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Evaluation of Pavement Condition Index for Highway Pavement Subjected to Overloading by Using Micro Paver 5.2.3 (Case Study Road No. 80)

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Abstract

The assessment of the pavement condition index (PCI) is one of the main goals of the current research. The best maintenance management procedure and riding level may be attained with the fewest resources and fastest trip times. PCI values play a significant role in determining pavement maintenance, choosing economical alternatives and increasing the development of engineers and technician's capabilities. Using survey data, PAVER software calculates a pavement condition index that should range from (zero) which indicates a failing pavement condition to (100) which indicates a good pavement condition. The state of the pavement helps to foretell the need for maintenance and rehabilitation. Instead of using evaluation technologies, a manual geometry and categories of defects survey were utilized to identify the kind, level of seriousness and defects for sample units along the road. In this research, PAVER 5.2 Program used to determine PCI values for Road No. 80 in Hilla City which is a minor arterial urban roadway The implementation of the PAVER 5.2 Program based on the collection of field inspection data yielded a PCI average value of (63.33) and this indicates that the road in chosen research section was in fair condition.

Keywords: Pavement Condition Index, Pavement Distresses, PAVER 5.2, Flexible Pavement.

1.Introduction

Pavements is the highway systems primary resources. After a highway construction is finished and enters its operational phase, it will be under stresses which generated from amount of traffic, environmental effects, other design, construction and operating conditions that have an influence on it. Therefore, keeping the roadway in good condition with observation are an important matter for maintaining the highest level of service [1].

The Pavement Condition Index (PCI) has been utilized as a pavement condition indicator and one of the most often used performance measurements of pavements [2]. Each sort of distress amount and severity should be included in this index [3]. It measures the situation of the pavement (excellent, acceptable, or bad) with a range of (0 to 100)

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where 0 represents the worst pavement condition while 100 represents the best and forecast maintenance or repair strategies [4].

To determine the current PCI a pavement management, forecast the state of the pavement in the future and choose the most appropriate times and priorities for maintenance and rehabilitation, then the system called PAVER is use. The PAVER software was established by the U.S. Army Construction which developed and validated during the last ten years and is currently being used by numerous organizations globally [5].

Ewadh et. al [6] created a pavement condition index model by employed Paver 6.5.7 for a flexible pavement urban route in heart of Karbala, Iraq. Hussain and Al Jameel [7] searched into types of defects and evaluation of PCI at Ibn Hayan road brunch and Al-Hussain Zone in Al-Muthanna Governorate, Al-Samawa City, Iraq. The length of the examined segment was approximately 1 km with median distances of 3 m and 7.5 m in each direction. If given real data based on an accurate diagnosis, PAVER has been proven to be an effective application for evaluating pavement conditions and for measuring PCI properly and fast.

2. Description of Study Area

Road No. 80 is one of the roads implemented in late 2010 which is connects the Hilla-Karbala road with the Hilla-Najaf road. The implemented roadway section consists of four layers (Binder, Base, and Subbase) with a thickness of (6, 12, 30) cm respectively (Hilla Municipality) with used flexible pavement type. The length of this road is about 10.60 km that starting from Karbala - Hilla to Hilla - Najaf according to the coordinates (32.447121,44.394594) and there are 3 lanes in each direction with 3.65 m wide per lane and shoulder width is 2.0 m for each direction.

Plate (1). Show Study Area (Road No. 80)

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3. Defects of Flexible Pavement

Generally, there are two different forms of distress in flexible pavement as follows [8 ,9]:

Structural Distress: This condition refers when one or more pavement structure layers collapse or break down to the point where they can no longer support the load applied on surface.

Functional Distress: That is functional may or may not be accompanied by structural defect which made driving difficult for vehicle's drivers.

Hot mix asphalt pavement represents a significant portion of highways built in Iraq. Distresses in flexible pavement types have been suggested in this paper which is evaluated by occasion preservation treatments. The procedure of pavement distresses valuation has been known in terms of inspection survey. Lack of a preventive maintenance strategy, poor design, use of low-quality materials, inadequate building methods and weak structural capability are some significant causes of pavement defects. The PAVER 5.2 software categorizes hot mix asphalt pavement surface defects into five major types [10] which there are categories below and (Table 1) shows flexible pavement defects classes.

