Journal of Civil Engineering and Applications

E-ISSN: 2707-8396
P-ISSN: 2707-8388
www.civilengineeringjournals.com/jcea
JCEA 2024; 6(2): 34-44
Received: 04-06-2025
Accepted: 10-07-2025

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Evaluating the flexible road pavement condition index theoretically and using micro-paver software: Case study in Baghdad, Iraq

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DOI: https://www.doi.org/10.22271/27078388.2025.v6.i2a.53

Abstract
The pavement condition index (PCI) is a quick, appropriate, and inexpensive technique of assessing the degree of pavement surface distress brought on by upkeep and rehabilitation. It may also be used to forecast whether or not the maintenance budget is enough. This study assesses the state of the flexible pavement distresses that are now present in Baghdad Iraq furthermore, to identify practically solution of road distress, and Providing recommendations for the required maintenance work according to the condition of the road from Ministry of Water Resources Staff Complex to Alzaytoon intersection in Abo Ghreeb about 7.06Km total length that was inspected according to ASTM as well as in the Micro-Paver software in this research. Assessment revealed variety distress; as a result, PCI values (52-70) were in good shape and, in the end, compared fairly with all road networks.

Keywords: Flexible pavement evaluation, micro-paver software, Pavement condition index (PCI), visual condition survey

Introduction
An indicator of the condition of the pavement, the pavement condition index (PCI) is among the most often used efficiency. Measurements of pavements [1]. The pavement's efficiency level is defined by its capacity to meet the needs of road users over its design life. A key part of any pavement management system (PMS) is the forecast of the pavement performance level or degradation [2]. The pavement maintenance management system (PMMS) is a mechanism for inspecting and assessing the condition of a certain area's pavement. A cost-effective study of various maintenance and restoration options is also performed by the system 3PCI is a numerical metric used to assess the surface quality of pavement. Based on the distresses seen on the pavement surface, the PCI provides an indication of the present pavement status. It also displays the road surface's structural soundness and operational state. The PCI cannot directly assess surface roughness or skid resistance, nor can it provide an indicator of the road's structural capability. It provides a logical and impartial foundation for establishing priorities and requirements for upkeep and repairs. The rate of pavement deterioration is measured continuously using PCI, which enables the early detection of major restoration needs. The PCI is a potent indicator that provides input on pavement performance for the purpose of validating or improving current pavement design and maintenance procedures [5]. An urgent problem in infrastructure maintenance is the deterioration of road pavements brought on by environmental causes, which calls for accurate pavement distress detection [11]. An essential component of pavement management systems' decision-making process is an evaluation of the pavement's condition. In Chapter 3, Basic Components of Pavement Management System 30, it provides a quantitative criterion for evaluating the degradation of pavement sections across the whole pavement network [12].
The PCI scale typically ranges from 0 to 100, shown in figure (1) with higher values indicating better pavement condition and lower values indicating poorer condition. Here's how it breaks down**.**

- **0-25:** Failed to Serious, requiring major repairs or complete replacement.
- **26-50:** Poor, requiring significant repairs.

- **51-70:** Fair, may need preventive maintenance.
- **71-85:** Satisfactory, minor issues but generally serviceable.
- **86-100:** Good, no significant issues.

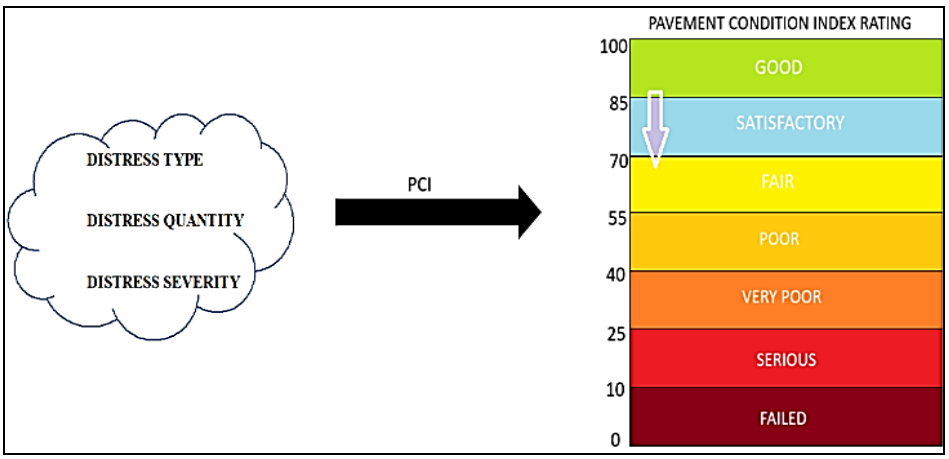

Fig 1: pavement condition index (PCI) scale

The PCI is determined through a combination of visual inspection and analysis of distress data. The collected data is then used to create a comprehensive pavement management system (PMS) that prioritizes maintenance actions and allocates resources effectively. This index is a key tool for maintaining infrastructure and extending the lifespan of roadways by enabling timely and cost-effective maintenance strategies.

