Master of Science

Scheduled Maintenance Cost Allocation for Military Facilities Based on Factor Methods Considering Indirect Environmental Effects

February 2019

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Abstract

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Military facilities play an important role in providing rest and training places for soldiers, protecting ammunition and equipment for wars. Also, the asset value of military facilities is about 30 trillion won. Maintenance of military facilities is very important in order to maintain constant battle readiness and to preserve asset value. There have been studies on the maintenance of military

facilities in the past, but the consideration of scheduled maintenance was insufficient and it was complicated to use in the military. Scheduled maintenance is a kind of military facility maintenance that can prevent deterioration efficiently at low cost at the beginning of deterioration. It has the characteristic that the facility user can decide the target, amount, and timing when making a decision for maintenance. However, without considering the indirect environmental effects of the facilities, the budget is distributed based on age and types of facilities. Therefore, facilities placed in a poor environment, for example, frequently used, or located in the coast or the river, lack maintenance cost because much deterioration occurs. This leads to degradation of facility function and shortening of service life. Therefore, in this study, Factor Method was used to develop the service life expectancy calculation model considering the environmental factors of the facilities. As a result of the survey of the military facility experts, ventilation, insulation, location, maintenance team and frequency were found to have a great influence on the life span of the facility. As a result of applying the developed model to the similar age and type facilities, the estimated service life of the facilities in the severe environment was calculated to be shorter. The proposed methodology can calculate the service life considering various indirect environmental factors affecting the military facilities. The proposed methodology will provide a basis

for distributing more maintenance costs to facilities with shorter service life expectancy among facilities of similar facility type and age. The results of this study will enable effective preventive maintenance of military facilities and contribute to maintain their function and extend the service life of military facilities.

Keywords: Military Facilities, Factor Method, Environmental Factor, Scheduled Maintenance

Student Number: 2017-21313

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Chapter 1. Introduction

1.1 Research Background

Military facilities play an important role in providing rest and training places for soldiers, protecting supplies and equipment for battle. According to the National Defense Statistics in 2017, military facilities have an asset value of 31.8 trillion won, which is 31.7% of the Ministry of National Defense property (MND, 2017).

Table 1.1 Asset Value Trend of Military Facilities (National Defense Statistics, 2017)

단위 : 억원	2011	2012	2013	2014	2015	2016
Total	702,158	761,300	797,326	820,663	842,490	973,797
Facility	171,262	202,601	234,232	256,073	279,014	308,324
Rate	24.4	26.6	29.4	31.2	33.1	31.7

In order to maintain the asset value and function of military facilities, more than 430 billion Won is used for maintenance cost annually.

According to the Ministry of National Defense's (MND) defense budget in 2018, the paradigm of military facility shifts from construction to maintenance, minimizing new construction and prolonging the life of facilities (MND, 2018).

In addition, in the Statistical Yearbook of National Defense in 2017, it is analyzed that the increase of facilities maintenance and operation cost is

influenced by aging facilities (MND, 2017). The welfare improvement for new generation soldiers and the increase of advanced equipments will make the asset value of the facility and its maintenance more important.

There have been many studies on the maintenance of the facilities due to the importance of the maintenance of the facilities in other fields other than the military. As a result, it is known that timely maintenance is required at the initial stage of deterioration in order to maintain the function of the facility with a minimum effort, time, and cost and extend the service life (Shin & Lee, 2008).

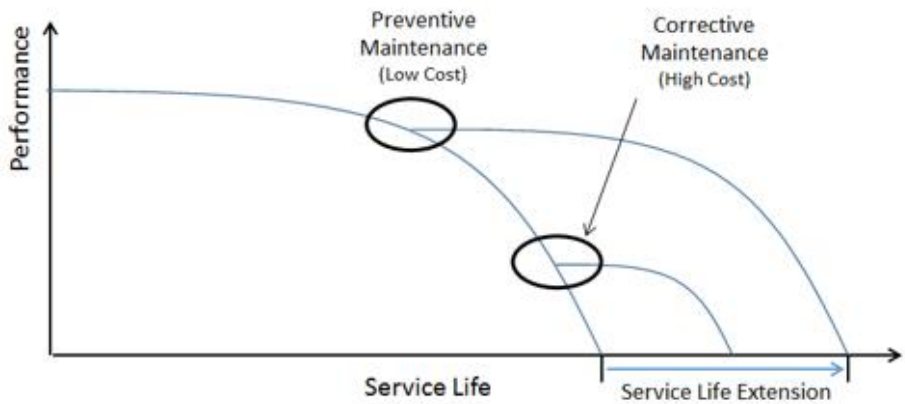

Figure 1.1 Effect of Preventative Maintenance (Shin & Lee, 2008)

Scheduled maintenance, which is a kind of military facility maintenance, is the initial preventive maintenance assigned to all facilities. Scheduled maintenance costs have the advantage that facility users can determine the maintenance timing and cost.

However, scheduled maintenance costs are distributed into unit cost per area, taking into account only the type of facilities and the age of the facility. Therefore, environmental factors during the use of military facilities such as climate, location, user, maintenance level are not reflected. According to a number of previous studies, environmental factors have an important influence on the deterioration of facilities.(A. Balars et al., 2005; A. Moncmanova, 2007) In other words, the facilities located on the coast and the river, or the facilities used by the early 20s soldiers who have a lot of activity, are likely to suffer relatively faster deterioration. However, budget allocations do not reflect these differences, and repeatedly occur when facilities in harsh environments fail to perform initial maintenance in a timely manner

1.2 Problem Statement

Studies on maintenance of military facilities focus on small-scale maintenance and large-scale maintenance. Although small-scale maintenance and large-scale maintenance can improve the function of the facility by using a large amount of budget, it is very difficult to obtain such a maintenance opportunity. Because there are a lot of facilities that need maintenance, but the budget is not enough. Scheduled maintenance, on the other hand, are the smallest scale between military maintenances, but they are assigned to all facilities, and although the facility owner can determine the subject and timing, research on this is not sufficient.

It is evenly distributed according to the age and type of facility without regard to the environmental factors. However, military facilities are located in various parts of the country, from the city center to the shore and mountainous areas, and environmental factors such as different climate, users and maintenance influence. If the budget is distributed evenly without reflecting these differences, facilities with severe deterioration will not be adequately maintained. This causes degradation of the function of the facility, inconvenience to the user, and more cost and time for maintenance in the future

1.3 Research Objective

The purpose of this study is to develop an Estimated Service Life calculation model for a facility considering various environmental factors. For this purpose, environmental factors affecting the military facilities are selected and the estimated service life is calculated by considering these factors.

Based on the estimated service life calculated through the model, it is possible to distribute reasonable maintenance costs by allocating more maintenance costs to facilities that are expected to have a short life span. Through this, it is aimed to maintain the function of the facility and extend the service life, thereby minimizing the inconvenience of the facility user and reducing the maintenance cost and effort.

1.4 Research Scope

The scope of the study covers residential, environmental, storage, and administrative facilities in the whole of Korea that occupy the largest portion of the Military facilities.

Figure 1.2 Storage Facility and Residential Facility

The service life of the facilities covered in the research refers to the functional life span including the function of the facility and the satisfaction of the user. In order to select the variables and build the model, the survey was conducted to military facility specialists with various units, various positions, and various experiences.

In this study, the environmental factor means the situation and the background of the building which affects the deterioration of the building in addition to the structure, type and age of the building.

1.5 Research Process

This research is organized as follows. In chapter 2, literature review about military facility maintenance, preventative maintenance, factors affecting deterioration and Factor Method are conducted. The model development process and survey are proposed in chapter 3. The verification of the applied model to actual facilities is described in Chapter 4. The paper concludes with contributions and future research opportunities of the study in Chapter 5.

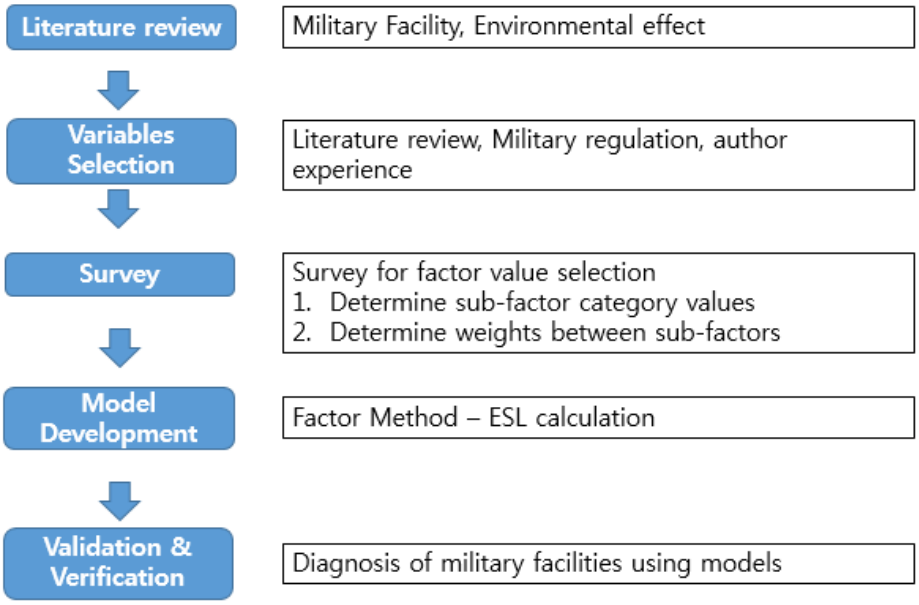

Figure 1.3 Research Process

Chapter 2. Literature Review

2.1 Military Facility Maintenance

2.1.1 Type of Military Facility Maintenance

Maintenance of military facilities is divided into three types according to the purpose of use and execution method (Rok Army, 2015). First, large-scale maintenance can be used within 50% of the facility price, and the army headquarters decides maintenance projects. It is most effective because it has a large budget at once, but it is very difficult to get a chance because there are many facilities to be repaired.

