Evacuation from tsunamis

【Background】
The coastal areas of Sendai City were preparing to enable citizens to evacuate from tsunamis, including introduction of a tsunami information transmission system. However, the tsunami triggered by the Great East Japan Earthquake was far larger than expected. The measures were inadequate, resulting in many fatalities and significant damage.

【Response】
On the assumption that tsunamis as large as those triggered by the Great East Japan Earthquake will occur, we developed the basic concept for evacuation from tsunamis. Based on this concept, we developed tsunami evacuation facilities, and created and distributed a hazard map. We established a system that enables all people in the coastal areas to safely evacuate from tsunamis.

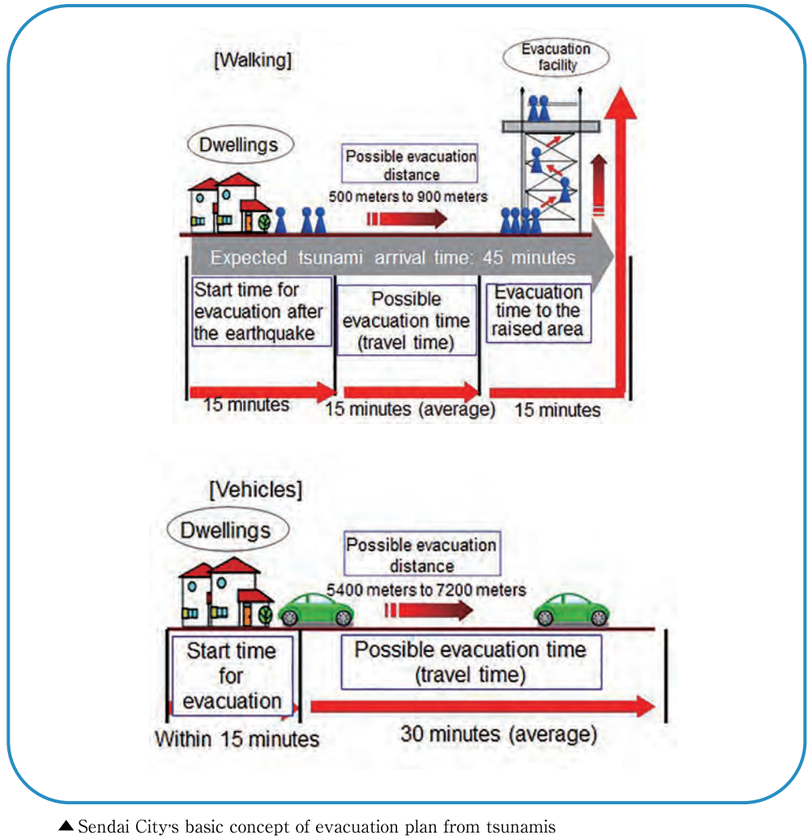
1 Basic concept

The City of Sendai formulated a plan to enable residents in the coastal areas, which were damaged by the tsunami triggered by the Great East Japan Earthquake, to evacuate safely from tsunamis.

First, we conducted simulations and found that evacuation by car causes traffic congestion, making it difficult for everyone to evacuate safely. We placed priority on evacuation on foot in principle. We assumed that only individuals who meet certain conditions, such as those who face difficulty evacuating on foot (e.g., elderly people, people with disabilities, expectant and nursing mothers, babies and infants) and who are driving their cars at the time of an earthquake, can evacuate by car.

Based on the past tsunami arrival times and simulation results, we assumed that the estimated tsunami arrival time is about 45 minutes after an earthquake. Given that it takes 15 minutes to start evacuation after an earthquake and another 15 minutes to evacuate to higher ground in the 45-minute period, evacuees on foot have 15 minutes for mobility, and evacuees by car have 30 minutes for mobility. Based on this assumption, we have developed evacuation facilities and evacuation roads to ensure sufficient evacuation space for all evacuees.

To promote awareness to citizens, we have established a system to inform all citizens about the evacuation methods and evacuation sites and enable safe evacuation by ensuring notification through various warning systems, hazard maps, awareness promotion signs, etc. and by conducting evacuation drills based on cooperation between local governments and local communities, among other methods.



▲Sendai City's basic concept of evacuation plan from tsunamis

2 Hazard map (Budget : about 6.5 millon yen/year)

The City of Sendai created a tsunami hazard map so that citizens can evacuate properly in the event of a disaster. The map is distributed to citizens free of charge.

