A Study of the Asset Valuation Method for Efficient Road Facility Maintenance

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Abstract

In this study, an asset valuation process suitable and effective for the actual conditions in Korea is proposed through the examination and analysis of the asset valuation method of road facilities, which can help strategic decision-making for road facility asset management. Moreover, the proposed evaluation method is applied to the asset valuation of bridges currently in use in Korea. Two methods are used in this study: the modified Government Accounting and Standards Board Statement 34 (GASB34) and the depreciated replacement cost (DRC). As they are both based on replacement cost(RC), the results generally show similar trends. Overall, the current value based on DRC is relatively higher than that of the modified GASB34 method.

The valuation method based on RC considers depreciation. If the lifetime is extended, the depreciation for the service life is calculated to be low. Therefore, the method based on DRC provides a higher current value than does the modified GASB34 method. The modified GASB34 method also considers the cost of maintenance. For a recently constructed bridge, the maintenance cost is absent or small. Therefore, the resulting value is found to be low.

Keywords: asset management; valuation; maintenance; road facilities

1. Introduction

In Korea, major road facility construction was carried out between the 1970s and the 1980s in order to secure national competitiveness. Recently, the need to perform maintenance on these road facilities has significantly increased, and, thus, serious budget shortages for the management authorities are expected in the future. It is necessary to prepare a rational evaluation standard for road facilities in order to propose a systematic maintenance budget based on the abrupt increase in maintenance costs compared to new construction, and to lay the foundation for preventive maintenance in the future. Considering the importance of efficient management of infrastructure including road facilities, in Korea, the Ministry of Strategy and Finance has been conducting inspections for the valuation of infrastructure since 2009. Through this objective investigation of the value of major infrastructure elements (e.g., roads, airports, and ports), the government expects to establish a foundation for the continuous and systematic management of national assets. However, considering the characteristics of

road facilities, it may not be meaningful to perform valuation based only on an accounting method. Likewise, when valuation is performed based only on an engineering method, the valuation approach could be questionable in terms of cost.

Efficient management of road facilities requires the preparation of a method and standard that define and evaluate performance measures to support the balanced budget decision-making that allows distribution of limited resources among various kinds of road facilities. Moreover, road facilities need to be perceived as assets, and changes in performance level and value depending on management action should be estimated rationally. These procedures will allow the management authority of road facilities to establish optimal management strategy and budget distribution tasks with a limited budget based on information concerning changes in future performance level and value.

This study aims to suggest a valuation guideline for the efficient asset management of road facilities by proposing a valuation process through the establishment of a method and procedure that measures the objective value of road facilities considering domestic and overseas engineering/accounting characteristics.

For this purpose, first, a valuation process considering the actual status of road facilities in Korea was proposed using asset valuation methodologies that classify road facilities based on their characteristics.

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The established process was applied to actual road facilities, and, based on the applicability and the analysis results; the future utilization of the process was reviewed.

2. Methods

The aim of this study is to select an accounting/engineering valuation method that can be used as a supporting tool for efficient asset management and decision-making. First, valuation methodologies used in diverse research and asset management fields were examined and classified into methods based on construction cost and methods based on replacement cost(RC).

(1) Valuation methods based on construction cost

A valuation method based on construction cost estimates value based on the past acquisition cost record. This method has the disadvantage of not being able to consider changes in price and service depending on changes in technology, but in most cases, valuation for accounting purposes requires a report based on construction cost.

The modified Government Accounting and Standards Board Statement 34 (GASB34) method is one of the valuation methods currently used in the United States. In this method, it is assumed that the government defines the minimum condition level of facilities, and the condition of the facilities is properly maintained through the operation of asset management systems such as Bridge Management System(BMS) and Pavement Management System(PMS). Because it is based on the acquisition cost of assets, depreciation is not considered; instead, maintenance cost and conservation cost are processed as expenses, and only additional and improvement costs are capitalized.

In the United States, regulations stipulate that infrastructure should be valued using GASB34. In this method, asset value is evaluated by depreciating acquisition cost using the straight-line method. The asset is depreciated, maintenance cost is expensed, and addition, improvement, and conservation costs are capitalized.

