



Establishment of the Repair Cycle of the Components of the Apartment Housing

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ABSTRACT

Building has been deteriorated over the year after construction. The deterioration has caused to hinder the living condition and to decrease the building value. Thus, it is important to prevent or delay the building deterioration as well as to proceed the maintenance. The long-term repair program for the apartment in Korea plays a key role to make the repair plan after construction and to assure the function decent. This is not flexible to the change of the material and component because the program is provided by the Korean-law. Many items are omitted in the long-term program so that the maintenance experts face many difficulties to make a repair plan.

In this paper, it aimed at providing the repair cycle and repair ratio according to the repair scope, which are not provided in the current program. This study shows that the repair ratio is presented with quartile range in 25%, 50%, 75% and 100%. This has an advantage to take an overall look in repair items. Under this presentation of the repair ratio, each item has a unique repair value. Second, the repair scope is divided into partly repair, fully repair, partly alteration and fully alteration. If a fully repair has a repair ratio close to 100%, it would mean that a fully repair is a fully alteration. Third, the short repair cycle means that it requires to maintain the function or performance of the components in a short term.

KEYWORDS

long-term repair program,
apartment,
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1. Introduction

1.1 Study background and purpose

The building has the characteristics to gradually deteriorate as time passes by after construction. Unlike the general consumables, it has long life span and requires the maintenance activities including the improving and repairing in order to keep the designed living environment. The apartments are the representative type among the communal housing in the urban housing types. Presently in 2012, the ratio of the apartment buildings take on the

national level is about 59%, while in the city it is above 65%. Likewise, the apartments are predicted to be continuously supplied as the urban housing's major type.

The communal housing supply including the apartments is continuously growing, while the continuous maintenance activities, such as improving and repairing, have to be accompanied in order to secure the living environment at a certain level. Currently, for the communal housing building maintenance after construction, the maintenance plans are prepared utilizing the Long-term Repair Plan Establishment Standard.¹⁾ However, the contents in the Long-term Repair Plan Establishment Standard of the Housing Laws do not reflect the building technology, material, construction method, function of component, etc., that are being improved/developed. Thus, when the new structural and construction method, materials are included in the field, it is the general practice to set up the

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1) Housing Law implementing regulations [*5] are divided into 6 common areas in the apartment buildings and specifying each the repair timing, repair range, repair rates, composing the construction, part, and material.

improving and repairing timing, repair rate assuming from the existing items. In other words, in the communal housing maintenance field, it doesn't specify clearly the repair replacement item division or include the new construction method or materials and the maintenance plan and implementation is realistically being limited.

Thus, in this study we intend to propose the repair timing and repair rate for the structural and construction method, material and member, part, etc., that the Long Term Repair Plan Establishment Standard doesn't specify for the apartments maintenance. Such study results can be utilized as the fundamental data for the repair plan to establish the apartments function and performance of the new member, material, parts, etc., that are not being provided by the establishment standard of the existing long term repair plan.

1.2 Study method and contents

The Long-term Repair Plan proposes 6 main division categories and the repair timing and rates for the repairing building construction for each item. However, it doesn't provide the repair timing, repair rate, etc. for the new construction contents for the technology development of the construction methods and materials. In this study, with the construction materials and members as the subject matter that are not being specified in the long term repair plan, we proposed the repair timing and the repair rate. The study method and contents are as follows:

1st, the subject construction for the analysis was limited to the apartments among the communal housing. Also, the building exterior and the interior were set up as the subject among the 6 long term repair plan establishment due to the limitations of the data collection.

2nd, the long term repair plan data was collected per construction works for the building exterior and interior being recorded at the management center. Based on the collected data, we extracted the construction material that is not being proposed in the existing "[*5] Long-term Repair Plan Establishment Standard." The construction, members, and materials of the extracted building exterior and interior are shown in <Table 1>.

