Investigating Distress Types and PCI for selected road segments in Al-Muthana City

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Abstract

Knowing the type of distresses dominate within specific type of roads will help in selecting the suitable maintenance technologies. This study has focused on investigating the type of distresses spreading in Al-Muthana city. Then, pavement conditions have been evaluated by collecting distresses data from "Ibn Hayan" road brunch in Al-Muthanna governorate, Al-Samawa city, Al-Hussain zone. The road has two lane in each direction, with asphalt concrete surface. After sampling process, distresses data collected and diagnosed according to their type, density and severity. Collected data have been analyzed by PAVER software to calculate Pavement Condition Index (PCI) which is the basic indicator to evaluate surface condition of the pavement. As the PCI of the studied pavement was "50" that means the pavement needs major rehabilitation operations. Each type of distresses has been discussed to predict failure causes. Treatments suggested as countermeasures for each type of distresses. These treatments include overlay, patching and crack sealing.

Keywords: Distress type, PCI, PAVER, maintenance, crack

Background

The condition of pavements is monitored regularly and this is known as pavement condition monitoring. These condition monitoring surveys play a vital role in pavement management since it provides valuable information that forms the basis of repair and rehabilitation activities. The given information to management staff is usually in the form of condition ratings of specific sections or an entire pavement network based on which sound and informed decisions are made (Attoh-Okine and Adarkwa, 2013). The distresses developed in pavement due to internal and external causes, such as traffic over loading, inadequate design, poor paving mix, insufficient construction techniques and week subgrade or deficient drainage system (Javed, 2011). Al-Muthana city suffers from absence using such system in order to put the priority to make maintenance for its road network. Although extensive research has been carried out on specific cities in Iraq, no such single study exists which deals with evaluation pavement condition in Al-Muthana city. Therefore, the aim of the present study is to shed light on the type of distress spreading in the city and to evaluate Pavement Condition Index (PCI) using PAVER software.

2.2 Pavement Management System (PMS)

PMS is a term that relates to a system that utilizes the condition coding of roadways coupled with the identification of strategies to determine maintenance or re-construction activities (Obead, 2012). Furthermore, PMS is a set of analytical tools or methods that assist decision makers in finding optimum strategies for maintaining pavements in a serviceable condition over a given period(Fred, 1997).

Haas et al., (1994) postulated that, the pavement management activities are behaved at two levels: network level and project level. Network level is the inclusive view of pavement infrastructure; it deals with issues like the overall budget and planning, whereas the project level focus locally on limited components of the larger network.

In other words, project level is where specific decisions are made on funding allocations and maintenance strategies (Hass et al, 1994).

Iraq has a basic and important network of roads. The estimated funds invested to build the expressway which is a portion of this network are 1.2 Billion ID. Expressway section is 23000 km of the highways (Obead, 2012).

Jaber (2007) developed a model to select the optimum set of projects from Iraqi network. Budget constraint and accomplishment of multiple objectives were considered throughout his research. The performance of a network with different budget scenarios and different objectives were studied. The study considered the environmental impact of maintenance decisions extended to identify the links to be maintained under each activity type.

Obead (2012) formulated maintenance alternatives based on Analytical Hierarchy process (AHP) optimization technique to predict an optimal pavement maintenance alternative. Several factors that effect on asphalt pavement maintenance such as; traffic volume, roughness, pavement condition, pavement strength, safety, budget allocations, and environmental effect were evaluated, estimated and used as an input data for the selected case study (Section R4/B-expressway NO.1).

Ferman (2016) developed a multi-objective optimization model to brace the process of multi-year decision making, relates to Iraqi PMS. Two optimization objectives are considered; maintenance cost minimization and pavement condition maximization. Vary field measurements are carried out to evaluate Pavement Performance Indicators (PPI) which included PCI, International Friction Index (IFI), and International Roughness Index (IRI), maintenance cost also calculated to formulate multi-objective optimization models to select optimal maintenance alternative for the selected case study. The result was that when the pavement performs in a good condition, inexpensive treatments of preventive maintenance are applied, whereas if the pavement reaches to the end of its design life, expensive reconstruction maintenance type will be necessary.

