Progress in Engineering Application and Technology Vol. 4 No. 1 (2023) 942-948

PEAT

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Analysis of Pavement Maintenance Using Geographical Information System (GIS)

Muhammad Imran Shah Ahmad Sabri[1], Abd Sukor Sarif[1]*

[1] Department of Civil Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2023.04.01.098
Received 14 January 2023; Accepted 4 February 2023; Available online 4 February 2023

Abstract: In the current world, the problems regarding pavement deterioration are still becoming a major concern since the road users are increasing day by day and they are demanding a good pathway and a good access road which can provide them comfort while driving and safety from disastrous accident. This study will be concerning about the pavement maintenance and rehabilitation system used in construction industry. The study will be focusing on the area which are frequently being maintained and repaired to identify the root of the occurring problems. As the world embraces technology, the components of Industry 4.0 will drive the development of pavement maintenance in the construction industry. The main objective of this study is to analyze and assess the condition of pavement roads by gathering data on pavement road damages, creating a database, and mapping the data using GIS technology. The Pavement Condition Index (PCI) will be used to evaluate the extent of damage to the roads and provide a numerical value indicating their overall condition. The database and map will be useful tools for decision-makers and road maintenance organizations to prioritize repairs and allocate resources. The study uses QGIS software to design maps for pavement restoration work. The data is collected through visual inspection and includes information on the type of pavement failure, condition, location, and date. The level of degradation is evaluated using the PCI technique. The collected data is organized in a spreadsheet to create a database, which is used to generate the map. The map provides a comprehensive visual representation of the pavement damage and helps in making informed decisions about repairs. Thus, QGIS displays its efficiency in aiding pavement maintenance, and at the same time, more data are advised to be added to the database to have a better analysis of pavement failure.

Keywords: Pavement, QGIS, Pavement Condition Index (PCI)

Corresponding author: abdsukor.psm@gmail.com

1. Introduction

When it comes to economic and social growth, one of the most essential things that a country may examine is its road quality. [1]. Unfortunately, no country has an ideal road network. This is why governments must take steps to preserve roads in their own regions. [2] Paved surfaces are frequently used in highway infrastructure. Maintaining and restoring these pavements to the necessary degree of serviceability is one of the toughest difficulties that pavement engineers and administrators confront in the highway sector. Road deterioration occurs by a variety of reasons, including weather, traffic, and poor material selection. This problem is projected to intensify as road repair becomes more regular.

A Pavement Maintenance Management System is a methodology for assessing and rating the condition of pavement in a specific area. PMMS includes integrated and structured exercises intended at inspiring asphalt pavements maintenance and management. Based on the input, the pavement management system creates a degradation trend for each segment and assigns the most effective maintenance strategy. [6] PMMS is a collection of measures that work together to guarantee that road pavements are managed and maintained effectively. [5] The photographic data will be examined and inspected using the Pavement Condition Index, a unique technique of assessment (PCI).

The evaluation of pavement performance using pavement condition indicators is a critical component of any Pavement Management System. For many years, the pavement condition index (PCI) and other indicators have been used to assign a maintenance plan to existing pavements. The combined Overall Pavement Quality Index (OPCI) is used to describe the pavement condition of selected urban road sections. The developed index consists of the Pavement Condition Distress Index, Pavement Condition Roughness Index, Pavement Condition Structural Capacity Index, and Pavement Condition Skid Resistance Index. These indices were constructed independently and then combined to form an OPCI that prioritized the importance of each indicator. All of the individual condition indices and the overall index ranged from 0 to 100. [3]

1.1 Background of Study

The occurrence of road damages at Persiaran Sarjana, Jalan Panchor, 84600 Pagoh, Johor is becoming a major problem because the maintenance of the pavements needs to do frequently. The factor of the problem needs to be identified in order to prevent pavement damage. The methods of data collection used are visual inspection and the method of evaluating the pavement condition using the Pavement Condition Index (PCI). All of the data will become a database for QGIS software. Conducting a study and data collection will help to clarify more about the problems regarding pavement conditions. The suitable method of pavement maintenance will reduce the occurrence of road damages and consume less time for pavement inspection routine. This particular study has its own limitations both in scope and methodology. The photographic data will be analyzed using the Pavement Condition Index (PCI). All data will be transformed into the database of QGIS software.

