4-3-1 Earthquake and Tsunami Countermeasures of Tokyo's Sewerage

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Abstract

The Tokyo Metropolitan Government created a committee consisting of academic experts to summarize Tokyo's basic policy for earthquake and tsunami in light of the extensive damages caused by the Great East Japan Earthquake. Based on the recommendations from the committee, the Bureau of Sewerage is formulating and implementing a series of countermeasures against earthquake and tsunami, including protection of sewerage facilities from flooding in the event of a tsunami, automation and remote control of storm surge gate to prevent tsunami-generated backflow to sewers, and aseismic reinforcement of sewerage facilities.

Keywords

tsunami, protection of sewerage facilities from flooding, protection of sewer pipe from backflow, storm surge gate, aseismic reinforcement of sewerage facilities

1. Tokyo's Measures for Earthquake and Tsunami after the Great East Japan Earthquake

On March 11, 2011, an earthquake of magnitude 9.0, the biggest in Japan's modern history, hit Northeast Japan. The earthquake, later named the Great East Japan Earthquake, had its epicenter in the Sanriku coast; the northern part of Miyagi Prefecture measured the seismic intensity 7. The subsequent tsunami attacked a wide range of the Pacific coast areas from the Tohoku to Kanto regions, causing about 20,000 dead or missing and serious damages on sewerages, levees, water gates, etc., on the Tohoku and surrounding regions.

Although several parts of Tokyo areas observed the seismic intensity 5 upper and

tsunami wave of 1.5m height, higher than the official assumption of maximum height of 1.2m, no major damages occurred on sewerages, rivers, and coastal protection facilities, thanks to the continued improvement on the facilities up to date.

However, in light of the extensive damages caused by the earthquake and to respond to the expected damages by a possible Tokyo inland earthquake in near future, the Tokyo Metropolitan Government created a committee consisting of academic experts to summarize Tokyo's basic policy for earthquake and tsunami, in addition to the immediate inspection and survey of potentially impacted facilities in cooperation with concerned bureaus and departments in charge of river, port, and sewerage.

The committee, based on the results of the emergency investigation, issued the recommendations on the anti-quake and anti-flood measures regarding levee, water gate, pumping station, water reclamation center, etc. Based on the recommendations, the Tokyo Metropolitan Government formulated Tokyo's Basic Policy for Flood Disaster Prevention Associated with Earthquake and Tsunami in August 2012. To embody the basic policy, the Bureau of Sewerage formulated the Sewerage Facility Development Plan to Counter Earthquake and Tsunami in December 2012, followed by the implementation of the measures from subsequent fiscal 2013.

2. Tokyo's Basic Policy for Flood Disaster Prevention Associated with Earthquake and Tsunami

In August 2011, the Tokyo Metropolitan Government formulated Tokyo's Basic Policy for Flood Disaster Prevention Associated with Earthquake and Tsunami. In the document, the Tokyo Metropolitan Disaster Prevention Council assumed the maximum magnitude caused by a subduction zone earthquake to be 8.2. Based on the assumption, the Tokyo Metropolitan Government aimed to promote anti-flood measures to resist the above possible biggest earthquake and subsequent tsunami, by protecting facilities from inundation and retaining the functions of levees, water gates, pump stations, water reclamation centers, etc.

The concept of preventive measures is based on the data in the Damage Assumption Caused by A Tokyo Inland Earthquake published in April 2012 by the Tokyo Disaster Prevention Council, which assumed the maximum height of tsunami wave to be T.P+2.6m, not exceeding the height of currently planned levees (T.P+3.5-8.9m) along Tokyo coasts and rivers. Therefore, the Tokyo Metropolitan Government decided to promote anti-storm surge measure under the current plan in principle, without increasing the height of levees (Figure 1).

