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Development of an automated pavement condition assessment tool based on Ge-Road mobile monitoring data and the ASTM D6433 methodology

M.A. Malikov[1][a], F.K. Jumaev[1]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: This article investigates the possibilities of processing pavement distress data collected through the Ge-Road mobile application and automatically calculating the Pavement Condition Index (PCI) in accordance with the ASTM D6433 international standard. The study focuses on the digitalization of pavement distress assessment procedures, the reduction of human-related calculation errors, and the development of an Excel-based automated evaluation tool that is practical and accessible for road maintenance organizations. The proposed approach enables rapid assessment of pavement conditions, accurate identification of maintenance needs, and improved efficiency in operational decision-making processes. The results demonstrate the potential of integrating mobile data collection and automated analysis tools to enhance pavement management practices and support more effective maintenance planning.

Keywords: Ge-Road, Pavement Condition Index (PCI), ASTM D6433, pavement condition, road maintenance, mobile monitoring, automation, Microsoft Excel, pavement distress

1. Introduction

Roads are among the most important components of transportation systems. The technical condition of pavement directly affects traffic safety, vehicle operating costs, and the service life of road infrastructure. Therefore, regular monitoring of pavement conditions and the timely implementation of maintenance measures are among the primary responsibilities of road management agencies.

One of the most widely used methods for pavement condition assessment is the Pavement Condition Index (PCI) methodology based on the ASTM D6433 international standard. This methodology evaluates pavement condition on a scale from 0 to 100 by considering the type, quantity, and severity of pavement distresses [1,2].

However, the PCI calculation process involves numerous intermediate computations. In particular, determining distress density, identifying deduct values, calculating corrected deduct values, and deriving the final PCI score become increasingly complex when dealing with large datasets. As a result, the influence of human error increases and the time required for analysis becomes significantly greater [3].

In recent years, mobile technologies have been widely adopted for pavement condition monitoring. In particular, the Ge-Road mobile application enables the rapid collection of pavement distress information, including distress types, geographic coordinates, and photographic records. Nevertheless, the processing of these data in accordance with the ASTM D6433 methodology and the automated calculation of PCI values have not been sufficiently investigated [4,5].

Therefore, the objective of this study is to develop an Excel-based automated system for pavement condition assessment and PCI calculation using data collected through the Ge-Road mobile application. The proposed system aims to simplify the evaluation process, reduce human-related calculation errors, and improve the efficiency of pavement management and maintenance decision-making.

Literature review

The Pavement Condition Index (PCI) methodology has been widely used for pavement condition assessment and maintenance decision-making processes. Originally developed by the U.S. Army Corps of Engineers, the methodology was later adopted as the ASTM D6433 standard and has become an internationally recognized approach for evaluating pavement conditions [3].

The PCI methodology enables pavement condition to be expressed as a numerical indicator by considering the type, quantity, and severity of existing pavement distresses. This method is extensively applied in the assessment of highways, airport pavements, and urban street networks.

In recent years, increasing attention has been given to the digitalization of pavement monitoring processes. Mobile applications and Geographic Information System (GIS)-based technologies have significantly expanded the possibilities for rapid collection, storage, and management of pavement distress data. Such approaches contribute to reducing inspection costs, improving data accuracy, and simplifying pavement monitoring procedures [6].

Nevertheless, many existing studies have not adequately addressed the development of automated algorithms for processing data collected through mobile monitoring systems in accordance with the ASTM D6433 methodology and calculating PCI values automatically. In particular, scientific research on integrating data collected through the Ge-Road mobile application into an automated PCI calculation system remains limited [7,8].

Therefore, investigating the potential for automated PCI calculation based on Ge-Road mobile application data and developing a practical Excel-based evaluation tool represent both scientifically and practically significant research objectives.

2. Research methodology

The Small Ring Road, one of the principal arterial roads in Tashkent City, was selected as the study area. This

[a] https://orcid.org/0000-0002-2175-6240

roadway serves as a major transportation corridor connecting different parts of the city and operates under conditions of high traffic demand. Due to its strategic importance and intensive utilization, the road provides a suitable case study for evaluating pavement condition and assessing the effectiveness of automated PCI calculation methods.

