ESTIMATION OF THE WHOLE LIFE COST OF POST OFFICES BASED ON A SURVEY OF ACTUAL CONDITIONS AND CONSIDERATION OF INVESTMENT CORRECTION

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By undertaking an enumeration survey of the operating costs of 1255 general post offices throughout Japan, we were able to grasp the characteristics of the life-cycle costs of post office buildings. After analyzing the relationship between the rebuilding cycle, and rebuilding, repair and improvement costs, by changing the present rebuilding at age 40 to building additions at age 40 and rebuilding at age 60, it became apparent that we could expect a significant reduction in facilities investment costs.

Keywords: life cycle cost, rebuilding, life of post office, investment correction

Introduction

With public works, reflecting consideration of global environmental problems and the financial conditions, there is a need to make facilities last longer and reduce upkeep and running costs. One of the main financial steps taken to reduce public works costs, according to the "Action guidelines concerning the reduction of public works costs (Cabinet decision of April 4, 1997)," calls for improvements in government system procedures, creative efforts by those involved, and administrative reforms of the public works system. By integrating improvement work and using VE designs, the Ministry of Posts and Telecommunications was able to reduce the work costs in 1999 by 7.1 percent compared to 1997. Following the "Action guidelines concerning the reduction of public works costs," according to the "New action guidelines concerning the reduction of public works costs (Cabinet decision of September 1, 2000)," in addition to the reduction of direct work costs, there is a call for a reduction in costs from the viewpoint of the lifecycle, thereby aiming at a reduction in overall costs. However, there is no detailed information about the running costs of public facilities, so it is necessary to first undertake a survey of the present conditions. To apply the results of research on life-cycle cost (LCC) to actual business, in addition to the existing theoretical studies (*1-4), a study must be done on the actual situation of buildings according to the uses (*5-8), because there are differences in specifications, operational methods, and maintenance methods, depending on the type of building. However, in the past, there have been few enumerative studies conducted on buildings with specified uses. Moreover, if the studies were conducted on a small number of samples, they might not represent the real trend. This paper features that it is based on the results of an enumerative study of the post office building operation costs in a specific year.

Since 1991, international conferences involving the departments responsible for post office facilities throughout the world and particularly from western nations have been held, and the each country has been developing its own benchmark for their post office buildings *9). Due to the differences of structure and specifications of post office buildings from those of ordinary office buildings, it is not meaningful to compare these facilities with some buildings within each country. Therefore, it is considered to be effective to make a mutual comparison of the post office buildings of each country throughout the world. Each country is aware of the importance of the running costs of these facilities, and in Norway, when a new post office building is constructed, a life-cycle calculation computer program on the market is used for reference when making the investment decision. In France, the average rate of return, and in Finland, the internal rate of return and the pay back period indices are used when making an investment decision. In Japan, in order to reduce running costs of the facilities and make more accurate investment decisions, when the budget is being put together for new work or extension work, the Ministry of Posts and Telecommunications is presently considering using LCC calculations for reference.

In reality, the LCC overview is used as when making an investment decision, to choose whether a building should be rebuilt, or continued to be used after improvement and repair work. At this stage, a rough cash flow estimate is required. The discount rate has a major effect on the results of LCC calculations *10), but because no money is being borrowed when constructing new post offices in Japan, and because no respect is put on the opportunity cost of cost reductions because they are public work projects, a simple cash flow analysis is made taking into account cost adjustments, but without taking into regard interest payments. This is easily understood by the departments responsible for funding and business management than investment decision indices reflecting the discount rate such as NPV (Net Present Value).

This paper reports on the results of the study of the actual conditions of long-term expenditures, which is required for using LCC in investment decisions. Based on the results of the study, a long-term cash flow forecast of post office buildings is made. Consideration is then made of the influence on total cost reductions when using the buildings for a longer time.

1. Survey of actual conditions of LCC of post offices

The 2000 operating costs of 1,255 general sorting post offices throughout Japan were surveyed, excluding those which were having rebuilding work done. The total floor space by age of the general post offices throughout Japan is shown in Figure 1; the total floor space was 6,331,854 square meters, average age was 23 years. The Ministry of Posts and Telecommunications (the present Postal Services Agency) began monitoring the LCC of five standard post office buildings, selected from the post office buildings completed in 1981 throughout the country. The structure and specifications of post office buildings these days are different to those that were built 20 years ago, so last year an enumerative study was made of about 1,300 general post offices throughout the country, and this data is being used along with the data from the monitored post offices.

