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The Causes and Impact of Incorrect Identification of Pavement Distresses

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ABSTRACT

The conditions of road pavement affect economy, safety and comfort, traffic and travel times, emission levels, and vehicles' operating costs. The research paper focuses on one of the most important factors that lead to road deterioration and the failure of maintenance operations, which is the incorrect identification of the causes of distresses and their negative impact on the economy, safety, and the environment. To identify these causes and effects, the researcher used an integrated methodology that included reviewing and analyzing previous studies, preparing a questionnaire filled out by experts, and analyzing historical data for a case study (AL-Kut-Maysan Road). The results show that the reasons for the inaccurate identification of the causes of distresses are seven factors, the most important of which is the adoption of old and fixed work methods for all cases of deterioration, as well as the lack of training and tools used in some maintenance departments. The results of the case study analysis also show the negative effects, including economic losses, an increase in the number of accidents and emissions, as well as the road being out of service due to the failure of the maintenance process.

KEYWORDS: *pavement distress; road deteriorations; causes of incorrect identification; effect of pavement failures*

1. Introduction

The condition of roads is an essential aspect of the country's growth, it's an indicator of the economic level, and the World Bank has adopted it as a rating criterion [1]. The road provides transport services with high quality for the movement of people and goods [2, 3]. Keeping the road on the same performance level as the beginning of the traffic opening is difficult. This requires periodic and preventive maintenance [4]. Road public authorities have difficulties in maintaining an adequate quality of service for the whole road network and, in particular, evaluating an efficient pavement maintenance and repair program [1].

Pavement distresses may be attributed to age, traffic loads, fluctuating temperatures, varying levels of wetness, and other factors. It is possible that the service life of the pavement will be significantly decreased if pavement distresses are not recognized and fixed in a timely way. This may lead to a rapid decline in the performance of the pavement. Therefore, the timely detection and quantitative evaluation of pavement distress through a process known as pavement condition monitoring and assessment are of utmost importance for maintaining a high-quality pavement, extending the service life of the pavement, and decreasing the cost of life-cycle pavement maintenance [5].

Measurement of pavement surface distress is an important step for municipalities to take when developing efficient maintenance and rehabilitation plans [6]. The initial stages in evaluating the need for road repair are often the identification and classification of pavement distress, including the measurement of its type, severity, and extension [7]. Lack of uniformity in the concept of distress may make this step particularly important, as might the possibility of discrepancy in the categorization [6]. When assessing the pavement, it is possible to look at its structural quality, roughness, surface distress, safety, and skid resistance [1].

delayed and Inadequate maintenance of roads is significant factors in the significant number of road accidents [8]. According to the World Health Organization (WHO) report on road safety for 2015, road traffic injuries cause more than 1.25 million fatalities per year, and 50 million people are wounded in traffic incidents on the world's roadways each year. That's approximately 3,000 deaths daily About 500 of them are kids [9]. Unneeded maintenance raises total maintenance costs, but delayed maintenance may increase many expenses, the most important of which is reconstruction [10, 11]. Because of this, highways suffer hidden costs that are many times higher than the cost of maintaining and rehabilitating them. Road users face the burden of these increased expenditures, which far outweigh any savings realized by a road agency due to delaying, ignoring, or repeatedly failing maintenance and repair operations [12].

The main objective of this paper is to study the causes of incorrect identification of the causes of destresses. As well as the negative effects on financial waste, safety and the environment.

2. Research Methodology

A work methodology consisting of several steps was followed, which included (1) reviewing and analyzing many previous studies related to the subject of research, (2) preparing a mini-questionnaire to find out the most important reasons that lead to inaccurate identification of the causes of distortions, and (3) conducting a case study analysis to find out the causes and effects of inaccurate identification of the causes of distortions. Experts were consulted to verify the steps followed.

I. Previous Studies

This part of the methodology involves collecting and analyzing several previous studies related to the research topic. The aim of analyzing these studies is to find out the most common types of deformations in the pavement, the causes that lead to their appearance, and the proposed treatment for each type.

