

**Management of rural road maintenance and ideal methods of
maintaining (A case study of rural roads Within the aljiza municipality)**

MAHMOUD MOHAMMAD M DAKHALALAH

Civil Engineer

Aljiza Municipality

<https://jasps.com>**ABSTRACT**

This paper studies and searches for the best and ideal methods used in the maintenance of rural roads in the Municipality of Jiza Governorate, so we searched for the defects and methods used in the maintenance of rural roads in order to complete the maintenance work in the best way and with the best quality. And to facilitate these works for the municipality so that the municipality has successful management in the maintenance of rural roads.

Personal interviews were conducted with 5 people with experience in the Jiza Municipality in the field of road maintenance, to answer a set of questions about the availability of maintenance roads in the Jiza Municipality. The answer was unanimous there is no ideal method of repair except by issuing a tender for road maintenance. The paper helped to identify the defects of the methods and provide the ideal methods and ways to fix these defects.

Keywords: road maintenance management, village road maintenance management, road maintenance methods

<https://jasps.com>

1. INTRODUCTION

Road maintenance can be defined as continuous work to protect the road from damage and deterioration to maintain the various elements of the road.

Roads in rural areas need regular maintenance from the moment the road is built until it is completed so that the road remains passable in its original form for the life of the road. Roads are exposed to many factors that lead to the deterioration of the road condition, and this deterioration is slow at the beginning of the road's life, then the road condition gradually decreases from excellent to very good until it becomes in an acceptable condition. During this period, the maintenance to be followed is the regular maintenance to extend the life of the road.

Therefore, the deteriorating roads, in which it is difficult to drive, lead to many traffic accidents, which in turn lead to damage and harm to the cars of road users, which cost them a lot to maintain.

Among the most important reasons that lead to the deterioration of roads are excessive and repeated axial loads on the road, change in daily temperatures, water, humidity, traffic density and frequency, external human and natural influences, and weak properties of the foundation soil.

<https://jaspss.com>

The types of defects in road surfaces are classified according to the causes that lead to their occurrences, such as cracks, tears, sagging, gradations and potholes, and the different levels of manholes.

The Department of Maintenance of Rural Roads in Jiza Municipality mainly deals with these problems and provides various repair techniques. Therefore, this paper will deal with the different ways of maintaining private Rural roads in the Rural of the Jiza area.

2. AIMS AND OBJECTIVES:

This research aims to explore the defects of rural roads within the boundaries of the municipality of Jiza.

The objectives of this research are summarized in the following points:

- 1- Identify the most important defects of rural roads.
- 2- A simplified explanation of the defects of rural roads and methods of prevention to avoid their occurrence.
- 2- Determining the most important ideal methods for maintaining defects in rural roads.

Literature review

The PAVER and Micro PAVER Pavement Maintenance Management Systems are designed to optimize the use of financial resources allocated for pavement

<https://jasps.com>

maintenance and restoration. PAVER, a field-tested and validated mainframe computer system, and Micro PAVER, a mini-computer interpretation of the PAVER system, can be used to manage roads, streets, parking lots, and field sidewalks. This report brings together information from many previous publications to provide a single, accessible reference for the field. In addition, advances in the systems since 1981 are described. The PAVER and Micro PAVER use the Pavement Condition Indicator Condition Check and parking procedures developed in the United States. USACERL Army Construction Engineering Research Laboratory. This report outlines the procedures for dividing the pavement network into operating units, performing PCI status checking and PCI identification, determining MR requirements and precedence's, and selecting the most cost-effective MR option. Recently developed technologies, including pavement degradation methods that are being integrated into the PAVER and Micro PAVER systems, are being coupled with new reporting capabilities, CAP-specific and long-term medication, and design development. [1]

<https://jasps.com>

This paper deals with issues of image analysis of cracks in pavement operating systems based on computer vision technique. The development of pavement operating systems is essential for predicting long-term road performance and prioritizing maintenance programmers. An algorithm for crack detection in pavement images is proposed. The algorithm includes the following method to improve image contrast; morphological opening operation; convert the image to halftones; Transform the bottom shape. threshold conversion; clean the image from noise by opening the process; the process of ligation of possible broken cracks; Find the edges of the cracks. Arch the edges of the crack. Visualize the edges of the notches being erected. The configuration also describes the perpetrator of the proposed algorithm in the form of an experimental automated system program. This program was developed in C++ using the OpenCV computer vision library and runs on the Jetson TX2 modular supercomputer processing platform. The results of the studies for the proposed approach are given. [2]

