

ADDIS ABABA UNIVERSITY
ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF
CIVIL AND ENVIRONMENTAL ENGINEERING



IMAGE BASED PAVEMENT CONDITION ASSESSMENT

A Thesis in Road and Transport Engineering

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Master of Science



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The undersigned have examined the thesis entitled ‘**IMAGE BASED PAVEMENT CONDITION ASSESSMENT**’ presented by **Jibril Akmel Mohammed**, a candidate for the degree of **Master of Science** and hereby certify that it is worthy of acceptance.

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ABBREVIATIONS AND ACRONYMS

AACRA	Addis Ababa City Roads Authority
ERA	Ethiopian Roads Authority
ERCC	Ethiopian Road Construction Corporation
PMMS	Pavement Maintenance Management System
MRR	Maintenance Rehabilitation and Reconstruction
PSI	Present Serviceability Index
PSR	Present Serviceability Rating
AASHTO	American Association of State Highway and Transportation Officials
PCI	Pavement Condition Index
PCR	Pavement Condition Rating
PI	Priority Index
PMS	Pavement management system
NOMAD	National optimization of maintenance allocation by decade
QCP	Quality Control Plan
QMP	Quality Management Plan
PASER	Pavement Surface Evaluation and Rating
TM	Technical Manual
ASTM	American Society for Testing Materials
HMA	Hot Mixed Asphalt
DV	Deducted Value
TDV	Total Deducted Value
CDV	Corrected Deducted Value
DI	Distress Index
OPI	Over All Pavement Index
MNDOT	Minnesota Department of Transportation
SR	Surface Rating
DOT	Department of Transportation
PCA	Pavement Condition Assessment
QC	Quality Control

QA	Quality Assurance
LTTP	Long Term Pavement Performance
QRS	Condition Rating Survey
FHWA	Federal Highway Administration
NIH	National Institute of Health
AC	Asphalt Concrete
PCC	Portland cement Concrete
MDR	Modified Distress Rating
PSC	Pavement Structure Condition
ARAN	Automatic Road Analyzer
ADC	Automated Data Collection

ABSTRACT

For the purpose of developing and implementing pavement management plans, it is the duty of all road authorities to gather pavement distress data from their network of roads. The Addis Ababa Road Authority invests a considerable sum of money in paving upkeep each year. The major goal of this thesis is to suggest a creative, sound method for evaluating the quality of asphalt pavement in order to maintain it effectively using a semi-automated system.

This study makes use of video data that was gathered from a camera mounted on a moving car. Pavement photos were collected from Addis Ababa's pavement road segments that were chosen at random. Images of pavement defects such as cracks, potholes, pitching, raveling, and rutting were imported straight into an image-j program for analysis. The analysis's findings are also utilized to calculate the pavement condition index (PCI). The pavement condition has been assessed in this study in terms of the surface distress present at the time of the field evaluation. Because it covers the topic of pavement distress identification the most thoroughly and is based on a reliable statistical technique of pavement samples, the PCI procedure has been employed in this case.

Based on the PCI of the road sections, the ASTM D 6433 condition rating process was applied to the evaluation. The research's findings show that the maximum PCI value for 10 sections of asphalt-damaged pavement is 98.5, indicating that the PCI curve is in its typical position for recently constructed pavement. The minimum value of PCI is 20, which indicates a very serious severity level. It needs reconstruction. Each pavement section's PCI values may have been used to determine the priority of its upkeep. Due to Ethiopia's restricted maintenance fund availability, prompt and logical determination of maintenance and rehabilitation are required. The study also states that it is crucial to prioritize repairing deteriorated pavement components.

Key words: Condition assessment, maintenance, pavement priority, pavement condition index, rehabilitation.

CHAPTER ONE

1.0 INTRODUCTION

1.1 General Background and the concept of the study area

The administrative and financial capital of Ethiopia, Addis Ababa, serves as the headquarters of several international organizations. It is currently seeing continuous economic expansion. The city is transitioning from being primarily a financial and industrial hub to being a center for administration and services. To ensure that inhabitants have access to adequate infrastructure, AACRA allots a sizable portion of its budget for the maintenance and extension of the current road network.

The evaluation of road surface distress is one of the critical responsibilities for creating repair and maintenance strategies in a road maintenance management system. It is essential to be aware of pavement conditions in order to schedule short, medium, and long-term maintenance tasks for an organized management system (Pavement Management System, PMS), which allows for the optimization of available resources and ensures that functional standards and pre-established protection [6]. In the Addis Ababa AACRA Bulletin, assessing certain types of road surface distress, including potholes, cracks, and patches, is crucial [2]. According to documented field methods, road distress data assessment is carried out by gathering raw data on the condition of the roads and processing it. This makes use of several data evaluation methodologies for road discomfort. According to the methodologies or procedures used by manual, sensor, and imaging-based systems, the assessment systems currently in use in the field can be divided into three categories [7]. Currently, the collection of distress data is being mechanized more and more through the use of various imaging techniques.

Nearly all of the nations that spend resources now acknowledge the importance of road network management, backed by the adoption of a PMS. Research funding for maintaining the condition of standing pavements is more abundant than funding for the construction of new roadways [10]. On the other hand, many local authorities are deploying decision support systems for improved management of the road network alarmingly slowly. Additionally, because of the controlled network's size and the cost of conducting regular condition surveys, there is frequently a paucity of information surrounding it [9]. Therefore, it is essential to

provide a data collection technique that enables the acquisition of a suitable understanding of the network in the smallest amount of time and at minimal administrative expense [11].

The three technologies that are now accepted are digital line scan imaging, 35mm analog continuous film, and digital cameras [12]. Infrared thermography for surface distress surveying has recently been developed, adding another technique to this list [13]. Images were captured for the purpose of the current study using a digital camera that was placed on the back of a car. It permits the use of GPS and a digital image data capture device to conduct high-speed surveys of georeferenced digital photographs of the pavement.

For a very long time, field data for surface distress assessments has been collected manually, which is both labor-intensive and rather dangerous. Rapid road inspection techniques have been developed as a result of new technical advancements, combining equipment and cutting-edge software to automatically detect digital photos, identify trouble, and gauge it. In the collected works, there are several instances that demonstrate how digital image processing technologies may give pavement engineers a cost-efficient and objective way to gauge the severity of surface distress. The approaches are frequently similar but modified to meet the unique requirements of management agencies and research. For surveys and analysis methods, standardized approaches are helpful for this reason [8].

Today, the ideal conditions for gathering reliable, consistent data have not been systematically specified, nor have standards governing the quality of imaging devices and tactics. The current work provides a low-cost picture collection and processing system that has been shown to be sufficiently accurate in identifying cracks, patches, and potholes, deviating from manual measurements just slightly. It is feasible to demonstrate that the technique can be practically incorporated into a pavement management system for a local road network due to the ability to conduct surveys under normal traffic conditions while not traveling at extremely high speeds (25-30 km/h). By plotting each profile of the distress, the process enables the pavement's cracks, potholes, and patches to be identified.

Additionally, it specifies the surface area of the pavement cracks, spots, and potholes. In order to subordinate a level of concern to these places, the operator can intervene at this point. For the purpose of describing pavement distress indices, this information identifies a measureable evaluation and distress organization. In order to classify and rate pavement problems, the research's next step will be to develop a Pavement Distress Index (PDI). This will enable the user to create multiple classifications using a mix of distress type, location, severity, and density.

1.2 Statement of the problem

Even though it was stated in 2004, the current amount will be significantly higher. The Addis Ababa Road Authority spends about 300 million Ethiopian Birr annually on road building and upkeep. In addition, more than 30 million birr was spent on normal maintenance, which is excessively large and needs special attention. AACRA Newsletter (2000-2004). Unfortunately, our city's paved roadways have a severe problem with pavement deterioration. Due to a faulty pavement condition assessment and maintenance plan, the road quickly deteriorated and the impact of both the environment and car use ultimately caused it to fail.

The main issues with pavement include cracking, surface deformation, disintegration (potholes, etc.), and surface flaws (raveling, etc.). These deteriorations harm the city's road assets unless a sound scientific pavement condition assessment and maintenance strategy have been implemented. It is suggested that distinct pavement portions undergo different pavement condition evaluation activities, which include the following procedures, to help reduce such poor practice.

- Video pavement picture collecting was done with a camera mounted to a vehicle.
- The imagej program performed distress analysis for the app imports photos of cracks, potholes, raveling, rutting, and patching, and automatically creates distress profiles. The length, depth, and area will then be calculated. Finally, the pavement condition index for each pavement segment will be determined, and the associated engineering advice will be suggested.

A city can gradually become more functional for movement, more comfortable for drivers, and accident-free if a pavement condition evaluation approach is used efficiently.

1.3 Objective of the Study

1.3.1 General objective

The major objective of this study is to suggest a creative, sensible method for evaluating the condition of an asphalt pavement in order to maintain it effectively using a semi-automated system.

1.3.2 Specific objective

The following specific objectives are established for the study in accordance with the broad goal mentioned above.

1. To make data collection on pavement distress simple and automated.
2. To create a tiny version of the Image-J program for analyzing pavement deterioration.
3. To use image processing to evaluate the state of the pavement.

1.4 Significant of the study

The report will serve as a helpful resource for the Addis Ababa Road Authority Office in helping them understand the importance of maintaining their asphalt and which roads have the most damage. A sound maintenance strategy must be used in order to satisfy the needs of road users for comfort, speed, safety, and lower vehicle running costs.

Identification of a sound and innovative method for evaluating the condition of paved roads in order to develop a maintenance strategy that will reduce traffic and accidents while protecting national assets. The major objective of this work is to offer a novel pavement condition evaluation that improves the current AACRA maintenance practice. The government (the policymakers) will be better able to implement successful road maintenance activities if they have a good understanding of routine and effective maintenance.

Finally, the work provides a foundation for further scholarly investigation. This helps academicians better grasp the gaps between what has been taught and what will be seen via conducting empirical research.

1.5 Scope of the Study

The goal of this study is to evaluate a few of Addis Ababa's collector highways using images taken by a digital camera placed on a moving car. using imagej software to analyze the distress in these photos. Finally, it is possible to calculate the pavement condition index (PCI), which will help more with determining the importance of maintenance and the best method of maintenance for each road stretch.

However, the AACRA's asphalt repair procedures are only based on on-site visual examination and persistent public complaints, not on current scientific knowledge. So, this research will be really useful. Precincts that were encountered over the course of the investigation are included in this thesis. The expense of a high-quality camera mounted on the inspection vehicle, the need for appropriate software to import and analyze the images, and the lack of extensive documentation.

1.6 Limitations of the study

While this thesis offered a number of intriguing and legitimate conclusions, it also had certain drawbacks, which are listed below:

- The main drawback was the inability to locate precondition data for the roadway prior to the application of the treatment.
- A significant factor in determining how the PCI will develop on the new surface is the PCI of the preceding surface. As a result, this data set's life cycle Extensions for each therapy are solely based on the findings of this research.
- Due to a lack of current tools and software, the amount of distress must be assessed visually.

1.7 Organization of the Paper

This paper is divided into seven chapters, which are explained below: The background of the study, the statement's difficulty, the study's purpose, its significance, its limitations, and the definition of words were all covered in the first chapter of this essay. An overview of the theoretical and empirical literature on image-based pavement assessment is provided in the following part (chapter two). The third chapter describes pavement quality management, and the fourth chapter deals with how pavement condition assessments are conducted in AACRA, ERA, and around the globe. The research design and data collection methodology are described in Chapter 5; the data analysis, discussion, and results of the study are covered in Chapter 6, which is based on the data acquired on the topic of the study area. Finally, the study conclusions and recommendations are discussed in the seventh chapter.

CHAPTER TWO

2.0 LITRATURE REVIEW

2.1 Importance of Condition Rating Assessment

When running the Department of Transport (DOTs), pavement condition surveys are a necessity for numerous reasons. One of the benefits of pavement condition monitoring is that it aids agencies in efficiently scheduling maintenance and rehabilitation operations [3]. Additionally, the DOTs provide information on when maintenance should be carried out to ensure proper asset utilization throughout its useful lifetime. This is done by assessing a fundamental level of performance, which will show if the operating conditions are acceptable or not.

On the other hand, pavement condition ratings are utilized as a fair means of contrast for various pavements. In other words, assessments of pavement condition are used to compare two or more pavement sections in a way that is more objective. This is crucial when deciding which maintenance and restoration projects to prioritize.

Thirdly, condition ratings assist DOTs and all other interested agencies in determining the degree of deterioration as well as the cost and scope of necessary repairs and rehabilitation. This is because the pavement's current condition is evident in the condition ratings. Finally, condition survey data can be used once more for long-term financial planning. The survey data from previous and existing conditions can be utilized to prepare for the future, and this can be used as a guide for managing the allocation of funds for prospective projects. Together with condition ratings, management choices are no longer based on feelings but rather on the insightful and trustworthy data that the condition ratings provide [3].

2.2 Condition rating process

2.2.1 Brief history

Highways primarily benefit the people who use them by providing a safe and comfortable ride to their destinations. Therefore, it was up to the Department of Transportation (DOT) to make sure that the needs of the general public were addressed when using the highways. The level of

comfort that the general public experiences must be defined for DOTs to carry out their duties. Given that comfort is a personal matter, this question is still challenging to answer. In other words, what may be comfortable for one person may not be for another? State departments maintain their highways based on the knowledge and experience of their workers [16]. Because of this, engineers and qualified inspectors carried out condition surveys to find flaws in the roads based on actual observations.

It was discovered that the employees regarded the manual techniques of conducting condition surveys as subjective and time-consuming. The entire condition survey and evaluation procedure was attempted to be mechanized. Some state DOTs currently use fully automated condition survey systems, like Maryland. The American Association of State Highway Officials (AASHTO) created a condition index in the 1960s to improve the validity of pavement condition surveys. The Present Serviceability Rating (PSR), which was similarly based on ride quality as experienced by a panel of raters traveling in a vehicle on the road, served as the foundation for a substantial portion of this index.

The state DOTs frequently conduct condition ratings. The gathered information is a great resource for assessing and predicting the performance of the pavement over time. Look at figure 1. This aids in determining the importance of competing projects and predicting the need for repair [17].

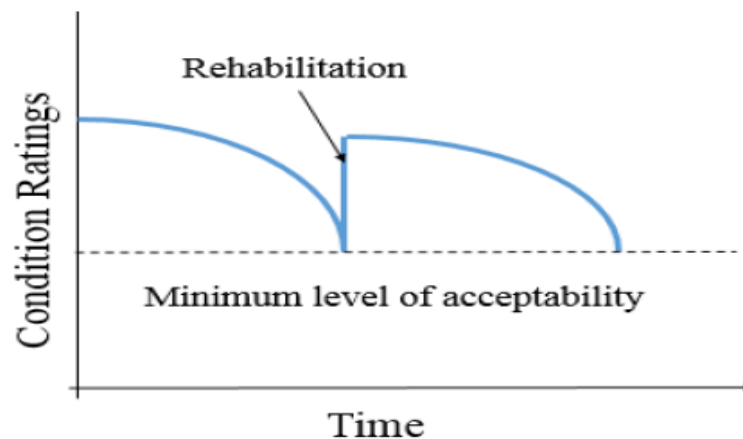


Figure 1: Pavement performance in terms of condition ratings over time [8].

Data collection, Quality Control (QC)/Quality Assurance (QA), and Condition rating are the three main components of the condition survey process. Another name for QC/QA is quality management. It is crucial to understand that the condition survey procedure is a step in the decision-making process that makes up the larger Pavement Management process. Information gathered from condition surveys is subsequently packaged and transmitted to management, as shown in figure 2.2. Then, decisions are made based on this knowledge. Through the use of Pavement Management Software (PMS) and other optimization technologies, the decision-making process may be improved. These instruments are built on models that forecast pavement performance over time and have an impact on choices. QC procedures are carried out prior to, during, and following data collection. Prior to sending data to management for decision-making, QA is performed.

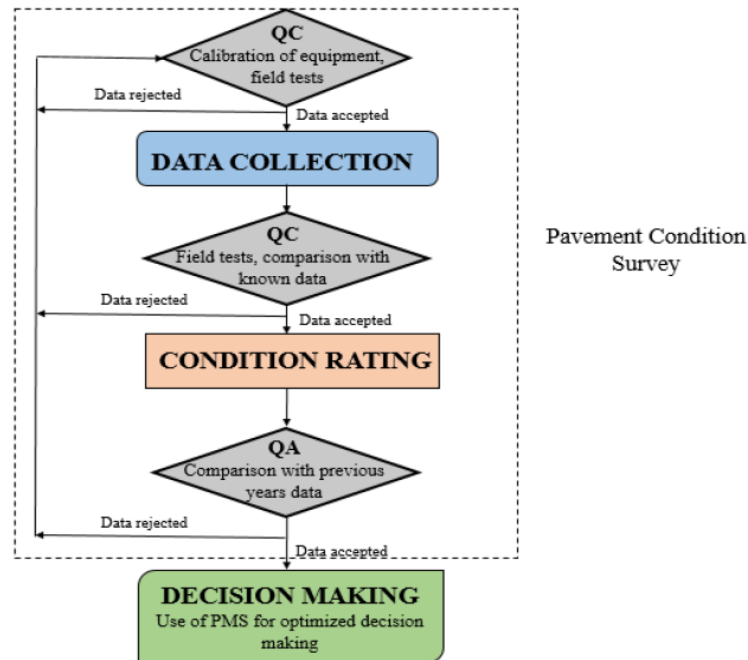


Figure 2 Pavement Management Process [18].

The pavement condition survey is an element of the pavement management process, which also comprises the decision-making processes, as shown in Figure 2.2 above. The pavement condition survey is the study's focus. The first step is the quality control step, which calls for random field tests and the calibration of equipment. Data collection starts after the field tests' findings are approved. To ensure acceptable data quality, QC is performed following data

collection. If QC results are unacceptable, corrective actions involving calibration and rating are taken. After that, condition ratings are applied to the data. Quality assurance is repeated to ensure that the outcomes are coherent before data is given to decision-making and optimization tools or sent to management [15].

2.3 Data collection

2.3.1 Manual & automated data collection

By using pedestrian surveys or windshield inspections, skilled inspectors can grade the pavements and detect any distress that is present. Data is written down on paper, and after being entered into a database, it can either be examined manually or digitally. Data can now be easily entered during manual inspections into handheld devices.

Automated surveys are typically conducted using specialized vehicles outfitted with high-resolution cameras and lasers. These are employed for collecting photos and movies. Depending on how the gathered data is handled and examined, there are semi-automated and completely automated approaches. When using semi-automated techniques, personnel examine the obtained photos to find the distress. Pattern recognition software is utilized in completely automated approaches to categorize and rank pavement distress.

Table 1: Comparison of Automated and Manual Pavement Data Collection Methods [18].

	Automated data collection	Manual data collection
Time	shorter data gathering period	longer time spent collecting data
Safety	Much safer methods of data collection	personnel gathering data while in danger
Objective	Objective measurements	Since it depends on the personnel's experience, it is typically subjective.
Cost	Very expensive equipment costs	Relatively less expensive
Data size	Vast amounts of data are gathered and stored depending on the equipment's capabilities.	Agencies may only be able to collect smaller amount of data at a time
Data handling	Not subjected to transcription errors	Subjected to transcription errors
Employers	It is appropriate for organizations looking to reduce the number of staff.	Sources of employment for rating staff
Coverage	May include the data collection vehicle's footprint. Sometimes multiple runs are required to cover the entire road width.	Inspectors can very easily traverse the entire width of a road section.

2.3.2 Data collection equipment

For the preliminary investigation, one 2001 Toyota Platz with a vehicle gross weight rating of 1200 kg was used. Table 2 contains further information regarding the vehicle.

Table 2: Survey Vehicle Information

Survey Vehicle Information					
Make	Model	Year	VGW (KG)	Tires	Tire pressure Mpa
TOYOTA	PLATZ	2001	1400	P195-55R15	168

The other factors considered were the following: 1) camera, 2) smart phone, and 3) two camera and smart phone mounts. The Toby's Digital Camera and Samsung GT-19082 smartphones were chosen for the pilot project, respectively.



Figure 3: (1-4) Devices Used for Distress image Collection

2.3.3 Pavement inventory data

The following information regarding each road section is contained in the pavement inventory data collected for this study: road name, functional class (collection roads), surface type (flexible), length, speeds and distresses, etc.

Table 3: Study Location Descriptions

SUMMERY DESCRIPTION OF EACH ROAD SECTIONS							
No.	ROAD SECTION	L (M)	W(M)	PAV. TYPE	CLASSIFICATION	V (KM/H)	DISTRESSES
1	ADDIS K. (CHEW B.-GULIT S.)	500	7	HMA	COLLECTOR	30	Cracking, Pothole
2	ARADA (SEBA DERE.-A. BER)	500	7	HMA	COLLECTOR	30	Crack., Poth., Ravel., Path., Rut.
3	GULELE (ETHIO C.-TIBEB ED.)	500	7	HMA	COLLECTOR	30	Poth., Pathing, Ravelling
4	KIRKOS (POSTA B.-WUDAS.)	500	7	HMA	COLLECTOR	30	Crack., Path., Potho., Ravel.
5	YEKA (FERESE.-M/ATEQAL.)	500	7	HMA	COLLECTOR	30	Crack., Poth., Ravel., Path., Rut.
6	KOLFE K. (EFOYTA-TAYWA.)	500	7	HMA	COLLECTOR	30	Crack., Path., Potho., Ravel.
7	NIFASILK L. (SARIS G.-B.TS.)	500	7	HMA	COLLECTOR	30	Crack., Ravel., Pathing
8	BOLE (DINB.-22 MAZORIA)	500	7	HMA	COLLECTOR	30	Crack., Potho., Ravelling
9	LIDETA (L. COND.-G. SEFE.)	500	7	HMA	COLLECTOR	30	Potho., Path., Ravel.
10	AKAKI (D/TULU-QALITY T.)	500	7	HMA	COLLECTOR	30	Crack., Pothole, Ravelling

2.4 Condition rating systems

A score that quantifies performance can be used to establish the condition rating of a stretch of pavement. based on measurements like roughness, skid resistance, deflection, and others gathered during the data collection procedure. The performance of two road sections is compared using the condition ratings as a foundation. They also assist organizations in estimating the cost of maintenance, rehabilitation, and treatment methods as well as the scope and severity of pavement flaws. They are also a crucial component of budget planning. The political pressure that played a larger role in decision-making has also been somewhat lessened as a result of the condition rating indices [15].

2.4.1 Evolution of Pavemrnt condition rating

In the 1950s, pavement condition assessments were made by a group of evaluators traveling down the roadway and verbally or numerically grading the pavement's condition. The American Association of State Highway and Transportation Officials (AASHTO) created this rating system, which utilized a 0–5 scale. The Present Serviceability Rating was its previous name (PSR). The ratings, however, did not offer sufficient engineering support for determining the nature and scope of the needed pavement repair and rehabilitation work. In order to identify the status of pavement sections based on the kind, severity, and amount of distress, researchers devised mathematical formulas. In the late 1950s, this made it possible to develop a more objective method of condition evaluation. The Present Serviceability Index (PSI), sometimes known as the PSI, was developed based on the correlation between panel ratings and metrics like rutting and roughness [21]. The PSI calculation equation is displayed in (1) below. This

gave rise to an index that could be computed using measurements of the pavement segment under consideration's slope variation, roughness, cracking, and patching.

$$PSI = 5.03 - \log(1 + SV) - 1.38(RD)^2 - 0.01(C + P)^{1/2} \quad (1)$$

where,

PSI= Present Serviceability Index

SV= Slope variance of section obtained using CHLOE Profilometer

RD= Mean rut depth (in)

C= Cracking (ft/1000 sq. ft)

P= Patching (sq. ft/1000 sq. ft)

Many states have a high level of acceptability for the PSR and PSI. But states started creating their own indexes, though, in the late 1960s to solve various pavement problems. Additionally, in 1976, the US Army Corps of Engineers created the Pavement Condition Index (PCI), which is being employed by many state DOTs today. The condition index scales can vary and sometimes fall between 0-5, 1-5, or even 0-100 [18].

2.4.2 Classes of Pavement condition indexes

Different ways to evaluate pavement conditions are used by several states around the nation. The two primary categories of condition rating systems are estimated condition ratings and measured condition ratings [20]. The measured condition rating systems are supported by physical measurements like roughness and mathematical expressions in addition to observations by qualified raters, as opposed to the estimated condition rating systems, which are based on the observed physical conditions of the pavements. Since they offer a more objective assessment of the performance of the pavements, the majority of governmental bodies rely on measured rating systems. Examples of rating schemes for the two categories can be found in figure 4.

