Stock management of sewer pipelines

1. Outline of Studies and Activities

Planning support	Survey implementation support	Reflection of results

2005-07 Study on life extension of pipeline facilities
- Consideration of deterioration detection rate and deterioration items
- Estimation of corrosion and load carrying capacity of reinforced concrete pipes due to hydrogen sulfide
- Study of measures to prevent inflow of building pit wastewater containing high concentrations of hydrogen sulfide

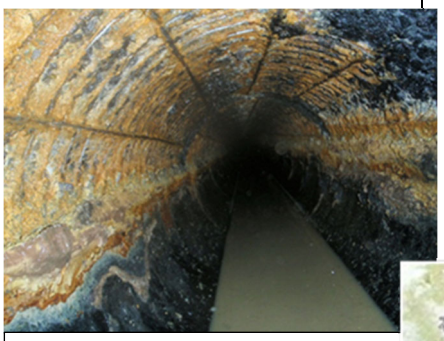

Photo-1 Example of corroded (brown area) sewer pipe (hume pipe)

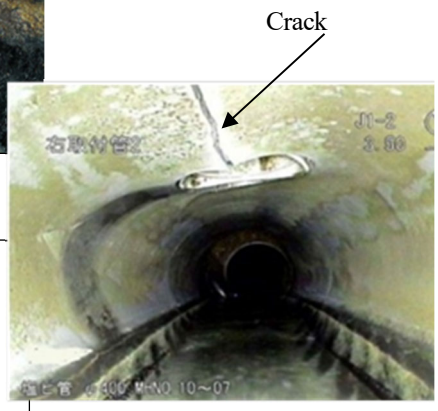

Photo-2 Example of damaged sewer pipe (PVC pipe)

2007-09 Social impact study on road cave-ins caused by sewers, etc.
- Analysis of national trends in terms of elapsed years, pipe types, etc.
- Study on failure risk assessment methods

2008-09 Study on the introduction of stock management of sewer pipes
- Creation of a formula for predicting the rate of soundness
- Consideration of survey frequency

2010-12 Study on the promotion of the introduction of sewer pipe stock management
- Update and improvement of soundness prediction equations
- Evaluation of reconstruction methods, etc.

2010-12 Development of inspection and monitoring technologies for preventive maintenance management of social infrastructure
- Evaluation of the effectiveness of screening surveys
- Performance evaluation of simple survey methods

2013-16 Development of information storage and utilization technology for efficient and advanced maintenance and management of social infrastructure, etc.
- Investigation of performance requirements for survey equipment

2013- Study on the promotion of introduction of stock management of sewerage pipelines, etc.
- Update and improvement of soundness prediction equations
- Evaluation of reconstruction methods, etc.
- Examination of screening methods
- Study on maintenance and management methods for hard bituminous pipes

2018-19 Research on comprehensive management for sewer pipelines
- Development of a method for selecting inspection and survey techniques according to the actual conditions of a city
- Proposal of optimal repair/reconstruction technology selection method according to deterioration conditions, etc.

2014 Guidelines on Sewerage Maintenance
- Publication of the investigation judgment criteria and urgency judgment criteria concerning rigid PVC pipes

2015 Revision of the Sewerage Law
- Establishment of maintenance and repair standards
- Expansion of the business plan to include maintenance, repair, and reconstruction

2015 Guidelines for Implementing Stock Management of Sewerage Projects
- Posting of soundness rate prediction equations

2020 Guidelines for establishing management starting from maintenance management information (pipeline facilities)

Background/Issues

- As a result of many years of investment and effort, the population coverage rate for sewerage treatment reached 79.7% at the end of FY2028, with a total pipeline length of 480,000 km and approximately 2,200 treatment plants, making life with a sewerage system the norm in many areas of Japan.
- The stock of sewerage facilities was intensively developed from the 1960s to 1998 and is expected to rapidly age in the future. On the other hand, the financial situation of sewerage operators is becoming tighter and tighter due to the decrease in usage fee revenue caused by the declining population, resulting in a shrinking capacity for investment.
- In light of the above, it is important to sustainably provide high-quality sewerage services through strategic maintenance, repair, and reconstruction, such as reducing the life cycle cost of sewerage facilities and ensuring safety through the introduction of preventive maintenance type facility management.
- In particular, since the aging of facilities has become a serious problem, with approximately 3,000 road subsidence accidents occurring annually due to damaged pipeline facilities, it is essential to conduct more efficient and effective inspection and investigation based repair and reconstruction of the vast stock of pipelines.

Research Overview

In response to the above situation, the National Research Institute (NRI) conducted the following studies on pipeline stock management.

