Performance Evaluation of a Building Structure With Nonlinear Dampers Under Strong Ground Motion on March 11 in 2011

Isao Nishimura
Department of Architecture , Tokyo City University

TOPICS

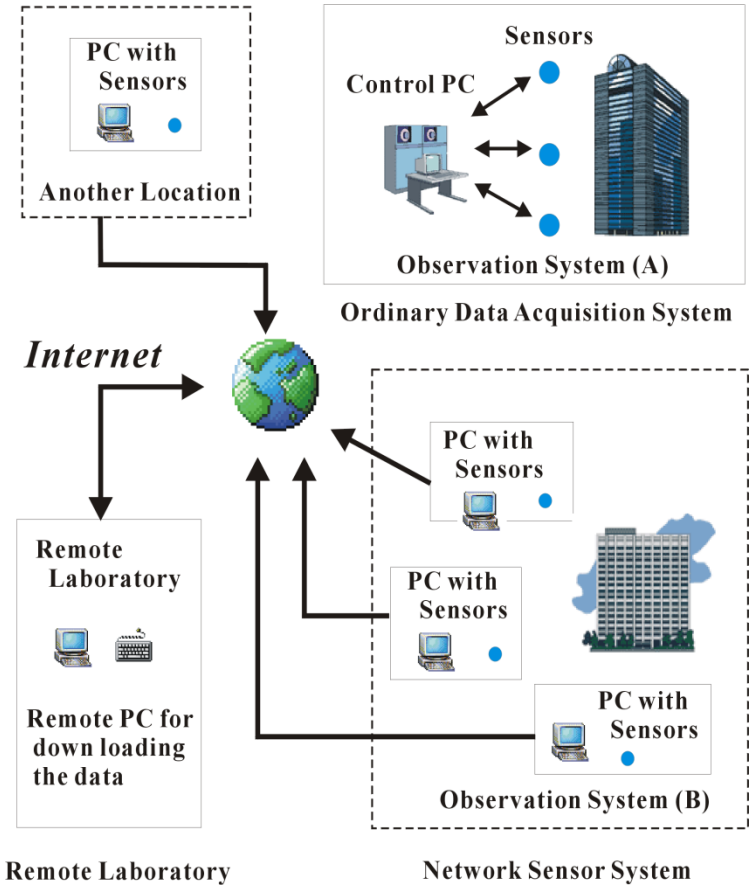
1. Structural health monitoring and network sensing system
   for a project building on the campus of Tokyo City University

2. Vibration control by connecting two building structures
   by way of nonlinear compressive dampers

3. Performance evaluation of the project by comparing
   the data accumulated before the earthquake on March 11, 2011
   and the data after the event

4. The damage detection procedure based on system identification
   by using network sensing system

Concept and purpose of the monitoring system

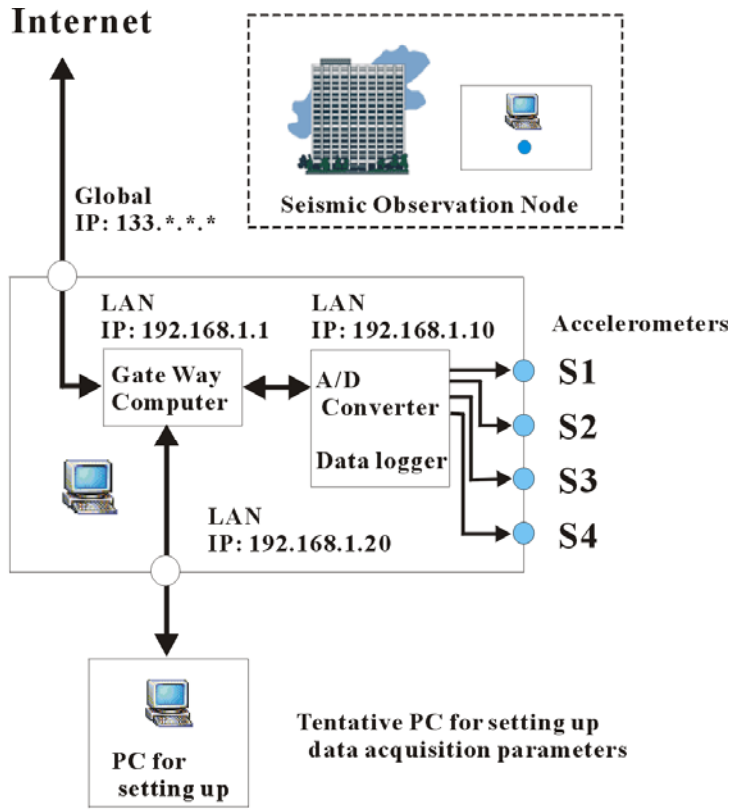


The Concept of
Network Sensing System

Each sensor node starts its data acquisition according to its own trigger level so that it is impossible to synchronize all the data.

But the data can be used to identify the transfer function rather easily.

Concept and purpose of the monitoring system



Constitution of Sensor Network for Seismic Observation

Example of
Network Sensor System

Each node has its own local IP as well as global IP so that it can create a virtual private network (VPN).

This sensor node is connected with and included in the laboratory network.

Concept and purpose of the monitoring system

Application of Network Sensor System

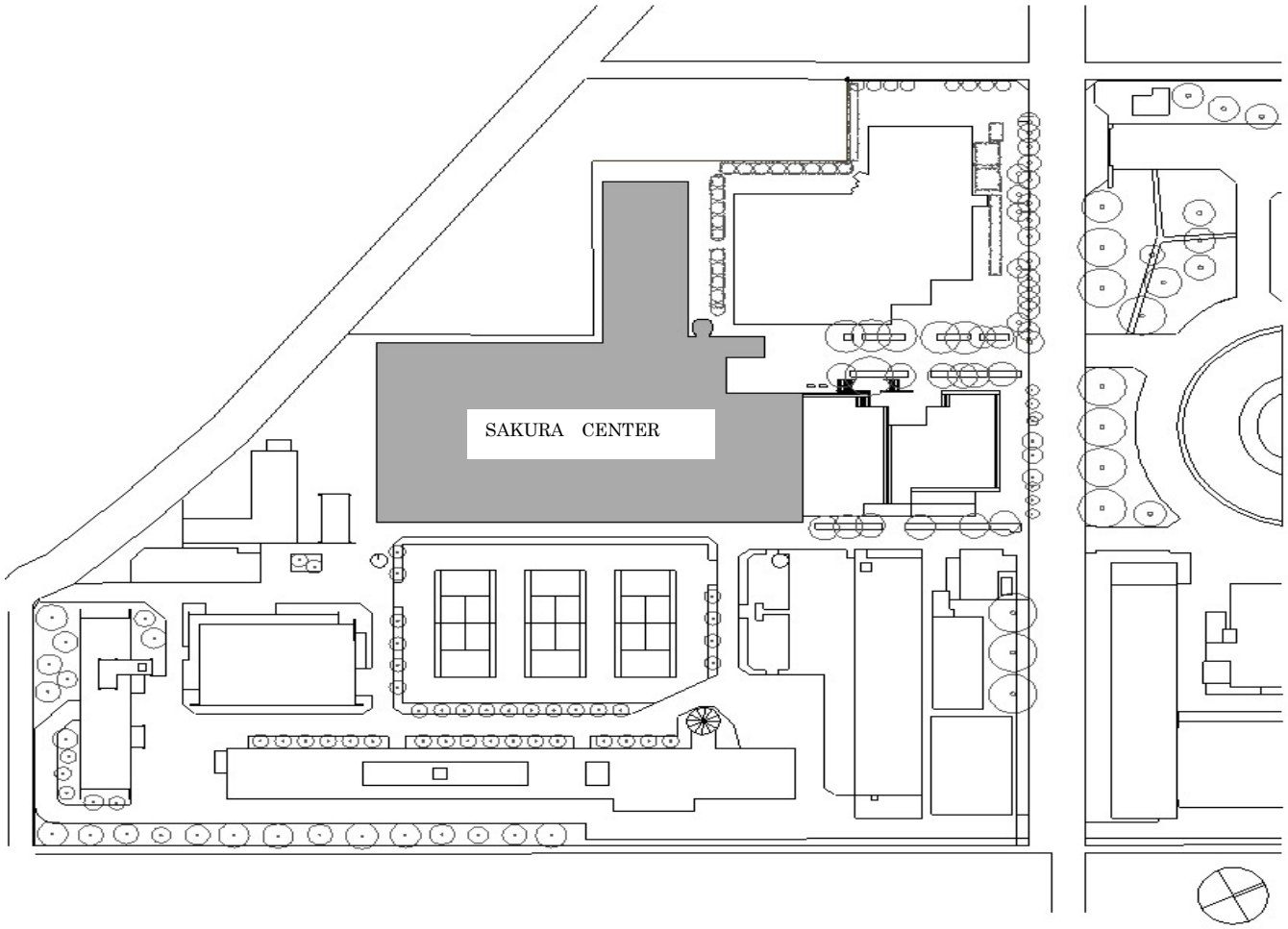
Force Balanced Type
Accelerometers

16bit Data Logger
/ Gateway PC

Concept and purpose of the monitoring system

- SHM system reduced the cost of data acquisition so much that it can be used to evaluate the performance of damping devices or seismic retrofit for many building structures.
- Data base obtained by implementing SHM systems into numerous building structures will be potentially useful for estimating the relative damage vulnerability against the seismic hazard.
- Interaction between the soil and the superstructure dynamics can be measured and it will increase our knowledge about the real behavior of structure damage in case of large earthquakes.

