RESEARCH AND DEVELOPMENT ON SAFETY OF BUILDINGS AGAINST NATURAL DISASTERS AND URBAN FIRES AT THE BUILDING RESEARCH INSTITUTE

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Contents

II. Summary of the BRI (its position and goals).

1. Summary of the BRI.

- National Research and Development Agency
  …70 years of history,
  in a fair and neutral perspective, also
  …Based on a medium to long-term objectives
  high level experimental facilities

- R&D on housing, building, and urban planning technologies / training on earthquake engineering

II. Summary of the BRI (its position and goals).

2. Medium to long-term objectives and main focus of R&D.

"To realize sustainable housing, buildings, and urban communities"

(the goal 4th medium to long-term objectives (FY 2016 - 2021) by MLIT)

2 programs in the 4th medium to long-term plan (by BRI):

- "Safe and Secure Program"
- "Sustainability Program",

The R&D is conducted through collaborating with public and private sectors (*Figure 1*).

Figure 1. The BRI's position and its goals.

III. Two R&D programs the BRI focuses on.

1. Summary of the Safe and Secure Program.

1. Summary of the Safe and Secure Program. In order to realize resilient housing, buildings and urban communities, the BRI works on three types of research (*1-1, 1-2, and 1-3*)

1-1. Ensuring structural safety of buildings through prevention of damage and collapse due to natural disasters such as a major earthquake, etc.

1-2. Ensuring fire safety for buildings and urban areas through prevention and reduction of fire damage.

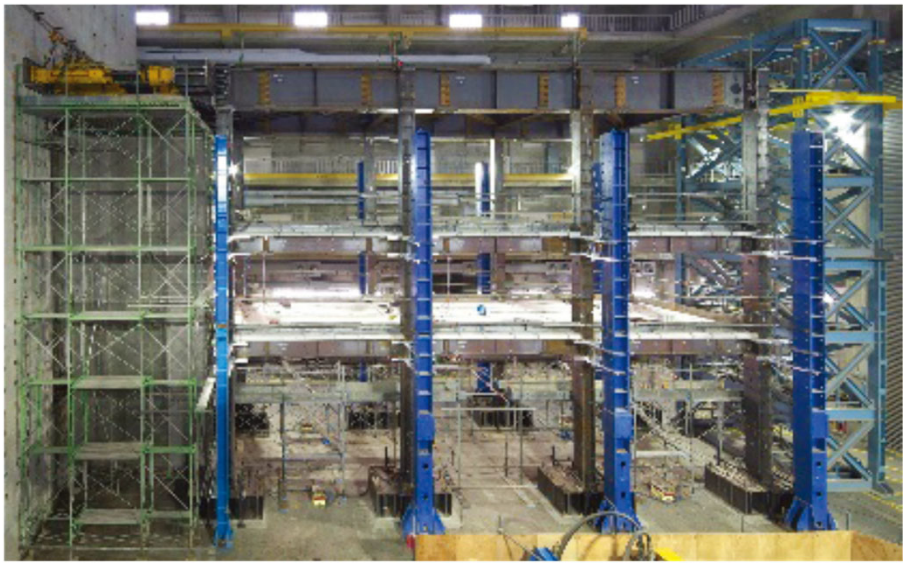
1-3. Advancement of assessment methods for damaged buildings and establishment of design methods for buildings that can remain functional post-disaster, aiding prompt recovery from earthquake or fire disasters.

III. Two R&D programs the BRI focuses on.

1. Summary of the Safe and Secure Program.

1-1. Ensuring structural safety of buildings through prevention of damage and collapse due to natural disasters such as a major earthquake, etc.

The BRI develops the seismic performance evaluation method for the ultimate limit state of steel buildings until beam fracture and collapse following earthquakes beyond the current seismic design level.



III. Two R&D programs the BRI focuses on.

1. Summary of the Safe and Secure Program.

1-2. Ensuring fire safety for buildings and urban areas through prevention and reduction of fire damage.

The BRI pushes forward performance-based fire safety design methods for new materials and spaces to promote safer large wooden buildings and to keep elderly or disabled people secure.

This photo shows the full-scale fire test for the wooden school building.

III. Two R&D programs the BRI focuses on.

1. Summary of the Safe and Secure Program.

1-3. Advancement of assessment methods for damaged buildings and establishment of design methods for buildings that can remain functional post-disaster, aiding prompt recovery from earthquake or fire disasters.

