Post-tsunami Recovery of Port and Harbor areas in Japan from the 2011 Great East Japan Earthquake Tsunami

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2011 Great East Japan Earthquake Disaster

[Earthquake]
Time : 14:46 JST, 11 March 2011
Length : 500km
Width : 200km
Mw : 9.0
The greatest earthquake ever recorded in Japan

[Tsunami]
The earthquake generated large tsunami source offshore.
Tsunami tends to be larger in ria coast areas than in normal ones. Ria coast areas extend in Miyagi and Iwate.

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<th>Prefecture</th>
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<tr>
<td>Iwate</td>
<td>4,673</td>
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<td>Miyagi</td>
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<td>Fukushima</td>
<td>1,612</td>
<td>200</td>
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<td>others</td>
<td>67</td>
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<td><strong>total</strong></td>
<td><strong>15,893</strong></td>
<td><strong>2,567</strong></td>
<td><strong>18,460</strong></td>
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The 2011 tsunami significantly exceeded the design tsunamis: approx. 2-5 times.

[three kinds of design tsunami in Tohoku Region until 2011]

(A) The off Northern Sanriku Earthquake
(B) The off Miyagi Earthquake
(C) Meiji-Sanriku Earthquake type

Tsunami Heights
Damage and Recovery of Ports and Harbors

Port Facilities

- **Severe damage to port facilities:** breakwaters, coastal dikes, berthing facilities, warehouses, cargo handling equipment, etc...

- **Sedimentation, and sunk or drifting obstacles in waterways:** Containers, cars, etc.

**Operation of the disaster-affected ports disrupted severely.**

- Collapsed coastal dike
- Drifted cargo vessel (4,724GT, Length=97m, Drift=7.2m)
- Damaged warehouse
- Sunk car
- Sunk container

Inundation Depth : 6-8m
Damage and Recovery of Ports and Harbors

Public works damages: 2,129 billion yen = 0.4% of Japan’s GDP

Port public works damages: 413 billion yen = 20% of public works damages
Damage and Recovery of Ports and Harbors

Port Facilities

Front-line Breakwaters

“Damage” includes ...

• caused by ground motion & tsunami
• serious (caisson) & slight (armor material)
Damage and Recovery of Ports and Harbors

Port Facilities

Damage of berths
- Damaged berthing facilities
- Sunk or drifting obstacles in waterways
- Sedimentation
- Land subsidence due to co-seismic deformation

Response
- Removing obstacles
- Temporary limitations:
  - draft restriction for vessel
  - loading limitation on berth
- Restoration, Reconstruction

Number and Rate of Available Public Berths (including berths available temporarily)

[Target]
299 public Berths
with 4.5m depth and deeper in the disaster-affected ports
Damage and Recovery of Ports and Harbors

Port Function

- Transport
- Capacity
- Recovery of berths
- Recovery of companies
- Demand

The most important function of ports is transport.

Recovery Rate of Private Companies in Ports & Rate of Available Public Berths

- ~20% after three weeks
- ~50% after three months
- ~85% after a year after

[Target]
104 private companies in the disaster-affected ports

2011-2012

~90% at present
~20% after three weeks
~50% after three months
~85% after a year after
Damage and Recovery of Ports and Harbors

Port Function

- The Cargo traffic of disaster-affected ports had been significantly decreased immediately after the disaster, and was almost recovered after a year.
- The transport function of disaster-affected ports had been supported by the other ports.

Ports on the Japan Sea Coast

**Total Cargo Traffic**

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**Container Traffic**

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Disaster-affected Ports

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Lessons Learnt from the 2011 Event

Worst Case Scenario

Tsunami Disaster in 2011

[Conventional Tsunami Disaster Management]

Single tsunami level

[Performance Design Scheme]

Two or three tsunami levels
Each level is based on each scenario including the worst case.

