Investigation of the Maintenance Condition in Public Facilities  
Focus on Comparison of the Municipalities in Tokyo

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Abstract
In recent times, studies on the management and maintenance of facilities have increased in Japan. However, these studies focus only on residential buildings and private offices. As far as public facilities are concerned, the government is focused only on surveying the amount of stock and on the basic notion of maintenance. There is a lack of government initiatives for the maintenance of public facilities. Only regular maintenance can help in increasing the efficiency and life cycle of these facilities. Further, to solve the current problems such as energy crisis, CO₂ emissions and decreasing of tax revenue caused by an aging society, it is necessary to prolong the life cycle of public facilities and efficiently maintain them.

This study examines the present state of management and maintenance of public facilities mainly focusing on the present conditions of municipalities receiving low financial support and compares the maintenance facilities of these municipalities. For this purpose, radar charts and the PPM matrix were used. It is found that even in badly supported districts, energy consumption and the number of facility users are high. Further, some municipalities are found to be efficiently managing the public facilities, and their management and maintenance skills are worth benchmarking.

Keywords: management and maintenance; municipalities; public facilities; life cycle; PPM matrix; radar chart

1. Introduction
1.1 The Background and the Purpose
In recent years, the interest in maintaining or expanding the life cycle of buildings has increased. A large body of literature exists on the method of maintenance, life-cycle-cost (LCC), building inspection, and case studies; however, the focus is only on residential buildings and private offices. As far as public facilities are concerned, the government or the municipalities are focused only on surveying the amount of stock and on the basic notion of maintenance. Public facilities, unlike the private facilities where the primary objective is to make profit, are being built from tax revenue and are lacking in efforts to improve their performance efficiency or increase their life cycle. Furthermore, all the costs are normally met with allocations from government funding or the municipalities' revenues. However, because of the nation's aging society, low birth rate, the crisis surrounding the supply and demand of energy, and the preponderance of industrial facilities, the revenues are gradually decreasing. Accordingly, conserving efficiency or increasing life cycle has become an essential factor in managing these facilities as effectively as possible. In particular, in municipalities, the financial support has become too weak to allow for investment on the management and maintenance of the facilities, unlike before. In this context, the authors' study investigates the problems faced by the municipalities in charting out a plan to maintain and manage public facilities and elucidates the factors involved in management of these facilities. In addition, it attempts to examine the possibility of setting up a benchmark for the management action for a municipality, through a comparative analysis of municipalities.

1.2 The Scope and the Method
At first, this study surveyed the present state of public facilities' management and maintenance and then examined the results in the context of each municipality's actual conditions to compare and contrast with Product Portfolio Management Matrix (PPM matrix)¹ and used various categories of compare-and-contrast methods with radar charts. With the cooperation of 26 different municipalities, the authors selected "social education and study facilities" (hereinafter called "the community facilities") as
research target facilities. These facilities are close in proximity to the people in the region, but are ranked lower than the school facilities or the government buildings, by priority.

2. Former Study

From the related researches carried out until now, it is understood that NILIM\(^1\) has surveyed the amount of stock and technology of management of the public facilities. Murakami\(^2\) has examined the consumption of energy in public facilities and analyzed the distribution of the amount of consumption by area and the effect it has on the municipalities. Kosibe\(^3\) has studied LCC analysis, facility management evaluation methods, and application of FM by using facilities' data. However, no study has attempted to compare and contrast the management and maintenance conditions of the facilities in the municipalities.

3. Questionnaire

Prior to gathering data, "The Sheet of Fundamental Survey of Public Facility" was created with Microsoft Excel. This table includes such data as the facility's fundamental data, building data, building running cost, fundamental data of community facility rent, and data on the conditions of use of a facility. The composition of each datum is shown below in Table 1.

In October 2006, the Excel files were distributed to 26 municipalities. From late November, data were gathered from these municipalities, and until January 2007, this research received data from 20 municipalities and 194 facilities. Because it was found from the first stage of analysis that there were many errors and omissions in these data, the municipalities and facilities had to be re-surveyed and the data re-input for about 10 months.

