



Progress Asphaltic Pavement Deformations and Change in Pavement Condition Index in Najaf City

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Abstract

Pavement deformations take a cumulative rate with time, in case of monitoring and providing maintenance activities or not. The rate of progressed deformations depends on the maintenance strategies depended. A numerical index depended in describing pavement condition or in other words the level of pavement deformation, i.e., the pavement Condition Index (PCI). The current paper is a trial in monitoring the progress of asphaltic pavement deformation over five years and finds pavement condition index (PCI) through PAVER software version 5.2 application. PCI values indicate the main aspect of maintenance strategies, evaluating economic alternatives, and improving engineers' and technicians' experiences, which is aimed to discover suitable maintenance process and accomplish comfort riding level or shortest travel time with lowest costs. The selected study area was one urban arterial road in Najaf city, (Najaf-Karbala road segment) liked Al-Askarain Tunnel intersection to the end of Nidaa district, with 8011m length, in addition to four main collector roads divaricate from both sides of it. These road segments are Al-Rahhma, Hezam Al Akhdar, Al Maaridh, and Garage-Al Shamal that extended through 11.54 km length in both directions of movement. Data collected from field survey. Results show the network PCI found equal to 69.8, which mean that the road segments in fair surface condition, progress deformation rate in arterial road segment was 21%, while the average rate for collector segments was 7.5%, the effect of traffic loads on the road surface is more than the effect of other factors for almost studied segments, while, the effect of climate on all road segment Less than the effect of other factors on the roads surface. Although, the use of major road maintenance techniques (overlay) leads to an increase in the value of the PCI and an enhancement in condition of road such as on Hezam Al-Akhdar road Section, but the progress deformation rate happen in high level equal to 9.5%. The road network need rehabilitation maintenance for going toward Najaf- Karbala, Hezam Al-Akhdar Sections for going from Najaf-Karbala direction and Al-Maaridh highway section for two directions.

Keywords: Asphaltic Pavement deformation, PAVER 5.2, progressive deformation, pavement maintenance management system (PMMS), pavement condition index (PCI).

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1. Introduction:

Highway maintenance aimed to achieve a respectable involvement between loading and

environmental conditions from one side, and ride comfort and safety requirements from another side. The increase in traffic load and



repetition, cumulative road mileage, and high commercial vehicle weight, required focusing on maintenance specifications that demonstrate the main factors controlling the necessity of maintenance and rehabilitation, (Almuhanna, et al, 2018). Maintaining road segments and monitoring their deformation is crucial in keeping them at an acceptable level of service. PCI refers to the Pavement Condition Index taking (0 to 100) values, where, value of 100 is the best level and 0 is the worst level of the pavement. PCI provides a range of indications of pavement conditions of good, fair, or poor as shown in figure (1). Pavement condition is essential to predict maintenance or repair strategies necessary to improve safety and comfort presented by pavement (ASTM, 2011). PAVER is a pavement management software that widely depends on estimating PCI and recommends maintenance treatment types in an economical condition.

Effective approaches to maintain process strategies and keep fund resources are pavement maintenance operations (Haas et al, 1994). Flexible Pavement maintenance management system procedure phases for any pavement section, began with evaluating present pavement condition, forecasting new conditions, analyzing choices, and finally selecting a proper rehabilitation strategy (Garber & Hoel, 2008). Furthermore, optimum cost-effective maintenance treatment is the main rule of forecasting pavement condition at a time period, economical approaches, and maintenance practices (TRB, 2005).

In Gaza city- Palestine, a (PMMS) had been done by Micro PAVER and Geo-Media professionals, the study proved that, both programs are dependable and suitable for enhancing the management process, Hallaq (2004). In Irbid city-Jordan, a combination of (GIS) i.e., geographic information system and PAVER software had been investigated to discover technological, programmed, useful, applied, and reliable systems, Obaidat (2012). In the first trial in Iraq, sustainability attention in terms of roadway geometric and