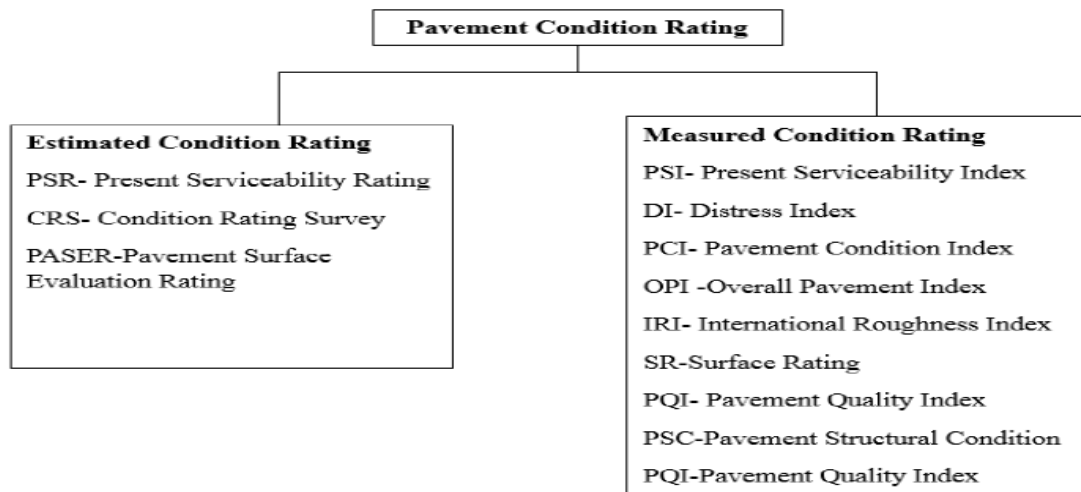


Figure 4: Pavement Condition Rating System [8].

2.4.3 Estimated condition survey

Present serviceability rating (PSR)

The Present Serviceability Rating is the most common and essential pavement condition rating measure (PSR). This information comes from AASHTO and is based on the ride quality felt by a panel of observers while driving on a specific stretch of pavement. According to figure 5 below, the rating scale is from 0 to 5. The current serviceability rating is calculated as the average of the individual ratings [22].

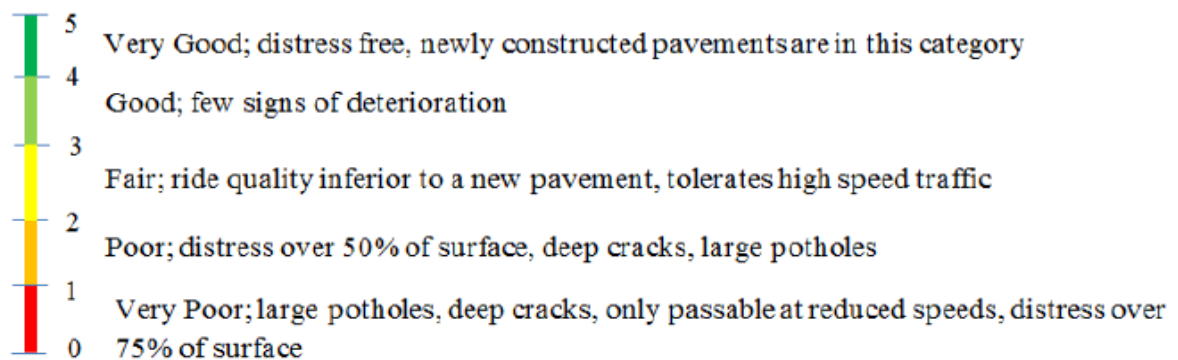


Figure 5: Present Serviceability Rating [21].

Condition rating survey (CRS)

The Illinois Department of Transportation also uses the Condition Rating Survey (CRS), another approximation of a condition rating system (IDOT). The scale has 0.1 increments and ranges from 1.0 to 9.0. A number of 9.0 denotes a freshly built pavement, whereas a value of 1.0 represents complete failure. The values are assigned in accordance with the 2004 CRS Manual. The guidebook includes a number of illustrations that help the inspector assign the proper values. Since methods have been created to take into account the observed faults in the calculation of condition rating values, CRS has developed over time into a measured condition rating at the state level. The CRS's original format is still used by some local agencies [26].

Pavement surface evaluation and rating system (PASER)

The Pavement Surface Evaluation and Rating System is a different approximated rating system (PASER). Given that it is also a visual evaluation of the pavement conditions using a 1–10 scale, it falls under the category of estimated rating systems. Similar to the CRS, there is a guidebook that instructs inspectors on how to select the proper value on the scale that accurately depicts the conditions. A broad translation of the PASER ratings is shown in Table 2.4 [22].

Table 4: PASER ratings and maintenance requirements [21].

PASER Ratings	Description of Maintenance
9-10	No maintenance needed
8	Little maintenance
7	Routine maintenance, crack sealing, minor patching
5-6	Scale Coating
3-4	Overlay
1-2	Reconstruction

2.4.4 Measured condition rating***Present serviceability index (PSI)***

The Present Serviceability Index (PSI), a 0–5 index, is regarded as a measured rating system for the measured condition ratings because it is based on actual measurements of pavement features in addition to observations from experienced raters. This score was created using data from a panel of raters who evaluated roads in Illinois, Minnesota, and Indiana along with

measurements of the pavement's roughness, rut depth, cracking, and patching. In order to provide a far more objective method of determining pavement conditions, AASHO (American Association of State Highway Officials) conducted this test and analysis between 1958 and 1960 [15]. To create formulations for determining the PSI, the measurements of the pavement were connected with the raters' observations.

Distress index (DI)

The Distress Index (DI) is another system for grading measured conditions. The Michigan Department of Transportation makes use of this (MDOT). MDOT uses a video survey to collect a survey for every 0.1 miles of pavement. The Distress Index is only a weighted score of the distress points from the video survey, which were assigned according to the kind, extent, and severity of the distress. The expression for DI is

$$DI = \sum DP/L \quad (2)$$

Where L = number of 0.1 mile sections, DP = distress points, and DI = distress index. The DI has no upper limit and a starting rating of 0. A DI of 20 or less is typically regarded as low, but one of 40 or more is seen as severe. Between 20 and 40 is the medium DI range. A DI of 50 might mean there is no more service life left [24].

Pavement condition index (PCI)

The American Public Works Association and the American Society for Testing and Materials both use the Pavement Condition Index, a measurable condition assessment system created by the US Army Corps of Engineers (ASTM). It uses a 0-100 scale as its basis. For an example, see figure 6 [22]. A value is assigned to it based on the kind, intensity, and extent of each distress found on the pavement. The rating of the pavement condition is then determined by adding all the points and subtracting them from a total of 100. The condition of the entire section is then determined by averaging the PCIs for each sub-segment.

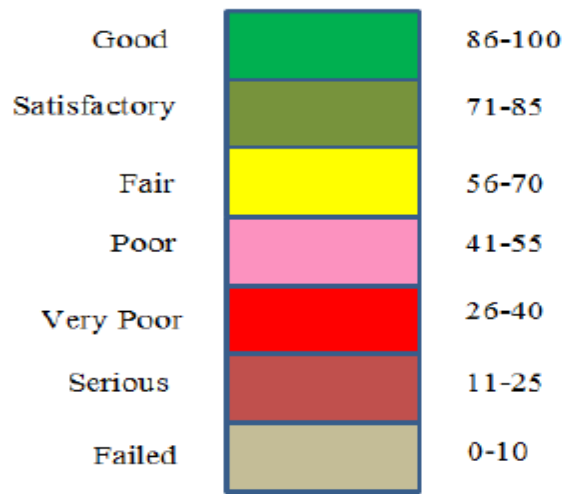


Figure 6: PCI Ratings [3]

Overall pavement index (OPI)

Some organizations also employ the Modified Distress Rating-based Overall Pavement Index (MDR). The PSI, which is generated from the IRI, serves as the foundation for the MDR as well. The PMS Implementation for Nigerian Federal Roads used this [23]. The OPI is further explained by the ensuing formulae.

$$PSI = 5e^{0.198 - 0.000261(IRI)} \tag{3}$$

$$MDR = 20(PSI) \tag{4}$$

$$OPI = MDR(PSR/5)^{0.22} \tag{5}$$

Surface rating

The Minnesota Department of Transportation used this index (MNDOT). It has a rating range of 0.0 to 4.0. The higher scores correspond to better pavement conditions, just like the PSR. The pavement distress is rated and measured by two raters. This is afterwards transformed to distress percentages. The percentages are then given the proper weighting factor based on the different types of discomfort. The final step is to convert the total percentage weighted distress to a Surface Rating (SR). The weighting variables for bituminous pavement distresses are displayed in Table 5. The weighting factors for concrete pavements and continuously reinforced concrete pavements are displayed in Tables 6 and 7, respectively. The overall weighted and accompanying surface ratings are displayed in Table 8.

Table 5: Bituminous Pavement Weighting Factors [18].

Distresses type	Severity	Weighting
Transverse crack	Low	0.01
	Medium	0.10
	High	0.20
Longitudinal Crack	Low	0.02
	Medium	0.03
	High	0.04
Longitudinal joint Deterioration	Low	0.02
	Medium	0.03
	High	0.04
Block cracking		0.15
Alligator cracking		0.35
Rutting		0.15
Raveling and weathering		0.02
Patching		0.04

Table 6: Concrete Pavement Weighting Factor [18].

Distresses type	Severity	Weighting
Transverse Joint Spalling	Low	0.10
	High	0.20
Longitudinal joint Spalling	Low	0.10
	High	0.20
Cracked Broke /Faulted Panel		0.07
100% overlaid panels		0.00
Patched Panels		0.14
D-cracking		0.10

Table 7: Continuously Reinforced Concrete Pavement Weighting Factors [18].

Distress Type	Weighting Factor
Patch deterioration	0.30
Localized Distress	0.40
D-cracking	0.05
Transverse cracking	0.25

Table 8: Total Weighting and SR [18].

Total Weighting	SR	Total Weighting	SR
0	4.0	21	1.6
1	3.8	22-23	1.5
2	3.6	24	1.4
3	3.4	25-26	1.3
4	3.2	27	1.2
5	3.0	28-29	1.1
6	2.9	30-33	1.0
7	2.8	34-40	0.9
8	2.7	41-47	0.8
9	2.6	48-54	0.7
10	2.5	55-61	0.6
11	2.4	62-68	0.5
12	2.3	69-75	0.4
13	2.2	76-82	0.3
14	2.1	83-89	0.2
15	2.0	90-96	0.1
16-17	1.9		
18	1.8		
9-20	1.7		

Pavement quality index (PQI)

The MNDOT employs PQI, which combines the PSR with the SR. It is the product of PSR times SR squared. The scale goes from 0.0 for failed pavements to 4.5 for perfect pavements [24].

Pavement structural condition (PSC)

The Washington State DOT rates the state of the pavement using the PSC [24]. A score of 0 indicates severe distress and a score of 100 indicates no concern. The PSC is a single figure that, like the majority of rating systems, is used to indicate the pavement conditions in terms of the severity and degree of all distress. Different formulas are used to compute the PSC on rigid and flexible pavements. Below are the formulas for calculating PSC.

$$\text{Flexible Pavement: } PSC = 100 - 15.8EC^{0.5} \quad (6)$$

$$\text{Rigid Pavement: } PSC = 100 - 18.6EC^{0.43} \quad (7)$$

where,

PSC=Pavement Structural Condition; and EC= equivalent cracking

Based on the extent and severity, each distress category is converted to an equivalent cracking number. The EC is the sum of the defects produced after summing up the defects that have been assigned numerical values. Look at table 9. Table 10 below categorizes PSC values in the following ways.

Table 9: Equivalent Cracking Valuation for Asphalt Concrete [16].

Distress	Type of coefficient	Coefficient	Power
% Length patching high*	0.75	1	1
% Length patching medium*	0.75	0.445	1.15
% Length patching low*	0.75	0.13	1.35
% Both wheel paths of Alligator cracking high	1	1	1
% Both wheel paths of Alligator cracking medium	1	0.445	1.15
% Both wheel paths of Alligator cracking low	1	0.13	1.35
% Length Transverse cracking high	0.8	1	1
% Length Transverse cracking medium	0.8	0.445	1.15
% Length Transverse cracking low	0.8	0.13	1.35
% Length Longitudinal cracking high	0.1	1	1
% Length Longitudinal cracking medium	0.1	0.445	1.15
% Length Longitudinal cracking low	0.1	0.13	1.15

Table 10: PSC Categories [16].

Condition	PSC Rating
Excellent	75-100
Good	50-75
Fair	25-50
Poor	0-25

CHAPTER THREE

3.0 PAVEMENT QUALITY MANAGMENT

To make sure that the data gathered satisfies the requirements of the pavement management process, many transportation authorities are adopting methods and guidelines for managing the quality of pavement data gathering operations. Because data quality has a significant impact on management decisions for pavements, it is attracting more attention. Adopting a comprehensive and systematic quality management approach that encompasses methodologies, techniques, tools, and model issue solutions is the most effective way to obtain high-quality pavement condition data. The definition of data collection methods, quality standards, employee roles, quality control, quality acceptance, corrective action, and quality management documentation are all included in quality management [27].

It is possible to define quality control (QC) as actions taken to ensure that the tools and procedures used for data gathering are in compliance, resulting in the production of high-quality data. The phrase "quality assurance" (QA) refers to the actions taken to guarantee that the pavement condition data gathered satisfies the standards and requirements for quality. It is often carried out by a quality assurance auditor who examines data management spreadsheets, confirms that the data is complete, and examines a randomly selected sample of 2–10% of the data gathered. QC measures must typically be carried out throughout the entire data gathering process [25]. QC methods ensure that the equipment's accuracy and precision meet industry standards throughout the pre-project phase.

QC is carried out during post-processing to guarantee accuracy and completeness. After that, QA is carried out to further guarantee the dependability and correctness of the data given. The goals of quality control are to measure process variability, keep it within acceptable bounds, and take the required steps to reduce controlled variability. Environmental factors and the training of the rater or operator are sources of variability. Sixty-four percent of state and provincial highway authorities have a formal quality control plan for data collection.

Among the standards that serve as recommendations for organizations that manage data quality are the AASHTO Standards, ASTM Standards, and the Long Term Pavement Performance (LTPP) Guide. These standards talk about quality assurance and control in terms of hiring

qualified staff, including validation sections, calibrating equipment, and performing further checks using data from prior years. The rules are not very precise, but they have been used as a model by organizations to develop comprehensive state-specific data quality management manuals. It should be noted that the data's variability must be lower than its annual growth rate. In any other case, this denotes a significant level of "noise" and/or bias, which may not produce accurate analytical results. By definition, managing data quality is the duty of both the data collectors and the final users of the data.

Since bias and error are always present in data, quality assurance rules specify tolerance thresholds to ensure that data variability is acceptable. Inconsistencies in the rating process as well as when managing, referencing, and processing the data can all result in variation [20].

Data quality assurance and control have undergone a great deal of work. However, sensor-collected data quality management is more well-established than distress data. This is brought on by the equipment utilized to acquire pavement photos' intrinsic unpredictability as well as how the images were processed [25].

3.1 Quality management of distress data

Pilot tests are typically carried out by data collectors, whether they are internal or external. The data surveys are chosen at random as they are being collected. The gathered information is then contrasted with information from manual surveys. To make sure the equipment is of high quality, data is collected. Agencies need to establish their criteria in order to reduce the allowed variability in data. In-depth statistical analysis and a review of the sources of variability can accomplish this [27].

3.2 Pavement management system

A public works program's pavement component's planning, design, construction, maintenance, evaluation, and rehabilitation activities collectively fall under the umbrella of pavement management. A pavement management system (PMS) is a collection of tools or techniques that aid decision-makers in coming up with the best plans for supplying, assessing, and keeping pavements in operation for a predetermined amount of time. The most important thing is to create and implement a sustainable PMS, which means that there is a strong desire,

commitment, and availability of resources within the business to maintain and later improve the PMS with the assistance of local employees and resources.

A PMS's functions include enhancing decision-making effectiveness, enlarging its scope, providing feedback on the effects of decisions, facilitating the coordination of activities within the agency, and ensuring consistency among decisions made at various levels of management within the organization. As pavements continue to deteriorate and get older, systematic pavement maintenance has become more crucial. As funding competition has intensified, funding amounts have fallen. Using a pavement management system (PMS) is meant to give road managers a methodical procedure for coming up with answers to questions like:

- A. What roads are we responsible for? When were the roads built and when were they rehabilitated?
- B. What is the current state of the road network?
- C. What is the expected level of service we provide?
- D. How much funding is needed to provide the expected level of highway services? Now and in the future?
- E. How will the condition of the road network change if funding levels change?
- F. What type of services does the highway require? (maintenance, preservation or rehabilitation)
- G. What type of strategy is the most profitable in our road network?
- H. Are there alternative strategies that would be more profitable and result in better conditions?
- I. What is the cheapest way to maintain the road network over time? [26].

3.3 Pavement management levels

All organizational decisions, including those made at each level (strategic, network, and project), can be supported by pavement management.

Strategic Policymakers make choices at the strategic level that have an impact on the organization's long-term strategic initiatives. Setting performance objectives, allocating financing, and devising preservation plans are a few examples of these choices.

Network In a typical setting, tactical decisions concerning the effects of various short-and long-term budgets, the implications of various investment plans, and work alternatives for the

pavement network are made at the network level using information such as existing and future network conditions [22].

Over a five-year span, a project The choice of maintenance activities, materials, and pavement design thicknesses are just a few examples of decisions made at the project level that are centered on a limited time frame (for instance, two years).

3.4 Pavement maintenance priorities

All road repair organizations must take budget restrictions into account when establishing a maintenance program. A further difficulty that engineers in charge of road maintenance face is that there are never enough resources. To guarantee that the resources that are available are used as effectively as possible, it is necessary to evaluate the significance of various workplace interventions. The majority of the time, financial requirements will be greater than funding options. One of the approaches for prioritization and optimization will be required in this situation to get ready for the upkeep of a rehabilitation program.

The amount and type of deterioration on the road currently, as well as the rate at which it is deteriorating, as well as its importance and the volume of traffic it receives, can all affect how maintenance activities are prioritized. [22]

Here is a list of techniques for setting priorities:

- A. *Matrix method*
- B. *Condition index*
- C. *Benefit-cost ratio*
- D. *Cost Effectiveness*
- E. *Maximum benefits procedure*

CHAPTER 4

4.0 Pavement condition assessment practices

4.1 Introduction

Different agencies approach pavement condition assessment tasks in different ways. The experiences of the Ethiopian Roads Authority (ERA) and Addis Abeba City Road Authority (AACRA) are briefly discussed in the paragraphs that follow. These organizations were chosen based on their institutional structures, methods for evaluating the quality of the pavement, and road maintenance management systems. In order to give an effective and long-lasting pavement condition evaluation practice, their performance offers vital information by highlighting present relative strength, from which helpful lessons can be acquired. Using the pavement condition index and taking into consideration the severity and kind of failure, the Pavement Management System (PMS) featured methods for prioritizing road maintenance projects [26].

4.2 ERA pavement condition assessment experience

In accordance with the district road network, ERA uses the visual inspection method to conduct road condition surveys twice a year. ERA has inspection machinery (a vehicle) that can travel at a speed of 80 km/h. The apparatus is utilized for planning, though.

It was discovered during the ERA interview that the district road network management, using the results of the condition survey, quantifies the pavement problems and sends them to the ERA central office for the central office to allocate the funding for maintenance. The majority of maintenance tasks at ERA are completed by its in-house construction company, Ethiopian Road Construction Corporation (ERCC), and only a small number of labor-intensive tasks are subcontracted to private businesses. Although they go through routine and periodic repair, they don't use novel pavement maintenance delivery technologies as a substitute for the current road maintenance system [26].

4.3 Pavement assessment experience in AACRA

The condition of the current pavement must be assessed in order to carry out the restoration and maintenance of the pavement. Such an evaluation often entails evaluating the state of the current pavement surface and evaluating safety by visual inspection. Different nations and highway authorities utilize different pavement evaluation methods; these methods are primarily concerned with identifying the underlying causes of current problems in order to choose the most effective repair techniques.

The Road Management System Team of ACCRA is in charge of evaluating the pavement in this evaluation task research. It is carried out yearly on a thorough spreadsheet utilizing a visual condition survey method. street name, number, length, kind of road, kind of fault, and specifics of the defective area (specific area, length, width, area, and condition). The data collection form that AACRA utilized to conduct a study on the state of current asphalt roads is displayed in Appendix. They conduct studies at the state level for all varieties of roadways, stairways, sewers, and bridges [26].

4.4 Current world practices in pavement condition assessment

Every country's Department of Transportation (DOT) has a unique method for maintaining its pavement infrastructure. When monitoring and assessing the status, they use several data collection techniques. Financial limitations and employee qualifications have a significant impact on the method of choice. It also depends on how well those techniques for gathering data and evaluating them correspond to the requirements of the agency.

The most efficient option at the moment is to monitor a state's highway system using a dedicated inspection truck, which is quickly taking the place of more conventional techniques. For instance, the Minnesota Pavement Management Unit gathers information on pavement condition, determines the extent of surface damage on about 60% of the highway system, and publishes a Summary Report of the Condition of the Pavement each year [26]. A sophisticated digital inspection vehicle outfitted with digital cameras and lasers is used to gather information on pavement roughness and surface deterioration (cracks, grooves, patches, and joint deterioration, among other things).

In order to evaluate pavement roughness, grooves, and flaws, downward-facing cameras and lasers measure the pavement's longitudinal and transverse profile. The gathered information is then manually examined. The Automatic Road Analyzer (ARAN) platform from Fugro Roadware Inc. asserts that it can automatically or semi-automatically measure all significant road condition data, including the longitudinal profile (roughness), transverse profile (grooves), and wear of the pavement [13]. Pavement inspection vehicles are another common type (cracks, potholes). Video cameras are used to image the surface; optical sensors to measure distance; lasers to profile; extra ultrasonic sensors to find grooves; and accelerometers to quantify roughness. It is ideal for the automatic collection of all types of pavement breaks.



Figure 7: Pavement inspection vehicle ARAN [13]

CHAPTER 5

5.0 RESERCH APPROACH AND METHODOLOGY

5.1 Introduction

The primary themes covered in this chapter, which outlines the methodology of this thesis, are research methodology, research scope, limitations, data sampling procedures, and data collection. This section's goal is to outline the fundamental approach that the thesis employs for measuring the various types of pavement distress and their corresponding severity levels. This issue focuses on the creation of the ImageJ software, the Java programming used to create it, and the development's end result, the addition of a new toolbar to the software.

5.2 Study area

To establish an evaluation of pavement condition, the first step is to find a road network for which a condition evaluation has to be developed. In order to conduct this study, a pilot visual condition survey of all Addis Ababa sub cities was first carried out. Due to equipment limitations in automated data collection, collector roads were then chosen. Finally, ten locations on collector pavement road sections in Addis Ababa city were selected. Data about the damaged pavement was gathered using a digital camera mounted on a car. A total of five kilometers of asphalt road were chosen, with one segment for each of Addis Ababa's sub cities, measuring roughly 500 meters each.

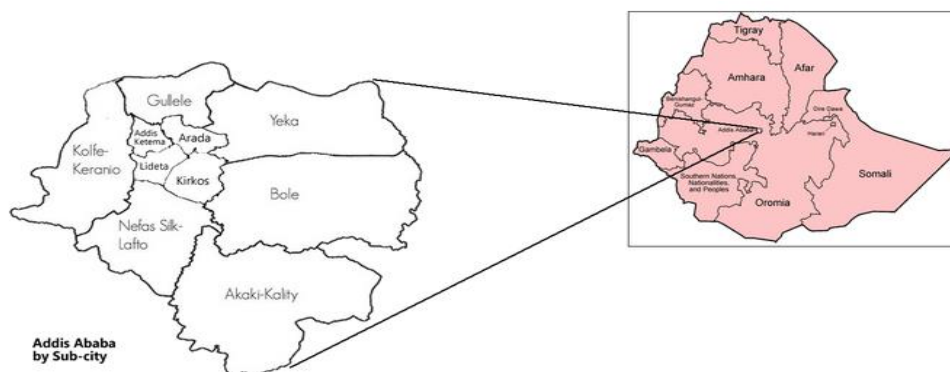


Figure 8: Addis Ababa Sub Cities [26].

5.3 Research approach

Semi-automated data analysis and automated pavement distress data collection are used in the study. The procedures used to gather data are known as research methods. Automated pavement distress data collection and semi-automated data analysis were the tools the researcher used to collect data for this study under a mixed methods approach. The researcher used both quantitative and qualitative data analysis for this study, which is discussed in the following subsections.

5.4 Target Population

The term "population" refers to all individuals or objects that have the traits that the researcher is interested in. The population of the study consists of 10 distressed asphalt road sections, one from each Addis Ababa sub-city, and each with a length of roughly 500 meters.

5.5 Data Source and Collection Method

5.5.1 Source Data

Primary and secondary data sources served as the study's data sources. Thanks to primary data collected through field surveys and secondary data collected from a variety of books, articles, documented reports, and research journals, the researcher was able to gain a better understanding of image-based pavement collection assessment in the study area.

5.5.2 Data Collection Technique

There are two methods for gathering information about paving. They are methods for both manually and automatically collecting pavement data. Currently, for a variety of reasons, the majority of state DOTs are leaning toward the automated method. For instance, the most developed city has a system for completely automating pavement condition surveys. However, DOTs still rely on manual procedures because of their distinct advantages. The characteristics of both strategies are listed before.