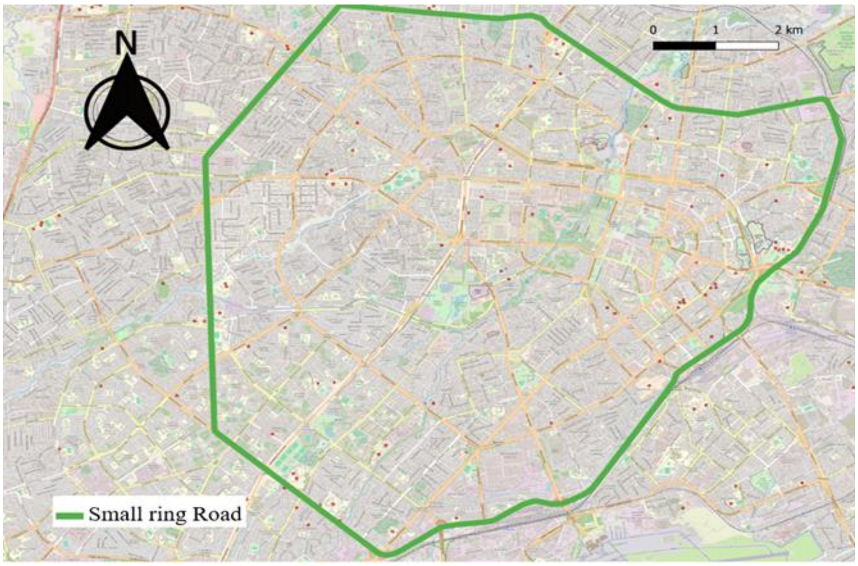

Fig-1. Small ring road map in Tashkent city

The study covered a 32.3 km section of the Small ring Road. The roadway is surfaced with asphalt concrete pavement, and for pavement condition assessment purposes, it was divided into individual 250-meter sections in accordance with the requirements of the ASTM D6433 methodology [3].

Pavement distresses within each section were recorded using the Ge-Road mobile application, and a digital database was subsequently created to store and manage the collected information for further analysis. This database served as the primary source for the automated PCI calculation and pavement condition evaluation.

Fig-2. General View of the Major Pavement Distresses Identified on the Small Road in Tashkent City

During the study, pavement conditions on the selected sections of the Small Ring Road in Tashkent City were monitored using the Ge-Road mobile application. The monitoring process identified various pavement distresses, including longitudinal and transverse cracking, pavement deformations, surface deterioration, and potholes. The location and condition of each distress were recorded and incorporated into a digital database for further analysis.

Using the Ge-Road mobile application, pavement distresses within the study area were documented based on geolocation data, enabling accurate spatial identification and mapping of defect locations. This approach facilitated the systematic collection of pavement condition information and provided a reliable dataset for subsequent PCI calculations and pavement performance evaluation [8].

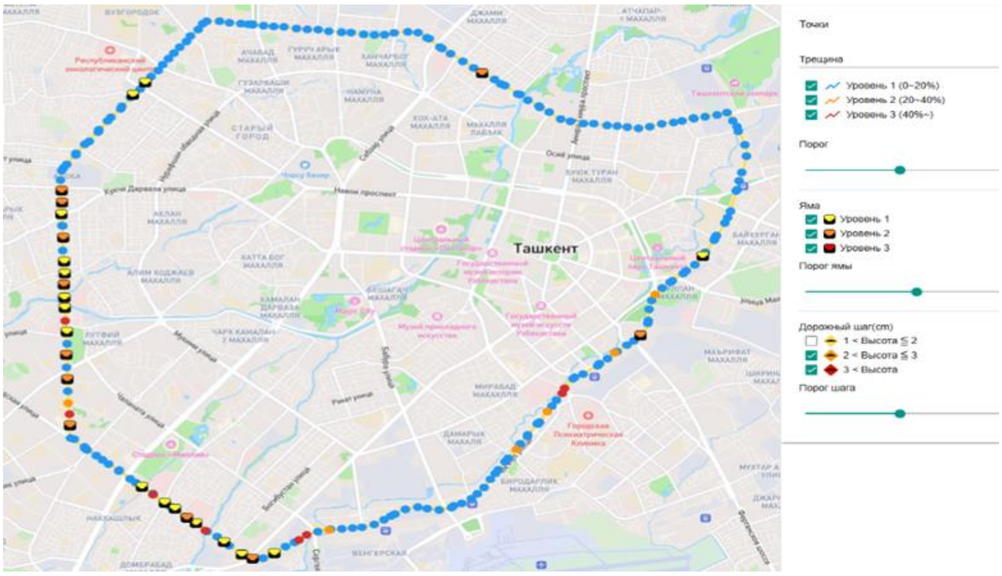

Fig. 3. Map of Pavement Distresses Identified Along the Small Road in Tashkent City Using the Ge-Road Mobile Application

The monitoring results were visualized on the map using a three-level severity classification system for cracks, potholes, and pavement deformations. These data were subsequently adapted to the requirements of the ASTM D6433 methodology and used as the basis for PCI calculation [3].

