Effectiveness of Pavement Management System and its Effects to the Closing of Final Account in Construction Project in Malaysia

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Abstract. Federal roads maintenance needs a systematic and effective mechanism to ensure that the roads are in good condition and provide comfort to the road user. In implementing effective maintenance, budget is main the factor limiting this endeavor. Thus Public Works Department (PWD) Malaysia used Highway Development and Management (HDM-4) System to help the management of PWD Malaysia in determining the location and length of the road to be repaired according to the priority based on its analysis. For that purpose, PWD Malaysia has applied Pavement Management System (PMS) which utilizes HDM-4 as the analysis engine to conduct technical and economic analysis in generating annual work programs for pavement maintenance. As a result, a lot of feedback and comment have been received from Supervisory and Roads Maintenance Unit (UPPJ) Zonal on the accuracy of the system output and problems that arise in the closing of final account. Therefore, the objective of this paper is to evaluate current system accuracy in terms of generating the annual work program for periodic pavement maintenance, to identify factors contributing to the system inaccuracy in selecting the location and length of roads that require for treatment and to propose improvement measures for the system accuracy. The factors affecting the closing of final account caused by result received from the pavement management system are also defined. The scope of this paper is on the existing HDM-4 System which cover four states specifically Perlis, Selangor, Kelantan and Johor which is analysed via the work program output data for the purpose of evaluating the system accuracy. The method used in this paper includes case study, interview, discussion and analysis of the HDM-4 System output data. This paper has identified work history not updated and the analysis is not using the current data as factors contributing to the system accuracy. From the result of this paper, it is found that HDM-4’s system accuracy used by PWD Malaysia attains average 65 per cent only and had not achieved level that had been set by PWD Malaysia namely 80 per cent. Hence, this paper has revealed the causes of the occurrences in the pavement management system in construction project in Malaysia and investigated the consequences of the late payments and final account problems confronted by contractors in Malaysia, which eventually proposed strategic actions that could be taken by the contractors in securing their payments.
1. Introduction

The developments of infrastructure especially in road and highway network are very important to generate the country economic excellence growth. In line with the rapid development that has been taken thus far, it is clearly evidence that the government aspiration is to develop Malaysia as a developed country in the year 2020. It is essential to give the priority for infrastructure development. Thus, the Government of Malaysia has entrusted Ministry of Work Malaysia (MWM) to materialise the aspiration. MWM thru the agency of Public Works Department (PWD) has planned to forge these integrated developments. PWD also manages and maintains the existing Federal Road to ensure the good road network system is always safe, efficient and comfortable to the road users. The government also reserves and spends a huge budget for construction of the new road and maintains the existing road. In the Ninth Malaysia Plan (9MP), the government has budgeted the amount of RM 2.5 billion for road maintenance. In ensuring the smoothness of the Federal Road maintenance, government has decided the mechanism for systematic and well-planned road maintenance management.

Nevertheless, in implementing effective maintenance, budget is observed by this paper as the major factor limiting this effort. Thus, PWD has used HDM-4 System to help the management of PWD to determine the location and length of roads to be repaired according to the priority based on its analysis. For that purpose, PWD Malaysia has applied PMS which utilizes HDM-4 as the analysis engine to conduct technical and economic analysis in generating annual work programs for pavement periodic maintenance.

It is widely recognized that a good road infrastructure of a country is a pre-requisite to the development of a nation. Besides constructing new roads in Malaysia, Road Authorities are now aware of the needs to maintain and upkeep the existing roads in hand. With the large road network currently at about 17,500 km for Federal Roads and about 61,000 km for the state roads in Malaysia, roads maintenance budget accounts for sizeable proportion of public expenditures and is currently at about RM 580 million a year. If road user costs or vehicle operating costs (VOC) are taken into considerations, the total expenditure by road transport sector is even greater. Minimising the total road transport costs is the approach that is now widely accepted by most road authorities around the globe. To undertake such task in minimizing the road transport cost, a few strategies have been adopted in Malaysia. One of the most common approaches is a creation of a Pavement Management System (PMS) where the collection of data has been regarded as one of the most important components of the PMS. The results of PMS will be then transferred to the final account to show the effectiveness of allocated provision by the government.

