ASSESSMENT OF ROAD SAFTY INDEX FOR ROAD MAINTENANCE “A CASE FOR BUTAJIRA TO SODO ROAD”

An Independent Project Submitted In Partial Fulfillmentforthe Requirement of Degree of Masters of Engineering in Civil Engineering with Specialization In

HIGHWAY ENGINEERING

BY: Habtamu Wossene

Advisor: Oluma Gudina (Msc)

July, 2020

JIMMA, ETHIOPIA

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By

Habtamu Wossene

Advisor: Eng. Oluma Gudina (Msc)

DECLARATION

Habtamu Wossene, declare that this independent Project is my own original work that has not been presented and will not be presented by me to any other University for similar or any other degree award.

_____

Signature

Thisindependent Projecthas been submitted for examination with my approval as university supervisors.

Approved by

Chairman Ing Oluma Gudina_____ _____

Signature Date

Main advisor Ing. Oluma Gudina_____ _____

Signature Date

Co adviser _____ _____

Signature Date

Examiner 1 _____ _____ _____

Signature Date

Examiner 2 _____ _____ _____

Signature Date

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ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to the Ethiopian Roads Authority for giving us such an opportunity for postgraduate program. I am so grateful to get such an opportunity to study in the field which I am most interested in.

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I would like to appreciate my family, neighbors, and friends for their indirect involvement in this project by continuous support and motivation throughout the process. Thank you all.

At last, but above all, my praise goes to the generous God cause of all the acknowledgments.

ABSTRACT

Now a day, the road network in Ethiopia provides the dominant mode of freight and passenger transport and thus plays a vital role in the economy of the country. Accordingly, the Ethiopian government allocated sufficient budget to maintenance-heavy economical roads. One of the heavy maintenance road projects that carried out by ERA with this fiscal year is Butajira-Wereba-Hossana-Areka-Sodo (BWHAS) B51, road-heavy maintenance Projects. The objectives were addressed by detail review of literature about the subject matter and also by collecting relevant data which used for Butajira-Wereba-Hossana-Areka-Sodo (BWHAS) 195km which required an appropriate choice of maintenance methods to preserve this investment becomes increasingly important. Therefore, this project study attempts to assess, evaluate, and present the performance measure of road safety index for heavy road maintenance of BWHAS, especially in problematic routs. In order to measure the performance capacity of the existing roads, the study of the project applies the five basic road safety index characteristics.

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ABREVATION

1- BWHAS---- Butajiira, Werabie, Hosanna, Areka and Sodo.
2- ECDSWC----Ethiopian Construction Design and Supervision Works Corporation
3- ERA ---------Ethiopia Road Authority
4- RSI---------- Road Safety Index
5- TDSWS---Transport Design and Supervision Works Sector

CHAPTER ONE

1. INTRODUCTION

1.1General

The Ethiopian Roads Authority (ERA) is responsible for managing, maintaining upgrading, and rehabilitation of trunk, link, main access, and feeder roads and timely maintenance and developing the national road network across Ethiopia to support economic development, growth, and poverty reduction. The Government of Ethiopia allocates a significant part of the Budget towards the roads program, and external financiers also assist ERA with important credit and infrastructures.

Consequently, the Ethiopian Roads Authority invited the consultancy Services of Butajira-Wereba-Hossana-Areka-Sodo (BWHAS) B51, 195km road-heavy maintenance Projects for TDSWS, ECDSWC. To get better information on the overall existing conditions of the road Pavement types, various types of crossing structures, material quarry sites, and land-use conditions of the towns especially along the maintenance routes. Accordingly, the project study writer has visited the sites and prepared report of the site visit will be used as an input for this project area. The existing routs of road network comprises a huge national asset that requires adherence to appropriate maintenance to provide a high level of service. Besides, the length of the BWHAS road network is 195km which required an appropriate choice of maintenance methods to preserve this investment becomes increasing important.

Therefore, this project study attempts to assess, evaluate, and present the performance measure of road safety index for heavy road maintenance of BWHAS, especially in problematic routs. In order to measure the performance capacity of the existing roads the study of the project applies the five basic road safety index characteristics and a project site visit was conducted.

1.2 Case study area

The heavy maintenance project located along the main B51 roads of Butajira-Wereba-Hossana-Areka-Sodo. The starting coordinates is at the inlet of Butajira town (38.390461E, 8.145224N at elevation of 2088m and ending coordinate is in Sodo town (37.762761E, 6.8644164N) at elevation of 2260m.

