A PROJECT

ON

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

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

BY

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HND/23/SGI/FT/0083

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.

DECLARATION

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:ABDUL ABDUL QUDUS SHUKURAH TEMITOPE

MATRICNO.:HND/23/SGI/FT/0083

SIGNATURE: ………………………………….

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

CERTIFICATION

This is to certify that **ABDUL QUDUS SHUKURAH TEMITOPE** with matriculation number **HND/23/SGI/FT/0083** 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, whose guidance, strength, and blessings have been my constant source of inspiration and perseverance. 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

As I stand at the threshold of this significant milestone, I am overwhelmed with gratitude and love for the people who have made this journey possible.

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 Lecturer.

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. ABDUL-QUDUS for their un-measured words of encouragement, financial, moral and spiritual support given to me all through this program.

My profound gratitude goes to my wonderful friends and my group Member thanks for the good experience we have together.

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ABSTRACT

This project undertakes a thorough comparison and analysis of the performance of Total Station and digital level instruments in determining terrain heights, with a focus on accuracy and reliability. Height observations are a critical component of surveying and geodetic science-related areas, and this project aimed to evaluate the effectiveness of these two instruments in obtaining accurate height measurements. A fieldwork was conducted within the Kwara State Polytechnic campus, Total station was used to measured the perimeter points and 20 stations were established randomly within the site perimeter, Total station and Digital level instrument were used to determine the height of those station (as spot height). The data obtained from digital leveling and Total Station measurements were carefully processed and analyzed, revealing that both instruments produced comparable results. The maximum and minimum heights obtained using the digital level instrument were 356.680m and 354.208m, respectively, while the Total Station instrument yielded maximum and minimum heights of 356.736m and 354.268m, respectively. The project found that the differences between the heights obtained using both instruments were relatively small, ranging from 28mm to 62mm. Importantly, the project concluded that both instruments can be used interchangeably for terrain height determination, given the absence of significant differences in their performance. The findings of this project contribute to the understanding of the capabilities and limitations of Total Station and digital level instruments in surveying and mapping applications, and have implications for the selection of instruments for specific projects.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER ONE

1.0 INTRODUCTION

Height determination is an essential aspect of surveying that involves determining the vertical location of a point relative to a reference datum. Surveyors typically use different techniques to determine the elevation of a point, including trigonometric levelling, barometric levelling, and digital levelling (Simbolon et al., 2017). Levelling is a widely used method for determining the elevations of ground points relative to a reference datum. It involves measuring the vertical distance between the ground point and the reference datum to obtain what is known as the reduced level. This is an important procedure that is used in various fields such as mapping, engineering design, construction, and setting out. The reference datum used in levelling is usually the mean sea level, which is assumed to be an equipotential surface. This means that points on this surface have the same gravitational potential energy. As such, the mean sea level is adopted as the reference surface for vertical control surveys (Schofield & Breach, 2007; Uren & Price, 2010).

Leveling Schofield and Breach (2007) opined that levelling is a technique used to determine the vertical location of a point on or beneath the surface of the earth relative to a reference datum, while planimetry refers to the horizontal position of a point relative to a coordinate system. The authors also noted that these two procedures are separate and distinct, as each involves different equipment, procedures, and techniques. This idea is further supported by Ghilani and Wolf (2014), who stated that levelling is primarily concerned with determining the elevations of ground points, whereas planimetry is focused on determining the position of those points in a horizontal plane. The choice of height system is critical in many applications, especially those that require accurate determination of elevation. For instance, in civil engineering projects such as road construction, it is important to know the elevation of the terrain to design the road profile, drainage, and culverts. The orthometric height system is widely used in such projects as it provides a meaningful height reference that is directly linked to the earth's gravity field. However, other height systems, such as the ellipsoidal height system, are used in different applications. The ellipsoidal height system is based on the normal to the reference ellipsoid and is commonly used in satellite positioning systems such as GPS. The choice of height system depends on the application, and it is important to understand the differences between them to avoid errors in height determination (Torge, 2001). Orthometric heights are determined by measuring the vertical distance between the point of interest and the geoid. This can be achieved through traditional techniques such as spirit levelling, trigonometric levelling, and GPS measurements (Odumosu et al., 2018). In spirit levelling, a series of measurements are taken with a level instrument, and the heights are computed based on the height of the instrument and the readings taken at the different locations. Trigonometric levelling involves measuring the angles and distances between two points and computing the height difference between them using trigonometric functions. GPS measurements use satellite signals to determine the height of a point above the ellipsoid and geoid is computed with high accuracy (Ghilani & Wolf, 2014). The process of levelling involves using a levelling instrument to measure the vertical distance between the ground point and the reference datum. The levelling instrument consists of a spirit level and a graduated staff. The spirit level is used to ensure that the staff is held World Scientific News 189 (2024) 87-101 -89- vertically, while the graduated staff is marked with a series of divisions that enable the observer to measure the vertical distance between the ground point and the reference datum. There are several methods for leveling observations in modern days, they include geometric leveling and trigonometric leveling methods (Lee & Rho, 2021). The choice of method to use largely depends on the accuracy desired, nature of the work to do and the availability of instrument to use.

