A PROJECT

ON

COMPARATIVE EVALUATION OF ACCURACY AND RELIABILITY OF DIGITAL LEVELLING AND TOTAL STATION EQUIPMENT TO DETERMINE THE HEIGHT MEASUREMENT

(*A CASE STUDY OF PART OF KWARA STATE POLYTECHNIC*)

BY

ADEOTI QUDUS ADEBAYO

HND/23/SGI/FT/0080

SUBMITTED TO

DEPARTMENT OF SURVEYING AND GEO-INFORMATIC, INSTITUTE OF ENVIRONMENTAL STUDIES (I.E.S), KWARA STATE POLYTECHNIC, ILORIN.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE HIGHER NATIONAL DIPLOMA (HND) IN SURVEYING AND GEO-INFORMATIC.

JULY, 2025.

CERTIFICATE

I hereby certified that all the information given in this project were obtained as a result of observations and measurements made by me and that the survey was carried out in accordance with Survey Rules, Regulations and Departmental instructions.

NAME: ADEOTI QUDUS ADEBAYO

MATRICNO.:HND/23/SGI/FT/0080

SIGNATURE: ………………………………….

DATE OF COMPLETION: ………………………………………………….

CERTIFICATION

This is to certify that **ADEOTI QUDUS ADEBAYO** with matriculation number **HND/23/SGI/FT/0080**has satisfactorily carried out this project under our instructions and direct supervision.

SURV. A. G. AREMU ____________________________

(PROJECT SUPERVISOR) *SIGNATURE AND DATE*

SURV. AWOLEYE R. S ____________________________

(PROJECT COODINATOR) *SIGNATURE AND DATE*

MR. ABIMBOLA I. ISAU ____________________________

(HEAD OF DEPARTMENT) *SIGNATURE AND DATE*

____________________________ ____________________________

EXTERNAL MODERATOR *SIGNATURE AND DATE*

DEDICATION

I dedicate this project to Almighty God. Through every challenge and triumph, your presence has been my guiding light and steadfast support. Thank You for granting me the wisdom, knowledge, and patience to complete this goal.

ACKNOWLEDGEMENTS

I earnestly express my deepest gratitude to my project supervisor Surv. A.G. AREMU for the guidance and patience throughout my research work indeed he is an epitome of a great supervisor and a good father also the HOD of this department and the entire staff of Surveying and geoinformatics department.

My sincere gratitude also goes to My (H.O.D) MR. ABIMBOLA ISAU and other lecturers at the Department of Surveying Geo-informatics (SUR. A.G AREMU, SUR. R.S ASONIBARE, SUR. R.O AWOLEYE, SUR. BANJI, SUR. AYUBA, SUR. DIRAN, SUR. KAZEEM, SUR. KABIRU), for nurturing me in my academic activities. May Almighty Allah continue to bless you all abundantly.

My unreserved appreciation goes to my beloved parent, Mr. and Mrs. **ADEOTI** for their un-measured words of encouragement, financial, moral and spiritual support given to me all through this program.

ABSTRACT

This project undertakes a thorough comparison and analysis of the data obtained using Total Station and digital level instruments in height measurement, with a focus on accuracy, efficiency, and reliability. The project site boundary was measured with Total station with approximately area of 8.945hects, 20 points were established randomly within the site perimeter and their X, Y, Z coordinates were determined using a Total Station. The heights of the same points were also determined using a digital level instrument, and the data obtained from both instruments were processed and analyzed using Microsoft Excel and AutoCAD. The results of the study demonstrate that both instruments produced comparable results, with the Total Station yielding a maximum height of 356.736m and a minimum of 354.268m, while the digital level gave a maximum height of 356.680m and a minimum of 354.268m. A statistical analysis of the data revealed that both instruments share similar accuracy and are both good any height determination on the surface of the ground. however, a comparison of time expenditure revealed that the Total Station is 7% faster than the digital level in height measurement. The findings of this project have significant implications for surveying and mapping applications, where accuracy, efficiency, and reliability are paramount.

TABLE OF CONTENTS

CHAPTER ONE

CHAPTER TWO

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

In scientific studies and engineering works, it is required to determine height differences between points or the height of points itself in those applications such as measurements of national or local networks, vertical applications of the bridge, dam and infrastructures, maintenance and control measurements, determination of vertical crustal movements, motorway, railway, sewerage, and pipeline measurements. Precise height determination is also required for photogrammetric and remote sensing purposes (Ayhan et al, 2005).

Height measurement is a critical aspect of surveying and mapping applications, providing essential information for various engineering, construction, and geospatial projects. Accurate height data is necessary for determining elevations, creating topographic maps, monitoring terrain changes, and designing infrastructure.

Vertical surveying (levelling) is the process of determining elevations above a chosen datum, Mean Sea Level. In geodetic surveys, a geodetic position (y, x) refers to an ellipsoid, and the elevations of those positions referenced to the geoid. Precise geodetic levelling surveys will establish the basic network of vertical control points (Wang and Soler, 2015).

Traditionally, surveyors have used instruments like leveling equipment to measure heights with high precision and accuracy. With the advancement of technology the determination of the coordinates(XYZ) for an unknown point in relation to a known coordinate is achievable through the utilization of a total station, provided that a direct line of sight can be established between the two points

Total station is an optical instrument commonly used in surveying. It is useful for measuring horizontal angles, vertical angles and distance; it does this by analyzing the slope between itself and a specific point.

The basic properties are unsurpassed range, speed and accuracy of measurements. Total stations are developed in view of the maximal convenience of work of the user.

However, despite the advancements in technology, there is still a need to comparatively evaluate the performance of digital leveling and total station equipment. The comparison of height measurements obtained using total station and leveling instrument is vital to understand the strengths and limitations of each method.

1.2 Statement of the problem

The accuracy and precision of height measurements are essential in many surveying and engineering projects. Total station and leveling instrument are commonly used technologies for measuring height above a reference point, but there is a lack of comprehensive research comparing the accuracy and efficiency of these two methods.

The main problem to be addressed in this project is to determine the difference in height measurements obtained using total station and leveling instrument, additionally, to assess the cost-effectiveness, reliability, and suitability of each method for different surveying applications.

By evaluating the strengths and limitations of total station and leveling instrument for height measurement, this project seeks to provide valuable insights for choosing the most appropriate technology based on project requirements and constraints.

1.3 Aim of the Project

The aim of this project is to compare the accuracy and precision of height measurements obtained using a total station and levelinginstrument.

1.4 Objectives of the Project

The following are the objectives of the project

1. To compare the accuracy and precision of height measurements obtained using a total station and leveling instrument.
2. To evaluate the strengths and limitations of total station and leveling instrument indetermining height.
3. To assess the reliability and potential sources of error in height measurements conducted using each instrument.
4. To provide recommendations for selecting the most appropriate height measurement method based on project requirements and constraints.

1.5 Scope of the Project

This project will focus on comparing height measurements using a total station and leveling instrument in a controlled test environment with known elevation control points. The comparison will involve assessing the consistency of height readings, identifying sources of error, and determining the efficiency of each method in height determination.

1.6 Project Justification

At the end of the project, the research should be able to identify and ascertain the accuracy of both methods and able to determine which method provides the most cost-effective solution for height data collection.

1.7 Significance of the Project

Understanding the differences between height measurements obtained from a total station and leveling instrument is crucial for surveyors, engineers, and researchers involved in topographic mapping and elevation studies. By comparing the performance of these two methods, this project aims to provide valuable insights into the strengths and limitations of each technique, helping professionals make informed decisions in choosing the most suitable method for their specific surveying tasks.

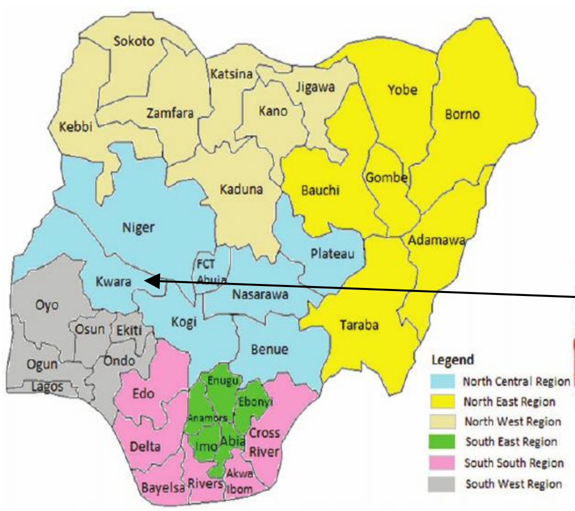
1.8 Personnel

The projectwas successfully carried by the personnel listed below;

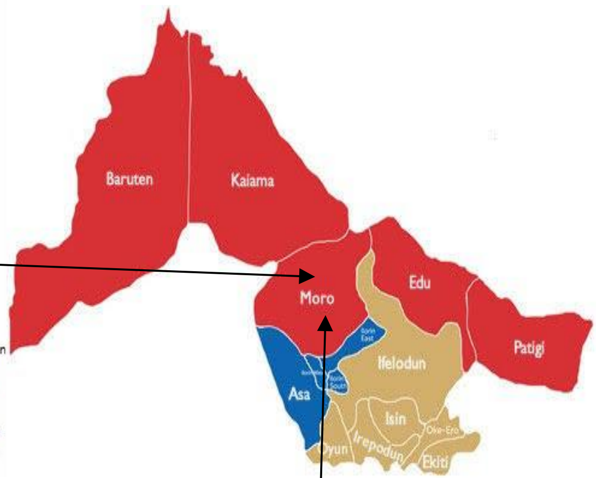
NAME	MATRIC. NO.	
Adeoti Qudus Adebayo	HND/23/SGI/FT/0080	Writer
Abdul Kareem Ramota Olawumi	HND/23/SGI/FT/0078	Member
Kazeem Kabirat Damilola	HND/23/SGI/FT/0079	Member
Ganiyu Akeem Abiodun	HND/23/SGI/FT/0076	Member
Adeleye Sheriffdeen Olawale	HND/23/SGI/FT/0081	Member
Abdul Qudus Shukurah Temitope	HND/23/SGI/FT/0083	Member
Ogunsuyi Babatunde Sunday	HND/23/SGI/FT/0118	Member
Jimoh Halimah Titilayo	HND/22/SGI/FT/082	Member