Pavement networks require a structured maintenance and repair (M&R) process control approach to set priorities and ensure optimal resource allocation. A Pavement Maintenance Management System (PMMS) is a useful tool for assessing, prioritizing, and identifying allocation and financing needs for M&R

<https://jasps.com>

projects. A new PMMS architecture was used in this study; The Wireless Sensor Network (WSN) uses image processing to identify specific pavement defects, namely alligator cracks. Automated analysis provides a tool to accurately analyze and classify pavements into predefined categories so that appropriate actions can be taken. The datasets used in image processing are collected from typical areas in the road network, and these data are analyzed to generate the Road Condition Index (PCI). PCI is a numerical scale for assessing the condition of road surfaces. Provides an indication of current road conditions based on measured pollution levels on the road surface. A new architecture for real-time data collection and transmission to a remote central processing management system using a cellular network has been proposed. An image processing algorithm is proposed for alligator rupture detection and data integration into the WSN structure. Crocodile tears were chosen because they are a common strain associated with purely (structural) stress. [3]

Identifying and quantifying the characteristics of surface defects such as cracks is an important task for road bodies. Measurement of key characteristics, including extent, severity, and intensity of cracking, allows for a better assessment of the pavement condition. Crack strength (crack spacing) and development can be expressed through the spatial distribution of cracks. The

<https://jasps.com>

importance of this critical property is rarely considered due to the difficulty in measuring crack strength. Moreover, no practical method for measuring and determining the crack distribution in the selected road segments has been provided. In this paper, using the location of pavement cracks and GIS, a practical method for representing and determining the strength of cracks is proposed, in which the spatial distribution of pavement cracks is determined. At the project level, longitudinal, transverse, and cross-sectional cracks were examined in several parts of the road to evaluate the proposed method. Crack assessment was performed in GIS using automatic data acquisition systems and location-based image processing techniques. The results of the study showed that by using the proposed method, the intensity of cracking can be determined and, in practice, considered as the main feature of cracking. [4]

3. RURAL ROAD MAINTENANCE DEPARTMENT:

Rural roads are generally defined as roads located within the boundaries of a given area, which are unoccupied roads that branch off from major or secondary roads, or that start from a city and lead to a Rural or population centers and end there and this perimeter of the road is less than 20 meters. The paved road about 6 meters serves the residents of the villages and serves them to move from one place to another. [5] Rural road maintenance can be

<https://jasps.com>

defined as continuous work to protect portions of a road from deterioration and damage to perpetuate the various components of a road so that village roads remain of the same quality as they were when they existed. Director. Road networks are exposed to many factors that lead to the deterioration of road conditions. [5]

Rural road maintenance works include the typical method of repairing defects, including patching, crack injection, filling potholes, roughening the road surface by giving it a final face, raising the friction coefficient, removing snow, removing grass, painting roads, placing signs, and other tasks. Air compressors, tippers, conveyors, asphalt cutting saw, snow sweeper, injection machine, small asphalt shredder, and others, as well as public safety tasks, which are an important part in road maintenance by closing the area to be maintained by using the funnel and the appropriate barriers and signs that indicate the presence of a worksite. [6]

The operations of skimming, filling, leveling, preparing the base, laying surface materials, placing them on the side pavement, and placing handrails are some of the implementations of road construction. Therefore, the planning of the road maintenance department is a measure for solving the problems of the maintenance management of rural roads at present. Therefore, the planning of

<https://jasps.com>

the maintenance department must be integrated and the maintenance management at present. In the coming days, there is an urgent need for various modern methods and techniques for road maintenance. [6]

Government investment helps in effectively financing the Road Maintenance Department through grants and external support to the state for the maintenance or paving of roads. There must be a successful plan for how to use these technologies, as well as a successful plan represented in the planning of the Road Maintenance Department in the implementation of a study road that is implemented with the best materials and the best equipment for its longevity of use. [7]

4. INTERVIEWS DATA ANALYSIS

Through personal interviews conducted with five engineers from the municipality of Jiza about the defects of the methods and ideal methods used in Jiza Governorate. They are well versed in road maintenance, but they lack the perfect methods and methods to address these defects that exist within the municipal boundaries of Jiza, because they lack these methods.