A software program that guarantees that all pavement sections are maintained at suitably high serviceability levels and structural conditions with minimal expenditure of funds and resources is an effective pavement management system (PMS) [10].

Networks, branches, and sections form the hierarchical framework upon which the section, the smallest controlled unit in PAVER inventory management, is based. With the help of this framework, users can easily organize their inventory and store pavement data in a variety of variables and levels. It serves as a tool for decision-making on the creation of alternatives for reasonably priced parking lots, airports, and road and street upkeep and repair. According to the [8], PAVER provides many essential characteristics. To maximize the use of resources saved for pavement repair work, the PAVER and Micro-PAVER Pavement Maintenance and Management Systems were developed. [9].

Methodology

Research Problem

The route that connects the Abu Ghraib neighborhood, which is situated in the extreme west of the Baghdad Governorate, to the city center was the subject of this investigation. Because so many vehicles, including workers, transport trucks, and employees, reach the capital's core, this road is deemed essential. The portion will be examined and the pavement condition index (PCI) will be assessed because of its significance. Additionally, data is entered into the Micro Paver software to produce results, which are then compared to computations done by hand.

Research Design

This study report used an experimental design as one of the research methodologies. In order to accomplish the goals of evaluation and maintenance policy development, the PMMS [21] presented a technique that can be assessed and maintained pavement section as well employed in this study work.

Description of the Selected Road

The research region has been selected as the Baghdad Governorate, Iraq's capital city and republic. It's positioned in the center of Iraq. The geographic coordinates of the governorate are (44°25'59.99") longitude, (33°19'59.99") latitude, and (44°25'59.99") above sea level (43 meters) on average. A portion of Baghdad City's main road network, which consists of urban areas with a variety of pavement kinds and distresses, is included in the research area (chosen road). The segment begins at the Ministry of Water Resources or the Alamal Alshaby intersection in the Al-Amiriya area and concludes at the Al-Zaytoun intersection in the Abu Ghraib area. It is a two-way urban road with two lanes, a total length of 7.02 km, and a width of 14.5m. The road divided into 3 sections (A, B, and C) shown in figure (2).

Fig 2: Description of field area in three sections.

Determination of PCI method

A visual condition survey is a technique for examining pavement surface distress that can give the maintenance department the necessary information. Based on this information, decision makers can determine the current state of the road, predict its future state, and specify and "prioritize" road M-R because all pavement M-R requires it. Design the cost treatment and quantities, and seek into the performance of several MR materials and methods.

The military and the paving industry may visually examine the current state of roads using PCI, an international technique. This approach was also used in this article and was first presented by [4], [5], and [6].

The road network must first be split up into branches in order to evaluate the pavement surface. Each branch must then be further subdivided into sections, and each section must be further subdivided into sample units, which are the smallest part of the pavement network.

- Determined the density of distress [7].
- The deduct value was specified using the deduct value curves for various distress types and distress intensities.
- The sum of each individual deduct value is used to calculate the total deduct value (TDV) [7].
- Correction curves must be used to indicate the Correct Deduct Value (CDV) during TDV computation. When deduct value exceeds the CDV while defining the CDV, the CDV is set up to match the greatest individual deduct value [7].
- Although PCI was computed using the pertinent formula

PCI = 100-CDV eq (1) [7],

- The whole sample unit is randomly surveyed. The PCI section of road surface is determined by averaging the sample units' PCI. Weighting of additional sample units is required. The weighted averages are derived using this equation.

$$PCI_f = \frac{N-A}{N} * PCI\ 1 + \frac{A}{N} * PCI\ 2 \qquad \text{eq (2)}$$

In this equation, (PCIf) represents the road section PCI and PCI1 represents the random average PCI. PCI 2 represents further samples of average PCI. N represents the total number of samples in the section, whereas A represents the number of extra samples that were examined.

To compute the percentage of density, divide the number of distress types at each severity level by the sample unit's entire area and multiply by 100.

Using Figures (4-12) calculate the deduct value for each distress severity and type level.

PCI value data gathering on a route segment

First and foremost, the sample size needs to be appropriatelypicked, which is why the road has four lanes; its overall width is 14 m, and the pavement's land is 80 m. The sample's result is equivalent to (14 m * 80) = 1120$m2$. Additionally, to determine the sample units that should be chosen for analysis.

The total number of samples (N) in a branch must be divided by the branch's length by the sample's length, as the context below illustrates.

$$N = \frac{Length\ of\ section}{Length\ of\ the\ sample} \qquad \text{eq (3)}$$

$$N = \frac{1835}{80} = 22.94 \cong 23\ Samples \text{ in section A}$$

It can choose the smallest number of sampling units to be seen, as seen in Figure 3. The PCI rate into the road section, or the PCI of the smallest sample unit less the PCI of the greatest PCI sample unit, should be 25 for the asphalt surface based on the performance in the initial inspection. It is important to return to Figure 3, begin over on the N scale, to the curves for PCI rates more than 25, read the number of samples for inspection on the n scale, and determine the additional sample involved whenever the PCI rate exceeds 25.

