Assessment of the Functional Performance of Mohammed Al-Qasim Expressway Pavement Surface

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Abstract

To achieve these requirements need to assess the pavement surface condition (Functional Performance). The pavement surface damage that frequently happens has an effect on the safety and comfort of road users. Pavement condition assessment is the basic step to select a suitable type of maintenance and rehabilitation program. This study aims to estimate the functional condition of the Mohammed Al-Qasim Expressway pavement surface by the Pavement Condition Index (PCI) assessment with data collected throughout 2017. The result showed that the AC pavement surface condition assessment is equal to 70 based on PCI value, and rated as fair, and the transverse tining PCC pavement surface condition is rated as satisfactory and PCI value equals 77.

Keywords: Mohammed Al-Qasim Expressway; Pavement distress; Functional performance; Pavement Condition Index (PCI).

1. Introduction and Literature Review

The transportation systems aim to provide the safe and efficient movement for people and goods [4]. To achieve these requirements we needs to assess the pavement condition or performance. The pavement failure can be classified into functional and structural failure. Functional failure is the failure of the upper layer of pavement (surface) and will often affect comfort and safety of the roads users and it can be treated with periodical maintenance. Structural failure represents the most serious type of failure that occurs in all the layers of pavement, thus, the pavement is unable to withstand the traffic loads and rehabilitating is the only treatment possible [8].

Pavement damage frequently happens and has an effect on the safety and comfort of roads' users as mentioned earlier. It could be caused by several conditions such as the age of the pavement, a presence of water on the pavement surface, excessive traffic load and repetition of load, inappropriate planning, and poor monitoring of the road. Moreover, the lack of maintenance, delays in financing, inappropriate handling, and climate change [7] can be further causes of pavement damage.

Thus, the condition of the pavement needs to be monitored periodically according to both sin terms of structural and functional conditions, and this is known as pavement condition monitoring. The data obtained from the pavement condition monitoring surveys play a vital role in selecting maintenance and rehabilitation activities [6, 7], as well as the pavement condition rating, which gives an indication of the type and prioritizing maintenance and rehabilitation projects, in other words, gives a more objective comparison of two or more pavement sections.

The data collection and pavement condition rating activities are carried out to provide an indication of the serviceability and physical conditions of the pavement and known as Pavement Condition Surveys. One of the common techniques to assess the pavement surface condition (pavement distress) is the Pavement Condition Index. It is one of a measured condition rating technique developed by the US Army Corps of Engineers and adopted by the American Public Works Association and American Society for Testing and Materials (ASTM) [6].

Previous research has been done to relate the PCI and the service life of pavement, as well as the correlation between pavement distress and the rate of traffic [7], and there is a similarity in the determination of the pavement condition by the PCI method and that by the laboratory tests [1].

The operation and maintenance problems of the highway network in Iraq become worse in up-keeping and serviceability offered, although the doubling of efforts and financial allocations to improve the serviceability of the pavement and increase the design age, the main reasons for highways network failure are the rapid occurrence and increase in the intensity of deformation, lack of periodical maintenance to the pavement surface [3], in addition to the lack of control of traffic load with the temperature that exceeded the 50°C [5].

The objective of this study is assessing the existing pavement surface condition for two sections of Mohammed Al-Qasim Expressway which is considered the first highway in the middle region of Iraq. The surface of existing pavement can be assessed by visual condition survey (distress type, density and severity) based on a pavement condition index (PCI) criteria with aiding PAVER 5.2 software for both AC and transverse tining PCC pavement surfaces and storing the collected data in Geographical Information Systems (GIS) to indentify the condition of every pavement surface with details. Moreover, these data can be used later for the pavement maintenance program.

2. Experimental work

2.1 Study area

Mohammed Al-Qasim Expressway is the first highway in the middle region of Iraq, and due to a heavy traffic volume passing it and the expansion of population density on both sides around the road, two sections were chosen to examine the functional performance of existing pavement surfaces. It is a multi-lane road with three lanes in each direction. Section No.1 is transversely textured PCC pavement surface about 1000 m from Toyota SAS Baghdad Automotive service to Sulaikh bridge, and section No.2 is an AC pavement surface about 880 m after Al-Nidaa bridge as it is shown in Figure (1), and Figure (2) shows AC and PCC.

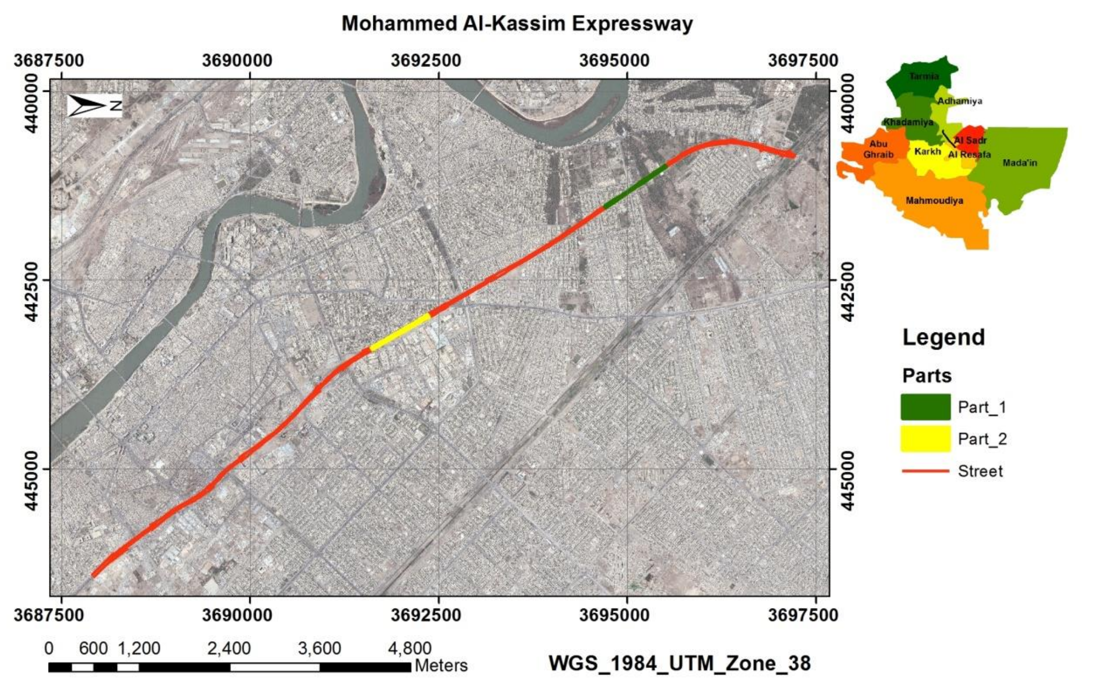


Figure (1) Mohammed Al- Qassim Expressway (Part 1(Transverse Tining PCC pavement surface) Part 2 (AC pavement surface))

a) Transverse Tining PCC pavement surface texture (Section No.1)

b) AC pavement surface texture (section No.2)

Figure (2) Surface Texture of both AC and Transverse Tining PCC Pavement

2.2 Pavement Condition Index (PCI)

PCI is a numerical index, ranging from 0 for a failed pavement to 100 for a pavement in perfect condition. The PCI calculations depend on the results of a field visual condition survey (distress type, severity, and quantity). The PCI was developed to provide an index of the pavement's structural integrity, and surface operational condition. The distress information obtained as part of the PCI condition survey provides insight into the causes of distress, and whether it is related to load or climate conditions [2].

