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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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.

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CERTIFICATION

This is to certify that **ADELEYE SHERIFFDEEN OLAWALE** with matriculation number **HND/23/SGI/FT/0081**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.

ACKNOWLEDGEMENTS

First and foremost, my profound gratitude goes to the Almighty God who saw me through this program. Human endeavors cannot be a success without the help of Almighty God in heaven who made this project a success from the beginning to the end.

My profound gratitude goes to my wonderful supervisor in person of Surv. A.G. AREMU for his professional advices and supervision on the execution of my project, giving me all the necessary corrections where needed and appropriate. God bless you Sir.

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

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ABSTRACT

This project presents a comparative analysis of the performance of Total Station (TS) and digital level instruments in height measurement. The perimeter of the site area was determined and observed using Total station and was estimated to approximately 9.945hect. 20 points were established on the ground randomly, 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 through the process of leveling and computations. The data obtained from both instruments were meticulously processed and analyzed using Microsoft Excel and AutoCAD to produce detailed plans, perimeter maps, and contour maps of the project area. The results of the study reveal that both instruments produced comparable results, with the Total Station yielding a minimum height of 354.268m and a maximum of 356.736m, while the digital level gave a minimum height of 354.208m and a maximum of 356.680m. The study concludes that while both instruments can be used for leveling and generating height measurements, the Total Station offers several advantages, including faster data capture, shorter processing times, and safer means of data processing. Additionally, the Total Station's ability to store and retrieve data electronically and its telescopic feature, which allows for greater flexibility in sighting points, make it a more efficient and accurate method for height measurement.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the study

Surveying is a critical discipline in civil engineering, geospatial studies, and construction projects. The accuracy and reliability of measurements directly influence the quality of the final product in infrastructure development, land subdivision, and other applications (Ghilani& Wolf, 2017). Among the most commonly used instruments in modern surveying are digital levels and total stations. These tools provide precise elevation and positional data but differ in their operational methodologies, accuracy levels, and reliability in various conditions (Kavanagh & Bird, 2009). This study aims to provide a comparative evaluation of digital levelling and total station equipment, focusing on their accuracy and reliability in practical surveying applications.

Accuracy and precision in surveying are essential to minimizing errors in construction projects and geospatial mapping. Traditional levelling methods using dumpy and tilting levels have been largely replaced by digital levelling and total stations due to their advanced capabilities (Uren & Price, 2010). The importance of accurate surveying extends to areas such as road construction, building foundations, and environmental monitoring, where even minor deviations can lead to significant structural and financial consequences (Mikhail et al., 2001).

Historically, theodolites and manual levelling instruments were the primary tools used for surveying (Ghilani& Wolf, 2017). The advent of digital technology led to the development of more precise and efficient tools. Digital levels use electronic sensors and bar-coded staffs to provide highly accurate elevation measurements, reducing human errors and increasing efficiency (Kavanagh & Bird, 2009). Meanwhile, total stations integrate electronic distance measurement (EDM) and angular measurement capabilities, providing both elevation and horizontal positioning data in a single instrument (Uren & Price, 2010).

Digital levelling is an advancement over traditional spirit levelling, offering higher accuracy and efficiency (Mikhail et al., 2001). Digital levels use a CCD (Charge-Coupled Device) camera to read bar-coded levelling staffs, which eliminates the need for manual readings, reducing human error and improving measurement precision (Ghilani& Wolf, 2017).

Total stations integrate the functionalities of theodolites and EDMs, allowing for both angular and distance measurements. They use a laser or infrared beam to measure distances and employ electronic sensors to determine angles, which are then processed to calculate horizontal and vertical positions (Uren & Price, 2010).

The accuracy of surveying instruments is influenced by several factors, including environmental conditions, instrument calibration, and operational errors (Mikhail et al., 2001). Digital levels provide higher accuracy in elevation measurements due to their reliance on precise optical readings and bar-coded staffs. However, total stations offer a more versatile approach by combining distance and angular measurements, making them suitable for diverse surveying applications (Ghilani& Wolf, 2017).

1.2 Statement of Problem

The increasing complexity of construction and geospatial projects necessitates the use of highly accurate surveying instruments. However, discrepancies often arise due to the varying capabilities of digital levelling and total station equipment. Digital levels are widely regarded for their high precision in elevation measurements, yet they are limited in range and application scope. Conversely, total stations offer a broader range of measurements, integrating both horizontal and vertical data collection but are often susceptible to environmental factors such as atmospheric disturbances. The lack of a definitive understanding regarding the optimal use of these instruments under different conditions presents a challenge for surveyors and engineers in selecting the most suitable tool for specific projects.

While both technologies are designed to minimize human errors and improve efficiency, differences in reliability and ease of use impact their practical applications. The operational complexity of total stations requires a higher level of expertise compared to digital levels, potentially leading to inconsistencies in data collection. Additionally, factors such as cost, maintenance, and susceptibility to external conditions further complicate the decision-making process. This study seeks to address these challenges by providing a comparative assessment of digital levelling and total station equipment, evaluating their performance in terms of accuracy, reliability, and overall efficiency in field applications.

1.3 Aim of the Project

The aim is to compare the accuracy, efficiency and reliability of digital leveling and total stations equipment for height measurement in part of Kwara State Polytechnic.

1.4 Objectives of the project

1. To evaluate the accuracy of digital leveling and total station equipment in measuring heights.
2. To assess the reliability of digital leveling and total station equipment in measuring heights.
3. To determine the most suitable surveying for precise height determination.
4. To compare the performance of digital leveling and total station equipment in different environmental conditions.

1.5 Justification of the Study

The increasing complexity of construction and geospatial projects necessitates the use of highly accurate surveying instruments. However, discrepancies often arise due to the varying capabilities of digital levelling and total station equipment. Digital levels are widely regarded for their high precision in elevation measurements, yet they are limited in range and application scope. Conversely, total stations offer a broader range of measurements, integrating both horizontal and vertical data collection but are often susceptible to environmental factors such as atmospheric disturbances. The lack of a definitive understanding regarding the optimal use of these instruments under different conditions presents a challenge for surveyors and engineers in selecting the most suitable tool for specific projects.

While both technologies are designed to minimize human errors and improve efficiency, differences in reliability and ease of use impact their practical applications. The operational complexity of total stations requires a higher level of expertise compared to digital levels, potentially leading to inconsistencies in data collection. Additionally, factors such as cost, maintenance, and susceptibility to external conditions further complicate the decision-making process. This study seeks to address these challenges by providing a comparative assessment of digital levelling and total station equipment, evaluating their performance in terms of accuracy, reliability, and overall efficiency in field applications.