1.9 Project Location

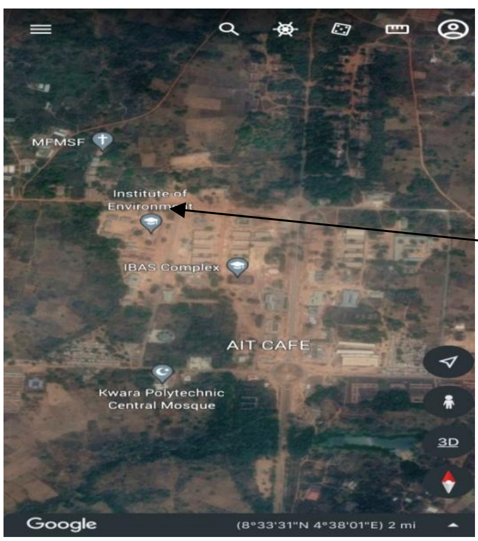
The project site is located inside Kwara state polytechnic Ilorin, Kwara state is a significant provider of technical and vocational education and is situated in Ilorin, Nigeria. Spread across a wide area, it is roughly located at latitude 8.4791^{0}N and longitude 4.5418 ^{0}E



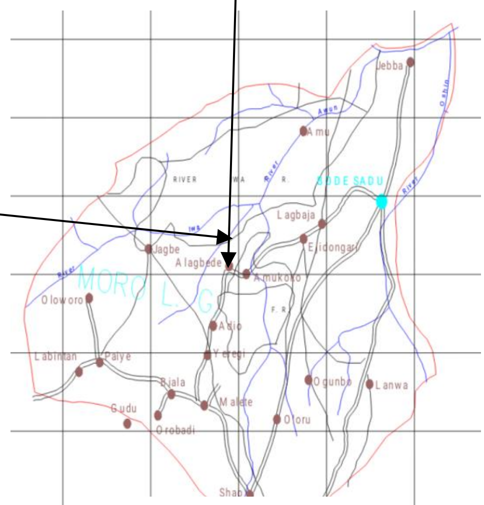
Map of Nigeria



Map of Kwara State



Google Imagery of the Study Area



Map of Moro L.G.A

***Figure 1.10**: Study Area Map*

CHAPTER TWO

2.0 LITRATURE REVIEW

2.1 Introduction

Height measurement is a fundamental aspect of surveying and geodesy, and its accuracy plays a crucial role in various applications such as construction, engineering, and mapping. With the advancement of technology, various instruments have been developed to measure heights with high accuracy and precision. Two popular instruments used for height measurement are Digital Leveling instruments and Total Stations.

The accuracy and reliability of height measurements directly impact the quality and safety of projects (Kavanagh & Bird, 2017). In recent years, advances in technology have led to the development of digital leveling and total station equipment, which have improved the efficiency and accuracy of height measurements (Schwarz & El-Sheimy, 2011).

2.2 Total Station

2.2.1 Overview

A Total Station (TS) is a modern surveying instrument that integrates an electronic theodolite with an Electronic Distance Meter (EDM). Total stations use electronic transit theodolites in conjunction with a distance meter to read any slope distance fromthe instrument to any particular spot. They are hence two essential surveying instruments in one and when used with other technology such as mapping software are able to deliver the ‘total’ surveying package, from measuring to mapping. The development of total stations has markedly increased productivity in the surveying profession in many ways. Improved accuracy is one of the major advantages of total station. Now GPS technology can be used by a total station to include unseen points in the survey. Other increases in productivity are due to efficiency and functionality. Total Stations also include up-to-date image capture

technology, which can record any image or screen-view from the surveying site, eliminating the need for costly revisits, and

producing high-resolution images of site conditions. A total station has electronic documentation and sketching functions, which reduces the need for paper field notes.

2.2.2 Accuracy of Total Station

Total Stations are known for their high precision and accuracy in measuring angles and distances:

- Angular Accuracy:- Typically ranges from 0.5 to 5 arc-seconds (Schofield & Breach, 2007).
- Distance Accuracy:- Usually within 1 to 2 millimeters plus 2 parts per million (ppm) of the distance measured (Wolf & Ghilani, 2012).

2.2.3 Factors Affecting Accuracy of Total Station

- Instrument Calibration:- Regular calibration ensures high accuracy.
- Line of Sight:- Requires a clear line of sight between the instrument and the target.
- Environmental Conditions:- Weather conditions like heat waves and wind can affect measurements.

- Operator Skill:- Proficiency of the operator in setting up and using the instrument.
- Target Quality:- Reflective prisms and targets must be properly maintained.

2.2.4 Applications of Total Station in Height Measurement

Total Station is a versatile instrument used in surveying and geodesy for various applications, including height measurement. Here are some of the applications of Total Station in height measurement:

1. Topographic Surveying: Total Station is used to measure the height of points on the Earth's surface for topographic surveying (Schwarz, 2002). This is essential for creating detailed topographic maps and models.

2. Engineering Surveying: Total Station is used to measure the height of points for engineering surveying, such as for the construction of buildings, roads, and bridges (Kavanagh, 2003).

3. Geodetic Surveying: Total Station is used to measure the height of points for geodetic surveying, such as for determining the shape of the Earth and the precise location of points on its surface (Vaníček, 2005).

4. Monitoring of Structures: Total Station is used to monitor the height of structures, such as buildings and bridges, to detect any changes or movements (Schwarz, 2002).

5. Deformation Monitoring: Total Station is used to monitor the deformation of structures, such as tunnels and dams, by measuring the changes in height and position of points on the structure (Kavanagh, 2003).

2.2.5 Advantages of Total Station in Height Measurement

Total Station is a versatile instrument used in surveying and geodesy for measuring heights, distances, and angles. Here are some of the advantages of using Total Station in height measurement:

1. High Accuracy: Total Station provides high accuracy measurements, typically within ± 2-5 mm over short distances (Schwarz, 2002).

2. Long-Range Capability: Total Station can measure heights over long distances, typically up to 5 km (Kavanagh, 2003).

3. Fast Measurement: Total Station allows for fast measurement, typically within seconds (Vaníček, 2005).

4. Versatility: Total Station can be used for various applications, including topographic surveying, engineering surveying, geodetic surveying, and monitoring of structures.

5. Automatic Data Recording: Total Station can automatically record data, reducing errors and increasing efficiency (Kavanagh, 2003).

2.2.6 Limitations of Total Station in Height Measurement

1. Atmospheric Conditions: Weather conditions such as fog, rain, and extreme temperatures can affect the accuracy of Total Station measurements (Schwarz, 2002).

2. Multipath Errors: Signals can bounce off nearby surfaces, causing multipath errors that can affect the accuracy of measurements (Vaníuser, 2005).

3. Instrument Calibration: Total Station requires regular calibration to ensure accurate measurements, which can be time-consuming and costly (Kavanagh, 2003).

4. Operator Error: Human error can occur during measurement, such as incorrect instrument setup or data entry (Schwarz, 2002).

2.3 Leveling Instrument

2.3.1 Overview

Levelling is the operation required in the determination, or more strictly, the comparison of heights of points on the surface of the earth (Bannister et al., 1992). Levelling is useful in designing highways, railways and canals, setting out projects according to planned elevations, calculating volumes of stacks, earthworks and embankments, investigating and laying out of drainage systems among other uses. There are various methods of determining difference in elevation of points. They include; taping methods, differential levelling, barometric levelling, trigonometric leveling and the modern methods such as GPS levelling. Spirit levelling isa surveying technique that employs spirit levels to orient the line of sight to coincide with the horizontal line in order to determine change in elevations between two points. Spirit levelling observations were carried out with automatic levelling instrument and alevelling staff. The levelling procedure is performed by taking a back sight reading to a levelling staff placed vertically at a benchmark, then reading a foresight on a staff placed on a point whose height is to be determined.

2.3.2 Accuracy of Digital Leveling Instruments

Digital leveling instruments are electronic instruments that use sensors to measure the difference in height between two points. The accuracy of digital leveling instruments depends on various factors, including the type of instrument, the quality of the instrument, and the environmental conditions.

Types of Digital Leveling Instruments and Their Accuracy

- Basic Digital Level: ± 1-2 mm/km (Kavanagh, 2003)
- Advanced Digital Level: ± 0.5-1 mm/km (Schwarz, 2002)
- High-Precision Digital Level: ± 0.1-0.5 mm/km (Vaníček, 2005)

2.3.3 Factors Affecting the Accuracy of Digital Leveling Instruments

- Instrument calibration: Instrument calibration is crucial to ensure accurate measurements (Kavanagh, 2003).
- Atmospheric conditions: Atmospheric conditions such as temperature, humidity, and air pressure can affect the accuracy of measurements (Schwarz, 2002).
- Measurement technique: The measurement technique used can also affect the accuracy of measurements (Vaníček, 2005).
- Operator error: Operator error can also affect the accuracy of measurements (Kavanagh, 2003).

2.3.4 Applications of Digital Leveling Instruments

Digital Leveling Instruments are versatile tools used in various fields to measure the difference in height between two points. Here are some of the applications of Digital Leveling Instruments:

1. Surveying and Mapping**:** Digital Leveling Instruments are used in surveying and mapping to measure the height of points on the Earth's surface (Kavanagh, 2003).

2. Construction and Building: Digital Leveling Instruments are used in construction and building to measure the height of buildings, bridges, and other structures (Schwarz, 2002).

3. Monitoring of Structures: Digital Leveling Instruments are used to monitor the height and settlement of structures, such as buildings, bridges, and towers (Kavanagh, 2003).

4. Geodetic Surveying: Digital Leveling Instruments are used in geodetic surveying to measure the height of points on the Earth's surface with high accuracy (Schwarz, 2002).

5. Land Surveying: Digital Leveling Instruments are used in land surveying to measure the height of points on the Earth's surface for property boundary determination (Vaníček, 2005).