Total Station The total station is a surveying instrument that combines the angle measuring capabilities of theodolite with an electronic distance measurement (EDM) and processing capabilities to calculate and determine horizontal angle, vertical angle and slope distance to the particular point (Lin, 2014). The determination of the coordinates 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 (Putra et al., 2023). The process involves measuring angles and distances from the total station to the points under survey. Subsequently, trigonometry and triangulation are employed to calculate the coordinates (X, Y, and Z or northing, easting, and elevation) of surveyed points concerning the position of the total station (Reyes, 2021). To get data on the distance of a point, the Total Station emits a wave, then the object will reflect the wave and be received back by the tool. Then the software inside the tool will automatically calculate the distance from where the tool stands to the measured point. To determine an absolute location, a total station requires line of sight observations and must be set up over a known point or with line of sight to two or more points with known location (Solomon, 2014).

1.2 STATEMENT OF THE PROBLEM

In height determination we have a number of instruments of different precisions and relatively different field procedures which ends with different precisions. The highest precision in levelling is obtained by the use of digital levelling. Total station is less precise but how much is it imprecise compared to conventional digital levelling? The use of digital levels saves 3 computational and observation time. It is therefore expected to be less tedious than the conventional digital levelling. The question is how much tedious is it? Does it give the same precision compared to conventional analogue digital levelling? These are some of the problems which are going to be discussed in this project.

1.3 AIM AND OBJECTIVES OF THE PROJECT

1.3.1 AIM OF THE PROJECT

The primary aim of this project is to compare the accuracy and reliability of digital leveling and total station equipment in determining height measurements.

1.3.2 OBJECTIVES OF THE PROJECT

The objective of this study is to assess the performance of total station instrumentation and digital levels to determine the height measurement in executing levelling for vertical control in topographic surveys for route engineering projects.

1.4 SCOPE OF THE PROJECT

This study is limited to the comparison between total station levelling and digital levelling on the four segments that are 7km in lengths. The comparison will be judged by statistical quantities such as maximum, minimum, mean and root mean square differences.

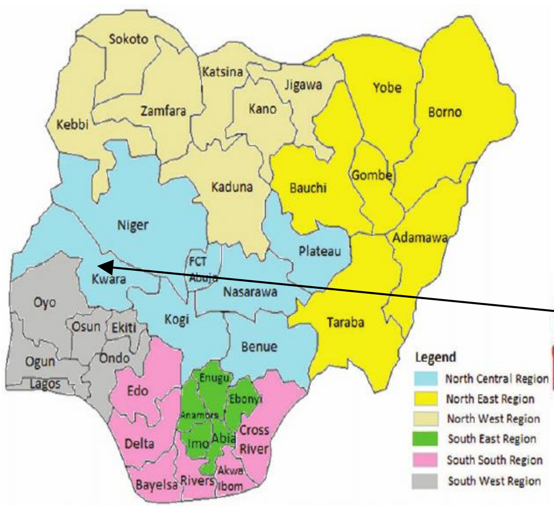
1.5 PERSONNEL INVOLVED

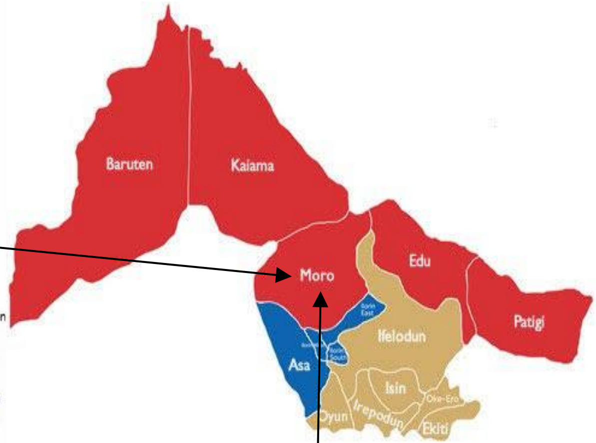
The project was assigned to and was successfully carried by the personnel listed below;

NAME	MATRIC. NO.	
Jimoh Halimah Titilayo	HND/22/SGI/FT/082	Writer
Ganiyu Akeem Abiodun	HND/23/SGI/FT/0076	Member
Abdul Kareem Ramota Olawumi	HND/23/SGI/FT/0078	Member
Kazeem Kabirat Damilola	HND/23/SGI/FT/0079	Member
Adeoti Qudus Adebayo	HND/23/SGI/FT/0080	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

1.6 PROJECT LOCATION

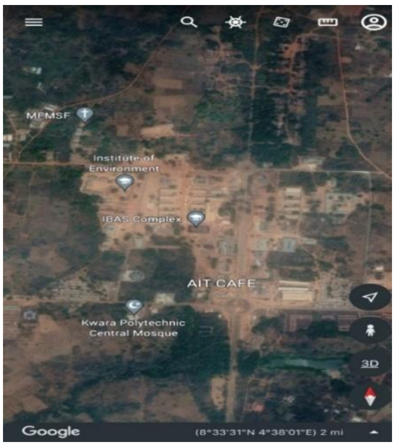
The project site is located inside Kwara state polytechnic Ilorin, Kwara state.