A. Pavement cracking includes "alligator cracking also known as fatigue cracking, longitudinal and transverse cracking, block cracking, slippage cracking, joint reflective cracking and edge cracking".
B. Surface deformation includes "rutting, corrugations, shoving, depressions, swell, bumps and sags".
C. Disintegration faults that occur from the surface to the lower layers such as; "potholes, patching and utility cut patching".
D. Surface flaws such as "weathering and raveling, bleeding and polishing."
E. Miscellaneous distresses include "lane/shoulder drop off, railroad crossing."

Table (1): PAVER 5.2.3 Classification defects for Flexible-Surfaced Roads and Parking. [11, 12-13].

Code	Distress	Measure Unit	Define severity level	Distress type	Main cause
1	Alligator Cracking	m^2	Yes	Structural	Load
2	Bleeding	m^2	Yes	Functional	Other
3	Block Cracking	m^2	Yes	Structural	Climate
4	Bumps And Sags	m^2	Yes	Structural and functional	Other
5	Corrugation	m^2	Yes	Functional	Other
6	Depression	m^2	Yes	Functional	Other
7	Edge Cracking	m^2	Yes	Functional	Load

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8	Joint Reflection	m^2	Yes	Structural	Climate
9	Lane/Shoulder Drop-Off	m^2	Yes	Functional	Other
10	Longitudinal And Transverse Cracking	m	Yes	Structural	Climate
11	Patching And Utility Cut Patching	m^2	Yes	Structural and functional	Other
12	Polished Aggregate	m^2	No	Functional	Other
13	Pothole	Number	Yes	Structural and functional	Load
14	Railroad Crossings	m^2	Yes	Functional	Other
15	Rutting	m^2	Yes	Functional	Load
16	Shoving	m^2	Yes	Functional	Load
17	Slippage Cracking	m^2	Yes	Functional	Other
18	Swell	m^2	Yes	Functional	Other
19	Weathering And Raveling	m^2	Yes	Functional	Climate

3. Field Measurements

Field measurements used in current research include types of defects, quantity and their severity level as determined by the relevant criteria. Defects existing in this study represented below:

1. **Transverse cracking:** The degree of defects and average crack width based on length and width of the crack. A linear tape measure calibrated in (m) is used to manually measure it.
2. **Longitudinal cracking:** The average crack width influences how many cracks there are. The prevalence and intensity of this category are present on all highway sections.
3. **Fatigue cracking:** The degree of alligator cracking and also known as 'alligator cracking' is indicated by the propagation of cracks within the network. Tape measurement in square meters (m^2).
4. **Potholes:** Their intensity is based on their width and depth while the quantity of distress is determined by their number.
5. **Rutting:** The area of each rut is measured in square meters (m^2) and the average depth of each rut calculates severity.

6. **Edge Cracking:** The average width of this distress defines how severe it is and the amount is measured using a tape in linear (m) units.

7. **Patching:** The driver's ride quality and the amount measured by square meters by tape define the degree of distress in this category.

8. **Raveling:** The quantity of this discomfort is physically measured using tape and represented in square meters (m^2), where the quantity of coarse aggregate lost affects the level of the distress.

9. **Weathering:** The degree to which the asphalt binder and fine aggregate matrix had been worn down was used to gauge the severity of the distress. The amount of this distress is manually assessed using tape and expressed in area unit (m^2).

