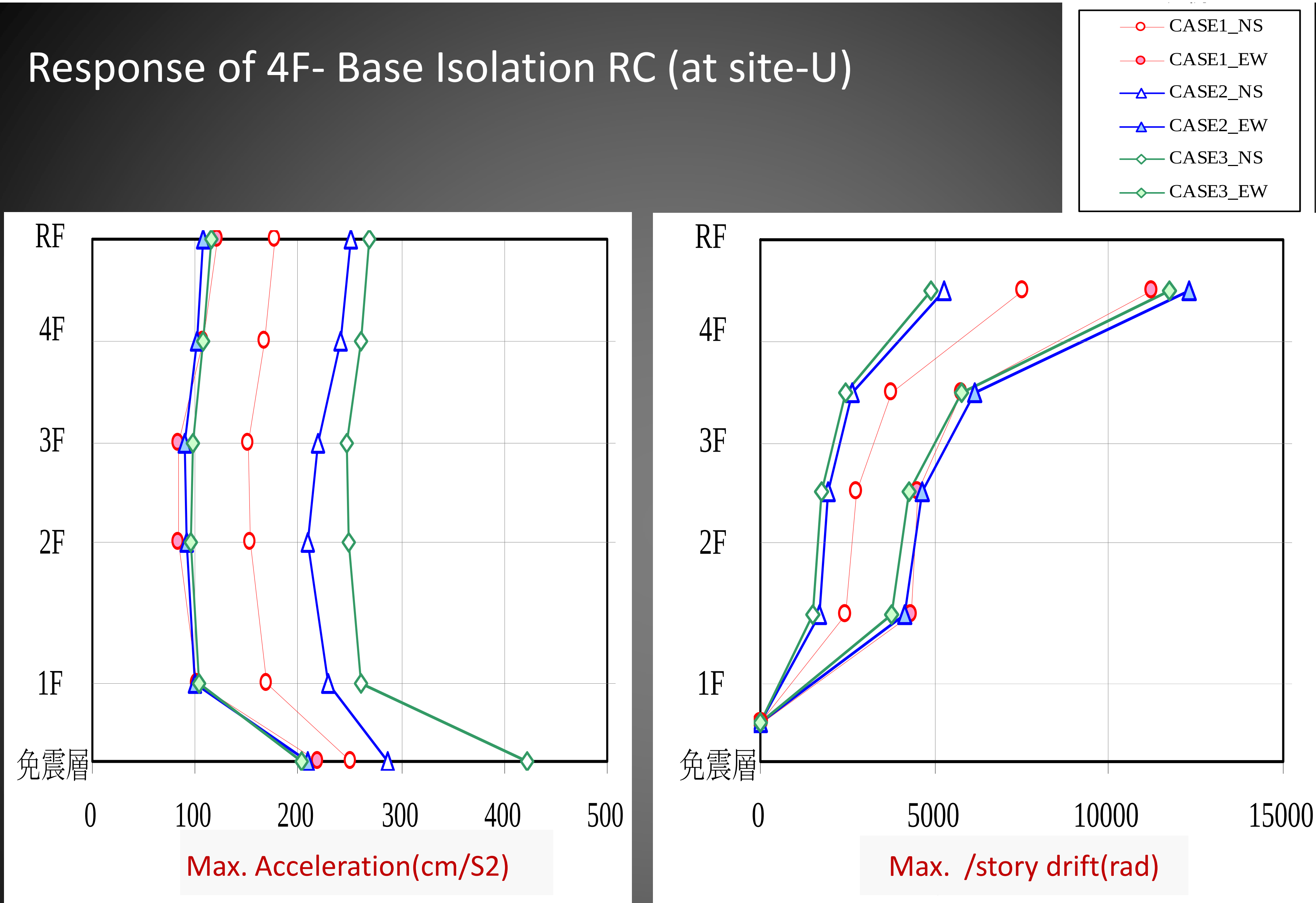
Response of 10F-RC (at site-S) T1=1.47s