1.6 Scope of the Project

The scope of this project encompasses a comparative evaluation of digital levelling and total station equipment, focusing on their accuracy, reliability, and efficiency in surveying applications. It examines the performance of both instruments under varying field conditions, including environmental factors and operational constraints. The study aims to identify the strengths and limitations of each technology, providing insights into their suitability for different types of surveying tasks such as elevation determination, topographic mapping, and construction layout. The findings will be beneficial to surveyors, engineers, and geospatial professionals in selecting the most appropriate instrument for specific projects, ultimately improving precision and efficiency in the field.

1.7 Personnel

This project was assigned to and done by the personnel listed below;

NAME	MATRIC. NO.	
Adeleye Sheriffdeen Olawale	HND/23/SGI/FT/0081	Writer
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
Ganiyu Akeem Abiodun	HND/23/SGI/FT/0076	Member
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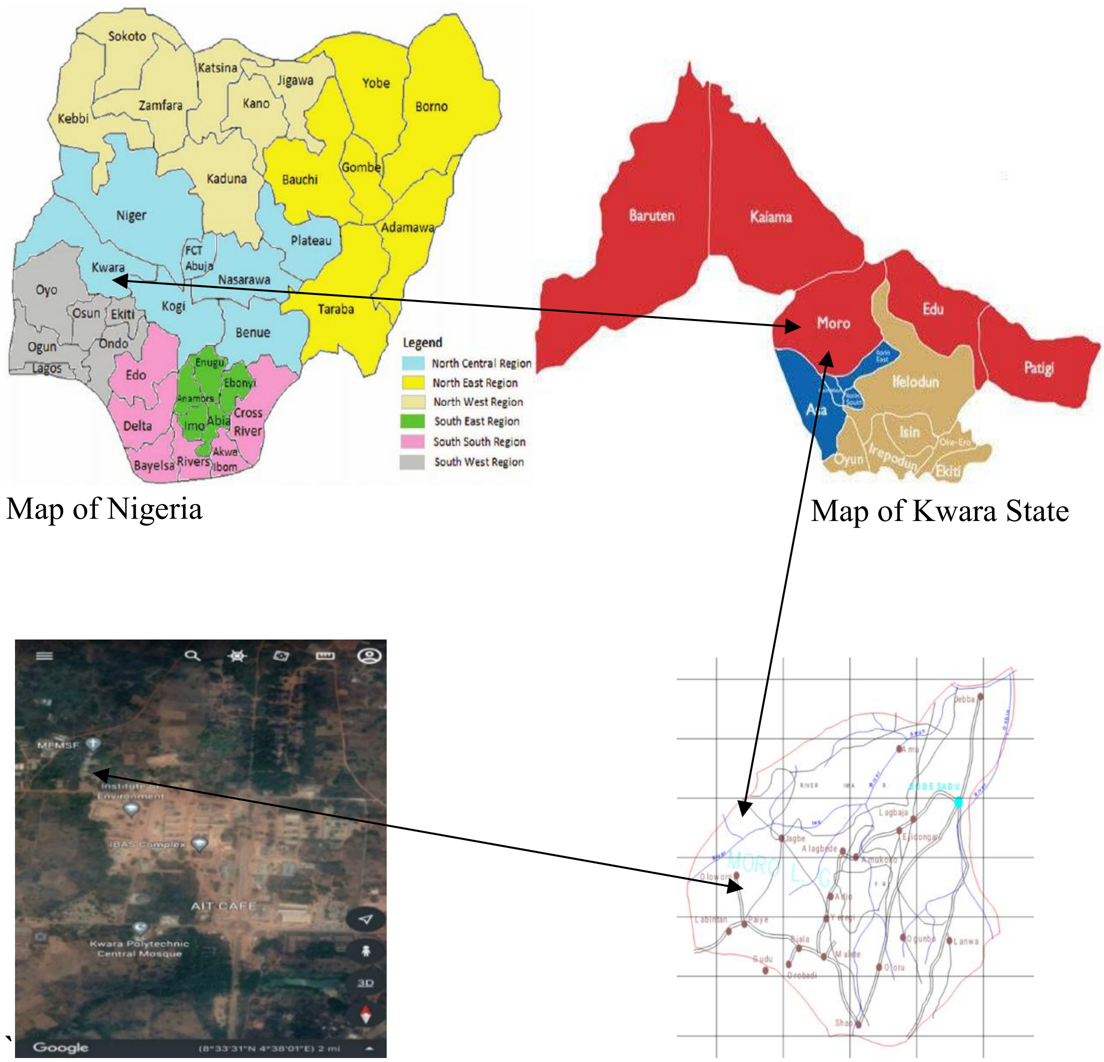
Ogunsuyi Babatunde Sunday	HND/23/SGI/FT/0118	Member
Jimoh Halimah Titilayo	HND/22/SGI/FT/082	Member

1.8 Study Area

Kwara State Polytechnic 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° N and longitude 4.5418° E.



Google Imagery of the Study Area

Map of Moro L.G.A

Figure 1.10: Study Area Map

CHAPTER TWO

2.0 LITERATURE REVIEW

Surveying is the science and technique of determining the positions of points on the Earth's surface and the distances and angles between them. It plays a crucial role in engineering, construction, and geospatial sciences, ensuring that structures and land developments are accurately positioned (Ghilani& Wolf, 2017). The primary purpose of surveying is to gather data for mapping, construction, and land division, providing critical information for designing roads, bridges, buildings, and other infrastructure projects.

The history of surveying dates back to ancient civilizations, where the Egyptians used rudimentary tools to measure land for taxation and construction purposes. The Great Pyramid of Giza, constructed around 2500 BCE, is believed to have been built with the aid of early surveying techniques (Uren & Price, 2010). Similarly, the Romans developed advanced surveying methods to construct roads, aqueducts, and city layouts, demonstrating the importance of precise measurements in civil engineering.

Modern surveying incorporates advanced technology such as total stations, digital levels, and global positioning systems (GPS). These tools enhance accuracy and efficiency, reducing human errors and improving the reliability of measurements (Kavanagh & Bird, 2009). Digital surveying instruments provide automated data collection and real-time processing, making them indispensable in contemporary construction and geospatial applications.

Surveying can be classified into various types, including geodetic and plane surveying. Geodetic surveying accounts for the curvature of the Earth and is used for large-scale projects such as national mapping and satellite positioning. In contrast, plane surveying assumes the Earth's surface to be flat and is suitable for smaller areas, such as building construction and land subdivision (Mikhail et al., 2001).

A critical aspect of surveying is accuracy, which refers to how closely a measured value aligns with the true value. Precision, on the other hand, relates to the consistency of repeated measurements (Ghilani& Wolf, 2017). Surveyors must minimize errors caused by environmental conditions, instrument calibration, and human mistakes to ensure reliable data collection.

