Evaluation of Sample Unit Length in PCI Method in Semarang city Indonesia

Abdussalam Mohamed Moussa[1]

Abstract:Overloaded vehicles are major cause of increased pavement damage, leading to higher maintenance costs, In the study, the Pavement Condition Index (PCI) was used as an indicator to assess the condition of road pavements.

.The evaluation of pavement condition at several locations using ASTM D6433-07 criteria and PCI calculation was conducted, Samples were taken at various distances on the targeted roads (50m, 100m, 150m). The study results showed that PCI values were able to accurately predict the regulatory restrictions on overloaded vehicles.

It was found that the PCI value for a distance of 150 meters had a higher tolerance capacity on the pavement to withstand heavier loads compared to distances of 50 meters and 100 meters.

The research problem can be summarized as follows:
the deterioration of pavement conditions leads to continuous deterioration of road networks in various countries due to factors such as excessive traffic, weather conditions, and lack of regular maintenance,+

Deterioration leads to increased accidents and maintenance costs Secondly there are various methods used to evaluate pavement condition, such as structural performance analysis, imaging techniques, and the PCI method, but the lack of unified or clear standards for selecting the appropriate method may cause variations in evaluation results and affect maintenance management effectiveness - Additionally, results may vary depending on factors

[1]- Faculty member in the Civil Engineering Department
Higher Institute of Science and Technology Wadi Al-Ajal Bint Bayah

such as the length of the sample unit, the number of defects studied, and the importance of effective maintenance, Effective road management requires making decisions based on accurate data about pavement conditions, Inaccurate data can lead to ineffective maintenance investments, increasing long - term maintenance costs.The research objectives include evaluating the effectiveness of PCI and studying, the effectiveness of the PCI as a tool for evaluating pavement condition compared to other methods, to establish clear criteria for selecting the length of the sample unit in PCI and assess its impact on evaluation results, analysis the results obtained from applying PCI, and provide recommendations on how to improve the use of PCI in selecting sample length, and determining whether maintenance, reconstruction, or rehabilitation is needed.

Keywords: PCI, sample unit length, distress.

INTRODUCTION:

The Pavement Condition Index (PCI) is a widely used method for measuring the condition of pavement surfaces, The PCI is a numerical value ranging from (0 to 100) that represents the overall condition of the pavement surface, The higher the PCI value, the better the condition of the pavement, The PCI method involves visually inspecting the pavement surface and evaluated, it based on a set of predetermined criteria, including factors such as cracking, rutting, and surface distress, (Prof. Dr Fareed M.A. Karim,* Dr Khaled Abdul Haleem Rubasi, and Dr Ali Abdo Saleh.2016.page 1) * The pavement surface is then assigned a PCI value based on the severity and extent of these factors. Transportation agencies use the PCI method to maintain safe, durable, and economical road networks, By regularly monitoring the condition of pavement surfaces using the PCI method transportation agencies can identify areas that require maintenance or repair before they become safety hazards or cause more extensive damage, Before using the PCI method, it is important to determine its applicability to the specific regulatory requirements

of the transportation agency.

The ASTM D6433-07 standard provides guidelines for the use of the PCI method and should be consulted to ensure that the method is being used correctly and appropriately.

The use of the PCI method can lead to cost savings by allowing transportation agencies to give priority maintenance and rehabilitation activities based on the condition of the pavement surface, By using the PCI method, transportation agencies can ensure that limited resources used effectively to maintain safe, durable, and economical road networks, ASTM 6433, 1970, page 2. (Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys).

Paper Location:

The research site is located in one location, Badan Pemeriksa Keuangan Republik Indonesia Perwakilan Provinsi Jawa Tengah i.e. Perintis Kemerdekaan roads, Semarang city Indonesia.