6. Mining and Quarrying: Digital Leveling Instruments are used in mining and quarrying to measure the height of excavations and monitor the movement of rock and soil (Kavanagh, 2003).

7. Archaeological Surveying: Digital Leveling Instruments are used in archaeological surveying to measure the height of ancient structures and monuments (Schwarz, 2002).

2.3.5 Advantages of Digital Leveling Instruments

1. High accuracy: Digital leveling instruments can provide high accuracy measurements (Schwarz, 2002).
2. Easy to use: Digital leveling instruments are easy to use and require minimal training (Kavanagh, 2003).
3. Fast measurement: Digital leveling instruments can provide fast measurement results (Vaníček, 2005)

2.3.6 Limitations of Leveling Instrument

1. Limited Range: Leveling Instrument has a limited range, typically up to 1 km, which can make it less suitable for large-scale surveys (Kavanagh, 2003).

2. Collimation Error: Leveling Instrument requires precise collimation to ensure accurate measurements, which can be affected by instrument wear and tear (Schwarz, 2002).

3. Atmospheric Conditions: Weather conditions such as fog, rain, and extreme temperatures can affect the accuracy of Leveling Instrument measurements (Vaníuser, 2005).

4. Manual Data Entry: Leveling Instrument requires manual data entry, which can be time-consuming and prone to errors (Kavanagh, 2003).

2.4 Project Review

Total Station and Leveling Instrument are both effective instruments for height measurement, but they have different strengths and limitations. Total Station offers high accuracy and long-range capability, but is susceptible to atmospheric conditions and multipath errors. Leveling Instrument provides high accuracy over short distances, but has a limited range. Understanding the principles, accuracy, range, and limitations of these instruments is essential for selecting the most suitable instrument for specific applications.

CHAPTER THREE

3.0 METHODOLOGY

Methodology is the systematic theoretical analysis of the methods applied to a field of study, it comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. Typically, it encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques.

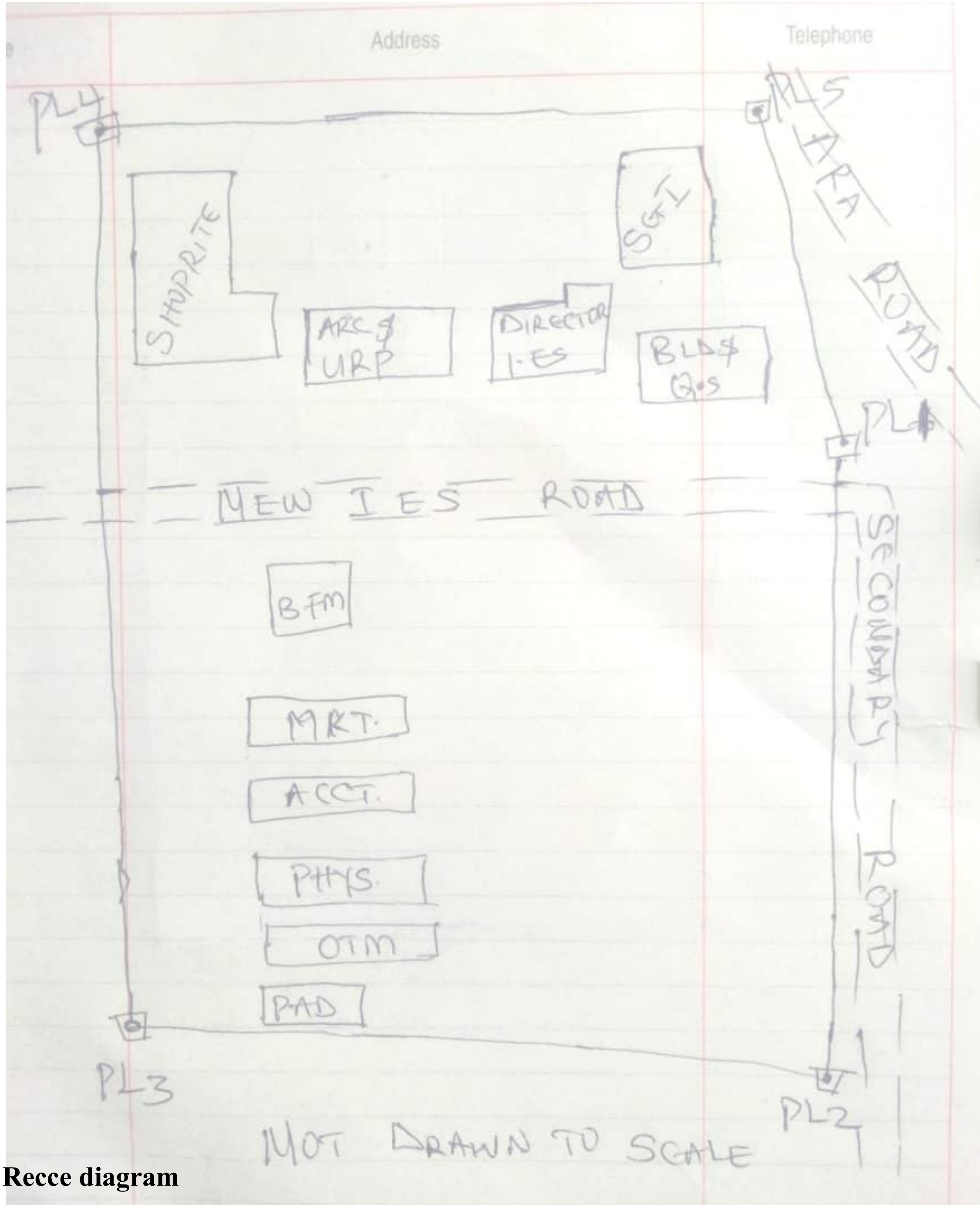
3.1 Reconnaissance

This has to do with framework of survey operation whereby all survey operations are going to base on.

Reconnaissance is also known as (Recce). Reconnaissance is examination of all part of an area accomplished insufficient detail to make generalization about the type and distribution of historical properties that may be present with a given project area. Also, is the process of having the general overview of the area to be surveyed with the view of determining the arrangement of the work such as method to employed, personnel to be involved, instrument to be used, scale at which plan/map is to be drawn. There are two stages of reconnaissance namely: Office and Field reconnaissance.

3.1.1 Field Reconnaissance

The first stage in this project was search for existing information in connection with the area in which the project was undertaken. Rough sketch diagram (recce) of the project area was drawn selecting and marking the approximate position of each point. To sum up, the reconnaissance facilitated the planning and execution of the actual survey as its takes into consideration, the possible problems that are likely to be encountered, and how such problems can be overcome or reduced to minimum.



Recce diagram

3.1.2 Office Reconnaissance

Office reconnaissance/data gathering as the name implies is the exploratory survey, scouting or examination, to collect information necessary for the successful execution of the project. It can be simply define as making a preliminary survey before the actual mobilization for the project site. For the purpose of this project, the data search involved retrieving of the coordinate of three (3) existing control.

Pillar No.	Easting(m)	Northing(m)	Height	Location
KWPT 49	674341.289	937679.115	353.682	Kwara Polytechnic
KWPT 50	674555.841	937618.402	354.903	Kwara Polytechnic

Table 1: *Show coordinates of existing and used control point.*

3.1.3 Selection of Station

The boundaries as shown in the recce diagram were laid down by marking points on the ground (station).

The factors considered in selecting these stations include:

1. Inter visibility between two points.
2. Firmness of the ground at the selected point.
3. Working convenience over the station.

4. Points located where not disturbed.

3.2 Survey Rod

A survey rod is a physical marker, typically made of metal, used to mark the boundaries of a parcel of land. These markers are used to define the limits of a property and can be used as reference points for future surveys. Rods are durable and can be used in a variety of environments.

3.2.1 Survey rules guiding rod uses:

1. Placement: Rods should be placed at boundary corners or points of change in the boundary.

2. Visibility: Rods should be visible and easily identifiable

3. Durability: Rods should be durable and resistant to weathering.

4. Accuracy: Rods should be placed accurately, following the surveyed boundary.

5. Documentation: the location and description of rods or pegs should be documented in the survey records.

Figure 3.1*: Graphical View of Cadastral Survey Rod*

3.3 Instrumentation

It refers to the equipment and accessories employed for the successful execution of this project and they are as follows:

Hardware Used

- Stonex R2 Plus Total Station and its accessories
- Leica Digital Level instrument and its accessories
- Handheld GPS

- Hp Core i5 vPro 8th Gen Laptop
- Cutlasses
- Head-pan
- Nail and bottle cover
- 1 Hammer
- 1 Spade
- 1 Hand-trowel

Software Used

- AutoCAD 2007
- Golden Software Surfer 20.0
- Microsoft Office Excel 2013
- Microsoft Office Word 2013

Material Used

- Water
- Cement

Total Station:- It is an electronic or optical instrument used in modern surveying and building construction that used Electronic Distance Measurement (EDM). It is also known as electronic data collection and storage system of which all the data acquired on site is been stored and secured for office reconnaissance.

Digital Leveling:- It is considered one of the most precise methods for height determination. It employs an electronic level instrument and a bar-coded staff to measure vertical distances, reducing human errors common in conventional leveling.

Table 3.2: *Equipment Description*

S/N	**Equipment**	**Uses**
1	Stonex R2 Plus Total Station	X, Y and Z coordinates of boundaries
2	Leica Automatic Level	Determination of the reduced level
3	Handheld GPS	X & Y coordinates of details
4	Autodesk AutoCAD 2007	Presentation of the boundaries
5	Golden Software Surfer 20.0	Contour and Generation of 3D model
6	Microsoft Office Excel 2013	X, Y and Y coordinates editing&program
7	Microsoft Office Word 2013	Report writing

3.4 Test of Instrument

For any survey job, testing of the instrument must be done before execution of the job, the instruments used for data acquisition were tested to ascertain whether they are in good working condition.

The following test were carried out,

3.4.1 Total Station

The total station instrument used (Stonex R2 Plus Total Station) underwent a two-phase check. Firstly, the vertical and horizontal angles were verified using pre-established control points within the school campus. Secondly, the electronic distance measurement (EDM) capability was tested for horizontal distances. The instrument passed all tests and was deemed suitable for use.

