Evaluation of Asphalt Pavement Distresses in Main Roadways in Al-Diwaniyah City

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Abstract:

Asphalt pavement influenced by many factors effect on its performance and serviceability, factors like excessive traffic loads, temperatures, water, design and execution mistakes, and lack of maintenance, these make the Pavement has fast deteriorated with time. The temperature in Iraq exceeded the 50^{o} c, and without controlling on traffic loads and no plans in maintenance management lead to appear severity distresses in most of roads in Iraq. Road maintenance management system improvement leads to reduce time and cost and the pavement condition survey is taking a big role in the pavement management at network level provides the information for pavement performance. Three different main roads were selected in the city of Diwaniyah and the distresses amount was surveyed by using two methods: present serviceability rating and pavement condition index to determine the pavement performance. 10 defects were identified in the asphalt pavement out of (19) defects mentioned by the PCI method, the cracks are the densest distresses in the pavement followed by the rutting and potholes and the rest of the distresses are less dense, all of which are due to poor mix design and poorly implemented. The results showed that the users' opinions of the studied roads were affected mainly by the roads roughness, the PSR values gave a fair rating of the studied roads while the PCI method gave a poor rating that is meaning Iraqis are more bearing to the hardships they face while using the roads. A periodic survey shall be conducted on the transportation network which shall be consisting of a database.

Keywords: Asphalt Pavement Distresses; Pavement Management System (PMS); Present Serviceability Rating (PSR); Pavement Condition Index (PCI).

الخلاصه

يتاثر التبليط الأسفلتي بالعديد من العوامل التي تؤثر على أدائه وقابليته للخدمة، كما أن عوامل مثل الأحمال المفرطة للمرور، ودرجات الحرارة، والماء، وأخطاء التصميم والتنفيذ، والافتقار إلى الصيانة، تجعل من الرصيف يتعرض لتدهور سريع مع مرور الوقت. ان تجاوز درجات الحرارة ال50 سيليزيه في العراق من دون السيطرة على الأحمال المرورية وليس هناك خطط في إدارة الصيانة يؤدي إلى ظهور عيوب شديده في معظم الطرق في العراق. ان تحسين نظام إدارة صيانة الطرق يؤدي الى تقليل الوقت والتكلفة، ويؤدي مسح حالة الرصيف دورا كبيرا في إدارة الرصيف على مستوى شبكة النقل التي توفر المعلومات عن أداء الرصيف. تم اختيار ثلاثة طرق رئيسية مختلفة في مدينة الديوانية وتم مسح كمية العيوب باستخدام طريقتين: تقييم الخدمة الحالية ومؤشر حالة الرصف لتحديد أداء الرصيف، وقد تم تحديد 10 عيوب في رصيف الأسفلت من اصل (19) من العيوب التي وردت في طريقة PCI. ان الشقوق هي الأكثر كثافة في الرصيف يليها التخدد والحفر أما بقية العيوب فهي أقل كثافه وكلها بسبب سوء تصميم الخلطه الاسفلتيه وسوء التنفيذ. وأظهرت النتائج أن آراء مستخدمي الطرق المدروسة تأثرت بشكل رئيسي بوعورة الطرق، وإن قيم PSR تسجل تصنيفا متوسط للطرق التي تمت دراستها ومن طريقة PCI تصنف بضعيف وهذا يعني أن العراقيين أكثر تحملا للصعوبات التي يواجهونها أثناء استخدام الطرق. يجب اجراء مسح دوري يتضمن استقصاء لشبكة النقل و يتألف من قاعدة للبيانات.

الكلمات المفتاحية : عيوب التبليط الاسفلتي; نظام ادارة التبليط; تقييم الاداء الحالي; مؤشر حالة التبليط.

