

Focus Area 4: Seismic Risk Management Applications in Infrastructure Management

Overview of Great East Japan Earthquake in Tohoku Areas

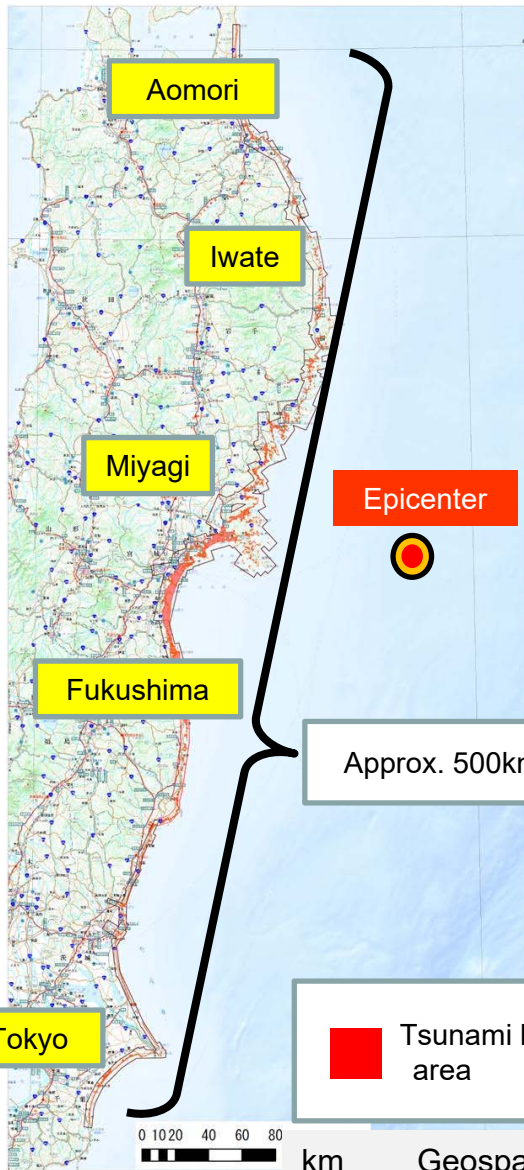
March 13, 2018

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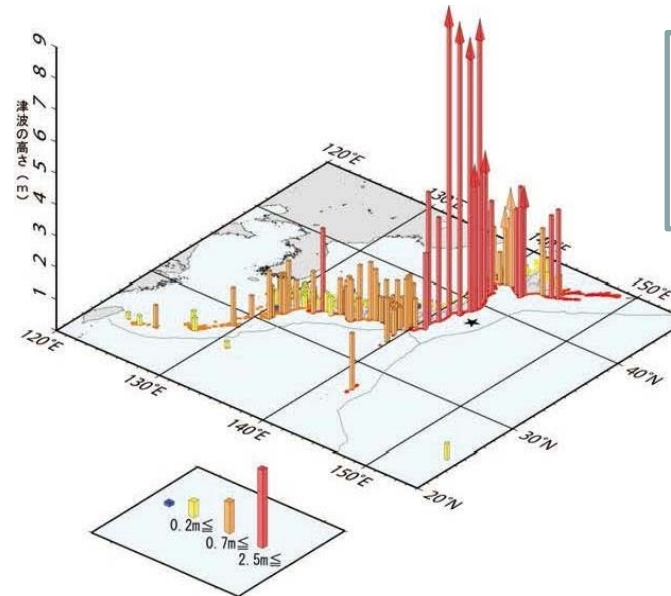
1. Overview of Great East Japan Earthquake and Tsunami Disaster

○Tsunami affected vast areas extending 500km north-south.



Outline

- Date:** March 11, 2011 02:46 p.m.
- Magnitude:** 9.0
- Epicenter:** Sanriku Offshore (approx. 130 km east-southeast of the Oshika Peninsula)
- Depth:** Approx. 24 km depth
- Seismic intensity:** Max. 7 (Kurihara City, Miyagi Prefecture)



- **Amplitude: 8 - 10m** along the coastal area of eastern Japan
- **Run-up height: over 30m** found in some places

Arrows mean higher tsunami were expected but the earlier tsunamis damaged observation facilities and prevented their actual data acquisition.

Tsunami heights observed by Japan Meteorological Agency (JMA) observation facilities

From JMA Special Report 1: The 2011 earthquake off the Pacific coast of Tohoku

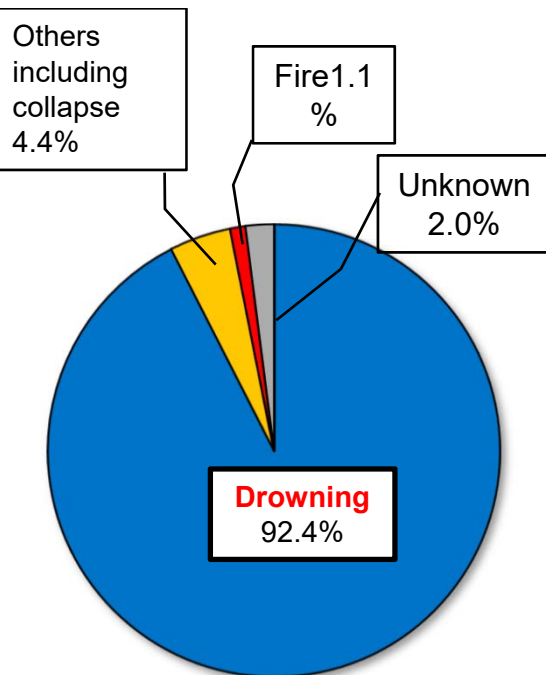
Disaster

Comparison with past earthquake disasters

Great East Japan Earthquake (2011)

Approx. **90%** killed by **Tsunami**

Approx. **90%** killed by **Tsunami**



(As of April 11, 2011)