Below is the procedure for carryout the tests

3.4.1 Total Station

Instrument used in data acquisition was checked for integrity before moving them to site. Apart from check carried-out on Total Station, the following instruments were also checked: Tripod stand legs and their screw were confirmed okay, foot screws, focusing knob, vertical and horizontal knob for slow motion and clamp were all confirmed okay.

3.4.1.1 Horizontal Collimation Test

This error exists when the optical axis of the total station is not exactly perpendicular to the telescope axis. To test for horizontal collimation error, station A was selected and the instrument was set on it and leveled using three foot screws. Then, the telescope was rotated through 360°, but the bubble did not run out of the level tube centre which shows that the line of sight is parallel to the axis of the level tube.

Furthermore, the telescope was pointed to a target on station B in face left, then, pointed back to same target in face right; the difference in horizontal circle readings after averaging the result from both faces of the instrument was 180° except small variation is seconds which is permissible based on the allowable accuracy limit (least Count). The following results were displayed below.

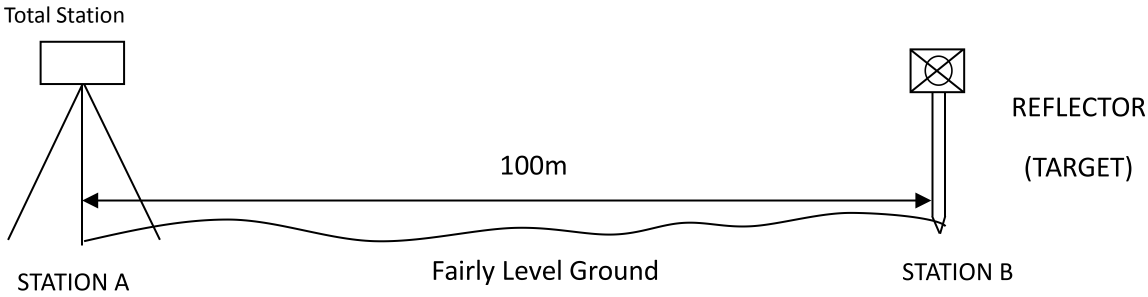


Fig 3.4.1.1: Horizontal Collimation and Vertical Index error test.

Table 3.4.1.1: *Horizontal Collimation Data*

Station	Target	Face	Hz Reading	Difference	Error
A	B	L	38˚42'32"		
		R	218˚42'35"	180˚00'03"	03"

3.4.1.2 Vertical Index Error Test

This test was performed to ensure that the vertical reading is exactly ninety degrees (90˚) when the line of sight is horizontal. Any deviation from this figure is known as vertical index error.

The Total Station was set over a point and necessary temporary adjustments were performed. A target set about 100m away from the Total station was sighted and bisected with the instrument on the face left and the reading was recorded. The target was also sighted and bisected on face right and the reading was also recorded. These readings are shown below

Table 3.4.1.2: *Vertical Index Data*

Instrument Station	Target Station	Face	Vertical	Sum	Error
A	B	L	90˚00’00”		
		R	270˚00’02”	360˚00’02”	02”

3.4.1.3 Analysis of Collimation and Vertical Index Data

The reading obtain during calibration were reduced to obtain new collimation and vertical errors.

Horizontal collimation = {(FR – FL) – 180}/2 = {(00˚00’03”}/2 = 1.5”

Vertical collimation = {(FL + FR) – 360} = (90˚00’00” + 270˚00’02”) - 360} = 02”

The result shows that the instrument is still in good working condition.

3.4.2 Digital Level Instrument

The level instrument employed for the research was Leica Digital level. Two pegs test was carried out on the digital level to check the collimation error of the instrument. The level instrument was set on a specific point A, with initial adjustments made for proper alignment, levelling, and focusing to eliminate parallax, it was now backsight on peg 1 and foresight on peg 2, the instrument was then now moved to another point B, and all the necessary adjustments were made, the peg 2 was bisected as backsight, and the peg 1 as foresight.

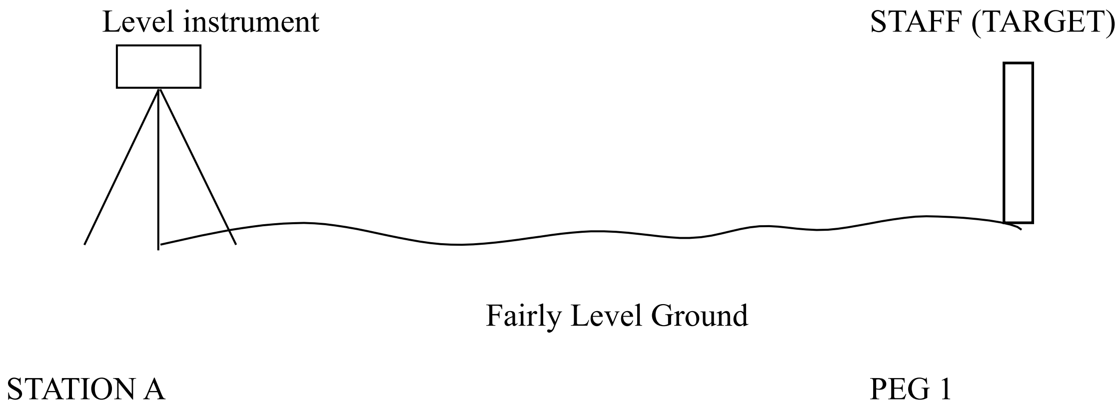


Fig3.4.1.1.: *Horizontal Collimation error test*

Table3.4.2.*Horizontal Collimation Data*

STATION	Remarks	BS	IS	FS	Diff.
A	Peg 1	1.734			
	Peg 2			2.042	
					0.308
B	Peg 2	1.578			
	Peg 1			1.262	
					0.316
	Collimation Error				**0.008**

The difference of the two-pegs test from 2 stations (0.008), shows the instrument is in good condition and can be used for the project.

3.5 Control Check

The control points were found along the road in Kwara State Polytechnic. In order to determine their correctness and their true position, one was used as station point KWPT 49 while the point KWPT 50 was used as the back sight. The coordinates obtained were compared with the received data from Department Field Data Records, the difference falls within the allowable accuracy of 3rd order survey job as can be seen in Table 3.3 below:

Table 3.3: *Analysis of control check*

PILLAR	**COORDINATE**	**EASTING(m)**	**NORTHING(m)**	**HEIGHT(m)**
KWPT 49	RECEIVED	674341.289	937679.115	353.682
	OBSERVED	674341.289	937679.115	353.682
	DIFFERENCE	0.000	0.000	0.000
PILLAR	COORDINATE	EASTING(m)	NORTHING(m)	HEIGHT(m)
KWPT 50	RECEIVED	674555.841	937679.115	353.682
	OBSERVED	674555.853	937679.097	353.691
	DIFFERENCE	0.012	0.018	0.009
Allowable accuracy		0.600	0.600	0.600

3.6 Data Acquisition

Data acquisition in land surveying refers to the process of collecting and recording data about the land, its features, and boundaries. This can include:

- Geometric data acquisition

- Attribute data acquisition

3.6.1 Geometric Data Acquisition

Geometric data acquisition involves collecting data that defines the spatial relationships and positions of features on the land. This can include:

1. Coordinates: Collecting X, Y, and Z coordinates of points on the land using instruments like total stations, GPS, and levels.

2. Distances and angles: Measuring distances and angles between points on the land using instruments like total stations and tape measures.

3. Elevations: Determining the height of points on the land above a reference datum using instruments like levels and GPS.

The geometric data of this project was obtained using the total station i.e. combination of electronic theodolite and the Electronic Distance Measurement (for X, Y, Z determination), and Level instrument (for height measurement) Geometric data are positional data, (i.e. they have the X, Y, Z) coordinates which make it easy to locate their actual position of features on the earth surface.

Here is a step-by-step procedure used for Total Station for geometric data acquisition:

Preparation

1. Setup: The Total Station was set over a known control point (KWPT 49).

2. Leveling: Level the instrument to ensure accurate measurements.

3. Orientation: It was done using two know control points KWPT 49(as occupy station) and KWPT 50(as backsight)

Data Collection

1. Target sighting: Sight the target (reflector) at the point to be measured.

2. Measurement: Determination of X, Y, Z of the target.

3. Recording: Record the measured data (coordinates).

4. Repeat: Repeat the process for each point to be measured.

Here's a step-by-step procedure used for Level instrument for data acquisition:

Preparation

1. Setup: The Level instrument was set on a stable surface, ensuring it's level and secure.

2. Leveling: Level the instrument using the built-in leveling mechanism.

3. Focus: The telescope was focused on the target (staff or rod).

Data Collection

1. Backsight: Took a backsight reading on a benchmark (KWPT 49).

2. Foresight: Take foresight readings on points to be measured, ensuring the staff is held plumb.

3. Reading: Record the readings, including the staff readings and points description.

4. Repeat: Repeat the process for each point to be measured.

3.6.2 Attributes Data Acquisition

Attribute data refers to information that describes the characteristics and properties of spatial features. It provides details such as names, classifications, and functions of geographic objects. In this study, the attribute data collected Include the names of buildings (e.g., lecture room of office), as well as information on roads. Handheld GPS was used to acquire attribute data for this project.

Handheld GPS units we used to gather attribute data by:

Collecting positional data: the GPS determines the location (LATITUTDE, Longtitude, and sometimes elevation) of the point where we standing.

Attaching attribute: you can then link attribute information to that location. This could be done by entering the information manually, (e.g. using the keypad on the GPS unit) or by uploading the data to a computer.

Saving the data: the GPS saves the location data along with the attributes, creating a dataset of points with associated information.

3.7 Perimeter, Detailing and Spot Heighting

Perimeter is the total distance covered along the boundary line and an area of land, the total distance covered is 1.214km. It is very important in order to get the exact location of a property. Traversing is a subordinate to perimeter and it may be defined as the process of connecting the series of lines with known bearing and distances (or XYZ).