Following the suitable curves vertically (PCI rate = 25) and reading 9 on the scale, 23 samples were taken based on the N scale Figure 3 to determine the sample size for the road that begins at the Ministry of Water Resources Staff Complex and ends at the Alzaytoon intersection in Abo Ghreeb. It implies that 15 sample units need to be polled. The following equation must be used to select and compute the units in the spacing interval (i).

i= N/n eq (4)

i= 23/9 ≈ 4 m (for Section A)

It means later 4m step would be took a sample from the pavement network of Abu Ghareeb city, and start randomly survey from sample 2 and it only lasting 22 samples in section A of the hole highway such as 2 + 4 = 6 and 6+4 = 10, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60), and 92 respectively.

The following data sheet represents the fieldwork and section evaluation for pavement condition index (PCI), which includes determining the section area and determining the types of distress occurring in the surface layer of the pavement, such as block crack, bleeding, long & trans crack, etc. In addition to that, determining the severity value for each distress type and the density value to obtain the deduct value (DV), after that finding the maximum number of deducts for a sample unit, including fractions depending on the highest deduct value, then performing a correction process to obtain the corrected deduct value (CDV) value.

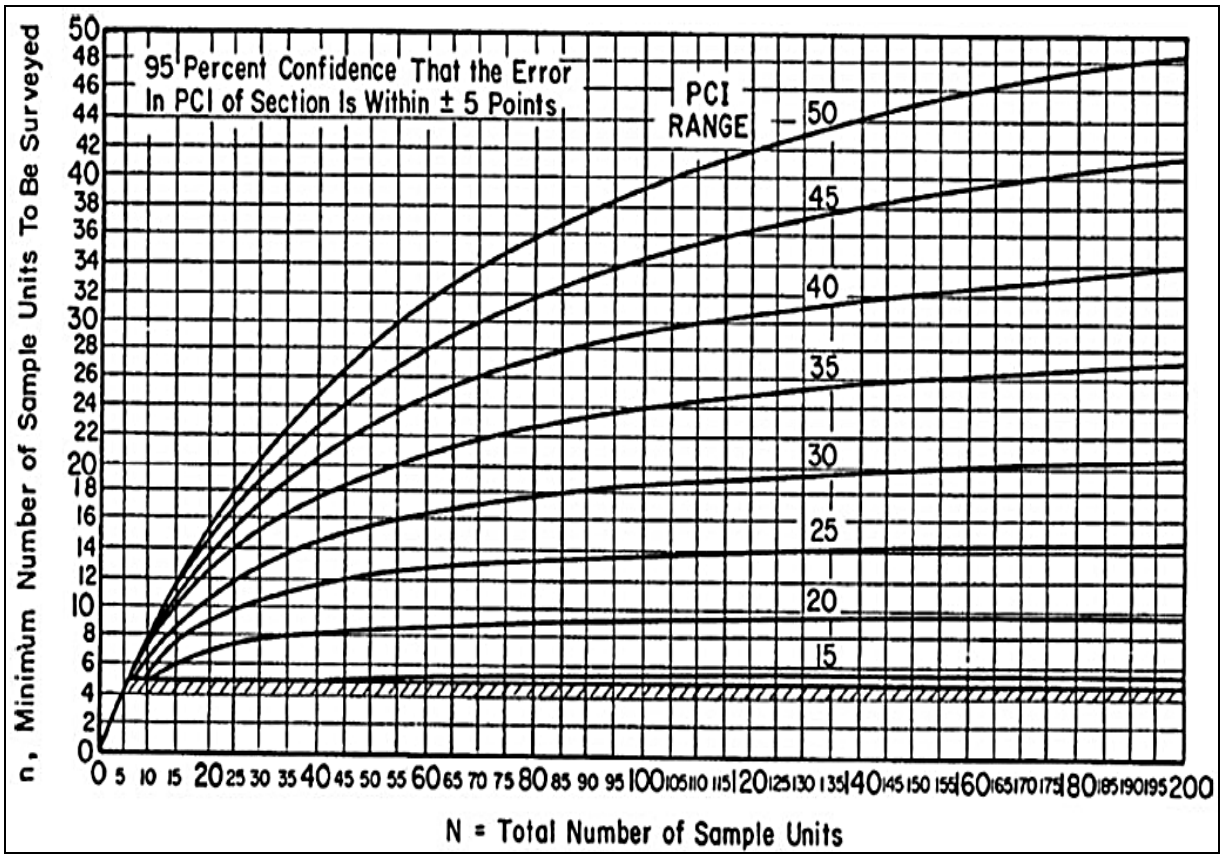

Fig 3: indicating the number of sample units that will be examined [6].