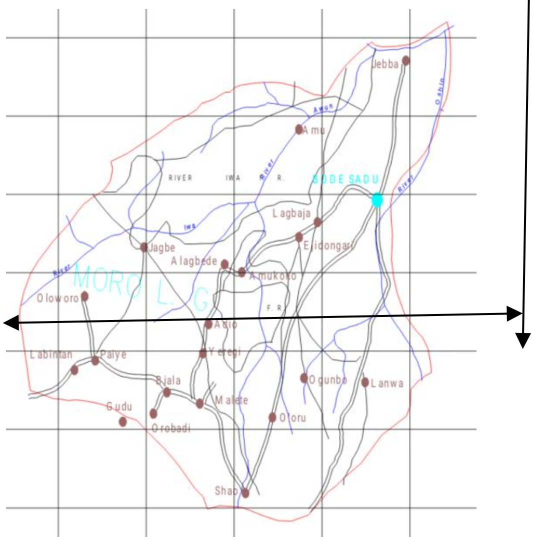




Map of Nigeria

Map of Kwara State





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Map of Moro L.G.A

Google Imagery of the Study Area

Google Earth Imagery of the Study Area,

CHAPTER TWO

2.0 LITERATURE REVIEW

Height measurement is a crucial aspect of geospatial and civil engineering projects, whether for land surveys, construction, or topographic mapping. Traditionally, height measurements were obtained using optical and mechanical instruments such as spirit levels and total stations. However, advancements in technology have introduced digital levelling systems and modern total stations as alternative methods for determining height with high precision. This literature review explores the comparative evaluation of the accuracy and reliability of these two technologies in height measurement, providing insights into their respective strengths and weaknesses.

The process of levelling involves using a levelling instrument to measure the vertical distance between the ground point and the reference datum. The levelling instrument consists of a spirit level and a graduated staff. The spirit level is used to ensure that the staff is held World Scientific News 189 (2024) 87-101 -89- vertically, while the graduated staff is marked with a series of divisions that enable the observer to measure the vertical distance between the ground point and the reference datum. There are several methods for leveling observations in modern days, they include geometric leveling and trigonometric leveling methods (Lee & Rho, 2021). The choice of method to use largely depends on the accuracy desired, nature of the work to do and the availability of instrument to use.

The determination of the coordinates 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 (Putra et al., 2023). The process involves measuring angles and distances from the total station to the points under survey. Subsequently, trigonometry and triangulation are employed to calculate the coordinates (X, Y, and Z or northing, easting, and elevation) of surveyed points concerning the position of the total station (Reyes, 2021). To get data on the distance of a point, the Total Station emits a wave, then the object will reflect the wave and be received back by the tool. Then the software inside the tool will automatically calculate the distance from where the tool stands to the measured point. To determine an absolute location, a total station requires line of sight observations and must be set up over a known point or with line of sight to two or more points with known location (Solomon, 2014).

1. Digital Levelling Technology

Digital levelling technology involves the use of digital levels (also known as electronic levels) which combine a digital sensor with an electronic display to automate the process of measuring height differences. The device measures the difference in elevation between two points by automatically capturing data through a digital readout. Some models also incorporate automatic compensators to maintain precise horizontal alignment, increasing measurement stability.

Accuracy

Digital levelling is known for its high accuracy in measuring vertical distances. According to studies, digital levels can achieve accuracy levels up to 0.2 mm/km (2 mm over a 10 km distance). The primary advantage of digital levelling over traditional optical levels is its automated data capture, which reduces human error, particularly with reading the staff measurements.

Reliability

The reliability of digital levelling is influenced by factors such as atmospheric conditions, the quality of the instrument, and the terrain over which measurements are taken. Digital levelling instruments have proven to be reliable under standard survey conditions and have low susceptibility to errors in measuring elevation, as they are less sensitive to environmental disturbances (e.g., wind, temperature) compared to optical systems.

Limitations

Despite the advantages, digital levelling has certain limitations:

- Limited Range: Digital levelling equipment is usually confined to short-range measurements compared to total stations, typically within a few kilometers.

- Cost: Digital levelling systems can be more expensive than traditional optical systems, which may limit their use in some survey projects.

- Sensitivity to Setup: The instrument setup and calibration require careful handling to ensure maximum accuracy.

2. Total Station Technology

A total station is an electronic/optical instrument that combines the functions of an electronic theodolite and an electronic distance measuring device (EDM). It is used to measure both horizontal and vertical angles, as well as distances. When measuring height, a total station calculates the elevation difference between two points by capturing both the horizontal distance and angle of inclination between the instrument and the target.

