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Development of a Pavement Management System to be Used in Highway Pavement Evaluation in Jordan

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Abstract
Since year 2000, the main road network in Jordan has witnessed large developments in the fields of design, construction, evaluation and maintenance. This development aimed at keeping up with the socio-economical and social development and to accommodate the large increase in the number of vehicles of heavy loads and to contribute in reducing traffic accidents through constructing more corridors around the capital city of Amman. In addition, to rehabilitate and develop the present main roads and construct more new roads that link isolated areas with industrial centers and residential communities.The road network length in Jordan has increased to reach up to 8200km of major and minor roads. During the last ten years, expenditure on roads rose up to 547 million JD. This means that 76% of the allocated budget for roads was spent on road construction.The Ministry of Public Works and Housing (MPW&H) has paid a particular attention to road maintenance with the purpose of conserving this national wealth in spite of the limited allocated amounts for maintenance and rapid increase in maintenance costs. MPW&H took the initiative and awarded maintenance of some of the major roads to Private Sector so that they could contribute in improving this sector. This helped in opening up the opportunity to exchange experiences and to be aware of the sate- of –the- art in road maintenance. The total expenditures on road maintenance for the same period rose up to 173 million JD representing 24% of the road financial budget. Road maintenance includes periodical maintenance, rehabilitation, improvement and reconstruction.
This study aims at introducing the presently adopted pavement management system by MPW&H, showing its positive and negative points, along with suggestions for development.
Keywords: Pavement management, Road maintenance, Pavement evaluation, Roughness, Serviceability, Cracks

1. Introduction

Road maintenance plays a key role in conserving national wealth. Since one of the main aims of MPW&H is to keep the major and minor roads in a good condition, MPW&H established the first independent ministry department that is concerned with road maintenance and traffic safety in 1984. In order to help the department to achieve its goals, an agreement was signed in 1985 with Deleuw Cather International –USA to prepare a comprehensive system to manage the maintenance of all the roads in the Kingdom (Majed., Reema., 2009, MPW&H., 2008-2010). In 2000, an agreement was signed with Sweden to keep up with scientific developments in road maintenance. This agreement included developing the road sector in Jordan, which also implied maintenance of roads and bridges. Within this agreement Road Information System, road maintenance system and bridges maintenance system were prepared in addition to a system to evaluate the roads condition, which consisted of five evaluation levels (SWEROAD., 2009, MPW&H., 2008-2010).

Roads and Bridges Maintenance Department prepared future programs and plans to satisfy the requirements needed for road maintenance. In addition, the department was responsible for supervising and following up the implementation of the projects of routine and periodical rehabilitation, development, improvement and reconstruction. The total expenditures on road maintenance throughout the last ten years rose up to 173milion JD as indicated in Table 1. (Majed., Reema., Mouna., 2009, MPW&H., 2008-2010).

Due to the increase of the length of the road network, and because of the urgent need to conserve this national wealth, which is estimated to be 3.5 billion JD, MPW&H invited the Private Sector to take part in road maintenance through submitting tenders for the international main roads(MPW&H., 2008-2010).

2. Objective

This study aims at presenting the currently used pavement maintenance management system by MPW&H, showing its advantages and disadvantages.

The presently used maintenance management system by MPW&H depends on functional pavement evaluation through measurement of the Present Serviceability Rating (PSR) subjective procedure. Therefore, the second study objective is to suggest a development of the used system by fine tuning the evaluation subjective levels, add objective evaluation procedure taking into consideration condition and functional evaluation of the pavement.

3. Functional Pavement Evaluation

Functional road performance is evaluated through roughness evaluation of the road surface. Road Roughness is defined as an expression of irregularities in the longitudinal profile of pavement surface that adversely affects the riding quality of a vehicle. These irregularities lead to uncomfortable feeling for road users. Smoother roads are required because they provide comfort and safety to road users, reduce vehicle operating cost by reducing fuel and oil consumption, tire wear, maintenance cost and vehicle depreciation, and reduce pavement maintenance cost (Al-Rosan et al., 2010, Al-Swailmi et al., 2004).

The International Roughness Index (IRI) is a scale for roughness based on the simulated response of a generic motor vehicle to the roughness in a single wheel path of the road surface. Many distresses affect the road roughness such as cracks, potholes, surface corrugation, and depression (Al-Rosan et al., 2010, AUSTROADS., 2001).

