

**MAKERERE**



**UNIVERSITY**

**COLLEGE OF ENGINEERING, DESIGN, ART AND TECHNOLOGY**

**SCHOOL OF BUILT ENVIRONMENT**

**DEPARTMENT OF CONSTRUCTION ECONOMICS AND MANAGEMENT**

**POST GRADUATE DIPLOMA IN CONSTRUCTION MANAGEMENT AND**

**PLANNING.**

**TRAINING REPORT ON THE UPGRADING OF MISAGA ROAD (0.42KM)**

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**A TRAINING REPORT SUBMITTED TO THE DEPARTMENT OF CONSTRUCTION AND PLANNING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A POST GRADUATE DIPLOMA IN CONSTRUCTION MANAGEMENT AND PLANNING OF MAKERERE UNIVERSITY.**

**AUGUST 2024**

## DECLARATION

I **Namugala Nathan**, a student of Makerere University declares that to the best of my knowledge the information in this field report is an original copy produced by myself for the duration of my field work as a representative of KCCA during the upgrading of Misaga Road (0.42), and has never been presented to any other institution for the award of a Post graduate diploma in construction Management and planning.

Signature .....

Date .....

**NAMUGALA NATHAN**

## APPROVAL

This training report written by NAMUGALA NATHAN proves that he has carried out his training with Kampala Capital City Authority under the supervision of a great team and has been approved for presentation to the University.

Signature.....

**Dr. MANGA MUSA**

Date .....

15/08/2024

## **DEDICATION**

I dedicate this training report to my parents Mr. Malaala Lwidu Paul and Mrs. Eva Ayanga Malaala, my wife, brothers and sister. I also recognize the endless support from my friends and supervisor, Dr. Manga Musa that cannot be exhaustively expressed. May the Almighty God multiply your blessings for the continued love and care.

## **ACKNOWLEDGEMENTS**

First and foremost, I thank God for the gift of life given to me and my family. I wish also to express my sincere gratitude the management and staff of Kampala Capital City Authority for having allowed me to train with them, the supervising and non-supervising staff for their great role during my entire training.

Special thanks to Dr. Manga Musa who provided me with unreserved comments and guidance throughout the training, which enabled me to complete this report.

Finally, I would like to extend my special thanks to my entire family and friends who kept on encouraging me to carry on and work hard to become a better person in life.

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## ACRONYMS/ABBREVIATIONS

KCCA:	Kampala Capital City Authority
F/w:	Formwork
mm:	millimeter
T:	Tensile stress
M/steel:	Mild stress
R:	Round bar
PPC:	Portland Pozzolana Cement
CML:	Central Materials Laboratory
BS	British Institute of Standards
CBR	California Bearing Ratio
F/w	Full road width
FDT	Field Dry Density Test
HMA	Hot Mixed Asphalt
LHS	Left Hand Side
MDD	Maximum Dry Density
OMC	Optimum Moisture Content
PI	Plasticity Index
PL	Plastic Limit
RHS	Right Hand Side
G3	Gravel material with minimum CBR value of 3% after 4 days soaking
G7	Gravel material with minimum CBR value of 7% after 4 days soaking
G15	Gravel material with minimum CBR value of 15% after 4 days soaking
G30	Gravel material with minimum CBR value of 30% after 4 days soaking
G45	Gravel material with minimum CBR value of 45% after 4 days soaking
G60	Gravel material with minimum CBR value of 60% after 4 days soaking
CRS	Crushed stone
CRR	Crushed rock

## ABSTRACT

This project report presents a comprehensive overview of the upgrading of Misaga Road in Nakawa Division, undertaken by MJ Suppliers and Contractors Ltd and supervised by the in-house team of Kampala Capital City Authority (KCCA). The project's primary goal was to enhance the road to a bitumen standard, addressing structural issues and improving durability and usability. This report provides insights into project appreciation, contract documentation and administration, and the application of project management principles. It highlights the critical aspects of contract management, challenges faced, and strategies employed to overcome them, emphasizing the importance of effective project management in achieving successful outcomes.

## **1 CHAPTER ONE – INTRODUCTION**

This project report details the upgrading of Misaga Road by MJ Suppliers and Contractors Ltd, under the supervision of the in-house team of the client, Kampala Capital City Authority (KCCA). The report focuses on the company's role as the contractor tasked with improving the carriageway. It provides an in-depth analysis of project appreciation, contract documentation and administration, and the application of project management principles throughout the contract implementation process.

The Government of Uganda, through KCCA, procured services for the upgrading and reconstruction of Misaga Road in Nakawa Division. This project aimed to transform the road into a bitumen standard, enhancing its durability and usability. The initiative is part of a broader effort to improve infrastructure within Kampala, ensuring better connectivity and accessibility for residents.

The project's scope included the complete reconstruction of the existing road, addressing underlying structural issues, and ensuring it meets the required standards for bitumen roads. The supervision by KCCA's in-house team ensured that all activities adhered to the set specifications and quality standards, while MJ Suppliers and Contractors Ltd brought their expertise to the execution phase, ensuring timely and efficient delivery.

This report aims to provide a comprehensive overview of the project, highlighting the critical aspects of contract management, the challenges faced during implementation, and the strategies employed to overcome these challenges. It also emphasizes the importance of effective project management in achieving successful project outcomes.

This project report presents the upgrading of Misaga Road by MJ Suppliers and contractors Ltd being supervised by the in house team of the client (Kampala Capital City Authority) while working as the representative of KCCA. It provides in-sight on project appreciation, contract documentation and administration, and application of project management knowledge in the process of contract implementation.

### **1.1 OBJECTIVE OF THE PROJECT.**

To improve the road state to meet the design and construction standards for durability and longevity.

#### **1.1.1 SPECIFIC OBJECTIVES**

- I. To reduce congestion and travel times with in the area
- II. To ensure the road meets legal and regulatory standards for safety, accessibility, and environmental impact.

## 1.2 ORGANISATION CHART

The project organization for this road development under the Kampala Capital City Authority (KCCA) is structured to leverage the strengths of both KCCA's internal capabilities and the expertise of an external contractor, MJ Suppliers and Contractors Ltd. The collaboration between these entities is aimed at delivering a high-quality infrastructure project while ensuring efficient use of resources.

### 1.2.1 KAMPALA CAPITAL CITY AUTHORITY (KCCA)

KCCA is the governing body responsible for overseeing the infrastructure development within Kampala. For this particular road project, KCCA took a direct approach by utilizing its in-house engineering team to supervise the project. This decision reflects KCCA's commitment to maintaining strict oversight and ensuring that the project aligns with its standards and strategic goals. This includes ensuring that all projects comply with safety standards, are built to last, and contribute to the broader objectives of improving mobility, reducing traffic congestion, and enhancing the overall quality of life for residents.

#### Key Responsibilities:

- **Project Oversight:** KCCA's in-house team is responsible for the daily supervision of the project, ensuring that all activities meet the required specifications and quality standards, that's to say verifying that all materials, equipment, and workmanship meet the required standards and specifications as per the design and contract documents. The team is also responsible for identifying any deviations or non-conformities from the planned work. This allows for immediate corrective actions to be taken, ensuring that small issues do not escalate into major setbacks.
- **Regulatory Compliance:** The in-house team ensures that the project adheres to local regulations and guidelines, maintaining compliance throughout the construction process. It also involves maintaining accurate records of all project activities, inspections, and approvals.
- **Stakeholder Engagement:** KCCA manages communication with local stakeholders, including residents and businesses, to minimize disruptions and gather feedback. The team actively gathers feedback from stakeholders, which can be valuable in adjusting the project to better serve community needs. Engaging with the public ensures that concerns such as noise, traffic disruptions, or safety hazards are addressed promptly, enhancing the project's overall impact on the community.

### 1.2.2 MJ Suppliers and Contractors Ltd

MJ Suppliers and Contractors Ltd, chosen for this road project based on their proven expertise and extensive experience in road construction, is tasked with executing the project under the careful supervision of KCCA's in-house engineering team. The contractor's responsibilities include managing the day-to-day construction activities, ensuring that the work adheres to the project design, timelines, and quality standards. While MJ Suppliers handles the practical aspects of the construction, KCCA's team ensures that every phase of the project complies with regulatory requirements and meets the strategic goals set for Kampala's infrastructure development. This collaboration ensures that the project is delivered to the highest standards while maintaining KCCA's oversight and quality control.

#### **Key Responsibilities:**

- **Construction Execution:** MJ Suppliers and Contractors Ltd manages all construction activities, including mobilizing resources, coordinating labor, and managing on-site operations that's to say the contractor is tasked with coordinating labor, ensuring that workers are efficiently assigned to various tasks, including earthworks, grading, paving, drainage installation, and other technical operations. In addition to coordinating labor, they must manage logistics and site operations, ensuring that machinery, materials, and manpower are deployed optimally to avoid delays.
- **Quality Control:** The contractor is responsible for ensuring that the work is performed to the highest standards, meeting the specifications set by KCCA. That's to say it involves ensuring that all materials used in the project meet the specifications provided by KCCA and that the workmanship adheres to both the technical standards and best practices in road construction. This may include on-site testing of soil compaction, concrete, and asphalt quality, as well as the review of drainage systems and road alignment to ensure they meet the set specifications.
- **Timely Delivery:** MJ Suppliers and Contractors Ltd is tasked with completing the project within the agreed timelines, ensuring minimal delays. This requires effective project planning and management to avoid delays that could result from issues such as resource shortages, unfavorable weather conditions, or unforeseen technical challenges. Their performance is also evaluated based on their ability to minimize disruptions to the surrounding area, such as road closures or disturbances to local businesses, and ensure that the project reaches completion without significant overruns or extensions.

#### **Collaboration Dynamics**

The in-house supervision by KCCA allows for close monitoring of the contractor's work, facilitating real-time decision-making and swift resolution of any issues. This collaborative approach ensures

that the project is delivered efficiently, with a focus on quality and compliance with KCCA's objectives.

This project organization structure is shown below.