Accuracy

Total stations offer high accuracy for both horizontal and vertical measurements, with typical vertical accuracy within 1-3 mm depending on the model and measurement range. The vertical accuracy is achieved by measuring angles and distances, and then applying trigonometric calculations to determine the height difference.

Reliability

Total stations are versatile and can be used for long-range measurements, making them suitable for large survey projects. Their reliability is also high, especially when combined with modern technology like GPS or robotic total stations that can automate the targeting and tracking of survey points. However, total stations are more sensitive to weather conditions, particularly for longer-range measurements, where visibility and atmospheric refraction can affect results.

Limitations

- Environmental Sensitivity: Total stations can be affected by weather conditions such as rain, fog, and extreme temperatures, which can introduce measurement errors.

- Line of Sight: The performance of a total station depends on clear line-of-sight, which can be obstructed by buildings, trees, or other obstacles.

- Setup Time: Setting up and aligning a total station is time-consuming and requires skilled operators, especially for complex surveys.

3. Comparative Evaluation: Digital Levelling vs. Total Station

Accuracy and Precision

Several studies have shown that digital levelling provides superior vertical accuracy compared to total stations. For example, Kula et al. (2015) found that digital levelling systems could achieve vertical accuracy of 0.2 mm/km, while total stations typically achieve 1-3 mm accuracy for vertical measurements over similar distances. This makes digital levelling a preferred choice for high-precision projects where vertical accuracy is critical.

However, for long-distance or large-scale surveys, total stations are more versatile because they can measure horizontal and vertical distances with a single instrument. Total stations are also able to measure in more complex environments, such as urban areas, where measurements are taken over larger distances.

Reliability

In terms of reliability, digital levelling is generally less prone to environmental factors than total stations. According to studies by Elashmawi et al. (2017), digital levelling instruments were found to be less affected by weather conditions such as fog or rain, whereas total stations may experience errors due to these factors. Moreover, digital levelling instruments provide more consistent results as they minimize operator influence and the need for line-of-sight, a limitation for total stations.

However, total stations offer more flexibility in data collection, as they can measure multiple points without needing to be recalibrated, and they can measure both horizontal and vertical distances simultaneously.

Cost and Practical Application

While digital levelling offers superior accuracy, total stations are more widely used in surveying due to their multifunctionality. The ability to perform both angle and distance measurements makes them ideal for more comprehensive survey projects. However, digital levelling tends to be more cost-effective for projects that primarily require high-accuracy height measurements.

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.

