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# The Great East Japan Earthquake Disaster


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PWRI

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- Damage of road bridges
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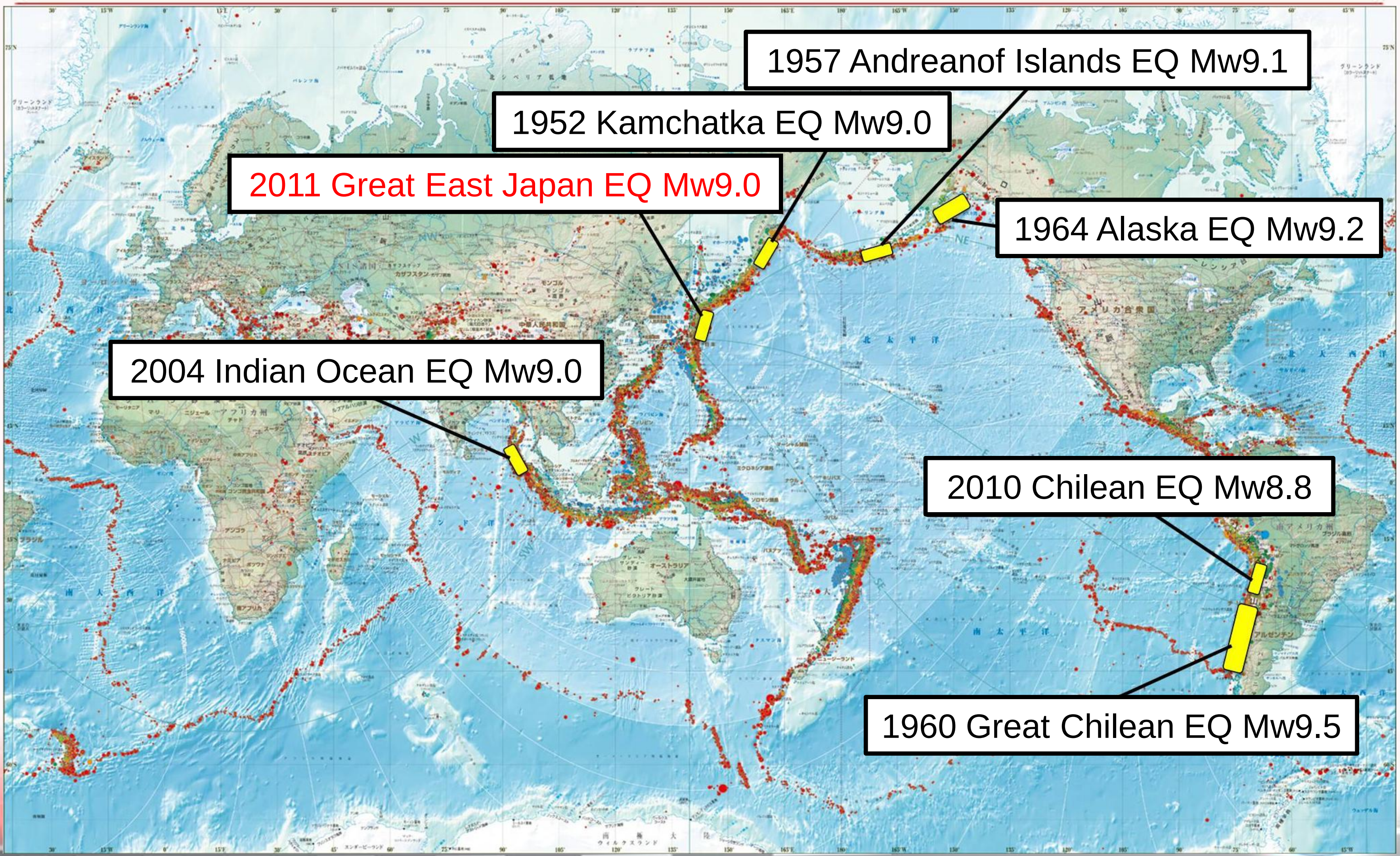
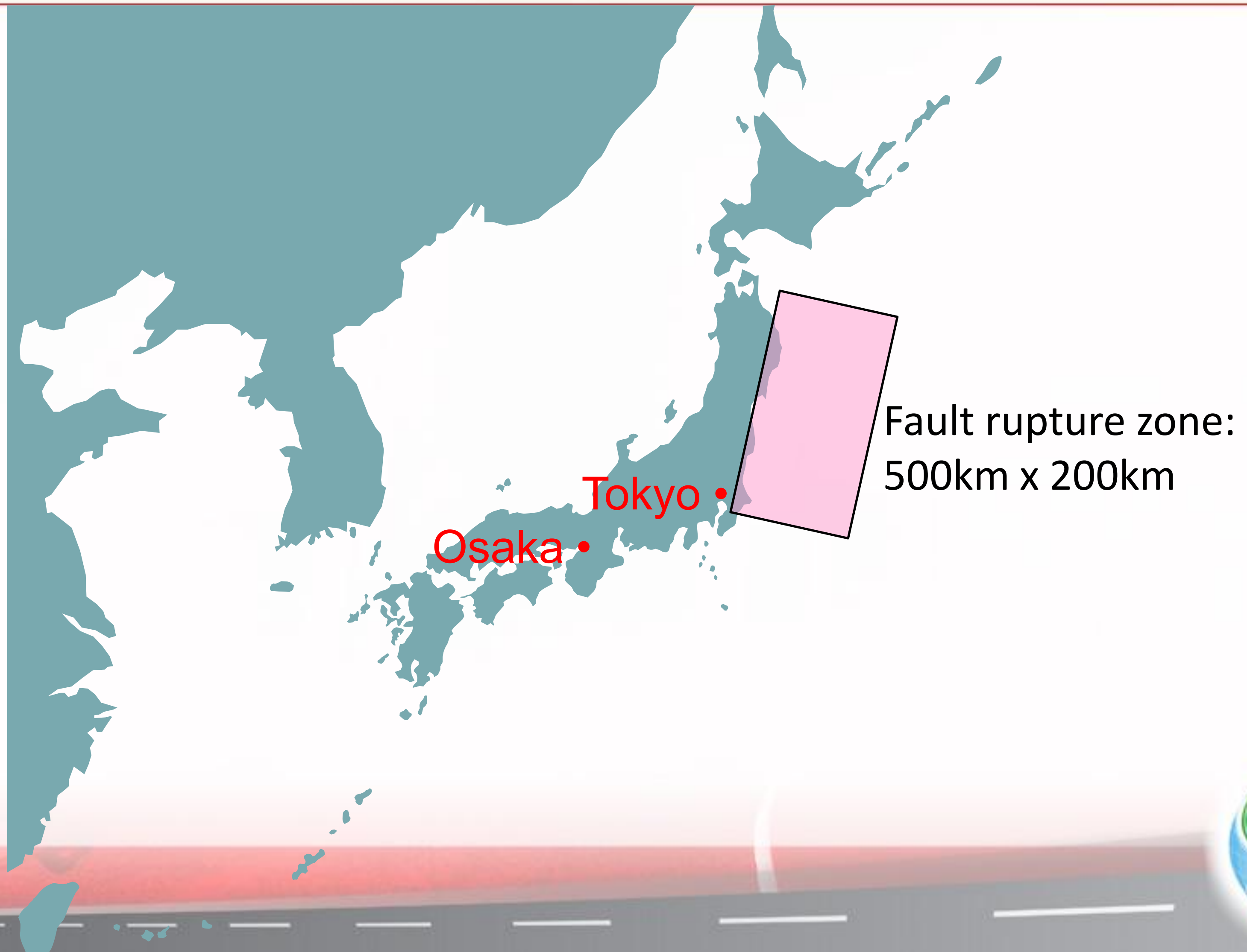
# World mega earthquakes
(Earthquake Research Institute, University of Tokyo)