DISCUSSION AND RESULTS

Determination of Deduct Value (DV) According to the ASTM D6433 Methodology. After the pavement distresses identified through the Ge-Road mobile application were classified in accordance with the ASTM D6433 standard, Deduct Value (DV) scores were determined for each distress type. According to the ASTM D6433 methodology, the deduct value depends on the type of distress, severity level, and distress density, and is obtained using standardized deduct value curves.

In this study, three of the most frequently observed pavement distress types were selected for pavement condition evaluation:

- Longitudinal and Transverse Cracking;
- Potholes;
- Rutting

These distress types were analyzed to determine their respective deduct values, which were subsequently used in the calculation of the Corrected Deduct Value (CDV) and the final Pavement Condition Index (PCI).

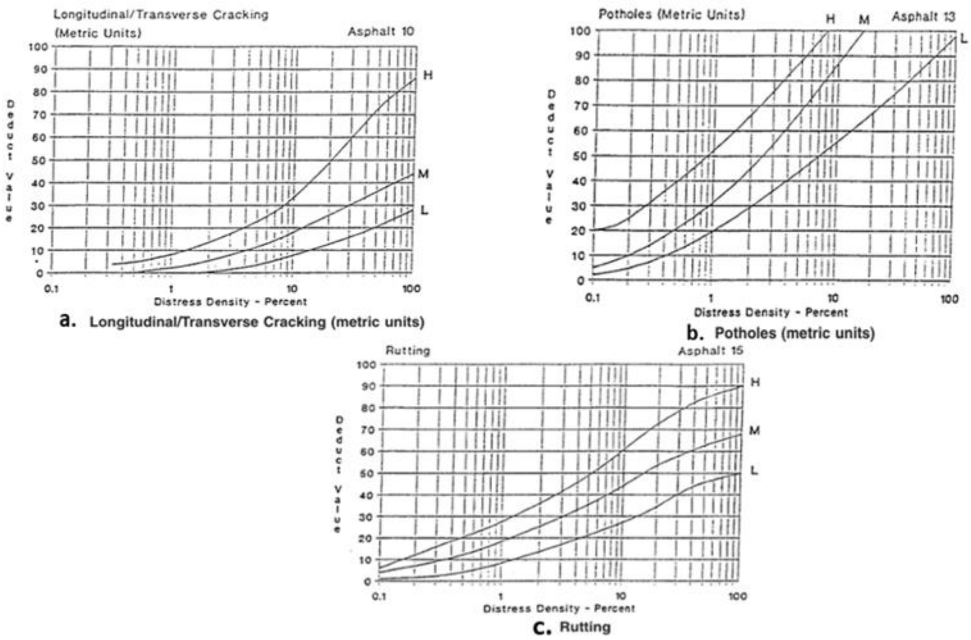

Fig. 4. Deduct Value Curves for Cracks, Potholes, and Rutting Deformations According to the ASTM D6433 Methodology

For each distress type, the severity levels (L, M, H) and density (%) values obtained from the Ge-Road system were entered into the ASTM D6433 deduct value curves, and the corresponding deduct value scores were determined.

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Determination of Total Deduct Value and Corrected Deduct Value

The deduct value scores identified for each section were summed to calculate the Total Deduct Value (TDV). However, according to the ASTM D6433 methodology, the combined effect of multiple pavement distresses cannot be accurately represented by a simple summation. Therefore, the TDV values were adjusted using the Corrected Deduct Value (CDV) correction curves.

To determine the CDV, a special graph provided in the ASTM D6433 standard was used. In this graph, the horizontal axis represents the Total Deduct Value (TDV), while the vertical axis represents the Corrected Deduct Value (CDV). The parameter q denotes the number of distress types with deduct value scores greater than 2.