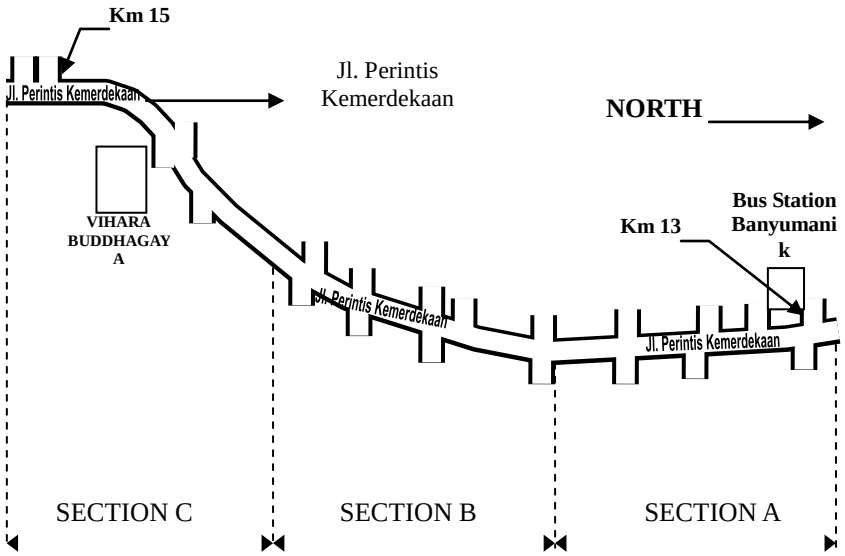

Figure (1) Division Layout Section (Field survey, 2012)

Geometric Data Road:

This research was carried out at the Perintis Kemerdekaan Road Km 13 to Km 15 Semarang. Furthermore, the segments are divided into 3 sections, namely section A (STA 13 +000 s / d STA 13 +500), Section B (STA 13 +500 s / d STA14 +200), Section C (STA 14 +200 s / d STA 15 +000). Then each section is divided into a number of sample units with 50-m long, The details of each section and sample unit can be seen in Figure 4.1 to Figure 4.4.

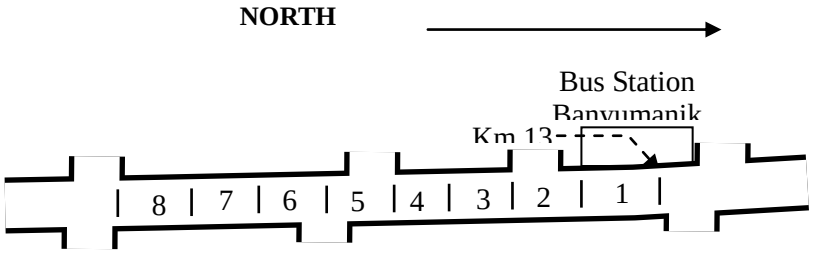

Figure 2-2 Layout section sample unit (A) (Field survey, 2012)

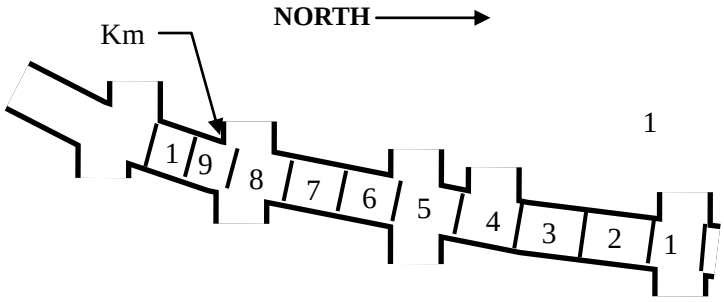

Figure 2-3 Layout section sample units (B) (Field Survey, 2012)

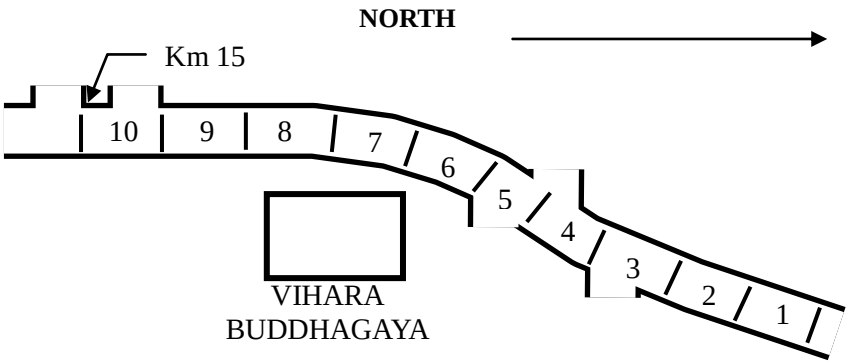

Figure (2-4) Layout section sample units (C) ,(Field Survey, 2012)

Objective of study:

The objective of this Paper is to evaluate the dimension of sample unit in ASTM 6433 standard that gives the most optimum pavement maintenance, rehabilitation, and reconstruction. mention previously, PCI number alone cannot give a complete description on the damage of the road, especially what is the main type of road distress and its severity that contributes more to the damage of the road. PCI number, together with the individual distress information, such as cracking or rutting, provides insight into what are the causes of pavement deterioration.