II. Questionnaire

In accordance with the requirements of scientific research, this questionnaire was developed. It consists of several paragraphs, but in this paper the focus will be on using one part, which applies to the objective of this paper. It was conducted with a group of experts who have extensive experience in road maintenance and rehabilitation operations. To find out the most important reasons that lead to inaccurate identification of the causes of distortions and lead to the failure of maintenance operations.

III. Case Study

This part of the methodology includes analyzing the historical data of the maintenance operations that were conducted for the AL-Kut-Maysan Road to find out the negative effects of the repeated failure and lack of success of the maintenance process as a result of the inaccurate identification of the causes of deformations. As shown in details in Figure (1) below. The road information is listed in Table (1) below:

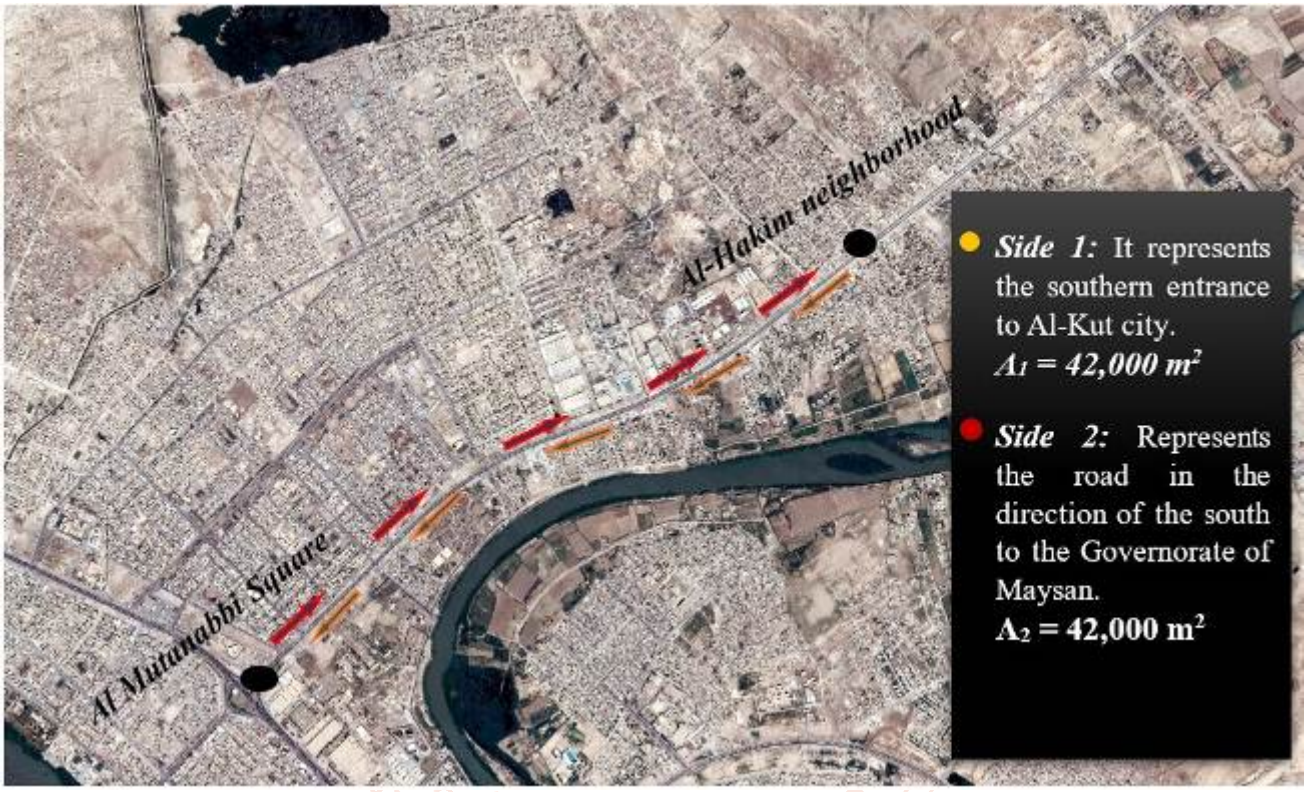

Figure (1): Satellite Image for AL-Kut-Maysan Road.