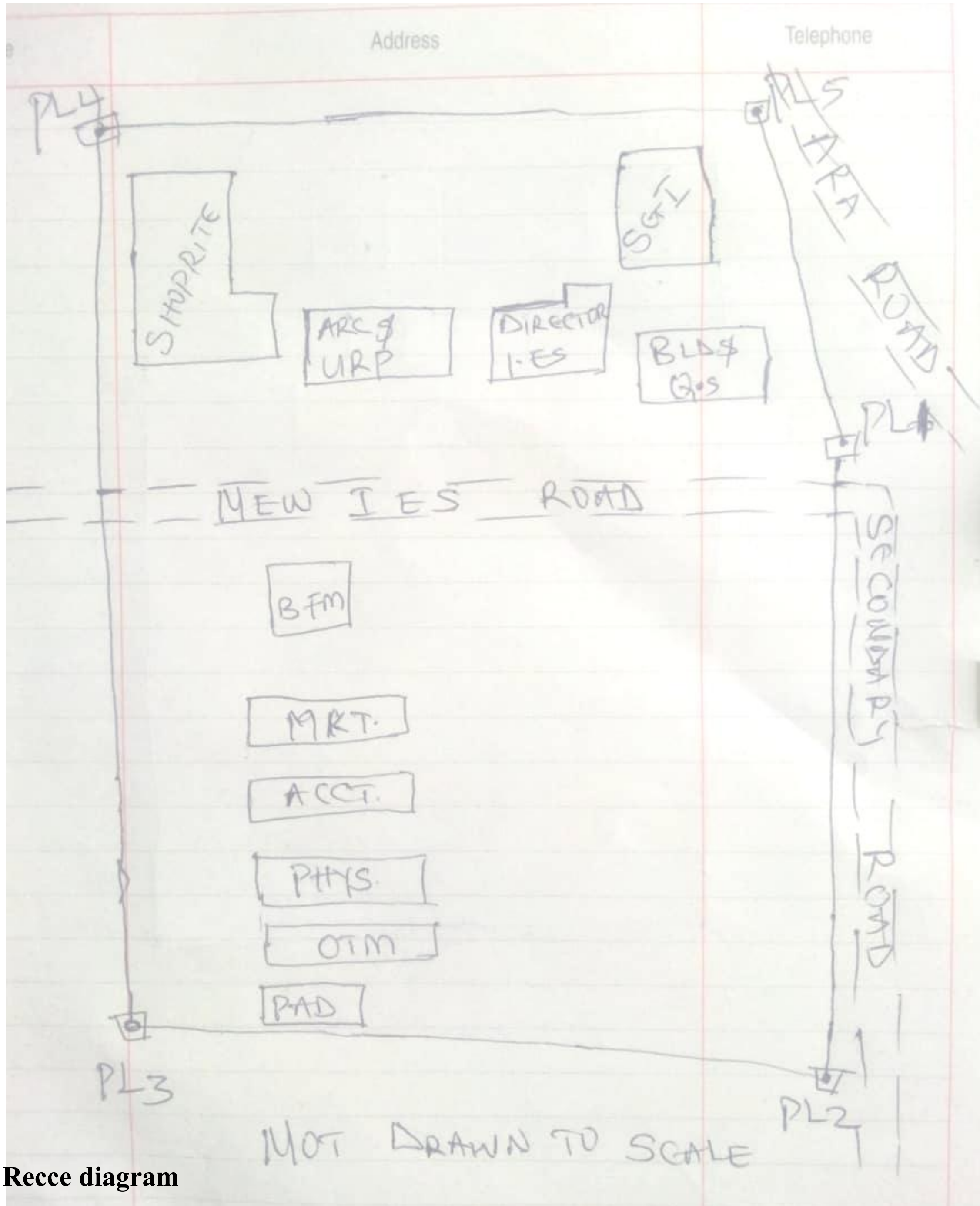
3.1 Reconnaissance

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.

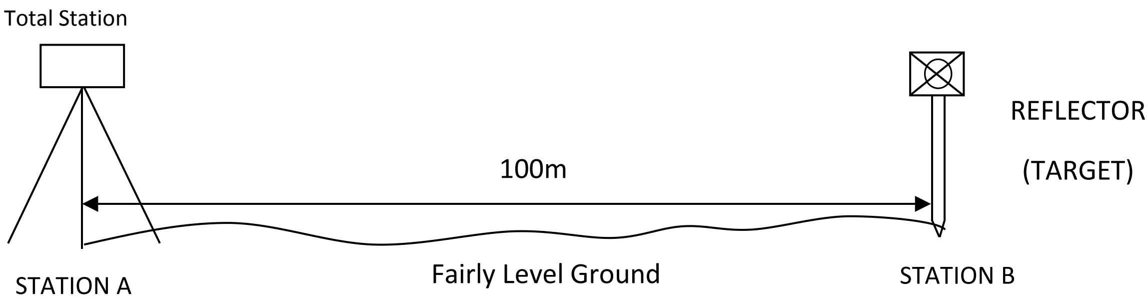


Fig 3.4.1.1: Horizontal Collimation and Vertical Index error test.

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.

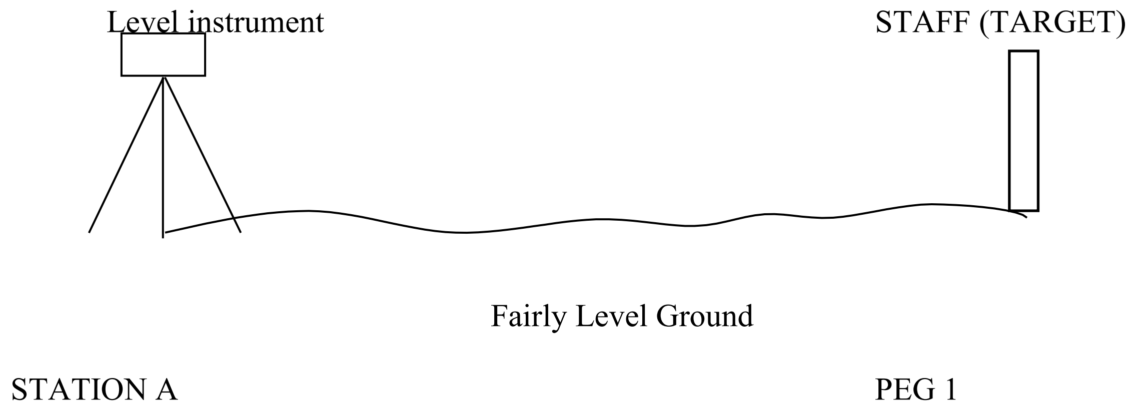


Fig3.4.1.1.: *Horizontal Collimation error test*

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.