- From a macroscopic perspective, we have developed a soundness rate prediction method to support the establishment of scenarios for long-term reconstruction projects and inspection and survey plans. We have compiled the results of surveys of pipeline facilities and published a database of pipe deterioration. The soundness rate prediction method is used as a demand forecasting method for long-term reconstruction in the “Guidelines for Implementation of Stock Management of Sewerage Projects - 2015 Edition” (Ministry of Land, Infrastructure, Transport and Tourism, Sewerage Department, National Institute of Advanced Industrial Science and Technology, Sewerage Research Department). In addition, the pipe deterioration database is used by local governments to create their own soundness rate curves tailored to urban conditions when conducting stock management studies.
- From a microscopic perspective, we are developing screening techniques and new methods to improve the efficiency of inspections and surveys. We are also preparing draft judgment criteria for the survey results and conducting surveys and research on the recording and utilization of maintenance management information. The draft criteria for the judgment of survey results were adopted and published in the “Sewerage Maintenance and Management Guidelines - 2014 Edition” (edited by the Japan Sewage Works Association, hereinafter referred to as the “Maintenance and Management Guidelines”), which include the judgment criteria for inspection survey results and the urgency judgment criteria for hard polyvinyl chloride pipes, which were previously judged based on the same criteria as reinforced concrete pipes.
- In addition, the “Guidelines for the Establishment of Management Based on Maintenance Management Information (Pipeline Facilities)” (Ministry of Land, Infrastructure, Transport and Tourism, Sewerage Department, National Institute of Sewerage Research) reflects the results of research on the recording and utilization of maintenance management information.

2. Main Research Results

1. Nationwide survey of road cave-ins caused by sewers

- The number of cases of sinking roads caused by sewerage systems that occurred from 2006 to 2009 was analyzed in terms of the number of years elapsed since the pipe installation, the pipe type, pipe diameter, month of sinking, and causative facilities (main pipe related, pipe installation related, manhole related, and catch basin related).
- The number of road cave-ins tends to increase with the number of years elapsed since the pipe installation, and in particular, the percentage of cave-ins increases significantly when the number of elapsed years exceeds 30 (Figure-1).
- The number of road cave-ins tends to concentrate in and around the summer season. This may be due to the softening of asphalt caused by high temperatures and the expansion of underground cavities caused by the rise and rapid fluctuation of the groundwater table due to typhoons and other factors.
- The most frequent cause of sinking was mounting pipes, which accounted for about half the total number of sinking.

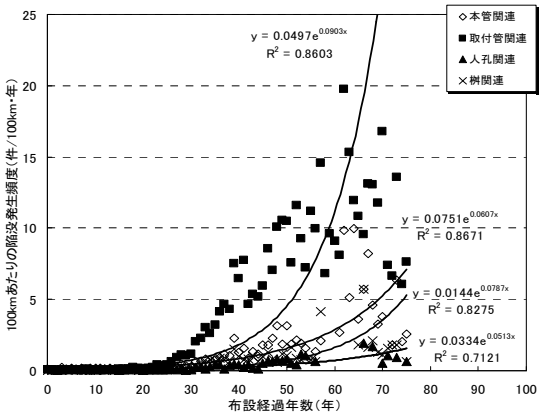

Figure-1 Relationship between the number of years since the pipe installation and the number of cases of sinking per 100 km of pipe

2. Creation of survey judgment criteria and urgency judgment criteria for rigid PVC pipes

- Rigid pipes such as reinforced concrete pipes and plastic flexible pipes such as rigid polyvinyl chloride (PVC) pipes are the main pipes used in sewers. Since the structure and materials of these pipes are very different, the characteristics of the pipe deterioration are also different. However, the current judgment criteria are mainly designed for rigid pipes such as reinforced concrete pipes, which were developed earlier.
- In order to establish investigation judgment standards, etc. for rigid PVC pipes, performance tests such as the flattening test (Photo-3) were conducted in accordance with the Japanese Sewerage Works Association standards for pipes with axial and circumferential cracks, followed by structural analysis. Based on the results, draft standards were developed and reflected in the maintenance and management guidelines (Table-1). Furthermore, the urgency (timing of repair, etc.) for the entire span was determined and used to establish the level of repair.