2.0 Literature Review

2.1 Federal Road Maintenance Management in Peninsular Malaysia

In the year 2001, the Government of Malaysia has privatized the federal road maintenance in Peninsular Malaysia to three (3) concession companies and divided the nation into the zone as decided by PWD Malaysia. List of the company with the selected zone for the maintenance works are as shown in Table 1.

| No | Zone            | State                        | Consession Company          |
|----|-----------------|------------------------------|------------------------------|
| 1. | North           | Perlis, Kedah, Pulau Pinang & Perak; Selangor, Pahang, Terengganu & Kelantan; Negeri Sembilan, Melaka & Johor | Belati Wangsa Sdn. Bhd. Roadcare Sdn. Bhd. Selia Selenggara Sdn. Bhd. |
| 2. | Middle / East   |                              |                              |
| 3. | South           |                              |                              |

The concession company which has been awarded to maintain the federal road have to complete their scope of work as instructed by the PWD Malaysia or as agreed in the contractual agreement signed by both PWD Malaysia and the concessionaire. The main scopes of work for the concessionaire
are in routine maintenance, periodic pavement maintenance, periodic non-pavement maintenance and emergency work. In these programmes, the maintenance of the road is only stressed for the periodic pavement maintenance only. This is because, every year PWD will come out with the Periodic Pavement Maintenance programme for the Federal Road in Peninsular Malaysia undertaken by the concessionaire. The lists of the programme location for the Periodic Pavement Maintenance are produced by RAMS thru HDM-4 system analysis which have been used by PWD Malaysia. Based on the Road Statistic Report 2005, the overall total length of the paved federal road in Peninsular Malaysia is 12,958.58 km excluding East Malaysia and Labuan. The report is produced by PWD Malaysia.

2.2 Pavement Management System (PMS)

According to Mulholland (1989) Pavement Management System (PMS) can be identified as a method of data collections, analysis and improve engineer to decide and design optimum resources for maintenance, repair and rebuild pavement. It is also defined by this paper as a set of activity coordination in optimising civil value of money by providing an economic, safe and comfortable road.

On the other hand, IKRAM (1993) defines PMS as coordination process and a set of comprehensive activities control to maintain pavement by using optimum available resources. In other words, PMS is a systematic process which objectively functions as a pavement quality controller and maintenance programme as a result of situation, limited reallocation and economical optimum within cost reduce and optimum agency maintenance cost. Elements included in PMS are as below:

- Major and minor road inventory to be updated once in two years
- Pavement assessment for all route by using International Roughness Index (IRI) and updated once in 2 years
- Pavement progress history
- Identification of all pavement section which has to be repaired
- Reallocation of budget to repair pavement for the latest period or 2 coming years
- Effect of reallocation of pavement budget for the upcoming years

PMS is designed to provide work framework structure to record route network database systematically. Main objective of PMS is to assist decision maker in the development of effective cost strategy and provide existing maintenance budget to be prioritized where the balance of budget will be used for other non-prioritized roads. Objectives of Pavement Management System are to determine optimum maintenance policy, determine maintenance budget post time, determine the best strategy under sub-optimum budget and assess of Progress Scheme Capacity as well as determine early remedial design and assessment of Axel Load Policy. According to Safry (2000), there are four processes involved in pavement management. The processes are policy, planning, programming, preparation and operation as discussed in the following sub-topics.

2.2.1 Policy

It is a basic foundation or regulation made by PWD Malaysia to determine financial budget in achieving road standard in certain time based. From the existing budget, PWD Malaysia has decided to collect data once in three years for each zone and accuracy of work programme produced by this system should achieve 80% and above.

