

Systematic and Efficient Reinstallations of Sewers Culverts in the Tokyo 23 Wards

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Urban sewer system had completed almost 100% in the Tokyo 23 wards by the end of 1994. However, the development of the urban sewer system started in the Meiji Period, and due to the aging of that system, many problems like cave-ins in the roads have appeared seriously.

Sewer system is an indispensable infrastructure to secure a healthy and civilized living environment and also a clean and safe water environment in an urban life. Despite financial constrains, the Tokyo Metropolitan Government has to do proper maintenance, repair and renewal of the sewer system in order to maintain and improve the quality of services.

The metropolitan government has been conducting a full-scale reconstruction of aged sewer culverts since 1995. This paper presents their methods, techniques and technologies of the sewer culverts installations.

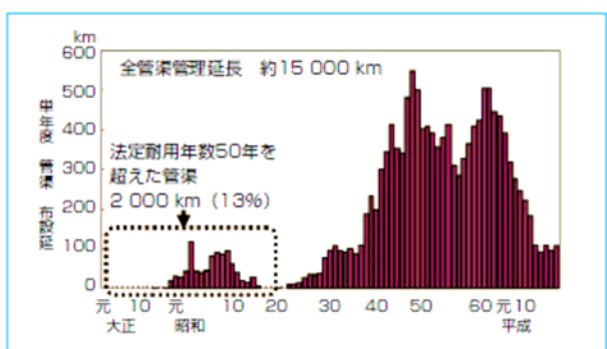


Figure 1: Yearly length of sewer culverts installation

Challenges to the Aging of Urban Sewer System and Reinstallations

Road Cave-ins

The development of sewer system was made with a focus on the central areas in Tokyo at first: sewer network expanded to about 2,000 kilometers before the WWII. The sewer culverts installed under the Taito, Chiyoda and Chuo wards are aging rapidly, about 80 % of which have served for fifty years and longer now.

The major problem caused by the aging of sewer culverts is road cave-ins: more than 1,000 cave-ins per year are reported within the entire wards, which have affected to the people's daily lives.

Figure 2 shows the relationship between the average age of the sewer culverts and the cave-ins caused by those culverts' deterioration by ward. The deterioration is caused by not only aging, but possibly the constructions done by companies other than the metropolitan government, the amount of traffic above ground, improper constructions and the poor quality of the culverts' materials. As the figure shows, the areas in which sewer reinstallations were done earlier such as Chiyoda, Chuo and Taito wards have a greater chance of road cave-ins than any other wards.

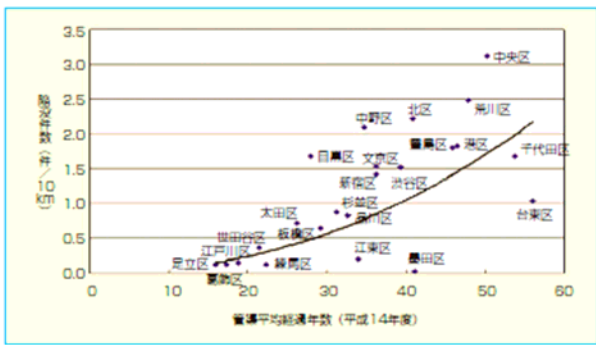


Figure 2: Relationship between the average area of the sewer culverts and the cave-ins



Figure 3: Four designated blocks in central Tokyo as the first installation area

Insufficient Sewer's Performance to Drain Rainwater

The metropolitan government has developed the sewer system to deal with the hourly rainfall intensity of 50 mm. However, along with rapid urbanization of the city, the amount of flow of rainwater into the sewer system has been increasing, in mainly the areas where sewer system has been laid for a long time, the system is not capable to fully deal with the flow of rainwater: to make things worse, several regional torrential rainfall have triggered floods during the rainy season to autumn. Accordingly, while the index for rainfall control on the sewer system has stayed the hourly rainfall intensity 50%, the one for rain runoff has moved up to 80% from 50%, in order to

compensate for the insufficient performance of the sewer system.