Pavement Maintenance Strategies

Maintenance strategies have been defined by Lu and Lyton (1976) as different activities to be selected for each highway system in analysis to increase pavement rating above specific minimum requirement. Johanson (2000) classified pavement maintenance strategies to three types: firstly, preventive maintenance which is used to improve or prolong the functional life of the pavement. It involves the surface treatments and operations those intended to retard progressive of failures and reduce the need for routine maintenance and service works. Secondly, corrective maintenance which is applied when a deficiency occurs in the pavement, such as loss in friction, moderate to severe rutting or expanded cracking. It may also be named as “reactive” maintenance. Thirdly, emergency maintenance which is performed during an emergency situation, such as a sever potholes or blowup that needs to be repaired immediately. It also includes temporary treatments designed to hold the surface together, until a permanent repairs can be performed.

Various indices have been developed to evaluate pavement performance whether individual indices or a combination of them (Zhang et al, 1993). Functional index of performance used to characterize ride quality of a pavement such as Present Serviceability Index (PSI) and (IRI), while the structural index, such as the Structural Number (SN) used to measure the structural capacity.

Condition Rating Systems

The rating is based on measures such as roughness, skid resistance, deflection among others obtained during the data collection process. Condition rating is utilized as a basis to compare between two road sections' performance. Most importantly, it helps agencies in determining the severity and extent of pavement defects and calculating the cost of repair and rehabilitation, besides prioritizing treatment procedures. It is also used as a basis for planning budgets. Condition rating indices have also reduced the political pressure which forms the greater part of the decision making process (Attoh-Okine and Adarkwa, 2013).

Hass, (1978), mentioned that, pavement condition and performance are topic of central concern in pavement management because most pavement designers and maintenance personnel must consider pavement condition in their activities.

Pavement Condition Index (PCI)

PCI is a measured condition rating system developed by the US Army Corps of Engineers and adopted by the American Public Works Association and American Society for Testing and Materials (ASTM). It is based on a 0-100 scale as shown in Figure 1 for an illustration (Illinois Center for Transportation, research Report). Each distress identified on the pavement is assigned a value based on the type, severity and extent. The points are then summed up and deducted from a score of 100 to give the pavement condition rating. The weighted average of the PCIs for multiple sub-sections is then the condition of the entire section. There are 39 distresses with 3 levels of severity namely high, medium and low. There are 20 distresses for Asphalt Concrete (AC) pavements and 19 distress types for Portland Cement Concrete pavements (PCC) (Attoh-Okine and Adarkwa, 2013).

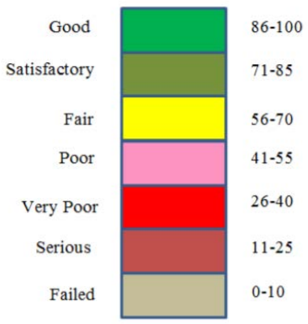

Figure 1 Pavement condition index, rating scale, and suggested colors (ASTM D 6433-07)

PAVER Software

Currently, PAVER is being used by over 600 countries, cities, private consulting firms and airports (Obead, 2012). PAVER is the pavement management software has received the ASTM standard certification in the (ASTM 1999b) standards. This standard, with the PAVER earlier receipt of (ASTM, 1998b) Standard for condition rating of airfield pavements, together makes PAVER PCI a standard for determining the condition of all pavements uses.

PAVER provides many important capabilities (U.S Army Corps of Engineers, 2011), including:

1. Inventory of pavement network.

2. Pavement condition rating

3. Development of pavement condition deterioration models (Family Curves)

4. Determination of present and future pavement condition (Condition Analysis)

5. Determination of M&R needs and analyzing the consequence of different budget scenarios (Work Planning)

6. Project Formulation

Data collection for all pavement sections may consume a lot of time. This normally happens if testing program or extensive coring or is conducted during the primer setup of the PMS (Shahin, 2005).

Network Identification

Network identification is the first task in the establishment of a PMS. A network is a term used to identify rational grouping of pavements for the purpose of M&R management. In large cities many networks may identify their pavements, a network for each city council district for example. Alternatively, all the pavements may be identified as one network and then for each council district, create a separate computerized database.

Commercial industry of several geographical locations, such as hotel chain or department store, may identify the pavements at each of these geographical locations as one network.

Branch Identification

Branch part of a pavement network is easily to identify, and it has a distinct use. An individual road street would be considered as a distinct branch of the network, as well as a parking lot. Similarly, airfield pavements such as a taxiway or a runway would each be marked as a separate branch.

Each street on the network map is defined as a distinct branch and given the name of the street. The process of naming can be used also on parking lots where parking lots that do not have assigned names could be recorded with descriptive names to correlate them with their locations.