Seismic design methods for structural systems with post-earthquake functional use and quick seismic inspection methods for damaged buildings will be developed.

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

1. Study on performance evaluation method for the ultimate limit state of steel buildings and damage detection under excessive seismic motions(1)

In a massive earthquake (possibly occur in the near future)

- Earthquake underneath the metropolitan area
- Trench-type big earthquake

The ground motion with
- unexpectedly larger velocity response spectrum,
- with longer duration than the one in the current design (the ground motion with large energy spectrum)

To prevent collapse of buildings

To prevent collapse of buildings, it is necessary
- to reveal the ultimate limit state, post-peak behavior of buildings and
- to establish seismic performance evaluation method

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

1. Study on performance evaluation method for the ultimate limit state of steel buildings and damage detection under excessive seismic motions(2)

実験的、
解析的検討

This study (targeting steel buildings)

・Seismic performance evaluation method for ultimate limit state of steel buildings (under the excessive seismic motions)
= Experiments and analysis
- A method to evaluate the fracture and local buckling of beam
- The subsequent ultimate limit state behavior until the collapse

・Damage detection method of steel buildings
= Method to estimate the fractures occurred in a beam etc. of actual buildings after the earthquake by using earthquake records etc.

Following 3 topics are investigated
in line with the above research purpose

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

1. Study on performance evaluation method for the ultimate limit state of steel buildings and damage detection under excessive seismic motions

3 topics to investigate

1) **Ultimate cyclic performance** until the beam fracture.
2) **Seismic performance evaluation method** at the ultimate limit state of steel buildings.
3) **Damage detection method** for beam fracture etc.of buildings.

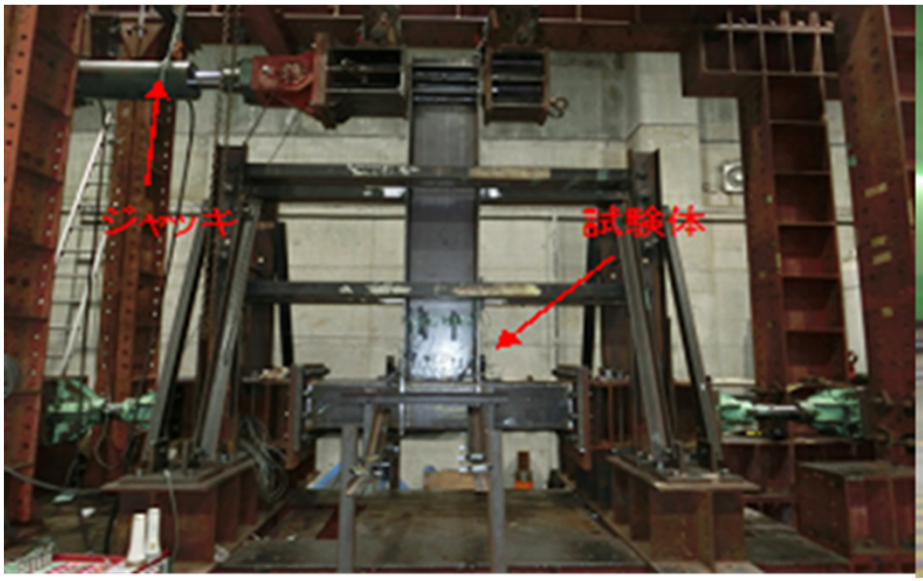


Photo 3. Cyclic loading test on beam.

Photo 4. Shaking table test on two-bay frame

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

2. Development of fire-evacuation safety-design technology of buildings with wooden interior.

The study aims to formulate
- Performance evaluation framework
- Fire-evacuation safety-design method

⇒ **More flexible use of interior materials such as timber.**

Popularization of green buildings / Utilizing wooden materials

⇓

A higher demand for **wooden interior** etc. in various buildings

Timber is **strictly limited** (not classified as fire-proof material in a current fire safety standard)

Recent findings in engineering research
- Wooden material (used in an interior) has a certain **fire performance** as fire proof materials.

⇓

1) **Development of predictive method for fire performance in an interior lining**
2) **Development of fire-evacuation safety-design method**

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

3. Development of seismic assessment method for existing buildings that can remain functional post-disaster.

To secure the capability of existing buildings to **remain functional post-disaster**.

Target : General existing buildings
(apartment houses, office buildings and so on)

3-1) Proposal of the **seismic assessment method for buildings** which contributes to post-earthquake functional use.