The second is small-scale maintenance that can be used for less than 20% of the facility price, the object to be repaired is selected by the general commanding unit. There is limited opportunity for each unit due to limited budget and many facilities requiring repair.

The third is scheduled maintenance that can be used within 3% of the facility price. The budget is allocated by multiplying the standard cost considering the facility type and age by the area of the facility, and the budget is allocated to the company level. It is used to replace and repair the failed part of the target facility, and the user of the facility can decide the maintenance target and timing. Therefore, it is suitable for preventive maintenance at the beginning of deterioration.

Table 2.1 Type of Military Facility Maintenance

Type	Range of Maintenance	Decision	Cycle
Small Maintenance	Scheduled Maintenance - Under 3% of the facility price - Maintenance by facility user	Battalion	On Demand
	Small-scale Maintenance - 4% ~ 20% of the facility price - To prevent massive maintenance	A unit commanded by a general	Quarter
	Emergency Maintenance - Maintenance for sudden damage that directly affect combat power and life of soldiers	A unit commanded by a general	Emergency Situation
Massive Maintenance	- 21% ~ 50% of the facility price - Maintenance that can significantly increase the service life	Headquarters	Year

2.1.2 Characteristics of Military Facility Maintenance

Military facilities have increased in construction from 1970s to 1990s, but have since dropped sharply. Most buildings built during this period are still in use, so many facilities are outdated. The average life span of the facility is 25 to 30 years, but if there is no alternative facility, it can not be removed immediately. (Lee et al, 2014)

The military facilities are severely aged and systematically not maintained. The military facilities have increased in number since the 1980s due to modernization and welfare improvement, but system maintenance is not done and the need for performance improvement is increasing (Cho et al., 2015).

In addition, the military facilities are located in the mountainous areas and beaches, and there are many natural disasters and maintenance conditions are poor. Also, young users in their early 20s frequently use them, which is likely to damage them (Kim, 2000; Kim, 2011).

The deterioration degree of the facilities is evaluated based on the structural safety diagnosis, but the inconvenience due to facilities, finishing work, etc. is not reflected (Cho et al., 2015).

The maintenance budget is allocated less than 80% of the military demands, and the facilities to be repaired continue to accumulate. In addition, the army does not perform preventive maintenance, but only after the breakdown, conducts follow-up maintenance. As a result, the function of the facility is degraded, and the user feels inconvenience and the efficiency is lowered. In addition, the service life of the facility is shortened, the economic loss is

expected due to the larger repair work, and the facility level gap with the private facility is widened (Kim, 2000).

Most prior studies have pointed out the problems of aging of military facilities, insufficient maintenance system and insufficient preventive maintenance and dealt with much of the adequacy of relatively large maintenance, such as small-scale maintenance and large-scale maintenance

In addition, GP and GOP roads are narrow and poorly packed, making it difficult for large construction vehicles to pass through. Also, there are many facilities exposed to extreme cold such as northern Gyeonggi Province and Gangwon Province, which cause problems such as insulation, poor ventilation and condensation. Facilities located on the coast and in the river are often exposed to chloride attack.

Border surveillance units will perform their duties alternately, which will also change the users of the facility. In this case, the facility will be used without the owner's consciousness.

Military facilities use standard design drawings when constructing and use government materials according to laws and regulations and in many cases, the constructions are supervised by the beginner officer.

Table 2.2 Literature Review about Military Facility Maintenance

Author	Contents
Kim(2000)	Optimal Military Facility Maintenance Cost
Lee et al. (2002)	Economic Evaluation Method for Remodeling of Deteriorated Military Facilities
Lim (2003)	Remodeling Method For Deteriorate Military Apart Upgrade
Yang (2003)	Military Facility Remodeling Priority
Park et al. (2005)	Budget Estimation Model for Military Facility Construction using cost index
Kim et al. (2008)	Future Military Facilities Development Direction
Kim (2011)	Adequate Military Maintenance cost
Cho et al. (2015)	Remodeling Target Selection Applying Service life and Functionality Evaluation
Maeng et al.(2016)	Efficient Insulation Considering Climatic Characteristics of Military Station Region

2.2 Preventive Maintenance

Preventive maintenance is active maintenance that is performed before failure or at the initial stage of deterioration, rather than manual maintenance after failure. As the importance of maintenance becomes increasingly important, preventive maintenance, a more economical and efficient way, has attracted attention. It related to the safety and finances of the facility, so neglecting safety management, such as the collapse of Seongsu Bridge or Sampung Department Store, cause Personal injury and financial loss (Jo et al., 2014).

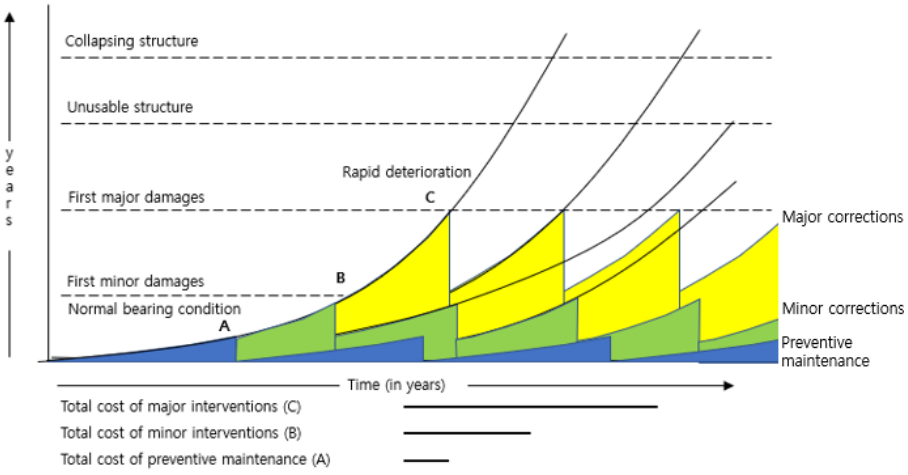

Figure 2.1 Relations among maintenance costs, maintenance and damages within the building life-cycle (N.Rustempasic, 2015)

In general, deterioration of facilities is faster as time goes by. Therefore, it is possible to prevent the deterioration of the deterioration at a relatively low cost in the case of preemptive response at the initial stage of deterioration (M.C. Eti et al., 2006). As a result, The deterioration is widened, requiring a large-scale repair work, and the user is inconvenienced (R.M.W Horner et al., 1997).

Lee(2017) also suggested that developed countries such as the US and Europe are doing preventive maintenance to save budgets and maintain their functions in the maintenance of roads, and suggested that this technique should be introduced in the road management in Korea.

Preventive maintenance can be a good alternative when there is not enough budget for the facility. If an administrator can determine the expected service life in advance and set up a maintenance plan and distribute the maintenance budget, it can save time and money. In addition, preventive maintenance is more important for facilities such as bridges, roads, and large buildings that cause huge human and material damage if maintenance fails. Even in the case of military facilities, if the function ceases, the damage to the national security will be so great that the preventive maintenance is important.

Table 2.3 Literature Review about Preventive Maintenance

Author	Contents
R.M.W Horner et al. (1997)	Building maintenance strategy
M.C. Eti et al. (2006)	Cost of preventive Maintenance
Kim (2006)	Application of road preventive maintenance using PMS
Shin and Lee (2008)	Management of road facilities in Seoul through asset management system
Jo et al. (2014)	Preventive Maintenance of U-city infrastructure
N.Rustempasic (2015)	Life-cycle assessment of masonry cultural heritage buildings
Lee (2017)	Field performance evaluation of preventive maintenance

2.3 Environmental Factors on Facility Deterioration

A number of studies have been conducted on the impact of environmental factors on building degradation. H. Viitanent et al.(2010) have proved that humidity, temperature, and biological agent affect deterioration in buildings.

A. Moncmanova (2007) reported that humidity, temperature, solar radiation, wind, atmosphere, and soil affected deterioration. It can be seen that these various weather factors are also factors to consider in military facilities.

Koh et al.(2001) suggested that freezing and thawing and Chloride attack have an bad effect on concrete deterioration. In the case of military facilities, there are many facilities located in Gangwon-do and Gyeonggi-do, so they are often exposed to very low temperatures in winter. There are many facilities located on the river and coast for the surveilance operation, these are easily exposed to chloride attacks.

Kang(2004) suggested that storms, abnormal high temperatures, etc. are frequently generated, which adversely affects the construction and maintenance of buildings.

A. Balars et al.(2005) reported that frequency of use affects facility degradation. In the case of military facilities, in particular, residential facilities are used by military personnel 24 hours a day, year round, and are frequently used.

Ad Straub(2015) suggested that climate, quality of materials, function and use, design level, construction level, and maintenance level affect the service life of the building.

In addition to the structural problems, various environmental factors influence

the deterioration of facilities through these previous studies. Military facilities are distributed all over the Korean Peninsula, so the environment of each facility is different. Also, depending on the unit's mission and characteristics, the usage environment will be different. Therefore, different environmental factors affect the lifetime of the facility and these various environmental factors must be considered.

