CE 437

Evaluation of Pavement condition index for a Ar Rabia district

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Content

Introduction:

In a perfect world, pavement would last forever. Unfortunately, this is not the case. Before deciding on the proper repair, we need to understand why there may be premature distresses and to evaluate the severity of it to decide that we need to do maintenance.

Why Roads Fail Prematurely ?

shows how the load is spread out by the pavement. A thicker pavement will result in less stress on the subgrade. Figure 1 shows how pavement deflects under a wheel load. As the pavement flexes, there will be a combination of compression (pushing) and tension (pulling) stress in the pavement. This can eventually lead to cracking due to *fatigue*.

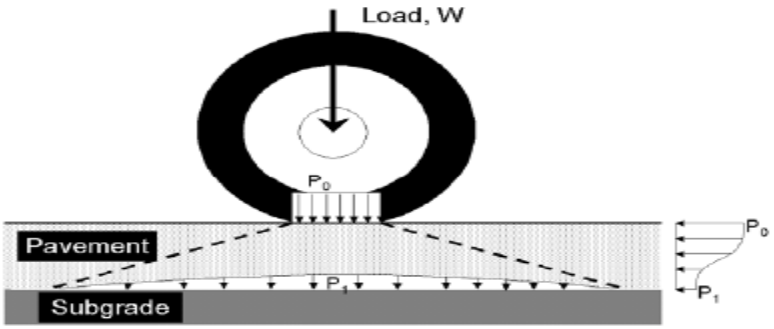

Fig.1

The amount of deflection and stress in the pavement is also related to the amount of moisture in the subgrade soils. If the subgrade soils are wet, there will be a great deal of deflection under the wheel loads. The deflection will be much less for the same soil when it is well drained. The excess moisture in spring thaw will result in higher stresses in the pavement. Larger loads and thinner pavements result in more stress on the pavement. Pavements will fail sooner than expected if:

- There are heavier loads than expected
- There are more loads than expected
- The pavement is too thin for the traffic loads
- The materials used in the pavement are weaker than expected

Other primary cause of failure is the penetration of water into the asphalt base. Oxidation of the pavement surface begins this process which caused the asphalt to dry and become brittle. This oxidation leads to the erosion of the top layer of fine particles ' and the appearance of larger stones and small cracks on the surface.

Premature failure

Pavements fail prematurely because of many factors. When boiled down to the basics, there are
four primary reasons pavements fail prematurely:

- Failure in design
- Failure in construction
- Failure in materials
- Failure in maintenance

Pavement condition rating:

The pavement condition is related to several factors ,including structural integrity , structural capacity , roughness , skid resistance . direct measurement of all of these factors need expensive equipment and highly trained personal . these factors assessed by observing and measuring distress in the pavement .

In this study we are going to talk about :

- The principle distresses that cause the failure .
- The PCI
- Case of study with an example .

Objectives :

- **Definition of distress asphalt together with the reason**
- **Definition and importance Pavement condition Index .**
- **Method of calculating the PCI**
- **Evaluation of pavement condition index for a Ar rabia district .**

Distress Identification :

it is important to understand the distresses that occur in a pavement , Distress is defined as a condition of pavement structure that reduces serviceability or leads to a reduction in serviceability. Serviceability is defined as the ability of a pavement to provide a safe and comfortable ride to its users. Distresses may be treated with a range of repairs, each having a varying degree of success.

The four major categories of common asphalt pavement surface distresses are :

1. Cracking
2. Surface deformation
3. Disintegration (potholes, etc.)
4. Surface defects (bleeding, etc.)

I. Cracking

A. Alligator Cracking or Fatigue cracking

1. Description:

Alligator cracking is a series of interconnected cracks in an asphalt layer forming a pattern, which resembles an alligator's hide or chicken wire. The cracks indicate fatigue failure of the asphalt layer generally caused by repeated traffic loadings and this distress allows water to penetrate the surfacing materials and subgrade, which furthers the damage. Alligator cracking, also called fatigue cracking, usually first begins as a single longitudinal crack in the wheel path. As show Fig.2

2. Possible Causes

- Insufficient pavement structure
- Inadequate base support
- Poor base drainage
- Aging and traffic loading

Fig.2

B.Edge Cracking :

Edge cracking is similar to alligator cracking only located within 1 to 2 feet of the edge of the pavement. Failure begins at the edge of the pavement and progresses toward the wheel path. Pavement edge distress can result in worsening of the wheel path condition and allow moisture into the subgrade soils and base materials. Edge cracking also includes the longitudinal cracking associated with concrete basecourse widening .as show Fig.3 .