3-2) Development of the **seismic assessment method for parts and members** critical for post-earthquake functional use and the seismic technology to improve post-earthquake functional use of buildings.

3-3) Development of the technology to **detect functional use of damaged buildings**.

IV. Introduction of the specific R&D subjects in Safe and Secure Program.

3. Development of seismic assessment method for existing buildings that can remain functional post-disaster.

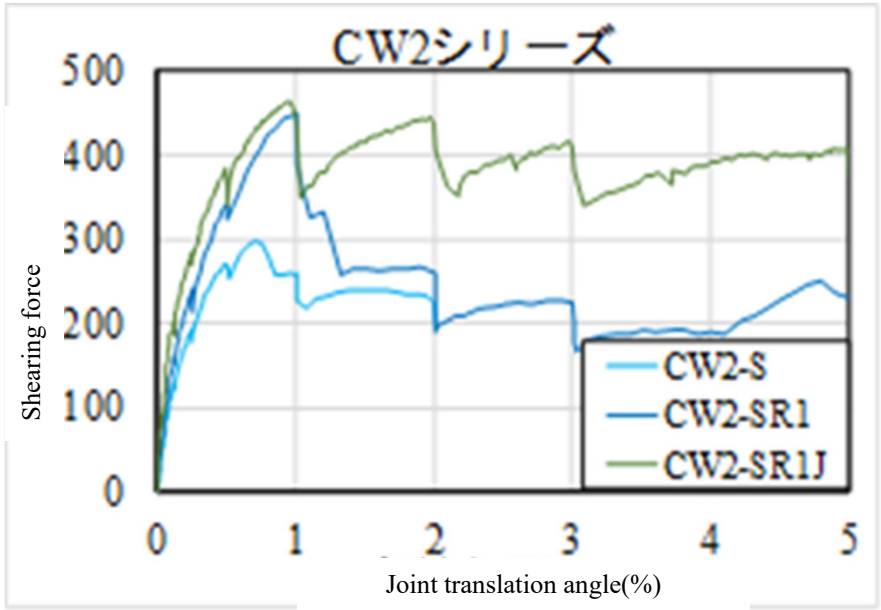


Figure 5. Effectiveness of seismic retrofitting using UFC Panel

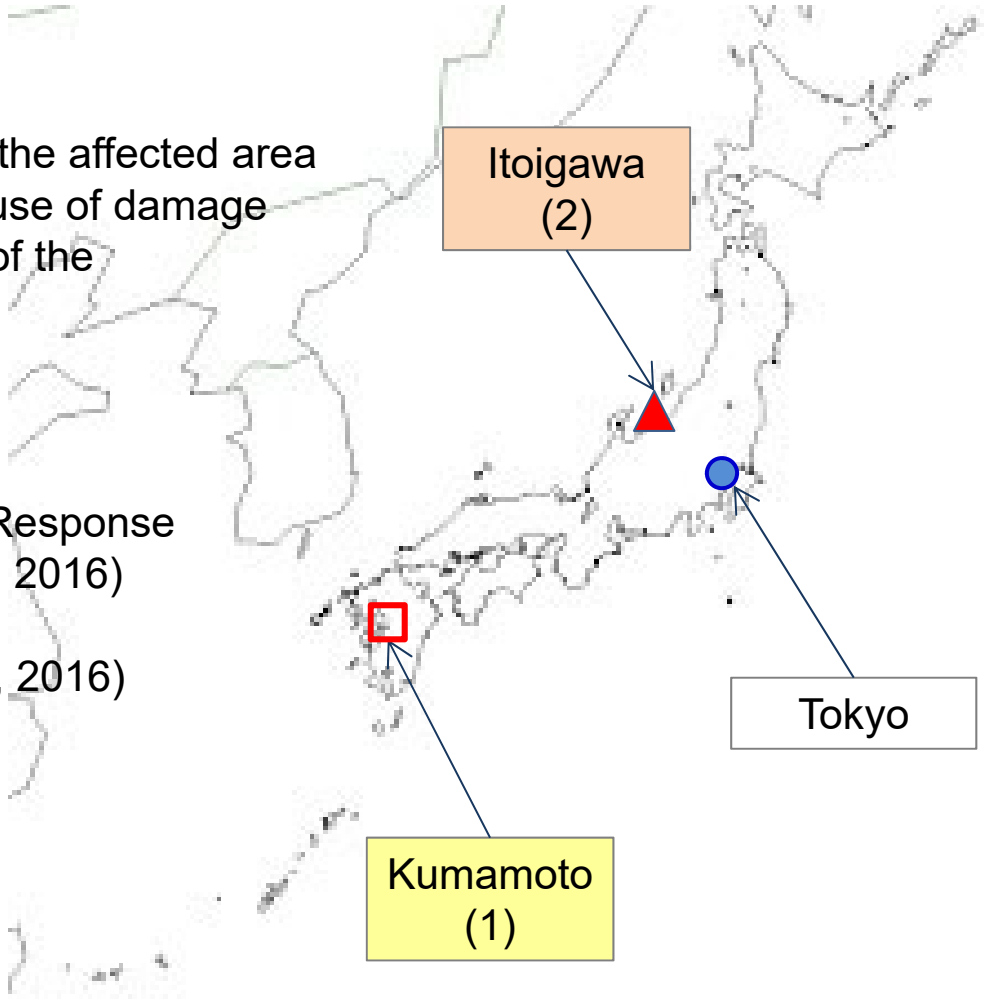
Full-scale experiment on a pile with pile-cap

