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69

Establishment of Service Life of Educational Facilities
- Focused on the rooftop waterproofing and floor finishing -

Lee, KangHee* · Chae, ChangU**

* *Dept. of Architectural Eng., Andong National Univ., South Korea (leekh@anu.ac.kr)*
** *Corresponding author, Korea Institute of Construction and Technology, South Korea (cuchae@kict.re.kr)*

ABSTRACT

Building has been deteriorated gradually owing to geographic, physical complex and other factors. School living condition has a key role to improve the learning ability, life attitude and qualifications to adopt to social life. Therefore, it is important for school environment to keep the living condition. Repair time and scope of school facilities are required to maintain the function and performance to plan the long term repair. But there are little information about the school maintenance such as repair time and function.

In this paper, it aimed at providing the service life to suggest the repair time and scope in the roof-proofing and floor finishing which used the three estimation method in probabilistic approach. The service life has a key role to decide the repair time and to make the plan for the repair maintenance. Results of this study are as follows ; First, the 1st repair time were taken through three methods in probabilistic and deterministic functions to eliminate the estimation bias. Second, the service life is suggested 36 years of an elementary school, 34 years of a middle school and 41 years of a high school. Third, the service life of a floor finishing is 43 years of an elementary, 39 years of a middle school and 41 years of a high school. The above study could not include the detailed information about the materials and repair works. Therefore it needs a further study to reflect the detailed information and to make a repair strategy.

KEYWORD

service life,
apartment,
maintenance,
repair scope,
repair cycle,
repair rate

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1. Introduction

1.1. Background and goal of research

Educational environment is crucial for academic achievement and character formation of students. However, criteria for maintaining educational facilities tend to be ambiguous and not standardized. Since 2000, there has been incresing interest in maintenance for and supply of educational facilities via increased social interest in eduction and educational process. Moreover, with continuous aging of existing educational facilities, the cost is increasing for functional enhancement and repair/maintenance.

Educational facilities provide students with living and educational space. It is a basic element of forming educational environment. Compared to general-purpose residences, there are differences in use hours, use area and frequency. It is a space used by many students and used intensively during academic terms. On the other hand, repair and maintenance in the field remain at ad hoc level and systematic decision-making process is lacking.

Systematic repair and maintenance programs and basic data for technical facility management are severely lacking today. The current maintenance criteria for educational facilities is mostly based on information suggested by long-term repair plan for common residences. On the other hand, applying the maintenance guideline used for common residences to school facilities is problematic in reality because of the differences in building types, use hours and users.

The priority in building maintenance and management is to predict service life of parts and materials that compose a building. Ideally, repair life cycle and its scope and rate should be planned based on predicted service life period. In this paper, we determined service life cycle for rooftop waterproofing and floor furnishings in educational facilities. The research results will be used as basic information for making plans for repair and maintenance performed for a given service period.

1.2. Research method and description

Parts or materials that compose a building are diverse. Their service life could be defined as the period during which their usefulness is exhausted. In this research, we focused service life of rooftop waterproofing and floor finishing of educational facilities. The following research methods were used.

First, repair history of each elementary, middle and high school

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is based on repair and maintenance history since their respective completion date. Data was obtained from ___ Office of Education. Then, time series data on period, method, scope and cost of repair for rooftop waterproofing and floor finishing was collected and summarized. However, document retention period was set for 5 years and therefore it was difficult to collect repair history before then.[1]. Accordingly, data before retention period was collected from school after an interview with school facility manager.

Second, in terms of service period, primary service period is first determined, which is then used to determine recovery rate to perform analysis. There are three methods for determining primary service period: use normal distribution of the period when first repair occurs since completion; use 3-D model for repair period and cost; use probabilistic theory on when repair should be done first. In order to remove bias caused by different calculation results, primary service period was determined by calculating the average of the values obtained from the three methods described above. Then, recovery rate was calculated based on function and performance before the first repair was done to complete calculation of final service period.

1.3. Scope of research

The scope was the research was limited to rooftop waterproofing and floor finishing in educational facilities. The schools were divided into elementary, middle and high schools. Table 1 shows the sample count of elementary, middle and high schools by rooftop waterproofing and floor finishing used in analysis. The sample count for rooftop waterproofing includes 15 elementary schools, 48 middle schools and 13 high schools. The sample count of rooftop waterproofing includes 28 elementary school, 13 middle school and 21 high school.