The two approaches are contrasted in terms of timing, worker security, measurement objectivity, cost, and volume of data, handling, and employers' perspective. Based on its financial and human capital resources as well as the level of detail and quality of data

necessary, an agency may favor one of these ways or perhaps a mix of them. With the cluster sampling technique, Addis Ababa already has ten subcities. A random sample is then drawn from these clusters.

5.5.3 Method of Data Analysis

After the data was collected, various data processing tasks had to be completed. The raw data was transformed into a format that could be analyzed and interpreted. After gaining the necessary information from the relevant parties, including government agencies, the Addis Ababa City Road Authority, construction partners, consultants, field surveys, and service providers, a direct field photographic image will be obtained and appropriately done. Image-J was used to examine the data.

5.5.4 Data collection methodes

This various pavement distress data was gathered over time utilizing a variety of methodologies. The majority of the information was gathered straight from the field. The study used the following procedures for gathering data:

1. In order to design a straightforward, cost-effective, and scientifically based pavement condition evaluation technique, a variety of documents pertaining to the assessment of pavement distress conditions were examined.
2. Two-Stage pavement inspections were performed on Addis Ababa city roads. A visual inspection was conducted first to determine which sorts of pavement roads were more defective. Following the acquisition of these, a patrol inspection was conducted with the aid of a camera mounted on the front and rear sides of the vehicle, and an image of pavement distress was obtained.
3. Various secondary data documents from numerous studies and government agencies, particularly from AACRA, were used. The researcher came to the conclusion that the following categories best describe the pavement distress on all of the selected road sections that are covered in this report.

- A. Cracking
- B. Patching and Potoles
- C. Surface deformation
- D. Surface defects

Table 11: Description of various types of pavement distress and unit of measurement with its defined severity levels [3].

PAVEMENT DISTRESS TYPE	UNIT OF MEASUREMENT	DEFINED SEVERITY
CRACKING Transvers cracking Longitudinal cracking Alligatory cracking	Number, meter Number, meter squarmeter	Yes Yes Yes
PATCHING AND POTHOLES Patch/patch deterioration Potholes	Number, squarmeter Number, squarmeter	Yes Yes
SURFACE DEFORMATION Rutting Shoving	Millimeter Number, squarmeter	No No
SURFACE DEFECTS Bleeding Polished aggregate Raveling	Squarmeter Squarmeter squarmeter	No No No

5.6 Methodology

The pavement condition rating system can be done either by estimated condition rating or measured condition rating. This research follows measured condition rating to determine the pavement condition index. Below, the general methodology of the research will be covered. We first select our road network, and then we move the vehicle equipped with a camera along the same road at a constant speed to record pavement distress data in an image, which we then import into the Image J software to assess the severity of the distress. We compute the overall deduced value of each distress after reading the deduced value of each distress from the deduced curve according to the severity degree. Additionally, we offer it in accordance with ASTM D6433.

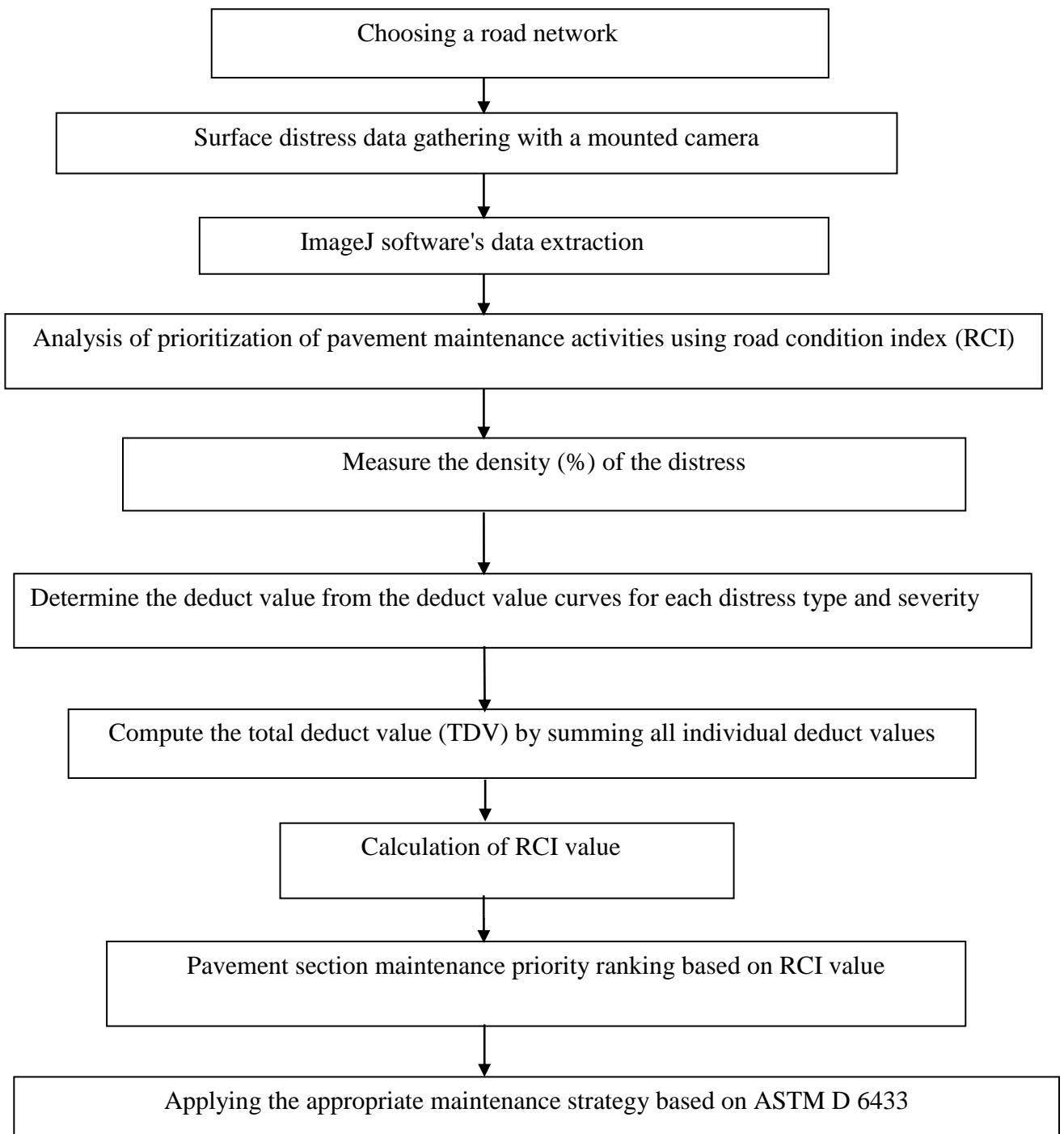


Figure 9: Framework of Study Methodology

5.7 Imagej software calibration

According to this study, IMAGEJ software is compatible with any photographic images that are 8-bit, 16-bit, or 32-bit in size and in a variety of image formats, including TIFF, GIF, JPEG, BMP, DICOM, FITS, and "raw" [28].

1. A calibration procedure should be used in order to take a measurement from a picture. The following steps are included in the calibrating process.
2. Open the test image that hasn't been calibrated. The photos are not calibrated, and the top info bar reports the scale in pixels rather than actual units.
3. Create a selection line with a known length using the Line Selection tool.
4. Click "Analyze - Set Scale" on the menu.
5. Enter the "Know Distance" Field with the known length of the line you drew. The tool is aware of the length in pixels of the line you created!
6. Decide on the measuring units (mm, cm whatever)
7. Select the "Global" option now by checking the box, and when you click OK, all open photos will do the same spatial calibration.
8. Choose a line or an area now. The findings will be spatially calibrated if you utilize the measure function Analyze Measure or Ctrl+M.

The image below shows how the software calibration process can be altered in this way

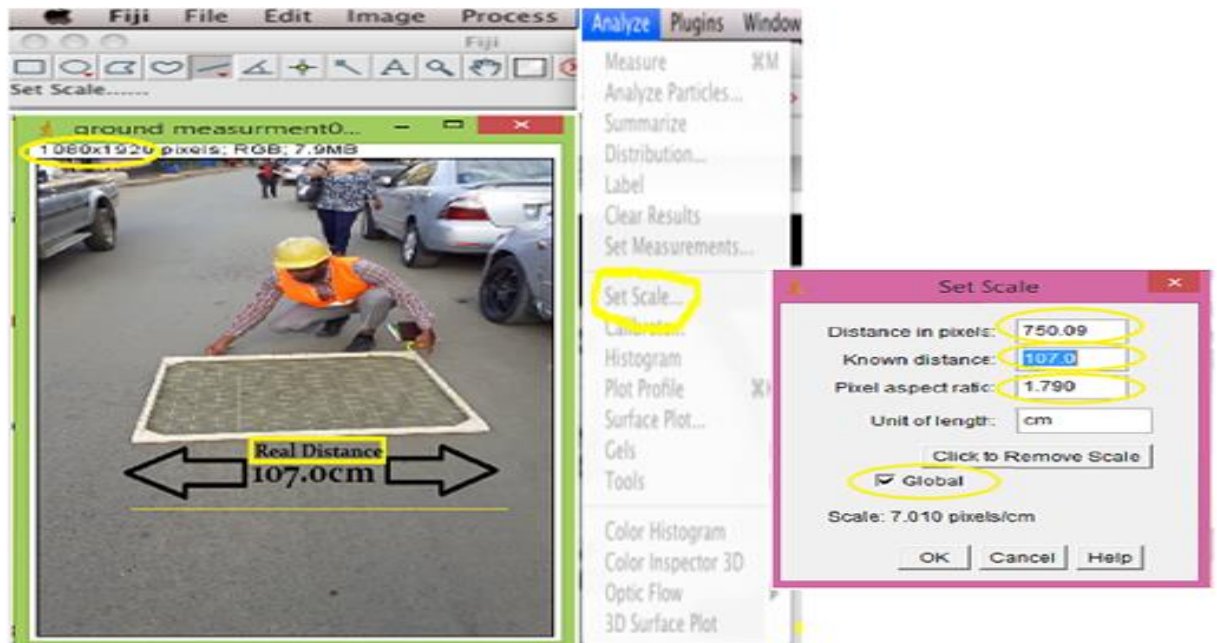


Figure 10: Image Calibration Process

Here be present below, the different pavement distresses, that will be imported in to the software after calibration for analysis.



Figure 11: Flexible Pavement distresses

5.7.1 Imagej software development

As the imageJ interface description below shows, the software is Java-based and so powerful that anyone can write Java code and add macros. The researcher decided to write a Java program that would draw a line and overlay a profile of all pavement distresses in order to add more toolbars to this research (see Java program in Appendix E). The results of the imagej installation and distress profile drawing tool are shown in the following figures.

The original ImageJ program interface is seen here.

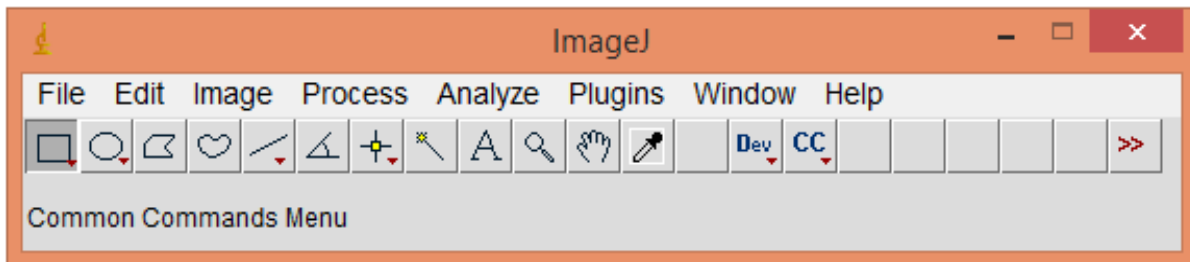


Figure 12: Imagej software interface before programming installation

The additional tool bar shown below and circled can be added after installing Java programming.

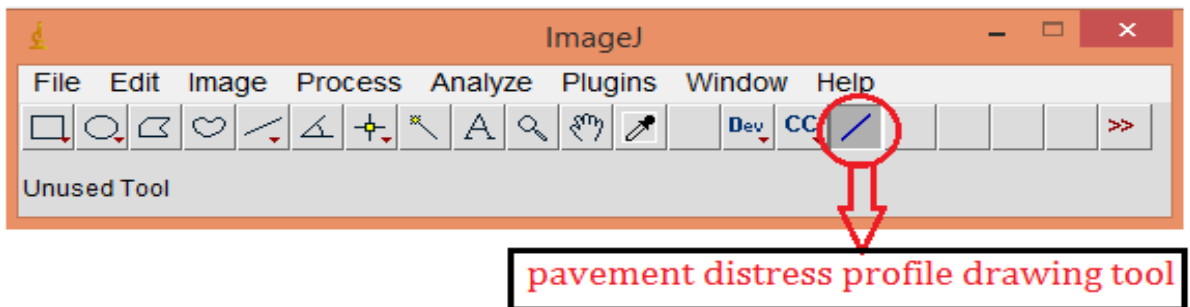


Figure 13: Imagej software interface after java programming installation

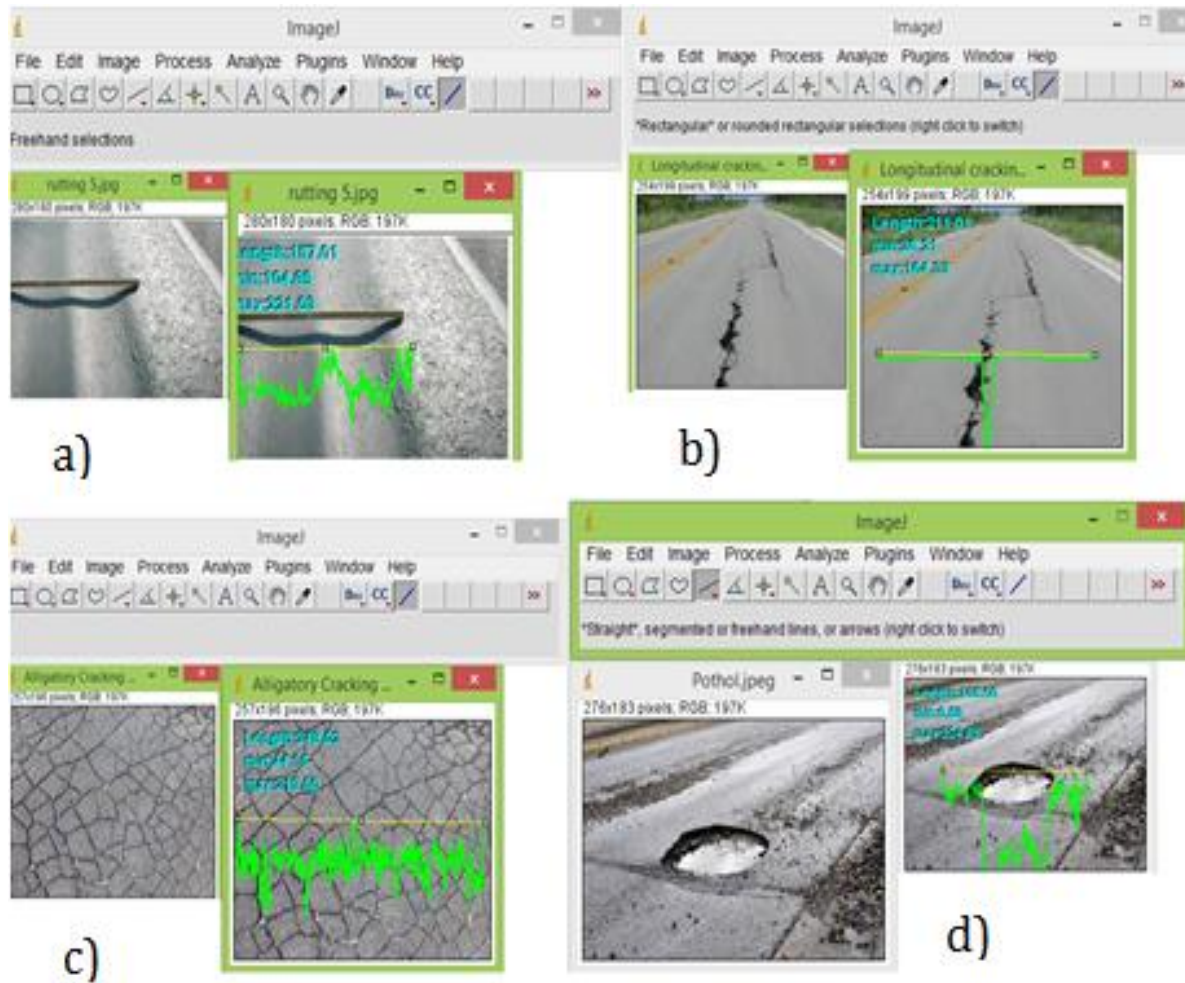


Figure 14: Distresses profile drawing tool Results: a) Rutting b) Longitudinal Cracking

Following software customization for our case in point, it is demonstrated on the aforementioned photographs that the software is able to construct corresponding profiles of the distress image for each type of pavement distress, which aids in determining the severity level and further analysis.

CHAPTER 6

6.0 DATA ANALYSIS, DISCUSSION AND RESULT

6.1 Introduction

The length, width, and area of cracks are only a few examples of the dimensions of the road damage that are measured using the suggested imaging technique. For alligator cracks, longitudinal cracks, rutting, and pothole areas, manual length and width measurements are taken using a tape, ruler, and square net after drawing some marks in the disturbed area as a complement to the imaging technique for comparative purposes. For these issues, pictures are taken alongside the required road markings and in the presence of a known unit of length, like a metal ruler. To demonstrate and contrast manual and image measurements, some selected photographs from the digital camera images are picked after analysis. The image processing program ImageJ, created by NIH Image, was used for this study. The system is free to use and offers programmers an excellent environment for displaying, enhancing, designing, and applying filters, as well as performing geometric and mathematical operations and computing metrics like mean and standard deviation. A Java class plugin can be used to alter ImageJ. These classes may have calls or routines that ImageJ will interpret and carry out.

6.2 Software analysis and results

6.2.1 Measurement of an alligator cracking

A group of points near the location of the alligator crack were first fitted using a fin curve. The scale needs to be calibrated before performing the measurements. As seen in Fig. 15,

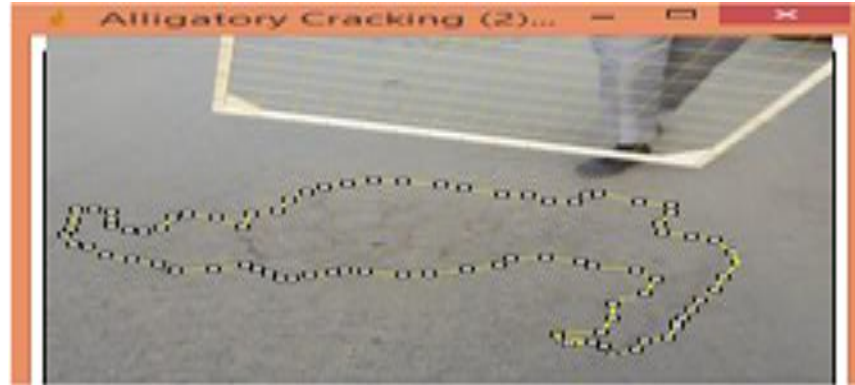


Figure 15: Digital measurement of an alligator cracking

The result of the image measurement is shown in Fig. 17. The manual findings for the 0.634 m² alligator cracking area are quite comparable to these results.

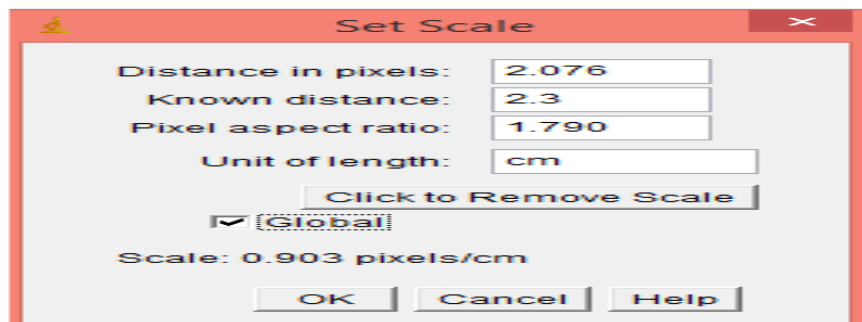


Figure 16: Imagej window to set the scale of measurement

File	Edit	Font	Results	
	Area	Perim.	Slice	Length
1	6622.123	4497.173	1	4497.173

Figure 17: Measurement results for the alligator cracking

6.2.2 Measurement of a pothole

This section outlines the procedures needed to determine the area of a pothole. It can act like an alligator cracking if you enter the curve fit software in specific areas on a pothole's edge. In Figure 18, a spline curve is fitted using a set of points that are situated along a polygon's edge.

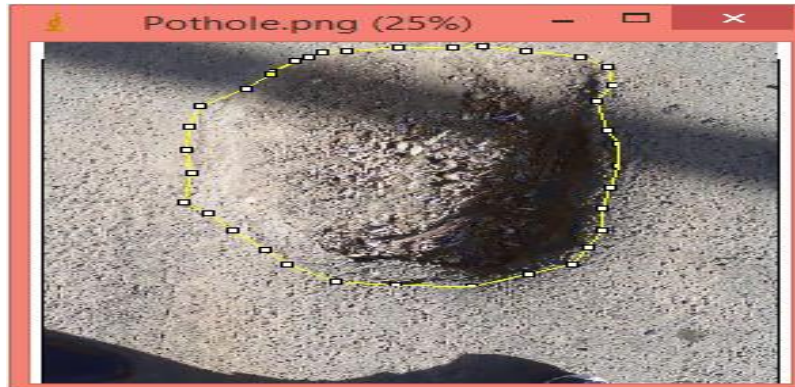


Figure 18: fitting a set of polygon border points

6.2.3 Measurement of rutting

A portion of a paved road with significant rutting was chosen for this study. A 2.0 m ruler is used to manually measure 76.5 mm of wheel travel as well as the grooved length of a segment.

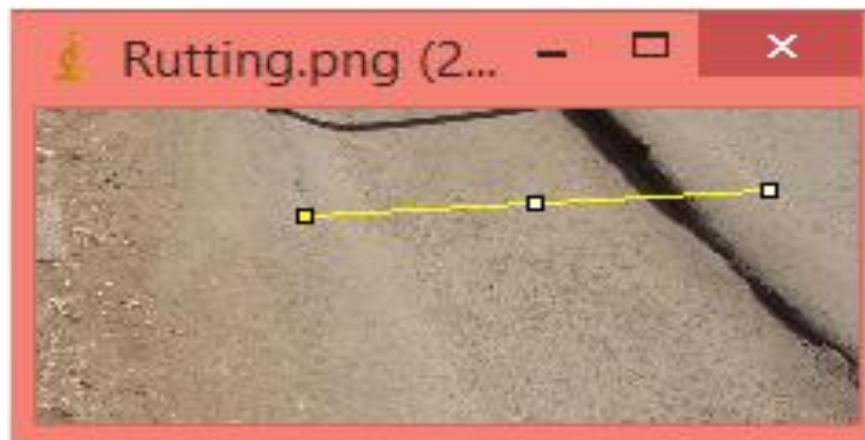


Figure 19: Rutting section

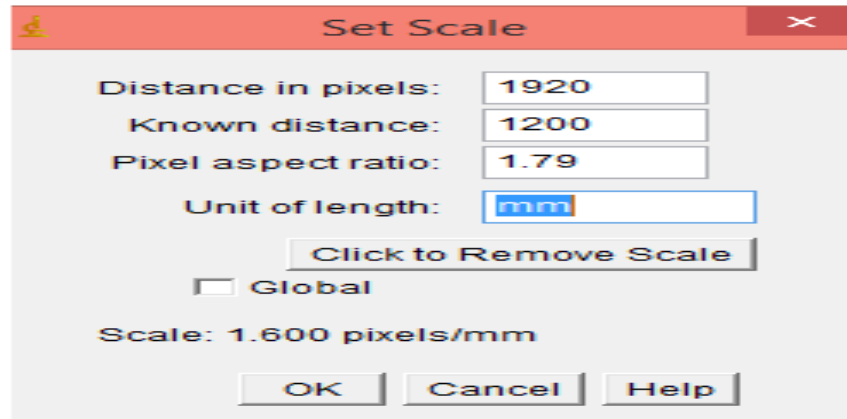


Figure 20: ImageJ window to set the scale of measurement

The software rutting depth shows as that, it is 78.0mm

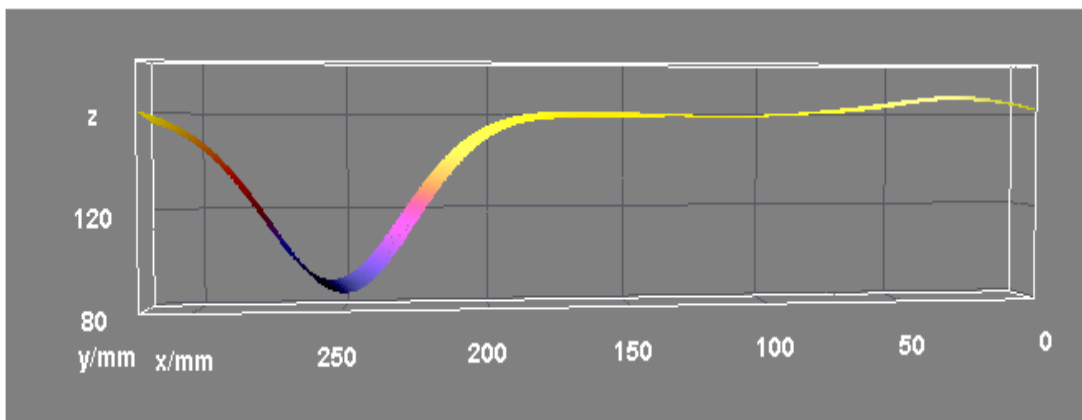


Figure 21: Measurement result for rutting

The tabulated distress results used for the research's chosen region distress computation were based on the aforesaid distress software measurement.