Net salvage value(NSV)is the difference between the cost to replace assets and the cost to rehabilitate assets. In NSV, the value of facilities is represented by RC minus the cost needed to rehabilitate facilities to their original condition.

(2) Valuation methods based on replacement cost

RC defines the value of facilities as the cost needed to replace them with substitute structures at this point in time. However, it has the disadvantage of not being able to reflect the decrease of value depending on the deterioration of road facilities during the period of use.

In deflated depreciated replacement cost(deflated RC), current value is estimated by deflating the RC at this point in time to the amount at the time of completion. However, it has the disadvantage of not being able to consider the value of the cost that has been

invested in the maintenance and performance of lifetime improvements to road facilities during the period of use.

Using depreciated replacement cost(DRC), optimized value is estimated by subtracting the decrease in value due to deterioration and performance and service level drops from the RC of target facilities to be replaced at this point in time. This method is efficient in estimating the value of assets that omit or lack cost information, and it estimates the minimum cost for replacing the service potential inherent in assets with other assets that have an equivalent function. In this method, inherent DRC value decreases as the optimization level gradually increases from the lower stage, where only depreciation is adjusted, to the upper stage, where surplus asset removal, functional and technical deterioration removal, economical and external deterioration removal, building site reconstruction, and location change are considered.

Written down replacement cost(WDRC) is the value depreciated based only on the current condition of facilities after the calculation of the RC. This method reflects facilities' service level (the current condition of assets). WDRC can estimate more practical value than other valuation methods because detailed data on road facilities is not required and the changed level of facilities based on previous maintenance can be reflected in the asset evaluation process. In the United States and Canada, the WDRC method has been used in the asset valuation of bridges as the Bridge Health Index (BHI: United States) and the Bridge Condition Index (BCI: Canada). These indices enable the estimation of a more realistic asset value by judging the performance degradation of bridges and by subtracting the failure cost corresponding to the damaged condition of bridges from the RC.

3. Suggested Road Facility Valuation Process

Accounting valuation methods can be used in decision-making relevant to budget investment efficiency analyses, such as the comparison of the valuation results of road facilities having the same form, size, or year of completion and the valuation of road facilities compared to the invested budget. In this regard, the value of each road facility can be compared by converting the value during its life cycle to the value at a specific time using the discount rate. However, it is necessary to consider an engineering valuation method that includes the accounting, social, and functional values of road facilities because effective decisions must include an analysis of effects compared to invested cost, which is linked with the performance of road facilities. This analysis cannot be done using an accounting valuation method only.

Therefore, in this study, the road facility valuation methods examined in the previous section were classified into a valuation method based on construction cost, which is an accounting valuation method, and a valuation method based on RC, which is

Table 1. Data Required for Valuation in Each Evaluation Methodology.

Valuation Method	Year of Completion	Specification	Average Unit Cost of Construction	Repair and Reinforcement Activities	Initial Construction Cost		Lifetime		Real Discount Rate	Depreciation
					₩	Yr	₩	Yr		
Construction Cost	○			○	○	○	○	○	○	○
Replacement Cost	○	○	○					○	○	○

an engineering valuation method.

(1) Asset valuation process based on construction cost

The valuation of road facilities based on construction cost is a current value estimation method, which uses elements such as the total construction cost at the time of road facility construction, maintenance cost, management cost, real discount rate, and depreciation. In this method, the construction cost required at the time of construction and the maintenance and management costs invested during the service life are converted to current monetary value considering the real discount rate and depreciation of the corresponding year to estimate the current value of road facilities.

