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Assessment of Pavement Surface Defects & Its Mitigation Measures: Case Study of Hawassa City, Ethiopia

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Abstract – **This paper will visually inspect and evaluate the flexible pavement failures and their causes as well as resolution methods. It is quite important to examine and identify the causes of the failed pavement to select a proper treatment option. The study consisted of two tasks: the first covers the visual inspection of the existing pavement failures, whereas the second investigates the actual causes of these failures. As a case study, Hawassa city main road from Hawassa University main gate to Monopole was selected for investigation. An intensive field work was carried out on the existing pavement condition of this road. It was found that most of the damaged pavement sections suffered from severe cracking, potholes and raveling failures. These failures might have been caused by fatigue failures on pavement structure due to the movement of heavily loaded truck - trailers. The damage could also be attributed to poor drainage, inadequate design and improper pavement materials use.**

Keywords — Structural failure, Functional failure, Materials failure, surface texture failures, deformation failures, Edge crack, pothole, depression, block cracking, longitudinal Cracks, alligator/Fatigue cracking and transverse Cracks

I. INTRODUCTION

A. Background

Pavement distress refers to the condition of a pavement surface in terms of its general appearance. A perfect pavement is level and has a continuous and unbroken surface. In contrast, a distressed pavement may be fractured, distorted, or disintegrated. Fractures can be seen as cracks or chipping of the pavement surface. Cracks can be further described as generalized, transverse, longitudinal, alligator, and block. A pavement distortion may be evidenced by ruts or corrugation of the surface. Pavement disintegration can be observed as raveling (loosening of pavement structure), stripping of the pavement from the sub base, and surface polishing [1]. Hawassa city, the study area of this research.it is most attractive city in Ethiopia.it attracts tourists for visiting lakes and resorts that are found in the city.as result the city must to have safe road for serviceability and save movements of strangers. We are initiated to identify the pavement defect and resolve the problems for safe riding purpose.

B. Statement of the Problem

The problems of pavement failure on the road are highly affects the road users. It leads increase the travel time, decrease the comfort and safety of passengers , decrease traffic flow of neighbors, exposé the vehicle owners for additional maintenance cost, traffic congestion And also affect economic growth and forebode of tourism. Quality of public transport highly affected that is distribution of low leveled vehicles for that area. Preventive maintenance is an essential tool for extending the life of a pavement. Used early in a pavement's life, preventive maintenance corrects small problems before they become big problems, saves money, reduces delays and improves safety and ride ability [1]. Therefore our research intends to resolve flexible pavement surface defects in Hawassa city (from Hawassa university main gate to monopole). Underground conditions, structures, traffic characteristics, and environmental contexts all have a tremendous impact on the performance of highway pavements [4].

C. Objectives

(i) To identify different pavement surface defects
(ii) To investigate the cause of pavement surface defects
(iii) To suggest the possible remedial measures based on observed pavement surface defects.

II. LITERATURE REVIEW

Pavement is the most common element of the transportation infrastructure and is built to provide a safe and comfortable ride for the public. To maintain a pavement system with an acceptable ride quality [2]. Pavement failure may be considered as structural, functional, or materials failure, or combination of these factors.

Structural failure: is the loss of load carrying capability, where the pavement is no longer able to absorb and transmit the wheel loading through the structure of the road without causing further deterioration [3].

Functional failure: is a broader term, which may indicate the loss of any function of the pavement such as skid resistance, structural capacity, and serviceability or passenger comfort [3].

