

Survey Result on Highway Maintenance along PLUS Expressway to Develop Mobile Application Road Maintenance

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Abstract

Road maintenance management is a major test in many nations on the planet today. Innovation anyway has been adequately used to tackle a portion of these issues in a few nations. The point of this study was to recognize sorts of imperfection, issues, and deficiencies of the ebb and flow road maintenance practice and build up a mechanized road maintenance management framework for PLUS Expressway. A survey was utilized among the LLM, PLUS, UEM EDGENTA Propel and road users to evoke information on sorts and factor of road defect and the present road maintenance rehearses along PLUS roadway. Information gathered was examined, abridged and portrayed utilizing Statistical Package for Social Science (SPSS) 21.0. The outcomes demonstrated that road maintenance works are not appropriately and effectively arranged. The present techniques for observing and writing about time, physical and budgetary advancement of road works are not standard and wasteful since they take additional time and include a ton of printed material. As an answer for the present study, a PC based road maintenance management framework was created which fuses with phases of a maintenance cycle i.e. road stock review, road condition overview, road maintenance plan, maintenance timetables and advancement, estimation, work and budgetary advancement detailing. The result of the data analysis of this survey will be utilized as the input for the mobile application development that focuses on road maintenance along the PLUS Expressway.

Keywords: Road maintenance, mobile application, statistical package for social science (SPSS), maintenance management system

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1. Introduction

Roads are one of the real resources of each nation. Street network infrastructure gives financial and social advantages to people, gatherings of individuals, organizations, and enterprises. It empowers products and enterprises to be conveyed convenient and viably, and additionally upgrades the free development of individuals. With proper settings and areas, the development of new roads can advance sizeable economic and social advantages and many creating nations are obtaining from worldwide moneylenders or arranging access to their characteristic assets to expand

their transportation framework. In China, the 'Belt and Road' and '21st Century Maritime Silk Road' ventures have been arranged to traverse 70 nations reaching out crosswise over the vast majority of Asia to Europe and Africa (Honjiang, 2016; Laurance, 2017). While in Africa, the 35 remarkable 'development corridors' are being arranged that surpassing 53,000 km long with the expectation to give positive results to economic development and social mix, and access to bigger urban markets for nearby makers (Laurance, Sloan, Weng and Sayer, 2015; Hettige, 2006; Weinhold and Reis, 2009).

According to Alexander (2014), a great number of funds has been allocated as resources into the road and another framework extends in creating nations. Laurance and Balmford (2013); and Dulac (2013) stated about 25 million km of extra paved roads are normal by 2050 which is sufficient to surround the planet over multiple times. With the road enhancements, it can convey numerous advantages to individuals and the expressway up-grades must be trailed by an all-around arranged observed program of upkeep to ensure these advantages could be continued. Fallah (2009) believe that the road maintenance is profoundly influenced by the wild factors of nature, for example, atmosphere, landscape, area, and so forth and besides the wild factors speaking to the operational troubles, for example, traffic, load, traffic accidents and so forth. Without regular maintenance, roads condition can quickly fall into deterioration which will keep the acknowledgment of longer-term effects of street enhancements for improvement as much as the development of the nation in social and economic.

2. Literature Review

According to Emeasoba & Ogbuefi (2013), the maintenance of roads famously known could enhance the economic growth and social benefits though road system that poorly maintained destructs mobility, upsurges the accidents rate, and worsens other main aspects. Foster and Collin (2013) believe that road maintenance is an essential short-term transport policy that policymakers need to pay attention to because it helps to enhance road safety and improves the social welfare of the citizenry. This also includes the maintenance of highways. Highways infrastructure and its provision have a significant impact on economic prosperity and its development is reflected in the economic well-being of the country as well as bringing important social benefits. Thus, the goal of maintenance is to preserve and sustains the asset and the maintenance must be done regularly. Road maintenance comprises activities to keep pavement, slopes, drainage facilities, and all other structures and property as near as possible to their as constructed or renewed condition. Adebayo (2015) believes that road maintenance must be categorized as routine, periodic, and urgent for proper management and its operational convenience. Therefore, the road infrastructure must be monitored systematically and inconsistent intervals to recognize damaged road fragments and road hazards which is labor-intensive and require extensive manual paper processes. In improving the quality of road maintenance, the mobile application implementation is expected to overcome the usual paper-based road survey reports which were manually entered into a system, a process that was both laborious and prone to errors. With the advent of technology, smartphones have played a vital role in men's' 24/7 many activities. To be in line with the Malaysia government's strategic goals of increasing efficiency through modernization and making more effective use of its complement, the toll expressway

should be aggressively pursued the adoption of innovative mobile technologies to transform the existing toll expressway maintenance as well as its business processes.