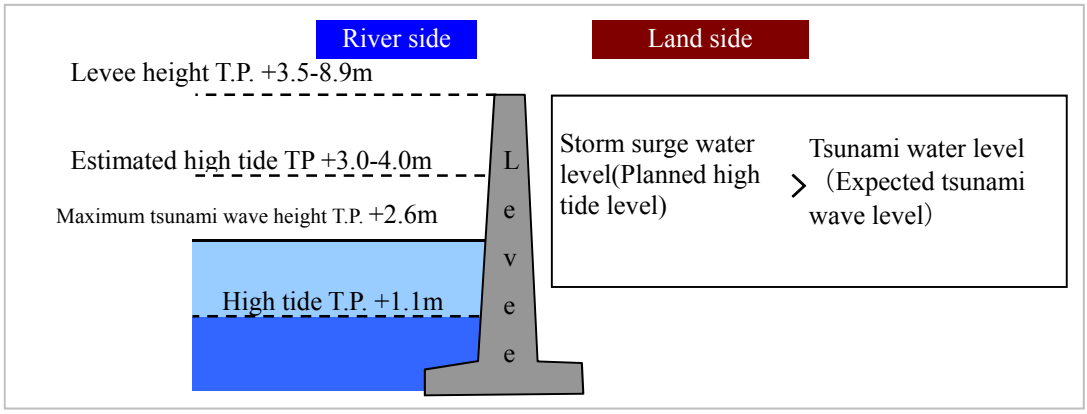

Figure 1: Tsunami and storm surge

The above assumption of maximum height of tsunami wave T.P+2.6m was based on a possible earthquake of magnitude 8.2 with an epicenter near the Sagami Trough located from the Sagami Bay to off the Boso Peninsula, as well as the biggest tsunami Tokyo suffered in history. The following is our basic course of action in each field.

◎ **Anti-quake measures**

Aseismic reinforcement of facilities should be immediately started to retain the facilities' functions even after the ground motion caused by the largest class earthquake, such as a subduction zone earthquakes of magnitude 8.2 or a possible Tokyo inland earthquake assumed by the Tokyo Disaster Prevention Council.

◎ **Anti-flood measures**

Electric and mechanical equipment of each facility, depending on its specific location and condition, should be protected from inundation to retain its function, even in the event of flooding caused by destroy of levee and water gate.

◎ **Water gate operations**

Function of backup facilities and multiplexing of communication network should be strengthened, while introduction of off-site remote control system to replace on-site manual operation should be studied. Also, information regarding weather, water level, opening/closing of water gate, etc., should be shared by using existing communication network that each facility's administrator currently operates.

Tokyo's Basic Policy for Flood Disaster Prevention Associated with Earthquake and Tsunami recommended a cross-sectional approach to the above prevention. More specifically, the policy recommended that not only the Bureau of Sewerage, but also the Bureau of Constructions and the Bureau of Port and Harbor, formulate the development

plan regarding quake-resistant and flood-resistant levees and remote control of water gate in cooperation with each other.

Under the policy, the Bureau of Sewerage formulated the development plan for anti-quake, anti-flood measures for water reclamation center and pumping station, and remote control of storm surge gate installed at storm water outlets along rivers and port areas.

3. Development plan for sewerage facilities resistant to earthquake and tsunami

(1) Protection of water reclamation center and pumping station from flooding (measures against tsunami)

The most of sewerage facilities in Tokyo are located in the inside of storm surge levee of the Tokyo Bay, and so in principle they are protected from tsunami and storm surge. However, there are possibilities that a quake-generated tsunami may destroy these levees and water gates, causing damages on sewerage systems. To prepare for such case, retention of sewerage discharging function and early recovery from tsunami disaster is desired. In this direction, the Bureau of Sewerage is formulating and implementing a series of flood-resistant measures to protect electrical equipment at water reclamation centers and pumping stations located in the areas lower than the maximum tsunami wave height in the Tokyo Bay (T.P.+2.6m) assumed by the Damage Assumption Caused by A Tokyo Inland Earthquake published by the Tokyo Disaster Prevention Council.

More specifically, the Bureau of Sewerage is installing watertight doors and water bars to the openings of doors and shutters of building. The Bureau assumed that the water level would rise gradually in flooding caused by partial damage on levee, creating no dynamic water pressure. Therefore, the water pressure at the protected height was assumed to be the hydrostatic pressure at a depth of flooding. In addition, the position of ventilation opening should be raised, so not to be affected by the maximum height of tsunami wave. The outdoor operation panel should be elevated to a higher position or replaced with water-resistant types(Figure 2).