V. Examples of disaster response. .

- Disaster Response
  = Important Role of the BRI
  - Survey and Investigations at the affected area
  - Study and Analysis of the cause of damage
  - Consideration and Proposal of the countermeasures

- Recent Examples of Disaster Response
  (1) Kumamoto Earthquake (April, 2016)

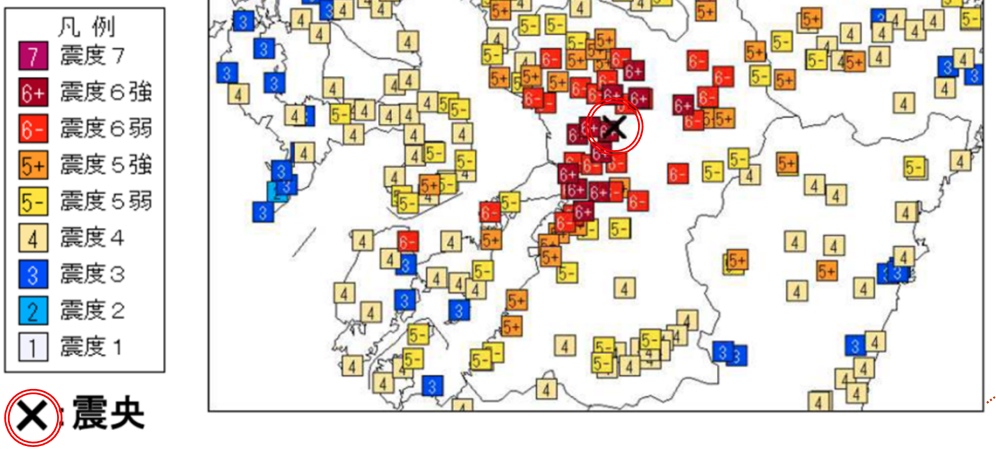
  (2) Itoigawa City Fire (December, 2016)



V. Examples of disaster response. .

1. Kumamoto Earthquake.

[Building damage investigations and factor analysis for 2016 Kumamoto Earthquake]



Distribution of Seismic Intensity

V. Examples of disaster response. .

1. Kumamoto Earthquake.

[Building damage investigations and factor analysis for 2016 Kumamoto Earthquake]

The 2016 *Kumamoto* Earthquake

- Foreshock: magnitude-6.5 quake on 14th April,
- Main shock: magnitude-7.3 quake on 16th April),

BRI dispatched reconnaissance teams (in cooperation with NILIM) to determine

- the damage aspects
- the cause of damage

Verification of effectiveness and validity of the current building code
Data accumulation related to the BRI's research subjects.

The results of investigations conducted by various organizations such as Architectural Institute of Japan were widely collected upon organizing and summarizing the data.

The house shown above without column and brace wooden frame

wooden house in a new residential area

V. Examples of disaster response. .

1. Kumamoto Earthquake.

[Building damage investigations and factor analysis for 2016 *Kumamoto* Earthquake]

Collapsed wooden house

Hugely tilted wooden apartment

Second floor hugely tilted in a S+W house

The house shown above without column and brace wooden frame

brace part of the house shown above

wooden house in a new residential area

Old houses which do not conform to the current standards were severely damaged.