1.2 Geographical Information System (GIS)

The Geographical Information System (GIS) is introduced to maintain road condition and help road inspection is one of the ideas that will be highly useful. A GIS system's capacity to link data and information to its geographical position, such as latitude and longitude, is one of its fundamental characteristics. It can also supply plane coordinates rather than the typical transportation reference-point technique. Technology of GIS can identify highway repair spots since it can swiftly obtain data from a database and instantly build customized maps to fit individual demands. Additional data may include traffic volume, sign and signal positions, political and checkpoint sites, population, weather data, and any other information that may impact road performance. [4]

2. Methodology

The primary requirement for any pavement maintenance as well as management is information on its state. As a result, a standardized approach for surveying the status of the pavement is required. After the status of a pavement is not fixed in stone, a decision about the need for maintenance may be taken. Geological Information Systems (GIS) is the best technique to address the gathered information and the proposed answers for issue. While GIS is the most impressive, it is in no way, shape or form the main technique. Google Earth could be utilized to show the information. While Google Earth and comparable programs are valuable, they are not exactly as strong as GIS.

The information will be collected by conventional method which is visual inspection by an individual. The data collected from visual inspection will be a primary data for a well-developed database for GIS Software used. The secondary data and information regarding the pavement and traffic will be obtained from the local authorities to become a supporting data for the research. Google Earth Pro is used to obtain the coordinates and locations as spatial data.

The research will be started by a preliminary study to recognize the issues and the unpleasant plans to foster a fundamental point. During this stage, the reasonable scope of not entirely settled to complete a doable arrangement. In each research, the reason for study will be the objectives of finishing the research. The research will be following the objectives until the objectives are reached effectively. The key for arriving at the objectives will be the means or strategies which are being done. The practical strategy will be a determinant for finishing the research. Collection of data is a mandatory advance to accomplish important confirmations in research. A major data is required for fostering a database.

3. Results and Discussion

The pavement at Jalan Persiaran Sarjana will be digitized and analyzed using QGIS software. The data collected was imported and the table of attribute data will be created. The results of analysis are shown below.

3.1 Results

The database was developed successfully as the QGIS software is able to represent the data in the software smoothly for identifying the pavement damages at the concern area. From the software itself, one of the objectives of this project can be fulfilled by observing the trend of PCI value on each location. Each PCI value is classified into different colors according to its severity. The analysis can be done through the software by filtering out the symbology in Layer Toolbar. Figure 1 to Figure 3 shows the results of database analysis of pavement failure at Jalan Persiaran Sarjana. Table 1 shows the data attribute for this study. Table 2 shows the data of road failures with their respective road segments. Table 3 shows the maintenance action.