Section Identification

A section is the smallest management unit and it must be of the same surface type (i.e. AC, PCC or asphalt over concrete, etc.). One branch consists of one section at least, but it may include more than one section if pavement properties vary throughout the branch. Several factors must be considered when separating branch into sections, these factors are: pavement structure, traffic, pavement rank (or functional classification), drainage facilities, construction history, shoulders, condition and size.

Description of Study Area

The study area, as shown in Figure 2, has been taken in Al-Muthanna governorate in Iraq, Samawa city, Al-Hussain zone, as a brunch of distributer road named “Ibn Hayan street” with length of 1 kilometer, one end at Al-Hussain hospital intersection, and the other end intersect with “Al Shaheed Basim Al Aaraji street”, the road has two way in each direction separated by a median of width 3 m, each direction has 7.5 meter width as shown in Figure 3.

Figure 2 Study area, Al-Muthanna governorate in Iraq, Samawa city, Al-Hussain zone.

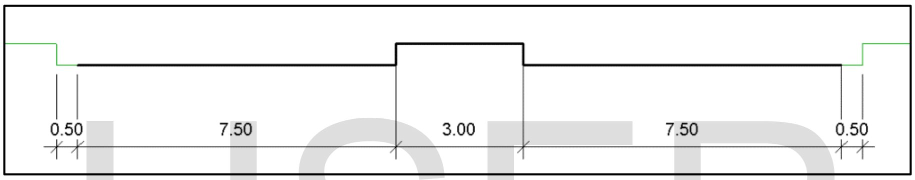

Figure 3 Cross sectional sketch of the study area

Data Collection

This type of data is usually in the form of pavement images and videos which are analyzed by trained engineers who identify the distresses present. Similarly, the data can also be collected through visual inspections during condition surveys. All in all, distresses data collected manually. Pavement distresses are major signs of deterioration and usually manifest as distortions, disintegrations and fractures (Attoh-Okine and Adarkwa, 2013).

Recent improvements in data collection equipment technology have been very beneficial. The cost of storing data is not as high as it used to be and processing speeds have improved to ensure computers function efficiently even when high resolution equipment is used. The manual walking survey procedure mentioned earlier is one method of data collection which has been used for many years. It has been done on selected inspection units in the management section. An inspection unit is a small segment of a management section with a convenient size that is selected and inspected in detail. Typically, inspection units may range in lengths from 50 to 200 feet and may also be up to four lanes wide. Inspection units may be selected at random or through a defined sampling procedure. The manual distress surveys are slow, labor-intensive and subject to errors. Consistency between classification and quantification of the distresses observed by the raters can also be a major problem. After the data has been summarized and corrected, the only recourse for checking apparent anomalies in the data is to return to the field. Safety of field crews is also another major concern.

The study area is divided into two sections based on the two directions. Each section is divided into inspection units (pavement segment), called sample units, after collecting distress data, which include; distress type, severity and quantity, estimate the PCI for the sample units and the PCI of the road section using PAVER 5.2.3 software.

Determining Sample Units to Be Surveyed

The procedures of performing a PCI condition survey differ depending on the surface type of the pavement to be surveyed. But whatever the surface type is, pavement section must be divided into number of sample units, a sample unit is an area of about 2500±1000 ft^2 (225±90 m^2) for asphalt surfaced pavement (Shahin, 2005). Sampling procedure for PAVER software is used to get a reasonably accurate PCI, by inspecting a limited number of sample units in each section. The first step in sampling procedure is to find the minimum number of sample units (n) that should be surveyed to reach an adequate estimation for the PCI of the pavement section. According to Shahin et al.,(1976-84),there are curves used to determine the minimum number of unit samples for project level evaluation (see Figure 4). Using this number, a reasonable estimate of the true mean PCI of the section will be obtained, but this estimate is within ±5 points of the true mean PCI that means there is 95% confidence. It useful to know that true PCI is the PCI obtained if all the sample units were inspected.