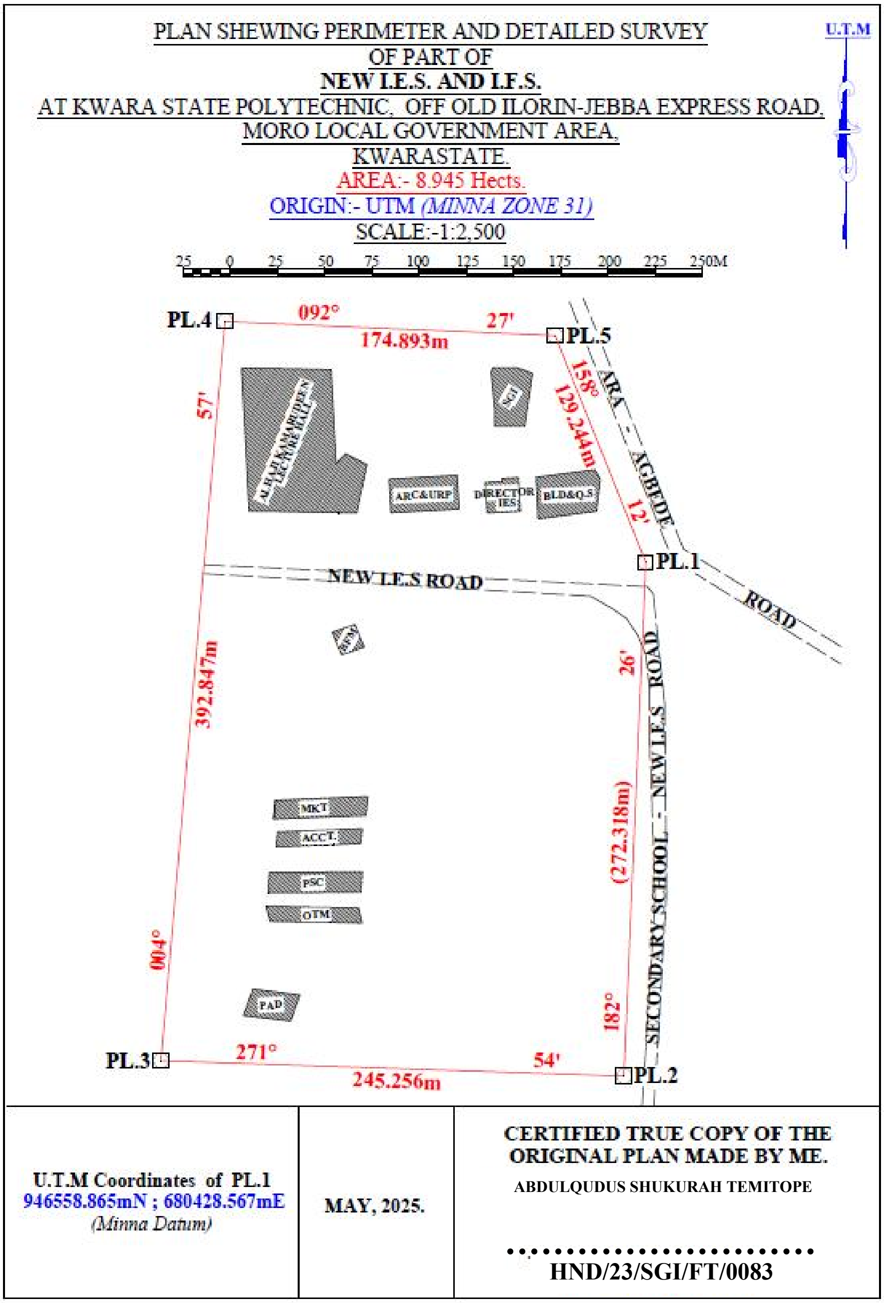


Figure 3.7: *Plan showing Perimeter and Detailed Survey.*

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

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

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

$$\frac{178{,}894.67}{2}$$

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:

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

μ= mean

xi = each point height

n = number of points

The variance is calculated as:

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

$^2=$ variance

$xi =$ 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

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

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

$\mu=$ 7116.326

20

μ=355.8163

Mean calculation for Reduced Level Height readings

μ=355.715+356.362+354.772+354.208+354.984+355.668+355.386+356.240+356.68 0+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

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

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

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

20

$^2 = \underline{51.516}$

20

^{2} **= 2.5758**

Variance calculation for Reduced Level Height readings

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

$^2 = \underline{51.762}$

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.

