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Tsunami and Damage to Coastal Facilities of the March 11, 2011, Tohoku, Japan Earthquake

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Damage of Otsuchi



Taken by resident





Detailed profiles of the first crest off the Tohoku region coast



The appearance time was earliest at Central-Iwate and South-Iwate among totally six sites off the Tohoku region coast. The top height was 2.6-6.7 m at these sites and was largest at South-Iwate

Tsunami source models derived from inversion of observed tsunami waveforms.



(Takagawa and Tomita, 2012)

Colored lines are contours of 1 m uplift in these models purple: Fujii et al., 2011 red: Central Disaster Prevention Council, 2012 green: Tsushima et al., 2011 orange: Saito et al., 2011 blue: Takagawa and Tomita, 2012

Colored squares indicate maximum uplifted point of these models. The star indicates epicenter of main shock. Open circles indicate geodetic observation points of sea bottom.

Maximum uplift is located on the east of epicenter of main shock and near the Japan Trench in all models except model Ts.

Snapshots of tsunami propagation

(Takagawa and Tomita, 2012)



plane (upper) and bird's-eye view (lower).



joint survey group

Difference with overflow above the seawalls (wind waves & tsunami)



Wind waves:

Offshore wave height 0.5m Period 4.0s Tsunami:

Offshore wave height 0.5m, Period 20.0s



IF the



Overflow (Miyako Port)



Miyako weather TV (by courtesy of NHK)

Bore (Sand beach at Sendai)



Breaking (Kuji fishery port)



taken by a residence

Typical time histories of tsunami Force



Bore Type Tsunami



Tsunami Height in front of the wall is 2.0m

Destruction of concrete wall by tsunami impulsive wave force thickness 60mm





Topography of Sea Bed at Kamaishi after tsunami

25th , March, 2011



Failure of Breakwater at North Part

TOHOKU REGIONAL BUREAU MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT



From video by public people

15:18 (1st positive wave, 32 minutes after)



15:28(negative tsunami started, 42 minutes after)



North side of Kamaishi breakwater



Experimental Video under overflow tsunami



Experimental Video under overflow tsunami

Plan View





Failure of Breakwater at North Part

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Effect of breakwater (Tomita et. al, 2012)



Design policy of physical countermeasures

It is necessary to estimate two levels of tsunamis, and develop measures to mitigate damage for both of them.

Tsunami Level	Definition	Planning or design
Tsunami Prevention Level (L1)	Tsunamis that occur frequently and cause extensive damage even though they are not high	To prevent the protected lowland from being flooded, it plans and it designs.
		Continued mitigation through physical countermeasures
Tsunami Reduction Level (L2)	The largest class of tsunami, which occurs at an extremely low frequency, but which causes enormous damage when it does	It plans and it designs so that it is made easily not to destroy and to collapse, and damage should not expand though the flood of the protected lowland is permitted. That means 'resilient' structures Disaster mitigation by evacuation



New Earthquake Model(Nankai Trough)

the Disaster Management Council of the Cabinet Office, 2012

(*) Tsunami Height Tsunami height in this figure is including not only "Tsunami" and "Mean Monthly-Highest Water Level" but also "Land Subsidence" due to the tectonic deformation. However, that is not including "Land Uplift".

The value by Central Disaster Prevention Council indicates the maximum tsunami height in the municipality of each port.



Resilient city against Tsunami

"hardware" (disaster prevention facilities, etc.) and "software" (disaster prevention training, etc.) measures



Against Human body



Inundation height is about 50cm, Inundation speed is about 4.0m/s

Lessons from The Great East Japan Earthquake

- The power of the tsunami is greatly different depending on the place and the condition
- The breakwater and seawall cannot prevent the tsunami perfectly, but can help people to evacuate.
- It is important to mitigate the tsunami disaster by using the hardware and software measures.
- Even if the tsunami is very small, people may be washed away by tsunami.