2.2.2 Planning

Planning includes overall road analysis system which requires preparation for short term and long term strategy to estimate the development, restoration and maintenance cost of the road under variety budget and economy scenario. Forecasting can be done on the condition of the road network in terms of Pavement Performance Index under varieties of budget. When a need budget and service target archive have been fixed, a standard work schedule should be formed where it will show the best treatment for different level of damages.
2.2.3 Programming
This includes the preparation of yearly road work program, the selected road for maintenance or the selected road to be upgraded and analyzed. The Cost Analysis should be taken for applicability in terms of economy for each work to be done. Programming activity will produce estimation each year expenses under fixed budget for each type of different road and for each road section.

2.2.4 Preparation
Preparation is a short term planning where road planning package is to be applied. At this stage, the design should be completed and detailed, encompasses the detailed list of quantity and costing with instruction of work and contract. Detailed specification and cost will be prepared and the benefit cost analysis will be done to make sure the applicability.

2.2.5 Operation
Operation includes organization of operation and the result for the management operation to be done every day or week which the schedule encompasses of work programmed supervision in terms of worker, tool and material, completion work record and the use of this information and controlling. Each function represents consecutive activity called cycle of Pavement Management System as shown in Figure 1.

![Figure 1. Process involved in pavement management](image)

2.3 *HDM-4 as a Mechanism System for Pavement Management System*
HDM-4 provides an established system for analysis of road management and an alternative investment. This system can be applied in other matters like road management to concentrate on preventive work in maintenance road network, make a programme for construction work/rehabilitation/road care, make an estimation fund needed and allocation of budget, indicate the road network performance in providing safety driving and comfortable to users, assess/evaluate project and study the effectiveness of the policy implementation. The framework of HDM-4 is based on pavement life cycle analysis concept. It is used to forecast the matters on pavement life cycle: declining road, road work effect, road used effect and socio-economic as well as environmental impact.

When the road is built, road pavement will be affected by several factors such as vehicle load, environmental weathered and effect from irrigation which is supported sufficiently. Road pavement
The decline rate will give impact to standard maintenance which is used to pavement failure such as crack, raveling, puddle and etc. For long term pavement life cycle, it is depending on standard maintenance used for that particular road. Figure 2 shows the flow of pavement performance which is delegated by driven quality and always been measured as international roughness index (IRI). From IRI graph versus time as shown in Figure 2, it is see that road pavement will decline year by year if not properly treated. Standard maintenance excepted by PWD is IRI 3.5 and above. If declining road scale has reached IRI 3.5 and above, pavement should be treated. Delay in treatment will cause road pavement get worst and treatment cost will increase. Figure 2 also shows that IRI will reduce after treatment is undertaken.

Pavement management process can be assumed as a function of pavement management activity cycle which highlights the concept and work frame where HDM-4 can fulfill pavement management. According to Kerali (1999), there are three main items in management concentrate suitable for HDM-4 which are:

a. Project Analysis  
   i. Assessments for one or more road projects or choice in investigation.  
   ii. Concentration in road network analysis or section with choice of treatment method by users, related to project cost and benefit every year.  
   iii. Economic indicators are based on choice of differences in investigation.

b. Programming Analysis  
   i. Used to prepare annual programs for road network where choice in investigate is identified based on limited reallocation of source.  
   ii. Road network analyzed based on section and cost estimate will produce for road maintenance and financial requirement for each section for each year.

c. Strategy Analysis  
   i. Used to analyze road network that is selected to provide medium and long term forecast planning for financial requirement for road development and maintenance under different budget scenario.  
   ii. Road network is characterized according to road length in different category and can be explained based on parameters such as road class, pavement type, road situation and traffic flow.
iii. Forecast will be produced for financial requirement for medium and long term period which is within 5 to 15 years.