Longitudinal crack

Alligator crack

Edge crack

Transverse cracking

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Patching

Pothole

Rutting

Raveling

Plate (2). Types of Distress in Study Area

4. Input Data from Results of a Field Survey

The first step is that divide pavement section into sample units. According to Shahin [11] each sample unit has an area of 2500 by 1000 feet (225 by 90 meters). A sample size of 297 m^2 was used for all study area portions. The sample length was then obtained by dividing sample area (297 m^2) by section width, also the total number of sample units in pavement section (N) was computed by dividing the section length by the sample length. In addition, the sampling interval was then computed using i=N/n, and the minimum number of samples (n) by utilizing (Equation 1).

$$n = \frac{N * S^2}{(e2/4)\,(N-1)+S^2} \qquad \text{Eq. (1)}$$

where:

N: The total number of sample units in pavement section.

e: The permitted error in the PCI estimate (often, e=5 [8]).

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s: Standard deviation of the section's sample units (often taken to be 10) [8].

For section one from (Karbalaa Roadway to Tuhmaziya Roadway)

Sample length $=\frac{297}{11} = 27$

$N=\frac{1000}{27} = 37$

$n= 37 * 10^2 / (5^2/4) * (37 - 1) + 100 = 11$

$i= N/n = 37/11 = 3$

Use first sample number 3 after that.

So, numbers of samples (s, s +i, s+2i, s+3i, 1+4i ,s+5i ,s+6i ,s+7i ,s+8i ,s+9i, s+10 i)

Then the sample sequence will be (3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33)

Table (2) Dimension Details of Three Sections of Road No. 80

Road name	Direction	Road length	Road width	Sample unit area(m^2)	Section count	Total sample (N)	Sample surveyed (n)
Road No.80	From Karbalaa Roadway to Tuhmaziya Roadway	4.5 Km	11m	297	5	166	52
	From Al-Tuhmaziya Roadway to Shirefaa Intersection	1.2 Km	11m	297	1	44	12
	From Shirefaa Intersection to Najaf Roadway	5.9 Km	11m	297	5	185	55

5. Paver Software of Calculating PCI

The analysis process was carried out to calculate the PCI as follows:

1. From the Preferences menu (Metric Units) select the measurement unit to be used.
2. Using an inventory menu, enter network, branch and section information as illustrated in (Step 1, 2 and 3) respectively.
3. Using the PCI menu, determine the pavement condition index's value 3.
4. Edit inspections: You can enter the total number of samples for the section analyzed using this command as shown in (Step 4).

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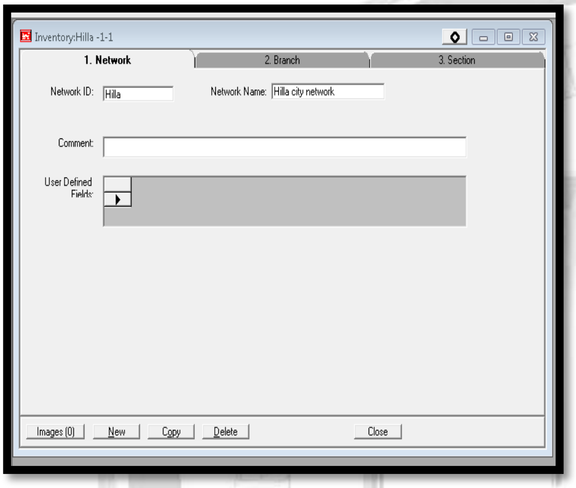
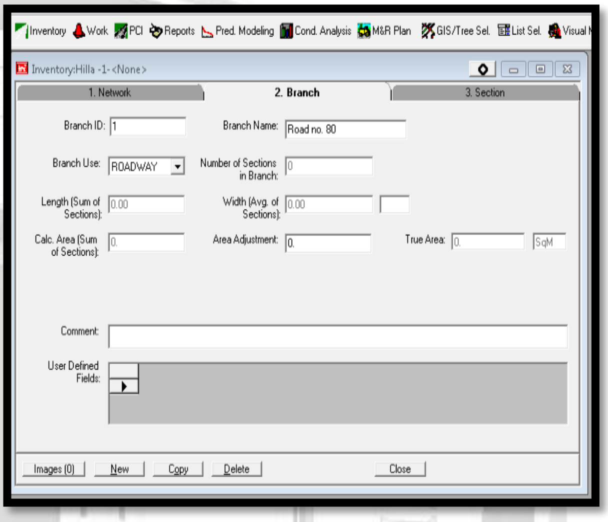
5. Edit the sample units. This command enters the number of inspection sample units and the area of each sample as shown in (Step 5).

