International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

PREDICTION OF PAVEMENT CONDITION INDEX USING DISTRESS VALUES IN FLEXIBLE PAVEMENT

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ABSTRACT :

This study explores the utilization of the Pavement Condition Index (PCI) as a pivotal tool for evaluating pavement conditions and guiding maintenance strategies within transportation infrastructure management. Employing a Linear Regression model, correlations between PCI values and various pavement distress types are established, enabling precise prediction of PCI values based on distress data. The analysis underscores the diverse condition of pavement sections, ranging from excellent to fair, indicative of varying distress levels. Sections with lower PCI values necessitate immediate maintenance to halt further deterioration, whereas those with higher PCI values require consistent upkeep to sustain their condition. Prioritizing maintenance based on PCI values optimizes resource allocation, effectively prolonging the lifespan of the pavement network. Furthermore, continual monitoring of PCI values aids in assessing maintenance effectiveness and identifying evolving pavement conditions, thereby improving overall infrastructure management strategies. This research highlights the significance of PCI analysis in formulating targeted maintenance plans to safeguard infrastructure assets and ensure the reliability of transportation systems.

Keywords: Pavement Condition Index (PCI), Distress analysis, Linear Regression, Maintenance optimization, Infrastructure management, Resource allocation, Transportation network.

INTRODUCTION :

Pavement is a durable material used to create a hard surface that is laid down in areas intended for vehicle or pedestrian use. Spreading applied vehicle loads over many levels of the subgrade is its main function. Enough skid resistance, smooth riding, favorable light-reflecting qualities, and minimal noise pollution should all be present on the road surface.

Pavement design involves strategically selecting the optimal combination of pavement layers, considering factors such as material types, thickness, and soil foundation, to accommodate anticipated traffic levels throughout the pavement's lifespan cost-effectively. Pavement structure design is distinct from bridge and building design due to its reliance on empirical or semi-empirical methodologies rather than purely logical techniques. In India, the design of flexible pavements follows guidelines outlined in the Indian Roads Congress (IRC) Code, specifically IRC-37: 2018. Assessing pavements involves observing and documenting their condition, including surface characteristics and structural integrity. Evaluation can take two forms: functional or structural. Functional analysis focuses on the surface layer, examining factors that impact pavement usage, safety, and comfort. In assessing defects in flexible pavements, methods for distinguishing between different types of defects are typically utilized. The categories introduced by the Strategic Highway Research Program (SHRP) in 1993 are widely recognized and employed in studies evaluating pavement conditions. However, it's important to note that while these categories provide a standard parameter for assessing pavement condition, adjustments may be necessary in different cases to accurately characterize the condition. An essential part of the management procedure is understanding the state of the pavement in each segment. Managers find it easier to make decisions when information is shown since it makes it easier to identify areas that require repair immediately. Pavement distresses fall into two different groups. "Functional failure" is the word used to describe the first. In this case, the pavement does not function as expected in a way that puts excessive strain on automobiles or discomforts passengers. The second kind of failure, known as structural failure, occurs when one or more pavement components significantly break down or the pavement collapses, rendering it unable to withstand the stresses applied to it. The primary element determining functional failure is surface roughness. The occurrence of fatigue, consolidation, or shear in the subgrade, sub-base, base course, or surface of a flexible pavement may result in structural collapse. One method for assessing pavement problems is the Pavement Condition Index (PCI).

Functional failure primarily correlates with the assessment of pavement surface roughness. Structural failure in flexible pavements is typically attributed to factors such as fatigue, shear stresses, moisture infiltration into the subgrade, hydraulic bonding issues within the mixture layers, and compaction-related issues in the base and surface courses. When distress occurs on the surface of flexible pavement, road deterioration begins as soon as traffic is introduced. Initially, the deterioration progresses at a slower pace, but over time, it accelerates more rapidly. Pavements require ongoing maintenance and rehabilitation (M, R) to mitigate deterioration from repeated traffic loads and environmental factors. However, due to limited budgets allocated for pavement maintenance, it's essential to utilize existing resources efficiently and effectively. To achieve this goal, there is a need for a systematic approach to plan and schedule M, R activities. This approach presents opportunities to benefit pavement users while minimizing costs for organizations responsible for pavement management by identifying suitable quantities of maintenance and rehabilitation work.

Based on the evaluation of surface distress, the Pavement Condition Index (PCI) assesses the state of pavements. However, PCI does not provide accurate measurements of skid resistance, structural capacity, or road roughness. Despite these limitations, it serves as an objective tool for assessing the needs of maintenance and rehabilitation (M-R) in road sections, especially concerning the ideal pavement approach. Many maintenance agencies leverage the benefits of PCI to identify urgent M-R works. It aids in the development of pavement network strategies, budget allocation for preventive maintenance, and evaluation of materials and pavement structure designs. The PCI method is the most commonly used survey approach in the United States and internationally.

METHODOLOGY :

The ASTM D6433-07 procedure offers a set of curves to adjust for the combined impact of multiple distresses, as their effects are not cumulative. These curves, exemplified by the deduct value curves for alligator cracking (fatigue cracking) in Figure 3, serve as a reference. The process of determining deduct values for a specific pavement distress involves several steps. Firstly, the total quantity of the distress at each severity level is calculated and recorded separately. Secondly, this total quantity for each distress type and severity level is divided by the total area of the pavement section, then multiplied by 100 to ascertain the percent density of each distress type and severity. Finally, the distress deduct value (DV) for each distress type and severity combination is determined from the distress deduct value curves.