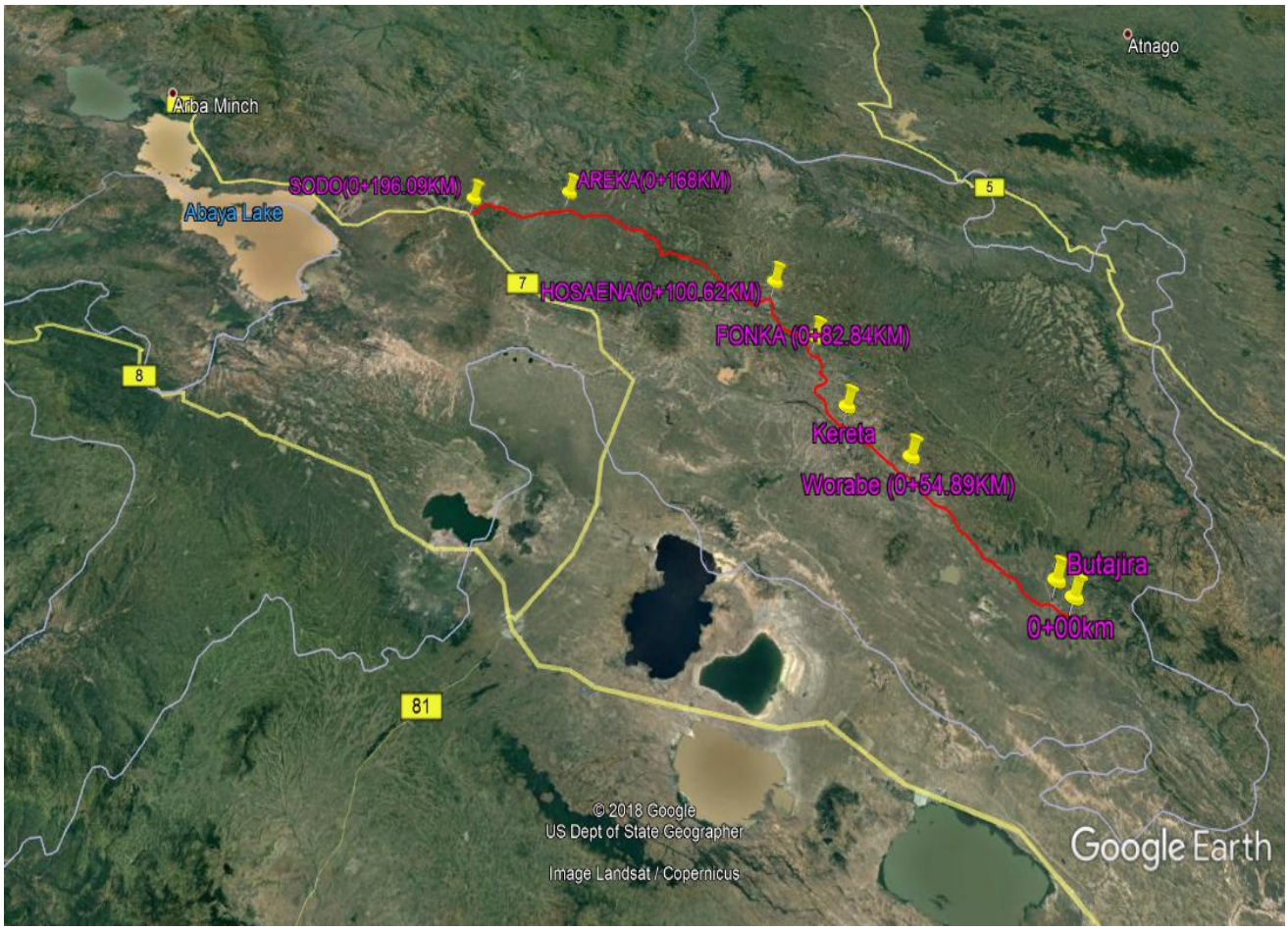


Figure: - 1 Project Inlet and Outlet B51 Routes Location Map (Nov29/2019, 4:15pm)

1.3 Statement of problem

Road pavements are built for an expected design life but deteriorate over time. This causes the road pavement to exhibit a number of fatigue symptoms. The deterioration process continues up to a point where maintenance intervention is applied to remove the defects. Then the cycle repeats itself until the road reaches the end of its service life known as terminal serviceability where it is reconstructed.

Many times, engineers encounter major pavement and structures failure and defects, which are happened due to long time serviceability and poor rectification or maintenance period.

1.4 Objective of the study

The main objective of this report was to assess, evaluate, and indicate the road safety index measurement characteristic in ERA heavy maintenances project which is located in the SNNPR of Ethiopian particularly in Butajira-Wereba-Hossana-Areka-Sodo routs.

The Specific objective of this study can be pointed out as follows: -

- To study the existing condition of BWHAS routes
- To conduct detailed site investigation whether the existing road project apply RSI parameters.
- To evaluate the heavymaintenance road project can consider RSI parameters during rehabilitation period
- To compare existing RSI parameter of BWHAS heavymaintenance project with the Five RSIstandard parameter and validation, recommended the output.
- To assess type of maintenance for the projected road.

1.5 Scope of the study

The main scoping of the project is to assess, evaluate, and address the standard RSI parameter in BWHAS project. Besides, this project has been intended to recommend how to reduce traffic accident in the existing BWHAS routesthroughapplication of standard RSI parameters in the project. Finally the project study addresses the general objectives and tries give a direction to authorized body to apply RSI parameters on heavy maintenance road project.

1.6 The significant of this Project

Evaluate and address the standard RSI parameter in road is one of mechanisms which will allow the road to be used for the intended purpose without any failure. The development of roads is the responsibility of governments, and the extent to which this responsibility can be met is a function of the ability to set aside funds from government revenue. The overall performance of the economy, therefore, whether measured in GNP, GDP or per capital income, compelled with competing demands from other development sectors establishes the limits of expenditure on road engineering, whether it is construction or maintenance. The benefactor of this research relies not only to governmental and non-government institutes rather to every living inhabitant relying on long time serviceability and poor rectification or maintenance period. Further it will promote as construction solution, sustainable development, better construction quality control at site and less environmentally sensitive.

1.7 Organization of the project

This project report consists of six chapters. The first chapter is introduction part and it discusses briefly the general background, description of case study area, and statement of problem, objective of study, significant of study, and the scope of project. The second chapter is literature review of various researchers. The third chapter encompasses project area and location.The fourth chapter discusses detail about problem and defect the project area. The fifth chapter is discussing onconclusion and recommendation of the project work.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents various aspects of the issue of road maintenance relevant. It defines the road deterioration problem and describes road maintenance interventions. It also reviews the impacts of road maintenance and the causes of poor road maintenance with emphasis on the road maintenance funding problem. It describes the different mechanisms used for road maintenance funding and the related challenges. It presents the fiscal strategies being pursued in some developing countries for sustainable and effective funding for road maintenance. It reviews the fiscal strategies for road maintenance funding by international practices with regards to the need for optimal road fund allocation and the related gaps in current knowledge.

2.2 THE ROAD DETERIORATION PROBLEM

Road pavements are built for an expected design life but deteriorate over time. This causes the road pavement to exhibit a number of fatigue symptoms. The deterioration process continues up to a point where maintenance intervention is applied to remove the defects. Then the cycle repeats itself until the road reaches the end of its service life known as terminal serviceability where it is reconstructed. Road maintenance intervention delays the rate of total failure until the pavement reaches the end of its design life. The process is referred to as the road deterioration cycle (Paterson, 1987) and it is illustrated in Figure 2.1.

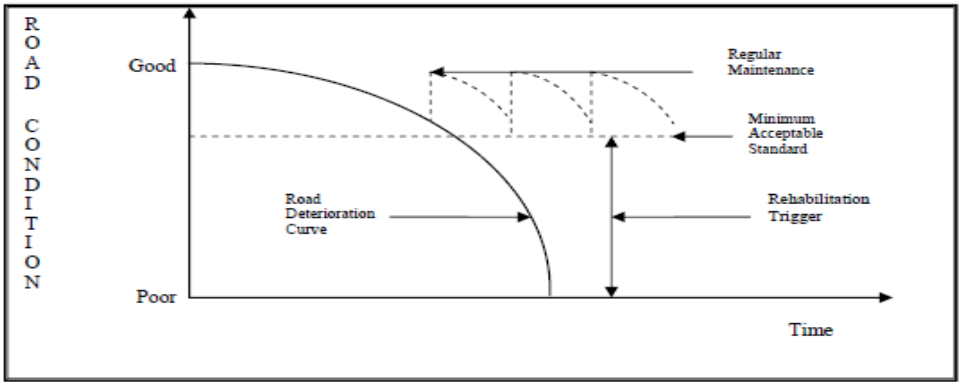


Figure 2. Pavement Deterioration Curve (Adapted from Highway Engineering Economy FHWA, 1983)

2.2.1 Causes of Road Deterioration

Road deterioration is caused by the effects of the physical environment, traffic, material properties, and quality of road construction, design standards and the age of the pavement. The details are discussed in the following paragraphs.

