# Current Status of Seismic Retrofitting Technology

Building Control Section
Urban Building Division
Bureau of Urban Development, TMG

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## Damages by the Great Hanshin-Awaji Earthquake

- Severe damages observed for the buildings constructed before 1981
- Buildings after 1981 were not severely damaged, indicating basically the adequacy of the current earthquake resistance standards

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## Damages by the Great Hanshin-Awaji Earthquake

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**Damages by the Great Hanshin-Awaji Earthquake**

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**Damages by the Great Hanshin-Awaji Earthquake**

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**Damages by the Great Hanshin-Awaji Earthquake**

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**Damages by the Niigata Chuetsu Earthquake**

- The quake caused many ground failure and landslide
- Long rain before the quake softened the ground
- Buried houses and road by landslide (Yamakoshi village 2004.10.29)

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## Damages by the Niigata Chuetsu Earthquake

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**The column failed to support the vertical load due to the large horizontal deformation as the result of the cross cracks caused by shear force**

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**There were big shear cracks on the wall and the opposite side can be seen through.**

**Columns considerably distorted**

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## Seismic Diagnosis (for RC structures)

**(Judgment on whether or not a building satisfies the required seismic performance against the possible large earthquakes)**

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## First Order Diagnosis

- **The most simple method**
- **Suitable for buildings with sufficient shear walls**
- **Determining the seismic performance from the horizontal section area of shear walls and columns as well as the strength of concrete**

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## Second Order Diagnosis

- **The most common method**
- **Suitable for the buildings whose vertical members (column and shear wall) are likely to collapse before horizontal members (beam) collapse**
- **Determining the seismic performance with the ultimate strength of vertical members, such as columns and shear walls**

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## Third Order (Precise) diagnosis

- Suitable for the buildings whose horizontal members (beam) are likely to collapse before vertical members (column and shear wall) collapse
- Determine the seismic performance with the strength of columns, shear walls as well as beams
- Frame analysis and advanced knowledge and judgment skill are necessary

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## The Result of Seismic Diagnosis

**Index**

- Is = Index of seismic performance

**When**

**Is ≧ 0.6**

**the risk of collapse is considered low**

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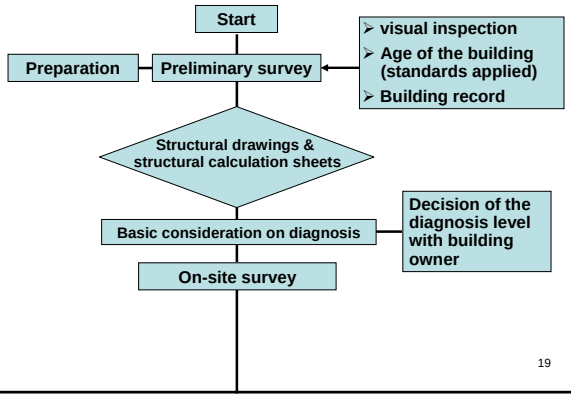
## The Process of Seismic Diagnosis/Retrofitting

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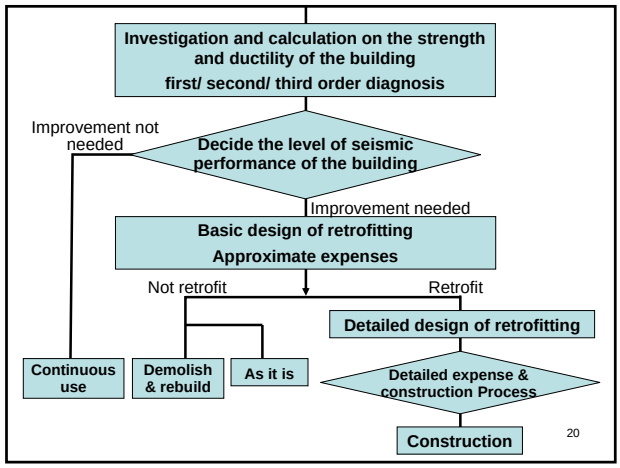


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## Seismic Retrofitting Methods