roadway performance could be practical to improve application routines of evaluation and design, Ferman (2016) established model of multi-objective optimization to confirm Iraqi PMS procedure of multi-year decision maker. Knost (2016) applies PAVER software as a (PMMS) to evaluate maintenance decision maker procedure they take regularly. PAVER depended values of PCI to predict deterioration and modeling them, in addition to present maintenance and repair requirements, as well, evaluation future budget requirements. In Karbala city, a PCI model established through PAVER software version 6.5.7 application for flexible pavement, Ewadh et. al., (2017). Al Jameel (2018) take Al-Samawa city in Al-Muthanna governorate, as trial of investigation on a one km branch length, 3m median width, and 7.5m each direction width. The types of distresses and evaluated PCI had been established. Within Al-Kut city, also, in (2018) Al-Neami et al, valuation highway of Al-amarah PCI with GIS system. Another study on pavement condition had been done in Al-Rumaitha within Al-Muthanna governorate, evaluating Al Shahid Mohammed Ali road segment. The segment was 2 km in length divided by median (4m), and each direction was 7.5m in width, Al-jameel (2019). In (2020) Hasan et. Al., investigate PMMS for multilane road sections in Baghdad, depending Micro PAVER software in establishing the surface condition. Mahdi & Shubber 2020, considered PCI values for urban arterial highway in Najaf- city, (Najaf-Karbala) section linked Al-Askarain Tunnel with Nidaa district. Selected section has 8011m, length. As a result of collected data was: PCI was 80. That means the selected road section was evaluated as good condition. Abbas & Shubber, 2021, present a study of assessing PCI for some collectors diverging from the Najaf- Karbala highway. Studied area covers Al-Rahhma, Hezam Al-Akhdar, Al Maaridh, and Garage-Al Shamali road segments with total length of 11.54 km in both directions of traffic movement. The current



research represents the next step of (Mahdi & Shubber 2020) and (Abbas & Shubber, 2021), by investigating the progress distresses and development values of PCI, in addition to checking the effectiveness of maintenance strategies depending on Al Hizam Al Akhdar section. Also, this research focused on suggesting appropriate maintenance. PAVER software is used to find current value of PCI, estimate pavement conditions in the future, and choice maintenance & rehabilitation requests according to alternatives priorities at optimal time. The U.S. Army Construction developed PAVER software, was conventional and substantiated over the past 20 years, furthermore is formerly implemented by almost developed highway organizations worldwide (U.S Army Corps of Engineers, 2011).

2. Study Area:

Figure 2 & Table 1, show the Najaf- Karbala road segment and the four sections diverging from it with their geometric design details.

The study area is located in Najaf city, within Najaf Al-Ashraf governorate. Najaf-Karbala road section was lengthy from Al-Askariin intersection tunnel to the district of Nidaa. The other four road segments lay on Najaf-Karbala both sides.

On Najaf-Karbala right side there are two minor collector, Al-Hezam Al Akhdar road segment, which links Al Askariin tunnel intersection and City Games junction, and Garage-Al Shamali road segment connects the Garage-Al Shamali bridges to the Salam, Jameha, and Wafa intersection. While the other two road segments on Karbala- Najaf right side are Al-Maaridh and Al-Rahhma minor collector road segments. Al-Maaridh road segment joins garage Al-Shamalii bridge through Al-Mohandessin district. Finally, Al-Rahhma road segment joins Al-Askariin tunnel and main entrance of cemetery (wadi- Al-Salam), transient through Al-Rahhma district.

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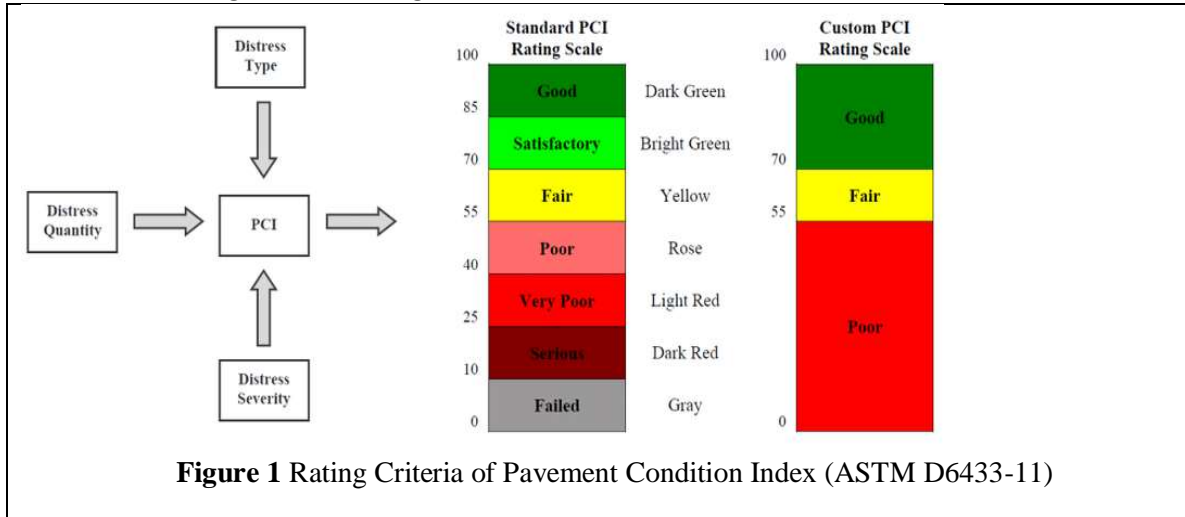




Figure 2 Aerial Shot for Najaf- Karbala highway.