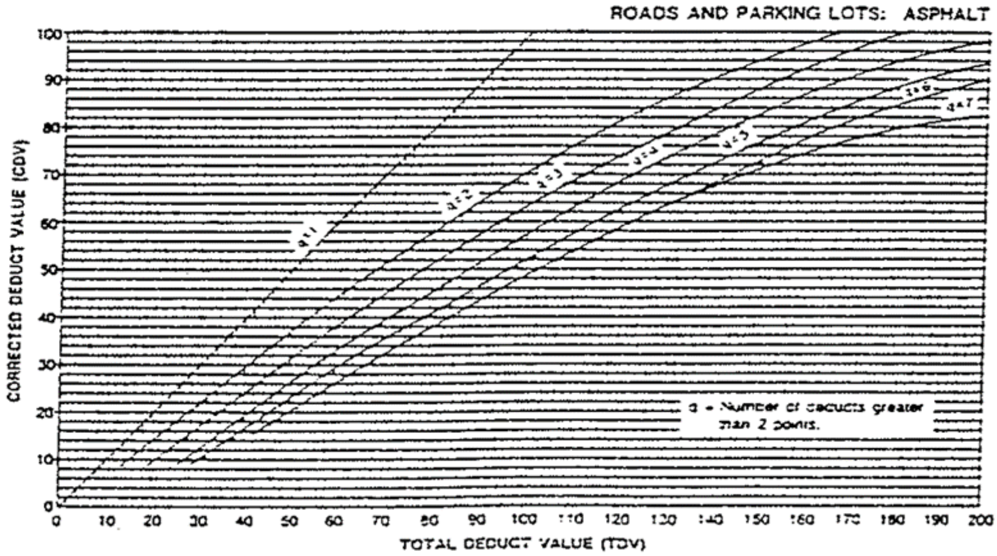

Fig. 5. Graph for Determining the Corrected Deduct Value (CDV) According to the ASTM D6433 Methodology

Calculation of the Pavement Condition Index (PCI)

After determining the Corrected Deduct Value (CDV), the pavement condition was evaluated using the Pavement Condition Index (PCI) in accordance with the ASTM D6433 methodology.

$$PCI=100-CDV \quad (1)$$

where:

PCI — Pavement Condition Index;

CDV — Corrected Deduct Value.

The PCI ranges from 0 to 100. A higher PCI value indicates a better pavement condition (1).

Excel-Based Automated PCI Calculation Model

The manual calculation of PCI according to the ASTM D6433 methodology involves multiple steps and requires processing a large volume of data. To simplify the calculation process, an automated PCI calculation model was developed using Microsoft Excel.

The model requires the user to input the following information:

- distress type;
- severity level (L, M, H);
- density (%).

The program automatically determines:

- deduct value;
- total deduct value (TDV);
- corrected deduct value (CDV);
- PCI value;

and recommends appropriate pavement maintenance and rehabilitation actions.

In this study, the following decision-making criteria were adopted based on the calculated PCI values:

PCI	Recommended Maintenance Action
PCI < 40	Reconstruction
40 ≤ PCI ≤ 70	Repair Works
PCI > 70	Preservation Works

Figure 3.5. Automated PCI Calculation Model Developed Based on the ASTM D6433 Methodology.

Within the scope of this research, an automated calculation model was developed in the Microsoft Excel environment to process data obtained from the Ge-Road mobile monitoring system in accordance with the ASTM D6433 methodology. After entering the pavement distress type, severity level (L, M, H), and density (%), the program automatically calculates the Deduct Value (DV), Total Deduct Value (TDV), Corrected Deduct Value (CDV), and Pavement Condition Index (PCI).

In addition, based on the calculated PCI results, the developed model automatically generates recommendations for pavement preservation, maintenance, rehabilitation, or reconstruction. This approach significantly simplifies the calculation process, minimizes the influence of human error, and improves the efficiency of operational decision-making.

Development of an Automated PCI Calculation Program

As a result of the research, an automated PCI calculation program compliant with the ASTM D6433 methodology was developed using data collected from the Ge-Road mobile monitoring system. The program was created in the Microsoft Excel environment and designed to process key pavement distress data [9].

The developed program consists of the following functional modules:

- Selection of pavement distress type;
- Determination of severity level;
- Input of density value;
- Calculation of Deduct Value (DV);
- Calculation of Total Deduct Value (TDV);
- Determination of Corrected Deduct Value (CDV);
- Calculation of Pavement Condition Index (PCI);

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Operational decision-making and maintenance recommendations.

