Endeavour for Asset Management in Tokyo Waterworks

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Abstract

The existing water supply system of Tokyo Metropolis is one of the leading facilities in the world, having 11 major water purification facilities with treatment capacity of 6.86 million m^3 per day and water distribution pipelines of 27,000 km in total length. In particular, approximately 70% of water purification facilities were constructed during this time and thus, will come into intensive renewal period after the 2020s.

To be ready to cope with such situation, Tokyo Waterworks introduced “Water Purification Facilities Asset Management System” in 2012 and has utilized this system as operation and maintenance of water facilities and the formulation for renewal plans.

Keywords : Renewal of water purification facilities, renewal of pipeline, asset management, inspection, prediction of degradation, repairing

1. History of Construction and Expansion of Facilities of Tokyo Waterworks

Tokyo Waterworks started its modern water service by starting operation of the Yodobashi Purification Plant, which was constructed at the current location of Tokyo Metropolitan Government Office building. Since then, it has been supporting urban activities and citizens' living without a break for approximately 120 years. As water demand increased sharply along with the economic growth in the 1960s and 1970s, and additionally, a large-scale drought occurred before the Tokyo Olympic Games on 1964, expansion to large-scale facilities and construction of large-scale facilities were conducted in a short-term and intensive manner in this time.

Regarding water purification plants in particular, facilities equivalent to approximately 70% of the total treatment capacity of Tokyo Waterworks were constructed during the period from 1960 to mid-1970, and since it has been almost half a century since the start of their operation, they became increasingly deteriorated due to aging and thus, it is necessary to renew those facilities in a planned matter (Figure-1, Figure-2).