Photo 5. Examples of damage to wooden houses affected by the Kumamoto Earthquake.

V. Examples of disaster response. .

1. Kumamoto Earthquake.

[Building damage investigations and factor analysis for 2016 *Kumamoto* Earthquake]

Local government office building (RC)

Pile foundation had been broken and the building slanted which had once been seismic retrofitted.

V. Examples of disaster response. .

2. Itoigawa city fire.

[Damage investigations
for huge fire
occurred in *Itoigawa city*
on 22nd December 2016]

Photo 6. Damaged area in the Itoigawa city fire

V. Examples of disaster response. .

2. Itoigawa city fire.

[Damage investigations for huge fire occurred in *Itoigawa city* on 22nd December 2016]

- **147 burned buildings** (burned total floor area approximately 30,000m^2)
- 17 injured people.

The strong south-wind
→ Many leaping flames
→ The fire spreading damage had enlarged

The BRI has been collaborating with NILIM in investigation and analysis on this fire damage. (to reveal damage-increasing factors)

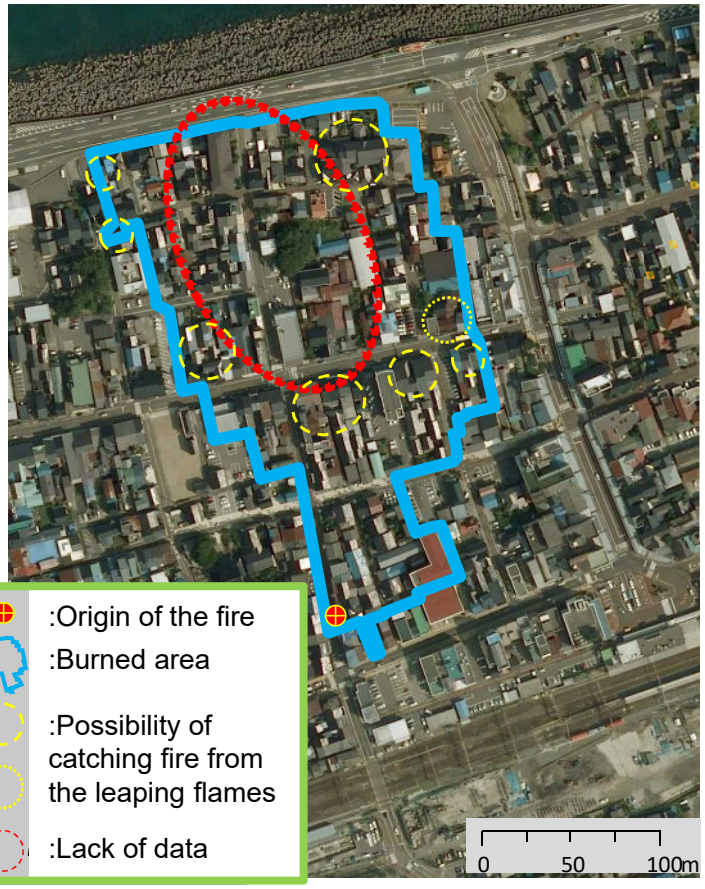
1) prediction of the **time for catching fire** in each building and the situation of **leaping flames** (by analyzing aerial images taken during the fire)
2) the verification test **on tiled roof's tolerance** for leaping flames,
3) the analysis of the difference of **fire-spreading** situation in case of different building structures in the city by using a computer-simulation.

V. Examples of disaster response. .

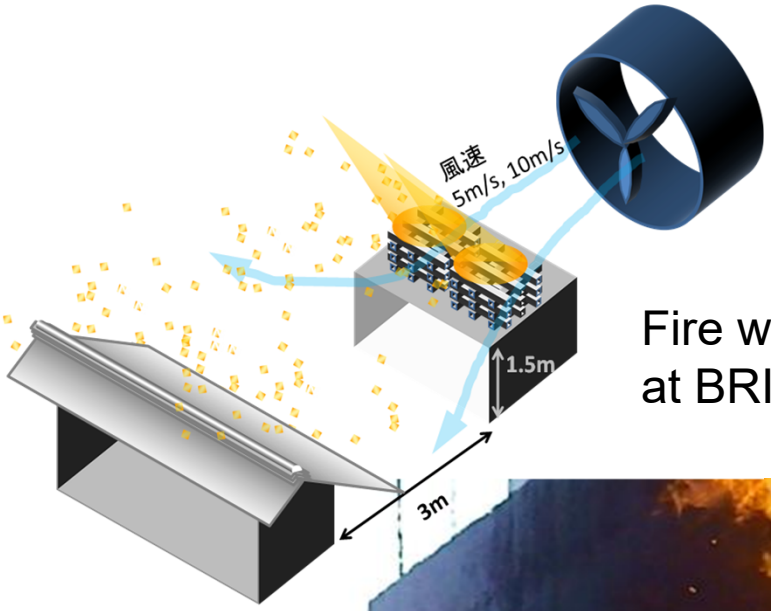
2. Itoigawa city fire.