2.2.1.1 Environmental Factors

Climatic factors such as rain water, solar radiation, temperature, soil type and terrain may cause roads to deteriorate. Rain water can alter the moisture balance in the sub grade of a road with clayey and silt soils. This may cause swelling and shrinkage resulting in reflective cracking and heaving in the road surface. Sunlight may cause a continuous, slow hardening action on bituminous surfaces. This can increase the cracking process of the surface chip seal. Seasonal changes in temperature or night and day temperatures may cause expansion and contraction of the carriageway. This may progressively cause fatigue, failures and reflective cracks in the road surface, (TRL, Overseas Road Note 31, 1993).

2.2.1.2 Traffic Volume and Loading

Roads are structures basically built to carry and sustain vehicular loads. Therefore traffic is an important factor that influences pavement performance. The impact of traffic on the deterioration of pavements is caused by vehicle loads and volume. Every vehicle, which passes over a road, causes a momentary but significant deformation in the road structure. This is determined by the magnitude of each of its axle loads, the spacing between the axles, the number of wheels, the contact pressures of the tires and the travelling speed. The passage of many vehicles has a cumulative effect which causes repeated flexing of the pavement leading to fatigue, crazing and structural failure, (Paterson, 1987).

2.2.1.3 Material Properties and Composition

The choice of materials used for the construction of pavement layers may also cause road deterioration. This is due to inherent variability in the materials used for road construction in terms of soil properties such as strength or load bearing capacity, gradation mix properties, and elastic and resilience modulus. Poor choice of materials used for pavement layers can have a drastic effect on the strength of the layers and their subsequent performance, (TRL, Overseas Road Note 5, 1988).

2.2.1.4 Construction Quality

The quality of road construction if not built to the desired specifications can also facilitate road deterioration. For example, failure to obtain proper compaction, improper moisture

conditionsduring construction, poor quality of materials and inaccurate layer thickness (after compaction) all directly affect the performance of a pavement. (TRL, Overseas Road Note 5, 1988).

2.2.1.5 Road Maintenance Standards

The rate of pavement deterioration is directly affected by the maintenance standards applied to repair road defects. When a maintenance standard is defined it imposes a limit to the level of deterioration that a pavement is allowed to attain. Low maintenance standard therefore causes roads to deteriorate at a faster rate, (TRL, Overseas Road Note 5, 1988).

2.2.1.6 Age of Pavement

As pavements age and experience traffic repetitions, pavement distresses begin to accumulate. For example the hardening effect increases the stiffness of asphalt with age making the material more susceptible to thermal cracking, (Yonder, 1975).

2.2.2 Types of Road Defects

Pavement deterioration manifests itself in various kinds of distresses. Pavement distress is defined as any indication of poor or unfavorable pavement performance; or signs of impending failure or any unsatisfactory performance of a pavement short of failure, (Highway Agency, 1997). There are different classifications of pavement distresses with different manifestations but a more comprehensive classification is defined in Table 1.1, (Lecture Notes ST 2DMB, 2008).

Table 1.1 Classification of Pavement Distress (Peterson,W.D.O,1987)

Mode	Manifestation	Mechanism
Fracture	Cracking	Excessive loading, repeated loading, thermal changes, moisture changes, slippage
Disintegration	Stripping, ravelling, edge break, potholes	Adhesion loss, chemical reactivity, abrasion by traffic, degradation of aggregate, failure of binder, environment
Distortion	Permanent Deformation(Rutting)	Excessive loading, repeated loading, consolidation
Profile	Roughness	Structural déformation surface distresses, age, environnent
Friction	Texture depth skid-resistance	Abrasion by traffic, aggregates embedded

An overview of the different manifestations characterizing each pavement distress mode is also presented in Table 1.1.

2.3 ROAD MAINTENANCE

Road maintenance may be described as an intervention that reduces the rate of pavement deterioration. The purpose of road maintenance is to enable the continued use of the pavement by traffic in an efficient and safe manner. The characteristics of road maintenance activities are presented in the following paragraphs.

2.3.1 Road Maintenance Activities

Road maintenance activities are categorized according to the frequency of operation, (TRL, Overseas Road Note 1, 1981). It involves minor activities undertaken on routine basis and major activities undertaken on periodic basis to eliminate pavement defects, (Paterson, 1987). It could also be in response to an urgent situation. The road maintenance activities determine the threshold of funding needed for road maintenance. Each activity corresponds to a specific budget head and this determines the threshold of funding required for maintenance.

2.3.1.1 Routine Maintenance

It is a timely intervention to prevent minor faults from further deterioration which might require costly repair. The operations are carried out on a regular or cyclic basis. The frequency may vary in a particular year or season. They are small scale but widely dispersed and require skilled or unskilled manpower. Routine maintenance is funded under recurrent budget heads and its application is aimed at achieving savings in delivery costs. It is considered to be the most effective use of funds to assist the pavement to remain in sustainable condition for further time before periodic maintenance is applied. A summary of the routine activities is presented in Table 2.1.

Table 2.2 Summary of the routine activities (Robinson et al 1988)

Type of Maintenance Activity	Description
Surface Maintenance	-Pothole Patching -Repair of depressions, Ruts, Shoving and Corrugations -Edge failure repairs -Crack Sealing -Break-up Spot Grading of High Gravel Shoulder
Surface Maintenance on Gravel Roads	-Reshaping of Gravel Roads -Grading of Gravel Roads -Sectional Patching
Drainage Maintenance	-Ditch cleaning -Re-excavation of Drainage Ditches -Cleaning and Minor Repairs of Culverts -Crack repairing on drainage structures -Erosion and Scour Repairs
Road Side Maintenance	-Grass cutting
Road Side Furniture Maintenance	-Cleaning, repairing and replacement of traffic signs guide posts and guard rails, road line marking

2.3.1.2. Periodic Maintenance

These are operations that are occasionally required on a section of road after a number of years to protect the structural integrity. It includes development works to expand the capacity of the network, the provision of stronger pavement and the improvement of the geometric characteristics of the road. The timely application of periodic maintenance delays ultimate full reconstruction at higher costs. Periodic maintenance activities are funded under capital budget heads. They include large scale pavement maintenance such as sealing of cracked surfaces, resurfacing, overlay, pavement reconstruction, or strengthening, maintenance of drains and road shoulders. Examples of periodic maintenance activities are summarized in Table 3.3