① Information provided in the hazard map

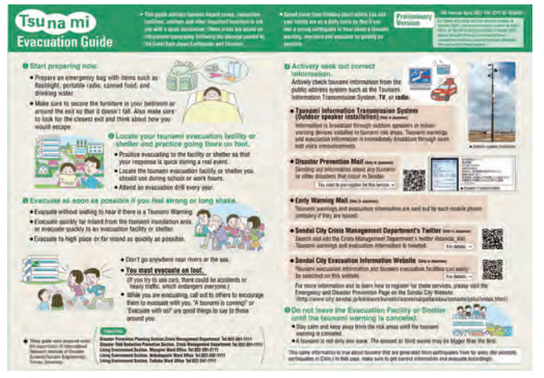
To help citizens evacuate safely from tsunamis as large as those triggered by the Great East Japan Earthquake, the tsunami floodwater line from the Great East Japan Earthquake, which was created based on investigation by the Ministry of Land, Infrastructure, Transport and Tourism (Government of Japan), is shown on the hazard map. We advise citizens to evacuate to locations outside the line.

When the Great East Japan Earthquake hit, an expressway (Sendai Tobu Road) which had an embankment structure blocked the tsunami and served as a seawall in Sendai City. To make good use of the lesson, we decided to elevate the main road (Shiogama-Watari Prefectural Road) that is closer to the sea side than the Sendai Tobu Road by six-meters embankment so that it serves as a seawall as well.

On the hazard map, the area on the sea side from the Shiogama Watari Prefectural Road, which is a newly constructed elevated road, is designated as the Tsunami Inundation Area I (red). The area on the inland side from the Shiogama Watari Prefectural Road, which was inundated when the Great East Japan Earthquake hit,is designated as the Tsunami Inundation Area II (yellow). In the Tsunami Inundation Area I, evacuation is necessary when a Tsunami Warning is issued. In the Tsunami Inundation Area II, evacuation is necessary when a Major Tsunami Warning is issued. The hazard map indicates the locations of tsunami evacuation facilities and designated evacuation facilities in the Tsunami Inundation Areas and adjacent areas. We clearly inform citizens about the evacuation areas.

The Tsunami Evacuation Guide is printed on the reverse side of the hazard map. This guide describes the mindset when evacuating from tsunamis, such as "You must evacuate on foot" and "While you are evacuating, call out to others to encourage them to evacuate with you." Such descriptions not only inform citizens of the evacuation sites correctly but also raise awareness about evacuation from tsunamis on a daily basis. These descriptions were prepared under the supervision of the International Research Institute of Disaster Science, Tohoku University.

▲Hanard Map



▲Tsunami Evacuation Guide

② Distribution method

The City of Sendai cooperates with private companies to distribute the hazard map regularly each year to all households regardless of revisions. We concluded an agreement with a private company that distributes phone books to all households in the city. We produced a booklet that includes the hazard map and explains the mindset for disaster risk reduction as a separate volume of the phone book, which are distributed with the phone books by the private company. This makes it possible to distribute the hazard map every year to all citizens, including those who have moved into Sendai City. The separate volume of the phone book contains information about evacuation from tsunamis and other disasters such as earthquakes and heavy rains.

▲Phone book including hazard map

③ Utilization method

The City of Sendai organizes a hazard map workshop several times a year. If the hazard map is revised, the city gives explanations to local communities in the areas related to the revision.

In addition, the hazard maps are used in disaster-prevention drills and volunteer citizens' workshops, etc.

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3 Tsunami warning system (Budget : about 10 millon yen/year)

① Types of warnings, etc. when tsunamis occur

The Japanese government (Japan Meteorological Agency: JMA) issues the following warnings when tsunamis are expected to occur. The City of Sendai issues these warnings to citizens using various warning systems.

