Sewerage facility disaster investigation and upgrading of countermeasures

1. Outline of Research and Activities

Event	Research	Reflection of results
1978 Miyagiken-oki Earthquake	1994 Investigation of sewer manholes uplifted by the Kushiro-Oki Earthquake (Wastewater System Division, Water Quality Control Department, Vibration Laboratory, Earthquake Disaster Prevention Department, Public Works Research Institute)	1981 Guidelines and Explanations for Seismic Protection of Sewerage Facilities - 1981 Edition ・Describes examples of damage to pipeline facilities
1995 The Great Hanshin-Awaji Earthquake	1997 Model vibration test on seismic uplift of pipeline facilities (Dynamics and Soils Laboratory, Seismic Technology Research Center, Public Works Research Institute)	1997 Guidelines and Explanations for Seismic Response of Sewerage Facilities - 1997 Edition ・ Liquefaction countermeasures (ground improvement) described for the first time
2001 Inauguration of NILIM	**2002** **Influence of Backfill Sand on Seismic Lift of Sewer Pipeline Facilities Effect of Backfill Sand on Seismic Surfacing of Sewer Pipeline Facilities (Soil and Ground Research Institute Vibration Team)**	
2004 Mid Niigata Earthquake	**2004** **Survey of damage to sewage pipeline facilities and emergency response at sewage treatment plants**	**2006** **Guidelines and Explanations for Seismic Response of Sewerage Facilities - 2006 Edition** **・Liquefaction countermeasures (backfill soil) are described**
2007 Noto Island Earthquake **Niigataken Chuetsu-oki Earthquake**	**2007** **Survey of damage to sewer pipeline facilities and investigation of soil quality in damaged areas** **2009** **Study on application of cementitious improved soil to backfill of sewer pipeline facilities**	**2012** **Approach to Sewage Elimination and Treatment in Times of Disaster (draft)** **・ Describes the concept of emergency measures and emergency recovery methods in the event of a disaster**
2011 Great East Japan Earthquake	**2011-12 Technical Study Committee on Earthquake and Tsunami Countermeasures for Sewerage Systems (Secretariat)** **・Recommendations for future earthquake and tsunami countermeasures**	**2014** **Guidelines and Explanations for Seismic Response of Sewerage Facilities - 2014 Edition** **・ First mention of tsunami countermeasures**
2016 Kumamoto Earthquake	**2013-15** **Research on maintenance and early restoration of minimum sewage system functions in the event of a large-scale earthquake disaster** **・Establishment and release of earthquake damage database** **・ Development of an evaluation method and damage estimation system for prioritizing earthquake resistance measures**	**2015** **Release of database on earthquake damage to sewer pipelines** **2017** **Database updated (Kumamoto earthquake damage information**
2018 Hokkaido Eastern Iburi Earthquake		
2019 East Japan Typhoon (Typhoon No. 19)	**2019** **Technical advice on damage assessment and emergency response for sewerage facilities**	

Background and Issues

- In the Niigata earthquake of June 1964, which triggered the start of full-scale research into liquefaction in residential and industrial areas, sewerage facilities also suffered damage, including the uplifting of manholes. Although the direct impact on the lives of citizens in Niigata City was limited because the sewage treatment plant had just started operations, the impact of damage has been growing as the system spreads throughout the country. As of the end of fiscal year (FY) 2028, the population penetration rate for sewerage treatment will have reached 79.7% on average nationwide, making it an indispensable facility and service for the daily lives of citizens. In the event of damage to sewerage facilities, public health and social activities could be severely impacted.
- As of the end of FY 2017, only 50% of the sewerage facilities had been earthquake-proofed based on the earthquake resistance standards, including 50% of the pipelines of important trunk lines and 36% of the sewage treatment plants. Therefore, it is necessary to promote comprehensive earthquake countermeasures that combine not only "disaster prevention" to improve the earthquake resistance of important facilities, but also "disaster mitigation" to minimize damage in the event of a disaster. Furthermore, in addition to earthquakes, sewage treatment plants are being increasingly damaged by typhoons, etc., which requires time for restoration, and emergency response and phased restoration methods have also become an issue.

Research Overview

- A survey was conducted on the damage to sewerage facilities after earthquakes and tsunamis and the soil quality related to the damage factors, which will provide basic information for enhancing "disaster prevention" measures such as making facilities earthquake-proof and tsunami-proof.
- To confirm the effectiveness of the countermeasure methods described in the "Guidelines and Explanations for Earthquake Resistance of Sewerage Facilities" (hereinafter referred to as "Guidelines for Earthquake Resistance"), we conducted a survey of areas where countermeasures had already been implemented and a survey of damage factors in areas that had been damaged again, and we examined methods for earthquake resistance, including ensuring construction quality. In addition, we examined tsunami countermeasure methods after organizing basic concepts such as functions that must be maintained even in the event of damage and functions that must be restored quickly, although temporary suspension of functions is acceptable.
- When a sewage treatment plant loses its function due to damage caused by a tsunami or flood and it takes time to complete the main restoration, a method to gradually improve the quality of the discharged water was studied to minimize the impact on the water body to which the water is discharged.