PAVER5.2 software is used to assess existing pavement surface condition by computing the Pavement Condition Index (PCI). PAVER5.2 is developed by the U.S. Army Corps of Engineers (ASTM D6433 - 07). Figure (3) shows the requirement of the program to compute PCI and output ranges for each condition [9] [2].

Figure (3) Pavement Condition Index (PCI) requirement, Ranges, and Suggested Colors [2]

The minimum sample units (n) required for an adequate estimation of the PCI value of the sections and the (n) parameter can be calculated by following equation:

$$n = \frac{NS^2}{((e^2/4)(N-1)+S^2)} \qquad (1)$$

Where:

N: Total number of sample units in the pavement section,
e: Permitted error in the estimate of the section PCI,
S: Standard deviation of the PCI between sample units in the section.

Based on equation (1) the (n) parameter of PCC pavement surface is equal 11.29 ≈ 12 samples, and for AC pavement surface it equals 9.5 ≈ 10 samples.

Then determine the sampling interval (í) by using the following equation:

$$í = \frac{N}{n} \qquad (2)$$

So that, the sampling interval (í) for PCC pavement surface equals 1.3 ≈ 1 sample, and for AC pavement surface it equals 2.2 ≈ 2 samples.

The final step of hand calculation is a random start (s) where there is arbitrary choice between sample unit 1 and the sampling interval (í). Then the sample units to be surveyed are identified as s, s+ í, s+2í, etc.

PAVER5.2 software used to calculate PCI value for AC pavement surface is shown in figure (4), (5) and (6) after calculating the PCI for each sample unit where the section (880 m) was divided into 22 samples; each sample area equals 288 m^2. The eleven sample units were surveyed starting with sample unit 2 (random start (s)) and then 4, 6, 8, etc.

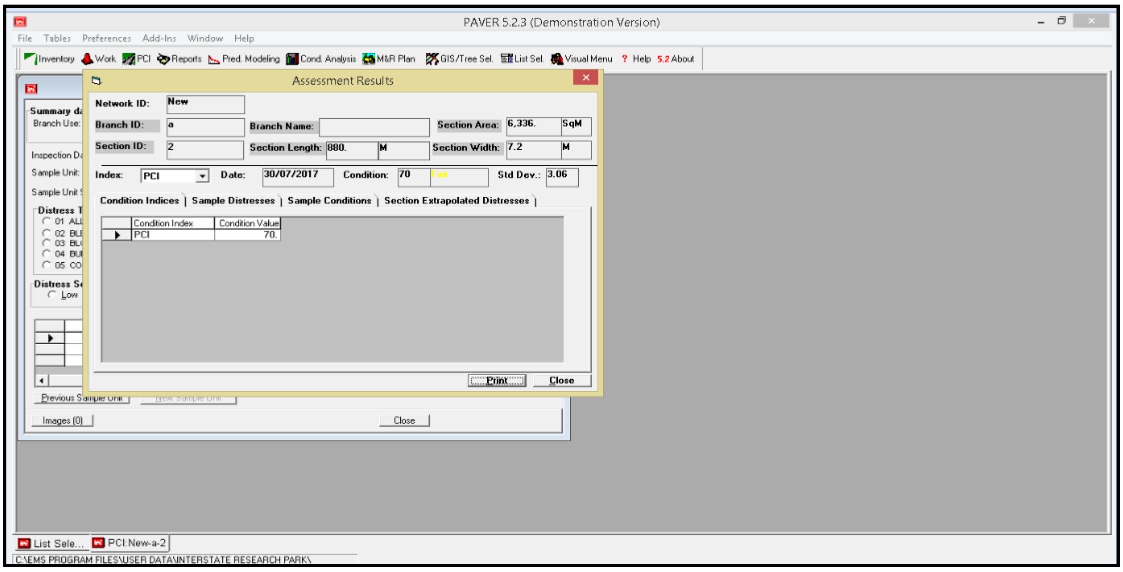


Figure (4) PCI for AC Pavement Surface

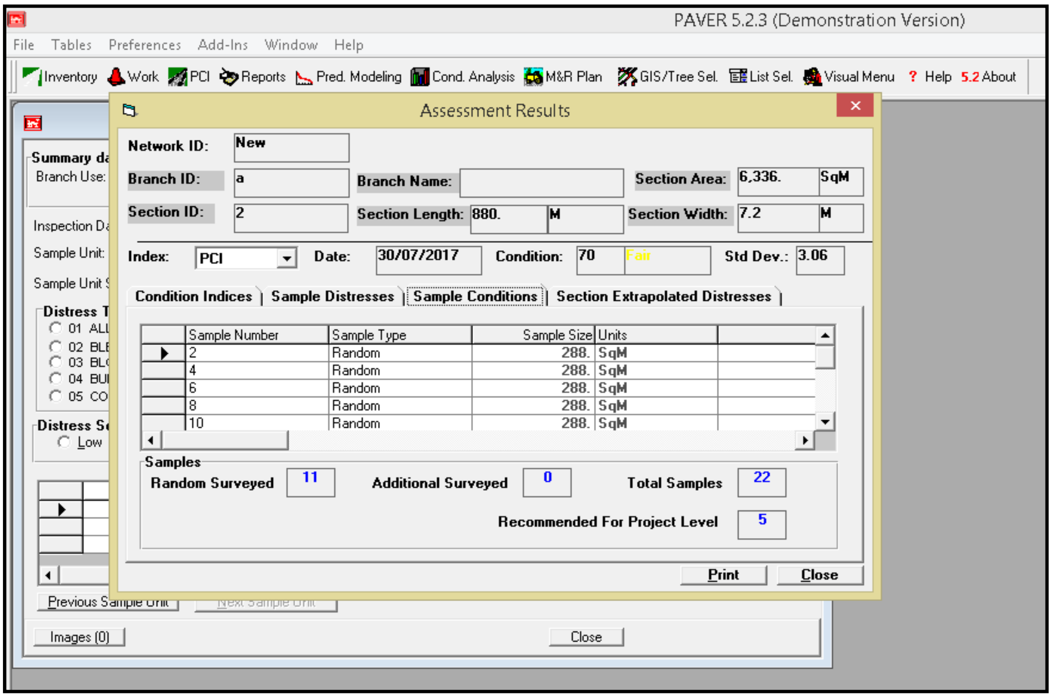


Figure (5) PCI for AC Pavement Surface and PCI for each Sample Unit with no. Sample Surveyed