4. Data Analysis

This section presents the condition of the management and maintenance of the community facilities of 20 municipalities, based on the data collected from 194 facilities. First, the building data were converted into standard units and called the first processed data. Then, they were classified on the basis of municipalities for simplicity of comparison. PPM matrix was used to compare the present condition of the facility management of each municipality based on the first processed data. To perform evaluation of multiple categories, a second set of data was processed and compared.

4.1 Fundamental Data and Building Data

Table 2. indicates the average value of each municipality's building data. The total floor area of any community facility is under 2,000m\(^2\) and that of some facilities is even under 1,000m\(^2\). In addition, most of the buildings have 3 floors, on average, and

| Municipality | Total floor area (m\(^2\)) | (DCS) distance from the closest station (Minutes) | Revised construction cost (1000JPY/m\(^2\)) | Elapsed life (Year) | Space use rate | Degree of supplementation against deterioration caused by social activities |
|--------------|---------------------------|------------------------------------------------|-----------------------------------|-------------------|---------------|---------------------------------------------------------------|
|              | BCUR | FAUR | RER (%) | AFR (%) | BFR (%) | EIR (%) |
| A            | 1,174 | 23 | 219 | 19 | 0.54 | 0.36 | 2.0 | 82 | 100 | 61 | 61 |
| B            | 1,244 | 11 | 170 | 20 | 0.71 | 0.51 | 2.2 | 17 | 83 | 83 | 88 |
| C            | 889 | 14 | 271 | 24 | 0.83 | 0.54 | 2.3 | 88 | 81 | 94 | 50 |
| D            | 939 | 17 | 207 | 26 | 0.64 | 0.24 | 2.2 | 91 | 100 | 27 | 18 |
| E            | 1,936 | 11 | 214 | 31 | 0.50 | 0.44 | 3.3 | 55 | 100 | 100 | 100 |
| F            | 689 | 14 | 217 | 24 | 0.67 | 0.44 | 2.0 | 44 | 100 | 100 | 33 |
| G            | 1,824 | 11 | 360 | 21 | 0.78 | 0.69 | 2.4 | 64 | 91 | 82 | 67 |
| H            | 1,454 | 10 | 102 | 28 | 0.71 | 0.74 | 2.4 | 20 | 40 | 20 | 40 |
| I            | 632 | 16 | 288 | 16 | 0.66 | 0.49 | 1.9 | 100 | 100 | 100 | 82 |
| J            | 2,320 | 10 | 173 | 12 | 0.52 | 0.32 | 2.9 | 80 | 100 | 80 | 50 |
| K            | 1,171 | 12 | 220 | 20 | 0.87 | 0.54 | 1.5 | 90 | 91 | 64 |
| L            | 720 | 9 | 24 | 0.72 | 0.54 | 1.7 | 29 | 100 | 29 | 0 |
| M            | 714 | 13 | 228 | 26 | 0.65 | 0.32 | 2.2 | 100 | 100 | 0 | 22 |
| N            | 1,566 | 10 | 127 | 11 | 0.87 | 0.64 | 3.2 | 100 | 100 | 100 | 67 |
| O            | 3,350 | 12 | 320 | 17 | 0.72 | 0.41 | 3.6 | 0 | 100 | 100 | 100 |
| P            | 1,442 | 20 | 185 | 27 | 0.56 | 0.42 | 2.8 | 40 | 100 | 80 | 80 |
| Q            | 1,735 | 11 | 432 | 12 | 0.51 | 0.37 | 2.7 | 100 | 100 | 100 | 100 |
| R            | 1,982 | 13 | 244 | 26 | 0.69 | 0.43 | 2.6 | 60 | 100 | 100 | 100 |
| S            | 2,844 | 15 | 281 | 21 | 0.73 | 0.64 | 4.0 | 100 | 100 | 0 | 100 |
| T            | 404 | 12 | 245 | 15 | 0.68 | 0.67 | 2.4 | 86 | 100 | 43 | 29 |

