The Study on the Analysis of Elemental Maintenance Costs for Educational Facilities

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ABSTRACT: The purpose of this study is to analyze elemental maintenance costs for educational buildings. The adapted research method selected three school buildings in Seoul as BTL projects. On the basis of the selected case, the study suggested a model to establish a system for each parts and to estimate analyzed maintenance costs through that system. According to the analysis, the study proposed a partial maintenance costs standard and analyzed proper maintenance costs. The results of this study are as follows 1) The system is divided into 8 large-groups and 24 small-groups for the analysis elemental maintenance costs. 2) The average rations followed by analysis of partial maintenance costs of the three school buildings are as followings, the total maintenance costs are analyzed 3,992 million won and each part of average rations is exterior of building 10.9%, interior of building 41.58%, electricity & fire fighting facility 14.22%, water supply & healthy facility 11.39%, heating & water supply facility 12.93%, landscape 6.3%, civil engineering works 2.69%.

Keywords: Educational Facilities, elemental System Establishment, elemental maintenance costs.

1. INTRODUCTION

1.1 Study Background & Purpose

The Ministry of Education & Human Resources Development established an educational facility construction policy as an educational environment improvement project in 2005 and since then has carried out the project of reconstruction, repair and new construction of more than 30 years old outworn school facilities. This policy centers on the private capital-based BTL (Build Transfer Lease) construction and adopts a complex order method in order to induce construction business entities' intensive participation. But this complex order method has a problem in the estimation of maintenance costs. It is because there is no criterion of input costs for the estimation of elemental maintenance costs of facilities. This method estimates maintenance costs only with the size of present facilities and therefore cannot calculate accurate maintenance costs. In other words, this method does not take elemental maintenance costs into account, thus making the establishment of plan of detailed cost input difficult at the stage of facility operation.

Preceding studies on the maintenance costs of educational facilities mainly dealt with actual condition of elemental repair, long-term repair costs for the reasonable maintenance of educational facilities, and estimation of reserve fund for long-term repair. These studies adopted the traditional construction type-oriented construction cost estimation technique and therefore did not consider the elemental construction cost estimation technique. Therefore, it is necessary to carry out a study on the estimation of elemental maintenance costs.

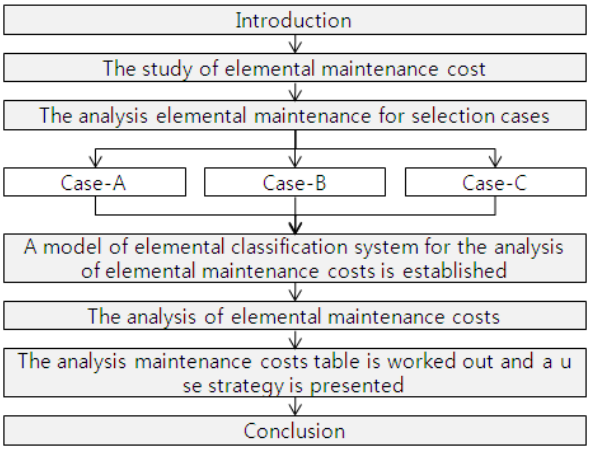
In this regard, the purpose of this study is to examine the estimation of elemental maintenance costs of educational facilities. Study purpose can be summarized as follows:

First, to present a estimation model of elemental maintenance costs.

Second: to estimate elemental maintenance costs of case school facilities on the basis of the above model.

1.2 Study Scope & Method

Study subjects are three primary school facilities in Seoul and they were constructed with BTL method in 2007. In order to estimate maintenance costs, a elemental classification system of facilities was established first and then analyzed its elemental maintenance costs. Study procedure and method are as follows (picture 1):



[Picture 1] Study Procedure & Method

Study methods are as follows in detail:

1) Based on domestic and overseas cases, elemental maintenance costs are theoretically examined.

2) In order to select study subjects, primary school facilities in Seoul, which were constructed with BTL method in 2007, are surveyed.

3) Focusing on the selected school facilities, a model of elemental classification system for the analysis of elemental maintenance costs is established.

4) Based on the established elemental system, maintenance costs are analyzed first and then the annual progress of input of maintenance costs is looked into.

5) By classifying analyzed elemental maintenance costs comprehensively, an analysis table is worked out and a use strategy is presented.

6) Finally, conclusion is deduced.