Fig.3

2. Possible Causes

- Traffic Loading
- Environmental
- Construction Related
- Low Shoulder
- High Shoulder Holding Water

C. Longitudinal Cracking

1. Description

Longitudinal cracking denotes cracks that run predominantly parallel to the centerline. These cracks may be in the wheel paths, between wheel paths and/or at lane joints such as centerline or shoulder/surface. Multiple parallel cracks may eventually form from the initial crack. This phenomenon, known as deterioration, is usually a sign that crack repairs are not the proper solution .Filling or sealing longitudinal cracks can work if the cracks are narrow and not deteriorated too much. Shows sealed longitudinal cracks. Multiple cracks may require patching or area repairs to fix the problem .as show Fig.4 .

2. Possible Causes

- Traffic Loading (wheel path cracks)
- Environmental (frost action)
- Improper Construction Practices
- (joint cracks)
- Poor Drainage
- Reflection Cracks

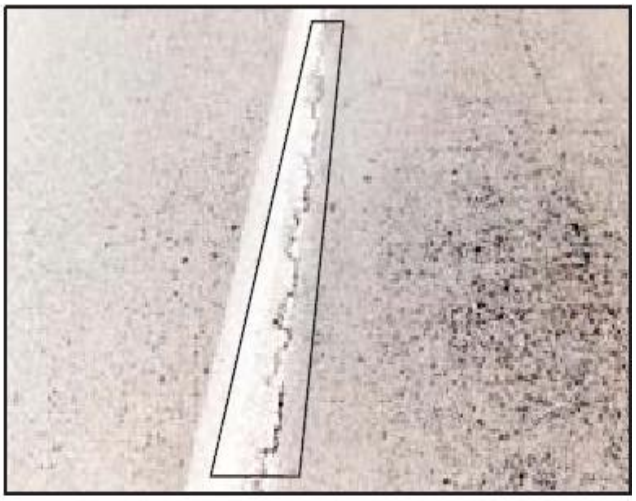

Fig.4

D. Block Cracking :

Random or block cracks divide the pavement into rough, approximately rectangular pieces and typically occurs at uniformly spaced intervals. This is sometimes the result of transverse and longitudinal cracks intersecting. They can also be due to lack of compaction during construction.. Low severity block cracking may be repaired by a thin wearing course. As the cracking gets more severe, overlays and recycling may be needed. If base problems are found, reclamation or reconstruction may be needed.as show Fig.5 .

2. Possible Causes

- Environmental (thermal)
- Aging

Fig.5

E. Transverse Cracking

1. Description

Transverse cracks are those considered to extend three-fourths of the width of the pavement or more, generally perpendicular to centerline They are regularly spaced and have some of the same causes as longitudinal cracks. Transverse cracks will initially be widely spaced (over 20 feet apart). They usually begin as hairline or very narrow cracks and widen with age. If not properly sealed and maintained, secondary or multiple cracks develop, parallel to the initial crack. As show Fig.6 .

2. Possible Causes

- Environmental (thermal)
- Swelling or shrinkage of the subgrade
- Reflection cracks
- Settlement (trench, backfill)

Fig.6

Surface deformation :
Pavement deformation is the result of weakness in one or more layers of the pavement that has experienced movement after construction. The deformation may be accompanied by cracking. Surface distortions can be a traffic hazard.

IV. Rutting

B. Description

Rutting is the displacement of pavement material that creates channels in the wheel path. Very severe rutting will actually hold water in the rut. Rutting is usually a failure in one or more layers in the pavement. The width of the rut is a sign of which layer has failed. A very narrow rut is usually a surface failure, while a wide one is indicative of a subgrade failure. Inadequate compaction can lead to rutting. Figure 7&8 shows an example of rutting due to subgrade failure..