A road maintenance should be implemented to maintain the road and enable it of performing its intended function of transporting people and commodity safely and comfortably. Hence, the road maintenance system cares about road distress evaluation (Asi et al., 2009). Various techniques are used in road evaluation, some of them depend on accuracy and cover all the expected road distresses, and others depend on the principle of general evaluation and estimation without the need to cover all the defects and to survey the entire surface (Yoder., 1975, Nicholas et al., 2010). Some of the evaluation techniques require that inspectors walk along the roads evaluating their conditions and locating the surface defects, others are executed by driving slowly along the road, and some others depend on electronic systems capable of surveying the road automatically (Yang., 2012, Al-Swailmi et al., 2004).

4. Functional Evaluation Criteria and Foundations

Pavement condition indices aim to evaluate the road condition systematically by avoiding being influenced by personal judgments or by any other surrounding circumstances (Yoder., 1975).

Pavement evaluation indices have witnessed various stages of development. Nevertheless, it is still considered discretionary and not direct measurement means of road performance. At the beginning, there was a general concept of performance evaluation, which is expressed by the drivers' comfort level. In this method, the road surface condition is considered a measurement to express the road performance level, overlooking the structural condition of the road (Nicholas et al., 2010, Al-Swailmi et al., 2004).

Later on, road performance level was expressed through the serviceability level of the road. This led to the development of the "Pavement Serviceability Index (PSI)". Studies showed that the road roughness forms 95% of the PSI and that the remaining 5% represent the other road distresses such as cracks and rutting (Yoder., 1975).

Serviceability evaluation is a subjective evaluation procedure depends solely on the human being judgment. This lead maintenance engineers to pay more attention to the studies that recommended a comprehensive evaluation approach. Focus began to be paid to the defects that affect the serviceability of surface and have, at the same time, connection with the structural road condition. This led to the adoption of the Pavement Condition Index (PCI), which focuses on road evaluation using a technique that includes the surface defects, structural road conditions, and the range of traffic load bearing capacity (Nicholas et al., 2010, Shahin., 2005, Al-Swailmi et al., 2004).

In the last few years, a great progress has been made in the concept of road evaluation considering both the functional and structural aspects of the road as main factors of the evaluation process. Still, differences are present when applying the indicators and indices of the road performance evaluation (Al-Swailmi et al., 2004).

5. Structural Pavement Evaluation

The main aim of structural evaluation is to determine the structural capacity of the road through measuring the ability to withstand the repeatedly increasing traffic loads. In addition to knowing the remaining chronological age of the road before it fails down, and defining the appropriate time for carrying out the required maintenance (Shahin., 2005, Al-Swailmi et al., 2004).

Some of the used roads are under designed in the amount of expected traffic, construction materials are sensitive to weather conditions, and or/ highly affected by the rise of the underground water which in turn weakens the road's structural capacity (Yoder., 1975).

Structural Road Evaluation depends on two methods: First, measuring the degree of the pavement deflection under the effect of falling loads that have the same amount and duration of traffic loads. If the deflection is high, this means that the road is structurally weak and vice versa. Secondly, measuring the quality and properties of the road layers to find their carrying capacity (Shahin., 2005, Yang., 2012).

Distresses can be divided into three kinds: Surface distresses such as raveling; Sub-surface distresses such as depression; and Cracks. There are four main reasons of such distresses: (Shahin., 2005, MPW&H., 1971).

1. Traffic load on pavement;
2. Materials, such as using inadequate construction materials;
3. Weather conditions such as high temperature and low temperatures; and
4. Moisture, whether from rain or because of rise of underground water which leads to reduction of bearing capacity or the disintegration of the asphalt layers.

Road distresses vary in relation to the traffic loads. Some distresses appear because of increase in traffic loads such as rutting. On the other hand, road distresses vary in terms of the initiation, direction and progress. There are distresses that occur at the asphalt surface and propagate downward until reaching the base layer, an example of such distresses is the environmental surface cracks. Other distresses are bottom up distresses like fatigue cracking, or occur due to failures in the subgrade like rutting. Some other distresses occur in a certain layer and increase within the same layer without stretching out to any other layer whether upward or downward. An example of such distress is the asphalt raveling which occurs at the surface layer and increases in the same layer (Nicholas et al., 2010, Shahin., 2005, Al-Swailmi et al., 2004, MPW&H., 1971).