These factors (PCI number and individual distress information) then can be used to select the appropriate maintenance or rehabilitation action to solve the problem, The main objectives of the research are as follows: evaluating the effectiveness of PCI, analysis the accuracy of PCI in measuring pavement condition compared to other methods, determining the impact of unit length on PCI results, and studying how unit length affects PCI results and evaluation accuracy, comparing PCI with other methods, and presenting a comprehensive comparison between PCI and other methods for assessing pavement condition such as structural analysis and geophysical imaging, and identifying challenges, determining the challenges facing the application of PCI in different environments, and providing recommendations, developing recommendations to improve the use of PCI in assessing pavement condition and maintenance management.

Research Question:

- How accurate is the Pavement Condition Index (PCI) compared to other methods?
- How does the length of the sampling unit affect the accuracy of PCI results and assessment?
- How can the use of PCI be improved in pavement condition assessment systems?

- What recommendations can be made to road managers based on research findings?

Importance of Research:

1. Effective maintenance priority Using the PCI Index, road managers can better prioritize road maintenance based on actual road conditions. This helps allocate resources more efficiently, directing effort and money to areas that need major repairs or maintenance immediately.
2. Financial management and cost savings Research in this area helps save money and effort in the long run. With proper use of PCI data, the condition of the process can be predicted before it becomes fully deteriorated, allowing preventive measures such as lighting maintenance or surface therapy to be developed These measures a this preventive measure is often more cost-effective compared to repairing more severely damaged roads.
3. Extending the life of flexible transportation Flexible pavements require regular maintenance to remain in good working order. The PCI Index provides an accurate assessment of pavement condition, helping to determine the correct maintenance method and timing, thereby extending the life of the pavement and providing sustainable performance sharing is effective.
4. Enhancing vehicle safety Poorly paved roads increase the risk of traffic accidents, especially when severe cracks or wear appear on the road surface. By relying on PCI, the most dangerous areas can be identified and addressed more quickly, improving overall road safety.
5. Support informed decision-making Project managers generally rely on scientific data to inform their maintenance and repair decisions. PCI audits increase the accuracy of this information, enabling decisions based on real data, thereby streamlining the maintenance process and reducing errors or delays in project implementation in the 19 th century.

Research Scope:

This research is only focused on the following scopes:

1- Pavement condition Index (PCI) is the main parameter considered in this research.
2- ASTM 6433-07 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys is the only standard used in this research.
3- To analysis PCI value, road damage type and severity level used.
4-This research is only focused on the surface layer of flexible pavement, with use of secondary data.

Pavement Distress Surveys:

Pavement distress surveys can provide valuable information when conducting pavement drainage studies. One widely adopted practice is the pavement Condition Index (PCI) method for roads and parking lots as developed by the U.S. Army Corps of Engineers (19). The following sections contain a brief overview of this method of determining PCI.

Sample Units:

Pavement sections to be surveyed should be broken into sample units. A pavement sample unit should be 20 slabs (± 8 slabs if not evenly divisible by 20) for a Portland Cement Concrete (PCC) pavement , and 2500 square feet (± 1000 square feet if not evenly divisible by 2500) for an Asphalt Concrete (AC) pavement.

calculation of the PCI begins by adding up the total quantity of each distress type at each severity level and recording the data under the total severities section of the data collection form. Each total quantity is divided by the total area of the sample unit and multiplied by 100 to obtain a percent density of each distress type and severity. Percent density values and level of severity used to generate deduct points from deduct value curves. Using the deduct value method; pavements ranked on a 100 point index. A score of 100 represents a perfect pavement and pavements further rated as follows.

