Sewer Management in Japan –an overview

Takashi SAKAKIBARA, Head
Wastewater System Division
National Institute for Land and Infrastructure Management
Ministry of Land, Infrastructure, Transport and Tourism

1. Sewers in Japan

Japan has been working on expansion of sewer network seriously for the past century. The sewered population rate reached 72% in 2007 (slide4). This 72% includes only sewers under the sewerage law of MLIT. If sewers under other laws and onsite system are included, sanitary treatment rate was 84%. It seems that Japan has almost caught up with US in accessibility to sanitation. It was our big dream for many years.

In the same time, Japan has been investing a lot of money for the expansion of sewerage system. Especially in the 1990’s, capital expenditure grew and reached almost 5 trillion yen or 50 billion dollars per year in 1998 (slide5). After the year 2000, capital expenditure started declining suddenly. This is largely because our government changed the public investment policy. Public investment has been reduced as part of restructuring program.

Japanese sewers are younger than American sewers. Intensive investment for installation started after 60’ in Japan while in the US it started in the 50’s (slide 6). In addition, in the US, sizable amount was installed even before the 40’ while Japan did only little during the time. The GAP analysis document shows that average age of sewer network is around 40 in the US, while 16 in Japan. Thus the magnitude of aging problem might be much smaller in Japan.

2. Sewer Asset Management

Currently, different attitude for O&M of sewers are seen between big cities and small-medium municipalities. Big cities try to maintain sewers with much effort. They have relatively enough human and financial resources while facing aging problems as immediate threat. However, those with experience in O&M are retiring and new hiring is almost frozen due to downsize program of each municipality. On the other hand, small-medium municipalities do not set aside resources for O&M. They say they are still busy for expanding networks. Consequently, O&M of sewers are neglected.
MLIT has been conducting national survey on cave-ins from failed sewers since 2005 because such problem has grown serious. The increase of the cave-ins is observed (slide 9).

Our research examined furthermore where cave-ins occurred. Failed parts were categorized into four groups. They include public sewer, lateral, manhole, and cleanout (slide 11). We found that laterals were blamed most and that frequency and age of public sewers are exponentially related (slide 12).

Although aging problems are on the rise, national O&M expenditure is flat or downward in recent years (slide 13). This may cause difficulty in future generation.

What are big cities with a population of one million and over doing for asset management? We asked them 7 simple questions. We found out that they emphasize long term budget planning, database build-up, and setting target life for sewers (slide 14). However, they see the decay curve and LCC of less importance. In our view, both long term budget plan and target life are goals while the decay curve and LCC are tools for justification. They need to put more emphasis on tools as well. Otherwise, the goals cannot be justifiable to those who are mandated to reduce the budget.

3. Research Topics-Macro and Micro approaches

Our prime research goal is to give justification basis for long term sewer rehabilitation budgeting by municipalities. The other important goal is to develop prioritization method to select sewers for condition assessment and rehabilitation works. The former is macroscopic and the latter is microscopic approaches.

3.1 Average Survival Curve (ASC)

The justification for long term rehabilitation budgeting relies on average survival curve (ASC). The ASC is the integration or multiplication of survival curve using survey data (SCS) and survival curve using rehabilitation data (SCR). The SCS is common approach to draw survival curve. However, it is underestimation of failures for two reasons. One is because condition is rated at the time surveyed. Failure surely happened before the time of survey. Second is because rehabilitated sewers are excluded from the condition assessment program. In other words, still-existing old sewers are ‘stronger’. That is why they still exist. The weaker sewers, which started to be used in the same year as stronger sewers, have already got rehabilitated. The ASC needs to show how fast sewers become conditions in need of rehabilitation. Then, the SCR comes to remove the second bias. To draw the SCS, 2,700km of condition assessment data were used. To draw the SCR, all sewers ever installed in Japan were surveyed. This survey revealed how many kilometers of sewers were rehabilitated by
municipality, age, and material type.

The result of SCS shows constant decrease of survival rate till around 50 years old (slide 18). After 60 years, the rates scatter. This is partly because the number of condition assessment data decreases after 60 years of age.

The result of SCR shows survival rate start decreasing at around 30 years old (slide 19). At 50 years old, around 70% of sewer survives. The SCR overestimates the failure when discussing aging of sewers because rehabilitation reasons include not only aging but also capacity augmentation and relocation accompanied by road construction works. Practically, it is impossible to separate the rehabilitation record into reasons. The ASC shows sewers start to die at the age of 13 (slide 20). The death rate or decrease of survival rate is 1.44% per year. At the age of 82, all sewers die. In other words, all sewers will become a condition necessary for rehabilitation by 82 years old.