Service period was analyzed first for each elementary, middle and high school [2]. The results from analysis of each school were used to suggest average service period for rooftop waterproofing and floor finishing each elementary, middle and high schools.

A difference arises between monetary value of a building when it is completed and after time passes. In order to remove such differences in monetary value, discount rate in this research was set at 2.6%. Discount rate was calculated based on consumer price index and savings deposit rate from 1993 to 2011.

Table 1. Number of School according to analyzed contents

	roof-proof	floor finishing
Number of school	elementary(15 schools)	elementary(28 schools)
	middle(48 schools)	middle(13 schools)
	high school(13 schools)	high school(21 schools)

1) It was learned that most schools retained information on previous repair history in order to request reimbursement for repair cost.

2) Such method is a bottom-up approach and is effective for analyzing both individual and overall characteristics of school.

2. Investigating repair period of rooftop water-proofing and floor finishing

It is rare to find a research that suggests service period for materials, parts and facilities that compose educational facilities. Most of researches are on repair cycle and repair rate and propose analysis of questionnaire survey data. Son SeKwan (2010) categorized parts and materials of educational facilities in terms of structure, exterior finishing, interior finishing and facilities and suggested repair rate and cycle for each.[3] Here, repair rate and cycle are being proposed as a tool to calculate life cycle cost. The result of analyzing repair cycle and rate shows that it is difficult to calculate repair and maintenance cost. Also, it was learned that, when it is difficult to define standard for repair cycle and rate, uncertainty associated with repair rate and cycle was high. In this research, statistical analysis was conducted on a questionnaire survey on parts, materials and facilities that compose school facilities, based on which we tried to propose more concrete repair cycle and rate. In case of cement liquid water-proof, repair cycle was 4 years at minimum and 8 years at maximum. Repair rate here was 3% and 10%, respectively.

Lee MiHye et. al. (2009) used the result of questionnaire survey on educational facilities to suggest repair and maintenance cost.[4] Analysis of repair and maintenance cost survey on government workers at educational facilities showed that, with common residence as 100, elementary schools required 126%, the middle school 127% and high school 139%. The figures were calculated based on repair cycle and rate for common residences. Repair and maintenance cost were estimated based on comparison to educational facilities. In addition, he uses the example of Belgium to suggest that retention period of overseas educational facilities were 30% shorter compared to common residences.[5]

Seo ChiHo et. al. (2001) analyzed the aging process of parts and materials using repair and maintenance of elementary school facilities. This research focuses on identifying current status on repair and maintenance of aging educational facilities, compositional materials, and problems associated with construction method and finding a way to enhance performance. Accordingly, we conducted an investigation to analyze the deterioration condition of parts and materials.

3) Son SeKwan (2010), Study on Estimating Educational Facility Repairing Cycle/Rate and Improving Reliability Using BSI, Doctoral Dissertation in Hong Ik University

4) Lee, M. Jung, M and Park, T.(2009), " A Study on the Establishment of Maintenance Standards(Repair Periods and Rates) of Educational Facilities", AIK J. in Structural Area25(29), pp145~152)

5) Lee, MiHye (2009), A Study on the Establishment of Maintenance Standards(Repair Periods and Rates) of Educational Facilities, Mokwon University, Ph.D. Dissertation

This research also points out problems associated with post-repair method in which repair is made after total functional paralysis occurs and suggests a need for facility management method that requires an overhauling of compositional materials. Also, we suggest need for repair cycle that is different from expected service life in order to remove possibility of functional paralysis.

Kim Songwha et. al. (2007) proposed a method in which space and parts are included in addition to parts and materials to implement facility classification system for repair and maintenance of existing educational facilities. In this research, we concluded that use of classification system based on space or parts could enhance effectiveness in calculating repair and maintenance cost and proposing repair cycle.