1- Introduction and Literature Review:

Asphalt pavement influenced by many factors effect on its performance and serviceability, factors like excessive traffic loads, temperatures, water, design and execution mistakes, and lack of maintenance (**Sharad and Gupta**), these make the pavement has fast deterioration with time. The temperature in Iraq exceeded the 50^{o} c, and without controlling on traffic loads and lack of plans in maintenance management lead to appear severity distresses in most of roads in Iraq. The main reasons of highways network failure middle part of Iraq are the fast appearance and increase in intensity of deformation with absence of periodically maintenance in the pavement surfaces, the increasing of traffic in weights and repetition, weakness of subgrade, deficiency of drainage system, and bad asphaltic mixture design (**Hassan, 2013**;**Alwan, 2015)** define of distresses reasons of two main roads in Hilla

city by the bad site execution and design of roads layers, bad quality of asphaltic wearing course to resist traffic, loads and temperature, bad adhesive, reduction in thickness and insufficient compaction, laboratory results of sections with Poor PCI shows there is higher disagreement with the specifications. **(Hall *et.al.*,1992)** in their research, road pavements require continuous maintenance and rehabilitation works to prevent deterioration caused by repetitive traffic loading and environmental factors (**Karim *et.al.*, 2016)**.

The distresses that appear in middle part of Iraq were the rutting in high percentage followed by bleeding due to the weather and the high traffic load, block and transverse cracks, raveling, and potholes were appear with less percentages **(Hassan, 2013)**, corrugation high percent followed by less percent of rutting then raveling **(Alwan, 2013),** high percent alligator cracks followed by depression and rutting (**Alwan, 2015**).

More than 70% of the existing roads network are not in a satisfactory condition and were in need of maintenance as reported by state commission for roads and bridges (**Sarsam, 2016)**. The Ministry of Housing and Construction yearly prepares a plan for the maintenance of roads all over the country, but the execution does not follow a schedule of priorities, impotency for the available funds (**Sarsam and Talal, 2009**). Road maintenance management system was improved in order to reduce time and cost (**Mohemed, 2010**).

Pavement condition survey is taking a big role in the Pavement Management System at network level. Also, gives the information for pavement serviceability analysis, predict maintenance & rehabilitation needs and priorities, and distribute funding (**Youssef and Elbasher, 2014**). Pavement distress (surface condition) is one of the characteristics of pavement condition for evaluating pavement rehabilitation needs (**Garber and Hoel, 2010**). Pavement condition can be measured by the Pavement Condition Rating (PCR). It considers current and future pavement condition and priorities, this helps maintain pavement structural capacity (**Abdulhameed and Sarsam**, **2014**). There is agreement between the laboratory and PCI methods in the determination of pavement conditions and their causes **(Alwan,2015)**.

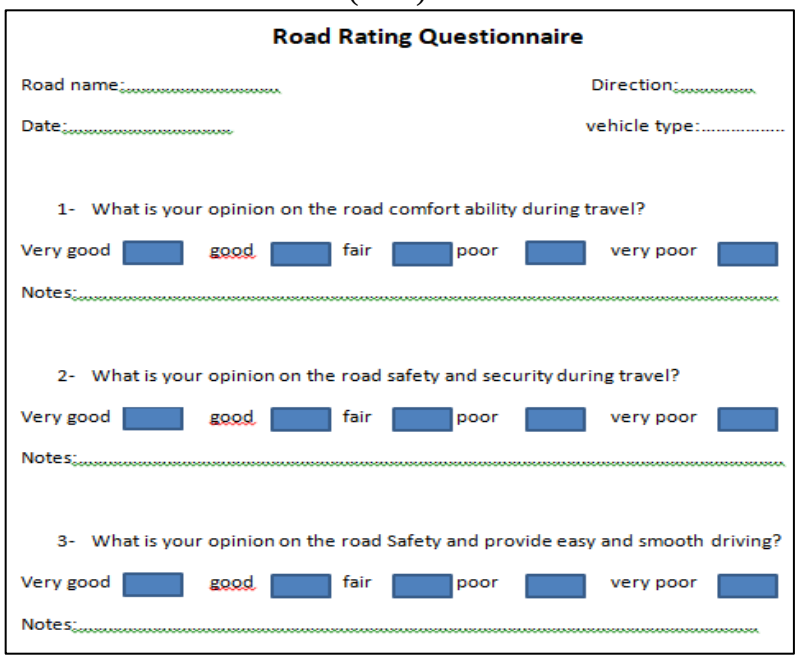
This research mainly aims to highlights the relationship between Present Serviceability Rating (PSR) defined in the **AASHTO road test** (which depending on users' opinions collected by cards) and the Pavement Condition Index (PCI) is an evaluation Survey process that is determined in accordance with **ASTM D 6433-07, (2007),** As the serviceability is based on the fact that the most important effect in the opinion of road users is the comfort, safety and ease of driving, although it is a personal opinion can be considered as an indicator of the road physical condition. And then work to compare these opinions with the results of the PCI, which depends mainly on the defects visible and existing in the methods depending on the intensity and area and then determine the acceptable values where this can be used in the process of design and rehabilitation of paving layers.