Table2.4 Environmental Factors affecting deterioration

	Factor	Ad Straub (2005)	A. Balaras et al. (2005)	H. Viitanent et al. (2010)	A. Moncmanova (2007)	Koh et al.(2001)
Climate	Humidity	●	●	●	●	●
	Temperature	●	●	●	●	●
	Light	●			●	
	Biological agent	●		●	●	
	Chemical	●			●	●
Design	Positioning	●	●			
	Provision for Maintenance	●				
Function & Use	Intensity	●	●			
	Type of Use	●				
Maintenance & Management	Maintenance Planning	●	●			
	Maintenance Skill	●	●			

2.4 Factor Method

It is important to know the lifetime of the facility in order to plan the maintenance of the facility. If the maintenance cycle is known, the building manager will be able to make financial forecast.(Ad Straub, 2015). Although the general reference service life is determined according to the type of facility, facilities used in various environments vary in their service life through various environmental factors.

Factor Method was developed as a way to predict the expected life of a building in order to establish a maintenance strategy. The international standard organization (ISO) proposes Factor Method as a method of calculating the estimated service life in the ISO 15686 standard.

The advantage of this methodology is that it can calculate the expected life span of the facility even if there is not much input data, and it can take into consideration various environmental factors. In addition, it is easy to reflect the characteristics of the military facilities by changing the sub factor of 7 factors according to the characteristics of the facility.

The equation for calculating the expected service life is:

$$\mathrm{ESL} = \mathrm{RSL} \times \mathrm{A} \times \mathrm{B} \times \mathrm{C} \times \mathrm{D} \times \mathrm{E} \times \mathrm{F} \times \mathrm{G}$$

$\mathrm{A} = \text{quality of components}$

$\mathrm{B} = \text{design level}$

$\mathrm{C} = \text{work execution level}$

$\mathrm{D} = \text{indoor environment}$

$\mathrm{E} = \text{outdoor environment}$

$\mathrm{F} = \text{in} - \text{use conditions}$

$\mathrm{G} = \text{maintenance level}$

In this equation, the RSL(reference service life) is the service life expectancy of the building in a certain set. The ESL is the estimated service life of building in a specific situation calculated by adjusting environmental factors such as materials, design, climate, use and maintenance. In Factor Method, 7 factors from A to G are suggested as factors affecting the service life of facility.

Factor A is the quality of the component. It is a factor associated with the type of materials used in the building, quality, manufacturing process, material storage and surface protection. For example, using components made from good raw materials and treating surfaces to protect them, such as painting, will increase the lifetime of the facility.

Factor B is the design level. It is a factor related to the organic and stable connection between components, reliable design and structure. Design flaws can lead to various problems such as user inconvenience, equipment breakage, aging, etc.

Factor C is the work execution level. This is a factor related to how easy it was to work when constructing the facility, what construction method was used, and so on. For example, using a prefabricated method such as modular construction, or using simple and easy construction method will help extend the service life of the facility.

Figure 2.2 Modular construction

Factor D is the indoor environment. This is an indoor climate-related variable and is related to humidity, temperature, chemicals, air flow, and light. For example, condensation from ventilation, humidity, and temperature control defects can cause damage to the interior of the facility, affecting the user's discomfort and health problem.

Figure 2.3 Damage Examples of poor condensation and ventilation

Factor E is an outdoor environment. This is a factor related to climate outside the building, which is a variable related to temperature, humidity, load, light, soil, chemicals, and biological agent. Depending on the location where the building is located, the temperature and humidity can vary widely, which can have a significant impact on the life of the building. In particular, it is known that facilities located on the coast and in the river are subject to a lot of damage due to chloride attack.

Figure 2.4 Chloride Attack

Factor F is in-use condition. This is a variable related to how the facility is used, including the frequency of use of the facility, the load, the characteristics of the facility user, and the purpose of use of the facility. If the facility is used frequently or the user is carelessly used, the service life will be adversely affected.

Factor G is the maintenance level. This is a variable related to maintenance-related regulations, plans, systems, maintenance frequency, and dedicated maintenance organization. The service life of the facility is improved if the maintenance organization is maintained by a well-planned plan

Each factor value has a default value of 1.0 and ranges from a minimum of 0.8 to a maximum of 1.2, and is determined by considering the detailed factors together. (Ad straub, 2015)

In this paper, we derive a model for estimating service life, reflecting previous research, surveys of military facility experts, and the author's experience. In order to apply this methodology to military facilities, the detailed factors are derived from the characteristics of military facilities. Each sub-factor is derived from its weight and category value and the factor value is calculated. Details are given in the next chapter.

Chapter 3. Estimated Service Life Calculation Model Development

For the development of the model, this paper selects sub factors that reflect the characteristics of the military facilities, and weights and categories through the expert survey.

3.1 Sub Factor Selection

As preliminary studies, the characteristics of the military facilities were confirmed. To reflect these characteristics from A to G factors, 1 ~ 3 sub factors were selected for each factor.

The sub factors related to Factor A were selected for the quality of materials and construction supervision level. The quality of the materials is categorized as whether they use public materials. The quality of the public materials is guaranteed by the government's deliberation (Public Procurement Service, 2018). Using good materials will affect the service life of the military facility.

In the case of the supervisory level, the category is divided into two categories: supervision of the construction by military executive and supervision by construction inspection company. It is known that the construction supervisor's career and qualification have influence on the quality of construction supervision (Ryoo & Park, 2008). In the case of large-scale construction, the supervision company supervises the construction, but supervision of the

military facility construction is generally performed by a less experienced beginner military executive.

Therefore, if the supervisor 's capacity is insufficient, construction problems are not found in advance, which leads to facility defects and shortens the service life.

The sub factor related to the factor B was selected for military standard design compliance. It is known that the standard design is guaranteed safety and construction through deliberation by the Construction Technology Review Committee of the Ministry of Land, Infrastructure and Transport (Ministry of Land, Infrastructure and Transport, 2014). The use of proven designs can prevent facility faults, user inconveniences, and improve the life of the facility due to design faults.

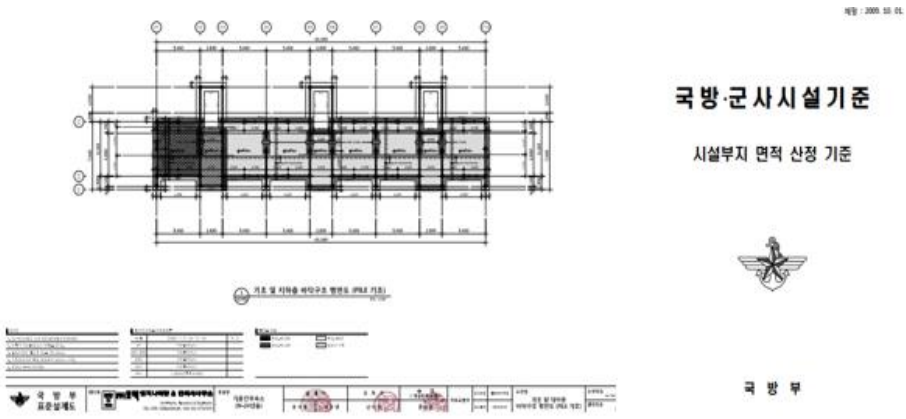

Figure 3.1 National Defense Facility Standard

The sub factor related to the factor C were seleted for road network, difficulty of construction, and weather at the time of construction. In the case of road network, GOP, coastal tactical road and GP supply road were defined as bad road network. These narrow and poorly packed roads are difficult to move or rotate because of large construction vehicles or equipment, which limits equipment selection and procurement. This will affect the completeness of the construction and the life of the building.

Figure 3.2 GOP Tactical Road

Difficulty of construction is known to affect the construction conditions and completeness (Park & Park, 2008). In case of difficulty of construction, it is defined that the degree of difficulty is high when the degree of difficulty of work is 'complicated' or the degree of difficulty is 'first type' according to 'criteria for reviewing construction management method' of Ministry of Land,

Infrastructure and Transport (Ministry of Land, Infrastructure and Transport, 2009).

The climate at the time of construction affects the continuity of the construction, the safety, the preservation of the materials, and the construction schedule (Kang, 2004). The case where the climate negatively affects the construction in this study means that construction is suspended for a period longer than the number of days of inactivity set at the contract.

The sub factors related to the factor D are selected for Ventilation facility and Insulator. Ventilation removes fungi and chemicals that cause damage to the facility and prevents condensation. Good ventilation in this study is defined as a facility where the window size is at least 1/20 of the floor area or mechanical ventilation is installed (Ministry of Land, Infrastructure and Transport, 2018).

Figure 3.3 Insulator Construction and Ventilation Facility

Insulator plays a role of reducing the heat loss of facilities and preventing the freezing and condensation (Meang et al, 2016). In the this study, good insulation is defined as the insulation grade is higher than '나' grade of 'energy saving design standard of buildings' (Ministry of Land, Infrastructure and Transport, 2018).

The sub factors related to the factor E are selected for Location and Rain / Snow. It is known that facilities located in coastal areas, river basins, and high mountainous areas are rapidly damaged due to the chloride attack and freezing and thawing (Koh et al, 2001). In this study, severe environmental area is defined as GOP area, GP, coastal boundary surveillance facility and air defense base.

Figure 3.4 Example of Severe Climate

Facilities in the area with heavy rain and snow can shorten the lifespan of facilities due to natural disasters such as erosion, landslides, and increase in

external load. In this study, rainfall and snowy areas are the areas where the average annual precipitation is more than 1350mm, which is the average annual precipitation in Korea, and the area without the station is based on the nearest station.