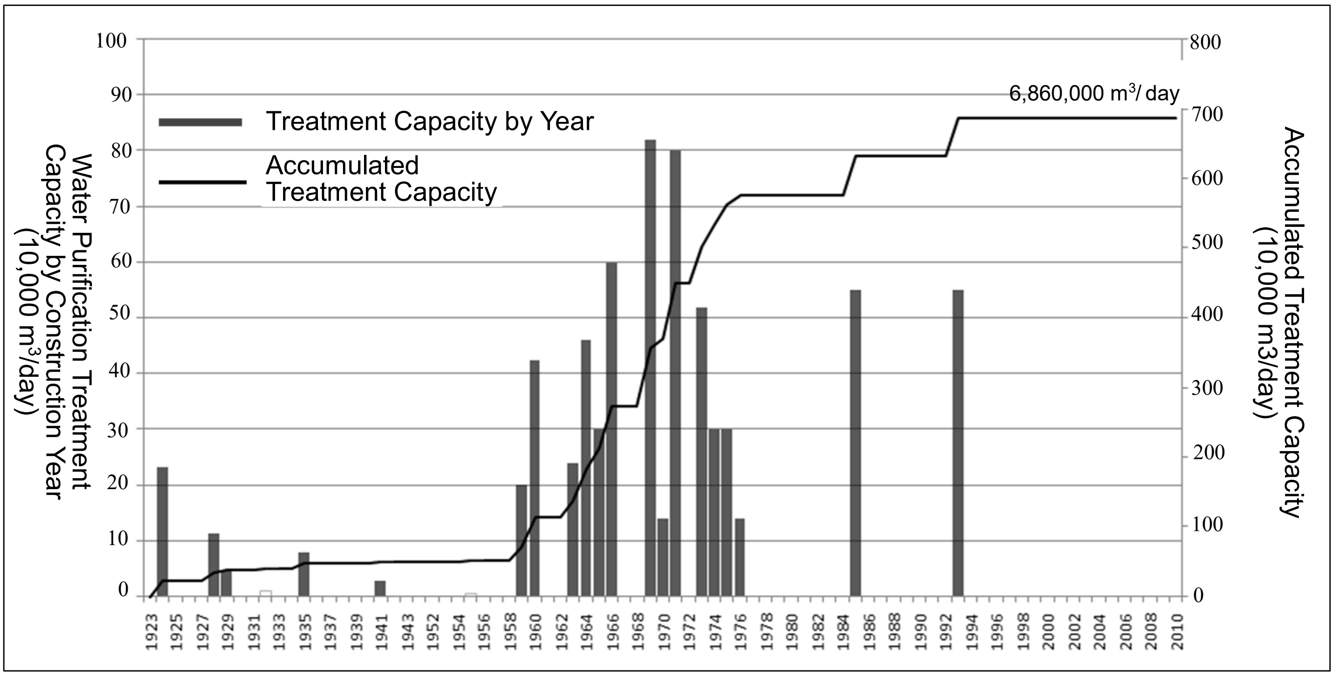

Figure 1:Construction Year of Water Purification Plant and Treatment Capacity

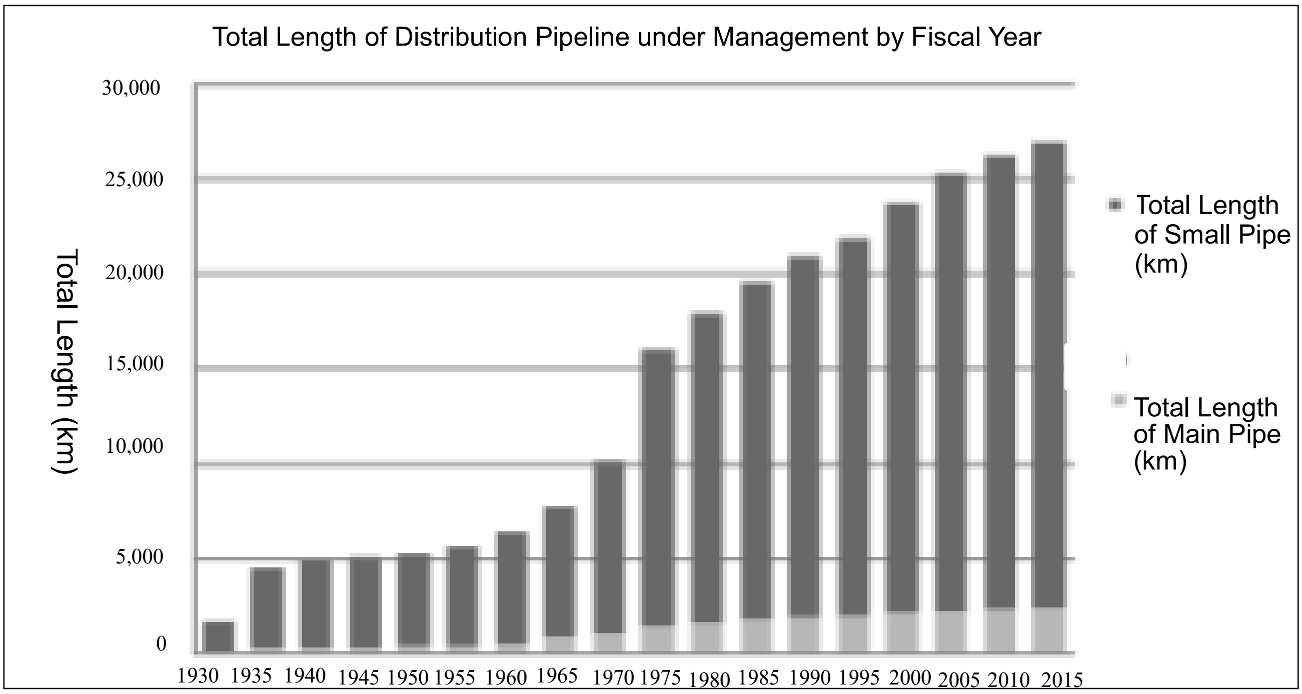

Figure 2:Total Length of Distribution Pipes under Management by Year

2. Asset Management of Water Facilities

Water facilities shall be maintained, managed and renewed in a planned and systematic manner from a medium and long term perspective in order to supply potable delicious water stably and efficiently in the future.

For this reason, Tokyo Waterworks introduced “Water Purification Facilities Asset Management

System” in FY2012 as a means for efficiently managing and operating facilities as well as performing medium to long term predictions by grasping soundness and degree of aging of functions of each water facility.

This system covers the concrete structures of water purification plants and consists of (i) inspection, (ii) making database, (iii) soundness evaluation and (iv) functionality evaluation (Figure 3).

