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Research paper

Ten Years Road Maintenance Activity and Forecast: A Case Study

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Abstract

This paper discusses the result of a research activity on forecasting activities as well as related financial requirement in maintaining state roads in a single local district. This forecasting is based on Pavement Condition Assessment (PCA) conducted on routes in this district, and then data was analyzed. Current practice of road maintenance does not allow local authority to project the financial requirement in maintaining the roads, as corrective actions are taken based on report and scheduled maintenance check. Hence, the condition of the road will deteriorate further and this may affect the socio-economics of the surrounding areas. For this situation, preventive maintenance will be a viable solution. With this, a method was developed to forecast 10 years of maintenance works and financial requirement. The steps taken to design this model are through pavement condition assessment (PCA) where the analysis were done. The result produces a 10 year forecast of the financial requirement for the purpose of road maintenance in the district. Based on analysis a total of RM 21.27 million is required in a span of 10 years, where 35% of the total amount is needed in the first year for corrective maintenance works.

Keywords: *Pavement Condition Analysis; Road Maintenance; Forecast Maintenance; Preventive Maintenance; Infrastructure Management*

1. Introduction

A program has been carried out in order to forecast the maintenance activities along with the financial requirement in a single district in Malaysia. This forecast duration is 10 years and was done through Pavement Condition Analysis on the roads within this district. This district is a mixture of urban and rural areas, where 20 routes was tested. Out of these 20, 12 are protocol roads while the remaining are primary roads with an approximate total of almost 100 km. The current implementation is in reactive manner. Maintenance works on roads will only be done after a report has been filed and verified. In some worse situations, damages that went unreported will remain. This also prevents any indicator of the road's health to be assigned. Due to the unpredictability of this reactive maintenance, financial forecasting is almost impossible. This can be overcome by understanding the damages and pavement condition of the road. This research was conducted for the local authority body, and the output provides a baseline for forecast of the road maintenance operating expenditure. To achieve the general objective, PCA was conducted on routes within this district. Several tests were conducted including Falling Weight Deflectometer (FWD), Asphalt Coring and Dynamic Core Penetrometer (DCP). These test data were then analyzed, where the projection of financial requirement will be formed.

This research allows the management of road maintenance on any district. Road maintenance is significant specifically to higher populated areas where road defects are the utmost. This research provides awareness of the entire financial requirement in optimizing the resources. This will have a direct impact to the current reactive maintenance method, where it predicts the damages on roads in ensuring the safety of the road users, while allowing major cutbacks in the financial impact on maintaining the roads from deterioration due to constant usage.
The current problem faced in road maintenance is that due to reactive maintenance, several issues faced by authority body over the maintenance process; mainly lack of funding and unsustainable design [1] as well as deteriorating funding [2]. Reactive maintenance often involves direct spending by the local authority in order to get it done [3]. Due to this, the roads are often listed based on priorities, and not all will be attended. Critical action was usually required for places that severe in damages, and typically gets the nod first for maintenance process to be carried out.
By not doing preventive maintenance, it has an adverse effect on the funding to be provided for the said purpose [4]. This is due to the fact that when the road is not well maintained, the direct impact towards the local economy is imminent, as the area will be unfavorable by business to pass through the area. This usually are resolved through outsourcing maintenance operations. This however, proved to be effective on longer roads [5]. Road maintenance should include data attainment, processing of the said data and actions taken in rectifying the issues on top of monitoring after maintenance work is done. The definition of pavement maintenance is the measures taken in ensuring that the road deterioration will be at minimal state through the application of various methods available [6]. According to Tillotson, Kerali & Snaith [7], the contributing factors in road maintenance are the PCA, traffic frequency, regulations, weather as well as budget given by the local government. For this to be improved, modern tool us-age is vital in maintaining the cost at lower level [8]. By

using a more modern technology with higher technical capability, projection for the following scheduled maintenance can be done, hence optimizing the reserves of the local authority.

2. Research design

This research was performed in two different phases, as the pavement condition analysis (PCA) is to understand the level of road health within the district. The structure of the road as well as the functionality of the road were assessed using DT and NDT testing [9]. These data were benchmarked in accordance to the standards set by the local authority. The following are the methods for the PCA.

For NDT, the following procedure were carried out

I. HSRS: High Speed Road Survey- In getting the road surface data, a mobile road vehicle were used. The roughness, rutting, depths and cracks data were taken.
II. Falling Weight Deflectometer (FWD)- To measure the structural strength of the layers of the road
III. Axle Load Test and Traffic Counting- This is to understand the extent of damages done on the road due to usage by commercial vehicles. This is paired by traffic counting that provides information in regards to traffic density of that particular road.