2. EXAMINATION OF ELEMENTAL CONSTRUCTION & MAINTANANCE COSTS

2.1 Conception of Maintenance Cost Analysis

Maintenance costs refer to the expenditure occurred to maintain the initial performance of facilities during its life cycle. Therefore, the conception of maintenance cost analysis is to analyze and estimate the costs occurred through repair and reinforcement after a certain point of time.

2.2 Conception of Elemental Maintenance Cost Analysis

Elemental maintenance cost analysis refers to the examination of elemental construction cost-based maintenance costs. Traditional analytic method of maintenance costs examines a portion of facilities or such specific areas as electricity, machinery and equipments. However, elemental maintenance cost analysis classifies the whole facilities into sections and then analyzes elemental costs out of the whole costs of the whole facilities. This elemental analysis presents the classified maintenance costs of the whole facilities and is useful for the establishment of a plan of maintenance cost input.

3. SELECTION OF CASES & PRESENTATION OF ELEMENTAL MODEL

3.1 Outline of Case Selection

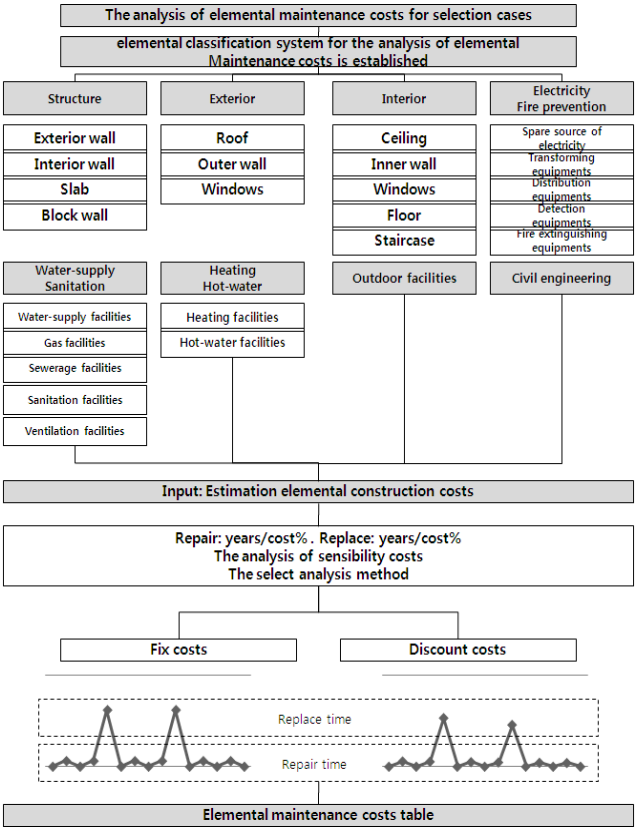
Study subjects are three primary schools in Seoul and they were constructed with BTL method in 2007. Its outline is as follows <table 1>:

<Table 1> Outline of Cases

School	Building size	Class	costs (won)
Case-A	13,629 ㎡	30	5,294,395,000
Case-B	14,263 ㎡	35	5,404,141,000
Case-C	14,592 ㎡	45	7,562,479,000
Total	42,484 ㎡	110	18,261,015,000

3.2 Elemental Classification System & Analytic Model of Maintenance Costs

Elemental classification system-based analytic model of maintenance costs is as follows (picture 2):



[Picture 2] Elemental Classification System-based Analytic Model of Maintenance Costs

The above model of elemental maintenance cost analysis is useful in the estimation of elemental classification-based proper maintenance costs. Since it

estimates the costs and time of elemental repair and replacement, it prevents unnecessary expenditure from wasting. In addition, by means of analyzing elemental maintenance costs, it provides the flexibility of input of maintenance costs and can estimate the time of cost input for vulnerable areas. Elemental maintenance costs are calculated on the basis of construction costs together with the application of repair cycle/rate and replacement cycle/rate. Therefore, it needs accurate construction costs. And as for the repair cycle/rate and replacement cycle/rate, it uses legal criteria or practical standards which are derived from the survey of actual performance of repair & maintenance.

4. ANALYSIS OF ELEMENTAL CONSTRUCTION & MAINTENANCE COSTS

4.1 Analysis of Case Facilities' Elemental Construction & Maintenance Costs

In this section, case facilities' maintenance costs are analyzed on the basis of classified elemental system.