These defects were as follows:

- cracks
- patches

<https://jasps.com>

- pits
- superficial deformations
- sclerosis
- other defects

Focusing on road maintenance will yield wide-ranging benefits not only by preserving current assets, but also by reducing future costs for citizens, road users, taxpayers and road owners.

5. METHODOLOGY AND DATA PRESENTATION

This research used the simple method to find out the best methods used in the maintenance of rural roads in the Municipality of Jiza, by conducting a personal interview with 5 people with experience and specialists in road maintenance, the municipality of Jiza, about the defects of rural roads and the methods used for road maintenance, and most of the answers were that there are no methods of maintenance except through A tender was put forward for the maintenance of these roads, and there was no special department for the maintenance of rural roads in the municipality of Jiza in Jordan. A literature review was conducted to determine the optimal methods of rural road maintenance.

6. TYPES OF DEFECTS AND THEIR CAUSES IN THE SURFACE OF RURAL ROADS

<https://jasps.com>

Often different forms of defects appear on the road surface, but in the form of lack of maintenance at the beginning of its destruction to complete ruin of the road. These defects can be divided into six groups:

- cracks
- patches
- pits
- superficial deformations
- sclerosis
- other defects

6.1. Cracks

They are longitudinal and transverse cracks, openings, and cracks present in the asphalt mixture and they come in many forms depending on the destruction of the asphalt mixture such as the degree of its depth and the length of the crack expansion. These fissures can be divided into the following types: [8]

Crocodile cracking:

It is a series of connected cracks that begin to appear from the bottom of the asphalt mixture layer to the top due to repeated axial loads on the road. The cracks appear directly in the area under the track of the car tires, which is the

<https://jasps.com>

area exposed to the highest tensile strength. This defect is classified as a defect caused mainly by axial loads, poor road body infrastructure, and insufficient thickness of the asphalt layers. These cracks begin to appear on the surface in the form of a parallel series of longitudinal capillary cracks, and after exposure to axial loads, these cracks are connected, forming cuts in several directions at sharp angles, forming a shape resembling crocodile skin, and these cuts are not more than 60 cm long in the longest direction.



Figure 1. Crocodile cracking

Block Cracking

They are regular intersecting cracks and divide the paving layer into squares ranging in size from about (0.3 m x 0.3 m) to (3 m x 3 m), and they are on three levels of intensity, some of which are light and do not exceed their size. Display.

<https://jaspss.com>

Its size exceeds 6 mm, while its width is about 19 mm, the narrowest is more than 19 mm. Polygonal cracks abound in village roads due to low traffic density and in car parks. Cracks in the mesh are functional and structural defects, and the main cause of these cracks is the thermal shrinkage of the asphalt binder as a result of periodic stress and pressure. The error density is measured by dividing the area affected by it by the total area of the scanned section multiplied by one hundred.



Figure 2. Block Cracking

Edge Cracking:

These cracks are in the form of longitudinal cracks and occur in the side part of the road at a distance of (30–60 cm) and start from the edge of the layer and head inward and are sometimes accompanied by ground cracks heading to the shoulder of the road, and the reason for the occurrence of these cracks is often

<https://jaspss.com>

the lack of side support or The absence of a shoulder for the road, as well as when cracks occur in the base layer, or the absence of a water drainage system.



Figure 3. Edge Cracking

Longitudinal Cracking

They are cracks that occur in the asphalt mixture layer of the road body and a longitudinal and parallel direction to the direction of traffic. These cracks begin to appear from the top of the surface of the asphalt layer and extend to the bottom, and the main reason for the occurrence of this defect is due to daily temperature fluctuations and poor implementation of longitudinal seams during paving and aging and hardening The asphalt material that binds the layers of the road surface, and the presence of anomalies or defects in the components of the asphalt mixture from the specifications.



Figure 4. Longitudinal Cracking

Transverse Cracking

They are cracks that occur transversely + the layer of the asphalt mixture from the road body and perpendicular to the direction of traffic. These cracks begin to appear from the top of the surface of the asphalt layer and extend to the bottom, and the main reason for this defect is due to daily temperature fluctuations poor implementation of accidental seams during paving and aging, And the hardening of the asphalt material that binds the layers of the road surface and the presence of anomalies or defects in the components of the asphalt mix from the specifications.



