

Investigation of Pavement Condition at Jalan Kampung Jawa, Pagoh, Johor

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DOI: <https://doi.org/10.30880/mari.2025.06.04.004>

Article Info

Received: 01 September 2025

Accepted: 15 October 2025

Available online: 01 December 2025

Keywords

Pavement, maintenance, Pavement Condition Index (PCI),

Abstract

Pavement distress encompasses a range of deteriorations in road surfaces, impacting their structural integrity and performance. The distresses can arise from factors such as traffic loads, climate variations and inadequate construction practices. Effective identification and classification of pavement distress are essential for informed maintenance and rehabilitation strategies. Pavement Condition Index (PCI) is a numerical rating assesses the overall condition of a road or pavement infrastructure. It takes into account various distress types, such as cracking, rutting and surface irregularities. PCI values range from 0 to 100, with higher scores indicating better pavement conditions. The PCI method was evaluated on Jalan Kampung Jawa, Pagoh, which has a length of 2km. The goals of this study are to analyze the factors that affect pavement distress, to evaluate pavement condition at Kampung Jawa, Pagoh and to propose the types of maintenance required for the road. To assess the pavement condition, the road was divided into 10 sections first, each with a length of 200m. At the conclusion of the study, the results indicate that sections 4, 5, 6, and 8 are in good condition, with a PCI rating of 86-100, followed by sections 7 and 9, which have a satisfactory condition rating of 71-85. While on the other hand, section 10 is in poor condition, with a PCI rating of 45-55. Sections 2 and 3 exhibit a very poor condition, with a PCI rating of 26-44, and finally, section 1 is deemed to be in a serious condition, with a PCI rating of 11-25. It is noteworthy that none of the sections in this study are categorized as fair or failed.

1. Introduction

Roads and pavement play a big role in transportation nowadays. Damage on roads and pavement may cause harm to the lives of people. The damage on the roads and pavements are stemming from a variety of factors. Functional failure depends primarily on the degree of surface roughness. Structure failure in a flexible pavement may be a result of fatigue, consolidation or shear, developing in the subgrade, subbase, base course or surface. Road pavements require continuous maintenance and rehabilitation works to prevent deterioration caused by repetitive traffic loading and environmental factors [1]. A proper maintenance of road infrastructure is crucial to preserve and enhance social benefits. Therefore, the importance of maintenance should be recognized by those competent authorities in decision making, proper funding, and management so as to ensure that maximum value

is reached [2]. Pavement condition Index (PCI) were introduced by the fields of engineering on how to track and manage any damages on roads and pavements.

PCI are among other pavement condition indices used to assess pavement surface condition [3]. It is a numeric index between 0 and 100 [4] used to grade the condition of pavement section surfaces. The PCI is a tool used by various industries, including transportation, civil engineering, and asset management, to assess the quality of road infrastructure and the level of service it provides. It involves collecting data through manual surveys of the pavement and using statistical analysis to calculate the index. Computing the PCI requires data about several types of distresses and their severity: potholes, fatigue cracking, rutting, block cracking, edge cracking, longitudinal and transverse cracking, patching, shoving, bleeding, polished aggregate [4]. The PCI was initially created by the United States Army Corps of Engineers as a method for evaluating the condition of airfield pavements, but it was later adapted for use on roadways and standardized by the American Society for Testing and Materials (ASTM). It is commonly employed by municipalities to monitor and maintain their roads.

Furthermore, the current approach to road maintenance in Kampung Jawa, Pagoh is primarily reactive, with repairs being carried out only after road damage becomes severe or accident occur. This reactive approach leads to higher repair costs, prolonged disruptions to traffic flow, and an inefficient use of resources. Shifting towards a proactive maintenance strategy, based on early detection and preventive measures, is necessary to minimize road damage, extend pavement life, and optimize resource allocation. The aim of this report is to analyze factor that affect pavement distress. Next, to evaluate pavement condition at Kampung Jawa, Pagoh. And lastly is to propose the types of maintenance required for the road.

2. Methodology

Pavement Condition Index (PCI) involves collecting data through manual surveys of the pavement and using statistical analysis to calculate the index. Computing the PCI requires data about several types of distresses and their severity: potholes, fatigue cracking, rutting, block cracking, edge cracking, longitudinal and transverse cracking, patching, shoving, bleeding, polished aggregate [4]. The PCI was initially created by the United States Army Corps of Engineers as a method for evaluating the condition of airfield pavements, but it was later adapted for use on roadways and standardized by the American Society for Testing and Materials (ASTM). It is commonly employed by municipalities to monitor and maintain their roads.