3rd, at the management center the collected data gets divided into the main categories as per its construction into

Table 1. materials, components for research

classified	area	materials, construction type
1. building exterior	a. roof	urethane proofing, watered proofing, roof finishings, roof frame
	b. exterior	stone finishings(fully repair), water paint(partly repair), dryvit, others(painting)
	c. exterior window	plastic window, fire door, automatic door, reinforced door, others(window, cleaning & alteration)
	d. others	steel handrail, ladder
2. building interior	a. ceiling	patterned coat, other ceiling finishings
	b. interior wall	patterned coat. mortar finishing
	c. floor	synthetic resin painting, oil painting, granite finishing, epoxy finishing, water proofing, vinyl sheet finishing, hardner finishing
	d. interior window	steel window, fire door, entrance door, oil painting
	e. stair	imitation stone flooring, mortar flooring, astile flooring, stair nonslip, steel handrail, stainless handrail, oil painting, terazzo flooring, granite stone flooring, patterned coat, fire door

repair timing, repair range, repair rate, etc. The repair range is divided into the part repair, frontal repair, part replacement and frontal replacement. On the other hand, in the "Long-term Repair Plan Establishment Standard", two of the 4 repair ranges are selected for the repair period, and the repair rate.

Thus, for the subject of this study, among the extracted construction, materials, and members, the items with the repair range that is not specified in the Long-term Repair Plan were analyzed.

2. Long-term repair plan contents and limitation

The maintenance plan of the communal housing is established after the construction. According to the Housing Law Article 47, the long term repair plan is established for the common part of the communal housing and is transferred to the management body, when the standard subject to the long-term repair plan establishment are targeting communal housing exceeding 300 units, communal housing with elevators installed and with central heating method.

Likewise, the communal housing management establishes the long term repair plan by the Housing Law and on the other hand, the expenses are accrued as the long-term repair cost, when the long-term repair expenses are used based on the long-term repair plan. In the long-term repair plan the repair construction subject to facility, drawings, construction period and construction method, etc. are

clearly established and according to them the long term repair cost is used.

The housing law implementation regulations set up the long-term repair plan subjects and propose the repair period and rates according to the repair range. There are 6 main divisions as follows : building exterior, building interior, electricity, fire extinguisher, elevator and intelligence home network equipment, water supply, hygiene, gas and ventilation system, heating and water heating system, exterior adjunct facility and exterior well-being facility. Each division includes the diverse items, for which the repair timing and the repair rate are specified according to the repair range of the part repair, frontal repair, part replacement, frontal replacement, etc. The long-term repair plan is revised every 3 years; if more than half of the residents provide written agreements regarding the management conditions, facilitating the new major facilities, the work can be facilitated before the 3 years time passes.

In order to establish the long-term repair plan, there have to be the clear standards established in many parts regarding the accumulated subject range, long-term repair cost accumulation rate, the unclearness of the long-term repair plan establishment standard, common part and exclusive right part division, long-term repair cost collection method, etc. From these, the contents to be improved in this study based on the part of the related long term repair plan establishment items are as follows:

1st, the building technology is constantly being developed regarding the material, member, structural and construction method, etc. On the other hand, in the long-term repair plan, such technology development is not keeping up with the flexible adaptations. In applying the developed construction method and material, there are limitations in proposing the repair range, repair period, repair rate.

2nd, in applying a new technology or materials, it is difficult to establish the expected contents durable period. In other words, there are limitations in specifying the contents durable period of the member or materials for the repair period and rate.

3rd, as there are limitations in predicting the repair period and rate for the new technology or new material, in

calculating the necessary long term repair cost, clear rate is not specified. Thus, in the field it is the general practice to apply the construction or material similar to the existing to accumulate the long-term repair cost.

In establishing the repair period and the repair rate for such long-term repair plan establishment subject, there are limitations in applying the new technology and the new material. Thus, the repair period and the repair rate data are required to organically adapt in applying the diverse building material and technology.

3. Repair period and repair rate for the building exterior and interior investigation analysis result

In order to calculate the repair period and repair rate for the construction materials and parts that are not being specified in the Long-term Repair Plan Establishment Standard, data is collected to prepare for the long-term repair plan with the communal housing management center as the subjects.²⁾ These data are collected for the new material and construction as well as the subject item, preparing the long-term repair plan in the field. The reviewed data are the repair period per the repair range, repair rate, and the number of the samples, etc. The repair range is divided into the part repair, frontal repair, part replacement and frontal replacement, etc. The proposed repair period and the repair rate have processed statistically, representing the mean values of the sample group. The analysis result is separated into two groups, building exterior and interior and summarized as follows:

3.1 Building exterior

<Table 2> shows the repair period and the repair rate for the construction or material the long term repair plan does not specify. In the asphalt waterproofing layers of the building roof items, the part replacement shows the 9 year repair period and the 15% repair rate. For Urethane waterproofing, the part repair has a 5 year repair period and 20% level repair rate. On the other hand, the frontal repair has about 10 year repair period, according to the

2) The parts of the repair timing, repair rate of the new material of the construction are done based on the field experts' knowledge and experience.