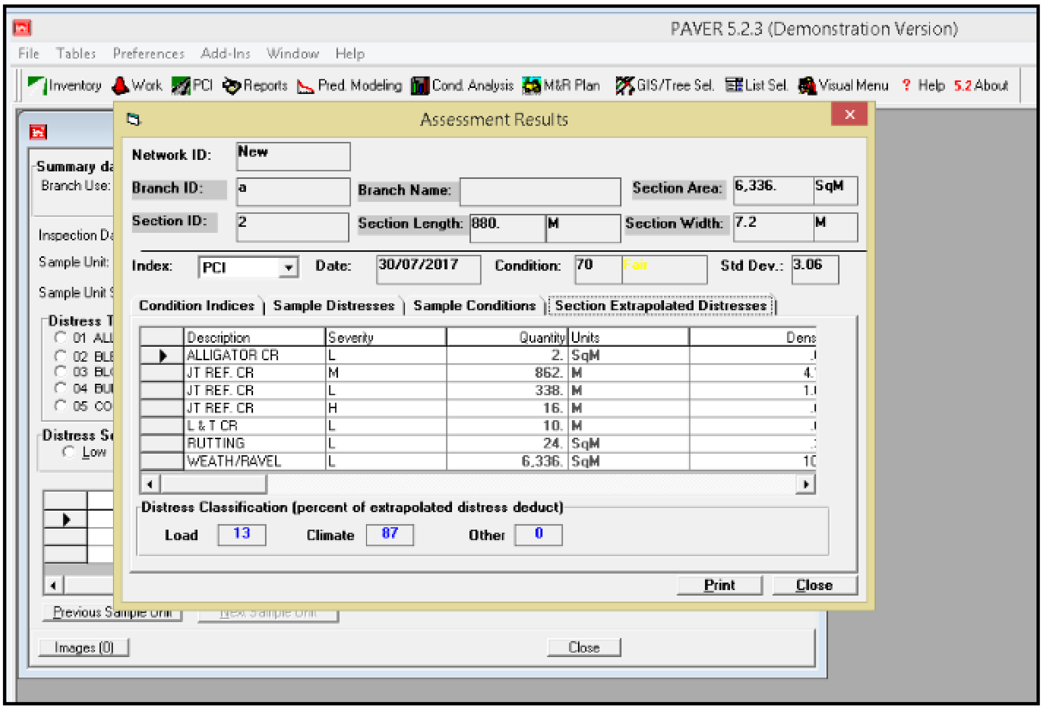


Figure (6) PCI of AC Pavement Surface with Distress Information and Classification

PCC pavement section (1000 m) is divided into 16 sample units; each sample consists of 20 slabs in each lane in one direction. After calculating the PCI for each sample starting with sample unit 1 and then 2, 3, 4, etc., the PCI was calculated for the whole section as shown in figure (7), (8) and (9).

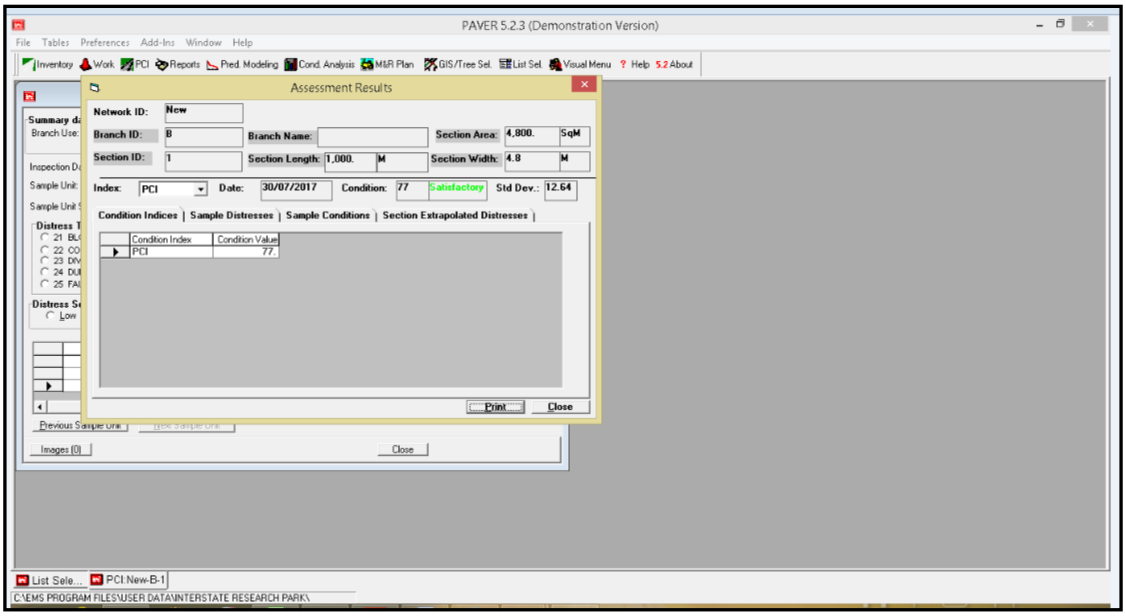


Figure (7) PCI for Transverse Tining PCC Pavement Surface

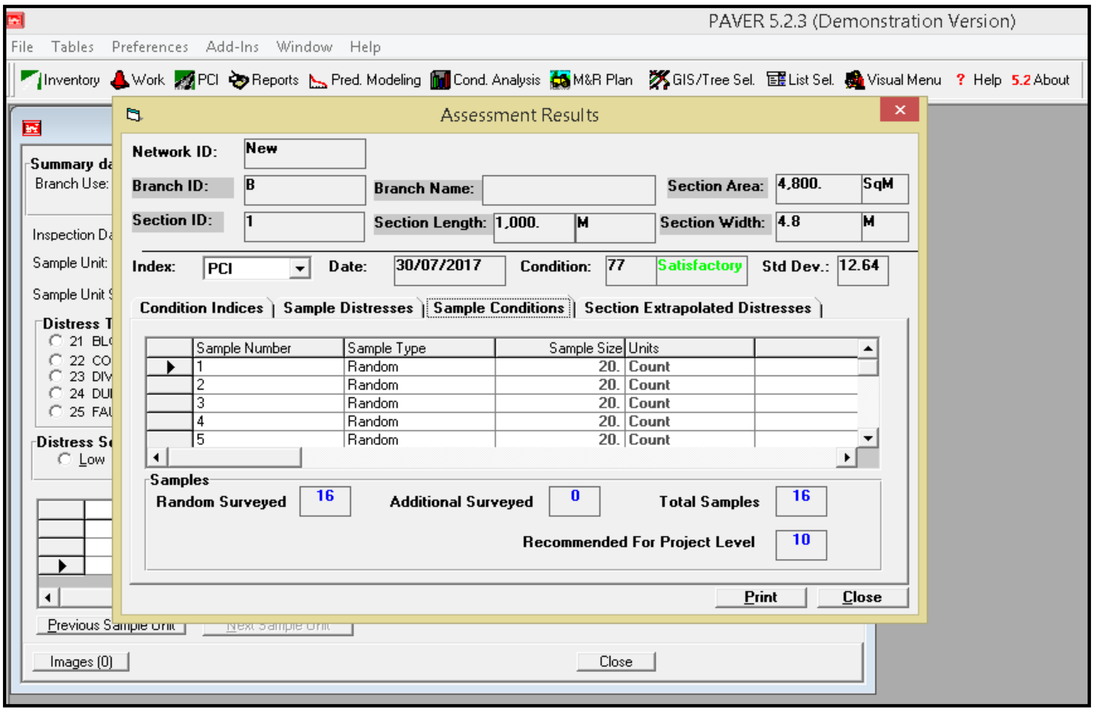


Figure (8) PCI for Transverse Tining PCC Pavement Surface and PCI for each Sample Unit with no. Sample Surveyed