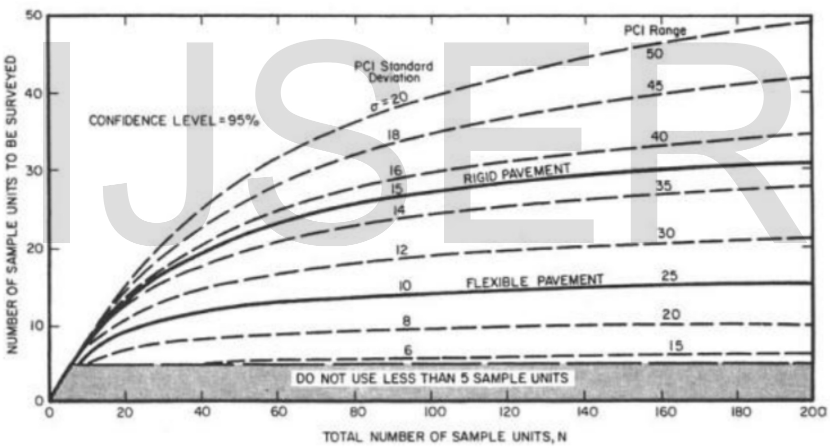

Figure 4 Selection minimum number of the sample units (Shahin et al., 1976-84)

The curves were constructed using Equation (1):

$$n = \frac{N*S^2}{\left(\frac{e^2}{4}\right)(N-1)+S^2} \qquad \text{............Eq.(1)}$$

Where:

N: is the total number of sample units in pavement section

$$N = \frac{Area\ of\ section}{Area\ of\ sample} \text{..................Eq.(2)}$$

e: is the allowable error in the estimate of section's PCI (e was set equal to 5 when constructing the curves of Figure (6).

s: is the standard deviation of PCI among sample units in the section (took as 10).

Area of one direction = 7.5m * 1000 m = 7500 m^2

N = 7500/250 = 30 (total number of samples)

$$n = \frac{30 * 10^2}{\left(\frac{5^2}{4}\right)(30-1)+10^2} = 10.67 = 11 \text{ (minimum number of samples).}$$

Then each section in the study area is inspected with 11 random sample units for each direction.

Selecting Sample Units to Inspect

Shain (2005), recommended that sample units to be surveyed should be spaced equally along the inspected section, and the first sample should be chosen randomly by a technique named as "systematic random" (Shahin, 2005). To determine these spaces among sample units the following steps should be taken in consideration.

a. Sampling interval (i): can be calculate by i = N/n. Where N equals the total number of available sample units, whereas n represent the minimum number of sample units to be inspected. The sampling interval i is rounded to the smaller integer number (e.g., 4.7 rounded to 4.0).

b. Random start (s): random selection between sample unit 1 and sampling interval (i) found in the previous step. For example, if i = 4, then the random starts would be a number among 1, 2, 3 or 4.

c. Sample units to be surveyed are determined as (s, s + i, s + 2i, etc.). If the selected start is 1, and the sampling interval is 4, then the sample units to be surveyed are 1, 5, 9, etc.

For the selected pavement section:

i=N/n = 30/11 =2.72 ~ = 2

Since i=2 then sample 1 could be the first sample to be inspected, then the successive samples as following:

1, 1+2, 1+2*2, 1+2*3…
1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21

Field Measurements

The field measurement in the present study consists of distress type, quantity and identifies the severity associated with the distress according to its related criteria. The distresses presented in the study area can be classified according to the following articles:

1. Alligator Crack: The distress severity of this type of distress is determined according the degree of development of cracks into a pattern or network. The quantity of this type of distress is measured manually by the use of tape, in area unit (m2). Figure 5 presents the alligator crack in the study area.
2. Polished Aggregate: This distress can be seen in one sample units in the study area. The quantity of polish aggregate is measured manually by the use of tape in area unit (m2). Figure 6 displays polished aggregate distress in study area.

Figure 5 Alligator crack distress in study area

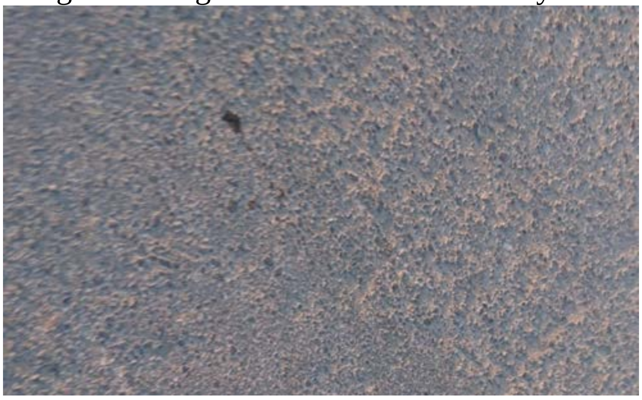

Figure 6 polished aggregate distress in study area.