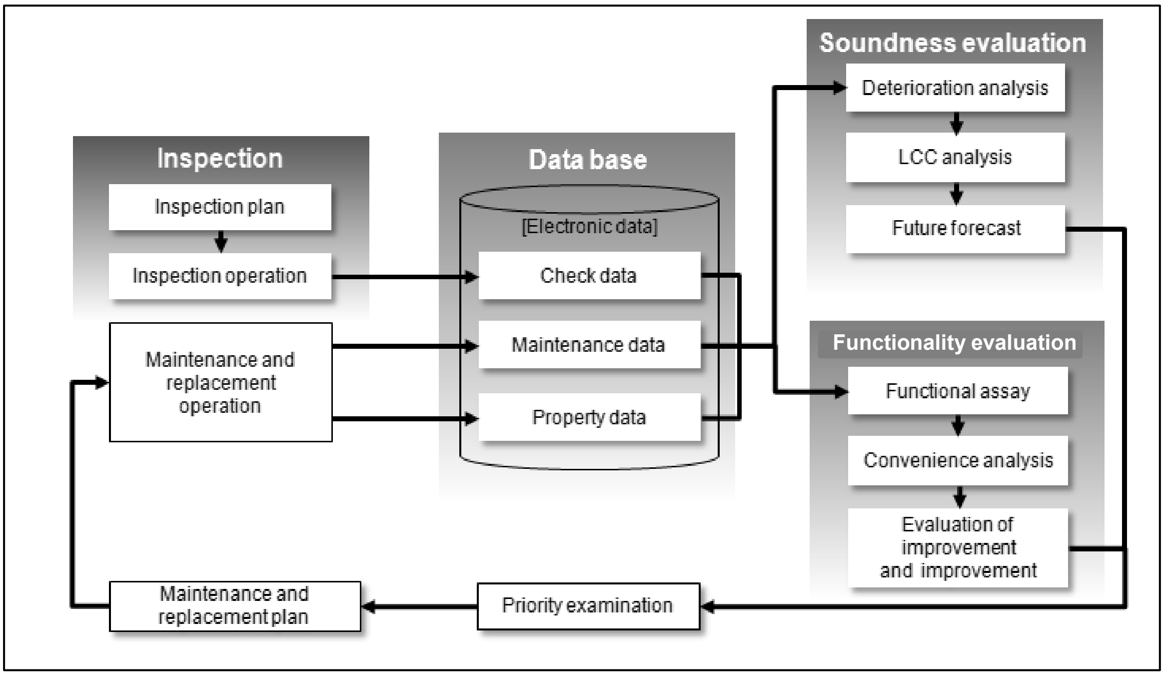

Figure 3: Conceptual Diagram of Asset Management

3. Introduction of Asset Management According to Types of Facilities

(1) Water Purification Facilities

Introduction method of the system to concrete structures of water purification plants is as follows:

(i) Inspection and Making Database (Table 1)

We set up the unified criteria for inspection works of which judgement had been irregular depending on the experience and individual differences of inspectors. In particular, regarding the crack which is a typical indicator for deterioration of the concrete structures, condition survey to evaluate the degree of deterioration progression and quantitative survey such as for crack density which is basis for performing deterioration predictions are conducted regularly. The results of each survey are evaluated by 5 grades from A to E (Picture 1).

In addition, we built a database of the results obtained by such inspection and repair history and utilize such database for analyzing deterioration progression of each facility.

Table 1: Criteria for Concrete Structures

Grade	Criteria	
	Condition Survey	Quantitative Survey
A	No crack found	Less than 0.01m/㎡
B	No water leakage or free lime found	0.01～0.03m/㎡
C	Free lime found	0.03～0.25m/㎡
D	Minor water leakage found	0.25～0.50m/㎡
E	Marked leakage found	0.50m/㎡ or more

Picture 1: Inspection Work

(ii) Prediction of Deterioration and Calculation of Life Cycle Cost (LCC)

Furthermore, it becomes possible to predict deterioration based on the establishment model by utilizing the data accumulated in the database.