The sub factors related to the factor F are selected for User Change, Main User, Frequency of use. Some GOP, river basins, and coastal boundary surveillance units alternate boundary surveillance missions. In this case, because they move to another facility after a few months, they are reluctant to maintain and use the facility without the owner's consciousness. In addition, there is a disadvantage in that it is not easy to take over the damage of facilities or precautions for use. These problems adversely affect the service life of the facility

The main user of military facility depends on the nature of the unit. In the policy department or senior troop, the main user is a military officer or NCO, and For units below the battalion size, the main user is soldier. User habits and behavioral patterns affect the deterioration of facilities. Generally, it is known that soldiers who are active in their early 20s have an adverse effect on the deterioration of facilities (Kim, 2000).

The frequency of use of military facilities also depends on the type of facility. Dormitories used by soldiers are available 24 hours a day, but educational facilities and ammunition warehouses are used only when necessary. Excessive use will result in deterioration of the facility.

The sub factors related to the factor G are selected for Dedicated Maintenance team and Maintenance Frequency. For some military facilities, maintenance companies are subject to facility management. There are also units that have

specialized facilities maintenance teams organized as civilian worker in the military. In this case, the user can easily receive the maintenance, thereby preventing the deterioration of the facility and extending the service life.

The number of maintenance of the facility also affects the extension of the life of the facility. In this study, the number of maintenance is calculated only for the maintenance done on the small-scale maintenance or more.

Table 3.1 Sub Factors of Military Facility

Factor		Sub Factor of Military Facilities
A	Quality of Component	Quality of Material, Level of Construction Supervisor
B	Design Level	Use Military Standard Design
C	Work Execution Level	Road Network, Construction Difficulty, Weather During Construction
D	Indoor Environment	Ventilation, Insulator
E	Outdoor Environment	Location, Rain / Snow
F	In-use Condition	User Change, Main user, Frequency of Use
G	Maintenance Level	Dedicated team, Maintenance Frequency

3.2 Factor Value Calculation from Sub Factors

As indicated above, sub factors were selected to reflect the characteristics of military facilities. However, the following formula was applied to convert qualitative sub-factors into quantitative factor values (RE CECCONI, F. et al., 2015).

$$\boldsymbol{Factor\ A = \alpha X + \beta Y + \gamma Z}$$

X, Y, Z : Value of Sub Factor

$\boldsymbol{\alpha, \beta, \gamma}$ **: Weight between Sub Factor**

In the above formula, X, Y, and Z are the category values of each sub-factor, and α, β, and γ are the weights among the categories. The factor method calculates the ESL by multiplying each factor so that the calculated value is sensitive if the particular variable is too large or too small. Therefore, the range of each factor value is limited to a value between 0.8 and 1.2 (Ad Straub, 2015).

To obtain category values and their weights, surveys were conducted with military facility specialists.

3.3 Survey

The survey was administered to 31 military experts. In terms of the survey respondents' experience, 97% are executives of engineer branch with more than five years of career experience. The rank distribution is 14 captain, 11 major, 1 lieutenant colonel, 4 master sergeant, 1 civilian worker in the military. The military base of the survey respondents varied in Gyeonggi Province, Gangwon Province, Rear District, and Seoul.

Table 3.2 Rank Distribution of Survey Respondent

Rank	Captain	Major	Lt. Colonel	Master Sergeant	Civilian in The Military	Total
Person	14	11	1	4	1	31
%	45.2	35.5	3.2	12.9	3.2	100

Table 3.3 Military Career of Survey Respondent

Military Career	Under 5	5~10	10~15	15~20	Over 20	Total
Person	1	19	5	5	1	31
%	3.2	61.4	16.1	16.1	3.2	100

There were two surveys for this study. The first is a survey to determine the weight between sub-factors, and the second is a survey to determine the category value of sub-factors. Survey method used online questionnaire using Naver form and printed matter.

3.3.1 Survey for Weight of Sub Factor

First, the Analytic Hierarchy Process (AHP) was used for the survey to determine the weight between the sub factors. AHP is widely known as Thomas Saaty and is often used as an aid to decision making in situations where multiple criteria need to be considered simultaneously. It is assumed that the evaluator can make more precise and clear decisions through a pairwise comparison that compares two complex criteria rather than simultaneously considering the selection criterion. It also allows us to measure the intangible and to prioritize and weight alternatives. (RE CECCONI, 2017).

In this study, pairwise comparisons were made to determine the weights among the quantitative sub-factors.

Sub Factors	Most				More				same				More				Most	Sub Factors
Road network	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	Construction difficulty
Road network	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	Weather
Construction difficulty	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	Weather

Figure 3.5 Survey Example of Pairwise Comparison

A pairwise comparison was made between each of the sub-factors for six

factors except factor B with only one sub-factor. Pairwise comparisons consist of a scale from 1 to 9, 1 means that the two comparisons are similar, and 9 means that one subject is 9 times more important.

	Road Network	Difficulty	Weather
Road Network	1	1/2	3
Difficulty	2	1	4
Weather	1/3	1/4	1
Sum of Row	10/3	7/4	8

	Road Network	Difficulty	Weather	Sum of Column	Average
Road Network	3/10	2/7	3/8	0.9607	0.3202
Difficulty	6/10	4/7	4/8	1.6714	0.5571
Weather	1/10	1/7	1/8	0.3679	0.1226

Figure 3.6 AHP Weight Calculation

The method of calculating the weight through the questionnaire results is shown in Fig. First, create a pair comparison table. The numbers should be reciprocal with respect to 1 on the diagonal. After subtracting the sum of the columns, divide the pair comparison by the sum of these columns. The weight is then calculated by calculating the sum of the rows and dividing by the number of sub-factors.

Factor A, D, E, and G have two sub factors, Factor B has one sub factor, Factor C, and F has three sub factors. Micro Soft Excel program was used for the

summarization and weight calculation of the survey results, and used geometric means to reflect the results of several respondents (Aczél, J., & Saaty, T. L., 1983). The AHP calculates the consistency ratio to assess the consistency of the respondents' responses. At this time, if two comparison objects are not calculated, the consistency ratio is calculated from three or more. Therefore, in this study, the consistency ratios were calculated only for factor C and F with three sub factors. Saaty, T. L., & Kearns, K. P. (1985) suggested that the consistency ratio is acceptable if the consistency ratio is less than 0.2. Therefore, for Factors C and F, priority was calculated except for responses whose consistency ratios were too far out of this range. The results are as follows.

Table 3.4 Weight of Sub Factors

Factor	Sub Factor	Weight
Factor A	Quality of Material	0.67
	Level of Construction Supervisor	0.33
Factor B	Military Standard Design	1.0
Factor C	Road Network	0.15
	Construction Difficulty	0.3
	Weather during Construction	0.55
Factor D	Ventilation Facility	0.5
	Insulator	0.5
Factor E	Location	0.5
	Rain/Snow	0.5
Factor F	User Change	0.27
	Main User	0.43
	Frequency of Use	0.3
Factor G	Dedicated team	0.33
	Maintenance Frequency	0.67

3.3.2 Survey for Category Value

A second survey was conducted to determine the category value. In the questionnaire, each sub factor was divided into two categories, one that affects the life extension and the other that affects the lifetime shortening. An example of the questionnaire is as follows.

7)Factor G(유지보수 수준)의 각 세부인자 카테고리 값 도출 설문

■ 유지보수 횟수

유지보수를 실시한 시설물은 그 기능 및 수명을 향상시킬 수 있습니다. 본 항목에서 유지보수는 위임보수, 대보수(계획보수)로 정의 합니다.

일반적 시설의 참고수명을 100으로 가정하면, 유지보수를 실시한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 ← → 수명증가

매우 부정적	부정적	영향없음	긍정적	매우긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 유지보수를 한번도 실시하지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 ← → 수명증가

매우 부정적	부정적	영향없음	긍정적	매우긍정적
80	90	100	110	120

Figure 3.7 Survey Example of Category Value

In the first part of the survey, the criteria for dividing the category into two are described. After that, respondents were asked to choose between 0.8 and 1.2 how much the life of the building was affected. The final category value used the arithmetic mean of respondents' responses.

Table 3.5 Category Value

Factor	Sub Factor	Category	Value
Factor A	Quality of Material	Public procurement	1.013
		Private procurement	0.968
	Level of Construction Supervisor	Military Executive	1.003
		Supervision Company	1.071
Factor B	Military Standard Design	Standard Design	1.077
		No Standard Design	0.923
Factor C	Road Network	Good	1.074
		Bad	0.923
	Construction Difficulty	Difficult	0.935
		Easy	1.058
	Weather during Construction	Good	1.116
		Bad	0.877
Factor D	Ventilation Facility	Good Ventilation	1.139
		Bad Ventilation	0.852
	Insulator	Good	1.139
		Bad	0.848
Factor E	Location	Good	1.071
		Bad	0.871
	Rain/Snow	Heavy	0.868
		Normal	1.097

Factor	Sub Factor	Category	Value
Factor F	User Change	Change	0.894
		Unchange	1.09
	Main User	Soldier	0.881
		Executive	1.011
	Frequency of Use	High	0.893
		Low	1.067
Factor G	Dedicated team	Yes	1.168
		No	0.839
	Maintenance Frequency	Implement	1.145
		Not Implement	0.832

3.3.3 Model application example

The final model was developed through two survey. If you do not have data for each Factor when calculating the ELS using the model, you can not calculate the effect. In this case, 1 is assigned to the Factor Value. To help you understand the use of the model, an example of ESL calculation is shown below.

