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A Study on Estimating Maintenance Cost due to Bridge Pavement Service Period

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Abstract. This research categorized the maintenance area for bridge-decks pavement into three parts by construction method. Also, estimating optimal life distribution and mean life of each part using survival analysis to analyze serviced time by construction method. The results show that the Lognormal distribution is the best distribution method of describing life information of target area's bridge-decks pavement. Mean life of the bridge-decks pavement by construction method turned out that the part applied with cutting and overlaying methods has 8.2 years, that the part with re-paving has 14.1 years, and that the part with improvement work has 16.8 years. Further to this, it can be expected that calculation formula of maintenance cost by period can be developed to estimating maintenance budget per year.

Keywords: Bridge, Pavement, Maintenance Cost, Service Period, Survival Analysis

1 Introduction

In order to support balanced budget distribution between various types of road facilities under limited resource and improve the level of service (LOS) provided to users, it is necessary to develop the decision-making system including engineering and economic evaluation that improves the performance of bridge management system and considers bridges as assets. For establishing comprehensive decision-making system, methods and procedures to carry out the establishment of optimal management strategies and budget distribution through correct estimation of maintenance time and cost of bridges should be prepared. Therefore, this study was a preliminary study on the decision-making system for efficient bridge maintenance, and the bridge sur-face pavement with the largest number of maintenance works among bridge members was divided into maintenance sections (cutting+overlay, reconstruction, improvement of bridge surface) according to the maintenance method, the optimal life distribution and average life for each target section were calculated through the survival analysis, and

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the maintenance method according to the performance period of bridge surface pavement was analyzed. In addition, the cost calculation equation according to the performance period of bridge surface pavement was calculated through the regression analysis with cost for each maintenance method.

2 Estimation of optimal life distribution for each construction method

Determining which life distribution the observed life data follows is a very important process in the reliability analysis. So if the life distribution of such population is determined, it is possible to infer the measure for reliability due to the parametric method by using the method of maximum-likelihood estimation. The method of maximum likelihood estimation is one of estimation methods of parameter which determines f(t) using samples when n number of samples are extracted from a population which has probability density function f(t), and it is being frequently used also in civil engineering field since it satisfies various desirable properties statistically (Bae, 1999; Do, 2010). In case independent observation values are obtained from a population with probability density function f(t), is set for the parameter of f(t), the likelihood function of is defined as shown in equation (1).

$$L\ 0 = f\ t_1,\ 0\ f\ t_2,\ 0\ \square\ f_{t..,}\ 0 \tag{1}$$

In other words, the likelihood function L of is given, it is expressed as function of , and the value of which takes this function as the maximum is called maximum likelihood estimator (MLE). Equation (1) takes a form of multiplication, log likelyhood function which takes natural logarithm is frequently used due to the convenience in calculation, and the log likelihood function which is the function to maximize takes a form of equation (2)..

$$\begin{aligned} &Maxe\ InL\ 0 \\ &\quad n \\ &= \quad Inft_1,\ 0 \end{aligned} \tag{2}$$

The optimal distribution was selected through AD statistics of 4 distributions compared for selecting the optimal life distribution using the method of maximum likelihood estimation. In this study, the target section was divided into 3 sections according to the construction method, and the analysis result showed that the most suitable lognormal distribution was shown at all 3 sections in case of the optimal life distribution estimation. AD (Anderson-Darling) statistical value was used in the goodness-of-fit test which measured how closely the relevant life data followed a specific distribution, and it is determined that smaller AD statistics, higher the suitability to follow a specific distribution.

Table 1. Estimates of Optimal Life Distribution(Anderson-Darling)

Distribution	Maintenance Method		
	Cutting+Overlay	Reconstruction	Improvement
Weibull	7.885	0.947	1.586

Log-Normal	3.043	0.933	1.388
Exponential	33.076	5.219	2.684
Normal	13.26	1.054	1.998

3 Calculation and application of average life for each method

When life data of road surface pavement follows the log normal distribution, it is possible to obtain very useful information for BMS operation such as average life, distribution, reliability and life by using the reliability theory (Do, 2010). At first, the average life and distribution of pavement can be expressed as equation (3) and equation (4) using the location parameter and scale parameter obtained previously.

