

# Optimal Bridge Maintenance Algorithms Considering Subordinate Relation with Bridge Members



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**Abstract** Recently, social interest in the deteriorated bridges and infrastructure has been increasing. Also, studies on performance prediction and maintenance decision making of structures are underway. In this study, it was proposed an algorithm to create an optimal maintenance scenario that takes into consideration the relationship between the members of bridge that affect each other, rather than the conventional maintenance that is focused on single members of the bridge.

Since maintenance scenario creation is discrete in terms of time and cost. So in this study, it is used a genetic algorithm. Each member of bridge has a subordinate relation that takes into account member damage transitions effect and the elimination of duplication maintenance cost, which was established through the Korean bridge maintenance manual and expert opinion. In order to predict the performance change of each member, the algorithm used the condition prediction model of each member of the bridge, which was created by multiple regression analysis based on the actual bridge case. Also, it used the maintenance cost model of members for cost estimation, it has created and applied it through actual maintenance case analysis. The constraint of the algorithm is set to the minimum maintenance level of

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the bridge by the bridge administrator. And, it was conducted the case study about real bridge model using the optimal maintenance model, analyzed the cost-effect and made maintenance scenario.

**Keywords** Optimal bridge maintenance · Condition prediction model · Genetic algorithm · Subordinate relation

## 1 Introduction

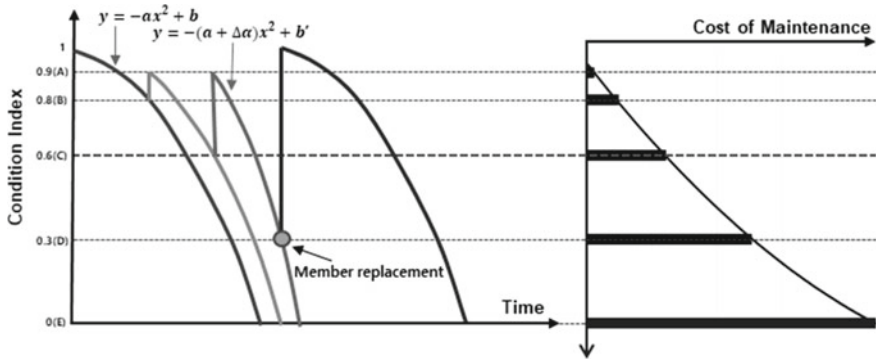
Recently, interest in preventive maintenance of bridges and infrastructure has increased, and research has been conducted on the performance of structures and maintenance costs [1–4]. After collecting the safety inspection and in-depth inspection data of the national road bridges, the condition prediction model was established through polynomial regression analysis considering the deterioration rates [5]. In order to make these studies practical, optimization algorithms were proposed to take account of the various constraints and correlations between members.

## 2 The Optimal Maintenance Algorithm for Time and Costs

To optimize time point and cost for maintenance are required to satisfy correlation in each member and various constraints. And then, a genetic algorithm has some effective advantages to estimate various variables and constraints. So, in this study, there is suggested the model to predict optimal time point and cost for bridge maintenance, using a genetic algorithm(G,A).

### 2.1 *The Prediction Model of Bridge Member Condition and the Maintenance Cost*

The prediction model of bridge member condition is made to forecast each member condition rate up to the target life of the bridge. And this model is based on safety inspection and in-depth inspection data of the national road bridges in Korea since 1995. In Fig. 1, the condition prediction model was developed by polynomial



**Fig. 1** Concept about prediction model of bridge member condition and maintenance cost

regression results which were based on bridge condition ratings, and the difference in the degree of deterioration expressed the deterioration ratio in the point of maintenance before and after.

The rating maintenance cost function was proposed by specialists' opinions and maintenance rating cost data, and it was shown that the curve was newly updated by rating resulting from maintenance.

## 2.2 Optimization Model Using the Genetic Algorithm

The genetic algorithm (G.A.) is suitable as maintenance optimization methods because they do not have to be constrained by differential and continuous conditions in the purpose function. So, in this study, it was applied to. Figure 2 is described in the genetic algorithm for the absence-specific correlation and constraints.

Each Member of the bridge is needed to consider the correlation with the increased deterioration ratio. When it was reached condition-index Grade D(0.3), it has to replace as the maintenance and resets as the initial deterioration ratio(a). At this time, it should be considered some relationship with each member and decided to main or sub-member. Then, it is calculated the cost of bridge maintenance using relationship about bridge members.