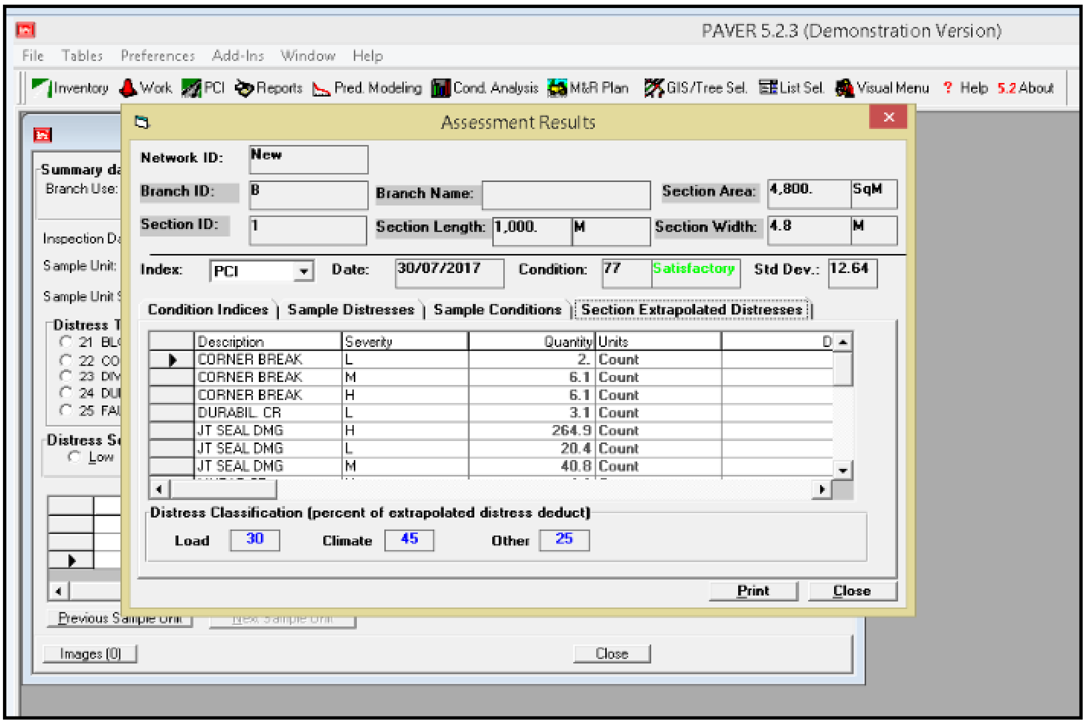


Figure (9) PCI for Transverse Tining PCC Pavement Surface with Distress Information and Classification

2.3 Geographic Information System (GIS) Software

The ArcInfo10.3 was full-featured Geographic Information System (GIS) software for visualizing, creating, managing, and analyzing geographic data. Each distress type was interred in the GIS Software with type, severity, quantity and location for each sample unit as it is shown in figure (10) and (11).

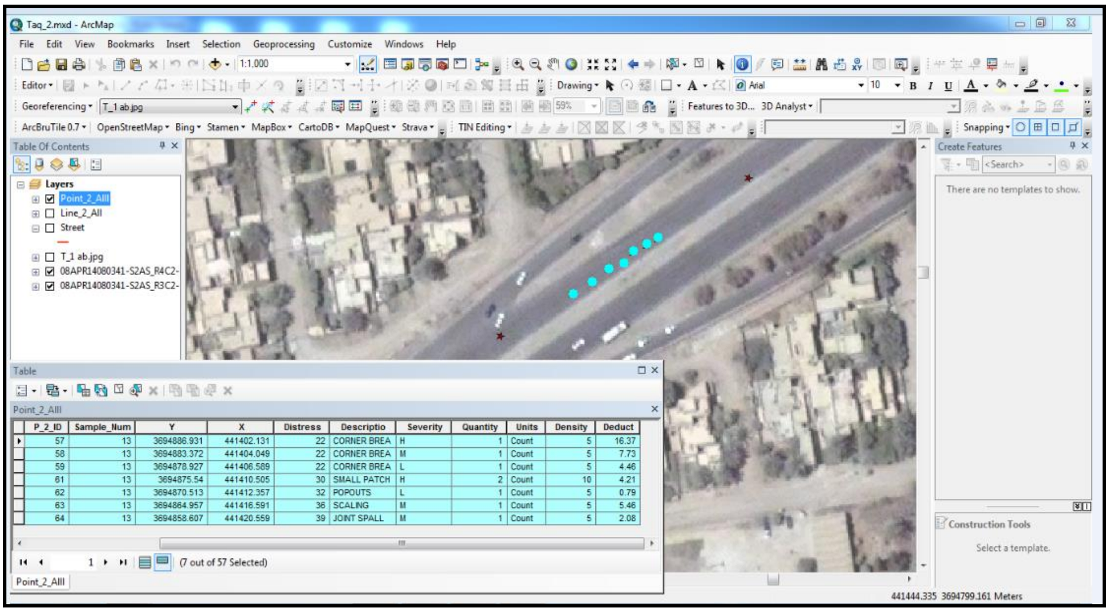


Figure (10) Database of distresses for sample unit 13 of Trans. Tining PCC Pavement Surface

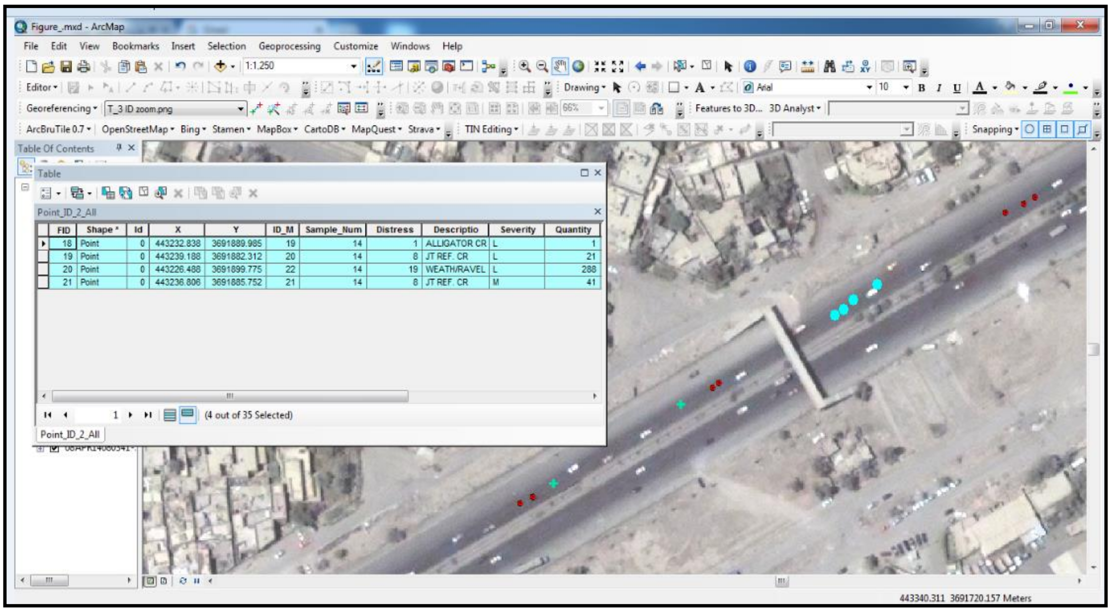


Figure (11) Database of distresses for sample unit 14 of AC Pavement Surface

Based on the symbol types in the legend of the map, the type of distress can be classified as it is shown in figure (12) and (13).