B. Possible Causes

- Poor mixture quality
- Insufficient support
- Improper construction procedures

Fig.7

Fig.8

Disintegration :

The progressive breaking up of the pavement into small, loose pieces is called disintegration. If the disintegration is not repaired in its early stages, complete reconstruction of the pavement may be needed.

Patholes:

A. Description:

Potholes are bowl-shaped holes similar to depressions. They are a progressive failure. First, small fragments of the top layer are dislodged. Over time, the distress will progress downward into the lower layers of the pavement. Potholes are often located in areas of poor drainage. As show Figure 9&10 .

B. Possible Causes

- traffic loading,
- the presence of water

Fig.9

Fig.10

Surface defects

Whereas the previous types of distress are mostly related to the supporting layers beneath the surface, surface defects are related to problems in the surface layer.

1. Raveling

A. Description

. Raveling is the loss of material from the pavement surface. It is a result of insufficient adhesion between the asphalt cement and the aggregate. Initially, fine aggregate breaks loose and leaves small, rough patches in the surface of the pavement. As the disintegration continues, larger aggregate breaks loose, leaving rougher surfaces. Raveling can be accelerated by traffic . Some raveling in chip seals is due to improper construction technique. This can also lead to bleeding.

B. Possible Causes

- Poor mixture quality
- Asphalt hardening due to aging
- Insufficient asphalt content
- Improper construction methods

Fig.11

2. Excess Asphalt

A. Description

Excess asphalt, also called bleeding or flushing, is used to describe a free film of asphalt on the surface of the pavement that creates a smooth, shiny, greasy, and reflective surface. It is usually found in the wheel paths and becomes quite sticky when hot. Excessive asphalt cement reduces the skid-resistance of a pavement, and it can become very slippery when wet, creating a safety hazard.

B. Possible Causes

- Mixture problems (bad oil, stripping aggregate, low air voids, high AC content, etc.)
- Improper construction practices
- Paving over excess asphalt

Fig.12

pavement condition index

- **Introduction**

There are two ways to measure the condition of a road network. The first way is to call it the Squeaky Wheel, sit back and wait for the complaints. The more complaints, the worse the condition of the roads. The second way is to use a more thorough, comprehensive and pro-active approach to review the entire road network. The Pavement Condition Index is a simple, convenient and inexpensive way to monitor the condition of the surface of roads, identify maintenance and rehabilitation needs, and ensure that road maintenance budgets are spent wisely.

- ***What It Is ?***

The Pavement Condition Index rates the condition of the surface of a road network.
The PCI provides a numerical rating for the condition of road segments within the road network, where **0** is the **worst** possible condition and **100** is the **best** .as show Fig.13 .

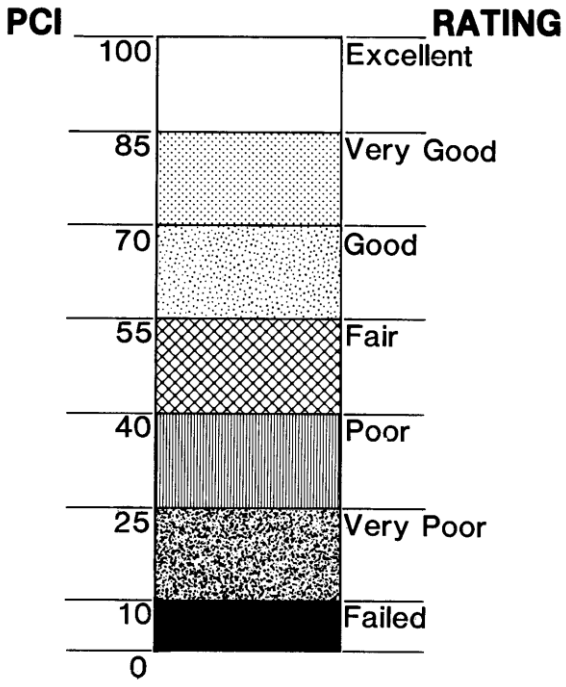

Fig.13

- **What It Measures *?***

The PCI measures two conditions:

• The type, extent and severity of pavement surface distresses (typically cracks and rutting)

• The smoothness and ride comfort of the road

- **How To Do It ?**

The PCI is a subjective method of evaluation based on inspection and observation.