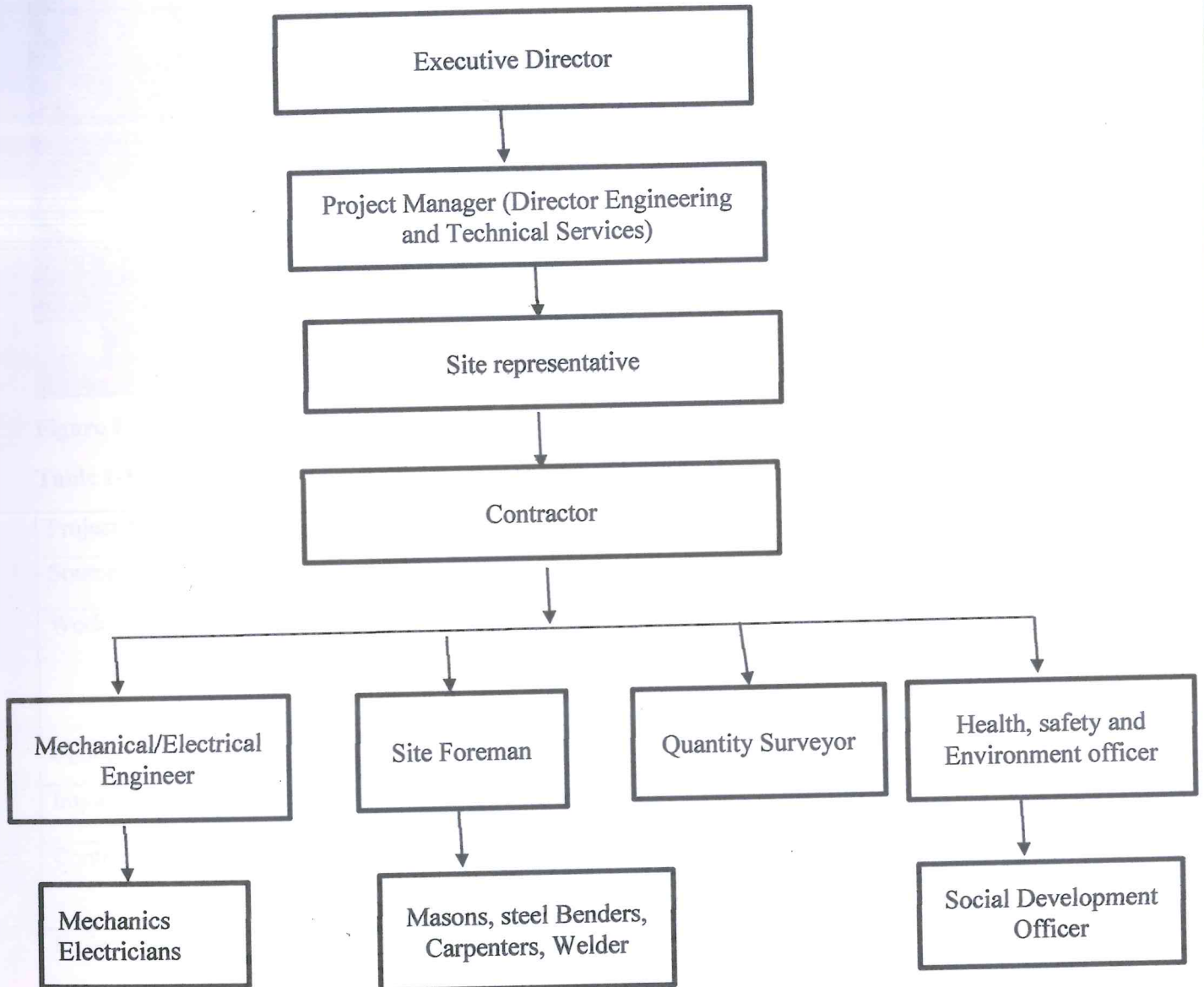
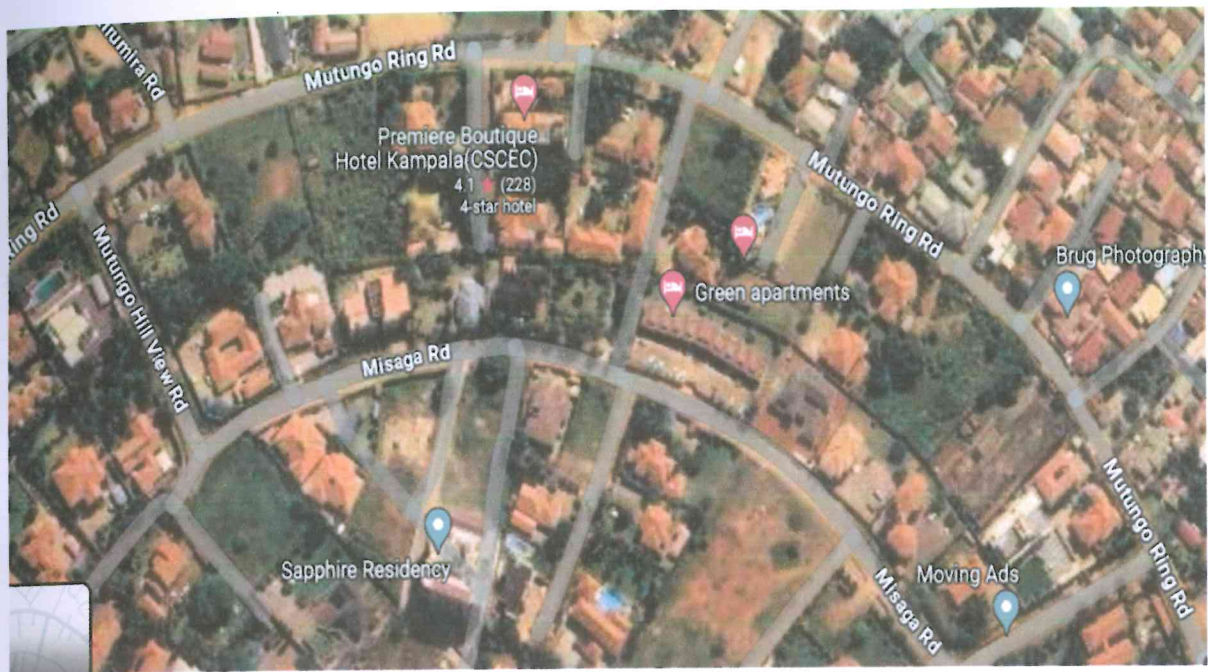


Figure 1:1 Project Organisation Structure

### 1.3 PROJECT DESCRIPTION AND LOCATION

The project consists of the Upgrading of Misaga Road by M/S MJ Suppliers And Contractors Ltd being supervised by the Nakawa Engineering team led by the roads officer. The road starts from Mutungo View Road and ends at Mutungo Ring Road. The road length is 0.425Km and an average width of 7.0m



**Figure 1:2 Location of Misaga Road**

**Table 1-1 Summary of Works Contract Data Summary of Works Contract Data**

Project Name	Upgrading of Misaga Road in Nakawa Division-0.425 km,
Source of Funding	Government of Uganda
Works to consist of:	Design updates, Site clearance, drainage works, earthworks, pavement layers of gravel or crushed stone, bituminous layers and seals and ancillary works.
Contract No.	KCCA/WRKS/22-23/00117.
Implementing Agency	Kampala Capital City Authority (KCCA)
Contractor	MJ SUPPLIERS AND CONTRACTORS LTD, P.O Box 27030, Kampala, TEL: 0392901583, 0783-701851
Project Manager	Director Engineering and Technical Services
Date of Site Possession	December 29 <sup>th</sup> , 2023
Commencement Date	December 29 <sup>th</sup> , 2023
Completion Date	June 29 <sup>th</sup> , 2024
Contract Sum	1,005,176,071 /=

#### 1.4 SCOPE OF WORKS

The scope of works for the Misaga Road upgrade involved a comprehensive set of tasks including the removal of existing materials and structures, excavation and preparation of the roadbed, installation of drainage culverts, construction of the sub-base and base layers, manhole construction, priming and blinding of the base layer, and the application of asphalt to create a durable and functional road surface.

#### 1.5 PROSPECTIVE IMPACT

- **Improved Connectivity and Accessibility:** The upgraded Misaga Road will directly benefit at least 50,000 residents in the Nakawa Division by providing a more reliable and efficient transportation route. This improvement is expected to reduce travel times and improve overall mobility within the community.
- **Increased Property Values:** The improvement in road quality and accessibility is likely to lead to an increase in property values along and around Misaga Road, attracting more investments in the area. That's to say as the road becomes a more attractive and functional route, it is likely to attract increased interest from property developers and investors. This surge in investment can lead to the development of new properties and commercial ventures, boosting the local economy and further elevating property values.
- **Reduction in Traffic Congestion:** The upgraded road will help in decongesting traffic, particularly during peak hours, by providing a more robust and durable carriageway that can handle increased traffic loads. By improving the road's structural integrity and capacity, the project will enhance traffic flow and reduce bottlenecks

#### 1.6 PERSONAL INVOLVEMENT

My practical professional involvement in this project began at the construction stage, serving as the Site Engineer representing Kampala Capital City Authority (KCCA) on the Misaga Road upgrade. The tasks executed during the course of the project were specific to contract implementation and interpretation:

- **Valuation of Works:** Conducting valuations of the work completed and preparing interim payment claims to ensure accurate and timely compensation for the contractor.
- **Progress Reporting:** Preparing weekly and monthly progress reports as required by the contract to keep KCCA and other stakeholders informed of the project's status.
- **Cost Control and Monitoring:** Ensuring that material and labor costs remained within the budgeted costs, thereby maintaining financial efficiency and preventing cost overruns.
- **Quality Control:** Monitoring the size and quality of construction materials to ensure

compliance with project specifications and standards, and maintaining the integrity of the construction process.

- **Site Coordination:** Coordinating site meetings and inspections to ensure smooth communication and workflow among all project stakeholders, including contractors and KCCA representatives.
- **Safety Management:** Ensuring the adequate provision of personal protective equipment (PPE) for workers and visitors to the site, thereby maintaining a safe working environment and compliance with safety regulations.

## **2 CHAPTER TWO: SUPERVISION AND CONSTRUCTION METHODOLOGY**

This chapter delves into the detailed supervision and construction methodology employed during the execution of the Misaga Road upgrade project. It outlines the systematic approach taken to ensure the successful completion of the road works, focusing on key aspects of supervision, construction techniques, and quality assurance practices.

### **2.1 SUPERVISION**

The Success of the project was greatly attributed to the site management practices used by the contractor. Our supervising team of KCCA constantly reviewed and advised on any arising contradictions and community concerns accordingly. This was done to ensure that the project is carried out within the stipulated time, cost and as specified in the contract.

This chapter entails the major construction activities undertaken from commencement of works to completion of the project.

#### **2.1.1 Site Possession and Commencement**

The contractor was issued a commencement order effective December 29<sup>th</sup>, 2023 within a duration of 6months; therefore, the intended completion date was June 29<sup>th</sup>, 2024. The contract specified that updated work programs were to be submitted not more than 7 days from the start date.

#### **2.1.2 Project Planning and Mobilization**

After the site handover, the contractor's preliminary works kicked off in preparation for the execution of the Misaga Road upgrade project. These preliminary works included mobilizing the technical team and the necessary plant and equipment.

The technical team comprised the site engineer, site agent, site quantity surveyor, and site supervisor. During mobilization, works such as site clearance, construction of temporary structures like site offices and storage facilities, selection of possible sources of materials, and testing of materials were carried out.

#### **2.1.3 Key Project Documents in Supervision**

For proper and successful implementation, the following documentation was periodically referenced and adhered to:

##### **2.1.4 Contract Document**

The construction contract between MJ Suppliers and Contractors Ltd and Kampala Capital City Authority (KCCA) was duly signed. The contract was admeasurement. The following documents were deemed to form and be part of the contract:

Performance Security

Special Conditions of Contract

## General Conditions of Contract

Call off order

### 2.1.5 Site Diary

The diary was used to keep evidence of any activities that took place on site as well as anomalies that arose during project runtime, such as rainfall events, which could be used as evidence for extension of time.

### 2.1.6 Measurement Forms

The works were executed as per the drawings, and valuation was carried out jointly at the time of certification. This allowed the contractor and the employer to have consensus on the works executed.

### 2.1.7 Quality Control

All materials used on the project were subject to approval from the project management team before use. Common materials such as aggregates and asphalt were approved as stockpile and later recommended for use. A mix design for concrete was carried out and submitted to the project manager, accepted, and used.

## 2.2 CONSTRUCTION METHODOLOGY

The construction methodology for the Misaga Road upgrade project involves a series of well-defined steps designed to ensure the successful execution of the roadworks. This methodology outlines the processes and techniques used to transform the existing road into a durable and high-quality bitumen standard road. The following sections provide a detailed explanation of the key stages in the construction process:

### 2.2.1 SURVEYING

Surveying is defined as the science of determining the position in three dimensions of the natural and man-made features on or beneath the surface of the Earth. It involves the measurement of distances and angles. The angles may be measured in horizontal and vertical plane. Horizontal angles serve to express the directions of land boundaries and other lines. These features are then represented in analog form as a contoured map, plan or chart, or in digital form as a three dimensional mathematical model stored in the computer. The next step in the operation is that of data processing to produce the desired reference points that can guide the construction work most especially in setting out.

Surveying techniques are used in setting out of the designed constructional elements and also in the monitoring of deformation movements. It involves making alignments and establishing the level of the road. Alignment consists both the vertical and horizontal. Horizontal is based on the X and Y

axis of the road ie length and width while vertical deals with the elevation ie Z-axis.

Surveying was objectively done to;

- Define the boundaries of the pavement layers.
- Define cuttings for unwanted material and filling with the required material.
- Give demarcations for different culverts, bush clearing and grabbing
- Check the levels of the different pavement layers in comparison to the design plan.

