

# Innovative Modern Surveying Instrument

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**Abstract:** *This paper presents the development and implementation of a novel readable surveying staff with a 2 mm least count, designed to improve precision and usability in various fields such as surveying, civil engineering, and construction. Conventional staffs typically have a least count of 5 mm, limiting the accuracy of measurements in projects that require high precision. This new design offers a significant improvement in accuracy, making it ideal for applications requiring fine measurements, such as geodetic surveys, precision construction, and long-term structural monitoring.*

*The design of the staff includes meter reading on one face and centimetre reading on another face for enhanced flexibility and user convenience. This dual marking system allows surveyors to take readings from both sides, thereby improving the workflow. Additionally, It has a base plate which provides stability to the staff. The methodology involves designing, prototyping, and testing the staff to ensure optimal accuracy, readability, and durability. By reducing the need for interpolation and minimizing human error, the staff enhances efficiency and reduces rework in field operations. Key benefits include faster workflows, reduced measurement errors, improved project accuracy, and increased competitiveness in high-precision industries..*

**Keywords:** Precise levelling staff, base plate, improved project accuracy

## I. INTRODUCTION

Leveling staff or readable staff, also known as a leveling rod or graduated staff, is a crucial tool used in surveying to measure height differences and establish a reference point in relation to a specific benchmark. It is typically a long, graduated rod, often marked with precise measurements, that is used in conjunction with leveling instruments like optical levels or laser levels. The leveling staff allows surveyors to determine the relative elevation between different points on the ground, making it essential for projects like construction, road design, and drainage planning. The staff is usually read by a surveyor from a distance, providing accurate readings of vertical distances. Skilled leveling staff operators play a key role in ensuring precision and reliability in leveling surveys, which are critical for achieving accurate topographical data and aligning infrastructure properly.

Leveling staff plays a pivotal role in the surveying profession. Whether used for determining elevation differences for topographic surveys, ensuring accurate construction measurements, or designing drainage systems, it is an essential tool for establishing reliable, high-quality survey data. The accurate operation of leveling staffs is fundamental to the success of various engineering, construction, and land development projects.

## II. CONVENTIONAL STAFF

A conventional leveling staff is a traditional tool used in land surveying to measure height differences or vertical distances. It typically consists of a long, straight graduated rod, often made of wood, metal, or fiberglass, and is marked with precise scale divisions. The least count of the staff refers to the smallest measurable unit, and in this case, a least count of 5mm means that the smallest difference that can be reliably read on the staff is 5 millimeters.

This type of leveling staff is typically used with optical levels, automatic levels, or other traditional surveying instruments to determine the elevation or height differences between points on the ground. The scale is usually marked in meters or feet, and the staff can be telescopic, allowing for adjustments in height to facilitate measurements at different locations.

**Disadvantages:**

- Limited Precision: With a least count of 5 mm, the staff may not provide very high precision, especially for tasks requiring more refined measurements.
- Human Error: The accuracy of readings can be affected by the observer's skill, leading to potential errors in readings when trying to estimate between divisions.
- Not Suitable for Large-Scale Surveys: For larger surveys or highly precise projects, more advanced equipment with finer least counts would be preferred.



Fig.1 Conventional Staff

**III. NEW LEVELLING STAFF**

**A. LEAST COUNT**

This staff consist of a least count of 2mm which provides a precision of 2mm in readings, which is suitable for precise construction and surveying tasks.

**Key Features:**

Graduation with 2 mm Least Count: The "least count" refers to the smallest measurement that can be read with the instrument. In this case, the staff is graduated such that each division represents a minimum of 2 mm. This high degree of precision allows surveyors to take accurate readings, crucial for tasks requiring fine measurement, such as construction, topographic surveys, and engineering projects



Fig.2 Levelling Staff

**B. BASE PLATE**

A stable base is critical for minimizing errors in measurement. The base helps ensure that the staff remains vertically upright and steady during measurements. This stability is vital when measuring elevation differences over long distances or in areas with varying terrain. A stable base can also help minimize errors caused by slight tilts or movements of the staff. This base plate is detachable and has spikes or horseshoe at its bottom which penetrates into the soil and provides stability.



Fig.3 Detachable Base Plate

**IV. DIFFERENCE BETWEEN CONVENTIONAL STAFF AND NEW LEVELLING STAFF**

Description	Conventional Staff	New Leveling Staff
Least Count	5mm	2mm
Accuracy	Less	More
Precision	Less Precise	More Precise
Base Plate	No base plate	Detachable Base Plate
Stability	Less Stable	More Stable

**V. LITERATURE SURVEY**

A surveying staff with a least count of 2 mm and a stable base is a precision instrument used in land surveying to measure vertical distances. It consists of a graduated scale that is typically made from materials such as wood, aluminum, or fiberglass. The staff is used in conjunction with an optical instrument, such as a theodolite or a level, to measure height differences (or elevations) between points on the ground.