2- Methodology:

In order to achieve the objectives of the research, three different roads were selected in the city of Diwaniyah (Diwaniyah-Najaf Road) as a rural highway and the (Rubber Plant Road) as an urban main road and (Diwaniyah-Sadir road) as a rural, The amount of defects in this way using two methods of measurement commonly known as:

Present Serviceability Rating: AASHTO engineers have developed a method in the field of road tests to predict paving surface condition called the concept of serviceability (the current service), which is defined as the ability of a section of the road surface to provide a smooth, to the users' opinions ranging from zero to (5), (1) for a very bad answer and (5) for a very good answer. In this research, a survey of the user's opinions of three road lines to express the condition of the road and use rates start from very poor to very good as form shown in figure (1). This form was distributed on samples of drivers of different types

of vehicles in both directions (50 samples per direction) include questions about the user's opinion on the road in terms of comfort, safety, then calculating the rate of the marks of these answers and considering the result the value of (PSR) according to each opinion Sample, finally calculate the mean values (PSR) for each of the studied road.



Road Rating Questionnaire

Road name:..... Direction:.....

Date:..... vehicle type:.....

1- What is your opinion on the road comfort ability during travel?

Very good ☐ good ☐ fair ☐ poor ☐ very poor ☐

Notes:.....

2- What is your opinion on the road safety and security during travel?

Very good ☐ good ☐ fair ☐ poor ☐ very poor ☐

Notes:.....

3- What is your opinion on the road Safety and provide easy and smooth driving?

Very good ☐ good ☐ fair ☐ poor ☐ very poor ☐

Notes:.....

Figure (1): Present Serviceability Rating Form (as worked by 2008 المسوتي وسعود)

Pavement Condition Index: This method was developed by the US Army Corps of Engineers to determine the condition of paving (PCI). This method is based on the survey of the defects on the paving surface and determines the intensity, surfaces and lengths and the use of discount curves to calculate the pavement condition index as shown in the table (1), this method was achieved according to **ASTM D 6433-07**. Figure (2) shows the basic steps followed in this study, work consists on-site evaluation form to identify distresses from the 19 standard defects listed in the specification and determine whether they are high, medium, low severity according to the standard specifications of each defect with its specifications by working on site survey when riding on the pavement to record the type of distresses closure and measure the length, area or depth and taking photos. The taking distance was 1 km length of each road and it is divided into five sections with 200 meters each.

Table (1): Standard PCI Scale and Associated Condition Ratings

PCI value	Rating
0 - < 10	Failed
≥ 10 - < 25	Serious
≥ 25 - < 40	Very poor
≥ 40 - < 55	Poor
≥ 55 - < 70	Fair
≥ 70 - < 85	Satisfactory
≥ 85 - < 100	Good

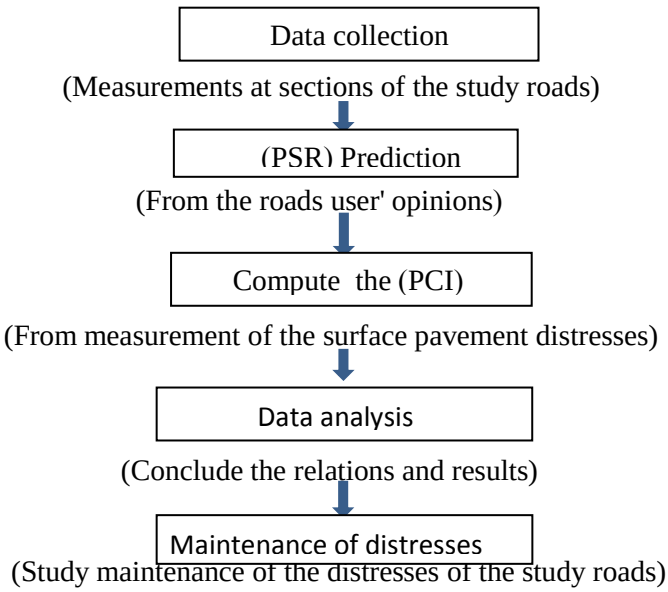


Figure (2): The Flowchart of the Work Plan

3- Serviceability Computations and Data Analysis:

3-1 Present Serviceability Rating (PSR):

The table (2) shows the results recorded of this questionnaire. Knowing that the initial serviceability of flexible pavement as specified in AASHO test was 4.2. The terminal severability for express way is 3, main road is 2.5 and for secondary road are 2. The results show that rating is Fair and all roads need for maintenance because they reached or close to their terminal serviceability.

Table (2): The Value of (PSR) According to the Results of the Questionnaire

Name of the road	Sudair - Diwaniyah	Diwaniya - Sudair	Rubber plant Road (coming from the international road)	Rubber plant road (going to the international road)	Najaf-Diwaniya	Diwaniya - Najaf
Result	2.3	2.6	2.3	2.4	3.1	2.2
PSR	Fair	Fair	Fair	Fair	Good	Fair
Av. result	2.45		2.35		2.65	
Av. PSR	Fair		Fair		Fair	

3-2 Pavement Condition Index (PCI):

Tables (3, 4) represented samples of the pavement distresses detecting sheet and pavement condition survey data sheet (for one section /one road in the study); the tables (5-7) show the PCI for each section in the three roads.

Table (3): Detection of the Distresses of the Pavement for a Part of the Road (Diwaniyah - Najaf)

Section	Type of distress	Quantity	Unit	Degree of severity
(0+00)-(2+00)	Alligator cracks	65	ft^2	Low
	Blocks cracks	35	ft^2	Medium
	Longitudinal and transverse cracks	102	Foot length	Medium
	Rutting	96	ft^2	Medium
	Rutting	45	ft^2	High
	Potholes	4	Number	Low
	Potholes	7	Number	Medium
	Depression	18	ft^2	Medium

Table (4): Asphalt Pavement Distresses Form for Finding the Value of (PCI)

Road name: Diwaniya – Najaf				Section area= 17213.44 ft^2
Distresses types 1-alligator cracking 6-depression 11-patching & util cut patching 2-bleeding 7-edge cracking 12-polished aggregate 16-shoving 3-block cracking 8-jt-reflection cracking 13-potholes 17-slipage cracking 4-bumps and sags 9-lane/shoulder drop off 14-railroad crossing 18-swell 5-corrugation 10-long & trans cracking 15-rutting 19-weathering/raveling				
Distress severity	Density %	Deduct value	Total deduct value	119.2
1low	0.378	12.3		
3medium	0.203	15.1	Corrected deducted value	73
10medium	0.593	25		
15medium	0.558	24	PCI=100-corr. Dedu. Val. =100-73	26
15high	0.261	23.7		
13low	0.023	5	Pavement condition	Very Poor
13meduim	0.041	4		
6medium	0.105	10.1		

Table (5): Shows the Pavement Condition of Road Sections (Diwaniyah - Najaf) According to the Values of (PCI)

Sec. No.	Road sections (meters)	PCI value	Pavement condition
1	(0+00) - (2+00)	26	Very Poor
2	(2+00) - (4+00)	38	Very Poor
3	(4+00) - (6+00)	42	Poor
4	(6+00) - (8+00)	49	Poor
5	(8+00) - (10+00)	31	Very Poor
For total road		39.2	Very poor

Table (6): Shows the Pavement Condition of Road Sections (rubber plant) according to the Values of (PCI)

Sec. No.	Road sections (meters)	PCI value	Pavement condition
1	(0+00) - (2+00)	37	Very poor
2	(2+00) - (4+00)	28	Very poor
3	(4+00) - (6+00)	35	Very poor
4	(6+00) - (8+00)	51.7	Poor
5	(8+00) - (10+00)	39	Very poor
For total road		38.14	Very poor