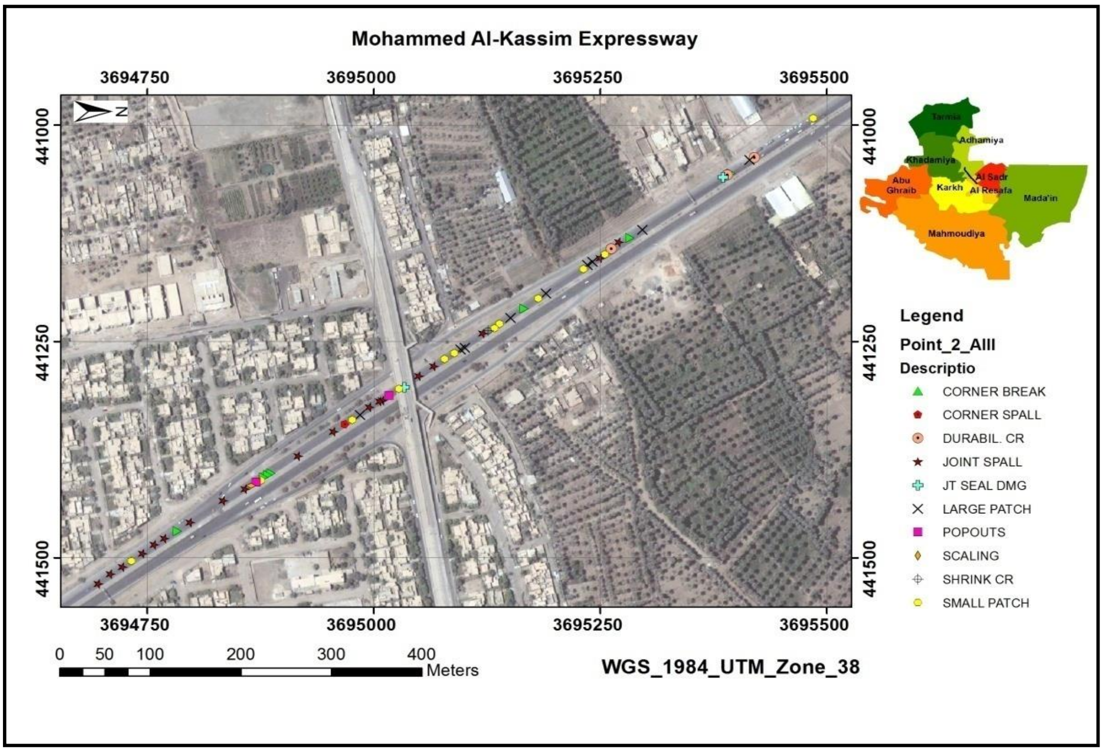


Figure (12) Distress Types in Transverse Tining PCC Pavement Surface

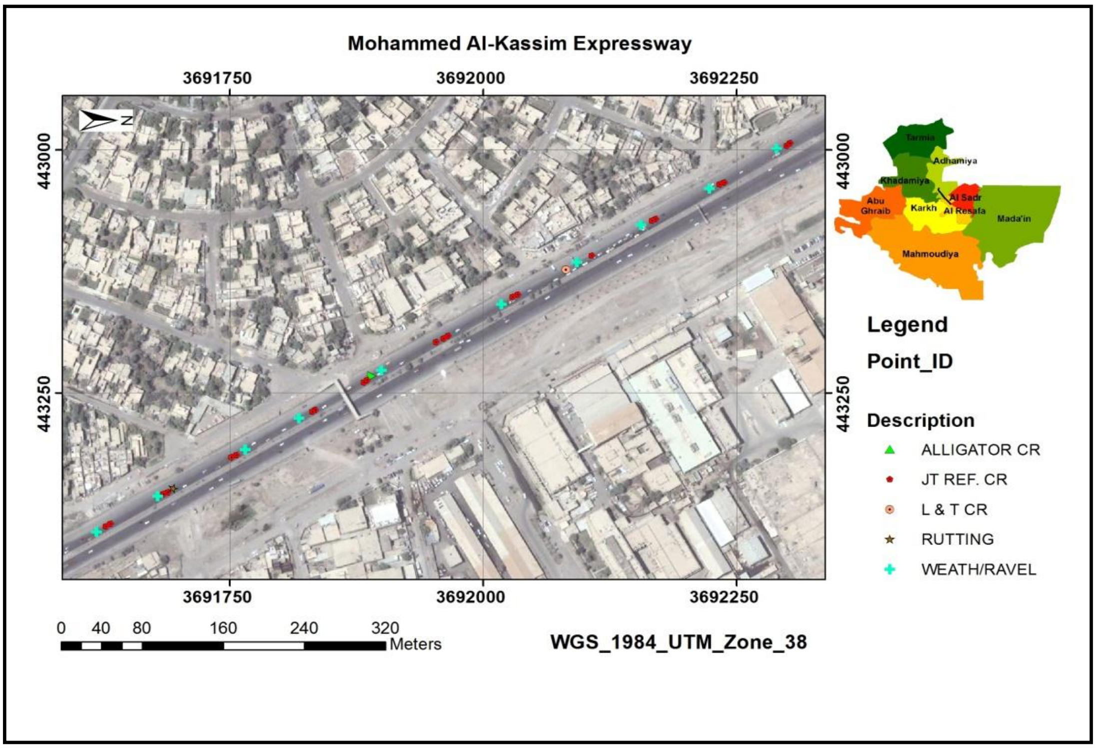


Figure (13) Distress Types in AC Pavement Surface

The features of each distress point can be displayed through activated a Hyperlink button in the GIS Arc Map as it is illustrated in figure (14) and (15).

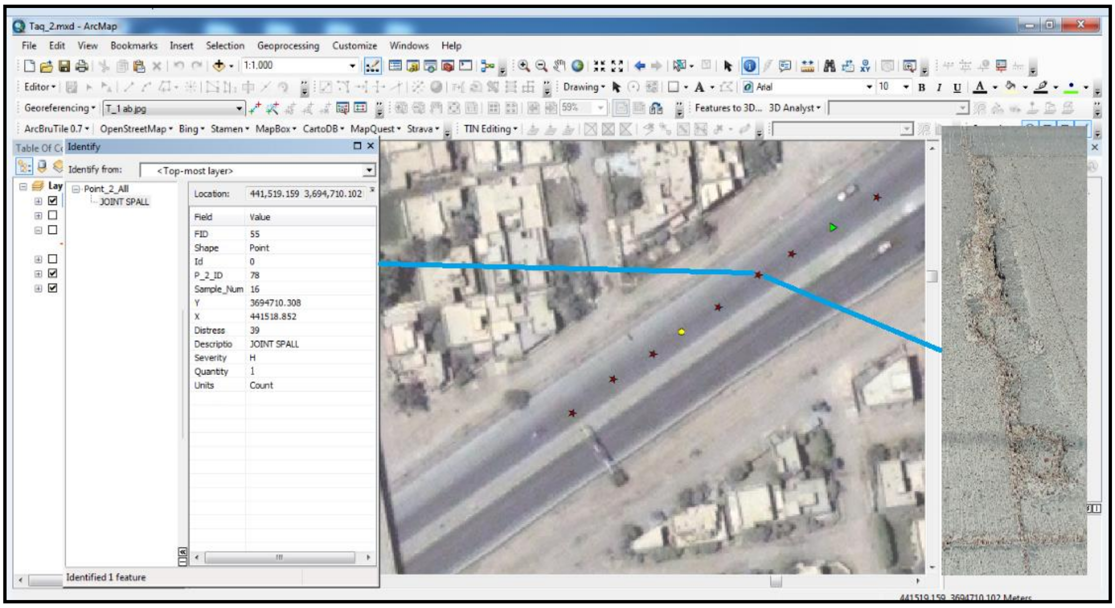


Figure (14) Connect Digital Image to Failure Exist in the Trans. Tining PCC Pavement Surface

