EFFECT OF DELAYING MAINTENANCE ACTIVITIES ON THE REPAIR COSTS OF ROADS IN ADDIS ABABA, ETHIOPIA

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1. INTRODUCTION

The construction industry is one of the main sectors that provides an important role for the economy of a country. For the sustainability of infrastructure, maintenance activities have a key role. However, many maintenance projects experience extensive delays and thereby deterioration increases which ultimately increases maintenance cost. Maintenance delay is one of the most recurring problems in the construction industry, especially in developing countries such as Ethiopia. In Addis Ababa, the capital of Ethiopia, the Addis Ababa City Roads Authority (AACRA) is responsible for conducting three types of maintenance activities: patching, overlay and rehabilitation. Selection of maintenance activity type is according to the road section and damage level of the roads. However, some roads are not repaired in the planned year and their maintenance is postponed to the next year. If the maintenance is not carried out in the planned year, roads will deteriorate further, needing replacement or major repairs after just a few years. That deterioration spread across a road system very quickly which results in escalating costs and a major financial impact on the economy.

The main objective of this research is to analyze the effect of delayed maintenance on maintenance cost. It is assumed that the increase in maintenance cost due to delay has some relationship with the initial maintenance cost, which may be used for the allocation of budget for the next year. The significance of this research is finding out the impact of delayed maintenance on the economy and raising awareness in the government about the importance of carrying out maintenance work in timely manner. This will help to optimize the budget and other resources.

2. METHODOLOGY

2.1 Data

The data for analysis was collected from the Road Asset Management Department, AACRA. The sample consists of 106 unrepaired asphalt pavement road section's cost estimates in the planned year and the year after from the west region. Of the five regions of road asset management, the west region database is recorded properly and well organized, so it was chosen for this analysis. The number of road sections that were not repaired in the planned year was 18 in 2017, 18 in 2018, and 70 in 2019, for a total of 106 data points. The pavement type of these road sections are asphalt pavements, and most of them are principal arterial roads 20 to 40 meters in width and exposed to high traffic congestion. The other road sections are sub-arterial roads 10 to 15 meters in width. Maintenance activity is carried out in three ways: patching, overlay and rehabilitation. The selection of maintenance method depends on the road section and damage type. More than 67% of the road section maintenance activity is patching and the remaining part is overlay and rehabilitation.

2.2 Analysis

The data collected from the road authority were analyzed using descriptive statistics and regression equation. Independent variable is the cost estimate in the planned year (t) and the cost estimate after one year delay (t+1). This research examines the effect of delaying maintenance using the cost increase ratio, which describes how much the estimated maintenance cost increases from the planned year to the next year due to the delay of maintenance activities, relative to the cost estimate in the planned year (Equation 1).

$$\triangle \text{Cost} = [C_t - C_{t+1}] / C_t \quad (1)$$

Where C_t is the road cost estimate in the planned year, C_{t+1} is the road cost estimate after one year delay. Patching, overlay and rehabilitation cost estimates have been analyzed separately to see the effect of maintenance delay on maintenance cost and compare the average cost of the planned year cost with the average maintenance cost after one year delay.

To analyze the relationship between the initial maintenance cost and the cost increase ratio, regression analysis with the logarithmic function is used because the data distribution is nonlinear (Equation 2).

$$y = a + b*\ln(x) \quad (2)$$

Where y is the dependent variable, x is the independent variable, a is the intercept, and b is the slope.

3. RESULTS & DISCUSSION

The average cost estimates for the road sections in the planned year and after one year of delay are illustrated in Figure 1 for patching, overlay, rehabilitation, and the overall cost. Overall, it was found that, when maintenance is delayed for one year the maintenance cost estimates for most of the road sections tended to increase.

Patching maintenance was planned for 67 road sections. Out of these sections, 25 road sections' cost estimates increased by less than 50%, 23 road sections' cost estimates increased by 50% to 200%, and 18 road sections increased by more than 300%. The average cost estimate in the planned year was 517,317 ETB, and after one year it increased to 915,061 ETB.