### 3 Case Study of Optimal Algorithm About Maintenance Time Point and Cost

In this study, to confirm the applied performance ability about the optimal algorithm, it conducts a case study using by deck and pavement members of the common bridge in Korea. As shown from the Table 1, it is represented factors - the deterioration ratio, deterioration increase ratio, C.I.- Cost function, and constraints. Each factor is set into the algorithm and calculates the optimal time point and cost of maintenance. And then, it makes the maintenance scenarios with the member-specific correlation. The deck and pavement maintenance scenario of Fig. 3 is represented the optimal maintenance scenario considering the member-specific correlation and scale for the target life of 100 years.

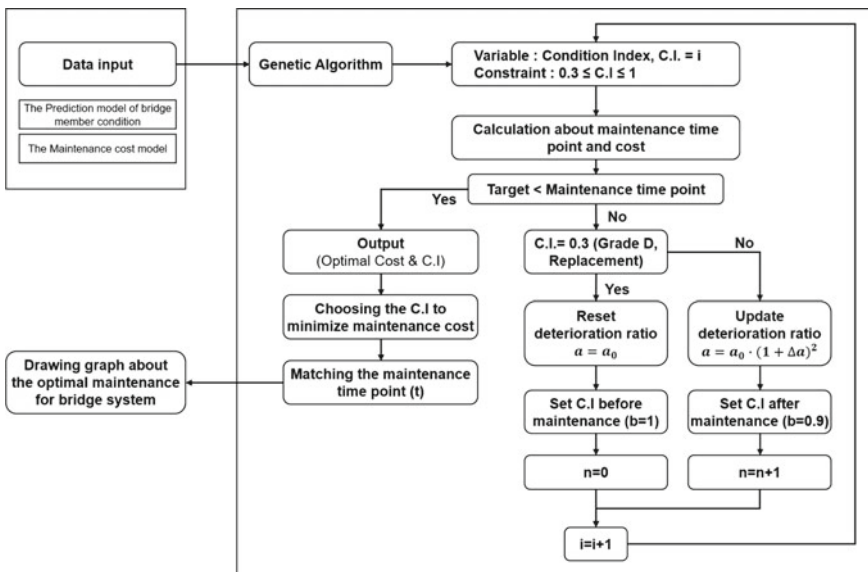
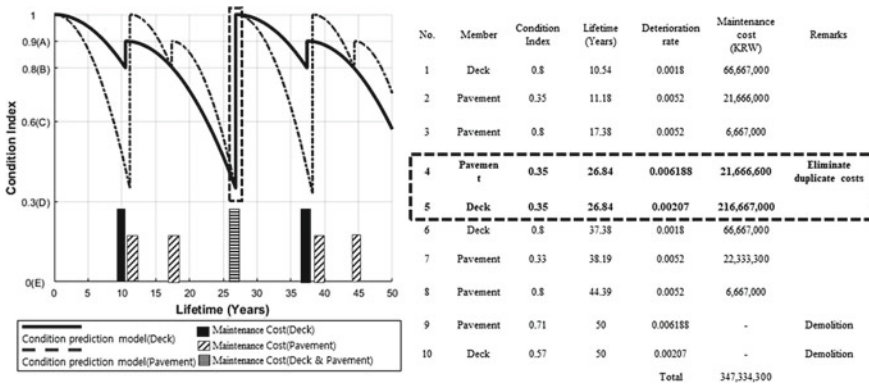


Fig. 2 Optimal algorithm for bridge maintenance about time point and cost using G.A.

**Table 1** The factors of optimal algorithm about maintenance using G.A.

Bridge member	Deterioration ratio (a)	Deterioration increase ratio ( $\Delta\alpha$ )	C.I. - Cost function	Constraint
Deck	0.0018	0.15	$cost = -\frac{10^9}{3} C.I. + \frac{10^9}{3}$	1) If deck were replaced, pavement was automatically replaced 2) Each member was satisfied that C.I. was over D grade (C.I. = 0.3)
Pavement	0.0052	0.19	$cost = -\frac{10^8}{3} C.I. + \frac{108}{3}$	



**Fig. 3** The scenario study about bridge maintenance

### 4 Conclusions

In this study, to optimize time point and cost for maintenance, there is suggested the model to predict optimal time point and cost for bridge maintenance. Then, it is represented the optimal algorithm about maintenance of bridge using and genetic algorithm.

This algorithm can establish an optimal maintenance scenario considering correlation about each member of bridge to maintenance efficiently and reasonably. In addition, it is expected to be able to further apply a variety of member-specific correlations.

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