Table 3.3 Periodic maintenance activities (Robinson et al 1988)

Type of Periodic Maintenance Activities	Description
Regravelling	Placing of adequate subbase gravel on an existing gravel road to strengthen the pavement. (This is usually performed at 3-5 years interval depending on the traffic and climatic condition
Resealing	Placing of a fresh seal coat on an existing bituminous surfaced to seal cracks and improve resistance. (This is usually performed at 5-7 years interval depending on the traffic and climatic condition
Overlay	Placing of asphaltic concrete on an existing bituminous surfaced or asphaltic concrete road to strengthen the pavement. (This is usually performed at 10-12 years interval depending on the traffic and climatic condition.
Partial Reconstruction (Resurfacing)	Scarifying of existing bituminous surfaced road, strengthening the base year with addition of adequate thickness of base material and applying surface treatment.
Minor Rehabilitation	Improvement of an unpaved or paved road including widening, earthworks and construction of drainage structures.

2.3.1.3. Emergency Works

These include works of any nature which arises out of emergency and requires immediate attention. It normally has a lumped sum budget which may be drawn from a special account set for the purpose. It includes activities such as clearing debris and repairing washouts.

2.3.2 Road Maintenance Intervention Criteria

The selection of road maintenance interventions are based on two fundamental rules which determines the timing and limits on the works to be carried out. The rules ensure that a consistent approach is undertaken to planning and specifying works. It also ensures that funds are spent to the greatest effect, Robinson *et al* 1988). The two rules are defined as either scheduled or responsive.

1. Scheduled: Works are fixed at intervals of time or points in time for maintenance and at a fixed time for improvement or construction works.

2. Responsive: Road works are triggered when road condition reaches a critical threshold known as ‘intervention level’. It is considered to be very useful for judicious disbursement of maintenance funds.

2.3.3 The Road Maintenance Process

The approach involves defining activities, planning, allocating resources, overseeing implementation, monitoring, and evaluation of works, (Adair, 1983). It normally contains the following components:

1. Inventory: This is used as the basic reference for planning and carrying out maintenance and inspections. Inspection of road condition is the process of taking physical measurements of defects on the road network in the field.
2. Maintenance needs: These are determined by comparing the measurements of road condition with predetermined maintenance intervention levels that are based upon economic criteria.
3. Costing: Unit costs are applied to the identified maintenance tasks to determine the budget required.
4. Priority setting: If the budget is insufficient for all of the identified work to be carried out, it is then necessary to determine priorities to decide which work should be undertaken and which should be deferred.
5. Execution of works: The work identified is carried out through with the assistance of several systems of scheduling and cost-accounting.
6. Monitoring: Monitoring serves two purposes. That is it ensures that work identified has, in fact, been carried out and it also provides data to enable unit cost and intervention levels to be checked and adjusted if necessary.

2.4 IMPACTS OF ROAD MAINTENANCE

The benefits of road maintenance include the protection of initial capital investment in road construction, reduction in transport costs, traffic safety, environmental sustainability and the facilitation of social and economic development.

2.4.1 Protection of Investments

Road maintenance prevents the loss of investment made in an initial road construction. Routine and periodic maintenance cost for the entire life of a road is estimated to be between 2 and 3 percent of the initial capital investment, (Zietlow and Bull, 1999). However, neglected maintenance could cause this amount to increase. According to Harral and Faiz, (1988) timely maintenance expenditures of US $12 billion in Africa would save road reconstruction costs of $ 45 billion over a decade. A PIARC Publication (1995) estimates the threshold of capital investment which is lost on annual basis from neglected maintenance to be about 1 to 3 percent of GDP of individual countries in Sub Saharan Africa. About 75 percent of this is in the form of scarce foreign exchange. In Latin America and the Caribbean equivalent figures were estimated at $1.7 billion per year in 1992, amounting to 1.4 percent of the individual country’s GDP.

2.4.2 Reduction in Transport Costs

Empirical evidence suggests that well maintained roads reflect in savings in vehicle operating cost (VOC). This is from reduced fuel and oil consumption, vehicle maintenance, tyre wear and vehicle depreciation, (World Bank, 1998). An illustration of the relative discounted life cycle costs of maintenance spending scenarios is provided in Figure 2.3. For, a traffic level of about 1000 vehicles/day a road in good condition will require 2 percent of discounted total costs to be spent on maintenance. However if maintenance funds are reduced, VOC's are likely to increase by about 15 percent. If there is complete neglect of maintenance, a paved road will eventually start to disintegrate and annual VOC will increase by 50 percent and if continued will result in the need for new road development. Heggie (1995) estimates that each dollar spent on patching on an annualized basis, saves at least US $3. Robinson, et al, (1988) suggests a 10 fold or more returns on each dollar spent on patching.

2.4.3 Safety

A significant number of road accidents and fatalities can be directly attributed to the state of the road network. For example, inadequate skid resistance on neglected roads can contribute to traffic accidents. Potholes pose a threat to all road users, particularly to cyclists and motorcyclists. The correction of such defects through road maintenance interventions can reduce the number of road accidents. However, improved riding quality from road maintenance interventions can also have negative impacts from increased speeds which can result in accident fatalities.

2.4.4 Environmental Sustainability

Road maintenance has a positive impact on the environment. For example, well planned maintenance schemes can have good environmental vehicle performance which can reduce vehicular pollution. However road maintenance can also cause negative impacts through environmental damage such as water contamination from oil spillage, poor air quality from dust pollution and noise and vibration during construction.

2.4.5 Facilitation of Social and Economic Development

The road network is the only transport infrastructure that reaches virtually any location. Logically a road is the main provider of individual and goods mobility. Improvement in the quality of road service therefore increase personal mobility and facilitate economic growth which contributes towards poverty reduction in developing countries.

CHAPTER THREE

MATERIALS AND METHDOLOGY

3.1 PROJECT AREA AND LOCATION

Butajira-Wereba-Hossana-Areka-Sodo are the major transfer and marketing point for Various Crop grown farther the towns lies in the southern nations nationalities, and people region (SNNPR) escarpment of the Ethiopian fertile green mountains and is also known for the excellent Crop grown in its vicinity and the project area located on the main road from Addis Ababa to Butajira-Wereba-Hossana-Areka-Sodo, 329km from the Addis Ababa.

The heavy maintenance project located along the main B51 roads of Butajira-Wereba-Hossana-Areka-Sodo. The starting coordinates is (38.390461E, 8.145224N at elevation of 2088m.and ending coordinate is (37.762761E, 6.8644164N) at elevation of 2260m.