This paper analyses the 2000 expenditure figures from both the national enumeration survey and the survey of the five post offices being monitored.

(1) Analysis of repair and improvement work costs

Figure 2 shows the relationship between the total costs (in 2000 prices **19**) of repair work and improvement work carried out in 2000 per square meter, and the age of the post offices. "Cost per square meter" refers to the total repair and improvement cost in the year divided by the total floor space of the post offices. Repair work does not include work to improve performance and functions, while improvement work improves the performance and functions of the original building and for budget and accounting purposes, they are handled separately. However, in reality, it is possible that some repair work items are included in improvement work budget orders, and vice versa, some orders made with the repair work budget may be for improvement work items. Therefore, it is appropriate to look at the differentiation of improvement and repair work as a rough estimate.

The total budget for improvement and repair work in 2000 was 26,676,568,537 yen, or 4,213 yen per square meter, and the simple average for the "improvement and repair cost per square meter over each of the past years" was 4,896 yen per square meters per year. From Figure 2, we can see: 1) there is a tendency for costs to increase as the buildings get older up to around year 40; 2) there is a small peak in years 11 and 23, and a large peak between years 35 and 45; and, 3) even though there are 40 post offices which are being looked at after year 40, the improvement and repair work cost per square meter of these post offices is not really that high.

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Figure 1 Total floor space by age of general post office buildings (as of 2000)
X: Age (years) Y: Total floor space (m²)

Figure 2 Total cost per square meter for repair and improvement work (2000 figures for 1,255 general sorting post offices) X: Age (years) Y: Cost per square meter of floor space (yen/m²)

Figure 3 Changes in total repair and improvement costs per square meter with age for the five post offices where the life-cycle costs are being monitored
X: Age (years) Y: Cost per square meter of floor space (00yen/m²)

Fig3, Fig5, Fig7, Fig8
①②: Odate, ③④: Shimozuma, ⑤: Kasai, ⑥: Tamagawa
⑤: Miyakonojo, ⑥: Average for 5 post offices
Figure 3 shows the changes in total repair and improvement costs per square meter with age for the post offices where LCC are being monitored. The reason why the costs are high between the 10 and 15 years after completion is because renewal work and expansion of customer windows and lobbies was carried out at general post offices throughout the country during this period.

(2) Analysis of utility costs

The total electricity cost for the 1,255 post offices throughout the country that were surveyed was 15.8 billion yen, or 2,506 yen per square meter (2000 prices). The national average costs (and volume) were: 329 yen per square meter (0.85 cubic meters per square meter) for service water, 241 yen per square meter (4.86 cubic meters per square meter) for gas, 270 yen per square meter (11.93 yen liters per square meter) for heavy oil, and 95 yen per square meter (4.54 liters per square meter) for kerosene. The total amount for these utility costs was 3,441 yen per square meter (2000 prices).

Figure 4 shows the changes in utility costs per square meter with age for the post offices where LCC are being monitored. The common factor with all the post offices is the high proportion of electricity costs.

Because there was a revision in electric power charges due to factors such as gains from the high yen, there was a temporary drop in usage charges. The reason for the escalation in utility costs is because as the facilities age, there is an increase in the floor space being used, and an increase in the length of time they are being used. There are some rooms in post offices which are only used during the season when new year's cards are being sorted. Some post offices are sorting 24 hours a day, so a simple comparison of utility costs with facilities with different usage cannot be done.

With regard to utilities costs, there is a difference in the amount used depending on the area. With electricity costs, which account for 70 percent of the utilities costs, when multiple linear regression analysis was made using the total floor space, number of workers, the rate of filled vacancy*, whether or not there is a cooling tower and climatic areas as the variables, it became apparent that in each different climatic area, electricity costs had a strong correlation between the total floor space and the rate of filled vacancy. In Area I (cold area), electricity cost is low because they do not need air conditioning in summer (Figure 5, Table 1).

