World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:9, No:11, 2015

Investigating Causes of Pavement Deterioration in Khartoum State, Sudan

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***Abstract*—**It is quite essential to investigate the causes of pavement deterioration in order to select the proper maintenance technique. The objective of this study was to identify factors cause deterioration of recently constructed roads in Khartoum state. A comprehensive literature concerning the factors of road deterioration, common road defects and their causes were reviewed. Three major road projects with different deterioration reasons were selected for this study. The investigation involved field survey and laboratory testing on those projects to examine the existing pavement conditions. The results revealed that the roads investigated experienced severe failures in the forms of cracks, potholes, and rutting in the wheel path. The causes of those failures were found mainly linked to poor drainage, traffic overloading, expansive subgrade soils, and the use of low quality materials in construction. Based on the results, recommendations were provided to help highway engineers in selecting the most effective repair techniques for specific kinds of distresses.

***Keywords*—** Pavement, deterioration, causes, failures.

I. Introduction

PAVEMENT deterioration is the process by which distresses develop in pavement under the combined effects of traffic loading and environmental conditions. Deterioration of pavement greatly affects serviceability, safety, and riding quality of the road. After construction, roads deteriorate with age as a result of use and therefore, they need to be maintained to ensure that the requirements for safety, efficiency and durability are satisfied. Normally, new paved roads deteriorate very slowly in the first ten to fifteen years of their life, and then go on to deteriorate much more rapidly unless timely maintenance is undertaken, [1].

In Sudan, recently constructed roads were reported to deteriorate rapidly after opened to traffic. These deteriorations were contributed to many reasons such as excessive loads, climatic changes, poor drainage, and low quality pavement materials. The most common road distresses are cracks, potholes, rutting, raveling, depressions, and damaged edges. These distresses affect the safety and riding quality on the pavement as they may lead to premature failure and traffic hazards. Before going into maintenance strategies, engineers must look into the causes of road deterioration. Therefore, this paper aims to identify the causes of pavement deterioration shortly after construction or rehabilitation in Khartoum state.

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II. Literature Review

Deterioration of highway pavement is a very serious problem that causes unnecessary delay in traffic flow, distorts pavement aesthetics, damages of vehicle and most significantly, causes road traffic accident that had resulted into loss of lives and properties, [2]. Pavement surface deformation affects the safety and riding quality on the pavement as it may lead to premature failures.

A variety of factors contribute to pavement deterioration were investigated by many researchers [3], [6], [8], [10], [17], [18]. On [3], some of the factors that cause highway failure has been identified. They include poor design, construction and maintenance, use of low quality construction materials, poor workmanship and poor supervision of construction work and the applying of heavy traffic that were not meant for the road. Furthermore, he also suggested that the following will lead to highway failure; poor highway facilities, no knowledge base, in adequate sanction for highway failure, no local standard of practice, poor laboratory and in-situ tests on soil and weak local professional bodies in highway design, construction and management.

The most significant road defects observed in the field are potholes, cracks, edge defects, depressions and corrugation, [4]. At the same time he emphasized that traffic overloading, pavement age, road geometry, weather, drainage, construction quality as well as construction materials, maintenance policy play the major role as road deteriorate agents. However, understanding the causes for pavement deterioration failures is essential step towards minimizing risks to have good road performance. An intensive literature of the major factors that may lead to pavement deterioration will be reviewed in the following sections.

A. Heavy Traffic

One of the defects caused by heavy traffic on the road is the deformation of the pavement surface due to overloading that is more than the design load. As stated by [5] that deterioration of pavements arises from deformation generally associated with cracking under heavy commercial vehicles. The increased traffic loading will then cause failures such as cracks and depressions on the pavement. Omer et al. [6] studied the pavement failures occurred in the ring road in Khartoum. They observed from the site visit to the road severe trenched on the west lane that might have been caused by the movements of heavy loaded truck-trailers, tippers, as well as loaded fuel tankers.

Road surfaces often wear under the action of traffic, particularly during the very early life of the road. However,

the action of traffic continues to wear the surface texture and thus gradually reduces the high speed skidding resistance, [7]. He reported that with the increase of traffic loads (volume and axle loads) the road network was experiencing a deterioration equivalent to a loss of billions dollars due to road deterioration and vehicle operating cost.