Table (1): AL-Kut-Maysan Highway Information

Property	Information
Location information	It lies in Wassit Province, and it is considered as Al-Kut city entrance from Maysan Province
Coordinates of the center line	N 576723 E 358049 N 584771 E 3603902
Length	6 KM
Number of lanes	2 per direction
Length width	3.75

IV. Research Outcomes

This research provides two main outcomes based on the research method and connected steps. First, the causes that lead to incorrect identification of pavement distresses. Secondly, knowledge about the negative effects of the process of road deterioration, the most important of which are the economy, safety, and environmental issues.

3. Distress (Pavement Distress)

Distresses in the pavement are those flaws that are evident on the pavement surface. As defined by the International Road Federation, it is an indicator of poor pavement performance (unsatisfactory pavement performance), as well as a warning sign of approaching breakdown (impending failures). Cracks, spots, and ruts are all signs of pavement degradation and are indications of a problem or phenomena of pavement deterioration. The kind and level of distress that pavement is experiencing may give valuable insight into what maintenance and/or rehabilitation will be required in the future. The degree, extent, and kind of distress are all often used phrases to define anguish. The processes for identifying and measuring distress, on the other hand, may differ somewhat from one organization to another [13].

3.1. Causes of Distress

Various causes may cause pavement deterioration, including severe traffic loads, high temperature and moisture levels, design and construction errors, poor quality materials, and lack of maintenance [14, 15]. Figure (2) below shows most of the reasons, which will be explained in detail.

Figure (2): Factors Impacting Pavement Distresses [16].

3.2. Type of Pavement distresses

Emphasis was placed on the deformations that occur in the asphalt pavement because most of Iraq's roads were built using asphalt pavements.

According to previous Iraqi studies, the focus was on the most common and widespread types of distortions in Iraqi roads. are classified into the following four major groups.

A. Cracking: Cracking is one of the most common problems encountered by asphalt pavements [17]. Their depth, length, and density can all vary, as can their shape and size. They are longitudinal holes in the surface of the road's asphalt layer that vary in depth, length, and density [18].

Table (2): Types and Probable Causes of Cracking.

Type of Distress	Possible Causes	Possible Repair
Fatigue (Alligator) Cracking	• Tensile stresses and shear stresses due to repeated traffic loading (wheel paths) [19]. • Inadequate pavement thickness [20, 21]. • Low modulus base [20, 21]. • Poor base drainage [20, 21].	• Reconstruction or Base recycling [20]. • Reconstruction or strengthening the pavement [21]. • Strengthen the base [20, 21]. • Reconstruct and improve the drainage [20, 21].
Transverse Cracking	• Semi-rigid base shrinkage [22]. • Shrinkage in low temperature [21, 22]. • Construction joint in bituminous surfacing [20]. • Shrinkage crack bituminous surfacing [20].	• Cut and patching together [20, 21]. • Replace bituminous surfacing or Seal cracks [20]. • Crack sealant [20]. • Overlay or replace bituminous surface [20].
Longitudinal Cracking	• Low temperature [23]. • Poor joint construction [23]. • Reflection of shrinkage crack [20, 21]. • The differential settlement between cut and fill [20].	• Cut and patching together [20, 23]. • Joints reconstruction [20, 23]. • Cut and patch [21]. • Overlay of crushed aggregate [20].
Edge Cracking	• Inadequate pavement width [21]. • Inadequate edge support [23]. • Seepage and heavy rainfall [20, 23].	• Expand the pavement width [23]. • Strengthening of the shoulders [20]. • Improve and efficient drainage [20].
Block Cracking	• Joints in the underlying layer [23]. • Shrinkage cracks (due to bitumen hardening) [21]. • Fatigue cracks in embrittled bituminous [20].	• Overlay of crushed aggregate [20]. • Replace bituminous surfacing or seal cracks [20]. • Cut and patch or overlay [20].