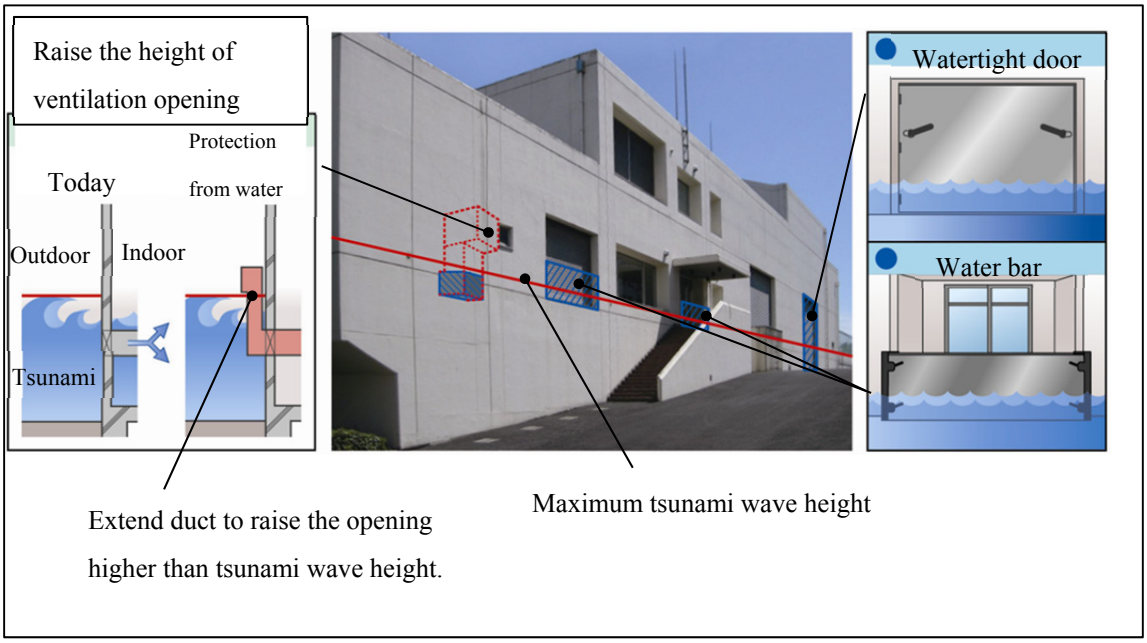

Figure 2: Pumping station protected from flooding(measures against tsunami)

(2) Backflow prevention for sewer pipe

To protect from extra-high tide induced by approaching typhoon, many storm surge gates are installed at storm water outlets along rivers and port areas in Tokyo. The gates, which are designed to prevent the backflow and flooding to sewers from increased water at rivers and port, are mostly closed by hands of operators on site.

Fortunately, during the Great East Japan Earthquake, there was no damage caused by the backflow of the tsunami in Tokyo, but the closure of storm surge gate became necessary when tsunami warning was issued. During the gate closing, however, it took some time for our operators to arrive the sites with gate closing equipment, because of delayed instruction to operators due to emergency restriction of telephone communication and heavy traffic congestion in Tokyo then. Moreover, the Great East Japan Earthquake reminded us that the manual gate operation on site is dangerous, evidenced by the victims of local gate operators during tsunami.

Therefore, in order to close the storm surge gate safely, quickly, and securely, the Bureau decided to promote automatization, remote control of storm surge gate. In converting the system into electrical operation, we specially paid attention to the location of emergency power supply, which will substitute normal power source in case of power outage. We studied the suitable place at each site to carry out the ongoing project.

Further, to respond to sudden happening and quickly arriving tsunami, remote control terminals should be installed at several offices in the Bureau of Sewerage, so that the

gate can be immediately closed according to tsunami warning, even in night or on holidays when staff is absent. In installing remote control system, laying optical fiber cable in sewer pipe, which has strong resistance to earthquake, should be positively used (Figure 3).