6.3 Comparison between manual and image-j software measurement result

6.3.1 Manual vs. software pothole area measurement comparison

✚ Pixel distance = 2.0736, Known distance = 11.5cm, Pixel ratio = 1.79, Unit of length = cm

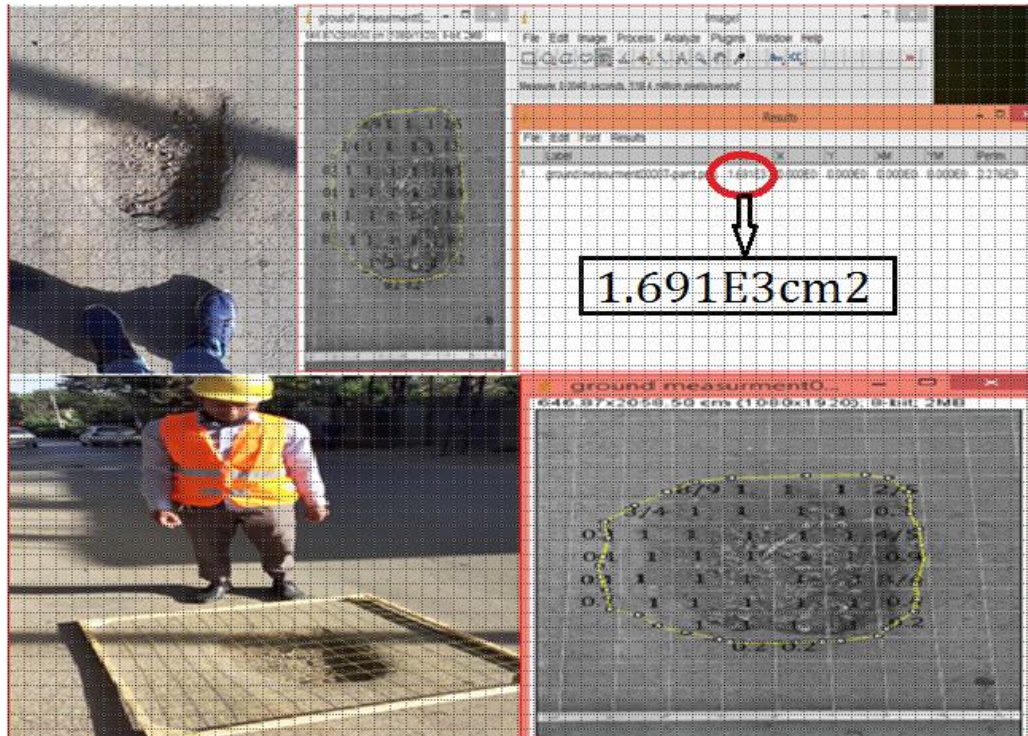


Figure 22: Pothole Manual vs. Software Measurement Comparison

✚ Each box area=7cm*7cm=49cm²=0.0049m²

✚ Pothole Area Manual Measurement = [(31*1) +8/9+2/5+3/4+0.3+4/5+ (4*0.1) +0.9+3/4+0.4+(3*0.2)]*0.07m*0.07m=0.182m²

- Error= Manual Measurement – Software Measurement
- Error= 0.182m²- 0.1691m²=0.0129m²
- %Error= (0.182-0.169)/ (0.182*100)=7.08%

In this measurement of pothole distress, the manual result is 0.182 square meters and the imagej software result is 0.169 square meters, meaning the percentage error is 7.08%. This makes it bearable.

6.3.2 Manual vs. software rutting depth measurement comparison

Pixel distance=1.92, Known distance=1200mm, Pixel ratio = 1.79, Unit of length = mm

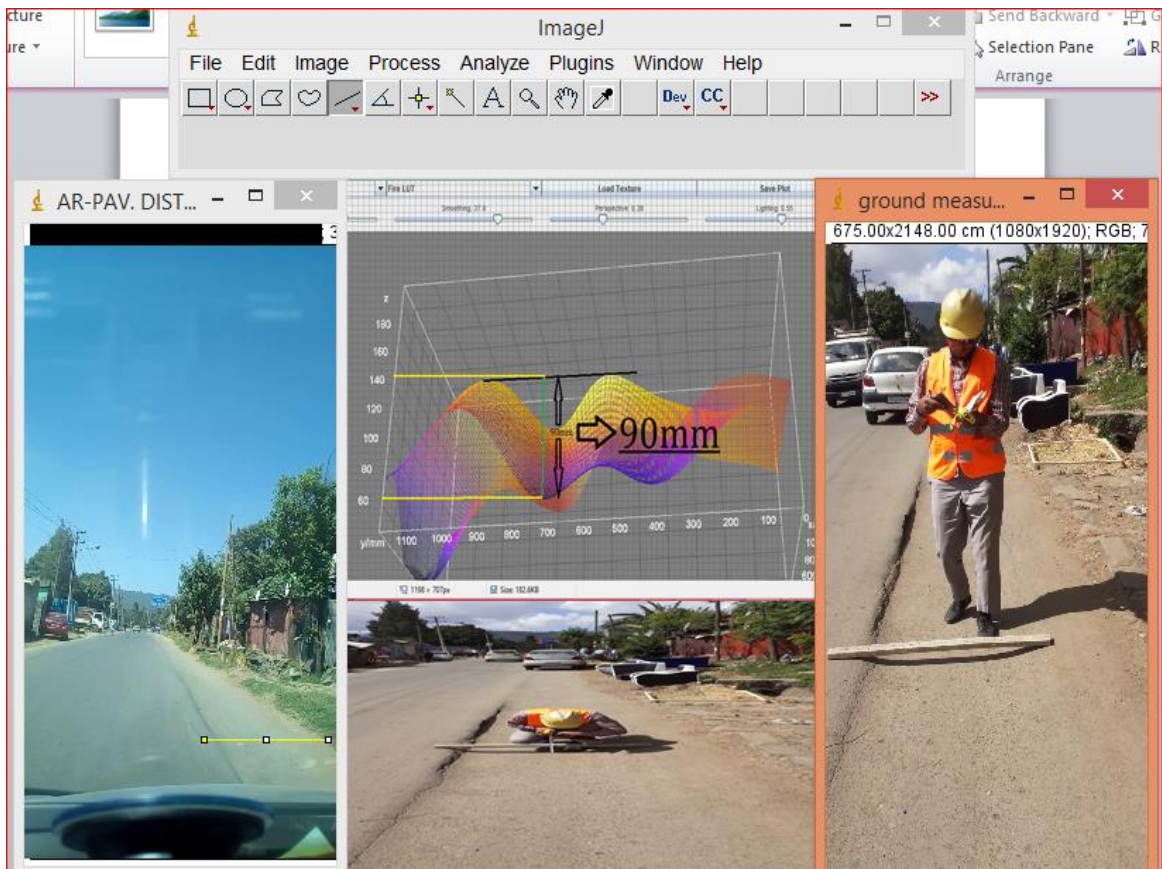


Figure 23: Rutting Manual vs. Software Measurement Comparison

Rutting depth Manual Measurement =9.95cm

Software Rutting Depth=90mm

- Error= Manual Measurement – Software Measurement
- Error= 99.5-90.0= 9.5mm
- %Error= (99.5-90.0)/ (99.5*100)=9.54%

The error in this rutting computation, with 9.54%, which has a greater than 90% confidence range, is acceptable at 9.95 cm by manual measurement and 9.0 cm by software.

6.3.3 Manual vs. software alligator cracking area measurement comparison

✚ Pixel distance=2.0736, Known distance=250 cm, Pixel ratio=1.79, Unit of length=cm

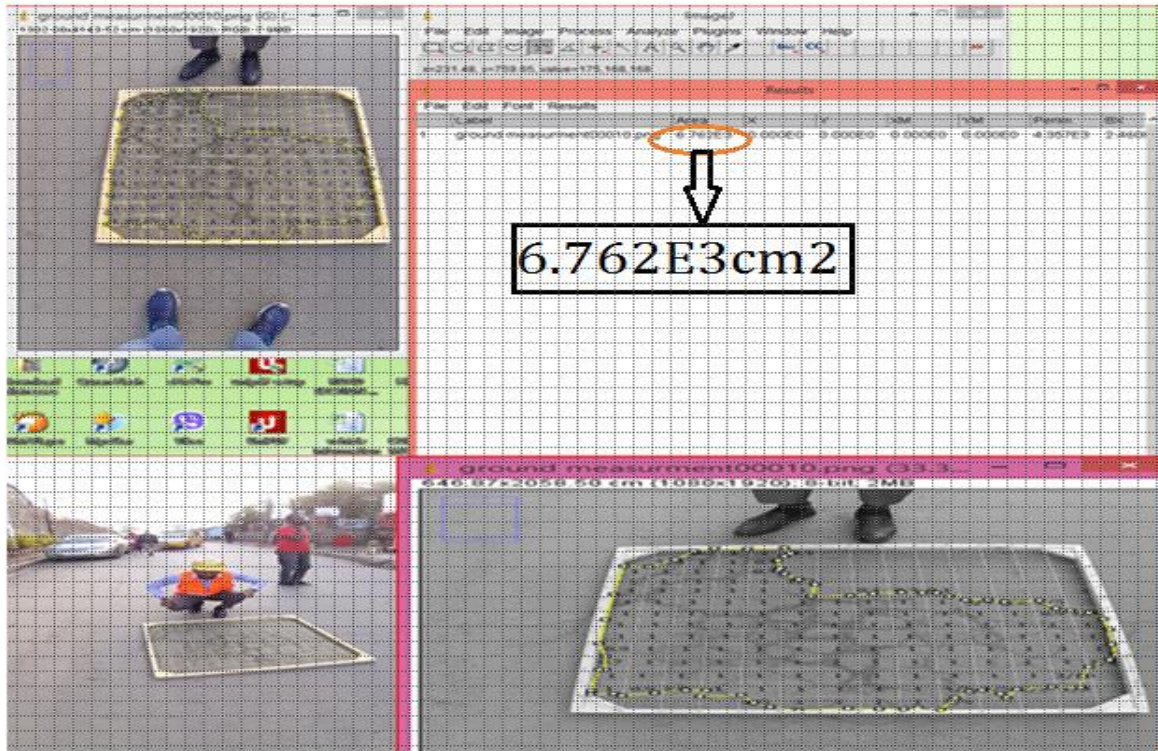


Figure 24: Cracking Manual vs. Software Measurement Comparison

✚ Alligator cracking Area Manual Measurement

$$= [(0.7*2) + (117*1) + (0.1*3) + (1/5*3) + (0.9*5) + (1/2*3) + (0.2*1) + (3/4*2) + (3/10*1) + (2/5) + (4/5*2) + (3/5*1) + (1/9*1)] * 0.07m * 0.07m = \underline{0.6345m^2}$$

- Error= Manual Measurement – Software Measurement
- Error = 0.6345-0.6762= -0.0417m
- %Error= (0.6345-0.6762)/ (0.6345*100)= -6.57%

In a similar vein, the alligator cracking manual and software results are both 0.6345 and 0.762, respectively, indicating an acceptable error of 6.57% with a better than 90% confidence interval.

6.3.4 Manual vs. software longitudinal/transverse cracking length measurement comparison

✚ Pixel distance= 1920, Known distance= 500m, Pixel ratio=1.79, Unit of length=cm

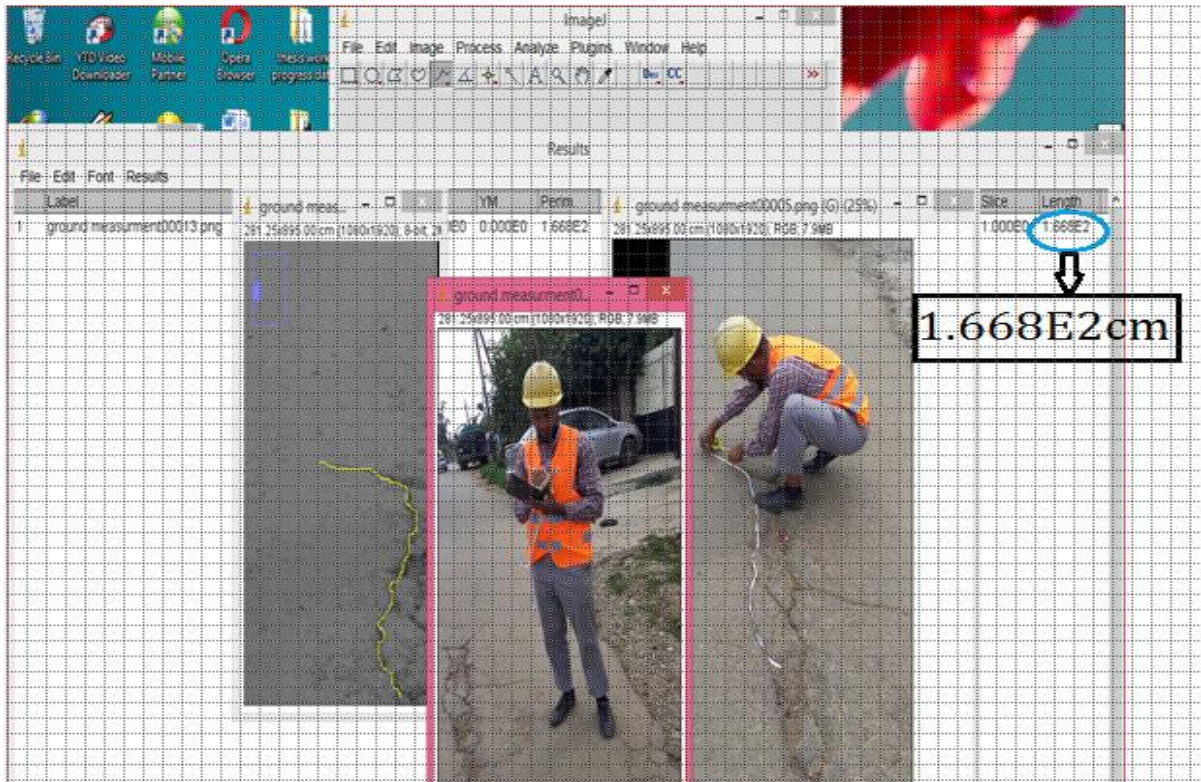


Figure 25: Longitudinal Cracking Manual vs. Software Measurement Comparison

✚ Longitudinal Cracking Manual Measurement

Road Length=1.7m

- Error= Manual Measurement – Software Measurement
- Error = 1.7m-1.67m= 0.03m
- %Error= (1.7-1.67)/(1.7*100)= 1.76%

The longitudinal cracking manual result in the same calculation is 1.67 m, whereas the software result is 1.7 m; this suggests that the confidence interval is greater than 95%, making it more accurate than the other distress calculations.

Table 12: Manual vs. software Measurement Comparisons Summary

No.	Types of distress	Manual Measurement			Automated Measurement			Error			%Error
		Area(m ²)	Length (m)	Depth (mm)	Area (m ²)	Length (m)	Depth (mm)	m ²	m	mm	
1	Pothole	0.182			0.169			0.013			7.08791
2	Rutting			99.5			90			9.5	9.54774
3	Alligator cracking	0.6345			0.6762			-0.04			-6.5721
4	Longitudinal Cracking		1.7			1.67			0.03		1.76471

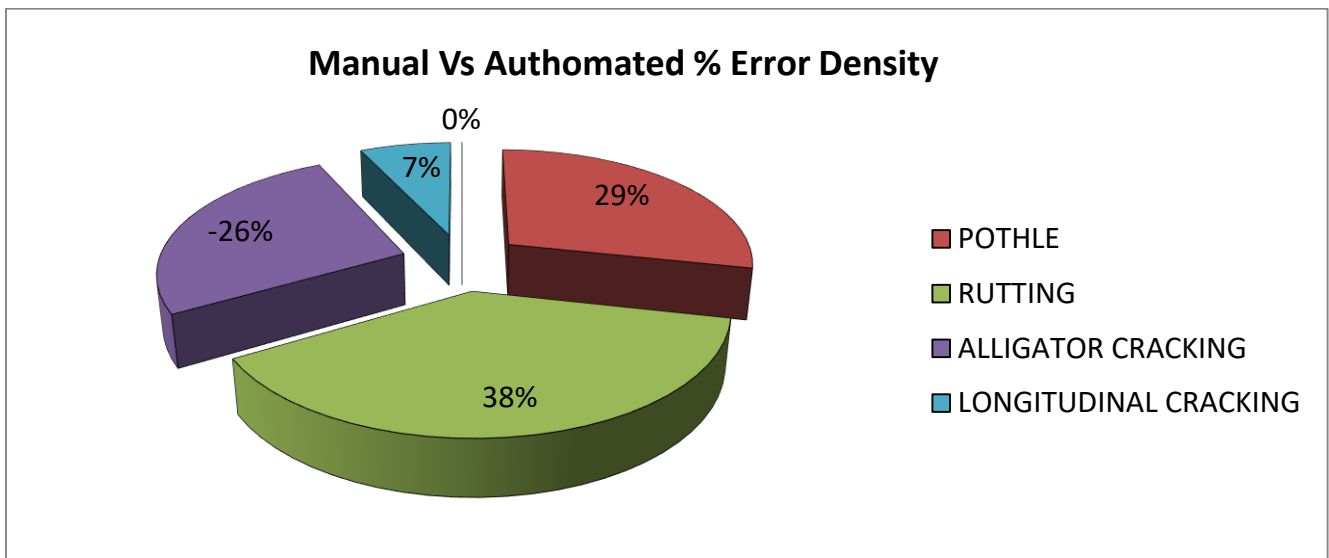


Figure 26: Manual Vs Software Measurements Distresses Percentage Error Composition

The examination of manual vs. software measurement methods mentioned above reveals that the rutting measurement error has a maximum size of 9.5 percent. This demonstrates that the assessment technique software produces accurate results. Measurement errors account for 38% of the total comparison, which is the highest.

Table 13: Density % of All Pavement Distresses by Severity Level

Location	Starting Pt.	Ending Pt.	Distress Severity Level (m ²)		
			L	M	H
A. Ketama	Chew Berenda	Gulit Sefer	0.14928	0.372	0
Akaki	D/Tulu School	Quality Total	106.08	148.3	34.31
Arada	Seba Dereja	Afinchober	0.657	0.808	20.99
Bole	Dinberuwa	22-Mazoria	0.33	0	0.025
Gulele	Ethio-Clinic	Tibeb Edget	2.4	3.01	1.139
Kirkos	Posta Bet	Wudassey	83.69	4.807	5.222
Kolfe	Efoyta	Taywan	1.0504	1.387	2.254
Lideta	Lideta Cond.	Geja Sefer	0.0745	0.417	1.777
Nifas Silk L.	Saris Gebeya	Bihere Tsige	16.617	2.065	4.199
Yeka	Fereseigna	M/Ateqalay	1.965	4.178	5.626
Total			213.014	165.34	75.55
Density %			46.93	36.43	16.64

According to the results of Table 13 above, the distressed severity levels of the chosen study sections have a density of 46.93% low, 36.43% medium, and 16.64% high. This shows that the majority of distressed vehicles are at low damage levels, and if immediate maintenance actions have been taken, we can reduce the maintenance cost and guarantee the comfort of the ride.

Table 14: Summary of Pavement Distresses over the study area

Distresses Summary m ²								
Total study Area = 7*500*10 = 35000m ²								
No.	Sub-City	Starting Pt.	Ending Pt.	Patching	Pothole	Ravelling	Cracking	Rutting
1	A. Ketama	Chew Berenda	Gulit Sefer	-	0.52	-	0.0128	-
2	Akaki	D/Tulu School	Quality Total	-	12	1.5	206	-
3	Arada	Seba Dereja	Afinchober	19.4	2.41	1.1	20.652	0.258
4	Bole	Dinberuwa	22-Mazoria	-	0.33	2.04	0.025	-
5	Gulele	Ethio-Clinic	Tibeb Edget	4.01	3.21	3.11	-	-
6	Kirkos	Posta Bet	Wudassey	144	9.43	6.08	0.157	-
7	Kolfe	Efoyta	Taywan	2.31	2.43	2.38	0.0528	-
8	Lideta	Lideta Cond.	Geja Sefer	0.865	1.67	0.757	-	-
9	Nifas Silk L.	Saris Gebeya	Bihere Tsige	-	5.72	2.31	14.9	-
10	Yeka	Feresegna	M/Ateqalay	6.69	4.71	2.59	0.369	0.057
Total				177.275	42.43	21.867	222.0263	0.315
Grand Total				463.9133				
Composition of Distresses				38.25%	9.15%	4.62%	47.90%	0.07%
Total Distresses Over the Study Area				(463.9133/35000)*100 = 1.32%				

The pavement condition survey of the study's chosen sample units is shown in the above table, and it was discovered that 463.46 sq.m. A total of 35000 sq.m. Or 1.32 percent, of the study area was affected by various distresses. Cracking accounts for the largest portion of total distresses (222.02 square meters), and rutting accounts for the smallest portion (0.315 square meters).

Table 15: Distresses Density and Corresponding causes

Total Study Area = 35000m²						
Distress Type	Distress Description	Units	Distress Area	Distress Density%	Distress Density Over Study Area %	Causes of Distress
1	Alligator Cracking	Sq.m	222.0263	47.906	0.634	Load
13	Pothole	Sq.m	42.43	9.155	0.121	Load(abrasion of small pieces of pavement surface by traffic)
11	Patching	Sq.m	177.250	38.250	0.507	All
4	Raveling	Sq.m	21.417	4.621	0.061	Durability(poor quality mixture) and hardened binder
10	Rutting	mm	0.315	0.068	0.001	Load/Material
Total			463.4633	100%	1.32%	

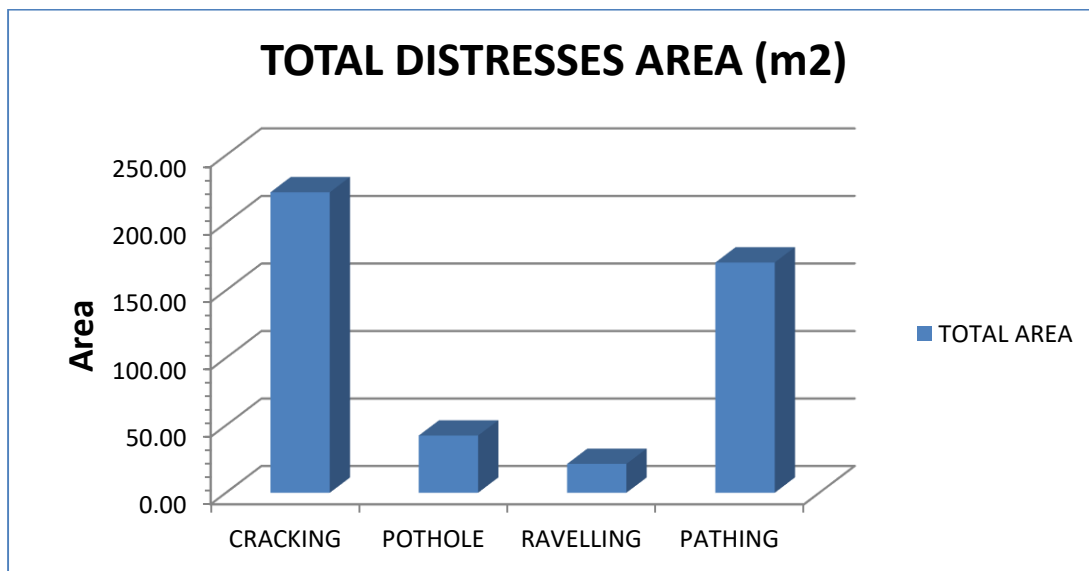


Figure 27: Cumulative Distresses Area

The above table and image illustrate the overall distress area covered by the study sections. Vehicular load, which has a distress density of 47.906%, is the main factor contributing to the large area of the distress case.

