

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 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.