Highway in Malaysia

The toll turnpikes or thruways in Malaysia are controlled by a statutory body known as the Malaysian Highway Authority (MHA) (Highway Authority Malaysia (consolidation) Act 1980, Retrieved 21 July 2018). These parkways are privatized and managed by the MHA. The foundation of MHA is among all to concentrate on executing the plan, development, direction, activity, and support of parkways, to enhance and gather tolls, to go into contracts and to accommodate any issues associated therewith. The MHA is controlled by a Board delegated by the Minister of Works regulated the MHA. The MHA is additionally dedicated to utilizing top of the line innovation for the maintainability of the nation's expressway. The MHA business is working intimately with the college to join green and manageability innovation in the parkway (LLM, Annual Report 2014). The MHA or Lembaga Lebuhraya Malaysia (LLM) has its official entrance which can be reached at (<http://www.llm.gov.my/>). The entry gives helpful data and reports on its motivation for a foundation. With the coming of media period, the MHA has fundamentally affected its clients through Facebook, Twitter, and portable application, featuring the administrations they bring to the table. The Authority has additionally propelled a Tollroads Evaluation and Monitoring System Version 2 (TEAMSv2) which fundamental purposes will go about as an administration apparatus for execution and support pointers (<http://teams.llm.gov.my/site/login>). Both advancements are critical keys in accomplishing a proficient expressway the executive's upkeep which is the focal point of this exploration proposition.

Highway Asset and its Typical Defect

Highway assets include the pavements, bridges, traffic control devices, drainages, tunnels, and others. The operational activities of these assets are usually administered by a team of highway asset management. The management is a systematic process aimed at efficient and cost-effective preservation and necessarily incorporates an analytical tool for rational and integrated decision-making. A key component of any highway asset management system is multiple decision-making which involves determining the effect of decreasing one or more key factors and simultaneously increasing one or more other key factors in a decision, design, or project which is simply called the trade-off analysis, project selection, and programming.

According to Chaney, McGowan-Martin, Perez & Clark (2016), even though road maintenance is an extensive open administration that influences all residents, yet generally, it is made do with almost no utilization of information technology aside from radios, computer records, and networking which makes road

maintenance tasks less economical and road conditions less sheltered than they could be. Thus, for optimum asset preservation, PLUS undertakes asset management activities that are centered on a structured maintenance organization. This approach focuses on preventive maintenance to capture defects for early intervention. The structured organization involves the integration of activities such as network planning, network asset condition assessment, investigation of defects, detailed inspections and investigations by specialists, design, and procurement, works implementation, information management as well as technical development and research.

Highway asset requires maintenance to sustain its usability. Nevertheless, the road defects are commonly occurred because of many things e.g. heavy rains, human error, etc. As noted by Fares et. al. (2010), the damaged pavement in Malaysia is considered as one of the largest contributing factors to fatal motor vehicle crashed. Thus, public (functional or structural) road failures present danger to vehicle drivers (Zakaria, 2011), who face increased risk of accidents as road damage, such as surface cracking or potholes, becomes more severe (Kumar and Gupta, 2010). The various natures of defects identified and described have been categorized by Lembaga Lebuh Raya (LLM) according to the functional category of the expressway, namely road surface, drainage structure, structures, earthworks, and road safety furniture. Without proper maintenance, the highway will become easy to fail in the short term where will also lead to an increase in a traffic accident. Some of the accidents will occur due to the pavement problem, landslide, and some other factors that contribute to the accident. It will also increase the cost of maintenance when maintenance is often done in the same place. Also, it will lead to difficulty to the road users where the traffic-jammed will occurs and give the harder to them. Therefore, the good road conditions must be maintained to encourage road safety; road damage not only leads to accidents but is also costly in terms of cyclic and responsive maintenance (Hashim and Rahim, 2009).