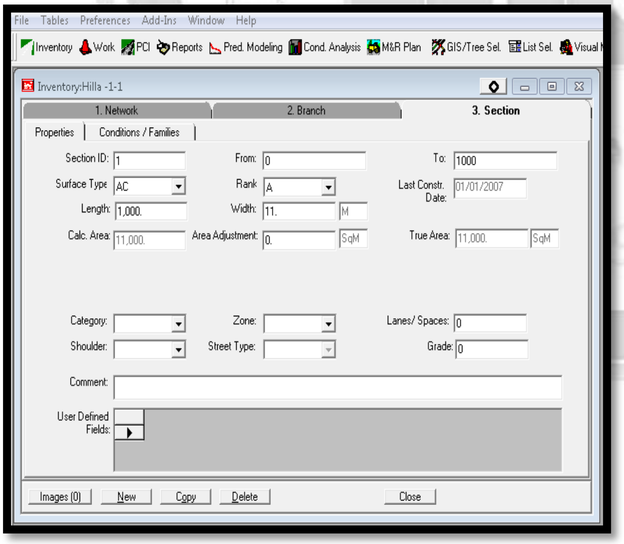
6. Calculate Conditions. Distress type, amount and severity for each inspected units should be added from the PCI menu as shown in (Step 6). Next, use the Calculate conditions command to determine the PCI scale and rating shown in (Step7).