Table 2. repair time and ratio in building exterior

classified	construction type	repair type	analyzed results		
			repair time(yr)	repair ratio(%)	number of sample
			mean (standard deviation)	mean (standard deviation)	
A. roof	(4) asphalt proofing	partly alteration	9(2.8604)	14.5(13.7276)	12
		fully alteration	12.2(10.2054)	65.2(48.6985)	23
	(7) urethane proofing	partly repair	5.0(0.9056)	19.7(4.3568)	3,179
		fully repair	10.4(2.1332)	99.6(6.0913)	4,881
	(8) watered proofing	partly repair	4.9(2.9479)	14.2(10.5748)	31
		fully repair	12.7(7.7885)	76.6(42.7976)	47
	(9) other proofing	partly repair	3.8(2.0769)	16.7(8.7501)	22
		fully repair	9.7(6.1260)	80.7(38.637)	44
	(10) roof finishing	partly repair	5.3(1.6604)	10.6(3.6033)	1,218
		fully repair	13.7(10.8549)	69.8(45.7927)	383
	(11) roof frame	partly repair	4.5(2.7343)	11.4(7.5006)	24
fully repair		12.7(9.1801)	75.6(41.5094)	34	
B. exterior	(5) stone patch	fully repair	17.1(12.7510)	74.7(43.6733)	75
	(6) water painting	partly repair	2.1(3.5605)	16.4(30.5543)	7,206
		fully repair	5.6(4.0504)	18.1(32.1278)	24
	(7) dryvit	partly repair	14.8(13.2549)	81.4(39.3749)	43
		fully repair	9.2(7.9014)	30.4(32.1450)	24
	(8) other finishings	partly repair	8.4(8.2481)	94.4(22.8485)	106
		fully repair	4.5(4.1540)	13.9(21.4333)	41
	(9) other paintings	partly repair	7.8(7.2630)	87.2(33.5167)	164
		fully repair	6.6(1.8468)	37.5(39.5510)	8
	(10) othe proofing	partly repair	10.7(6.7977)	80.6(40.0386)	15
		fully repair	5.1(5.6592)	44.1(42.3922)	24
(11) crack repair	partly repair	6.7(5.3630)	85.3(35.7839)	41	
	fully repair	28.9(4.7073)	95.6(18.8325)	118	
C. exterior window	(1) steel window, door	partly alteration	28.9(4.7073)	95.6(18.8325)	118
	(3) oil paintings	partly repair	3.1(2.3799)	40.4(43.2213)	38
		fully repair	14.2(6.8272)	18.8(21.4050)	1,012
	(5) plastic window	partly repair	25.6(14.7330)	74.5(42.4953)	876
		fully alteration	32.8(11.1269)	100(0)	971
	(6) fire door	partly repair	7.8(6.0182)	15(9.3541)	29
		fully repair	18.7(12.2762)	77.7(41.3765)	88
	(7) auto door	partly repair	5.1(0.9948)	29.4(3.5467)	1,576
		fully alteration	15.0(1.4895)	99.6(5.5661)	3,033
	(8) fire door	partly repair	4.6(5.7604)	9.6(13.3002)	308
		fully alteration	29.7(2.2293)	99.9(2.1080)	2,653
(9) other windows	partly repair	18.5(4.2818)	10.8(6.3154)	1,021	
	fully repair	37.0(8.5793)	96.7(17.4981)	872	
	fully alteration	38.8(4.8469)	99.2(8.6273)	1,415	
(10) caulking & proofing	fully repair	6.4(4.7113)	77.1(42.6043)	35	
	partly repair	10.0(7.1513)	14.6(15.4639)	227	
(11) cleaning & alteration	fully repair	18.3(15.8232)	78.5(41.7855)	28	
	partly alteration	29.4(3.8353)	98.4(11.9132)	558	
	fully alteration	29.8(2.5958)	99.5(5.9061)	1,079	
D. others	(1) roof drain	partly alteration	5.1(1.0701)	10.0(1.3439)	1,471
	(2) home drain	fully repair	26.5(5.6133)	96(20)	25
	(3) steel handrail	partly repair	5.6(5.8940)	9.1(11.5171)	298
		fully repair	20.7(11.0632)	78.8(41.0891)	99
	(4) steel escape stair	fully repair	18.8(13.2349)	72.2(46.0888)	18
	(5) nonpower aspirator	fully repair	10.1(4.0071)	93.0(25.7769)	43
	(6) ladder	partly repair	7.8(1.2187)	14.6(4.5544)	17
fully repair		21.1(11.6501)	84.3(36.8902)	32	
(7) drain	partly repair	5.5(7.0903)	7.2(6.4666)	11	
	fully repair	24.9(8.7996)	90(31.6227)	10	