Lee ChoonKyung (2007) has studied status of repair and maintenance of school facilities and problems associated with them. He conducted an interview with facility managers of elementary and the middle schools. The results show that it is urgent to revise a manual for repair and maintenance of school facilities and develop and allocate professional resources. In addition, he suggests need for standardized repair and maintenance process, accumulation of repair and maintenance data, etc.[6)]

Table 2. Repair time &scope of the roof-proofing in Japan

type	repair scope	repair time(yr)	repair rate(%)
mortar finishing	partly fully	5 15(10,winter)	15 100
tile	partly	10(5, winter)	15
mortar block	partly	8(5, winter)	10
asphalt proofing	partly fully	7 20	16(15)
mortar proofing	partly fully	5 10	14 100
asphalt proofing	10	10	30
expansion joint	10	10	30
floor clinker tile	5	15	15
floor mortar painting	10	10	30
clinker tile and mortar paingting	10	15	30
asphalt proofing	partly fully	10 25(20)	15 100
expansion joint	partly fully	3 25	15 100
clinker tile	partly, fully	10(5)	15 100
mortar block	partly fully	8(5) 25	15 100
mortar finishing	partly fully	5 15	15 100
	repair	5	15
tile	partly	10	5
asphalt proofing	partly fully	10 25	10 100
polymer screen proofing	partly fully	5 15	10 100
polymer sheet proofing	partly fully	10 20	20 100

source) BELCA(1998), Report on the Service Life Survey of the Building Structure and Facilities, 49~63

6) Lee ChunKyung et.al. (2007), "A Study on the Support System for Maintenance Efficiency of Educational Facilities", AIK J. of Structural Area23(8), pp191~199)

In addition, the analysis results of rooftop waterproofing, repair cycle of floor finishing, repair rate and service life were collected. We can use the information to study service life of root water-proof and floor finishing in the following ways. Table 2 is the result of studying repair cycle and repair rate related to rooftop waterproofing. According to Table 2, repair cycle for rooftop waterproofing in Japan was about 20 years for complete overhaul. In case of asphalt water-proof, replacement period was set for about 25-30 years.

Table 3. Repair time &scope of the roof-proofing in UK

type	service life(yr)
PVC	26
high performed polyester	23
asphalt	36
composite rubber	24
tile	63
cement	36

source) BCIS(2006), Life Expendency of Building Components, RICS, pp41~77.

Table 4. Repair time &scope of the floor finishing in Japan

type	repair scope	repiar time(yr)	repair rate
mortar finishing	partly fully	5 20	15 100
tile	partly fully	7 30	14 100
terrazzo	partly fully	8 30	15 100
flooring block	partly fully	7 25	15 100
linoleum	partly fully	6 18	14 100
lignoid mortar coating	partly fully	4 15	16 100
rubber tile	partly fully	5 18	15 100
tile		10	30
mortar coating		5	30
vinyl sheet		10	25
vinyl tile		10	20
synthetic resin coating		10	30
mortar coating	partly fully	5 25	15 100
tile	partly fully	7 30	10 100
terrazzo	partly fully	10 30	15 100
linoleum	partly fully	10 25	10 100
vinyl sheet, asphalt tile, linoleum tile	partly fully	6 20	10 100
mortar finishing	partly fully	5 20	5 100
tile	partly fully	10 30	10 100
terrazzo	partly fully	15 30	10 100
flooring block	partly fully	10 25	15 100
carpet	partly fully	5 15	10 100
rubber tile	partly fully	10 20	10 100

source) BELCA(1998), Report on the Service Life Survey of the Building Structure and Facilities, 49~63

Table 5. Repair time &scope of the floor finishing in UK

type	service life(yr)
concrete slab	75/73/72/70/66
precast con'c slab	72/72/76
wood	71/51/49
cement 25㎜(thickness)	40
limestone con'c 20㎜	50
latex cement	20
epoxy	12
terrazzo	50
tile	50
vinyl tile	15
linoleum	20
vinyl sheet	15
carpet	10
chip board	30

source) BCIS(2006), Life Expediency of Building Components, RICS, pp31~39

Table 3 is a study on service life for rooftop waterproofing in the UK. According to this data, service life for asphalt, synthetic rubber and tile is 36 years, 24 years and 63 years, respectively.

Table 4 shows the result of studying repair cycle and rate for floor finishing materials in Japan. The cycle for complete overhaul/replacement of finishing for imitation stone is about 30 years; for linoleum, 18 years; for mortar finishings, about 20 years; tile, 30 years; vinyl sheet, 25 years.

Table 5 is the result of service life for floor finishing in the UK. According to this data, service life for concrete floor slabs is about 75 years. According to this data, service life for tile is around 50 years; vinyl sheet, around 15 years; latex cement, around 20 years; and wood finishing, around 50 years.