One of the fundamental techniques in surveying is levelling, which determines the height differences between points. Traditional spirit levelling has been largely replaced by digital levelling, which uses bar-coded staffs and electronic sensors to improve measurement accuracy and efficiency (Uren & Price, 2010). Digital levelling minimizes human errors associated with manual readings and transcription.

Another essential surveying technique is triangulation, which involves measuring angles between known points to determine new positions. This method is widely used in geodetic surveys and GPS applications. Similarly, trilateration, which relies on distance measurements rather than angles, is a key component of modern satellite-based positioning systems (Kavanagh & Bird, 2009).

Despite technological advancements, challenges in surveying remain, including atmospheric refraction, instrument limitations, and accessibility to difficult terrains. Surveyors must apply correction techniques and best practices to minimize these issues (Ghilani& Wolf, 2017). Regular calibration of instruments and proper field procedures are necessary to maintain measurement reliability.

2.1 Digital Levelling

Digital levelling is a modern surveying technique that enhances traditional levelling methods by incorporating electronic sensors and digital processing. It is primarily used for determining height differences between points with high accuracy and efficiency. Unlike conventional spirit levelling, which requires manual reading and recording of measurements, digital levelling automates the process, reducing human error and increasing precision (Ghilani& Wolf, 2017).

The working principle of digital levelling relies on electronic image processing and bar-coded staff readings. A digital level is equipped with a Charge-Coupled Device (CCD) camera or an image sensor that captures and interprets the pattern on a bar-coded staff. The instrument then processes the data electronically, minimizing observational errors and improving consistency in measurements (Kavanagh & Bird, 2009).

One of the primary advantages of digital levelling is its enhanced accuracy compared to traditional levelling methods. Digital levels are capable of achieving millimeter-level precision, making them ideal for high-accuracy applications such as geodetic surveys, structural monitoring, and deformation analysis. This level of accuracy is critical in construction projects where even minor errors in elevation measurements can lead to significant structural and financial consequences (Mikhail et al., 2001).

Another major benefit of digital levelling is the reduction of reading and transcription errors. In conventional levelling, surveyors must manually interpret staff readings and record values, which increases the risk of human mistakes. Digital levels automatically read and store data, eliminating potential misreadings and ensuring greater reliability in field measurements (Uren & Price, 2010).

Digital levelling also improves efficiency in surveying operations. The automated reading and data storage capabilities of digital levels allow for faster measurement collection and processing. Surveyors can complete tasks more quickly compared to traditional levelling methods, reducing fieldwork time and overall project costs. This makes digital levelling particularly useful in large-scale projects where time efficiency is crucial (Ghilani& Wolf, 2017).

Despite its advantages, digital levelling has certain limitations. One of the key challenges is its dependency on bar-coded staffs, which must be maintained properly to ensure accurate readings. External factors such as dust, moisture, or damage to the staff can affect measurement accuracy. Additionally, digital levels require proper calibration and periodic maintenance to ensure long-term reliability (Kavanagh & Bird, 2009).

Environmental conditions also play a role in the effectiveness of digital levelling. Factors such as atmospheric refraction, heat waves, and extreme temperatures can influence the accuracy of digital level readings. While digital levels compensate for some of these effects through internal error correction algorithms, surveyors must still account for environmental influences during data collection (Mikhail et al., 2001).

Digital levelling is widely used in various surveying applications, including construction, geodetic monitoring, and infrastructure projects. In construction, it is essential for establishing accurate elevation benchmarks and ensuring proper alignment of structures. In geodetic monitoring, digital levelling helps track land subsidence, tectonic movements, and structural deformations with high precision (Uren & Price, 2010).

2.2 Total Station

A total station is an advanced electronic surveying instrument that integrates an electronic theodolite, an electronic distance measurement (EDM) device, and a microprocessor to measure angles and distances with high accuracy. This multifunctional device has revolutionized modern surveying by providing precise, efficient, and automated measurements in geospatial applications (Ghilani& Wolf, 2017).

The primary components of a total station include an optical telescope, which enables angular measurements, an EDM system that measures distances using laser or infrared signals, and a control panel with a microprocessor that stores and processes data. These components allow surveyors to obtain both horizontal and vertical angles, as well as slant distances, which can then be converted into three-dimensional coordinates (Mikhail, Bethel, & McGlone, 2001).

Total stations operate on the principle of trigonometric surveying. The EDM emits a laser or infrared signal to a prism reflector or a non-reflective target. The time taken for the signal to return is measured to determine the distance. Simultaneously, the instrument measures horizontal and vertical angles, allowing for precise coordinate calculations (Van Sickle, 2017). These capabilities make total stations superior to traditional theodolites and levels, which require manual data recording and calculations.

One of the greatest advantages of total stations is their ability to store and process data digitally. Modern total stations are equipped with internal memory, USB ports, or Bluetooth connectivity, enabling seamless data transfer to computers and Geographic Information Systems (GIS). This feature significantly reduces human error and increases efficiency in data collection and analysis (Leick, Rapoport, &Tatarnikov, 2015).

Total stations are widely used in engineering, construction, and geodetic surveying. In construction projects, they are employed for layout and alignment of structures, ensuring precise placement of foundations, roads, and bridges. In geodetic applications, they contribute to topographic mapping, boundary surveys, and deformation monitoring of buildings, dams, and other infrastructure (Uren & Price, 2010).

Despite their advantages, total stations have certain limitations. One major drawback is the requirement for a clear line of sight between the instrument and the target. Obstructions such as buildings, trees, or extreme weather conditions can affect measurements. Additionally, atmospheric conditions like temperature variations and humidity can introduce errors in EDM calculations, requiring correction models for accurate results (Wolf &Ghilani, 2012).

The introduction of robotic total stations has further advanced surveying technology. Unlike conventional total stations, robotic total stations are operated remotely, eliminating the need for a second person to hold the prism. These instruments utilize automatic target recognition (ATR) and motorized tracking systems, significantly improving efficiency in large-scale surveying and construction projects (Kavanagh & Bird, 2009).

Accuracy and precision in total station measurements depend on factors such as instrument calibration, observation techniques, and environmental conditions. Proper calibration ensures that angular and distance measurements remain reliable. Surveyors also employ redundant observations and error reduction techniques, such as least squares adjustments, to enhance data accuracy (Caspary, 2020).

2.3 Accuracy and Precision

Accuracy and precision are fundamental concepts in measurement, statistics, and engineering. Although they are often used interchangeably, they have distinct meanings. Accuracy refers to how close a measurement is to the actual or true value, while precision describes the consistency of repeated measurements (Taylor, 1997). Understanding these concepts is critical in fields such as surveying, manufacturing, and scientific research, where measurement reliability directly impacts results.