There are residential facilities that use government materials and supervise the construction by military officers. The facilities used standard design, and the road network was not good because it was located in the GOP. Construction difficulty was easy, weather during construction was bad, ventilation was good, but insulation performance was not good. The facility is located in the area with a lot of rain, the facility user changed every 6 months, and the main user was a soldier. The frequency of use was very high, there was a dedicated maintenance organization, and a large-scale repair was performed once. This facility is a reinforced concrete residential facility with a reference service life of 40 years.

$$\text{Factor A} = \alpha X + \beta Y + \gamma Z$$

The weighted values derived from the survey results and the category values appropriate to the environment of the given facility are allocated to the above formulas.

$$\text{Factor A} = 0.67 \times 1.013 + 0.33 \times 1.003 = 1.01$$

$$\text{Factor B} = 1.077$$

$$\text{Factor C} = 0.15 \times 0.923 + 0.3 \times 1.058 + 0.55 \times 0.877 = 0.938$$

$$\text{Factor D} = 0.5 \times 1.139 + 0.5 \times 0.848 = 0.994$$

$$\text{Factor E} = 0.5 \times 0.871 + 0.5 \times 0.868 = 0.87$$

$$\text{Factor F} = 0.27 \times 0.894 + 0.43 \times 0.881 + 0.3 \times 0.893 = 0.888$$

$$\text{Factor G} = 0.33 \times 1.168 + 0.67 \times 1.145 = 1.153$$

$$\text{ESL} = \text{RSL} \times \text{A} \times \text{B} \times \text{C} \times \text{D} \times \text{E} \times \text{F} \times \text{G}$$
$$= 40 \times 1.01 \times 1.077 \times 0.938 \times 0.994 \times 0.87 \times 0.888 \times 1.153 = 36.137$$

Chapter 4. Interpretation of Survey Results and Model Verification

4.1 Interpretation of survey results

As mentioned earlier, in this study, weights and category values of the detailed factors derived from the survey for military facility experts were derived.

In Factor A, the quality of the material was found to have a greater impact on the service life of the facility than the supervision level. However, it can be seen that the category value is not significantly different from the default value of 1.0. This is because even if it is not an public material, the quality level is secured by KS certification. In addition, there was an opinion that the supervisor of the corporation can be supplemented because it is reconfirmed by the senior commander, the construction inspector, and other advanced personnel.

For Factor B, the use of standard designs has been shown to affect the service life of the facility.

In case of Factor C, the road network was relatively less weighted, and the weight of weather during construction was heavier. The category values also showed that the weather during construction had a more effect.

In Factor D, ventilation and insulation have the same weighting, and both category values have a significant impact on the service life of the facility. It seems that the military facilities are exposed to extreme cold environment, and problems such as poor insulation and condensation often occur.

For Factor E, location and rain / snow weights are the same, and the category values of facilities located in GOP, coast and riverside or heavy rainfall area indicate that these parameters adversely affect the service life of the facility.

Factor F shows that the weight of the 'main user' sub-factor is large, and the category value has a great effect on the shortening of the life span of the facility when the user is changed, the main user is soldier, or the frequency of use is high.

In the case of Factor G, the maintenance frequency was more weighted, and the category value had the greatest effect on the service life of the facility depending on the presence of the maintenance team and maintenance frequency.

In summary, the category that adversely affects the service life of facility are ' bad weather during construction, bad ventilation, bad insulation, lots of snow and rain, user change, use of soldiers, high frequency, No maintenance team, and No maintenance.'

Conversely, the categories that affect lifespan were good weather during construction, good ventilation, good insulation, dedicated maintenance team, and large scale maintenance.

4.2 Verification through Application of Case

4.2.1 ELS Calculation and Comparison of Facilities

In order to verify the model performance, two real facilities in different environments were selected and the ELS was calculated to confirmed whether the calculated value could reflect the functional service life of the facilities. The names of facilities or details of the units of the selected facilities were not mentioned as military security concerns.

The two selected facilities are operational facilities used as command posts and were built in the late 1970s. It is made of reinforced concrete and has a useful life of 40 years. Both facilities use standard designs, and there is no information about weather during construction and supervision of construction. The area where the two facilities are located is an area with an annual average rainfall of about 1,500 mm.

The distance between the facility A and the river is about 1.2km, and the altitude is about 200m. There is one unpaved tactical path leading up to this place, and there is limited crossing and rotation and steepness. This facility is used only when there is training or an appraisal, ventilation facilities are poor, and insulation is not used. The primary user is the executive, and the facility user is not changed. There was no dedicated maintenance team and small maintenance was done due to leakage. The ESL using the Factor Method model reflecting the above environmental factors is as follows.

$$\text{Factor A} = 0.67 \times 1 + 0.33 \times 1 = 1$$

$$\text{Factor B} = 1.077$$

$$\text{Factor C} = 0.15 \times 0.923 + 0.3 \times 1.058 + 0.55 \times 1 = 1.006$$

$$\text{Factor D} = 0.5 \times 0.852 + 0.5 \times 0.848 = 0.86$$

$$\text{Factor E} = 0.5 \times 0.871 + 0.5 \times 0.868 = 0.87$$

$$\text{Factor F} = 0.27 \times 1.09 + 0.43 \times 1.011 + 0.3 \times 1.067 = 1.05$$

$$\text{Factor G} = 0.33 \times 0.839 + 0.67 \times 1.145 = 1.044$$

$$\text{ESL} = \text{RSL} \times \text{A} \times \text{B} \times \text{C} \times \text{D} \times \text{E} \times \text{F} \times \text{G}$$
$$= 40 \times 1 \times 1.077 \times 1.006 \times 0.86 \times 0.87 \times 1.05 \times 1.044 = 35.545$$

Facility B is located in the city area and access road network is good. This facility is used throughout the year, and the ventilation and heat insulation is disadvantageous in the building structure, but the temperature and humidity maintenance device is used to maintain the ventilation and the temperature. The main user of the facility is the cadre, and the facility user is not changed. There is a dedicated team for facility maintenance and maintenance for leakage prevention and exterior painting. The ESL using the Factor Method model reflecting the above environmental factors is as follows.

$$\text{Factor A} = 0.67 \times 1 + 0.33 \times 1 = 1$$

$$\text{Factor B} = 1.077$$

$$\text{Factor C} = 0.15 \times 1.074 + 0.3 \times 1.058 + 0.55 \times 1 = 1.029$$

$$\text{Factor D} = 0.5 \times 1.139 + 0.5 \times 1.139 = 1.139$$

$$\text{Factor E} = 0.5 \times 1.071 + 0.5 \times 0.868 = 0.97$$

$$\text{Factor F} = 0.27 \times 1.09 + 0.43 \times 1.011 + 0.3 \times 0.893 = 0.997$$

$$\text{Factor G} = 0.33 \times 1.168 + 0.67 \times 1.145 = 1.153$$

$$\text{ESL} = \text{RSL} \times \text{A} \times \text{B} \times \text{C} \times \text{D} \times \text{E} \times \text{F} \times \text{G}$$
$$= 40 \times 1 \times 1.077 \times 1.029 \times 1.139 \times 0.97 \times 0.997 \times 1.153 = 56.3$$

As can be seen from the calculated ESL values, despite the same useful life and building type, the two facilities have different life expectancies, reflecting different environments. In other words, it was found that the facility in a poor environment shortened the service life expectancy.

In fact, the results of interviewing users of each facility are the same as those of life expectancy calculation. A facility is said to be inconvenient to use the facility because water leaks into the ceiling when it rains, condensation and mold are often generated due to bad ventilation, and in winter the inner temperature becomes very low due to poor insulation. On the other hand, the B facilities often have electrical equipment failures, but the maintenance team quickly fixes them, and if they manage only the temperature and humidity maintenance devices, they are not inconvenient to use

For facilities with a short life expectancy, users of the facility feel more inconvenience, and the maintenance of the facility is more demanding.

The model is applied to two other residential facilities for further case study.

The two selected residential facilities were barracks for soldiers and were built in the late 1990s with reinforced concrete structures. Both facilities have a dedicated maintenance team and have done maintenance work.

The facility C is located in downtown Goyang, Gyeonggi-do, and access road network is well developed. The average annual precipitation in this area is over 1350mm.

The facility D is located in Yanggu, Gangwon-do, and the temperature is very low and the altitude is about 400m. According to a study by Maeng et al. (2016), this region is classified as a region with insufficient heat insulation due to its low temperature.

The ESL of factor C using the Factor Method model reflecting the above environmental factors is as follows.

$$\text{Factor A} = 0.67 \times 1 + 0.33 \times 1 = 1$$

$$\text{Factor B} = 1.077 \times 1 = 1.077$$

$$\text{Factor C} = 1.074 \times 0.15 + 1.058 \times 0.3 + 0.55 \times 1 = 1.0285$$

$$\text{Factor D} = 1.139 \times 0.5 + 1.139 \times 0.5 = 1.139$$

$$\text{Factor E} = 1.071 \times 0.5 + 0.868 \times 0.5 = 0.9695$$

$$\text{Factor F} = 1.09 \times 0.27 + 0.881 \times 0.43 + 0.893 \times 0.3 = 0.941$$

$$\text{Factor G} = 1.168 \times 0.33 + 1.145 \times 0.67 = 1.1526$$

$$\text{ESL(year)} = \text{RSL} \times \text{A} \times \text{B} \times \text{C} \times \text{D} \times \text{E} \times \text{F} \times \text{G}$$
$$= 40 \times 1 \times 1.077 \times 1.0285 \times 1.139 \times 0.9695 \times 0.941 \times 1.1526 = 53.068$$

The ESL of factor D using the Factor Method model reflecting the above environmental factors is as follows.

$$\text{Factor A} = 0.67 \times 1 + 0.33 \times 1 = 1$$

$$\text{Factor B} = 1.077 \times 1 = 1.077$$

$$\text{Factor C} = 0.923 \times 0.15 + 1.058 \times 0.3 + 0.55 \times 1 = 1.0059$$

$$\text{Factor D} = 1.139 \times 0.5 + 0.848 \times 0.5 = 0.9935$$

$$\text{Factor E} = 0.871 \times 0.5 + 1.097 \times 0.5 = 0.984$$

$$\text{Factor F} = 1.09 \times 0.27 + 0.881 \times 0.43 + 0.893 \times 0.3 = 0.941$$

$$\text{Factor G} = 1.168 \times 0.33 + 1.145 \times 0.67 = 1.1526$$

$$\text{ESL(year)} = \text{RSL} \times \text{A} \times \text{B} \times \text{C} \times \text{D} \times \text{E} \times \text{F} \times \text{G}$$
$$= 40 \times 1 \times 1.077 \times 1.0059 \times 0.9935 \times 0.984 \times 0.941 \times 1.1526 = 45.943$$

In fact, the results of the precise safety diagnosis of these two areas showed that the facility C had grade B and the facility D had grade D. It can be seen that the calculated ESL value represents the state of the facility.