Figure 5. Transverse Cracking

Reflection Cracking

They are cracks that appear when the asphalt mixture layer is applied over the tiles. Concrete, where the cement slab joints are reflected on the asphalt mixture layer and this results from the movement of the cement slabs under the asphalt layer, whether the movement of the tiles is caused by a change in temperature (expansion or contraction) or a drop in the cement tiles.

6.2. The patches

It is a specific area of the road body that has been treated by patching, in addition to the areas of the road body in which service lines have been extended and re-established, which is in itself a type of defect regardless of the method and accuracy of its implementation. [9]



Figure 6. The patches

6.3. Pits

It is the presence of small potholes in the road surface as a result of one or more defects in it, such as (all kinds of cracks, flying gravel grains, ... etc.), and the size of these potholes increases as a result of water gathering in them and the passage of traffic over them. Among the most important reasons are the presence of cracks of various kinds and in an advanced degree, the flying of gravel grains from the road surface, the low percentage of asphalt binder in the mixture, high temperatures in the asphalt mixer during mixing, which leads to the combustion of the asphalt binding material in the mixture, poor workmanship during the implementation of the asphalt mixture such as Lack of dahlia or nesting of grains of grit in the mixture. [10]



Figure 7. Pits

6.4. Superficial deformations of the road

The superficial deformations are in the form of grooving or creeping and are as follows:

Rutting:

It is descents in the road body that occur in the path of the vehicle tires, which leads to a lateral displacement in the asphalt mixture and the base layers, which leads to the rise of the surface of the asphalt mixture on both sides of the landing area, This defect occurs as a result of high axial loads associated with one of the following reasons: Defects in the components and workmanship of the asphalt mixture, Increasing the proportion of asphalt binder in the mixture, Increasing the proportion of the fine material filler (Filler) in the asphalt mixture, Low percentage of angular gravel grains in the asphalt mixture, Reducing the

<https://jaspss.com>

percentage of air spaces in the asphalt mixture, Inadequate dredge of the asphalt mixture layer. And also Defects in the infrastructure (foundation layers):

– Insufficient thickness of paving layers, Double the components of the paving layers, Inadequate Dahl for layers of paving. [11]

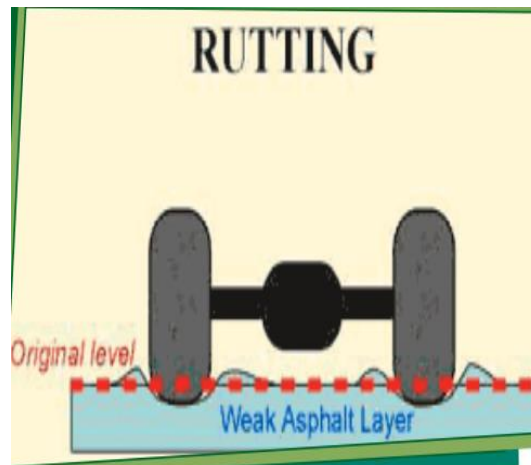


Figure 8. Rutting

Slippage cracking:

They are crescent-shaped cracks with pointed ends that occur on the surface of the asphalt mixture, due to the slipping of the surface mixed layer from the lower layer in the direction of traffic. This defect occurs as a result of frequent traffic, especially in areas of use of the brakes, areas of stopping, turning, and sloping areas. And from Causes: It is happening The defect as a result of frequent heavy vehicle traffic on the road surface is related to one of the following reasons: Weak strength and stability of the asphalt mixture, Weakness of the bonding strength between the layers of the asphalt mixture as a result of 1.

<https://jaspss.com>

Increase or decrease of the asphalt adhesive material. 2. The smoothness of the surface of the old asphalt layer to be applied to a new asphalt mixture, or the lack of a good roughening of the old surface. 3. Not cleaning the surface of the asphalt mixture to be implemented a new asphalt mixture.