# Where a M9.0 earthquake occurred



# Overview of earthquake

| | | |
|---|---|---|
| Origin time | 2:46 pm, March 11, 2011 (JST) | |
| Epicenter | Off the Pacific coast of Tohoku | |
| Magnitude | 9.0 | |
| Focal depth | 24km | |
| Seismic intensity | 7 (Kurihara, Miyagi Prefecture)<br>6+ (28 Cities and towns in Miyagi, Fukushima, Ibaraki and Tochigi Prefectures) | |
| Aftershocks (M≥7.0)* | 3:08 pm, March 11, M=7.4 | |
| | 3:15 pm, March 11, M=7.7 | |
| | 3:25 pm, March 11, M=7.5 | |
| | 11:32 pm, April 7, M=7.1 (Seismic intensity 6+) | |
| | 5:16 pm, April 11, M=7.0 (Seismic intensity 6-) | |
| | 9:57 am, July 10, M=7.3 (Seismic intensity 4) | |

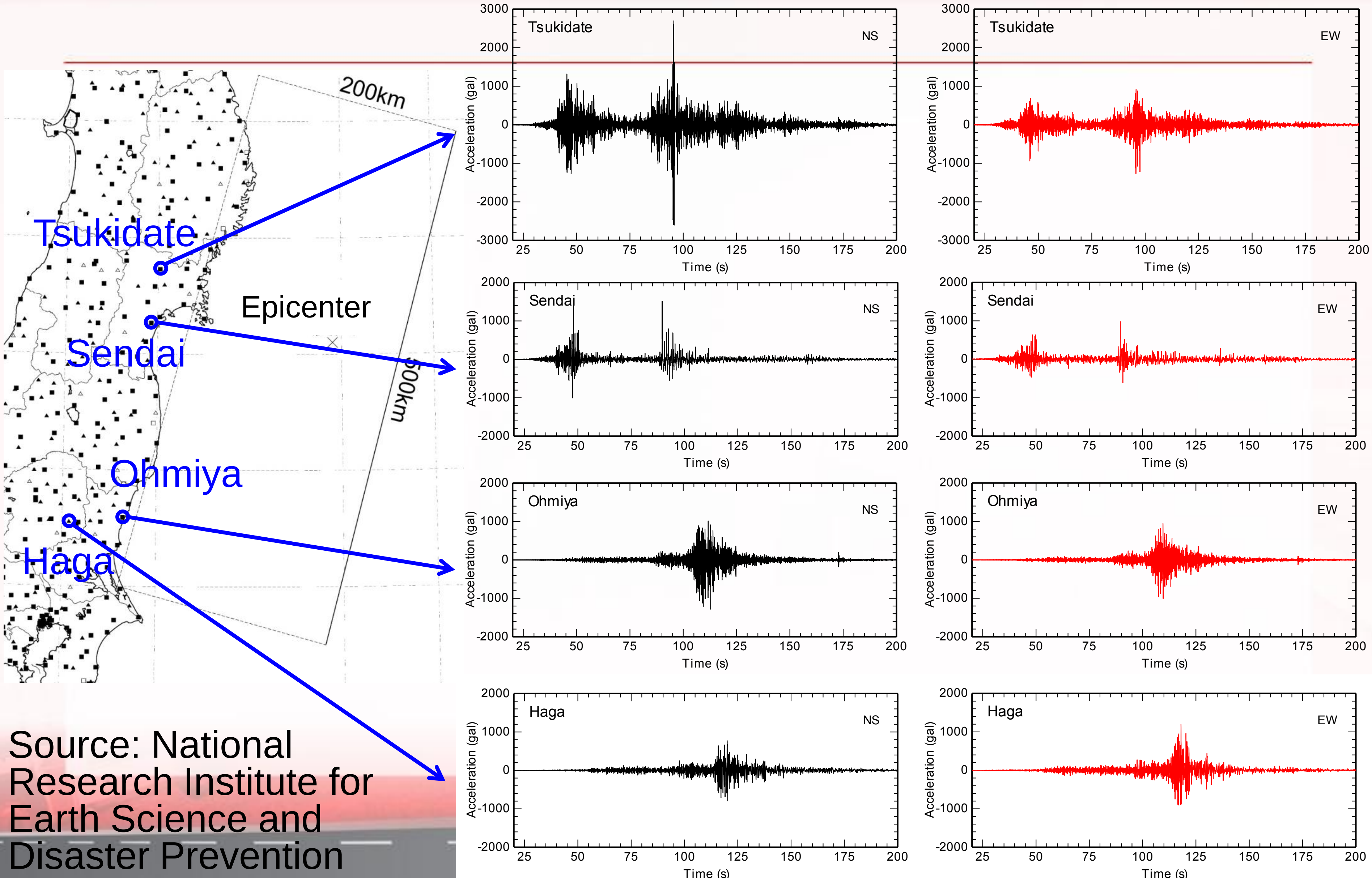
* From March 11 to September 15, 2011

# Damage statistics (Fire Defense Agency)

| | |
|---|---|
| Casualty | 15,960 |
| Injured | 6,110 |
| Missing | 4,004 |
| Destroyed houses | 115,222 |
| Partially destroyed houses | 162,457 |
| Partially damaged houses | 579,476 |
| Fires | 287 |