LCC is the total sum of "renewal cost during the evaluation period", "running costs such as chemicals and electricity costs", "expenses for renewal of equipment" and "repair costs of concrete structures". It is possible to calculate future repair costs by multiplying future repair quantity (points to be repaired) obtained from the deterioration prediction by repair unit price (Figure 4).

LCC in this system is calculated for 2 generations.

$LCC=(Y_1+Y_2)+(R_1+R_2)-B$

(Y1: Construction Cost of Water Purification Plant, Y2: Renovation Cost of Water Purification Plant, R1 and R2: Running Cost, B: Benefit from Renovation)

Furthermore, Annual Total Cost is calculated by dividing LCC by durable years for 2 generations, and the renewal plan is formulated in order to minimize the total amount of Annual Total Cost (ΣATC).

$\Sigma ATC=\Sigma \min\{ (LCCn) ／Tn \}$

(ΣATC: Total Sum of Annual Total Cost for 2 Generations, LCCn: LCC for 2 Generations, Tn: Durable Years for 2 Generations)

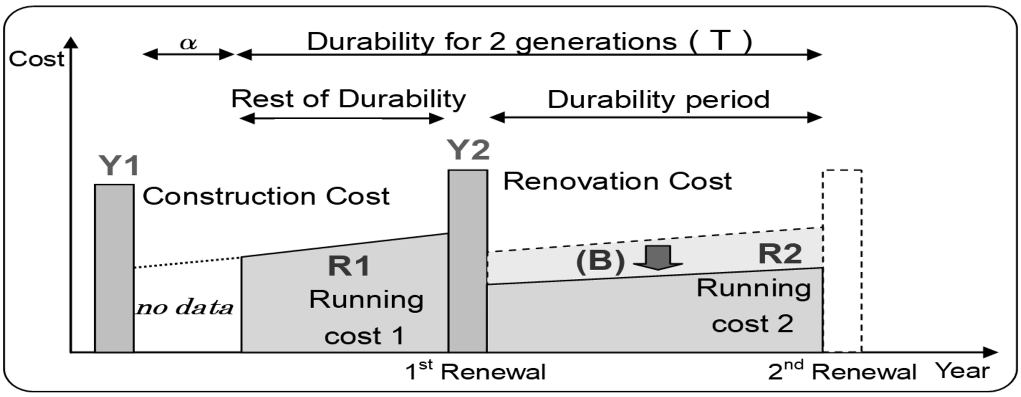

Figure 4: Image of Calculation of Life Cycle Cost

Furthermore, LCC and ΣATC of all water purification plants are calculated by taking into account conditions such as leveling of work volume and restriction of water operation, and the timing and order of renewal will be determined (Figure 5).