Figure 9. Slippage cracking

6.5. Superficial damage

Surface damage to the road occurs in three forms: asphalt tearing, volatilization, and erosion, as shown in the figure. These defects are known as follows:

1- Bleeding

It is the formation of a layer of asphalt material on the surface of the road, and because of this, the surface becomes shiny and sticky like glass. The tearing is formed on the road surface due to an increase in the asphalt material in the

<https://jasps.com>

mixture or an increase in the asphalt adhesive material on the surface of the base layer. (MC) or on the surface of the old mixture (RC) or (RS) or the lack of air spaces in it. Such a problem usually appears on the road surface in hot weather. And since the tearing process is not reversible, that is, in cold weather it will not return to the mixture, as it collects on the surface, which leads to an increase in the smoothness of the road surface and a decrease in the coefficient of friction, causing slips to occur.

2- Weathering and raveling:

It is the scattering and flying of gravel grains and the erosion of the asphalt binding material from the surface of the asphalt mixture, which leads to roughness in the road surface in its initial stages, and excavation in its advanced stages. Among the reasons for its occurrence: Low percentage of asphalt material in the mixture, which leads to a weak bonding strength between the components of the asphalt mixture. , The presence of dust on the gravel grains during the production of the asphalt mixture in the mixer, causes the presence of an insulating layer between the gravel and the asphalt binder, The presence of roughness in the components of the asphalt mixture, The presence of nesting in the asphalt mixture during the individual process, Insufficient tamping during the process of implementing the asphalt mixture, Oil and fuel spills on the road

<https://jaspss.com>

surface, Surface run-off of water on the road surface, especially in sloping areas, in the absence of a good road surface rainwater drainage system, The age of the mixture leads to a weakening of the strength of the bonding material between the components of the asphalt mixture.[12]



Figure 10. Slippage cracking & Weathering and raveling.

6.6. Various Defects

Other disadvantages can occur to the road, which are:

1- A drop in the pavement layer or the shoulders. This is especially noticeable after rain (to collect water with it). This defect is considered one of the defects resulting from the subsidence of the foundation layers during construction or as a result of excessive loads that put pressure on the foundation layer and affect it.

<https://jasps.com>

2-Water flows to the road surface through cracks in the pavement layer and this occurs due to the high level of surface water. [13]

7. IDEAL METHODS OF MAINTAINING RURAL ROADS:

The surface of the asphalt pavement is affected by changes in temperature, the accumulated rain on it, and the increase in repeated traffic loads. All of these factors cause minor cracks to occur on the surface in the first stage, but by accumulating these cracks expand and lead to the fragmentation of the paving layer and the collapse of the road completely. If minor cracks occur in the road surface, this requires inexpensive maintenance work to close them and repair the road, but if these cracks are left without maintenance, this causes rainwater to leak into the road body, which leads to the disintegration and subsidence of the various paving layers so that the road remains valid throughout its life span requires continuous maintenance scientifically. The road must be constantly monitored to identify defects that may occur in the pavement from the first moment, correct them, identify their causes, and then correctly maintain them.

1. **Maintenance of cracks:** if the cracks are superficial, they are filled with liquid asphalt as shown in Figure. As for the cracks that are in the entire construction sector, they must be removed until reaching the

<https://jaspss.com>

bearing soil, then filled with asphalt mixture and compacted as shown in Figure. 11. [14]



Figure. 11

2. **Patching:** Patching is considered the most maintenance work that asphalt roads need, because of the defects that may occur in them as a result of natural factors or due to excavation work carried out by humans to make extensions for the public services. Patching operations need high accuracy in implementation, otherwise, they will turn into other defects by themselves. To treat the pits, it is necessary to remove the surface crumbling material and then dig until reaching solid ground, and it may be necessary to remove something from the

<https://jaspss.com>

natural ground. The pits must include about 30 cm of good asphalt surrounding the pit, then the sides of the pit are sprayed with a thin layer of liquid asphalt and then the pit is filled with a hot asphalt mixture. The gravel is inserted and compacted well to the same level as the road surface adjacent to the pit. Figure (12) shows the steps of patching the pits. [15]