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. Progress Deformation Methodology:

In the present research, in order to evaluate the progress deformation in pavement structure in study area, Field data collection involves distress types, deformation quantities, and severity levels related to distresses conferring to applicable standards

have been done twice. First time as published in(Mahdi &Shubber 2020) and (Abbas &Shubber, 2021), where the field survey had been done in December 2017 by team of training engineer Distresses establish in current research are summarizes in Table 2 below.

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Table 1 Geometric Design of Road segments Selected

Section Name	Total length (m)	Total width (m)	Median width (m)	No. of lane	Lane width (m)	Shoulder width (m)
Najaf- Karbala	8011	27	2.0	3	3.5	2.0
Al Hizam Al Akhdar	1440	28.5	2.5	4	3.25	2.5
Garage-Al Shamali	1930	21.6	1.5	3	3.35	1
Al-Rahhma	1000	15	1	2	3.5	1
Al Muaridh	1400	23.5	1	3	3.75	1

Table 2 Geometric Design of Road segments Selected

No.	Distress	Severity
1-	Raveling	Quantity of coarse aggregate dislodged



2-	Rutting	Quantity is (m ²), severity is average depth and percent of repetition.
3-	Alligator Crack	Quantity square meters,Severity frequently seen in all four road segments.
4-	Transverse crack	Quantity is crack lengthand severity is average width.
5-	Longitudinal crack	Quantity isaverage width of crack.
6-	Edge crack	Quantity is average width.
7-	Potholes	Diameter and depth, quantity of potholes measured by number
8-	Patching and Utility Cut Patching	Ride quality, while quantity is measured by squared meter by tape

4. ApplicationField Survey Results on PAVER (5.2):

First of all, the road section is divided for numbers of sample units, as shahin 2005 methodology,sample area of pavement is 225±90 m². Where the section width usedto find sample length, total number of sample units for each section (N) by divided section length to sample length. Then, calculate minimum samplenumber (n) according to eq.

(1) (shahin 2005), finally, sampling interval equal to $i = N/n$.

$$n = (N * S^2 / ((e^2 / 4)(N - 1))) + S^2$$

.....Eq.(1)

Where:N: Total samplenumber units in the section.

e: Estimate PCI allowable error, used e= 5, (shahin, 2005)).

s: Sample units standard deviation (s= 10, (shahin, 2005)).

The results of the all section illustrated in Table 3.

Table(3) Dimension Details of FiveRoad segments in Both Direction.

Dimensions	Road segments Taking in The Study				
	Najaf-Karbala	Al-Rahhma	Hezam Akhdar	Al-Al-Maaridh	Garage-Al Shamali
Length (m)	8011	1000	1440	1400	1930
Width (m)	10.5	12	14	11.25	11.25
Sample unit(m ²)	315	271	271	271	271
Sample Length(m)	30	22.5	19	24	24
N	267	44	75	58	80
n	15	12	13	13	13
i	17	4	6	4	6

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5.Progress deformation According to PCI Values:

According to previous data obtained from survey had been in 2017, PCI value was considered for five road sections as shown in Table 4. After data application into (PAVER)software. The PCI values for Najaf-

Karbala, Al-Rahhma, Hezam Al-Akhdar, Al-Maaridh, Garage-Al Shamaliroad segments were shown in terms of PCI values andextrapolated distresses which are categorizedin three reasons, that are traffic load, climate conditions, or other.