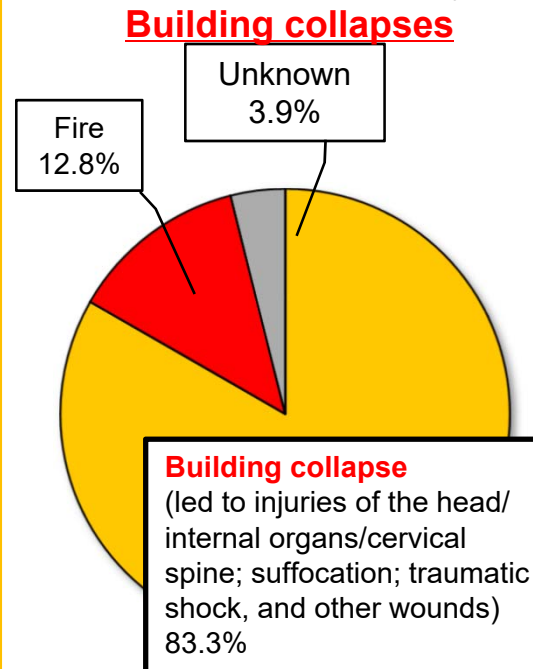
From the 2011 white paper on disaster prevention, the Cabinet Office Japan

15,856 Dead
3,084 Missing
 (As of April 4, 2012)

Great Hanshin-Awaji Earthquake (1995)

Approx. **80%** killed by **Building collapses**

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Building collapse
 (led to injuries of the head/
 internal organs/cervical
 spine; suffocation; traumatic
 shock, and other wounds)
 83.3%

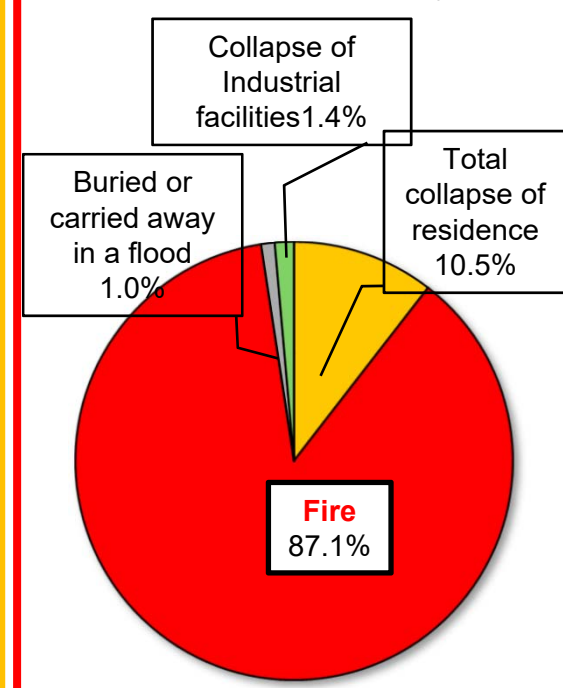
From the statistics of postmortem in Kobe, 1995, Hyogo Prefecture Autopsy Doctors

6,434 Dead
3 Missing

Great Kanto Earthquake (1923)