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Materials failure: occurs due to the disintegration or loss of material characteristics of any of the component materials (Woods and Adcox) [13]. Also pavement failures are classified as either deformation failures or surface texture failures. Surface texture failures: include bleeding, cracking, polishing, stripping and raveling. These failures indicate that while the road pavement may still be structurally sound, the surface no longer performs the function it is designed to do, which is normally to provide skid resistance, a smooth running surface and water tightness. Other miscellaneous types of pavement failures include edge defects, patching and roughness (Caltrans) [15]. Deformation failures: include corrugations, depressions, and potholes, rutting and shoving. These failures may be due to either traffic (load associated) or environmental (no-load associated) influences. It may also reflect serious underlying structural or material problems that may lead to cracking. The formation of cracks in the pavement surface causes numerous problems such as discomfort to the users, reduction of safety, etc. [5]. In addition to the above, intrusion of water causing reduction of the strength in lower layers as well as lowering of bearing capacity of sub grade soil by pumping of soil particles through the cracks is also a major problem associated with the pavements. This leads to the progressive degradation of the road pavement structure in the neighborhood of the cracks. The origin of cracks differs by their shapes, configuration, and amplitude of loading, movement of traffic and rate of deformation. Crack sealing and seal coating can reduce the effect of moisture in aging of asphalt pavement [10].

III. MATERIALS AND METHODOLOGY

A. Method of Data Collection

In order to meet the objectives of the study, a concise method of data collection has to be devised and implemented to get a reasonable quality output. We used two methods of data collection, those are:

i. The primary data: Consists of observation on defected pavement, by questioner and interview

ii. The secondary data: Literature review on many related issues from the different published and unpublished sources will be collected to get enough information on such related issues and mitigation measures in order to go for solution from internet and referring other related documents.

B. Method of Data Collection

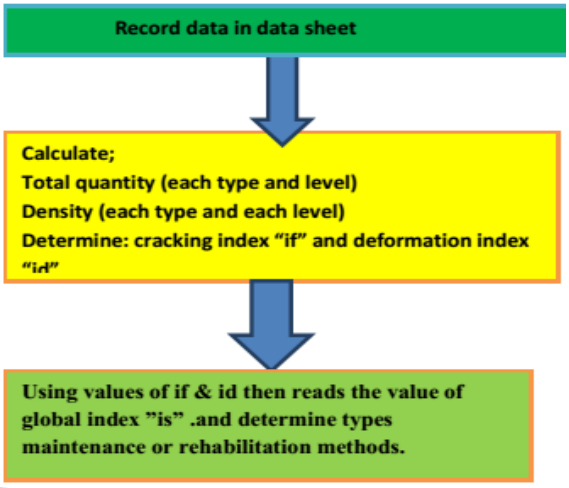

Figure 1 Flow Chart of Data Analysis

The data analysis consists of classification and quantification of distresses so as to identify causes of distress and propose possible maintenance options.

The following steps are followed:

i) Classification of distresses: Classify the type of distresses into possible causes such as load associated, climate/durability associated and moisture/drainage associated distresses based on the results of the visual condition survey.

ii) Identify Probable Cause of Pavement distress: The second stage in the data analysis is to establish causes of pavement distress by interpreting the data collected during the visual inspection of the site and other field investigations and from questioner.

Analysis of Visual Distress Survey

• Quantify the existing defects with relation to their severity for each test section.
• Calculate the global index value for each test section and mean global index for test road.
• Rate the overall condition of the pavement section using global index scale.
• Classify the quantified distresses into their probable causes such as Load associated, material durability associated and drainage associated distresses.
• Quantify the most dominated distresses in the whole test roads.

IV. RESULTS, ANALYSIS AND DISCUSSION

A. Types of Observed Pavement Distress

Based on the pavement condition by visual observation, the types of defects on the surface layer of the pavement were assessed. Pavement deterioration usually occurs from both loading and weathering [9]. The following section describes the major problem that found

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in area of study during the field condition surveys. And include elements to assess the situation visually as follows:

i. Longitudinal Cracks

From our observation longitudinal cracks which is parallel to the pavement's center line and lay down direction is clearly exist.

a. Problem

Allows moisture infiltration, roughness, indicates possible onset of alligator cracking and structural failure.

b. Possible Causes

Pavement that is fatigue or "worn out" from heavy traffic especially that due to high pressure truck tires; an unstable base; poor Construction [8].

c. Options for Repair (Cures)

Also treatment these cracks depend on the severity and intensity. In the case of low severity nothing is there but in the medium severity resort to fill the cracks. In the case of high severity use overlays surface, or implementing to thin overlay.