3. Service life calculation method

As component of school facilities, rooftop waterproofing and floor finishing have unique properties according to materials, shapes and location of use. Accordingly, ideally, service life should be calculated by reflecting attributes of parts.

Service life for rooftop water-proofing and floor finishing can be estimated based on evaluation of construction materials, construction techniques, the competence level of construction technicians, etc. In addition, early performance of construction materials, the level of construction technique and the competence level of construction technician should be comprehensively evaluated. Also, geographical conditions of building; environmental conditions such as humidity and illumination; and artificial conditions such as air pollution, user requirement and automobile exhaust must be considered at the same time. As such, service life is determined by the building's various internal conditions as well as external environmental conditions. However, there is a limitation in securing relevant information needed to explain a relationship to service life as well as conditions of individual influence. In addition, in order to reflect the requirements described above or other environmental factors, technical information related to construction and design-related technical materials must continue to accumulate.[7]. Also, even if the service life calculated based on such information is accurate, there is a limitation in reality in terms of securing accumulated relevant information on construction-related techniques, repair and maintenance and design. Therefore, if accumulated time series data on construction technique and repair and maintenance are not available in systematic ways, statistical techniques can be used instead. This way, we can explain individual factors from the perspective of past history. Assuming that the repair and maintenance history from past to present will continue to exhibit the same pattern in the future, we can make predictions using statistical techniques.

We can use statistical techniques to estimate service life for rooftop water-proofing and floor finishing based on three different approaches. First, normal distribution can be used. Second, choice probability can be used based on repair cycle and repair history. Finally, a cubic function model based on repair cost and elapsed years can be developed.[8]

Standard normal distribution takes the shape of bell-type curve with mean of 0 and standard deviation of 1. Population mean of standard normal distribution is located inside a certain interval of sample mean. The interval is determined by population mean according to confidence level.

$$p\left[\bar{x}-k\frac{Sx}{\sqrt{n}} \le \mu \le \bar{x}+k\frac{Sx}{\sqrt{n}}\right] = 1-\alpha \quad (1)$$

Here, $\bar{x}$: $sample\,mean$ μ : $population\,mean$
k : $confidence\,coefficient$ α : $significance\,level$

Repair history can be identified in the time series data of elapsed years from completion of construction of school facilities. The occurrence of repair in the time series can be described as making a choice for repair. This can be analyzed using choice probability model for repair behavior based on elapsed years. The model based on repair time and the repair occurrence is shown in equation 2 below.

$$P(t)=\frac{\exp(t)}{\sum\exp(t)} \quad (2)$$

7) If we can accumulate information on finishing materials requirement or technical data on construction and design for environment from the period of construction, we can systematically analyze and evaluate how various factors influenced service life.

8) Lee KangHee and Chae ChangWoo.(2006), " A Study on the Analysis of the Service life in the Office Building Finishings", AIK J. in Structural Area22(11), pp139~148)

The relationship between service period and cost can be described in two ways. First, accumulated repair cost increases over time and to reach the potential maximum. Second, accumulated repair cost continues to increase over time. In the first case, repair cost continues to increase until the cumulative cost reaches the potential maximum and then gradually starts declining.

Here, we take advantage of the inflection point where change in increase rate in cumulative repair cost occurs. This can be expressed using a cubic equation (Equation 3) as below.

$$Y = a_1 X + a_2 X^2 + a_3 X^3 \quad (3)$$

Here, Y : cumulative repair cost, X : elapsed years

The value calculated by averaging the first repair occurrence using the three approaches described above can be set as the average first repair period (t1). In order to calculate service life for rooftop waterproofing and floor finishing based on t1, it is necessary to establish recovery rate for function and performance enhanced by maintenance activities such as repair and replacement.

Even if rooftop waterproofing and floor finishing have certain recovery rate, considering natural deterioration rate according to time flow, it naturally flows down to right. This means the shape of deterioration rate curve continues to decrease at the size of recovery rate. If repair occurs continuously according to time elapsed, it will ultimate reach the point (t3) when its function is completely removed.