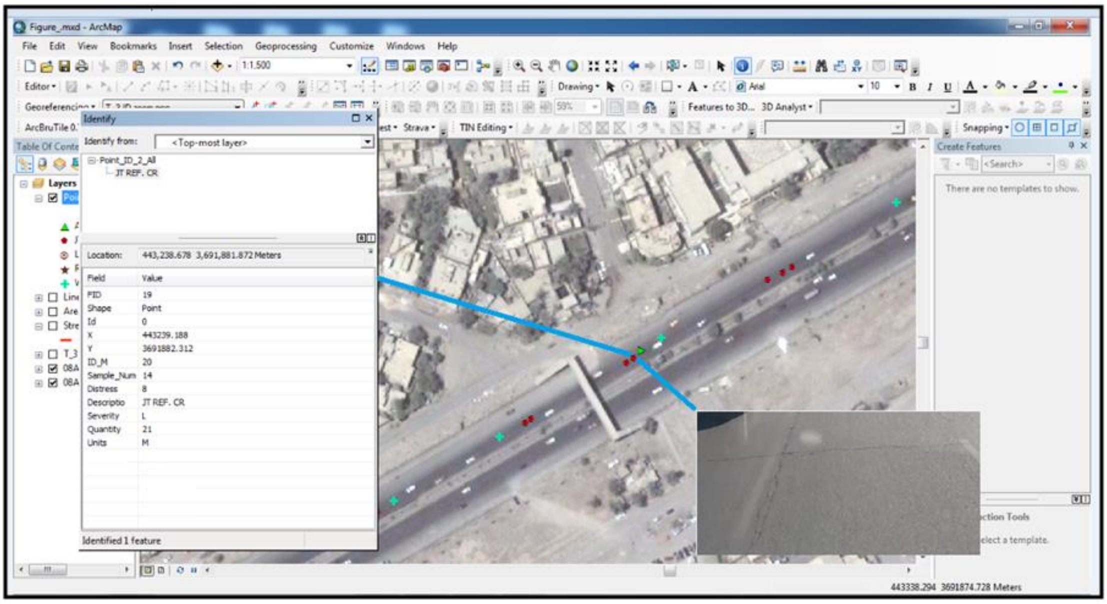


Figure (15) Connect Digital Image to Failure Exist in the AC Pavement Surface

The dividing process of the section into sample units also are illustrated using GIS as it is shown in figures (16) and (17) where the selected sample units are in blue color with illustration of their lengths, widths, area and PCI values of each inspected unit.

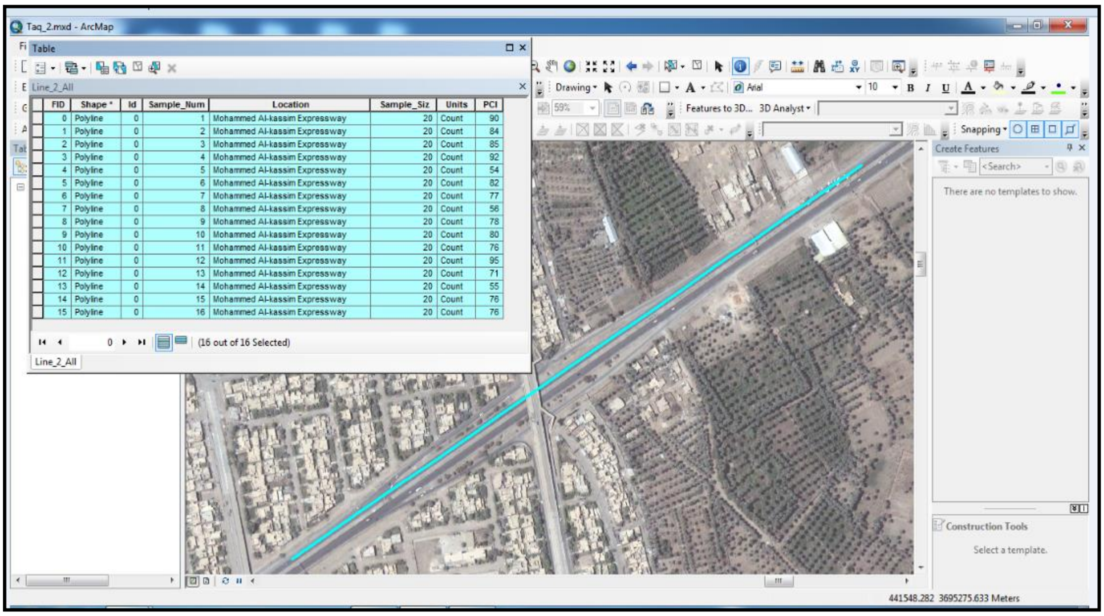


Figure (16) Information of Sample Units of Trans. Tining PCC Pavement Surface

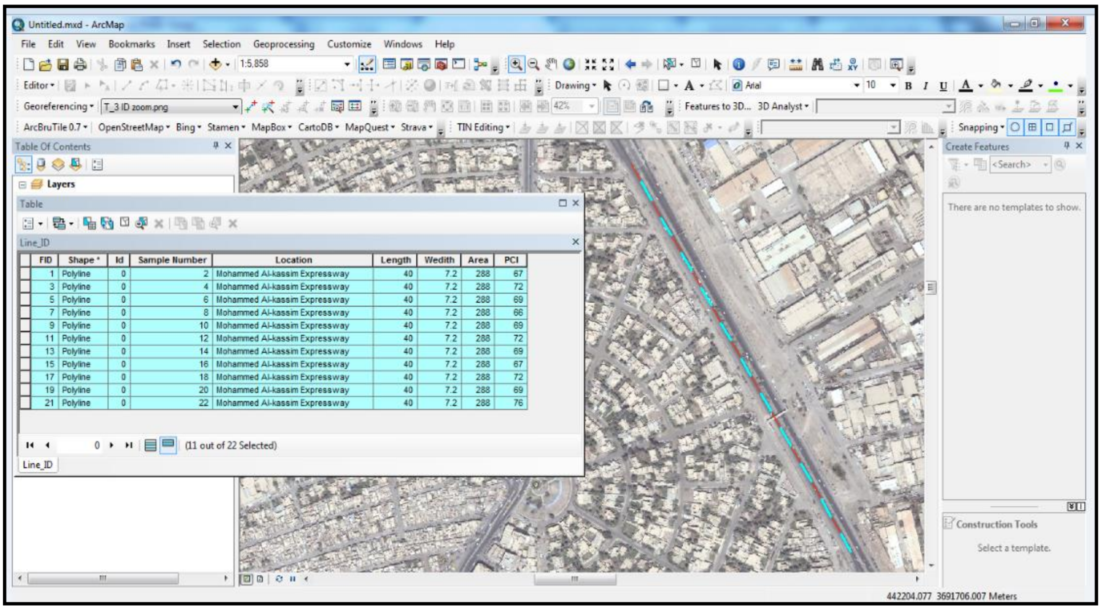
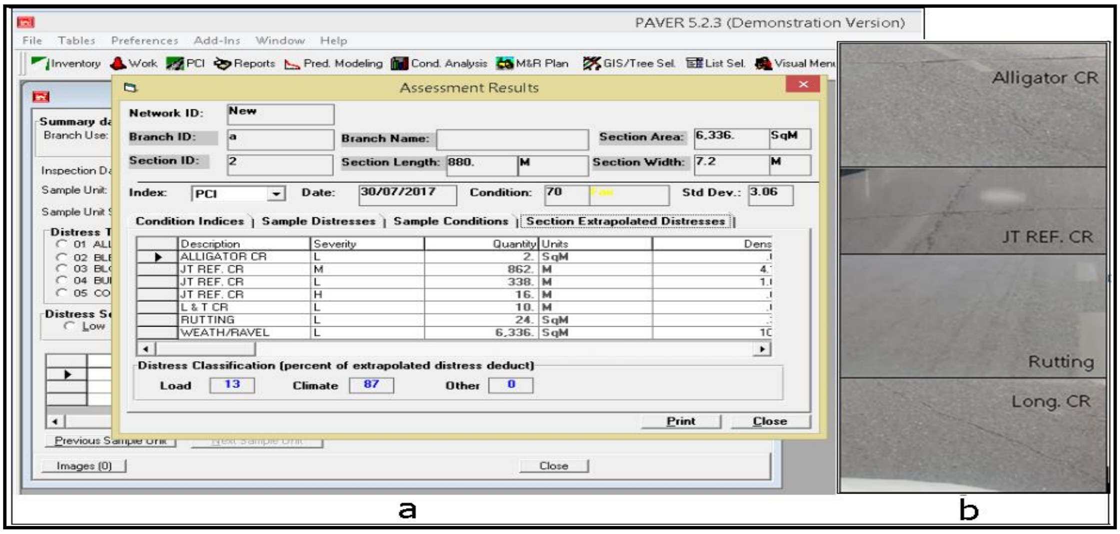