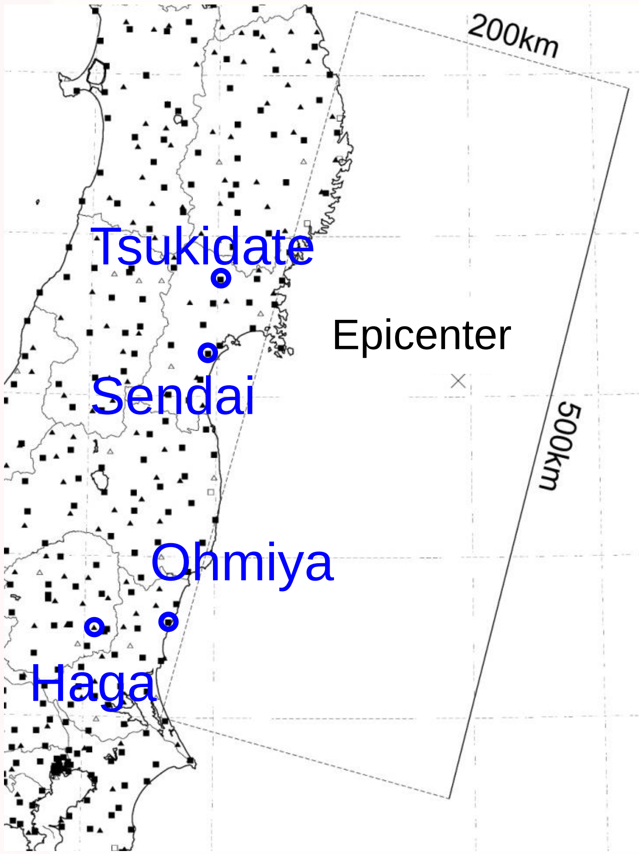
* As of September 9, 2011

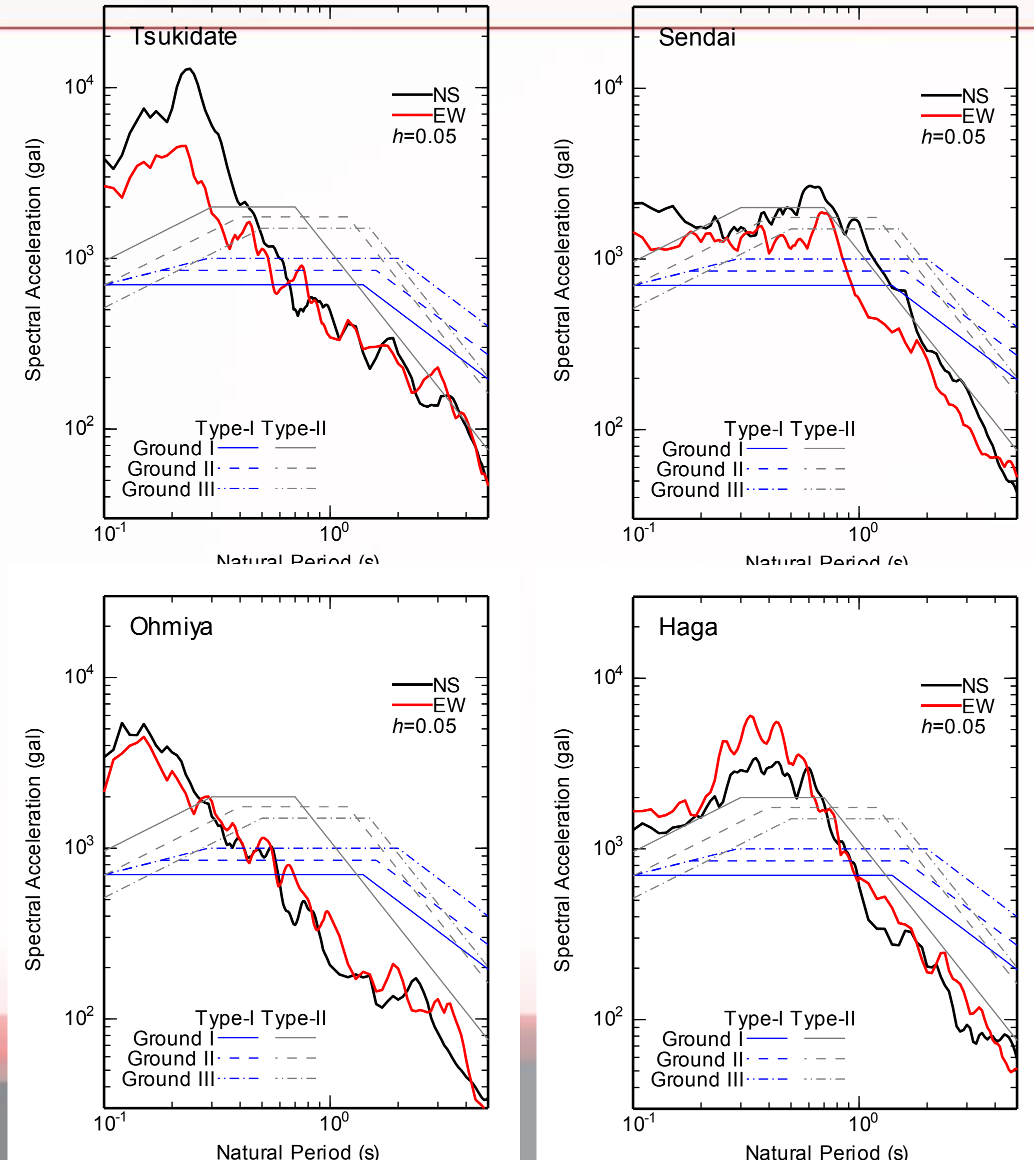
# Typical strong motion records




Source: National Research Institute for Earth Science and Disaster Prevention

# Acceleration response spectra



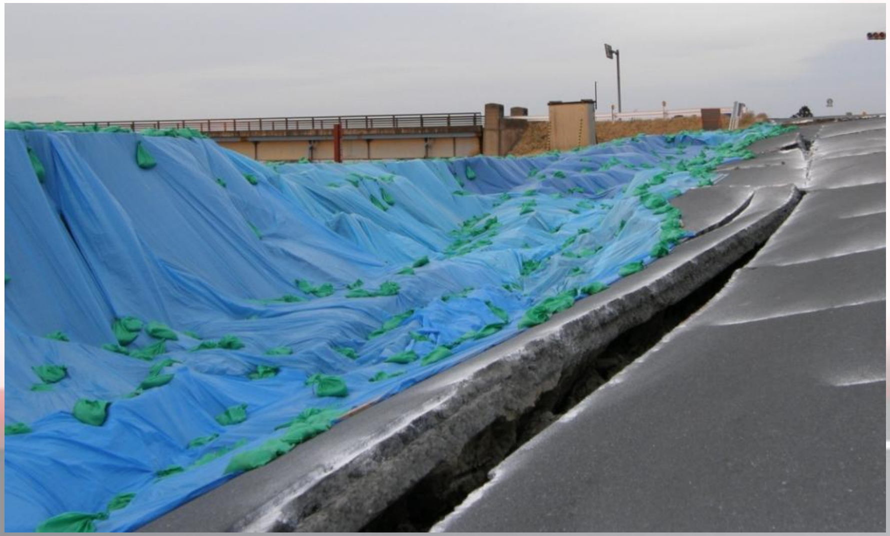

Source: National Research Institute for Earth Science and Disaster Prevention

# Classification of damage to highway bridges

Effects of tsunami