4.2.2 Comparison with Safety Inspection Grade Data

The Defense Facilities Integrated Information System collects and stores data related to military facilities. It includes the structure of the facility, type, reference service life, location, maintenance costs, safety inspection results, usage units, and floor space. This study utilizes the Facility Integrated Information System data up to the first half of 2017, and the performance of the model is confirmed through the safety inspection grade data. In this study, we compared whether facilities with low safety ratings such as D or E have poor environmental characteristics as described in the model.

The data of safety inspection grade obtained from the Ministry of National Defense is 855 as of 2017, 275 of D grade and 47 of E grade. The reason why the grade data is smaller than the number of facilities is that it is because the safety diagnosis is requested only if severe inconvenience or flaw of the facility occurs and there is not enough personnel to carry out the safety diagnosis.

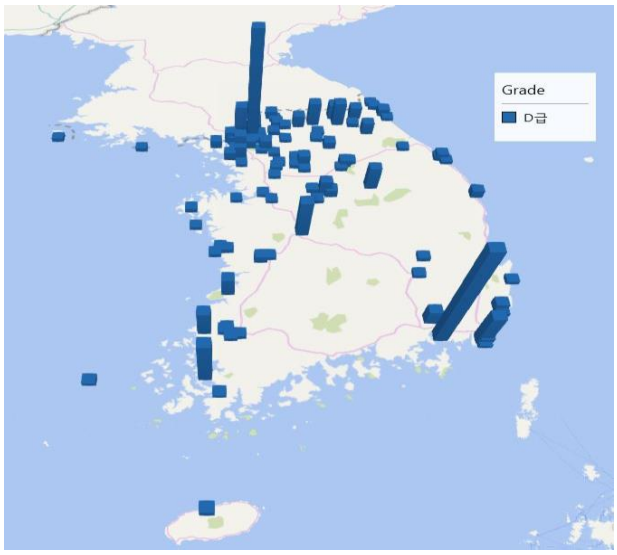

Figure 4.1 Distribtion of D grade Facilities

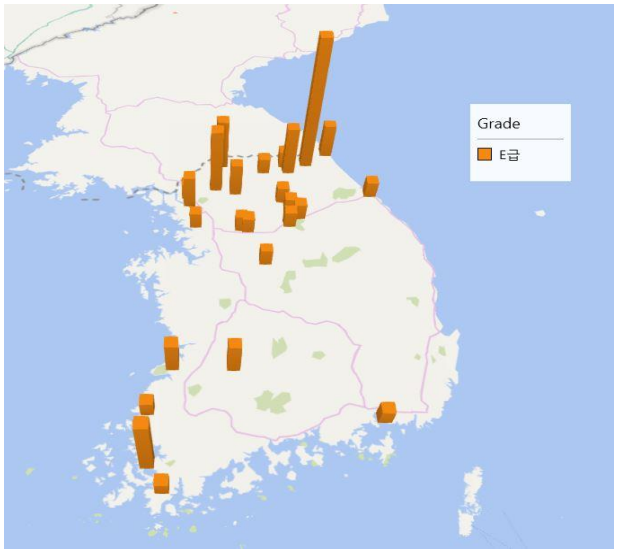

Figure 4.2 Distribtion of E grade Facilities

In terms of geographical distribution, D and E grading facilities were distributed in coastal, GOP base in Gyeonggi-do and Gangwon-do. These areas

are often exposed to extreme climatic conditions and often have problems such as condensation due to lack of insulation performance (Meang et al, 2016). Also, access roads were not good and there were many areas exposed to chloride attack. In addition, as a unit to carry out the boundary mission, most of the facilities where the main users were soldiers. It can be seen that the environmental factors considered in the model actually affect the service life of the facility.

Chapter 5. Conclusion

5.1 Summary and Contributions

Military facilities are very important as a facility to provide soldier with rest and training places, to prepare for war, and maintenance is very important to continue functioning. Preventive maintenance should be carried out to save enormous maintenance budget and to prevent expansion of facility deterioration. However, the distribution of scheduled maintenance costs of the military facilities does not take into account the different environments of facilities. Therefore, in this study, we developed a model to calculate service life using Factor Method which can reflect various environmental factors. In this study, the parameters related to deterioration of military facilities were selected by referring to previous research and military regulations. To investigate the effect of these variables on the service life of facilities, survey were given to military facility specialists, weight and category value were derived.

The results of applying this model to actual facilities, which are located in different environments but which were built at similar times and which are of the same building type, show that the facilities in a poor environment have a relatively short life expectancy.

In the verification using the distribution data of the safety diagnosis data of the defense facility information system, the D and E grade facilities are mostly located in northern part of Gangwon-do and Gyeonggi-do and coastal area

which have poor in road network, poor heat insulation with extreme weather and are exposed to chloride attack.

The contribution of this study was to develop a model specific to the military facilities by selecting the variables to calculate the expected life span and military can used the model easily because the model is easy to use. Based on the survey of military facility experts, this study developed the existing methodology by deriving the factor values by deriving categories and weights.

In particular, the strength of this model is that facilities with the same type and age can be analyzed and compared based on the same environmental factors. This model can be used as a basis for allocating more maintenance costs to a facility in a poor environment by calculating the expected life span according to the environment of the facility.

This study will support the distribution of reasonable user maintenance cost and will ultimately help maintain the function of the facility and increase the life span through preventive maintenance. In addition, it can be used as a basis for the scientific estimation of maintenance costs by using a similar method when calculating other kinds of maintenance costs.

5.2 Limitations and Further Study

Three points still remain as limitations of this study. First, The calculation of lifetime through simple calculation is a criterion for comparison between facilities, but there is a limitation that it can not be regarded as the absolute service life of facilities. Second, In addition, the deterioration of facilities due to fire and earthquake was not considered. Third, However, when comparing ESLs, it is only possible to compare facilities of the same type, structure, and similar age, and if they are different, applying the results of the model is limited.

Future research is concerned with how ESLs, calculated by extending the model's results, are linked to rational maintenance costs. This study has provided a basis for allocating more budget to facilities with shorter life expectancy, but more research is needed to determine the appropriate proportion of the budget. Also, for smooth use within the military, data related to the variables should be put in The Defense Facilities Integrated Information System .

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Appendix

설 문 조 사 서

【환경인자를 고려한 Factor Method 기반 군 시설물 사용자보수비 분배방안 연구】

안녕하십니까?

바쁘신 중에도 불구하고 귀중한 시간을 내어 주셔서 진심으로 감사드립니다.

저는 현재 『환경인자를 고려한 Factor Method 기반 군 시설물 사용자보수비 분배방안 연구』논문을 준비 중에 있습니다. 이와 관련하여 군 시설물의 열화에 영향을 미치는 환경인자의 가중치를 도출하기 위한 설문조사를 하고자 합니다.

본 설문은 익명으로 처리되며, 학문적 연구목적 이외에는 사용되거나 공표되지 않습니다. 또한 개인의 어떠한 불이익도

초래하지 않을 것을 약속드립니다.

전문가 여러분의 성의있는 답변 부탁드리며 다시 한 번 귀하의 협조에 감사드리며 건강과 행운이 함께 하시길 기원합니다.

2018.10.

서울대학교 공과대학 건설환경공학부

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연 구 개 요

■ 환경인자를 고려한 Factor Method 기반 군시설물 사용자 보수비 분배방안 연구

남북이 대치하고 있는 우리나라의 특수한 안보상황에서 전쟁을 대비하기 위한 군 시설물의 강건성은 매우 중요하다. 이러한 시설물의 기능을 유지하면서 장기간 사용하기 위해서는 체계적인 유지 보수가 매우 중요하다. 건물 유지관리에 관한 다수의 연구들을 통해 건물 열화의 확대 방지를 위해 열화 초기에 시의적절한 유지보수를 실시하는 것이 적은 노력과 비용으로 장기간 시설의 기능을 유지 하는데 기여한다고 알려져 있다. 그러나 초기 유지보수에 사용되는 비용인 사용자보수비는 기후, 사용 환경 등 군 시설물의 각기 다른 환경요인을 반영하지 못하고 공용연수, 시설유형과 면적만을 고려 하여 분배되고 있다. 즉 해안, 강안, 고산지대에 위치하거나, 사용 빈도가 많은 시설과 같이 상대적으로 열악한 환경에 처한 시설물이 일반적인 시설물에 비해 열화가 더 빨리 진행됨에도 불구하고, 예산편성은 이러한 환경의 차이를 반영하지 못하고 있다. 따라서 본 연구에서는 문헌 고찰 및 전문가 자문을 통해 군 시설 열화에 영향을 주는 환경적 인자 및 가중치를 도출하고, 이를 Factor Method에 투입하여 서로 다른 환경에 놓여 있는 군 시설물 열화의 차이를 식별하는 모델을 구축하며, 이러한 열화의 정도 차이를 반영한 유지보수 분배 방안을 제안하고자 한다.