For DT, two methods were carried out:

I. Core Extraction- to measure the bound layer thickness by extracting the core of the asphalt
II. Dynamic Cone Penetrometer (DCP)- to obtain the layer data of the road

The data were then processed. This analysis provides a mean to create plans for the roads, for further part of the management of the roads within the district as well as road maintenance related actions. Considerations were taken to incorporate the result of the analysis such as the local authority financial constraints as well as the maintenance standard. This allows to determine the critical areas that requires treatment or maintenance action first, ranked by the severity of damages as well as importance of the particular road.

3. Result

All The output obtained was benchmarked according to Key Performance Indicator (KPI). For some of the conditions, colour mapping was used in representing the health of the roads. These colour maps able to clearly indicates the severity of the damages, and capable of helping the authority to decide on the type of maintenance to be implemented.
For roughness, roads roughness is measured in accordance to International Roughness Index (IRI). Based on the data obtained shown in figure 1, almost 38% of the roads are in good condition and an amount of 36% are found to be in fair condition. 15% were found to be at poor state and 9.7% is in bad shape. This indicates immediate correction action required due to almost 10% of the road are in bad shape (were marked as "red" region during the test). This is the first advantage of having these type of test, where it allows us to understand the health of the road in term of roughness, and how much is required in immediate or preventive maintenance.

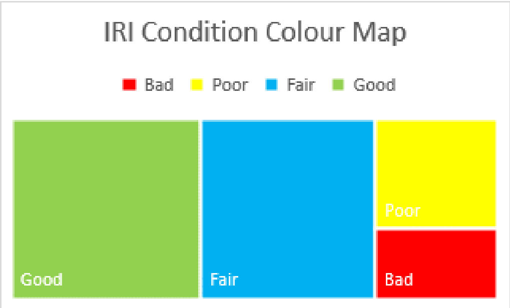

Fig. 1: IRI rating colour map based on the condition of the roads.

In term of rutting, based obtained data, 56% of the roads are in "good" condition, indicating no rutting presence in the said area. However, a percentage of 14% of roads are in poor condition in term of rutting. This indicates that some of the financial requirements are required to be allocated to this area in order to improve the rutting condition. Based on this map shown in figure 2, the bad condition is negligible.

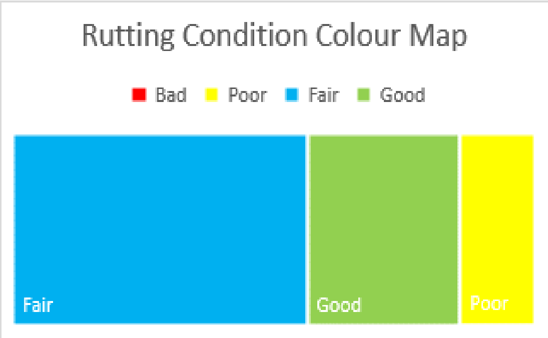

Fig. 2: Rutting condition colour map based on the condition of the roads.

Meanwhile, analysis in form of surface texture, 51% of the road surface were found in "good" condition. Not visible in figure 3, a negligible 0.04% of the roads, an amount of 0.04 km, is in poor condition. This indicates no major corrective action is required in term of the surface texture, hence allowing the funding to be utilised on other more critical areas.

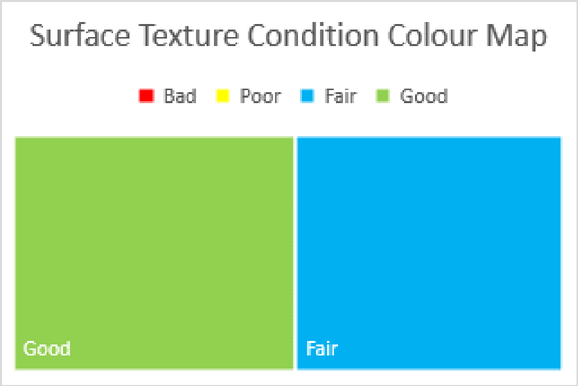

Fig. 3: Surface texture colour map based on the condition of the roads.

In crack assessments, the measured cracks are categorized into three types of standard cracks namely crocodile, transverse and longitudinal cracks. According to the analysed data, 0.2% of the total distance measured has cracks. Of the crack occurrence, 0.5% are crocodile crack, 0.1% are transverse crack and 0.1% are longitudinal crack.