The survey equipment used for setting out the road alignment included; reference pegs, survey pegs, measuring tape, dumpy level, the GPS machine, total station, and ranging rods. These activities were made with precision in order to achieve a maximum of accuracy with a minimum expenditure of time and money thus surveying served to be the art of this engineering work.

#### **2.2.1.1 THE GPS MACHINE**

The GPS machine was comprised of three main parts namely, the base that is screwed to the tripod stand at a bench mark point, the data collector that stores and retrieves back information for references in case of need and the Rover that connects to the satellite for the global signal connections. All these parts must first be connected for coordination before any work is done.

During the connection of the GPS machine, the tripod stand was first set on a bench mark of known coordinates at a favorable height with its head just in correlation with the bench mark pin.

The tri-brush (triangular form) was then placed on the tripod head and tightened using an adjusting screw just underneath the tripod head. The tri-brush had three screws located at each corner of the triangle point that were used for vertical adjustments during the centering of the bubble. It also had the eye piece used for focusing of the bench mark pin and the bubble that must always be adjusted to the center before operation. When the tripod stand and the brush are set and ensured that they are horizontal, the base is screwed on a tri-brush, switched on and followed by connection to the data collector.

**The following steps were involved in connecting both the base and the rover to the data collector.**

- Start the data collector.
- Choose the top survey app and open it to bring a job list.
- Select the desired job and open it, click the connection option, select base, Bluetooth and then connect. Specify the type of receiver that you are going to use.
- Select the survey option from the menu and then start base, feed in the height for slant mode, the bench mark name and then start the base.

- It brings two Oks and base connected successfully that gives ago ahead to close the base.
- Move at least two meters away from the base and then switch on the Rover.
- Connect the rover with the data collector.
- Then select the stake out option from the menu, lines or points or topple are staked. If the network is in fixed mode, the machine is ready for use.



**Figure 2:1 GPS Machine**

### **Setting out of the pavement layers**

The procedures for setting out of the different pavement layers was the same though the dimensions varied from one layer to another. After the Rover was connected to the data collector has explained above, lines from the stake out option was selected and set to the design dimensions as per the design manual, the centerline was selected and the rover was moved on the left-hand side of the road at the required distance from the centerline. The above procedure was repeated for the right-hand side.

The rover was then moved to the design offset from the other staked point and a picket inserted into the ground. The rover was then held on top of the picket and the elevation to which the layer being made was to stop as specified in the design was indicated on top of a peg which was placed next to the pickets.

### 2.2.1.2 THE DUMPY LEVEL

This machine was used for heighting of different ground level points basing on the already existing bench marks of known coordinates. It helped in giving of heights for addition of one layer onto the other, checking the levels of the different road layers in comparison with that of the design levels, giving of levels for the cut or fill of different road layers in order to reach the desired design ones and also transferring of coordinates from one bench mark to other points in a way of establishing other temporary bench marks. It consisted of the staff and the level and it was both automatic and manual in terms of operation. The level consisted of a telescope used for focusing the staff readings at both auto and manual readings. This machine was practically used at different road layers, culverts both cross and access and other simple emergency works.



**Figure 2:2 Showing the Dumpy Level**

#### **Setting out of a dumpy level machine for work**

Before this machine is set out for work at any given place, the following factors must be put into considerations.

**Nature of the ground;** the ground should be stable and free from inconveniences

**Topography;** it should easily be in line with the reference point (bench mark) and free from obstacles and disturbances.

**Stuff Distance;** it should be in a distance that can easily be focused and observed. The recommended range is 100m.

#### **Process of setting out**

The tripod stand is firmly set to a favorable working height on ground ensuring that its tripod base is visually horizontal. The level is then screwed tightly on the tripod base and adjusted using its screws in order to center its bubble.

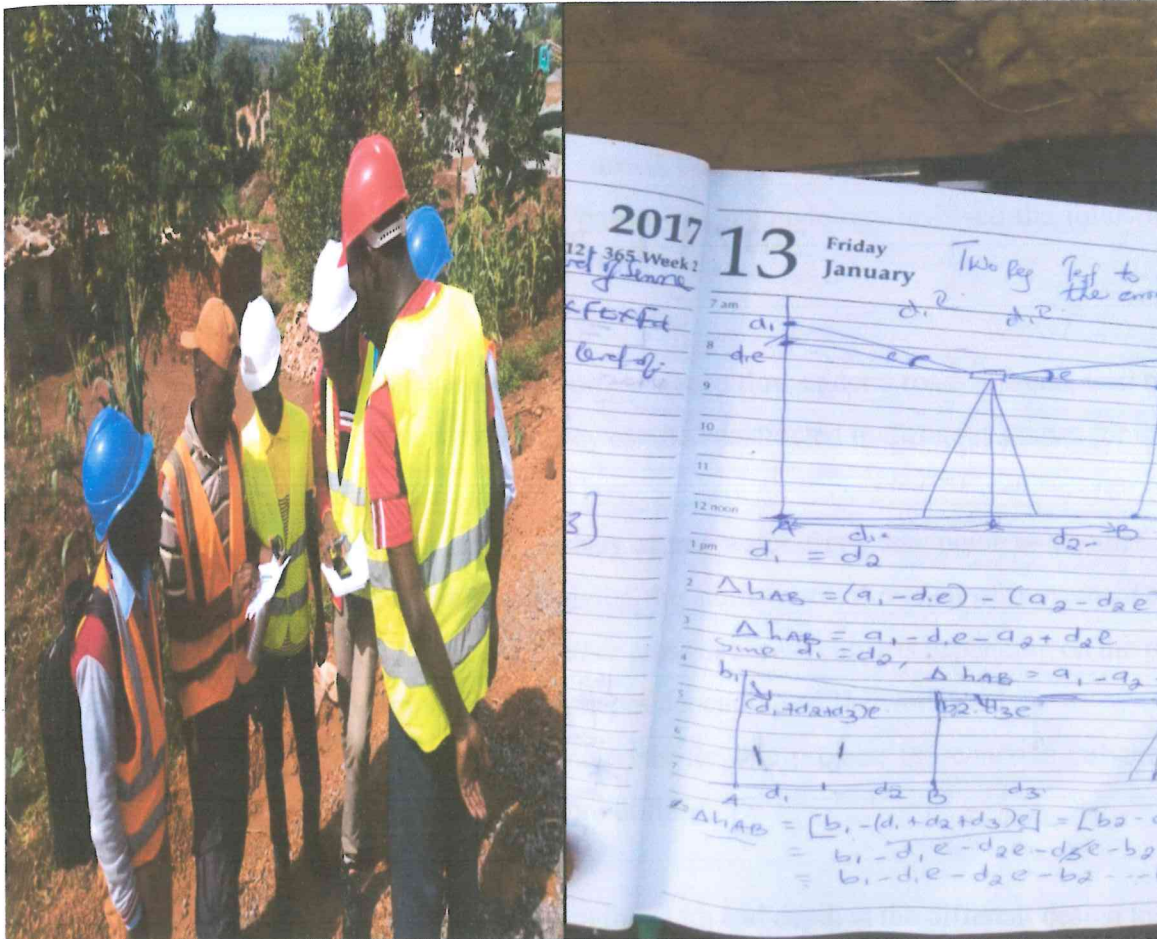


Figure 2:3 Showing how to read a dumpy level and taking levels

### Checking the height of the different pavement layers

Once every pavement layer had been established, checking in comparison to the design plan was conducted. The checking procedures for the different road layers were the same as described below

#### Procedure

After setting out the dumpy level has described above, the graduated staff was vertically placed on a point of known elevation (Bench mark) and focused until a crosshair is clearly observed. The height of the instrument (HI) is then calculated by adding the staff reading value to the elevation of the bench mark. Once the height of instrument is established, staff readings can be taken on subsequent points and their elevations calculated by simply subtracting the readings from the height of instrument.

### 2.2.2 DRAINAGE WORKS

This section involved the construction of drainage channels to aid the movement of water and prevent it from damaging our road layers. Both surface and ground water has to be catered for during drainage

works in order to achieve the expected life span of the designed road. Among the drainage design systems, the following were constructed during my training.

The drainage works on Misaga Road were carried out systematically to ensure efficient water management and durability of the drainage system. The methodology involved the following key steps:

#### **2.2.2.1 Culvert installation**

Culverts are hydraulic structures that allow storm water to flow under a road, railroad, trail or other construction obstruction (Creamer, 2007). They can be constructed in different shapes for example round, elliptical, flat-bottom, pear-shaped and box.

Culverts are open end conduits used to convey storm water from one point to another. These structures provide an opening at both ends giving the storm water direction of movement to flow from high altitude to low ones. They can be either cross or access culverts depending on the purpose they serve and can be designed into different shapes depending on the work load.

According to the design specifications of materials for this project, the concrete culverts were installed both 600mm and 900mm culverts were utilized.

#### **Process of construction**

It first involved excavations to the required length, width and depth at the different design locations followed by blinding using CRR material and compaction to form a strong bed for the culvert.

After compaction of the CRR, the precast culverts were installed and backfilled using grave G30 while at access and crossings they were encased with C25 instu concrete.

#### **BASIC CHARACTERISTICS OF CULVERTS**

The structural and hydraulic design of culverts are different from that of bridges, because of their construction, maintenance, repair, and replacement procedures. The characteristics of culverts are:

##### **1. Hydraulic – Culverts;**

These are usually designed to operate at peak flows with a submerged inlet to improve hydraulic efficiency. The culvert constricts the flow of the stream and may cause ponding at the upstream or inlet end.

##### **2. Structural – Culverts;**

These are buried in soil and designed to support the dead load of soil over the culvert as well as live loads of traffic. Either the live load or the dead load may be the most significant load element, depending on the type of culvert, type and thickness of cover, and amount of live load.

#### **General Problems with Culverts**

There is a wide variety of types of problems that occur with culverts. The problems may be classified

by serviceability and strength-related criteria. Listed below are general types of culvert problems:

**1. Serviceability-related problems:**

- Scour and erosion of streambed and embankments
- Inadequate flow capacity

**2. Strength-related problems:**

- Cracking of rigid culverts
- Undermining and loss of structural support
- Loss of the invert of culverts due to corrosion or abrasion
- Stress cracking of plastic culverts

**3. Blockage:**

Culverts usually constrict flow, there is an increased potential for waterway blockage by debris and sediment, especially for culverts subject to seasonal flow.

**TYPES OF CULVERT**

There is a very wide range of style and designs of culverts in service; all culverts may be classified into two basic types: rigid (concrete) and flexible (steel). Culverts are also often described by their shape, which may be circular, arch, elliptical, or box.

**CULVERT SHAPES**

A wide variety of standard shapes and sizes are available for most culvert materials. Shape selection is often governed by factors such as depth of cover or limited headwater elevation. In such cases a low profile shape may be needed. Other factors such as the potential for clogging by debris, the need for a natural stream bottom, or structural and hydraulic requirements may influence the selection of culvert shape. The common culvert shapes are discussed as here below:

**1. Circular Pipes**

The circular shape is the most common shape manufactured for pipe culverts. It is hydraulically and structurally efficient under most conditions.

**1. Pipe Arch and Elliptical Shapes**

Pipe arch and elliptical shapes are often used instead of circular pipe when distance from channel invert to pavement surface is limited or when a wider section is desirable for low flow levels. These shapes may also be prone to clogging as the depth of flow increases and the free surface diminishes. Pipe arch and elliptical shapes are not as structurally efficient as a circular shape.