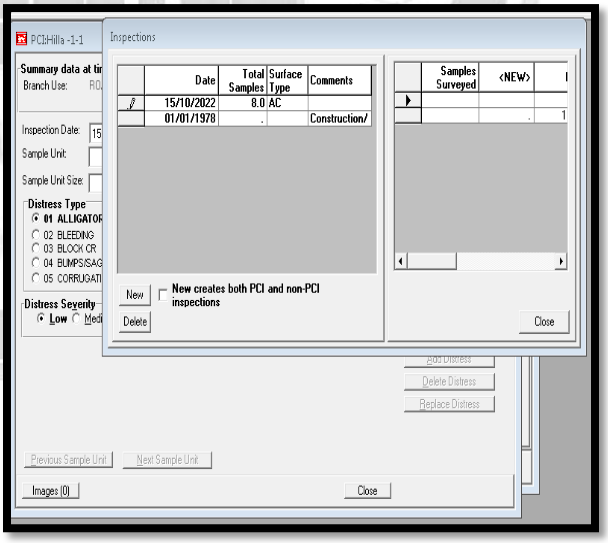
Step 1



Step 2



Step 3



Step 4

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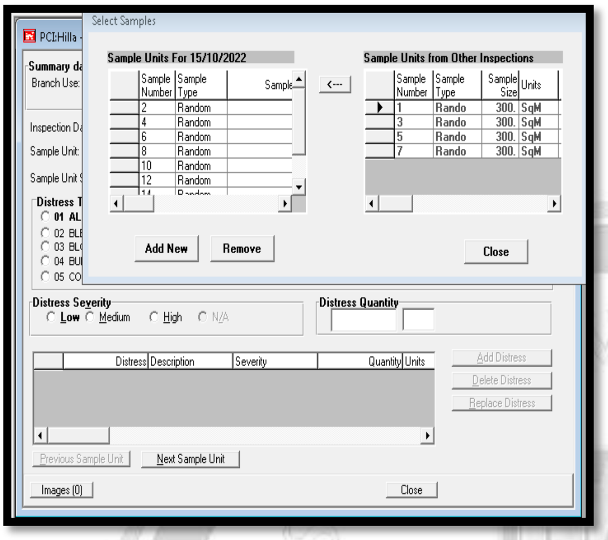
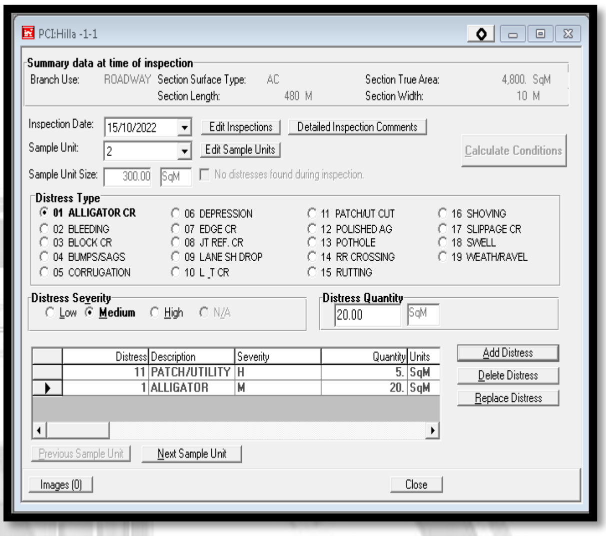
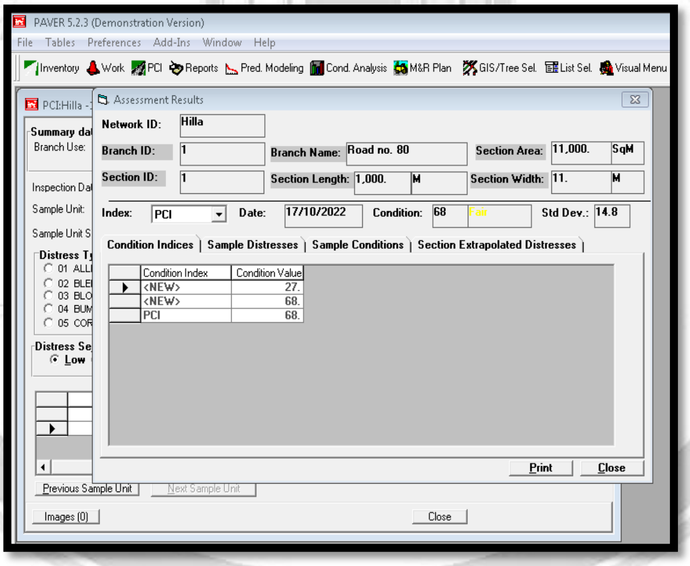


Step 5



Step 6



Step 7

Plate (2). An Application of PAVER of Road No.80 Section

5.1 PAVER Application Results 5.2 Software

Using the steps described above, after entering the data into the PAVER application. The pavement condition index values for Road No.80 for the three sections are shown in (Table 3). Based on results the PCI value for Road No. 80 in direction (Karbala-Hilla to Mall Qariya) indicated that 40% have a" Satisfactory" condition with an average of PCI 68.6, 100% have a "fair" condition in direction (Mall Qariya to Shariefa Intersection) with an average of PCI 61 and for (Sharifa Intersection to Hilla – Najaf) indicated that 100% of the pavement surface area have" Fair" condition with an average of PCI (60.4) as shown in (Figure 1).