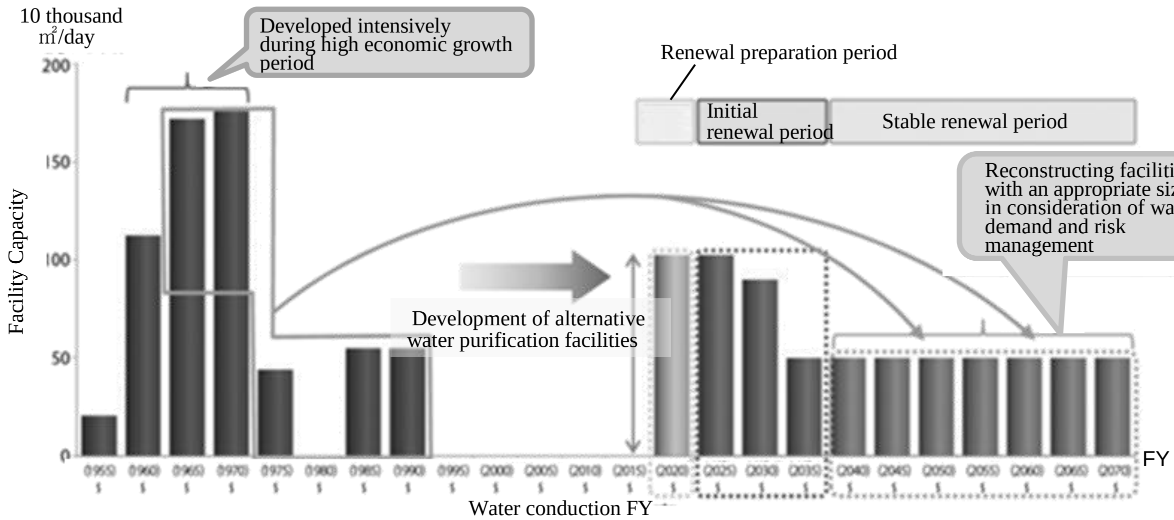

Figure 5: Image of Leveling of Renewal Period

(2) Inspection of Pipelines

Tokyo Metropolitan Government has been conducting functionality survey and deterioration inspection of its pipelines regularly since 1987. However, it is virtually impossible to conduct a comprehensive survey of all pipelines with the total length of 27,000km. Therefore, we conduct sampling inspection surveys according to the following contents (Table 2):

Table 2: Items and Contents of Pipeline Inspection

Survey Item	Survey Content (Example)
Pipeline Specs	Diameter, pipe type, joint
Outer Survey	Corrosion, pitting, covering condition, bolt condition
Inner Survey	Corrosion, carbonation, seal coat, lining condition
Soil Survey	pH value, pipe-to-soil potential
Laying Condition	Railway, road traffic, etc.

Based on the data obtained from this inspection, the statistical quantitative analysis on degradation tendency of inner and outer faces of pipe and its factors is conducted based on the correlation with pipe specifications, laying environment, and installation year, and used for pipeline renewal plans. In addition, a mapping system is being utilized as a database for pipeline replacement and renewal work.

It is also used as a ledger in the construction department as well as for initial response to leakage accident, etc. and ranking of renewal works (Figure 6).

Regarding the mapping system, new functions have been added as appropriate. In FY2014, improvements were made so that pipeline information can be compiled by diameter and installation year, and information on locations of important roads for ensuring traffic of emergency vehicles in the event of a disaster was added to the system.

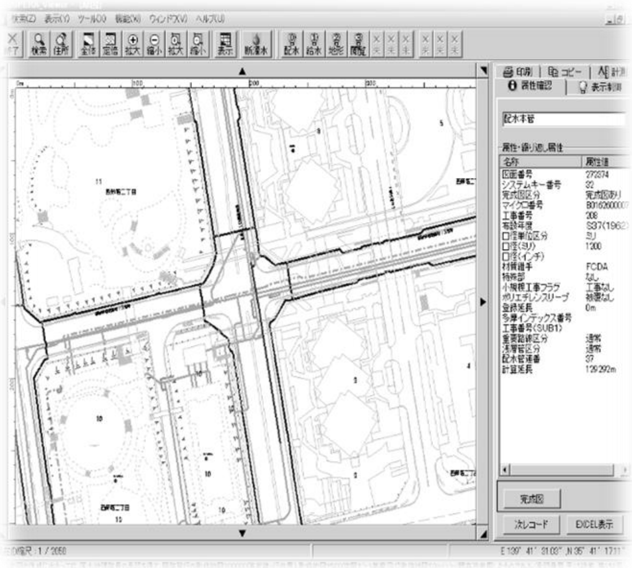

Figure 6: Mapping System Screen;
covering lying conditions and pipe information (diameter, material, depth, valve position, etc.)

4. Conclusion

Since asset management can be an effective tool to make it possible to efficiently maintain, manage and renew water facilities towards stable water supply as a preparation for the future intensive renewal period, we have established a structure under which the planning department and the maintenance and management department work together in collaboration to perform asset management.

In order to continuously operate asset management without obsolescence after introduction, cost consciousness for maintenance and renewal of facilities of each of us as facility managers and technical skills at worksites for efficient operation are considered necessary.

Along with such cost leveling, we are also promoting adoption and introduction of new materials and construction methods, etc. to contribute to reduction of renewal cost, facilitation of operation and maintenance, and reduction of environmental burden. In addition to the continuous operation of asset management, Tokyo Metropolitan Government secured reserve funds of 5 billion yen a year, 50 million yen for 10 years as a stock of facility renewal expenses from 2007 to 2016 to prepare for the coming intensive renewal period and is promoting establishment of a financial back-up system for such period.