Table 1. Composition of Fundamental Survey of Public Facilities

| Data Type | Content |
|-----------|---------|
| Fundamental Data of Facilities | Location, Executive, Site synopsis |
| Building Data | Building synopsis, Construction cost, Facilities synopsis |
| Building Running Cost Data | Energy and Water Consumption, Management cost, Contract cost |
| Room Rent Data & Use Condition Data | List of Rooms, Size, Number of accommodation, Use hour, Rental price, Use record of latest one month |

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are 20 minutes away from the nearest station. It can be said that community facilities are close to places of residence and that small-scale buildings are great in number. The entire cost of construction of the past was converted to revised construction cost by applying the present value method. After the conversion, the construction cost per m² ranged from JPY 102,000 to JPY 432,000. After construction, the elapsing life of the facilities in three municipalities was less than 20 years, while it was over 20 years in most other municipalities and even over 30 years in some municipalities. Space use rate is employed to analyze how the equivalent sites are being used within a permitted limit. A building coverage use ratio (BCUR) of 0.5 means that half of the permitted building coverage ratio is being used. A floor area use ratio (FAUR) of 0.5 means that half of the permitted floor area ratio is being used. Almost all the facilities evaluated in this study have an FAUR of less than 0.5. The degree of supplementation against deterioration caused by social activities is the value that shows how efficient a facility is in satisfying demand. The study looked into 4 categories: the reinforcement of earthquake-proof performance rate (RER), asbestos free rate (AFR), barrier free rate (BFR), and elevator installation rate (EIR). The results show that only 5 municipalities had 100% RER. The study also found that there were a lot of municipalities with an RER of under 30%. In certain municipalities, education and government facilities were more prioritized than community facilities. Hence, the community facilities received far less financial support or even none. AFR was 100% in most municipalities. BFR was 0% in two municipalities, but in others, it was mostly 80%. Among the four categories, EIR was the lowest. However, the community buildings were mostly three stories high. Hence, it can be said that community facilities are usually housed in smaller buildings. From the study, municipality "H" was found to be below 40% in all the four categories and to have the least degree of supplementing to compensate for deterioration caused by social activities.

### 4.2 Running Cost and Facility Use

To analyze the running cost, this study examined energy and water consumption and the contract cost of management and maintenance. The consumption rate of energy, water, electricity, gas, and heavy oil was calculated in units of Mega Joules (MJ). To calculate the total consumption rate, all the different forms of energy as well as water were converted into primary energy. The standard conversion was carried out in accordance with the agency for National Resource and Energy's "Standard Calorific Value Table of Each Energy Source." (Refer to Table 3.)

Furthermore, this study examined five categories of the facility's annual maintenance contract cost: reception, security, monitoring, cleaning, and maintenance. Before analyzing the use of facilities, this study classified the room's name into eight categories, because different rooms had different names but the same usage in different buildings. (Refer to Table 4.)

Table 4. shows the data on energy and water consumption and on the management of the facilities. Energy and water consumption per m² varied greatly in each municipality: the highest was 10 times the difference. The study expected to find a difference in the quality of management, as management contract cost per m² varied greatly in each municipality. However, it was observed that the quality of management was not too different despite the great difference in contract cost. The ratio of facility users to the entire population, the user population ratio (UPR), shows how often the residents of a municipality use the facility. In municipality "J," it can be seen that over 40% of the population is using the facility. The number of users per facility (NUF) refers to the number of users per month per facility. The entire operation rates (EOR) of community facilities were approximately 50%; however, those of some municipalities were below 30%.

### 4.3 PPM Matrix Analysis

Fig.1. is a PPM matrix with the number of users on the X-axis and the entire operation rate on the Y-axis. If the figure is divided into 4 areas according to the average value of each axis, area A is a case with many users and high operation rate; therefore, one can say it has a good management and maintenance system. According to Fig.1., the facilities of municipalities "A" and "G" are mostly in area A. Area B has a high operation rate but lesser number of users, which means it hosts many meetings without filling the rooms to full capacity. Area D, with many users and low operation...
rate, can possibly be considered as one in which only a limited number of rooms are being used. Area C shows the condition wherein neither operation rate nor the number of users is high; therefore, it can be said that the management condition is substandard. In the figure, facilities of municipality "K" are located in the lower part of Area C.