6. Evaluation Criteria and Foundations

In the past, road engineers depended only on the road surface condition to judge the road structural and functional performance levels since the road surface condition reflects the road structural condition. After years of scientific research, road experts realized that the relation between the surface condition (functional condition) and the structural performance is not necessarily direct. The road surface might be in a good condition while the structural condition regarding bearing capacity is poor. The road surface might be poor while the structural condition is excellent. Therefore, road maintenance systems began to depend on structural road performance evaluation through measuring layers bearing capacity(Majed., Reema., 2009, MPW&H., 1971).

Developing new structural road evaluation systems did not eliminate the need to evaluate roads functionally. Both systems are required to identify the level of the road performance. In other words, structural evaluation compliments functional evaluation without eliminating it. Functional evaluation is carried out through evaluating the road surface (Shahin., 2005, Al-Swailmi et al., 2004).

7. Measurement of Roughness

Various roughness measurement devices vary in relation to the measurement technique. Some of these techniques depend on using wheels connected to mechanical and electrical monitoring devices. Other techniques rely on using laser or ultrasonic waves, or infra-red rays that are connected to information analysis units and computers that can process the information into tables and charts (Al-Rosan et al., 2010, AUSTROADS., 2001).

At MPW&H, the Mays Ride Meter (MRM) is used to measure road roughness. The MRM can be installed into an ordinary car that is driven within the speed limit. This device depends on a unit that measures the vertical vibrations of the rear axle of the car while being driven on the road. This information is displayed on a chart shown through a fixed screen on the front seat of the car. Figure 1 shows an image of a report prepared by MRM showing the surface profile (Majed., Reema., 2009).

8. Currently used Pavement Evaluation System at MPW&H

MPW&H developed a maintenance management system that depends on the subjective procedure in evaluating the serviceability of the road in order to identify the required pavement rehabilitation and maintenance activities that have to be implemented within the Ministry's limited budget and to decide the maintenance priority. The long-term objective of the system is to predict the road network future conditions depending on the available budget and implemented maintenance procedures (Majed., Reema., 2009).

The used evaluation system is divided into five rating levels. Level 5 is given for the road with excellent condition that does not require any major maintenance except some routine maintenance. An example of this case is a newly paved road or newly installed traffic light. The number 1 is given for the extremely failed road requiring reconstruction or replacement (SWEROAD., 2009, MPW&H., 2008-2010).

Table 2 represents a general description of each of the five rating levels used by MPW&H.

9. Currently used Road Information System by MPW&H

RIS is a system that provides the organization with the necessary information to make the right decisions at the right time and at the appropriate managerial level. Such system receives, imports, stores, processes and restores data and communicates it to users at the appropriate time and place (SWEROAD., 2009, MPW&H., 2009, MPW&H., 2011).

This can be done manually or electronically or by using both. The data collected through field surveys is processed through this computerized system .The road network is divided into links and nodes after being given numbers according to a system that depends on road classification.

Major roads are given two decimal numbers while odd numbers are given for the direction from North to South (for example, Road No. 5, Road No.15, Road No. 25) even numbers are given for the direction from the East to West (Road No.10, No. 20, No. 30).

Minor roads are given three decimal numbers. Odd numbers are given for the direction from North to South (for example, Road No. 311, Road No. 413, Road No. 715). Even numbers for the direction from East to West (Road No. 312, No. 414, No. 714).

Nodes are defined as the point at which a major road intersects with another major or minor road, or a minor road with another minor road. Links are known as the part that falls between two nodes .It takes the number of the road along with a serial number (10 +380, 10+390). It has a definite length that begins with zero. Road Information System contains information about the road elements such as the number of lanes, road classification (major, minor), lane width, shoulder width, ADDT and the surface condition, which is defined according to the Table 5. Road information (links) is fixed in geographical maps of the kingdom governorates as shown in Fig. 2 (SWEROAD., 2009, MPW&H., 2009, MPW&H., 2011).

10. Suggested Modifications to Currently used Pavement Evaluation System at MPW&H

a) Modification on the Classification Levels

Through using the five levels evaluation system and after acquiring adequate experience in this field, that the current evaluation system should be reconsidered to become more accurate and more comprehensive in describing the pavement condition in details. Therefore, it is suggested to add two new conditions to the five current levels. One level between condition 1 and 3 (this means modifying condition 2) and another condition between 3 and 4 (which means modifying condition 4) and giving description of the newly adopted seven levels system. The current and suggested evaluation grading systems are summarized in Tables 3 and 4, respectively (Majed., Reema., 2009).