3.0 Final Account

Whilst there is no universally written answer to what final account in construction industry means, because there are rare studies on this subject, the term final account has often been with and in existence in the construction contracts in Malaysia for more than 30 years. Although there is no specific definition, the term final account is taken in the construction contracts simply as a mechanism for dealing with the final contract sum or final payment due to the contractor after the Final Measurement Period (typical building contract) or after the Maintenance / Defects Liability Period (typical civil engineering contract). Sometimes, it also refers to the calculation and agreement of the final construction cost between the employer and contractor and incorporates a fair valuation of the works carried out [2]. The cost at tender will only reflect the cost of fulfilling the client's original brief and will not contain allowances for any subsequent omissions from or additions to the design on which the bills of quantities were prepared [4]. Therefore at the final account stage, the contract sum will include such items as day-work charges, adjustments in accordance with variation orders, and so on, and hence in some ways a clearer picture of the total cost is presented [4]. In the contractual view, upon completion of the contract requirements, the contractor is entitled to final payment including any retained sums [10]. The effect of this is that the original contract sum will be changed for a variety of reasons in pursuance to the provisions within the contractual conditions. The final contract amount includes all additions, alternations and deductions resulting from project changes. More often than not, variations and claims are inherent in construction projects because uncertainties lead, invariably, to the need for adjustments [3]. Therefore, the assessment and agreement of this final contract sum, i.e. the final account, is usually of the utmost importance to both the client and contractor [2]. Hence, delays of final accounts closing can be resolved at the early stage if the documents are kept properly and project manager has better understanding of critical success/failure factors in the construction project [12].

4.0 Research Methodology

4.1 Introduction

HDM-4 has been used since 2002 by PWD Malaysia to organize their yearly periodic routine maintenance work. The work programme used has to be very accurate and precise in order to get the correct location and the length of the road that to be taken care of. So far, there was no research that can be used/followed as a based procedure to ensure the preciseness and the accurateness of the system. In this paper, the new system that can be used to justify the accurateness and preciseness of the system will be discussed in the next sub topic.

4.2 Purpose of Paper

Every paper has their own purpose and this paper is to ensure the effectiveness and accurateness of HDM-4 system so that every yearly periodic routine maintenance work programme performed by this system will be successful and precise. Via this paper, HDM-4 output, i.e list of the work programme will be taken and compared with the actual needs that are approved by UPPJ zone. For those location lists that did not exactly follow the site requirement, the replacement location will be proposed by UPPJ zone.

4.3 Paper: Sources and Tools

To make this HDM-4 system effectively generates the periodic routine maintenance work programme, the followings are the tools and sources needed.
4.3.1 RAMS Data Base (RAMS DB)
Database needed to analyse all HDM-4 data includes road inventory, road pavement, pavement structure and its traffic. As for road inventory, data that are taken into consideration are pavements type, road lengths and its width, road geometric situation and type and width of the road border. For the road inventory, information that are taken into considerations are roughness, cracked, siltness, pothole and the depth of its textures. While for road structure, it will consider the road pavement lifetime, its thickness of its asphalt, its base and road sub-base as well as Falling Weight Deflectometer (FWD) Central Deflection.

4.3.2 HDM-4 Software
Basic raw data from RAMS DB will be used as the main input into HDM-4. These data will be analyzed by HDM-4 system based on the category either its state or federal road, year where they starts its analysis, year they ended the analysis, yearly budget approved and standard stage of maintenance. HDM-4 system will then start its analysis for the road conditions and its pavement by taking into consideration all the parameters set. The results of these analysis then will be used and set as its primary/based work programme to be followed for their annual routine pavement maintenance at the site location. All the work programme lists proposed by HDM-4 will be monitored by UPPJ zone officers.

4.0 Data Analysis Approach
This HDM-4 has the same workflow as what has been implemented in the yearly periodic routine maintenance work programme by PWD Malaysia. However, there are some differences where the list of work programme produced/proposed will be analyzed for its accurateness. The workflow for this accuracy calculation for HDM-4 system is shown in Figure 3.

![Workflow for accuracy calculation for HDM-4 system.](image)

4.1 Data Obtained
In order to get the data, the first step is exporting the data from RAMS DB to HDM-4 system. These have been explained well in Topic 2 where all data in RAMS DB have been taken from IKRAM s data collection through their yearly Road Data Collection Programme. Certain informations and parameters needed have to be set up during the implementation of the data export process. In this paper, data that are to be studied are the sample data that have been collected from four states representing each zone. The selected states are Perlis (North zone), Selangor (Middle zone), Kelantan (East Zone) and Johor (South Zone).