Highway Maintenance Management System

Support of the thruways is a noteworthy essential part of toll expressway activities since through legitimate upkeep, the alluring dimension of security can be achieved. By and large upkeep of roadways is ordered into routine support and fixes. Routine upkeep includes work, which is tedious, patterned or periodical while fixes specifically, overwhelming fixes incorporate fixes of asphalt, extensions, slants and so on. Salih. J., Edum-Fotwe, F. and Price, A (2016) had arranged sorts of systems of support even more purposely into routine upkeep, crisis support or fixes, and intermittent upkeep or recreation.

As per Sally and Natalya (2005) routine upkeep, which involves little scale works, directed consistently, means to guarantee the day by day pass capacity and

wellbeing of existing roads in the short-run and to counteract untimely crumbling of the roads. Recurrence of exercise shifts, however, is for the most part once or more a week or month. Run of the mill exercises incorporate roadside skirt clearing and grass cutting, cleaning of silted trench and courses, fixing, and pothole fix. For rock roads, it might incorporate regarding at regular intervals.

Mobile Application

There has been a sensational increment as of late in the number of individuals utilizing portable application to their everyday social status. The most recent data demonstrate the innovation is more prevalent than home telephones and PCs consolidated. Versatile applications which prominently alluded to as Mobile Apps are programming applications that are generally intended to be kept running on advanced cells and tablet PCs framework (Treeratanapon, 2012; Hussain et al. 2017a). These Mobile Apps are typically kept running on the Google Android and Macintosh iPhone framework. These Mobile Apps since it is versatile make it simple for clients to take their site, blog or an online store anyplace. The development of cell phones which is remote in correspondence has offered stimulus to the execution of universal portable utilization in supporting numerous parts of human exercises. In any case, changes have happened so quickly in the versatile application industry that a new pattern makes it's quality consistently. Cell phones and portable applications are the current trendiest items in the business. From this pattern investigation, one may figure the Mobile Apps items would be in much appeal in the future. With cell phone entrance currently is expanding now, the universe of applications is additionally observing an ascent in prevalence. These adjustments sought after have prompted relating increments in the supply of applications accessible in the application commercial centers. Versatile Apps are a worldwide wonder with mass purchaser requests.

According to Chaney, McGowan-Martin, Perez & Clark (2016), even though road maintenance is an extensive open administration that influences all residents, yet generally, it is made do with almost no utilization of information technology aside from radios, computer records, and networking which makes road maintenance tasks less economical and road conditions less sheltered than they could be.

In order to improve the quality of inspection reports for maintenance of highways and roads, the efficiency created by the mobile application will be allowed the management to lower the rate that it charges for inspections and pass along over their savings for their management asset maintenance. The mobile application utilization will further shorten project delivery time and engage users directly in shaping the application to provide maximum business value. According to Treeratanapon (2012), when the connection if mobile applications become available, the required data is

synchronized to update the highway databases that allows users to take advantage of the operational efficiency even in remote locations. Integration with Google Android and App Store Apple Macintosh is the best in meeting the needs of this application and to plan for future mobile applications across the expressway throughout the nation (Treeratanapon, 2012; Hussain et al. 2016; Hussain et al. 2017b). While Masino, Thumm, Frey & Gauterin (2017) believe, this technique offers the possibility to blend the output and road framework data from different vehicles to empower a progressively strong and exact forecast of the ground truth.

3. Methodology

In this study, two methods have been implemented in achieving the study's aim and objectives which firstly through the literature review and secondly by conducting a survey among the targeted respondents which fits the requirement of this study. To provide the groundwork for the design of the mobile application, the literature review has been done in the earlier chapter on the perspective on the nature of the highway maintenance management system. These reviews include highways assets, highway road defects and the insights of mobile application and its implementation in highway maintenances management system. Based on the literature review, the development of a research instrument has proceeded as the instrument for data collection in this study. before the analysis process could be implemented. The details of the research instrument will be further explained in sub-topic 3.2. Once the questionnaire has been developed, it has been distributed among that personnel that involves in the road maintenance management field for a pilot test. According to Babbie (2001), this test is vital in order of ensuring the questions' reliability especially is the choice of words have been done properly, while the meaning of projected sentences is relevance with each statement probed. After the implementation of this pilot test, this questionnaire has been distributed among the 400 targeted respondents for data gathering. This data will then analyze in the quantitative method as an input for the mobile application development.