Table 5 shows the description of the pavement conditions according to the suggested seven levels system.

Following is full description for each level:

Condition No 1, Failed:

- Extensive and deep potholes.
- Deep and wide alligator cracks extending along the pavement surface.
- Rutted pavement with difficulty of driving small cars on roads.
- Damage in the underlying layers.
- Unstable mix.
- Requires complete pavement reconstruction.

Condition No.2, Very Poor:

- Deep potholes.
- Extensive and deep alligator cracks.
- Rutted pavement in varying degree.
- Requires surface pavement removal and overlay.

Condition No.3, Poor:

- Extensive alligator cracks that requires treatment with deep patching
- Rutting or bleeding that requires a light surface pavement or surface treatment.
- Extensive crack sealing is required .Thin overlays may be required.
- Requires extensive patching

Condition No.4, Fair:

- Requires crack sealing.
- Surface treatment to seal surface cracks or to make it coarser.
- Pavement is so soft and needs to be coarse.
- Requires surface patches and pothole treatment.

Condition No 5, Good:

- Pavement requires crack sealing.
- No need for deep patching.
- Start and development of fatigue cracking.
- Pavement requires extensive cleaning with light patching.

Condition No.6, Very good:

- Pavement requires crack sealing.

- Start of some light cracks.
- Pavement requires extensive cleaning with some light surface patches

Condition No .7, Excellent:
- Pavement is in a good condition .
- Requires only minor routine maintenance and cleaning.

b) Addition of new Objective Pavement Surface Condition Survey Method

Each surface condition is individually located for each link of the road network according to the engineering criteria concerned with stresses and distresses (cracks, fatigue, rutting, broken edges and potholes), and International Roughness Index (IRI).The system depends on visual survey of the surface distresses by reporting distress type, distress level and distress extent.

Visual survey is used to measure distresses from which the road surface suffers .This is done specifically for each road link. The link is divided into a number of sections with a length of no more than 10 km except in the cases where the road surface suffers from a significant change (because of routine maintenance work or rehabilitation or reconstruction). In this case, the road is represented with a new section regardless of the section length. Random samples are taken with a length of 50 meters for each sample, four samples for each section. The various distresses are measured and written down in a special form that will be presented later in this paper. Following are the measured distress and the method of reporting their extent and severity.

A. Surface Cracks:

Surface cracks are calculated by adding the area of the cracks present in the sample and dividing it by the representative sample area (the sample length is 50 meters x the sample width (lane width). According to the following cases:

1. Longitudinal and transverse cracking

The lengths of the longitudinal and transverse cracks in the representative 50 m length sample are measured. These lengths are added up and then multiplied with half a meter, which represents the cracks effective width.

2. Alligator Cracking

These are measured based on the area they cover (square or rectangular).The area is calculated by multiplying length by width for each affected area and adding up all the affected areas in the representative sample, (sample length is 50 x the sample width (lane width).

The cracks severity is classified according to the criteria illustrated in Table 6.

Cracks extent is classified according to the criteria illustrated in Table 7.

B. Raveling

Raveling means dislodgement of aggregate particles due to the weather conditions. It is calculated by adding up the areas of the fatigue cracking at the surface road.

Raveling %= (Total raveled area (m2)/ Sample area (m2))

The severity is measured through the criteria illustrated in Table 8.

Extent of raveling percentage is calculated through the criteria illustrated in Table 9.

C. Rutting

Rutting on the road surface usually occurs in the wheel paths as a result of various factors such as: Excessive axial loadings, Traffic density, Hot pavement mix properties, Poor base layers.

Rutting depth is measured through the representative sample using straight edge. Readings are taken by millimeters. The rutting severity is measured through the criteria illustrated in Table 10.

D. Edge Cracking

This means that parts of the hot pavement mix are dispersed or broken at the pavement edge as a result of having variance between the road shoulder and the road body especially at places where the shoulder is poor. It is calculated as an area of the dispersed or broken parts of the sample present in section. The mean is calculated and multiplied by 20. The result is in a square meter unit for each km.

Severity of edge break is calculated through the criteria illustrated in Table 11.

E. Lane/Shoulder Drop-Off

This is evaluated through placing a straight edge on the road surface and calculating the elevation difference of the shoulder using a ruler

Severity of elevation difference is measured according to the criteria illustrated in Table 12.