The Total Station was carefully set up over control point KWPT49, with a back sight taken to point KWPT 50 after performing the necessary station adjustments, including cantering, levelling, and focusing, the KWPT50 (backsight) was measured and the observed coordinates was compared with given one, the difference is not significant and allowable. Then peg1 was established and measured in other to transfer the control to the site. The same procedure was repeated to determine the coordinates of the next point (peg2), and continued progressively until the site was reached. The radiation method was used for data acquisition, where two or more points were coordinated from a single instrument station.

The following steps outline the procedure:

I. After completing temporary adjustments, the instrument was powered on, and a new job titled *PRJT1* was created in the internal memory under the job menu.

II. In the coordinate menu, orientation was established by inputting the coordinates of the instrument station and back sight.

III. The height of the instrument and the reflector height were measured and entered into the instrument.

IV. The reflector at the back sight was accurately bisected before confirming the orientation.

V. Once oriented, the reflector was aimed at the next target (nail), and the "OBS" (observe) function was selected. The three-dimensional coordinates (Easting, Northing, and Height) were displayed and saved by pressing "REC" (record). For subsequent observations, the "ALL" option was used to streamline the process.

VI. It was ensured that the centre of the prism on the reflector was properly aligned and securely mounted on the tripod to minimize height determination errors.

VII. Once all visible details, including boundary points, spot heights and building, had been observed from the current station, the instrument was relocated to the next control nail, and the temporary adjustments were repeated.

This process was systematically carried out until all boundary points and elevation data were captured. In this project, spot heights were not recorded at regular grid intervals but were instead collected randomly after it has been pegged. For each building, three corner points were surveyed. Upon completing the data acquisition phase, all relevant features were accurately recorded and positioned accordingly on the final site plan.

CHAPTER FOUR

4.0 DATA DOWNLOADING, PROCESSING, ANALYSIS AND DISCUSSION

This chapter provides a detailed overview of the procedures involved in data download, data processing, correction, and data analysis conducted on the acquired data from the site and data presentation.

4.1 Data Download

All the recorded data was stored in the memory of the total station. To download the data, the total station was connected to a computer using a wired cable and downloading software. The software parameters were configured to match those of the instrument. The instrument's menu was accessed, and the memory manager was selected. From there, the "send data" option was chosen, and the file named "PRJT1" was located and downloaded to the computer through the software. The data was saved with a ".txt" file extension on the desktop of the laptop for further processing.

4.2 Data Editing

The downloaded geometric data were further processed to convert them into usable formats and improve their accuracy. The resulting coordinate data were edited using Notepad and Excel software. This file was then imported into AutoCAD2007 for additional processing.

4.3 Data Processing using Autocad 2007

Before using AutoCAD, we processed the coordinate data observed in the field by first transferring it into Notepad, then copying it into AutoCAD. The following steps outline the process for handling the data in AutoCAD:

1. Launch AutoCAD on the computer.
2. Click "New" from the application menu to start a new drawing.
3. Type UNITS in the command line and press Enter.
4. Select the desired unit type (e.g., decimal, architectural, engineering).
5. In the menu bar, select the "Polyline" tool.
6. Copy the data from Notepad and paste it into AutoCAD.
7. Type Z (for zoom) and press Enter, then type E (for extents) and press Enter to adjust the view.

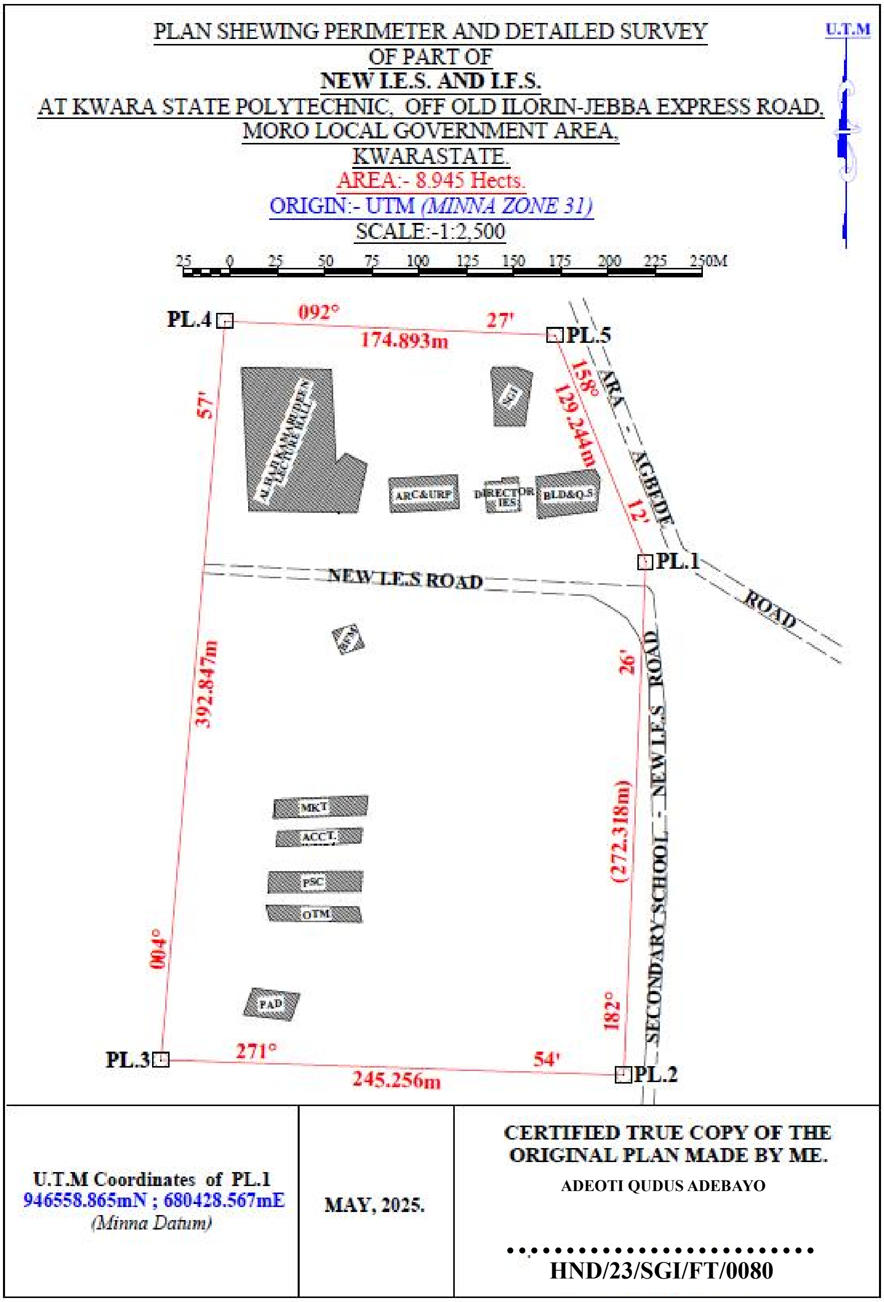


Figure 3.7: *Plan showing Perimeter and Detailed Survey.*

Area Computation using Cross Multiply Coordinates

E1 N1

E2 N2

E3 N3

E4 N4

E5 N5

E1 N6

680428.567	946558.865
680417.004	946286.792
680171.885	946294.956
680205.833	946686.334
680380.567	946678.865
680428.567	946558.865

$$\frac{\sum - \sum}{2}$$

$$\frac{460{,}787{,}138{,}011.03 - 460{,}786{,}959{,}116.36}{2}$$

178,894.67

2

Area = 89,447.335 sqft

Area = 8.945 hect.

4.4 Results and Discussion

Table 4.4: *Total station and Digital level Spot height Readings and their differences*

STATIONS	EASTING	NORTHING	HEIGHT		DIFF.
			T.S	LEVEL	
PT1	680272.275	946497.781	355.749	355.715	0.034
PT2	680267.717	946479.907	356.403	356.362	0.041
PT3	680273.327	946450.469	354.811	354.772	0.039
PT4	680287.358	946434.349	354.268	354.208	0.060
PT5	680317.873	946433.648	355.036	354.984	0.052
PT6	680304.544	946455.727	355.710	355.668	0.042
PT7	680337.867	946463.436	355.448	355.386	0.062
PT8	680342.774	946441.708	356.295	356.240	0.055
PT9	680342.774	946441.708	356.736	356.680	0.056
PT10	680348.740	946443.460	355.971	355.931	0.040

PT11	680377.262	946451.836	355.725	355.673	0.052
PT12	680382.060	946482.711	355.318	355.277	0.041
PT13	680381.009	946518.108	354.819	354.766	0.053
PT14	680350.494	946509.345	355.174	355.128	0.046
PT15	680356.104	946484.813	355.033	355.005	0.028
PT16	680332.603	946480.960	355.228	355.188	0.040
PT17	680308.051	946470.796	355.517	355.464	0.053
PT18	680298.581	946490.422	355.834	355.802	0.032
PT19	680318.222	946506.191	355.726	355.678	0.048
PT20	680308.753	946526.168	356.148	356.096	0.052
Mean			**355.8163**	**355.7726**	**0.0437**
Variance			**2.5758**	**2.5881**	**0.0123**
Standard Deviation			**1.6049**	**1.6088**	**0.0039**