**Key Features:**

**Graduation with 2 mm Least Count:** The "least count" refers to the smallest measurement that can be read with the instrument. In this case, the staff is graduated such that each division represents a minimum of 2 mm. This high degree of precision allows surveyors to take accurate readings, crucial for tasks requiring fine measurement, such as construction, topographic surveys, and engineering projects.

**Stable Base:** A stable base is critical for minimizing errors in measurement. The base helps ensure that the staff remains vertically upright and steady during measurements. This stability is vital when measuring elevation differences over long distances or in areas with varying terrain. A stable base can also help minimize errors caused by slight tilts or movements of the staff.

**Material and Build:** Surveying staffs are often constructed from lightweight yet durable materials, such as fiberglass or aluminum. These materials provide strength and resistance to environmental factors (e.g., moisture or temperature changes) while keeping the staff light and easy to handle.

**Use in Surveying:** The staff is typically used in leveling operations, where a surveyor measures the height of a point relative to a reference point. It is held upright at a survey point, and the corresponding reading is taken by an optical

instrument at a known distance. The accuracy of the staff, especially with a 2 mm least count, helps in achieving highly precise leveling measurements.

**Applications:**

- Topographic Surveys: To create detailed maps of landforms and elevations.
- Construction and Engineering: To ensure precise elevation measurements for structures like buildings, roads, and bridges.
- Geodetic Surveys: For accurate measurement of long distances and elevation differences across large areas.
- Hydrological Studies: In measuring water levels and determining floodplain elevations.

**VI. PROBLEM DEFINITION**

**Background**

Surveying is an essential practice in various fields, including construction, land development, and environmental management. Accurate measurements are critical for ensuring project success and compliance with regulations. Traditional surveying staffs often face challenges such as limited precision, instability during measurements, and user discomfort during prolonged use.

**Problem Statement**

Despite advancements in surveying technology, many existing surveying staffs do not meet the precision and usability standards required for modern applications. Specifically, the following issues persist:

1. Inadequate Precision: Many surveying staffs have a least count greater than 2 mm, leading to potential measurement errors that can significantly impact project outcomes. This lack of precision is particularly problematic in detailed land surveys and construction settings, where small discrepancies can result in costly corrections.
2. Instability: Many staffs lack adequate stability features, making them susceptible to movement and vibrations during measurements. This instability can lead to inaccuracies, especially in windy conditions or on uneven terrain, compromising the reliability of survey data.
3. Ergonomic Issues: Prolonged use of existing surveying staffs often results in discomfort for surveyors, which can affect their performance and lead to fatigue. Current designs may not adequately consider the physical demands of fieldwork, impacting usability and efficiency.
4. Limited Versatility: Existing surveying staffs may not be adaptable to different surveying conditions or compatible with advanced digital instruments, limiting their utility across various applications.

**VII. OBJECTIVES**

The primary objectives of this project are to:

1. Develop a surveying staff with a 2 mm least count that provides high measurement accuracy.
2. Incorporate a stable base design that minimizes movement during use.
3. Create an ergonomic design that reduces user fatigue and enhances comfort.
4. Ensure compatibility with modern surveying instruments to increase versatility and application range.

**VIII. PROPOSED DETAIED METHODOLOGY**

The methodology for this project will be divided into several phases, each with specific tasks, deliverables, and timelines. The approach emphasizes iterative design, prototyping, testing, and refinement to ensure that the final product meets the desired specifications and user needs.

Staff Material: The staff is constructed from aluminum due to their lightweight, weather-resistant, and durable properties.

Total Length: The surveying staff is designed with a total length of 4 meters, consisting of foldable sections for easy transportation and storage.

Width and Thickness: A standard width of 5 cm and a thickness of 1.5 cm is maintained for easy handling and stability.

**IX. CONCLUSION**

This project is carried to develop a readable surveying staff or levelling staff with a least count of 2 mm and a stable base and addresses significant challenges in the field of surveying, where precision, stability, and user ergonomics are critical. The conventional staff provides a least count of 5mm which gives less accuracy as compared to the new leveling staff.

**REFERENCES**

- [1]. Uren, J., & Price, B. (2018). Surveying for engineers. Bloomsbury Publishing.
- [2]. Gorse, C., Johnston, D., & Pritchard, M. (2012). A dictionary of construction, surveying, and civil Engineering. Oxford University Press, USA.
- [3]. Richardus, P. (2017). Project Surveying: Completely revised 2nd edition-General adjustment and optimization techniques with applications to engineering surveying. Routledge.
- [4]. Schofield, W. (2001). Engineering surveying: theory and examination problems for students. Elsevier.