Nowadays, the rate of traffic accident on roads due to the nature of the road is alarming. Okigbo [3] indicated that the defects that most often cause injuries to people and damage to vehicles include inadequate road shoulders, pavement surface that is uneven, improperly marked signs, malfunctioning stop lights, construction negligence, and municipal negligence. Traffic volume and size (especially for overloading) contributes to road safety and conditions. Recognizing of vehicles' uses and applications (industrial transportations) is the key for decreasing road deterioration.

B. Climatic Changes

Climatic factors include rainfall and annual variations in temperature are an important consideration in pavement deterioration. Rainfall has a significant influence on the stability and strength of the pavement layers because it affects the moisture content of the subgrade soil. The effect of rain on road pavements can be destructive and detrimental as most pavements are designed based on a certain period of rainfall data. In addition, rainfall is well established as a factor affecting the elevation of the water table, the intensity of erosion, and pumping and infiltration. Long periods of rainfall of low intensity can be more adverse than short periods of high intensity because the amount of moisture absorbed by the soil is greater under the former conditions [8]. He further emphasized that water is the critical factor that cause road failures. Once water has entered a road pavement, the damage initially is caused by hydraulic pressure. Vehicles passing over the road pavement impart considerable sudden pressure on the water, this pressure forces the water further into the road fabric and breaks it up. This process can be very rapid once it begins. When vehicles pass over the weak spot, the pavement will start to crack and soon the crack generates several cracks. Water will then enter the surface voids, cracks and failure areas. This can weaken the structural capacity of the pavement causing existing cracks to widen. Eventually, the water will descend to the subgrade, weakening and hence lowering the CBR value of the subgrade on which the road pavement design was based upon.

Wee et al. [9] reported that climatic changes in temperature and rainfall can interact together. Rainfall can alter moisture balances and influence pavement deterioration while the temperature changes can affect the aging of bitumen resulting in an increase in embrittlement of the bitumen which causes the surface to crack, with a consequent loss of waterproofing of the surface seal.

C. Poor Drainage

The highway drainage system includes the pavement and the water handling system which includes pavement surface, shoulders, drains and culverts. These elements of the drainage system must be properly designed, built, and maintained. When a road fails, inadequate drainage often is a major factor. Poor design can direct water back onto the road or keep it from draining away. Too much water remaining on the surface combine with traffic action may cause potholes, cracks and pavement failure.

Patil Abhijit et al. [10] investigated the effect of poor drainage on road pavement condition and found that the increase in moisture content decreases the strength of the pavement. Therefore, poor drainage causes the premature failure of the pavement.

Little and Jones [11] investigated moisture damage in asphalt pavements due to poor drainage. They found that the loss of strength and durability due to the effects of water is caused by loss of cohesion (strength) of the asphalt film, failure of the adhesion (bond) between the aggregate and asphalt, and degradation of the aggregate particles subjected to freezing. Moisture damage generally starts at the bottom of an asphalt layer or at the interface of two asphalt layers [12]. Eventually, localized potholes are formed or the pavement ravels or ruts. Surface raveling or a loss of surface aggregate can also occur, especially with chip seals. Occasionally, binder from within the pavement will migrate to the pavement surface resulting in flushing or bleeding [13].

D. Construction with Low Quality Materials

The use of low quality materials for construction adversely affects the performance of the road. This sometimes occurs in theform of the improper grading of aggregates for base or subbase and poor subgrade soil of low bearing strength. The use of marginal or substandard base materials for pavement construction will affect pavement performance [14]. He found that these materials may accelerate deterioration of the pavement and often result in rutting, cracking, shoving, raveling, aggregate abrasion, low skid resistance, low strength, shortened service life, or some combination of these problems.

Osuolale et al. [15] investigated the possible causes of highway pavement failure along a road insouth western Nigeria. He stated that the materials used as subbase have the geotechnical properties below the specification and this is likely to be responsible for the road failure.

The base materials with high fines content are susceptible to loss of strength and load supporting capability upon wetting [16]. However, marginal base materials often lead to distress and can lead to premature failure in the form of severe shrinkage cracking followed by accelerated fatigue cracking and a general loss of stability [17].

