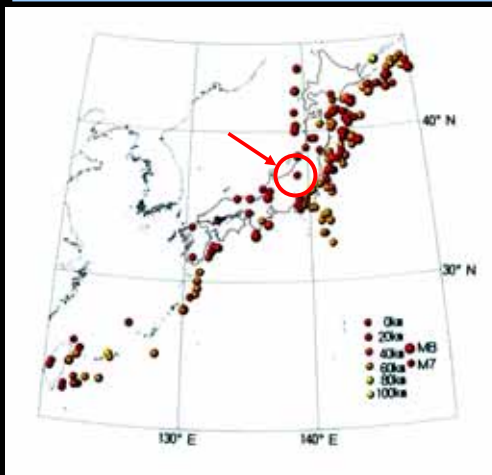


Presentation at IStructE on 11 October 2007

Performance of a Seismic Isolated Building at The Niigata Chuetsu Earthquake, 2004

Masatoshi Tamari
Hiroshi Kawamura
Mitsubishi Jisho Sekkei

IStructE, 11 October 2007



EARTHQUAKE MAGNITUDE over M7
For the past 100 years

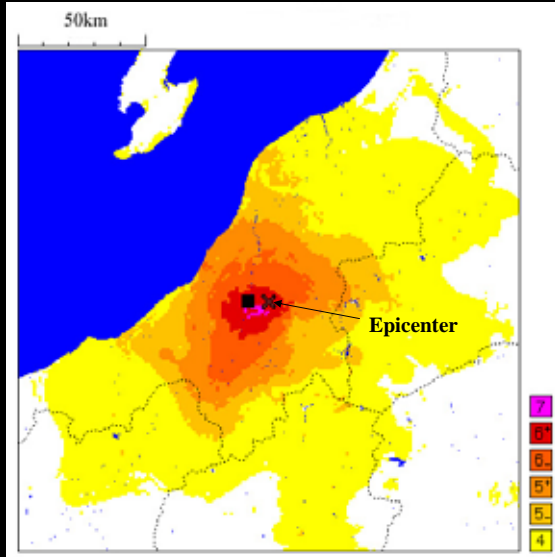


SEISMIC HAZARD
ZONING COEFFICIENT
from the Design Code

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Scale of Earthquake



Region and Country	Niigata Prefecture, Japan
Magnitude	6.8 (Mj) 6.6 (Mm)
Date	23 October 2004
Casualties	59
Injuries	4,700 (estimated)
Damaged Buildings	Collapsed: 3,175 Damaged: 13,772

Niigata Chuetsu Earthquake, intensity of the main shock

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Damaged Buildings and Roads



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Damaged Buildings and Roads



Cracks in the Road



Shear fracture at RC Column



Shear cracks at RC Wall



Inside the building

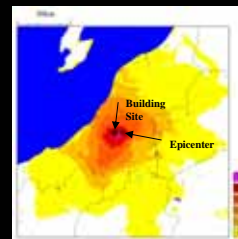
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Nursing Home Facility



Nursing Home Facility : SI Building



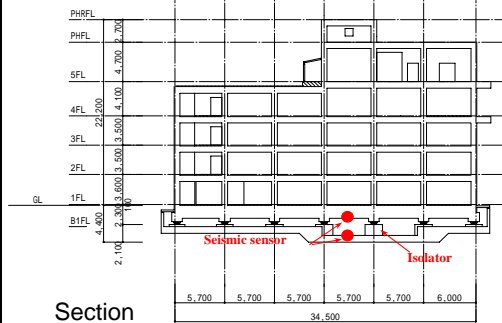
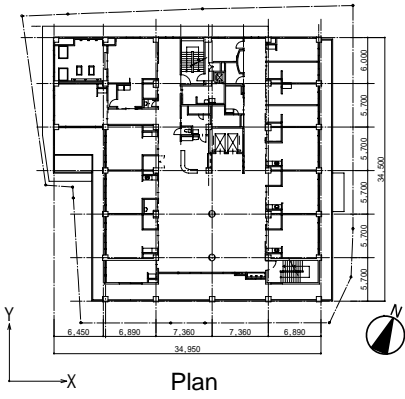
- Location: 7km distance from the epicenter.

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Performance of a Seismic Isolated Building

Nursing Home Facility

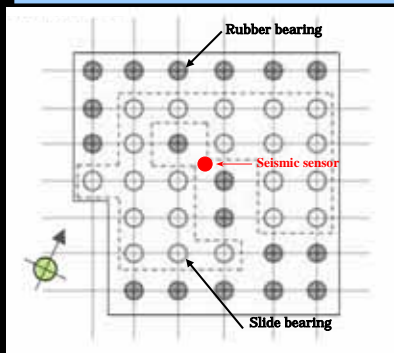


Number of storey	5 stories above ground
Building height	19.29m
Building area	1,156.21m ²
Total floor area	4,447.92m ²
Structural system	RC frame and shear wall
Foundation	Raft foundation
Base isolator	Rubber bearing and Slide bearing
Completion date	30 May 1997

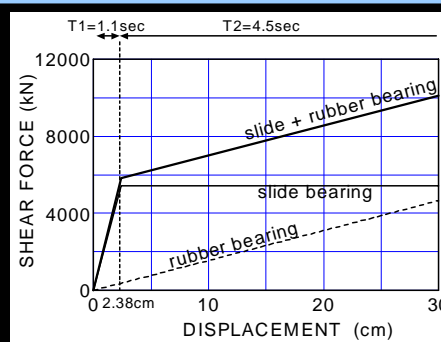
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Seismic Isolation System



Plan of isolators



Force-displacement: Bi-Linear



Rubber bearing, 18 No.