Fig.2. is a PPM matrix of the amount of energy consumption per m² and the amount of water consumption per m². The amount of water consumption is closely related to the number of users; the amount of energy consumption is related to the operation rate of the room. In this figure, area C has good efficiency since it is low in terms of both energy and water consumption. Comparatively, area A has a higher consumption of both energy and water; therefore, it is necessary to investigate the reasons. In this figure, the facilities of municipality "A" are mostly in area C and those of the municipalities "E," "Q," and "K" are in area A and the upper part of area D. In Fig.1. and Fig.2., municipality "A" has a high operation rate and many users but low energy and water consumption. Comparatively, municipality "K" has a lower operation rate and lesser number of users but higher energy and water consumption. This makes "K" unsatisfactory in terms of facility management and efficiency.

4.4 The Evaluation of FM

It is necessary to study more specific and variegated categories to grasp the reality of facility management and maintenance in each municipality. This section compares various categories with inconsistent units; computes the average and the standard deviation of each valuation index; and converts index values into deviation values. It composes deviation values into radar charts classified by evaluation categories, and finally, tries to evaluate the present state of facility management and maintenance of each municipality by.

Table 5. The Data on Energy and Water Consumption and on the Management of the Facilities

| Municipality | Energy consumption | Water consumption | Management contract cost per m² | UPR | NUF | EOR |
|--------------|--------------------|-------------------|--------------------------------|-----|-----|-----|
|              | (MJ/m²)            | (MJ/facility)     | (m³/m²)                        | (%) | (Persons) | (%) |
| A            | 442.83             | 760,513           | 0.30                           | 508.62 | 1,423 | 1,782 | 187 | 1,610 | 4,395 | 31.9 | 10,450 | 57.5 |
| B            | 800.84             | 996,626           | 0.72                           | 893.24 | 2,620 | -    | 202 | 3,152 | 1,019 | 37.5 | 3,804 | 44.6 |
| C            | 1255.61            | 1,178,423         | 0.78                           | 733.42 | -    | -    | -   | 34.3 | 2,947 | -    | -    | -    |
| D            | 1251.31            | 2,422,472         | 1.98                           | 3,833.09 | 3,456 | 464  | 1,744 | 946  | 39.4  | 5,081 | 49.2 |
| E            | 1105.08            | 760,907           | 0.74                           | 506.55 | 2,162 | 504  | 557 | 4,133 | 2,691 | 27.9 | 6,220 | 49.1 |
| F            | 1348.78            | 2,459,944         | 1.07                           | 1,954.83 | 10,098 | - | - | 304 | 654 | 1,068 | 25.5 | 3,514 | 44.5 |
| G            | 845.59             | 1,229,734         | 1.39                           | 2,028.00 | 3,214 | 3,781 | 142 | 2,391 | 2,158 | 14.6 | 5,887 | 67.4 |
| H            | 727.68             | 460,134           | 0.52                           | 330.35 | 3,422 | - | - | 2,935 | 640 | 34.9 | 7,761 | 56.2 |
| I            | 688.54             | 1,597,442         | 0.44                           | 1,027.50 | 9,816 | - | 744 | 2,342 | 680 | 37.6 | 4,069 | 53.9 |
| J            | 1314.57            | 1,539,395         | 1.10                           | 1,287,14 | 18,192 | 1,496 | 304 | 3,829 | 2,107 | 40.1 | 5,797 | 50.2 |
| K            | 665.08             | 478,823           | 0.48                           | 347.43 | 2,579 | - | 518 | 3,152 | 1,790 | 5.8 | 953 | 20.5 |
| L            | 871.33             | 622,499           | 0.84                           | 598.00 | 3,156 | - | 141 | 4,546 | 346 | 14.2 | 1,471 | 33.5 |
| M            | 632.54             | 990,641           | 0.71                           | 1,117.72 | 4,384 | 3,264 | 1,074 | 2,111 | 878 | 19.6 | 1,327 | 35.5 |
| N            | 2722.56            | 9,121,370         | 3.06                           | 10,258.00 | - | 1,424 | 305 | 2,192 | 2,017 | - | - | - |
| O            | 934.38             | 1,346,962         | 0.45                           | 655.80 | - | 244 | - | 4,551 | - | - | - |
| P            | 1837.32            | 3,188,038         | 1.89                           | 3,274.50 | 837 | - | 702 | 2,259 | 1,072 | 13.2 | 1755 | - |
| Q            | 937.11             | 1,856,879         | 0.84                           | 1,659.00 | 11,678 | - | 420 | 2,215 | 3,711 | 10.5 | 2559 | 46.9 |
| R            | 1416.20            | 4,028,004         | 1.81                           | 5,144.00 | 1,756 | 189 | 199 | 1,666 | 3,027 | 22.6 | 3446 | 50.4 |
| S            | 753.95             | 304,544           | 0.58                           | 233.86 | 2,830 | 772 | 52 | 2,315 | 5,828 | 14.0 | 7907 | 56.9 |
| T            | 1081.64            | 1,860,178         | 1.04                           | 1,915.32 | 15,330 | - | 452 | 606 | 1,177 | 5.8 | 1,571 | 46.2 |