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures



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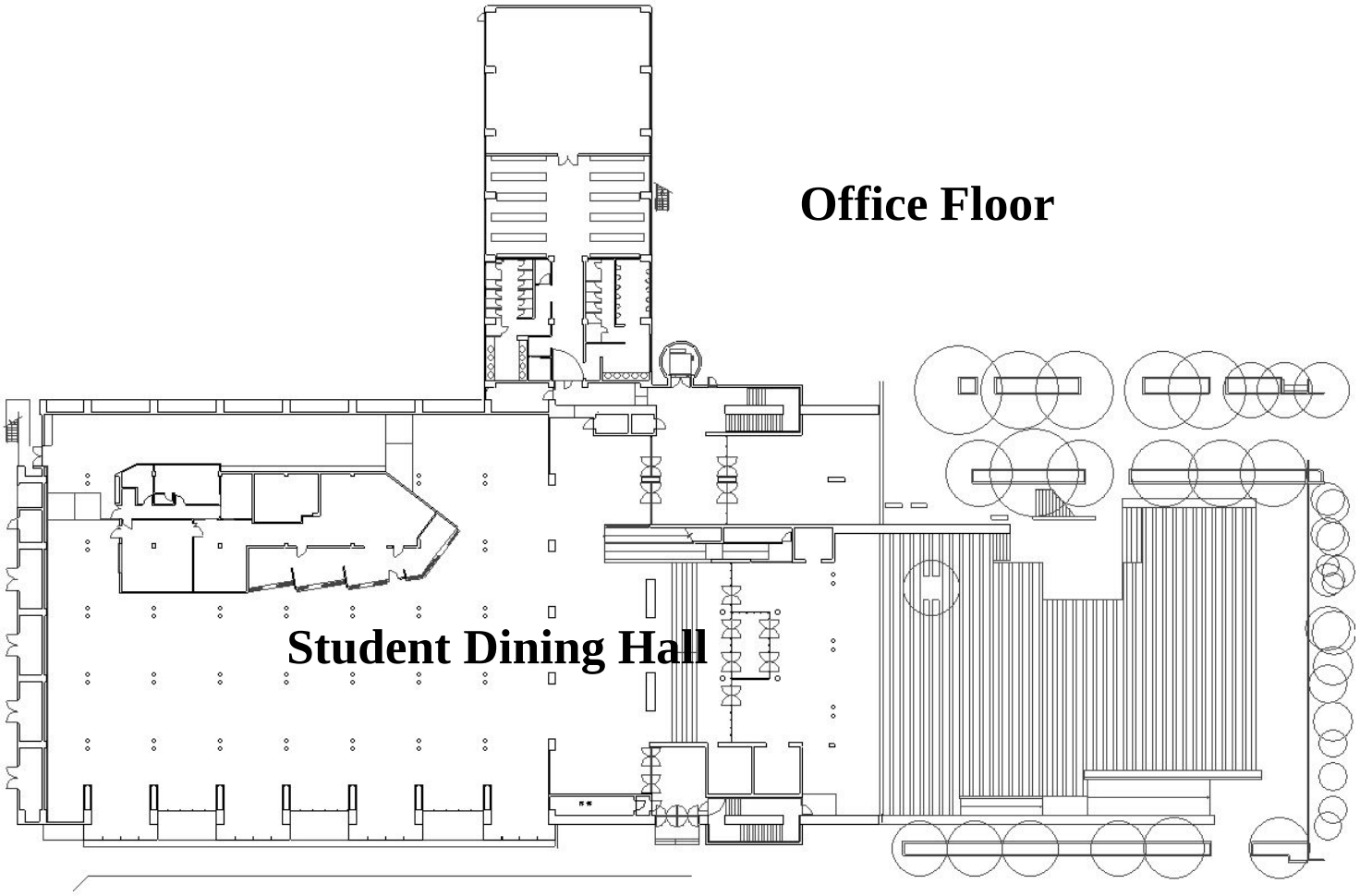

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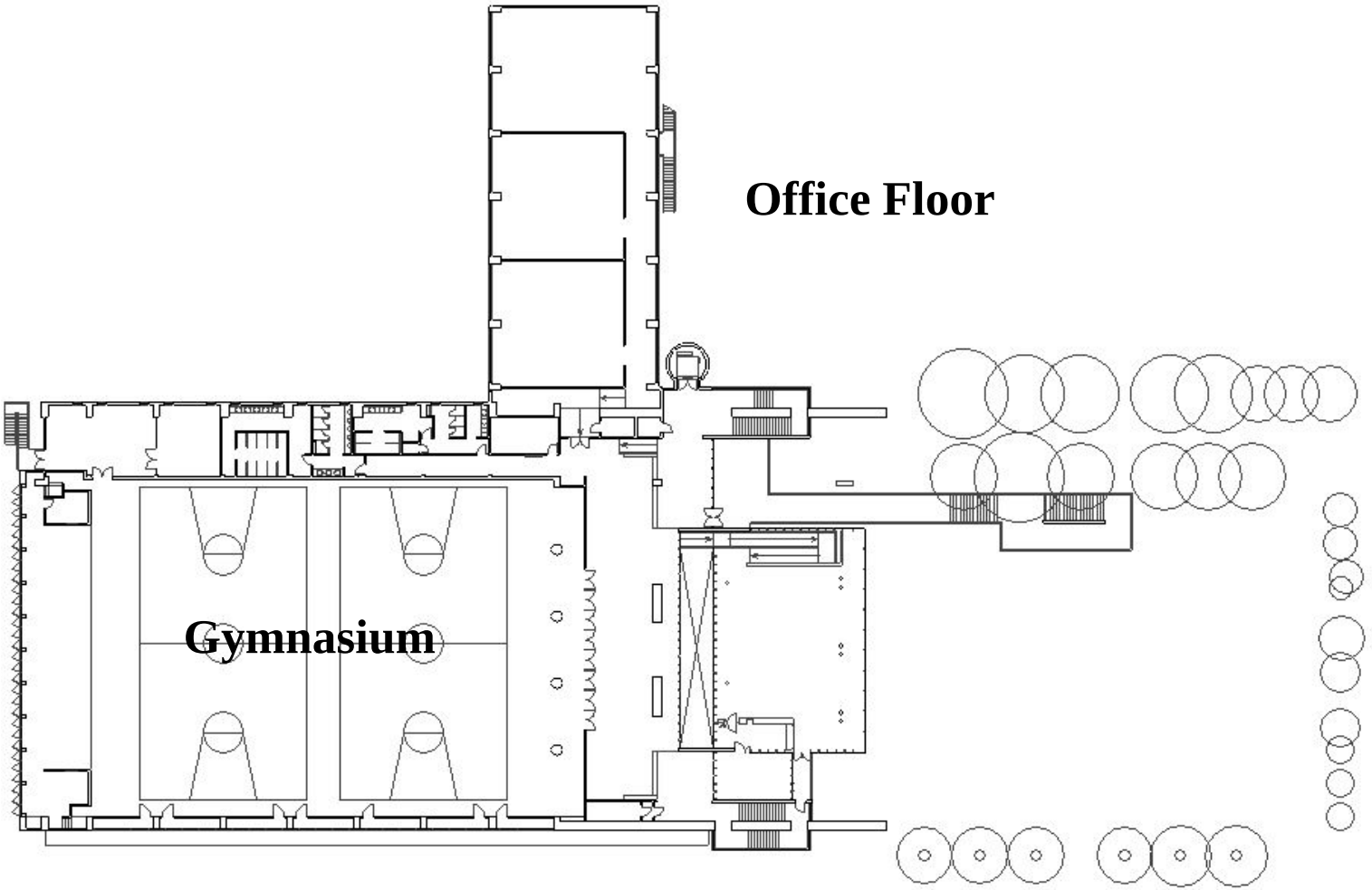
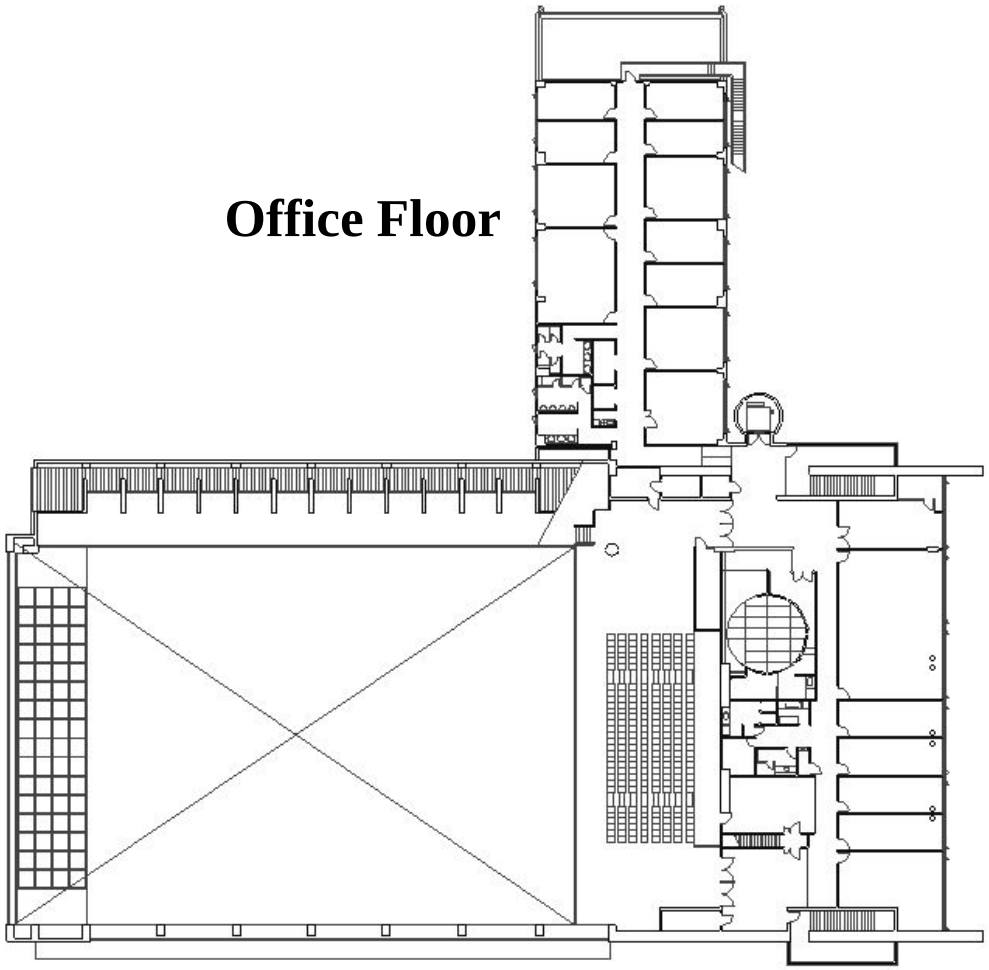