[Damage investigations for huge fire occurred in *Itoigawa city* on 22nd December 2016]

Average wind speed: 10m/s(aprx.)
Maximum instantaneous wind speed:20m/s(aprx.)



The Burned area and
the Situation of Leaping flames



Fire wind tunnel test
at BRI

Thank You for Your Attention.

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I would like to express my deep gratitude to everyone who gave me this opportunity.

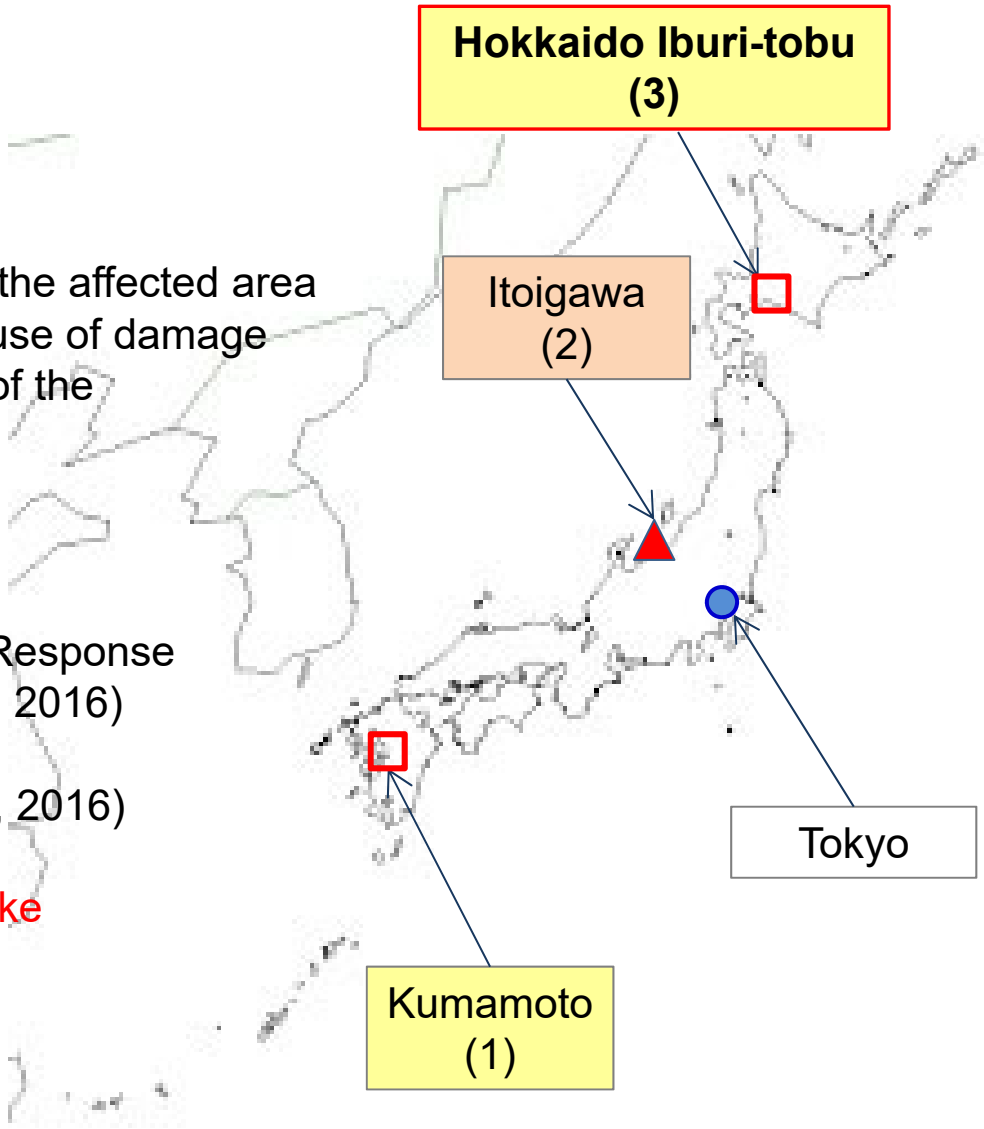
[Supplement] Another Example of disaster response.