Approx. **90%** killed by **Fire**

Approx. **90%** killed by **Fire**

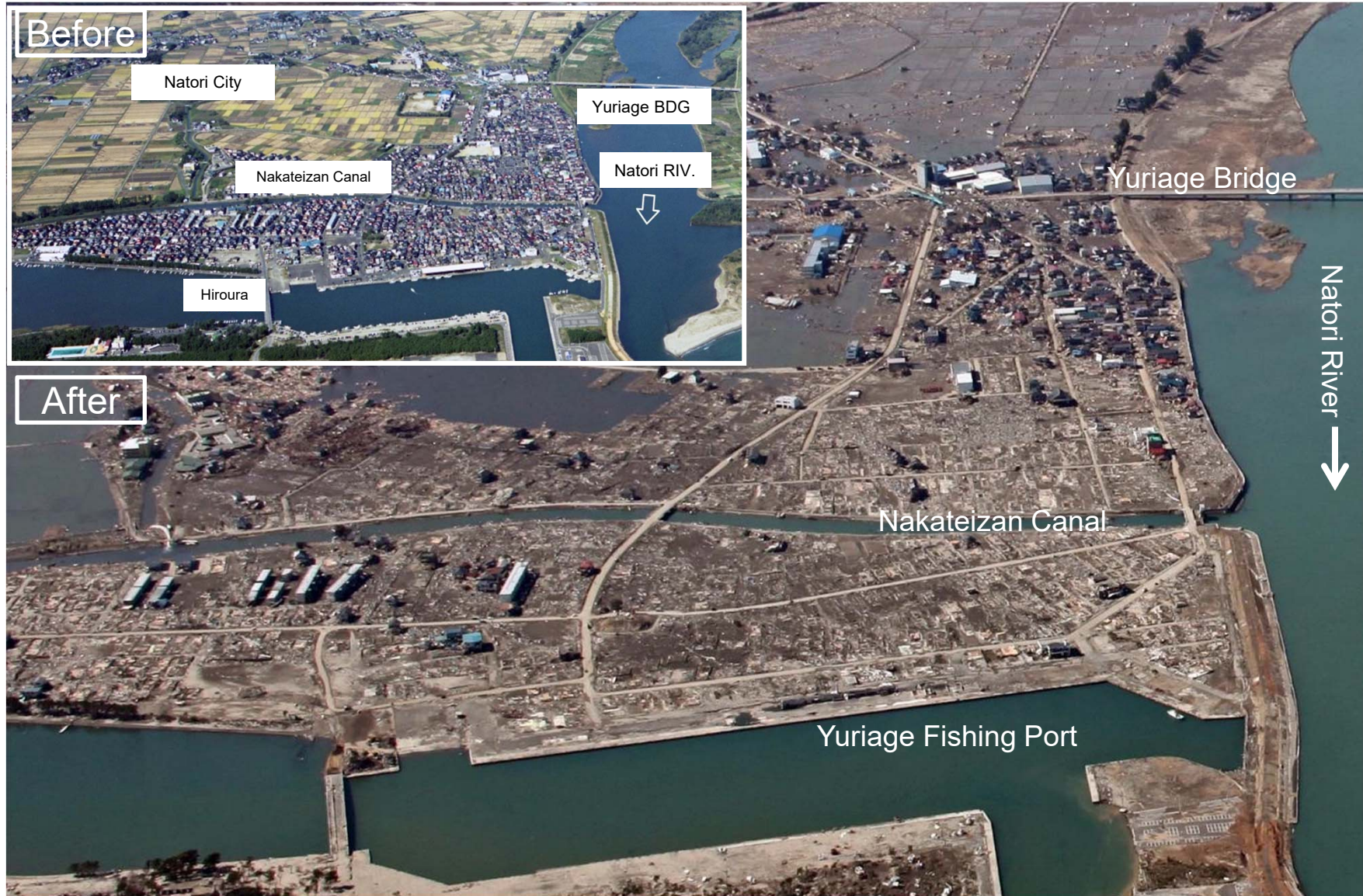


From T. Moroi and M. Takemura, *Estimates of death tolls per cause of mortality in the 1923 Great Kanto Earthquake*, The JAEE Journal vol.4, Sept. 2004 issue, Japan Association for Earthquake

105,385 Dead/Missing

2. Outline of the damage to core infrastructure

Tsunami disaster in Natori City, Miyagi Prefecture



2. Outline of the damage to core infrastructure

○ **Tsunami devastated many coastal areas;
Their maximum run-up height was approx. 40 m.**

Human and building damage

(Headquarters for Emergency Disaster Control, May 2011)

- over **19,000** people dead or missing
- approx. **1.1 million** houses collapsed



▲ Miyako City, Iwate Prefecture



▲ Tagajo City, Miyagi Prefecture

2. Outline of the damage to core infrastructure

Damage to rivers and coasts

approx. **1,800** locations on **River**
approx. **200km** span across **Coasts**



▲ **Seawalls broken by tsunami**
Southern coastline of Sendai Bay
Yamamoto Town, Watari Country, Miyagi Pref.



▲ **Massive land sinking under Seawalls**
Left bank of Naruse river,
Shimonakanome, Osaki City, Miyagi Pref.

2. Outline of the damage to core infrastructure

Damage to roads

(MLIT Report, May 2011)

- **19** sections of **Expressway**
- approx. **3,000** places on **General Roads** including approx. **350** places that MLIT managed **A1** directly
- **34** sections on **Route 45**
- = approx. **20%** of a total of **400km**
(impassable due to the debris)



▲Route 6 was heavily damaged.
Hirono Town, Fukushima Pref.



▲Bridge girders on Route 45 were completely swept away.
Minamisanriku Town, Miyagi Pref.

Slide 7

A1 「直轄」とは国土交通省直轄という意味にしました。ご確認お願いいたします。
作成者, 3/5/2018

2. Outline of the damage to core infrastructure

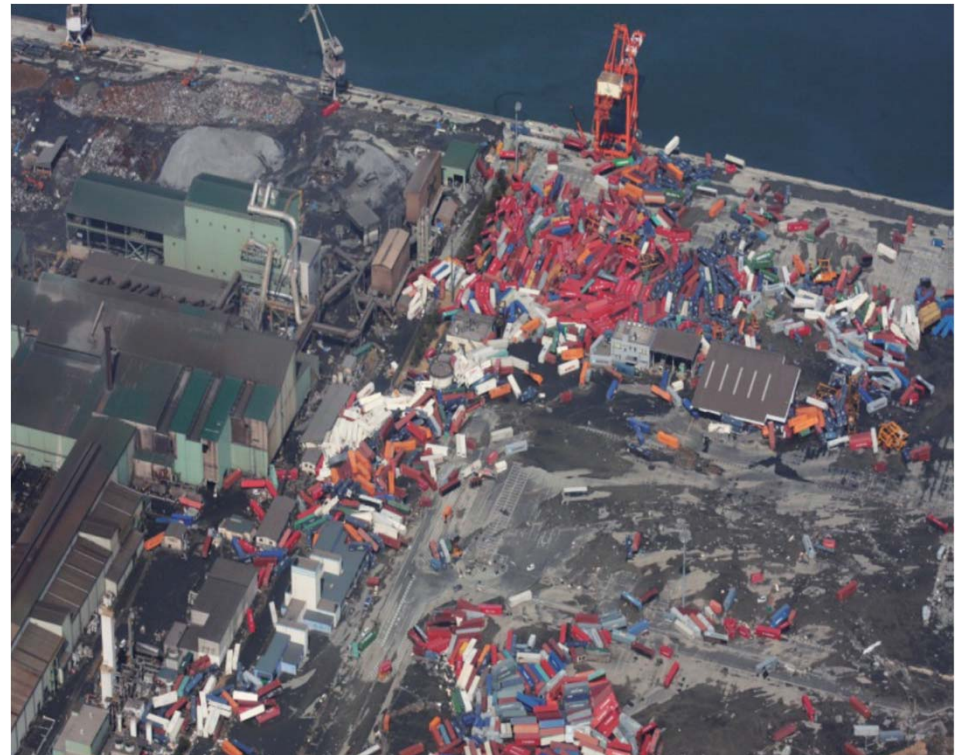
Damage to ports

- 9 major harbors and 14 minor ports A2

(MLIT Report, May 2011)



▲ Lumbers run off the port.
Ishinomaki Port, Ishinomaki City, Miyagi Pref.