The ASC is intended for calculating the work volume for rehabilitation. Necessary rehabilitation work arises after 13 years old. Small-medium municipalities are indifferent to aging problems even though many of their sewers are already over 13 years old. The ASC would alert them for the necessity of rehabilitation. The current ASC does not distinguish material type. This may hinder the use of ASC by municipalities because material type is considered big influence for sewer aging. PVC pipe is considered long life followed by reinforced concrete pipe and clay pipe. Our research team is now working on ASC by material type.

3.2 Prioritization of rehabilitation work

Another ongoing research is the method for prioritization of rehabilitation work and condition assessment. Why we start working on this is the simple question asked by a municipal officer. He asked, “Laterals are number one cause for sinkholes in frequency. At the same time, some big sewer mains under heavy traffic national roads are failing. No such big sewers have ever collapsed. But once it happens, enormous damage will be done to the society. Then, which rehabilitation work should we put higher priority on, laterals or trunks?”

MLIT conducts national survey on sewer cave-ins every year. Using the result of survey, risk evaluation method is being developed. Cave-in frequency formula is part of the research. Now, damage prediction model is under development.

Closing

Our institute was designed to help MLIT headquarters develop and conduct national policy. In line of the mission, our division’s mandate is to upgrade and sustain sewer service in Japan. Our research result will be of great value.
Sewer Management in Japan
-an overview

Takashi SAKAKIBARA, Yosuke MATSUMIYA, Yasuo FUKUDA
Wastewater System Division, NILIM, MLIT


Wastewater Planning
Asset Management, Quick-construction project
Technical strategy for wastewater engineering

Sewer System Maintenance
Road cave-in problem, storage pit problem

Stormwater Control
CSO control, rainfall infiltration enhancement
Communication method in heavy rainfall

Watershed Management
Northwest Pacific Sea Marine Env. Protection
Presentation Outline

1. Sewers in Japan - statistical overview

2. Sewers Asset Management - current status in Japan

3. Research Topics - for better Sewer Asset Management Plan

March 3, 2009

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Closing Gap on SPR, JP-US


Declining Capital Expenditure, JP

Sewer of JP is younger

Histogram of Sewer Installation Length per decade
Source: US data: Gap Analysis, JP data: New Info by Our Research

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March 3, 2009
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Current Sewer O&M

- Experience based approach by big cities
- Baby boomers retirement & downsizing
- Neglected O&M by Small/Medium Cities, due to insufficient resource; human & finance
- Need for AM approach for all cities

Increasing Road Cave-Ins, as Consequence of Failure

Source: Sewerage Budget Request Outline 2008

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Where do they happen?

8 causal structures into 4 groups

【public sewer g.】 = 【① public sewer】 + 【⑤ joint between PS. & M.】 + 【⑥ Joint between PS. & Lat.】

【lateral g.】 = 【② lateral】 + 【⑥ Joint between PS. & Lat.】 + 【⑦ joint between Lat. & M.】
+ 【⑧ joint between Lat. & CO.】

【manhole g.】 = 【③ manhole】 + 【⑤ joint between PS. & M.】 + 【⑦ joint between Lat. & M.】

【clean out g.】 = 【④ clean out】 + 【⑧ joint between Lat. & CO.】
Laterals Blamed Most, Exponential Increase

Source: Proceedings of Research Conference 2008, JSWA

\[ y = 0.0497e^{0.0903x} \]
\[ R^2 = 0.8603 \]

\[ y = 0.0751e^{0.0607x} \]
\[ R^2 = 0.8671 \]

\[ y = 0.0144e^{0.0787x} \]
\[ R^2 = 0.8275 \]

\[ y = 0.0334e^{0.0513x} \]
\[ R^2 = 0.7121 \]

Flat or Downward O&M Expenditure

Source: Proceedings of Research Conference 2008, NILIM

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What are Major Cities doing for AM?

Source: New Info by Our Research
National Institute for Land and Infrastructure Management

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Our research goal for Sewer AM

◆ Average Survival Curve (ASC)
⇒ Long term budget planning for financial sustainability
  • How many kilometers of failed sewers that need rehabilitation exist now?
  • How fast do those sewers increase in future?
  • How many kilometers of sewers need survey every year?

◆ Risk Evaluation Tool on Failed Sewers for Prioritization of Necessary Actions
⇒ Long term work program for sewer service sustainability
  • Which sewers should be surveyed & rehabilitated first?
  • Which sewers are likely to be failing?
  • How big are the consequences of failed sewers? How much is a sewer collapse damage?