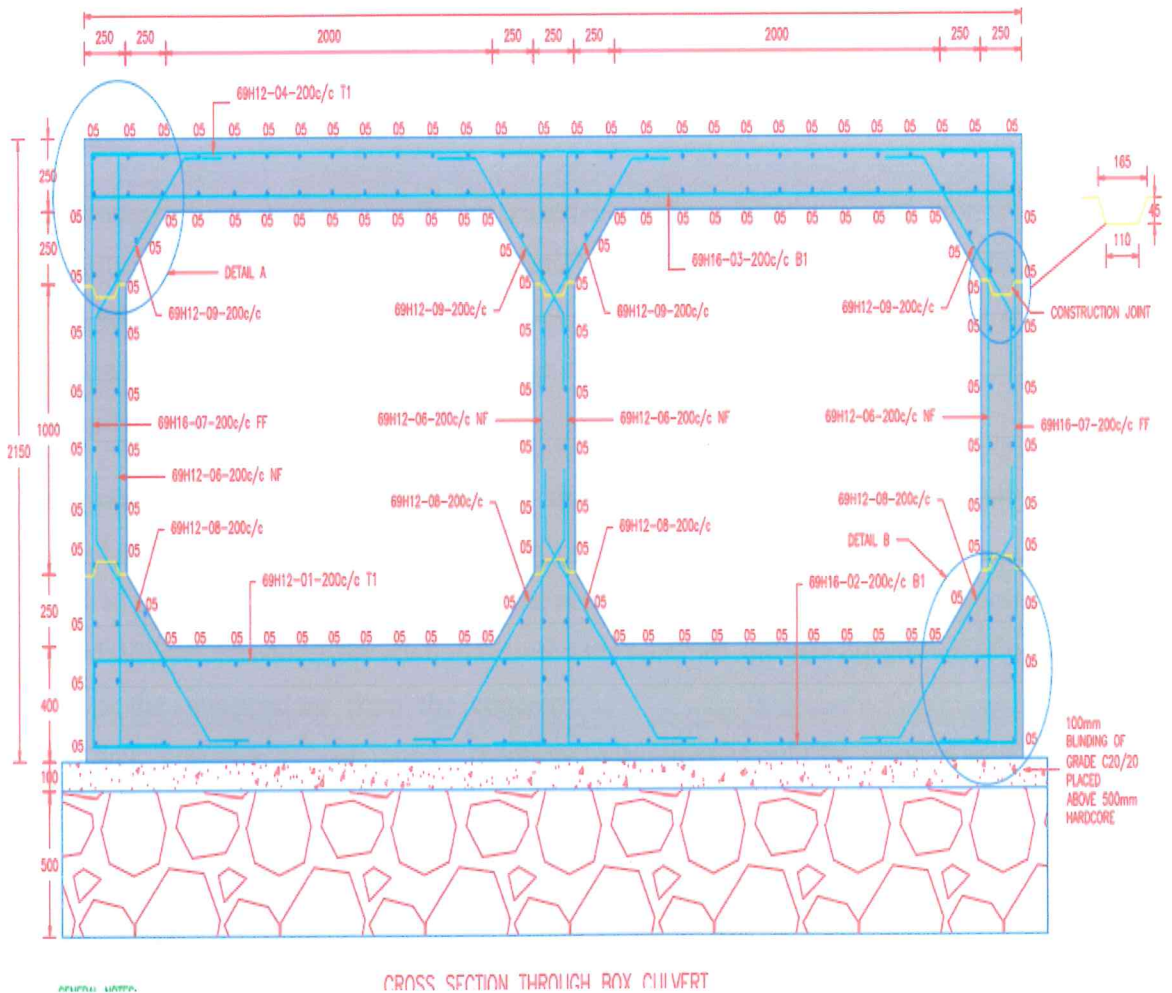
**2. Arches**

Arch culverts have no culvert barrel material at the bottom and offer less of an obstruction to the waterway than pipe arches and can be used to provide a natural stream bottom where the

stream bottom is naturally erosion and abrasion resistant. The structure should also meet scour design requirements.

### 3. Box Sections

Rectangular or square cross section culverts are easily adaptable to a wide range of site conditions, including sites that require low profile structures. Due to the angular corners, boxes are not as structurally and hydraulically efficient as other culvert shapes. Below is an illustration of a single box culvert:



**Figure 2:4 Box culvert**

#### 2.2.2.2 MIXING OF CONCRETE

At site the concrete mixer was used to mix the concrete because of its efficiency and effectiveness to it avail much concrete in a short period of time compared to hand mixing.

#### Preparing and Placing Concrete on Site

This is the process of batching, mixing, and compacting of concrete on site for use in the construction

works. The contents of the process are further defined as here under:

### 1. Batching

This is the act of determining the appropriate amounts of ingredients such as sand, Coarse aggregates, cement, among others to be used in the different mixtures to be made say mortar, concrete (Bolden, 2016).

A wooden gauge box was used on site since its volume is equivalent to that of one bag of cement. The gauge box was used to measure both fine and coarse aggregates. Its dimensions were 300mm-  
×300mm×500mm.

### 2. Mixing

This is the process of integrating the different materials to be used in the construction works for-example; insitu concrete mixing, which is a small batch concrete mixer is used to produce uniform and good concrete. The required quantities of solid ingredients are placed in the drum of the mixer and water is gradually added, as the drum rotates for 2 to 3 minutes.

### 3. Compacting concrete

This is the process of placing concrete to remove air voids entrapped. The entrapped air reduces the strength of concrete up to 30% efficiency; hence necessary to remove the it.

On site we used compaction by vibration using the needle or immersion vibrator with poker at the end of the rod. Vibration reduces the friction between the particles and sets the motion of particles; which removes the entrapped air from the concrete.

**NOTE:** Over vibration is not good, therefore vibrations should be stopped as soon as a cement paste is seen on the surface of the concrete.



**Figure 2:5 Sand and aggregate**

## **PROPERTIES OF FRESH CONCRETE**

There are basically two properties of concrete; workability and stability concrete, which can be reinforced during the construction works, using reinforced concrete. The properties and reinforcement are defined as here below:

### **A. Workability**

Workability generally implies the ease with which a concrete mix can be handled from the mixer to its finally compacted shape. The three main characteristics of this property are;

1. Consistency: This is a measure of the wetness or fluidity or the relative mobility or ability of fresh concrete or mortar to flow. It is measured by slump.
2. Compatibility: The ease with which a given mix can be fully compacted to remove all trapped air.

### **B. Stability**

This refers to the cohesion of the mix i.e. its resistance to segregation. Fresh concrete should have a composition such that its constituent materials remain uniformly distributed in the concrete during both the period of mixing and compaction.

### **C. Reinforced concrete**

This is a type of concrete that has been made by fixing steel bars in it for additional strength.

#### **Properties of reinforced concrete**

Reinforced concrete is a strong durable material that can be formed into many shapes and sizes ranging from a simple rectangular column to a slender curved dome or shell.

These two materials are more or less complementary. Thus when combined, steel is able to provide the tensile strength and probably some of the shear strength while the concrete, strong in compression, protects the steel to give durability and fire resistance. The columns, manholes, trench slabs, trench walls and a walk way were basically made by reinforced concrete.

**Table 2-1 Showing properties of reinforced concrete**

Property	Concrete	Steel
Strength in tension	Poor	Good
Strength in compression	Good	Poor
Strength in shear	Fair	Good
Durability	Good	Corrodes if unprotected
Fire resistance	Good	Poor; suffers rapid loss of strength at high temperatures

### 2.2.3 FORMWORK

Formwork this is a temporary support that is used to hold cast concrete until it attains its full strength. There are two types of formwork; panel forms and stationary forms. Panel forms are those which can be reused and stationary forms are those which are non-reusable.

It is important to note that the most common material used for formwork is timber and it is the very one that was used, though it has some disadvantages like warping, swelling and shrinking.

#### 2.2.3.1 Types of formwork

- i) **Timber formwork:** This is the most common type of formwork used on site. It's preferred to other types and should be; Well-seasoned, Light in weight, Free from loose knots, easily workable with nails without splitting and it should have a smooth and even surface on all faces that come into contact with the concrete
- ii) **Plywood formwork:** This is mostly used on the staircases of the building because the work was small to use steel formwork. The plywood is attached to timber frames to make up required panel sizes. It is noted that for small works the cost of using plywood is relatively cheaper.
- iii) **Steel formwork:** This is largely used on the slab formwork where steel plates were laid to for the soffit of the slab formwork. The main reason for their use is the need for reuse on the upper level slab formworks.



**Figure 2:6 Formwork on a manhole**

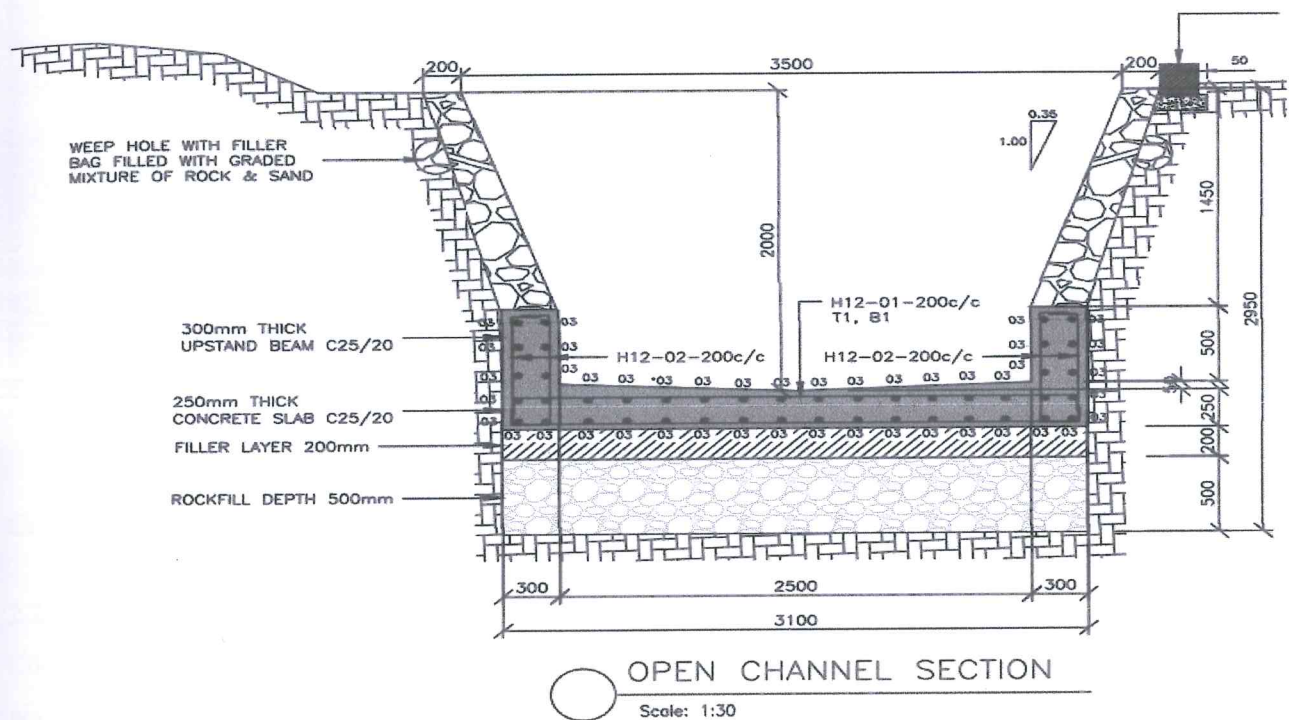
#### **2.2.4 Quality Control and Testing**

**Material Testing:** Conducted quality tests on materials like sand, gravel, concrete, and culverts to ensure they met required standards.

**Inspection:** Performed regular inspections to ensure compliance with design specifications and construction standards.

#### **2.2.5 CONSTRUCTION OF THE OPEN CHANNEL**

This refers to the construction of or improvement to a channel in which water flows with a free surface (not in pipe) and base flow. The purpose of this is to provide storm water conveyance and discharge capacity required for flood prevention, drainage, and/or other authorized water management purposes. For this project running water and also waste water from the residential places within the area was to be conveyed in this channel is to be directed to Mutungo ring Road drainage.



**Figure 2:7 Cross section of the open channel**

Excavation of the channel trenches was done using an excavator to the required depth in accordance with the channel plan that's to say 2.5m deep and 3.5m width. This was followed with adding hard cores to the excavated area to increase the bearing capacity of the soil, an aggregate blinding was used before adding a BRC coarse, Plain concrete was then cast and cured using water (curing was done the following day by sprinkling water onto the concrete). The bedding was constructed using reinforced concrete (using steel bars of diameter size 12).