What is Reconstruction of Sewers for?

To solve the problems discussed above, culvert installations are to be done for not just renewing the aged sewers, but also strengthening their poor performance, but also improving the function by implementing anti-seismic reinforcement and improving combined sewerage. Currently, in the four designated blocks, about 16,300 hectares, in central Tokyo, as the first reinstatement area, the reinstations of sewer culverts have been ongoing, which had been completed in about 1,053 hectares, equal to 6% of the entire designated blocks by the end of 2002.

Reconstruction Planning and Technologies

In the sewer culvert reinstations, efficiency and cost performance are emphasized on; on the premise of utilizing healthy existing sewer culverts as much as possible, the metropolitan government has considered culvert reinstations to be done by area, paying attention to traffic volume on the ground and the buried objects by other corporates, while inspecting the progress of aging and performance of discharging water throughout the sewer network. Based on the data of the inspections, the sewer culverts to be used in the reinstations can be divided into 4 categories:

to be remained, to be rehabilitated, to be newly installed (e.g. enlarging and bypassing) and to be replaced. Considering the conditions of those culverts, the metropolitan government plans and conducts reinstatement projects with chosen applicable methods and comparison of costs as well.

As to the sewer culvert reinstallations, the influences upon the neighborhood residents and road traffic on the ground should be controlled as little as possible because the area where reinstallation work will be done are under the fully developed towns and have various underground installments. The metropolitan government, solving these concerns, has developed a non-cut-and-cover method and operated the reinstallations with the method. The non-cut-and-cover method is not only highly efficient and cost-performance, but also environment-friendly in that it produces few construction by-products such as asphalt clusters and concrete chunks.

The method initially could be employed to install only the pipes with small cross-sectional area, but it has been improved to be able to use in the pipes with wider, or rectangular cross-section.

In addition to that method, the metropolitan government developed another method in cooperation with private sectors in 2003, which works for those culverts with sharp curves and the difficulty of securing pit space. The method has made it possible to scale down the finishing outer diameter by over 400 mm, from 2750mm to 2300mm of a shield tunnel, the finishing inner diameter of which is 2000mm. At the same time, they try to reduce construction costs, work schedule and excavation waste soil.

Optimization of Sewer Inspection and Utilization of Sewer Culverts Inspection System

It is important to know exactly current

conditions of aging sewer culverts to reinstall them systematically and efficiently along with a shift to sewer repair and maintenance management. The Tokyo Metropolitan Government has carried out sewer culverts' interior inspections with video cameras since 1982 and had completed the inspection of 6,900 kilometers, 45% of the entire sewer culverts by the end of 2002. They also have been employing digital technologies for the culverts interior inspections, which will significantly contribute to efficiency of inspections, more accurate damage evaluations and more effective database search. The metropolitan government has established the sewer inspection systems that collect the data on damages together with the data on road cave-ins and flooded conditions and has utilized that system for effectively and efficiently operating reinstallations such as pinpointing the damaged and deteriorated parts to be repaired any time soon.

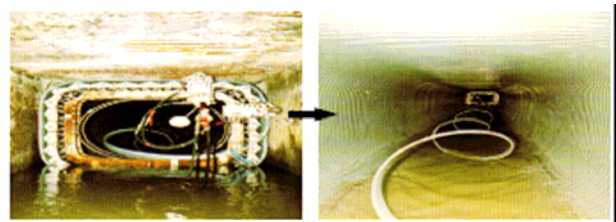


Figure 5: SPR (Sewage Pipe Renewal) method for mixed shape of pipes

Procedures for Future Reconstruction Projects Analysis of Life Cycle Cost (LCC) and Consideration of Project Leveling

Sound, or slightly damaged and deteriorated sewer culverts are used for many years by getting repaired to extend their serviceability. However, the costs for their repair and maintenance increase along with their progressive aging, and some need to be

replaced in case they are seriously damaged. In order to identify when is the best time to get sewer culverts replaced from an economic standpoint, an analysis of the sewer culverts' LLC in the 23 wards was done, and the result suggested that a culvert should be replaced in seventy-second years after its installation.