Note) () means the mean differential.

investigation/analysis. In liquid waterproofing, it requires a 15 year part repair period, when the repair rate shows 14% level. The roof finish part repair period is about 5 years and its repair rate 10% level. Also, in the case of the frontal repair, the repair period is about 14 years and its repair rate about 70%.

The repair period for the stone paving frontal repair on the building exterior is about 17 years, with its repair rate at 75% level. The part repair for the water painting is done about every 2 years, with its repair rate at 16% level. For dryvits, the repair period of the frontal repair is about 15 years, with its repair rate at 81% level.

Among the exterior window frames, the repair period for the steel window part replacement is about 29 years, with its repair rate at 95% level. For the exterior windows' oil based painting part repair, the repair period is about 3 years, with its repair rate at 40% level. For the plastic windows, the part repair and the frontal repair takes each about 14 years and 26 year repair period, with their repair rates at 19%, 75% level. For the automatic doors' part repair has about 5 year repair period, with its repair rate at 30% level. For the tempered door, the frontal replacement has about 30 year repair period. Besides, among the cleaning and replacement repair contents for the exterior window frames, the frontal replacement has about 30 year repair period.

Among the building exterior contents, the roof drain part replacement period is about 5 years, with its repair rate at 10% level. For the steel railing part repair, the period is about 5 years, with its repair rate at 9% level.

3.2 Building interior

<Table 3> shows the repair period and the repair rate for the construction material composing the building interior. The building interior items are the ceiling, floor, walls, interior window frame, stairs. Among the ceiling elements, the frontal replacement of the finishing of wall has 25 years' repair period; the part repair, about 5 year period and 9% repair rate; tex construction frontal repair, 17 year repair period and its repair rate 70% level; the pattern coat frontal repair about 12 years and repair rate about 70% level.