F. Potholes

All potholes present in the section are surveyed by standing on top of each pothole and measuring its size in millimeters and converting it into unit\km. Each unit equals 10 liter with an average of 300mm diameter and 100mm depth. The pothole is estimated by parts of the unit if it is less than one unit. The pothole severity is measured according to the criteria illustrated in Table 13.

G. Local Failure (damage) / Deep Rutting

The area which suffers from long parts of continuous damage as a result of fatigue cracking or deep rutting is located and its area is calculated in square meter through defining the length and width of the affected area.

H. International Roughness Index (IRI)

This refers to the ripples in the vertical section of the road, or the total inclination of the road surface in relation to a perfect surface with ideal leveling. The unit of measurement is m\km. It is an index used for the comfort of vehicle users on roads to improve road quality. It is measured by special devices that depend on rays or waves. Examples of these devices are Bump Integrator System and Laser Road Surface Testing System.
The lower the roughness factor, the better the road condition is. Table 14 shows the relation between the road surface condition and the roughness coefficient values. Figure 3 shows the Visual Survey Data Collection Form that is usually used to collect all visual survey data.

Road Information Analysis

Road information system is used to analyze the information of the road surface elements inventory. This is carried out through a computerized program that specifies the needs of the network maintenance and the cost as a preliminary step. Following this, future plans are produced (long term and medium term) on the light of the adopted maintenance strategies, maintenance priority and adopting annual programs in accordance with the available resources. Figure 4 shows the relation between the information of road elements inventory and the road information system and their relation with the computerized program.

The program uses analysis instruments that rely on models that are similar to the road surface condition and how it is changed through the course of time as a result of different distresses and the roughness index. These programs show the effect of the work strategies on the road surface condition and its users. This requires the following information:

Road network information:

- length of each link
- annual average traffic
- vehicle types and their percentage annual increase
- measures used in road development and maintenance for each damage (patches, crack sealing, top layer and new mix)
- financial allocation

The following technical analyses are required:

1. Road deterioration: to predict future damage of the road surface and the maintenance cost.
2. Work effects: to simulate the effect of maintenance on the road surface classification through the change in its elements (distress or roughness) and the result costs.
3. Social and environmental effects; through which environmental pollution resulting from emitted gases is analyzed in addition to energy consumption.

Road surface conditions are classified within the computerized program according to the criteria shown in table 15.

11. Conclusions

Continuous and hard work in evaluating pavements had a great effect in developing and updating presently used road maintenance system in Jordan. The local Road maintenance engineers were able , through local efforts of road maintenance engineers they will be able to update and develop the evaluation system which contributed in promoting the road maintenance performance.

Locating sites that have to be maintained and determining upon the kind of maintenance and methods of treatment has become more accurate and more feasible than before which led to reduction in financial costs reflecting in its turn development and improvement of road networks in the Kingdom.

12. Recommendations

1) Modern technology in pavement evaluation should be introduced.
2) Carrying on rehabilitation of engineering cadre through theoretical and practical training on applying pavement evaluation system so that an advanced level of experience is maintained.
3) Working on lengthening the asphalt mix age through using new scientific methods to design asphalt mix taking into account its functional defects.
4) Working on encouraging and supporting entrepreneurs and consulting engineering offices in the field of road maintenance to adopt modern technology in evaluating pavements.

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List of Tables:

Table 1: Total expenditure on road maintenance for the years 2002-2012

YEAR	TOTAL EXPENDITURE (MILLION JD)	YEAR	TOTAL EXPENDITURE (MILLION JD)
2002	8,50	2008	26,25
2003	9,70	2009	30,00
2004	11,85	2010	15,50
2005	15,35	2011	10,10
2006	15,38	2012	7,87
2007	22,50		

Table 2: The used five levels rating system by MPW&H

Road Surface	
CONDITION 1 BAD (FAILED)	Extensive alligator cracking and extensive deep pothole patching required. Extensive pavement removal. Base and sub base failures. Pavement removal or scarification required and new pavement base and surface course required.
CONDITION 2 POOR	Extensive pothole patching. Deep patching is required. Extensive alligator cracking which requires deep patch repairs. Rutting or bleeding has occurred which requires this overlays or surface treatment. Extensive crack sealing required. Thin overlays may be required.
CONDITION 3 FAIR	Routine pothole patching of wearing course is required. Crack pouring required. Some surface treatment of pavement surface required to reestablish skid resistance qualities or to seal cracked pavement areas.
CONDITION 4 GOOD	Pavement requires extensive cleaning and some light surface patching or crack sealing. (Not deep patching) - Some minor cracking evident.
CONDITION 5 EXCELLENT	Pavement is in new or nearly new condition. It requires only minor routine maintenance and cleaning or removal of debris.