It is neither a complex nor time-consuming exercise.
Knowledgeable and experienced public works officials drive the road network and evaluate its condition in a systematic way. The observations are entered into a database for evaluation and use.The PCI should be conducted annually so that changes in road condition can be evaluated.

- ***What It Provides ?***

The PCI tells public works officials :

• The current condition of the road network
• The rate of deterioration of the road network over time *PCI Uses and Benefits:*

- **A PCI is used to:**

• Identify immediate maintenance and rehabilitation needs
• Monitor pavement condition over time
• Develop a network preventive maintenance strategy
• Develop road maintenance budgets
• Evaluate pavement materials and designs

Setting Up a Performance Condition Index

While the PCI is based on subjective observations, the index itself must be both objective and systematic to be of value.

- ***A PCI needs to be based on:***

• Manageable road sections
• A roads inventory
• A classification and rating system for road defects

Road Sections: In order to develop a PCI, the road network needs to be divided into manageable segments. Sections with relatively uniform pavement structures, design and traffic volumes will have similar performance characteristics.

In urban settings, sections should be kept to a manageable length, typically one block long. Some road authorities limit the length to 150 metres for problematic sections. Other authorities will use longer segments for roads that are consistent throughout their length.
Road sections in rural settings can be considerably longer, in some cases as much as 10-kilometres. Each road section needs a unique identification so that the PCI observations can be maintained in a database.

- ***Road Inventory :***

Each road section should have a basic history attached to it:

• Class - local residential, collector, or arterial
• Length, width, and geometry
• Type and volume of traffic
• Pavement type - flexible, rigid, or composite
• Original construction date
• Maintenance and rehabilitation history
• Current condition based on the last PCI

Conducting a PCI

The Drive Through:

A PCI is developed based on visual inspection and observation– sometimes called a “windshield inspection”.
Ideally, two people should do the inspection together –one driving while the other takes notes – and both evaluating the pavement as they go.

Start by driving along the road section at the posted speed in one direction to evaluate the ride comfort. Then do a repeat drive through at a lower speed (about 30) examining the full width of the road for defects. The inspectors are looking for the frequency and severity of specific surface defects on the checklist. They should also be making observations as to whether the road section is fulfilling its function and how well it compares to other roads.

A digital photograph of each section of roadway provides a permanent record of the pavement condition. Data collection tools can simplify the task. Laptops and PDAs can record and upload data. GPS units can pinpoint locations accurately. But paper and pencil still works.

Evaluating Surface Distresses:

Surface distresses are evaluated based on type, frequency and severity.
MTO SP-024 – Manual for Condition Rating for Flexible Pavements gives a good description of the types of defects and how they should be evaluated. We had already talked about in the previous pages (5 – 11) .

The following form can be used by inspectors to record distresses (and the evaluation for a local road in relatively good condition). As show Fig.14

FLEXIBLE PAVEMENT
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

AIRPORT		DATE
FACILITY	FEATURE	SAMPLE UNIT
SURVEYED BY	AREA OF SAMPLE	

DISTRESS TYPES

41 ALLIGATOR CRACKING
42 BLEEDING
43 BLOCK CRACKING
44 CORRUGATION
45 DEPRESSION
46 JET BLAST
47 JT REFLECTION (PCC)
48 LONG & TRANS CRACKING
49 OIL SPILLAGE
50 PATCHING
51 POLISHED AGGREGATE
52 RAVELING/WEATHERING
53 RUTTING
54 SHOVING FROM PCC
55 SLIPPAGE CRACKING
56 SWELL

SKETCH

	EXISTING DISTRESS TYPES					
TOTAL SEVERITY L						
TOTAL SEVERITY M						
TOTAL SEVERITY H						

PCI CALCULATION

DISTRESS TYPE	SEVERITY	DENSITY %	DEDUCT VALUE
DEDUCT TOTAL			
CORRECTED DEDUCT VALUE (CDV)			

PCI = 100 - CDV = _____

RATING = _____

Fig.14

Consistency:

While every effort should be made to ensure that the PCI is as objective as possible, it is still based on the subjective observations of those doing the inspection.
If a PCI is to be used to track the deterioration of a road network over time, the observations of subsequent PCIs need to be comparable. It is, therefore, important whenever possible to use the same people to do the inspection each year.