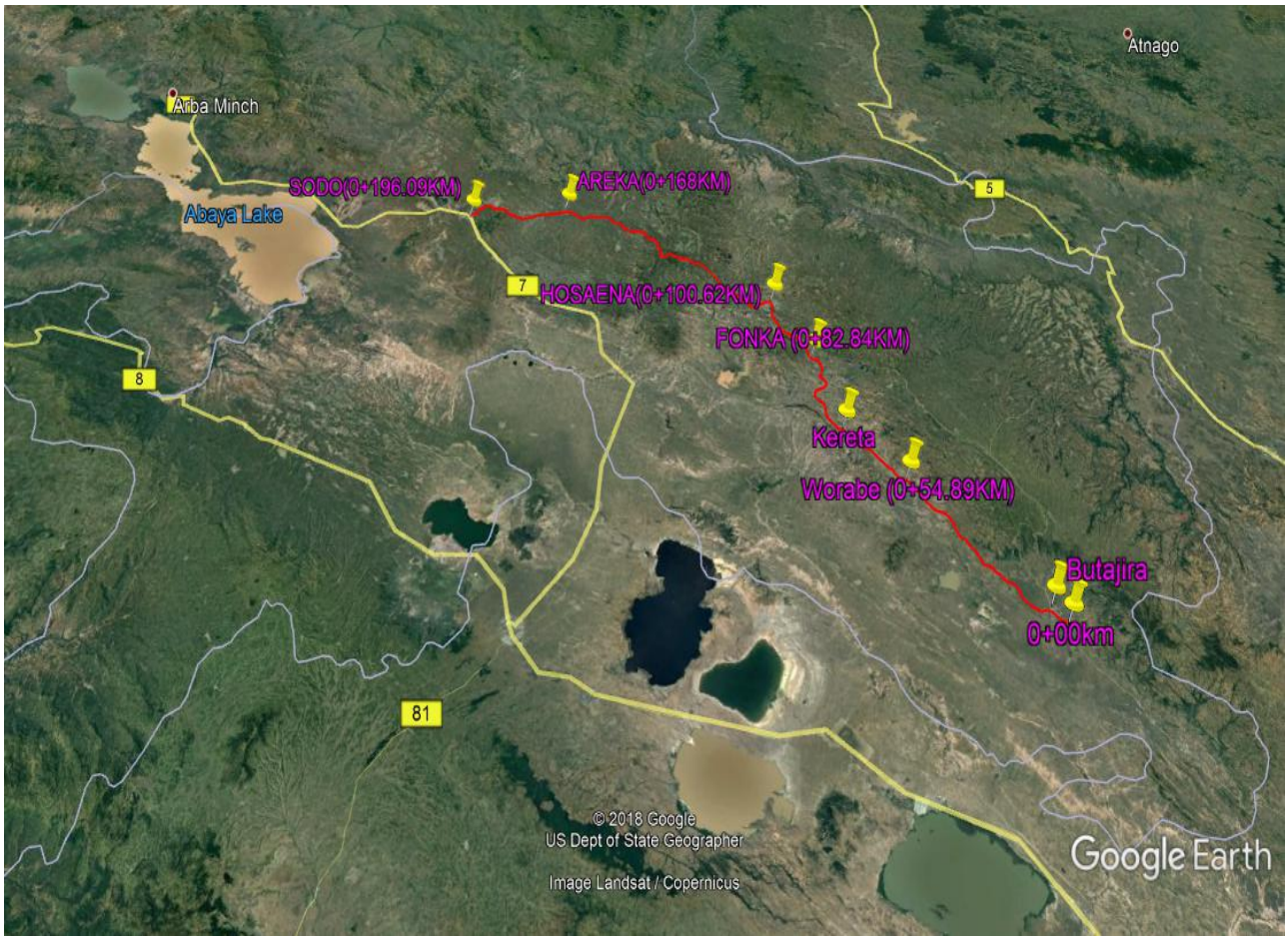


Figure: - 3.Project Inlet and Outlet B51 Routes Location Map (Nov.29/2019, 4:15)

3.2 Data Collection and material used

Primary data Method 1: Direct Observation

Type of Data:

- Roads with and without drainage lines / ditches /channels;
- Pavement distress and damage in different type
- Blocked cross drainage and scored inlet and outlet part
- Slope, flow direction, outlet type and protection;
- Traffic signs
- Road edge damage (shoulder)
- Water logging areas, etc.

- **Tools:** Direct observation, taking Photographs,
- **Source:** Existing reality on the ground.

3.3. Approach and Methodology

The project was conducted based on primary data the primary data were collected through field assessment using different approaches. And review of reports and graphic documents produced by the Ethiopian road Authority.

I have already been undertaken the project which includes field visit, data collection and preliminary project assessment on the existing road project from buta jira to soddo. During the field visit made to the town observations.