Performance Evaluation of Nonlinear Damper for Connecting two Building Structures

Office Floor



Office Floor

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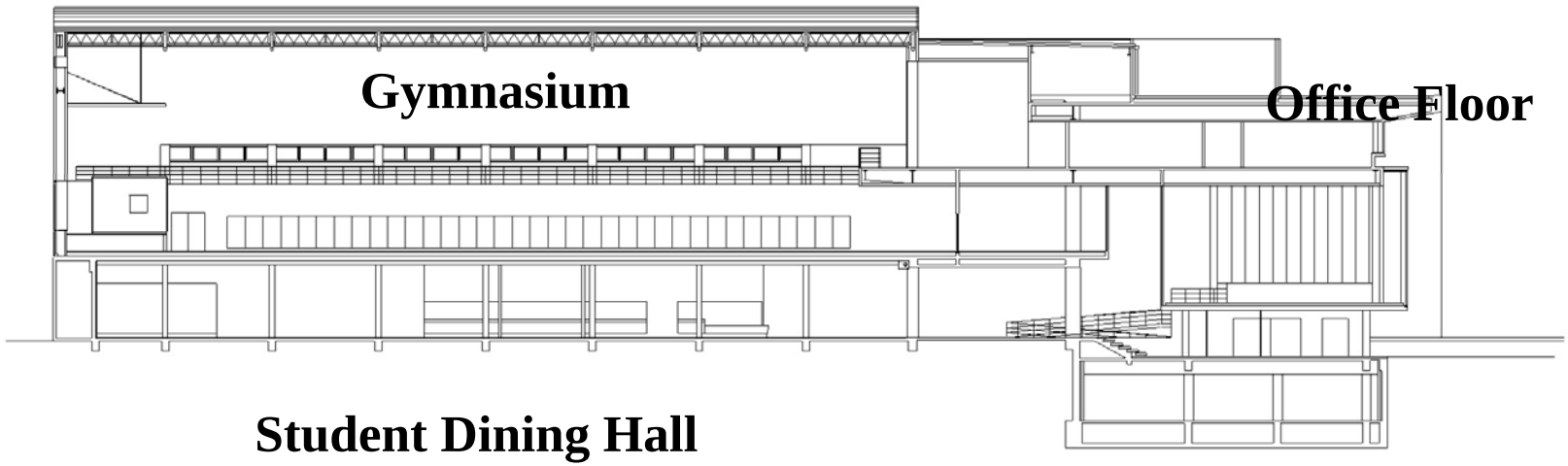
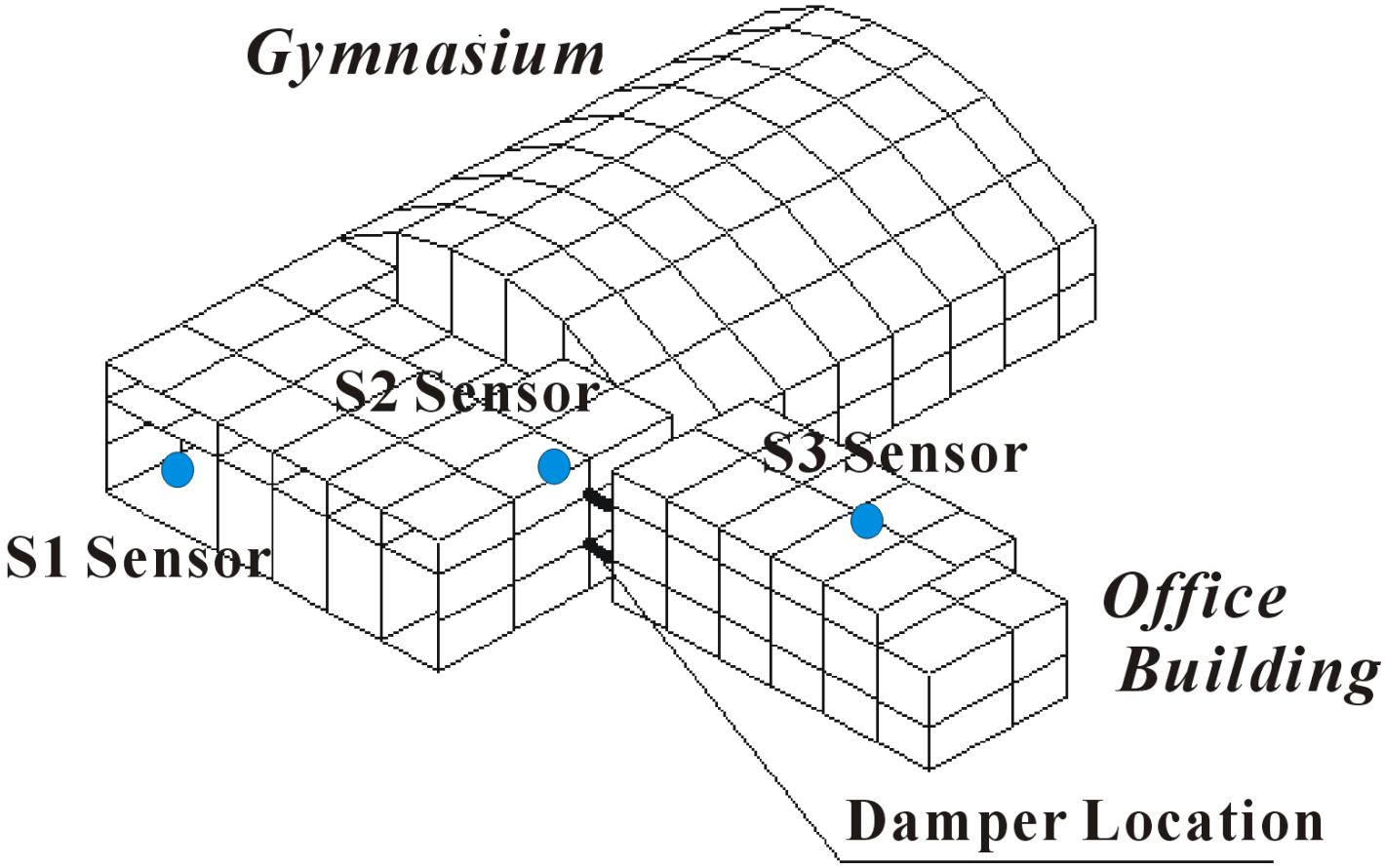