Bedding refers to a stable and uniform foundation necessary for the satisfactory performance of any structure for this case it was to support the trench walls. The bedding was prepared in accordance with the plans and specifications of the channel.

After the channel bed has been constructed and cured, the offset distances for the channel wall slope is taken. This was 500mm to get the bending angle of the channel walls since it was to be a trapezoidal shape. Walls were stone pitched using coarse mixed sand (a mixture of stone dust and lake sand in ratios of 1:3) that forms mortar where the cement: sand ratio was 1:4. Stones of fine flat facing were used however in the back fill; stones with irregular shape can be used. For fine finishing or pointing, fine sand with the cement: sand ratio of 1:3 was used. While constructing the trench walls wipe holes are inserted in the walls these are for draining water.



**Figure 2:8 Open channel**

Concrete blending and a BRC mash.

Stone pitched wall

### 2.2.6 COPING TO THE TRENCH WALL.

Coping is the process of covering stones, concrete, brick or terracotta, placed on exposed top of a wall, to prevent seepage of water.

The materials or masonry units used to form a cap or a finish top of a wall, pier to protect the masonry below from water penetration, commonly extended beyond the wall face and incorporating a drip. It also gives a beautiful outlook. Specifically, coping was employed on piers.

The trenches were provided with concrete coping 250mm wide by 40mm thick using a ratio of 1:3:4 that's to say 1 bag of cement mixed with 3 batches of sand and 4 batches of aggregate.

#### Tools used:

- Concrete nails
- Nails (2.5", 3")
- Timber
- Bow saw
- Tape measure
- Water level
- Building line

**Procedure;**

- i. Timber was fixed onto the trench by driving 3” concrete nails by the use of a hammer around the trench with the use of spacers.

**Construction of form work for coping**

These steps include;

- Propping and centering
  - Shuttering; this is the raising of props and formwork supports before casting of concrete.
  - Provision of camber
  - Cleaning and surface treatment
  - Striking formwork; is the removal of formwork from cast concrete after it has gained sufficient strength.
- ii. Water is poured into the area enclosed in the timber before the concrete is cast into the area.
  - iii. Concrete of ratio 1:3:4 was used when mixing the concrete to be used for the copying.



**Figure 2:9 Coping to the channel**

## 2.2.7 ROAD WORKS

It covers the comprehensive approach to road construction, beginning with the structural design that involves construction of the different road layers for stability and durability. It includes the subgrade, which serves as the foundation, the sub-base and base layers that provide additional support and load distribution, and the surface layer which forms the final driving surface.

### 2.2.7.1 STRUCTURAL DESIGN OF A ROAD

The purpose of structural design is to limit the stresses induced in the subgrade by traffic to a safe level at which subgrade deformation is insignificant whilst at the same time ensuring that the road pavement layers themselves do not deteriorate to any serious extent within a specified period of time.

By the nature of the materials used for construction, it is impossible to design a road pavement which does not deteriorate in some way with time and traffic, hence the aim of structural design is to limit the level of pavement distress measured primarily in terms of riding quality, rut depth and cracking, to predetermined values.

Deterioration of roads depends on the nature of the traffic, the properties of the road-making materials, the environment, and the maintenance strategy adopted

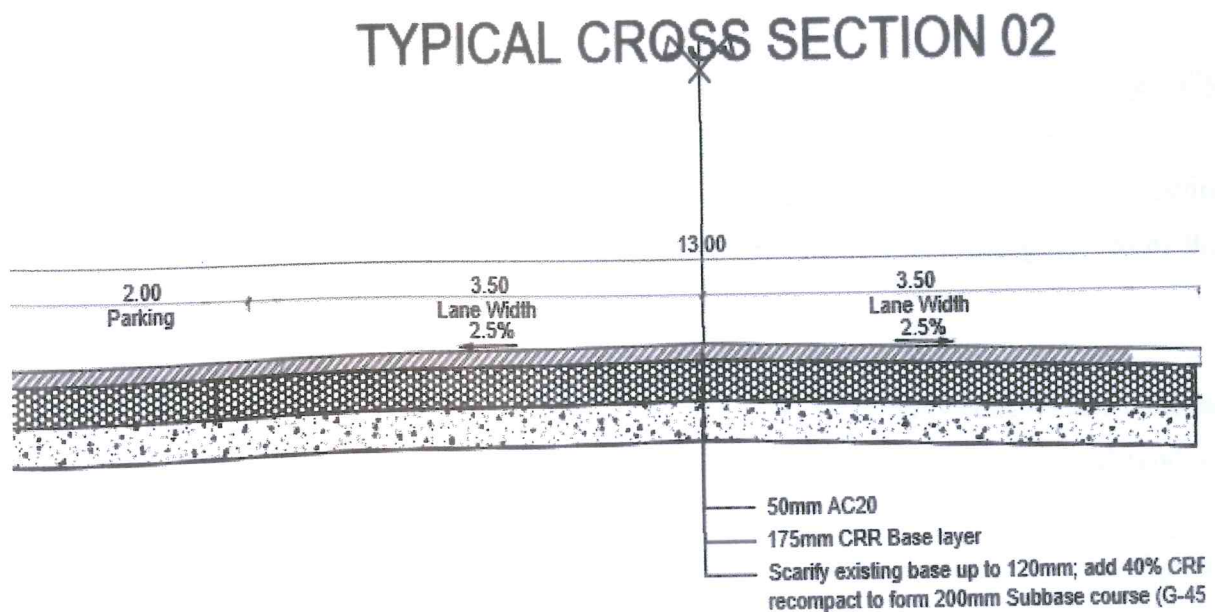


Figure 2:10 Road section

**Designing a new road pavement involves three main steps as explained below.**

- 1) Estimating the amount of traffic and the cumulative number of equivalent standard axles that will use the road over the selected design life. For the purposes of structural design, cars and similar sized vehicles can be ignored and only the total number and the axle loading of the heavy vehicles that will use the road during its design life need to be considered. Heavy vehicles are those having an unladen weight of 3000 kg or more.
- 2) Assessing the strength of the subgrade soil over which the road is to be built. The strength of road subgrades is commonly assessed in terms of the California Bearing Ratio (CBR) and this depends on the type of soil, its density, and its moisture content.
- 3) Selecting the most economical combination of pavement materials and layer thicknesses that will provide satisfactory service over the design life of the pavement (It is usually necessary to assume that an appropriate level of maintenance is also carried out).

### **Subgrade**

This is first layer of the road on which the pavement structure and shoulders including kerbs are constructed. It is the upper layer of the natural soil which maybe undisturbed local material or may be soil excavated elsewhere and placed as fill. In either case it is compacted during construction to give added strength.

The subgrade was constructed to a total thickness of 200mm but in two layer divisions each of 100mm to achieve maximum compaction. The material used was soil that met a CBR value of 15 and all that could not rime to it was cut.

According to the project design, this was composed of G3, G7 and G15 materials. G3 was basically the fill and G7 or G15 was the 200mm layer just above the fill all constructed using gravel.

The density of the sub grade soil was controlled within limits by compaction at suitable moisture content at the time of construction. The moisture content of the sub grade soil was governed by the local climate and the depth of the water table below the road surface.

### **Sub-base**

It is the secondary load-spreading layer underlying the road base. It normally consists of a material of lower quality than that used in the road base such as unprocessed natural gravel, gravel-sand, or gravel-sand-clay.

This layer serves as a separating layer preventing contamination of the road base by the subgrade material and under wet conditions, it protects the subgrade from damage by construction traffic.

For this project, the sub base was made up of crushed stones of thickness 100mm using G45 material only and compacted to 98% field density following the same process.

### Road base

This is the main load-spreading layer of the pavement. It normally consists of crushed stone or gravel, decomposed rock, sands and sand-clays stabilized with cement, lime or bitumen. It distributes the applied wheel loads to the subgrade in such a way that the bearing capacity of the subgrade is not exceeded.

It was composed of two layers base 1 and base 2 each compacted at 100mm thickness to attain maximum compaction. It was made up of CRR (G60) material which was compacted to 102% field density. Compaction was first done using a vibrating compactor and later a static compactor (tyre roller).



**Figure 2:11 Construction of the base layer**

### **Binder Course:**

Priming process was done after the construction of the final base 2 layer. It is the first seal that helps in binding the aggregate of the top base layer together. It acts as a proof membrane preventing water penetration underneath the already laid layers and also providing better binding properties for surface dressing. It consisted of 70% bitumen and 30% kerosene.

Before application of this prime coat, it was first heated to a temperature of 78°C to achieve the required spray rate of 0.8-0.9L/m<sup>2</sup> as specified in the design standards. The section to be prime coated was also cleaned by sweeping to ensure that the surface was free of dust and foreign matters. This was aided by heavy mechanical machines such as the drag broom followed by a rotary broom equipped with a compressor.

During application, the Bitumen distributor containing bitumen mixture being maintained 78°C was then allowed to spray the bitumen at a speed of 5.6km/hr in order to attain the rate of 0.8-0.9L/m<sup>2</sup> in the cleaned section.

The blinding aggregates would then be applied after an elapse of 4hrs to remove the excess prime that didn't penetrate the layer.

The rates of application for both prime and blinding aggregates were controlled by putting sample two sample trays in every 100m. This was done by the lab technician.

Laid a binder course of prime coat (MC30) to bind the base layer and prepare for the surface layer.

### **Wearing Course:**

This is the uppermost layer of the pavement and normally consists of a bituminous surface dressing or a layer of premixed bituminous material. Where premixed materials are laid in two layers, these are known as the wearing course and the base course. Applied asphalt, to ensure a smooth and durable road surface.



**Figure 2:12 Laying and compaction of asphalt**

## Quality Control and Testing

**Material Testing:** Conducted tests on materials such as aggregates and bitumen to ensure they meet the required specifications.

**Compaction Testing:** Performed compaction tests on each layer to ensure proper density and stability.



**Figure 2:13 Testing of the sub base layer**

**Table 2-2 Compaction requirements for pavement layer**

Layer and material type specified	MDD, Lower specification limit, BS 1377: Part 4
Base course layers, G60 material (CRR)	102% BS-Heavy
Sub base course layer 2, G45 material (CRS)	98% BS-Heavy
Sub base course layer 1 (Modified sub base), G30 material (70% borrow pit + 30% CRS)	97% BS-Heavy
Fills (Sub grade):	
G15	95% BS-Heavy
G7	93% BS-Heavy
G3	90% BS-Heavy
Road bed	93% BS-Heavy

## 2.2.8 Safety Measures

Safety measures were implemented throughout the project, including:

Provision of personal protective equipment (PPE) for all workers and visitors.

Establishing safety protocols and emergency response plans.

Regular safety inspections and audits to ensure compliance with safety standards.

## 2.2.9 TESTS ON SOILS

These tests were conducted to evaluate the materials and workmanship throughout the construction process. These tests were designed to assess the structural integrity of the road layers, including the subgrade, sub-base, base, and surface, as well as to verify the effectiveness of the drainage systems.

### 2.2.9.1 Moisture content determination

This test was conducted to determine the amount of water present in a soil sample expressed as a percentage of the mass of dry soil

#### Main principle

The moisture content of the soil was assumed to be the amount of water within the pore spaces between the soil grains which is removed by oven drying at a temperature not exceeding 110.

#### Apparatuses

- An oven
- A weighing balance readable to 0.1g
- A metal container

#### Test procedure (This test was done according to BS 1377-2: 1990)

A representative sample was crumbled and loosely placed in clean dry containers.

The containers with the samples were immediately weighed and placed in an oven at a temperature of 105°C for 12hours.