In the data collection and classification step for target bridges, analysis using data such as total construction cost at the time of road facility construction, maintenance cost, bridge management cost, and depreciation is used to determine whether the current value of road facilities based on depreciation will be applied. In the calculation of total construction cost at the time of construction, the price, which includes the construction cost, land cost, and incidental costs at the time of construction, is calculated as the total construction cost for the initial construction of the corresponding road facility. In the estimation of service life, the individual lifetime of a road facility is estimated considering the reduction or extension of lifetime; lifetime reduction due to structural form and characteristics, environment, and traffic volume, and lifetime extension due to maintenance history differ for each road facility. In the estimation of salvage value, salvage value refers to the value at the end of a road facility's lifetime, and it is estimated based on the difference between the cost required for the dismantlement and disposal of the road facility and the cost acquired from the recycling. In the calculation of maintenance cost, maintenance cost refers to the costs required for the period of common use, such as the management, inspection, and diagnosis costs for road facilities or each element of the road facilities, and the maintenance and repair costs required for repair and replacement. It is divided into every repair and replacement cost required during the service year, and includes various maintenance and repair cost items for each road facility and constituent element. In general, if the cost spent for road facility assets returns a profit, the expenditure is capitalized; if not, it is regarded as a simple expenditure. In the depreciation step, depreciation refers to the decrease in the value of assets

due to the passage of time or environmental factors. For the depreciation method, if assets are used at the same rate every year, it is rational to use the straight-line method because this method implicitly assumes that the value of assets decreases by a constant amount as time passes.

(2) Asset valuation process based on replacement cost

In the valuation of road facilities based on RC, the reconstruction of target facilities at this point in time is assumed, and the construction cost calculation result from the cost estimate process is used as the current value of assets.

In the data collection and classification step for road facilities, using the detailed classification data of completed road facilities rather than the drawing and the statement, the data necessary for the calculation of approximate construction cost in the estimation process of standard RC (i.e., the next step) is collected, and it is determined whether the unit cost of road facility construction for the estimation of RC will be applied. In the estimation step of standard RC, the approximate construction cost estimation method can be used. In general, the estimation of approximate construction cost is used to predict construction cost without design drawings and specifications, and thus data from previous similar construction projects and information from construction work participants are utilized. In the estimation of service life and salvage value, individual lifetime is estimated considering the characteristics of road facilities, similar to the process based on construction cost. In the depreciation step, the important process of converting the construction cost of road facilities at this point in time (obtained from the RC estimation process) to the value at this point in time includes various methods such as the straight-line method, the declining balance method, and the production method. However, in this study, for easy depreciation, the current value estimation of road facilities was conducted using the depreciation process that utilizes lifetime.

For the process of calculating current value using the RC method, the principle is to re-estimate based on drawings, written calculation of the amount, or the estimate sheet, but this has the disadvantage of requiring significant time and cost.

Therefore, this study used the unit cost estimation method based on the approximate construction cost estimation method for the RC estimation of all domestic road facilities.

Fig.1. Integrated Valuation Process

As for the two evaluation methods, for the method based on construction cost, current value is estimated based on the cost incurred in the past, including the construction cost, whereas for the method based on RC, the current value is estimated based on re-estimation results. As shown in Table 1., each current value evaluation method requires different data.

As the required data values are different, the estimated current values could also be different. However, the future change in asset value could essentially be predicted through the obtained results, and the results could be used as the basis for asset maintenance and management decision-making. Fig.1. shows the integrated process to perform valuation based on construction cost and RC.

4. Case Study on the Valuation of Road Facilities

(1) Field survey and data construction

1) Valuation subject selection

Road facilities on four routes were valued using the proposed integrated valuation process that considers construction cost and RC. Among the road facilities on the corresponding routes, the bridge facilities, where the valuation model of this study can be applied and analyzed due to relatively easy data collection, were preferentially selected as the subject. Then, the field survey was performed and BMS data collected, and the valuation was carried out.

2) Valuation subject data collection

The target bridges were classified into routes A, B, C, and D, respectively, and codes were assigned. For the lifetime estimation and RC calculation of the bridges, they were again divided depending on the bridge form. Data from BMS were collected to classify the bridges by route.

3) Asset lifetime calculation

In this study, the data distribution was analyzed to calculate the lifetime of the assets. The results indicate that the average physical lifetime of the PC bridge was calculated to be 51 years, that of the RC bridge was 59 years, and that of the ST bridge was 55 years. Further, the influence factors affecting the lifetime of the assets were drawn. Each degree of influence was established by consulting experts. The influence factor was drawn through a field survey for each bridge suitable for that factor, and was reflected in the physical lifetime of the bridges. The degree of influence for each influence factor was reflected in the estimated physical lifetime of the bridges, as shown in Equation 1. Table 2. summarizes the results of this estimation.