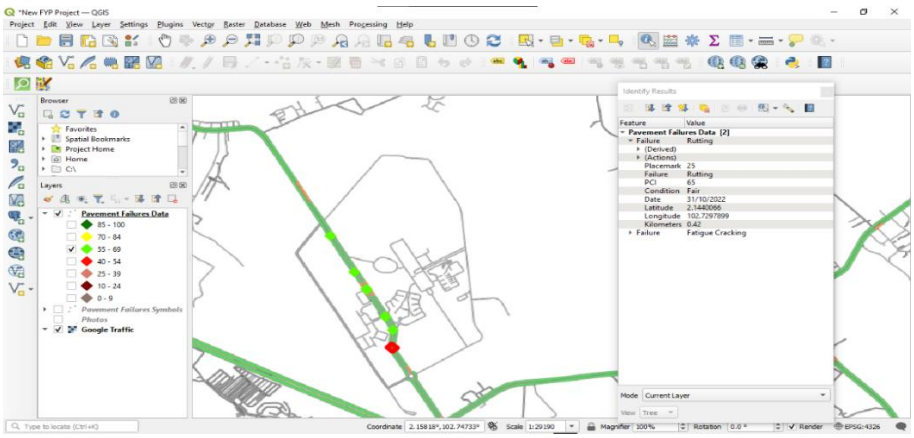

Figure 1: Data Showing by Identify Feature Tool

Table 1: Attribute Data

Placemark	Failure	PCI	Condition	Date	Latitude	Longitude	Kilometers
1	No Failure	100	Good	17/10/2022	2.159896	102.7223	2.40
2	Patches	80	Satisfactory	17/10/2022	2.159266	102.7226	2.32
3	Pothole	20	Serious	17/10/2022	2.158059	102.7232	2.17
4	Fatigue Cracking	65	Fair	17/10/2022	2.158344	102.7230	2.21
5	Pothole	50	Poor	17/10/2022	2.157357	102.7237	2.08
6	Pothole	42	Poor	17/10/2022	2.159026	102.7227	2.30
7	Pothole	45	Poor	17/10/2022	2.156298	102.7243	1.94
8	Pothole	45	Poor	17/10/2022	2.153839	102.7255	1.63
9	Fatigue Cracking	60	Fair	17/10/2022	2.153731	102.7256	1.62
10	Longitudinal Cracking	75	Satisfactory	17/10/2022	2.152093	102.7267	1.40
11	Fatigue Cracking	70	Satisfactory	28/10/2022	2.151739	102.7269	1.36
12	Pothole	45	Poor	28/10/2022	2.151703	102.7268	1.37
13	Depression	60	Fair	28/10/2022	2.151539	102.7269	1.34
14	Fatigue Cracking	65	Fair	28/10/2022	2.151397	102.7270	1.33
15	Pothole	30	Very Poor	28/10/2022	2.148185	102.7289	0.91
16	Pothole	62	Fair	28/10/2022	2.147986	102.7290	0.89
17	Shoving	65	Fair	28/10/2022	2.147983	102.7289	0.9
18	Fatigue Cracking	72	Satisfactory	28/10/2022	2.147822	102.7290	0.88
19	Fatigue Cracking	70	Satisfactory	31/10/2022	2.147164	102.7295	0.78
20	Ravelling	15	Serious	31/10/2022	2.146109	102.7299	0.65
21	Pothole	45	Poor	31/10/2022	2.146211	102.7298	0.66
22	Fatigue Cracking	60	Fair	31/10/2022	2.146264	102.7298	0.61
23	Pothole	30	Very Poor	31/10/2022	2.145912	102.7300	0.63
24	Rutting	80	Satisfactory	31/10/2022	2.144663	102.7298	0.49
25	Rutting	65	Fair	31/10/2022	2.144007	102.7298	0.42
26	Pothole	45	Poor	31/10/2022	2.143261	102.7300	0.33
27	Fatigue Cracking	60	Fair	31/10/2022	2.144047	102.7296	0.47
28	Pothole	30	Very Poor	31/10/2022	2.142502	102.7304	0.24
29	Fatigue Cracking	80	Satisfactory	31/10/2022	2.141980	102.7308	0.16

Table 2: Road Maintenance Data by Road Segments

Road Segment	KM	PCI	Condition	Color Code	Maintenance Action
A (KM0 - KM0.48)	0.42	65	Fair		Immediate
	0.33	45	Poor		
	0.47	60	Fair		
	0.24	30	Very Poor		
	0.16	80	Satisfactory		
B (KM0.48 - KM0.96)	0.91	30	Very Poor		Immediate
	0.89	62	Fair		
	0.9	65	Fair		
	0.88	72	Satisfactory		
	0.78	70	Satisfactory		
	0.65	15	Serious		
	0.66	45	Poor		
	0.61	60	Fair		
	0.63	30	Very Poor		
	0.49	80	Satisfactory		
C (KM0.96 - KM1.44)	1.4	75	Satisfactory		Regular
	1.36	70	Satisfactory		
	1.37	45	Poor		
	1.34	60	Fair		
	1.33	65	Fair		
D (KM1.44 - KM1.92)	1.63	45	Poor		Regular
	1.62	60	Fair		
E (KM1.92 - 2.4)	2.4	100	Good		Immediate
	2.32	80	Satisfactory		
	2.17	20	Serious		
	2.21	65	Fair		
	2.08	50	Poor		
	2.3	42	Poor		
	1.94	45	Poor		

Table 3: Maintenance Action by Road Conditions

Maintenance Action	Road Condition	Color Code
Immediate	Must include one serious, one very poor or one poor	
Regular	Must include at least one poor and one fair	
Preventive	Must include only good and satisfactory	