In the context of surveying and geospatial sciences, accuracy ensures that the measured coordinates or elevations are as close as possible to their actual positions. Surveyors strive for high accuracy in tasks such as cadastral mapping, road construction, and geodetic control networks to prevent costly errors (Van Sickle, 2017). Conversely, precision is more concerned with the repeatability of measurements. For example, if a total station records multiple distances to the same point with minimal variation, the measurements are considered precise, regardless of whether they are accurate (Wolf &Ghilani, 2012).

A key distinction between accuracy and precision is that measurements can be precise but not accurate, or accurate but not precise. For example, if a GPS receiver consistently records a position 5 meters away from the actual location, the measurements are precise but inaccurate. Conversely, if different readings vary widely but average out to the correct position, they are accurate but not precise (Mikhail, Bethel, & McGlone, 2001). Ideally, measurement systems should aim for both high accuracy and high precision.

The relationship between accuracy and precision is particularly relevant in instrument calibration and error analysis. Systematic errors, such as instrument misalignment or environmental effects, affect accuracy and must be corrected through calibration and error modeling (Leick, Rapoport, &Tatarnikov, 2015). Random errors, which affect precision, result from unpredictable variations in measurement conditions and can be minimized by taking multiple readings and applying statistical adjustments (JCGM, 2008).

In surveying and engineering applications, measurement accuracy is influenced by factors such as instrument quality, atmospheric conditions, and operator skill. For example, total stations, GNSS receivers, and digital levels provide high accuracy when properly calibrated and used under optimal conditions. However, precision is influenced by factors like instrument stability, observation techniques, and environmental interference (Ghilani& Wolf, 2017).

Statistical methods play a crucial role in improving accuracy and precision. The least squares adjustment method, widely used in surveying and geodesy, helps reduce random errors and optimize measurement precision. Similarly, error propagation analysis assesses how measurement uncertainties affect overall accuracy, allowing surveyors and engineers to refine their methodologies (Caspary, 2000).

In metrology and manufacturing, precision is crucial for quality control, where consistent production tolerances are required. Instruments such as coordinate measuring machines (CMMs) and laser scanners rely on both accuracy and precision to ensure product specifications are met (BIPM, 2012). In aerospace and medical applications, even minor inaccuracies can lead to critical failures, emphasizing the need for precise and accurate measurements (ISO, 1993).

2.4 Error in Surveying

Errors in surveying refer to deviations between measured and true values caused by various factors, including instrument limitations, environmental influences, and human mistakes. Understanding these errors is essential to improving the accuracy and reliability of surveying results. Errors can be classified into systematic errors, random errors, and gross errors, each with different implications on measurement quality (Ghilani& Wolf, 2017).

Systematic errors are consistent and repeatable deviations caused by instrument defects or environmental conditions. These errors follow a predictable pattern and can often be corrected through proper calibration and error modeling. For example, collimation error in a total station occurs when the line of sight is not perfectly aligned with the instrument's axis, leading to angular measurement deviations (Wolf &Ghilani, 2012).

Random errors result from unpredictable variations in measurement conditions, such as atmospheric fluctuations or minor observational differences. Unlike systematic errors, random errors do not follow a specific pattern and are minimized through statistical methods such as least squares adjustment. For instance, in levelling, minor inconsistencies in reading a staff due to visual fatigue introduce random errors (Mikhail, Bethel, & McGlone, 2001).

Gross errors, also known as blunders, arise from human mistakes such as incorrect instrument setup, misreading measurements, or transcription errors. These errors are typically large and can significantly impact survey accuracy if not detected and corrected. For example, mistaking meters for feet in distance measurement can lead to substantial positional discrepancies (Kavanagh & Bird, 2009).

Environmental factors such as atmospheric refraction and temperature variations contribute to errors in surveying. Refraction occurs when light or laser beams bend as they pass through layers of air with different densities, causing distortions in angular and distance measurements. Similarly, temperature fluctuations affect EDM instruments by altering the speed of electromagnetic waves, requiring correction factors for precise distance calculations (Leick, Rapoport, &Tatarnikov, 2015).

Instrument-related errors stem from manufacturing imperfections or inadequate maintenance. For instance, optical errors in total stations may result from imperfect lenses, while mechanical errors in GNSS receivers can arise from antenna misalignment. Regular calibration and adjustment of surveying instruments are crucial to minimizing such errors (Uren & Price, 2010).

Errors in levelling can be attributed to staff settlement, parallax, and curvature of the Earth. If the levelling staff is not held perfectly vertical, readings become inaccurate. Parallax errors occur when the observer's eye is not aligned with the crosshairs of the instrument, leading to incorrect staff readings. Additionally, over long distances, the Earth's curvature causes elevation differences that require correction formulas (Ghilani& Wolf, 2017).

Surveyors apply various error reduction techniques, such as double centering in theodolite observations, balancing backsight and foresight distances in levelling, and redundant measurements in control surveys. Additionally, software tools assist in error propagation analysis and least squares adjustment, improving data accuracy (Van Sickle, 2017).

2.5 Application of Height Measurement in Surveying

Height measurements are fundamental in various fields, including construction, mapping, geospatial analysis, and infrastructure development. Accurate measurements of distances, angles, and elevations are crucial in ensuring precise land division, planning, and project execution. The continuous advancement of surveying instruments, such as total stations, GPS, and remote sensing technologies, has expanded the application of surveying in different industries (Ghilani& Wolf, 2017).

One of the primary applications of surveying is in civil engineering and construction. Surveying is essential for planning and executing infrastructure projects such as roads, bridges, buildings, and tunnels. Before construction begins, topographic surveys determine site conditions, while control surveys ensure that structures are built in the correct positions. Techniques such as digital levelling and total stations help in setting out foundation levels and alignments, preventing costly errors (Kavanagh & Bird, 2009).

Surveying plays a crucial role in land surveying and cadastral mapping, which involves defining property boundaries and land ownership. Governments and private entities use cadastral surveys to establish legal land records, preventing disputes over land ownership. Advanced techniques such as GNSS-based surveys and aerial photogrammetry enhance the accuracy of boundary determination, ensuring precise land subdivision and titling (Uren & Price, 2010).

In transportation engineering, surveying is used to design and construct highways, railways, and airports. Route surveys determine the best possible alignment for roads and railways by analyzing terrain, elevation, and environmental conditions.

Mining and resource exploration rely heavily on surveying techniques for mapping and monitoring excavation sites. Surveyors use underground and surface surveys to determine mineral deposits, monitor excavation progress, and ensure compliance with safety regulations.