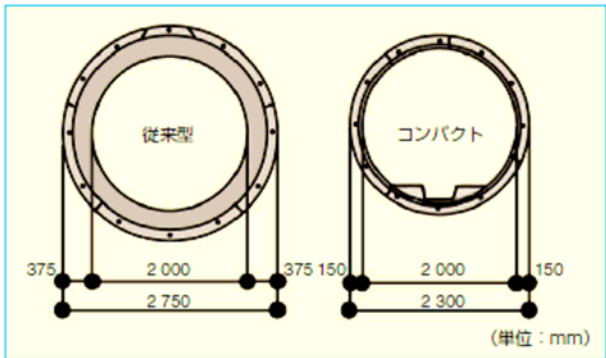


Figure 6: Sections of conventional shield (left) and compact-shield (right)

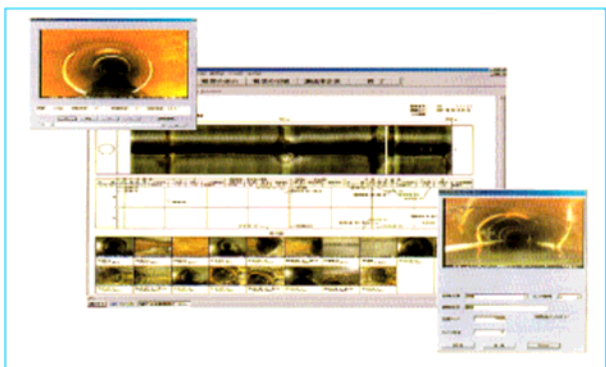


Figure 7: Digitalization of sewer culverts inspection

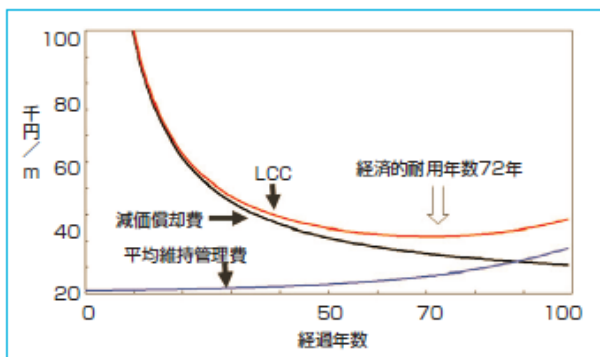


Figure 8: LCC of sewer culverts

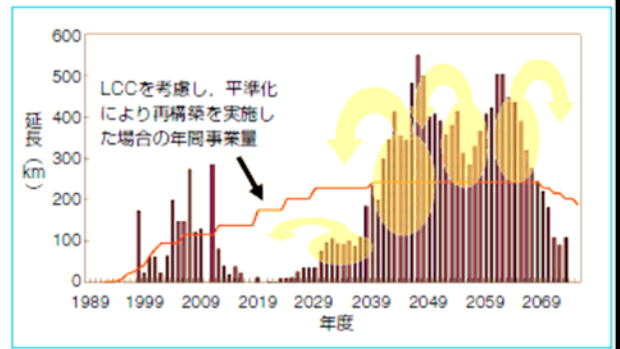


Figure 9: Reinstallation plan based on the leveling of repair and maintenance projects for LCC standpoint

Table 1: Main items of "Reinstallation Quick-Plan"

	対策内容
道路陥没対策	・道路陥没多発地区での再構築 (273ha) ・国道・都道の老朽化対策 (50km) ・下水道老朽幹線の更生 (5.5km)
臭気対策	・水再生センター・ポンプ所での臭気防止 (14施設) ・市街地における臭気苦情多発地区での民間ビルビットの維持管理指導 (76ha)
震災対策	・避難所等の排水を受入れる管渠の耐震化 (約500か所)