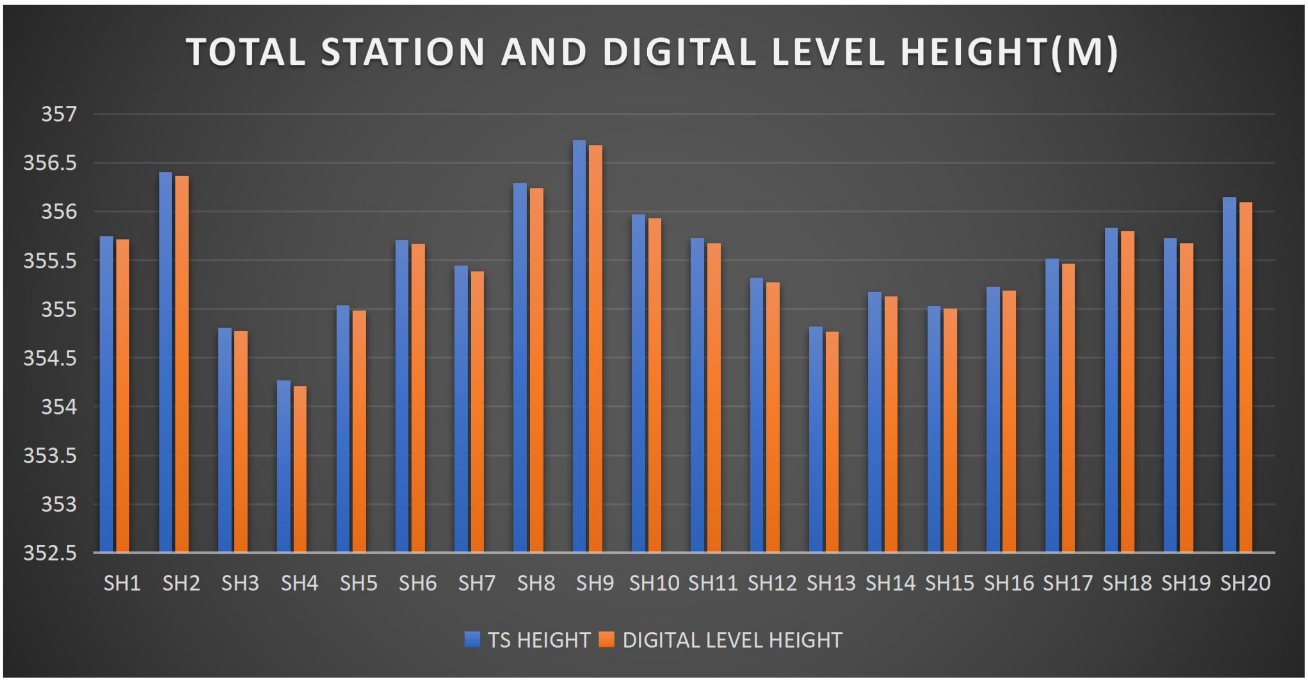


Figure 1:*Bar chart showing heights obtained from the total station and level instrument*