- Disaster Response
  = Important Role of the BRI
  - Survey and Investigations at the affected area
  - Study and Analysis of the cause of damage
  - Consideration and Proposal of the countermeasures

- Recent Examples of Disaster Response
  (1) Kumamoto Earthquake (April, 2016)

  (2) Itoigawa City Fire (December, 2016)

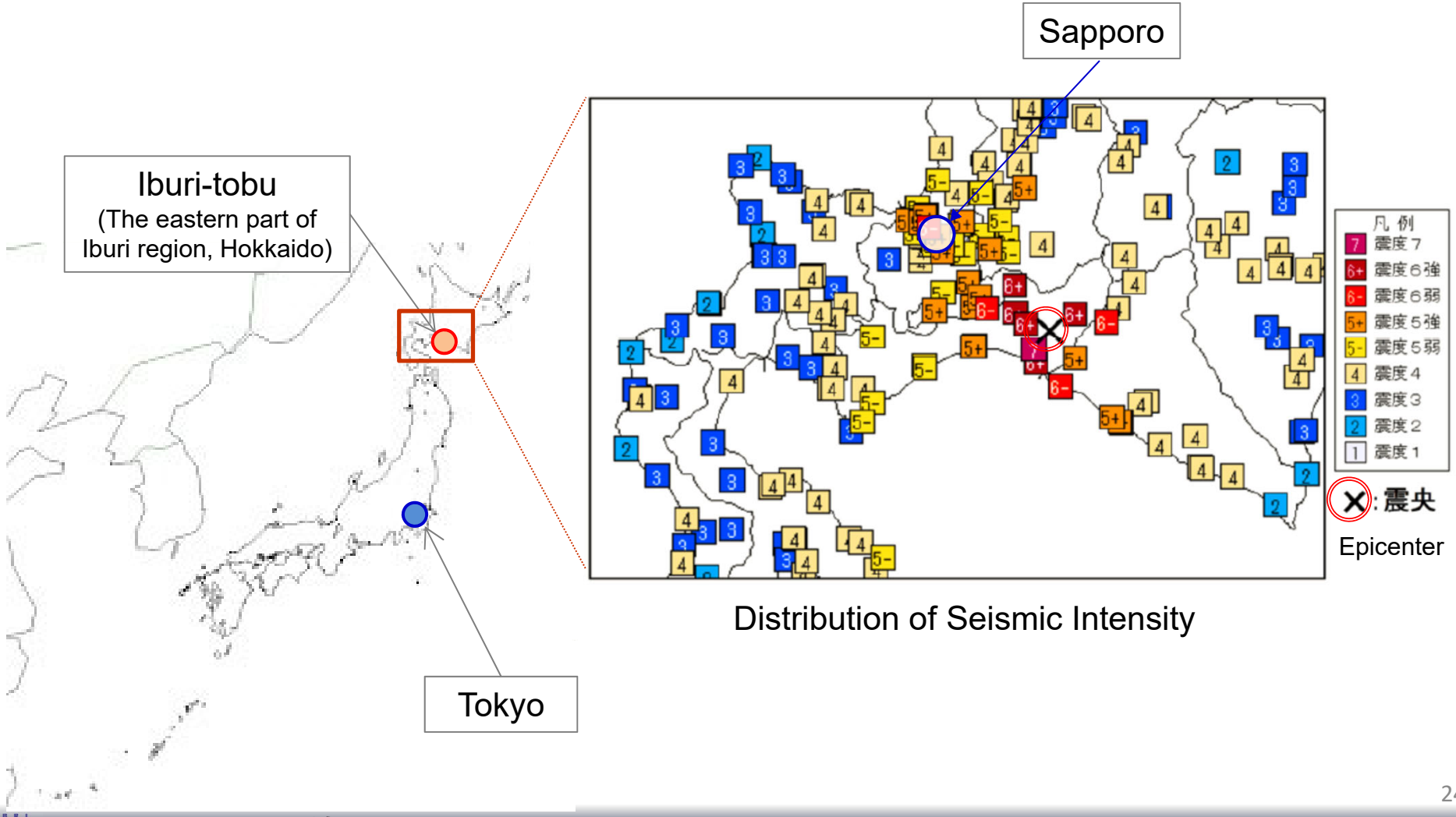
  (3) Hokkaido Iburi-tobu Earthquake (September, 2018)