<table>
<thead>
<tr>
<th>Level 1 Tsunami</th>
<th>Design tsunami</th>
<th>Required performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Tsunami</td>
<td>Larger tsunamis</td>
<td>Disaster Prevention</td>
</tr>
<tr>
<td></td>
<td>• Occurring frequently</td>
<td>• To protect human lives</td>
</tr>
<tr>
<td></td>
<td>• Causing major damage</td>
<td>• To protect assets</td>
</tr>
<tr>
<td></td>
<td>(return period: ~100 years)</td>
<td>• To stabilize economic activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• To secure industrial bases</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 2 Tsunami</th>
<th>Design tsunami</th>
<th>Required performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 2 Tsunami</td>
<td>Largest-possible tsunamis</td>
<td>Disaster Mitigation</td>
</tr>
<tr>
<td></td>
<td>• Extreme low possibility</td>
<td>• To protect human lives</td>
</tr>
<tr>
<td></td>
<td>• Devastating</td>
<td>• To reduce economic loss: especially by</td>
</tr>
<tr>
<td></td>
<td>(return period: ~1,000 years)</td>
<td>✓ preventing severe damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓ enhancing prompt recovery</td>
</tr>
</tbody>
</table>

Level 2 tsunami is the worst case.
We are now making the worst case scenarios for each coastal areas.
Lessons Learnt from the 2011 Event

Worst Case Scenario

[Nankai Trough Earthquake Tsunami]
Tsunami scenario had been assumed in 2003, and was revised as the worst case after the 2011 event.

Tsunami Heights due to the Scenarios

The Worst Case Scenario

- Fundamental Tsunami Source
- Area of Tsunami Earthquake
- Tsunami Source (2003)
- Nankai Trough Axis

The worst case scenario
Tsunami scenario in 2003

[Graph showing tsunami heights at various locations]
Lessons Learnt from the 2011 Event

Resilient Coastal Communities

Safe Evacuation + Damage Mitigation = Early Recovery = Resilience

Extending the lead time for evacuation

Efficient evacuation

- Coastal protection facilities
  - Robustness, Redundancy
- Multi-layer protection system
  - Coastal protection facilities
  - Transportation infrastructures: Raised roads etc.

- Warning delivery system
  - Multiplex: mobile phones, TV, etc.
- Offshore observation system
  - Accuracy of tsunami prediction
- Evacuation buildings and sites
  - Vertical evacuation
- Raising disaster awareness
  - Hazard maps, Education

- Facilities of public organization
  - National and local government
  - Hospital, Power companies, etc.
  - To be built in areas with low risk or improvement

- City planning
  - Link to disaster prevention plans

Level 2 Tsunami

Robustness & Redundancy

Prevent scoring damage
Lessons Learnt from the 2011 Event

Port-Business Continuity Plan (Port-BCP)

- Several scenarios
- Transport-demand curve for each scenario
- Eliminate “Transport Demand-Supply Gap”

Transport Demand > Transport Capacity in Current situation

Necessary Transport Capacity

Disaster

[Transport capacity] > [Transport demand]

Port-BCP is based on the BCPs of some sectors.
- Many port-related sectors
- Cooperation of Port-BCPs
  - Alternative ports for severe scenario

Ports are important for transport.

Short Term: Emergency Supplies (foods, water, etc.)

Middle Term: Industrial Supplies (general cargo)
  Construction Materials

[Diagram showing cooperation among Port-A, Port-B, Port-C, Port-D, Port-E, Government, Port Authority, Pilot, Coast Guard, Electric Power, Terminal Operator, Shipping Company, Custom, Communication, Etc.]
Concluding remarks

◆ The 2011 Great East Japan Earthquake Tsunami was much larger than the design tsunamis, and caused severe damage to the Pacific coast of Tohoku Region.

◆ It is necessary to design several tsunami levels with different scenarios including the worst case scenario.

◆ There are some measures to make coastal communities, including ports, resilient: vertical evacuation, early warning system with offshore tsunami observation, and preparedness for early recovery.

◆ Port-BCP (Business Continuity Plan) is a measure to ensure early recovery of ports.
Thank you for your kind attention.

I’d like to express my sincere sympathy to the victims, their families, and their friends due to the 2011 Great East Japan Earthquake Tsunami.