2.1 Materials

Prior to the test, materials were acquired and used in this investigation. First, the main component is the PCI table form, which is utilized to record every kind of deflection on the pavement. There are supporting materials such as odometer, measuring tape, safety jacket and helmet. Fig. 1 shows the materials that were conducted for the test.



Fig. 1 The materials for PCI preparation (a) PCI table form; (b) odometer; (c) measuring tape; (d) safety jacket; (e) safety helmet

2.2 Methods

The methods were properly adhered to the American Society for Testing and Materials. The ASTM standards for roads and parking lots pavements are used in the PCI survey procedures and calculation methods. The PCI was calculated based on the data collected. The type of pavements used for making the road in the study area was obtained from the observation to use in the calculation method. Pavement Condition Index (PCI) is a numerical index with a value between 0.0 and 100 [5].

2.3 PCI Concept

The pavement condition was determined by the score obtained where the perfect score which is a 100 indicates the best possible condition of the pavement and 0 were presented as the worst possible condition of the pavement. To obtain the PCI scale of a pavement, the data of a damaged road on a study area must be taken beforehand. Fig. 2 shows the index of PCI Rating Scale. Distress type, severity level and density of the road

damaged is what is needed for this PCI method. This particular subject was transferred to the PCI table in density equation. The density of a damages can be obtained from following equation. The following formula can be used to determine a damage's density.

	Standard PCI Scale Rating	Customized PCI Scale Rating
100	Good	Adequate
85	Satisfactory	
70	Fair	Medium
55	Poor	
44	Very Poor	Unsatisfactory
25	Severely	
10	Failed	

Fig.2 PCI Rating Scale

$$Density = \frac{Distress\ amount\ in\ m^2(ft)^2}{Sample\ unit\ are\ m^2(ft)^2} \times 100, \quad (1)$$

$$Density = \frac{Distress\ amount\ in\ linear\ m\ (ft)^2}{Sample\ unit\ are\ m^2(ft)^2} \times 100, \quad (2)$$

$$Density = \frac{Number\ of\ potholes}{Sample\ unit\ are\ m^2(ft)^2} \times 100. \quad (3)$$

2.4 Types of Road Damages

One of the main damages of the road was cracking. It could have described as damaged occurred in the surface layer of the road, divided into 9 (nine) typed of cracked such as hair cracking, alligator cracks, edge cracks, edge joint cracks, lane joint cracks, widening cracks, reflection cracks, shrinkage cracks and slippage cracks [6]. Cracking could cause because the soil road base was less stable, the drainage system is not good, the job execution procedure is not good and there is not good paving material which exceeds the loaded capacity of the road traffic. The cause of the higher than cracking square measured as aging of binder or initial over heated ended up in break ableness of binder [7].

Other than that, surface deformation was also one of road damages. Pavement deformation was the result of weakness in one or more layers of the pavement that had experienced movement after construction. Cracking might have accompanied the deformation. Surface distortions could have been a traffic hazard [8]. The basic type of surface deformation rutted, corrugations, shoved, depressions and swelled.

Otherwise, disintegration can also cause road damaged. The progressive broke up of the pavement into small, loose pieces called disintegration. The two most common types of disintegration were potholes and patches. Potholes were bowl-shaped holes of various sizes in the surface layer or extended into the base course. These are caused by localized disintegration of material and usually appeared at watered logged placed or after rained [9]. Patches was defined as a portion of the pavement that had been removed and replaced. Patches were usually used to repair defects in the pavement or to cover a utility trench.

Next, surface defects related to problems in the surface layer. The most common type of surface defects is raveled, bleeding and polished. Raveling was the loss of material from the pavement surface because of insufficient adhesion between the asphalt, cement, and the aggregate. Raveling typically tended to occur on an

older pavement that had already oxidized [10]. Bleeding occurred when the bituminous mixed contained too much asphalt cement relative to the aggregates. In this case, the asphalt cement tended to bleed through the surface, hence, reduced the skid-resistance of a pavement thereby made the pavement very slippery when wet, created hazard to the road users. Polished was a failure mode of the pavement surface consisting of rough exposed aggregates which was caused by excess repeated traffic on an ageing pavement system. It could result in a dangerous low friction surface with a decreased skid-resistance. Fig. 3 illustrates the types of defects used in determining the PCI.