Table 1: Units of area and length for each surface distress type.

S. No.	Distresses type	Measure Unit
1	Edge Cracking, Lane Shoulder Drop Off, Long. & Trans. Cracking, Reflection Cracking	Meter Length
2	Potholes	Number
3	Swell, Rail Road Crossing, Shoving, Rutting, Polished Aggregate, Patching & Utility Patching, Depression, Corrugation, Bleeding, Weathering/Raveling, Bumps and Sags, Slippage Cracking, Alligator Cracking, Block Cracking	$Meter^2$

The authorized pavement index table (2), which shows the survey values for the deformations occurring in the pavement's surface layer and indicates the kind, density, and severity of each deformation, is evaluated in the table that follows. The coordinates of the section where the sample was surveyed are also included.

Table2: Pavement condition index (PCI) data sheet

Asphalt Surfaced Roads Condition Survey Data Sheet for Sample Unit	Sketch: L=80M W=14M
Branch: Abu Ghareeb Road Section: A Sample Unit: 2-92 Surveyed By: Noor Aldeen. N. Date: 10/4/2025 Sample area:1120m^2	

1.Alligator cracking 2. Bleeding 3. Block cracking 4. Bumps and sags 5. Corrugation 6. Depression 7. Edge cracking 8. Reflection cracking 9. Lane/shoulder drop 10. Long & Trans cracking 11. Patching &Utility patch 12. Polished Aggregate 13. Potholes 14. Railroad crossing 15. Rutting 16. Shoving 17. Slippage Cracking 18. Swell 19. Weathering/Raveling

Location	Distress severity	Quantity			Total	Density%	Deduct value
Sec. (A) location coordinates Start Latitude: 33°18'25.65"N Longitude: 44°16'26.66"E End Latitude: 33°18'46.15"N Longitude: 44°15'18.92"E	3M	7*11.4			80	7.14%	12.5
	4H	7*0.17			1.20	0.11%	21
	10M	35			35	3.125%	17
	12L	7*65			455	40.625	5
							Total deduct Value (TDV)=54.5
	mi= 1+(9/98) * (100-HDV)… eq(5) Where: m: The maximum number of deductions, including fractions, for a sample unit. HDV: stands for "highest individual DV. mi= 1+(9/98)*(100-21) = 8.25 > q=4, OK q: numbers of deducts values from Chart q with TDV we can find the CDV =30 PCI= 100-CDV= 100-30=70						

Results and Discussion

Results of field evaluation for pavement condition index (PCI)

The road survey and evaluation were carried out by a hired civil engineer, specialized in road and bridge engineering, with supervision of the work on 9/4/2025, where differences were found between the sections (A, B, and C) in terms of distortions in the paving layer, as section C contains more distortions than the other two sections, A and B, where distortions such as block cracking, bumps and sags, longitudinal and transverse cracking, and polished aggregate (3M, 4H, 10L, 12L) Also, distress was observed in all sections, such as bumps and sags, potholes, long & trans cracking, weathering and raveling, and block cracking in different severities. The figures (4-7) showed the density of all distress type.

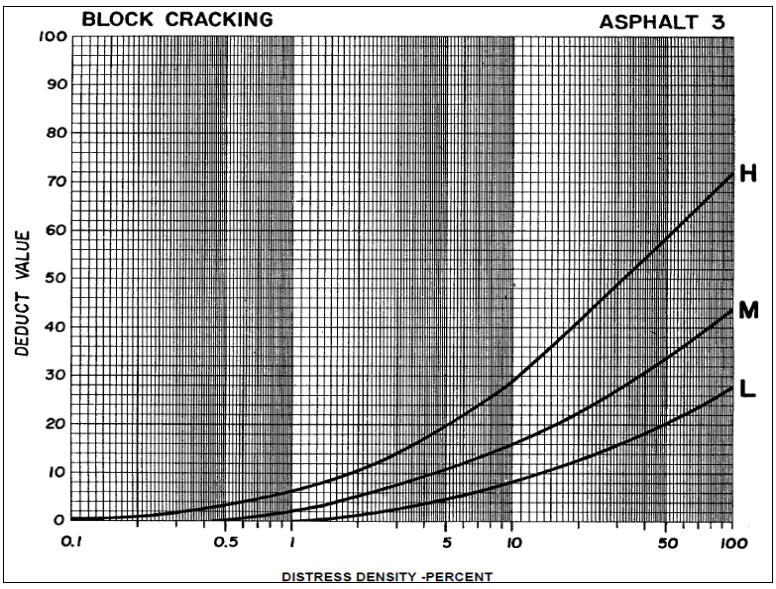

Fig 4: Desnsity for Block Cracking [6]