Effects of ground motion

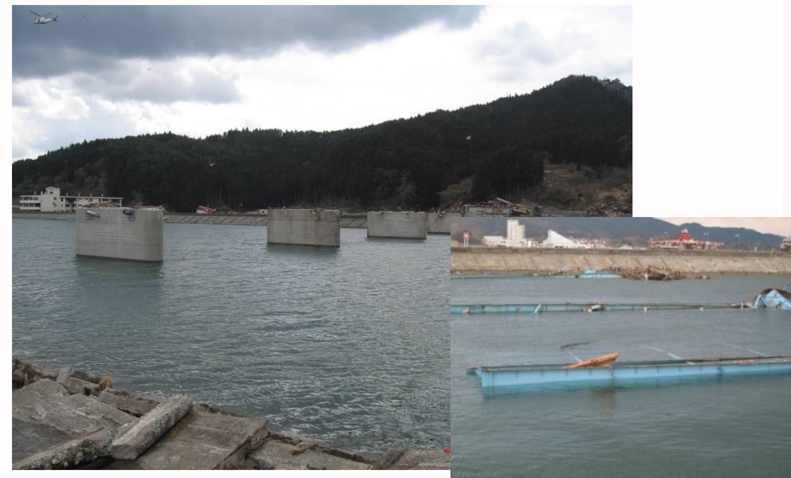
Effects of soil liquefaction



# Bridges damaged by tsunami

- About 80 bridges collapsed due to tsunami.
- Backfill soils were washed out.

Shi-Kitakami Ohashi Bridge



Kesen-Ohashi Bridge

Nijyuichihama Bridge

# Bridges damaged by ground motion

- One bridge collapsed due to ground motion on national highways.
- Old or not-retrofitted bridges suffered damage at RC piers, bearings, etc.