3. Potholes: The quantity of this distress is measured by number, with its severity that depends on the diameter of the pothole and its depth. Figure 7 views pothole distress, as seen in study area.

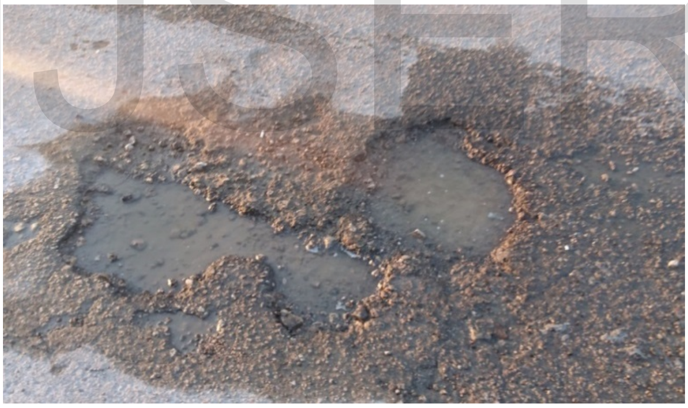

Figure 7 Pothole distress in study area

4. Rutting quantity is measured manually in (m2) of surface area and its severity determined by the average depth of the rut. Figure 8 shows this type of distress, as shown in the study area.

Figure 8 Rutting and depression distresses in study area

5. Raveling: The distress severity is determined in terms of the amount of loss of coarse aggregate; where quantity of this distress is measured manually by the use of tape, in area unit (m2). Figure 9 include the raveling, as shown in the study area.

Figure 9 Raveling, corrugation and longitudinal crack distresses in study area

6. Weathering: This distress can be seen in most of the sample units in the study area. The distress severity was determined as the amount of wearing away of the asphalt binder and fine aggregate matrix. The quantity of this distress is measured manually by use of tape, in area unit (m2). Figure 10 shows the weathering as shown in the study area.

7. Depression: it’s a part of the pavement surface area has an elevation lower than surrounding pavement area. In many cases, depressions may not be noticed until rain fall, ponding water creates an area "birdbath" on dry pavement. Depressions can be measured by square feet (square meters), and its severity levels depend on mean depth of these depressions. Figure 11 presents the depression as shown in the study area.

8. Corrugation: is a series of closely spaced crests and sags (ripples) frequenting at properly regular intervals (usually less than 10 feet or 3 m) across the pavement. These ripples are perpendicular to the traffic direction and measured by squared meters, while its severity depends on ride quality.

9. Shoving: its permanent displacement of localized area of the pavement surface, it is caused by traffic loads. When the traffic rushes against the pavement, it will produce short, abrupt waves in the pavement surface. It is measured by squared meters and its severity depends on ride quality. Shoving in study area can be seen in Figure 12.

Figure 10 weathering and polished aggregate distress in study area

Figure 11 Depression distresses filled with wate

Figure 12 Shoving distress in study area

Modeling and Analysis by PAVER Software

This program is basically used to evaluate pavement condition; PAVER software is able to implement pavement condition analysis. Selected network/branch/section should be verified and inspection data of the pavement sections should be entered to estimate PCI.

Pavement Inventory

PAVER software divides pavement network to branches and sections before performing condition analysis. Inventory button provides tools to edit view and define the pavement networks. It also includes two windows (U.S Army Corps of Engineers, 2011): inventory data and list selector. Inventory data window allows the user to edit inventory access data for a particular level of the network by clicking the tab window for network, branch, or section while the list selector is a window contains drop-down boxes. These boxes allow the user to select a particular inventory item by working down the hierarchy of the database at each level whether network, branch or section, by selecting its ID or Name. In the following articles there is a description of creating each of the inventory tabs.

Creating a Network

Creating a network is the first step in the building of pavement inventory. In PAVER software, there is hierarchical structure for pavement inventory items (U.S Army Corps of Engineers, 2011). To create pavement branch and section, create a network first.

Creating a Branch

Branches could be created from inventory button on PAVER button bar. Branch tab involve three fields related to area: calculated area (the sum of the sections), area adjustment and true area. The field of "Calculated area" is the true areas summation of all sections forming the branch. Field of "area adjustment" is used to illustrate special information about the branch area which is not comprised in calculated area. If there are decreases in branch area, they should be entered as negative values. Section tab also has an area adjustment field. If the user filled down the area adjustments in the section level, there is no need to reflect it on area adjustment field of brunch level. Then the true area equals the calculated area plus area adjustment and it is the value used in the program's calculations and reports (U.S Army Corps of Engineers, 2011).