Table (7): Shows the Pavement Condition of Road Sections (Diwaniyah - Sudair) according to the Values of (PCI)

Sec. No.	Road sections (meters)	PCI value	Pavement condition
1	(0+00) - (2+00)	29	Very poor
2	(2+00) - (4+00)	45.3	Poor
3	(4+00) - (6+00)	26	Very poor
4	(6+00) - (8+00)	36.6	Very poor
5	(8+00) - (10+00)	37.4	Very poor
For total road		34.8	Very poor

According to PCI method, the average rating is very poor for all roads, and the roads must treat and rehabilitate. As comparing with the PSR –users' opinions-, the PCR the "standard" method – which is depending on distresses measurements- was less rating than the users' opinions (PSR), they was satisfied because their rating was fair, when converted PSR to percentage value, results was from 47 to 53 % this percentages in PCR scale represents poor rating as shown in table (8). As shown in table (10), there is an agreement between the PSR results and the PCR (corresponding to PSR %) when depending on the common PCI scale for rating (shown in table (9)), so; the PCI common scale is more compatible with the PSR scale (or users' opinions scale) than the standard PCR scale. The deference is still between the PCR from measurements and PSR.

Table (8): Comparing Between the PSR and PCI of the Study Roads

Roadway	PS value		PSR		PS %		AV. PCI	PCR	PCR corresponding to PS %	
Sudair - Diwaniyah	2.3	2.45	Fair	Fair	46	49	34.8	Very poor	Poor	Poor
Diwaniyah - Sudair	2.6		Fair		52				Poor	
rubber plant Road (from the international road)	2.3	2.35	Fair	Fair	46	47	38.14	Very poor	Poor	Poor
Rubber plant road (to the international road)	2.4		Fair		48				Poor	
Najaf- Diwaniyah	3.1	2.65	Good	Fair	62	53	39.2	Very poor	Fair	Poor
Diwaniyah-Najaf	2.2		Fair		44				Poor	

Table (9): the PCR Scale (as mentioned in Alwan (2013, 2015), Setyawan (2015) and Karim et al (2016))

PCI value	Rating
0 - < 10	Failed
≥ 10 - < 25	Very poor
≥ 25 - < 40	Poor
≥ 40 - < 55	Fair
≥ 55 - < 70	Good
≥ 70 - < 85	Very good
≥ 85 - < 100	Excellent

Table (10): PCR and PSR According to Common Scale of PCR

Roadway	PSR		PS %		AV. PCI	PCR	PCR corresponding to PS %	
Sudair - Diwaniyah	Fair	Fair	46	49	34.8	Poor	Fair	Fair
Diwaniyah - Sudair	Fair		52				Fair	
rubber plant Road (from the international road)	Fair	Fair	46	47	38.14	Poor	Fair	Fair
Rubber plant road (to the international road)	Fair		48				Fair	
Najaf- Diwaniyah	Good	Fair	62	53	39.2	Poor	Good	Fair
Diwaniyah-Najaf	Fair		44				Fair	

The higher percent of distresses was cracks which are influenced with climate followed by rutting and potholes which are influenced with load. The severity of distresses is medium to low and the longitudinal & transverse cracking is the densest and most common. Rutting noticeably appears in both Rubber plant road and Diwaniyah-Najaf road, on the other hand; raveling noticeably appears in Sudair-Diwaniyah road. This research also showed that the cracks and rutting appear with the highest percent like the other researches on distresses in middle part of Iraq from literatures (Hassan (2013) and Alwan (2013 and

2015))**,** which is influenced with climate and high traffic load, and the bad mixture design and execution might be the main reasons which are also the same reasons in these researches. Table (11) illustrates the most distresses that found in this study and its possible causes with their treatment according to **the ministry of transportation and infrastructure (2016), Sharad and Gupta, David (2006),** and **FHWA (2009).**

Table (11): Distresses Appears in Roads of the Study with Its Possible Causes and Treatments