▲ Scattered marine containers
Sendai-Shiogama Port, Sendai City,
Miyagi Pref.

Slide 8

A2

以下を参照しました。<http://www.japaneselawtranslation.go.jp/law/detail/?id=2512&vm=04&re=02>

作成者, 3/5/2018

3. First response to the disaster

Road re-opening and rubble removal

- Immediate road re-opening and rubble removal to secure the routes for rescue and relief operations.
- Cooperation from **52 local teams** including construction firms based on the disaster contingency agreement
- Collaboration with official agencies (**including local governments, fire departments, and police agencies**)



▲ Road-opening operation on a tsunami hit national road (taken on March 17, 2011)



▲ Emergency vehicles heading to disaster areas through the re-opened road

3. First response to the disaster

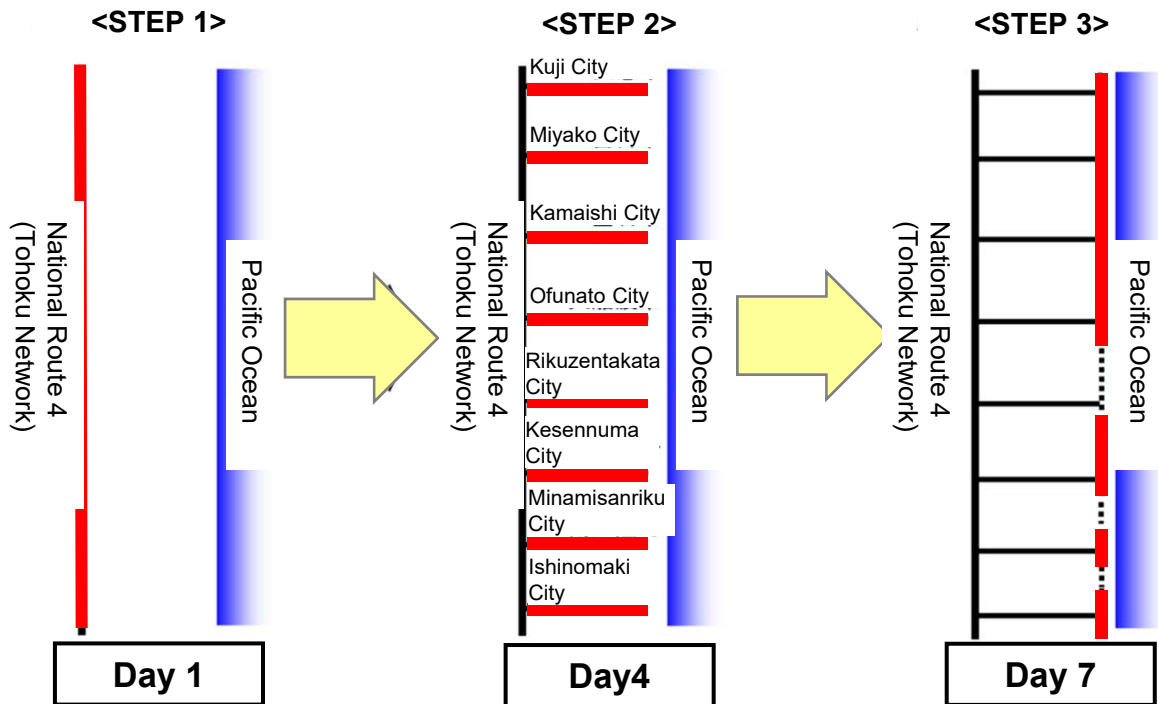
“Operation Comb”

STEP 1 Extend **North-south inland routes**
from Tohoku Expwy, National Highway 4

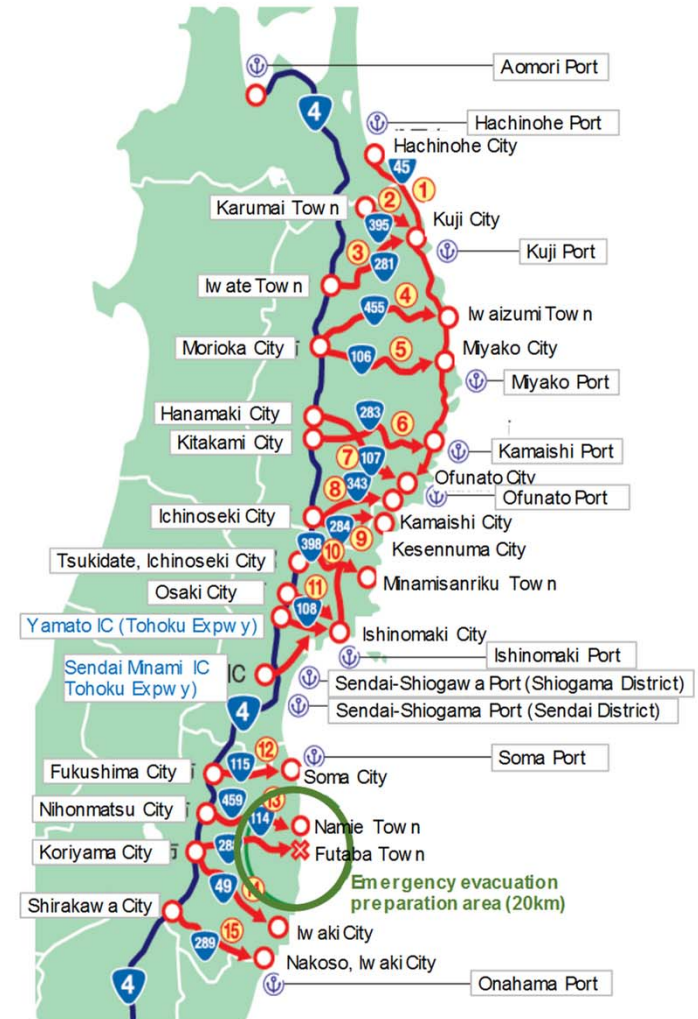
STEP 2 Extend **East-west routes and west routes**
from Tohoku Expwy, National Highway 4

March 12 11 of 16 routes open to traffic
March 15 15 of 16 routes open to traffic

STEP 3 **March 18** 97% of Route 45 & 6 open to traffic
(Mission Completed)



Operation Comb



4. Infrastructure Functions in Disaster: Secondary Function of Roads

Elevated expressways functioned as levees.

