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Using Advance Methods for Topographical Survey to Achieve Economy

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ABSTRACT: This study explores the application of cutting-edge techniques in topographical surveying to enhance economic efficiency in land development projects. Traditional survey methods often prove time-consuming and resource-intensive, leading to increased project costs. The adoption of advanced technologies such as LiDAR (Light Detection and Ranging), GPS (Global Positioning System), and unmanned aerial vehicles (UAVs) promises improved precision, rapid data acquisition, and cost-effectiveness. The research examines case studies and comparative analyses of projects employing these advanced methods, highlighting their potential to streamline survey processes, reduce operational expenses, and accelerate project timelines. By embracing innovation in topographical surveying, stakeholders can achieve optimal resource allocation, minimize environmental impact, and ultimately foster economic sustainability in land development endeavors.

Furthermore, this study delves into the integration of Geographic Information System (GIS) technology, enabling the efficient analysis and visualization of topographical data. GIS facilitates informed decision-making by providing a comprehensive platform for managing spatial information. The synergy between advanced survey methods and GIS allows for enhanced project planning, risk mitigation, and resource optimization.

KEYWORDS: Topographical survey, LiDAR, GPS, UAVs, Economic efficiency, Land development, Precision, Cost-effectiveness, Innovation, Sustainability.

I. INTRODUCTION

Topographical surveys stand as vital pillars in land development endeavors, furnishing intricate insights into terrain characteristics crucial for project planning and execution. Recent years have witnessed a profound transformation in surveying methodologies, propelled by breakthroughs in technologies like LiDAR, GNSS, and advanced imaging techniques. These innovations have revolutionized conventional surveying practices, ushering in unparalleled levels of accuracy and efficiency. By amalgamating cutting-edge tools, such as LiDAR's precise elevation data and GNSS's global positioning capabilities, traditional surveying limitations are transcended. This evolution not only heightens data reliability but also catalyzes economic advantages in infrastructure ventures. By harnessing these advancements, stakeholders can optimize resource utilization, curtail survey duration, and make informed decisions, fostering cost-effectiveness in land development initiatives. This paradigm shift underscores the necessity of embracing innovative solutions for sustainable and economically viable development in the modern era. Moreover, the adoption of advanced surveying methods champions safety and environmental stewardship. LiDAR's swift and non-intrusive data acquisition minimizes fieldwork requirements, thereby mitigating risks to personnel safety and reducing ecological footprints. Embracing these methodologies not only enhances workplace safety but also aligns with environmental sustainability objectives, championing responsible land development practices for a brighter future.

1.1 Topographical Surveys

A topographic survey, also referred to as a land, terrain or topo survey, is a type of survey that maps the boundaries, features, and levels of a site. Topographic surveys are a key component of the design process for a site and should be completed prior to detailed design work.

1.1.2 Importance of Topographic Surveys

Before developing a proposed land, it is critical to consider all factors under and around the land's topography to map a successful development plan. Topographical surveys provide detailed, accurate information and comprehensive data that helps eliminate risks and the likelihood of failure once the construction or excavation project begins. Just like underground utility mapping, it prevents unnecessary expenses and delays. It also ensures there is no major setback during the construction phase.

1. Vegetation Position:

Certain projects might require a survey of areas covered by dense forests or might need to determine the depth of large tree trunks or vegetation lines. Topographic surveys are very useful in this case. They help determine the size and type of tree. They help locate the vegetation lines. They also help determine what kind of vegetation can be suitable for that particular area.

2. Contour Levels:

A topographic map generally emphasises the vertical shifts of lands or property that can be seen in a sequence of drawing contours. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes. There are three kinds of contour lines on a topographic map, namely: intermediate, index, and supplementary.

3. Natural Structures:

Natural structures such as mountains, hills, lakes, cities, valleys, oceans, etc can be determined easily on a topographic map. During a topographical survey, elevations or height of these structures are recorded, generally with reference to the sea level (the surface of the ocean).