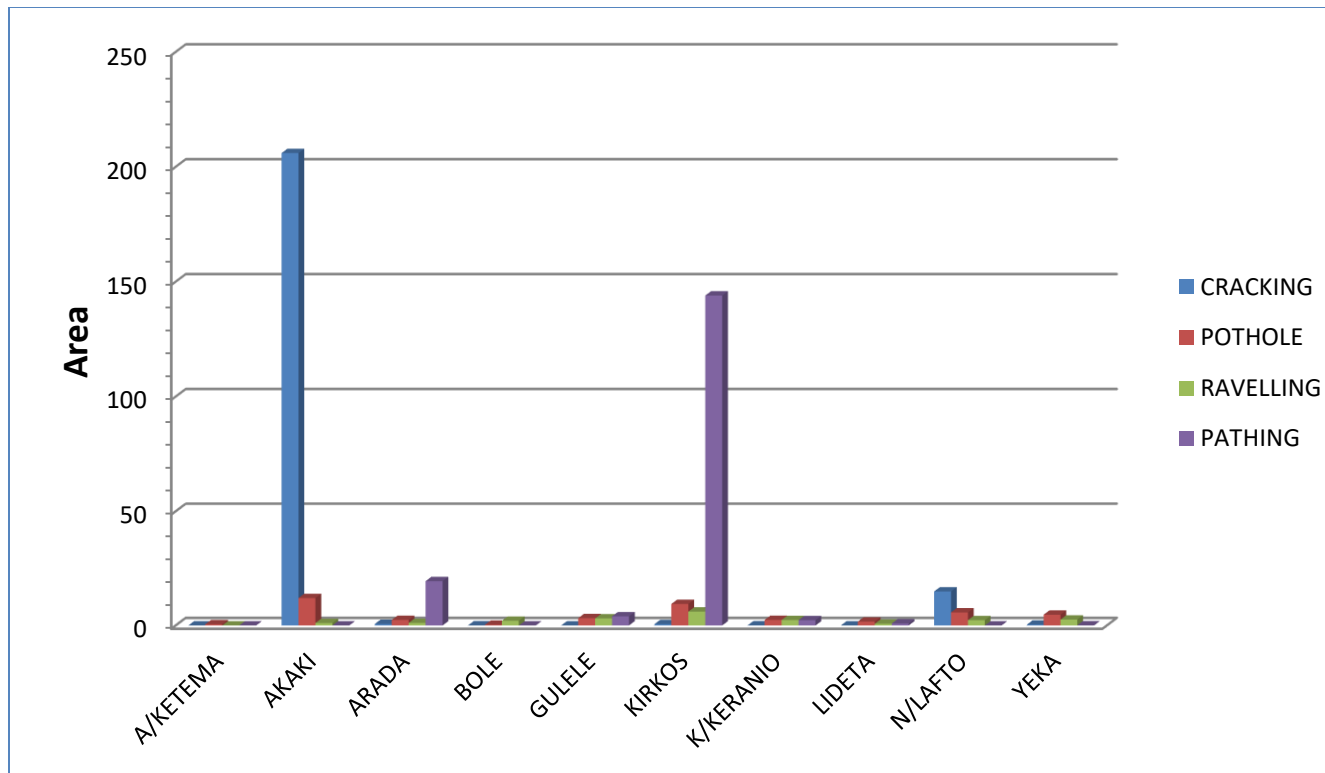


Figure 28: Distress Area Distribution on Selected Road Section

The figure below shows how the study road sections' distress areas are distributed. The areas with the most distresses were in Akaki Sub city under Derartu Tulu High School to the quality total road section, while the areas with the least distresses were in Addis Ketema Sub City with in Chew Brenda to Gulit Sefer pavement section, which was recently built when the data was collected.

Table 16: Number of Distresses per Each Section

Distresses Summary By Number								
No.	Sub-City	Starting Pt.	Ending Pt.	Patching	Pothole	Raveling	Cracking	Rutting
1	A. Ketama	Chew Berenda	GulitSefer	0	15	0	2	0
2	Akaki	D/Tulu School	Qality Total	0	39	2	15	0
3	Arada	SebaDereja	Afincho ber	1	9	2	2	3
4	Bole	Dinberuwa	22-Mazoria	0	2	2	1	0
5	Gulele	Ethio-Clinic	Tibeb Edget	6	13	4	0	0
6	Kirkos	Posta Bet	Wudassey	7	53	10	1	0
7	Kolfe	Efoyta	Taywan	5	22	4	6	0
8	Lideta	Lideta Cond.	GejaSefer	1	7	2	0	0
9	Nifas Silk L.	Saris Gebeya	BihereTsige	0	13	4	1	0
10	Yeka	Feresegna	M/Ateqalay	14	24	4	12	1
Sub Total				34	197	34	40	4
Total				309				

The frequency of the various distresses across all research sections is displayed in the table above. As a result, the research area's overall maximum number of instances of discomfort related to potholes is 197. For rutting, four times is the minimum number of occurrences that have been reported. This demonstrates that abrasion from traffic load occurred often on a section of pavement material.

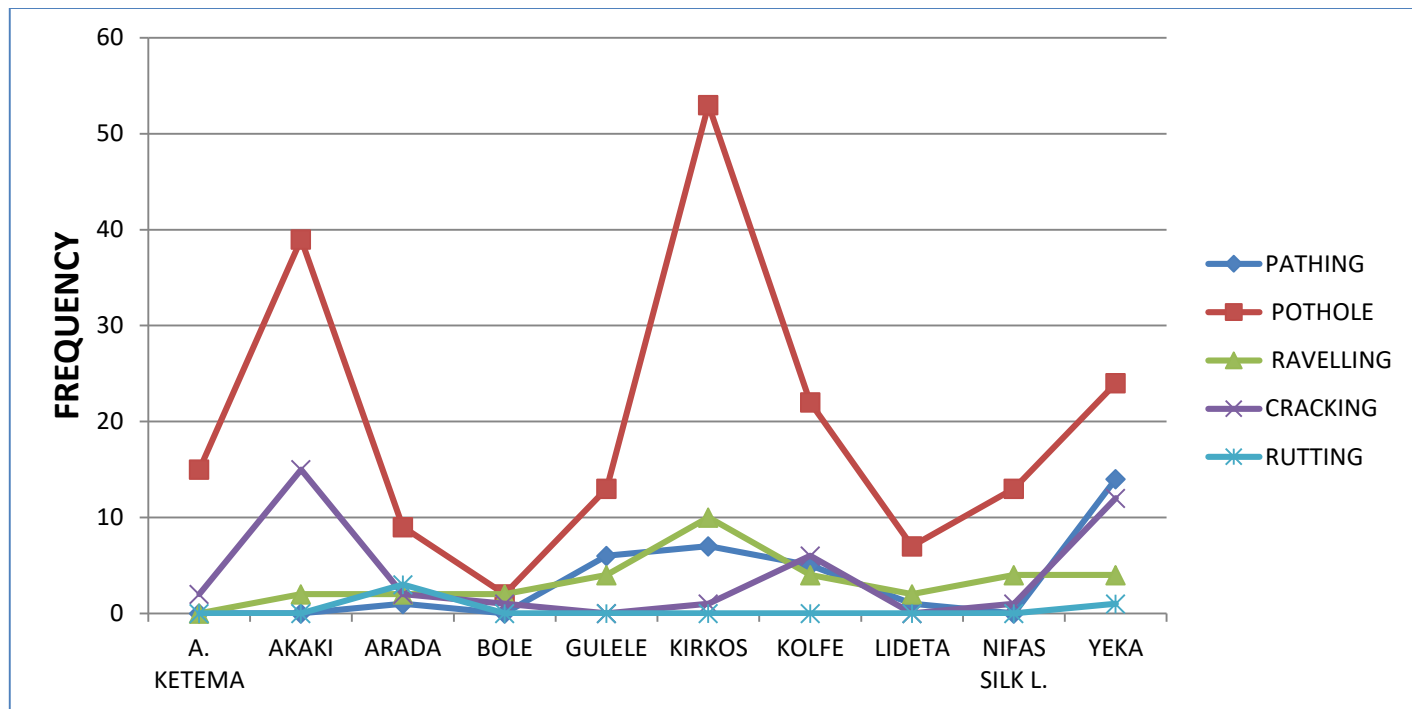


Figure 29: Distresses Frequency per Each Section

Figure 29's line graph shows how frequently pavement distresses occur throughout the study area. The red color denotes potholes with a maximum frequency, whereas the pale blue tint refers to minimum frequency distresses that indicate rutting. Which suggests that potholes caused a significant portion of the distress in the research area, possibly as a result of heavy traffic.

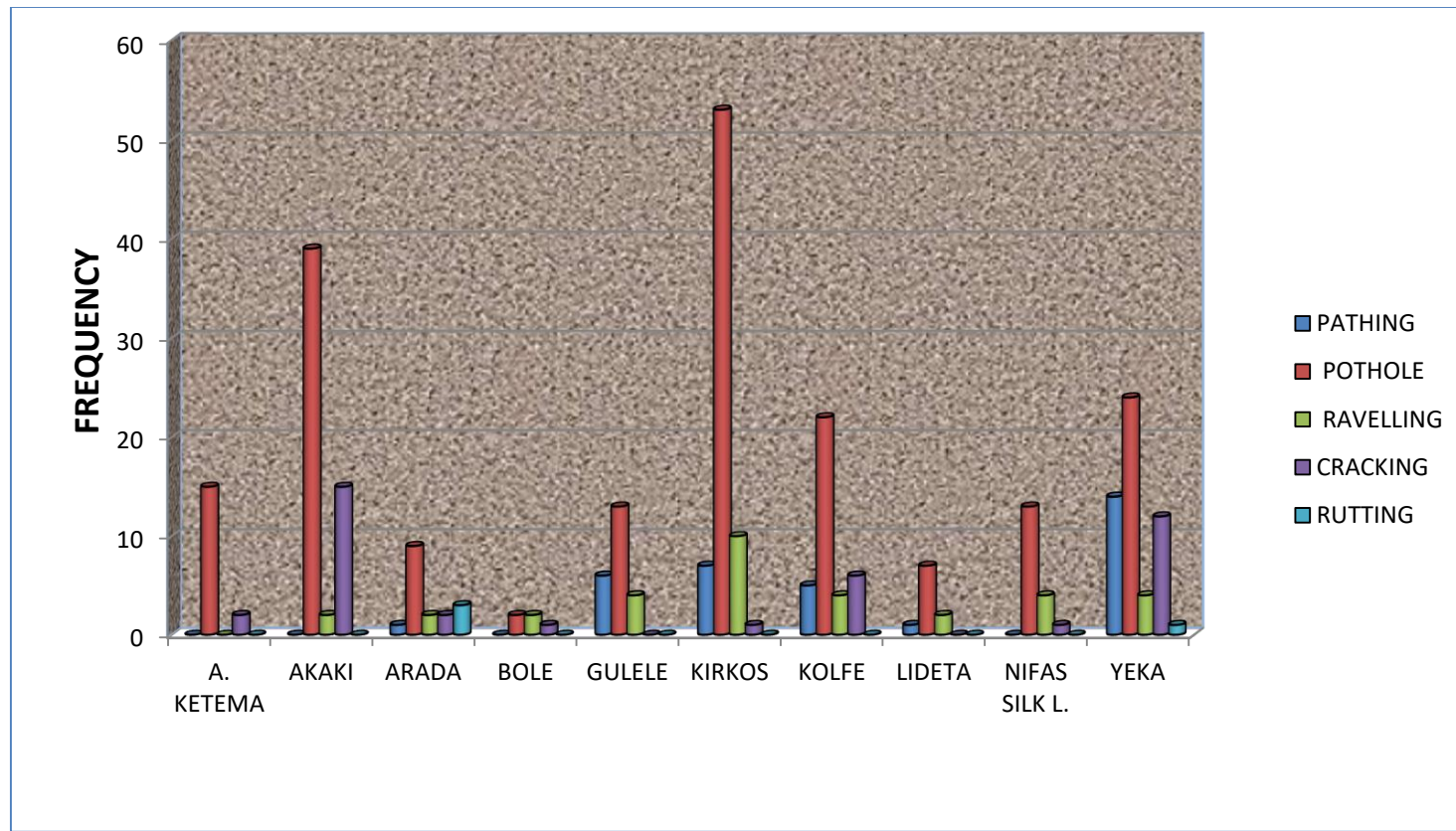


Figure 30: Pavement Distresses Distribution

The aforementioned graphic illustrates how frequently the pavement segments under consideration experience distress. The Posta Bet to Wudasse pavement segment of the Kirkos sub-city saw the highest distress on average, according to this graphic and the output described above. The lowest frequency was found in the Dinberuwa to 22 Mazoria pavement stretch of the Bole sub-city.

6.4 PCI calculation

The PCI (pavement condition index) is thought to be the most important component in assessing the state of the road. The following methods are used to determine PCI after distress data is generated using ASTM D 6433.

1. Examine a sample unit, identify the type of distress and its degree, and then quantify the density (percent)
2. For each distress kind and severity, the deduct values are calculated using the deduct value curve.
3. By adding up all of the individual deduct values, a total deduct value (TDV) is calculated.
4. After computing the TDV, the correction curves can be used to calculate the corrected deducted value (CDV). If an individual deducts, the CDV is calculated accordingly.
5. Value is higher than the CDV, the CDV is set equal to the highest individual deduct value.
6. The PCI is computed using the relation $PCI = 100 - CDV$.

From PCI value the paved ID rated as per the following

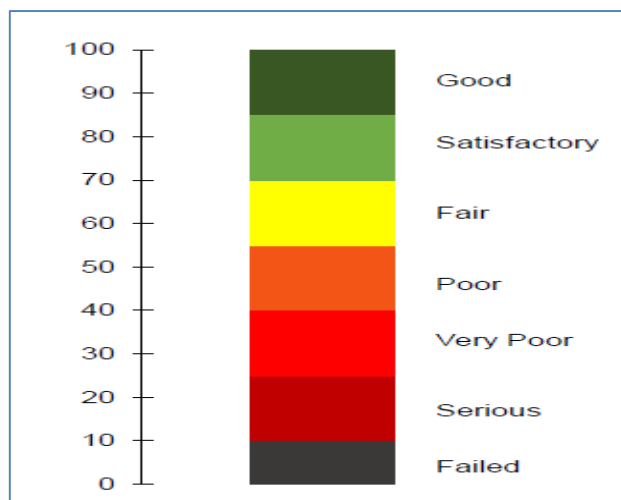


Figure 31: ASTM D6433 Standard PCI Rating Scale [3].

6.4.1 Pavement condition index (PCI) results

Having each pavement's density upset the software, On the basis of the information gathered during the pavement condition survey, comprehensive calculations for PCI evaluation for each pavement segment are described below.

To calculate the pavement condition index, the aforementioned tables were examined. These are chosen in accordance with the methodology described. According to the analysis's findings, the pavement segments on Chew Berenda, Ethiopia Clinic, Dinberuwa, and Taywan Roads have PCI values greater than 90, indicating that they are either newly constructed or nearly so, as shown by the position of the normal PCI curve. The pavement sections at Seba Dereja and Lideta Condominium have PCI values of 77 and 63, respectively, indicating that the roads are rated as satisfactory and fair, respectively. A prompt maintenance action is required due to the crucial PCI value of 56 for the Feresegna Sefer pavement segment. Finally, the pavement sections of Posta Bet, Bihere Tsige, and Quality Total have PCI values that are less than 37, indicating that the road is about to collapse and that action should be taken to reconstruct it. See table 17 below for a summary of the findings.

Table 17: Summary of the Pavement results

Final pavement sections summary					
Name of pavements	TDV	CDV	PCI	Rating	Rank
Addis K.(Chew Berenda-Gult Sefer)	2	2	98	Good	9
Arada(Seba Dere. - Afincho Ber)	48.2	37	63	Fair	5
Gulele(Ethio Clinic - Tibeb Edget)	4.4	5	95	Good	8
Kirkos(Posta Bet – Wudasse Diagnostic)	143	63	37	Very poor	3
Yeka(Feresegna S. – Mesrak Ateqalay)	59.6	44	56	Fair	4
Kolfe K. (Efyta – Taywan gebeya)	7	7	93	Good	7
NifasSilk L.(Saris Gebeya - Bihere Tsige)	137	68	32	Very poor	2
Bole(Dinberuwa - 22 Mazoria)	0	0	98.5	Good	10
Lideta(Lideta Cond. - Ggja Sefe)	23	23	77	Satisfactory	6
Akaki(Tulu Dimtu - Quality Total)	286.26	80	20	Serious	1

According to the above summary of pavement distress sections, the pavement conditions in Chew Berenda, Ethiopian Clinic, Efoyta, and Dinberuwa are in a Good condition. Posta Bet and Saris Gebeya portions are in very poor condition, whereas Seba Dereja and Feresegna Sefer sections are in fair condition. Lideta Condominium section is rated satisfactorily. The school area of Derartu Tulu is now in a serious severity level. Conferring to the results of the PCI calculation, the road section that needs to be maintained first is the road from Akaki Sub City to

Tulu Dimtu Kaliti Total, and the last level is the pavement section from Dinberuwa to the 22 Mazoria in Bole Sub City.

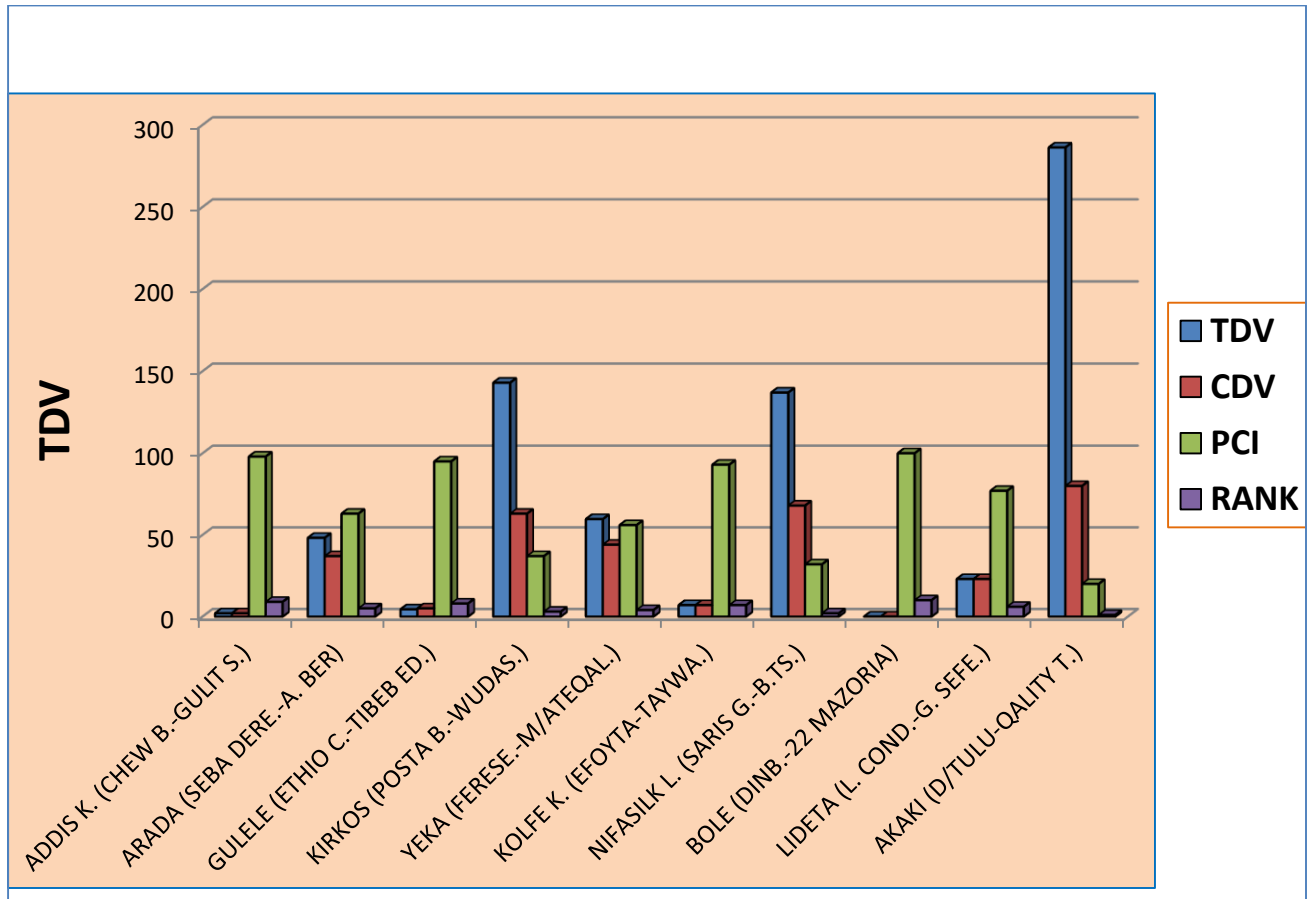


Figure 32: Summery of Pavement Results

The aforementioned bar graph shows the overall study pavement sections' calculated value, corrected computed value, pavement condition index value, and priority order of the distressed parts. Therefore, based on the results, the Derartu tulu pavement portion will receive first priority maintenance, whereas the Dinberuwa pavement section will receive last priority maintenance due to its severe pavemen condition.

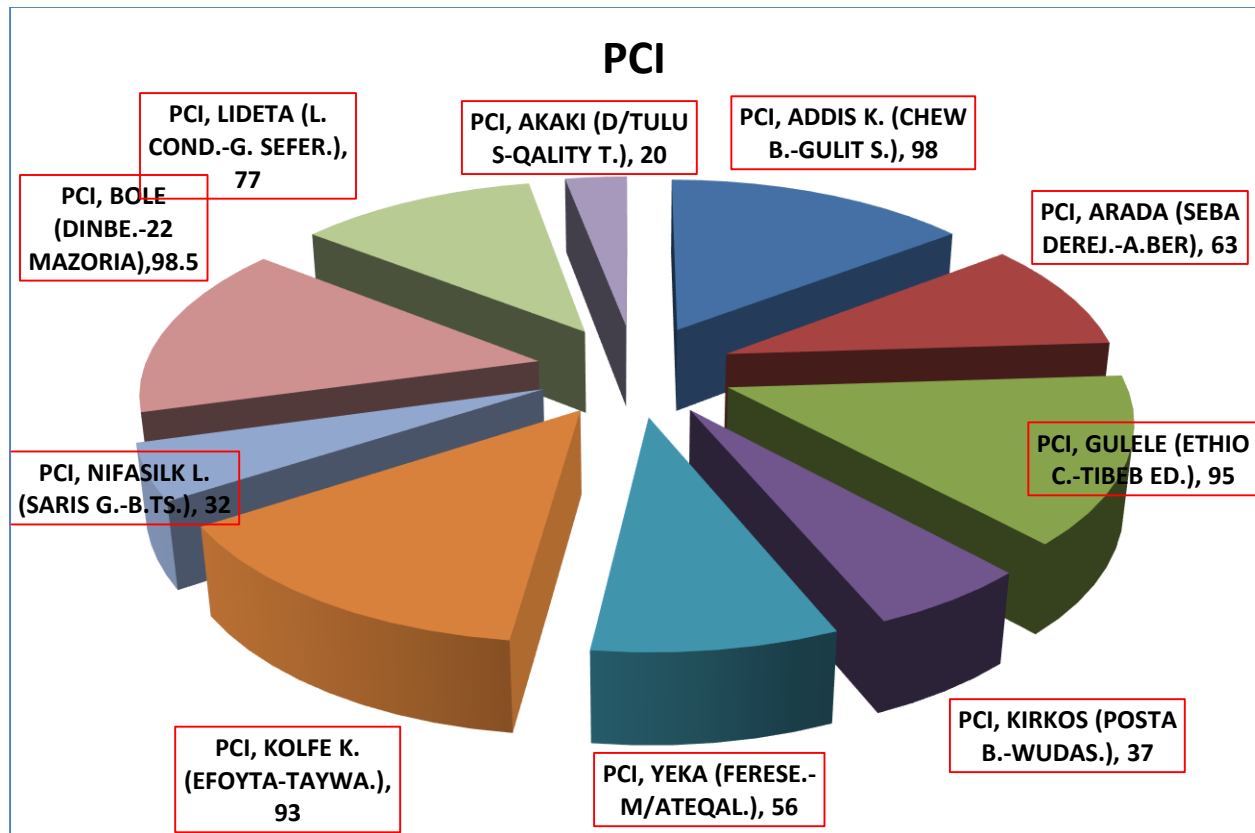


Figure 33: Pavement Condition Index Value

The final pavement condition index result for the study area is depicted in the pie chart above. The PCI value varies from 98.5 to 20, which denotes good and collapsed pavement conditions respectively.

6.5 Pavement priority ratings and ranking using PCI method

The Pavement Condition Index Values vary from zero (pavement in degraded condition) to 100 based on the analysis's findings (perfect condition pavement). Sections with lower PCI Values had higher maintenance priorities. This PCI Value was later transformed into a priority rating scale. Each section was given a priority ranking based on the priority rating value, as shown in the table below. Akaki section Road is discovered to have the highest priority rank with the lowest priority rating value in this study, while Bole section Road has the lowest priority rank with the highest priority rating value.

Table 18: PCI, Rating and Rank Summary

PCI, Rating and Rank Summary				
No.	Name of pavements	PCI	Rating	Rank
1	Addis K.(Chew B.-Gult S.)	98	Good	9
2	Arada(Seba Dere. - A. Ber)	63	Fair	5
3	Gulele(Ethio C. - Tibebe Ed.)	95	Good	8
4	Kirkos(Posta B. - Wudas)	37	Very poor	3
5	Yeka(Ferese. - M/Ataqal)	56	Fair	4
6	Kolfe K. (Efyta - Taywa.)	93	Good	7
7	NifasSilk L.(Saris G. - B. Ts)	32	Very poor	2
8	Bole(Dinb. - 22 Mazoria)	98.5	Good	10
9	Lideta(L. Cond. - G. Sefe)	77	Satisfactory	6
10	Akaki(D/Tulu - Qality T.)	20	Serious	1

The Derartu Tulu pavement part will receive first priority for maintenance due to a serious severity rating, and the Dinberuwa pavement section will receive last priority because of the pavement's good state of condition.