4.1.1 Analysis of "A" School Facilities' Elemental Maintenance Costs

In order to analyze "A" school facilities' elemental maintenance costs, its construction costs are calculated based on the elemental classification system and then analyzed the calculated maintenance costs with the elemental application of repair cycle/rate and replacement cycle/rate. "A" school facilities' elemental maintenance costs are as follows (table 2):

<Table 2> "A" School Facilities Maintenance Costs

Section		Maintenance costs(won)	
		Repair	Replacement
Exterior	Roof	19,974,721	107,321,973
	Outer wall	13,225,070	96,955,372
	Windows & doors	45,384,042	60,029,094
Sum		78,583,833	264,306,439
Interior	Ceiling	92,972,030	344,053,410
	Inner wall	72,661,316	244,355,183
	Floor	56,370,980	328,285,975
	Windows & doors	66,574,516	169,744,412
	Staircase	24,071,075	81,606,247
Sum		312,649,917	1,168,045,227
Electricity Fire prevention	Spare source of electricity	8,762,791	79,141,415
	Transforming equipments	14,099,095	85,502,373
	Distribution equipments	43,984,560	50,916,376
	Detection equipments	6,044,867	49,240,489
	Fire extinguishing equipments	36,518,609	130,169,339
Sum		109,409,923	394,969,993
Water-supply Sanitation	Water-supply facilities	31,927,926	61,219,702
	Gas facilities	12,356,410	18,253,520
	Sewerage facilities	19,439,691	52,393,763
	Sanitation facilities	23,407,777	93,165,760
	Ventilation facilities	2,717,327	82,079,191
Sum		89,849,131	307,111,937
Heating Hot-water	Heating facilities	12,964,406	324,144,098
	Hot-water facilities	12,039,730	109,874,578
Sum		25,004,135	434,018,676
Outdoor facilities	Attached Facilities	33,077,262	182,548,044
Sum		33,077,262	182,548,044
Civil engineering	Civil engineering work	43,289,059	50,846,257
Sum		43,289,059	50,846,257

As it is shown in table 2, maintenance costs are analyzed after estimating elemental classification system-based construction costs. maintenance costs are classified into repair and replacement. These maintenance costs are discounted costs in which an average discount rate of 3.08% for the period of 1998 ~ 2008 is applied. Elemental maintenance costs can be added up as follows (table 3):

<Table 3> "A" School Facilities' Elemental Maintenance Costs (sum total) (won)

Section	Maintenance costs	Deviation between Construction costs and maintenance costs
Exterior	342,890,271	-104,552,007
Interior	1,480,695,145	227,163,442
Electricity Fire prevention	504,379,915	196,453,506
Water-supply Sanitation	396,961,067	167,830,154
Heating Hot-water	459,022,811	177,402,924
Outdoor facilities	215,625,307	142,722,673
Civil engineering	94,135,316	-147,946,757
Sum total	3,493,709,832	659,073,935

Elemental maintenance costs in the <table 3> consist of interior 42%; electricity & fire prevention 15%; heating & hot-water 13%; water-supply & sanitation 11%; and other sections less than 10%.

4.1.2 Analysis of "B" School Facilities' Elemental Maintenance Costs

"B" school facilities' elemental maintenance costs are summarized as follows (table 4):

<Table 4> "B" School Facilities Maintenance Costs

Section		Maintenance costs(won)	
		Repair	Replacement
Exterior	Roof	33,728,849	108,236,183
	Outer wall	12,648,653	84,178,696
	Windows & doors	45,477,753	61,308,762
Sum		91,855,254	253,723,640
Interior	Ceiling	49,182,251	349,454,920
	Inner wall	66,844,351	249,591,366
	Floor	57,763,273	335,320,674
	Windows & doors	65,042,495	173,381,792
	Staircase	21,790,239	83,354,953
Sum		260,622,609	1,191,103,704
Electricity Fire prevention	Spare source of electricity	12,083,151	61,782,159
	Transforming equipments	17,758,535	87,529,985
	Distribution equipments	45,382,538	46,515,495
	Detection equipments	13,123,493	49,585,382
	Fire extinguishing equipments	31,606,800	132,879,965
Sum		119,954,516	378,292,986
Water-supply Sanitation	Water-supply facilities	27,749,707	47,551,357
	Gas facilities	12,713,148	17,725,091
	Sewerage facilities	26,632,140	56,472,181
	Sanitation facilities	21,278,660	95,039,728
	Ventilation facilities	2,775,555	83,838,031
Sum		91,149,210	300,626,388
Heating Hot-water	Heating facilities	16,118,592	410,409,002
	Hot-water facilities	6,659,313	55,874,110
Sum		22,777,905	466,283,113
Outdoor facilities	Attached Facilities	24,835,433	227,507,423
Sum		24,835,433	227,507,423
Civil engineering	Civil engineering work	47,030,934	45,330,103
Sum		47,030,934	45,330,103

