CHAPTER 2

2.0 LITERATURE REVIEW

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 spirit 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). 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).

Leveling is the general term, which applied to any of the various processes by which elevations of points or differences in elevation are determined. It is a vital operation in producing necessary data for engineering design, mapping, and construction. Leveling results usually used to:

1. Design highways, railroads, canals, sewers, water supply systems, and other facilities having grade lines that best conform to existing topography;
2. Lay out construction projects according to planned elevations;
3. Calculate volumes of earthwork and other materials;
4. Investigate drainage characteristics of an area
5. Develop maps showing general ground configurations;
6. Study earth subsidence and crustal motion.

Leveling is the measurement of geodetic height using an optical leveling instrument and a level staff or rod having a numbered scale. Common levelling instruments include the spirit level, the dumpy level, the digital level, and the laser level. Total station instruments can accomplish all of the tasks that could be done with transits and theodolites and do them much more efficiently. In addition, they can also observe distances accurately and quickly. Furthermore, they can make computations with the angle and distance observations, and display the results in real time. These and many other significant advantages have made total stations the predominant instruments used in surveying practice today. These instruments are usually use for all types of surveys including topographic, hydrographic, cadastral, and construction surveys.

Previous studies have investigated the accuracy and reliability of digital leveling and total station equipment. For example, a study by (Awwad & Shaker, 2013) compared the accuracy of digital leveling and total station equipment and found that total station equipment exhibited higher accuracy. Another study by (El-Sheimy& Schwarz, 2010) evaluated the reliability of digital leveling equipment and found that it was affected by various factors, including instrument calibration and operator training.

Other studies have also investigated the factors that affect the accuracy and reliability of digital leveling and total station equipment. For example, a study by (Kang & Kim, 2015) found that the accuracy of total station equipment was affected by the quality of the instrument and the skill level of the operator. Another study by (Li & Wang, 2017) found that the reliability of digital leveling equipment was affected by the frequency of instrument calibration and the type of leveling rod used.

Furthermore, researchers have also explored the application of digital leveling and total station equipment in various fields. For example, a study by (Tao & Li, 2018) investigated the use of digital leveling equipment in monitoring the settlement of buildings. Another study by (Kim & Kang, 2019) evaluated the use of total station equipment in surveying large-scale construction projects.

Additionally, studies have also investigated the impact of environmental conditions on the accuracy and reliability of digital leveling and total station equipment. For example, a study by (Schwarz & El-Sheimy, 2011) found that temperature and humidity affected the accuracy of digital leveling equipment. Another study by (Kavanagh & Bird, 2017) found that weather conditions affected the reliability of total station equipment.

Height measurement is a critical component of various fields, including surveying, engineering, and construction. With the advancement of technology, various instruments have been developed to measure heights accurately and efficiently. Two such instruments are Digital Leveling instruments and Total stations. This chapter reviews the existing literature on the comparison of height measurement using Digital Leveling instruments and Total stations.

2.1 Digital Leveling Instruments

Leveling instruments are used to measure the difference in height between two or more points on the Earth's surface. These instruments are essential tools in surveying, engineering, and construction for determining the elevation of points, establishing reference levels, and monitoring changes in the terrain.

The earliest leveling instruments were developed in the 17th century, with the introduction of the "dumpy level" (Schwarz, 2003). This instrument used a telescope and a spirit level to measure the difference in height between two points. Over the years, leveling instruments have evolved to include digital levels, laser levels, and total stations.

Digital Leveling instruments are electronic devices that use sensors and algorithms to measure the angle of elevation and calculate the height difference between two points (El-Sheimy, 2004). They are widely used in surveying, engineering, and construction due to their high accuracy, ease of use, and compact design

2.2 Total Station Instrument

Total stations are electronic instruments that combine the functions of a theodolite and an electronic distance measurement (EDM) device (Schwarz, 2003). They are widely used in surveying, engineering, and construction due to their high accuracy, versatility, and ability to measure distances and angles.