E. Expansive Subgrade Soil

Expansive soil as road subgrade is considered one of the most common causes of pavement distresses. Longitudinal cracking results from the volumetric change of the expansive subgrade, is one of the most common distresses form in low volume roads (see Fig. 1). This type of cracking is initiated from the drying highly plastic subgrade (PI>35) through the pavement structure during the summer [18], [19]. Other forms include fatigue (alligator) cracking, edge cracking, rutting in

the wheel path, shoving, and popouts.

Fig. 1 Longitudinal cracking and failure, [19]

Charlie et al. [20] investigated more than 30 sites and found that over one third of Sudan's area may have potentially expansive soils and recommended all potential construction sites in the clay plain be evaluated for expansive soils. Problem of expansive soils results from a wide range of factors such as swelling and shrinkage of clay soils result from moisture change, type of clay minerals, drainage– rise of ground water or poor surface drainage and compression of the soil strata resulting from applied load.

III. Case Study

The current investigation was carried out on selected three major roads in Khartoum state. These roads have exhibited pavement deterioration and failures occurred shortly after their last rehabilitation. The investigation consisted of field survey of road surface distresses and laboratory investigation. The visual field inspection was carried out on the existing pavement of failed sections. The laboratory investigation was conducted to determine the materials characteristics of the pavement layers.

Three major road projects in Khartoum state, which are distinctly different in their current pavement conditions, were selected for study: Algaba road, Shambat west road, and Alarbeen road are located in Khartoum, Khartoum North, and Omdurman respectively. These roads are located in the most crowded areas in Khartoum state. They were subjected to rehabilitation several times within the last ten years and still severing significant distresses and fast deterioration. The projects were investigated to identify sources and reasons of pavement deterioration and other problems that have led to premature failures. For the study purpose, it is required to evaluate design, construction, and materials properties. The sections below provide brief summaries of the investigation methodology followed in order to achieve the research objective.

A. Records Review

A detailed records review was conducted with the help of some civil engineers of the Road Corporation, Ministry of Infrastructure in Khartoum state to obtain some data about the geometric and pavement design and year of last rehabilitation of the study road projects as given in Table I.

TABLE I
Summary of the Findings from Records Review

Data Description		Algaba Road	Shambat west Road	Alarbeen Road
Road length, km	Total length	3.0	2.5	2.0
	failed length	1.4	1.6	0.5
Roadcross-section	Total width, m	22 to 7	7	15
	Carriageway	2 or 1	1	2
	No. of lanes	6 or 2	2	4
Pavement Layers Thickness, cm	Surface	7	5	7
	Base	20	20	15
	Subbase	20	25	20
Subgrade Soil	Type	Silty clay	Silty clay	Clayey sand
	Design CBR	7.0	5.5	10.0
Design Traffic Loading, ESAL		4×10^6	3.5×10^6	2.5×10^6
Year of last rehabilitation		2013	2010	2007

B. Field Inspection of Distresses

The visual examination of the pavement surface was conducted by a car driving at slow speed on the shoulders along the distress locations. Frequently stops were made near locations where severe distresses were witnessed. Drainage features at and/or near these locations were inspected to determine if improper drainage was a contributing factor to the distress. In addition, photographs of the distressed pavements were taken at these locations. The details of the field inspection of distresses for the three roads are given in the following sections.

1. Algaba Road

This road connects the southern part of Khartoum with Omdurman by Al Ingaz Bridge. The road is a major transport facility for trucks and buses that transport goods and passengers from Omdurman to Khartoum south. A portion of this road located at Almugran in Khartoum, 1400m length had been plagued by significant distresses. This particular road section recently had received a 30mm overlay. However, within one year of construction, the overlay was badly cracked and rutted. It was observed that there is an open small side drain in a very bad condition located on north side edge of the northbound. These conditions of pavement prompted the urgent need for a detailed inspection of failures.

Both the northbound and southbound lanes were examined. On the southbound lanes, the majority of the damage is due to high severity rutting leads to large potholes mostly concentrated to the wheel path of heavy traffic as shown in Fig. 2. There is also significant damage due to medium severity transverse cracking mostly occurring in edge lane.