Distress	Possible causes	Treatment
Longitudinal & Transverse Cracking	Heavy traffic and construction problems, Shrinking due to low temperatures, Reflecting the cracks	Crack Treatment or Spray Patching
Pavement Edge Cracking	Poor edge drainage, Passing axle loads on the outer edges of the road. Insufficient paving layers on the sides of the road	Crack treatment and/or rebuilding the shoulder wider. As the severity increases, patches and replacement of distressed areas
Alligator Cracking	Due to poor quality materials, inadequate structure, lack of base strength, or lack of drainage	Repair of drainage if necessary, possibly replacement of base materials, and then a full depth patch.
Rutting	Excessively soft asphalt due to poor mix design or improper compaction during construction	Grinding pavement level. Severe rutting a full depth patch
Distortion	settling of the base materials	Leveling. Should be replaced with a full depth patch as soon as possible
Pothole	The existence of cracks of various types and at an advanced level. Localized issues with the asphalt mix or drainage.	Filling with cold mix. Otherwise, a pothole patch
Raveling	Poor adhesion of aggregates due to wet aggregate or lack of asphalt or dust on the aggregates, aggregate Fracturing due to heavy loads, poor compaction allowing water to strip aggregate, poor construction causing segregation of asphalt and aggregate and old pavement that has been weathered.	A surface treatment. Sealcoat or micro-surface if raveling is extensive, sprays patching if localized areas.
Block cracking	Daily temperature variation, the aged of asphalt in the mixture. They can also be due to lack of compaction during construction	Recycling may be needed. If base problems are found, reclamation or reconstruction
Corrugation	The instability of the asphalt concrete surface course may be caused by too much asphalt cement, too much fine aggregate, or rounded or smooth textured coarse aggregate	Minor corrugations can be repaired with an overlay or surface milling. Severe corrugations require a deeper milling before resurfacing
Depression	Drop in the base layer, which leads to the reflection on the surface of the road. lack of base layers and asphalt pavement	Apply sand asphalt mixture, cold mill and overlay

4- Conclusions and Discussion:

1. The results showed that the users' opinions of the studied road in Diwaniyah city were affected mainly by the roads roughness. However, the effect of distresses such as cracks, potholes and rutting didn't have any effect. Therefore; when comparing the results in the two methods, the PSR values gave a fair rating of the studied roads while the PCI method gave a poor rating of most of the studied sectors because the PCI method depended directly on the types of defects and their severity.

2. The PSR value of (Sudair – Diwaniyah) and (Diwaniyah – Sudair) roads are 2.3 and 2.6 respectively, (Rubber plant from / to international road is 2.3-2.4, (Najaf- Diwaniyah) and (Diwaniyah – Najaf) roads are 3.1 and 2.2 respectively. The AV. PCI value of roads Diwaniyah to/ and from Sudair is 34.8, Rubber plant road (connected with international road) is 38.1 and roads Diwaniyah to/ and from Najaf is 39.2.
3. When comparing our findings with developed countries, we find that Iraqis are more bearing to the hardships they face while using the road to travel, where the assessment of the quality of driving is very high, in the sense that the appeared distresses less impact on the evaluation process.
4. Using the PCI method, 10 defects were identified in the asphalt pavement out of (19) defects mentioned by this method. The cracks are the densest distresses in the pavement followed by the rutting and potholes. The rest of the distresses are less dense, all of which are due to poor mix design and poorly implemented.
5. Using the PCI method to determine the causes of the distresses before performing the maintenance work to avoid wasting the cost, effort and time in the tests as the specifications (PCI) proved to be efficient in this area.

5- Recommendations:

Through research, the following recommendations can be made:

1. A periodic survey shall be conducted, including a survey on the transport network, which shall be consisting of a database.
2. Study the effect of road roughness on passenger comfort and safety; increase the costs of operating vehicles on it, and the economic feasibility of implementing the road rehabilitation project.
3. Use good materials and manage road construction projects properly to avoid such defects. If necessary, an extensive study of how to repair and rehabilitate them should be carried out.
4. Spread the traffic awareness for road users as well as the owners of the houses and shops that are on both sides of the roads for the purpose of using it correctly, where we see recently the work of drilling is incorrect as well as the drainage of rain water, heavy water and washing water are all discharged on vital roads incorrectly.
5. Putting traffic signs and marks in the designated places, as well as setting warning signs to avoid accidents when there are severe defects in the roads as well as when starting maintenance work.
6. Improve the properties of asphalt mixtures used in roads by adding polymeric additives or using reinforcing materials such as geogrids.
7. Must focus on the modern methods in the design of the mixture (SUPERPAVE) being interested in the performance of mixing and resistance to moisture, in addition to the adjustment of asphalt to suit the temperature of the country.