$$BLT = PLT \times \left(1 + \sum_{n=1}^5 IF \right) \quad (\text{Eq. 1})$$

where BLT: bridge lifetime

PLT: physical lifetime

IF: influencing factors

Table 2. Service Life Estimation Result Considering the Influence Factors

Code	Bridge Form	Lifetime	Code	Bridge Form	Lifetime
A-01	RC	72	B-14	RC	69
A-02	ST	76	C-01	RC	81
A-03	ST	80	C-02	ST	80
A-04	PC	70	C-03	RC	69
A-05	ST	74	C-04	PC	70
B-01	ST	80	C-05	PC	70
B-02	RC	74	C-06	PC	70
B-03	RC	74	C-07	PC	74
B-04	RC	71	C-08	ST	70
B-05	PC	60	C-09	ST	74
B-06	RC	81	C-10	RC	71
B-07	ST	80	C-11	PC	64
B-08	RC	71	C-12	ST	83
B-09	PC	74	C-13	RC	74
B-10	RC	71	D-01	ST	77
B-11	RC	71	D-02	PC	71
B-12	PC	71	D-03	PC	71
B-13	PC	74	D-04	RC	83

(2) Asset valuation of bridges based on construction cost

1) Total construction cost

The BMS, an information system that can perform integrated management of every piece of information for all bridges, and the FMS, which can manage information on the facility life cycle, such as facilities' safety management and maintenance, were utilized to obtain data for the calculation of the total construction cost. The NPV method, which considers the real discount rate, was used for the current value of the total construction cost, as shown in Equation 2. In this study, a 10-year average real discount rate of 4.5% was used, as presented by the Ministry of Land, Transport and Maritime Affairs in 2010. Table 3. summarizes the results.

$$C_p = C \times (1+i)^{(VY-CY)} \quad (\text{Eq. 2})$$

where C: total construction cost

i: real discount rate

VY: valuation year

CY: completion year

Table 3. Bridges' Total Construction Cost (Monetary Unit: Thousand Won)

NO.	Code	Completion Year	Total Construction cost	Current Total Construction Cost
1	C-02	2000	17,949,000	27,874,248
2	C-05	2007	5,348,000	6,102,956
3	C-06	2006	3,582,000	4,271,602
4	C-07	2006	2,527,000	3,013,495
5	C-09	1990	3,710,000	8,947,459
6	D-01	2007	30,069,000	34,313,724
7	D-02	1993	8,560,000	18,090,505
8	D-03	1997	3,000,000	5,316,588
9	D-04	1993	67,620,000	142,906,540

2) Maintenance cost calculation

In this study, for the cost of each constituent element of the assets depending on the maintenance measures, data on the maintenance cost of the assets were selected

Table 4. Current Value of the Capitalized Maintenance Cost (Monetary Unit: Thousand Won)

Code Year	C-02	C-09	D-02
2000	0	48,763	0
2001	0	4,458	0
2004	99	326,165	17,868
2005	0	618,567	12,725
2007	0	0	30,861
Current Maintenance Cost	99	997,953	61,454

only when they improved the performance or function of the bridges, and the maintenance cost for the selected cases was converted to current monetary value considering the real discount rate, as shown in Table 4.

3) Consideration of the depreciation

In this study, the depreciation in the base year was calculated using the straight-line method. The method for estimating the accumulated depreciation is shown in Equation 3. Table 5. summarizes the results.

$$D_k = \frac{(C_c - S_v)}{A_y} \times U_y \quad (\text{Eq. 3})$$

where Cc: construction cost

Ay: available year

Sv: salvage value of the bridge

Uy: service year

Table 5. Accumulated Depreciation

No.	Code	Completion year	Available Year	Construction Cost	Accumulated Depreciation
1	C-02	2000	80	17,949,000	2,243,625
2	C-05	2007	70	5,348,000	229,200
3	C-06	2006	70	3,582,000	204,686
4	C-07	2006	70	2,527,000	144,400
5	C-09	1990	73	3,710,000	1,016,438
6	D-01	2007	77	30,069,000	1,171,519
7	D-02	1993	71	8,560,000	2,049,577
8	D-03	1997	82	3,000,000	475,610
9	D-04	1993	73	67,620,000	15,747,123

4) Current value estimation based on construction cost

The current value based on construction cost was calculated by subtracting the accumulated depreciation from the total construction cost and maintenance cost, which had been estimated considering the real discount rate. Table 6. shows the obtained current values.