Figure 2 Longitudinal Cracks

ii. Alligator/Fatigue Cracking

In our study Alligator Cracking begins at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface in all direction equally.

a. Problem

Indicator of structural failure, cracks allow moisture infiltration, roughness, may further deteriorate to a pothole.

b. Possible Causes

Repeated traffic loading, poor materials used in pavement, insufficient thickness of the pavement and poor drainage.

c. Options for Repair (Cures)

Treatment based on the severity and intensity of cracks starting using overlays, surface patching or re-construction.

Figure 3 Alligator/Fatigue Cracks

iii. Block Cracking

These types of cracking are interconnected cracks that divide the pavement up into rectangular Pieces. In our cases block cracking normally occurs over a large portion of pavement area but sometimes will occur only in non-traffic areas).

a. Problem - Allows moisture infiltration and roughness effect

b. Possible Causes

Typically caused by an inability of asphalt binder to expand and contract with Temperature cycles because of: Asphalt binder aging, poor choice of asphalt binder in the mix design [11].

c. Options for Repair (Cures):

Treatment based on the severity and intensity of cracks starting using overlays, surface patching or re-construction.

Figure 4 Blocking Crack

iv. Transverse Cracks

The selected road section transverse cracks extend across the pavement at approximately right angles to the pavement centerline or lay down direction.

a. Problem

Allows moisture infiltration, roughness

b. Possible Causes

Shrinkage of the pavement surface due to low temperatures or asphalt binder hardening. Reflective crack caused by cracks beneath the surface layer.

c. Options for Repair (Cures)

Treatments to these cracks depend on the severity and intensity. In the case of low severity, doing something in

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the medium severity resort to fill the cracks leads to worse. In the case of high severity use overlays surface, or implementing to thin overlay.

Figure 5 Transverse cracks

v. Potholes

Pothole defects are not widely observable in this road section. But some of them generally have sharp edges and vertical sides near the top of the hole [7].

a. Problem

Roughness (serious vehicular damage can result from driving across potholes at higher speeds), moisture infiltration.

b. Possible Causes

Generally, potholes are the end result of alligator cracking. As alligator cracks become severe, the interconnected cracks create small chunks of pavement, which can be dislodged as vehicles drive over them. The remaining hole after the pavement chunk is dislodged is called a pothole.

c. Options for Repair (Cures)

The treatments are surface patching or deep depend on depth of the hole. No matter what cure is chosen, it is important to fix the situation which caused the pothole.

Fig. 6 Pothole

vi. Raveling and Weathering

Raveling and weathering type of pavement defects are common in our section. This distress indicates that either the asphalt binder has hardened appreciable or that a poor quality mixture is present. Loose materials (usually aggregate) that "ravel" from the surface or edges of the pavement, resulting in depressions which may fill with moisture and loose aggregate which may pose problems[6].

a. Problem

Roughness and potholes.

b. Possible Causes

May be caused by certain types of traffic (tracked vehicles), Poor quality mixture, Segregation of the mix during construction.

c. Options for Repair (Cures)

If the cause is superficial, a surface treatment will solve the problem. If poor drainage is causing a stripping problem, the drainage should be corrected.

vii. Depression

Depressions are also other pavement surface defects with elevations slightly lower than those of the surrounding pavement. This occurs severally in road section. In many instances, light depressions are not noticeable until after a rain, when ponging water creates a “birdbath” area; on dry pavement. It is created by settlement of the foundation soil or a result of improper construction, causes roughness, and when deep enough or filled with water.