B. Distortion: It is a change in the original pavement surface caused by either a lack of compaction of the concrete asphalt layer or a mixture containing a high proportion of soft materials and asphalt or it can be caused by changes in the size of the materials under the paving (swelling) or it can be caused by subsidence [17]. The following are the different types of deformations:

Table (3): Types and Probable Causes of Distortion.

Type of Distress	Possible Causes	Possible Repair
Corrugations	• Instability of asphalt concrete or base course [20]	• Patching or reconstruction [20],
Rutting	• The main reason is excessive and repetitive loads on the Pavement [25, 26]. • Changes in soil volume and materials used [25]. • Unstable bituminous mixes [25].	• Reconstruction [20, 21]. • Reconstruction or base or sub-base strengthening [20, 21]. • Bituminous surfaces may be recycled or replaced with a firmer mix [20, 21].

C. Disintegration: As a result of the cracking, the pavement surface is fractured and divided into tiny, detachable pieces. If the cracking process is not stopped immediately, it might progress to the point of structural collapse [**17**]. Pavement collisions may be classified into two categories**:**

Table (4): Types and Probable Causes of Disintegration.

Type of Distress	Possible Causes	Possible Repair
potholes	• the breakaway of material under the action of traffic [27]. • Loss of surface course due to heavy rainfall (poor drainage) [21, 27].	• Cut and patch [20]. • Patching [21].
Raveling	• Insufficient adhesion between the asphalt cement and the aggregate (Insufficient bitumen content) [21]. • construction during wet weather [21].	• Overlay of thin bituminous asphalt [20, 21]. • Overlay of thin bituminous asphalt [20, 21].

D. Skid Hazard: Some sections of the road are very slippery, and there are a variety of factors that contribute to slippage. It is possible that slipping is caused by the presence of a thin layer of water on the upper surface of the road, as well as the fact that a smooth surface of the road is produced by the appearance of a layer of asphalt on the road's surface, or it may be caused by the fact that the raw materials used in the mixture are smooth. Draining the water from the road surface and eliminating the tar layer from the road surface may be accomplished by making the paving surface rough [**18**]. Tiling slippage might manifest itself in one of the following ways**.**

Table (5): Types and Probable Causes of Skid Hazard.

Type of Distress	Possible Causes	Possible Repair
Bleeding	• The HMA contains an excessive amount of asphalt binder [28]. • An overabundance of asphalt binder used during the application of BST [21]. • Low HMA air void content [21, 28].	• The surplus asphalt binder may be blotted off by using coarse sand. To do this, a motor grader or heated planer may be used to remove the surplus asphalt [21].
Polished Aggregate	• Insufficient resistance to the polishing of surface particles in regions where severe traffic movements or significant tensions are created between the surface and tyres. • Aggregates that are naturally smooth and uncrushed are used [21].	• Using a tougher mix for the bituminous overlay. • Overlay with a thin layer of bituminous material [20, 21].

4. Results and Discussion

After conducting and analyzing the questionnaire, the results of the survey that were answered by a specific group of specialists who have sufficient experience in the field of road maintenance show that resorting to the use of old and static methodologies in the repair process is the most influential element in the process of inaccurate identification of the causes of deformations. The table below shows the answers received and the relative importance index (RII) of the most influential component of the inaccurate determination.