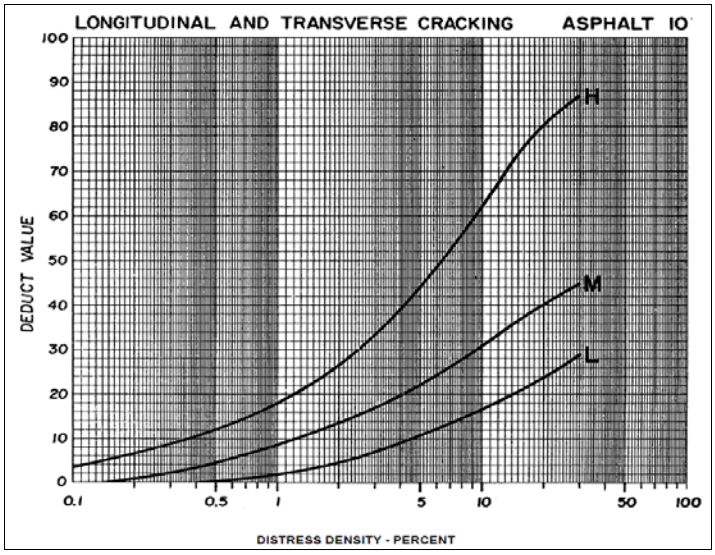

Fig 5: Density for Long.and Trans. Cracking [6]

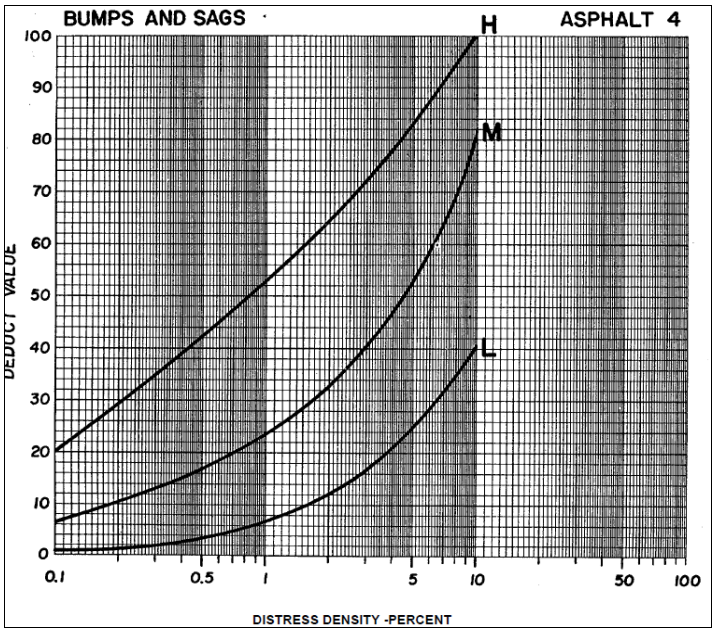

Fig 6: Density for Bumps and Sags [6]

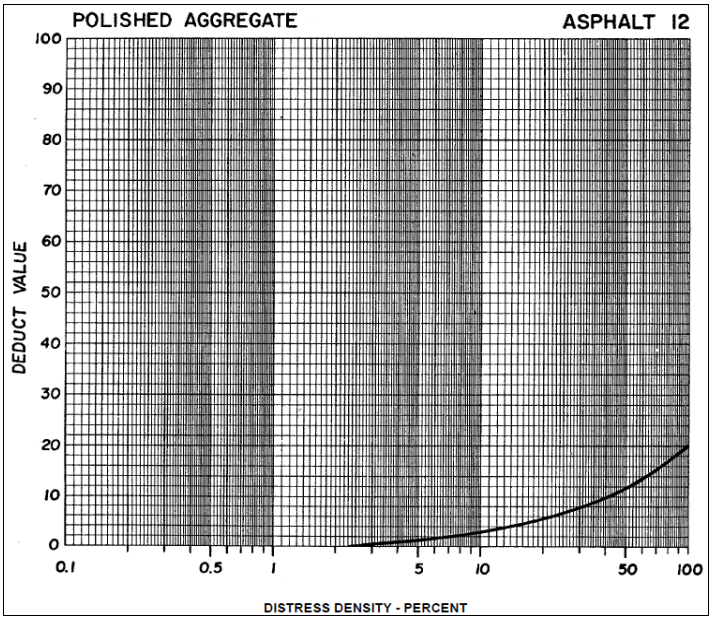

Fig 7: Density for Polished Aggregate [6]