- In the 2011 Tsunami disaster, elevated expressways prevented the inflow of water to residential areas, working like levees.
- Town reconstruction plans are making the best use of this lesson learned.



● “Disaster Reduction” efforts including elevation of prefectural roads <Sendai City>

- Disaster reduction measures are being implemented: construction of seawalls and banking as well as raised roads with an embankment function (including the Shiogama-Watari line prefectural road), recreation of tougher tsunami-prevention forests on coastal areas

Tsunami Prevention (Cross-section view)



Excerpt from Sendai City Earthquake Disaster Reconstruction Plan

4. Recovery from the Great Eastern Japan Earthquake : Function of roads

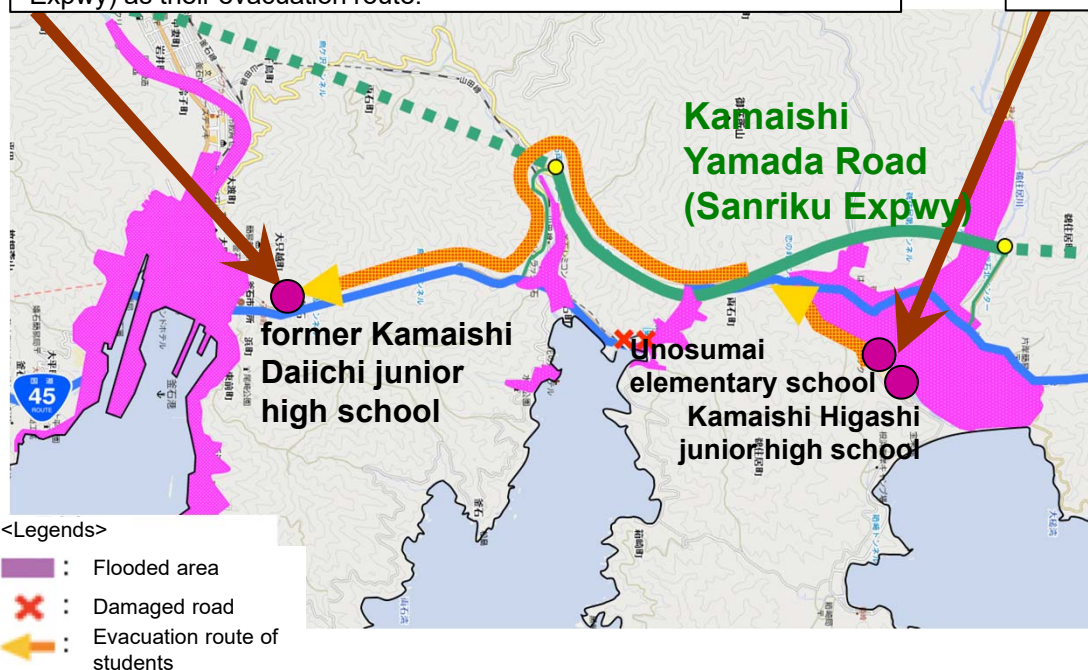
Function of roads as “Road of Life”



Approx. 570 students were evacuated to Kamaishi Daiichi Junior High school using the higher ground Kamaishi Yamada Road (Sanriku Expwy) as their evacuation route.



Kamaishi Higashi junior high school students and Unosumai elementary school children evacuated during tsunami alert.



■ Kamaishi Yamada Road: Safe evacuation route for children

Tsunami hit both Kamaishi junior high school and Unosumai elementary school, but all of approx. 570 students were safely evacuated via the high ground Kamaishi Yamada Road.

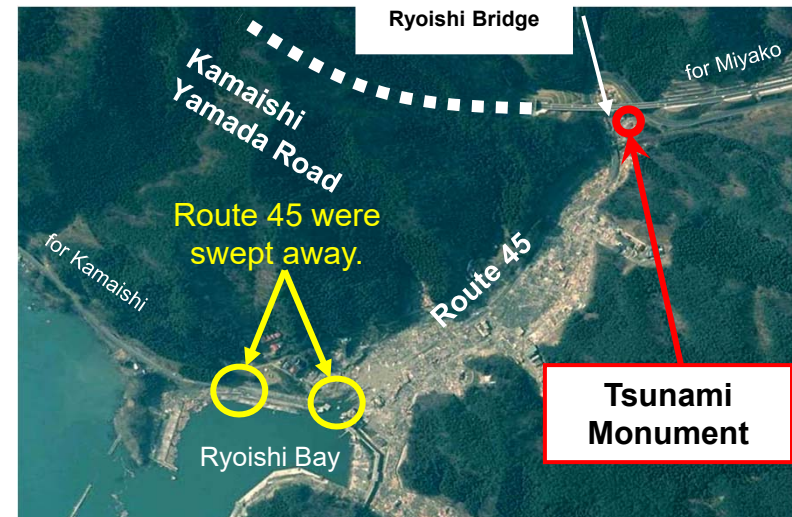
The road enabled them to safely reach the gymnasium of the former Kamaishi Daiichi junior high school, which is designated as an evacuation center.