Research Design

As the purpose of this study is measure the highway maintenance management system and to attempt in digitalizing the system through the Mobile Apps platform, a research design is essential which works as the fundamental commands in conveying the research project (Hair et al 2007). According to Hair et al (2007), quantitative approach aids to offer review information on several characteristics that become more useful for testing. By engaging the quantitative approach, this study has been utilizing a self-developed questionnaire whereas this questionnaire survey acts as the best method in collecting the data vis-à-vis to attitude, orientation, and preferences. Self-administered questionnaires were distributed to 400 respondents who are involved in maintenance activities such as PLUS Berhad, UEM

EDGENTA PROPEL, Lembaga Lebuhraya Malaysia (LLM) and road user.

This descriptive study has been adapted with a belief that it would facilitate to comprehend the problem and suggested the solution which shall focus on matters related to objectives. Supported with Sekaran & Bougie (2010) point of view, the adaptation of a descriptive study in determining the study where it will allow the researchers in gathering the profile information and in describing the relevant aspects of the area of interest. Data obtained were analyzed using the Statistical Package for Social Science (SPSS) 21.0. Other than interviews, this research also involves archives data which has been obtained from the PLUS authority, UEM EDGENTA PROPEL and Lembaga Lebuhraya Malaysia (LLM). These archives' information will enable the identification of an area of study. The use of this data is to confirm all information and other details to be used in the final analysis of this research. Apart from that, secondary data were also obtained through literature, references such as books, journals, conference papers, magazines, newspapers, reports, internet surfing and so on.

Research Instrument

To gather the required information, the researcher developed a self-completed questionnaire and it has been tested earlier afore distributed. The questionnaire form was prepared in a booklet by using the English language. Each question in this questionnaire was developed and adapted based on the variables specified in the framework from the earlier study. Some of the questions have been modified or developed in simple and direct words to help the respective respondents easy to understand and answer them.

A Likert scale was applied for the rating scale which in line with Mahotra (2004) point of view that this scale is fit to ration the attitude, behavior, and preferences. Multiple choice questions been used in Part B to Part E which allow the respondent to select one of the response alternatives by using 5-point scale ranging from number 1 represents 'Strongly Disagree', number 2 represents 'Disagree', number 3 represents 'Moderate', number 4 represents 'Agree' and number 5 represents 'Strongly Agree'. The arrangements of questionnaire can be summarized in the table that have been showed below:

Table 1: Arrangement of Developed Questionnaire

Section	Description	Number of Question
Part A	Demographic profile	6
Part B	Type of Defect	12
Part C	Factors of defect	11
Part D	Suggestion for implementation of management system	7
Part E	Enhancement of maintenance system	6
Part F	Method of maintenance road effect	11

Total number of questions	53
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4. Result And Analysis

The data presented and visualized are obtained from the Statistical Package for Social Science (SPSS) software. The data analysis discussed is regarding the improvement of the PLUS Highway Maintenance System. In this research, data were gathered from 400 respondents using a questionnaire survey method.

Type of Defect

According to the descriptive analysis for items in the types of the defect (Table 2), the mean of these 12 items started from 3.24 to 3.92 while the highest mean is crack due to pressure from vehicle which is 3.92. The total mean of these items is 3.49. This shows the overall responses for types of defects are at the average level.