Meanwhile, it is unpractical to replace the sewer culverts running under the 23 wards by age automatically because reinstallation peak times come in the course of repair and maintenance: in the years when the most culverts were installed, over 500 kilometers of culverts were installed a year, could cover about 2,000 hectares of area. Fig-9 shows a reinstallation plan made based on the leveling of repair and maintenance projects and a consideration of the 72 year serviceability period from the LCC standpoint, along with the past operations of repair and maintenance. Even if the plan is carefully made, the culverts to be redone a year can be about 225 kilometers long, which will cover about 900 hectares of area.

Highly Efficient and Cost Performance Methods: Introduction of Pre-Sewer Management against the Aging of Sewer Culverts

In next 10 years, voluminous sewer culverts

installed after the rapid economic growth period will reach the age of calculated serviceability one after another while investments in constructions have been decreasing. Even if reinstallation projects are leveled carefully based on a LCC analysis, it is not easy to reinstall the old culverts timely. Given this situation, the metropolitan government has to consider about the reinstallation projects in terms of efficiency and cost performance.

Moreover, past reinstallations of sewer culverts have been done in lower to upper river regions to cover culverts' deficiency; however, in the areas where road cave-ins occur often, it is an urgent task to apply measures against the progressive aging of culverts.

The metropolitan government has collected the data on the areas which have suffered from floods recently: in the areas which less urgently need for flood control measures, they have decided to take step-by-step approaches of maintenance prior to taking measures against the aging of the culverts, but not to improve culvert drainage performance.

That step-by-step approaches of maintenance offers the advantages of more flexibility in choosing culverts to reinstall, shorter construction periods and less than half the construction costs than conventional reinstallations need. With those approaches, the metropolitan government has planned to redo the sewer culverts in about 3500 hectares of the first section 16300 hectares of reinstallation.

However, they need to record the details of the reinstallations done in two levels, which will be helpful to further consider how to improve their maintenance skills and technologies. They have another issue to solve: given that a flood occurs after sewer culverts are repaired, they have to devise some measures to cover their insufficient performance such as installing bypass pipes and looping with storage.

Sewer Culvert Reinstallations from Short-Term Viewpoint: Reinstallation Quick Plan

Sewer culvert reinstallations work well when the sewer facilities installed in lower river regions are repaired and maintained properly first and then ground surface are in order to solve sewer culverts' poor performance, and till then it requires a good amount of time and costs.

Thus, taking another approach, the metropolitan government has drawn up "Reinstallation Quick-Plan" for the five years starting from year 2000, and worked based on that plan with close attention to each region and each facility to solve such the issues disturbing people's daily lives as road cave-ins, odor pollution and earthquakes for that short period, by using the step-by-step approaches of maintenance as well.

Since the implementation of the reinstallation quick plan, that government has been successfully produced positive results: for instance, regarding road cave-ins, they had completed 30 % reinstallations of culverts and reduced the occurrence of road cave-ins by half in target areas by 2003.

Currently, they have been reviewing that quick plan to revise towards its completion in 2004.

They try to enhance the quick plan more effectively by identifying the causes of cave-ins, which tend to occur at the lateral sections linking houses and culverts, and devising maintenance approaches like doing the renewals and replacements of laterals in a specific area intensively.

Future Challenges

Needs for reinstallations of sewer culverts will increase further and never stop. Given that, the metropolitan government has not only continued the conventional manner of culvert reinstallations from mid- and long-term viewpoints, but also carried on the step-by-step approach of maintenance against the aging facilities fully and revised the quick-plan from a short-term viewpoint so as to operate reinstallations more efficiently and economically.

Last, they take their responsibility to ensure daily repair and maintenance on the facilities, to make efforts continuously to develop new skills and technologies and to maintain and improve the quality of services to the public.