Working Formulas for Mean, Variance and Standard Deviation Calculation

The mean is calculated as:

$$\mu = \frac{\sum x_i}{n}$$

$\mu =$ mean

$x_i =$ each point height

$n =$ number of points

The variance is calculated as:

$$^2 = \frac{\sum (x_i - \mu)^2}{n}$$

$^2 =$ variance

$x_i =$ each point height

$\mu =$ mean

$n =$ number of points

The Standard Deviation is calculated as:

$$= \sqrt{\;^2}$$

$=$ standard deviation

$^2 =$ variance

Mean calculation for Total Station Height readings

$$\mu = \frac{\sum x_i}{n}$$

$$\mu = \frac{355.749+356.403+354.811+354.268+355.036+355.710+355.448+356.295+356.736+355.971+355.725+355.318+354.819+355.174+355.033+355.228+355.517+355.834+355.726+356.148}{20}$$

$$\mu = \frac{7116.326}{20}$$

μ=355.8163

Mean calculation for Reduced Level Height readings

$$\mu=\frac{355.715+356.362+354.772+354.208+354.984+355.668+355.386+356.240+356.680+355.931+355.673+355.277+354.766+355.128+355.005+355.188+355.464+355.802+355.678+356.096}{20}$$

$$\mu=\frac{7115.452}{20}$$

μ = 355.7726

Mean calculation for Total Station Height readings - Mean calculation for level height readings 355.8163 – 355.7726 = 0.0437

$$^{2}=\frac{\sum(xi-\mu)^{2}}{n}$$

$$^{2}=\frac{\sum(xi-\mu)^{2}}{n}$$

$$\frac{0.0673^2+0.5867^2+1.0053^2+1.5483^2+0.5327^2+0.2521^2+0.1582^2+0.4126^2+0.9284^2+0.0992^2+0.1104^2+0.1327^2+1.0217^2+0.6184^2+0.7834^2+0.4926^2+0.2581^2+0.0164^2+0.0428^2+0.3317}{20}$$

$$^{2}=\frac{51.516}{40}$$

20

$^2 =$ **2.5758**

Variance calculation for Reduced Level Height readings

$$\frac{0.576^2+0.5894^2+1.006^2+1.5686^2+0.5285^2+0.2375^2+0.1382^2+0.4103^2+0.9126^2+0.0821^2+0.1013+0.1104^2+1.0102^2+0.6014^2+0.7695^2+0.4818^2+0.2443^2+0.0071^2+0.0289^2+0.32047}{20}$$

$^2 = \frac{51.762}{20}$

$^2 =$ **2.5881**

Variance calculation for total station – variance calculation for level height readings 2.5758 – 2.5881 = 0.0123

The Standard Deviation for Total Station Height readings:

$= \sqrt{\ \ }^2$

$= \sqrt{2.5758}$

$=$ **1.6049**

The Standard Deviation for Reduced Level Height readings:

$= \sqrt{2.5881}$

$=$ **1.6088**

The standard deviation for total station – standard deviation for level height reading 1.6049 – 1.6088 = 0.0039

The table above shows the station Id, eastings, northings, total station height, digital level reduced level and the difference between the total station height and the digital level reduced level.

The comparison of the two pieces of equipment revealed variations within a specific range. The differences observed between the two pieces of equipment were found to be in the range of 0.028 to 0.062 meters. These differences indicate slight disparities in the measurements obtained from each instrument. Statistical analysis was performed to evaluate the mean, variance, and standard deviations of the observed differences. The mean difference was calculated to be 0.0437, indicating an average deviation between the measurements obtained by the two equipment. The variance, which quantifies the spread of the differences, was found to be 0.0123.

This value suggests that the variations in the measurements obtained by the two pieces of equipment were relatively consistent. The standard deviation, which provides a measure of the dispersion of the data, was determined to be 0.0039. This indicates that the differences between the measurements obtained from the two pieces of equipment had a moderate level of variability.

Overall, the results of the analysis demonstrate that there were slight variations between the measurements obtained from the two pieces of equipment. The mean, variance, and standard deviations provide insights into the magnitude and consistency of these differences, offering valuable information for assessing the accuracy and reliability of the equipment in question.

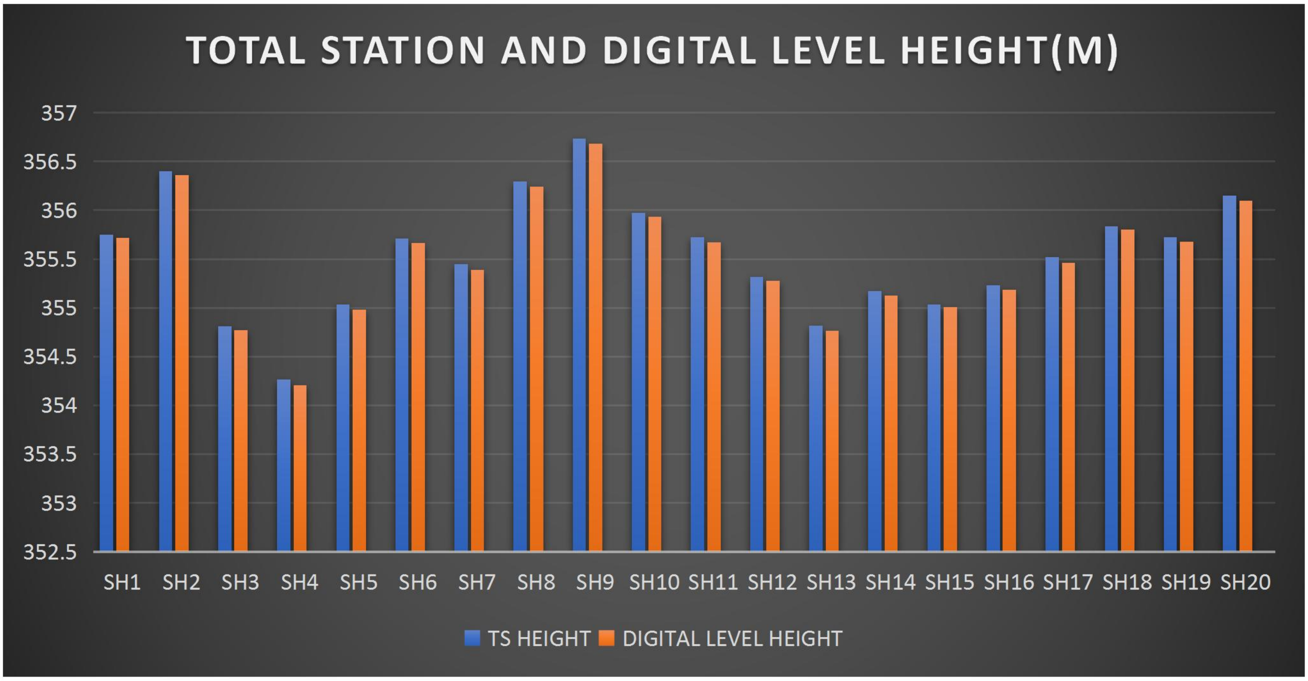


Figure 1:*Bar chart showing heights obtained from the total station and level instrument*

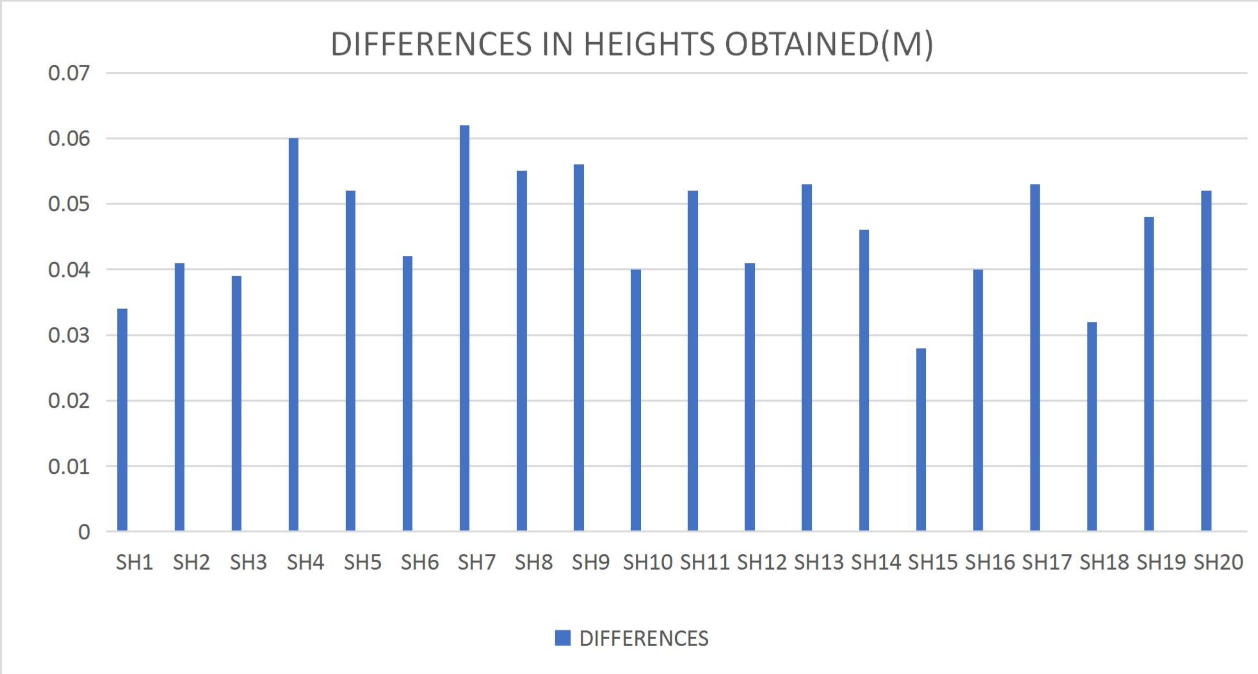


Figure 2: *Histogram showing the difference in the two instrument's result*

The histogram presented above illustrates the distribution of deviations between the two methods being compared. The deviations are depicted in centimeter, showcasing the level of accuracy achieved by both methods. The histogram highlights that the deviations are tightly clustered and exhibit a consistent pattern.