Surveying is also applied in hydrographic and marine surveys, which involve mapping underwater topography, riverbeds, and coastal regions. Hydrographic surveys use sonar and GPS technology to measure water depths, identify navigational hazards, and support port construction and dredging activities. These surveys are crucial for maritime safety, environmental monitoring, and offshore engineering projects (Ghilani& Wolf, 2017).

Surveying is critical in urban planning and smart city development. City planners use geospatial data and topographic surveys to design sustainable cities, optimize land use, and improve public infrastructure

2.6 Comparison of Total Station and Digital Levelling Instrument in Height Measurement

Surveying techniques have evolved significantly over time, transitioning from traditional manual methods to advanced digital and remote sensing technologies. The primary objective of surveying is to obtain accurate spatial data for applications in engineering, construction, mapping, and geospatial analysis. Different surveying methods offer varying levels of precision, efficiency, and applicability depending on the nature of the project and environmental conditions (Ghilani& Wolf, 2017).

Traditional surveying techniques, such as chain surveying, compass surveying, and theodolite-based methods, were widely used before the introduction of electronic and satellite-based systems. These methods rely on manual measurements and calculations, which, although fundamental, are prone to human error and require significant time and effort. Modern surveying techniques, such as total stations, digital levelling, GPS/GNSS, and LiDAR, have greatly improved data collection and processing, enhancing accuracy and efficiency (Kavanagh & Bird, 2009).

Digital leveling 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 (Wolf &Ghilani, 2012). The technology ensures high precision by minimizing reading errors, making it ideal for precise engineering projects such as dam construction, bridge alignment, and geodetic surveys. However, digital leveling can be time-consuming and less efficient over long distances, which limits its use in large-scale projects (Kavanagh, 2014).

Total stations integrate electronic distance measurement (EDM) and angular measurement capabilities, allowing surveyors to determine both horizontal and vertical positions efficiently. Unlike digital levels, total stations are multifunctional, supporting a range of applications from topographic mapping to construction staking (Schofield & Breach, 2007). However, the accuracy of height measurement using total stations is influenced by factors such as instrument calibration, target reflectivity, and atmospheric conditions, leading to potential errors in elevation determination (Ghilani, 2017).

Several studies have compared digital leveling and total station equipment for height measurement. For instance, Alkan and Karslı (2011) analyzed the precision of both instruments and found that digital leveling provides superior vertical accuracy compared to total stations. Similarly, Ata and Arslan (2015) observed that while total stations offer greater flexibility, their elevation measurements are more susceptible to errors when compared to digital leveling techniques. These findings highlight the need for further comparative evaluations in different environments and project conditions.

In many institutions and construction sites, surveyors rely heavily on total stations due to their efficiency in collecting data over large areas. However, this preference sometimes leads to the compromise of vertical accuracy, especially in projects requiring precise elevation data (Ghosh, 2013). While total stations provide satisfactory results for general land surveying tasks, their limitations in height determination necessitate a more detailed assessment of their reliability when compared to digital leveling.

In conclusion, 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.

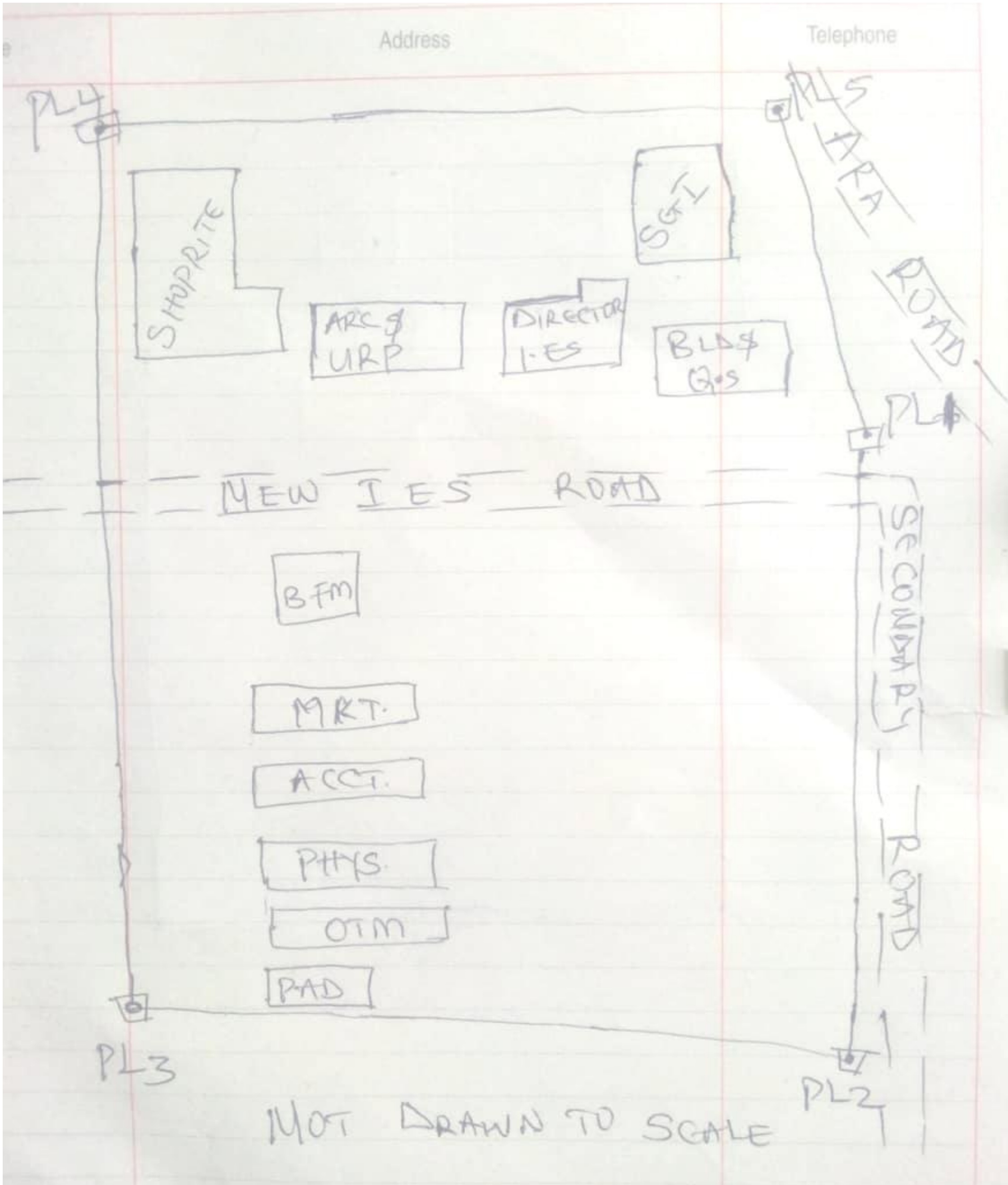
3.1 Reconnaissance

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.