Table (6): The RII of Factors Influencing Incorrect Identification

No.	Factors	No. of received responses%					RII	Rank
		Strongly Agree	Agree	neutral	Reject	Strongly Reject		
1	Static routine with repair methods (Old Methodology)	20	12	5	-	-	0.88	1
2	Weak scientific engineering capabilities in the field of road maintenance	7	12	10	8	-	0.70	7
3	Weakness in using the devices used for the survey process	10	12	15	-	-	0.773	5
4	Poor quality or non-availability of the tools used	15	15	7	-	-	0.843	3
5	Lack of interest in soil investigations	17	5	7	8		0.77	6
6	Poor or no training	17	13	7	-	-	0.854	2
7	Insufficient staff experience	12	17	5	3	-	0.81	4

According to experts, these causes are the most fundamental causes that lead to inaccurate identification of the causes of distresses. As shown in table (6), the methodologies used are old and almost represent a routine and fixed solution for most cases of road deterioration, which is the most important element. While it was also emphasized that a lack of training or training, as well as a lack of tools and other causes, as shown in the table above, contributed to the problem.

Figure (3): Causes of Incorrect Identification

All of these causes are interconnected with each other in some way. The occurrence of one of these causes leads to the emergence of many other causes. These causes can be considered complementary to each other, as shown in figure (3).

With regard to the analysis of the historical data of the case study, the results show that more than one comprehensive road repair process was carried out within a short period, which ultimately led to the road reaching a state of failure due to unsuccessful maintenance operations as a result of inaccurate identification of the causes of distresses, and thus this led to a large financial waste, a significant impact on safety, causing an increase in the number of accidents on the road, and also affecting the environment by increasing emissions from cars. The figure below shows the PCI values for the maintenance process extending from 2017 to 2022.

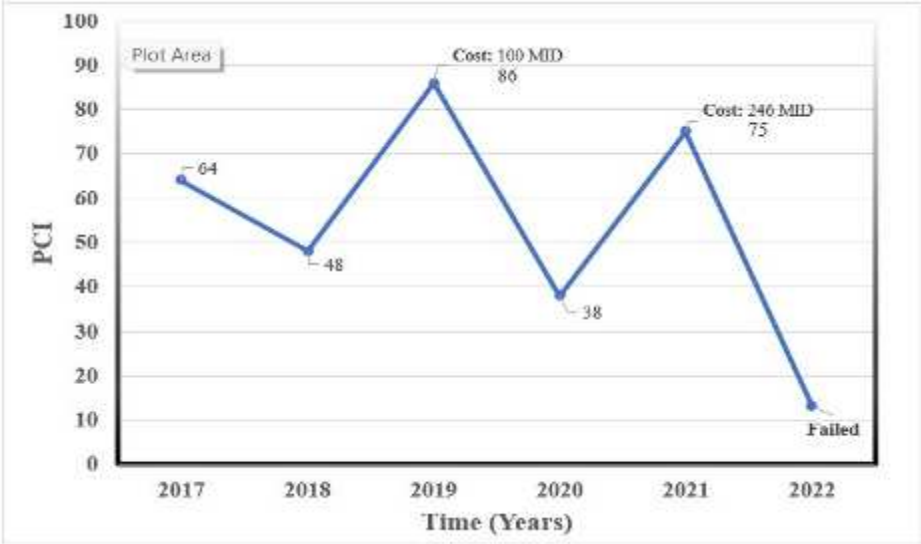

Figure (4): PCI Value & Cost for Southern Road Entrance of Al-Kut City (AL-Kut-Maysan).

As shown in figure 4, the results show a significant fall in the PCI values after each maintenance process, and thus this led to a large amount of financial waste, road failure, and out-of-service.

Conclusion

Road deterioration continues to be one of the main challenges and problems for society. One of the most important causes of road deterioration is incorrect identification of the causes of distress. The results of this paper show the causes of inaccurate identification, the most important of which is the adoption of fixed work methodologies. This is due to administrative shortcomings in some maintenance departments. As well as the lack of training, the incompetence of the work team, the weakness of the tools and not using them with sufficient accuracy, relying on personal evaluations, and neglecting soil investigations. All these reasons and others led to the inaccurate identification and deterioration of roads and, thus, to direct and indirect financial waste incurred by road users, in addition to an increase in the number of road accidents and vehicle emissions.

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