![Figure 4 Changes in utility costs per square meter with age for the post offices where the life-cycle costs are being monitored. X: Age (years) Y: Cost ('000yen/m²)](image)

Because the building was finished and began to be used

![Figure 5 Relationship between the floor space sizes of the post offices and the electricity costs per square meter X: Floor Space (m²) Y: Cost ('000yen/m²)](image)

Table 1 Relationship between climatic area and electricity costs

<table>
<thead>
<tr>
<th>Climatic areas</th>
<th>Correction R²</th>
<th>Number of measurements</th>
<th>Regression equation</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>0.9763384</td>
<td>73</td>
<td>Y=2272·X₁-70969·X₂+5449047</td>
</tr>
<tr>
<td>II</td>
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<td>0.98083</td>
<td>48</td>
<td>Y=2877·X₁-54125·X₂+2928933</td>
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</tbody>
</table>

The climatic areas are: Climatic area 1: Hokkaido, Climatic area 2: all the prefectures in the Tohoku region, and Ibaraki, Tochigi, Gunma, Niigata, Nagano, Yamanashi, Toyama, Ishikawa, Gifu, Fukui, and Shiga Prefectures, Climatic area 3: Tokyo, Chiba, Saitama, Kanagawa Prefectures, all the prefectures in the Toyama, Kinki, Chugoku and Shikoku regions, and Fukuoka, Oita, Saga, Nagasaki and Kumamoto Prefectures, Climatic area 4: Miyazaki, Kagoshima and Okinawa Prefectures.

The heat insulation specifications for the post office buildings are different according to the different climatic areas.

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(3) Analysis of maintenance costs

We could see that the national average maintenance cost for the 1,255 post offices was 2,681 yen per square meter. This broke down into 691 yen per square meter for security-related costs, 1,448 yen per square meter for building cleaning and other costs, and 27 yen per square meter for garbage disposal. With regard to the total maintenance costs, regardless of the age of the post offices, about the same costs were incurred nationwide.

The changes in maintenance costs with age for the post offices where LCC are being monitored are shown in Figure 6. Sewage work was completed at the Odate Post Office in 1993, doing away with the need for septic tanks, and leading to a reduction in costs. In 1989 a freight elevator was installed in the Kasai Post Office, leading to an increase in costs.

(4) Outline of the life-cycle cash flow

Based on the results of the analysis of the operating costs of the 1,255 general sorting post offices, the life-cycle cash flows for these buildings were calculated for 20, 40 and 60 years. The calculation conditions were:

1) The post office rebuilding cost per square meter (S) was assumed to be 220,000 yen. (There are differences depending on whether or not the post offices have floors below ground, but here the average cost is used)
2) The average annual improvement and repair work for operating the post office (C):
   i) For 20 years:
      The cumulative amount of 47,451 yen per square meter (from the actual results of 1,255 post offices; Figure 2) was used.
   ii) For 40 years:
      For years 1 through 35, the cumulative amount of 122,619 yen per square meter (from the actual results of 1,255 post offices; Figure 2) was used. For years 36 through 40, the average value of the actual results of the 1,255 post offices for years after year 41 (4,181 yen per square meter) multiplied by the remaining number of years (4,181 x 5 = 20,905 yen per square meter) was used.
   Reason: the improvement and repair costs per square meter between years 35 and 40 are high, but this is because they reflect repair costs to enable the buildings to be used for over 40 years.
   iii) For 60 years:
      The accumulative amount from years 1 through 40 of 199,500 yen per square meter (from the actual results of 1,255 post offices; Figure 2) was used. For the years after year 40, the average value of the actual results of the 1,255 post offices for years after year 41 (4,181 yen per square meter) multiplied by the remaining number of years (4,181 x 20 = 83,620 yen per square meter) was used.
      The total of the above (199,500 + 83,620) is used as the improvement and repair cost over 60 years.

3) With regard to utilities costs (E) and maintenance costs (M), no big changes could be seen as the buildings got older, so the average annual cost per square meter was multiplied by the number of years.
4) Demolition and disposal costs (D) were assumed to be 17,000 yen per square meter
5) LCC (LC, n years) = S + C + (E+M) x n + D

<table>
<thead>
<tr>
<th>Table 2 Life-cycle cash flow of post office buildings for 20, 40, 60 years</th>
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<td></td>
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<tr>
<td>New building</td>
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<tr>
<td>Repair and improvement</td>
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<td>Utilities</td>
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<td>Maintenance</td>
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<tr>
<td>Demolishment and disposal</td>
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<tr>
<td>Total</td>
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<td>EUAC (equivalent uniform annual cost)</td>
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</table>
The movement in the total amount of LCC per square meter by age for the post offices where LCC are being monitored is shown in Figure 8. About the same expenditure costs were required between 20 to 25 years after the post offices were constructed, as were required when they were first built (after adjustment to present values). After deducting the demolition and disposal costs from the cash flow accumulative total of 406,891 yen per square meter based on the results of the analysis of the 1,255 post offices, the figure becomes 389,891 yen per square meter, which is about the same amount as for the 5 post offices that are being monitored.