Creating a Section

Section is created by inventory on the PAVER software button bar. The section file card contains three area fields, calculated area, area adjustment and true area. Calculated area is the product result of the section's length and width entered by the user so it cannot be edited. Calculated area and area adjustment summation obtains true area which used in PAVER calculations and reports. As a contrast to branch file card, the true area field could be edited directly, and then PAVER will automatically calculate the area adjustment (U.S Army Corps of Engineers, 2011).

Entering Inspection Information

To enter inspection data, first be sure that the desired network/branch/section is selected with the select inventory window. The PAVER inspection data entry window is designed to be easy used and to enable experienced users from entering large amounts of inspection data rapidly useing either the mouse activities or the keyboard to enter all inspection information. Inputting the distress data is the most frequented part of inspection data entry.

A familiar user with the PAVER's window of inspection data entry can enter distress data completely with the keyboard. Selecting the proper distress severity is done by typing "L" for Low, "M" for Medium and "H" for High. Once the distress quantity is typed as shown in Figure 13, the distress is added to the list by pressing the Enter key or by typing "A" for Add.

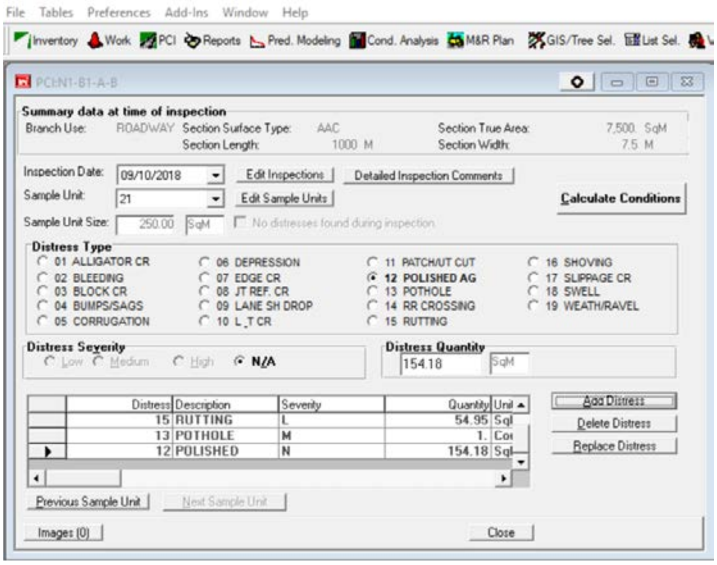

Figure 13 Inspection data entry window

Results of PAVER Software Application

The PCI of each sample unit inspected is automatically calculated by the program, the program also determines the overall PCI for the entire section, and in addition it calculates the quantities of extrapolated distress. Based on distress mechanism (load, climate and other), the PAVER determines the percentage of deduct values of the section. The percentage of deduct values related to each distress mechanism is the basic for determining the primary reasons of pavement deteriorations. Table (1) assorts distress causation for AC-surfaced road and parking lots based on climate, load, and other factors (Shahin, 2005).

Calculating PCI after Inspection

After complete entering the information of each sample unit of an individual section, the PCI will be calculated for each examined sample units, and then for the whole pavement section. Calculation of PCI is based on the deduct values; weighting factors from 0 to 100 represent the impact of each distress on pavement condition. A deduct value of 0 gives an indication that no effect of this distress on pavement surface operational condition and/or structural integrity, on the other hand a value of 100 indicates an extremely serious deterioration (Shahin, 2005).

An assessment results window views the condition of the individual section immediately by selecting “calculate conditions” button shows in the window of inspection data entry. Section properties are displayed at the top part of the window, while condition index, condition value and inspection date are displayed in the middle part of the window. The results showing on this window include the following (U.S Army Corps of Engineers, 2011).