6- References:

Alwan Jasim A., 2013 , "**Definition of Pavement Distresses of Road No. (80) in Hilla City by Paver (PCI) Method and its Repair Methods**", Al-Kufa engineering journal, vol.4, 2, pp 1-18.

Alwan Jassim A., 2015 , **"Asphaltic Pavement Distresses and The possibility of repair"**, Al-Qadisiyah journal for engineering sciences, vol.8, 1, pp 15-42.

ASTM D6433-07, 2007 , American Society for Testing and Materials, "**Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys**", United States.

David P. Orr 2006 ," **Pavement Maintenance Engineer Cornell Local Roads Program. Cornell Local Roads Program**" P.P: 17-40.

Federal Highway Administration, 2009 ," **Pavement Distress Identification Manual",** for the national park service NPS road inventory program Cycle 4, 2006-2009**,** department of transportation, united states of America.

Garber NJ, Hoel LA, 2010 , "**Traffic and Highway Engineering**", Fourth edition, United State Copyright, Cengage Learning, Canada.

Hall J. W., Grau R. W., Grogan W. P., & Hachiya Y.,1992 , "**Performance indications from army airfield pavement management program**", Pavement Management Implementation. ASTM, STP 1121, pp. 297-317.

Hassan Khawla H., 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, pp 50-62.

Karim Fareed M.A., Rubasi Khaled A., H., and Saleh Ali A., 2016 , "**The road pavement condition index (PCI) evaluation and maintenance: a case study of yemen**", technology and management in construction organization; 8: 1446–1455.

Ministry of Transportation and Infrastructure, 2016 ," **Asphalt Pavement Maintenance**", Fourth Edition, British Columbia.

Mohemed NW., 2010 , **"Road Maintenance Management System: A Case Study at Public Work Department**", [MSc. Thesis], Faculty of Civil Engineering, University of Technology, Malaysia.

Sarsam S, Talal A., 2009, "**Development of Pavement Maintenance Management System for Baghdad Urban Roadway Network**", Proceedings, 1st scientific conference of Civil Engineering College – AL Baath University. Industry of Engineering Constructions, Humus – Syria, 11-13.

Sarsam Saad I., 2016 , " **Pavement Maintenance Management System: A Review",** Trends in Transport Engineering and Applications, ISSN: 2394-7284 (online) Volume 3, Issue 2 pp 19-30 © STM Journals.

Sarsam Saad I., Abdulhameed Amina T., 2014 , "**Development of Pavement Maintenance Management System for Baghdad Urban Roadway Network**", Number 3 - March Volume 20 Journal of Engineering.

Setyawana A., Nainggolanb J., Budiartoc A., 2015 , " **Predicting the remaining service life of road using pavement condition index**", The 5th International Conference of Euro Asia Civil Engineering Forum (EACEF-5), 1877-7058 © 2015 Published by Elsevier Ltd Science Direct, Procedia Engineering 125 417 – 423.

Shahin M.Y. and Walther J.A. 1990 , "**Pavement Maintenance Management for Roads and Streets using the PAVER System**", U.S.A. CERL Technical Report M-90/05, Champaign, IL.

Sharad.S.Adlinge , Prof.A.K.Gupta , " **Pavement Dererioration And Its Causes** ".IOSR Journal Of Mechanical & Civil Emgineering,2278-1684,PP:09-15.

Youssef M. A. Elbasher, Abdelbary A.,2014 , **"Best Practices Maintenance for Aborshada Road in Libyain Western Region**", Journal of Engineering and Development, Vol. 18, No.5, ISSN 1813- 782292-pp 92-105**.**

المسوتي محمد فواز ، سعود اندراوس، 2008 ،" **تحليل قابلية خدمة الطرق وعلاقتها بقرينة الاستوائية**" ،مجلة جامعة دمشق للعلوم الهندسية، المجلد الرابع والعشرون، العدد الثاني – صفحات 265-291