Table 2: Descriptive Analysis for Types of Defects

Items	Types of Defect		Indication
	Mean	Std. Deviation	
Cracks due to pressure from vehicle loads	3.92	0.724	Average
Indentation due to poor road construction work	3.32	0.992	Average
Potholes	3.50	0.907	Average
Bumpy or uneven road surface	3.66	0.771	Average
Blocked drainage system	3.24	0.772	Average
Broken edge of the road due to the road shoulder settlement	3.40	0.756	Average

Premix deprived as a result of the pavement work done during the rainy season	3.37	0.774	Average
Dividers damaged due to vehicles collisions	3.61	0.790	Average
Landslides or erosion	3.56	0.776	Average
Ground settlement	3.58	0.778	Average
Damage highway signage	3.27	0.897	Average
Road lighting does not work	3.41	0.907	Average
Overall Mean	3.49	0.496	Average

Factor Contributing to Road Defect

The second variable for this research is factors contributing to the road defect have been analyzed according to the mean as below. The mean is being computed by referring to the eleven questions such as below. As referring to the table, the means score of overload vehicles is highest with a computed mean score of 4.14 compared to other items. On the other hand, the lowest mean score is 3.11 referring to items of imperfect road construction that contributed to the road defect.

Table 3: Factor Contributing Road Defect

Items	Types of Defect		Indication
	Mean	Std. Deviation	
Overload vehicles	4.15	0.726	High
Poor road design	3.20	1.027	Average
Accident	3.56	0.924	Average
Usage of non-quality materials	3.19	1.062	Average

Inefficiency of control and monitoring by authorities	3.15	1.026	Average
Imperfect road construction	3.11	1.042	Average
Improper maintenance	3.12	1.075	Average
Heavy traffic	3.54	0.834	Average
Exposed to water and flood	3.73	0.802	Average
Imperfect drainage structure	3.58	0.831	Average
Heavy rain	3.73	0.717	Average
Overall Mean	3.46	0.577	Average

Implementation of Management System

The third variable for this research is the implementation of management system for a concession company such as PLUS. The mean is being computed by referring to the seven questions such as below. As referring to the table, the computed means score Road management should often meet or discuss with the road operator is the highest with the computed mean score is 4.23. While the lowest suggestion for implementation of management system is to provide road maintenance financial reports with the computed score mean is 4.03.

Table 4: Implementation of Management System

Items	Types of Defect		Indication
	Mean	Std. Deviation	
Provides comprehensive maintenance schedule	4.17	0.589	High
Conduct regular inspections	4.20	0.572	High
Prepare reports after the inspections	4.22	0.598	High
Carry out technical assessments based on the degree of damage	4.21	0.573	High

Provides road maintenance financial reports	4.03	0.691	High
Road management should often meet or discuss with the road operator	4.23	0.604	High
Conduct road safety campaigns to the road users	4.06	0.702	High
Overall Mean	3.46	0.476	High

Suggestion for Improvement of Maintenance System

The fourth variable consists of six suggestions that related to the improvement of maintenance system towards the effectiveness of maintenance management system. Based on the table, it can be concluded that create an effective and comprehensive mobile application to be the highest respondent's suggestion with the computed mean of 4.33. Therefore, the objective of this research is achieved. While the lowest computed mean was tolled highway system needs to be maintained to cover the cost of maintaining the highway with a score of 3.31.

Table 5: Suggestion for Improvement of Maintenance System

Items	Types of Defect		
	Mean	Std. Deviation	Indication
Perform road enhancements quickly and continuously	4.22	0.606	High
Improve service against complaints received from highway users	4.23	0.597	High
Create an organized planned work schedule	4.28	0.550	High
Must be committed and quick to perform maintenance work if asset damage complaint is received	4.26	0.610	High
Tolled highway system needs to be	3.31	1.099	High

maintained to cover the cost of maintaining the highway			
Create an effective and comprehensive mobile application	4.33	0.780	High
Overall Mean	4.08	0.464	High

Maintenance Method for Road Defect

Table below indicates the findings on the suggestion of maintenance method for road defect in Malaysia. According to the items, controlling surface erosion is the most suggested method by the research respondents. This can be proved by the highest value of computed mean which is 4.01 compared to other items that averagely scored below 4.00. While the lowest value for the most suggested method by the research respondents is patching by scoring 2.98 for the computed mean.