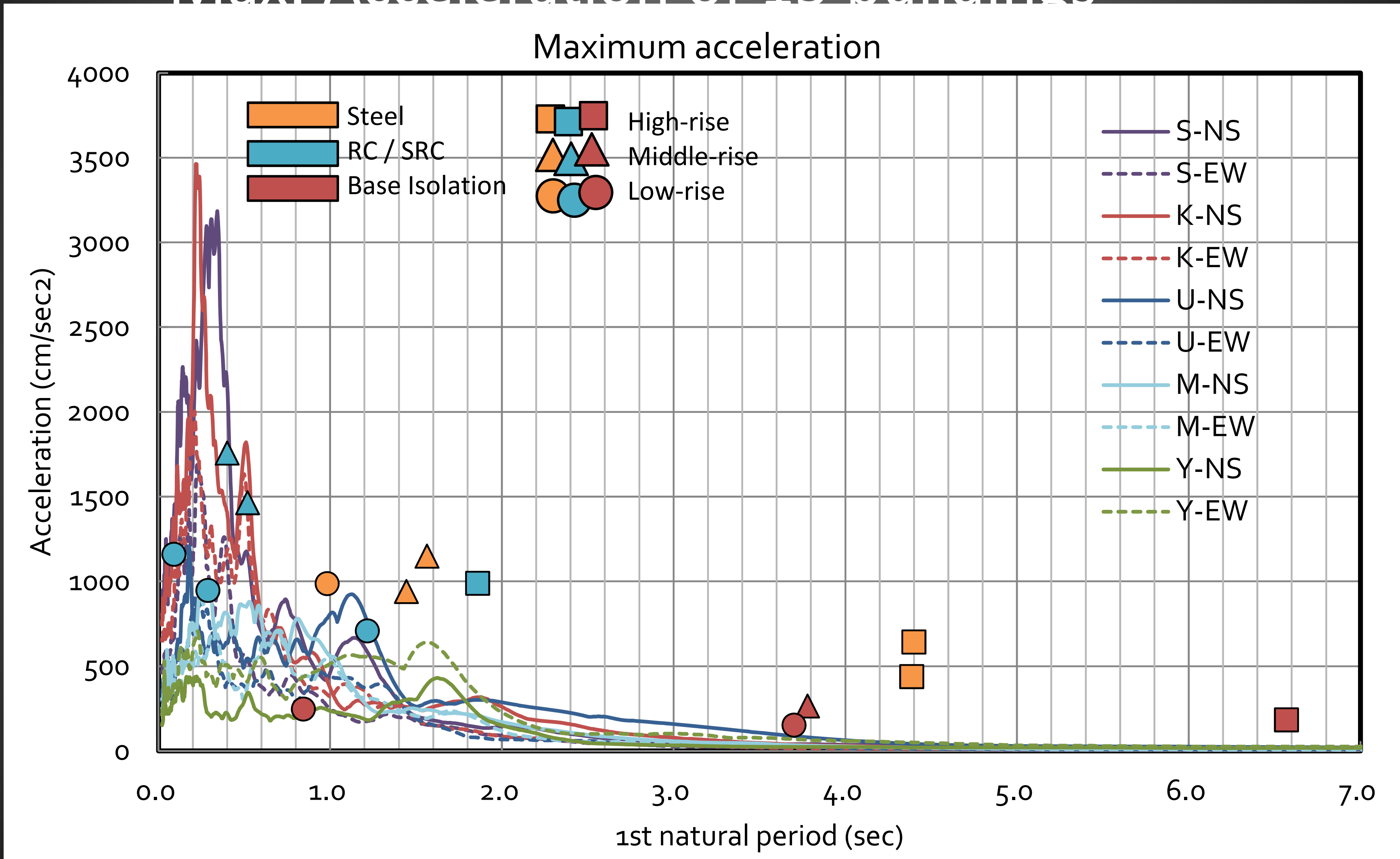
Response of 30RC (at site-S)   T1=1.99s