Collapse of bridge with pile-bent columns

Damage to RC pier with small amount of reinforcement

Damage to pier top

Damage to movable bearing

# Bridges damaged by soil liquefaction

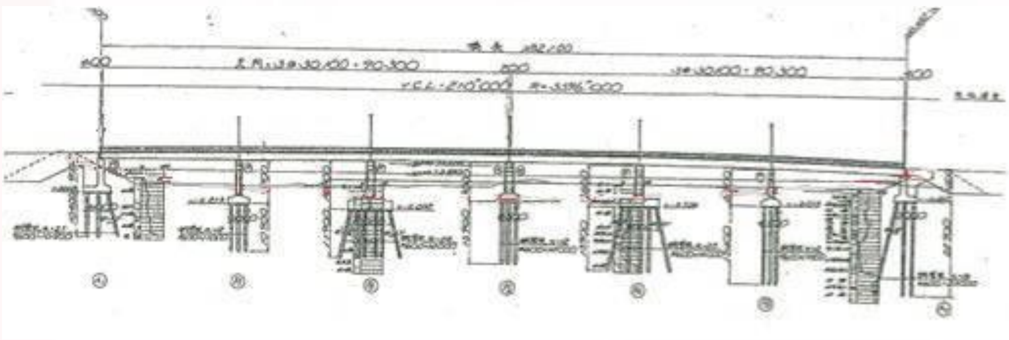
- Subsidence of backfill soil of abutment, shortening of deck-end gap resulting from movement of substructure, etc. occurred.




Trace of movement of pier and liquefaction

# Koizumi Ohashi Bridge damaged by tsunami

- 6-span steel girder bridge (two 3-span-continuous girders).
- All girders and one RC pier were washed away.



After earthquake (March 15)

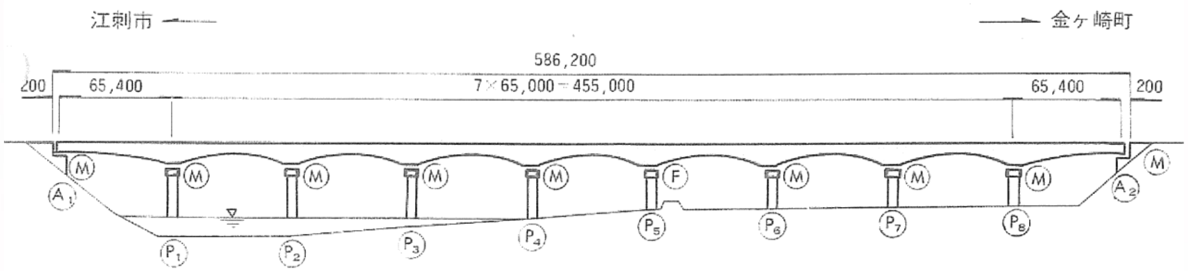

About 6 years ago

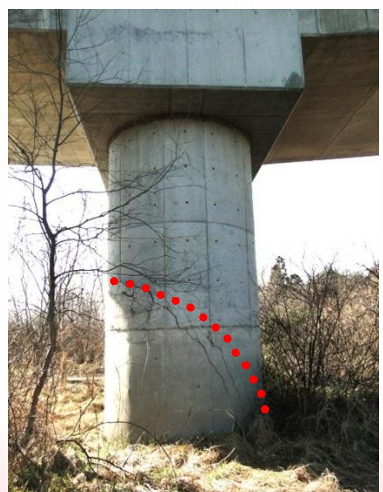

Steel girder washed away


P3 Pier

# Ezaki Ohashi Bridge damaged by ground motion

- 9-span PC box girder bridge designed by pre-1980 specifications
- Shear cracks, spalling off of cover concrete and buckling of longitudinal rebars at section of cut-off of longitudinal rebars



Damage to RC columns at section of cut-off of longitudinal rebars

Temporary repair by wrapping up with carbon fiber sheet

# Sendai-Tohbu Viaduct damaged by ground motion

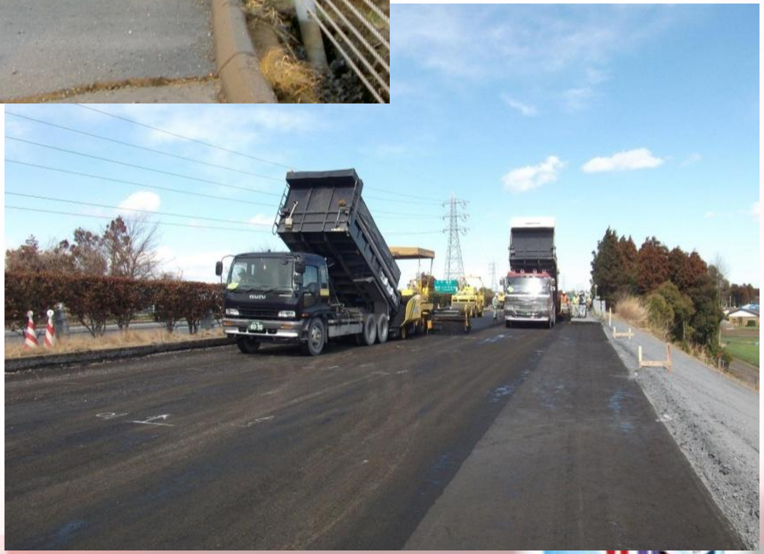
- 4-span steel box girder and 2-span steel girder bridge
- Designed by post-Kobe Earthquake specifications
- Elastomeric rubber bearings were ruptured.