How to draw ASC?

① ASC by integration of SCS&SCR
⇒ Shows ASC with no rehab

② Survival Curve using Survey data (SCS)
⇒ Collect CCTV & Eye Inspection data from 2,700 km Sewers. Death defined by deterioration level.

③ Survival Curve using Rehab incl. Repair & Replacement data (SCR)
⇒ Use rehab length data for 400,000km of entire nationwide sewers in 2006. Death defined by Rehab & Replacement
Grading Criteria for Sewer Span

<table>
<thead>
<tr>
<th>Emergency category</th>
<th>Criteria of Assessment</th>
<th>Timing of Necessary Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>critical A dominant</td>
<td>immediate</td>
</tr>
<tr>
<td>II</td>
<td>bad few A &amp; B dominant</td>
<td>Within 5 years after makeshift repair</td>
</tr>
<tr>
<td>III</td>
<td>not well No A, few B &amp; C dominant</td>
<td>In 5 years or later after makeshift repair</td>
</tr>
</tbody>
</table>

Definition of ‘Dead’ sewers for SCS

- Dead: Emergency 1+2, most municipalities rehabilitate EM 1+2 sewers
- Alive: Emergency 3 & No Problem
- Underestimate for physical decay

CCTV Survey of Sewer Span

Criteria of Sewer Condition Assessment, Example

<table>
<thead>
<tr>
<th>Mode by Span Basis</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>corrosion</td>
<td>exposed metal bar</td>
<td>exposed gravel</td>
<td>rough wall</td>
</tr>
<tr>
<td>sag</td>
<td>Diameter or over</td>
<td>Half Diameter or over</td>
<td>below half diameter</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode by Pipe Basis</th>
<th>a</th>
<th>b</th>
<th>c</th>
</tr>
</thead>
<tbody>
<tr>
<td>fracture</td>
<td>partially missing or longitudinal crack of 5mm or 2mm or over</td>
<td>longitudinal crack of 2mm or over</td>
<td>longitudinal crack of below 2mm</td>
</tr>
<tr>
<td>crack circumferential</td>
<td>5mm or over</td>
<td>2mm or over</td>
<td>below 2mm</td>
</tr>
<tr>
<td>joint</td>
<td>displaced</td>
<td>70mm open or over</td>
<td>below 70mm open</td>
</tr>
<tr>
<td>leak</td>
<td>splashing</td>
<td>runnig</td>
<td>surface stain</td>
</tr>
<tr>
<td>lateral projection</td>
<td>Half Diameter or over</td>
<td>1/10 Diameter or over</td>
<td>below 1/10 Diameter</td>
</tr>
<tr>
<td>root intrusion</td>
<td>Half Diameter or over blocked</td>
<td>below Half Diameter blocked</td>
<td>na</td>
</tr>
<tr>
<td>grease slime</td>
<td>Half Diameter or over blocked</td>
<td>10% diameter or over blocked</td>
<td>below 10% diameter blocked</td>
</tr>
</tbody>
</table>
Actual Survival Curve

\[ y = -1.44x + 118 \]

\[ R^2 = 0.953 \]

13 yrs

48 yrs

82 yrs

Source: Proceedings of Research Conference 2008, JSWA

Conclusion & Necessary Research

① Average Survival Curve for the estimate of work volume of Survey & Rehabilitation was gained.

② 1.44 % of sewers over age 13 added each year to the work volume.

③ Necessary to draw ASC by sewer material type as it is influential
Risk evaluation based on sewer cave-in events

1. Sewer cave-ins are increasing, especially in major cities, totaling more than 4000 cases each year. Prevention of the cave-ins is requested socially.

2. MLIT HQs & NILIM conduct national survey on sewer cave-ins every year.

3. Using the data, cave-in frequency prediction formula was developed as part of risk evaluation tool.

4. Currently, working on prediction model of damage magnitude by failed sewers to develop prioritization method for survey & rehabilitation

Future necessary research

\[ y = 0.0751e^{0.0607x} \]

\[ R^2 = 0.8671 \]

1.56 (件/100km年）

Risk Valuation ↓

By span or Area ↓

Prioritization of action; survey & rehab

Damage cost prediction ↓

Possible parameters; time & cost for repair work, traffic density, depth of sewers ↓

Under Research
Thank you for your attention

Image of Budget Annuity

LCC minimization

Economical useful life

Annualized Capital Cost

Annualized O&M Cost

Within the period of LCC small increase, annuity is made

Before annuity

After leveled annuity

Image of leveling annuity

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