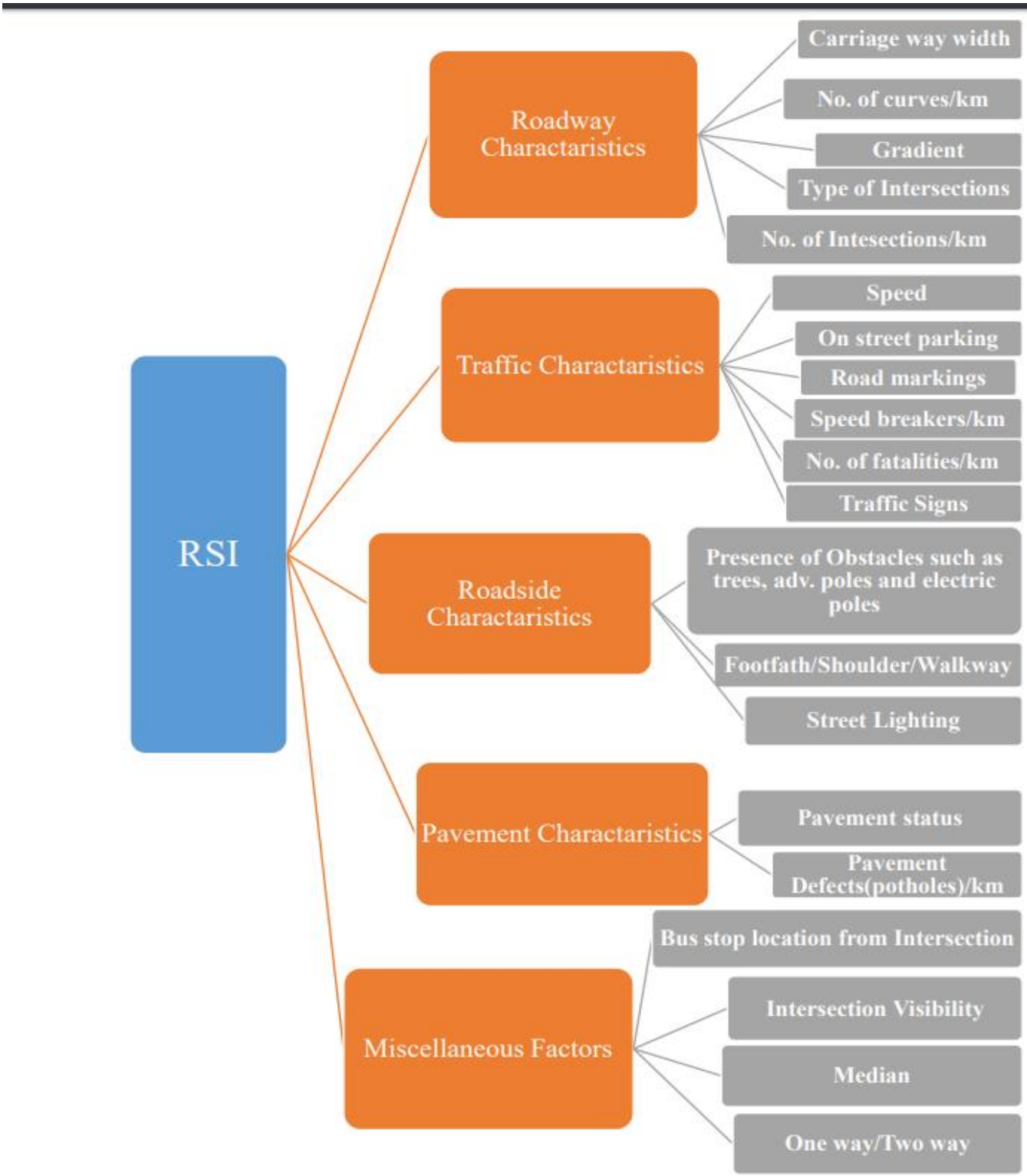


Figure 1.1:- Road Saftey Index chart

CHAPTER FOUR

RESULT AND DISCUTION

4.1- The Existing pavement (road) conditionOverall Defect observed

- Edge cracking and slide is observed.This happened due to lose compaction on the side fill and excess moisture above the required optimum moisture.
- The side support or one side gutter wall is failed by heavy truck trail as a result the edge of placed pavement is failed.
- Aging is due to long time serviceability,
- Crack propagates from bottom to top, and this may be due to the underneath pavement layer failure.
- Detrition and distress of pavement
- The potholes are found in very wider stretches and it can be treated by cutting reasonable area in the defect place and patch with same quality HMA

4.2- Road safety index survey for existing Road

Road way characteristics:

Most of the carriage width between 7-18m which is faced different pavement problems (like angulation, deteriorate surface,etc.) Geometrical nature have curves and gradient same of them very long stretch slope (6-8%).Regarding road intersection and its quantity depends on town distance

Traffic characteristics:

In general when we are surveying the traffic characteristics parameters, nevertheless which is compulsory but not properly implemented as per it necessary on the project route.

Road side characteristics:

During site observation the road side obstacles like trees and shrubs not widely affect the road condition during driving vehicles also there is free area for further activity, similarly

Table 4.1 Existing Road Structure

No.	Structure Name	Number
1	Pipe Culvert	69
2	Slab Culvert	59
3	Box Culvert	13
4	Girder Bridge	9
5	Retaining	1
	Total	241

Source from project report data were taken, Nov 2019

4.3-Road safety index survey for maintained road

Items were considered during New Maintained Road according to the Road Safety Index

General items

1- Horizontal & vertical alignment
2- Sight and stopping distance
3- Traffic lane safety and visibility
4- Street lighting, roadways signs

Traffic signs and pavement markings

1- Signs, location/ placement
2- Day/Night, winter / Summer requirement
3- Delineation and reflection markers
4- Pavement marking

Road pavement

1- Pavement defects
2- Skid resistance, painting

3- Loose screenings

4- Contrast (curb and pavement)

Traffic speed management

1- Speed restriction

2- Speed management

3- Sign requirement

4.4- Maintenance strategies (type) for the projected road

The purpose of road maintenance is to enable the continued use of the pavement by traffic in an efficient and safe manner. The types of road maintenance activities are Routine and Periodic Maintenance.

4.4.1. Routine Maintenance

It is a timely intervention to minor faults from further deterioration which might require costly repair.

The operations are carried out on a regular or cyclic basis. The frequency may vary in particular year or season.

Type of activates which is included in routine maintenance

A) Surface Maintenance
   - Pothole patching
   - Repair of depressions, Ruts, Shoving and corrugations
   - Edge failure repairs
   - Crack sealing
   - Break-up Spot
   - Grading of High Gravel Shoulder
   - Reshaping of Gravel Roads
   - Grading of Gravel Roads
   - Sectional Patching

B) Drainage Maintenance

   - Ditch cleaning
   - Re-excavation of Drainage Ditches
   - Cleaning and Minor Repairs of Culverts
   - Crack repairing on drainage structures
   - Erosion and Scour Repairs

C) Road side and Road side Furniture Maintenance

   - Grass cutting
   - Cleaning, repairing and replacement of traffic signs guide posts and guard rails, road line marking.

4.4.2. Periodic Maintenance

These are Operations that are occasionally required on a section of road after a number of years to protect the structural integrity.

Type of activates which is included in Periodic maintenance

A) Regravelling Maintenance
   - Placing of adequate sub base gravel on an existing gravel road to strengthen the pavement.

B) Resealing Maintenance
   - Pacing of a fresh seal coat on an existing bituminous surfaced to seal cracks and improve resistance.

C) Overlay Maintenance
   - Pacing of asphaltic concrete on an existing bituminous surfaced or asphaltic concrete road to strengthen the pavement.

D) Partial Reconstruction(Resurfacing)
   - Scarifying of existing bituminous surfaced road, strengthening the base year with addition of adequate thickness of base material and applying surface treatment.

E) Minor Rehabilitation
   - Improvement of an unpaved or paved road including widening, earthworks and construction of drainage structures.