CONTOUR MAP USING AUTO LEVEL

CONTOUR MAP USING TOTAL STATION

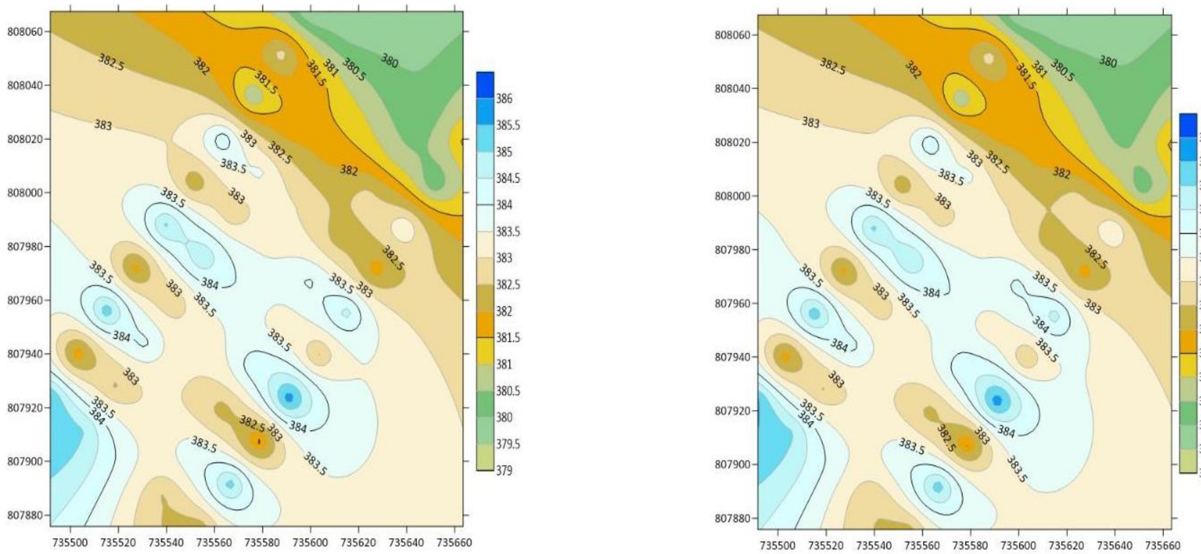


Figure 3: *Showing the contour map obtained from the two instrume*

3-D SURFACE MODEL USING AUTO LEVEL

3-D SURFACE MODEL USING TOTAL STATION

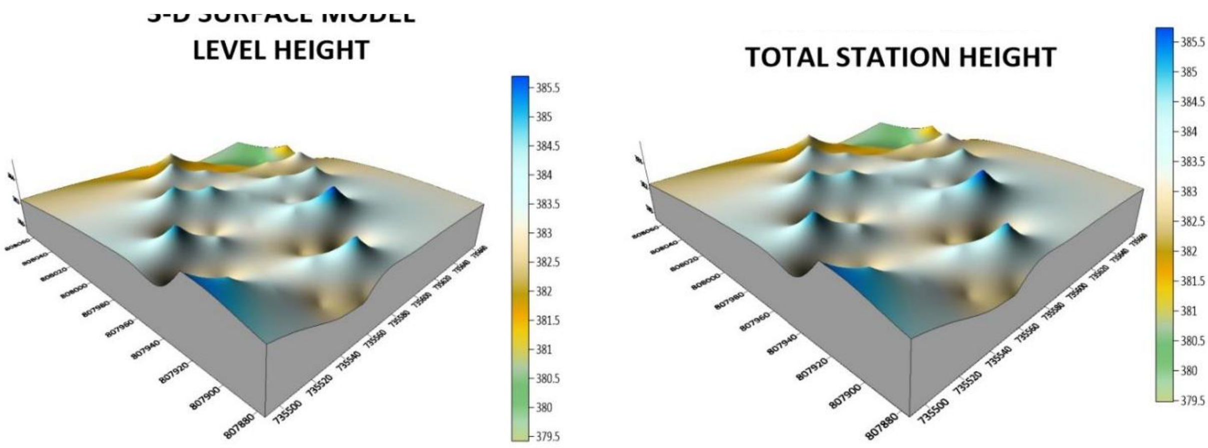


Figure 4: *Showing the 3D surface map obtained from the two instruments*

The mean of the deviations, calculated to be 0.0437m, provides an indication of the average difference between the measurements obtained from the two methods. This value signifies a small average deviation, suggesting that the two methods generally yield similar results with minimal variation.

The histogram provides a visual representation of the data, allowing for a comprehensive understanding of the distribution of deviations. By examining the histogram, one can observe the concentration of deviations around the mean value, indicating a central tendency in the measurements obtained by the two methods.

The centimeter-level accuracy exhibited by the deviations underscores the precision of the measurement techniques employed. This level of accuracy is crucial, particularly in applications that require high precision, such as engineering, construction, or geospatial analysis. The contour maps presented above exhibit strikingly similar patterns, which serve as a testament to the high degree of precision achieved by the instruments used. The consistent and replicated patterns observed on the maps reinforce the reliability and accuracy of the measurements obtained.

The similarity in the contour patterns indicates that the instruments employed in the surveying process were able to capture the subtle variations in elevation with great precision.

This level of accuracy is crucial in applications such as topographic mapping, land surveying, and engineering, where even minor deviations can have significant implications. By displaying the contours of the surveyed area, the maps provide a visual representation of the landscape's topography and elevation changes.

The congruity in the contour lines across the maps signifies that the instruments effectively captured and recorded the elevation data, resulting in a reliable representation of the terrain

4.5 Statistical Analysis

A statistical investigation was carried out using Paired Two Samples as Means to test whether there is any significant difference in the performance of the two instruments for terrain height determination. The independent sample t-test is a member of the t-test family, which consists of tests that compare mean value(s) of continuous-level (interval or ratio data), normally distributed data (Hinton, 2004). The independent-sample t-test evaluates the difference between the means of two independent or unrelated groups. That is, we evaluate whether the means for the two independent groups are significantly different from each other.

Hypothesis

A hypothesis was set up and tested using an Independent – sample T-Test:

1. Null Hypothesis: H0: There is no difference between the terrain height obtained from the total station and digital level instrument.

2. Alternative Hypothesis: H1: There is a difference between terrain height obtained from total station and digital levelling instrument.

The null hypothesis is rejected if the calculated t value has a probability sig. (p) greater than the chosen significance level. An Independent sample T-Test was used in testing the hypothesis at a significance level of 0.05. Data analysis Package extension in Excel was activated and used in running the T-Test.

Table 4.5: *T-Test: Two-Sample Assuming Unequal Variances*

	Digital Level	Total Station
Mean	355.77262	355.81628
Variance	2.588092118	2.575687471
Observations	20	20
Pearson Correlation	0.032104369	0.031950494
Hypothesized Mean Difference	0.001605218	0.001597525
t Stat	0.056215684	0.056208782
P(T<=t) one-tail	0.145413689	0.144776257
P(T<=t) two-tail	0.290982737	0.289552551
Sum	7096.631	7095.814
Kurtosis	2.049052417	2.0403051292
Skewness	0.612867732	0.5907755549
Median	354.772	354.811
Maximum	356.680	356.736
Minimum	354.208	354.268
Range	2. 472	2.468

The statistical data provided supports our discussion by indicating a high degree of agreement and consistency between the digital level and total station measurements. The mean values are very close, the variances are similar, and the Pearson correlation coefficient indicates a strong linear relationship. The t-test results suggest that any observed difference between the two instruments' means is likely due to random variation rather than a significant discrepancy.

After carrying out the project, we observe that digital level is more accurate than total station, although the different can be quite small.

CHAPTER 5

5.0 COSTING, SUMMARY, RECOMMENDATION AND CONCLUSION.

5.1 Cost Estimation of the Project

The project costing was based on number of variables which includes area to be covered, instruments, personnel, transportation and so on. However, another critical factor to be considered is the time duration in which the project was executed. The table below shows the duration the project was accomplished.

Table 5.1: Scheduled and Duration of the Project Execution

Description	**Duration (Days)**
Reconnaissance	1
Beaconing / Monumentation	1
Spot height points establishment	1
XYZ acquisition of the spot height points (using TS)	1
Height observation of the spot height points (using level instrument)	1
Detailing (using handheld GPS)	1
Data Downloading / Processing	3

Plotting and Report Writing	7
Submission of Report and Plan	5
Total No. of Days Spent for the Project	**21**

5.1.1 Project Costing Breakdown

Costing of this project was based on Professional Scale of Fees as approved by Nigerian Institution of Surveyor (NIS) in 2017 using 1996 Federal Government Approved Scale of Fees for Consultants in the Construction Industry. The prevailing inflation rate as at February 2023 was 21.91 % and this was applied to the cost estimate.

Table 5.2: Worked out Calculation for the grand Total Cost

S/N	OPERATION	RATE/DAY	NO OF DAYS	UNIT COST (#)	AMOUNT (#)
1	**RECONNISSANCE(1 DAY)**				
	4 Technician	15,189.11	1	15,189.11 x 4	60,756.40
	1 Skilled Labour	9,468.61	1	9,468.61x 1	9,468.61

	Transportation (Field vehicle + Driver / Mechanic + fuel	46,027.61	1	46,027.61 x 1	46,027.61
	Basic equipment (Hand held GPS etc.)	46,027.61	1	46,027.61 x 1	46,027.61
	SUB TOTAL				**157,546.00**
2	**(A) BEACONS** (5) (standard Cadastral Beacon)	5,000 per Beacon		5,000 x 5	25,000.00
	(B) BEACONING/ MONUMENTATION (1 day)				
	6 Surveyors	15,189.11	1	6x 15,189.11x 1	91,134.11
	3 Skilled Labour	9,468.61	1	3x 9,468.61x 1	28,405.83
	Transportation (Field vehicle + Driver / Mechanic + fuel)	46,027.61	1	46,027.61 x 1	46,027.61

	Basic tools (Crow bar, Trowel, Shovel etc)	13,929.00	1	13,929.00x 1	13,929.00
	SUBTOTAL				**179,496.55**
3	**Spot Height Establishment (1 DAY)**				
	2 surveyors	15,189.11	1	2x15,189.11 x 1	30,378.22
	3 Unskilled Labour	9,468.61	1	3 x9,468.61x 1	56,811.66
	Basic Equipment	46,027.61	1	46,027.61x1	92,055.22
	Transportation (Field vehicle + Driver / Maintenance + Fuel)	46,027.61	1	46,027.61 x 1	92,055.22
	SUBTOTAL				**271,300.32**
4	**XYZ ACQUISITION USING (TS)**				