Above elemental maintenance costs can be added up as follows (table 5):

<Table 5> "B" School Facilities' Elemental Maintenance Costs (sum total) (won)

Section	Maintenance costs	Deviation between Construction costs and maintenance costs
Exterior	345,578,894	-111,451,433
Interior	1,451,726,313	171,333,217
Electricity Fire prevention	498,247,502	183,722,670
Water-supply Sanitation	391,775,599	157,734,738
Heating Hot-water	489,061,018	201,406,419
Outdoor facilities	252,342,856	177,878,023
Civil engineering	92,361,037	-154,908,509
Sum total	3,521,093,219	625,715,125

Elemental maintenance costs in the <table 5> consist of interior 41%; electricity & fire prevention 14%; heating & hot-water 14%; water-supply & sanitation 11%; and other sections less than 10%.

4.1.3 Analysis of "C" School Facilities' Elemental Maintenance Costs

"C" school facilities' elemental maintenance costs are summarized as follows (table 6):

<Table 6> "C" School Facilities Maintenance Costs

Section		Maintenance costs(won)	
		Repair	Replacement
Exterior	Roof	166,747,097	102,147,912
	Outer wall	39,749,543	92,409,715
	Windows & doors	130,937,543	84,866,578
Sum		337,434,183	279,424,205
Interior	Ceiling	156,491,432	371,324,546
	Inner wall	98,614,014	353,434,462
	Floor	85,203,742	471,176,155
	Windows & doors	122,975,954	232,365,644
	Staircase	39,065,730	117,746,157
Sum		502,350,872	1,546,046,963
Electricity Fire prevention	Spare source of electricity	14,501,504	86,615,405
	Transforming equipments	27,674,977	124,490,989
	Distribution equipments	63,395,480	73,436,560
	Detection equipments	17,666,538	62,473,634
	Fire extinguishing equipments	42,426,586	187,554,957
Sum		165,665,085	534,571,546
Water-supply Sanitation	Water-supply facilities	36,527,789	88,331,285
	Gas facilities	5,327,792	25,893,391
	Sewerage facilities	22,055,017	107,536,267
	Sanitation facilities	31,234,566	134,599,159
	Ventilation facilities	5,381,776	118,428,548
Sum		100,526,941	474,788,650

Heating Hot-wate	Heating facilities	25,605,261	463,283,873
	Hot-water facilities	32,881,768	78,502,208
Sum		58,487,028	541,786,081
Outdoor facilities	Attached Facilities	49,727,181	237,396,908
Sum		49,727,181	237,396,908
Civil engineering	Civil engineering work	62,230,348	73,363,885
Sum		62,230,348	73,363,885

Above elemental maintenance costs can be added up as follows (table 7):

<Table 7> "C" School Facilities' Elemental Maintenance Costs (sum total) (won)

Section	Maintenance costs	Deviation between Construction costs and maintenance costs
Exterior	616,858,388	-28,736,899
Interior	2,048,397,836	239,730,665
Electricity Fire prevention	700,236,631	255,942,812
Water-supply Sanitation	575,315,591	244,712,416
Heating Hot-water	600,273,110	193,935,845
Outdoor facilities	287,124,089	181,936,003
Civil engineering	135,594,233	-213,695,615
Sum total	4,963,799,878	873,825,227

Elemental maintenance costs in the <table 7> consist of interior 41%; electricity & fire prevention 14%; heating & hot-water 12%; water-supply & sanitation 12%; exterior 12%; and other sections less than 10%.

4.2 Summary of Elemental Maintenance Costs

In this section, analyzed maintenance costs are summarized and the time of generation of maintenance costs is analyzed annually

4.2.1 Summary of Elemental Maintenance Costs

All the three school facilities' elemental maintenance costs are summarized as follows (table 8):

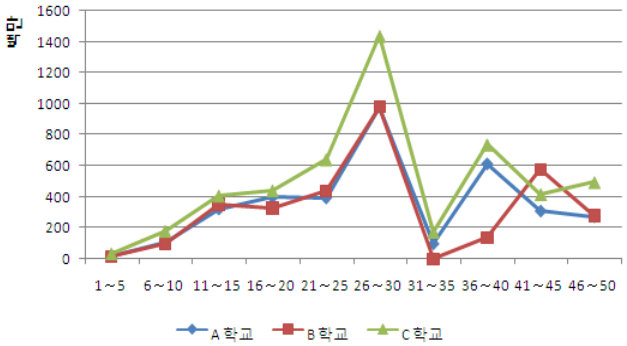
<Table 8> Summary of Three School Facilities' Elemental Maintenance Costs (won)