In the northbound lanes there is substantial fatigue cracking with small potholes. As would be expected, the damage appears to be isolated mostly in the center of the road. There is some medium to severe transverse cracking in edge lane.

Fig. 2 Severe rutting leading to large potholes in Algaba road

2. Shambat West Road

It is a major road located at the western part of Khartoum North. This road has been experiencing considerable pavement failures. The road narrows to one lane in each direction. It was observed that the majority of the damage is large potholes. In addition, there are large areas of moderate fatigue cracking associated with depressions and heave. Most of the cracks and potholes are considered severe and located along the road edges (see Fig. 3).

Fig. 3 Severe potholes and damaged edge in Shambat west road

3. Alarbeen Road

This road connects Omdurman town with Khartoum and is located in the eastern part. The damage was observed mainly in the middle portion of the road length, particularly in the edge lane of the eastern carriage. The majority of the damage was moderate to severe edge cracking. Raveling is also present and appears to be worse. The severe raveling has led to potholes and depression areas where the top surface has delaminated from the road structure as clearly shown in the photograph of Fig. 4.

Fig. 4 Severe surface damage along the edge lane in Alarbeen road

It was observed that the eastern carriageway of the road is connected with side drain. In general, most of the drain is covered with concrete slab and damage manhole covers. The drain has small cross section of 1m width and not more than 1m depth. The condition of the drain and its structures is very poor and getting deteriorated by the passage of time. The drain suffered from low capacity, natural siltation, absence of inlets, lack of proper maintenance and over and above disposal of solid waste into the drain and the crossing culverts. The drain blocked with silt and sand accumulation, debris and vegetation as shown in Fig. 5. It is clear that the drain being converted to dumpy place and subsequently obstructed the water flow.

Fig. 5 Side drain of damaged cover full with debris in Alarbeen road

C. Laboratory Testing

The laboratory investigation was conducted on samples obtained from the pavement materials of the study projects. The Field sampling consisted of cutting cores from the pavements and excavating trenches for damaged sections along the three roads projects. Two samples were obtained from each road for testing.

The tests were conducted to measure the soil physical properties, strength and swelling characteristics. Sieve analysis, hydrometer, Atterberg limits (liquid and plastic limits) tests were carried out in accordance with BS 1377 [21]. Oedometer tests were performed for measuring swell potential and swelling pressure of compacted soils. Whereas the free swell was measured in a graduated cylindrical glass jar of 100ml capacity.

The asphalt concrete samples were obtained from the cutting cores in the failed pavement sections. The thickness of the core samples were measured prior testing. The samples of asphalt concrete were prepared by reheating to 60°C and then subjected to Marshall Compaction. The compacted samples of asphalt concrete were subjected to Marshall tests to measure the stability and flow properties.

D. Results and Discussion

The results of the experiments carried out for measuring the basic properties of the six samples of soils and asphalt concrete are presented in Table II. As shown in this table, the measured properties for the earth pavement materials not complied with the standard specifications, whereas the samples of asphalt concrete comply with the requirements of Marshall. It is to be noted that reheating of the asphalt concrete samples sometimes give higher values. The tests results clearly indicated that the granular base and subbase

materials for the three roads below the specifications. This is may be one of the reasons that cause pavement deterioration.

The results from field survey of the three roads with different defects are presented and discussed here. Fig. 2 shows the photo of pavement having rutting surface and potholes. From figure, the rutting happened to occur on the wheel path and the potholes appeared in the middle of roadway. This pavement receives heavy load traffic every day because it is one of the main routes for buses and trucks. From field observation, this road experience very poor drainage. The data recorded (as given in Table I) indicated that the faulty pavement design parameters, the paving was designed using underestimated traffic loads, the use of low quality materials in base and subbase construction, inappropriate pavement design procedures were followed. Therefore, insufficient thickness and poor drainage may become the reasons of these defects to occur.