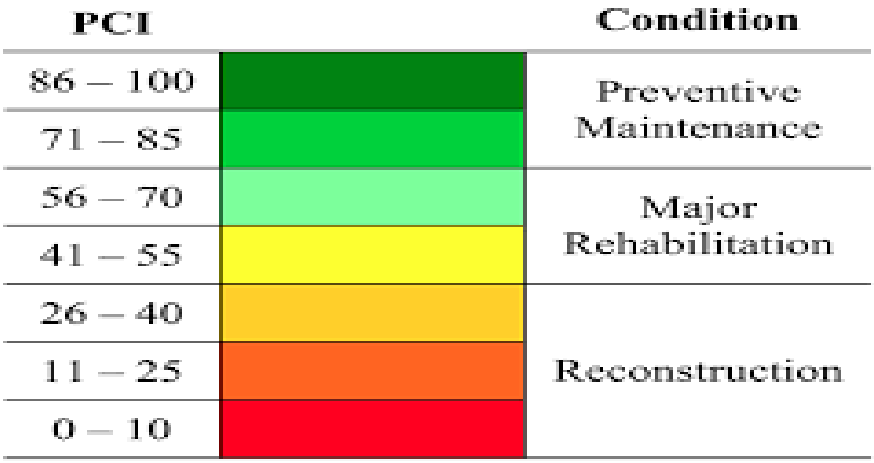

Figure (5) Pavement Condition Index and Rating (Emery 2006)

The described method works under the philosophy that a pavement containing two distresses each having a deduct value of 35 is not as severe as a pavement containing one distress with a deduct value of 70. However, a series of curves were developed to correct the total deduct value using the total number of distresses with a deduct value greater than 5 and the total deduct value. The corrected deduct value is subtracted from 100 to define the PCI.

Severity level of Distress in Asphalt Pavements:

Description-Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt surface, or stabilized base, where tensile stress and strain are highest under a wheel load .The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are generally less than 0.5 m (1.5 ft) on the longest side. Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths. Pattern-type cracking that occurs over an entire area not subjected to loading is called “block cracking,” which is not a load associated distress.

Alligator cracking:

Fine longitudinal hairline cracks running parallel to each other with no, or only a few interconnecting cracks. The cracks are not spalled.

Figure.7.1 Low-Severity Block Cracking
Source: ASTM (2007)

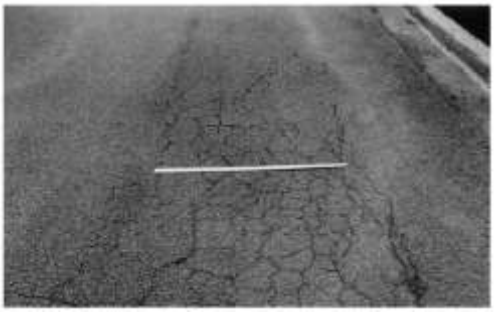

Figure.7.2 Medium-Severity

Figure.7.3High-Severity

Alligator Cracking Alligator Cracking

Source: ASTM (2007)

Bleeding:

Figure.7.4 Low-Severity Bleeding

Figure.7.5 Medium-Severity Bleeding

Source: ASTM (2007)

Figure.7.6 High-Severity Bleeding

Source: ASTM (2007)

Block cracking:

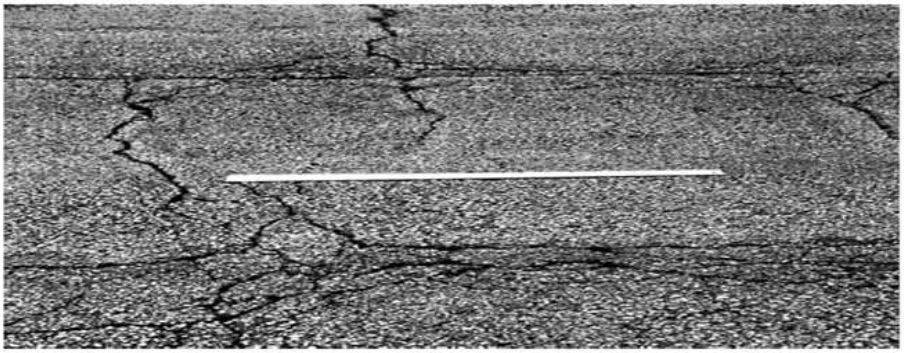

Figure.7.7 Low-Severity Block Cracking

Source: ASTM (2007)

Figure.7.8 Medium-Severity Block Cracking - Figure.7.9 High-Severity Block Cracking

Source: ASTM (2007)

BUMPS AND SAGS:

Figure.7.10 Low-Severity

Figure.7.11 Medium-Severity

Source: ASTM (2007)

POTHOLES:

Figure.7.12 Low-Severity Pothole

Figure.7.13 Medium-Severity Pothole

Source: ASTM (2007)

SHOVING:

Figure.7.14 Low-Severity Shoving

Figure.7.15 Medium-Severity Shoving

Source: ASTM (2007)

Calculation of PCI:

The PCI number provides an overall measure of condition and an Indication of the level of road damage, and thus it is closely corresponding with the maintenance or rehabilitation work that will be required to maintain or conserves the pavement, This value also provides an objective means of prioritizing and scheduling pavement rehabilitation work, However, as mention previously, PCI number alone cannot give a complete description on the damage of the road, especially what is the main type of road distress and its severity that contributes more to the damage of the road. (Ali Mohamed Zaltuom,2011, page 92) PCI number, together with the individual distress information, such as cracking or rutting, provides insight into what the causes of pavement deterioration, These factors (PCI number and individual distress information) then can be used to select the appropriate maintenance or rehabilitation action to enhance the problem, (Zafar, M. S., Shah, S. R., Memon, M. J., Rind, T. A., & Soomro, M. A.)(2019).

Table (1): Survey form for Calculation of PCI

Type of Damage	Severity	Density	Deduct value	PCI = 100-CDV PCI=100-28=72 Rating is Very GOOD
Alligator cracking	M	2.03	28.2	
TDV CDV			53.7 28	

TDV- Typical deduct value curve.

CDV- Determine the maximum corrected deduct value.

M- Number of additional sample units surveyed.

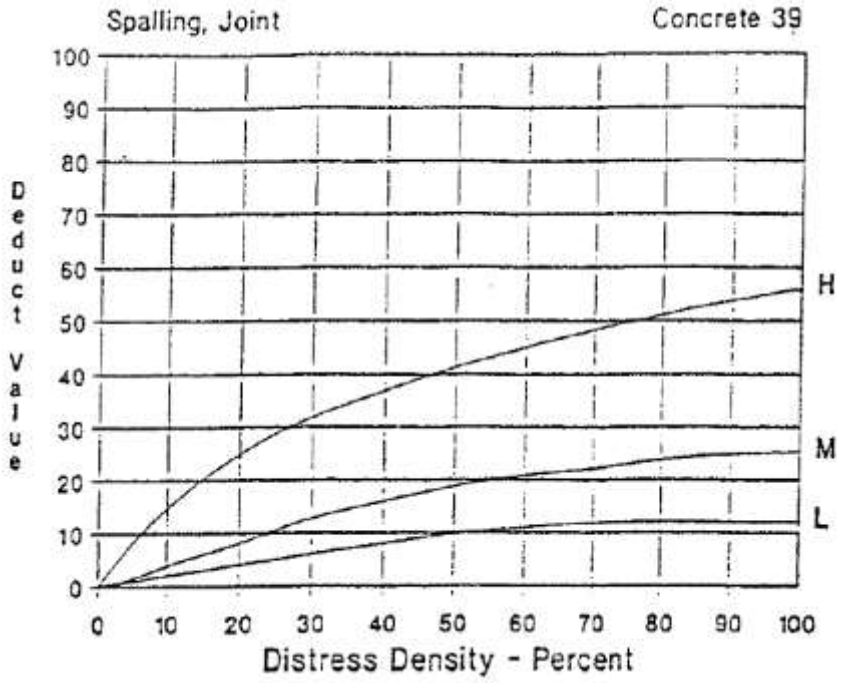

Figure.8 X4.19 Spalling, Joint

H- High
M- Medium
L- Low

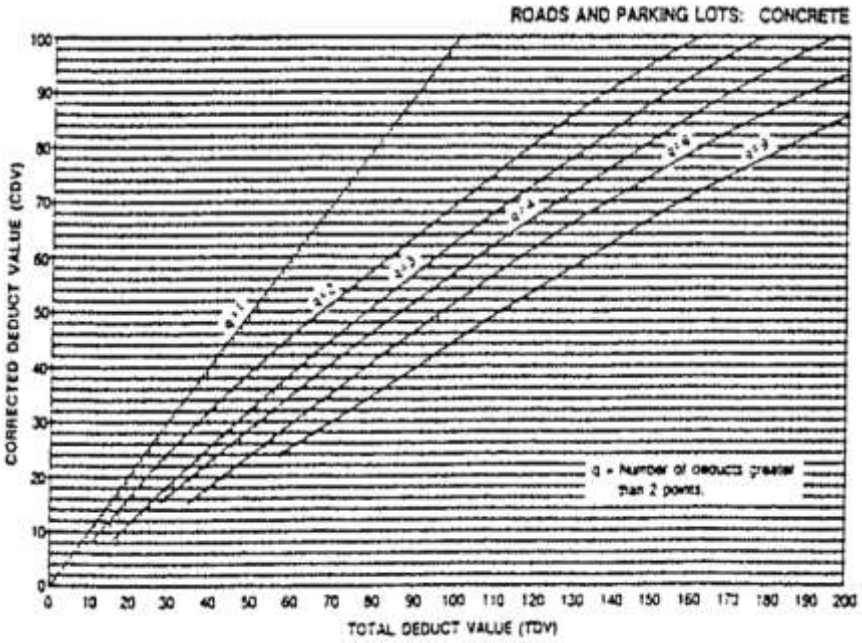

Figure. 9 Corrected Deduct Values for Jointed Concrete

Pavement

Pavement Condition:

PMS prioritize the maintenance and rehabilitation of pavement sections by evaluating pavement performance at the network level (Reza et al. 2006).To evaluate pavement performance, most provincial / states in Canada and the United States perform data collection activities in one or more of the following four main areasur face distress, roughness, structural adequacy and friction (NCHRP 2004),Collection and utilization of pavement distress data varies amongst agencies, Each agency typically develops their own data collection guidelines or protocols according to their needs, However, some agencies such as the Ministry of Transportation of Ontario (MTO), American Association of State Highway and Transportation Officials (AASHTO), American Society for Testing and Materials (ASTM), Strategic Highway Research Program

(SHRP), and the Federal Highway Administration (FHWA) usually establish well developed guidelines to standardized data collection methodologies (Chamorro et al. 2008).

These protocols can be found at (MTO 1989, MTO 1995, AASHTO 2003, ASTM 2003, FHWA 2003). Most of the agencies use a distress index, index/rating, priority rating, and serviceability as the output for the distress survey (NCHRP 2004). However, almost all agencies have differences in quantifying both the severity and density of distresses. More than 80% of the agencies combine their distress index or ratings with other indices or ratings such as roughness (NCHRP 2004).

Pavement Distress Surveys:

Pavement distress surveys can provide valuable information when conducting pavement drainage studies. One widely adopted practice is the pavement Condition Index (PCI) method for roads and parking lots as developed by the U.S. Army Corps of Engineers (19). The following sections contain a brief overview of this method of PCI determination. (Ronald, Thevenot, 2020.page5).

This study area 50m,100m,150m for the three sections. (A, B, C):

Table (8.1): Summary of PCI Calculation and its Corresponding reatment Type

For Section A (50m)

STA	PCI	Rating	Treatment type
13+000 – 13+050	66	Fair	Maintenance
13+050 – 13+100	56	Fair	Rehabilitation
13+100 – 13+150	24	Serious	Reconstruction
13+150 – 13+200	46	Poor	Rehabilitation
13+200 – 13+250	26	Very poor	Reconstruction
13+250 – 13+300	24	Serious	Reconstruction
13+300 – 13+350	23	Serious	Reconstruction
13+350 – 13+400	64	Fair	Maintenance

Table (8.2): Summary of PCI Calculation and its Corresponding *Treatment Type* *For* Section B (50 m)

STA	PCI	Rating	Treatment type
13+500 – 13+550	58	FAIR	Rehabilitation
13+650 – 13+700	38	VERY POOR	Reconstruction
13+700 – 13+750	20	SERIOUS	Reconstruction
13+750 – 13+800	72	SATISFACTORY	Maintenance
13+800 – 13+850	42	POOR	Rehabilitation
13+850 – 13+900	6	FAILED	Reconstruction
13+900 – 13.950	26	VERY POOR	Reconstruction
13+950 – 14+000	40	VERY POOR	Reconstruction
14+000 – 14+050	32	VERY POOR	Reconstruction
14+050 – 14+100	38	VERY POOR	Reconstruction

Table (8.3): Summary of PCI Calculation and its Corresponding Treatment TypeFor Section C (50 m)

STA	PCI	Rating	Treatment type
14+200 – 14+250	30	VERY POOT	Reconstruction
14+250 – 14+300	18	SERIOUS	Reconstruction
14+300 – 14+350	40	VERY POOR	Reconstruction
14+350 – 14+400	40	VERY POOR	Reconstruction
14+400 – 14+450	40	POOR	Rehabilitation
14+450 – 14+500	54	POOR	Rehabilitation
14+500 – 14+550	62	FAIR	Maintenance
14+650 – 14+700	62	FAIR	Maintenance
14+800 – 14+850	62	FAIR	Maintenance
14+850 – 14+900	70	FAIR	Maintenance
14+900 – 14+950	68	FAIR	Maintenance
14+950 – 15+000	52	POOR	Rehabilitation