ANNEX: - STUDY SITE PHOTOGRAPH

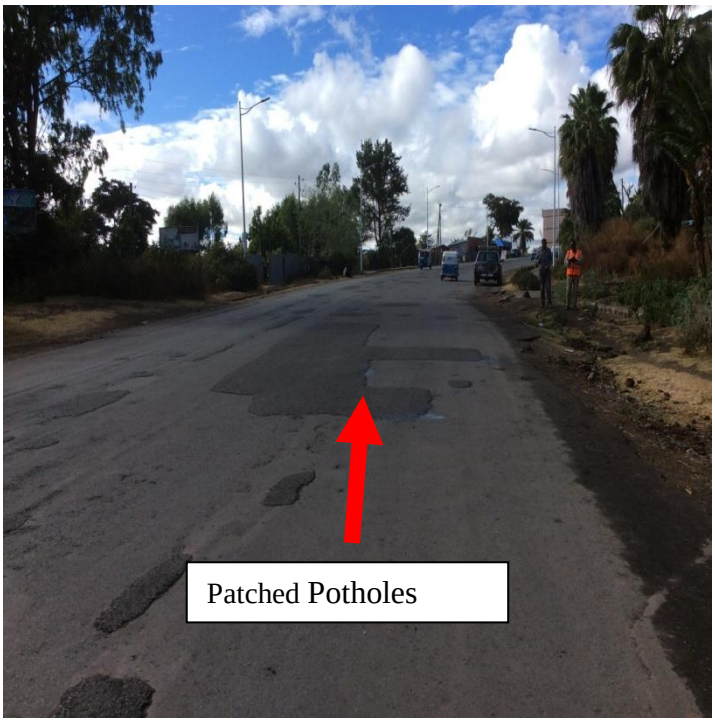
Figure 4:-Butajira Town Pavement

RHS and LHS Carriageway and Shoulder Failure

Butajira@ 0+133km Coordinated (38.390461E,8.145224N)

Butajira Town @ Coordinated (38.377711E,8.120616N)

@ Butajira to Zeway road Junction view



Butajira Town @ **(38.377711E,8.120616N)** pot holes pavement

@ Butajira Carriageway shoulder and RHS Masonry Ditch Failure

@ Butajira Town Pavement Carriageway Failure **@ Coordinated (38.379035E,8.100408N)**

@ Butajira Town End Pavement CarriagewayFailure

Figure 5 :-Kibet Town Pavement

KIBET Town @ Coordinated(38.328786E,8.026767N)

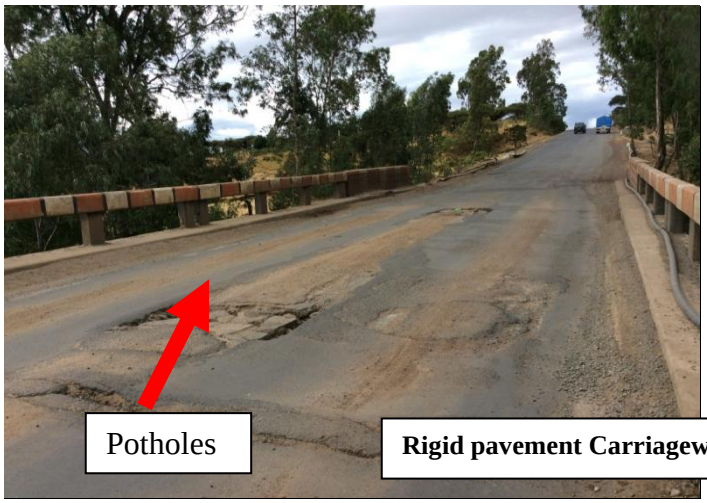
Existing Carriageway View

KIBET Town end @ Coordinated (38.320512E,8.013693N)

@ KIBET Town Carriageway and steel Guide view

Figure 6:-Wereba Silti Town Pavement

WEREBA Inlet @ Coordinated (38.19253E,7.861801N)



Wereba Town Girder Bridge Carriageway Failure**@ Coordinated (38.197364E,7.868368N)**

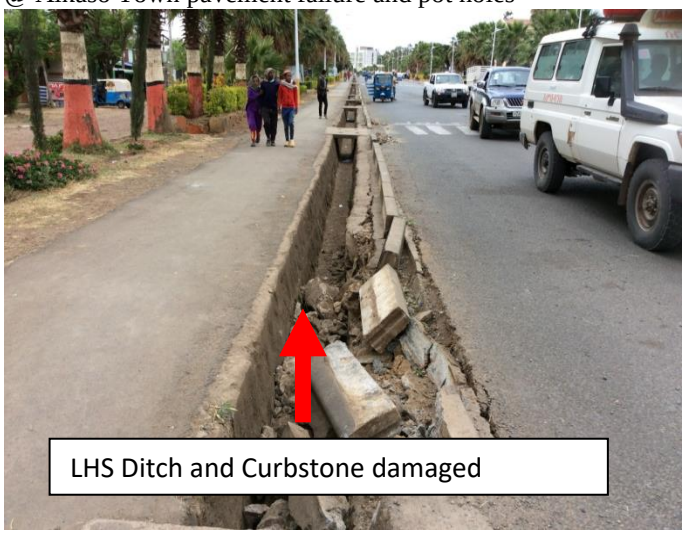
WEREBA town inlet @ Coordinated (38.186682E,7.852355N)

Wereba Town Inlet Carriageway and steel Guide view**@ Coordinated (38.19253E,7.861801)**

@ Silita Zone Meneharya City bridge pavement layer failure

@ Alkaso Town pavement failure and pot holes

Wereba Town Pavement Carriageway and Ditch View**@ Coordinated (38.186682E,7.852355N)**

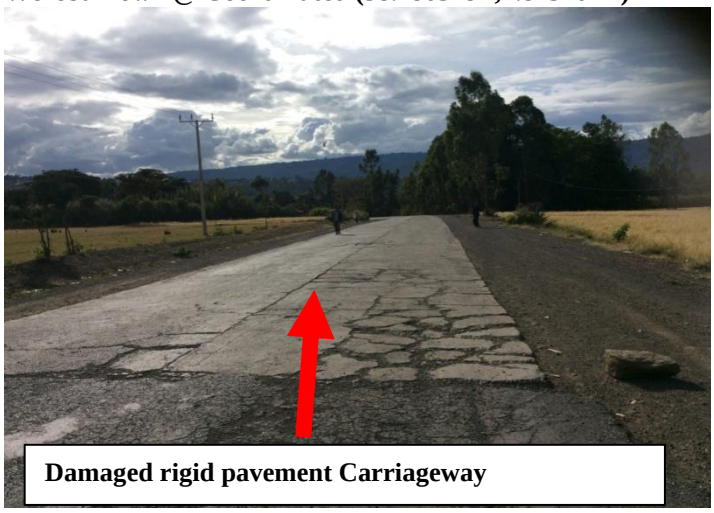


Wereba Town Concrete Ditch failure view

@ Coordinated (38.186577E,7.847471N)