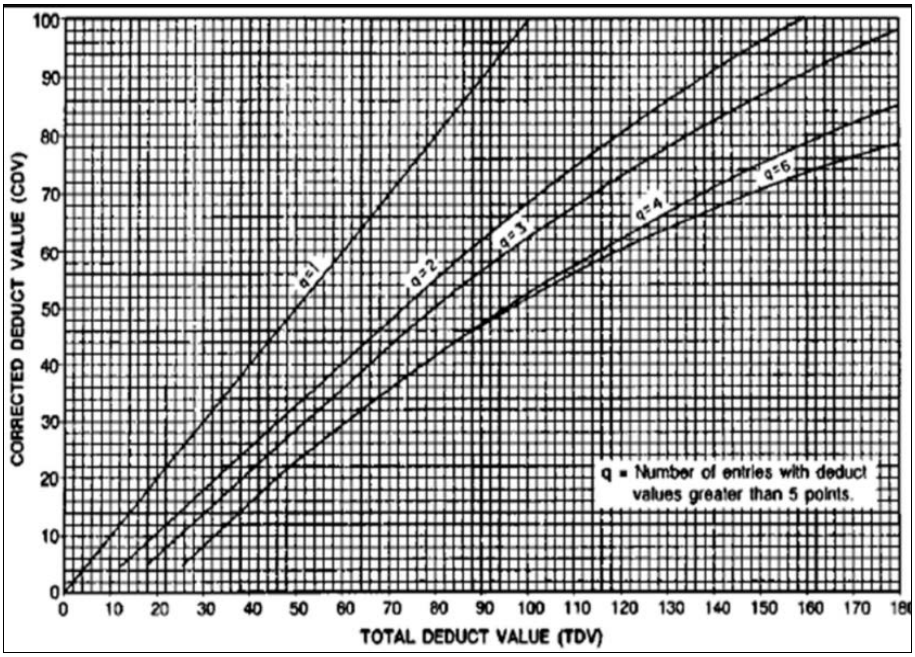

Fig 8: Corrected Deduct Value Chart [6]

Tables attached below (3to5) represent each samples number, area, and pavement condition index (PCI) values for each section, as well as the calculation.

Table 3: pavement condition index values for section (A).

Pavement condition index (PCI) of section (A)				
Section Length 1835 m				
S. No.	**Samples No.**	**Sample unit area, m^2**	**PCI Values**	**Rating**
1	2	1120	70	Satisfactory status
2	6	1120	68	Fair status
3	10	1120	73	Satisfactory status
4	16	1120	61	Fair status
5	20	1120	70	Satisfactory status
6	24	1120	64	Fair status
7	28	1120	77	Satisfactory status
8	32	1120	52	poor status
9	36	1120	59	Fair status
10	40	1120	63	Fair status
11	44	1120	69	Fair status
12	48	1120	70	Satisfactory status
13	52	1120	70	Satisfactory status
14	56	1120	73	Satisfactory status
15	60	1120	69	Fair status
16	64	1120	71	Satisfactory status
17	68	1120	67	Fair status
18	72	1120	76	Satisfactory status
19	76	1120	80	Satisfactory status
20	80	1120	77	Satisfactory status
21	84	1120	74	Satisfactory status
22	88	1120	66	Fair status
23	92	1120	69	Fair status
Average of PCI			69	Fair status

Table 4: pavement condition index values for section (B).

Pavement condition index (PCI) of section (B)				
Section Length 2255 m				
S. No.	**Samples No.**	**Sample unit area, m^2**	**PCI Values**	Rating
1	2	1050	63	Fair status
2	5	1050	64	Fair status
3	8	1050	64	Fair status
4	11	1050	59	Fair status
5	14	1050	69	Fair status
6	17	1050	70	Satisfactory status
7	20	1050	69	Fair status
8	23	1050	60	Fair status
9	26	1050	65	Fair status
10	29	1050	66	Fair status
11	32	1050	60	Fair status
12	35	1050	62	Fair status
13	38	1050	64	Fair status
14	41	1050	65	Fair status
15	44	1050	62	Fair status
16	47	1050	60	Fair status
17	50	1050	59	Fair status
18	53	1050	60	Fair status
19	56	1050	65	Fair status
20	59	1050	69	Fair status
21	62	1050	69	Fair status
22	65	1050	62	Fair status
23	68	1050	60	Fair status
24	71	1050	70	Satisfactory status
25	74	1050	64	Fair status
26	77	1050	69	Fair status
27	80	1050	60	Fair status
28	83	1050	65	Fair status
29	86	1050	68	Fair status
30	89	1050	66	Fair status
Average of PCI			64.26	Fair status

Table 5: Pavement condition index values for section (C).