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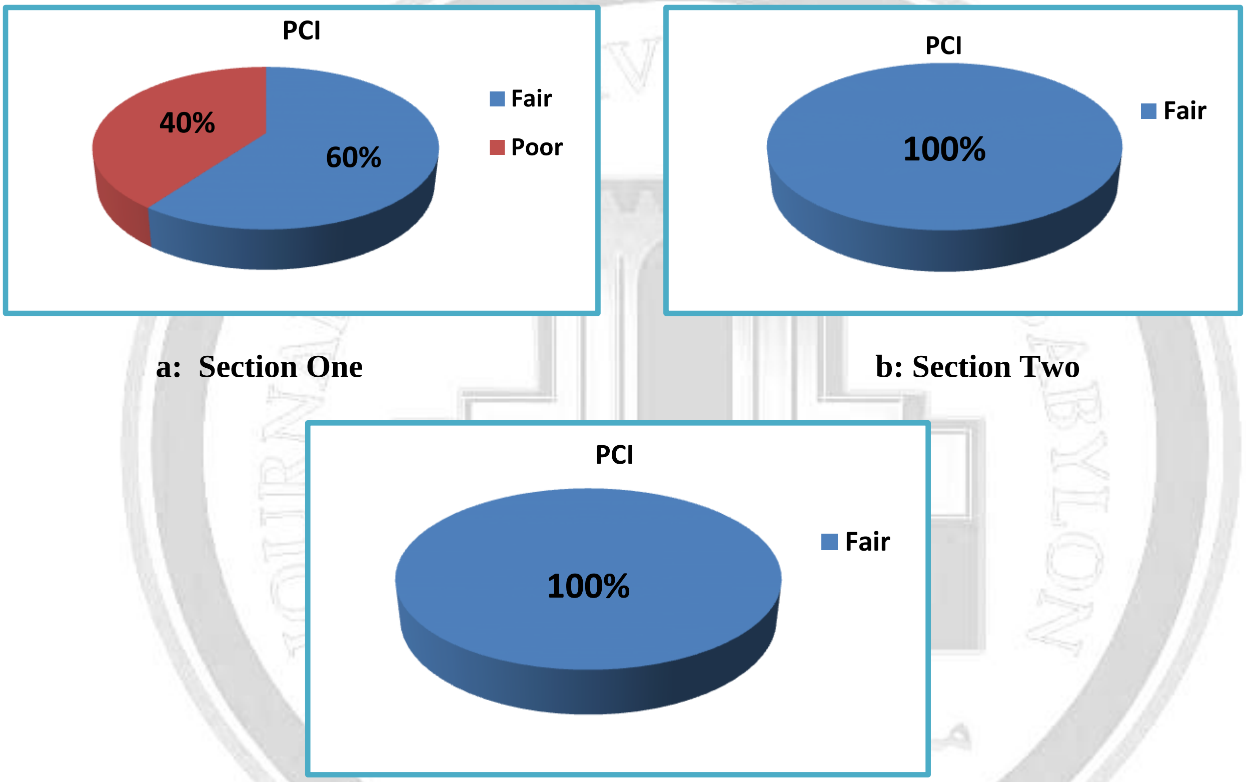
5.2 Section Extrapolated Distresses

When clicks "section Extrapolated Defects", PAVER can calculate section extrapolated distresses directly. Extrapolated defect deductions are divided into load, climate and other categories. (Table 4) shows the projected distresses for each kind in the sample tab for Road No. 80. The primary source of the pavement deformation is depicted in (Figure 2).



a: Section One

b: Section Two

C: Section Three

Figure (1): PCI Distribution of the Road no. 80 at Inspection in Direction (Hilla-Karbala to Najaf-Hilla)

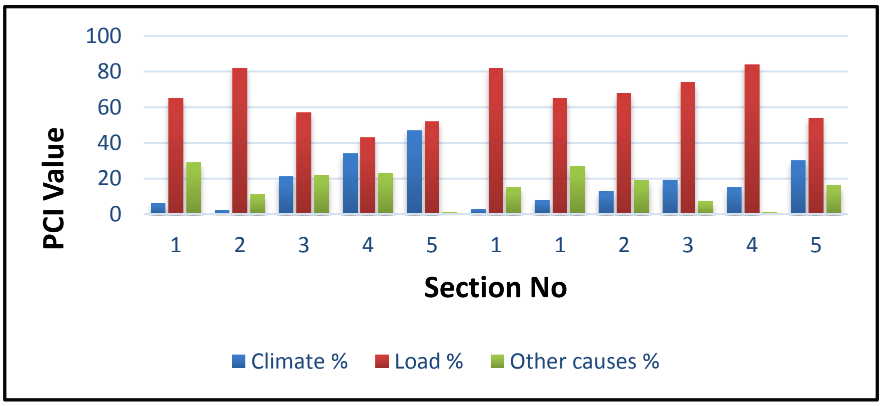


Figure (2). The Primary Contributing Factor of Average Values for Highway Section Pavement Deformation

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Table (3). Results of PCI for Highway Sections Studied