Table 6: Maintenance Method for Road Defect

Items	Types of Defect		Indication
	Mean	Std. Deviation	
Rejuvenating	3.94	0.598	Average
Crack sealing and filing	3.09	0.998	Average
Patching	2.98	1.071	Average
Thin bituminous overlays	3.30	0.853	Average
Resurfacing	3.38	0.816	Average
Re-tread	3.64	0.833	Average
Repave and re-mix	3.45	0.778	Average
Reconstruction	3.86	0.656	Average
Maintaining	3.75	0.650	Average
Creating, restoring or improving soil structure	4.00	0.487	High
Controlling surface erosion	4.01	0.432	High
Overall Mean	3.48	0.461	Average

Spearman's Correlation Analysis

Similar to Pearson's correlation, Spearman correlation indicates that the closer the correlation to ± 1 , the stronger the relationship will be between the variables as stated by Pallant, 2005. Below is the coefficient table in order to determine the level of correlation between the variables according to Pallant (2005). Based on the survey, this study also tends to be a correlational study since the researcher is interested in measuring the relationship between each parameter for the software development and computer program which delineating the important variables associated with the problem (Sekaran & Bougie, 2010).

Table 7: Maintenance Method for Road Defect

Correlation Value	Indicator
± 0.00 to ± 0.19	Very weak correlation
± 0.20 to ± 0.39	Weak correlation
± 0.40 to ± 0.59	Moderate correlation
± 0.60 to ± 0.79	Strong correlation
± 0.80 to ± 1.00	Very Strong correlation

As for the Spearman's correlation coefficient test between types of defect and maintenance management system, the value between the types of defect and maintenance management system is 0.226. According to Pallant (2005), the correlation value of these two variables can be categorized in the range of ± 0.20 to ± 0.39 . This indicates a weak positive correlation between types of defect and maintenance management systems. Somehow, according to the data findings shown that the Spearman's significant value is equal to 0.000 and less than the alpha value which is 0.01. The finding showed that although the correlation between the variables is weak, the correlation is still significant. Therefore, based on table 8 the research determines that the data does provide enough evidence to conclude that there is a significant relationship between types of defect and maintenance management systems.

Table 8: Correlation Between Type of Defect and Maintenance System

			Defect Types	Management System
Spearman's rh	Defect Types	Correlation Coefficient	1.000	.226**
		Sig. (2-tailed)	.	.000
		N	400	400
		Correlation Coefficient	.226**	1.000
	Management System	Sig. (2-tailed)	.000	.
		N	400	400

** . Correlation is significant at the 0.01 level (2-tailed).

Table 9 shows the relationship between types of defects and factors of defect has proved significant as the findings in Spearman's significant value. The significant value 0.000 which is below the alpha value which is 0.01. Moreover, the value of Spearman's correlation coefficient which is 0.629 falls under category ± 0.60 to ± 0.79 . This indicates a strong relationship between the two variables. Based on the result from Spearman's correlation it can be concluded that the data does provide enough evidence to

conclude that there are significant relationship types of defect and factors of the defect.

Table 9: Correlation Between Type of Defect and Defect Factor

			Defect Types	Management System
Spearman, s rh	Defect Types	Correlation Coefficient	1.000	.629**
		Sig. (2-tailed)	.	.000
		N	400	400
		Defect Factor	.629**	1.000
		Sig. (2-tailed)	.000	.
		N	400	400

**. Correlation is significant at the 0.01 level (2-tailed).

5. Result and Discussion

Based on the analysis findings that have been obtained from surveys on 400 respondents, it has been found that there is a significant relationship between types of the defect with factors of the defect with the significant value of 2.26. This is in line with Pallant's (2005) point of view whereby the correlation value of these two variables can be categorized in the range of +0.20 to +0.39. Based on this result analysis too, it has shown that the findings of a conducted survey can be utilized as an input for the mobile application for road maintenance.

6. Conclusion

Highway maintenance management is important to ensure the expressway is safe to the road user and optimizing maintenance expenditure. With the identification of types of road defects and a factor contributing to a road defect, the maintenance team can find the solution to enhance the maintenance works by using the user-friendly mobile application. Other than being the first mobile application that focuses on aiding input for the road maintenance on this facility, this data and how it has been processed will become a significant resource to the management to upgrade their services to the users.

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