Social Implementation

- In the case of earthquake and tsunami damage to sewerage facilities, we provide technical advice for emergency restoration and main restoration. In addition, research results on liquefaction countermeasures and tsunami countermeasures have been reflected in the revision of the earthquake resistance guidelines.
- In the case of flood damage at sewage treatment plants, which have recently become more severe, we provide technical advice on emergency restoration. In addition, we are conducting pilot plant experiments on sedimentation treatment and disinfection in emergency restoration in order to improve efficiency and speed up the restoration process.

2. Main Research Results

1: Reflected in the "Guidelines and Explanations on Seismic Countermeasures for Sewerage Facilities"

・In the 2004 Niigata Chuetsu Earthquake, liquefaction of backfill soil caused pipelines to rise to the surface, so countermeasures against liquefaction of backfill soil were additionally described in the H18 Seismic Guidelines. The main restoration of pipeline facilities in the Niigata Chuetsu Earthquake was carried out with measures for solidification, and no major damage occurred in the 2007 Niigata Prefecture Chuetsu Offshore Earthquake.

・The Great East Japan Earthquake of 2011 caused tremendous earthquake and tsunami damage, the likes of which sewerage facilities have never experienced in the past. At the same time, we recognized many issues and gained knowledge on how to execute the design for seismic and tsunami resistance in the future.

・In areas where the seismic retrofitting method was implemented, there was no major damage such as traffic obstructions or flow obstructions, indicating that the method was effective to some extent. However, some of the pipelines did not meet certain standards required to prevent liquefaction due to construction and construction management problems, including cases of incorrect construction due to a lack of understanding of the construction method. Therefore, we proposed a construction management method by conducting backfill soil compaction experiments on pipeline facilities in order to study construction methods and quality control methods suitable for restoration work, and this method was reflected in the seismic guidelines.

・ Disaster prevention measures for sewerage facilities have mainly focused on earthquake countermeasures, and tsunami resistance measures have not been discussed. Therefore, we proposed measures for this restoration, including (1) the concept of an assumed tsunami in the sewerage facility design, (2) the concept of tsunami resistance performance in sewerage facilities, and (3) the concept of tsunami resistance countermeasures, which were reflected in the earthquake resistance guidelines (Figure-1).

<table>
<tr><td>施設種別</td><td>管路施設</td><td>ポンプ場</td><td colspan="3">処理場</td></tr>
<tr><td rowspan="3">機能区分</td><td colspan="5">全体機能</td></tr>
<tr><td colspan="3">基本機能</td><td colspan="2">その他の機能</td></tr>
<tr><td>逆流防止機能</td><td>揚水機能</td><td>揚水機能
消毒機能</td><td>沈殿機能
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許容するものの
「早期に復旧」</td></tr>
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Figure-1 Typical tsunami resistance of sewerage facilities to "Maximum Class Tsunami"

2: Publication and Updating of Earthquake Damage Database

・ Although damage data on sewer pipelines during past earthquakes is useful information for damage estimation, etc., it has not been consolidated and has been stored separately for each earthquake. Therefore, we again collected information on damage to sewer pipeline facilities (about 50,000 spans) for 12 earthquakes of intensity 6 or higher that occurred from 1993 to 2011, and we constructed and published a database. Damage information (approximately 2,000 spans) from the 2016 Kumamoto earthquake was also added.

・ The database contains earthquake information (seismic intensity, magnitude, SI), ground information (ground type, microtopography classification), sewer information (soil cover, pipe type, pipe diameter, manhole type, etc.), and damage information (damage status and extent) organized by span (Figure-2).

・ It is important to incorporate a risk assessment perspective in the evaluation of earthquake resistance priorities, and sewage operators can now evaluate the likelihood of damage to their facilities based on the database, taking into account geotechnical information and other factors.