Road Name	Direction	Section No.	PCI	PCI Category
Road No.80	From Karbala –Hilla to Mall Qariya)	1	71	Satisfactory
		2	66	Fair
		3	76	Satisfactory
		4	68	Fair
		5	62	Fair
	From Mall Qariya to Shariefa Intersection	1	61	Fair
	From Sharifa Intersection to Hilla – Najaf	1	58	Fair
		2	57	Fair
		3	63	Fair
		4	63	Fair
		5	61	Fair
Average			63.33	Fair

Table (4). Percent of Extrapolated Distress for Road No. 80 Sections

Road Name	Direction	Section No.	Load %	Climate %	Other Causes %
Road No. 80	From Karbala –Hilla to Mall Qariya)	1	65	6	29
		2	82	2	11
		3	57	21	22
		4	43	34	23
		5	52	47	1
	From Mall Qariya to Shariefa	1	82	3	15

	Intersection				
	From Sharifa Intersection to Hilla - Najaf	1	65	8	27
		2	68	13	19
		3	74	19	7
		4	84	15	1
		5	54	30	16
	Average		66	18	16

* Other factors include all elements other than load and environmental conditions such as (insufficient subgrade support, seepage, water in the pavement layers and building materials and methods).

6. Conclusions

In comparison to conventional approaches, this study's Micro PAVER version 5.2 has a good potential and provides a more precise pavement condition index (PCI) assessment. It is also simpler to use and understand. The major guidance from the examination of field data are as follows:

1. The three sections of Road No. 80's three portions produced fair results for the PAVER software application, with values of 68.6, 61, and 60.4, respectively. In light of this, it can be said that rehabilitation is the most appropriate repair for this part based on the average PCI value.

2. The findings indicated that traffic volume is the leading cause of defects, followed by climate, with the remaining causes having a little impact.

3. It is suggested to perform high quality control during the construction of the roadway project and to apply early maintenance in the case of defect to extend roadway life and decrease maintenance expenses.

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تقييم مؤشر حالة الرصف لأرصفة الطرق السريعة المعرضة للحمل الزائد باستخدامMicro Paver 5.2.3 (دراسة حالة الطريق رقم ٨٠)

عالية جاسم زغير حيدر عباس عبيد
قسم الهندسة المدنية/ كلية الهندسة/ جامعة بابل

الخلاصة

يعد تقييم مؤشر حالة الرصيف (PCI) أحد الأهداف الرئيسية للبحث الحالي. يمكن تحقيق أفضل إجراءات إدارة الصيانة ومستوى القيادة باستخدام أقل الموارد وأسرع أوقات للرحلة. تلعب قيم PCI دورًا مهمًا في تحديد صيانة الرصيف واختيار البدائل الاقتصادية وزيادة تطوير قدرات المهندسين والفنيين. باستخدام بيانات المسح، باستخدام بيانات المسح، يقوم برنامج PAVER بحساب مؤشر حالة الرصف الذي يجب أن يتراوح من (صفر) الذي يشير إلى حالة الرصيف الفاشلة إلى (١٠٠) الذي يشير إلى حالة الرصيف الجيدة. تساعد حالة الرصيف على التنبؤ بالحاجة إلى الصيانة وإعادة التأهيل.. بدلاً من استخدام تقنيات التقييم، تم استخدام المسح اليدوي وفئات من دراسة العيوب لتحديد النوع، مستوى الخطورة والعيوب لوحدات العينة على طول الطريق. في هذا البحث تم استخدام برنامج PAVER 5.2 لتحديد قيم PCI لشارع ٨٠ في مدينة الحلة وهو طريق حضري شرياني ثانوي. أدى تنفيذ برنامج PAVER 5.2 على أساس جمع بيانات المسح الميداني إلى متوسط قيمة PCI وقدره (63.33) و يشير ذلك إلى أن الطريق المختار في البحث في حالة جيدة.

الكلمات الدالة: مؤشر حالة التبليط، عيوب التبليط، مايكرو بيفر ٥.٢، الرصيف المرن.