6.6 Recommended maintenance type for the study pavement sections

The distress data had entered the Pavement management & maintenance system, and a PCI was produced after gathering and summarizing the distress kind, severity, and amount for each of the inspected sample units. Depending on the density of the distress, the PCI technique employs predefined deduct curves to calculate how many points should be subtracted for each distress type/severity combination. To determine an overall PCI for that segment, the PCIs of the examined sample unit were then averaged. The PCI rating gives a broad idea of the degree of rehabilitation that could be required to fix a particular pavement. In general, when the PCI is higher than 60, maintenance procedures like crack sealing and patching frequently benefit. However, more sophisticated and expensive remedies will be required as the pavement continues to erode. A variety of substantial repairs, from overlays to reconstruction, are suitable for pavements with a PCI between 40 and 60. Reconstruction is often the only workable option once the PCI falls below 40. The PCI inputs, rating scale, and related general job repair levels are shown in Figure 34.

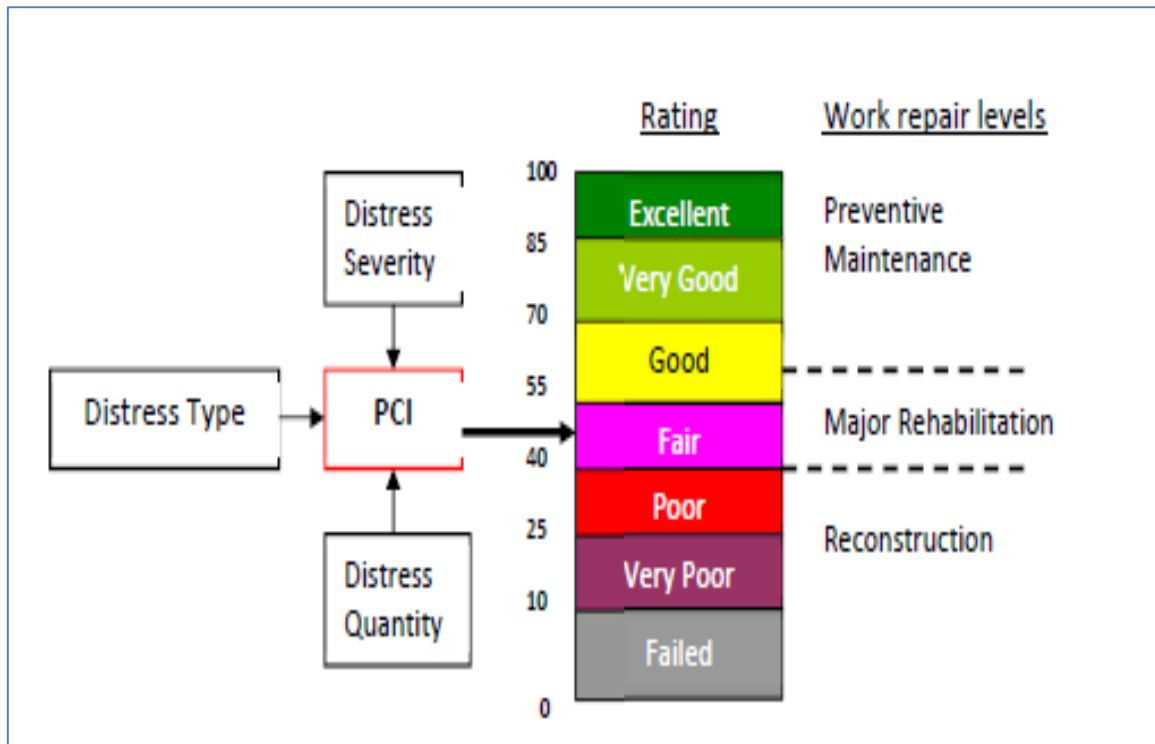


Figure 34: PCI rating scale and repair levels [27]

The advised maintenance for the pavement portions is continuation of the current maintenance strategy based on the calculated rating. The analytical results shown in Table 18 were utilized as a guide to pick the best maintenance strategy for this study. For each form of distress at a specific severity level, the maintenance techniques presented in Figure 34 are realistic.

CHAPTER 7

7.0 CONCLUSION AND RECOMMENDATION

7.1 Conclusions

Based on the results the following points had concluded

1. The image-based pavement condition assessment methodologies proposed in this thesis are more cost-effective, effective, and practically adaptable than the conventional visual pavement inspection methods since they don't require the usage of specialist equipment like lights, lasers, etc.
2. The PCI value of the pavement segment helps the road authority decide on upcoming maintenance and rehabilitation activities in addition to providing information on the asset's existing state.
3. Roads require a simple, suitable, and refined decision-making methodology, and the thesis's Pavement Assessment Method provides such a program. It is an innovative, sound maintenance program that also considers databank availability and economics.
4. This study demonstrates the applicability of the advantages of utilizing image processing to assess traffic distresses. It demonstrates how simple, secure, and quickly the procedure may be executed. This method can replace conventional road measures, which are tiresome, time-consuming, and risky for the individuals involved. Using ImageJ software, image measurements had been applied to various highway distresses. Digital and manual measurements have been made of the disturbed area's length and width in cases of longitudinal, transverse fractures, and potholes. The findings demonstrate that picture measurements are fairly close to those made using manual techniques. Additionally, this inquiry demonstrates how image measurement can be used in a variety of civil engineering specialties.
5. Based on the pavement distress summary pictured above, we can deduce that potholes occur more frequently than other distresses in all pavement sections. Alligator cracking, which accounts for 47.9 percent of the overall distress area coverage, is also a result of severe traffic load. Additionally, 46.93% of all distresses have low severity, meaning that the majority of pavement sections require preventive treatment to increase the pavement's useful life.

6. In the 3D approach, as we saw with the rutting analysis, it has been employed to enable a 3D construction of the pavement surface, which may provide sufficient information to conduct a thorough road condition survey for various types of distresses.

7.2 Recommendations

1. The image processing software Imagej that we utilized for this thesis is really effective. It can be developed by a researcher because it is java-based. Therefore, in addition to what we attempted in this thesis, we can process the pavement distress photographs in a highly efficient and accurate manner by writing java code to the macro of the software.

2. It is advised that, a researcher conduct a condition assessment survey on pavements and determine its PCI based on the lessons learned from the activities performed during the completion of the thesis. Every year, a different researcher should survey and count the same pavement, and every four years, a researcher should be tasked with combining the results of the four surveys to create PCI curves with features or families that may be used to predict future PCI conditions.

3. The PCI value for the Quality pavement in the study area parts is 20, which indicates a serious severity level due to heavy traffic load. Since this segment is a part of the Addis to Djibuti Corridor, concrete pavement is advised to have instead of asphalt pavement.

4. The existence of the pavement condition in question in a Critical PCI Range, such as the Feresegna Sefer Pavement Section, justifies prompt rehabilitation. If not, reconstruction is required, which will cost a lot of money.

5. According to the study, six pavement sections (Chew Berenda, Seba Dereja, Ethiopia Clinic, Efoyta, Dinberuwa, and Lideta Condominium) need preventative maintenance, the remaining pavement parts (Posta Bet, Saris Gebeya, and Derartu Tulu School) require reconstruction because they are in extremely poor and serious severity levels, respectively.

7.3 Recommended future work

1. To create a more dependable real-time, fully automated pavement inspection system, incorporate the 2D and 3D Automatic distress detecting mechanism.

2. An iterative excel deducted and corrected deducted curve template could be created to calculate PCI rather than searching for deductive curves for each distress.

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APPENDIX A

Table: Localized maintenance policy for asphalt surfaces.

Distress type	Distress severity	Maintenance treatment
Alligator cracking	Low	Crack Sealing - AC
	Medium	Patching - AC Deep
	High	Patching - AC Deep
Bleeding	N/A	Monitor
Block cracking	Low	Monitor
	Medium	Crack Sealing - AC
	High	Crack Sealing - AC
Corrugation	Low	Monitor
	Medium	Patching - AC Deep
	High	Patching - AC Deep
Depression	Low	Monitor
	Medium	Patching - AC Shallow
	High	Patching - AC Deep
Jet blast	N/A	Patching - AC Shallow
Joint reflection cracking	Low	Monitor
	Medium	Crack Sealing - AC
	High	Crack Sealing - AC
Longitudinal & transverse cracking (L&T cracking)	Low	Monitor
	Medium	Crack Sealing - AC
	High	Crack Sealing - AC
Oil spillage	N/A	Patching - AC Shallow
Patching	Low	Monitor
	Medium	Patching - AC Shallow
	High	Patching - AC Deep
Polished aggregate	N/A	Monitor
Raveling	Low	Monitor
	Medium	Surface Treatment
	High	Patching - AC Shallow
Rutting	Low	Monitor
	Medium	Patching - AC Deep
	High	Patching - AC Deep
Shoving	Low	Monitor
	Medium	Patching - AC Shallow
	High	Patching - AC Deep
Slippage cracking	N/A	Patching - AC Shallow
Swelling	Low	Monitor
	Medium	Patching - AC Deep
	High	Patching - AC Deep
Weathering	Low	Monitor
	Medium	Surface Treatment
	High	Patching - AC Shallow

APPENDIX B

Table: Distress Data Survey Sheet for Sample Unit

PAVEMENT ROADS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT		Sketch 500m				
BRANCH..... <u>GULELE</u> SURVEYED BY..... <u>JIBRIL</u> SAMPLE AREA..... <u>3500m²</u> SECTION..... <u>TIBEB EDGET</u> DATE..... <u>FEB./2019</u>						
1. Alligator cracking * 6. Depression 11. Patching * 2. Bleeding 7. Edge cracking 12. Polished Aggregate 3. Block cracking 8. Jt. Deflection cracking 13. Potholes* 4. Weathering/Raveling* 9. Long & Trans cracking* 5. Corrugation 10. Rutting*						
Distress Severity	Quantity(m ²)			Total	Density%	Deduct value
13M	0.381	0.120	0.307	0.808	0.023	5
13L	0.128	0.401	0.129	0.827	0.236	2.1
13H	0.418	0.229	0.298	0.945	0.027	20.1

where, L = LOW, M= MEDIUM and H= HIGH

APPENDIX C

Table: Pavement condition index result

ADDIS KETEMAK.K (CHEW BERENDA – GULITSEFER)															
NO.	DEDUCTED VALUES (DV)										TOTAL (DV)	q	CDV		
1	0	0	2	0	0	0	0	0	0	0	BLANK	BLANK	2	1	2
2	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	1	0
SUM (TOTAL DV)												2			
CDV												2			
PCI												98			
RATING												Good			

ARADA K.K (SEBADEREJA – AFINCHOBER)															
NO.	DEDUCTED VALUES (DV)										TOTAL (DV)	q	CDV		
1	2	0	2	0	0	3	0	0	0	0	BLANK	BLANK	7	1	7
2	0	0	0	14	0	0	0	0	0	0	BLANK	BLANK	14	1	12
3	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
4	5	0	0	20.1	0	2.1	0	0	0	0	BLANK	BLANK	27.2	4	11
5	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0		0
SUM (TOTAL DV)												48.2			
CDV												25			
PCI												75			
RATING												Fair			

GULELEK.K(ETHIOPIA CLINIC – TIBEBEDGET)															
NO.	DEDUCTED VALUES (DV)										TOTAL (DV)	q	CDV		
1	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
2	0	0	2.3	0	0	2.1	0	0	0	0	BLANK	BLANK	4.4	1	5
3	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
SUM (TOTAL DV)												4.4			
CDV												5			
PCI												95			
RATING												Good			

Image Based Pavement Condition Assessment

BOLE K.K(DINBERUWA - 22 MAZORIA)																			
NO.	DEDUCTED VALUES (DV)											TOTAL (DV)	Q	CDV					
1	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	1.5	1	1.5
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
												SUM (TOTAL DV)	1.5						
												CDV	1.5						
												PCI	98.5						
												RATING	Good						

KOLFEKEANIOK.K(EFOYTA MARKET CENTER - TYWAN ROAD)																			
NO.	DEDUCTED VALUES (DV)											TOTAL (DV)	q	CDV					
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
2	0	0	0	0	7	0	0	0	0	0	0	0	0	0	BLANK	BLANK	7	1	7
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
												SUM (TOTAL DV)	7						
												CDV	7						
												PCI	93						
												RATING	Good						

KIRKOS K.K(POSTA BET - WUDASSIEY DIAGNOSTIC)																			
NO.	DEDUCTED VALUES (DV)											TOTAL (DV)	q	CDV					
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
2	0	0	0	0	7	0	0	0	0	0	0	0	0	0	BLANK	BLANK	9	1	9
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	134	6	65
												SUM (TOTAL DV)	143						
												CDV	63						
												PCI	37						
												RATING	Very poor						

LIDETAK.K (LIDETA CONDOMINIUM- GEJASEFER)																			
NO.	DEDUCTED VALUES (DV)											TOTAL (DV)	q	CDV					
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
2	0	0	0	0	23	0	0	0	0	0	0	0	0	0	BLANK	BLANK	23	1	23
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
												SUM (TOTAL DV)	23						
												MAX. CDV	23						
												PCI	77						
												RATING	Satisfactory						

Image Based Pavement Condition Assessment

NIFAS SILK LAFTOK.K(SARIS MARKET CENTER - BIHERE TSIGE)															
NO.	DEDUCTED VALUES (DV)										TOTAL (DV)	q	CDV		
1	3	0	0	0	0	0	0	0	0	0	BLANK	BLANK	3	1	3
2	12	0	24	27	8	7	6	25	25	BLANK	BLANK	134	7	62	
3	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0	
SUM (TOTAL DV)												137			
MAX. CDV												68			
PCI												38			
RATING												Very poor			

AKAKI KALITY K.K(DERARTU TULU HIGH SCHOOL - KALITY TOTAL)															
NO.	DEDUCTED VALUES (DV)											TOTAL (DV)	q	CDV	
1	1	1	2	0.38	1	1	0.74	0.99	0.15	BLANK	BLANK	8.26	1	2	
2	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	1	0	
3	48.2	42.8	40	42.7	21.1	21.8	20.1	20.5	20.8	BLANK	BLANK	278	7	80	
SUM (TOTAL DV)												286.26			
MAX. CDV												80			
PCI												20			
RATING												Serious			

YEKAK.K(FERESGNASEFER – MISRAQATEQALAY POLY THECHNIQUE COLLEGE)														
NO.	DEDUCTED VALUES (DV)										TOTAL (DV)	q	CDV	
1	3	0	3.5	3.7	0	2	3.5	0	0	BLANK	BLANK	15.7	1	16
2	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
3	23	0	0	0	0	21	0	0	0	BLANK	BLANK	44	2	35
4	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
5	0	0	0	0	0	0	0	0	0	BLANK	BLANK	0	0	0
SUM (TOTAL DV)												59.7		
CDV												44		
PCI												56		
RATING												Fair		

APPENDIX D

DENSITY-DEDUCT VALUE CURVES FOR FLEXIBLE PAVEMENT

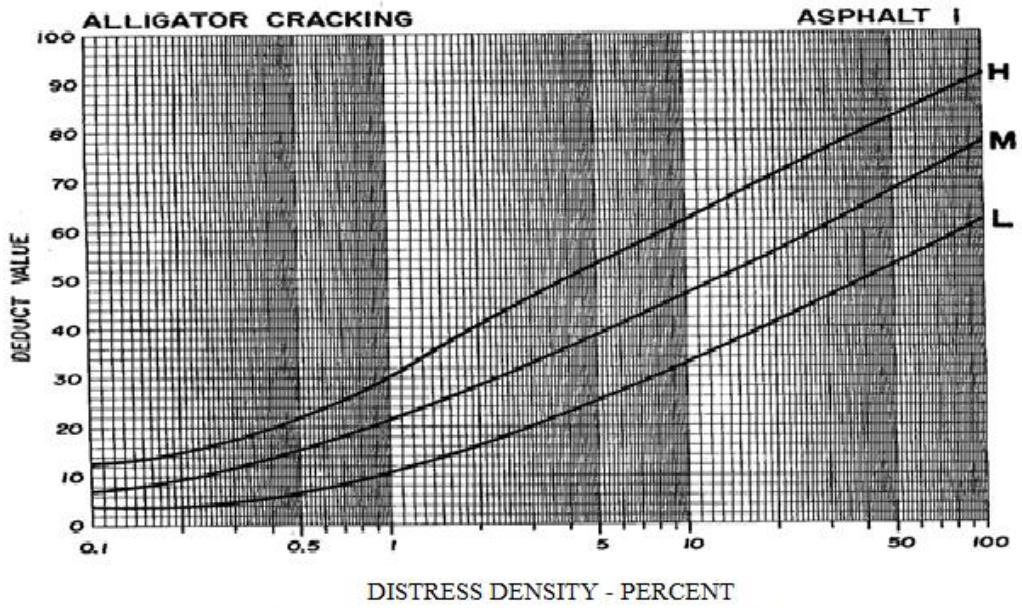


Figure C-1. Deduct value curves for alligator cracking

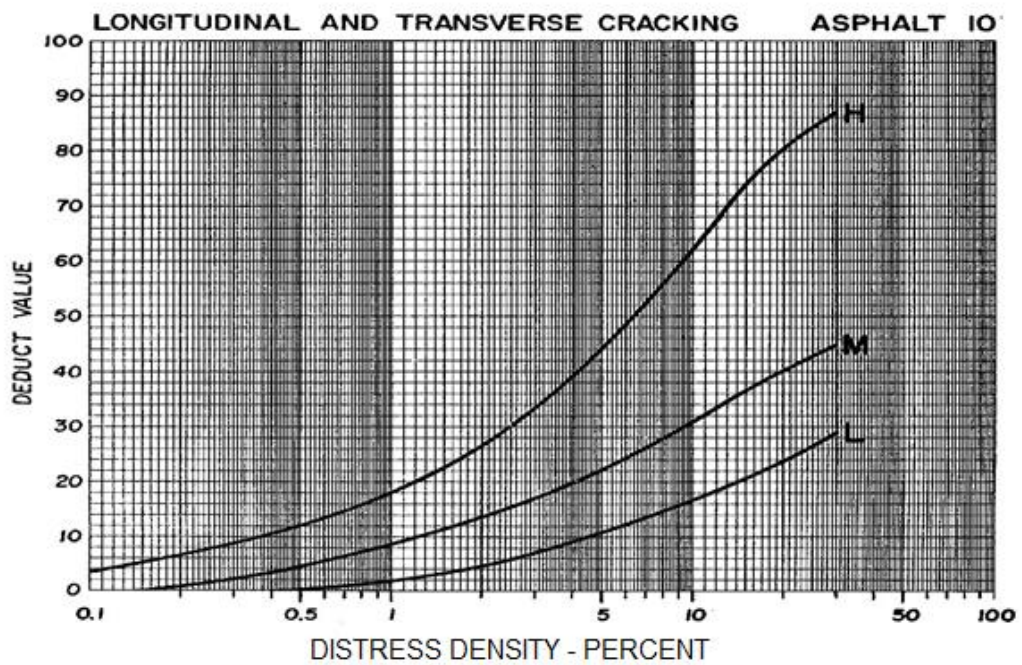


Figure C-10. Deduct value curves for longitudinal and transverse cracking.

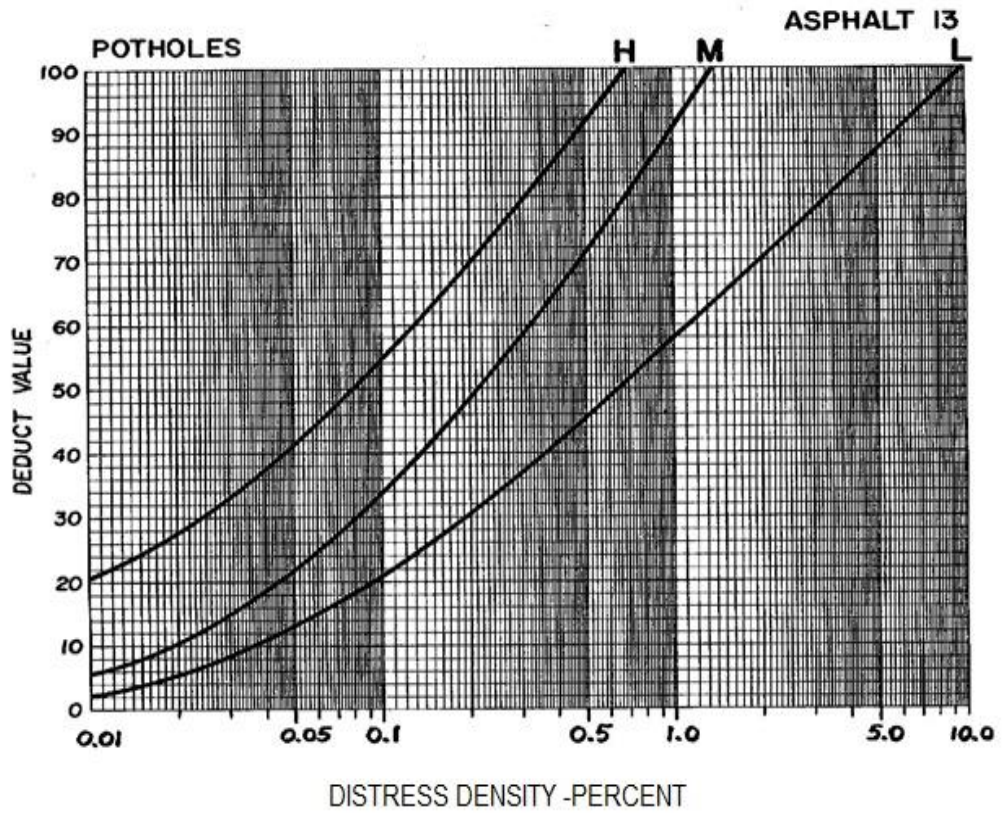


Figure C-13. Deduct value curves for potholes.

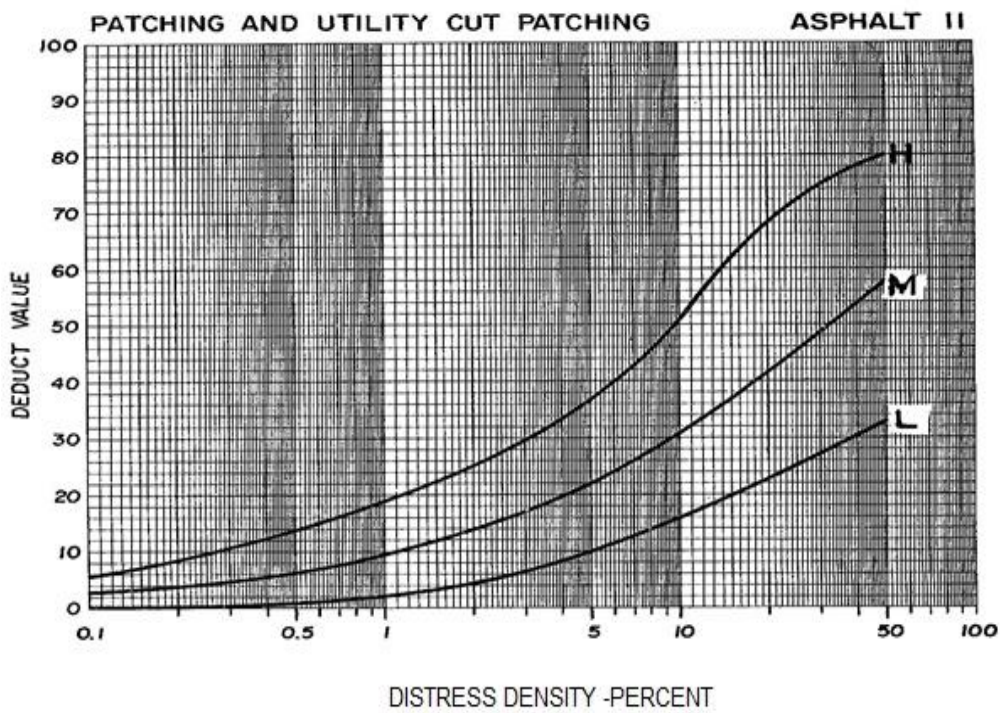


Figure C-11. Deduct value curves for patching and utility cut patching.