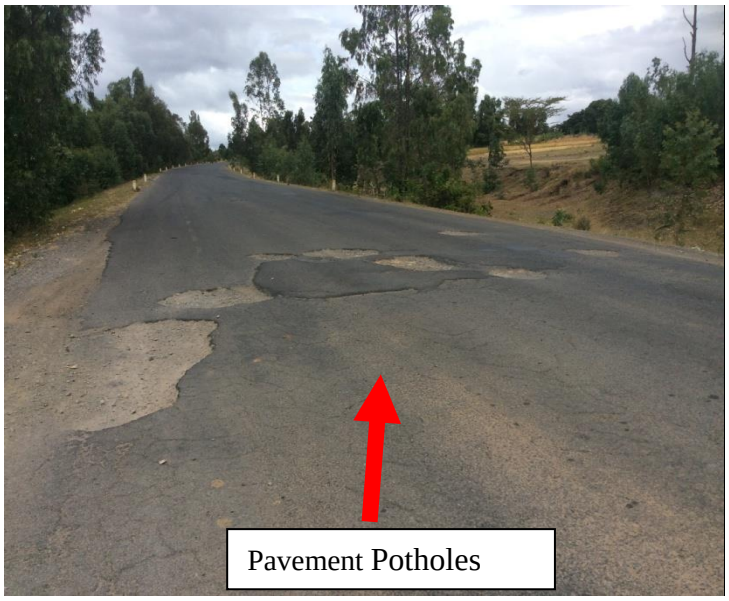
Wereba Town @ Coordinated (38.186518E,7.843464N)

Wereba Town shoulder and RHS Masonry Ditch Failure



@ Wereba Silita Zone to Achamo Town Rigid Pavement Carriageway Failure @ Coordinated (38.041011E, 7.665441N) and (38.036793E, 7.665827N)

Figure7:-Wuibareg Silti Town Pavement



@ Wuibareg Silita Zone potehole Pavement Carriageway Failure**@ Coordinated (38.115049E,7.733348N)**

@ Wuibareg Silita Zone to Alaba Town Junction view**@ Coordinated (38.12136E,7.738717N, E1983m)**

Figure 8:-Fonko Silti Town Pavement

Fonka Town Pavement Carriageway Failure **@ Coordinated (37.968852E, 7.7658579N)**

Fonka Town Pavement Carriageway Failure **@ Coordinated (37.968566E, 7.655235N)**

Fonka Town Pavement Carriageway Failure@ 0+222km **Coordinated (37.961151E, 7.643239N)**

@ Fonka Town Pavement **Coordinated (37.965403E, 7.64698N)**

Figure 9:-Hossana Town Pavement

@ Hossana Town @ 0+222km **Coordinated (37.864488E, 7.557123N, 2069m)**

@ Hossana Town @ 0+222km **Coordinated (37.85814E, 7.554033N, 2303m)**

@ Hossana Town inlet near to wachemo university @ 0+221km
Coordinated (37.873665E, 7.557976N, 2245m)

@ Hossanato Mare roadCorrugated Pavement@ 0+248km
Coordinated (37.821246E, 7.433378N, 2210m)

Figure 10: -Doyogena Town Pavement

Mare Zone to Doyogena Town Potholes on Pavement @
Coordinated (37.791227E, 7.37548N, 2399m)

Doyogena Town Pavement Carriageway View @ 0+258km
Coordinated (37.783944E, 7.352168N, 2555m)

@ Doyogena Town to Hobichebe @ 0+264km **Coordinated (37.789206E, 7.30993N, 2735m)**

@ Doyogena Town to Hobichebe Pavement Carriageway totally Failure**Coordinated (37.1895E, 7.317981N)**

Figure 11:-Areka Town Pavement

Areka Town Pavement Carriageway view @ 0+288km Coordinated (37.704352E, 7.083682N, 1720m)

@ Areka Town Pavement Carriageway view Coordinated (37.710462E, 7.5060903N, 1748m)

Areka to Sodo Town Carriageway & Steel Guide view @ 0+314km Coordinated (37.738730E, 6.94708, 1944m)

@ Arekato Sodo Town Carriageway shoulder **Coordinated (37.730746E, 6.91908 N, 1949m)**

Figure 12:-Sodo Town Pavement

Sodo town steel pipe culvert @ 0+323km Coordinated (37.470936E, 6.879384 N, 1939m)

@ Sodo Town Pavement view**@ 0+323km Coordinated (37.760632E, 6.867594 N)**

@ Sodo to chida Town Pavement Carriageway view**@ 0+323km Coordinated (37.725732E, 6.894923N, 1924m)**

Pumped and Swell Pavement

@ Sodo Town **@ 0+323km Coordinated (37.760632E, 6.867594N, 2036m)**

CHAPTER FIVE

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

On the existing road condition minor and major defects were observed on road pavement distress, drainage wing wall, side ditches damage and blockage, absence of traffic characteristics problems (like signal, paints, delineation and reflection markers) the above mentioned problem observed.

In some situations the effectiveness of drainage is not very important to pavement deterioration, such as in low traffic areas. In these circumstances the frequency of drainage maintenance can be reduced and the pavement damage risk is low. Where the traffic volume is high it is expected that poor drainage will lead to rapid pavement deterioration.

The problem related to excess water content in pavement layers is that there can be a decrease in strength, degradation of material and loss of bond between layers. Potholing is the typical mode of pavement failure, which can deteriorate a pavement quickly.

Pavement deformation within the wheel tracks (rut) can be primarily caused by factors other than moisture, such as wheel loads, but the rutting accelerates when the pavement is wet. The other mode of failure is fatigue cracking, which allows water ingress and loss of strength. (Appendix C: - @ Silita Zone Meneharya City bridge pavement layer failure)

5.2 Recommendations

It is recommended that road fund allocation for road maintenance should include stakeholder preferences to ensure accountability to the stakeholders.

It is therefore recommended that project should conduct and take these factors into consideration. In additionthe following recommendations areforwarded

- concerned body give attention in order to maintain the damaged shoulder which cause allowingfree flow of water to pavement internal layers base course and sub base
- the strategy of identifying and recording ‘hot spots’ be implemented
- rating of pavement condition be introduced on higher-risk sections
- The comparison of rut rates on both sides of a pavement be introduced as a standard process to indicate possible pavement failure.
- Safety risks for different users groups are identified (cars, pedestrians, bicycles)
- Expensive reconstruction can be avoided if road safety audit is done already at design stage.
- Reduce socio- economic cost caused by accidents.
- Improve design quality through structured discussions between planners.

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