Performance Evaluation of Nonlinear Damper for Connecting two Building Structures

Gymnasium / Student Dining Hall **Office Building**

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures

Performance Evaluation of Nonlinear Damper
for Connecting two Building Structures



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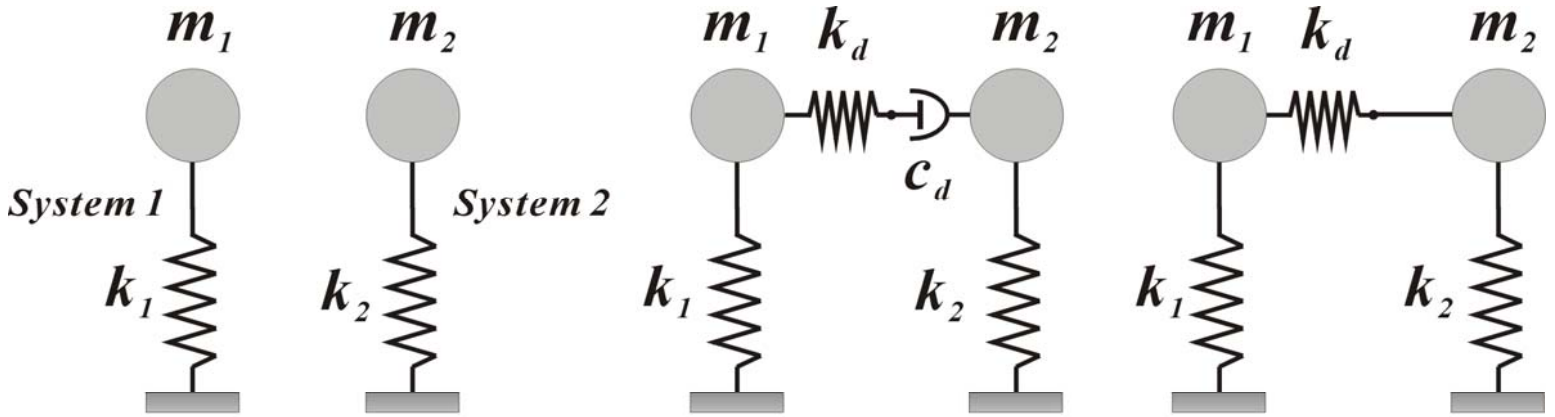

$$\eta_{eq} = \frac{\beta}{2+\beta}\sqrt{\frac{1}{2(2+\beta)}} \qquad \beta = \frac{\omega_\infty{}^2 - \omega_o{}^2}{\omega_o{}^2} = \frac{k_d}{k}$$

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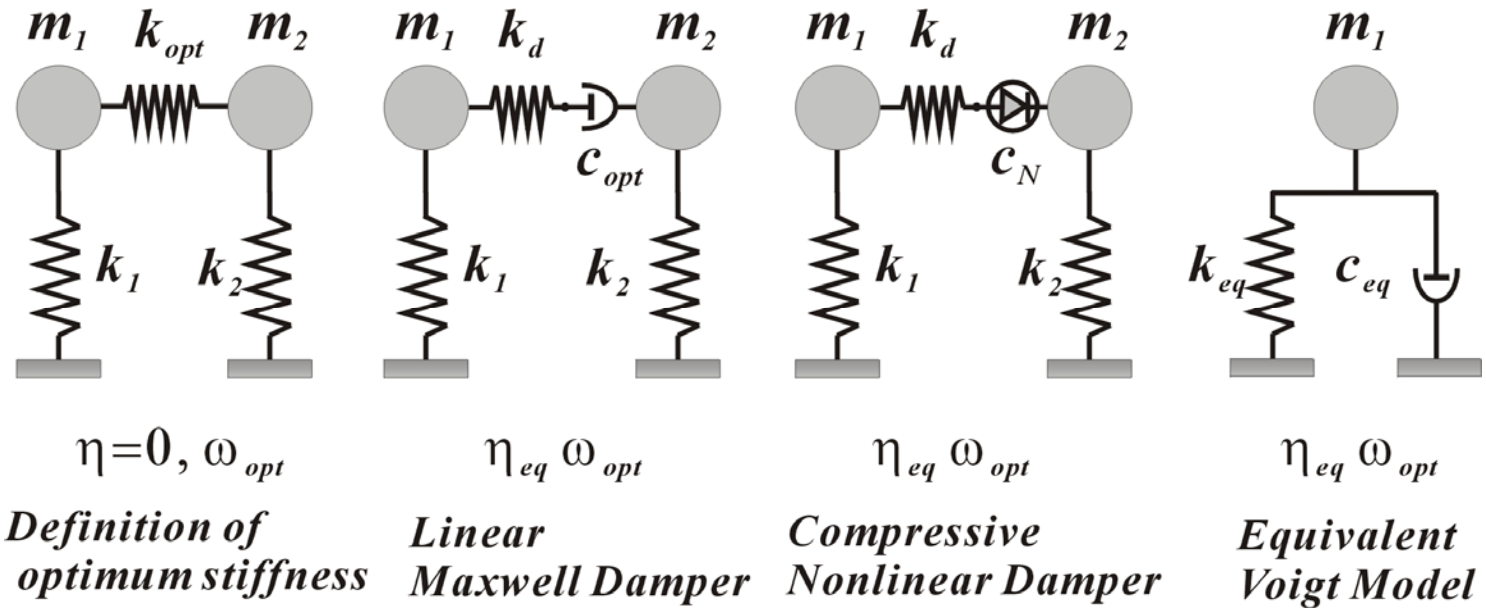
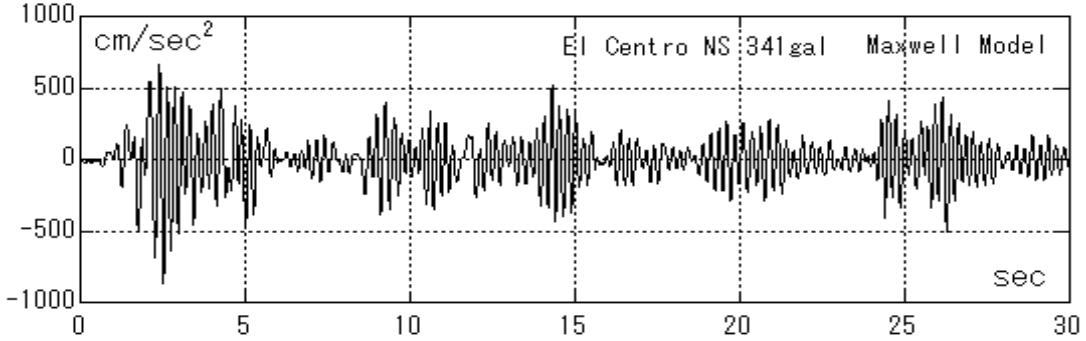
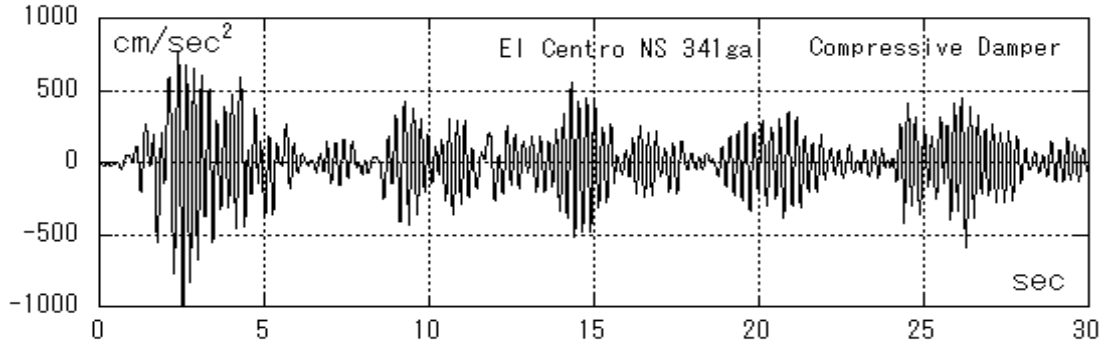


Two different damping devices have the same performance, regardless of the nonlinearity.