Calculating the PCI :

There are plenty of software programs available to help calculate and record the PCI for a road section (Municipal DataWorks, for example, has a PCI tool), but the calculations are relatively straightforward and can be done by hand or with the aid of a spreadsheet (Fig.14) . Since each type of surface distress indicates a different type of problem, some more severe and some less, each distress is given a weight to reflect its importance in a rehabilitation strategy . The numerical rating for the severity of the distress and for the density of the distress are combined and then multiplied by its weight. The sum of all the distresses gives the DMI (Distress Manifestation Index) for the road section. The inspector also rate the Ride Comfort Rating at posted speed, assigning it a numerical rating between 0 and 10, where 10 is equivalent to a brand new road. The PCI can then be calculated using either a software program or by hand based on well-established formulas.

This PCI is used as a guide to rehabilitation and maintenance decisions for the road network based on a decision matrix (see Making Decisions below).

PCI Decision Matrix

TIME OF IMPROVEMENT	FREEWAY	ARTERIAL	COLLECTOR	LOCAL
Adequate	>85	>85	>80	>80
6 to 10 years	76 to 85	76 to 85	71 to 80	66 to 80
1 to 5 years	66 to 75	56 to 75	51 to 70	46 to 65
NOW Rehabilitate	60 to 65	50 to 55	45 to 50	40 to 45
NOW Reconstruct	<60	<50	<45	<40

Table.1

Using the PCI

Making Decisions:

The PCI decision matrix provides specific guidelines for the improvements required for various road classifications. Using the PCI can help identify trigger points for preventive maintenance that can stop a road deteriorating to the point that it needs expensive rehabilitation.
As a rule of thumb, the higher the PCI, the better condition the road is in.

The PCI decision matrix is a guideline and should be used in conjunction with the personal observations of the road inspectors. Municipalities can adjust the matrix to provide alternative trigger points for rehabilitation or reconstruction. Specific maintenance and rehabilitation actions should always be based on the actual distress of the pavement itself.

Asset Management:

The PCI identifies roads that are exhibiting distress and at the network level can help categorize maintenance and rehabilitation requirements for budgeting and planning.
The PCI, as a condition rating index, can be used effectively with other asset management programs. The condition rating identifies the remaining useful life of an asset and assists with developing rehabilitiation and replacement
strategies for a particular asset.

Case Study

Introduction :

After we defined the main distresses in streets theoretically and we reviewed the way that we are going to use to evaluate them which is PCI , we go out into the field and do these measurement by ourselves and evaluate the road and take the PCI for them . We chose ar rabia district to do our study . we choose three streets with different Performance and functional as a sample and build upon it using the PCI the quality of the district's streets and a precise results for these streets .

Objectives :

- Identify the distresses at field.
- Taking the PCI at field.
- Calculate the result
- Evaluation the street in Ar Rabia

Location :

Ar rabia district locates in the north section of Riyadh . it is bounded from the south alnfl district &tee north ring road, from the west alghadeer district , from the north altakhassissy street ,from the east abubakr . its length from east to west 3 kilos and from south to north 4kilos.the main features of the district is kingdom school and kingdom Hospital.

Fig.15

We take a sample of three streets within the district abu moad alansary , alghtght and krimh alzbyryh .

Procedure :

W depend on eye notice to the sample , so we walk on the street and write down the distresses that we see in a special form writing down the name of the distress & its number then we write its severity depending on an accurate measurement .also, we write its length if it is measured with width or its area if it is measured with area . then we calculate the index manually using the curves in the lecture note and deducts the points from 100. After that , we rate it using the pci rating figure &give its rating .we calculated the pci using an average of sections with all information above (severity , length , area,..) and a took pictures each of a distress .