Any deflections that yields a value greater than 500 microns is considered as poor performance. Should the lower layer profile is the same with the rest it indicates that the layers are uniform [10]. However, if the deflections are not similar in between layers, the layers are dissimilar in characteristic. According to the falling weight deflectometer test, the asphalt layer shows 29% in "sound" category while almost 50% is in "poor" category. However, in road base layer, most of the roads are on "satisfactory" level with 82%. On subgrade layer, 68% is on "satisfactory" level. This indicates that only preventive maintenance is required on the most part of the roads. The deflections are represented by the colour map in figure 4.

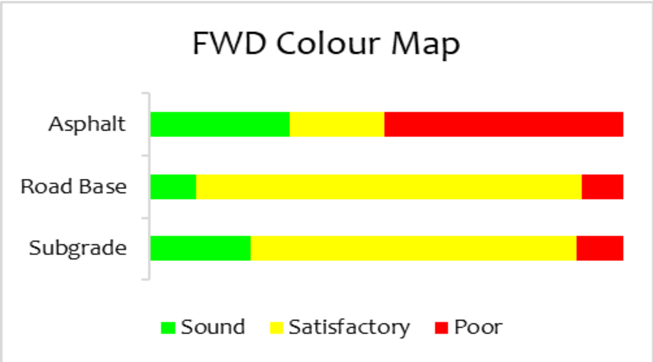

Fig. 4: FWD colour map based on the condition of the roads.

Coring and Dynamic Cone Penetrometer (DCP) test were conducted at all core holes to know the boundary of each layers. An average value of 25mm to 360mm is considered in this analysis. Most of the locations analysed were found to have no defects. Most locations yield CBR value above 5%, with the highest being 9.7%.

Prior to the study, two specific locations were identified and axle load survey was conducted. The test was done within 32 hours with 16 hours on each direction, covering both directions. 169 commercial vehicles were recorded with an equivalent factor of 0.370 (increasing bound) and 151 commercial vehicles with an equivalent factor of 0.562 on the decreasing bound. A total vehicle of almost 6000 were recorded within 24 hours in the slow lane, while 6640 were recorded on the fast lane for increasing direction. For decreasing direction, almost 3700 were recorded on the slow lane with 6369 on the fast lane, as shown in figure 5. This shows that the roads are in mild density and this can place consideration on the priority of the preventive maintenance to be carried out within this district.

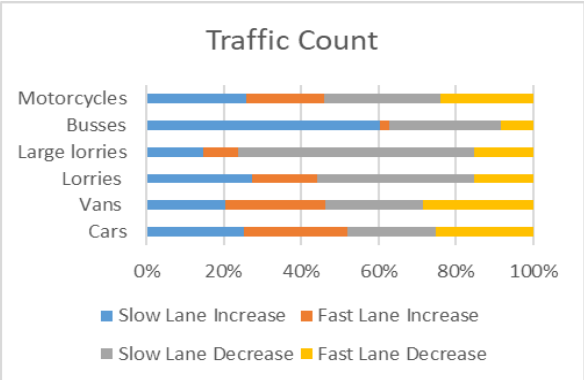

Fig. 5: Axle survey details of the location

The data from PCA are evaluated as the second stage of this research. Evaluated data will be used in considering the importance of the roads within the district for preventive or corrective actions. This is done based on the local authority benchmark, and recommendation will be provided based on this data obtained. This recommendation generates the financial forecast as well as prioritise the roads required for the maintenance actions.

The early forecast yields an approximation of RM 22 million needed to perform corrective actions and thus performing preventive maintenance on the roads within this district. This number were generated based on the priority of the action requirements on each of the roads based on the PCA released to the local authority, pinned against the standard benchmarking. However, further detailed computations are required to verify this value using Road Development and Maintenance software, which will serve as the second part of this research. However, for this forecasting, it is estimated that 30% of the total financial requirement will be placed in the first year, due to high corrective maintenance to be performed. It will then be significantly lower for the rest of 9 years' period.

It is important to note that this prediction does not considers variables of natural occurrences such as flood and seismic activities.

4. Conclusion

The data obtained from pavement condition analysis allows measures and predictions to be taken in generating a 10 years forecast of the road maintenance program within this district. It allows a better financial management of the local authority in term of segregation of allocations and tasks to multiple roads. This can be further improved by taking into measures of outsourcing cost of the current contract holders, to be suggested to the government in micro managing each corrective or preventive actions taken.

Acknowledgement

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