Pavement condition index (PCI) of section (C)				
Section Length 3030 m				
S. No.	**Samples No.**	**Sample unit area, m^2**	**PCI Values**	**Rating**
1	2	840	65	Fair status
2	5	840	61	Fair status
3	8	840	59	Fair status
4	11	840	65	Fair status
5	14	840	68	Fair status
6	17	840	58	Fair status
7	20	840	65	Fair status
8	23	840	67	Fair status
9	26	840	57	Fair status
10	29	840	61	Fair status
11	32	840	70	Satisfactory status
12	35	840	62	Fair status
13	38	840	66	Fair status
14	41	840	60	Fair status
15	44	840	68	Fair status
16	47	840	69	Fair status
17	50	840	58	Fair status
18	53	840	65	Fair status
19	56	840	57	Fair status
20	59	840	69	Fair status
21	62	840	68	Fair status

22	65	840	55	Fair status
23	68	840	64	Fair status
24	71	840	64	Fair status
25	74	840	56	Fair status
26	77	840	61	Fair status
27	80	840	55	Fair status
28	83	840	61	Fair status
29	86	840	62	Fair status
30	89	840	69	Fair status
31	29	840	67	Fair status
32	32	840	61	Fair status
33	35	840	56	Fair status
34	38	840	62	Fair status
35	41	840	68	Fair status
36	44	840	62	Fair status
37	47	840	55	Fair status
38	50	840	59	Fair status
39	53	840	55	Fair status
40	56	840	68	Fair status
41	59	840	66	Fair status
42	62	840	61	Fair status
43	65	840	60	Fair status
44	68	840	69	Fair status
45	71	840	55	Fair status
46	74	840	58	Fair status
47	77	840	66	Fair status
48	80	840	64	Fair status
49	83	840	60	Fair status
50	86	840	67	Fair status
Average of PCI			**63.42**	**Fair status**

subsequently was assumed that the PCI for flexible pavement in Figure 3 would be 25. However, the result as shown in this matter requires that the PCI be calculated as (Maximum PCI-Minimum PCI) = 48. This requires returning to Figure 3, where at 23 on the N scale proceed vertically, PCI is 45 and n scale is 16. Regarding this, the PCI requires additional surveying, such as (23-9) = 14, but it has been necessary to add 14 samples more, and divided 14 by 3 sections, or 5 samples in each section, table (6) shown the additional samples for all sections.

Table 6: Additional samples for three sections.

PCI of additional samples from three section					
Sample No.	**PCI (A)**	**Sample No.**	**PCI (B)**	**Sample No.**	**PCI (C)**
42	63	42	59	42	67
57	71	57	61	57	66
61	67	61	64	61	69
73	64	73	66	73	57
81	68	81	69	81	61

According to the formula of additional pavement condition index, now finding the PCIf which this equation is used to compute the weighting of PCI by three section pulse addition.

$$PCI_f = \frac{N-A}{N} * PCI\,1 + \frac{A}{N} * PCI\,2 \quad \text{…eq (2)}$$

PCI_f =

Results of PCI using Micro-Paver software

The results of field surveys and manual calculations were found as shown in the tables (2-5) above. Now we enter the same values of the pavement condition index (PCI) into the Micro paver program to obtain a result for the pavement condition index and compare it with the manual calculations to ensure the correctness of the work. If there are large differences, the figures (9, 10) below show the values of the distortions, their severity, and quantity in the table (1). We entered them into the software, and the results were very close and satisfactory.