θ

θ

Also, it is possible to calculate which probability the design life of pavement, which is 10 years, can be shared by using the reliability. When the life data of pavement follows the log normal distribution, the calculation result obtained using equations (3) and (4) for calculating the average life for each load can be summarized as Table 2. At first, the average life of section where each method was applied was 8.2 years for the section with cutting and coating, 14.1 years for section with the reconstruction of pavement and 16.8 years for the section with the improvement of bridge surface, and the maintenance method according to the performance period was analyzed.

Table 2. Average Life Expectancy and Applications

	Average Life	R(t=10)	Life
Cutting+Overlay	8.209	0.2604	3.750
Reconstruction	14.097	0.6504	6.233
Improvement	16.835	0.7708	7.552

4 Cost calculation according to the service period of bridge surface pavement

In this study, the equation to calculate the maintenance cost depending on the performance period using the average life for each section according to the selected method and the maintenance cost for each method (Korea Expressway Corporation) was developed through the regression analysis as shown in Figure 1 in order to calcu-

late the maintenance cost according to the performance period of bridge surface pavement.

The calculation equation developed in this study and average life would be helpful for deciding the priority order when calculating the bridge surface pavement maintenance budget. In other words, in case of carrying out the maintenance within 14 years of the performance period of bridge deck pavement, the maintenance can be done with cutting and coating, but after 14 years, the reconstruction of pavement and the improvement of bridge surface need to be carried out due to the accelerated degradation of floor slab so that the maintenance cost will increase. Therefore, when selecting the priority order for the maintenance of bridge surface pavement, it would be possible to use the limited budget efficiently by selecting the priority order targeting the sections with increased maintenance cost due to change of method in consideration of the performance period of bridge surface pavement.

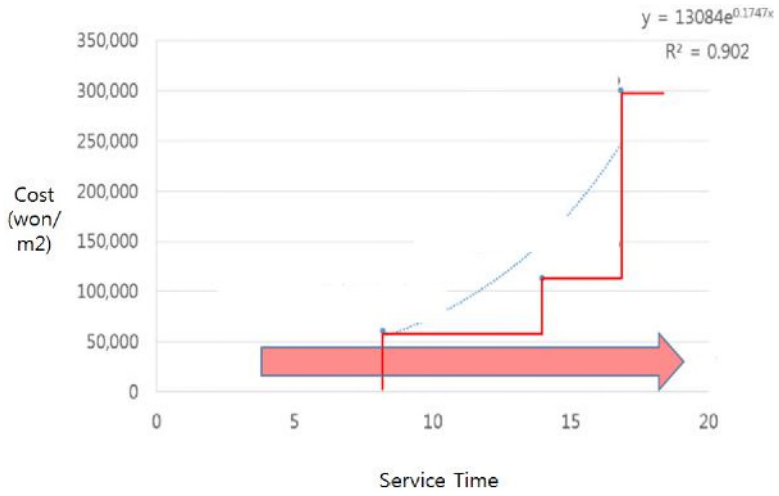

Figure 1. Maintenance cost according to the performance period of bridge surface pavement.

5 Conclusion and future studies

In this study, the target bridge surface pavement maintenance section was divided into 3 sections for each maintenance method, and the optimal life distribution and average life of each target section were calculated through the survival analysis, and the performance period of bridge surface pavement according to the application of each maintenance method was analyzed. Also, the cost calculation equation accord-ing to

the performance period of bridge surface pavement was developed through the regression analysis with cost for each maintenance method. In addition, the maintenance cost calculation equation according to the performance period was developed, enabling the calculation of maintenance cost using the performance period, so that this will be very helpful for estimating the maintenance budget for each year.

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