Section	"A" School	"B" School	"C" School
	Maintenance costs	Maintenance costs	Maintenance costs
Exterior	342,890,271	345,578,894	616,858,388
Interior	1,480,695,145	1,451,726,313	2,048,397,836
Electricity Fire prevention	504,379,915	498,247,502	700,236,631
Water-supply Sanitation	396,961,067	391,775,599	575,315,591
Heating Hot-water	459,022,811	489,061,018	600,273,110
Outdoor facilities	215,625,307	252,342,856	287,124,089
Civil engineering	94,135,316	92,361,037	135,594,233
Sum total	3,493,709,832	3,521,093,219	4,963,799,878

The above <table 8> shows that "C" School's maintenance costs are highest and it is followed by "B" School and "A" School in order. It shows that maintenance costs correspond to construction costs. It is because maintenance costs are analyzed based on the construction costs.

4.2.2 Analysis of Annual Progress of Input of Maintenance Costs

In order to estimate the progress of input of elemental maintenance costs over the period of its life cycle, the time of generation of costs is analyzed annually. The time of generation of costs is greatly influenced by the repair cycle and the replacement cycle applied. The time of generation of costs can be schematized as follows (picture 3):



[Picture 3] The Time of Generation of Costs

The results of analysis show that maintenance costs begin to generate in the 8th year on. And repair work is carried out over the period from the 10th year to the 20th year and therefore repair costs generate in this period. The replacement of facilities is taken place over the period from the 26th year to the 30th year, thus generating replacement costs in this period. Replaced facilities are machinery, equipments and parts in general. And as facilities approach to the final part of its life cycle, frequent repair and replacement are taken place. Since three schools' repair cycle and replacement cycle is the same, the time of generation of their maintenance costs is also similar. However, as the materials and items of facilities are different, so is the time of generation of their maintenance costs a little different. The estimation of time of cost generation is useful for the establishment of input plan of maintenance costs during the life cycle of facilities.

4.3 Effects of Application of Elemental Maintenance Cost Analysis

The application of elemental maintenance cost analysis allows to estimate the validity and input timing of maintenance costs which are generated during the period of operation of facilities. Because it is possible to estimate the elemental maintenance costs of facilities at the initial stage of construction, the estimation of maintenance time and cost can be also properly estimated, thus making the facilities maintain its initial state of use. It is also used as basic data for the used material-based VE/LCC analysis of facilities and therefore makes both ordering and contracting parties maximize the values of their expenditure and be able to make prompt decision making. Other useful aspects of elemental maintenance cost analysis can be that it makes the estimation of rough work at the initial stage of construction more accurate than traditional estimation methods. It also makes the estimation of appropriate maintenance costs possible. The estimation of time of cost generation allows the cost to be used in other areas.

5. CONCLUSION

The purpose of this study was to analyze elemental maintenance costs in order to estimate systematic maintenance costs. For this, three primary school facilities in Seoul, constructed with BTL method in 2007, were selected as study subjects. And based on the selected three schools, a model was presented to establish a elemental system. And then based on the established elemental system maintenance costs were analyzed. In addition, an analysis table of elemental maintenance costs was presented. Study findings are as follows:

1) The model of classification system for the analysis of case schools' elemental maintenance costs consists of 8 main sections and 24 sub sections. And according to this elemental system, construction costs-based maintenance costs are analyzed.

2) Three case schools' elemental maintenance costs are as follows in average: Sum total 3,992 million won; exterior 435 million won (10.9%); interior 1,660 million won (41.58%); electricity & fire prevention 567 million won (14.22%); water-supply & sanitation 454 million won (11.39%); heating & hot-water 516 million won (12.93%); outdoor facilities 251 million won (6.3%); and civil engineering 107 million won (2.69%).

Through the method of estimating elemental construction and maintenance costs, the preliminary construction costs of educational facilities can be efficiently estimated and the maintenance costs which are generated during the period of operation of facilities can be systematically estimated. This possibility allows to control prime costs promptly according to the changing situation of construction. The estimation of classified elemental construction costs improves the reliability of predicting construction costs at the initial stage of project. In addition, the analysis of elemental & annual maintenance costs allows to estimate the time of maintenance and the time of expending maintenance costs.

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