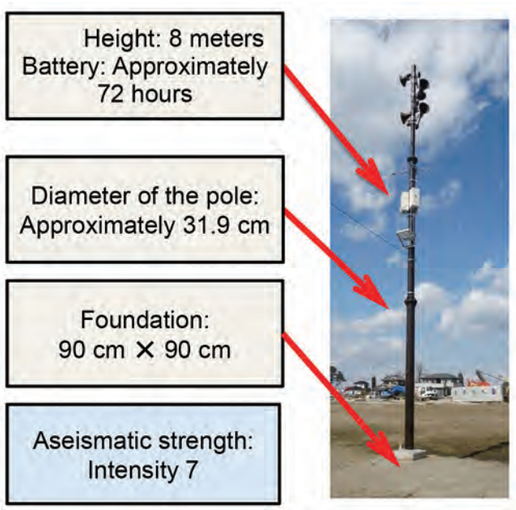
Types of Tsunami Warnings	Height of tsunamis to be announced	Action to be taken when a warning is announced
Major Tsunami Warning	Huge Over 10 m 10 m, 5 m	Evacuate immediately from the Tsunami Inundation Area I and Tsunami Inundation Area II to designated evacuation sites and evacuation buildings, etc.
Tsunami Warning	High, 3 m	Evacuate immediately from the Tsunami Inundation Area I to designated evacuation sites or evacuation buildings, etc.
Tsunami Advisory	1 m	Pay attention to upcoming information (on TV, radio, etc.), and evacuate immediately from the coast and estuaries.

② Types of warning systems

(a) Tsunami information transmission system

The system is used to broadcast tsunami evacuation information through siren and voice announcements from outdoor speakers. When JMA issues a Tsunami Warning, the tsunami evacuation information is broadcast from 79 outdoor speakers in total installed in the coastal areas of Sendai City.

When the Great East Japan Earthquake hit, 38 outdoor speakers became unusable due to the damage caused by the tsunami. As a countermeasure, the battery height, battery operation time, pole diameter, etc. were reviewed to increase resilience to tsunamis.



▲Tsunami information transmission system

(b) Email

- Emergency Early warning email

Mobile phone users can receive Tsunami Warnings distributed by JMA and evacuation information distributed by the City of Sendai without being affected by network congestion. No registration is required.

- *Mori no Miyako* disaster preparedness email

Pre-registered users can receive Tsunami Warnings and evacuation information by email.

(c) Website and Twitter

Tsunami Warnings and evacuation information are posted on the City of Sendai's website and Twitter.

⇒ The disaster information transmission tools (a) to (c) are under central management. The information is distributed simultaneously depending on the warnings issued by JMA and input to the City of Sendai's backbone system. This system has made it possible to disseminate disaster information quickly and accurately.

(d) Announcements from emergency vehicles, etc.

Announcements are made from fire engines and fire helicopters, etc., in the coastal areas to encourage citizens to evacuate promptly.

Recently, field tests have been conducted to utilize drones for tsunami evacuation announcements in the coastal areas.

● Information on TV and radio

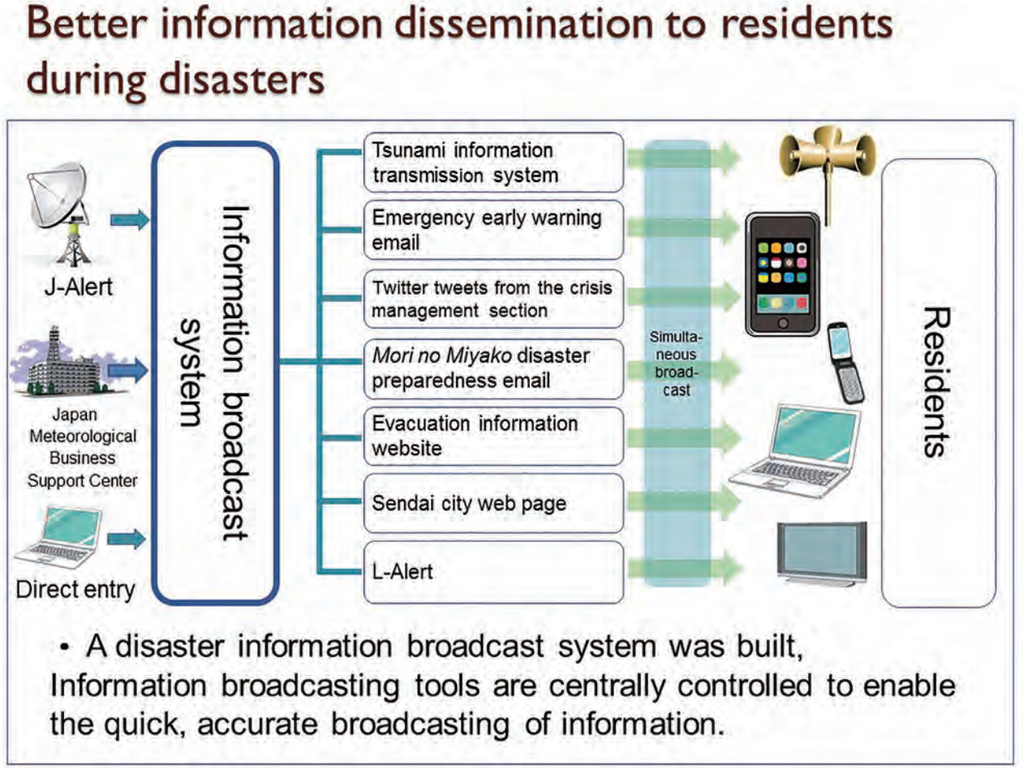
● Tsunami information transmission system