Figure (17) Information of Sample Units of AC Pavement Surface

3. Results Analysis

PCI value for AC pavement surface is equal to 70 as it is presented in figures (4) and (18). The condition of pavement is rated as fair as mentioned in ASTM D6433-07 due to several causes of distress. Some of the distress related to traffic load (Cracks for example) represents the ratio equals to 13% . While 87% of the distress is due to the climate condition such as weathering. Figure (18b) exhibits some of the distress types observed on AC pavement surface, including alligator crack (Alligator CR), longitudinal crack (Long. CR) and rutting in the right lane as well as longitudinal and transverse joint reflection cracks (JT REF.CR) at both right and middle lanes.



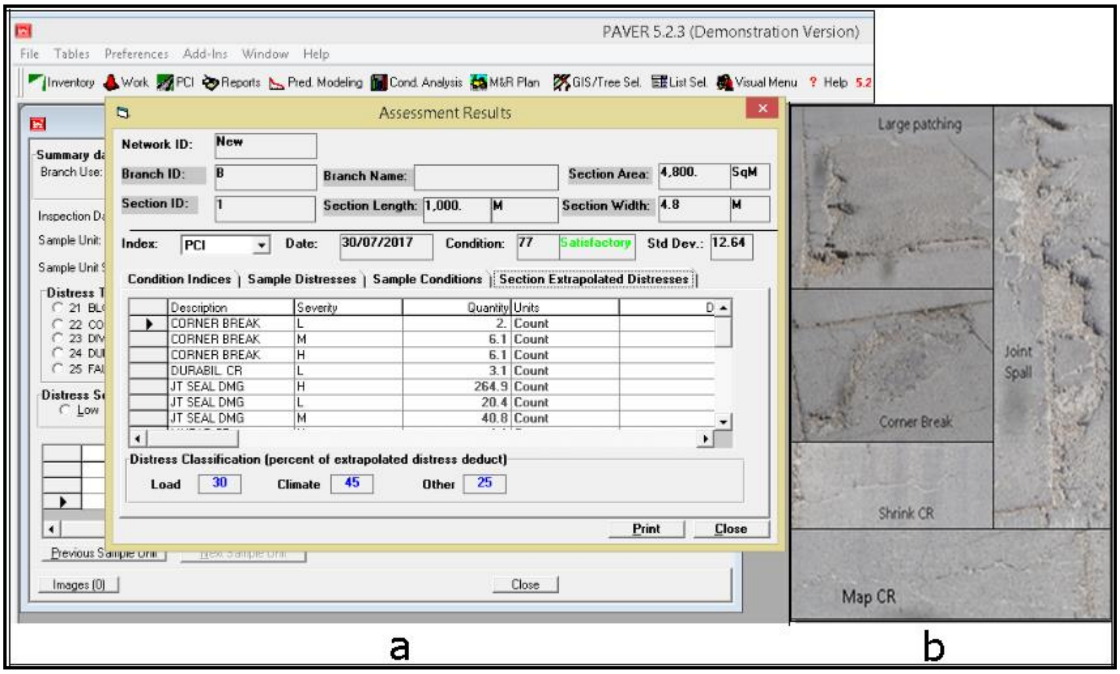
a) Assessment Result Output Form by PAVER 5.2 Software

b) AC Pavement Surface Distresses

Figure (18) PCI for AC Pavement Surface with Surface Distress.

For transverse tining PCC, the PCI value is equal to 77 and rated as satisfactory. Moreover, 30% of causes of distress are related to traffic load, 45% are due to climate condition and 25% are due to other causes presented in figures (7) and (19).

Figure (19b) shows some of the distress types that have been observed on the PCC pavement surface, such as large patching, corner break, shrinkage crack, map crack and joint spalling in the middle lane with varying severity levels, and some low patching, corner break and joint spalling at right lane.



a) Assessment Result Output Form by PAVER 5.2 Software
b) PCC Pavement Surface Distresses

Figure (19) PCI for Transverse Tining PCC Pavement Surface with Distress Types

PAVER software additionally displays the condition of each sample unit, where the sample units entered in GIS program with their PCI values as it is shown in the following figures.

From figure (20), it can be observed that out of the eleven examined sample units only seven units are rated as fair while others are rated as satisfactory for AC pavement surface. AS for transverse tining PCC, one the sixteen examined sample units rated as fair. In addition, two sample units are rated as poor while the remaining are units are rated in satisfactory and good condition as it is shown in the figure (21).

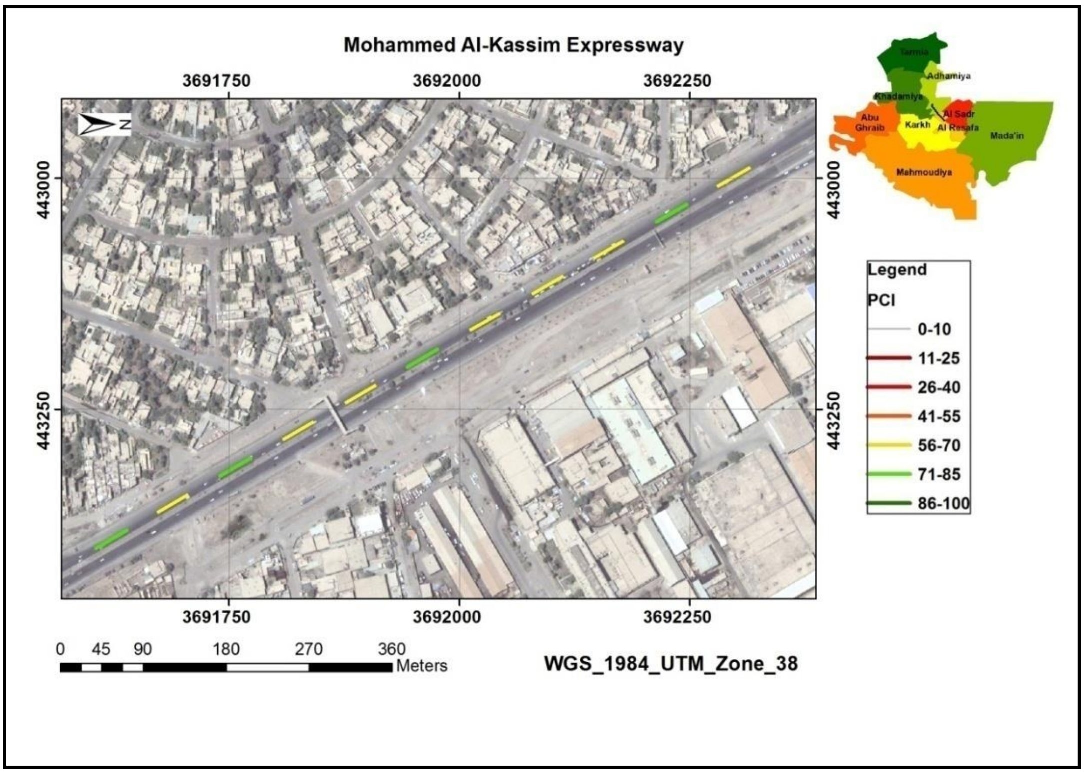


Figure (20) AC Sample Units in GIS Program with PCI Range Color Suggested by ASTM D6433-07

