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

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

From JMA Special Report 1: The 2011 earthquake off the Pacific coast of Tohoku
1. Overview of Great East Japan Earthquake and Tsunami Disaster

Comparison with past earthquake disasters

**Great East Japan Earthquake (2011)**
Approx. 90% killed by Tsunami

- Drowning: 92.4%
- Fire: 1.1%
- Unknown: 2.0%
- Others including collapse: 4.4%

(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

- Building collapse: 83.3%
- Fire: 12.8%
- Unknown: 3.9%

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

- Fire: 87.1%
- Collapse of Industrial facilities: 1.4%
- Total collapse of residence: 10.5%
- Buried or carried away in a flood: 1.0%


105,385 Dead/Missing
2. Outline of the damage to core infrastructure

Tsunami disaster in Natori City, Miyagi Prefecture
○ Tsunami devastated many coastal areas; Their maximum run-up height was approx. 40 m.

Human and building damage

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

(Headquarters for Emergency Disaster Control, May 2011)

▲ 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

- 19 sections of Expressway
- approx. 3,000 places on General Roads including approx. 350 places that MLIT manages 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.
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<th>「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。</th>
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<td>作成者</td>
<td>3/5/2018</td>
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2. Outline of the damage to core infrastructure

Damage to ports

- 9 major harbors and 14 minor ports

(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.
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)

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<tr>
<th>Day 1</th>
<th>Day 4</th>
<th>Day 7</th>
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<tr>
<td>National Route 4 (Tohoku Network)</td>
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National Route 4 (Tohoku Network)
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

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.
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 overflow into a residential area.**

  - Tsunami overflowed into the residential area, surpassing the levee.
  (Abukuma Riv. left bank, Terashima District, Iwanuma City, Iwate Pref.)
5. Impact of natural disaster on infrastructure plans

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.

4th Revision (1996)
- Seismic design standard was enforced, in the wake of the 1995 Great Hanshin-Awaji Earthquake

6th Revision (2012)
- Designed earthquake ground motion levels were re-evaluated in the wake of the Great East Japan Earthquake and Tsunami. “Improvement of manageability in the stage of structural design” was defined.

7th Revision (2017)
- Introduction of flexible construction methods that can respond to various structures and new materials
- Enhancement of standards for reasonable longevity of construction.
- In the wake of the 2017 Kumamoto Earthquake

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

- Re-evaluation of Designed earthquake ground motion
  - Revision of correction factors
  - Revision of motion level of the plate boundary type earthquake

- 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.
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」として訳出しています。
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)
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

- Public and medical facilities, residences were relocated to higher grounds.

Before

After

Source: Recovery Concept, Minamisanriku Town

To higher developed land: Iwanuma City, Iwate Pref.

Tamura-Nishi

- Finished public housing
- Opening Ceremony July, 2015

Collective Relocation: putting 6 districts into 1 large residential area

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)

Tamura-nishi area: view from the west

▲ Shizugawa, Minamisanriku Town (taken on Sept. 9, 2017)
How to warn future generations of the risks of earthquake and tsunami disasters

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

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.

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)