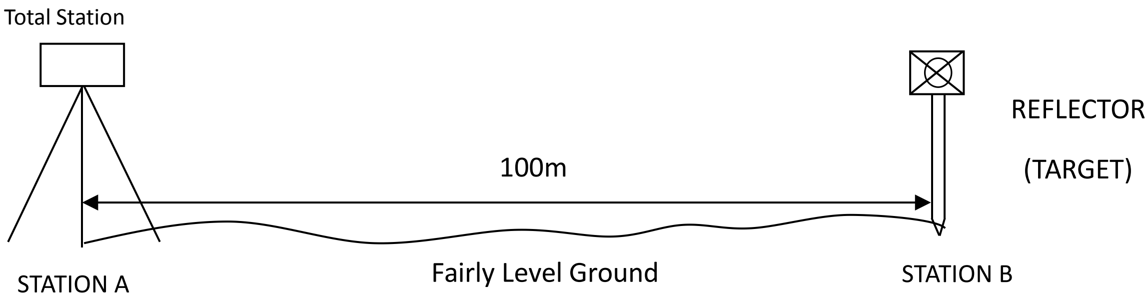


Fig 3.4.1.1: Horizontal Collimation and Vertical Index error test.

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.

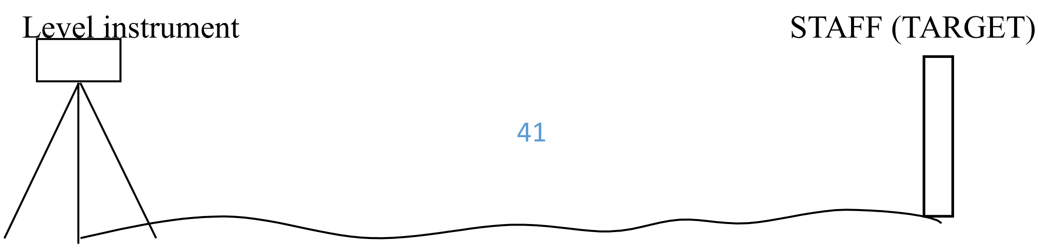
Horizontal collimation = {(FR – FL) – 180}/2 = {(00˚00’03”}/2 = 1.5”

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.



Fairly Level Ground

STATION A PEG 1

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.

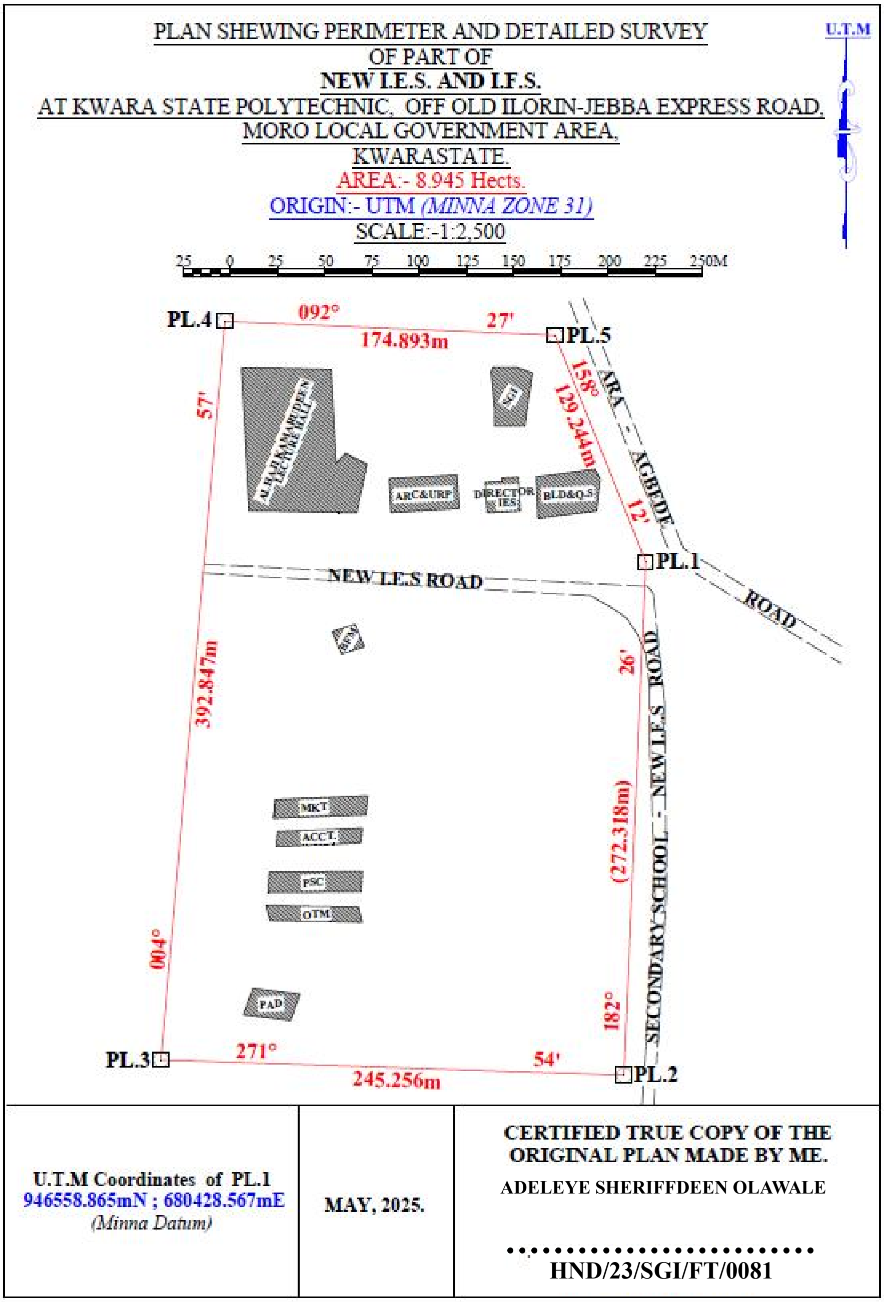


Figure 3.7: *Plan showing Perimeter and Detailed Survey.*

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

$$\frac{\sum \searrow \; - \; \sum \nearrow}{2}$$

460,787,138,011.03 – 460,786,959,116.36

2

178,894.67

2

Area = 89,447.335 sqft

Area = 8.945 hect.

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.