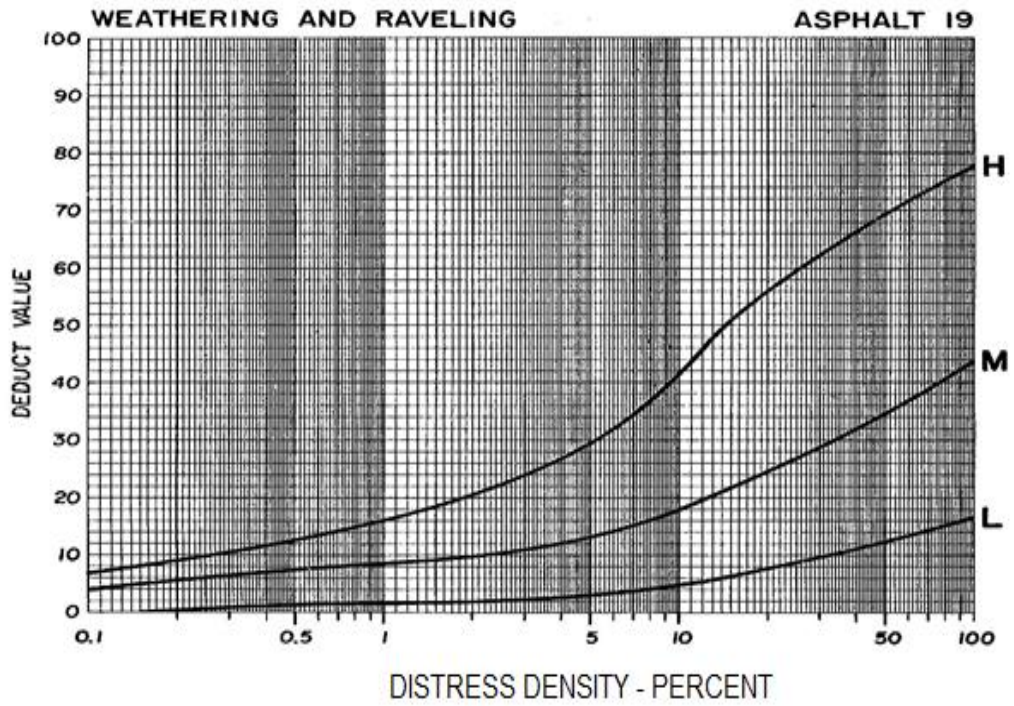


Figure C-19. Deduct value curves for weathering and raveling

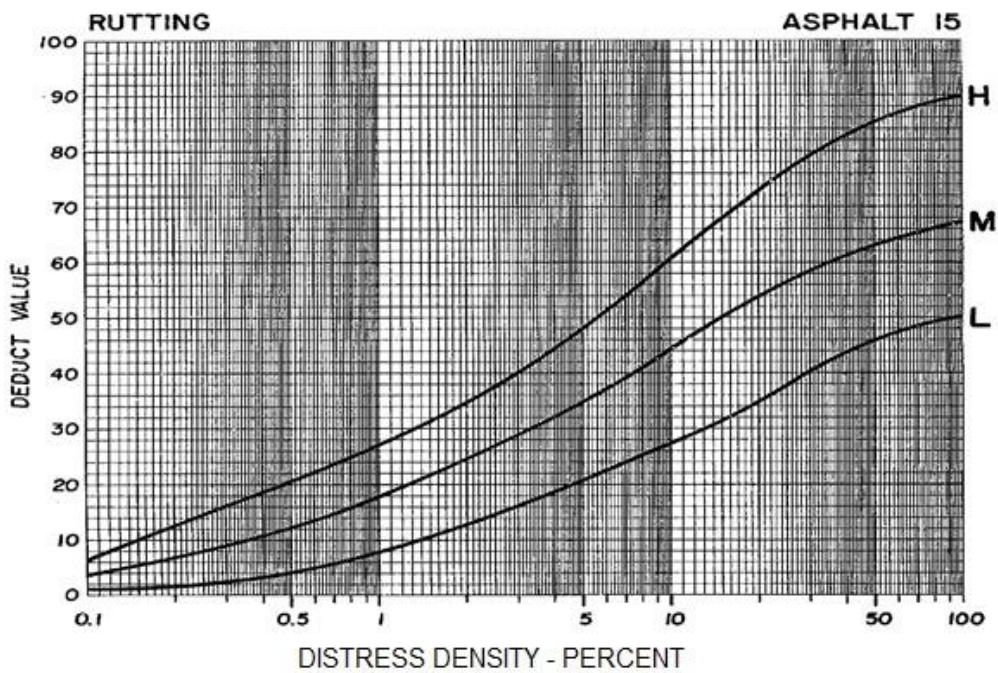


Figure C-15. Deduct value curves for rutting.

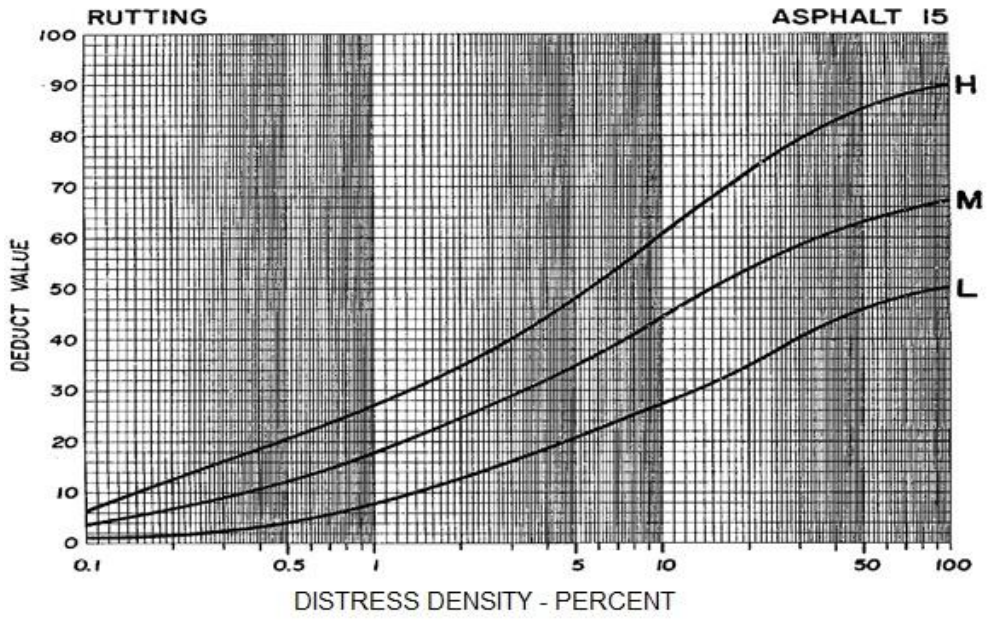


Figure C-15. Deduct value curves for rutting.

APPENDIX E

Java Programming Code

// This JAVA Programm Add a New tool Bar that draws a line, and overlays road pavement distress profile and do analysis

```
macro "Line and Profile Tool -C00bL1de0L1ee1" {
```

```
    getCursorLoc(x, y, z, flags);
```

```
    xstart = x; ystart = y;
```

```
    x2=x; y2=y;
```

```
    while (true) {
```

```
        getCursorLoc(x, y, z, flags);
```

```
        if (flags&16==0) {
```

```
            dx=x2-xstart; dy=y2-ystart;
```

```
            exit;
```

```
        }
```

```
        if (x!=x2 || y!=y2) {
```

```
            makeLine(xstart, ystart, x, y);
```

```
            overlayProfile(xstart, ystart, x, y);
```

```
        }
```

```
        x2=x; y2=y;
```

```
        wait(10);
```

```
    };
```

```
}
```

```
}
```

```
function overlayProfile(xa,ya,xb,yb) {
```

```
    Overlay.remove;
```

```
    p = getProfile();
```

```
    Array.getStatistics(p, min, max, mean, stdDev);
```

```
List.setMeasurements;

text =
'Length:'+d2s(List.getValue('Length'),2)+'\nmin:'+d2s(min,2)+'\nmax:'+d2s(max,2);

    setFont('SanSerif', 14, 'bold antialiased');

    setColor('black');

Overlay.drawString(text, 10-1, 20-1);

    setColor('cyan');

Overlay.drawString(text, 10, 20);

Overlay.moveTo(xa, ya);

    setColor('green');

    setLineWidth(2);

    for (i=0;i<p.length;i++) {

        xs = (xb-xa)/p.length;

        ys = (ya-yb)/p.length;

        d = 100-100*p[i]/max;

        a = atan ((yb-ya)/(xb-xa));

        Overlay.lineTo(xa+i*xs-d*sin(a), ya-i*ys+d*cos(a));

    }

Overlay.lineTo(xb, yb);

Overlay.show;
```

APPENDIX F

Tables: Pavement Distress Results

1. ADDIS KETEMA SUB CITY PAVEMENT DISTRESSES (CHEW BERENDA TO GULIT SEFER SECTION) RESULT

A. CRACKING RESULTS

NO.	Label	Severity	AREA(M2)	Perimeter (m)	Slice	Length
1	AK-PAV. 14.png	L	6.02E-03	9.92E-01	1.00E+00	9.92E-01
2	AK-PAV. 23.png	L	6.78E-03	1.12E+00	1.00E+00	1.12E+00
TOTAL			<u>1.28E-02</u>	<u>2.11E+00</u>		

B. POTHOLE RESULTS

ADDIS KETEMA K/KETEMA POTHOLE ANALYSIS						
NO.	Label	SEVERITY	Area (m2)	Perimeter (m)	Slice	Length(m)
1	AK-PAV.08.png	L	3.24E-02	1.60E+00	1.00E+00	1.60E+00
2	AK-PAV. 08.png	L	9.58E-02	4.65E+00	1.00E+00	4.65E+00
3	AK-PAV. 02.png	M	3.72E-01	1.84E+01	1.00E+00	1.84E+01
4	AK-PAV. 05.png	L	1.95E-02	1.25E+00	1.00E+00	1.25E+00
5	AK-PAV. 07.png	L	4.91E-06	2.46E-02	1.00E+00	2.46E-02
6	AK-PAV. 07.png	L	5.13E-06	2.59E-02	1.00E+00	2.59E-02
7	AK-PAV. 07.png	L	2.90E-06	1.54E-02	1.00E+00	1.54E-02
8	AK-PAV. 26.png	L	2.92E-07	1.44E-02	1.00E+00	1.44E-02
9	AK-PAV. 03.png	L	4.58E-08	2.49E-03	1.00E+00	2.49E-03
10	AK-PAV. 09.png	L	6.71E-08	3.29E-03	1.00E+00	3.29E-03
11	AK-PAV. 10.png	L	4.06E-08	2.07E-03	1.00E+00	2.07E-03
12	AK-PAV. 10.png	L	2.82E-08	1.46E-03	1.00E+00	1.46E-03
13	AK-PAV. 18.png	L	7.83E-08	3.88E-03	1.00E+00	3.88E-03
14	AK-PAV. 18.png	L	5.94E-08	3.09E-03	1.00E+00	3.09E-03
15	AK-PAV. 24.png	L	2.70E-07	1.37E-02	1.00E+00	1.37E-02
TOTAL			<u>5.20E-01</u>	<u>2.60E+01</u>		

2. AKAKI KALITY SUB CITY PAVEMENT DISTRESSES (DERARTU TULU HIGH SCHOOL TO QALITY TOTAL) RESULT

A. CRACKING RESULTS

AKAKI KALITY K/KETEMA CRACKING RESULT						
No.	Label	Severity	AREA(m2)	Perimeter (m)	Slice	Length(m)
1	AKK-PAV. 76.png	M	2.69E+01	9.53E+01	1.00E+00	9.53E+01
2	AKK-PAV. 68.png	M	2.15E+01	6.76E+01	1.00E+00	6.76E+01
3	AKK-PAV. 67.png	H	2.52E+01	7.73E+01	1.00E+00	7.73E+01
4	AKK-PAV. 63.png	M	6.09E+00	1.67E+01	1.00E+00	1.67E+01
5	AKK-PAV. 63.png	M	4.03E+00	1.13E+01	1.00E+00	1.13E+01
6	AKK-PAV. 63.png	M	3.69E+00	1.15E+01	1.00E+00	1.15E+01
7	AKK-PAV. 62.png	L	2.32E+01	7.36E+01	1.00E+00	7.36E+01
8	AKK-PAV. 61.png	L	2.76E+01	8.52E+01	1.00E+00	8.52E+01
9	AKK-PAV. 61.png	L	1.20E+01	3.74E+01	1.00E+00	3.74E+01
10	AKK-PAV. 60.png	L	8.15E+00	2.61E+01	1.00E+00	2.61E+01
11	AKK-PAV. 60.png	L	7.38E+00	2.44E+01	1.00E+00	2.44E+01
12	AKK-PAV. 60.png	L	1.12E+01	3.29E+01	1.00E+00	3.29E+01
13	AKK-PAV. 60.png	L	5.84E+00	1.91E+01	1.00E+00	1.91E+01
14	AKK-PAV. 58.png	L	1.83E+01	6.17E+01	1.00E+00	6.17E+01
15	AKK-PAV. 53.png	M	5.32E+00	1.67E+01	1.00E+00	1.67E+01
TOTAL			2.06E+02	6.57E+02	-	-

B. POTHOLE RESULTS

AKAKI KALITY K/KETEMAPOTHOL RESULT						
No.	Label	Severity	AREA(m2)	Perimeter(m)	Slice	Length(M)
1	AKK-PAV. 159.png	H	3.38E-01	1.36E+01	1.00E+00	1.36E+01
2	AKK-PAV. 159.png	H	1.46E-01	5.85E+00	1.00E+00	5.85E+00
3	AKK-PAV. 159.png	H	8.57E-02	3.17E+00	1.00E+00	3.17E+00
4	AKK-PAV. 159.png	H	5.11E-02	1.93E+00	1.00E+00	1.93E+00
5	AKK-PAV. 159.png	H	2.86E-02	1.07E+00	1.00E+00	1.07E+00
6	AKK-PAV. 159.png	H	2.86E-02	9.37E-01	1.00E+00	9.37E-01
7	AKK-PAV. 159.png	H	1.64E-02	4.64E-01	1.00E+00	4.64E-01
8	AKK-PAV. 159.png	H	1.06E-01	3.81E+00	1.00E+00	3.81E+00
9	AKK-PAV. 159.png	H	3.64E-02	1.20E+00	1.00E+00	1.20E+00

10	AKK-PAV. 159.png	H	4.07E-02	1.33E+00	1.00E+00	1.33E+00
11	AKK-PAV. 156.png	H	2.12E-01	8.00E+00	1.00E+00	8.00E+00
12	AKK-PAV. 156.png	H	2.89E-01	1.15E+01	1.00E+00	1.15E+01
13	AKK-PAV. 37.png	L	2.23E-01	7.99E+00	1.00E+00	7.99E+00
14	AKK-PAV. 37.png	L	2.14E-01	8.64E+00	1.00E+00	8.64E+00
15	AKK-PAV. 50.png	M	3.98E-01	1.62E+01	1.00E+00	1.62E+01
16	AKK-PAV. 50.png	M	2.76E-01	1.17E+01	1.00E+00	1.17E+01
17	AKK-PAV. 50.png	M	1.87E-01	7.78E+00	1.00E+00	7.78E+00
18	AKK-PAV. 74.png	H	4.46E-01	1.77E+01	1.00E+00	1.77E+01
19	AKK-PAV. 83.png	H	7.94E-01	3.09E+01	1.00E+00	3.09E+01
20	AKK-PAV. 83.png	H	1.54E-01	5.71E+00	1.00E+00	5.71E+00
21	AKK-PAV. 75.png	H	4.11E-01	1.65E+01	1.00E+00	1.65E+01
22	AKK-PAV. 78.png	H	6.03E-01	2.43E+01	1.00E+00	2.43E+01
23	AKK-PAV. 86.png	H	4.45E-01	1.65E+01	1.00E+00	1.65E+01
24	AKK-PAV. 89.png	H	3.62E-01	1.47E+01	1.00E+00	1.47E+01
25	AKK-PAV. 87.png	M	1.81E-01	5.96E+00	1.00E+00	5.96E+00
26	AKK-PAV. 87.png	M	3.20E-01	1.37E+01	1.00E+00	1.37E+01
27	AKK-PAV. 87.png	M	6.84E-02	2.67E+00	1.00E+00	2.67E+00
28	AKK-PAV. 72.png	H	5.90E-01	2.20E+01	1.00E+00	2.20E+01
29	AKK-PAV. 99.png	M	2.68E-01	1.10E+01	1.00E+00	1.10E+01
30	AKK-PAV. 99.png	M	1.47E-01	6.06E+00	1.00E+00	6.06E+00
31	AKK-PAV. 140.png	M	1.47E-01	5.62E+00	1.00E+00	5.62E+00
32	AKK-PAV. 144.png	H	2.54E-01	9.43E+00	1.00E+00	9.43E+00
33	AKK-PAV. 144.png	H	2.88E-01	1.19E+01	1.00E+00	1.19E+01
34	AKK-PAV. 144.png	H	7.42E-01	3.06E+01	1.00E+00	3.06E+01
35	AKK-PAV. 144.png	H	4.03E-01	1.69E+01	1.00E+00	1.69E+01
36	AKK-PAV. 42.png	H	6.40E-01	2.34E+01	1.00E+00	2.34E+01
37	AKK-PAV. 42.png	H	4.12E-01	1.74E+01	1.00E+00	1.74E+01
38	AKK-PAV. 38.png	H	5.31E-01	2.16E+01	1.00E+00	2.16E+01
39	AKK-PAV. 45.png	H	6.61E-01	2.75E+01	1.00E+00	2.75E+01
TOTAL			1.20E+01	4.73E+02		

C. RAVELLING RESULTS

AKAKI KALITY K/KETEMARAVLLING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	AKK-PAV.018.png	NOT	4.95E-01	2.08E+01	1.00E+00	2.08E+01
2	AKK-PAV. 017.png	NOT	5.55E-01	2.30E+01	1.00E+00	2.30E+01
TOTAL			1.05E+00	4.38E+01		

3. ARADA SUB CITY PAVEMENT DISTRESSES (SEBA DEREJA TO AFINCHO BER) RESULT

A. CRACKINGRESULTS

ARADA K/KETEMA CRACKING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	AR-PAV. 13.png	H	4.00E-02	7.04E+00	1.00E+00	7.04E+00
2	AR-PAV. 04.png	H	6.12E-01	2.88E+01	1.00E+00	2.88E+01
TOTAL			6.52E-01	3.58E+01		

B. POTHOLE RESULTS

ARADA K/KETEMA POTHOLE RESULT						
No.	Label	Severity	AREA(m2)	Perimeter(m)	Slice	Length(m)
1	AR-PAV. 05.png	M	3.81E-01	1.80E+01	1.00E+00	1.80E+01
2	AR-PAV. 01.png	L	1.28E-01	6.10E+00	1.00E+00	6.10E+00
3	AR-PAV. 25.png	M	1.20E-01	5.48E+00	1.00E+00	5.48E+00
4	AR-PAV. 19.png	H	4.18E-01	1.83E+01	1.00E+00	1.83E+01
5	AR-PAV. 18.png	M	3.07E-01	1.35E+01	1.00E+00	1.35E+01
6	AR-PAV. 12.png	L	4.01E-01	1.93E+01	1.00E+00	1.93E+01
7	AR-PAV. 11.png	H	2.29E-01	1.05E+01	1.00E+00	1.05E+01
8	AR-PAV. 11.png	H	2.98E-01	1.35E+01	1.00E+00	1.35E+01
9	AR-PAV. 07.png	L	1.29E-01	5.63E+00	1.00E+00	5.63E+00
TOTAL			2.41E+00	1.10E+02		

C. PATCHING RESULT

ARADA K/KETEMA PATCHING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(M)
1	AR-PAV. 15.png	H	1.94E+01	1.83E+02	1.00E+00	1.83E+02
TOTAL			1.94E+01	1.83E+02		

D. RAVELLING RESULTS

ARADA K/KETEMARAVELING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	AR-PAV. 02.png	NOT	6.97E-01	2.77E+01	1.00E+00	2.77E+01
2	AR-PAV. 08.png	NOT	4.02E-01	1.68E+01	1.00E+00	1.68E+01
TOTAL			1.10E+00	4.45E+01		

E. RUTTING RESULTS

ARADA K/KETEMA RUTTING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Depth(mm)
1	AR-PAV. 21.png	NOT	8.40E-02	1.80E+01	1.00E+00	7.00E+01

2	AR-PAV. 28.png	NOT	1.08E-01	6.10E+00	1.00E+00	9.00E+01
3	AR-PAV. 29.png	NOT	6.60E-02	5.48E+00	1.00E+00	5.50E+01
TOTAL			2.58E-01	2.95E+01	-	2.15E+02

4. BOLE SUB CITY PAVEMENT DISTRESSES (DINBERWA HOSPITAL TO 22 MAZORIA) RESULTS

A. CRACKING RESULT

BOLE K/KETEMA CRACKING RESULT						
No.	Label	Severity	Area(m2)	Perimeter (m)	Slice	Length(m)
1	BO-Pav.05.png	H	2.50E-02	4.46E+00	1.00E+00	4.46E+00
TOTAL			2.50E-02	4.46E+00	-	-

B. POTHOLE RESULTS

BOLE K/KETEMA POTHOLE RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	BO-PAV.01.png	L	1.82E-01	8.74E+00	1.00E+00	8.74E+00
2	BO-PAV.03.png	L	1.49E-01	6.51E+00	1.00E+00	6.51E+00
TOTAL			3.30E-01	1.53E+01	-	-

C. RAVELLING RESULTS

BOLE K/KETEMARAVELING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	BO-PAV. 06.png	NOT	9.99E-01	4.74E+01	1.00E+00	4.74E+01
2	BO-PAV. 15.png	NOT	1.04E+00	4.94E+01	1.00E+00	4.94E+01
TOTAL			2.04E+00	9.68E+01	-	-

5. GULELE K/KETEMA PAVEMENT DISTRESSES (ETHIPOIA CLINIC TO TIBEBE EDGET SCHOOL) RESULTS

A. POTHOLE RESULTS

GULELE K/KETEMA POTHOLE RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	GUK-PAV. 06.png	M	3.44E-01	1.55E+01	1.00E+00	1.55E+01
2	GUK-PAV. 05.png	M	3.31E-01	1.47E+01	1.00E+00	1.47E+01
3	GUK-PAV. 22.png	L	2.42E-01	1.06E+01	1.00E+00	1.06E+01
4	GUK-PAV. 19.png	L	4.58E-01	1.95E+01	1.00E+00	1.95E+01
5	GUK-PAV. 18.png	L	1.50E-01	7.03E+00	1.00E+00	7.03E+00

6	GUK-PAV. 18.png	L	9.00E-02	3.97E+00	1.00E+00	3.97E+00
7	GUK-PAV. 15.png	L	2.84E-01	1.38E+01	1.00E+00	1.38E+01
8	GUK-PAV. 09.png	H	4.13E-01	1.88E+01	1.00E+00	1.88E+01
9	GUK-PAV. 08.png	H	2.22E-01	9.44E+00	1.00E+00	9.44E+00
10	GUK-PAV. 08.png	H	1.79E-01	8.66E+00	1.00E+00	8.66E+00
11	GUK-PAV. 07.png	M	2.71E-01	1.18E+01	1.00E+00	1.18E+01
12	GUK-PAV. 07.png	M	1.08E-01	4.99E+00	1.00E+00	4.99E+00
13	GUK-PAV. 07.png	M	1.13E-01	5.38E+00	1.00E+00	5.38E+00
TOTAL			3.21E+00	1.44E+02		

B. PATCHING RESULTS

GULELE K/KETEMA PATCHING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	GUK-PAV. 01.png	M	4.71E-01	2.14E+01	1.00E+00	2.14E+01
2	GUK-PAV. 20.png	L	5.83E-01	2.38E+01	1.00E+00	2.38E+01
3	GUK-PAV. 21.png	L	5.96E-01	2.47E+01	1.00E+00	2.47E+01
4	GUK-PAV. 23.png	M	6.19E-01	2.76E+01	1.00E+00	2.76E+01
5	GUK-PAV. 25.png	M	7.50E-01	3.30E+01	1.00E+00	3.30E+01
6	GUK-PAV. 27.png	H	9.89E-01	4.91E+01	1.00E+00	4.91E+01
TOTAL			4.01E+00	1.80E+02		

C. RAVELLING RESULTS

GULELE K/KETEMARAVELING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	GUK-PAV. 12.png	NOT	1.05E+00	4.72E+01	1.00E+00	4.72E+01
2	GUK-PAV. 11.png	NOT	5.47E-01	2.26E+01	1.00E+00	2.26E+01
3	GUK-PAV. 16.png	NOT	7.12E-01	3.27E+01	1.00E+00	3.27E+01
4	GUK-PAV. 14.png	NOT	8.02E-01	3.71E+01	1.00E+00	3.71E+01
TOTAL			3.11E+00	1.40E+02		

6. KIRKOS SUB CITY PAVEMENT DISTRESSES (POSTA BET TO WUDASSIE DIAGNOSTICS) RESULTS

A. CRACKING RESULT

KIRKOS K/KETEMA CRACKING RESULT						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	KIK-PAV.88.png	L	1.57E-02	2.38E+00	1.00E+00	2.38E+00

TOTAL	1.57E-02	2.38E+00
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B. POTHOLE RESULTS