Among the wall elements, the water base painting and

Table 3. repair time and ratio in building interior

classified	construction type	repair type	analyzed results		
			repair time(yr)	repair ratio(%)	number of sample
			mean (standard deviation)	mean (standard deviation)	
A.ceiling	(3) board	partly repair	4.6(5.3343)	9.1(15.0002)	72
		fully alteration	24.7(3.0586)	98.7(11.1104)	401
	(4) water painting	partly repair	1.6(2.5961)	12.4(26.9141)	51
		partly repair	2.2(2.8724)	17.5(34.3563)	22
	(7) spandrel	fully repair	19.8(10.7561)	86.9(34.4350)	23
	(8) tex ing	fully repair	17(11.5165)	70(47.0162)	20
	(9) spray coat	partly repair	5.8(2.7247)	15.8(7.9296)	12
		fully repair	18.2(13.7397)	71.6(45.2689)	24
	(10) patterned coat	partly repair	4.0(4.7903)	12.1(15.4573)	21
		fully repair	12.2(4.8734)	70(45.9178)	143
(11) other ceiling finishings	partly repair	6.5(3.9145)	18.6(22.0831)	21	
	fully repair	12.8(11.4722)	70.5(45.8337)	143	
B. interior wall	(2) board	partly repair	6.9(6.4848)	19.4736(29.4342)	19
		partly repair	2.8(4.6881)	5(13.4450)	14
	(5) water painting	partly repair	2.0(3.1346)	14.1(26.3819)	65
	(6) oil painting	partly repair	2(2.7568)	14.4(27.6523)	26
	(7) synthetic resin painting	partly repair	6.0(4.7548)	11.5(15.9118)	121
	(8) partition(wood)	fully repair	4.6(6.3994)	34.3(48.2133)	15
	(9) partition(light steel)	fully repair	6.1(7.4032)	24.6(43.1306)	13
	(14) patterned coat	partly repair	5.0(3.9258)	28.5(34.9173)	30
		fully repair	5.6(4.4943)	75.6(42.9746)	209
	(15) mortar finishing	partly repair	5.8(3.3505)	15.7(8.9857)	80
		fully repair	19.3(11.2837)	76.6(42.3319)	119
	(16) washboard	fully repair	7.3(7.6814)	77.2(42.8932)	22
	(8) granite finishing	partly repair	6.3(6.9809)	5.9(6.4457)	21
		fully repair	13.9(13.9889)	51.9(6.4457)	31
	(9) limestone finishing	partly repair	5.2(4.8702)	8.2(8.4596)	14
		fully repair	18.3(10.6346)	80(41.4039)	15
(11) other sone works	partly repair	7.8(8.7397)	5(5.4232)	18	
	fully repair	17.0(14.1975)	63.6(49.2366)	22	
(12) other floor finishings	partly repair	5.3(4.1995)	17.2(19.0979)	31	
	fully repair	12.7(8.0046)	80(40.4519)	45	
(13) epoxy finishing	partly repair	4.4(2.3735)	15.8(8.5741)	150	
	fully repair	9.5(6.2410)	83.4(8.5741)	224	
(14) water proofing	partly repair	4.9(6.1900)	18.2(21.4056)	23	
	fully repair	16.2(7.3625)	83.8(37.3878)	31	
(18) hardner finishing	partly repair	6.4(3.0883)	18.3(15.5699)	12	
	fully repair	11.3(8.3354)	72.7(45.5842)	22	
(19) others	partly repair	3.5(4.5226)	12.5(18.5251)	12	
	fully repair	13.4(12.8045)	67.6(47.1067)	21	
D.interior window& door	(3) plastic window & door	fully repair	25.1(9.1293)	90.9(28.4897)	130
		partly repair	11.9(6.3747)	13.0(6.8825)	117
	(4) steel window	fully repair	20.8(14.3226)	68.2(46.0020)	123
		partly repair	10.1(7.1612)	15.5(15.5972)	44
	(5) fire door	fully repair	22.8(12.5411)	85.1(35.5376)	86
		fully repair	6.0(7.1601)	85.2(36.2014)	27
	(8) synthetic resin painting	fully repair	18.4(12.5573)	66.6(30.8606)	15
	(9) others	partly repair	17.9(4.7698)	10.3(3.9389)	317
		fully repair	37.0(8.3128)	95.5(19.2626)	239
fully alteration		38.9(4.0905)	99.7(4.5643)	480	

classified	construction type	repair type	analyzed results		
			repair time(yr)	repair ratio(%)	number of sample
			mean (standard deviation)	mean (standard deviation)	
E. stair	(1)imitation stone flooring	partly repair	9.9(2.2175)	5.6(2.0021)	521
		fully repair	20.6(4.2740)	97.6(15.1522)	541
	(2) mortar finishing	partly repair	5.3(1.5427)	10.7(2.4271)	363
		fully repair	20.8(3.3981)	99.1(9.2526)	580
	(3) astile flooring	partly repair	5.4(1.5773)	19.2(7.1514)	505
		partly repair	11.3(3.3690)	99.4(7.2301)	902
	(4) stair nonslip	partly repair	5.2(5.7822)	6.7(9.2452)	364
		fully repair	19.2(2.7354)	99.4(7.1088)	3,410
		fully repair	19.8(1.6198)	100(0)	114
	(5) steel handrail	partly repair	4.8(6.2477)	7.5(10.9570)	165
		fully repair	22.8(11.1630)	89.4(30.0445)	34
		fully repair	23.7(3.7702)	99.5(6.4469)	2,303
	(6) stainless handrail	partly repair	10.0(1.5551)	5.2(3.9931)	1,420
		fully repair	23.2(11.6035)	92.8(26.7261)	14
		fully alteration	15.1(13.2869)	58.7(49.1962)	776
(7) oil painting	partly repair	2.6(3.6482)	19.2(30.4028)	25	
	fully repair	5.3(2.2458)	99.2(8.4926)	1,221	
(8) other floor finishings	partly repair	6.7(4.0423)	12.5(16.5308)	66	
	fully repair	17.5(10.7216)	82.4(37.3355)	98	
(9) water painting	fully repair	2.4(3.0697)	38.9(49.1898)	59	
(10) terazzo flooring	partly repair	8.2(4.1029)	9.6(4.4084)	38	
	fully repair	19.0(12.2730)	75.2(43.4280)	44	
(12) granite flooring	partly repair	13.9(9.6346)	15.2(26.0400)	25	
	fully repair	18.1(11.058)	71.7(45.1712)	17	
(13) patterned coat	fully repair	4.9(3.9882)	71.1(45.5020)	111	
(14) fire door	fully repair	21.0(11.5306)	81.6(37.8241)	25	
(15) others	partly repair	7.2(5.1774)	11.4(9.0849)	36	
	fully repair	17.9(18.6841)	70.2(45.9141)	111	

Note) () means the mean differential.

oil base painting part repair is set up about 2 years with its repair rate 14% level; the synthetic resin painting part repair, about 6 years period, with its repair rate about 11% level; the wall pattern coating frontal repair, 5 year period and about 75% repair rate; the mortar finish frontal repair, about 19 year repair period and repair rate 77%.