Table 3: The current Evaluation System

RATING	CONDITION	PCI
Excellent	A-5	80-100
Good	A-4	60-80
Fair	A-3	40-60
Poor	A-2	20-40
Bad/ Failed	A-1	00-20

Table 4: The suggested modified evaluation system

RATING	CONDITION	PCI
Excellent	A-7	90-100
Very Good	A-6	75-90
Good	A-5	60-75
Fair	A-4	40-60
Poor	A-3	25-40
Very Poor	A-2	10-25
Failed	A-1	00-10

Table 5: General description for the suggested system

Evaluation	**General Description**
Failed	The surface is full of deep and large potholes
Very Poor	The surface is full of big potholes
Poor	Requires extensive patching
Fair	Requires light surface patching and potholes treatment
Good	The road surface requires extensive cleaning with light surface patching or crack sealing. (Not deep patching) - Some minor cracking evident.
Very Good	The road surface requires extensive cleaning with light surface patching
Excellent	Pavement is in good condition. It requires only minor routine maintenance and cleaning or removal of debris

Table 6: Crack Severity Level Criteria

Crack severity	**crack width**	**notes**
3 Thin Cracks	<5mm	Includes sealed cracks
2 Medium cracks	5-10 mm	pavement material is decomposed at edges
One wide crack	< 10mm	pavement material is decomposed at edges

Table 7: Crack Extent Level Criteria

Crack extent	**Percentage of the surface area**
Little	< 10%
Medium	10-25 % m
High	>25%

Table 8: Raveling Severity Level Criteria

Raveling severity	**Surface Condition**
Severity No.3 (Low)	the road surface (the mix) is dry (oxidized) with small parts being dispersed on the road
Severity No.2 (Medium)	the road surface (the mix) is dry (oxidized) with large parts being dispersed on the road surface with liability to penetrating water
Severity No.1 (High)	the road surface (the mix) is very dry and oxidized with most of the surface mix being dispersed with high water penetration

Table 9: Raveling Extent Level Criteria

Extent	**% of the surface area**
Low	less than 10% of the surface area
Medium	10-20% of the surface area
High	More than 30%

Table 10: Rutting Severity Level Criteria

Severity	**Rut depth**
Severity No.3 (Low)	less than 10 mm
Severity No.2(Medium)	10-25 mm
Severity No. 1(High)	More than 25mm

Table 11: Edge Cracking Severity Level Criteria

Edge Severity	**Cracks**
Severity no.3 (Low)	Less than 25 m^2\km
Severity no.2 (Medium)	25-150m^2\km
Severity no 1 (High)	More than 150m^2\km

Table 12: Lane/Shoulder Severity Level Criteria

Severity	**Elevation difference**
Severity no.3 (Low)	Less than 25 mm
Severity no.2 (Medium)	25-50mm
Severity no. 1 (High)	More than 50mm

Table 13: Potholes Severity Level Criteria

Severity of potholes	**Potholes size**
Severity no.3 (Low)	Less than 2 unit\km
Severity no.2 (medium)	2 -7 units\km
Severity no. 1 (high)	More than 7 unit\km

Table 14: International Roughness Index Severity Level Criteria

Road surface condition	**International roughness index IRI m\km**	
	Major road	**Minor road**
1. Failed	10	11
2.Very Poor	8	9
3.Poor	6	7
4.Fair	4	5
5.Good	3	4
6.Very Good	2	3
7.Excellent	1	2

Table 15: Used criteria to classify the road surface conditions

Road surface condition`	**Maximum distress level**					**m\km IRI**	
	Cracks %	**Raveling %**	**Potholes Unit\km**	**Edge drop off, m^2\km**	**Rutting mm**	**Major road**	**Minor road**
1. Failed	50	30	50	300	30	10	11
2.Very Poor	35	25	25	200	25	8	9
3.Poor	25	20	15	100	20	6	7
4.Bad	15	15	10	50	15	4	5
5.Good	10	10	5	25	10	3	4
6.Very Good	2	5	0	0	5	2	3
7.Excellent	0	0	0	0	0	1	2