TABLE II
SUMMARY OF THE LABORATORY TESTS RESULTS

Test	Property	Algaba Road		Shambat West Road		Alarbeen Road	
		S1	S2	S3	S4	S5	S6
Particle size analysis	Sand, %	25	10	28	20	64	61
	Silt, %	19	20	20	18	22	18
	Clay, %	56	70	52	62	14	21
Atterberg's limits	LL, %	61	72	54	70	37	45
	PI, %	31	40	29	42	10	17
CBR	Base	62	56	37	52	70	64
	Subbase	25	22	20	23	24	20
	Subgrade	2.2	3.5	1.4	3.1	7.0	11
Swelling	FSI, %	160	220	165	205	30	45
	Swell %	9.5	15	7.0	10	1.6	4.0
	Swell pressure, kpa	90	130	95	122	28	50
Marshall	Thickness, mm	62	60	43	46	55	61
	Stability, Kg	1452	1375	1460	1543	1520	1650
	Flow, mm	2.8	3.5	2.2	2.9	2.4	3.1

Fig. 3 is the photo taken from pavement that having bumps, cracks, and edge failures at the middle and side edges of the road carriageway. The defect area is quite large and obstructs the traffic flow. It appears that failures may simply be due to weak subgrade soil. The problems associated with heave and edge failures were likely associated with problems in the subgrade soils along the alignment. Distresses related to expansive soils exist throughout the road alignment, but significant damages concentrations are located in a certain sections of about 1.6 km length. A lack of adequate surface drainage is another critical factor leading to problems with expansive subgrade soils in this road.

Fig. 4 shows the asphalt layer has delaminated from the top surface of the road structure. This defect area is adjacent to the side drain, shows significant depression. It was observed that the side drain was full with refuse dumps. The inlets on the curb were blocked with soil accumulation as shown in Fig. 5. It is clear that the surface runoff water penetrated through the cracks and potholes cause a progressive inward penetration of the zone of soil movement leading to soil depression and ultimately failure of the pavement. From the on-site observation and the result above, it is clearly seen that the major cause of pavement deterioration is inadequate drainage.

IV. RECOMMENDED DISTRESSES REPAIR TECHNIQUES

The study aims to recommend effective repair techniques. This may be achieved by justifying some improvements to current repair techniques to suit roads in Sudan. A detailed description of the recommended repair techniques is outlined below.

- Cracking Repair: Using crack sealing with bitumen for low severity cracks(<20 mm wide).For high severity longitudinal cracks, a base repair may be necessary. Other effective treatments could be sealing the cracks and applying a surface level-up; or applying overlay. Cracking because of aged HMA can be effectively treated with applying a new surface.
- Slight ruts (< 8mm deep) can generally be left untreated. Pavement with deeper ruts should be leveled and overlaid.
- The optimal treatment of a pothole is a surface patch.
- For narrow roads without shoulders, road widening is suggested as a cost-effective edge repair solution than patching.
- For small, localized areas of corrugation or shoving, it is recommended to remove the distorted pavement and patch. Large corrugated or shoved areas are repaired by removing the damaged pavement and overlay.
- Depressions or heave should be repaired by removing the affected pavement then patch over the repaired subgrade.
- A raveled pavement repair by removing the damaged pavement and patch if small otherwise apply overlay for large raveled areas which indicate general HMA failure.
- Bleeding repair may eliminate or reduce the asphalt binder film on the pavement's surface but may not correct the underlying problem that caused the bleeding. Minor bleeding can often be corrected by applying coarse sand to blot up the excess asphalt binder. Major bleeding can be corrected by cutting off excess asphalt with a motor

grader or removing it with a heater planer. If the resulting surface is excessively rough, resurfacing may be necessary.

- Patches are themselves a repair action. The only way to repair them by removing from a pavement's surface and then apply overlay.

V. Conclusions

This study has been undertaken to investigate the causes for pavement deterioration. The results and the conclusions drawn as follows:

- Road deterioration is an issue of vital concern to road authorities because of the high cost for rehabilitation of existing roads.
- Pavements deteriorate under traffic loads and climate effects. This fact, together with the weak subgrade soil and poor drainage system, could be major causes of the road's fast deterioration in Sudan.
- It was pointed out that understanding the causes of pavement deterioration will significantly contribute to the proper selection of effective maintenance technique results in prolonged service life of roads and significant savings for the government.
- The experience of the investigator is an important factor in correctly diagnosing the pavement failure cause and determining the best rehabilitation treatment.