2. Post office rebuilding cycle

Up to now, the floor space size of post offices being newly built is decided by calculating the required floor space 12 years after the year in which the planning is being done. (Up to 1975, this was based on the required floor space 10 years later, but was changed to 12 years to allow for the period during which land is purchased, and planning and construction is carried out.) In calculating the required floor space, a forecast is made of future developments in the area, including population growth, and the number of workers, the volume of postage, the number of delivery areas, the number of delivery vehicles, and the amount of postage handling equipment are also taken into consideration.

New post offices are built based on the size required 12 years later, so the size becomes too small 17 to 20 years later. At that time additions are made based on requirements a further 12 years later. The size of the land is determined taking into account the size of the building after additions have been made. 40 to 45 years after post offices have been built, again they become too small. At that time the buildings have generally been constructed as far as the legal ratio of building volume to lot will allow, so if additional adjacent land cannot be purchased, the post office has to be rebuilt at another location. Therefore, for planning purposes, the serviceable life for a post office building is about 40 years.

With regard to post offices that were given budgets for rebuilding work in 1978, the average age for post offices in urban areas was 19.8, and for other post offices about 25.0. In 1994, the average age of post offices in urban areas was 25.5, and for other post offices about 30.3. There was a rapid growth in urban areas, centered on the three major cities during the period of high economic growth, and with the increase in postage volume along with the population growth, there was a need to increase the size of post office buildings. Because the size of post offices suddenly became too small, the buildings were rebuilt in a short period after initial construction. However, sudden population growth even in urban areas has settled down in recent years, and the time it takes for post offices to become too small has also reduced.
3. Reduction of overall costs by lengthening the life of the buildings

Aiming at consideration to global environmental problems, the reduction in industrial waste, and the effective use of natural resources, there is a call for increasing the life of architecture and equipment. Increasing the rebuilding cycle of buildings and increasing the number of years they are used reduces the initial investment cost of the overall stock. In general, increasing the number of years a building is used means an increase in repair and improvement costs, but because the increased amount is less than the reduced initial investment cost, increasing the life of a building is effective in reducing the overall initial investment and operating costs. Presently, post office buildings are being rebuilt in less than 40 years. We considered the economic feasibility of increasing this period to 60 years, by calculating the movement of future construction budgets.

Up to now, post office buildings have been rebuilt in less than 40 years, and the size of the buildings after rebuilding has been about more than two times that of the original size. However, Japan's population is forecast to peak in 2006, and after that begin to drop, so no urban growth as was seen during the period of high economic growth is expected. Therefore, in the calculations, an assumption was made of a model encompassing a 30 percent increase in the size of the buildings 40 years after initial construction, and a doubling in size 60 years later (Figures 9), and a comparison was made with the assumption that the buildings are rebuilt twice the size at age 40 (Figure 10)(10).

The calculation conditions were:

1) The work cost for a new work (S) was estimated to be 220,000 yen per square meter, based on the actual costs of recent work undertaken
(2) Improvement and renewal work were treated together as a total
(3) As the buildings became dilapidated, as shown in the distribution of the total floor space by age in Figure 1, it was estimated that there would be the following changes in the improvement and renewal work costs per square meter (C(i)):

1) In the case where a building would be rebuilt 40 years after construction
i) The actual figures of 1,255 post offices (Figure 2) would be used for years 1 through 35. (The accumulative total for 35 years is 143,524 yen per square meter)
ii) For years 36 through 40, the average value of the actual costs of these 1,255 post offices for the years after year 41 would be used (4,181 yen per square meter)
Reason: The same as 2. (4) 2ii) above.
iii) The average for one year is 3,588 yen per square meter ((143,524+4,181x5)/40)
2) In the case where additions would be made to 40 years after it had been rebuilt, and rebuilt 60 years after construction
i) The actual figures of 1,255 post offices (Figure 2) would be used for years 1 through 40. (The accumulative total for 40 years is 199,500 yen per square meter)
ii) For years after year 41, the average value of the actual costs of these 1,255 post offices for the years after year 41 would be used (a constant 4,181 yen per square meter)

iii) The average for one year is 4,718 yen per square meter ((199,500+4,181x20)/60)
The calculations consist of:
The new building costs in year \( n = T(n) \times S \)
\( T(n) \): the total floor space of the buildings to be rebuilt in year \( n \)
The total floor space in year \( (40 - n) \) in Figure 1 (for 1) above
The total floor space in year \( (60 - n) \) in Figure 1 (for 2) above
Year \( n \) improvement and renewal work costs

\[ = \sum_{i=1}^{40} \text{(the total floor space in age } i, n \text{ years later)} \times C(i) \]