	(1 DAY)				
	1 Senior Surveyor	22,783.67	1	1x 22,783.67 x 2	45,567.34
	2 Surveyors	15,189.11	1	2 x15,189.11 x 2	60,756.44
	2skilled Labour	9,468.61	1	2 x9,468.61x 2	37,874.44
	Basic Equipment	46,027.61	1	46,027.61x 2	92,055.22
	Transportation (Field vehicle + Driver / Maintenance + Fuel)	46,027.61		46,027.61 x 2	92,055.22
	SUBTOTAL				**328,308.66**
5	**HEIGHT OBSERVATIION (LEVEL INSTRUMENT) (1DAY)**				
	1 Senior Surveyor	22,783.67	1	1x 22,783.67 x 2	45,567.34
	2 surveyors	15,189.11	1	2 x15,189.11	60,756.44

				x 2	
	2skilled Labour	9,468.61	1	2 x9,468.61x 2	37,874.44
	Basic Equipment	46,027.61	1	46,027.61x 2	92,055.22
	Transportation (Field vehicle + Driver / Maintenance + Fuel)	46,027.61	1	46,027.61 x 2	92,055.22
	SUBTOTAL				**328,308.32**
6	**DETAILING (1 DAY)**				
	2 Surveyors	15,189.11	1	2x 15,189.11x 1	30,378.22
	3 Skilled Labour	9,468.61	1	3x 9,468.61x 1	28,405.83
	Transportation (Field vehicle + Driver / Mechanic + fuel)	46,027.61	1	46,027.61 x 1	46,027.61
	Basic Equipment	46,027.61	1	46,027.61x 1	46,027.61

	SUBTOTAL				**150,839.27**
7	**DATA DOWNLOADING / PROCESSING (3 DAYS)**				
	1 Senior Surveyor	22,783.67	3	22,783.67 x 3	68,351.01
	2 surveyors	15,189.11	3	2x15,189.11 x 3	91,134.66
	Computer Accessories	49,315.28	3	49,315.28 x 3	147,945.84
	SUBTOTAL				**307,431.51**
8	**PLOTTING AND REPORT WRITTING (7 DAYS)**				
	1 Senior Surveyor	22,783.67	7	1x22783.67 x 7	159,485.69
	2 surveyors	15,189.11	7	2x15,189.11 x	212,647.54

				7	
	Standard set (computer, plotter etc)	65,753.70	7	1x65,753.70 x 7	460,275.90
	SUBTOTAL				**832,409.13**
9	**SUBMISSION OF REPORT AND PLAN (1 DAY)**				
	1 Chief Surveyor	30,800.00	1	30,800.00x 1	30,800.00
	2 surveyors	15,189.11	1	2x 15,189.11x 1	30,378.22
	1 Computer	46,027.61	1	46,027.61 x 1	46,027.61
	Consumables	13,929.00	1	13,929.00 x 1	13,929.00
	SUBTOTAL				**121,135.41**
COST OF TH]E PROJECT =					**2,676,775.17**
ACCOMODATION(15% of the cost of the project)					595,177.22

MOBILIZATION/DEMOBILIZATION (10% of cost of the project) =	396,784.81
CONTINGENCIES (5% of cost of the project) =	198,392.41
VAT (7.5% of the Total cost of the project)=	297,588.61
ACTUAL BILL/ GRAND TOTAL =	**4,164,718.22**

Hence, the total cost of expenditure used for comparative evaluation of digital levelling and total station equipment for height measurement project was estimated to be Four Million, One Hundred and Sixty Four Thousand, Seven Hundred Eighteen Naira, Twenty Two Kobo only.

5.2 Summary

This project presents a comprehensive comparative evaluation of the accuracy and reliability of digital levelling and total station equipment for determining height measurements. The project reveals that both tools have distinct strengths and limitations, with digital levelling offering high precision and accuracy in precise levelling tasks, and total station equipment providing flexibility and versatility in various surveying applications. The results demonstrate that the choice between these two tools depends on the specific requirements of the project, including the range, precision, and type of measurement. The project's findings have significant implications for surveying professionals, researchers, and engineers, providing a deeper understanding of the capabilities and limitations of digital levelling and total station equipment.

5.3 Recommendation

Based on the findings of this study, it is recommended that surveying professionals and researchers consider the environmental conditions and potential sources of error when selecting and using digital levelling and total station equipment. By understanding the potential sources of error and taking steps to mitigate them, professionals can ensure the accuracy and reliability of height measurements. Additionally, it is recommended that professionals use multiple measurement techniques and equipment to validate results and ensure accuracy.

5.4 Conclusion

In conclusion, this project has provided a comprehensive assessment of the accuracy and reliability of digital levelling and total station equipment for determining height measurements. The results demonstrate that both tools have distinct strengths and limitations, with digital levelling offering high precision and accuracy, and total station equipment providing flexibility and versatility. By understanding these characteristics, surveying professionals can make informed decisions, selecting the most suitable equipment for specific projects. Ultimately, this study contributes to the advancement of surveying practices, enhancing the accuracy and reliability of height measurements and informing the development of more effective surveying methodologies.

REFERENCES

Audu, H.A.P., Tijjani, M.Y. (2017). Comparative Assessment of the Accuracy of the Elevation differences obtained from different Geomatics Techniques and Instruments. *Nigerian Journal of Environmental Sciences and Technology* Vol 1, No. 1 pp 136 – 145.

Beshr, A.A.A.; Abo Elnaga, I.M. (2011). Investigating the Accuracy of Digital Levels and Total Stations for Purposes of Geodetic Engineering. *Alex. Eng. J.* 50, 399–405.

Featherstone, W. E. (2002). Height systems and vertical datums: A review. *Reports on Geodesy,* 49(1), 97-107.

Journal of Geomatics: Reliability Analysis of Digital Levelling and Total Station Equipment.

Journal of Surveying Engineering (ASCE): Comparative Study of Digital Levelling and Total Station for Height Measurement.

Lee, J., & Rho, T. (2001). Application to levelling using total station. In New Technology for a New Century International Conference FIG Working Week 2001. Seoul, Korea: FIG Conference Proceedings.

M. Abdullahi and N. A. Yelwa, (2016). Structural Deformation Monitoring Surveys of New Administrative Building of Federal School of Surveying, Oyo – Nigeria, *International Journal of Science and Technology,* vol. 6, no. 1.

Maembe, w. (2012). Potential application of Total Station Levelling as a Precise Geodetic Levelling. B.Sc. Thesis, Department of Geomatics Ardhi University, Dar es Salaam, Tanzania.

Surveying and Land Information Science: Comparison of Digital Levelling and Total Station for Monitoring Vertical Displacements.

APPENDIX

ID	EASTING	NORTHING	TS HEIGHT	LEVEL HEIGHT
PL.1	680428.567	946558.865	356.128	
PL.2	680417.004	946286.792	354.746	
PL.3	680171.885	946294.956	353.013	
PL.4	680205.833	946686.334	357.652	
PL.5	680380.567	946678.865	356.849	
SH1	680272.275	946497.781	355.749	355.715
SH2	680267.717	946479.907	356.403	356.362
SH3	680273.327	946450.469	354.811	354.772
SH4	680287.358	946434.349	354.268	354.208
SH5	680317.873	946433.648	355.036	354.984
SH6	680304.544	946455.727	355.710	355.668
SH7	680337.867	946463.436	355.448	355.386
SH8	680342.774	946441.708	356.295	356.240
SH9	680342.774	946441.708	356.736	356.680
SH10	680348.740	946443.460	355.971	355.931
SH11	680377.262	946451.836	355.725	355.673
SH12	680382.060	946482.711	355.318	355.277
SH13	680381.009	946518.108	354.819	354.766
SH14	680350.494	946509.345	355.174	355.128
SH15	680356.104	946484.813	355.033	355.005
SH16	680332.603	946480.960	355.228	355.188

SH17	680298.581	946490.422	355.834	355.802
SH18	680318.222	946506.191	355.726	355.678
SH19	680308.753	946526.168	356.148	356.096
SH20	680342.774	946441.708	356.736	356.680

SHOPRITE	680275.567	946584.865	,	S.G.I	680364.567	946630.865
SHOPRITE	680229.567	946585.865	,	S.G.I	680368.567	946658.865
SHOPRITE	680218.567	946585.865	,	S.G.I	680360.567	946661.865
SHOPRITE	680214.567	946661.865	,	S.G.I	680347.567	946661.865
SHOPRITE	680262.006	946660.833	,	S.G.I	680346.567	946659.865
SHOPRITE	680264.633	946610.907	,	S.G.I	680348.567	946639.865
SHOPRITE	680269.493	946616.306	,	S.G.I	680348.567	946630.865
SHOPRITE	680281.021	946610.551	,	S.G.I	680364.567	946630.865
SHOPRITE	680281.021	946610.551				
DRCT. IES	680344.567	946584.865	,	BLD&QS	680371.567	946581.865
DRCT. IES	680343.551	946601.098	,	BLD&QS	680370.514	946603.802
DRCT. IES	680352.430	946601.591	,	BLD&QS	680401.497	946607.815
DRCT. IES	680352.329	946603.210	,	BLD&QS	680404.537	946602.905
DRCT. IES	680361.208	946603.703	,	BLD&QS	680402.499	946585.830

ARC&URP	680328.567	946604.865	,	BFM	680262.567	946521.871
ARC&URP	680292.567	946602.865	,	BFM	680267.567	946509.867
ARC&URP	680293.684	946585.013	,	BFM	680279.567	946513.862
ARC&URP	680329.684	946587.013	,	BFM	680274.567	946525.865
MKT.	680215.442	946426.097	,	ACCT.	680262.660	946428.209
MKT.	680214.930	946436.134	,	ACCT.	680218.483	946419.645
MKT.	680263.075	946445.466	,	ACCT.	680218.891	946411.655
MKT.	680263.587	946435.430	,	ACCT.	680263.068	946420.219
PHYS.	680266.105	946405.563	,	OTM.	680266.988	946386.384
PHYS.	680267.046	946394.755	,	OTM.	680218.393	946380.018
PHYS.	680218.331	946387.08	,	OTM.	680221.571	946372.409
PHYS.	680217.389	946397.897	,	OTM.	680270.166	946378.775
PAD.	680240.402	946321.660				
PAD.	680215.235	946320.874				
PAD.	680218.077	946335.465				
PAD.	680243.244	946336.252				