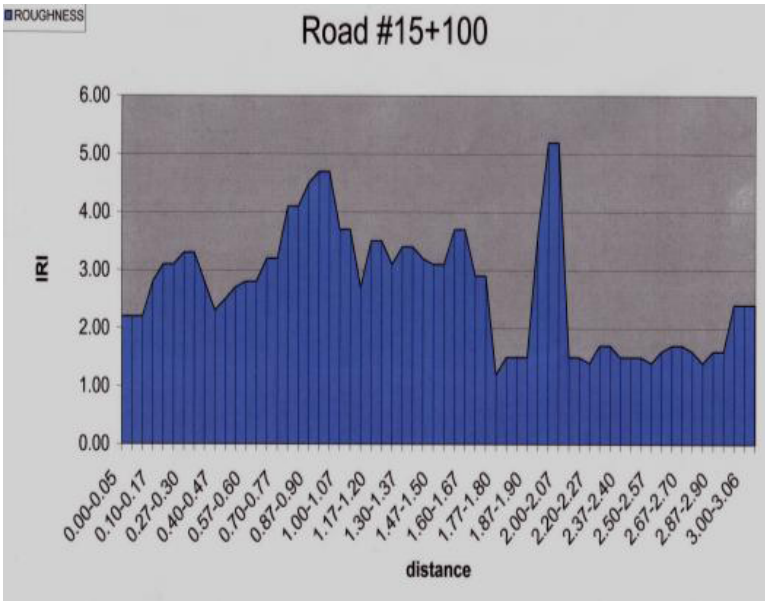

Figure 1: Image of a report prepared by MRM showing the surface profile.

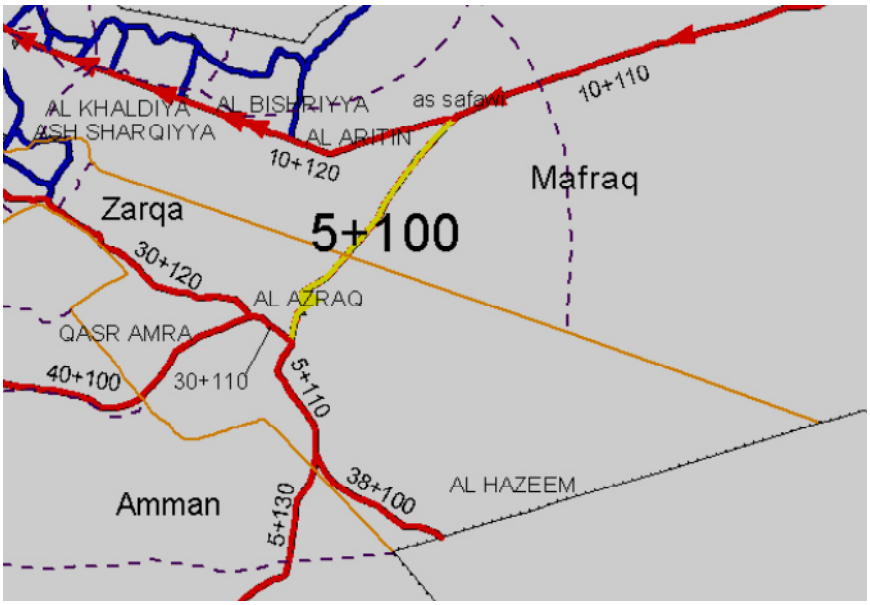

Figure 2: Example of a geographical map of tone of the kingdom governorate.

Data Collection Form
Road No. **Link:**
Length (m):

No.	Section*			Distress								Local Failure/ Deep Rutting		
	From	To	Length	All Cracking		Raveling		Rutting	Edge Damage	Shoulder Drop-off	Potholes			
	In km with two decimals			%	Severity	%	Severity	mm	m2/km	Mm	units	From	To	m^2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.00													
2			Sample1**											
3			Sample2											
4			Sample3											
5			Sample4											
6		Total /Avg.							*20=					
7														
8			Sample1											
9			Sample2											
10			Sample3											
11			Sample4											
12		Total /Avg.												
13														
14			Sample1											
15			Sample2											
16			Sample3											
17			Sample4											
18		Total /Avg.												
19														
20			Sample1											
21			Sample2											
22			Sample3											
23			Sample4											
24		Total /Avg.										Total		

* If no section established, created a new section when the condition changes considerably, for example as a result of recent major maintenance works.
** Each sample is 5m
Figure 3: Objective data collection form.

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