The impact of the tsunami on port infrastructure and the recovery efforts

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1. Outline of Earthquake, Tsunami and the Damage

9.5m height tsunami was observed in Ofunato, Iwate prefecture.
1. Outline of Earthquake, Tsunami and the Damage

The tsunami at Kamaishi port

Gigantic whirlpool generated by the tsunami

A vessel stranded onshore by the tsunami

The tsunami which goes up Teizan canal
1. Outline of Earthquake, Tsunami and the Damage

- **Typical example of damaged breakwater**: North Breakwater in Hachinohe Port (Hachitaro area)
  - Central part collapsed 837m
  - End part collapsed 700m

- **Typical example of damaged breakwater**: Breakwater in Kamaishi Port
  - North breakwater (990m)
    - Mostly collapsed
  - South breakwater (670m)
    - 12 of 22 caissons collapsed

- **Typical example of damaged quay**: (Quay No.4, Hitachi Port Area, Ibaraki Port (12m water depth))
  - Ground subsidence due to liquefaction (Up to 1.0m)
  - Sediment discharge from end part

Restoration cost exceeds $5 Billion in the port facility (as of September 2011)
Tsunami Breakwater

• Tsunami disaster reduction by breakwater in Kamaishi port
2. Japanese Port Technology on Natural Disaster

Earthquake Resistant Berth

- Effect of Earthquake resistant berth in Hitachinaka Port Area, Ibaragi Port

Earthquake Resistant berth

Conventional Container berth

North Pier berth B (-12m)
Land sank

Central Pier berth A (-7.5m)
No damage
"GPS buoy" measures water level by the RTK-GPS technology at a spot of 100-300m in water depth and 10-20 km off the coast.

After the March 11th earthquake, several GPS buoys observed tsunami waves approximately 10 minutes before tsunami hit the coastal areas.

Immediately after observing the Tsunami by GPS buoy, Japan Meteorological Agency revised upwardly the forecast of Tsunami heights.

GPS buoy observation data (South Iwate)

- JMA provided the tsunami warning and the forecast
- JMA revised the forecast
- Tsunami hit Kamaishi Port
- Tsunami traveled for 9 minutes from GPS buoy to Kamaishi Port
- Tsunami hit Kamaishi Port on 15:12
- JMA revised the forecast on 15:21
- JMA provided the tsunami warning and the forecast on 15:49

Graph showing the tsunami wave height from 14:46 to 15:21 with peak of 6.7m.

GPS buoy

Epicenter

Tidal gage

Kamaishi Port

Kamaishi Bay

GPS Buoy (South Iwate)
3. Outline of the Port Restoration

- Through the immediate and coordinated action for reopening ports, the very first vessel for relief supplies was able to docked at Kamaishi port only 5 days after the earthquake.
- At the Sendai-Shiogma Port where the first vessel docked 7 days after the earthquake, 531 obstacles in total were removed from the seabed and 13 berths were available with maximum depth of 12m after 3 months.

**Distribution of obstacles (531 points)**

**Salvage work of obstacles**
Hachitaro North Breakwater in Hachinohe Port is a major facility of Hachinohe Port. As seen in page 5, it suffered great damage by the tsunami and the calmness inside the port was left unsecure, leaving restrictions for use of the vessels including container carriers and ferries. Since June 2011, emergency restoration was implemented removing wave dissipating blocks as shown in the figure 2 below.

In April 2012, the first caisson started to be placed as shown in the figure 5, and the full restoration of the breakwater is expected to finish June 2013.

### Process of Breakwater Recovery

- **After the Tsunami (figure 1)**
  - Finished

- **Removal of Blocks (figure 2)**
  - On going

- **Crushing of Caissons (figure 3)**
  - By 2012

- **Flattening of Basement (figure 4)**
  - By 2012

- **Placement of new caisson (figure 5)**
  - By 2012

- **Hydration of Upper Structure (figure 6)**
  - By 2013

- **Removal of Blocks (figure 7)**
  - By June 2013

- **Full Restoration (figure 8)**
  - Finished
3. Outline of the Port Restoration

○ Marine disposal site for the debris is under construction at Hibarino Area of Ishinomaki Port
○ Expected to accept 2 millions tons of debris, nearly 10% of the debris from the disaster.
○ Plan to build Site Ⓐ first and is currently under construction, expected to start accepting from May 2013
3. Outline of the Port Restoration

Restoration Council established in each port to discuss the Restoration Plan

- Local government
- Industries located nearby
- Port management body
- Port users
- Branch office of Port & Harbors Bureau, MLIT

※Established in all 13 ports in scope

Promotion of hard & soft measure for restoration

- Established “Industry and Logistics Restoration Plan” at the Restoration Council with approval of all participating bodies.
- All of the port facilities essential for industry and logistics are scheduled to be **fully restored within roughly 2 years under the Restoration Plan**.
- Restoration and development of Protection Line (i.e. seawall) established by local government in conjunction with local community and industrial activity
- Establish the Business Continuity Plan on Port Activity under devastation of tsunami disaster and earthquake.

- Entire Damage in Port Facilities in the devastated region: $5 Billion
- Budget for the restoration in fiscal 2011: $3 Billion
4. Efforts to Reduce Disaster Impact

- Due to the devastating damage to the port facilities by the earthquake and the tsunami, revision of the technical standard of port facility is planned to strengthen against earthquake and tsunami.
- Content of the revision will be resiliency in structures including breakwaters and to improve measures to assess liquefaction.
- Technical discussions will be made and revise the standard as soon as possible.

Resilient structure

- The target of resilient structure is to avoid falling down of the breakwaters in case of huge tsunami that overflows the breakwaters.

Improve of Assessment of Liquefaction

- Due to the continued time span of the earthquake, the damage from the liquefaction increased. However, the conventional assessment did not consider the continued time of the earthquake.

- Improve the accuracy of the estimation of liquefaction by considering the continued time of earthquake in the assessment.
## 4. Efforts to Reduce Disaster Impact

### Comprehensive Counter Tsunami Measures in 2 Levels (Disaster Prevention/Disaster Reduction)

<table>
<thead>
<tr>
<th>Definition of Tsunami Level</th>
<th>Frequency of Tsunami</th>
<th>Protection Targets</th>
<th>Comprehensive Counter Tsunami Measure</th>
</tr>
</thead>
</table>
| **Frequent Tsunami**        | Once in several decades to hundred and some more years. | ・Lives  
 ・Properties  
 ・Economic Activities  
 ・Continuous Port Activities necessary for immediate action after the disaster | ・Plan and design to prevent inundation of the land inside  
 ・Plan to avoid damage of port facilities outside  
 ・Plan considering the worst scenario |
| **Maximum Class Tsunami**   | Once in several centuries to thousand years. | ・Lives  
 ・Reduce the Economic Loss  
 ・Reduce the secondary disaster  
 ・Early restoration | ・Plan and design to reduce inundation but to avoid fatal damages to the facility.  
 ・Multiple measures to be taken when necessary  
 ・Plan the land use considering the inundation inside  
 ・Plan considering the worst scenario |
4. Efforts to Reduce Disaster Impact

Ougishima Wide Area Disaster Prevention Base

In the devastation, emergency supplies must be transported both by land and by water in most efficient way. Distribution of Emergency Supplies will Facilitate through Wide-Area Disaster Prevention Base.