Table 4Previous PCI Valuesand Extrapolated Distressesfor Selected Road Segments

Road segment	Route	PCI	Extrapolated Distress			Av. PCI	Situation
			Load %	Climate %	Other %		
Najaf – Karbala	Najaf - Karbala	80	36	42	22	80	Satisfactory
	Karbala- Najaf	-					
Hezam Al-Akhdar	Going	48	58	8	34	47.5	Poor



	Najaf - Karbala						
	Return from Najaf - Karbala	47	54	10	36		
Al-Rahhma	Going to Najaf - Karbala	80	59	16	25	82.5	Satisfactory
	Return from Najaf - Karbala	85	47	24	29		
Al-Maaridh	Going to Najaf - Karbala	58	18	34	48	59	fair
	Return from Najaf - Karbala	60	17	38	45		
Garage Shamalii	Going to Najaf - Karbala	84	48	4	48	82	Satisfactory
	Return from Najaf - Karbala	80	51	5	44		
PCI value for network			43	20	37	70.2	Good

Through a ten days period of July/2022, survey for the same road sections had been done for deformation progress through last five years. It will be known that no maintenance process had been present for all road segments except Hezam Al-Akhdar segment. In its direction coming from Najaf-Karbala, an essential maintenance processes had been done in December 2020 by adding a layer with a thickness of (5) cm as known from the questioner and the information that taken from the Najaf Municipality Directorate. The overlay increases value of PCI to 95 immediately after completing overlay processlayer. Figure 2 shows the changes in PCI values in three stages of investigation. First stage depend on survey don one 2017 with The PCI value equal to 47 i.e., Poor pavement condition and approaching to structural failed. Second stage immediately after applying a 5cm overlay thickness and increase PCI value to 95. This stage very important maintenance process and should take an interest in design and application. Finally, the current evaluation represent, when conducting this study and performed a 2-

field survey on 2022, the PCI value became 84 which mean reduction rate approximated 9.5% through less than two year. Although, the pavement condition still Satisfactory, but it is a bad indicator about the field construction depended in overlay as a maintenance strategy. Table 5 illustrates the current PCI values and extrapolated distresses for selected road segments.

Table 6 shows the rate of deformation changes as obtained from comparison results for each road segment in both direction of movement in addition to the average value for the whole network. The following point represent the reasons of rate values that can't be calculate in Table 6:

- 1- In previous study (Mahdi&Shubber 2020) the results obtained depend on field data collected for one direction (Najaf-Karbala). While in current research both directions (Najaf- Karbala and Karbala-Najaf) were evaluated. In order to put a suitable values of rate of change the value of one direction will be depend in the next steps



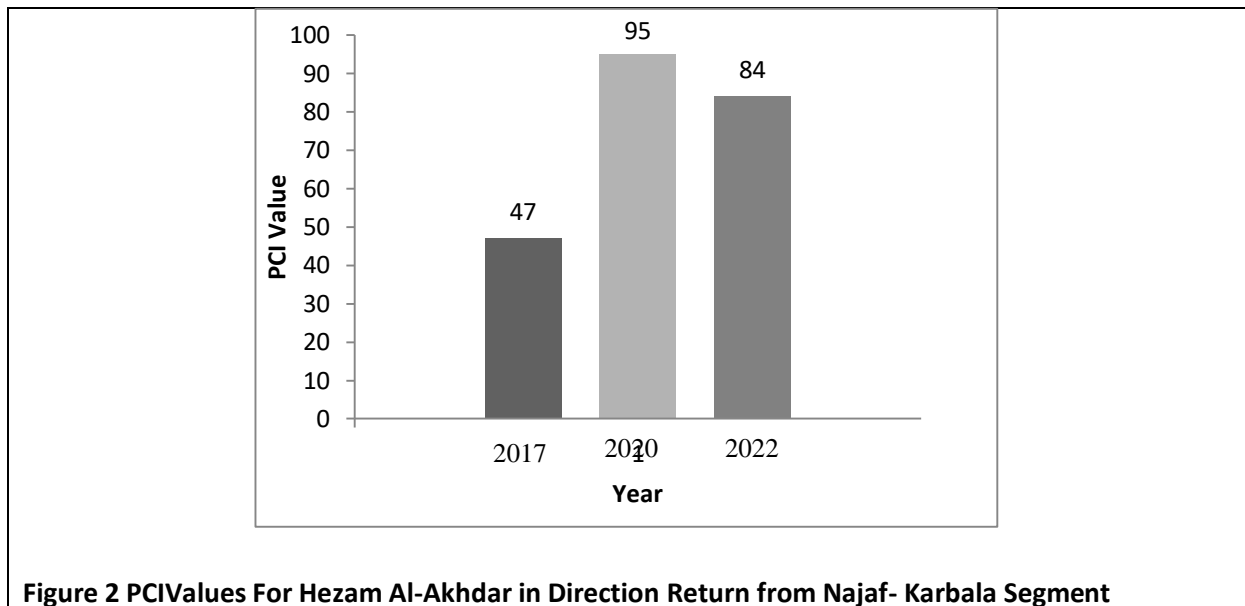


Figure 2 PCI Values For Hezam Al-Akhdar in Direction Return from Najaf- Karbala Segment