V. Examples of disaster response. .

3. Iburi-tobu Earthquake.

[Building damage initial survey for 2018 *Iburi-tobu (Hokkaido)* Earthquake]



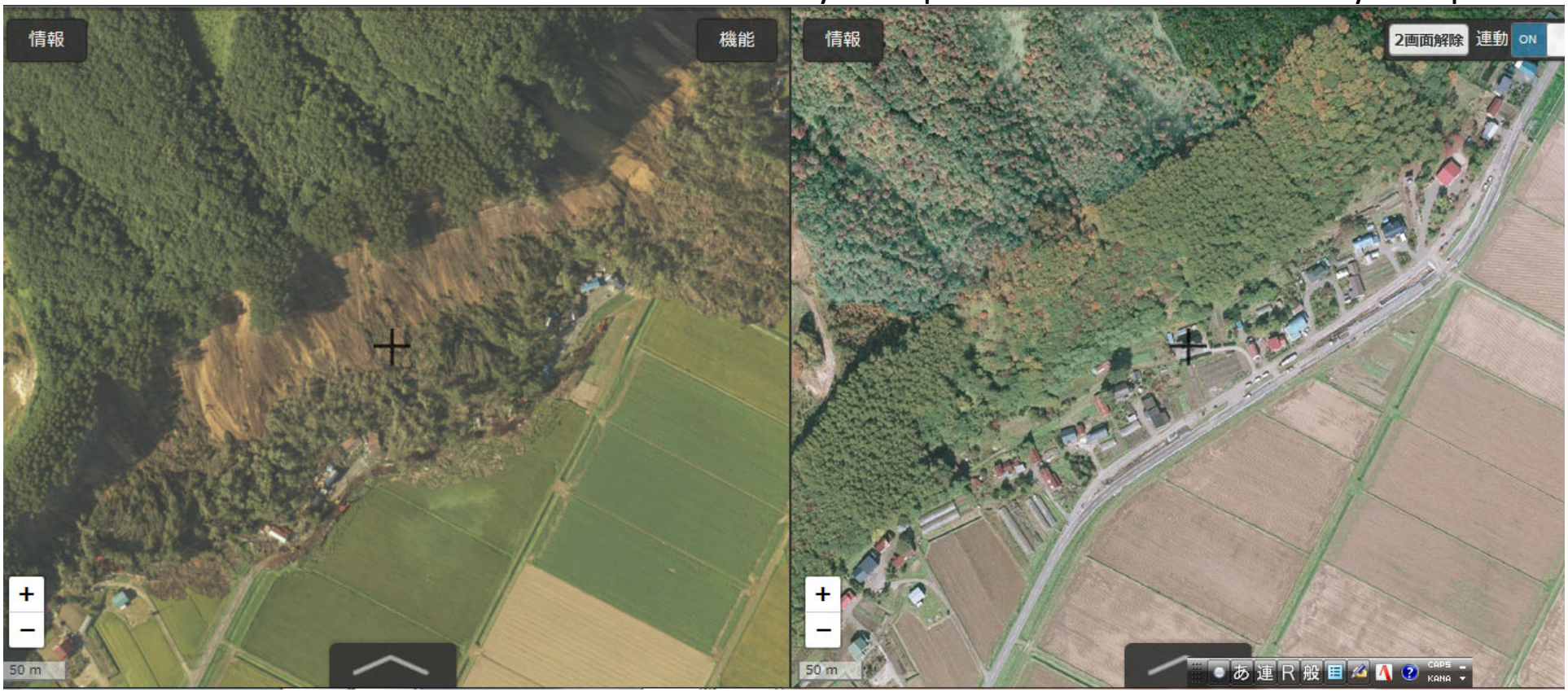
Distribution of Seismic Intensity

V. Examples of disaster response. .

3. Iburi-tobu Earthquake.

The landslides near the epicenter. The right photo shows the houses along the mountain, but the left one shows many of them were buried by the sediment after the earthquake.

Photos by Geospatial Information Authority of Japan



2018 2011

V. Examples of disaster response. .

3. Iburi-tobu Earthquake.

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