● Fire helicopters

● Email
● Website
● Twitter

● Fire (fire brigade) engines/vehicles

● Ward office publicity cars



▲Information broadcast system

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4 Development of tsunami evacuation

The City of Sendai constructed tsunami evacuation facilities at 13 coastal arealocations: 6 tsunami evacuation towers, 5 tsunami evacuation buildings, and 2 outdoor tsunami evacuation stairs.

① Tsunami evacuation tower

・Structure: Steel-frame construction (two-story)
・Height from the ground: Indoor evacuation space: about 6.5 m, rooftop evacuation space: 10 m
The height is sufficient from the projected depth of tsunamis.
・Measures against tsunamis: By taking into account the liquefaction, tsunami wave force, and collision of floating wreckage, foundation piles of more than 20 meters were driven into the ground to create a strong structure that can withstand tsunamis.
・Securing the means for external communication:
Radio equipment for disaster management administration is installed at each tsunami evacuation facility so that evacuees can contact the disaster response headquarters of the City of Sendai.

・Measures to provide protection against the cold and wind:
Evacuation spaces enclosed by external walls are ensured. We also stockpile blankets and cartridge gas stoves.

・Measures against nighttime power outages:
A pole-mounted photovoltaic panel is installed on the rooftop to illuminate the stairs, slopes, and rooftop and facilitate evacuation even during nighttime power outages. We also stockpile cartridge gas generators and LED floodlights.

▲Tsunami evacuation tower

・Consideration for people requiring assistance during a disaster:
The tsunami evacuation towers are designed to enable evacuation in wheelchairs and strollers on slopes.

〈Budget〉

Construction cost: 170 million yen/tower (average)
Maintenance cost: about 0.9 million yen/year
The project is subsidized by the national government (approx. 2,200 million yen).

② Inside a tsunami evacuation tower

・Total area: 218 to 398㎡
・Stockpile items
- Food, water, and blankets
- First aid kits, radios
- Generators, floodlights
- Cartridge gas stoves
- Temporary toilet sets
- Radio equipment for disaster management administration
- Ropes
- Life jackets, lifebuoys

・To reduce stress during evacuation, the interior space can be partitioned using an accordion curtain.
・Considerations such as securing toilet spaces slightly larger than usual and installing benches are given for the evacuation of elderly people etc.,

▲Inside a tsunami evacuation tower

③ Tsunami evacuation buildings

A tsunami evacuation building refers to a tsunami evacuation tower annexed by a fire corps(※) facility. In the event of a disaster, the building also serves as an activity center for the fire corps.

※Fire corps: A fire-fighting organization with which volunteer ordinary citizens are affiliated. Remuneration is paid by the local government. Most of fire corps members have a main job or schoolwork, etc. in addition to working on the fire corps activities.

▲Tsunami evacuation building

▲Outdoor tsunami evacuation stairs

④ Cooperation with private companies

The City of Sendai is cooperating with private companies to build a tsunami evacuation system. We conclude agreements with private companies to designate their facilities and tsunami evacuation facilities as official evacuation sites.

When the Great East Japan Earthquake hit, an expressway which had an embankment structure blocked the tsunami. Thus, the company that manages the expressway developed five evacuation stairs in Sendai City so that pedestrians can evacuate to the expressway when tsunamis occur.

▲Evacuation stairs

⑤ Drills and usage in the event of a disaster

The City of Sendai conducts tsunami evacuation drills on November 5 every year in line with the World Tsunami Awareness Day. The tsunami evacuation facilities are utilized for the drills. They are also used for local disaster-prevention drills.

The keys to the tsunami evacuation towers and tsunami evacuation buildings are owned by the City of Sendai and also lent to local residents so that they can unlock the doors in the event of a disaster. The towers and buildings have windows that can be broken from outside in the event of an emergency. It is possible to enter the towers and buildings without a key, enabling even people who are not local residents to evacuate quickly.

▲Tsunami evacuation drill

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