Table (1) PAVER distress classification for asphalt-surfaced road and parking lots (Shahin, 2005 & U.S Army Corps of Engineers, 2011)

Code	Distress	Cause
01	Alligator Cracking	Load
02	Bleeding	Other
03	Block Cracking	Climate
04	Bumps & Sags	Other
05	Corrugation	Other
06	Depression	Other
07	Edge Cracking	Load
08	Joint Reflection Cracking	Climate
09	Lane/Shoulder Drop Off	Other
10	Longitudinal/Transverse Cracking	Climate
11	Patch/Utility Cut	Other
12	Polished Aggregate	Other
13	Pothole	Load
14	Railroad Crossing	Other
15	Rutting	Load
16	Shoving	Other
17	Slippage Cracking	Other
18	Swell	Other
19	Raveling	Climate
20	Weathering	Climate

1. Condition indices: shows the condition value for the entire pavement section as shown in Figure 14.

2. Sample distresses: illustrate section’s inspected sample units and their corresponding distress codes, descriptions, quantity, severity, density and deduct value.

3. Sample conditions: The top part displays the sections inspected sample units as well as the individual unit’s sample type, size and PCI. Whereas the bottom views the number of samples have been surveyed and compares the total number of sample units to the recommended number for project level inspection.
4. Section extrapolated distress: displays each distress type exists in the inspected section. Distresses are cumulated based on the type and severity level. In other words, the program will deal with each severity level of each distress type as a distinct distress. The adjusted quantities of distress are illustrated also, to reflect the extrapolated value based on the total area of the section. Extrapolated distress deducts are sorted as resulting from climate, load or other. This portion of the tab views the percent of extrapolated distress deduct belonging to climate, load and other.

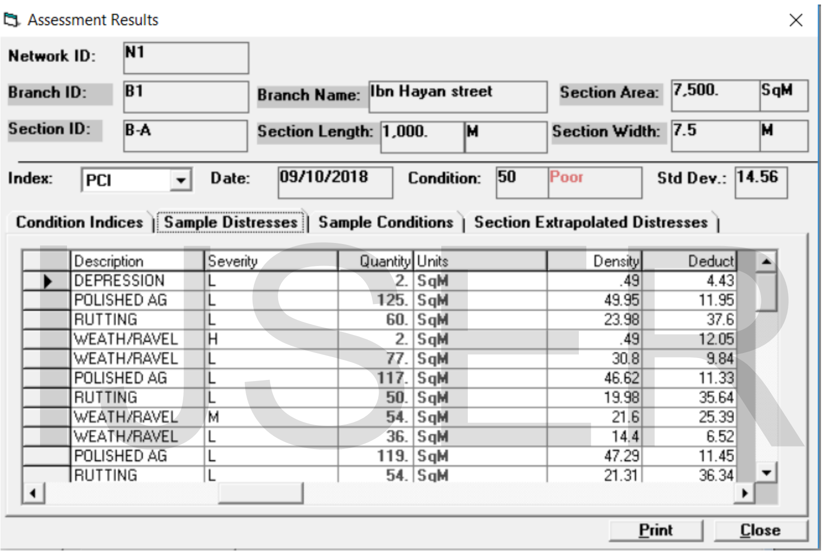

Figure 14 Example of automated PCI calculation from the PAVER system – sample distresses

Discussion of the results

PCI is a numerical indicator that evaluates pavement’s surface condition. It provides a measure of the current condition of the pavement based on the observed distress on the pavement surface, which also reflect the structural integrity, as well as surface operational condition. It provides a reasonable and objective basis for determining M&R needs and their priorities. Continued monitoring of the PCI is necessary to find out the rate of pavement deterioration, which permits early determination of major rehabilitation plans. The PCI supply feedback on pavement performance for improvement or validation of present pavement design and maintenance procedures.
The results of the present chapter have been determined using PAVER software that the average condition of the selected pavement PCI are 51 for section A-B and 50 for section B-A, that means the average PCI of the brunch road approximately 50. Following PCI category, this classifies the case study pavement section as being considered in “poor” condition and it falls between the values of 40 and 55, which mean that the pavement in the selected road brunch needs major rehabilitation operations.

Pavement Maintenance Repair Techniques

The types of repair techniques are illustrated below.

1. Crack Sealing

Crack sealing is a method of cleaning and sealing or resealing of cracks in AC surfaced pavement. This process is used to fill transverse, longitudinal and reflected cracks which are wider than (1/8) inch. The basic advantage of crack sealing for AC pavement is preventing moisture infiltration from the surface into the pavement foundation. This technique is more economic as a preventative measure, when the overall pavement is in good condition. But it becomes not cost effective if the pavement is deteriorated.