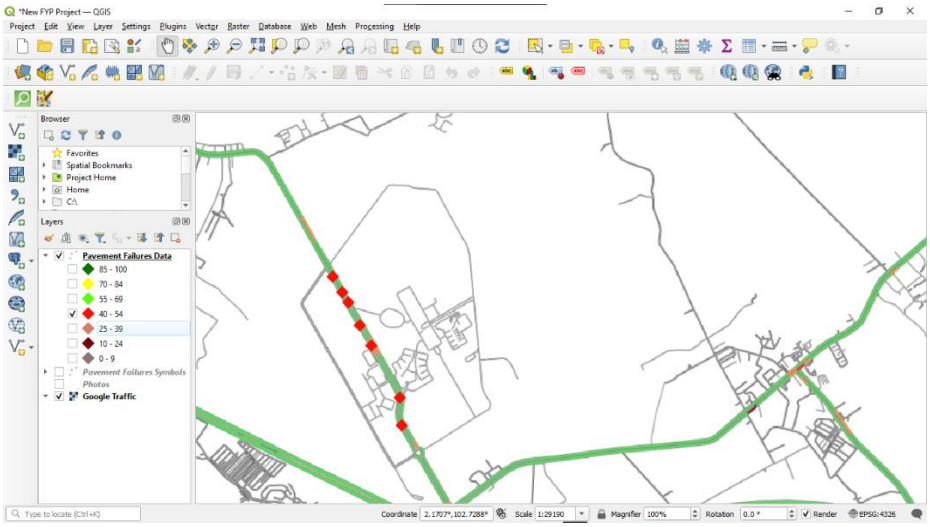

Figure 2: PCI Values Symbol Chosen on the Map

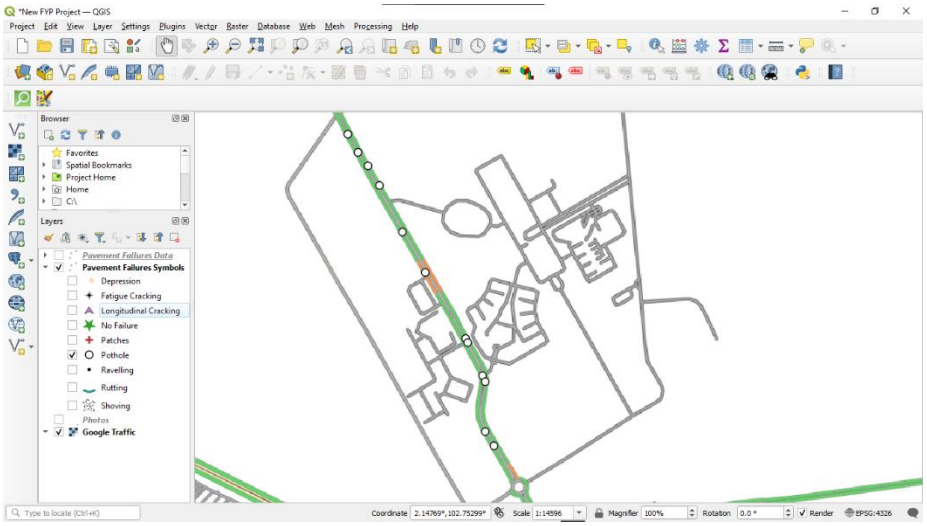

Figure 3: Location of Potholes

3.2 Discussions

The map created shows that the pavements in the study area are prone to undergo failure and need to do maintenance frequently. The location of pavement prone to be damaged will be acknowledged and it will help the maintenance team to act immediately. The data including the placemark, failure, PCI value, condition of the road, date, location and coordinate. The database is assisting the process of analysis the pavement failures. Each road segment has its severity which needed to repair and maintain. The maintenance work will be a lot easier by following the maintenance action for each road segment. Thus, it will promote a sustainable maintenance routine. Road A, B and E need an immediate action for maintenance while Road C and D just need a regular maintenance with scheduled. It shows that the condition of Road A, B and E are bad compared to Road C and D. Maintenance team can organize a scheduled maintenance to repair the road according to the specific action by road segments which is really helpful especially in tight budget situation and high demands in maintenance works.

4. Conclusion

From the database, QGIS was able to identify and interpret the data in mapping the location, pointing the exact location of failure and identify failures with multiple amazing features and helpful tools. It is proven to be effective in analyzing data by showing geographical properties on map without having people to read the raw data conventionally. Several factors were taken into account when creating pavement failure map including the type of pavement failure, PCI values, coordinates and locations. The map created shows that the pavements in the study area are prone to undergo failure and need to do maintenance frequently. The good side of having the map is that the local authorities can observe and analyze the failures carefully for future development of pavement. The location of pavement prone to be damaged will be acknowledged and it will help the maintenance team to act immediately. Thus, QGIS shows its effectiveness of helping in pavement maintenance. More data such as the length of pavement failures, size of failures, type of premix used, and drainage system underneath or near the pavement are recommended to be imported in the database to have a better analysis in pavement failures. Using high technology drone to conduct pavement inspection to get real time location and coordinates to provide precise data in the database which also can be share immediately as the data collected are saved in cloud system folder.

Acknowledgement

The authors would like to thank the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia for their supports.

References

[1] Madli, R., Hebbar, S., Pattar, P., & Golla, V. (2015). Automatic detection and notification of potholes and humps on roads to aid drivers. IEEE sensors journal, 15(8), 4313-4318.

[2] Al-Mushayt, O. S., Perwej, Y., & Haq, K. (2012). Electronic-government in Saudi Arabia: A positive revolution in the peninsula. arXiv preprint arXiv:1205.3986.

[3] Gharaibeh, N. G., Zou, Y., & Saliminejad, S. (2010). Assessing the agreement among pavement condition indexes. Journal of Transportation Engineering, 136(8), 765-772.

[4] Kmetz, R. J. (2011). GIS based pavement maintenance: A systematic approach.

[5] Farhan, J., & Fwa, T. F. (2009). Pavement maintenance prioritization using analytic hierarchy process. Transportation Research Record, 2093(1), 12-24.

[6] Sarsam, S. I. (2016). Pavement maintenance management system: a review. Trends in Transport Engineering and Applications, 3(2), 19-30.