Lessons from Different Types of Major Earthquakes and Models to Strengthen Measures

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Purpose

In areas where many disasters (natural disasters) occur, countermeasures are improved based on lessons learned from past experience.

However, it is rare that a single water utility experiences many disasters itself.

The purpose of this paper is to contribute to the improvement of disaster countermeasures at water utilities that have not experienced disasters themselves by sharing the lessons learned from three different types of earthquakes, and the response measures taken by the Tokyo Metropolitan Waterworks Bureau (TMWB).

TMWB's Planning System for Earthquake Disaster Response Measures

Currently, TMWB has two plans for earthquake countermeasures. These two plans were once a single plan when first formulated in 1973, but they were separated in 1982 and have been gradually revised since then. The measures described below were inserted during revisions of the respective plans and are included as Bureau measures.

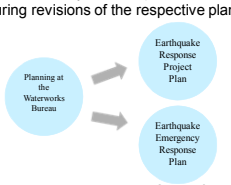

Fig. 1: TMWB's Planning System for Earthquake Disaster Response Measures

Plans	Description
Earthquake Response Project Plan	Establishes preemptory measures to prevent damage by earthquake disasters (primarily improved earthquake resistance for facilities)
Earthquake Emergency Response Plan	Establishes post-disaster emergency response activities.

Table 1: Content of TMWB's Plans for Earthquake Disaster Response Measures

1. Lessons Learned from the Great Hanshin-Awaji Earthquake and Strengthening of Measures

1. Damage caused by the Great Hanshin-Awaji Earthquake

The Great Hanshin-Awaji Earthquake (Kobe Earthquake) was a large M7.2 earthquake that hit western Japan on January 17, 1995. It created strong tremors and caused fires primarily in urban areas. The table below contains a summary of the damages (Table 2).

Category	Damage
Dead	6,434 people
Injured	43,792 people
Houses damaged	639,686 houses
Water outages (maximum)	Approx. 1.27 million households

Table 2: Damage caused by the Great Hanshin-Awaji Earthquake

2. TMWB Response

Beginning on the day of the earthquake, TMWB dispatched a total of 261 staff as an emergency water supply support team. Beginning on January 21, TMWB also dispatched a total of 852 people including contractors as a waterworks facility restoration support team. In addition to providing this support, TMWB established the "Re-examination Committee for Earthquake Disaster Countermeasures" in February 1995 to reexamine and strengthen its own earthquake countermeasures.

3. Lessons Learned and Strengthening of Measures

Distinctive lessons learned from earthquake damages and responses thereto, as well as measures that TMWB took, are as collected in Table 3 below.

We had already been using strong and highly earthquake-resistant ductile iron pipes for pipelines at the time of the earthquake. Beginning in FY1998, we decided to fully implement new earthquake-resistant joint pipes. The percentage of pipes equipped with earthquake-resistant joint pipes was 37%, and this is scheduled to improve to 61% by FY 2025.

	Lessons	Measures
Tangible	Separation of many pipe joints	Full adoption of earthquake-resistant joint pipes
	Insufficient backup from other systems	Duplexing of water conveyance channels and multiplexing of water transmission routes
Intangible	Delays in assembling staff members and conducting initial activities	Construction of "disaster countermeasure" housing; development of action manuals
	Obstruction of information collection caused by phone service interruptions	Achievement of a communication network via mobile phone

Table 3: Distinctive Lessons and Measures

2. Lessons Learned from the Great East Japan Earthquake and Strengthening of Measures

1. Damage caused by the Great East Japan Earthquake

The Great East Japan Earthquake was a massive M9.0 earthquake that hit eastern Japan on March 11, 2011. Broad-reaching, this earthquake caused a great deal of damage by creating not only tremors but a tsunami and nuclear power plant accident, and thereafter causing shortages of electricity. The table below contains a summary of the major damage caused (Table 4).

Category	Damage
Dead	19,533 people
Missing	2,585 people
Injured	6,230 people
Houses damaged	1,159,906 buildings
Total water outages	Approx. 2.57 million households

Table 4: Damage caused by the Great East Japan Earthquake

2. TMWB Response

Beginning on the day after the earthquake, TMWB dispatched a total of 61 staff as an emergency water supply support team. Beginning on March 16, TMWB also dispatched a total of 104 people including contractors as a waterworks facility restoration support team. In addition to providing this support, TMWB established the internal "Examination Committee on Countermeasures for Large-scale Disasters" in June 2011 to strengthen its own countermeasures.

3. Lessons Learned and Strengthening of Measures

Distinctive lessons learned from earthquake damages and responses thereto, as well as measures that TMWB took, are as collected in Table 5 below.

	Lessons	Measures
Tangible	Electricity shortages due to nuclear plant accident	Increase and augmentation of in-house power generation facilities at water treatment plants and water supply stations
	Submergence of waterworks facilities by the tsunami	Raising of facilities' altitude and installation of weirs to stop water
Intangible	Difficulties in providing information due to heavy traffic on websites	Provision of information by multiple methods such as Twitter
	Difficulty in confirming the safety of employees and other personnel due to poor communications	Introduction of a system to confirm individuals' safety

Fig. 2: Emergency water supply support team

Fig. 3: Restoration support

3. Lessons Learned from the Kumamoto Earthquakes and Strengthening of Measures

1. Damage caused by the Kumamoto Earthquakes

The Kumamoto earthquakes were a pair of earthquakes that hit the Kumamoto region on April 14 and 16, 2016, the largest being M7.3 in size. These earthquakes confronted authorities with the question of how quickly restoration work ought to begin, through the use of ICT and other methods, when a large earthquake occurs in a modern urban area. The table below contains a summary of the major damage caused (Table 6).

Category	Damage
Dead	228 people
Injured	2,753 people
Houses damaged	198,636 buildings
Total water outages (Maximum)	Approx. 450,000 households

Table 6: Damage caused by the Kumamoto Earthquakes

2. TMWB Response

Beginning on the day after the April 16 earthquake, TMWB dispatched a total of 111 people including contractors as a waterworks facility restoration support team.

3. Lessons Learned and Strengthening of Measures

Distinctive lessons learned from earthquake damages and responses thereto, as well as measures that TMWB took, are as collected in Table 7 below.

The water utilities in the table below that would serve as "coordinators" are those of the cities of Sendai and Osaka. The MOU (memorandums of understanding) were signed with Sendai in November 2016 and Osaka in January 2018, and by these MOU the cities agreed to serve as coordinators for external support requests and other actions immediately after a large earthquake or other disaster.

In addition, Tokyowater Rescue (Tokyo Waterworks Disaster Rescue Team) was founded in March 2017. This is a mechanism that consists of two systems: the "registration system," whereby candidates are registered in advance for dispatching to disaster-affected areas, and the "duty system," whereby team members are pre-assigned for "on-duty" dispatching on a monthly basis to offices in disaster-affect areas. This mechanism enables quicker response to support requests from disaster zones than ever before.

Further, when the Mayor of Kumamoto requested that city residents provide water leakage information via Twitter, a lot of information was gathered and contributed to the prompt repair of water leaks. Therefore, TMWB has also established a similar mechanism.

Lessons	Measures
Delayed requests and acceptance of support due to post-disaster chaos	MOU with a water utility that will act as a coordinator
Need to speed up response to requests for support	Establishment of "Tokyowater Rescue (Tokyo Waterworks Disaster Rescue Team)"
Effectiveness of water leakage information provided by residents in the achievement of prompt recovery	Creation of a mechanism for collecting water leakage information via Twitter

Table 7: Distinctive Lessons and Measures