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures



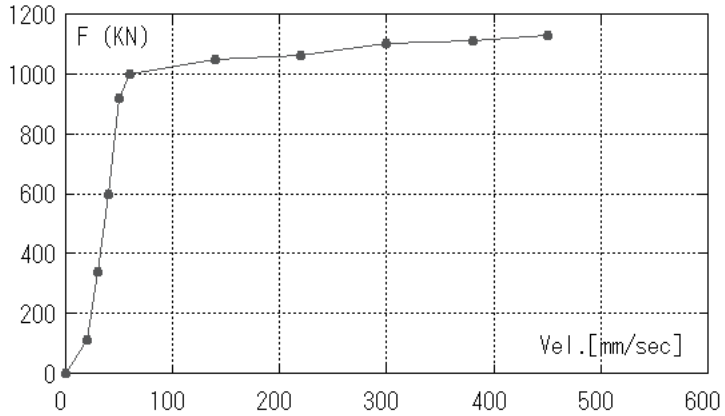
Maxwell Linear Damper



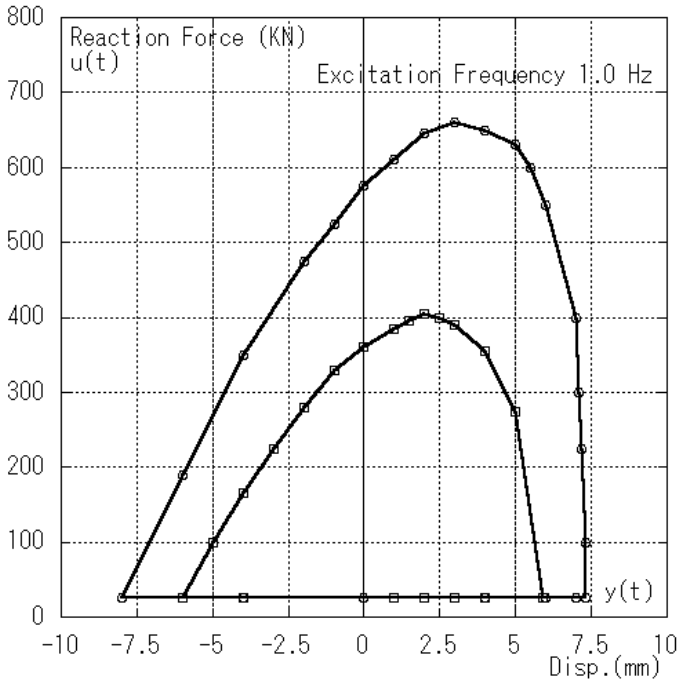
Compressive Nonlinear Damper

Numerical Simulation based on the Design Model

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures



Damping coefficient by Dynamic Test



Cyclic Loading Test Results

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures

Compressive Damper

Ground Floor

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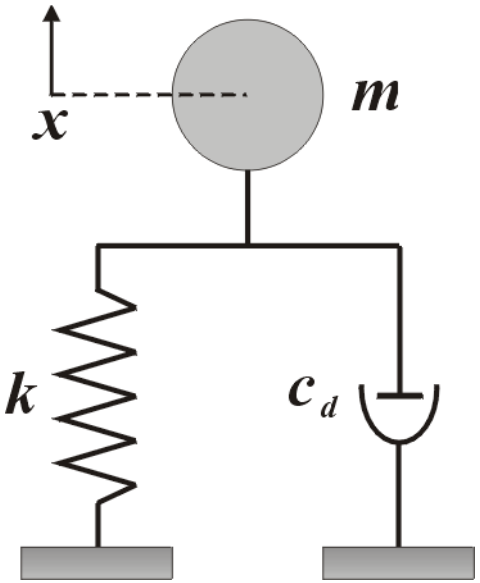
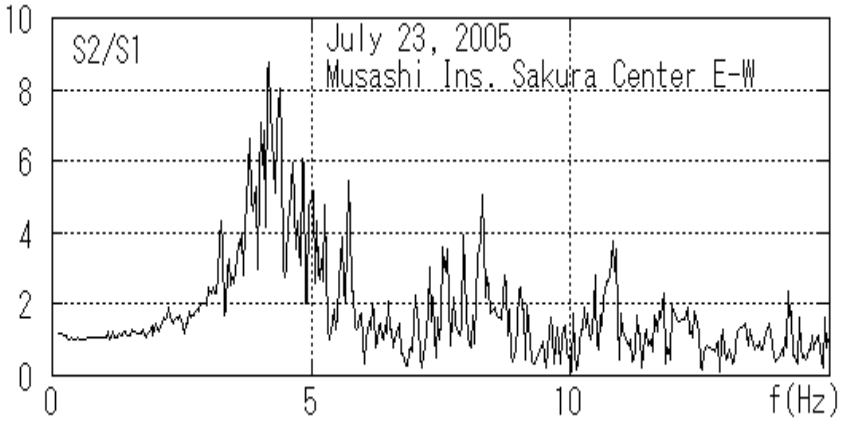


Identified Dynamic Parameters
Natural Frequency 4.25 Hz
Damping Factor 6.0 %



Transfer function of S2/S1

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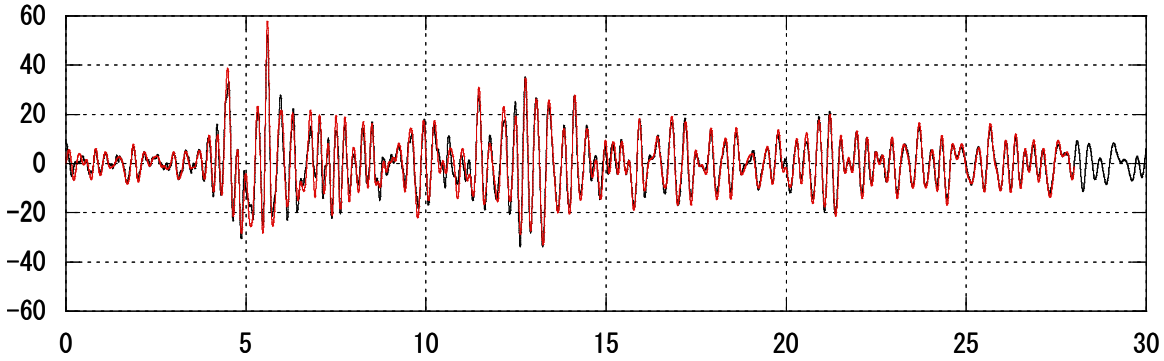
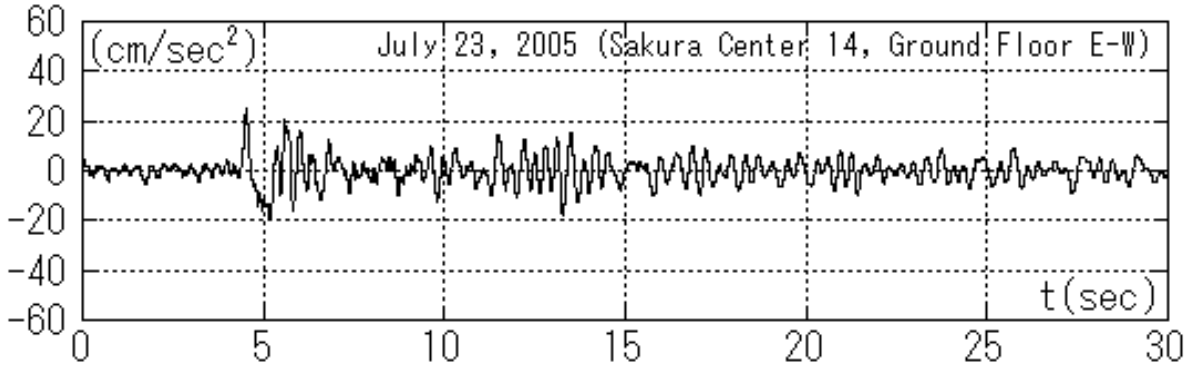


