Development of technology to determine the degree of priority for investigation of sewerage pipes

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1. Status of sewage pipe maintenance

The deterioration of sewage pipes has been progressing in the same way as other infrastructure facilities. As a realistic measure to deal with the increase in the total length to be investigated under limited budget and human resources, it would be desirable to develop a technology to determine the degree of priority for the investigation, as a desktop application, using data such as a sewerage register.

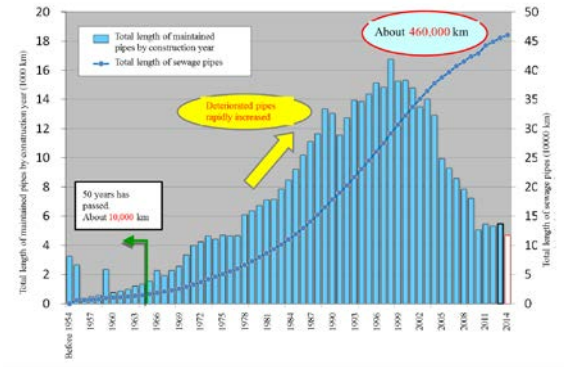

Figure 1 Total length of maintained pipes by construction year

2. Examination of causes of sinkholes using rough set analysis

2.1 Rough set analysis

At the NILIM, we have been examining methods to determine the degree of priority for an investigation based on the type of pipes and construction year from a macroscopic viewpoint, using multivariate analysis and the AHP method. In these methods, it is assumed that the variables used are independent, and we can define a determination function that has linearity. However, in reality, there is an interrelationship between variables, and it is possible for the occurrence rate of a sinkhole to specifically increase if particular conditions are simultaneously satisfied; therefore, sufficient accuracy has not yet been obtained. To understand what combinations can enhance the occurrence possibility for a sinkhole or malfunction, we conducted a study focusing on a rough set analysis, where "we compared two sets and studied how close they were by investigating the inclusion relation." In this analysis, we extracted "a rule for the combinations that were necessarily included" for combinations that had a high sinkhole occurrence probability. Please refer to the reference[1)] for the calculation details.

2.2 Analysis example

Here, we show an example of a rough set analysis for concrete pipes in City A, considering the relationship between the existence of a sinkhole on a road caused by the main pipe, and the result of an investigation using a TV camera. As factors in the high occurrence rate of a sinkhole on a road caused by the main pipe, this analysis not only extracted "corrosion at a moderate or higher level," which was pointed out long ago, but also the "protrusion of a sewer lateral," which has not previously been given attention, in combination with "damage," "misalignment of a pipe joint," and "invading water." Using the rough set analysis, we suggested that it was possible to extract information that had previously been overlooked (data mining).

Table 1 Result of rough set analysis

Combination	Damage	Misalignment of a pipe joint	Invading water	Protrusion of a sewer lateral	Corrosion	Corresponding number of spans	Occurrence rate of sinkholes caused by the main pipe
Rule 1	-	Moderate or higher level	Moderate or higher level	-	-	102	17.6%
Rule 2	Moderate or higher level	-	Moderate or higher level	Moderate or higher level	-	106	11.3%
Rule 3	Moderate or higher level	Moderate or higher level	-	Minor	-	30	26.7%
Rule 4	Moderate or higher level	-	Moderate or higher level	Minor	-	38	21.1%
Rule 5	-	Moderate or higher level	-	Moderate or higher level	-	75	13.3%
Rule 6	-	None	Moderate or higher level	Moderate or higher level	-	31	6.5%
Rule 7	-	Moderate or higher level	Minor	-	-	8	25.0%
Rule 8	Moderate or higher level	-	None	Minor	-	17	29.4%
Rule 9	None	None	None	Minor	-	22	9.1%
Rule 10	-	-	-	-	Moderate or higher level	5	40.0%

[Notes]
・In each rule, "-" represents "arbitrary," and "None" is shown when the judgment was that "it did not ".
・Each rule connects the corresponding item with "&."

[Calculation condition]
・In this analysis, a total of 430 spans were analyzed, and they were compared with the results of sinkholes on roads that occurred in the past nine years.
・For the following nine items, "damage," "crack," "misalignment of a pipe joint," "slack," "invading water," "protrusion of a sewer lateral," "corrosion," "invading tree root," and "removal of a rubber ring," we used the three ranks of "Moderate or higher level," "Minor," and "N ".
(Rank A and Rank B in the guideline for sewer system maintenance are categorized as Moderate or higher level, and Rank C is categorized as Minor.)
・We excluded the calculation for a combination where only one exists.

3. Future development

We have just started to develop a technology to determine the degree of priority for an investigation of pipes, in which this analysis method is used. We will

examine numerous issues such as data preprocessing, weighting, how to discriminate the determining attributes, and useful utilization methods.

☞Detailed information:

1) For example, Norihiko Mori and Sayuri Morita, Data analysis closest to how people think, Kaibundo, 2013 (in Japanese)