Road reconstruction with the lesson from the past in mind

Ryoishi Tsunami Monument



- In Ryoishi, Kamaishi City, Iwate Pref., a monument consisting of three stones stands along Route 45.
- Two of these three stones were built to remind people of the tragedy of the 1896 Meiji Sanriku Tsunami disaster. The stone on the left commemorates the 1933 Showa Sanriku Tsunami disaster.
- It has the engravings of words by then-Governor Hidehiko Ishiguro: "Massive earthquakes always bring Tsunami."



▲After the tsunami disaster (Ryoishi, Kamaishi City, Iwate Pref.) <View from a bridge on Sanriku coastline road>

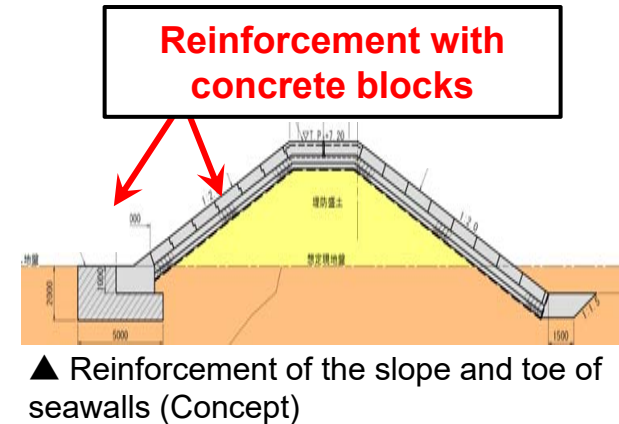
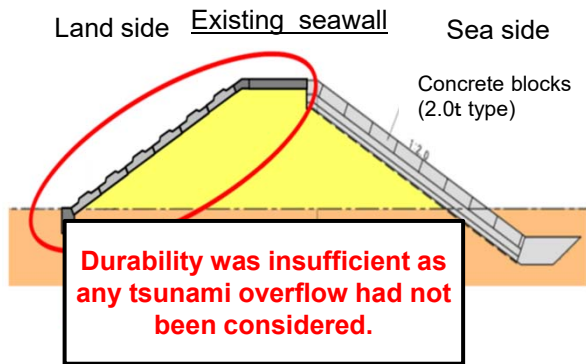


▲Current view around the monument <The picture on the left was taken from the bridge above the monument.>

5. Impact of natural disaster on infrastructure plans

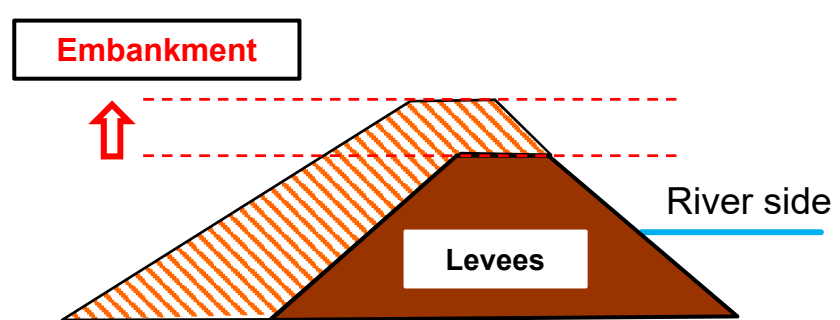
Seawall reconstruction plans were reviewed

- Many facilities were damaged by the tsunami inflow over seawalls.
- To secure sufficient time to evacuate, the durability of seawalls is being improved by providing more strength to the land side slopes with concrete blocks.



Tsunami protection at levees

- Many residential areas were devastated by the tsunami that ran up rivers and overflowed levees.
- Additional embankment works are being added to levees with insufficient height for tsunami protection.

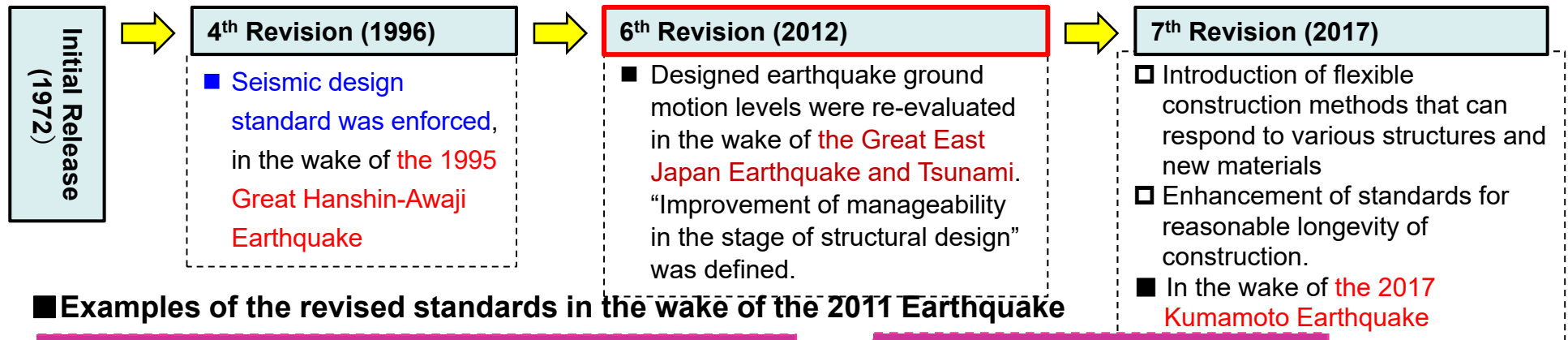


▲Tsunami overflowed into the residential area, surpassing the levee. (Abukuma Riv. left bank, Terashima District, Iwanuma City, Iwate Pref.)