Photo-3 Flattening test conditions

Table-1 Proposed new judging criteria

	項目	a	b	c
管1本ごとに評価	管の破損及び軸方向クラック	亀甲状に割れている	—	—
		軸方向のクラック		
	管の円周方向クラック	円周方向のクラック幅5㎜以上	円周方向のクラックで 幅：2㎜以上	円周方向のクラックで 幅：2㎜未満
	管の継手ズレ	脱　　却	接合長さの1／2以上	接合長さの1／2未満
	偏平	たわみ率15%以上の偏平	たわみ率5%以上の偏平	—
	変形 （内側に突出し）	白化または本管内径の 1／10以上内面に突出し	本管内径の 1／10未満内面に突出し	—

3. Study of prediction method for failure length of sewer pipelines

- However, it is difficult to survey all of them in a short period of time due to the financial situation of each city. Therefore,

we studied the soundness rate prediction formula (a method for predicting the current and future failure lengths) to estimate the deteriorated condition of pipe culverts macroscopically in small- and medium-sized cities, where survey data is not accumulated.

- In order to develop the prediction formula, about 150,000 spans were extracted from the results of in-pipe surveys of about 170,000 spans obtained from 12 sample cities, excluding those with an extremely small number of spans by the number of years elapsed since the pipe installation in each city, where the type of pipe, the number of years elapsed since the pipe installation, and the degree of urgency were known.
- The soundness ratio is the ratio of the number of healthy spans (of a certain urgency rank or higher) to the total number of spans, and is plotted for each elapsed year to approximate the soundness ratio (Figure-2).
- The data from TV camera surveys, including pipe diameters, soil cover, and other parameters, is made public as a database of pipe deterioration, and is used by each sewerage utility to formulate highly accurate reconstruction project plans by creating soundness rate prediction equations suited to the regional characteristics.

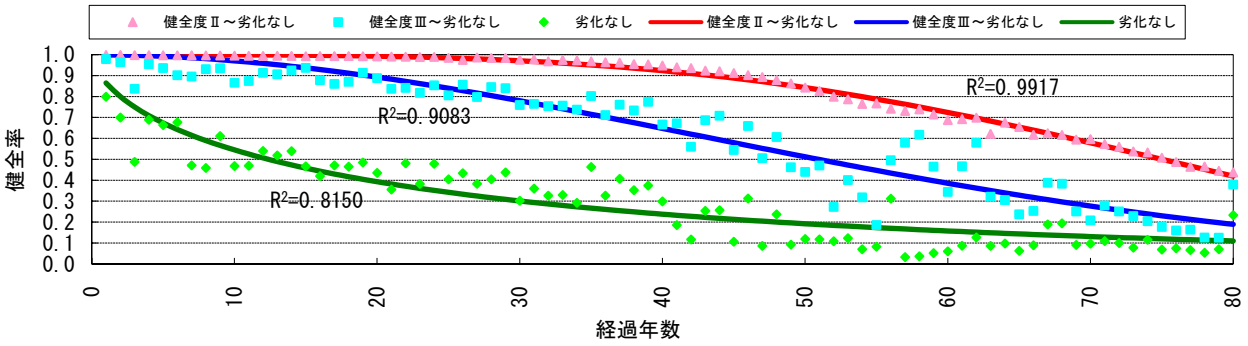

Figure-2 Example of soundness curve (public sewers, all pipe types, Weibull distribution formula)

3. List of Related Reports and Technical Documents

1) "NILIM Project Research Report" NILIM Technical Note No. 668
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0668.htm

2) "Study on the omen phenomenon discovery technique using the MMS of cave-in caused by sewer system - Joint research of a new efficient technique for the inspection of sewer pipe lines" NILIM Technical Note No. 750
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0750.htm

3) "Development of efficient inspection camera and simple criteria for abnormality classification of sewer pipe - Joint research of a new efficient technique for the inspection of sewer pipe lines" NILIM Technical Note No. 877
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0877.htm

4) "Study on developing criteria for abnormality and urgency classification of polyvinyl chloride pipes" NILIM Technical Note No. 878
http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0878.htm

5) "Development of Inspection and Monitoring Technology for Preventive Control of Infrastructure" NILIM Project Research Report No. 50
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0050.htm

6) "Development of Technologies for Accumulating and Utilizing Information in Order to Streamline and Upgrade

Maintenance of Social Capital" NILIM Project Research Report No. 63
http://www.nilim.go.jp/lab/bcg/siryou/kpr/prn0063.htm
7) Guidelines for the Implementation of Stock Management in Sewerage Projects - 2015 Edition
https://www.mlit.go.jp/common/001110722.pdf
8) Guidelines for Establishing a Management Cycle Based on Maintenance and Management Information (Pipeline Facilities) - 2020 Edition
https://www.mlit.go.jp/mizukokudo/sewerage/content/001338731.pdf

4. Future Outlook

Further data accumulation, analysis, and screening survey methods need to be established in order to efficiently survey the deterioration status of individual sewage pipes.

- Accumulation and analysis of soundness rate data, focusing on missing data such as for PVC pipes
- Study on the concept of screening methods and specific screening survey methods
- Study on how to record and utilize maintenance and management information