Fig. 3 Types of Defects used in Determining the PCI

3. Results and Discussions

The result of this study was the identified the conditions of the road pavement, types of defects on the road surface and the maintenance needed for the road. For this survey, the PCI method was selected as the assessment framework. It entails identifying and classifying the different types of distress seen on the pavement. Pavement condition index survey data sheet was used for data collection. The survey crew rated the level of the distress and identified it in accordance with established protocols. The procedure typically involves the following steps as visual inspection, data collection, distress identification, distress quantification, weighting factors, calculation of PCI, PCI ratings and reporting and analysis.

3.1 Condition Inventory

During the evaluation of road pavement condition using the PCI method, it's essential to take into account all available defects. This requires conducting a thorough examination of various distress types, including but not limited to cracks, potholes, rutting, and surface deterioration.

3.2 PCI Determination

The PCI determination involves a structured process to evaluate and quantify the condition of pavement surfaces. This process is critical for maintaining road infrastructure and involves several key steps. Table 1 shows a pavement condition survey for sample 1-10 of Jalan Kampung Jawa, Pagoh.

Data showed that section 1 of Jalan Kampung Jawa, Pagoh has the highest quantity of distress survey which is 12 amounts of distress recorded. A large number of vehicles that exiting and entering from the intersection of the road caused a longitudinal and transverse cracking, patching and utility cut patching and rutting. 8 amounts of high level of transverse and longitudinal and transverse cracking, 1 amount of high level and 1 amount of low

level of utility and cut patching, and 2 amounts of low level of rutting were recorded at section 1 of Jalan Kampung Jawa, Pagoh.

Section 4, 5 and 8 has the lowest quantity of distress survey recorded which is only one distress were recorded at each section. A high level of patching and utility cut patching were recorded at section 4, medium level of patching and utility cut patching were recorded at section 5 and low level of edge cracking were recorded at section 8.

Table 1 Pavement Condition Survey for Sample 1-10 of Jalan Kampung Jawa, Pagoh.

JALAN KAMPUNG JAWA (ASPHALT SURFACED ROAD)												
CONDITION SURVEY DATA SHEET												
BRANCH: TRAFFIC LABORATORY UTHM						DATE: 1/5/2024						
SURVEYED BY: BDD						SAMPLE UNIT: 1-10						
SECTION: 1-10						SAMPLE AREA: 4.6 n x 200 m						
01. Alligator Cracking (m ²)	06. Depression (m ²)	11. Patching & Utility	16. Shoving (m ²)									
02. Bleeding (m ²)	07. Edge Cracking (m)	Cut Patching ((m ²)	17. Slippage Cracking									
03. Block Cracking (m ²)	08. Joint Reflection	12. Polished	(m ²)									
04. Bumps and Sags (m)	Cracking (m)	Aggregate (m ²)	18. Swell (m ²)									
05. Corrugation (m ²)	09. Lane/Shoulder Drop	13. Potholes (no.)	19. Weathering/									
	Off (m)	14. Railroad Crossing	Ravelling (m ²)									
	10. Longitudinal &	(m ²) Transverse										
	Cracking	15. Rutting (m ²)										
	(m)											
NO.	DISTRESS SURVEY	QUANTITY								TOTAL	DENSITY %	DEDUCT VALUE
01	10H	31	5.3	0.7	0.52	2.4	1.5	7.3	1.8	50.52	25.3	84
	11L	4.7								4.7	1.02	2
	15L	0.84	0.6							1.44	0.3	2.3
	11H	1.7								1.7	0.4	14.5
02	01M	8.3	6.9	10.4	23	9.4	9.8	5.7	11.8	111.8	24.3	58
	12	20.1										
03	11L	1.61								1.61	0.35	0.6
	10M	17.2	15.4	5.2						37.8	18.2	39
	07H	15.3								15.3	7.7	37
	03M	1.83								1.83	0.4	0
04	11H	9.9								9.9	2.2	5.2
05	11M	0.8								0.8	0.17	0
06	03H	2.86								2.86	0.6	0.7
	11M	4.93	0.6							5.53	1.2	10
07	07H	1.2	0.8	0.53						2.53	1.26	15
	11L	0.88								0.88	0.19	0.1
08	07L	4.14								4.14	2.1	6
09	07H	2.2								2.2	1.1	14
	11L	1.7								1.7	0.4	0.8
10	04L	7.8	4.1							0.7	0.15	0.7
	07H	2.5	4.2	1.8						2	1	14
	09M	6.3								20.6	10.3	32
	10M	3.1	0.4							0.39	0.19	1
	17L	0.5	0.8							4	2	6

3.3 Volumetric Properties

Accompanying discussions that further explain observations of the results are usually placed immediately below the results paragraph.