Figure 9 Changes in construction costs over the next 100 years assuming the floor space is increased by 30% at age 40, and the buildings are rebuilt twice the size at age 60

X: Age(years) Y: Amount (100 million yen)
①: Total amount
②: New and additional building costs
③: Repair and improvement cost

Figure 10 Changes in construction costs over the next 100 years assuming the buildings are rebuilt twice the size at age 40

X: Age(years) Y: Amount (100 million yen)
①: Total amount
②: New and additional building costs
③: Repair and improvement cost
Compared to the rebuilding a post office to twice the size at age 40, if additions increasing the size by 30 percent are made in year 40, and rebuilding is undertaken in year 60, there is a reduction of 1,992.6 billion yen (38.9 percent) in rebuilding costs, looking at the accumulative costs in the next 60 years, and a reduction of 31 billion yen (1.4%) in repair and improvement costs, totaling a reduction of 2,023.6 billion yen (27.5 percent), or an annual reduction of 33.7 billion yen.

As opposed to an annual average of 3,588 yen per square meter for improvement and repair costs over 40 years, over 60 years in case of rebuilding after 60 years, the average is much higher, at 4,718 yen per square meter, but because there is a smaller increase in the total floor space of the facilities, the total improvement and repair costs are cheaper if rebuilding is done in year 60.

The total floor space in 60 years time would be 18,009,174 square meters if the size was doubled every 40 years, and 12,590,467 square meters if a 30 percent increase in the size of the buildings was undertaken at age 40 and the size was doubled at age 60. If the reduction in cost of 33.7 billion yen was divided by the total floor space in 60 years time of 12,590,647 square meters, it is 2,676 yen per square meter. As shown in Table 2, under the present conditions, the annual LCC is 14,284 yen per square meter if the post offices are used for 60 years, so about 20 percent of that cost can be reduced by extending the life of the facilities.

In order to stabilize the amount of facilities investment, in addition to increasing the rebuilding cycle, it is also necessary to control an increase in size. For the Postal Services Agency, which owns a large number of the facilities, in order to undertake the facility investment appropriate for the future size of the business, changes in investment policies are required, such as increasing the life and controlling growth of the facilities.

Conclusion
By analyzing the actual operating costs of general post offices nationwide, it was possible to make considerations about cash flow characteristics depending on the life-cycle of the post office. The results of the analysis must be understood while realizing that post office buildings mainly consist of a large room where postal work is carried out, with little interior finishing, and except for the customer window lobby areas no large improvement but basically only corrective maintenance is carried out, and with regard to utilities costs, taking into consideration that some post offices continue working throughout the night.

This paper makes a general analysis of the tendency of the entire stock, but in reality there are large differences in operating costs between each facility. There are differences in the operating costs of the facilities, depending on the building specifications, and how it is being maintained. With regard to the reason for the difference in operating costs, we believe it is important to undertake a detailed analysis at each facility, and work to reduce these operating costs.

Acknowledgement
The author would like to express his sincere thanks to Dr. Ranko Bon, Professor of Building Economics, the University of Reading for continuing advice to this research.

Notes
**1:** The Workplace Network (the Japanese Ministry of Posts and Telecommunications has been participating since 1998)
**2:** The Ministry of Posts and Telecommunications has been analyzing the following 7 categories: (1) Planning costs, (2) New building costs, (3) Maintenance costs, (4) Utilities costs, (5) Improvement costs, (6) Repair costs, (7) Waste disposal costs
**3:** With regard to planning and design, operation and maintenance costs, the “Consumer Price Index of Bureau of Statistics, the Ministry of Public Management, Home Affairs, Posts and Telecommunications” is used, and with regard to the new building, improvement and repair costs, the “Standard Construction Cost Index for Tokyo General RC Government Buildings of the Construction Industry Business Analysis Committee” is used.
**4:** The rate of filled vacancy is the total floor space of the present divided by the floor space required by the building. The size of the building is planned allowing for future requirements, so when the building is completed, the rate is over 100 percent, and falls as the buildings age.
**5:** Figures 9 and 10 show investment demand. The actual budgets are standardized for periods of several years. From Figures 9 and 10, we want to understand the long-term demand movement.

References

Literature about the methods for applying life-cycle cost analysis to facility planning.

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(2002年7月5日最終受付、2002年12月9日最終決定)

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