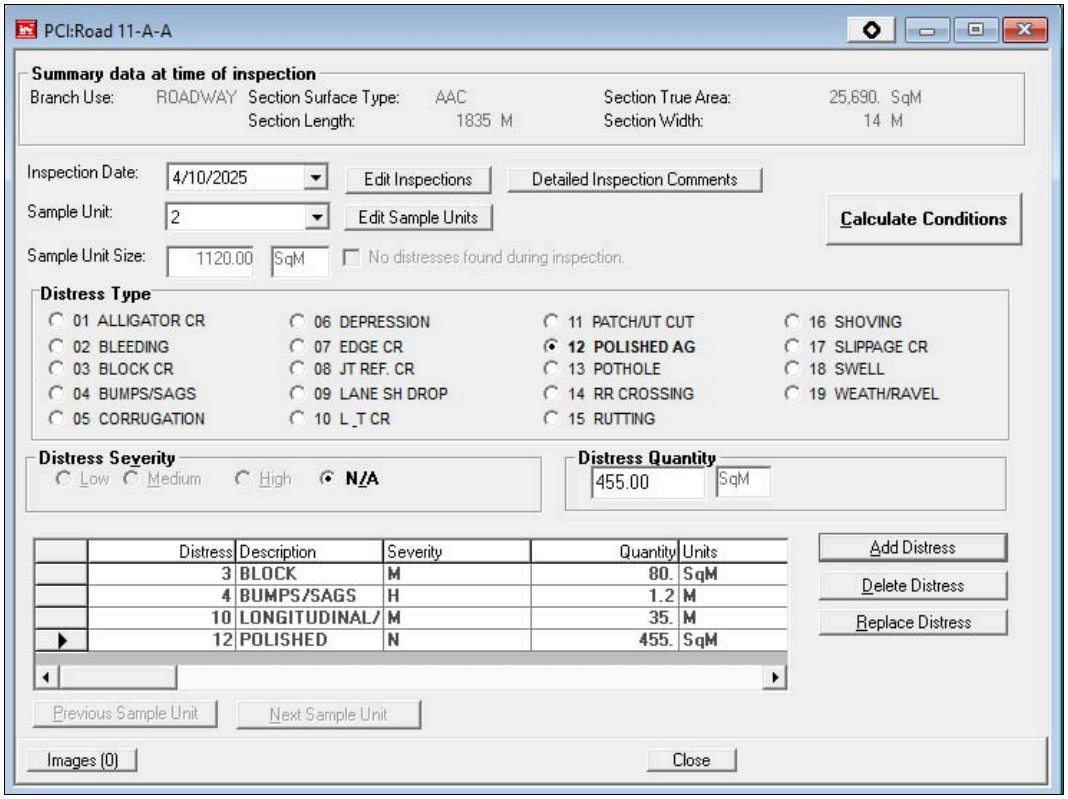

Fig 9: Micro-Paver input data screen to obtain PCI value.

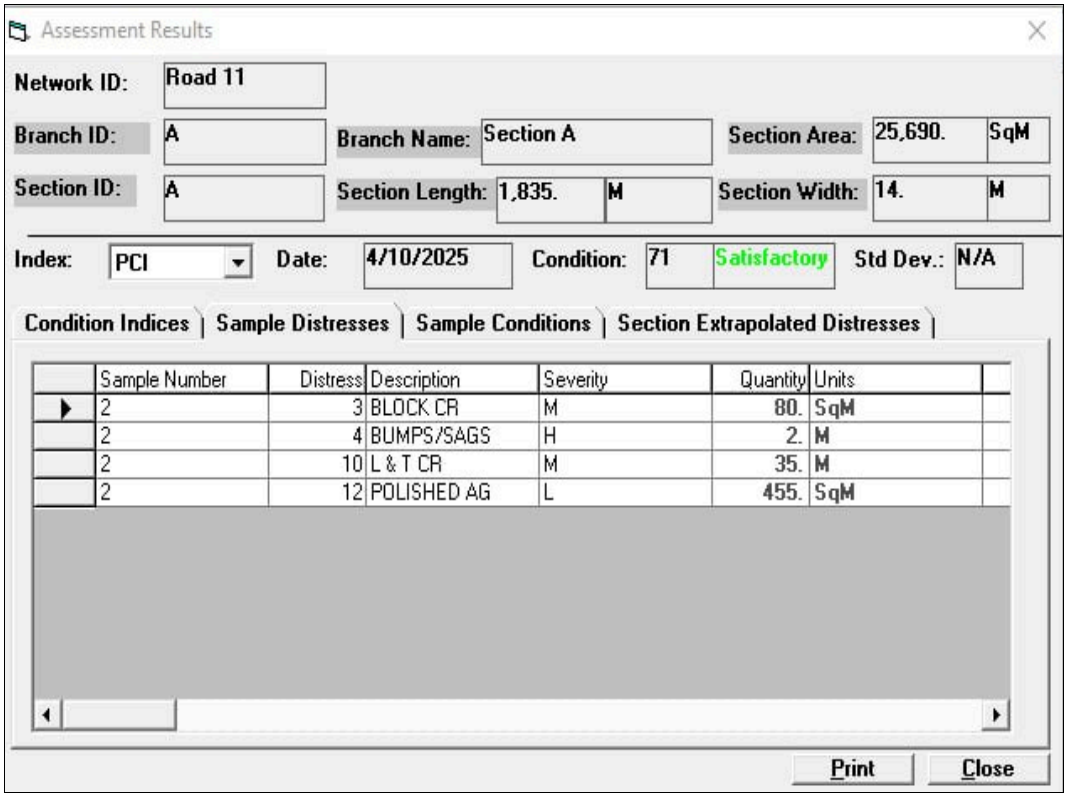

Fig 10: Results of Micro-Paver software

As we see, the result in the manual calculations of the pavement condition index is 70, and in the Micro-Paver software it is 71, which indicates the correctness of the manual calculations.

Conclusion and Recommendations

The research paper evaluated the highway linking Al-Amiriya area to Al-Karkh University of Science and Al-Zaytoun intersection in Abu Ghraib to assess the deformations in the flexible pavement. The three sections that were divided had results for pavement condition index (PCI) ranging from 52 to 80 for section A, 59 to 70 for section B, and 55 to 70 for section C. The road condition is considered to be somewhat satisfactory and needs periodic maintenance, such as treating the potholes in section C and removing the bumps also present in sections A and C. And

carrying out the fog sealing process to renew the road surface and close small cracks, in addition to increasing the road's resistance to water. In addition, the road needs sidewalks. Finally, and most importantly, it is necessary to install traffic signs and emphasize the importance of U-turns on this line because many accidents have occurred due to illegal U-turns. Create a storage lane and signage for safe U-turning. Furnishing the entire road with lighting and emergency stopping spaces on the road shoulders.

Conflict of Interest Statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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