3.3.1 Analysis on Pavement Distress

The data findings from the study on every section of Jalan Kampung Jawa, Pagoh indicate that there are low severity of bumps and sags, high severity of edge cracking, medium severity of lane/shoulder drop off, medium severity longitudinal and transverse cracking and else. Data shown that major distress that happens in Jalan Kampung Jawa is longitudinal crack. Whether minor distress happens in Jalan Kampung Jawa is potholes.

3.3.2 Analysis on PCI Rating Categories

Fig. 4 shows rating of PCI Index of every section of research area. The graph shows that section 1 of Jalan Kampung Jawa, Pagoh have amount of 22 of PCI rating. This is the lowest PCI rating of every section on Jalan Kampung Jawa, Pagoh. Meanwhile section 5 has 99.85 amount of PCI rating which is the highest PCI rating on every section of Jalan Kampung Jawa, Pagoh. High amount PCI rating indicates that the condition of the road is good. The data from the table can be displayed in a visual form, with each part coloured in accordance with its PCI rating categories.

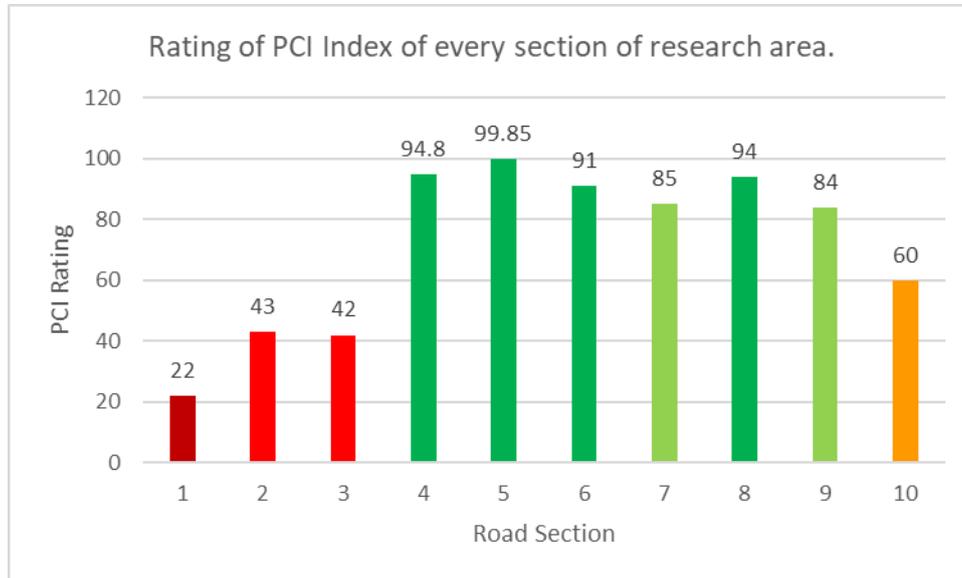


Fig. 4 Rating of PCI Index of every section of research area.

Conclusion

The investigation of the pavement condition across the designated sections has provided a comprehensive assessment of the current state of the infrastructure. The analysis revealed varying degrees of distress, with certain areas exhibiting severe degradation requiring immediate attention. Based on the results, major distress in Jalan Kampung Jawa, Pagoh is longitudinal cracking. This type of distress caused by reflections from shrinkage cracks, poor bituminous layer construction, joint displacement on road widening, differential deposits between cut and embankment areas and connection reflection on the site. Next, minor distresses in Jalan Kampung Jawa, Pagoh is potholes. Potholes were caused by loss of surface on the road, moisture entry into the base layer through cracks in the pavement surface and separation of the site due to impact of the load. Other than that, 20% of pavement conditions of Jalan Kampung Jawa was defined as satisfactory, 40% as good, 10% as poor, 20% as very poor and 10% as serious. These results can be classified as 60% of Jalan Kampung Jawa were still in a good condition and does not affect the user’s life. Whether 40% of pavement were in bad condition and can caused an accident or damage to vehicles. Lastly, the types of maintenance required for the road is rebuild the road, replace the bitumen layer, strengthen the site or subsite and reinforce the overlay.

Acknowledgement

This research was supported by Universiti Tun Hussein Onn Malaysia (UTHM) through Tier 1 (vot Q863).

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design, data collection, draft manuscript, draft manuscript preparation:** Azhan Haziq, Muhammad Syahmi Muhammad Shaiful, Muhammad Amir Ajwad, Hazirah Bujang. All authors reviewed the results and approved the final version of the manuscript.

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