Fig.16 (ALgadgad Street)

Fig.17 (calaculation of district patch)

Fig.18&19 (Longitudinal district)

Fig.20 (potholes)

Fig.21 (Alligator district)

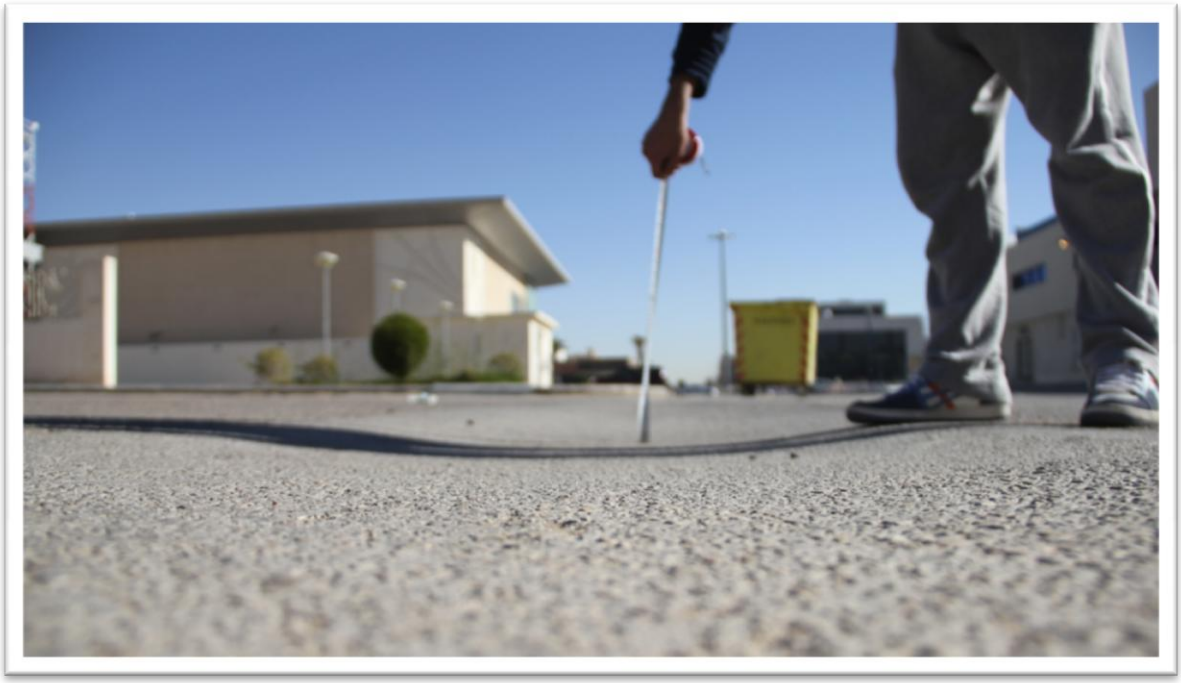

Fig.22 (Depression)