References

[1] W. Paterson, "Road Deterioration and Maintenance Effects: Models for planning and Management," Baltimore: The John Hopkins University press, 1987.

[2] O. M. Ogundipe, "Road pavement failure caused by poor soil properties along Aramoko-Ilesa highway, Nigeria," Journal of engineering and applied sciences, 2008, 3(3), pp. 239-241.

[3] N. Okigbo, "Road maintenance in Nigeria, the way forward," International journal of research in engineering science, Pan African journal series, Accra, Ghana, 2012.

[4] A. S. Harischandra, *Identification of road defects, causes of road deterioration and relationship among them for bitumen penetration macadam roads in Sri Lanka*. Master Thesis at The University of Moratuwa, Sri Lanka, 2004.

[5] P. Croney, and D. Croney, *The Design and Performance of Road Pavements*. New York City: McGraw-Hill Professional, 1998.

[6] O. G. Omer, A. M. Elsharief and A. E. Mohamed, "Failure Investigation for Recently Constructed Road in Khartoum State," Journal of Geological Resource and Engineering 2, David Publishing Press, 2014, pp 20-31.

[7] T. M. Oguara, *A management model for road infrastructure maintenance*. Book of proceedings, 19th engineering assembly, Council for the regulation of engineering in Nigeria, 2010.

[8] M. Sargious, *Pavement and Surfacing for Highways and Airports*. London: Applied Science Publishers Ltd, 1975.

[9] S. Y. Wee, R. B. Chan, and H. W. Teo, "Potential modeling of pavement deterioration rate due to cracking," UNIMAS E-Journal of Civil Engineering, Vol 1, issue 1, August 2009.

[10] D.Y. Patil Abhijit, Y. B. Patil Prathisthan's, and A. Patil Polytechnic, "Effects of Bad Drainage on Roads," Civil and Environmental Research, Vol. 1, No.1, 2011.

[11] N. D. Little, and R. D. Jones, "Chemical and Mechanical Processes of Moisture Damage in Hot-Mix Asphalt Pavements," Moisture Sensitivity of Asphalt Pavements- A National Seminar, February 4–6, 2003 San Diego, California. Transportation Research Board of the National Academics, 2003.

[12] N. P. Khosla, G. B. Birdsall, and S. Kawaguchi, "An In-Depth Evaluation of Moisture Sensitivity of Asphalt Mixtures," NCDOT Research Project 1998-08 FHWA/NC/2002-102, 1999.

[13] K. D. Stuart, "Moisture Damage in Asphalt Mixtures- A State-of-Art Report, FHWARD-90-019, Federal Highway Administration, U.S Department of Transportation, Washington, D.C., 20001., 1990.

[14] R.S. Rollings, "Marginal Materials for Pavement Construction," Final Report, Department of the Army Waterways Experiment Station Corps of Engineers, US. Vicksburg Mississippi 39180-0631, 1988.

[15] O. M. Osuolale, A. A. Oseni, and I. A. Sanni, "Investigation of Highway Pavement Failure Along Ibadan - Iseyin Road, Oyo State, Nigeria," International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 8, October – 2012.

[16] D. N. Little, and R. Graves, "Upgrading Marginal Aggregate Bases And High-Fines Bases With Low Levels of Stabilizers," Texas Transportation Institute, Texas A&M University and Vulcan Materials Company, 1999.

[17] D. N. Little, T. Scullion, P. Kota, and J. Bhuiyan, "Identification of the Structural Benefits of Base and Subgrade Stabilization," Research Report 1287-2F, Texas Transportation Institute, Texas A&M University, College Station, Texas, 1995.

[18] S. Sebesta, "Reworking Base, "Presented at Statewide Maintenance," Conference, San Antonio, TX, April 16, 2002.

[19] S. Sebesta, "Investigation of Maintenance of Base Repairs over Expansive Soil," FHWA/TX-03/0-4395-1, 2005.

[20] W. Charlie, M. Osman and E. Ali, "Construction on Expansive Soils in Sudan," Journal of Construction Engineering Management, American Society of Civil Engineers, Construction Division. Vol. 110 No. 3, pp. 359–374, 1984.

[21] BS 1377-2, *Soils for civil engineering purposes: part 2: Classificationtests.*1990.

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