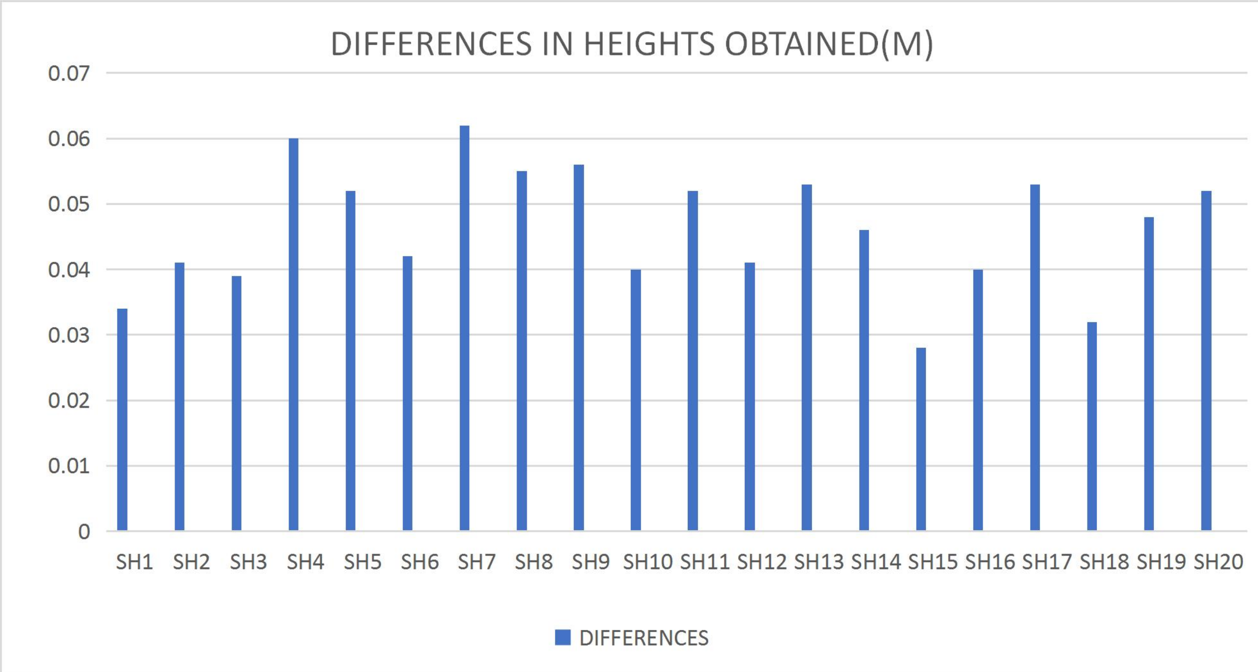


Figure 2:*Histogram showing the difference in the two instrument's result*

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**

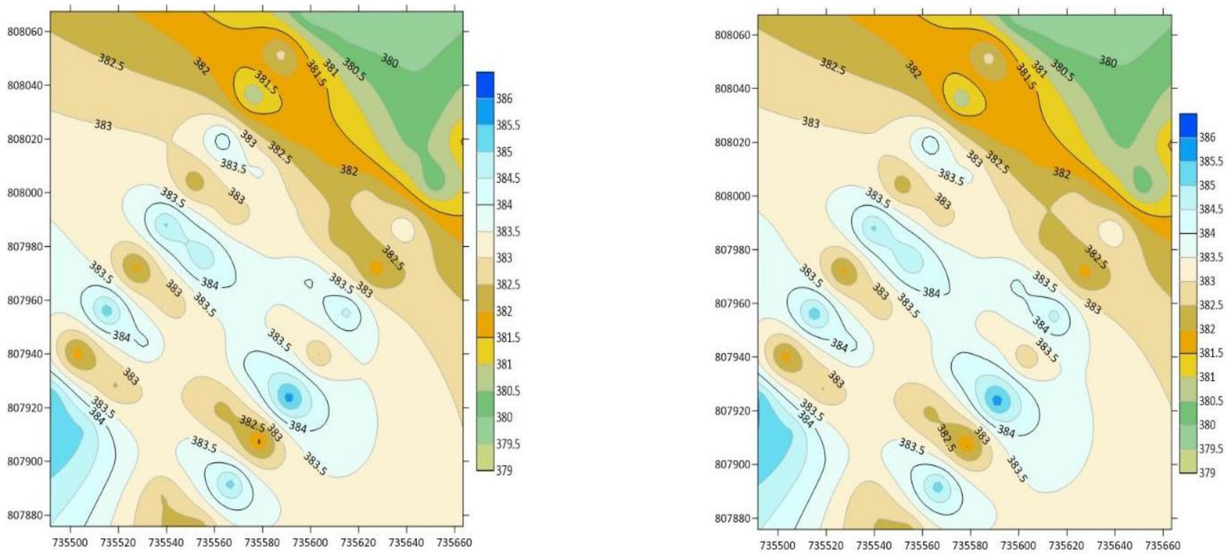


Figure 3: *Showing the contour map obtained from the two instrume*

3-D SURFACE MODEL USING AUTO LEVEL | **3-D SURFACE MODEL USING TOTAL STATION**

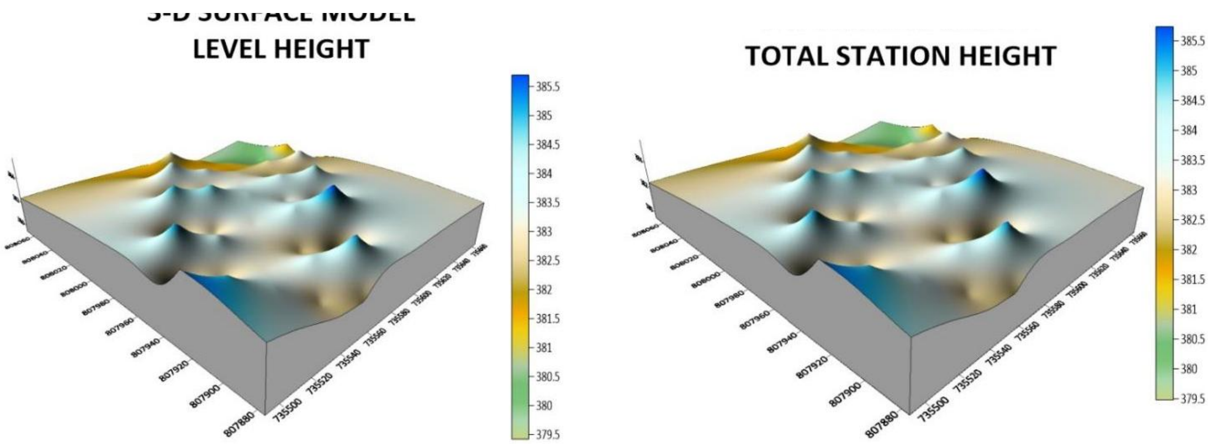


Figure 4: *Showing the 3D surface map obtained from the two instruments*

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 FIVE

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

The comparative evaluation of digital levelling and total station equipment for height measurement reveals that both tools have their advantages and disadvantages. Digital levelling offers high precision and accuracy, particularly in precise levelling tasks, whereas total station equipment provides flexibility and versatility in various surveying applications. The project demonstrates that the choice between these two instruments depends on the specific requirements of the project, including the range, precision, and type of measurement. The results of this research contribute to a deeper understanding of the capabilities and limitations of digital levelling and total station equipment, ultimately enhancing the accuracy and reliability of height measurements in various fields.

5.3 Recommendation

Develop long-term strategies for sustainable surveying practices by adopting eco-friendly technologies, such as solar-powered equipment or reducing the use of single-use materials. This will contribute to environmental conservation and improve the reputation of the surveying industry as it aligns with global sustainability goals. Allocate resources for continuous investment in emerging technologies like artificial intelligence (AI), machine learning (ML), and blockchain for data verification and storage. These innovations will improve data processing, enhance survey accuracy, reduce human error, and streamline project workflows in the long term.

5.4 Conclusion

Surveying is rapidly evolving with technological advancements, and staying ahead of the curve will be essential for the long-term success of the industry. Continuous adaptation to new technologies will improve precision, reduce operational costs, and expand the scope of surveying services, enabling the profession to meet future challenges.

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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				