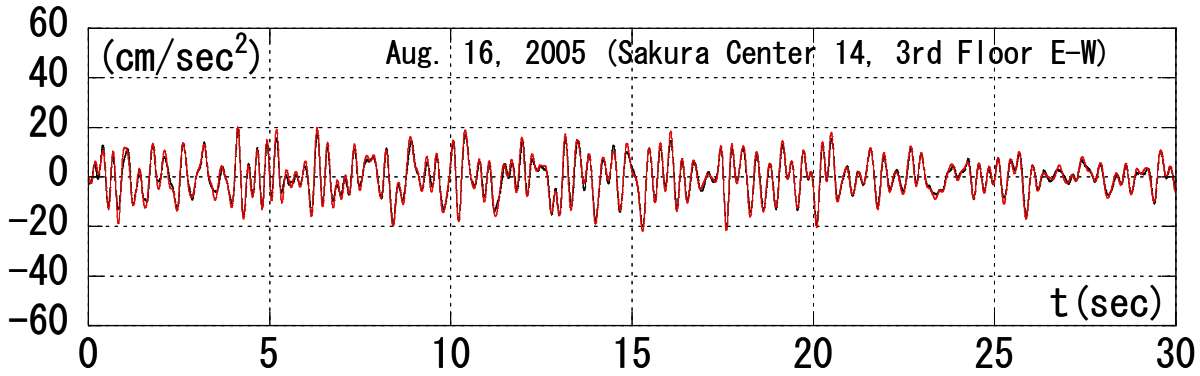
3rd Floor Response Acceleration



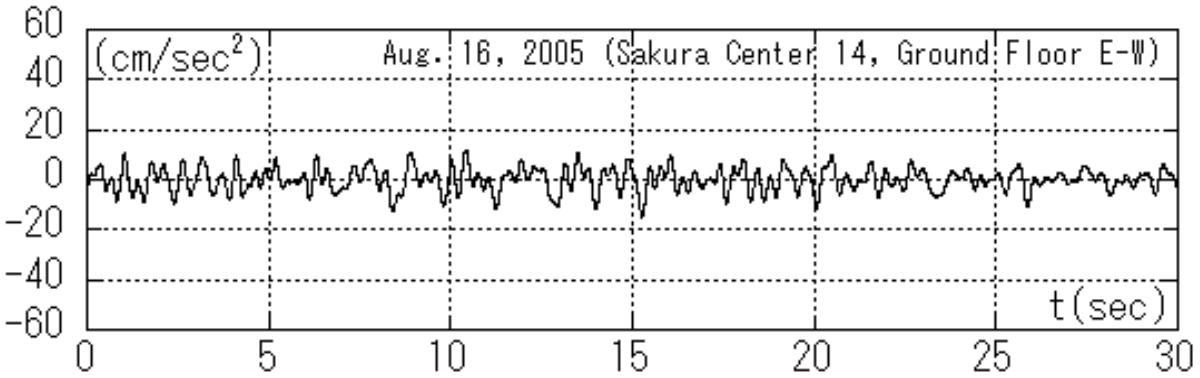
Ground Floor Recorded Acceleration

July 23, 2005 Earthquake

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures



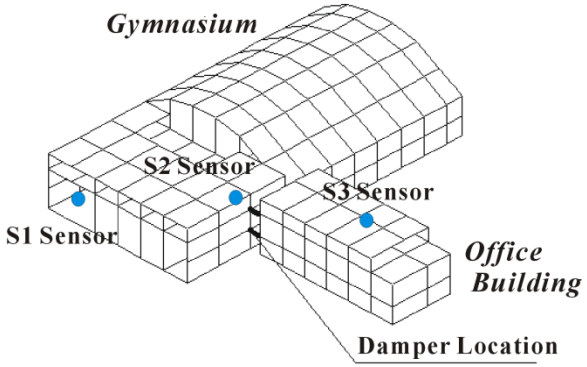
3rd Floor Response Acceleration

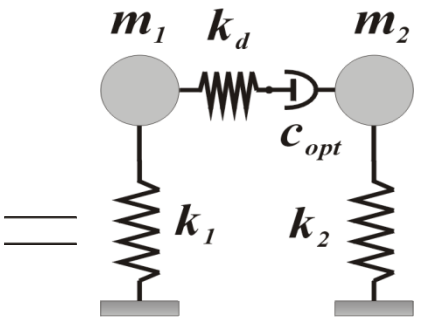


Ground Floor Recorded Acceleration

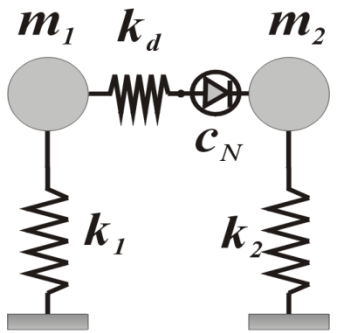
August 16, 2005 Earthquake

Performance Evaluation of Nonlinear Damper for Connecting two Building Structures

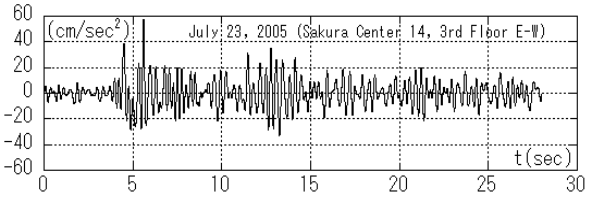


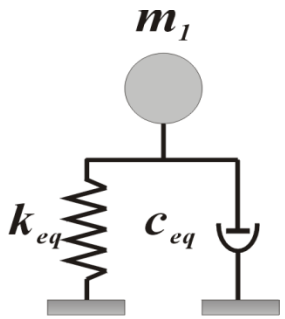


Linear Maxwell Damper



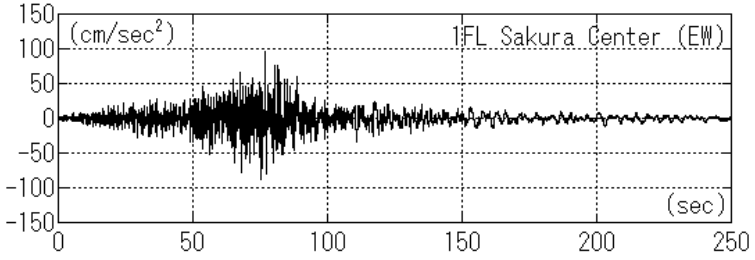
Compressive Nonlinear Damper

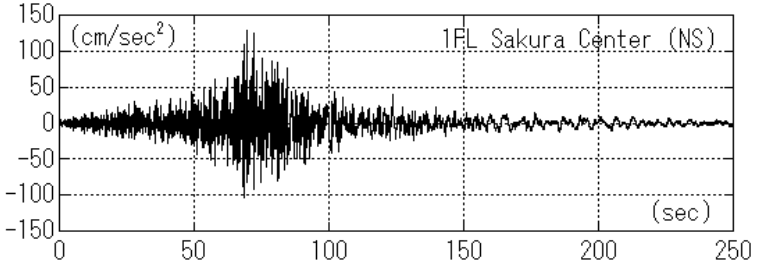


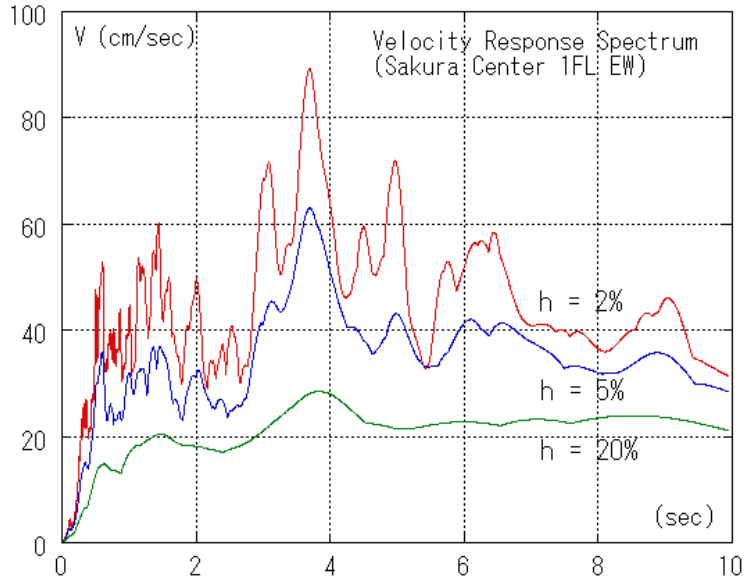


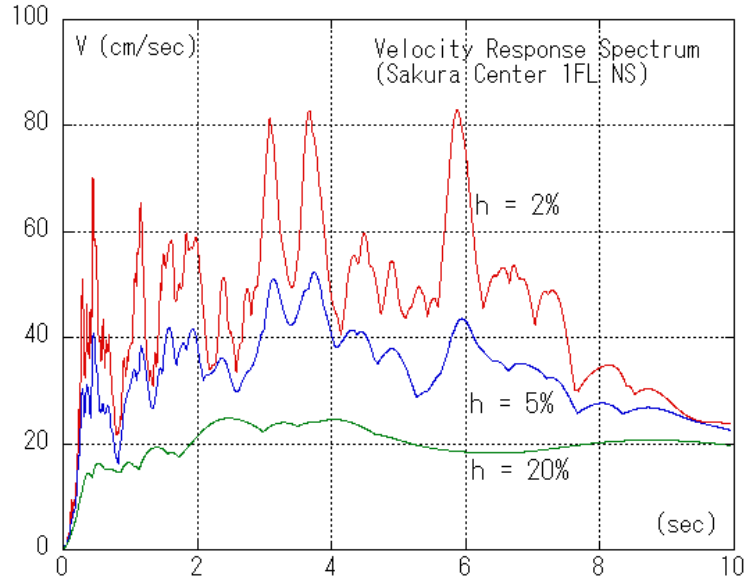
Equivalent Voigt Model

Damage Detection Procedure by Comparing Identified Dynamic Properties before and after the Major Event