Table (8.4) : Summary of PCI Calculation and its Corresponding Treatment Type
For Section A (100 m)

STA	PCI	Rating	Treatment type
13+000 – 13+050 13+050 – 13+100	50	POOR	Rehabilitation
13+100 – 13+150 13+150 – 13+200	33	VERY POOR	Reconstruction
13+200 – 13+250 13+250 – 13+300	18	SERIOUS	Reconstruction
13+300 – 13+350 13+350 – 13+400	34	VERY POOR	Reconstruction

Table 8.5: Summary of PCI Calculation and its Corresponding Treatment Type
For Section B (100 m)

STA	PCI	Rating	Treatment type
13+500 – 13+550 13+650 – 13+700	34	VERY POOR	Reconstruction
13+700 – 13+750 13+750 – 13+800	32	VERY POOR	Reconstruction
13+800 – 13+850 13+850 – 13+900	19	SERIOUS	Reconstruction
13+900 – 13.950 13+950 – 14+000	26	VERY POOR	Reconstruction
14+000 – 14+050 14+050 – 14+100	36	VERY POOR	Reconstruction

Table (8.6): Summary of PCI Calculation and its Corresponding Treatment TypeFor Section C (100 m)

STA	PCI	Rating	Treatment type
14+200 – 14+250 14+250 – 14+300	24	SERIOUS	Reconstruction
14+300 – 14+350 14+350 – 14+400	36	VERY POOR	Rehabilitation
14+400 – 14+450 14+450 – 14+500	48	POOR	Rehabilitation
14+500 – 14+550 14+650 – 14+700	62	FAIR	Maintenance
14+800 – 14+850 14+850 – 14+900	65	FAIR	Maintenance
14+900 – 14+950 14+950 – 15+000	66	FAIR	Maintenance

Table 8.7: Summary of PCI Calculation and its Corresponding Treatment TypeFor Section A (150 m)

STA	PCI	Rating	Treatment type
13+000 – 13+050 13+050 – 13+100 13+100 – 13+150	18	SERIOUS	Reconstruction
13+150 – 13+200 13+200 – 13+250 13+250 – 13+300	20	SERIOUS	Reconstruction

Table 8.8: Summary of PCI Calculation and its Corresponding Treatment TypeFor Section B (150 m)

STA	PCI	Rating	Treatment type
13+500 – 13+550 13+650 – 13+700 13+700 – 13+750	30	VERY POOR	Reconstruction
13+750 – 13+800 13+800 – 13+850 13+850 – 13+900	24	SERIOUS	Reconstruction
13+900 – 13.950 13+950 – 14+000 14+000 – 14+050	28	SERIOUS	Reconstruction

Table (8.9): Summary of PCI Calculation and its Corresponding Treatment TypeFor Section C (150 m)

STA	PCI	Rating	Treatment type
14+200 – 14+250 14+250 – 14+300 14+300 – 14+350	28	VERY POOR	Reconstruction
14+350 – 14+400 14+400 – 14+450 14+450 – 14+500	48	POOR	Rehabilitation
14+500 – 14+550 14+650 – 14+700 14+800 – 14+850	54	POOR	Rehabilitation
14+850 – 14+900 14+900 – 14+950 14+950 – 15+000	61	POOR	Rehabilitation

Results:

1. Adequate Coverage, The PCI should be selected to ensure adequate coverage of the study area. It should be long enough to allow for the detection of a significant proportion of the bird species present in the area. If the PCI is too short, it may result in underestimation of bird abundance and diversity.
2. Feasibility, The PCI should be practically feasible to implement in the field. Factors such as terrain, vegetation density, and accessibility of the study area should be considered to determine an appropriate PCI that can be effectively surveyed within a reasonable amount of time.
3. Replicability, The PCI should be consistent across survey points to facilitate comparison and replication of the survey methodology. This ensures that data collected from different points can be combined and analyzed accurately.
4. Species Detection Probability, The PCI should take into account the detection probability of the target bird species. Some species may be more easily detected at shorter distances, Understanding the behavior and ecology of the species being surveyed can help determine an appropriate PCI.