▲Embankment of levees (Concept)

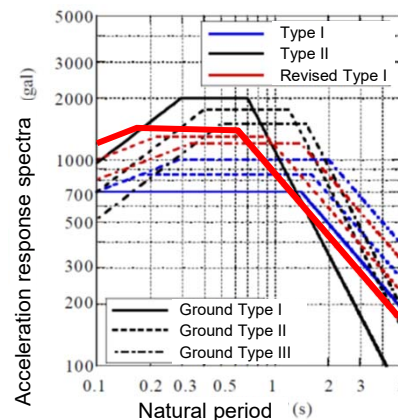
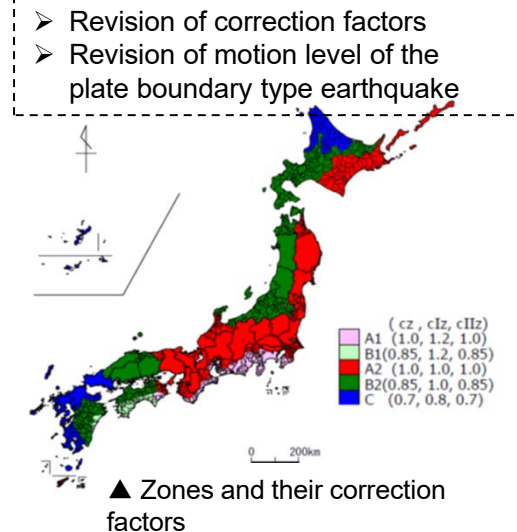
Revision of Specifications for Highway Bridges: Technical standard of highway bridge construction

- **Specifications for Highway Bridges** has been revised seven times since it was initially released in 1972. Every revision reflects the latest technical knowledge and changes in social conditions.
- Responding to occurrence of large scale of earthquakes, analysis of the damage and studies for revision of technical standards are made as needed.



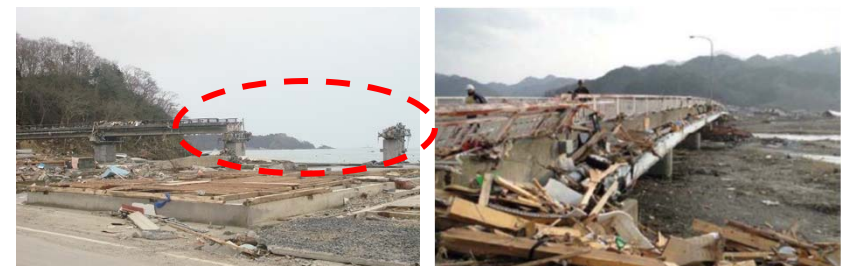
Examples of the revised standards in the wake of the 2011 Earthquake

◆ Re-evaluation of Designed earthquake ground motion



▲ Standard acceleration response spectrum to the plate boundary type earthquake motion

◆ Review on impact of Tsunami



▲ This superstructure was swept away by tsunami.

▲ This bridge superstructure withstood the tsunami strikes.

- Critical points on the highway bridge design should be clearer, reflecting the lesson learned from the tsunami disaster.
- A guideline for consideration in response to massive disasters like tsunami was issued.

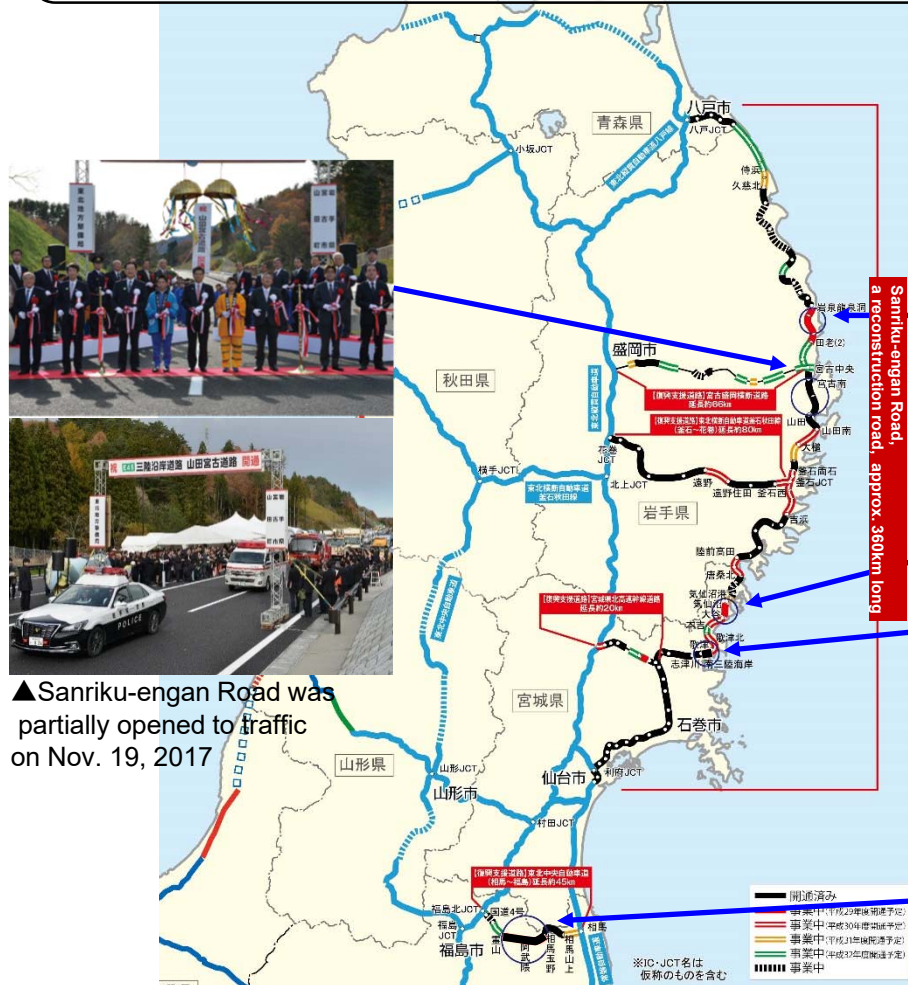
A3

原文「対応の考え方」が規定、とありますが、「考え方に対するガイドラインを設けた」として訳出してあります。

作成者, 3/4/2018

Road Restoration/ Recovery Support Road

- The project of road restoration and recovery support road construction is taking the initiative in all disaster recovery efforts; it is being promoted for swift improvement to support the town reconstruction plans.
- Some 312km of a total extension of 570km of the above roads are open to traffic. (As of March 13, 2018)