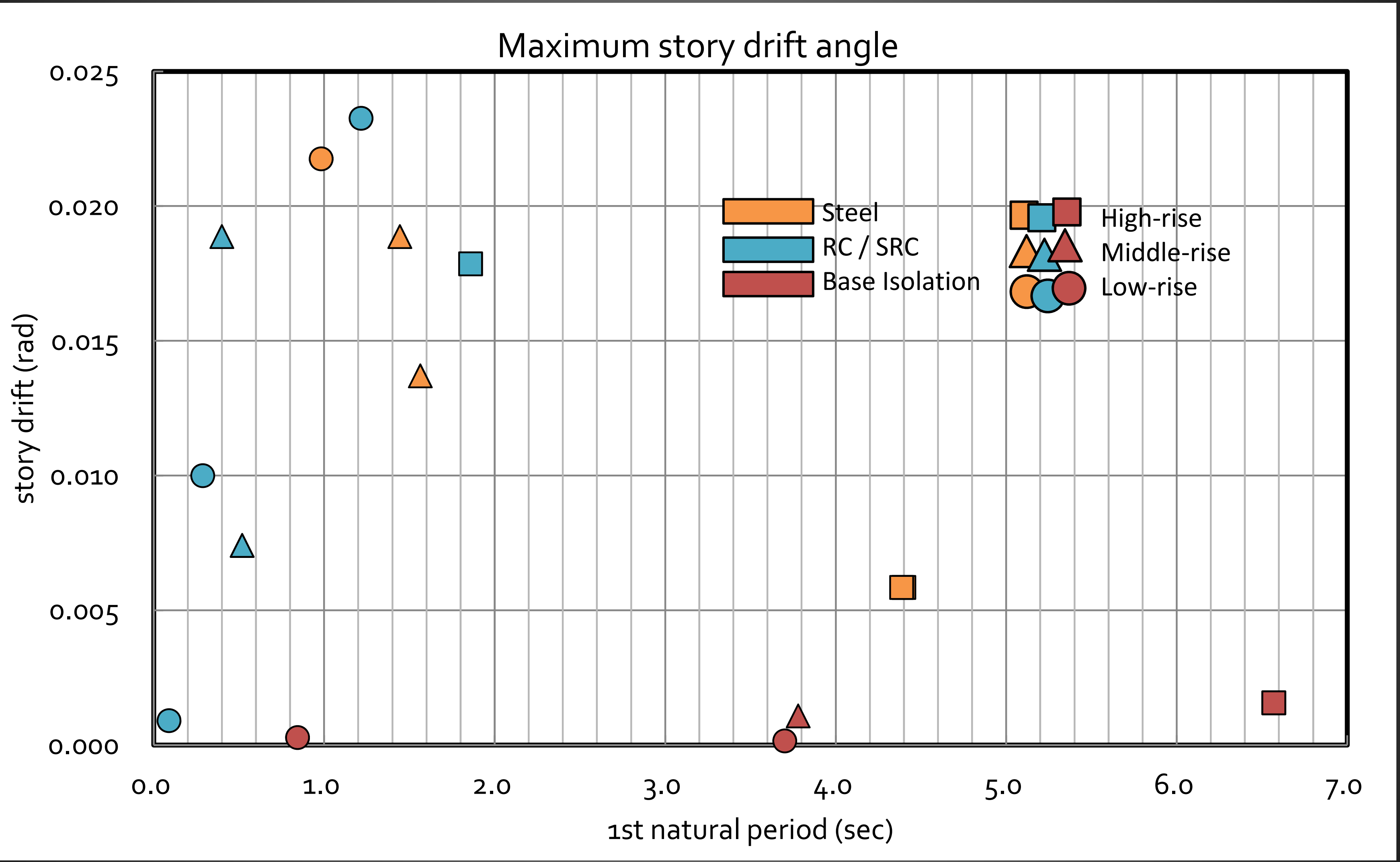
Response of 4F- Base Isolation RC (at site-U)