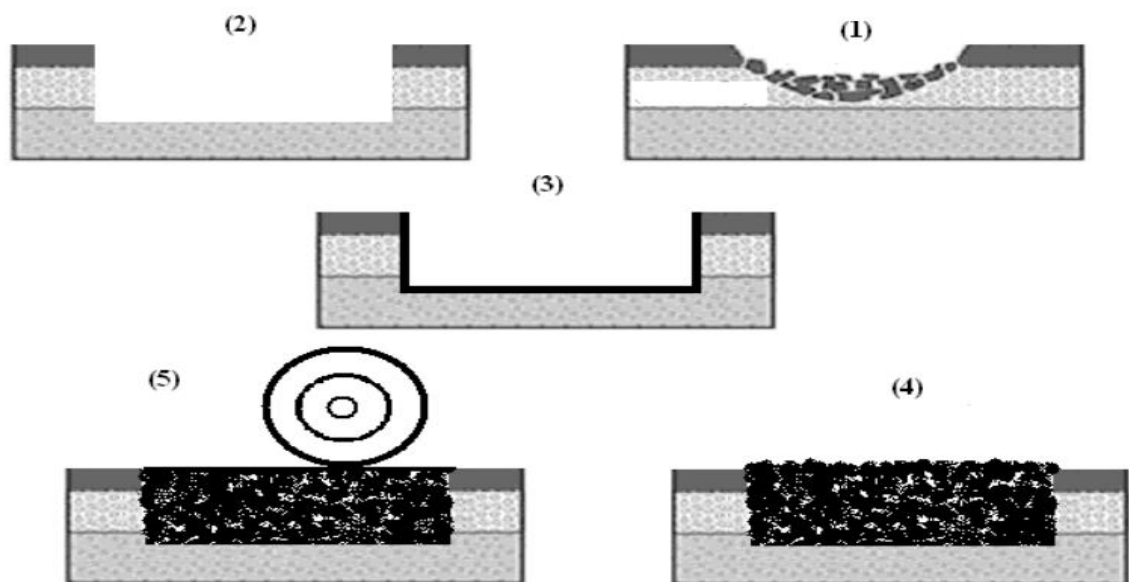


Figure. 12

3. **Rutting maintenance:** The grooves are repaired by leveling the surface with a mill and Channels with hot asphalt mixture if there is no side creep, and then covering the surface with an additional layer of light asphalt. But if the cause is the lateral movement of the asphalt layer, it must be removed and re-established. [16]

<https://jasps.com>

4. **Slippage crashing maintenance:** When surface creeps occur, the successful treatment is to scrape the area where the creep occurred, and then lay a hot asphalt layer as a new surface. [16]
5. **Maintenance of asphalt blisters (Bleeding):** asphalt blisters are repaired by spraying the road surface with a layer of hot fine aggregate and compacting it to absorb excess amounts of asphalt. [16]
6. **Laying a repair layer:** This process is known as laying an individual insulation layer, where a layer of liquid asphalt is sprayed on the road surface, then gravel with a limited gradation is sprayed and this layer is compacted with bullets. This process is used to increase the bearing strength of the road surface, treat erosion and volatilization of materials, and prevent water from seeping through the surface. [16]
7. **Laying a new surface layer:** A new surface layer is placed on an existing surface to strengthen it as shown in Figure (10-15). With the increase in the traffic volume and the increase in the loads on the road, the existing pavement does not bear the additional stresses on it and thus requires strengthening it by adding a new layer on the surface. And sometimes the existing pavement may erode and become in a state of complete deterioration. In these cases, it is preferable to

<https://jasps.com>

completely remove this sector and rebuild it again according to the new data. Before placing the new top layer, it must be carefully designed by designing the existing pavement, measuring the strength of the layers, determining the strength of the earthen base, and finding the California bearing ratio, then a new design is made to determine the thickness of the layers to be added. [16]



Figure. 13

CONCLUSIONS:

This paper introduces 6 disadvantages of roads and 7 ideal methods of maintaining rural roads, these methods are used to determine the ideal method of maintenance. collected from previous studies. This study presents personal interviews conducted to identify the main defects in rural methods.

<https://jasps.com>

The most important of the above methods worked to save cost and time greatly for the municipality because of the huge sums that the municipality spends to maintain these roads due to the inflation of prices at the present time and the abandonment of bids for road maintenance that cost the municipality annual sums that the municipality is indispensable for through the equipped department in the municipality.

RECOMMENDATIONS:

- 1- It is very important to hire experienced engineers, who are skilled to do a good job and act in good faith when it comes to maintenance work.
- 2- The use of a unique set of ideal methods for the maintenance of rural roads represents a saving on the municipality of cost and time.
- 3- The municipality is advised to adhere to the ideal methods through the use of experienced workers, good materials, supervision of materials and workers, implementation of the engineer's instructions, and carrying out remedial work.
- 4- The municipality is advised to specify all the responsibilities of the engineers and the work schedule in proportion to the volume of work for the roads.