Sendai-Tohbu Viaduct

Ruptured rubber bearings

# Damage of earth structures and slopes

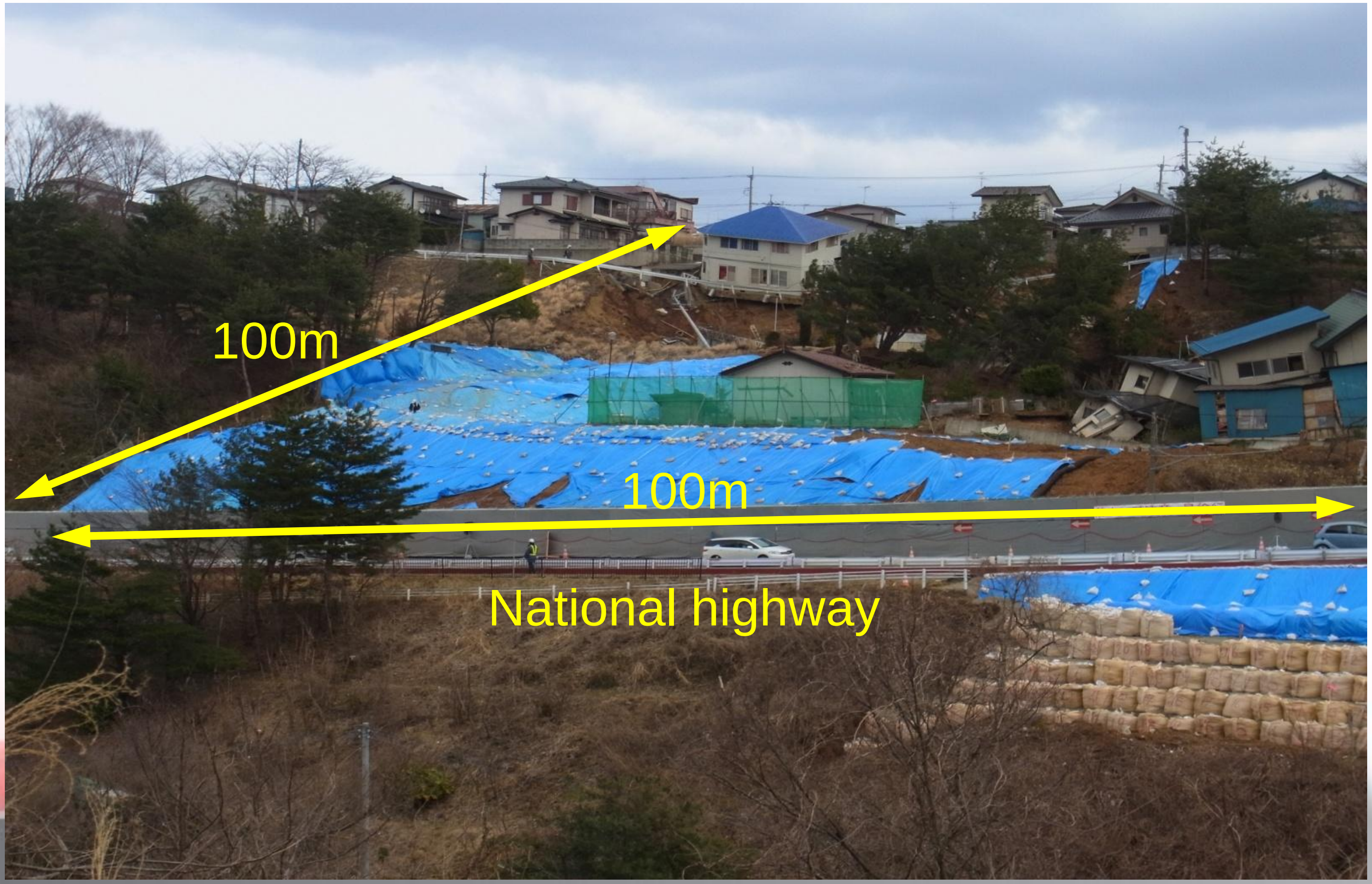
- Damage to road embankments was similar to those observed in the past earthquakes.
- Road slopes collapsed and blocked roads.
- Tsunami affected road embankments, retaining walls and slope protection works.