Assuming a given recover rate, service life years (equation 4) when function of rooftop waterproofing and floor finishing is completely removed can be calculated in the following ways.

$$Ultimate\ service\ life = \frac{Average\ first\ repair\ period}{1 - Post\ repair\ recovery\ rate} \quad (4)$$

However, using the equation 4 as calculation method has a short-coming of the rooftop waterproofing function, etc. completely deteriorating to the extent where they are unable to support living environment. Therefore, it is important to conduct analysis based on certain functional performance (fk) while considering repair action and recovery rate. Thus, performance recovery rate can be used to establish the period until repair occurs as service life of rooftop waterproofing and floor finishing for school facilities by taking living environment into account. This can be expressed as described in Fig. 1

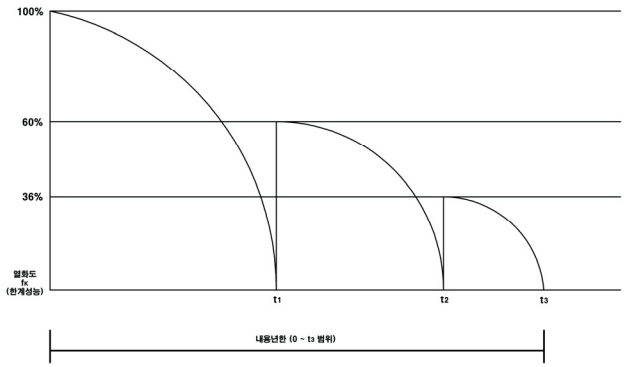

Fig. 1 Relation of the deterioration and service life under the 60% of the recovery rate

The time range during which rooftop waterproofing and floor finishing maintains a given level of performance can be used to establish service life. That is, when performance level required for parts is established at 60%, the time range in which this performance level is maintained can be explained as service life (0~t3).

4. Result of service life calculation

4.1. Rooftop waterproofing

Data from ○○ Office of Education was used to calculate service life. The analysis result of the first repair period needed to calculate service life is as follows. The results of calculating the first repair rate for rooftop waterproofing of elementary school are as shown in Table 6.

The first repair rate of rooftop waterproofing of elementary school came out to be 18.6 years. Using this result and taking 60% as recovery rate after the first repair, service life can be calculated. The service life calculated came out to be 36.5 years.

The results of calculating the first repair period for rooftop waterproofing for the middle school are shown in Table 7. The first

Table 6. 1st repair time calculation of the roof-proofing in the elementary school

School	1)	2)	3)	average
DaeR	24	30.2	15.0	23.1
GaeP	21	23.1	14.5	19.5
GeS	20	21.2	7.3	16.1
GoD	14	19.1	27.2	20.1
DongJ	21	23.3	9.2	17.9
MiS	23	25.2	13.0	20.4
SamS	24	35.1	9.2	22.8
SungiI	8	12.7	1.2	7.3
ShinD	24	26.6	10.5	20.3
ShinW	18	23.3	6.6	15.9
ShinJ	38	13.1	23.8	25.0
YongD	15	2.9	4.7	7.5
JungM	22	27.2	11.0	20.1
ChunD	14	22.7	8.9	15.2
HaengD	41	13.6	28.0	27.5
average				18.6

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

Table 7. 1st repair time calculation of the roof-proofing in the middle school

School	1)	2)	3)	average
Gar	12	18.2	4.0	11.4
KangN	29	31.2	10.6	23.6
GaeW	21	21.0	11.6	17.9
DaeP	21	22.1	7.0	16.7
KyungS	18	26.8	6.6	17.1
KongJ	10	10.7	15.1	11.9
KwanA	23	23.5	11.1	19.2
GuR	15	16.2	24.6	18.6
NanW	18	21.3	11.9	17.1
NamK	29	38.6	19.6	29.0
NamS	19	21.5	7.4	16.0
DaeC	17	18.5	6.1	13.8
DongJ	18	20.6	8.4	15.7
MohI	17	21.9	11.6	16.8
MoonJ	12	16.5	7.6	12.0
MoonC	23	25.6	16.0	21.5
MiS	12	18.6	3.9	11.5
BaeM	21	20.7	7.6	16.4
BongR	15	17.1	5.5	12.5
BongW	29	35.8	15.1	26.6
SangD	34	10.5	22.0	22.1
SuhW	20	20.5	7.1	15.9
SuhI	16	19.0	6.3	13.8
SukC	16	16.7	5.7	12.8
SungN	17	23.4	5.8	15.4
SeR	10	18.5	10.3	12.9
ShinDR	25	8.6	16.8	16.8
ShinR	20	22.1	8.0	16.7
ShinM	19	19.6	6.8	15.2
ShinBP	22	22.8	11.3	18.7
ShinS	20	24.6	11.7	18.8
ShinSu	22	29.9	14.7	22.2
ShinY	20	20.4	7.1	15.9
YangK	17	17.9	5.9	13.6
YangD	20	22.8	12.5	18.4
YonS	19	5.7	7.0	10.6
YoungR	27	29.1	15.8	24.0
YoungS	29	13.8	18.7	20.5
OG	20	24.9	13.5	19.5
OkJ	16	19.7	25.7	20.5
YongK	18	20.1	6.2	14.7
JamSn	19	20.3	32.8	24.0
JamSl	23	24.1	9.0	18.7
JungS	17	21.4	5.9	14.8
ChungW	53	32.3	34.1	39.8
PungS	10	14.3	3.5	9.3
HaengD	36	12.8	24.4	24.4
average				17.7