<https://jaspss.com>

- 5- The need to work on a report to determine the condition of the roads and to determine the best way to maintain the road.
- 6- The need to set a budget for all roads that need maintenance.
- 7- The need to determine the work budget for the maintenance of all roads and raise it periodically to be in line with the required changes and increases that occur due to the deterioration of roads.
- 8- Supervising engineers must monitor the performance of workers to ensure that they are following ideal methods and to ensure that works are completed according to schedule and to the best quality.

REFERENCES:

- 1 Shahin, Mohamed Y., and Jeanette A. Walther. *Pavement maintenance management for roads and streets using the PAVER system*. CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL, 1990
- 2 Lyasheva, Stella, Vladimir Tregubov, and Mikhail Shleymovich. "Detection and recognition of pavement cracks based on computer vision technology." *2019 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM)*. IEEE, 2019.
- 3 Al-Suleiman, Turki I., et al. "Assessment of the effect of alligator cracking on pavement condition using WSN-image processing." *8th International Conference on Engineering, Project, and Product Management (EPPM 2017) Proceedings*. Springer International Publishing, 2018

<https://jasps.com>

- 4 Fakhri, Mansour, et al. "Developing an approach for measuring the intensity of cracking based on geospatial analysis using GIS and automated data collection system." *International Journal of Pavement Engineering* 22.5 (2021): 582-596
- 5 Al-Tatari, A. A.-T. (1994, June 29). *The Analysis of Road Network characteristics in Irbid Governorate*. AlManhalPlatform. Retrieved December 1, 1996, from <https://platform.almanhal.com/Files/2/100210>.
- 6 Ahmad Muhammad, A. A.-A. (2020, October 12). *Road Maintenance Management System Using Artificial Intelligence*. SUST Repository. Retrieved October 1, 2018, from <http://repository.sustech.edu/handle/123456789/25118>
- 7 Al-Maani, O. M. E. R. (2008, January 1). *Greater Amman Municipality. The Hashemite Kingdom of Jordan Greater Amman Municipality Roads Maintenance Department*. <https://www.ammancity.gov.jo/ar/interactive/guide.aspx>
- 8 Kwon, T.J., Fu, L. and Melles, S.J., 2017. *Location optimization of road weather information system (RWIS) network considering the*

<https://jasps.com>

- needs of winter road maintenance and the traveling public. Computer-Aided Civil and Infrastructure Engineering, 32(1)*
- 9 Huidrom, Lokeshwor, Lalit Kumar Das, and S. K. Sud. "Method for automated assessment of potholes, cracks and patches from road surface video clips." *Procedia-Social and Behavioral Sciences* 104 (2013): 312-321
- 10 Hafezzadeh, Raheb, Federico Autelitano, and Felice Giuliani. "Asphalt-based cold patches for repairing road potholes—An overview." *Construction and Building Materials* 306 (2021): 124870
- 11 Ryan, Patrick H., et al. "Erionite in road gravel associated with interstitial and pleural changes—an occupational hazard in western United States." *Journal of occupational and environmental medicine* (2011): 892-898
- 12 Elseicy, Ahmed, et al. "Combined Use of GPR and Other NDTs for Road Pavement Assessment: An Overview." *Remote Sensing* 14.17 (2022): 4336
- 13 Eaton, Robert A. *Unsurfaced road maintenance management*. Vol. 92. No. 26. US Army Corps of Engineers, Cold Regions Research & Engineering Laboratory, 1992

<https://jasps.com>

- 14 Zhang, Lei, et al. "Road crack detection using deep convolutional neural network." *2016 IEEE international conference on image processing (ICIP)*. IEEE, 2016
- 15 Gavilán, Miguel, et al. "Adaptive road crack detection system by pavement classification." *Sensors* 11.10 (2011): 9628–9657
- 16 Bang, Seongdeok, et al. "Encoder–decoder network for pixel-level road crack detection in black-box images." *Computer-Aided Civil and Infrastructure Engineering* 34.8 (2019): 713–727
- 17 Gothane, Suwarna, and D. M. Sarode. "Case study: Analysis and study of different approaches for road network maintenance." *International Journal of Scientific Engineering and Research* 3 (2015): 1–4