2. Asphalt Seal-Coat

This technique composed of a thin layer of asphaltic material such as asphalt emulsions, paving-grade asphalt cement or cutbacks. Modifiers may be added to the asphaltic liquid mixture, and may include latex, rubber, rejuvenators and polymers. Coarse and fine aggregate, mineral and synthetic fillers, and rubber crumbs can be applied after the asphaltic mixture application on the pavement surface. Some kinds of seal coats, such as slurry seals and micro surfacing incorporate the gravel, sand and fillers in the mixture before applying it on the road.

3. Patching

This process involves replacement of full depth of the asphaltic layer, a replacing of the subbase and base layers may be included also. Full-depth patching used to treat distresses those are related to structural and material problems such as rutting, corrugation and cracking. If the failure is limited to the top layer of AC pavement as in slippage cracking, then the depth of the patch could be limited also to the top layer only, if it can be removed easily.

4. Overlay

Overlay technique includes addition of one or more of AC layers to the existing pavement. The purpose of using overlay is to improve or correct structural capacity or functional performance, such as ride quality and skid resistance. Using of an AC overlay is usually more cost effective if the existing pavement stills in good condition

Pavement Maintenance Alternatives

Many variables influence the selection of the right technique of treatment. Even treatment is selected; still there are many choices of the proper procedures to be applied and materials to be used. Selection of the suitable maintenance strategy and applying it in the right time is of high importance for effective management of highway pavements. Type, extent, frequency and severity of surface distresses, in addition to roughness and structural conditions, all these factors have an influence on the convenient maintenance strategy as indicated in Table 2.

Table 2 Distress type, description and how to repair.

Distress type	Repair
Alligator cracking	As the small cracking the repair will be removing of the cracked area of the pavement, dig out and replace area part of poor subgrade. Large fatigue cracked the treatment is by placing an HMA overlay.
Longitudinal crack	For the low severity crack (less than1/2 inch in wide and infrequent) crack seal is used to prevent water entry through the cracks into the subgrade, and stop raveling edges of the crack. HMA can be used to provide years of satisfied service after treating small cracks if they are kept sealed (Roberts et. al., 1996).
Corrugation and Shoving	Small, localized areas of corrugation or shoving. Remove the distorted pavement and patch. Large corrugated or shoved areas indicative of general HMA failure. Remove the damaged pavement and overlay.
Depression	they should be healed by removing the distressed pavement then digging out the area of poor subgrade and replacing it, then patching over the repaired subgrade.
Polished Aggregate	Applying a skid-resistant slurry seal which is the application of a mixture of water, asphalt emulsion, aggregate (very small crushed rock), and additives to an existing asphalt pavement surface.
Potholes	Fill the pothole in asphalt pavement by patching process. Repair of potholes helps to control further deterioration and avoid expensive repair of pavement. Otherwise water can enter to the subgrade layer and cause more serious failures. A full-depth is considered as a permanent repair.
Raveling / weathering	Small, localized areas of raveling. Remove the raveled pavement and patch. Large raveled areas indicative of general HMA failure. Remove the damaged pavement and overlay.
Rutting	Slight ruts (less than 1/3 inch in deep) can be left untreated. Otherwise pavement should be leveled and overlaid.

Conclusion and Recommendation

1. Depending on distresses data collected from Al-Samawa city’s pavement, it’s found that most of these distresses classified as surface defects meanwhile the less are crack ones. Where weathering and rutting distresses form the largest percent of these surface distresses and laying on most of the study area.
2. Through the evaluation of pavement condition with PAVER software application and depending on collected distress data from distributor road section in Al-Muthanna governorate, Al-Samawa city, Al-Hussain zone, the value of PCI of the pavement equal to 50, this falls in “poor” area between the boundaries of 40 and 55.
3. Based on the value of PCI it can be concluded that the pavement needs major rehabilitation operations. Some of these operations can be done by overlay, others by patching techniques; meanwhile small percent of distresses can be repaired by crack sealing.
4. It is recommended that all agencies have detailed quality control and quality assurance programs to ensure integrity of data. Quality control programs that are already in existence must also be reviewed at regular

intervals since pavement condition survey is constantly evolving automated equipment.

5. PAVER is efficient software in pavement condition evaluation and PCI calculation accurately and fast if it's fed with actual data based on an accurate diagnosis, so it is important to use the PAVER software in Iraq. This may assist decision makers and local engineers of PMS agencies (SCRB, Al-Muthanna governorate, and the Ministry of Municipalities) to make the proper decision in selecting optimum pavement maintenance

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