Factor Method는 시설의 내용연수를 예측하기 위하여 재료의 질, 설계 수준, 시공 수준, 내·외부 환경, 사용 상태, 유지보수 수준과 같은 인자를 고려하여 수식 (1)과 같이 시설물의 예상 수명을 계산하는 방법이다.

$$ESL = RSL \times A \times B \times C \times D \times E \times F \times G \qquad (1)$$

ESL = Expected Service Life
RSL = Reference Service Life
A = quality of component
B = design level
C = work execution level
D = Indoor environment
E = outdoor environment
F = In – use condition
G = Maintenance level

이때 RSL은 참고 내용연수로 시설의 유형에 따라 한국 감정평가원 등에서 건물의 유형별로 정해놓은 일반적 환경의 시설 수명을 말한다. A부터 G까지의 각 환경인자들은 가중치의 형태로 반영되어 예상 내용연수(ESL)를 계산하게 된다. 다음은 Factor Method를 적용하여 예상 내용연수를 계산하는 예시이다.

구분	RSL	A	B	C	D	E	F	G	ESL
시설1	20	1.0	1.0	0.9	0.9	0.8	0.8	0.9	9.33
시설2	20	1.0	1.0	1.0	1.1	1.0	0.9	1.1	21.8
:	:	:	:	:	:	:	:	:	:

그림 4. Factor Method 적용예시

각 환경인자들을 군 시설의 특성에 맞게 반영하기 위하여 문헌 고찰을 통해 군 시설 관련 Factor Method 세부인자를 도출하였다.

표 1. 군 시설물과 관련된 Factor Method 세부 인자 예시

Factor		군 시설 관련 세부인자
A	Quality of component	재료의 품질, 공사감독방식
B	Design level	군 표준 설계도 준용 여부
C	Work execution level	공사를 위한 접근 도로망, 시공 난이도, 시공 당시 기후
D	Indoor environment	환기시설, 단열재 사용여부
E	Outdoor environment	위치(해안·강안·고산 지역), 눈·비
F	In-use condition	시설사용부대 교체 여부, 주 사용자(병/간부), 사용빈도
G	Maintenance level	유지보수 횟수, 유지보수 전담조직

이에 따라 본 논문에서는 군 시설 전문가의 의견을 바탕으로 군 시설 관련 세부인자를 반영한 Factor Value를 계산하고 각 시설을 이 기준에 맞게 적용하여 예상 수명을 도출 할 것이다.

1. 각 Factor의 세부인자 가중치 도출을 위한 설문

Ⅰ. 쌍대비교 척도 기준

중요도	정의	설명
1	비슷함	어떤 기준에 대하여 두 항목이 비슷한 공헌도를 가진다고 판단됨
5	중요함	경험과 판단에 의하여 한 항목이 다른 항목보다 강하게 선호됨
9	매우 중요함	경험과 판단에 의하여 한 항목이 다른 항목보다 매우 강하게 선호됨
2,3,4, 6,7,8	위 값들의 중간값	경험과 판단에 의하여 비교값이 위 값들의 중간값에 해당한다고 판단될 경우 사용함

Ⅱ. 설문작성 방법

■ 예시

평가항목	매우 중요				중요				비슷				중요				매우 중요	평가항목
사용부대 교체여부	✓	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	사용자 수

* 항목을 평가함에 있어 사용부대 교체여부와 사용자 수 중 사용부대 교체여부가 매우 중요하다고 판단되시면, 위와 같이 기입하면 됩니다.

Ⅲ. 시설물간 중요도 평가(본 설문)

1)Factor A(구성품의 품질)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 구성품의 품질과 관련한 세부인자는 시공재료의 품질, 공사감독방식이 도출되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
재료의 품질	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	공사감독 방식

2)Factor C(시공 수준)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 시공수준과 관련한 세부인자는 공사를 위한 접근 도로망, 시공 난이도, 시공당시의 기후가 선정되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
접근 도로망	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	시공 난이도
접근 도로망	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	시공기후
시공 난이도	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	시공기후

3)Factor D(내부 환경요인)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 내부 환경요인과 관련한 세부인자에는 환기시설, 단열재 사용여부가 선정되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
환기 시설	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	단열재 사용여부

4)Factor E(외부 환경요인)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 외부 환경요인과 관련한 세부인자에는 시설물의 위치, 눈/비(연평균 강수/강우량)가 선정되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
위치	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	눈/비

5)Factor F(사용환경)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 내부 환경요인과 관련한 세부인자에는 사용부대 교체여부, 사용자 유형, 사용빈도가 선정되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
사용 부대 교체 여부	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	사용자 유형
사용 부대 교체 여부	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	사용빈도
사용자 유형	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	사용빈도

6)Factor G(유지보수 수준)의 세부인자 가중치 도출 설문

시설물의 수명에 영향을 주는 내부 환경요인과 관련한 세부인자에는 사용부대 유지보수 횟수, 유지보수 전담조직의 유/무가 선정 되었습니다. 아래의 인자들 중 어떤 것이 시설물의 수명에 더 많은 영향을 미친다고 생각하십니까?

평가 항목	매우 중요				중요				비슷				중요				매우 중요	평가 항목
유지 보수 횟수	⑨	⑧	⑦	⑥	⑤	④	③	②	①	②	③	④	⑤	⑥	⑦	⑧	⑨	전담조직

2. 각 세부인자의 카테고리 값 도출을 위한 설문

Ⅰ. 설문작성 방법

■ 예시

주 사용자가 용사인 시설물은, 주 사용자가 간부인 시설물에 비해 손상이 많다고 알려져 있습니다. 일반적 시설의 참고수명을 100으로 가정하면, 시설물의 주 사용자가 용사일 경우 시설물의 수명에 어느 정도 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120
√				

* 주 사용자가 용사일 경우 시설물 수명에 매우 부정적인 영향을 줄 것이라고 판단하시면 위와 같이 선택하시면 됩니다.

Ⅱ. 각 세부인자 카테고리 값 도출 설문(본 설문)

1)Factor A(구성품의 품질)의 각 세부인자 카테고리 값 도출 설문

■ 재료의 품질

관급자재는 정부가 조달함으로서 검증된 품질을 보증하는 것으로 알려져 있습니다. (조달청, 2013)

일반적 시설의 참고수명을 100으로 가정하면, 관급자재를 사용하는 것이 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 일반자재를 사용하는 것이 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 공사감독방식

공사 감독자의 경력 및 자격증 보유 여부는 공사감독의 질에 영향을 미치는 것으로 알려져 있습니다. (류종혁 외, 2008)

일반적 시설의 참고수명을 100으로 가정하면, 군 간부가 공사감독을 시행할 때, 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 전문 감리에 의한 공사감독을 수행할 때, 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

2)Factor B(설계수준)의 각 세부인자 카테고리 값 도출 설문

표준설계도는 국토교통부의 건설기술심의위원회의 심의를 거쳐 안전성, 시공이 보장되는 설계로 알려져 있습니다. 육규 490 시설업무규정(2015, 국방부), 표준설계도서등의 운영에 관한 규칙(2014, 국토교통부)

일반적 시설의 참고수명을 100으로 가정하면, 표준설계도를 사용한 시공이 것이 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 표준설계도를 따르지 않은 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

3)Factor C(시공수준)의 각 세부인자 카테고리 값 도출 설문

■ 공사를 위한 접근 도로망

공사 현장까지의 접근 도로망(복잡한 출입절차 포함)은 시공, 자재 조달, 장비 진입 등에 많은 영향을 미치게 됩니다. 본 연구에서는 폭이 좁고 통행성이 좋지 않은 GOP, 해안의 전술도로 및 GP 보급로의 경우 도로망이 좋지 않다고 정의합니다.

일반적 시설의 참고수명을 100으로 가정하면, 공사 현장까지 도로망이 양호한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 공사 현장까지 도로망이 좋지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 시공 난이도

시공 난이도는 시공 여건, 완성도 등에 많은 영향을 미치게 됩니다. 본 연구에서는 '감리 등 공사관리방식 검토기준'(2009, 국토교통부 고시)에 따라 공종난이도 '복잡' 또는 공사 난이도 '1종' 의 조건을 하나라도 만족할 경우 시공 난이도가 높다고 정의 합니다.

일반적 시설의 참고수명을 100으로 가정하면, 시공 난이도가 평이할 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 시공 난이도가 높을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 시공 당시 기후

시공 당시의 기후는 공사의 연속성, 안전, 자재의 보존, 공사일정 등에 영향을 미치게 됩니다. (강운산, 2004) 본 연구에서 공사에 부정적 영향을 주는 기후는 공사기간중 기상의 영향으로 계약시 설정한 작업불능일수보다 더 많은 기간 공사에 지장을 초래한 경우를 말합니다.