4.4 Results and Discussion

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

REMARKS	EASTING	NORTHING	HEIGHT		DIFF.
			T.S	LEVEL	

SH1	680272.275	946497.781	355.749	355.715	0.034
SH2	680267.717	946479.907	356.403	356.362	0.041
SH3	680273.327	946450.469	354.811	354.772	0.039
SH4	680287.358	946434.349	354.268	354.208	0.060
HSH5	680317.873	946433.648	355.036	354.984	0.052
SH6	680304.544	946455.727	355.710	355.668	0.042
SH7	680337.867	946463.436	355.448	355.386	0.062
SH8	680342.774	946441.708	356.295	356.240	0.055
SH9	680342.774	946441.708	356.736	356.680	0.056
SH10	680348.740	946443.460	355.971	355.931	0.040
SH11	680377.262	946451.836	355.725	355.673	0.052
SH12	680382.060	946482.711	355.318	355.277	0.041
SH13	680381.009	946518.108	354.819	354.766	0.053
SH14	680350.494	946509.345	355.174	355.128	0.046
SH15	680356.104	946484.813	355.033	355.005	0.028
SH16	680332.603	946480.960	355.228	355.188	0.040
SH17	680308.051	946470.796	355.517	355.464	0.053
SH18	680298.581	946490.422	355.834	355.802	0.032
SH19	680318.222	946506.191	355.726	355.678	0.048
SH20	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:

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

$=$ standard deviation

$^2 =$ variance

Mean calculation for Total Station Height readings

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

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

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

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

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

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

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

$$^2=\frac{51.516}{20}$$

$$\mathbf{^2 = 2.5758}$$

Variance calculation for Reduced Level Height readings

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

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

$$\mathbf{^2 = 2.5881}$$

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:

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

$$= \sqrt{2.5758}$$

$$= \mathbf{1.6049}$$

The Standard Deviation for Reduced Level Height readings:

$$= \sqrt{2.5881}$$

$$= \mathbf{1.6088}$$

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.

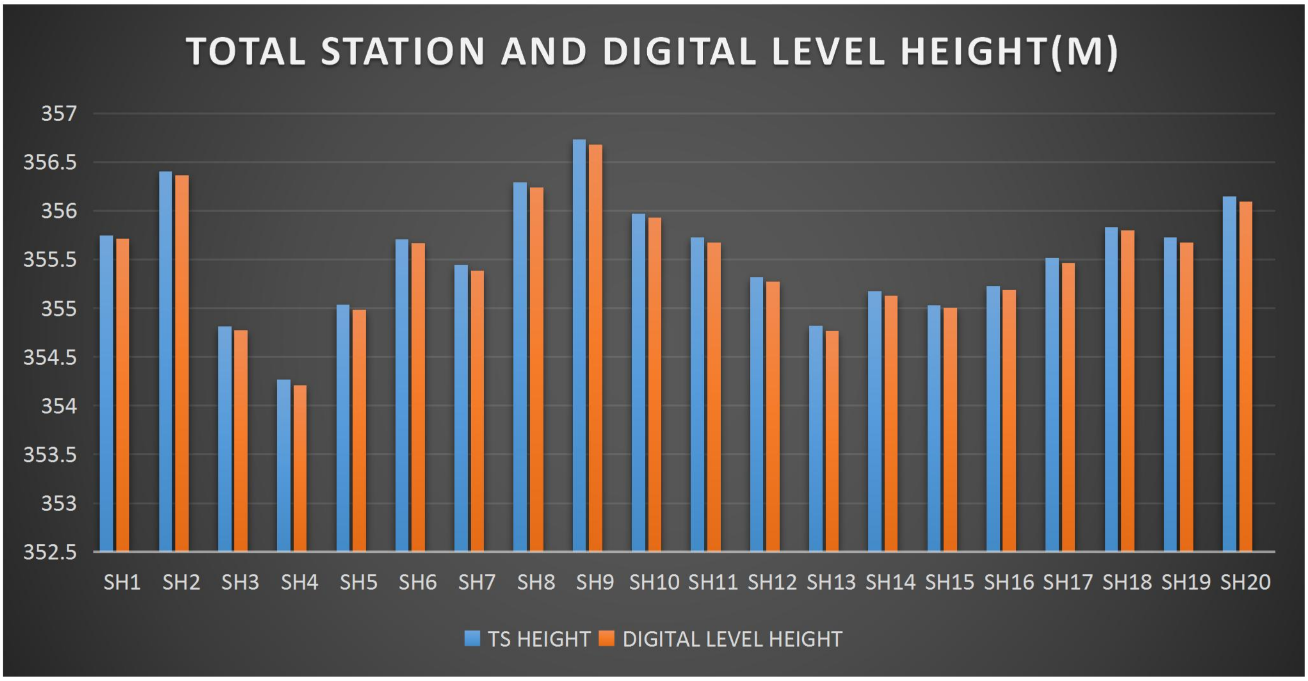


Figure 1:*Bar chart showing heights obtained from the total station and level instrument*