4.2 Generation of Work Programme
The data taken from RAMS DB for road and pavements have to be imported into HDM-4. The two imported files are programme file and road network file. Programme analysis will be performed in HDM-4 to produce 2007 work programme based on all the set up parameters. As the results, HDM-4 will produce a proposed list of work programme for the periodic road maintenance programme for that state or road.

4.3 Work Programme Accurateness Checker
Periodic road maintenance programme that is produced by HDM-4 system will be then forwarded to UPPJ zone to have it checked, decided and approved the work implementation by looking at the proposed job scope and approved cyling budget. Both inspections and verifications by UPPJ zone will then lead to which implementation to be chosen based on the site condition and also the maximum approved budget. Based on the proposed work programme by HDM-4 system, UPPJ zone will cancel those locations which are still in good conditions and do not need the maintenance or those locations that exceed the given budget. Final list will then be forwarded to the Road Maintenance Unit, HQ PWD which will follow and use this programme as their baseline for periodic road maintenance programme and hence this paper will be the most accurate analysis ever implemented.

5.0 Accurateness Work Programme Analysis
In general, the list programme for the annual pavement maintenance that would be implemented will list all the location that needs the maintenance produced by HDM-4 and accepted by UPPJ zone together with the proposal of replaced location given by UPPJ zone after considering which location maintenance is proposed by HDM-4 but do not need to do on site. Figure 4 shows representation of final periodic routine maintenance work programme breakdown.

![Figure 4. Final periodic routine maintenance work programme breakdown.](image)

Based on Figure 4, list of the periodic road maintenance programme produced by HDM-4 system or list periodic road maintenance programme proposed by UPPJ zone can be summarized as below:

a. L1 : Lengths of road on the locations that need maintenance in 2008 which were proposed by HDM-4 system and approved by UPPJ zone

b. L2 : Lengths of road on the locations that need maintenance in 2008 which were proposed by HDM-4 system but not approved by UPPJ zone.
c. L3 : Lists of road that need maintenance proposed by UPPJ in 2008 but were not approved by HDM-4 system.

Based on the discussion with the officer in charge for HDM-4 system in Malaysian HQ PWD and IKRAM, a formula has been formulated to calculate the accurateness of this system based on the location and also the lengths proposed. Formula is as follows:

\[
\text{System accuracy (\%) } = \frac{L1}{(L1 + L2 + L3)} \times 100 \% \quad (1)
\]

Based on this system accuracy calculation, the implementor can see the effectiveness of the system whether it reaches the goal target by comparing with the policy that has been fixed at 80 percent above. If this is not reachable, factors that contribute to the inaccuracy of the system will be studied to ensure future improvements and new input or ideas for effectiveness of the system.

5.1 Analysis Result HDM-4's Output of Paper Location

From responses received from UPPJ, HDM-4 output's analysis perpetrated upon paper location is as follows:

| No | State   | Location in Total | Location Agreed by HDM-4 and UPPJ | Location Suggested by HDM-4, Rejected by UPPJ | Location Replaced by UPPJ |
|----|---------|-------------------|-----------------------------------|-----------------------------------------------|--------------------------|
| 1. | Perlis  | 21                | 15                                | 6                                             | 0                        |
| 2. | Selangor| 33                | 21                                | 12                                            | 9                        |
| 3. | Kelantan| 17                | 11                                | 6                                             | 5                        |
| 4. | Johor   | 50                | 33                                | 17                                            | 9                        |

Analysis result HDM-4's output, periodic maintenance proposal location list pavement in Perlis state of year 2007 is amounted to 21 locations as indicated in Table 2. Of this list, 15 locations were agreed by UPPJ zone while six locations have been rejected by UPPJ zone based on the needs at the site. Nevertheless, it is found that no replacement list lodged by UPPJ zone of Perlis state.