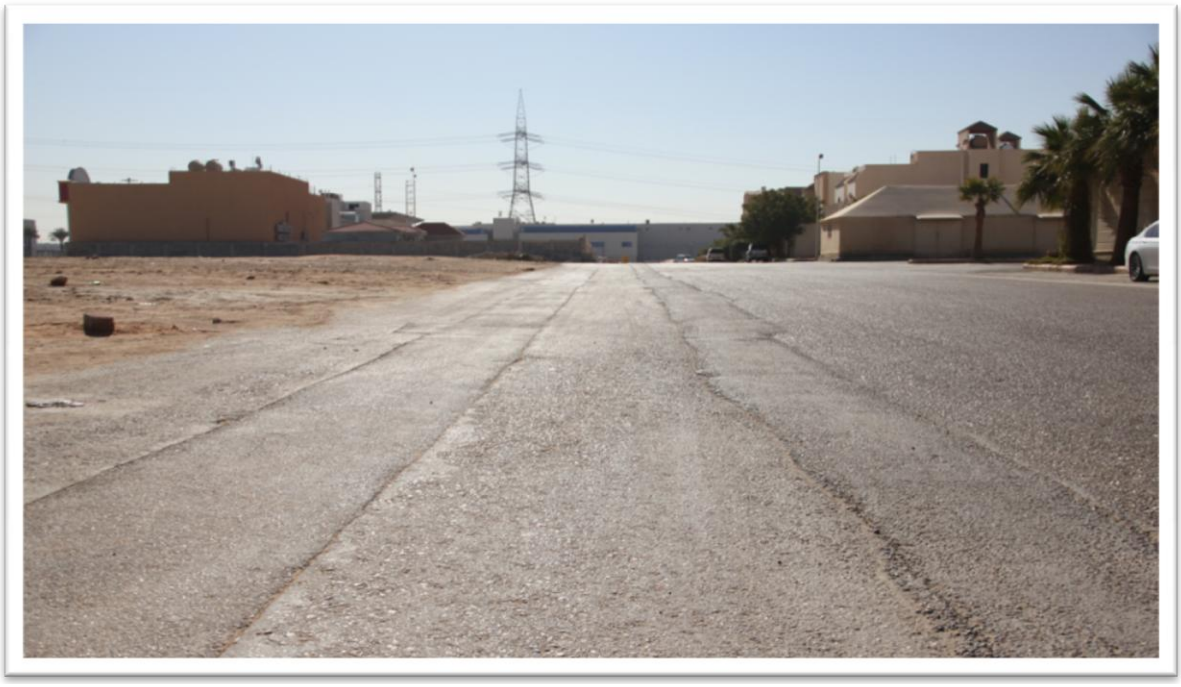

Fig.23 (Patching)

Data Collection :

(Next page)

Results and analysis :

AL gadgad Street (1)		ALAnsary Street (2)		AZ zabiria Street (3)	
Section No.	PCI	Section No.	PCI	Section No.	PCI
1	68	1	72	1	83
2	77	2	69	2	87
3	79	3	65	3	93
4	86	4	66	4	69
5	84	5	70	5	73
6	82	6	40	6	80
Avg =	79.33		63.66		80.83
	TotalAverage=74.61				

Table.2

After taking the average, we note that the road I got a good rating, while the second road as well as picking a good rating, while the third and got a very goodestimate.

We note the different readings in the figures to come.

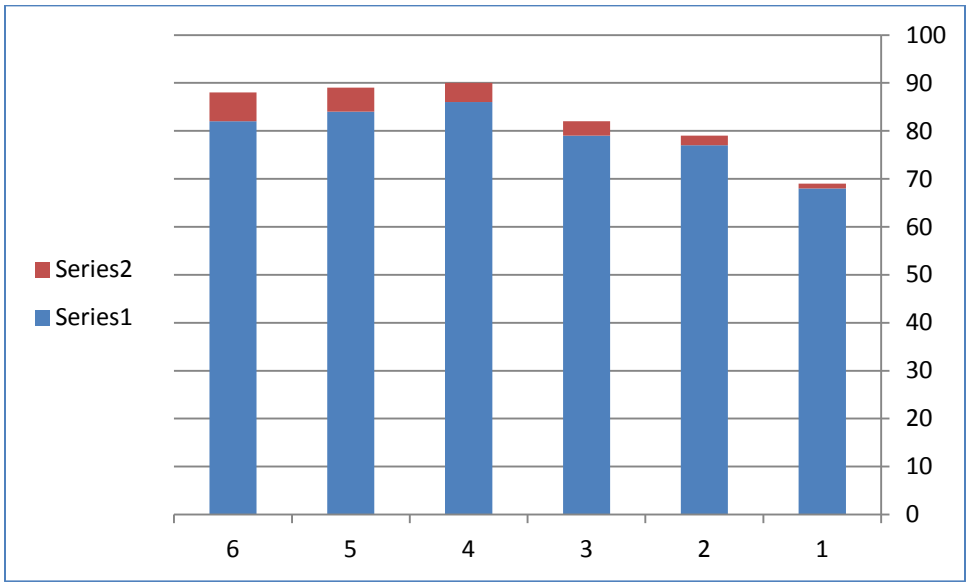

Fig.24 (Al Gadgad Street)