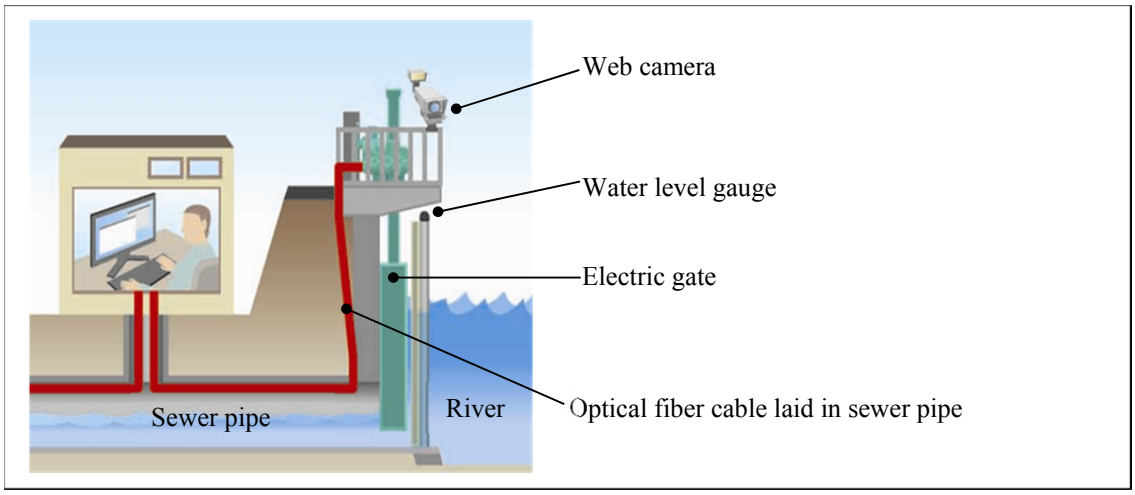

Figure 3: Remote control of storm surge gate

(3) Aseismic reinforcement of water reclamation center and pumping station

Designing of new water pumping station and water reclamation center is based on the assumption of the scale of Level 2 Ground Motion, which is not so much likely to occur during facility's service period, but has largest seismic motion. On the other hand, the aseismic reinforcement of existing facilities so far in principle is based on the scale of Level 1 Ground Motion, which is likely to occur once or twice during facility's service period, because the reinforcement in parallel with continuing operations of existing mechanical and electrical facilities is not so easy.

For future reinforcement to respond to a possible Tokyo inland earthquake, the Bureau of Sewerage reviewed its plan and prioritized the functions need to be retained as "pumping," "primary treatment," "disinfection," and "water discharge (Figure 4)." The asceismic reinforcement of the facility to perform the above function should be carried out based on the scale of Level 2 Ground Motion.

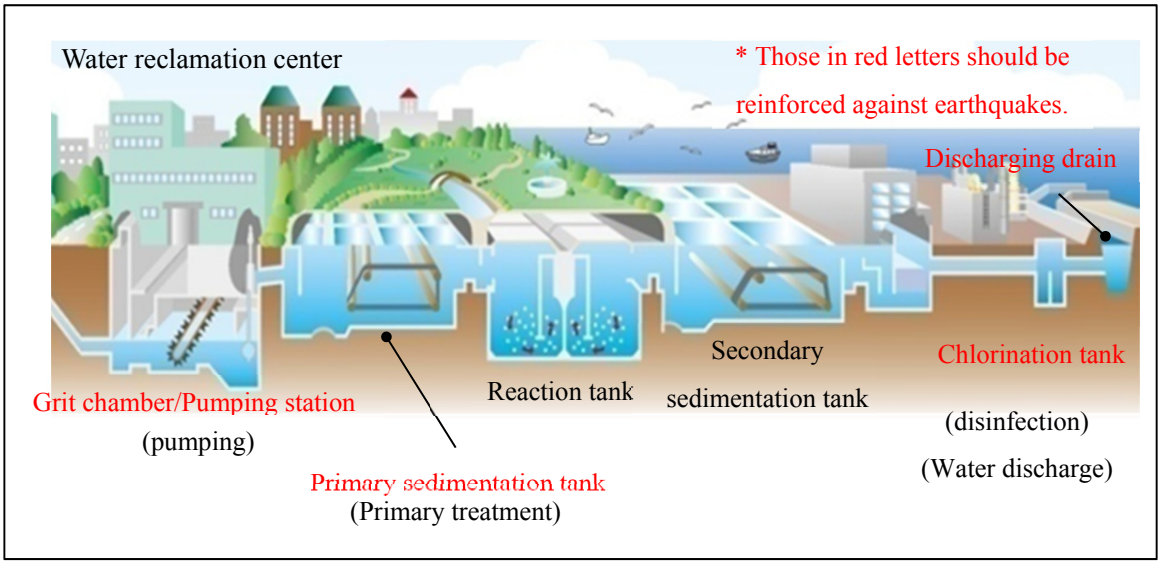

Figure 4: Facilities need to retain their functions even in disaster

4. Creating disaster-resistant Tokyo

Since the Great East Japan Earthquake hit Northeast Japan in March 2011, interest among citizens in safety and security is growing. People are expecting more quake-resistant, flood-resistant sewerage systems. In this belief, the Bureau of Sewerage is dedicated to contribute to the creation of the Disaster Resistant City Tokyo by innovating and improving sewerage system against earthquake and tsunami.

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