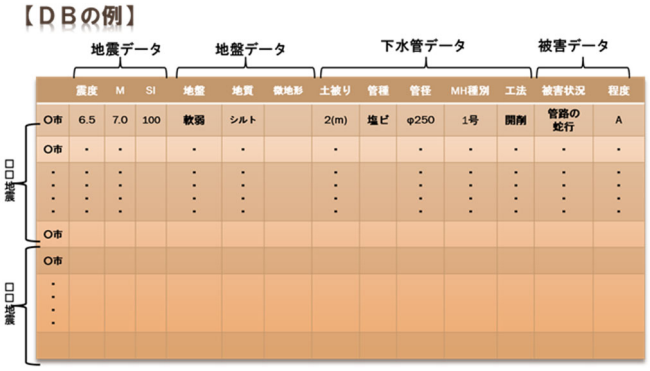

Figure-2 Outline of Earthquake Damage Database

3. Approach to Elimination and Treatment of Sewage in Times of Disaster (Draft)

・In cases such as the Great East Japan Earthquake, where the damage is so extensive that all treatment functions are lost, it is expected to take a considerable amount of time before restoration is completed, and it is undesirable to continue discharging water in the state of emergency measures.

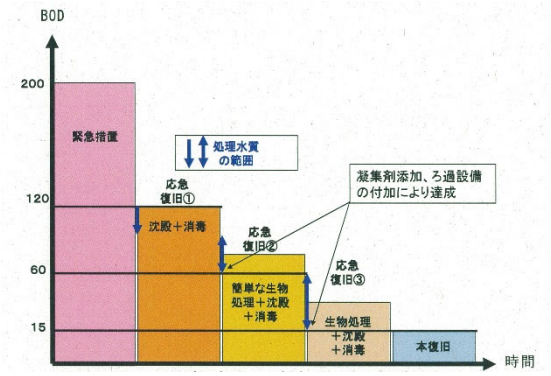

Figure-3 Conceptual diagram of target water quality and emergency restoration

・ The National Research Institute (NRI) has studied how to secure the minimum sewage removal and treatment functions required in times of disaster on an emergency basis according to the situation on site, and how to gradually improve the treatment level before the main restoration work begins. They have compiled and published the "Draft Concept on Sewage Removal and Treatment in Times of Disaster" (Figure 3).

4. Response to Typhoon No. 19 in East Japan in 2019

・Record-breaking rainfall caused by Typhoon No. 19 (October 10-13) caused extensive damage to sewerage facilities throughout Japan.

・On October 23-24, a field survey was conducted to assess the emergency response status of treatment and pump station facilities that had not yet returned to normal operation and to provide technical advice on emergency response.

Figure-4: Abukuma River Basin sewerage system, Kenpoku Sewage Treatment Center (Fukushima Prefecture) Survey Status

・ The targets were the Abukuma River Upper Basin Kenpoku Sewage Treatment Center (Figure 4), pumping stations in Motomiya City, Koriyama City, and Iwaki City in Fukushima Prefecture, and vacuum sewage facilities in Koriyama City, where we provided advice on thickening and dewatering methods for decomposing sludge that is difficult to treat.

・Since the disinfection effect may be insufficient depending on the properties of precipitation-treated water or simple treated water, we are clarifying the behavior of inhibiting factors of the disinfection effect at sewage treatment experimental facilities

and studying countermeasure methods for treatment and disinfection of sewage according to recovery conditions for the purpose of revising the "Draft Policy on Elimination and Treatment of Sewage in Disaster Situations."

3. List of Related Reports and Technical Documents

1) "Niigata Chuetsu-oki Earthquake Damage Survey Report," NILIM Technical Note No. 439
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0439.htm
2) "Report on the Application of Cementitious Improved Soil to the Backfill of Sewer Pipeline Facilities," NILIM Technical Note No. 531
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0531.htm
3) "Preliminary report on the 2011 off the Pacific coast of Tohoku Earthquake disaster investigation of civil engineering facilities," NILIM Technical Note No. 646
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0646.htm
4) "The National Institute for Land and Infrastructure Management (NILIM)'s response to the Great East Japan Earthquake of 2011: A record of activities related to emergency response and technical assistance for recovery and reconstruction," NILIM Research Report No. 52
http://www.nilim.go.jp/lab/bcg/siryou/rpn/rpn0052.htm
5) Database of earthquake damage to sewer pipelines
http://www.nilim.go.jp/lab/ebg/zishin_db.html
6) "Approach to Sewage Elimination and Treatment in Times of Disaster (Draft)"
http://www.nilim.go.jp/lab/ecg/doc/publish/saigai_01.pdf

4. Future Outlook

In preparation for possible future earthquakes, such as a Nankai Trough earthquake or an earthquake directly under the Tokyo metropolitan area, we will enhance our earthquake damage database by adding information on damage from the Fukushima Prefecture earthquake in order to promote earthquake resistance measures.

In addition to flood damage in urban areas, sewage treatment facilities have also been damaged, requiring time for functional restoration. As well as preventing damage, it is also necessary to study emergency measures and phased restoration methods in the event of damage.