After drying, the masses of water were got by subtracting mass of dry sample from mass of wet sample. Moisture content was then determined from the formula;

$$\text{Moisture content} = \frac{\text{mass of water}}{\text{mass of dry sample}} \times 100$$

### 2.2.9.2 Dry density-moisture content relationship (MDD compaction)

This test helped to obtain the relationship between the compacted dry density and the soil moisture content. It was used to give a guide for field compaction. BS heavy compaction using a 4.5kg rammer (5 layers and 62 blows per layer) was used.

### **Main principle**

The dry density of a soil which can be achieved depends on the degree of compaction and the moisture content of the soil. The moisture content which gives the highest dry density is called the optimum moisture content for that specific type of compaction.

### **Apparatus used**

- Metal rammers of 4.5kg
- Cylindrical compaction moulds of volume 1.0 liters. (105mm internal diameter and 115mm internal height)
- Electronic balance, readable to 1.0g
- 20mm standard sieve
- A large metal tray
- A straight edge
- Measuring cylinder
- Moisture tins
- Scoop

### **Sample preparations**

Five representative samples each about 6000g of material passing through the 20mm test sieve was prepared

The samples were mixed thoroughly with different amounts of water to give a suitable range of moisture contents and sealed in an airtight container for about 4 hours to cure.

### **Test procedure (The test was done with reference to BS 1377: Part 4: 1990)**

The weight of the mould with its base plate attached to it was obtained

The extension collar was then replaced and a certain quantity of moist cured soil was placed such that it occupies 1/5 of the height of the mould when compacted. The rammer was then placed on the material, lifted until it reached the top of the guide and then released allowing it to drop freely on the sample.

The process above was repeated systematically covering the entire surface of the sample and following the compaction criteria for each mould. The rammer was removed and next layer filled in the mould, compacted as the first layer. This process was repeated for all the remaining layers.

When all the layers were compacted, the extension collar was removed and the compacted soil leveled to the mould surface.

The weight of the compacted soil and the mould was then obtained. The compacted sample was removed from the mould and a representative sample of it taken for moisture content determination.

This all process was carried out for all the 5 portions of the sample.

## Reporting of results

The bulky density of each compacted sample was then calculated from

Bulky density = mass of compacted sample only/volume of mould

Dry density = (bulky density\*100) / (average moisture content +100)

A graph of dry density against moisture content was plotted and the peak of the curve was used to read the value for maximum dry density and the corresponding moisture taken as the optimum moisture content.

### 2.2.9.3 Particle size distribution (grading of soils)

The test was carried out to determine the proportion of different sizes of particles present in the soil or gravel materials. Particle size distribution is a necessary classification test for soils, especially coarse soils since it presents relative portions of different sizes of particles. This helps to determine whether the soil predominantly consists of gravel, sand, silt and clay sizes and, to a limited extent, which of these size ranges is likely to control the engineering properties of the soil.

#### Main principle

The procedure used involved preparation of the sample by wet sieving using a 0.75mm sieve to remove silt and clay sized particles followed by dry sieving of the remaining coarse material. It covered the quantitative determination of particle size distribution in essentially cohesionless soils, down to fine sand size.

#### Apparatus used

- Standard sieves; 75mm, 50mm, 37.5mm, 20mm, 14mm, 10mm, 6.3mm, 5.0mm, 2.0mm, 1.18mm, 0.600mm, 0.425mm, 0.300mm, 0.212mm, 0.150mm, 0.075mm
- Oven
- Rifle box
- Metal trays
- Wire brush

#### Sample description

A representative sample of 3kg was obtained using the riffing method. The sample was then washed thoroughly using the 425 $\mu$ m and 75 $\mu$ m sieves and then dried for 24 hours in the oven specified above for natural moisture content determination.

#### Test Procedure (The test was carried out with reference to BS 1377: Part 2: 1990)

Sieves were arranged to their diameter from the biggest according to the material envelope required for instance 14mm-75 $\mu$ m for lake sand and quarry dust, 20mm-75 $\mu$ m for chippings, among others. The sample that had been dried for 24 hours in the oven was then poured in the stack of nested sieves. The sieves were then shaken manually until there was no material passing through any of the sieves.

The mass of the sample retained on each of the sieves were weighed and recorded.

The cumulative mass retained on each of the sieves was then calculated by summing up the mass retained on each of the sieves and the mass retained on the preceding sieves.

The cumulative mass retained percentages were also computed basing on the initial dry weight before washing the sample.

The percentage passing through each of the sieves was calculated.



**Figure 2:14** Arrangement of sieves and dry sieving during the grading process.

#### **Reporting of results**

A semi-logarithmic graph of cumulative percentage passing as ordinate against sieve sizes as abscissa was plotted. The grading modulus was calculated from the formula below and was used to assess how fine or coarse the material was;

$$\text{Grading modulus} = 3 - ((\% \text{passing } 2\text{mm} + \% \text{passing } 0.425\text{mm} + \% \text{passing } 0.075\text{mm}) / 100)$$

#### **2.2.9.4 Liquid limit**

Liquid limit is the moisture content at which a soil passes from liquid state to plastic state. It is used together with plastic limit to determine plasticity index which is used in classification of cohesive soils. It provides a means of classifying and identifying fine grained cohesive soils especially when the plastic limit is known.

### Main principle

The cone penetration method was used. This method determines the liquid limit of a sample for material passing on a 0.425mm sieve. It is based on the measurement of penetration into a soil using a standardized cone.

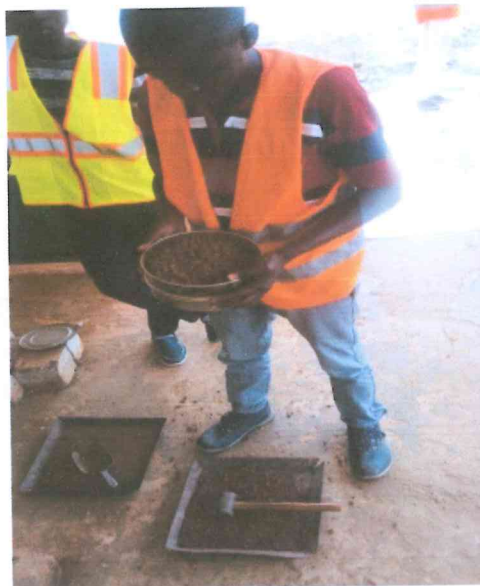
### Apparatus used

- Cone penetrometer
- Electronic balance
- Glass plate
- Wash bottle
- Moisture tins
- 0.425mm sieve
- Stop watch
- Palette knives
- Penetration cup

### Sample preparation

About 400g Of a soil sample passing through a 0.425mm sieve was taken. This had to be enough for liquid limit test, plastic limit test and shrinkage.

The sample was transferred to the glass plate and soaked using distilled water, mixed thoroughly with two palette knives until the mass became a thick homogenous paste. The paste was placed in an air tight container and allowed to stand for 16-24hours to allow the water to permeate through the soil.



**Figure 2:15 Sieving using a 0.425mm sieve**

**Test procedure (This test was done with reference to BS1377-2: 1990)**

400g of the sample that had been well prepared and soaked for 24 hours was taken and placed on the glass plate. The paste was mixed for at least 10 minutes using the two palette knives with distilled water being added carefully in bits. A portion of the mixed sample was pushed into the cup using a palette knife and taking care not to trap air, the cup was gently tapped on a hard surface.

With the penetration cone locked in the raised position, the cone was raised so that it just touched the surface of the soil. The dial gauge was lowered so that it touched the cone shaft and the readings were recorded to the nearest 0.1mm.

The cone was released for a period of 5 seconds. After the cone was locked in position, the dial gauge was lowered to contact the cone shaft and the readings of the dial gauge were recorded to the nearest 0.1mm. The difference between the readings was recorded as "cone penetration. The cone was lifted up and cleaned carefully to avoid scratching. A little more wet soil was added to the cup and the process repeated. If the difference between the first and the second penetration reading was less than 0.5mm, the average of the two was recorded. If the penetration was more than 0.5mm and less than 1mm difference from the first, a third test was carried out. If the overall range was more than 1mm, the average of the three penetrations was recorded. If the range exceeded 1mm, the soil was removed from the cup, remixed and the test repeated until consistent results were obtained.

A sample for moisture content of about 20g was taken from the area penetrated by the cone and the moisture content was determined. The penetration test was repeated three more times using the same sample to which further increments of water had been added. The increments of water were added so that the range of penetration values was approximately 15mm, 18mm, 21mm and 24mm by the four test runs.



**Figure 2:16 The cone penetrometer, paste mixing and samples for moisture content**

## **Reporting of results**

A graph of penetration against moisture content was plotted and a line of best fit drawn. The moisture content corresponding to 20mm penetration was read as the Liquid limit.

### **2.2.9.5 Plastic limit**

Plastic limit is the water content of the soil below which it ceases to be plastic. At this point, it begins to crumble when rolled into threads of 3mm diameter. This test is used together with the liquid limit to determine the plasticity index of cohesive soils.

#### **Main principle**

This method covers the determination of liquid limit of a soil in its natural state or soil which is free of material retained on a 0.425mm sieve.

#### **Apparatus used**

- Container to determine moisture content
- Electronic balance
- Oven
- Glass plate
- 3mm diameter rod, about 10cm long

#### **Sample preparation**

This test was performed as a continuance of the LL test and its sample was prepared as part of the liquid limit test.

#### **Test Procedure**

**This test was done with reference to BS 1377-2: 1990**

A 40g paste was picked from the prepared soil sample and placed on a glass plate.

The soil sample was spread and allowed to dry partially until it became plastic enough to be shaped into a ball.

The ball of the soil sample was molded between the fingers and rolled between the palms of the hands until the heat of the hands dried the soil sufficiently for slight cracks to appear on its surface.

The sample was divided into two sub-samples of about 20g each and separate determination on each sample was carried out. Each of the samples was further divided into four equal parts.

The soil was molded in the fingers to equalize the distribution of moisture. It was then formed into a thread about 6mm diameter between the first finger and thumb of each hand.

The thread was rolled between the fingers, from fingertip to the second joint of one hand and the surface of the glass plate. The diameter of the thread was further reduced to about 3mm in 5 to 10 complete, forward and back, movements of the hand.

The soil was picked up, molded it between the fingers to dry it further, formed into a thread and

rolled it out again as specified above.

The procedure was repeated until the thread sheared both longitudinally and transversely when rolled to about 3mm diameter. The first crumbling point is the plastic limit.

The pieces of crumbled soil thread were gathered and transferred them to a suitable container for determination of the moisture content and replaced the lid immediately.

The above procedure was repeated on the other three portions of the test sample, placing all of them in the container for moisture.

#### **2.2.9.6 Plasticity Index**

This is the range of moisture contents in which a soil is plastic; the finer the soils, the greater the plasticity index. The aim of determining liquid limit and plastic limit was to determine the plasticity index of the material which was determined from the formula;

Plastic index (PI) = liquid limit (LL) – plastic limit (PL).

This test helped me understand that soils with high plasticity index should not be used for road construction in upper layers as they expand due to wetting, become slippery and are weak generally.

#### **2.2.9.7 Linear Shrinkage**

Linear shrinkage value is a way of quantifying the amount of shrinkage likely to be experienced by a clayish material. This is also relevant to a converse condition of expansion due to wetting.

##### **Main principle**

This covers the determination of total linear shrinkage from linear measurements of a bar of soil of a sample passing through a 0.425mm sieve, originally having the moisture content of the liquid limit.

##### **Apparatus used**

- Glass plate
- Brass mould, 140mm long
- Palette knives
- Wash bottle
- Oil or grease
- Vernier caliper

##### **Sample Preparation**

The test was performed as a continuance of the LL and PL tests.

##### **Test Procedure**

**The test was done with reference to BS1377-2: 1990**

The mould was cleaned thoroughly and a thin film of silicon grease was applied to its inner faces to prevent the soil adhering to the mould.

A 150g soil paste sample at approximately the LL was taken and placed in the mould such that it is slightly proud of the sides of the mould.

The soil was leveled along the top of the mould with the palette knife and removed all soil adhering to the rim of the mould by wiping with a damp cloth.