Fig.1. Number of Users and Entire Operation Rate

Fig.2. Energy Consumption and Water Consumption per m²
The higher the deviation value of 8 evaluation categories, the more favorable is the facility; consequently, the added value of the numbers can be indicative of the degree of management and maintenance. In Fig. 3, a sample of the radar chart showing the degree of management and maintenance can be observed. The evaluation of management and maintenance of each municipality is expressed numerically; the status due to each category is expressed as a number between 0 and 80. It is assumed that the closer the number is to 80, the more efficient the management is in satisfying its objectives.

Although facilities of municipality "A" have weakness in terms of "Proximity to Facility" compared to other municipalities, many residents are using the facility. It has low consumption of energy and water, and the facility scale and contract cost are reasonable; therefore, this facility can be said to have much better management and maintenance than the others. It also scores 438 on management and maintenance degree, which is the highest. In contrast, municipalities "P," "N," and "K" score the lowest among them. However, since the deviation index of the operation rate and the number of facility users of municipalities "P" and "N" were not known, their scores on facility management and maintenance are low on reliability. Among the municipalities with complete data, the value of municipality "K" is the lowest. From the radar chart of municipality "K," it can be found that none of the 8 categories is higher than 60. Among the categories, operation rate, the number of users, and the propriety of facility scale are the lowest at below 40. Therefore, it can be concluded that either there are many unused rooms or there are too few users.

5. Conclusions

Although there are a number of studies on management and maintenance of public facilities, a comprehensive study that could assist in planning was found to be lacking. Therefore, this study aimed to lay the foundation stone for the establishment of a plan for management and maintenance of public facilities by focusing on the fact that there are many municipalities without an awareness of the present condition of their own public facilities. For this purpose, data were collected through surveys on the community facilities of 26 municipalities. In order to understand the present condition of facility management and maintenance of the target facilities from the collected data, PPM matrices and radar charts with evaluation indexes and deviation values were used. The result of the analysis shows that some municipalities are efficiently managing and maintaining the public facilities, despite their financial problems. This indicates the possibility of benchmarking the management and maintenance skills of these municipalities besides the potential for developing new maintenance methods and increasing maintenance cost; the authors are planning a more specific field study on the administrative organization and operation process analysis of facility management by municipalities. They will verify the analysis of this research through a field study; at the same time, they will study the deterioration status and collect data on repairing history. Further, by analyzing the organization
and operation process, the authors wish to classify municipalities as those with and without satisfactory efficiency in facility management and maintenance.

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Notes
1) PPM (Product Portfolio Management) is one of the evaluation techniques used for decision making concerning business strategy in order to effectively combine and manage two or more corporate businesses. This study tried to explain the state of facility management by municipalities using energy and water consumption and the facilities' use data.

Fig.4. Radar Chart of Management and Maintenance of Each Municipality