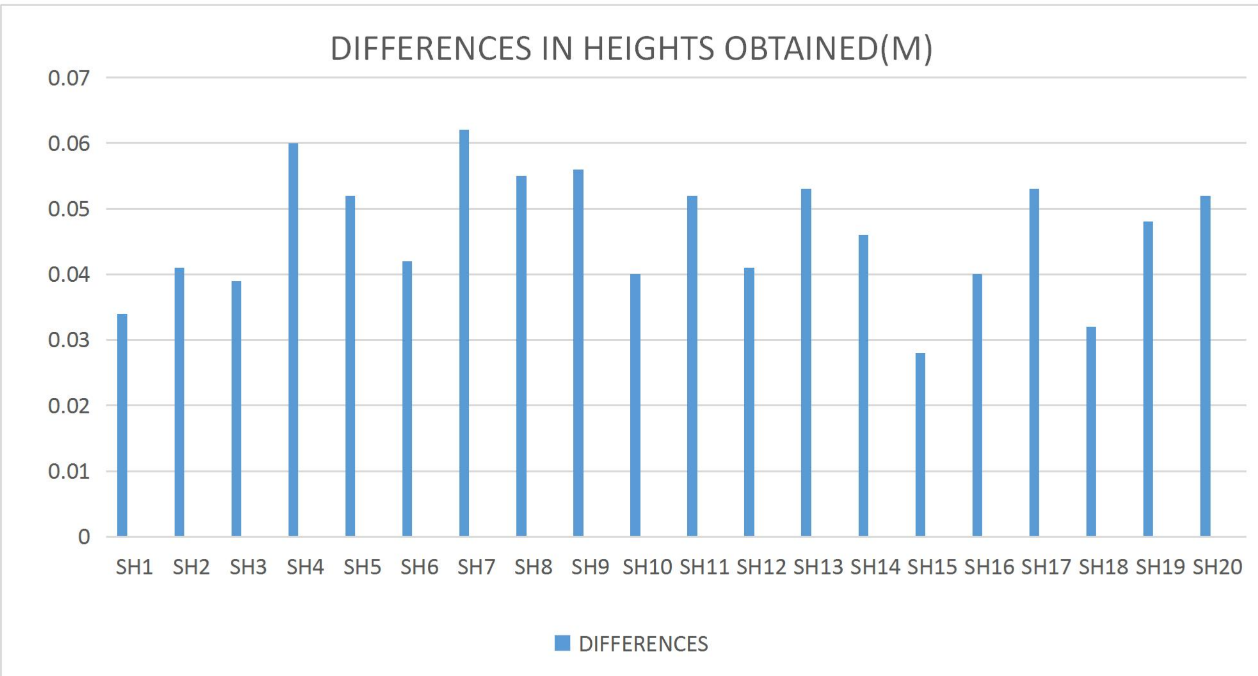


Figure 2:*Histogram showing the difference in the two instrument's result*

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**

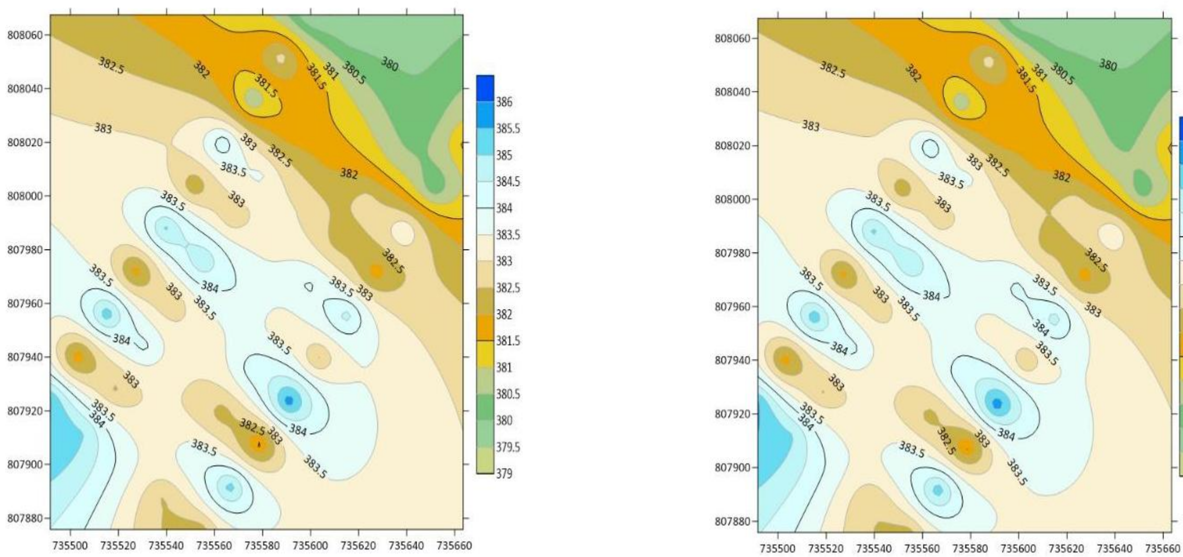


Figure 3. *Showing the contour map obtained from the two instruments.*

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

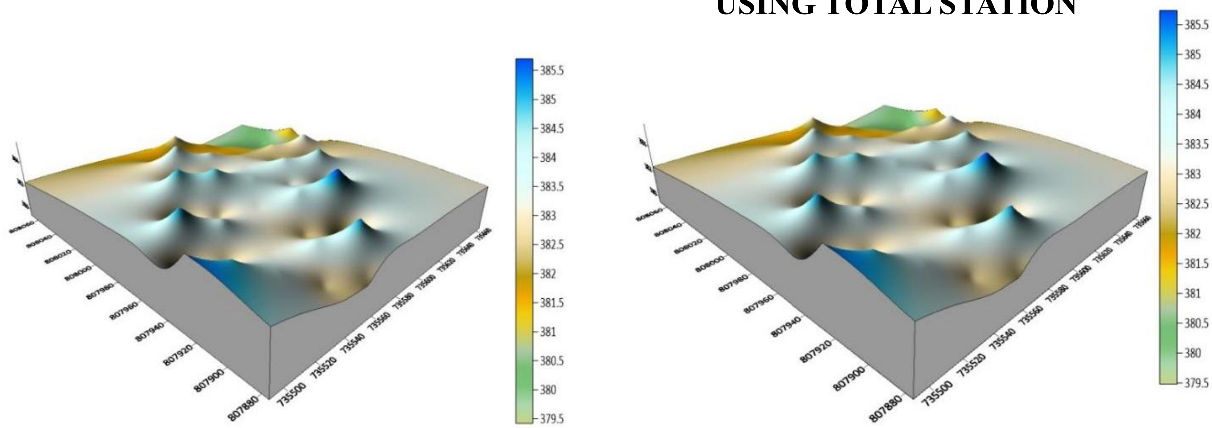


Figure 4:*Showing the 3D surface map obtained from the two instruments*

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 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	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 7	212,647.54
	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 demonstrates that both tools can achieve high accuracy and reliability, but with different characteristics. Digital levelling excels in precise levelling tasks, offering high precision and accuracy, whereas total station equipment provides a broader range of applications, including topographic surveys and construction layout. The project emphasizes the need for surveying professionals to understand the capabilities and limitations of each tool, ensuring that the most suitable equipment is selected for specific projects. The results of this research contribute to the advancement of surveying practices, enhancing the accuracy and reliability of height measurements.

5.3 Recommendation

This project recommends that surveying professionals and organizations establish standardized procedures for the calibration, maintenance, and operation of digital levelling and total station equipment. By following standardized procedures, professionals can ensure that equipment is properly maintained and operated, guaranteeing accuracy and reliability. Furthermore, it is recommended that professionals document their procedures and results, to facilitate the development of best practices and guidelines for surveying.

5.4 Conclusion

This comparative evaluation has demonstrated that digital leveling and total station equipment are both reliable tools for height measurement, each with its own advantages and disadvantages. In conclusion, the choice between these two tools depends on the specific requirements of the project, including the range, precision, and type of measurement. By selecting the most suitable equipment, surveying professionals can ensure the accuracy and reliability of height measurements, ultimately contributing to the success of their projects. This project's findings have significant implications for the development of more effective surveying methodologies and the advancement of surveying practices, highlighting the importance of understanding the capabilities and limitations of digital leveling and total station equipment.

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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				