The mould was placed where the paste could air dry slowly for 1-2 days until the soil has shrunk away from the walls of the mould. The drying was completed at 105°C -110°C in an oven.

The mould was cooled and the mean length of the soil bar determined by pressing it against the end of the mould where there is a better fit, while measuring the distance between the opposite side of the mould and the soil.



**Figure 2:17 Shrinkage moulds**

### **Reporting of results**

Linear Shrinkage of the soil was calculated as a percentage of the original length of the specimen,  $L_0$  (mm), from the equation:

$$\text{Percentage of Linear Shrinkage} = \left(1 - \frac{L_D}{L_0}\right) 100$$

Where;  $L_D$  is the length of the oven-dried specimen.

$L_0$  is the original length of the specimen

### **2.2.9.8 California Bearing Ratio (CBR); three point method**

This test was aimed at determining the strength of soils or gravels when exposed to severe conditions so that the strength of the sub-grade, sub-base and base courses are not compromised. The strength of the sub-grade, sub-base and base course materials are expressed in terms of their CBR values.

#### **Main principle**

The CBR value is the resistance to a penetration of 2.5mm of standard cylindrical plunger of 50mm diameter, expressed as a percentage of the known resistance of the plunger to 2.5mm penetration in crushed aggregates. (Taken as 13.2KN)

#### **Apparatus used**

- A perforated base plate fitted to a CBR mould
- 20mm standard test sieve
- Measuring cylinder
- Two metal rammers of 2.5 and 4.5kg
- Electronic balance
- Scoop
- Oven
- Moisture tins
- CBR compression machine (28KN capacity)
- Petroleum jelly
- Soaking tank
- A dial gauge having a travel of 25mm and reading 0.01mm
- Loading rings
- Filter papers

#### **Sample preparation;**

The material was obtained from the field by taking samples of the material to be laid from different parts and placed in a sack, spread for air drying.

Replacement method was used where the material coarser than 20mm was removed, weighed and replaced by the same quantity of material. A representative sample was then obtained using the riffing method, 3 portions each of about 6kg were then taken off and used for the test.

#### **Test Procedure (The test was done with reference to BS 1377: Part 4: 1990)**

The moulds were weighed with the base plates attached to them. The extension collar was then attached to the moulds and the base plate covered with a filter paper. The moist material was transferred to a mixing tray. It was thoroughly but rapidly mixed and then covered by a dump sack which was kept over the material until compaction was complete.

The first mould was tamped full of material using the 4.5kg rammer, five layers and 62 blows per layer. Each layer was filled such that it occupied a little more than one-fifth of the height of the mould. The blows were evenly distributed over the surface. The final level of the soil surface was about 5-10mm above the top of the mould body.

The collar was removed and the soil trimmed to flush with the top of the mould using the scraper and checking with the steel straight edge. The mould was weighed with the soil and base plate to the nearest 5g. A representative sample for moisture content was taken from the mixing tray.

The second mould was tamped full of material with the 4.5kg rammer, five layers and 30 blows per each layer with 4.5kg rammer and the above procedure repeated whilst the third mould was tamped full of material but this time, only three layers of the material were compacted and on each layer 62 blows of the 2.5kg rammer were applied. The mould material was then trimmed, weighed and recorded.

The moulds were then placed in an empty soaking tank with the filter papers on top of the samples, followed by perforated swell plate.

A reading of the dial gauges before filling the tank with water was determined and the tank was then immediately filled with water to the brim. The moulds were then left in the water bath for 4 days and the dial gauge was read in order to determine the swelling capacity of the sample.



**Figure 2:18 CBR moulds, tamping rammers, compacting and soaking of the CBR moulds**

### 2.2.9.9 Penetration Test Procedure

The mould with the base plate containing the sample was placed with the top face of the sample exposed centrally on the lower pattern of the testing machine.

The annular surcharge discs were placed on top of the sample.

The cylindrical plunger was placed into place on the surface of the sample.

A seating force was applied to the plunger depending on the expected CBR value as follows; for CBR value up to 5% apply 10N, for CBR value from 5% to 30% apply 50N, and for CBR value above 30% apply 250N.

The reading of the loading ring was recorded as the initial zero reading.

The plunger was started so that it penetrates the sample at uniform rate 1mm/min.

The readings of the force gauge in intervals of 25mm were recorded, to a total penetration not exceeding 7.5mm.

The values obtained from the penetration test were multiplied with the proving ring constant (0.0261kN/Division), for the machine used in this project.

A graph of load (KN) against penetration was plotted to obtain the CBR values.

#### Reporting of results

Penetrations at 2.5mm and 5.0mm were used for calculating the CBR value.

- For the plunger force, P, at 2.5mm penetration from the force-penetration curve;

$$\text{CBR} = \frac{P}{13.2} \times 100$$

- The plunger force, Q, at 5.0mm penetration.

$$\text{CBR} = \frac{Q}{20} \times 100$$

Calculation of the amount of swell; Swell,  $S = \frac{V_1 - V_0}{127} \times 100$

Where;  $V_1$  is the dial gauge reading after 4-days soaking.

$V_0$  is the dial gauge reading before soaking.

The highest value of CBR at 2.5mm and 5.0mm penetration was used for assessing the quality of the material.

**Table 2-3 Summary of CBR test procedure**

Type of Materials	Min % Passing Test Sieves	Type of Mould	Number of Blows	Number of Layers	Rammer (kg)
	20mm				
All Type of Materials	100	CBR	62	5	4.5
	100	CBR	30	5	4.5
	100	CBR	62	3	2.5

**2.2.9.10 In-situ density tests using sand replacement method**

The dry density of compacted soil or pavement material is a common measure of the amount of the compaction achieved. Knowing the field density and field moisture content, the dry density is calculated.

**Objective**

To determine the field density of compacted pavement layers by sand replacement method

**References**

IS: 2720- PART-28

**Principle**

The basic principle is to measure the in-situ volume of a hole from which the material was excavated for the weight of sand with known density filling the hole. The in-situ density of the material is given by the weight of the excavated material divided by the in-situ volume

**Required equipment**

- Well calibrated sand.
- Conical cylinder
- Trays and chisels
- Hammers
- Scoops
- Brushes
- Calculators
- Nails
- Heavy duty gloves and a tape measure

- Test sieves; 600mm and 300mm and 75µm aperture
- Balance 30kgs, accuracy 1g
- Air tight bags

### **Test procedure (Sand calibration)**

Sand was obtained from the field and then taken to the laboratory in sampling bags.

It was washed on a 75µm sieve to eliminate silt sized particles and then spread out on a clean surface to sun-dry for 36 hours.

The sand was then sieved through a setup of 600mm and 300mm sieves, and material retained on the 300mm sieve was transferred to a metal pan and the rest discarded. A mass of 16kgs of sand was poured into the sand pouring cylinder with a cone of known capacity placed on a glass plate, and the shutter opened

The shutter was then opened, sand left to pour into the cone of known volume and the remaining sand in the cylinder was weighed

Mass of sand in cone = Mass poured – Mass left in the cylinder after pouring

$$\text{Density of sand} = \frac{\text{Mass of sand in cone}}{\text{Volume of the cone}}$$

The procedure was repeated using different sized sand pouring cylinders, and the average density from the different tests was determined.

### **Measurement of field density**

- The points to be dug were measured.
- The tray was well fixed on the ground firmly using two metal rods to avoid tilting. The choice of the tray depended on the thickness of the layer being tested.
- A circular hole of approximately 15cm diameter (size of the tray hole) was excavated with a depth equal to that of the layer being worked on and all the excavated soil was collected in an airtight bag.
- The weight of the excavated soil was recorded.
- The sand pouring cylinder was refilled, weighed and placed over the hole.
- The shutter was opened and the sand left to run out into the hole.
- The shutter of the cylinder was closed when no further movement was seen.
- The cylinder was removed and the mass of the sand pouring cylinder with the remaining sand was determined
- A representative sample of the excavated material was kept for moisture content determination



**Figure 2:19 Field density test by the sand replacement method**

#### **Analysis of results**

The field density of the in-situ pavement layer was determined from the expressions below

$$\text{Density of sand} = \frac{\text{Weight of sand in cone}}{\text{Volume of cone}} \text{ (g/cm}^3\text{)}$$

$$\text{Field density of excavated soil} = \frac{\text{Weight of soil excavated from soil}}{\text{Volume of sand filling excavated hole}} \text{ (g/cm}^3\text{)}$$

Where

$$\text{Volume of sand filling hole} = \frac{\text{Weight of Sand in hole}}{\text{Density of sand}} \text{ (cm}^3\text{)}$$

$$\text{Relative compaction} = \frac{\text{in-situ density}}{\text{MDD}} \times 100$$

#### **2.2.10 TEST ON AGGREGATES (Ten percent fines value (TFV)):**

The ten percent fines value test is a relative measure of the resistance an aggregate sample to crushing under a gradually applied load.

#### **Main principle**

This test was determined by measuring the load required to crush the prepared aggregate sample to

- Metal tray
- Tape measure
- Scoop

### Procedure

The test was carried out with reference to BS 1881: part 102: 1983.



**Figure 2:20 Measuring the fall during the slump test**

### 2.2.11.2 Strength of concrete

Compressive strength testing on concrete cubes (150x150x150mm). The soaked cubes (7days and 28days) were removed from the curing tank and weighed.

#### Main principle

Concrete cubes are made, cured and stored in accordance with BS 1881: Part 116: 1983. One set has 3 cubes and the strength is taken as the average. At 7 days, the strength achieved should be about 2/3 of the strength at 28days.

#### Apparatus used

- Compression testing machine
- Electronic scale

#### Test Procedure (The test was carried out with reference to BS 1881: Part 116: 1983)

Moulds were placed on a flat horizontal ground and then freshly mixed concrete rod was poured into the moulds in five layers and properly compacted.

The cubes were then covered with polythene bags to maintain the humidity, they were then stored in

a place free from vibrations at room temperature.

After being at room temperature for 24 hours, the cubes were removed from the moulds and then taken to a soaking tank for 7 days and 28 days respectively.

The weight of the cubes was determined immediately after removing from water.

The cubes were then taken to a compression machine to determine their compressive strength.

If the strength of the cubes did not meet the specifications the concrete structures would be discarded.



**Figure 2:21: Sample compaction in moulds, soaking and compression**

## **2.2.12 TESTS ON ASPHALT**

Asphalt is a mixture of bitumen, aggregates and dust.

### **2.2.12.1 Determination of theoretical maximum specific gravity ( $G_{MM}$ ) of hot-mix asphalt (HMA)**

#### **Objective**

The test is used to determine the void content in the asphalt mixes.

#### **Apparatus**

- Balance
- Vacuum pump
- Pycnometer
- Thermometers
- Water bath
- Agitator device

### Test Procedure

A weighed sample of oven dry trial asphalt mixture in loose condition was placed in a tarred bowl. Water holding a temperature of 25°C was added to completely submerge the sample.

Vacuum was applied to remove entrapped air within the sample

The void free volume was measured by weighing the container (with sample) immersed in water.

The GMM was then calculated as follows;

**Table 2-4 Calculating the GMM of asphalt**

Test Property	TRIAL - 1
Percentage of Bitumen by total weight of mix (Pb)	4.6
Mass of Dry Sample in air , gms A	2012
Mass of pycnometer + water at 25 °C gms. B	9201
Mass of pycnometer + mix + water at 25 °C gms. C	10407
Maximum Specific Gravity of loose BWC mix $G_{mm} = A/(A+B-C)$	2.496
<b>Gmm</b>	<b>2.496</b>



**Figure 2:22: Sample preparation and weighing, oven dried and sieved asphalt, vacuum application.**

### 3 CHAPTER THREE: PROJECT MANAGEMENT PRACTICES

The Project Management Book of Knowledge (PMBOK) defines a project as a “temporary endeavor undertaken to create a unique product or service”. Furthermore, projects can be said to be performed by people, constrained by limited resources and are planned, executed and controlled. Chudley & Greeno, (2006) who described a construction site as a temporary factory employing the necessary resources to successfully fulfil a contract broke down this concept. The resource requirements mainly utilized are;

**Labour** -In form of managerial, supervisory staff and in form of artisans and general site operatives.

**Materials** -for temporary works, access positions, security and final structure.

**Plant and Equipment** - from the simple hand held tools to large items like tower cranes.

**Funds**—a building contractor who uses his money to buy materials, buy or hire plant and hire labour to enable the project to be realized.