Table Error! No text of specified style in document. Current PCI Values and Extrapolated Distresses for Selected Road Segments

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Road segment	Route	PCI	Extrapolated Distress			Av. PCI	Situation
			Load %	Climate %	Other %		
Najaf – Karbala	Najaf - Karbala	63	42	15	43	70.5	Satisfactory
	Karbala- Najaf	78	67	16	17		
Hezam Al-Akhdar	Going to Najaf - Karbala	53	37	13	50	68.5	Fair
	Return from Najaf - Karbala	84	48	22	30		
Al-Rahhma	Going to Najaf - Karbala	74	42	20	38	76	Satisfactory
	Return from Najaf - Karbala	78	54	15	31		
Al-Maaridh	Going to Najaf - Karbala	53	47	14	39	54	Poor
	Return from Najaf - Karbala	55	25	25	50		
Garage Shamalii	Going to Najaf – Karbala	79	29	29	42	80	Satisfactory
	Return from Najaf - Karbala	81	21	37	42		
PCI value for network			41	21	38	69.8	Fair

3- Hezam Al-Akhdar Highway in one direction have a major maintenance by applying an overlay layer with 5cm thickness, while the other direction appear an increase in PCI value that

because some correction maintenance. As a general result this section will be omitted from general progress evaluation.

4- A slightly increase in PCI value present in garage Al-Shamalii segment in return



direction from Najaf- Karbala highway. This results cannot be considered in overall rate of change for the highway, so

this value also omitted from general progress deformation evaluation

Table 6Progress Deformation Rates for Selected road segment

Road segment	Segment Type	Change Rate %
Najaf – Karbala	Arterial	21
Al-Rahhma	Collector	7.9
Al-Maaridh	Collector	8.5
Garage Al-Shamalii	Collector	6
Arterial section	One section	21
Ave. of Collector sections	Three collector section	7.5
Overlay of Hezam Al-Akhdar	Collector	9.5

The level of performance of the Najaf-Karbala road decreased and the impact of traffic loads and other factors on its surface increased, and it needs Rehabilitation maintenance in the direction going toward Karbala and preventive maintenance in the direction returning from it towards Najaf. The performance level of Hezam Al-Akhdar road has increased and a noticeable decrease in the impact of traffic loads on its surface in both directions. Partial patching was carried out at the beginning of the road in the direction leading to the city of Najaf, with an increase in the impact of other factors on it, and it is in poor condition and needs Rehabilitation maintenance. As for the direction returning from Najaf It has been fully covered and is in good condition and needs Rehabilitation maintenance. The performance level of Al-Rahhma road decreased with a decrease in the impact of the loads on its surface in both directions, and it needs preventive maintenance. Low performance level of Al-Maaridh road with high impact of loads on its surface in both directions and it needs corrective maintenance. A slight decrease in the performance of a road compared to the rest of the network roads with a decrease in the level of the impact of traffic loads on its surface, and it needs preventive maintenance in both directions.

6. Conclusions:

Relying on the field examination and data entry and analysis in the PAVER program, the following conclusions were found:

1. The PCI rate of the network is the focus of the study found equal to 69.8, which mean that the road segments in fair surface condition.
2. Progress deformation rate in arterial road segment was 21%, while the average rate for collector segments was 7.5%
3. The effect of traffic loads on the road surface is more than the effect of other factors for Najaf– Karbala, Hezam Al-Akhdar and Al-Rahhma road segment ,while effect of other is more than the effect of traffic loads for Al-Maaridh and Garage Al-Shamalii road segment.
4. The effect of climate on all road segment Less than the effect of other factors on the roads surface.
5. Although, the use of major road maintenance techniques (overlay) leads to an increase in the value of the PCI and an enhancement in condition of road such as on Hezam Al-Akhdar road Section, but the progress deformation rate happen in high level equal to 9.5%.
6. The road network need rehabilitation maintenancefor Return from Najaf-Karbala segment, Al-Rahhma road segment for two directions and Al-Shamalii Garage Highway for two directions.
7. The road network need rehabilitation maintenancefor going toward Najaf-Karbala highway, Hezam Al-Akhdar Highway Section for two directions and Al-Shamalii Garage Highway for going



toward Najaf - Karbala highway and Al-Maaridh highway section for two directions.

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