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

repair period for rooftop waterproofing for the middle school came out to be 17.7 years. Service life can be calculated by using this result and taking 60% as recovery rate after the first repair. The resulting service life is about 34.7 years.

Table 8. 1st repair time calculation of the roof-proofing in high school

School	1)	2)	3)	average
KyungD	36	11.3	21.1	22.8
KwanA	34	11.3	21.3	22.2
DangK	21	6.1	8.2	17.0
DaeS	20	6.1	7.9	16.7
MokD	13	2.5	4.5	16.5
BoS	14	4.2	5.2	12.2
SoeulBS	11	2.8	4.4	9.8
SeM	30	9.1	17.9	27.3
YangJ	12	3.9	4.7	12.2
YoungD	33	10.1	20.8	21.3
YoungR	20	6.1	9.1	16.9
YoungM	31	9.3	24.2	21.5
HaeSKC	28	8.7	15.8	26.1
average				18.6

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

The results of calculating the first repair period for rooftop waterproofing for high schools are shown in Table 8. The first repair period for rooftop waterproofing for high schools came out to be 18.6 years. Service life can be calculated by using this result and taking 60% as recovery rate after the first repair. The resulting service life is about 36.5 years.

4.2. Floor finishing

Data from ○○ Office of Education was used to calculate service life. The analysis result of the first repair period needed to calculate service life is as follows. The results of calculating the first repair rate for floor finishing of elementary school are as shown in Table 9.

The first repair period for floor finishing for elementary schools came out to be 22.0 years. Service life can be calculated by using this result and taking 60% as recovery rate after the first repair. The resulting service life is about 43.1 years.

The results of calculating the first repair period for floor finishing for the middle schools are shown in Table 10. The first repair period for floor finishing for the middle schools came out to be 19.9 years. Service life can be calculated by using this result and taking 60% as recovery rate after the first repair. The resulting service life is about 39 years.

The results of calculating the first repair period for floor finishing for high schools are shown in Table 11. The first repair period for floor finishing for high schools came out to be 21.0 years. Service life can be calculated by using this result and taking 60% as recovery rate after the first repair. The resulting service life is about 41.2 years.

Table 9. 1st repair time calculation of the floor finishing in elementary school

School	1)	2)	3)	average
KangS	22.0	26.0	15.8	21.3
GeaN	27.0	35.4	18.3	26.9
KoY	37.0	12.6	23.4	24.3
GongJ	11.0	13.7	19.8	14.8
KwangH	15.0	15.6	6.3	12.3
KuS	30.0	9.6	19.3	19.6
KeumS	22.0	22.1	8.9	17.7
NamS	29.0	9.6	18.0	18.9
DangS	24.0	30.3	15.3	23.2
DongJ	24.0	12.4	16.0	17.5
MokD	29.0	31.5	17.2	25.9
MooH	20.0	21.0	8.2	16.4
MooB	22.0	25.7	17.0	21.6
SangS	20.0	21.3	12.4	17.9
SukK	41.0	23.0	26.1	30.0
SuhBK	51.0	25.2	34.0	36.7
SuhJ	17.0	18.8	7.0	14.3
SungW	22.0	25.0	13.6	20.2
ShinK	20.0	23.5	14.1	19.2
ShinW	15.0	19.2	9.9	14.7
YangK	22.0	27.5	13.3	20.9
YangM	27.0	35.6	17.3	26.6
YeukC	32.0	10.1	20.4	20.8
YonS	26.0	35.6	18.1	26.6
YoungR	20.0	25.8	15.8	20.5
ORN	26.0	38.5	15.7	26.7
JangC	47.0	22.7	30.3	33.3
ChungP	42.0	14.0	28.0	28.0
average				22.0