Table 6. Current Value of the Bridges (Monetary Unit: Thousand Won)

No.	Code	Completion Year	Current Total Construction Cost	Current Maintenance Cost	Accumulated Depreciation	Current Value
1	C-02	2000	27,874,248	99	2,243,625	25,630,722
2	C-05	2007	6,102,956		229,200	5,873,756
3	C-06	2006	4,271,602		204,686	4,066,916
4	C-07	2006	3,013,495		144,400	2,869,095
5	C-09	1990	8,947,459	997,954	1,016,438	8,928,975
6	D-01	2007	34,313,724		1,171,519	33,142,205
7	D-02	1993	18,090,505	61,454	2,049,577	16,102,382
8	D-03	1997	5,316,588		475,610	4,840,979
9	D-04	1993	142,906,540		15,747,123	127,159,417

(3) Asset valuation of the bridges based on replacement cost

1) Standard replacement cost estimation

The standard RC was estimated based on unit cost per unit area (won/m²). The 2010 Road Work Manual (Korea Expressway Corporation, 2010) was used to obtain unit cost per unit area, and the estimation method is shown in Equation 4.

$$SRC(\text{won}) = SCC(\text{won} / \text{m}^2) \times FL(\text{m}) \quad (\text{Eq. 4})$$

where SRC: standard RC

SCC: standard construction cost

FL: full length

2) Consideration of the depreciation

Similar to the asset value estimation method based on construction cost, the depreciation was calculated based on the straight-line method. The current value considering the depreciation was obtained by subtracting the depreciation, which had been calculated using the straight-line method, from the standard RC, as shown in Equation 5. Table 7. summarizes the calculation results.

$$CVB = \frac{(SRC - SV)}{SL} \times (SL - SY) \quad (\text{Eq. 5})$$

where CVB: current value of the bridge

SRC: standard RC

SV: salvage value

SL: service life

SY: service year

Table 7. Current Value of the Bridges Considering the Depreciation (Monetary Unit: Thousand Won)

Code	DRC	Code	DRC
A-01	900,491	B-14	688,004
A-02	1,912,778	C-01	4,215,085
A-03	839,661	C-02	14,130,869
A-04	1,715,352	C-03	65,756
A-05	2,316,121	C-04	3,048,387
B-01	19,333,828	C-05	6,835,175
B-02	11,103,132	C-06	14,514,515
B-03	496,667	C-07	8,705,412
B-04	394,354	C-08	3,906,153
B-05	886,672	C-09	9,181,511
B-06	1,085,149	C-10	1,288,303
B-07	11,557,016	C-11	7,338,515
B-08	3,731,323	C-12	12,901,504
B-09	5,142,444	C-13	379,601
B-10	739,002	D-01	22,261,568
B-11	462,233	D-02	13,046,651
B-12	3,976,348	D-03	11,758,847
B-13	814,396	D-04	4,621,344

(4) Analysis of the asset valuation results

For the current value of the bridges on the target routes based on construction cost, the population size was very small due to a lack of data. Thus, the modified GASB34 method, which is commonly used for accounting purposes, was applied in order to compare it with the DRC. The modified GASB34 method regards the total cost invested in the bridge as the value of the bridge. As shown in Equation 6, it can be represented by the sum of the construction cost invested at the initial stage and the cost invested during the service year that has contributed to performance and function improvements for the bridge.

$$MG = CC + TCIB \quad (\text{Eq. 6})$$

where MG: modified GASB34

CC: construction cost

TCIB: total cost invested in the bridge

Table 8. summarizes the results for a comparison of the current values of the modified GASB34 and the DRC.