The PMBOK Guide (2004) further defines project management as “the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project”. Project management also involves project planning, monitoring and control.

This chapter entails my contribution during the implementation of this project in terms of project management. As the KCCA representative, my major role was to carry out project management, supervision and in particular cost control management.

#### 3.1 Project Cost Management

According to the PMBOK book (2004), project cost management includes the processes required to ensure the project is completed within the approved budget. It involves Resource planning, Cost Estimating, Cost Budgeting and Cost control

Cost estimating for this project was done at the pre-construction stage where detailed Bills of Quantities were prepared to be used in the bidding process.

This process, guided by the principles in **PMBOK (2004)**, ensured that the project remained financially stable and that payments were accurate and timely. Retention monies were managed effectively to protect the employer's financial interests and incentivize the contractor to address any defects.

#### 3.2 Interim valuation

The contract stipulates that the payment to the contractor will be done in instalments for the works done to maintain the contractor's cash flow. During the interim valuation process, I participated in joint site measurements alongside the Project Manager's representative, KCCA's internal auditor, and the contractor's site engineer. This hands-on experience allowed me to apply theoretical knowledge of project

cost management, ensuring that the values reported accurately reflected the work done on-site.

Interim certificates would then be prepared stating how much money is due to the contractor. Retention monies of 5% of the value of works executed was retained on each certificate. This retention fund was to provide the employer with finance in the event of contractor insolvency during the progress of works, and encourages the contractor to remedy any defects in the contract after completion. Half of the retention (2.5%) was paid to the Contractor at practical completion and 2.5% at completion.

### **3.3 Variations**

A variation (sometimes referred to as a variation instruction, variation order or change order) is an alteration to the scope of works in a construction contract in the form of an addition, substitution or omission from the original scope of works. Variations are an inevitable occurrence on construction projects. Variations are also a major cause of disruption, delay, disputes, escalated project cost, extended construction time, and compromised quality.

#### **3.3.1 Causes of variations**

Amiruddin Ismail, Towhid, Amir and Majid identified common causes, which were grouped under four categories.

1. Owner related variations - originate from the client
  - Owner's financial problems
  - Design change originated by owner
  - Acceleration of work
  - Conflict in the project site
2. Quality improvement
  - The scope of work for the contractor is not well defined
  - Substitution of material or procedures

3. Contractor related variations - originate from the contractor
  - Contractor's financial difficulties
  - The required labour skill are not available
  - Workmanship or material not meeting the specifications
  - Contractor desire to improve his financial conditions
  - Demolition and re-work
  - Strikes
4. Others variations - originate from other sources other than the Client and contractor
  - Differing site conditions
  - Safety consideration/emergency field condition
  - Weather condition

A major factor necessitating variations is attributable to preference or taste for enhanced finished product different from the initially agreed quality by the Client in a particular contractual agreement. In addition, there might be modifications to an initial design by consultant due to weather conditions and differing site conditions (Hsieh et al., 2004).

By understanding these potential causes, I was better equipped to manage and mitigate the impact of variations on the project, ensuring that changes were carefully controlled to minimize delays and cost overruns.

### **3.4 Project Time Management**

The PMBOK Guide, (2004) defines project time management as the processes concerning the timely completion of the project. It consists of the activity definition, activity sequencing, activity resource estimating, activity duration estimating, schedule development, and schedule control management processes. Construction projects are time bound and all activities are geared towards the achievement of project objectives within the stipulated time. However, there are instances in construction where the contract period may be extended for various specific reasons. Time overruns on a project are more detrimental to the project than useful; this is because of increase overheads, reduced planned revenue from sales and cash flow problems. Delays in contracted projects result in penalties, and adversely affect the reputation of the company; confusion and conflict among the project participants. In the event that that extension is given, the contractor is relieved from all liability of liquidated damages. (Murdoch and Hughes, 2008).

Murdoch and Hughes (2008) highlight that delays can lead to penalties unless there are valid reasons for time extensions, such as force majeure. I applied this understanding by ensuring that any justified delays were documented and communicated effectively, protecting the project from unwarranted penalties while maintaining a focus on timely completion.

### **3.5 Project Time Control**

This aims at the timely execution of the work according to the project-planned schedule and applies corrective measures in cases of time deviations. This process is assisted by the use of a work program from which progress of work is reviewed. The state of activities is measured by comparing the actual progress against the monthly Gantt chart work programme.

Timely valuations and payments to the contractor were also embarked on to enable smooth cash flow for the contractor.

I used a work program to compare actual progress against planned activities, enabling timely interventions where deviations occurred. Ensuring timely valuations and payments also played a key role in maintaining the contractor's cash flow, which is essential for sustaining the project's momentum.

### **3.6 Time Extension**

According to Murdoch and Hughes, (2008), Delays will allow the employer to charge liquidated damages to the contractor. However, there are delays that warrant extension of time. An example of such events is force majeure. It is important to note that granting an extension of time does not automatically entitle the contractor to extra money.

In line with Murdoch and Hughes (2008), we managed time extensions by evaluating the causes of delays, such as force majeure events. An extension was granted after justification, ensuring that the contractor was relieved of liquidated damages for delays beyond their control.

### **3.7 Project Quality Management**

Project Quality Management according to the PMBOK Guide, (2004) includes all activities of the overall management function that determine the quality policy, objectives and responsibilities and implements them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system. The quality management process involves the following:-

Quality planning- Identifying which quality standards are relevant to the project and determining how to satisfy them.

Quality assurance - Evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.

Quality control - monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance. This involves insuring compliance with minimum standards of material and workmanship in order to ensure the performance of the facility to the design.

For construction projects, whereas the contractor is required to submit a Quality Assurance plan at

bidding stage, during implementation of works, it is the project manager and team to ensure adherence to all quality standards put in place.

I applied these principles by identifying relevant quality standards, such as technical specifications and Ugandan building standards, and ensuring strict adherence throughout the project. Quality assurance measures were enforced through rigorous inspections and the approval of materials before use, ensuring that the final product met the required standards.

### **3.8 Quality Planning**

This involves identification of quality standards relevant to this project. Some of the standards identified included-

Technical Specifications including work and material specifications

The specifications given on the drawings and Bills of Quantities Building Standards in Uganda

### **3.9 Quality Assurance and Control**

Conformance to standards is used as a measure of quality during the construction process. This process was engaged in right before commencement of works with the following activities:-

I implemented quality control measures, including site inspections, material approvals, and adherence to technical specifications. Regular site meetings and inspections ensured compliance with quality standards, and the Defects Liability Period was utilized to address and rectify any post-completion defects.

### **3.10 Materials**

The materials used on this project had to be approved by the supervising team appointed by KCCA, which comprised of Performance and Monitoring team from Head Office and a team from urban poor branch- Kampala Water, before use. For materials like sand and aggregates, the source had to be verified by the KCCA in case of deliveries in their absence. Materials such as reinforcement bars had to be procured from approved hardware and concrete test tubes had to be tested and their results submitted to the Project Manager. Finishes like wall tiles; these had to be approved by the client before placement. Bricks and cement was visually approved before use to avoid usage of inferior material.

### **3.11 Safety and Health**

Safety on any construction project can only be so emphasized. In this particular contract the contractor was required to employ a full-time qualified Safety Officer on site until works have been completed. The Safety Officer was responsible for compliance with the contractor's Site Safety plan by all employees and held regular safety meetings with all employees. He had authority to halt any unsafe working methods and practices on site." A safety and health officer was available on the site

during the whole project. Adherence to building safety laws was good at the site.

### **3.12 Site inspection of work**

Site meetings were held regularly for this project depending on the prevailing situations. This was maintained until project completion to ensure that at every stage of project execution, the client and community can visually appreciate, approve or reject the works.

Apart from site meetings, site inspections were carried out as required; for example, inspection of reinforcements before casting slabs, monitoring of progress.

### **3.13 Defects Liability Period (DLP)**

This commences when the practical completion has been attained. The duration of the Defects Liability Period is always stipulated at the start of the project. For these works, it was 6 months. Site inspections were done every three (3) months during this time. The contractor is under obligation to repair any defects that become apparent during this time. All the snags as seen on the road were noted and the contractor notified. One of the outstanding snags on this project was the falling stone work;

### **3.14 Project Communication Management**

The PMBOK book (2004), describes project communication management as the process concerning the timely and appropriate generation, collection, dissemination, storage and ultimate disposal of project information. It consists of; communication planning, information distribution, performance reporting and manage stakeholders' process.

The major problems related to communication on a construction project include but are not limited to the following:-

- Miscommunication or misaddressing
- Misunderstanding due to misinterpretation or misconception
- Unclear/ambiguous understanding
- Lack of link or interruption of connection of communication
- Cultural barriers and/or language differences
- Inadequate information, time constraint, insufficient control
- Conflict and/or poorly informed participants
- The success of any project is determined by the effectiveness of the communication channels used to share information between the contractor, client and the project management team.

### **3.15 Information Flow**

Information flow, just as any other type of flow, requires four components: a starting point (source), an ending point (receiver), a path (interaction), and a driving force (mutual relevance). There are two

types of entities that can serve as sources or receivers of information: 1) people and 2) boundary objects (that's to say tools such as drawings, reports, building information models, requests for information, and other documents that enable communication between groups of people).

A person's role in information flow is determined by their contractual role, their informal technical role, and their social role within the project. These roles determine the types of information that are expected from a person, the type of information that the person can contribute, how that information is shared, and how it is received.

### **3.16 Site Information**

Ashworth (2006) indicates that in addition to the everyday running and organization of the contract, it is also the overseers' responsibility to maintain accurate records of the important happenings on site. This information should be properly recorded, so that whenever it is necessary it can be quickly retrieved for future use. The site records kept on site include; site diaries, material received sheets, daily labour allocation sheets, drawings register, day works report, site correspondences, site instruction book, and visitor's book and accident reports among others.

An example of site information that I used mostly was the actual site measurement sheets. These were imperative to the project as to ascertain actual work done during valuation time. Deviations and variations were easily tracked and evaluated using these measurement sheets.

## 4 CHAPTER FOUR: CHALLENGES AND LESSONS LEARNT

### 4.1 Lessons Learnt

During the execution of the Misaga Road project as the Site Engineer representing KCCA, different valuable lessons were learnt regarding project management. Key lessons include but are not limited to:

**Information Flow:** Efficient information flow is crucial for meeting project timelines. It is imperative that all project participants understand the hierarchy of communication channels. On this project, local leaders would direct their concerns to the media instead of the client and contractor, causing setbacks and delays as grievances took longer to reach the concerned parties.

**Contract Guidelines:** The contract provides guidelines on how the project should be managed and executed. This was evident when the contractor claimed an extension of time, and since none of his reasons were contractual, his request was not considered.

**Record Keeping:** Organized and efficient record keeping is essential. Every action taken had to be supported in writing, and payments for extra quantities and variations had to be backed up with records such as measurement sheets and written instructions.

### 4.2 Challenges faced

**Contract Interpretation:** Ensuring that all actions and decisions were in line with the contract terms was challenging, especially when dealing with requests for extensions or variations. The need to adhere strictly to contractual guidelines sometimes limited flexibility in responding to unforeseen circumstances

**Payment Delays:** Delays in processing payments for completed works impacted the contractor's cash flow and ability to sustain the pace of construction activities.

**Local Community Engagement:** Managing expectations and addressing concerns from the local community required continuous engagement and effective communication. Resistance or dissatisfaction from local stakeholders sometimes led to project delays

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