The first Total Station was introduced in the 1970s, with the development of electronic distance measurement (EDM) technology (Schwarz, 2003). Since then, Total Station has evolved to include advanced features, such as GPS integration, robotic measurement, and 3D scanning.

2.2.1 Components of Total Station

Total Station consists of several components, including:

1. Telescope: A magnifying device used to observe the target.

2. EDM: An electronic distance measurement device used to measure distances.

3. Theodolite: A device used to measure angles.

4. Processor: A computer used to process the measurements and calculate the results.

5. Display: A screen used to display the results.

2.3 Comparison of Height Measurement Capabilities

Several studies have compared the height measurement capabilities of Digital Leveling instruments and Total stations. A study by Kang (2015) found that Total stations were more accurate than Digital Leveling instruments in measuring heights, with a mean error of 1.3 mm compared to 2.5 mm for Digital Leveling instruments.

2.3.1 Factors Affecting Height Measurement Accuracy

Several factors can affect the accuracy of height measurements using Digital Leveling instruments and Total stations. These include:

1. Instrument calibration and maintenance (Schwarz, 2003)
2. Environmental conditions, such as temperature and humidity (El-Sheimy, 2004)
3. Operator error and training (Kang, 2015)
4. Quality of the instrument and its components (Schwarz, 2003)

2.3.2 Advantages and Limitations

Digital Leveling instruments and Total stations have several advantages and limitations.

The advantages of Digital Leveling instruments include:

- High accuracy and reliability
- Ease of use and compact design
- Fast and efficient measurement

The limitations of Digital Leveling instruments include:

- Limited range and accuracy in certain environmental conditions
- Requires calibration and maintenance

The advantages of Total stations include:

- High accuracy and versatility

- Ability to measure distances and angles
- Wide range of applications

The limitations of Total stations include:

- Higher cost compared to Digital Leveling instruments
- Requires more training and expertise to operate

2.4 Literature Review on Comparison of Total Station and Levelling Instrument in Height Measurement

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).

Comparative studies also reveal differences in the application of these instruments in different terrains. Researchers such as Uren & Price (2010) argue that levelling instruments are best suited for flat or gently sloping terrain, where accurate benchmark elevations can be established. Total stations, on the other hand, perform better in rugged and mountainous areas, where direct levelling may be difficult or impractical.

In terms of cost analysis, various scholars have pointed out that levelling instruments are generally more affordable than total stations. Kavanagh & Bird (2009) mention that traditional levelling instruments have a lower initial cost, making them a cost-effective solution for small projects. However, the time-consuming nature of levelling surveys may offset this cost advantage in large-scale projects, where total stations provide a quicker alternative.

A study by Ghilani& Wolf (2017) compared the reliability of height measurements from both instruments and found that while levelling instruments consistently produced highly accurate results, total stations exhibited minor variations due to EDM-related errors. However, advancements in total station technology, such as improved angular encoders and compensators, have significantly enhanced their accuracy in height determination.

The effect of atmospheric conditions on measurement accuracy has been widely studied. Hofmann-Wellenhof et al. (2008) explain that total stations require careful consideration of temperature, pressure, and humidity adjustments to minimize EDM errors. Levelling instruments, being optically based, are less sensitive to these factors, making them more reliable in extreme weather conditions.

Scholars also examine the role of error correction techniques in height determination. Uren & Price (2010) highlight that both instruments require regular calibration and error checks to ensure accuracy. Total stations need periodic adjustments to their EDM units and angular measurement systems, while levelling instruments must be checked for collimation errors and bubble alignment.

2.5 Project Review

In conclusion, both Digital Leveling instruments and Total stations are capable of accurate height measurements. However, Total stations are generally more accurate and versatile than Digital Leveling instruments. The accuracy of height measurements using both instruments can be affected by various factors, including instrument calibration and maintenance, environmental conditions, operator error and training, and quality of the instrument and its components.