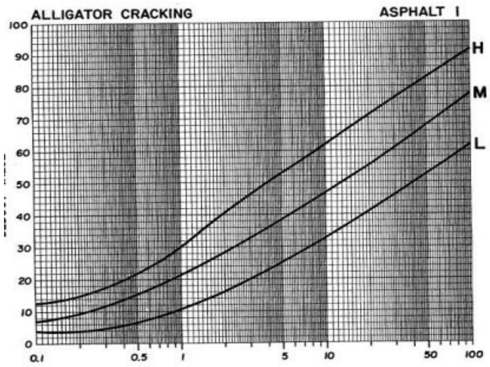

Fig 1. Deduct Value curves for Fatigue (Alligator) Cracking by ASTM

To determine the Pavement Condition Index (PCI), deduct values for each type of distress are applied, along with any necessary correction factors (Corrected Deduct Values, CDVs), to account for multiple distress types. The PCI is then calculated as 100 minus the maximum CDV. According to ASTM guidelines (ASTM, 2007), the following steps are followed to find the maximum CDV. Firstly, if only one or none of the individual deduct values exceed two, the total value is used as the maximum CDV for PCI determination. Otherwise, the maximum CDV is determined through a series of steps. The individual DVs are arranged in descending order, and the allowable number of DVs, denoted as 'm', is calculated using Equation 1, where HDV represents the highest individual DV. The number of individuals deduct values is then reduced to the 'm' largest DVs, including any fractional part. If there are fewer than 'm' DVs available, all DVs are retained.

Subsequently, the maximum CDV is determined through iterative steps:

1. The total deduct value (TDV) is computed by summing individual DVs.
2. 'q' is determined as the number of DVs with values greater than 2.0.
3. The CDV is calculated from TDV and q by consulting the appropriate correction curve, typically shown in Figure 4.
4. The smallest individual DV greater than 2.0 is reduced to 2.0, and steps a, b, and c are repeated until q equals 1.
5. The maxCDV, representing the largest CDV value, is determined. Finally, the PCI is calculated as PCI = 100 - maxCDV.

We employed a Linear Regression model to establish an equation that correlates the PCI value with various types of pavement distresses. The primary goal of this equation is to accurately predict the PCI value based on the given distresses, streamlining the process of obtaining PCI values, reducing the computational effort, minimizing time consumption, and enhancing the efficiency of the performance evaluation process.

RESULTS :

Recently the survey is done from each section of the road network. Overall, the pavement sections vary in their condition, with some requiring immediate attention (Sections B, C, F, H) while others are in better condition and need less maintenance (Sections A, D, E, G, I). Regular monitoring and appropriate maintenance strategies are essential to ensure the longevity and safety of the pavement network.

TABLE 1. PCI Values

Pavement Section	PCI Value	Condition
Section A	85	Good
Section B	72	Fair
Section C	68	Fair
Section D	91	Excellent
Section E	78	Good
Section F	64	Fair
Section G	87	Good
Section H	75	Fair
Section I	82	Good

CONCLUSIONS :

- The pavement sections exhibit varying degrees of distress and condition, ranging from excellent to fair, based on their PCI values.
- Sections with lower PCI values (e.g., Sections B, C, F, H) require immediate attention and maintenance interventions to prevent further deterioration.
- Pavement sections with higher PCI values (e.g., Sections A, D, E, G, I) are in relatively better condition but still require regular maintenance to preserve their condition.
- Prioritizing maintenance efforts based on PCI values allows for efficient resource allocation, optimizing the lifespan of the pavement network.
- Regular monitoring of PCI values over time is crucial for assessing the effectiveness of maintenance interventions and identifying trends in pavement condition.

REFERENCES :

1. Kumar, Rajnish, Sanjeev Kumar Suman, and Gautam Prakash. "Evaluation of pavement condition index using artificial neural network approach." *Transportation in Developing Economies* 7.2 (2021): 20.
2. Shahnazari, H., Tutunchian, M. A., Mashayekhi, M., & Amini, A. A. (2012). Application of soft computing for prediction of pavement condition index. *Journal of Transportation Engineering*, *138*(12), 1495-1506.
3. Nur, Wahyuddin, Bambang Sugeng Subagio, and Eri Susanto Hariyadi. "Relationship between the Pavement Condition Index (PCI), Present Serviceability Index (PSI), and Surface Distress Index (SDI) on Soekarno Hatta Road, Bandung." *Institut Teknologi Bandung* 26.2 (2019): 111-120.
4. Imam, Rana, et al. "Predicting pavement condition index from international roughness index using gene expression programming." *Innovative Infrastructure Solutions* 6 (2021): 1-12.
5. Gupta, Pardeep Kumar, and Parveen Atri. "Pavement Surface Distress Evaluation Using Pci." *Int. J. For Res. In Appl. Sci. & Eng. Technol.(Ijraset)* 6.3 (2018): 2321-9653.
6. Mergi, Kamal Masoud, and El Karim Mustafa Mohamed. "Application of Pavement Condition Index (PCI) Methodology in Pavement Distress Evaluation and Maintenance Prioritization." (2012).
7. Ali, Abdualmtalab Abdualaziz, et al. "Predicting pavement condition index based on the utilization of machine learning techniques: A case study." *Journal of Road Engineering* 3.3 (2023): 266-278.