일반적 시설의 참고수명을 100으로 가정하면, 시공 당시 기후가 양호한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 시공 당시 기후가 좋지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

4)Factor D(내부환경)의 각 세부인자 카테고리 값 도출 설문

■ 환기시설

환기시설은 시설의 손상을 유발하는 곰팡이, 결로 등을 예방하는 역할을 수행합니다. 본 연구에서 양호한 환기시설은 창문크기가 바닥 면적의 1/20 이상 또는 이를 만족하지 않을 경우 기계 환기장치가 설치된 시설을 말합니다. (국토교통부, 2017)

일반적 시설의 참고수명을 100으로 가정하면, 내부 환기시설이 양호한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 내부 환기시설이 좋지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 단열재

단열재는 시설의 열손실을 줄이고 곰팡이, 결로 등을 예방하는 역할을 수행합니다. 본 연구에서 양호한 단열시설은 ‘건축물의 에너지 절약 설계기준’ 상의 단열재 등급 ‘나’ 이상을 말합니다. (국토교통부, 2017)

일반적 시설의 참고수명을 100으로 가정하면, 단열이 양호한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 단열이 좋지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

5)Factor E(외부환경)의 각 세부인자 카테고리 값 도출 설문

■ 위치

해안, 강안, 고산지대 등의 격오지 위치한 시설물은 염해, 동결융해의 영향으로 인해 시설물의 손상이 빠르게 진행되는 것으로 알려져 있습니다. (고경택 등, 2001) 본 연구에서의 격오지는 GOP · GP 시설, 해안 경계 시설, 방공진지로 정의 합니다.

일반적 시설의 참고수명을 100으로 가정하면, 격오지에 위치한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 격오지가 아닌 지역에 위치할 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 눈, 비

눈, 비는 습도에 의한 영향뿐만 아니라, 홍수, 폭설, 산사태, 눈사태 등 물리적인 시설물의 피해를 야기합니다. 본 연구에서 눈, 비가 많이 오는 지역은 각 관측소별 30년 연평균 강수량을 기준으로 전국 평균인 1350mm 이상 지역을 말하며, 관측소가 없는 지역은 가장 가까운 관측소 값을 기준으로 합니다.

일반적 시설의 참고수명을 100으로 가정하면, 눈, 비가 많이 오는 지역의 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 눈, 비가 많이 오지 않는 지역의 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

6)Factor F(사용환경)의 각 세부인자 카테고리 값 도출 설문

■ 시설사용부대 교체 여부

시설 사용 부대가 교체될 경우 주인의식 부족, 인수인계 누락 등으로 인하여 시설의 열화에 영향을 미치게 됩니다.

일반적 시설의 참고수명을 100으로 가정하면, 시설 사용부대가 교체될 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 시설사용 부대가 변동 없이 사용될 때, 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 주 사용자(병/간부)

사용자의 습관, 행동양상 등의 특성은 시설물의 열화에 영향을 미치게 됩니다. 일반적으로 20대의 활동량이 많은 용사들은 시설물 열화에 악영향을 미치는 것으로 알려져 있습니다. (김석봉, 2000)

일반적 시설의 참고수명을 100으로 가정하면, 시설물 주 사용자가 용사일 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 시설물 주 사용자가 간부일 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 사용빈도

사용 빈도가 많은 시설은 손상과 열화에 많이 노출되어 수명에 악영향을 미치게 됩니다. 본 연구에서 사용빈도가 높은 시설은 야외 훈련 등 특수한 상황을 제외하고 1년 내내 8시간이상 이용되는 시설을 말합니다.

일반적 시설의 참고수명을 100으로 가정하면, 사용빈도가 많을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 사용빈도가 많지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

7)Factor G(유지보수 수준)의 각 세부인자 카테고리 값 도출 설문

■ 유지보수 횟수

유지보수를 실시한 시설물은 그 기능 및 수명을 향상시킬 수 있습니다. 본 항목에서 유지보수는 위임보수, 대보수(계획보수)로 정의 합니다.

일반적 시설의 참고수명을 100으로 가정하면, 유지보수를 실시한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 유지보수를 한번도 실시하지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

■ 유지보수 전담조직

유지보수 전담조직을 보유한 시설물의 경우, 즉각적인 유지보수를 시행하여 열화 초기에 대응함으로써 손상 확대를 방지하고 시설물 수명을 연장시키는데 도움을 줄 수 있습니다. (예 공우 ENC 등)

일반적 시설의 참고수명을 100으로 가정하면, 유지보수 전담조직을 보유한 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

일반적 시설의 참고수명을 100으로 가정하면, 유지보수 전담조직을 보유하지 않을 경우 시설물의 수명에 어느 정도의 영향을 미치게 될 것으로 판단하십니까?

수명단축 **수명증가**

매우 부정적	부정적	영향 없음	긍정적	매우 긍정적
80	90	100	110	120

1) 귀하의 근무지는 어디입니까?
( )

2) 귀하의 담당업무는 무엇입니까?
① 공병장교 ② 공병부사관 ③ 행정보급관 ④ 시설사용자

⑤ 기타 ( )

3) 귀하의 군 경력은 몇 년입니까?

① 5년 미만 ② 5년 이상 ~10년 미만

③ 10년 이상 ~ 15년 미만 ④ 15년 이상 ~20년 미만

⑤ 20년 이상

4) 귀하의 시설업무(공사행정, 집행, 감독)경력은 몇 년입니까?

① 5년 미만 ② 5년 이상 ~10년 미만

③ 10년 이상 ~ 15년 미만 ④ 15년 이상 ~20년 미만

⑤ 없음

설문조사에 응해주셔서 대단히 감사합니다.

초 록

군 시설물은 군인의 휴식과 훈련의 장소를 제공하고, 전쟁을 위한 물자와 장비를 보호하는 등 중요한 기능을 수행한다. 또한 군 시설물의 자산가치는 30조원에 육박한다. 항시 전투준비태세를 갖추고, 자산가치를 보존하기 위해서는 군 시설물의 유지보수를 통한 기능 발휘가 장기간 지속적으로 이뤄져야 한다. 그 동안 군 시설물 유지보수에 대한 연구들이 있었지만 사용자보수에 대한 고려가 부족하였으며, 지나치게 복잡하여 실제로 군에서 활용하는 데는 한계가 있었다. 사용자 보수는 열화 초기에 저비용으로 효율적인 열화 예방이 가능한 군 유지보수의 종류로, 시설 사용자가 대상, 금액, 시기를 결정할 수 있다. 그러나 비용 분배시 시설물의 환경적 특성을 고려하지 않고, 단순히 공용년수와 시설물 유형을 기준으로 예산을 분배하고 있다. 이로 인해 사용빈도가 많거나, 해안, 강안에 위치하는 등 열악한 환경에 놓인 시설물들은, 열화가 더 빨리 일어남에도 불구하고 균등한 분배로 인하여 유지보수비용이 부족하게 되고 이는 시설의 기능 발휘 저하로 이어지게 된다. 따라서 본 연구에서는 Factor Method를 활용하여 시설물의 다양한 환경 인자를 고려한 예상수명 계산 모델을 제안한다. 군 시설 전문가의 설문 결과 환기, 단열, 위치, 유지보수 전담 팀 및 빈도 등이 시설의 수명에 큰 영향을 미치는 것으로 나타났으며, 개발된 모델을 실제 유사한 공용 년수와 유형의 시설물에 적용한 결과, 열악한 환경에 놓인 시설의 예상 수명이 더 짧게 계산됨을 확인할 수 있었다. 제안된 방법론은 군 시설에 영향을 미치는 다양한 인자들을 고려하여 예상 수명을 계산할 것이며, 궁극적으로 유사한 시설 유형, 공용년수를 가진 시설물 중에 예상수명이 짧은 시설물에 사용자 보수비를 더 많이 분배하는 근거를 마련할 것이다. 이를 통해 군 시설물에 대한 효과적인 예방적 유지관리를 가능하게 하여 궁극적으로 군 시설물의 기능을

유지함과 동시에 사용수명을 늘리는데 기여할 것으로 기대된다.

주요어: 군시설물, Factor Method, 환경인자, 사용자보수
학 번: 2017-21313

Acknowledgement

먼저, 부족한 저를 연구실에 받아주시고 이렇게 논문으로 연구를 마무리 할 수 있게 지도해주신 교수님께 진심으로 감사 드립니다.

또 논문 심사를 흔쾌히 수락해 주신 박문서 교수님, 김두연 교수님께도 감사의 말씀을 드립니다. 그리고 저를 연구실의 진정한 구성원으로 받아주고 많은 것들을 알려준 건설혁신연구실 연구원들 정말 고맙습니다. 오랜만에 공부를 하러 입학해서 처음에는 뭘 해야 하는지도 모르는 채 멍하니 시간을 보내며 '이등병이 처음 군에 오면 이런 느낌이겠구나' 라고 생각했습니다. 2년동안 학업, 연구로 인해 힘든 일도 많았지만 여러분들의 도움으로 잘 버텨냈습니다.

특히, 오히려 짐이 되는 부사수를 끝까지 책임져준 임소람 연구원의 학구열과 따듯한 인성은 정말 잊지 못할 것입니다. 우리 스마트하고 착한 연구원들과 교수님의 앞날이 꽃길 만 가득하기를 진심으로 바라겠습니다.

또 힘든 육아를 책임져 주면서 남편을 외조 해준 사랑하는 아내가 너무 감사하고, 몇 년 전 아내가 첫째를 키우며 석사 학위를 취득했다는 사실이 새삼 존경스러워 지는 시간이었습니다.

위탁 교육 기간 동안 소령 진급, 둘째 출산 등 많은 좋은 일들이 있었습니다. 또한 사랑하는 아내와 두 딸과 함께 많은 시간을 보내는 소중한 기간이었습니다. 이제 제 원래 위치로 돌아가서 군과 서울대학교에서 받은 감사한 은혜를 보답할 수 있도록 최선을 다하겠습니다. 마지막으로 설문을 도와준 군 선후배 및 동기, 동료 분들께 다시 한 번 감사의 말씀들 드립니다. 부족한 제가 이 모든걸 이룰 수 있게 도와주신 하느님께 감사 드립니다.