Fig. 6 Depression

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station	Distress	Severity	Extent	Cracking Index(if)	Deformation index(id)	Global Index(is)
4+160-260	Edge cracking	3	47	4		5
	Potholes	2	1		2	
4+260-360	Edge cracking	3	81	5		6
	Raveling	1	55		3	
4+360-460	Edge cracking	2	9.5	2		5
	Raveling	1	15.2		3	
4+460-560	Edge cracking	3	85	5	1	4
	Raveling	1	6			
4+560-660	Edge cracking	3	69.1	5	1	4
	Raveling	1	6			
4+660-760	Edge cracking	3	87.4	5		6
	Potholes	1	7		3	

B. Result summary for data analysis

6+360-460	Edge cracking	3	23	4		4
6+460-560	Edge cracking	3	130	5		5
	Pothole	2	1		2	
6+560-660	Edge cracking	3	30	4		4
6+660-760	None					
6+780-860	None					
6+860-960	Edge cracking	3	142	5		5
	Pothole	2	2		2	
6+960-7+060	Edge cracking	2	45	3		5
	Pothole	3	1		3	
7+060-160	None					
7+160-260	None					
7+260-360	Edge cracking	1	10	1		5
	Raveling	1	29		3	
7+360-460	Edge cracking	3	98	5		4
7+460-560	None					
7+560-660	Edge cracking	2	69	4		4
7+660-760	Edge cracking	2	55	4		5
	Pothole	2	1		2	
7+760-860	Edge cracking	2	37	3		3
7+860-960	Edge cracking	1	50	3		4
	Pothole	2	1		2	
7+960-8+060	Depression	1	7		2	3
8+060-	Edge cracking	1	20	3		3
	Total extent value		2263.8			

The result is taken from data analysis. Based on the value of pavement distress has higher cracking index and deformation index. Because when resolve the problems of such distress also can resolve the other distress which have lower index values.

Table 1 Distribution of Pavement Distress in the test Roads

Distress Type	Total Distress Density	%age Distress Indicator
Edge Cracking	1682.8	74.31
Transversal Cracking	157.7	6.97
Raveling	383.2	16.93
Depression	11.1	0.49
Pothole	23	1.02
Block cracks	6	0.27
Total	2263.8	100

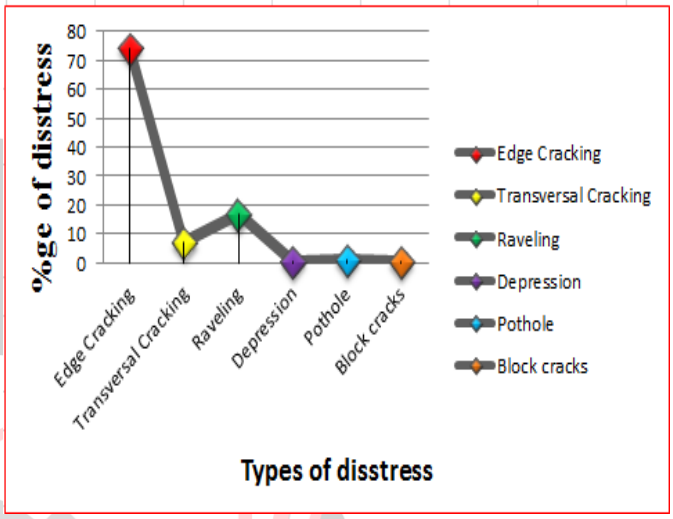

Figure 7 Graphical Representation of the Type of Distress

From 7 Graphical representations the majority of the road is affected by edge cracking. Next to edge cracking raveling is dominates the other.

V. CONCLUSION

The main target of this paper is to analyze flexible pavement defects, factors that cause road damages and possible rehabilitation system. From the study and analyses that has been carried out, the majority of distresses under the study area are Alligator cracking, depression, Potholes, raveling, edge cracking, longitudinal cracking and transverse cracking. The cause of the defect under the study area is weathering and traffic loading. Based on the type and cause distress as well as data analysis result we conclude that remedial work for the section to be maintenance or rehabilitation work. According to ERA manual states the global index value 5-6 requires maintenance or rehabilitation work [16], As result of the majority of the global index value in our analysis at the range 5-6 and the global index 5 highest percentage values.

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