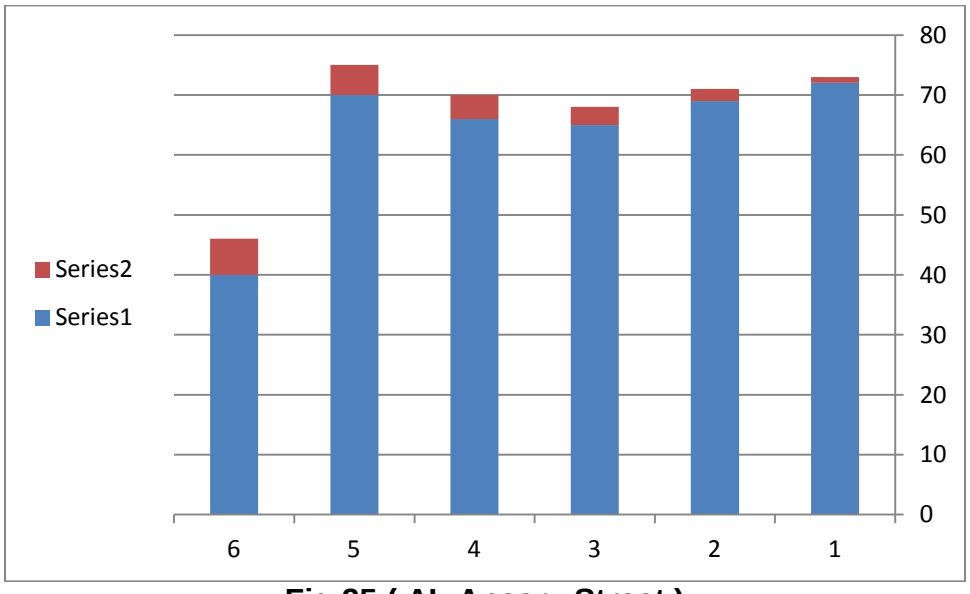

Fig.25 (AL Ansary Street)

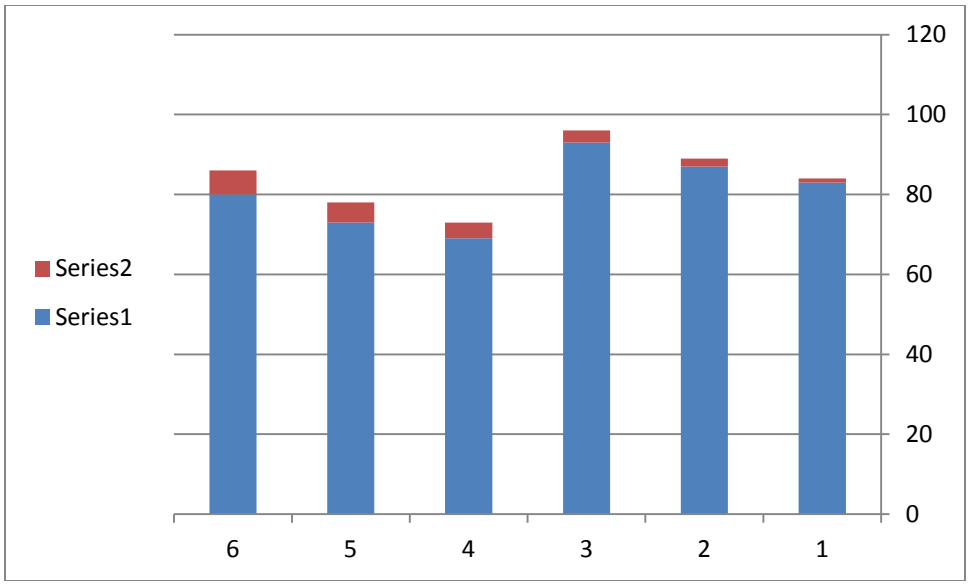

Fig.26 (AZ zabirea Street)

Recommendation :

After taking the general assessment of the three ways, the result is good grade, so this sample represents the entire district of ȦR Rabia .

The final arbiter of the ways is good, so do not require re-asphalt the roads in this district.

References :

- Lecture note .
- American Association of State Highway and Transportation Officials (AASHTO)
- Federal Highway Administration - Long Term Pavement Performance Program
- Pavement Condition Evaluation Manual

The End