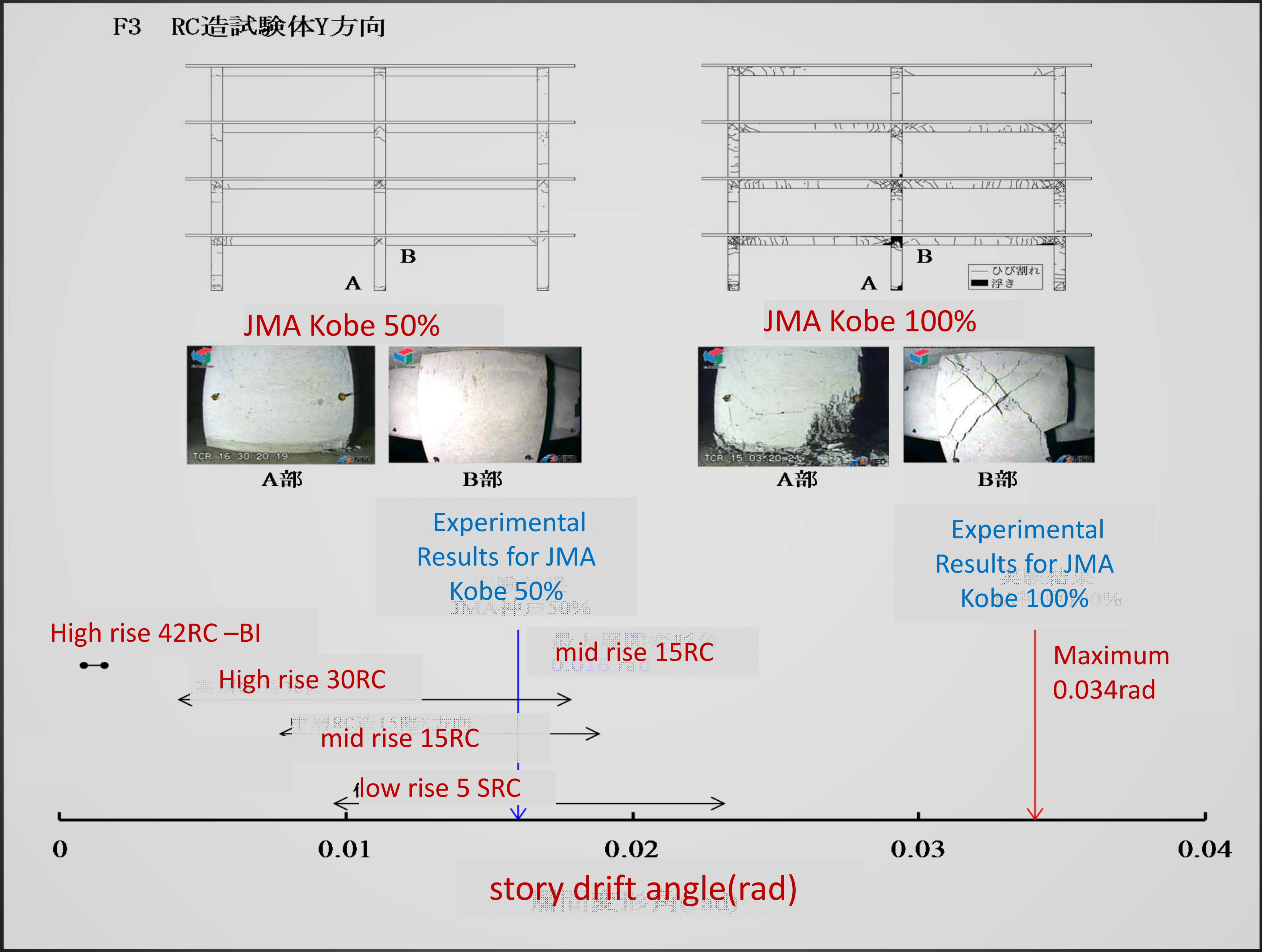
Max. Acceleration of 15 buildings



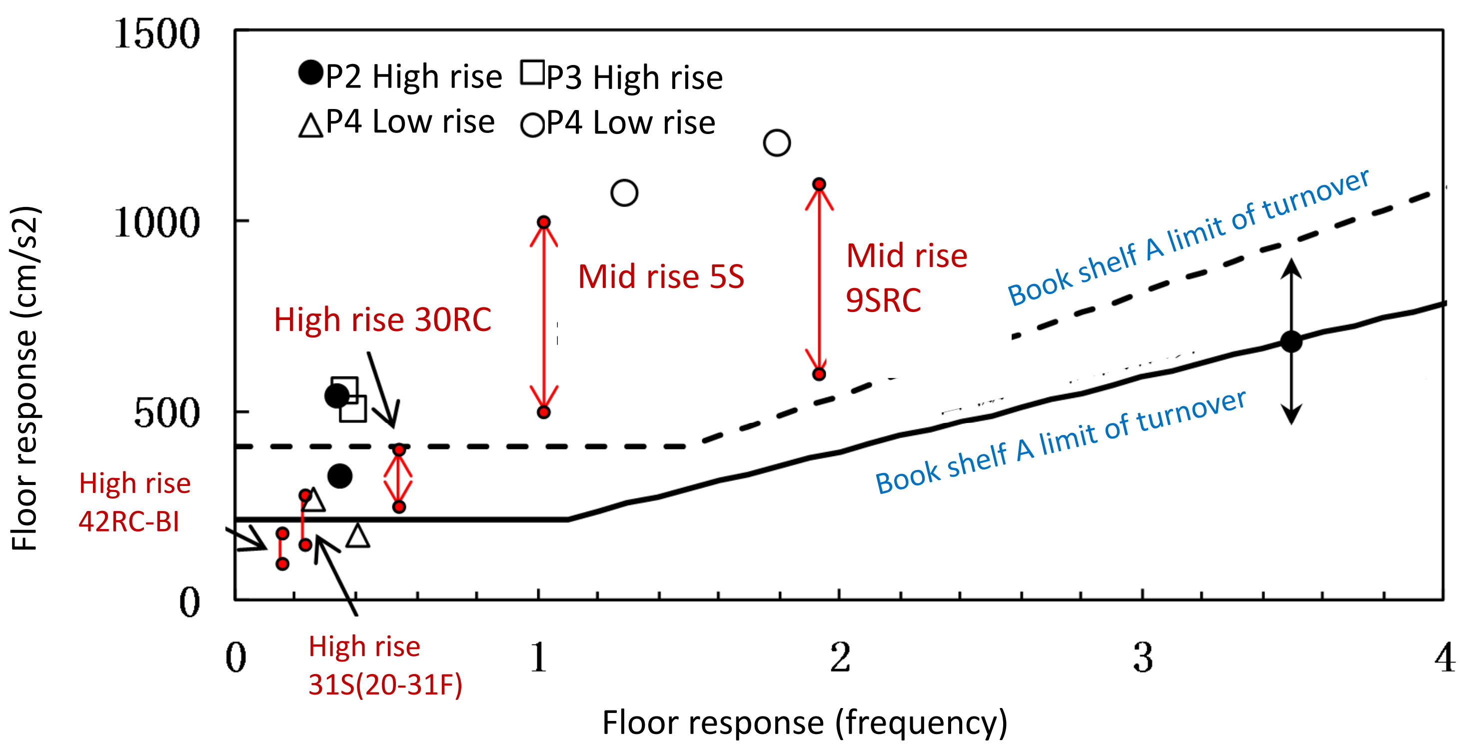
Max. story drifts of 15 buildings

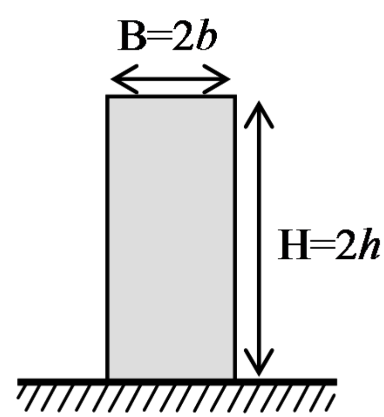


Assessment of response based on experimental results



Assessment of response based on experimental results





A : H=2150, B=450
B : H=1100, B=450

conclusion

- The response of the low-mid rise building may become larger than the design force depending on a site, while the response for high rise buildings may be smaller.
- The simulation for the ground motion at particular earthquake still have indefinite uncertainty.
- Structural engineers should understand there are still the uncertainties for artificial ground motion.
- Earthquake motion prediction and earthquake motion input evaluation are the information which should be made the big ground of a designer's judgment in the proper design of a building, and the designer needs to judge those information humbly and needs to make it reflected in a design.

ACKNOWLEDGEMENT

The contents of this paper summarize the details of research of the exchange meeting for the Ministry of Education, Culture, Sports, Science and Technology "task force about the promotion of utilization of Mid-size Earthquake ground motion beneath Tokyo metropolitan area." Gratitude is expressed here at the researchers concerned.