Automated Pavement Condition Index (PCI) Calculation Tool																	
Input Ge-Road severity and density values. DV, TDV, CDV, PCI and maintenance decision are calculated automatically.																	
Road Section	**Crack Severity**	**Crack Density (%)**	**Crack DV**	**Pothole Severity**	**Pothole Density (%)**	**Pothole DV**	**Rutting Severity**	**Rutting Density (%)**	**Rutting DV**	**TDV**	**q**	**CDV**	**PCI**	**Condition Rating**	**Maintenance Decision**		**Notes**
R/s 1	M	3.00	8	M	0.10	4	L	2.00	14	26	3	12	88	#NAME?	Preservation works / eliminate detected distress		
R/s 2	L	6.00	5	L	0.20	6	L	1.00	9	20	3	12	88	#NAME?	Preservation works / eliminate detected distress		
R/s 3	L	8.00	7	L	1.00	20	M	0.80	12	39	3	18	82	#NAME?	Preservation works / eliminate detected distress		
R/s 4	M	8.00	16	M	0.50	14	M	5.00	36	66	4	33	67	#NAME?	Repair works		
R/s 5	L	1.00	0	L	0.20	6	M	0.60	12	18	2	7	93	#NAME?	Preservation works / eliminate detected distress		
R/s 6	H	27.00	45	M	1.00	24	L	0.50	5	74	3	44	56	#NAME?	Repair works		
R/s 7	H	10.00	33	L	0.80	12	L	0.70	5	50	3	31	69	#NAME?	Repair works		
R/s 8	L	4.00	3	L	0.30	6	L	0.80	5	14	3	5	95	#NAME?	Preservation works / eliminate detected distress		
R/s 9	M	25.00	25	M	0.30	10	M	2.00	25	60	3	37	63	#NAME?	Repair works		
R/s 10	L	4.00	3	M	0.20	10	L	2.00	14	27	3	12	88	#NAME?	Preservation works / eliminate detected distress		
										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		
										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		
										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		
										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		
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										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		
										0	0	0	100	#NAME?	Preservation works / eliminate detected distress		

Fig.6. Interface of the Automated PCI Calculation Program Developed in Accordance with the ASTM D6433 Methodology

As part of this research, an automated PCI calculation program was developed to process pavement condition data obtained from the Ge-Road mobile monitoring system in accordance with the ASTM D6433 methodology. Developed in the Microsoft Excel environment, the program automatically computes the Deduct Value (DV), Total Deduct Value (TDV), Corrected Deduct Value (CDV), and Pavement Condition Index (PCI) based on the pavement distress type, severity level, and density values entered by the user.

3. Conclusion

This study investigated the possibility of processing pavement distress data collected through the Ge-Road mobile monitoring application and automatically calculating the Pavement Condition Index (PCI) in accordance with the ASTM D6433 international standard. During the research, the pavement distresses identified by the Ge-Road system were matched with the corresponding distress types defined in ASTM D6433, and an algorithm was developed for determining the Deduct Value (DV), Total Deduct Value (TDV), and Corrected Deduct Value (CDV) required for PCI calculation.

As a key outcome of the study, an automated PCI calculation program was developed in the Microsoft Excel environment. The program enables the automatic determination of PCI values and recommended maintenance actions based on the pavement distress type, severity level, and density values entered by the user.

The proposed approach simplifies the multi-stage calculations required by the ASTM D6433 methodology, reduces computation time, minimizes the influence of human error, and enhances the practical utilization of data obtained from the Ge-Road mobile monitoring system. The developed program can serve as an effective tool for road agencies to rapidly assess pavement conditions, identify maintenance needs, and support the digitalization of pavement management and operational decision-making processes.

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Information about the author

Mukhammad Malikov	Tashkent State Transport University, the department of “Urban infratructure engineering and artificial intelligent” assosiate professor, (PhD) E-mail: malikovmukhammad@gmail.com Tel.:+998939558844

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	https://orcid.org/0000-0002-2175-6240	
Fakhriddin Jumaev	Tashkent State Transport University, the department of "Urban infratructure engineering and artificial intelligent", Master's student	E-mail: fakhriddinjumayev02@gmail.com Tel.:+ 998990134301

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