KIRKOS K/KETEMA POTHOLE RESULTS						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	KIK-PAV. 62.png	H	7.10E-01	3.24E+01	1.00E+00	3.24E+01
2	KIK-PAV. 62.png	H	3.22E-01	1.57E+01	1.00E+00	1.57E+01
3	KIK-PAV. 61.png	H	4.59E-01	2.18E+01	1.00E+00	2.18E+01
4	KIK-PAV. 59.png	M	1.81E-01	8.48E+00	1.00E+00	8.48E+00
5	KIK-PAV. 59.png	M	1.33E-01	5.93E+00	1.00E+00	5.93E+00
6	KIK-PAV. 59.png	M	9.49E-02	3.77E+00	1.00E+00	3.77E+00
7	KIK-PAV. 48.png	L	2.62E-01	1.27E+01	1.00E+00	1.27E+01
8	KIK-PAV. 46.png	H	6.01E-01	2.91E+01	1.00E+00	2.91E+01
9	KIK-PAV. 45.png	L	1.65E-01	7.81E+00	1.00E+00	7.81E+00
10	KIK-PAV. 38.png	M	1.12E-01	4.72E+00	1.00E+00	4.72E+00
11	KIK-PAV. 38.png	M	8.26E-02	3.63E+00	1.00E+00	3.63E+00
12	KIK-PAV. 38.png	M	1.08E-01	5.09E+00	1.00E+00	5.09E+00
13	KIK-PAV. 36.png	M	1.43E-01	6.13E+00	1.00E+00	6.13E+00
14	KIK-PAV. 29.png	H	6.35E-01	2.99E+01	1.00E+00	2.99E+01
15	KIK-PAV. 27.png	H	1.24E-01	5.55E+00	1.00E+00	5.55E+00
16	KIK-PAV. 27.png	H	2.78E-01	1.33E+01	1.00E+00	1.33E+01
17	KIK-PAV. 27.png	H	1.95E-01	9.30E+00	1.00E+00	9.30E+00
18	KIK-PAV. 23.png	L	1.02E-01	5.13E+00	1.00E+00	5.13E+00
19	KIK-PAV. 11.png	L	1.15E-01	5.55E+00	1.00E+00	5.55E+00
20	KIK-PAV. 11.png	L	1.36E-01	6.59E+00	1.00E+00	6.59E+00
21	KIK-PAV. 10.png	L	2.75E-01	1.29E+01	1.00E+00	1.29E+01
22	KIK-PAV. 74.png	M	5.71E-01	2.69E+01	1.00E+00	2.69E+01
23	KIK-PAV. 70.png	L	2.18E-01	9.51E+00	1.00E+00	9.51E+00
24	KIK-PAV. 69.png	L	3.04E-01	1.35E+01	1.00E+00	1.35E+01
25	KIK-PAV. 69.png	L	1.19E-01	5.23E+00	1.00E+00	5.23E+00
26	KIK-PAV. 68.png	M	1.87E-01	8.52E+00	1.00E+00	8.52E+00
27	KIK-PAV. 68.png	M	1.36E-01	5.81E+00	1.00E+00	5.81E+00
28	KIK-PAV. 68.png	M	1.66E-01	7.56E+00	1.00E+00	7.56E+00
29	KIK-PAV. 68.png	M	8.50E-02	3.82E+00	1.00E+00	3.82E+00
30	KIK-PAV. 68.png	M	7.46E-02	3.11E+00	1.00E+00	3.11E+00
31	KIK-PAV. 65.png	M	3.33E-01	1.47E+01	1.00E+00	1.47E+01
32	KIK-PAV. 65.png	M	8.26E-02	3.50E+00	1.00E+00	3.50E+00
33	KIK-PAV. 65.png	M	6.96E-02	3.06E+00	1.00E+00	3.06E+00

34	KIK-PAV. 65.png	M	7.76E-02	3.24E+00	1.00E+00	3.24E+00
35	KIK-PAV. 65.png	M	7.52E-02	3.07E+00	1.00E+00	3.07E+00
36	KIK-PAV. 65.png	M	9.06E-02	3.87E+00	1.00E+00	3.87E+00
37	KIK-PAV. 65.png	M	1.53E-01	7.00E+00	1.00E+00	7.00E+00
38	KIK-PAV. 65.png	M	1.02E-01	4.50E+00	1.00E+00	4.50E+00
39	KIK-PAV. 64.png	M	1.85E-01	7.93E+00	1.00E+00	7.93E+00
40	KIK-PAV. 64.png	M	5.73E-02	2.54E+00	1.00E+00	2.54E+00
41	KIK-PAV. 64.png	M	5.73E-02	2.35E+00	1.00E+00	2.35E+00
42	KIK-PAV. 64.png	M	5.11E-02	2.23E+00	1.00E+00	2.23E+00
43	KIK-PAV. 64.png	M	1.13E-01	5.35E+00	1.00E+00	5.35E+00
44	KIK-PAV. 64.png	M	6.53E-02	2.92E+00	1.00E+00	2.92E+00
45	KIK-PAV. 64.png	M	6.41E-02	2.71E+00	1.00E+00	2.71E+00
46	KIK-PAV. 64.png	M	6.72E-02	2.93E+00	1.00E+00	2.93E+00
47	KIK-PAV. 63.png	H	3.54E-01	1.71E+01	1.00E+00	1.71E+01
48	KIK-PAV. 63.png	H	9.92E-02	4.68E+00	1.00E+00	4.68E+00
49	KIK-PAV. 63.png	H	7.95E-02	3.77E+00	1.00E+00	3.77E+00
50	KIK-PAV. 63.png	H	7.95E-02	3.77E+00	1.00E+00	3.77E+00
51	KIK-PAV. 63.png	H	3.02E-02	1.26E+00	1.00E+00	1.26E+00
52	KIK-PAV. 63.png	H	2.96E-02	1.31E+00	1.00E+00	1.31E+00
53	KIK-PAV. 63.png	H	2.59E-02	1.05E+00	1.00E+00	1.05E+00
TOTAL			9.43E+00	4.34E+02		

C. RAVELLING RESULTS

KIRKOS K/KETEMARAVELING RESULT						
No.	Label	Severity	AREA(M2)	Perimeter (M)	Slice	Length(M)
1	KIK-PAV. 39.png	NOT	9.72E-01	4.22E+01	1.00E+00	4.22E+01
2	KIK-PAV. 18.png	NOT	8.58E-01	3.88E+01	1.00E+00	3.88E+01
3	KIK-PAV. 17.png	NOT	4.70E-01	2.19E+01	1.00E+00	2.19E+01
4	KIK-PAV. 73.png	NOT	6.43E-01	3.03E+01	1.00E+00	3.03E+01
5	KIK-PAV. 72.png	NOT	4.44E-01	2.03E+01	1.00E+00	2.03E+01
6	KIK-PAV. 71.png	NOT	3.43E-01	1.57E+01	1.00E+00	1.57E+01
7	KIK-PAV. 43.png	NOT	5.41E-01	2.26E+01	1.00E+00	2.26E+01
8	KIK-PAV. 42.png	NOT	4.18E-01	1.65E+01	1.00E+00	1.65E+01
9	KIK-PAV. 41.png	NOT	7.29E-01	3.09E+01	1.00E+00	3.09E+01
10	KIK-PAV. 40.png	NOT	6.62E-01	2.79E+01	1.00E+00	2.79E+01
TOTAL			6.08E+00	2.67E+02		

D. PATCHING

KIRKOS K/KETEMA PATHING RESULT						
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	Label	Severity	AREA(M2)	Perimeter (M)	Slice	Length(M)
1	KIK-PAV. 21.png	L	6.27E-01	2.76E+01	1.00E+00	2.76E+01
2	KIK-PAV. 20.png	M	1.09E+00	4.91E+01	1.00E+00	4.91E+01
3	KIK-PAV. 55.png	H	1.05E+00	4.57E+01	1.00E+00	4.57E+01
4	KIK-PAV. 24.png	L	1.41E+02	1.34E+02	1.00E+00	1.34E+02
5	KIK-PAV. 24.png	L	1.20E-01	5.74E+00	1.00E+00	5.74E+00
6	KIK-PAV. 24.png	L	8.87E-02	4.15E+00	1.00E+00	4.15E+00
7	KIK-PAV. 22.png	H	1.49E-01	6.97E+00	1.00E+00	6.97E+00
TOTAL			1.44E+02	2.73E+02		

7. KOLFE KERANIO K/KETEMA PAVEMENT DISTRESSES (EFOYTA TO TAYWAN ROAD) RESULTS

A. CRACKING RESULTS

KOLFEKERANIO K/KETEMA CRACKING RESULTS						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(M)
1	KOK-PAV. 15.png	H	8.08E-03	1.13E+00	1.00E+00	1.13E+00
2	KOK-PAV. 13.png	L	6.17E-03	7.19E-01	1.00E+00	7.19E-01
3	KOK-PAV. 44.png	H	1.36E-02	1.79E+00	1.00E+00	1.79E+00
4	KOK-PAV. 33.png	M	7.02E-03	9.61E-01	1.00E+00	9.61E-01
5	KOK-PAV. 33.png	M	6.33E-03	7.99E-01	1.00E+00	7.99E-01
6	KOK-PAV. 16.png	H	1.16E-02	1.52E+00	1.00E+00	1.52E+00
TOTAL			5.28E-02	6.92E+00		

B. POTHOLE RESULTS

KOLFE K/KETEMA POTHOLE RESULT						
	Label	Severity	AREA(M2)	Perim.(M)	Slice	Length(M)
1	KOK-PAV. 29.png	L	1.28E-01	6.69E+00	1.00E+00	6.69E+00
2	KOK-PAV. 12.png	L	1.25E-01	6.12E+00	1.00E+00	6.12E+00
3	KOK-PAV. 11.png	L	7.09E-02	3.09E+00	1.00E+00	3.09E+00
4	KOK-PAV. 10.png	M	1.39E-01	7.22E+00	1.00E+00	7.22E+00
5	KOK-PAV. 10.png	M	6.10E-02	3.16E+00	1.00E+00	3.16E+00
6	KOK-PAV. 10.png	M	6.10E-02	3.16E+00	1.00E+00	3.16E+00
7	KOK-PAV. 09.png	M	3.82E-02	1.85E+00	1.00E+00	1.85E+00
8	KOK-PAV. 09.png	M	4.37E-02	2.35E+00	1.00E+00	2.35E+00
9	KOK-PAV. 09.png	M	4.37E-02	2.35E+00	1.00E+00	2.35E+00
10	KOK-PAV. 08.png	L	6.04E-02	2.89E+00	1.00E+00	2.89E+00
11	KOK-PAV. 07.png	L	1.04E-01	5.44E+00	1.00E+00	5.44E+00
12	KOK-PAV. 06.png	L	4.99E-02	2.47E+00	1.00E+00	2.47E+00

13	KOK-PAV. 06.png	L	2.96E-02	1.47E+00	1.00E+00	1.47E+00
14	KOK-PAV. 05.png	L	8.63E-02	4.46E+00	1.00E+00	4.46E+00
15	KOK-PAV. 03.png	L	8.75E-02	4.45E+00	1.00E+00	4.45E+00
16	KOK-PAV. 02.png	L	8.50E-02	4.18E+00	1.00E+00	4.18E+00
17	KOK-PAV. 51.png	H	2.00E-01	1.02E+01	1.00E+00	1.02E+01
18	KOK-PAV. 51.png	H	1.08E-01	5.36E+00	1.00E+00	5.36E+00
19	KOK-PAV. 40.png	L	1.53E-01	7.80E+00	1.00E+00	7.80E+00
20	KOK-PAV. 37.png	M	2.35E-01	1.17E+01	1.00E+00	1.17E+01
21	KOK-PAV. 36.png	M	4.58E-01	2.12E+01	1.00E+00	2.12E+01
22	KOK-PAV. 30.png	L	6.53E-02	3.12E+00	1.00E+00	3.12E+00
TOTAL			2.43E+00	1.21E+02		-

C. PATCHING RESULTS

KOLFE K/KETEMA PATCHING RESULTS						
No.	Label	Severity	Area(m ²)	Perimeter(m)	Slice	Length(M)
1	KOK-PAV. 43.png	M	3.99E-01	1.91E+01	1.00E+00	1.91E+01
2	KOK-PAV. 41.png	H	2.94E-01	1.26E+01	1.00E+00	1.26E+01
3	KOK-PAV. 22.png	H	4.61E-01	2.08E+01	1.00E+00	2.08E+01
4	KOK-PAV. 21.png	H	3.10E-01	1.59E+01	1.00E+00	1.59E+01
5	KOK-PAV. 52.png	H	8.47E-01	4.40E+01	1.00E+00	4.40E+01
TOTAL			2.31E+00	1.12E+02		-

D. RAVELLING RESULTS

KOLFE K/KETEMARAVELLING RESULTS						
No.	Label	Severity	Area(m ²)	Perimeter(m)	Slice	Length(m)
1	KOK-PAV. 25.png	NOT	7.44E-01	3.60E+01	1.00E+00	3.60E+01
2	KOK-PAV. 24.png	NOT	5.37E-01	2.67E+01	1.00E+00	2.67E+01
3	KOK-PAV. 27.png	NOT	4.88E-01	2.32E+01	1.00E+00	2.32E+01
4	KOK-PAV. 26.png	NOT	6.14E-01	2.86E+01	1.00E+00	2.86E+01
TOTAL			2.38E+00	1.15E+02		-

8. LIDETA K/KETEMA PAVEMENT DISTRESSES (LIDETA CONDEMINIUM TO GEJA SEFER) RESULTS

A. POTHOLE RESULTS

LIDETA K/KETEMA POTHOLE RESULT						
No.	Label	Severity	Area(m ²)	Perimeter(m)	Slice	Length(m)

1	LDK-PAV. 02.png	H	2.70E-01	1.36E+01	1.00E+00	1.36E+01
2	LDK-PAV. 02.png	H	1.85E-01	9.26E+00	1.00E+00	9.26E+00
3	LDK-PAV. 01.png	L	7.46E-02	3.58E+00	1.00E+00	3.58E+00
4	LDK-PAV. 04.png	H	4.58E-01	2.24E+01	1.00E+00	2.24E+01
5	LDK-PAV. 03.png	M	1.89E-01	9.14E+00	1.00E+00	9.14E+00
6	LDK-PAV. 03.png	M	2.29E-01	1.19E+01	1.00E+00	1.19E+01
TOTAL			1.40E+00	7.00E+01		

B. PATCHING RESULT

LIDETA K/KETEMA PATCHING RESULT						
No.	Label	Severity	Area(m2)	Perimeter (m)	Slice	Length(m)
1	LDK-PAV.07.png	H	8.65E-01	4.37E+01	1.00E+00	4.37E+01
TOTAL			8.65E-01	4.37E+01		

C. RAVELLING RESULTS

LIDETA K/KETEMARAVELLING RESULTS						
No.	Label	Severity	Area(m2)	Perimeter(m)	Slice	Length(m)
1	LDK-PAV. 02.png	NOT	4.09E-01	1.98E+01	1.00E+00	1.98E+01
2	LDK-PAV. 02.png	NOT	3.50E-01	1.71E+01	1.00E+00	1.71E+01
TOTAL			7.59E-01	3.69E+01		

9. NIFAS SILK LAFTO K/KETEMA PAVEMENT DISTRESSES (SARIS GEBEYA TO BIHERE TSI GE) RESULTS

A. CRACKING RESULT

NIFAS SILK LAFTO K/KETEMA CRACKING RESULT						
No.	Label	Severity	Area (m2)	Perimeter(m)	Slice	Length(m)
1	NLK-PAV.13.png	L	1.49E+01	4.70E+01	1.00E+00	4.70E+01
TOTAL			1.49E+01	4.70E+01		

B. POTHOLE RESULTS

NIFAS SILK K/KETEMA POTHOLE RESULT						
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No.	Label	Severity	Area(m ²)	Perimeter (m)	Slice	Length(m)
1	NLK-PAV. 03.png	L	2.95E-01	1.47E+01	1.00E+00	1.47E+01
2	NLK-PAV. 02.png	M	7.75E-01	4.10E+01	1.00E+00	4.10E+01
3	NLK-PAV. 01.png	L	2.46E-01	1.21E+01	1.00E+00	1.21E+01
4	NLK-PAV. 24.png	H	5.02E-01	2.56E+01	1.00E+00	2.56E+01
5	NLK-PAV. 21.png	H	6.98E-01	3.45E+01	1.00E+00	3.45E+01
6	NLK-PAV. 20.png	L	3.08E-01	1.58E+01	1.00E+00	1.58E+01
7	NLK-PAV. 19.png	M	5.40E-01	2.51E+01	1.00E+00	2.51E+01
8	NLK-PAV. 15.png	L	1.59E-01	7.51E+00	1.00E+00	7.51E+00
9	NLK-PAV. 11.png	L	2.08E-01	1.04E+01	1.00E+00	1.04E+01
10	NLK-PAV. 09.png	M	3.97E-01	2.05E+01	1.00E+00	2.05E+01
11	NLK-PAV. 08.png	M	3.52E-01	1.75E+01	1.00E+00	1.75E+01
12	NLK-PAV. 05.png	H	6.28E-01	2.90E+01	1.00E+00	2.90E+01
13	NLK-PAV. 04.png	H	6.15E-01	3.13E+01	1.00E+00	3.13E+01
TOTAL			5.72E+00	2.85E+02		

C. PATCHING RESULTS

NIFAS SILK RA K/KETEMA PATCHING RESULTS						
No.	Label	Severity	Area(m ²)	Perimeter(m)	Slice	Length(m)
1	NLK-PAV. 10.png	L	5.53E-01	2.76E+01	1.00E+00	2.76E+01
2	NLK-PAV. 07.png	H	5.53E-01	2.49E+01	1.00E+00	2.49E+01
3	NLK-PAV. 06.png	H	8.07E-01	3.67E+01	1.00E+00	3.67E+01
4	NLK-PAV. 17.png	H	3.97E-01	1.86E+01	1.00E+00	1.86E+01
TOTAL			2.31E+00	1.08E+02		

10. YEKA SUB CITY PAVEMENT DISTRESSES (FERESEGNA SEFER TO MISRAQ ATEQALAY POLY-TECHNIQUE COLLEGE) RESULTS

A. CRACKING RESULTS

YEKA K/KETEMA CRACKING RESULTS						
No.	Label	Severity	Area(m ²)	Perimeter (m)	Slice	Length(m)
1	YK-PAV. 93.png	H	3.64E-02	6.48E+00	1.00E+00	6.48E+00
2	YK-PAV. 90.png	M	1.81E-02	3.24E+00	1.00E+00	3.24E+00
3	YK-PAV. 90.png	M	1.61E-02	2.07E+00	1.00E+00	2.07E+00
4	YK-PAV. 84.png	L	3.33E-02	5.80E+00	1.00E+00	5.80E+00
5	YK-PAV. 81.png	H	4.31E-02	6.23E+00	1.00E+00	6.23E+00
6	YK-PAV. 80.png	H	4.82E-02	7.26E+00	1.00E+00	7.26E+00
7	YK-PAV. 77.png	L	1.41E-02	2.25E+00	1.00E+00	2.25E+00
8	YK-PAV. 76.png	L	2.32E-02	4.09E+00	1.00E+00	4.09E+00

9	YK-PAV. 54.png	M	4.34E-02	6.67E+00	1.00E+00	6.67E+00
10	YK-PAV. 26.png	H	4.26E-02	6.97E+00	1.00E+00	6.97E+00
11	YK-PAV. 22.png	M	1.83E-02	2.62E+00	1.00E+00	2.62E+00
12	YK-PAV. 21.png	H	3.09E-02	4.66E+00	1.00E+00	4.66E+00
TOTAL			3.68E-01	5.83E+01		

B. POTHOLE RESULTS

YEKA K/KETEMA POTHOLE RESULT						
NO.	Label	Severity	AREA(M2)	Perim.(M)	Slice	Length(M)
1	YK-PAV. 69.png	H	4.70E-01	2.39E+01	1.00E+00	2.39E+01
2	YK-PAV. 68.png	H	3.22E-01	1.67E+01	1.00E+00	1.67E+01
3	YK-PAV. 67.png	H	1.45E-01	7.09E+00	1.00E+00	7.09E+00
4	YK-PAV. 67.png	H	8.32E-02	4.14E+00	1.00E+00	4.14E+00
5	YK-PAV. 44.png	L	1.85E-01	9.06E+00	1.00E+00	9.06E+00
6	YK-PAV. 40.png	L	2.57E-01	1.20E+01	1.00E+00	1.20E+01
7	YK-PAV. 34.png	H	2.90E-01	1.52E+01	1.00E+00	1.52E+01
8	YK-PAV. 33.png	H	1.77E-01	9.20E+00	1.00E+00	9.20E+00
9	YK-PAV. 24.png	H	1.89E-01	9.47E+00	1.00E+00	9.47E+00
10	YK-PAV. 24.png	H	3.20E-01	1.60E+01	1.00E+00	1.60E+01
11	YK-PAV. 16.png	H	3.84E-01	1.75E+01	1.00E+00	1.75E+01
12	YK-PAV. 14.png	M	1.56E-01	7.29E+00	1.00E+00	7.29E+00
13	YK-PAV. 09.png	M	1.09E-01	5.69E+00	1.00E+00	5.69E+00
14	YK-PAV. 09.png	M	1.55E-01	7.37E+00	1.00E+00	7.37E+00
15	YK-PAV. 09.png	M	5.05E-02	2.47E+00	1.00E+00	2.47E+00
16	YK-PAV. 01.png	M	2.05E-01	1.04E+01	1.00E+00	1.04E+01
17	YK-PAV. 96.png	M	2.11E-01	1.09E+01	1.00E+00	1.09E+01
18	YK-PAV. 96.png	M	1.99E-01	9.83E+00	1.00E+00	9.83E+00
19	YK-PAV. 96.png	M	6.96E-02	3.35E+00	1.00E+00	3.35E+00
20	YK-PAV. 94.png	M	2.03E-01	1.02E+01	1.00E+00	1.02E+01
21	YK-PAV. 75.png	H	1.59E-01	8.44E+00	1.00E+00	8.44E+00
22	YK-PAV. 75.png	H	5.85E-02	2.67E+00	1.00E+00	2.67E+00
23	YK-PAV. 71.png	M	1.71E-01	9.03E+00	1.00E+00	9.03E+00
24	YK-PAV. 71.png	M	1.48E-01	7.63E+00	1.00E+00	7.63E+00
TOTAL			4.71E+00	2.36E+02		

C. PATCHING RESULTS

YEKA K/KETEMA PATCHING RESULTS						
No.	Label	Severity	Area (m2)	Perimeter (m)	Slice	Length(M)
1	YK-PAV. 12.png	H	9.86E-01	4.90E+01	1.00E+00	4.90E+01
2	YK-PAV. 06.png	H	4.55E-01	2.20E+01	1.00E+00	2.20E+01

3	YK-PAV. 64.png	L	3.35E-01	1.45E+01	1.00E+00	1.45E+01
4	YK-PAV. 64.png	L	3.28E-01	1.41E+01	1.00E+00	1.41E+01
5	YK-PAV. 64.png	L	3.46E-01	1.30E+01	1.00E+00	1.30E+01
6	YK-PAV. 62.png	M	4.71E-01	1.86E+01	1.00E+00	1.86E+01
7	YK-PAV. 51.png	H	5.22E-01	2.64E+01	1.00E+00	2.64E+01
8	YK-PAV. 49.png	M	8.83E-01	4.39E+01	1.00E+00	4.39E+01
9	YK-PAV. 47.png	M	5.52E-01	2.74E+01	1.00E+00	2.74E+01
10	YK-PAV. 31.png	H	2.21E-01	1.07E+01	1.00E+00	1.07E+01
11	YK-PAV. 28.png	H	2.37E-01	1.10E+01	1.00E+00	1.10E+01
12	YK-PAV. 18.png	H	4.08E-01	1.81E+01	1.00E+00	1.81E+01
13	YK-PAV. 17.png	M	5.01E-01	2.34E+01	1.00E+00	2.34E+01
14	YK-PAV. 13.png	L	4.44E-01	2.16E+01	1.00E+00	2.16E+01
TOTAL			6.69E+00	3.14E+02		

D. RAVELLING RESULTS

YEKA K/KETEMARAVELING RESULTS						
No.	Label	Severity	Area(m ²)	Perimeter(m)	Slice	Length(m)
1	YK-PAV. 05.png	H	8.88E-01	4.43E+01	1.00E+00	4.43E+01
2	YK-PAV. 03.png	M	8.73E-01	4.22E+01	1.00E+00	4.22E+01
3	YK-PAV. 02.png	L	3.92E-01	1.78E+01	1.00E+00	1.78E+01
4	YK-PAV. 86.png	H	4.37E-01	2.09E+01	1.00E+00	2.09E+01
TOTAL			2.59E+00	1.25E+02		

E. RUTTING RESULT

YEKA K/KETEMA RUTTING RESULT						
No.	Label	Severity	Area(m ²)	Perimeter (m)	Slice	Depth(mm)
1	AR-PAV. 21.png	NOT	5.70E-02	1.80E+01	1.00E+00	4.75E+01
TOTAL			5.70E-02	1.80E+01		4.75E+01

Declaration

I certify that research work titled “Image Based Pavement Condition Assessment” is my own work. The work had not be presented elsewhere for assessment. Where material had be use from other sources, it had properly paraphrased and acknowledged / referred.

Jibril Akmel Mohammed

Signature of Student.....

Submission Date.....

Addis Ababa Institute of Technology
School of Civil and Environmental Engineering