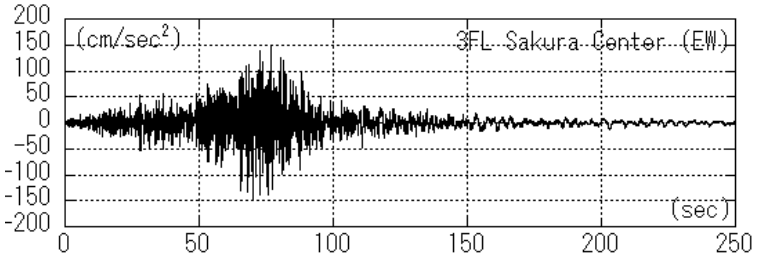


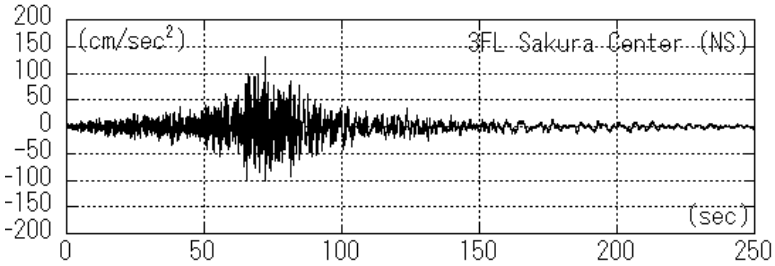


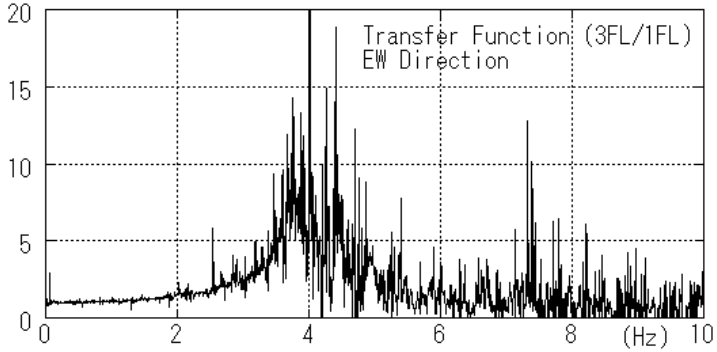
E-W Direction N-S Direction

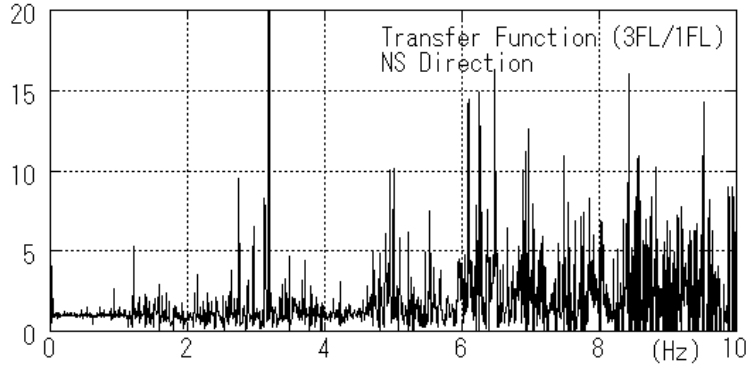
Record on the Tohoku Earthquake on March 11, 2011

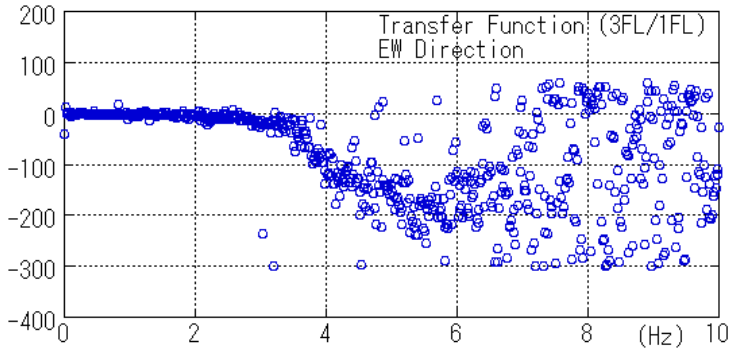
Damage Detection Procedure by Comparing Identified Dynamic Properties before and after the Major Event

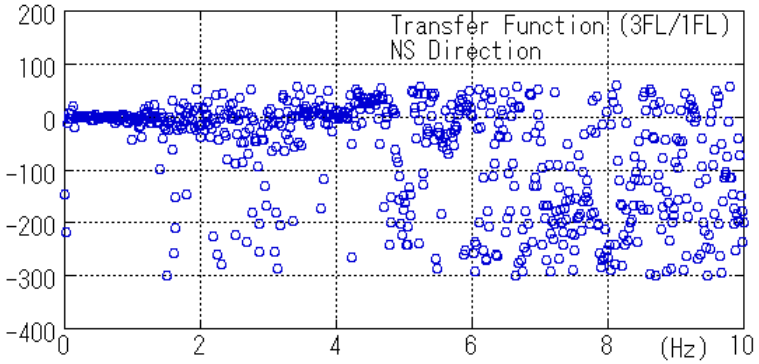












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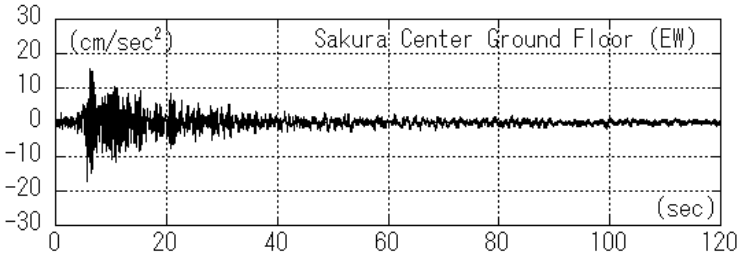
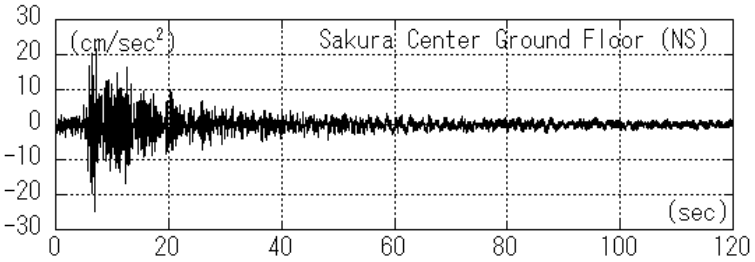
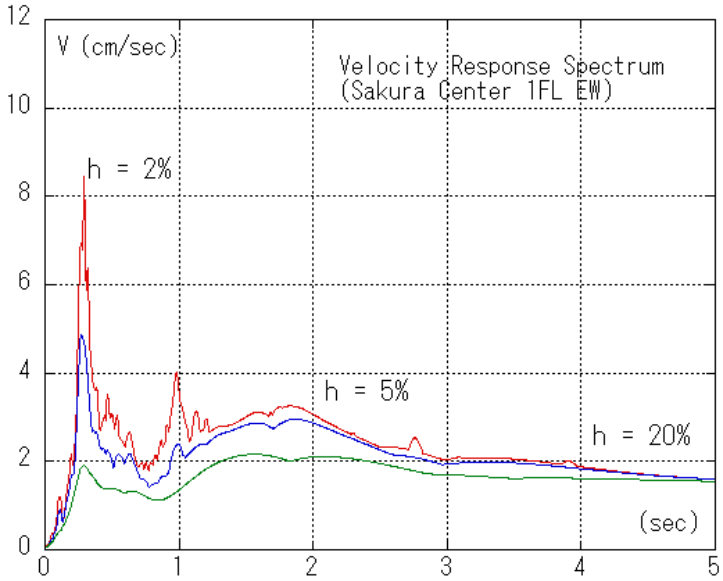
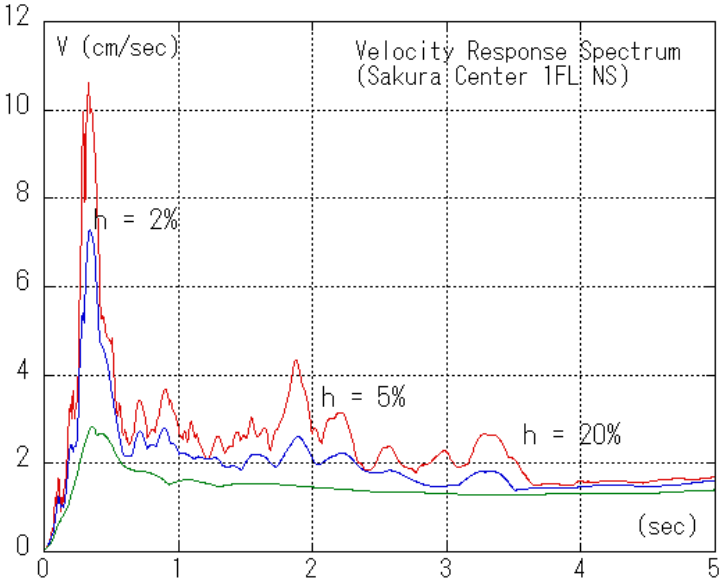
Damage Detection Procedure by Comparing Identified Dynamic Properties before and after the Major Event