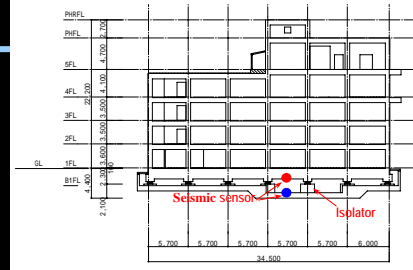
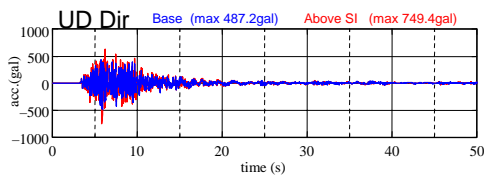
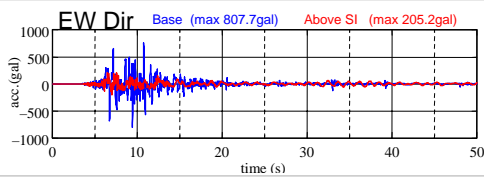
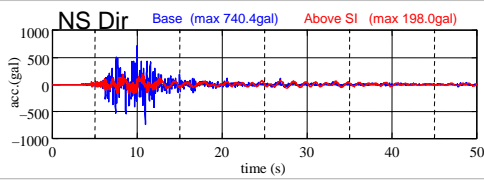
Slide bearing, 21 No.
(friction coeff.=0.12)

Natural period:
Elastic period = 1.1 sec
Post-yield period = 4.5 sec

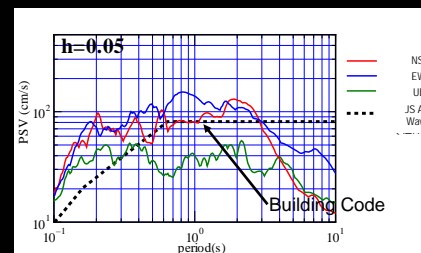
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Observed Motion Records



Peak Acc.
 Base 0.84 g (EW) Above SI 0.20 g (EW)
 0.68 g (NS) 0.23 g (NS)



Accelerograms of the observed motion

PSv Spectra

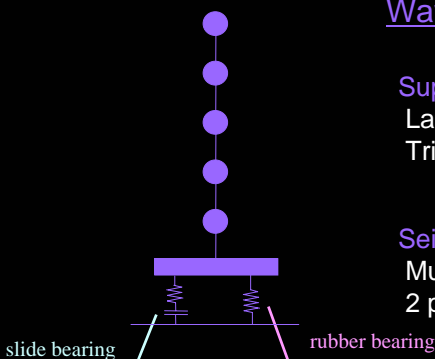
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Nonlinear Dynamic Analysis

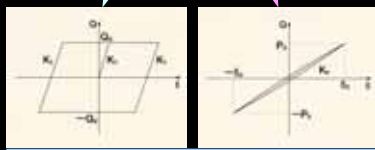
Analysis Model

Nonlinear dynamic analysis (NDA)
 Wave: Observed motion record



Superstructure :
 Lateral two-degree-of-freedom
 Tri-linear Force-disp. relationship.

Seismic isolation system :
 Multi-spring element in 8 lateral directions
 2 parallel elements



Modal periods

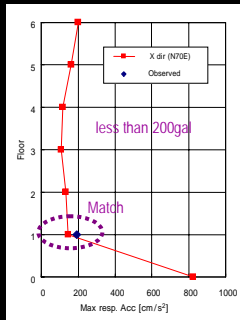
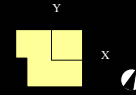
Mode	Period (sec)	
	X	Y
1	1.16	1.19
2	0.16	0.24
3	0.08	0.12

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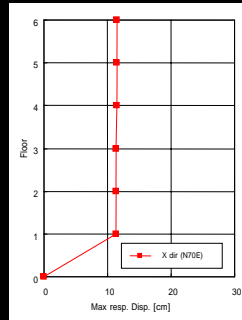


Nonlinear Dynamic Analysis

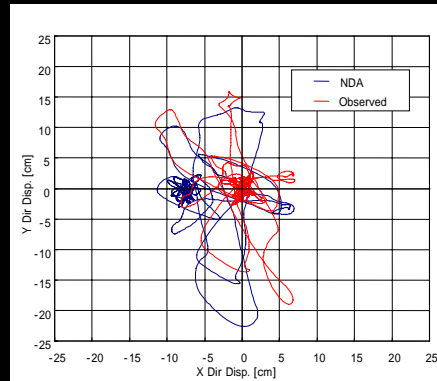
Result of analysis & comparison with the observed value



Maximum response acceleration [X dir]



Maximum response displacement [X dir]



Displacement diagram

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Post-Earthquake Conditions of the Building



North view



South-east view, no external damage



South view, no external damage



North view, no external damage

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Post-Earthquake Conditions of the Building



1FL Kitchen, no damage



1FL Food Storage, no falling down objects



2FL Terrace, only 1 Planter fell down to ground



3FL no falling down objects

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Post-Earthquake Conditions of the Building

All isolators were inspected.

No damage
Permanent offset = 3 cm
less than the allowable value
5 cm.



Rubber bearing

Maximum drift = 15 cm approx.
from the imprints on stainless
steel plate of slide bearing.



Slide bearing

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Post-Earthquake Conditions of the Building



Flexible joint at service pipe



Motion sensor above and below Isolator



Motion sensor

Data recorder installed at the isolation pit



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Conclusion



- Seismic sensors were installed above and under the isolators and the observed record indicates that the seismic isolation system reduced the horizontal acceleration by 75%.
- A field survey of the building after the earthquake identified that the building and its contents suffered almost no damage despite of the severe ground motion.
- Analytical simulation of the seismic isolation system matches with the observed response.
- The advantage of SI building is confirmed by motion record, under a M6 earthquake.

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