Table 8. Comparison of the Modified GASB34 and the DRC (Monetary Unit: Thousand Won)

Code	Modified GASB34	DRC	Code	Modified GASB34	DRC
A-01	409,656	900,491	B-14	425,640	688,004
A-02	1,663,200	1,912,778	C-01	3,226,955	4,215,085
A-03	798,751	839,661	C-02	17,949,076	14,130,869
A-04	1,585,472	1,715,352	C-03	24,087	65,756
A-05	2,053,855	2,316,121	C-04	2,817,574	3,048,387
B-01	13,635,379	19,333,828	C-05	5,348,000	6,835,175
B-02	5,544,559	11,103,132	C-06	3,582,000	14,514,515
B-03	263,305	496,667	C-07	2,527,000	8,705,412
B-04	150,744	394,354	C-08	2,040,433	3,906,153
B-05	235,469	886,672	C-09	3,994,861	9,181,511
B-06	605,883	1,085,149	C-10	447,023	1,288,303
B-07	5,680,329	11,557,016	C-11	4,948,580	7,338,515
B-08	1,219,913	3,731,323	C-12	6,014,214	12,901,504
B-09	2,994,779	5,142,444	C-13	226,526	379,601
B-10	439,595	739,002	D-01	30,069,000	22,261,568
B-11	269,281	462,233	D-02	8,610,975	13,046,651
B-12	2,351,912	3,976,348	D-03	3,000,000	11,758,847
B-13	546,693	814,396	D-04	67,620,000	4,621,344

The graph in Fig.2. compares the DRC and the modified GASB34 method, excluding the results of routes A and B, for which the data needed for valuation based on construction cost were insufficient.

Bridge C-03 on route C is not shown in the graph because the size was much smaller than other bridges, which also resulted in a much smaller evaluation result.

Fig.2. Replacement Cost Results

The construction costs of five bridges are included for route C (bridges C-02, C-05, C-06, C-07, and C-09); among these, the record indicated that bridge C-02 had an unusually high construction cost. Therefore, for the valuation based on construction cost, it also had a higher estimated value compared to other bridges.

For route D, the construction costs were included in every case, and the current value based on construction cost was generally higher than that based on RC. This is because the recorded construction cost was high. As explained earlier, the current value of the modified GASB34 was calculated based on construction cost. For bridges D-02 and D-03, the current values based on RC were estimated to be high; for bridges D-01 and D-04, the construction costs were estimated to be unusually high.

5. Conclusion

In this study, an asset valuation process suitable and effective for the actual conditions in Korea was proposed through an examination and analysis of the asset valuation method of road facilities, which can help with strategic decision-making for road facility asset management. Moreover, the proposed evaluation method was applied to the asset valuation of bridges currently in use in Korea, and the results were analyzed. It is expected that either the asset valuation method based on construction cost or the asset valuation method based on replacement cost could be used to evaluate the value of bridges; users should select the method appropriate for their accounting or maintenance purposes.

The two methods used in this study, the modified GASB34 and the DRC, were both based on RC, and the graphs generally showed similar trends. Overall, the current value based on DRC was relatively higher than that from the modified GASB34 method.

DRC considered depreciation. If the lifetime was extended, the depreciation for the service life was calculated to be low. Therefore, the DRC provided a higher current value than did the modified GASB34 method. The modified GASB34 method also considered the cost of maintenance. For a recently constructed bridge, the maintenance cost is absent or small. Therefore, the resulting value was found to be low.

The current value based on construction cost, the current value from DRC, and the current value from the modified GASB34, which were used in this study, have distinct characteristics. The current value based on construction cost, which is an accounting method, efficiently reflects the current value for the cost, considering the discount rate for the invested cost up to this point in time and the depreciation for the service year. However, this method is limited in that it cannot consider technical aspects (i.e., engineering method and new technology). Further, as the method is sensitive to the construction cost at the time of construction, it has the disadvantage of possibly overestimating or underestimating the value. The modified GASB34 is also an accounting method, and calculates the value based only on pure cost data without processing the invested cost. However, in this methodology, the value does not decrease as time passes; it gradually increases. In this case, the cost invested at the time of dismantlement can be known, but it is difficult to regard this as the value of a target facility.

For the current value from DRC, which is used for engineering purposes in comparison with the accounting method, the value is calculated considering the technical aspects and depreciation for the passage of time through the specification of a target facility. Therefore, DRC could be the rational method for the valuation of road facilities from the engineering perspective.

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