- **Reduce the weight of building**
- **Add new structural members to scale up the seismic performance**
- **Strengthen the existing structural members to increase their strength and ductility**
- **Reduce the seismic force inputted to the building**

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**Seismic retrofitting methods (examples)**

## 1. Reduce the weight of building

**One floor was removed from an old school building in 2008 to enhance its seismic performance**

**(The capacity of three-story is enough for the school due to low birthrate)**


**Seismic retrofitting methods (examples)**

## 2. Add new structural members to scale up the seismic performance

**Braces were added to the building to elevate the earthquake performance**

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**Seismic retrofitting methods (examples)**

## 2. Add new structural members to scale up the seismic performance


**New shear wall was constructed**

Seismic retrofitting methods (examples)

## 3. Strengthen the existing structural members to increase their strength and ductility

Wrapping carbon fiber sheets around reinforced concrete columns

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Seismic retrofitting methods (examples)

## 3. Strengthen the existing structural members to increase their strength and ductility

Wrapping carbon fiber sheets around reinforced concrete columns

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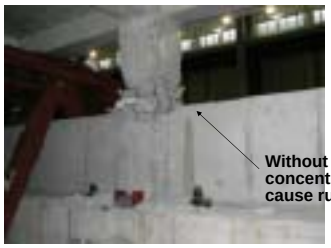
Seismic retrofitting methods (examples)

## 3. Strengthen the existing structural members to increase their strength and ductility

Separation of columns from low walls



Without separation, seismic force concentrates at one point and cause rupture

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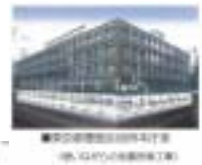
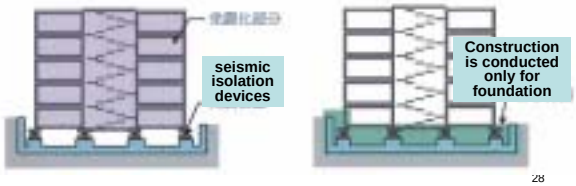
Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building



Installation of seismic isolation devices in the foundation

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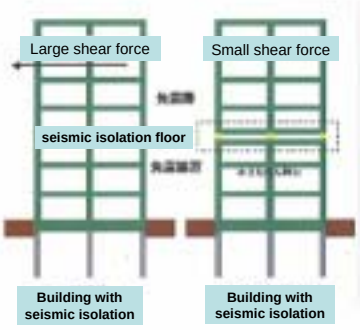
Seismic retrofitting methods (examples)

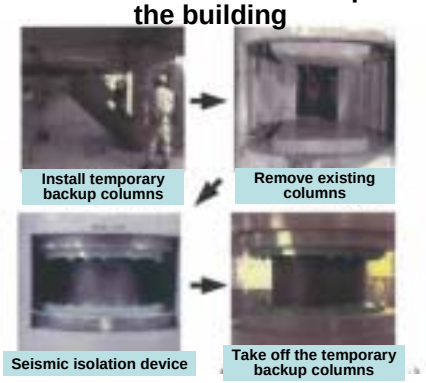
## 4. Reduce the seismic force inputted to the building

Installation of seismic isolation devices in the columns at the intermediate floor




Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building

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Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building

Seismic isolation device with fireproof covering

Seismic isolation device

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Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building

Set-up of vibration control brace to absorb earthquake energy

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Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building

A terminal building with two underground lines and one ground line
Higher floors for department store
Complex building used by general public
We will see it tomorrow

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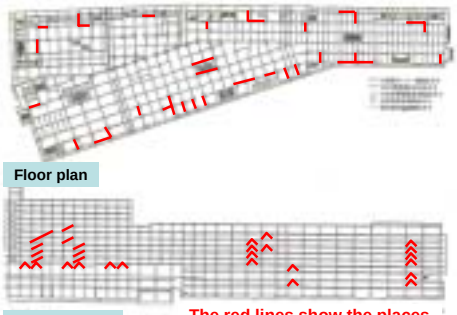
Seismic retrofitting methods (examples)

## 4. Reduce the seismic force inputted to the building



Floor plan



Elevation plan

The red lines show the places of vibration control brace

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