▲Sanriku-engan Road was partially opened to traffic on Nov. 19, 2017



▲Sanriku-engan Road under reconstruction



▲Completed Sanriku-engan road (opened to traffic on Dec. 9, 2017)

Sections to be opened to traffic in FY2017



▲Restored Sanriku-engan road



▲Tohoku-chuo Expwy, a recovery support road, will be opened to traffic on Mar. 10, 2018.

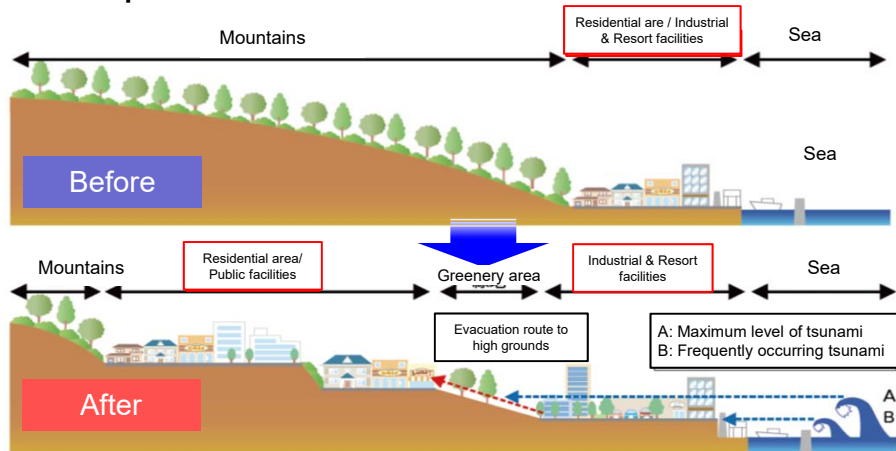
Recovery from the Great Eastern Japan Earthquake: Town Reconstruction

Modification in Residential Area Settings

- Residential areas damaged by tsunami have been moved to higher ground.

Move to higher ground: Minamisanriku Town, Miyagi Pref.

Concept of Town Reconstruction



Source: Recovery Concept, Minamisanriku Town



Public and medical facilities, residences were relocated to higher grounds

▲ Shizugawa, Minamisanriku Town (taken on Sept. 9, 2017)

To higher developed land: Iwanuma City, Iwate Pref.

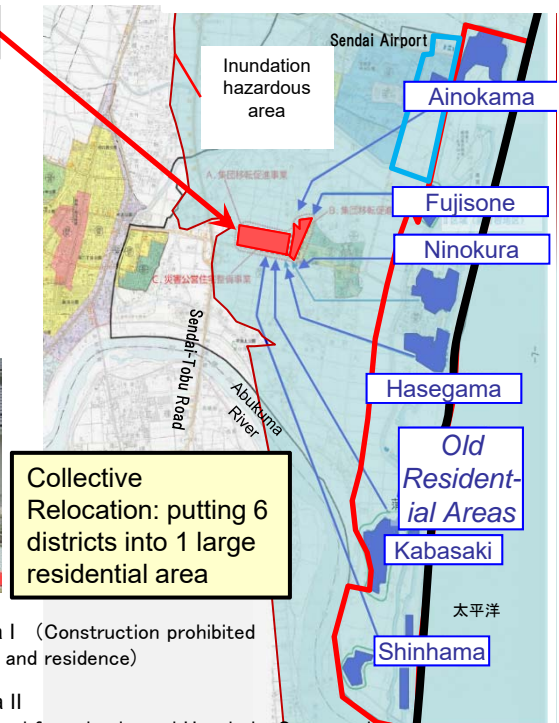
Tamaura-Nishi



▲ Finished public housing



▲ Opening Ceremony July, 2015



Disaster hazard area I (Construction prohibited for schools, hospitals, and residence)

Disaster hazard area II (Construction prohibited for schools, and Hospitals, Construction restricted for residence)

Tamaura-nishi area: view from the west



Making use of past experiences

Available for free:
Guidelines of first response
based on the experience of
the 2011 earthquake and tsunami disaster



LEADING THE FIRST RESPONSE TO LARGE-SCALE NATURAL DISASTERS (English Edition) Kindle版

by Tohoku Regional Bureau Ministry of Land, Infrastructure,
Transport and Tourism (著)

★★★★★ 1 customer

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At 14:46 on March 11, 2011, Tohoku, northeastern region in Japan, was soon inundated by a tsunami which stretched in some places over ten meters tall and five kilometers inland. The catastrophe is now known around the world as the Great Eastern Japan Earthquake. 15,882 people lost their lives.

[Read more](#)

This book was originally written as an internal material for Tohoku Regional Bureau Ministry of Land, Infrastructure, Transport and Tourism. Amid growing warnings of huge earthquakes in the Tokyo and the Tokai regions, it provides the guidelines on disaster response for various levels of leadership within the organization based on their experience and knowledge of harsh conditions after the Great East Japan Earthquake and Tsunami disaster.

Disaster memorial structures



▲ Taro Kanko (Tourist) Hotel
Miyako City, Iwate Pref.



▲ Matsurube Bridge (Ichinoseki City, Iwate Pref.)
(collapsed in the Iwate Miyagi Inland Earthquake
in June, 2008)