On the other hand, HDM-4's analysis of Selangor state shows that periodic maintenance proposal location list pavement in Selangor state of year 2007 is amounted to 33 locations as indicated in Table 2. Of this list 21 locations were agreed by UPPJ zone while 12 locations have been rejected by UPPJ zone based on the needs at the site. UPPJ zone has also put nine different locations alternately on location subtrahend from HDM-4's proposal.

HDM-4's analysis of Kelantan state demonstrates that periodic maintenance proposal location list pavement in Kelantan state of year 2007 is amounted to 17 locations as indicated in Table 2. Of this list, 11 locations were agreed by UPPJ zone while six locations have been rejected by UPPJ zone based on the need at the site. UPPJ zone has also put five different locations alternately on location subtrahend from HDM-4's proposal.

HDM-4's analysis of Johore state shows that periodic maintenance proposal location list pavement in Johore state of year 2007 is amounted to 50 locations as indicated in Table 2. Of this list 33 locations were agreed by UPPJ zone while 17 locations have been rejected by UPPJ bases on the needs at the site. UPPJ zone has also put nine different location alternately on location subtrahend from HDM-4's proposal.

5.2 System Accuracy Analysis
HDM-4 output's result of analysis such as in Table 2 and responses of UPPJ, it has been categorised again such as in Table 3. Accurate analysis work programme is issued by HDM-4's system which has been counted using Equation 1. The result is summarized in Table 3 and the calculation method shown as follows :

| State    | Precise system (%) | Notes                        |
|----------|--------------------|------------------------------|
| Perlis   | 69                 | No achieved on target        |
| Selangor | 62                 | No achieved on target        |
| Kelantan | 62                 | No achieved on target        |
| Johor    | 66                 | No achieved on target        |
| Average  | 65                 | No achieved on target        |

6.0 Summary and Conclusion
Through this paper some conclusions have been identified. Whereas for recommendation unit, it is aimed to propose to PWD Malaysia that further paper should be done to boost more HDM-4 s system s effectiveness. HDM-4 output's accuracy is an important element proposal in the process of producing periodic programme work pavement in PWD Malaysia. This is because it involves limited maintenance allocation and long road network number to be organized. From the result of this paper, it is found that HDM-4's system accuracy used by PWD Malaysia attains average 65 percent only and had not achieved level that had been set by PWD Malaysia namely 80 percent. Accuracy assessment revenue summary periodic maintenance work programme pavement is suggested by HDM's system. Periodic maintenance work programme proposal pavement is issued by HDM-4's system and it is very closely connected with data and information input included in generation current system programme carried out.

On the other hand, results obtained will also give effect to the allocation provisions for the implementation of PMS. The results HDM-4's system accuracy attains average 65 percent only and had not achieved level that had been set by PWD Malaysia namely 80 percent, thus will affect to the final account process. This results will give impact to PWD in managing PMS roads in Malaysia. Therefore, introducing payment department for every contractors incuding UPPJ Zone to report any late payments and final account problems is needed to formed. This department would be responsible in keeping records of every client with pavement management record and late payment history. Punishments would be given to them if they fail closing the final account as stipulated in contracts. It shall be reminded that time is the essence and this department shall be able to settle the problems as soon as possible.

From this paper, some factor that contribute to periodic maintenance work programme proposal inaccuracy pavement are identified. Besides, the results of the effectiveness of pavement management system that will affect the final account are also concluded. To help road management party in PWD Malaysia in maintaining federal road in Malaysia with more effectiveness and efficacy, several matters should be given attention to increase this HDM-4's system's effectiveness. As such, from conclusion above-mentioned, it is clear that this paper has achieved its objective. We believe that the information of this paper can be immense help the construction players (clients, contractors and consultants) and academicians. The construction players can better understand and make efforts to reduce the incidences of inefficiency management of PMS. In future paper need to be carried out on HDM4's system's effectiveness, with paper proposal accuracy treatment that proposed by HDM4 system.

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