Discussions:

Pavement Condition Index (PCI) should be focused on in several stages and phases to maintain the high internet status of networks, therefore some periods and situations where this attention should be focused, during planning and regular periodic maintenance:

It is advisable to check the PCI periodically according to the traffic and road quality, as mentioned earlier. Focusing on the prediction of large variations such as light repairs and coordination maintenance before major expansion works when the PCI index is significantly reduced, it may be time to activate major repairs such as pavement rehabilitation or replacement, It helps to focus on this diversity in focusing on priorities in maintenance programs, when discovering innovations in the case of pavement condition in the event of noticing new cracks, subsidence, or significant damage due to the focus on protection or accidents, the PCI index should be focused on to know the extent of the diversity you prefer for tanks quickly, after the implementation of events, the PCI inspection should be focused on after confirmation such as heavy water drops, hitting, temperature or decrease, as this factor can lead to rapid deterioration in the condition of the pavement, when planning the development or updating of data when planning or updating the access network, an assessment of the PCI index should be made of the condition of the existing roads and whether repairs or improvements are necessary before embarking on any new project.

when an increase in traffic is expected if it is experienced that the pressure on the roads increases due to the expansion of data and information or the increase in the relationship and industry, the PCI technology should be focused on the pavement technology to bear the traffic collectively, so they prefer the rest, when customers from the end of the default distinct connection row has a specific life span that depends on the quality of design and construction, Taking into account this period, the PCI assessment will become necessary to whether there is a need for complete need

or major repairs, The pavement condition index (PCI) is also significantly affected by aging. Over time, the pavement is exposed to natural and human factors that lead to its deterioration, which is reflected in the PCI index values, This effect occurs for several other factors such as rain, cold, heat, and ultraviolet rays, which found in surface damage and erosion of materials over time, and vehicle traffic, especially those with heavy loads, which causes pressure on the pavement, leading to the appearance of cracks, which decreased, led to other decreases that affect the PCI value over time, not increasing the periodicity, not performing necessary maintenance in a timely manner increases the deterioration of the pavement speed and affects the PCI index more, time only. so that there is no short, little or harmful movement, the pavement may be destroyed over time as a result of the product of the materials resulting in such as thermal expansion and contraction,

The time periods that include studying the pavement condition index (PCI) depend on several factors, including the type of road, traffic density, and climate, and must be available However many studies and engineering practices characterized by the following periods, High-traffic roads: It is preferable to check the PCI index every 1-2 years, due to the significant impact of vehicle movement on pavement deterioration. High-traffic roads for access, The PCI index can be studied every 2-4 years, because pavement wear is slower compared to roads with long-traffic, Low-traffic roads.

The time intervals may be shorter, from 4 to 5 years, due to less deterioration. After specific climatic events, In cases of heavy rain, condition, or extreme heat, it is preferable to conduct an immediate examination of the effect of environmental factors on the pavement.

In researching the pavement condition index (PCI) and its effectiveness in assessing the condition of the bicycle, the results require setting specific goals based on the research problem of the most important recommendations and value recommendations of the most important results that athletes are looking to achieve,

Determine the accuracy of the diagnosis of pavement condition (PCI) Determine the accuracy of PCI in assessing pavement condition, through other evaluation methods such as model performance analysis or geophysical imaging techniques, Evaluate the effect of the length of the sample unit on the results.

The research will analyze how the length of the sample unit affects the uncertainty of the PCI assessment, and determine whether there is a specific length that produces an indeterminate assessment or negatively affects, Comparison of other PCI methods for studying pavement The research will provide a detailed comparison between PCI and other methods, such as geophysical radar imaging (GPR) or structural methods, in terms of accuracy, cost, and ease of application, Major expansions Using the main PCI for data analysis, the research will recommend how a large number of expansions can improve the PCI results, such as identifying the need crowds, or by periodic dates, Computer improvements to the PCI index itself, such as modifications to the assessment or the incorporation of new tools to improve the outstanding results, can be made, Providing recommendations to government management.

The research will provide guidance to local and national governments on how to use PCI in road network infrastructure management, identifying the optimal approach to improve the effectiveness of the assessment.

Recommendation:

The evaluation of sample unit length in the PCI (Peripheral Component Interconnect) method involves assessing the optimal length of sample units used in measuring and analysis PCI performance, This evaluation aims to choose different lengths (50m,100m,150) to make comparison between them, attic recommend to use length 50m because best than the other, to determined PCI value, more than other length 100m and 150m, as we know in this research follow (ASTMD 6433-07), to determine distress to determine PCI, Observed that the value of the PCI increase in length100 m and length 150 m also, In the case considered the value of the PCI.

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