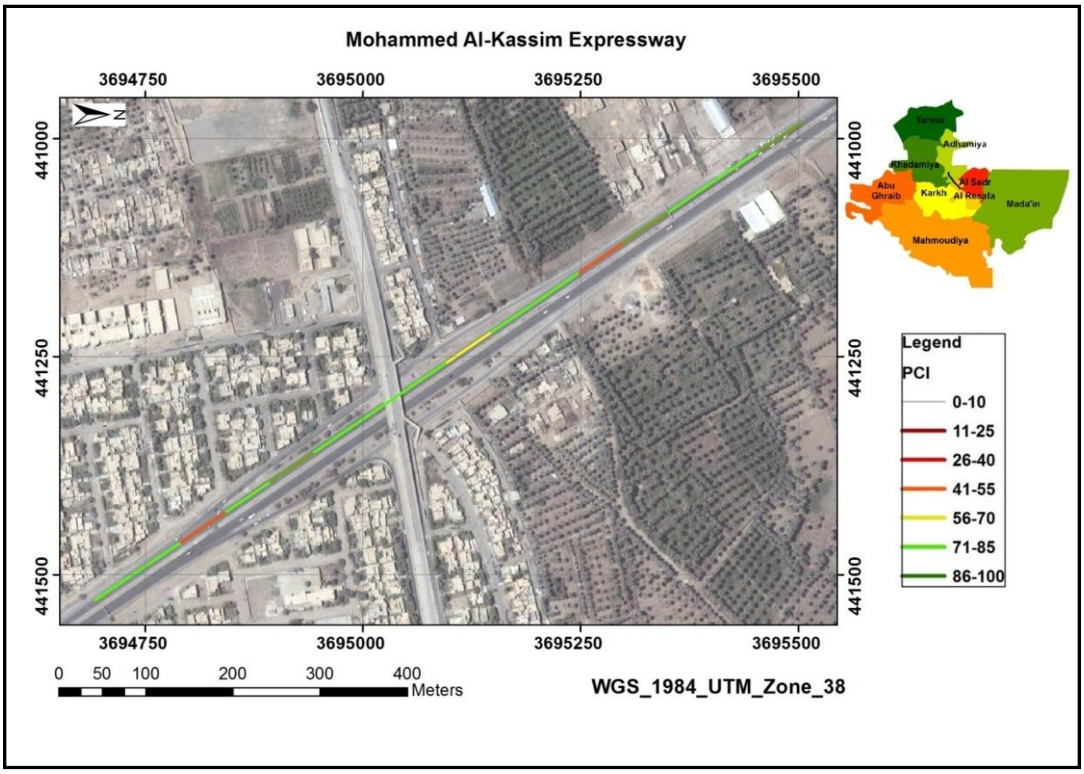


Figure (21) Trans. Tining PCC Sample Units in GIS Program with PCI Range Color Suggested by ASTM D6433-07

4. Conclusion

The assessment pavement surface condition of Mohammed Al-Qasim Expressway shows the following conclusions:

1. The value of the AC pavement surface condition assessment is equal to 70 based on PCI value, and it is rated as fair. The transverse tining PCC pavement surface condition rated as satisfactory with PCI value is equal to 77.
2. The causes of distress for AC pavement surface exhibited by PAVER software related to traffic load represents the ratio equal to 13% and 87% due to climate condition.
3. Five types of distress are observed on AC pavement surface; they are alligator crack (Alligator CR), longitudinal crack (Long. CR) and rutting in the right lane as well as longitudinal and transverse joint reflection cracks (JT REF.CR) at both right and middle lanes.
4. About 30% of causes of distress for PCC pavement surface are related to traffic load, 45% are due to climate condition and 25% due to other causes.
5. The ten types of distress which are observed on the PCC pavement surface include large patching, corner break, shrinkage crack, map crack and joint spalling in the middle lane with varying severity levels, and with some low patching, corner break and joint spalling at right lane.

5. Reference

[1] Alwan J. A., 2015, “Asphaltic Pavement Distresses and The possibility of repair”, Al-Qadisiyah journal for engineering sciences, vol.8, 1, pp 15-42.

[2] ASTM D6433-07, “Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys”, ASTM International, West Conshohocken, PA

[3] Hassan Khawla H., in24-15/4/2013, “Common Defects and Distresses in Flexible Pavements in the Middle part of Iraq and Their Main Reasons”, 1st International Conference for Geotechnical Engineering and Transportation ICGTE.

[4] http://www.dot.state.mn.us/materials/researchsurfacechar.html.

[5] Kadhim Z. A., and Mahdi, Z. A., 2018, “Evaluation of Asphalt Pavement Distresses in Main Roadways in Al-Diwaniyah City”, Journal of University of Babylon, Engineering Sciences, Vol. (26), No. (1).

[6] Nii Attoh-Okine, Offei Adarkwa, June 2013, “Pavement Condition Surveys – Overview of Current Practices”. Delaware Center for Transportation.

[7] Suryoto, Dendy P.S., Ary S., “The evaluation of functional performance of national roadway using three types of pavement assessment methods”. Procedia Engineering 171 (2017) 1435-1442, 2017.

[8] Yoder, E. J, & Witczak, M. W, “Principles of Pavement Design”, 2ed edition, p648, 1975.

[9] Yu, Jianxiong, “Pavement service life estimation and condition prediction”, Ph.D. thesis in Engineering, University of Toledo, (2005). http://utdr.utoledo.edu/theses-dissertations/1476

تقييم الأداء الوظيفي لمحمد القاسم طريق الرصيف السريع

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الخلاصة

تهدف أنظمة النقل إلى توفير حركة آمنة وكفوءة للناس والبضائع. ولتحقيق هذه المتطلبات تحتاج الى تقييم حالة سطح التبليط (كفاءه الاداء الوظيفي لسطح التبليط). يتأثر التبليط بالعديد من العوامل ويتعرض للتدهور مع مرور الزمن. حيث تؤثر هذه الاضرار التي تحدث بشكل متكرر على راحة وامان مستخدمي الطريق. تقييم حالة سطح التبليط هو الخطوة االاساسية لاختيار برنامج الصيانة المناسب. تهدف هذه الدراسة الى تقييم الاداء الوظيفي لسطح تبليط طريق محمد القاسم السريع باستخدام طريقة مؤشر حالة التبليط (PCI) لمقطعين من الطريق، بعد اجراء عملية المسح وتحديد نوع وكمية وشدة كل نوع من انواع الضرر الموجود في التبليط خلال سنة 2017 أظهرت نتائج تصنيف سطح التبليط الكونكريتي (الجزء الاول) على أنه في حالة مرضية او مقبولة، وان مؤشر حالة التبليط: 70 في حين تم تصنيف السطح الاسفلتي (الجزء الثاني) على انه في حالة متوسطة استنادا إلى قيم مؤشر حالة التبليط (PCI): 77.

الكلمات المفتاحية: الطريق السريع محمد القاسم، تبليط، كفاءة الأداء، مؤشر حالة التبليط.