Overlay maintenance was planned for 19 road sections. Out of this sections, 2 road section's cost estimates increased by less than 50%, 7 road sections increased by between 50% and 100%, 5 road sections increased by between 100% and

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150% and 5 road sections increased by more than 150%. The average cost estimate in the planned year was 408,840 ETB, and after one year it grew to 870,661 ETB.
In contrast, rehabilitation maintenance work needs more time and budget relative to patching and overlay maintenance activities. Once the maintenance type of the road is fixed to rehabilitation, patching or overlay maintenance is still done in the middle of the year for those roads which are seriously damaged to keep traffic flowing smoothly. The average cost estimate of rehabilitation in the planned year was 1,000,695 ETB, and after one year it increased to 1,770,664 ETB.
Of the 106 road sections that were planned for maintenance but had their maintenance delayed, 22 road sections' total cost estimates increased by less than 25%, 39 road sections increased by 25%-125%, 15 road sections increased by 125%-200%, and 29 road sections increased by more than 200% due to the one year delay in maintenance. The average total cost estimate in the planned year was 642,284 ETB, and after one year delay it increased to 1,185,462 ETB. Therefore, it can be seen that the total cost of maintenance increased by 85% due to a one year delay in maintenance activity.
The relationship between estimated maintenance cost in the planned year and the increase in cost due to maintenance delay is examined for patching and overlay (Figures 2 and 3, respectively), as well as for the total cost (Figure 4). For all three figures, the cost increase ratio has high variability for smaller maintenance projects and less variability as the maintenance cost increases. If it is assumed that the cost in the initial year is representative of the initial scope of damage and the cost increase ratio is representative of the progress of deterioration due to lack of maintenance, then the relative rate at which the damage increases is somewhat constant when the scale of the damage is large. However, when there is less damage, the damage progression and subsequent increase in cost varies widely. While the logarithmic regression equations were used to model the relationship between the cost in the planned year and the cost increase ratio, the model fit is low for patching and the overall cost. On the other hand, the model fit is somewhat good for overlay. Using these regression equations may help estimate how costs will increase should maintenance not be carried out as planned.

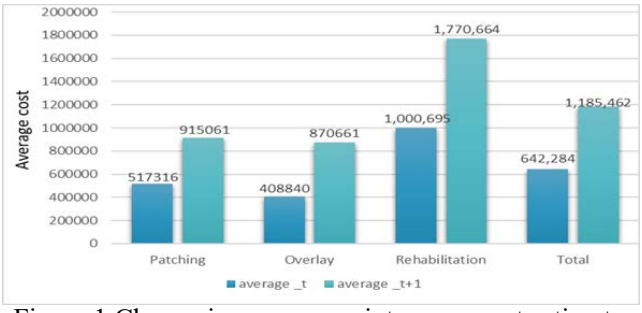

Figure 1 Change in average maintenance cost estimate due to one year delay

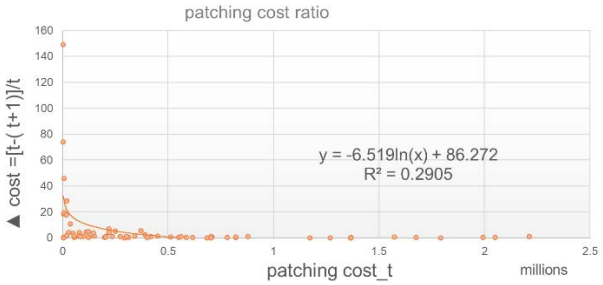

Figure 2 Relationship between initial cost and cost increase for patching

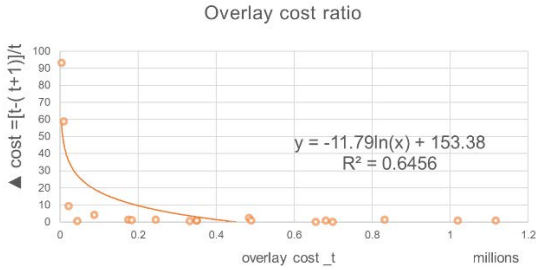

Figure 3 Relationship between initial cost and cost increase for overlay

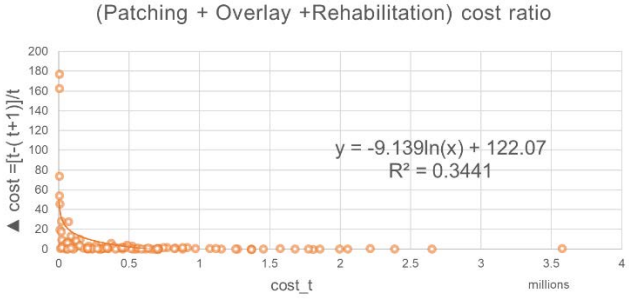

Figure 4 Relationship between initial cost and cost increase for total maintenance cost

4. CONCLUSION

In this paper, it was found that, due to delayed maintenance, the road sections deteriorated rapidly and the repair costs significantly increased, which may result in huge restoration costs in the long term. Furthermore, the increase in maintenance costs due to the delay was shown to have some relationship with the initial maintenance cost. This knowledge may help to optimize the budget and other resources. In the future, the whole Addis Ababa city database will be developed and analyzed, which will contribute to investigation of the factors contributing to maintenance delay and planning of the appropriate countermeasures for roads in Addis Ababa city.

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