Among the floor finishing material elements, the granite stone finishing part repair and the frontal repair period 6 years and 13 years each, its repair rate 6%, 52% level each; the epoxy finishing part repair and frontal repair, the repair period, 4 years, 19 years each, with its repair rate 16% and 83% level; for the floor finishing excluding the granite stone and marble stone, the part repair and frontal repair period, 5 years and 13 years each, with its repair rate 17%, 80% each.

Among the building interior windows and window frames, for the plastic frontal repair period is about 25 years, with its repair rate at 90% level. For the steel

window frame, the part repair and the frontal repair periods are each 12 years and 21 years, with their repair rates each at 13%, 68%. The fire doors' part repair period is 10 years, and the frontal repair period 23 years, with their repair rates each at 16%, 85% level.

Among the building interior space, the part repair and the frontal repair period for the synthetic stone paving installed at the stair are each 10 years and 20 years, with their repair rates each at 6%, 98%. For the mortar finish, the part repair and the frontal repair period are each 5 years and 21 years, with their repair rates each at 11%, 100%, as analyzed. Also, for the floor asphalt tiles paving that is recently popular, the part repair and the frontal repair period are each 5 years and 11 years, with their repair rates each at 19%, 99%. For the non-slip staircases, the part repair, the frontal repair, and the frontal replacement period are each 5 years, 19 years, 20 years, when the frontal repair and frontal replacement shows 100% repair rate, whereas the frontal repair and the frontal replacement do not show much difference. The frontal replacement timing for the steel railing is about 24 years; stainless steel (S.S.) railing about 15 years. The granite stone finishing part repair and frontal repair period can be set up 14 years and 18 years each, with their repair rates 10% and 75% each.

4. Conclusion and future study task

The communal housing tend to deteriorate after construction as time passes. The building deterioration not only ruins the living environment, but also lowers the building value. Thus, in order to prevent the building deterioration after construction as time passes, there has to be the mid to long-term plan along with the maintenance activities, such as the improving and repairing, repair. The Long-term Repair Plan Establishment Standard plays the fundamental data role for the maintenance plan establishment, such as the after construction plan repair for the construction, member, material, that compose the communal housing.

However, this is prepared by the related regulations and is not actively responding in terms of the material or method, technology development. In this study, we provided the repair period and the repair rate as per the repair range for the member, part, materials that are not

specified in the Long-term Repair Plan Establishment Standard.

1st, in this study the repair ranges are divided into the part repair, the frontal repair, the part replacement, and the frontal replacement, and the long term repair plan data prepared in the field was collected, by which we can determine that the material or member whose frontal repair rate being close to 100% is the same as the frontal replacement.

2nd, for the repair period and the repair rate for each member and material, part, etc. we utilized the mean value by statistically processing the collected data. The repair rate provides the diverse values in the 1~100% range. However, the repair rate means the repair degree for each member or part and it is provided first in the quartile units, such as 25%, 50%, 75%, 100%, rather than the concrete values. This can be explained for the overall repair rates as per the repair range for the part and the member. And more detailed repair rate, i.e., 10%, 15%, based on the quartile units.

3rd, the frontal repair and the frontal replacement shows the similar repair timing and repair rate, excluding some materials or members. This is seen as focused on the meaning of replacement rather than the repair.

Such study result provides the repair period and repair rate for the member, part, material, that are not specified in the Long-term Repair Plan Establishment Standard, based on which the long term repair plan can be more effectively prepared. However, this study result is the analysis of the long term repair plan data collected in the field, and therefore, the characteristics such as the neighborhood size or the building type are not reflected, or the used member, quality of the component, performance, etc. as well. In order to overcome such limitations, it is expected that we need the model to predict the performance reduction process as per the member and the material quality. Also, to remove the item confusion, recording errors that might come up from the preparation process of the long term repair plan, a written manual is required for the long term repair plan that is prepared concretely.

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