Subsidence of road embankment and temporary repair (Joban expressway)

# Collapse of embankment adjacent to national highway

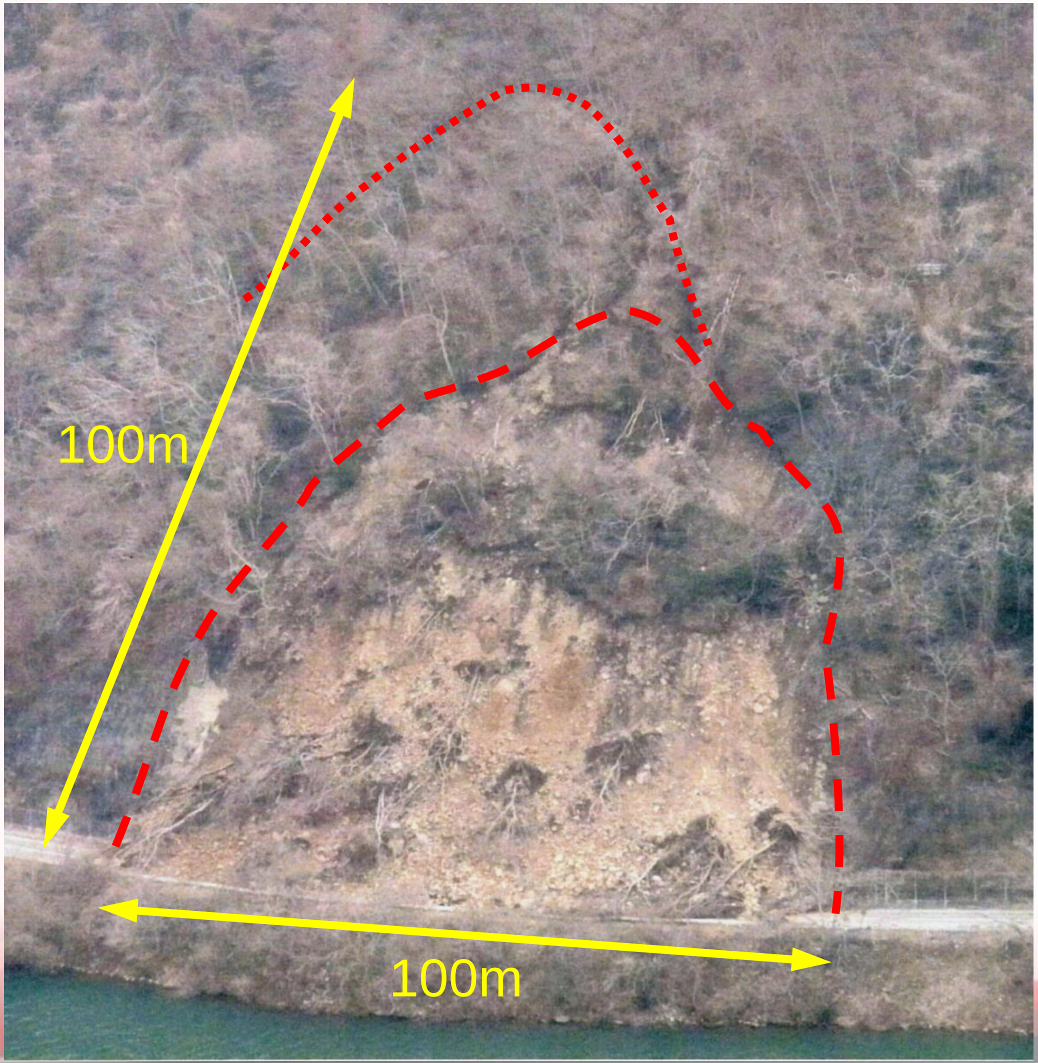
- Collapse volume was 11,000m$^3$.
- The embankment was developed by filling up a valley for residential area about 40 years ago.



# Upper part and toe of collapse

- Collapsed soils covered the entire width (4 lanes) of a national highway.

# Slope failure of national highway




- Collapsed by the main shock on March 11, and collapsed again 3 days later.
- Slope consists of Triassic slate.
- Red broken line : collapsed area by the earthquake

  Red dotted line : scarp in the upper slope

# Impacts of tsunami on earth structures and retaining walls

- Washed away embankment and stripping of the shotcrete on the cut slope.
- Undamaged concrete block retaining walls.


# Summary

- A magnitude 9.0 earthquake was the largest earthquake ever recorded in Japan and the fourth largest in the world since 1900.
- Tsunami was more influential than ground shaking in both human and physical damage.
- Bridges designed by new design specifications and seismically retrofitted performed well. While those designed by old specifications or not-retrofitted suffered damage at RC piers, bearings, etc.
- Damage to road embankments and slopes was similar to those observed in the past earthquakes.