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

Table 10. 1st repair time calculation of the floor finishing in middle school

School	1)	2)	3)	average
Kas	37	12.6	23.4	24.3
DaeR	26	8.5	16.2	16.9
DongD	52	33.2	33.8	39.7
DongI	14	20.1	10	14.7
DongM	5	4.7	11.8	7.2
SangGJI	30	29.8	12.2	24.0
SangH	37	11.7	24.2	24.3
SuhY	24	7.4	14.8	15.4
SungS	40	15.3	25.4	26.9
YonH	30	9.3	11.6	17.0
YongG	37	19	24.3	26.8
WooS	8	10.6	3.9	7.5
ChungW	17	19	7.9	14.6
average				19.9

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

Table 10. 1st repair time calculation of the floor finishing in high school

School	1)	2)	3)	average
DaeK	8	9.8	18.6	12.1
DaeDS	8	9.8	18.6	12.1
DaeW	30	14.7	19.2	21.3
RiRA고	40	19.6	26	28.5
MiRS	9	12.9	4.1	8.7
SoeulKK	38	12.5	24	24.8
SunI	24	30.3	14.8	23.0
SungB	22	25	9.9	19.0
SeMC	34	13.7	21.6	23.1
SeW	29	7.9	11.7	16.2
SongK	20	23.9	12.8	18.9
SoongM	25	14.4	15.9	18.4
ShinL	24	14.1	15.1	17.7
ShinJJ	41	10.2	18.2	23.1
YoungSK	21	22.9	12.8	18.9
YaleID	22	25	13.9	20.3
OS	44	26.9	28.4	33.1
WooS	26	30.4	21.9	26.1
JaeH	31	15.9	19.9	22.3
ChungW	22	8.8	13.7	14.8
HwanI	49	30.4	32.7	37.4
average				21.0

1) average year of the 1st repair after constructed
2) choice of repair according to elapsed year
3) cumulative cost function

5. Conclusion and future researches

All buildings undergo process of deterioration caused by various factors after being constructed. However, it is necessary to provide students with school facility environment that is pleasant and convenient. As such, as school facilities go through deterioration, it is crucial to provide pleasant study environment for students.

In this research, we proposed repair period for rooftop waterproofing and floor finishing, two of the components that constitute school facilities. The summary of our conclusion from our research is as follows.

First, quantitative approach was used to calculate service life for rooftop waterproofing and floor finishing. Deterioration process is not caused by one simple reason but various reasons in complex ways. Using elapsed years from construction that could encompass complex workings of deterioration process such as geographic and environmental factors, we calculated the first repair period based on average of results obtained from three methods: average of the first repair period; the relationship between elapsed years from construction and cumulative repair cost; and probability function model on the occurrence of repair. By taking the average of the first repair period obtained from three different approaches, we were

able to remove bias from the result. We calculated service life by using the average of the first repair period and recovery rate. That is, we determined as service life the period between the average first repair period (t1) and the second repair period (t2).

Second, the result of calculating service life for rooftop waterproofing and floor finishing in school facilities is as follows. For rooftop waterproofing, service life for elementary school, the middle school and high schools was 36 years, 34 years and 36 years, respectively. Overall, expected service life is around 35 years. For floor finishing, service life for elementary school, the middle school and high schools was 43 years, 39 years and 41 years, respectively. Overall, expected service life is around 4 years.

The data used in this research was repair history provided by ○ ○ Office of Education. Although the repair history included information on repair and maintenance done after construction, it did not include accurate history of materials and construction techniques used. Accordingly, this research has a limitation in terms of proposing materials used and repair period based on construction techniques. Repair history since construction should be studied and summarized in detail in the future. Using this information, we will also be able to explain the relationship between how various factors influenced each service life.

Also, in order to determine performance level, it is necessary to empirically verify physical phenomenon. Therefore, it is necessary to develop a quantitative model that can compare deterioration process and status during service life. Consequently, a research that can make quantitative prediction on deterioration process and verify the result empirically must be conducted.

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