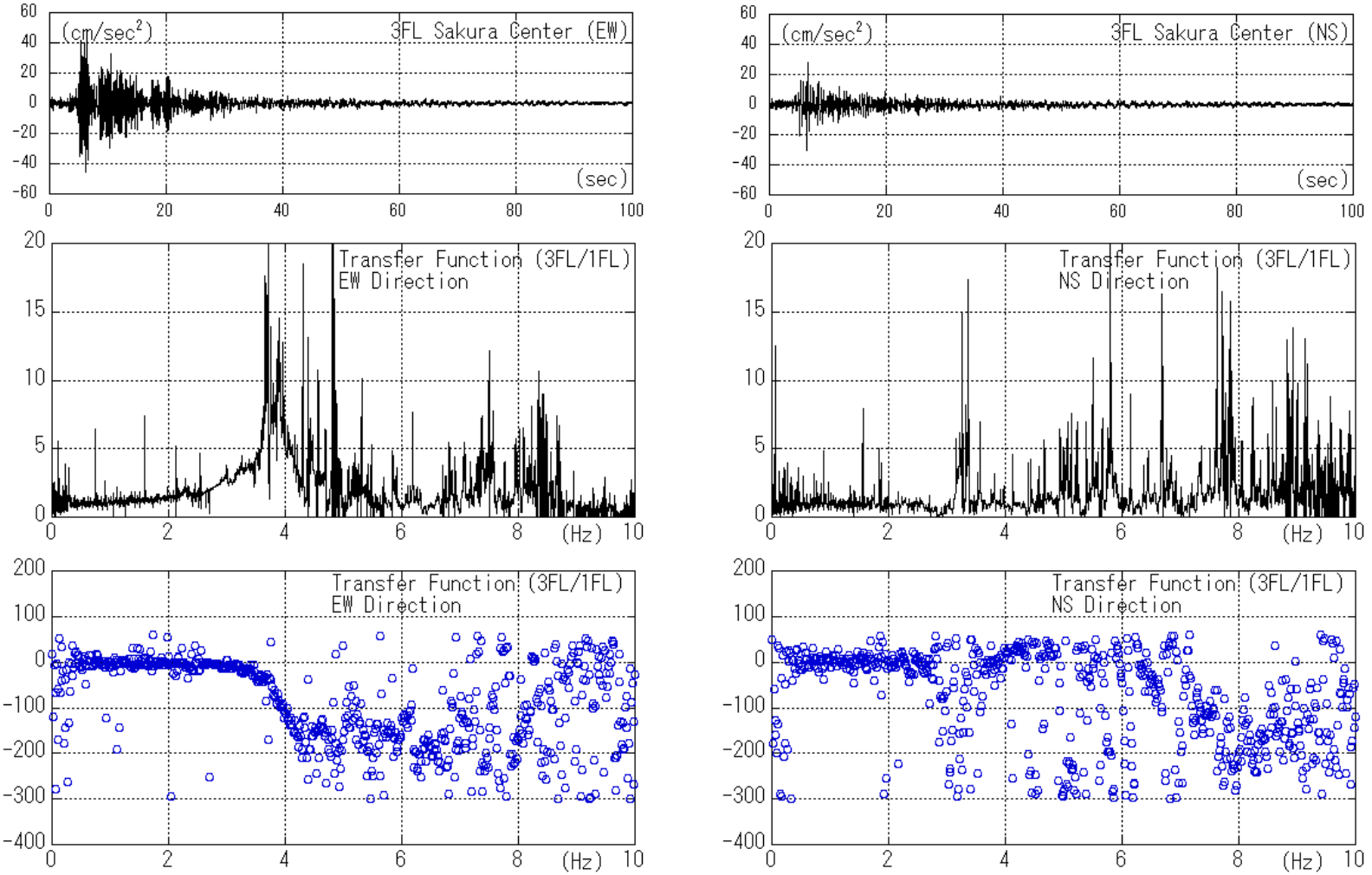




E-W Direction N-S Direction

Post Record on the April16 Earthquake, 2011

Damage Detection Procedure by Comparing Identified Dynamic Properties before and after the Major Event



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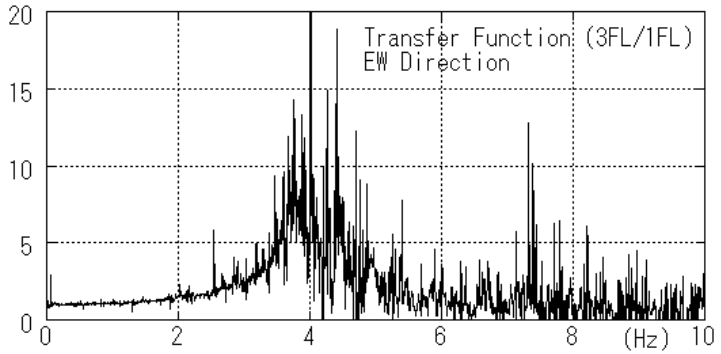

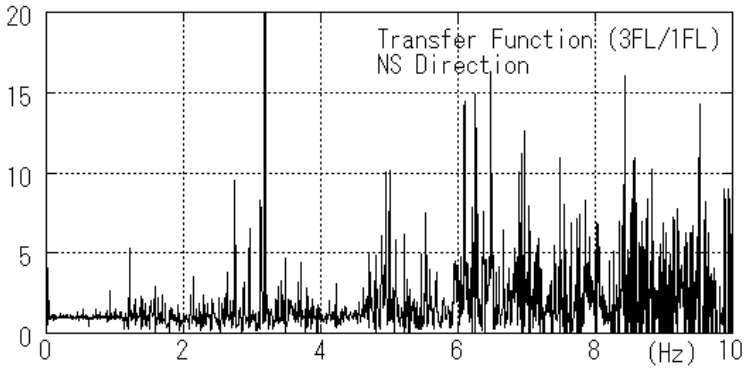

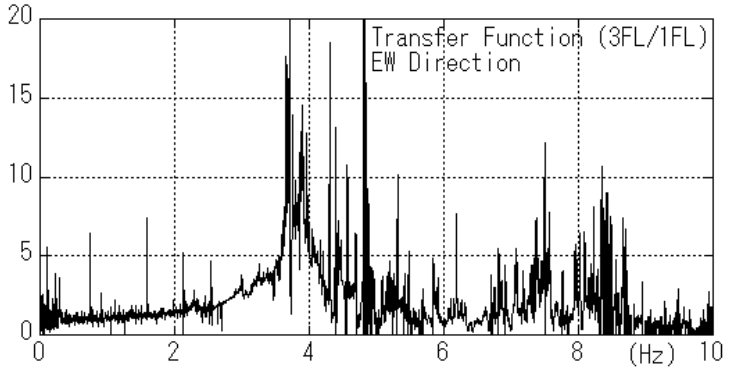

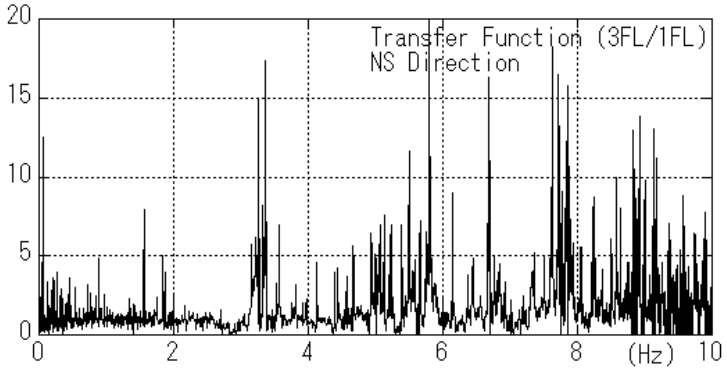

There is major damage detected by comparing response functions in EW and NS directions

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