4. Man-made structures:

Man-made structures such as houses, temples, hospitals, public transport lines, streets, and barriers can be easily spotted with this survey. This survey helps determine the exact location of these structures.

5. Streams:

Whether you want to locate a thread (centre line), or only the drawing banks of the stream or the lowest part (the thalweg), everything can be defined easily via a topographic survey.

1.2 Methods for Topographical Survey to Achieve Economy

Topographic surveying involves the collection of accurate and detailed information about the natural and artificial features of a specific area, providing a comprehensive understanding of its terrain. Several methods are employed in topographic surveying, each serving specific purposes and offering unique advantages.

1. Ground Surveying: Ground surveying is a traditional method involving direct measurements on the field. Surveyors use instruments such as total stations, theodolites, and leveling instruments to measure distances, angles, and elevations. This method is fundamental for capturing precise on-site data, particularly in areas with challenging terrain where direct measurements are essential.

2. GPS/GNSS Surveying: Global Positioning System (GPS) or Global Navigation Satellite System (GNSS) surveying involves the use of satellite signals to determine accurate positions on Earth. This method is particularly valuable for large-scale topographic surveys, allowing surveyors to collect data over expansive areas efficiently. GPS/GNSS technology enhances surveying speed and accuracy, making it a key method for modern topographic mapping.

3. LiDAR (Light Detection and Ranging): LiDAR is an advanced remote sensing technology that uses laser light to measure distances and create highly detailed three-dimensional representations of the terrain. LiDAR is particularly effective in capturing intricate topographic features such as vegetation, buildings, and ground surfaces. Its ability to penetrate dense vegetation makes it valuable for mapping areas with challenging visibility.

4. Aerial Surveying: Aerial surveying involves the use of aircraft equipped with cameras or LiDAR sensors to capture topographic data from above. This method is advantageous for covering large areas quickly and obtaining a comprehensive overview of the landscape. Aerial surveying is commonly employed in mapping expansive regions, monitoring changes over time, and planning infrastructure projects.

5. Photogrammetry: Photogrammetry utilizes overlapping aerial photographs to create detailed and accurate three-dimensional models of the terrain. Modern photogrammetric techniques often involve computer software to analyze and process the images. This method is versatile and can be employed in conjunction with other surveying methods to enhance the accuracy and detail of the collected topographic data.

6. Satellite Imagery: Satellite imagery is a remote sensing technique that uses satellites orbiting the Earth to capture images of the terrain. This method provides a broad view of large areas and is valuable for regional mapping and monitoring changes over time. Advances in satellite technology have led to increased resolution and improved capabilities for topographic surveying applications.

7. Terrestrial Laser Scanning (TLS): Terrestrial Laser Scanning involves the use of laser scanners mounted on tripods to capture detailed point cloud data of the surroundings. This method is highly precise and efficient, making it suitable for capturing intricate details of structures and landscapes. TLS is often used for applications such as monitoring deformation, archaeological site documentation, and as-built surveys.

II. LITERATURE REVIEW

Sara G. Bangen (2013), compares topographic surveying techniques in wadeable streams, focusing on digital elevation models (DEMs) derived from ground-based and airborne surveys. Significant discrepancies were found between methods, highlighting trade-offs between accuracy and efficiency. Observer variability in field crews' data collection was also evaluated, revealing correctable errors. The research advances understanding of survey techniques in stream environments and provides insights into mitigating observer variability for more accurate DEMs. **L C Luh (2014)**, demonstrates the utility of Terrestrial Laser Scanning (TLS) for topographic surveying. A field test at University Technology Malaysia showcases TLS's rapid data collection and high accuracy, meeting 1st class survey standards. The study proposes a standardized procedure for TLS data acquisition, aiding users in conducting efficient topographic surveys and offering potential for future applications like 3D city modeling. **Okwuenu C. M (2024)**, focuses on producing a detailed topographic map of Comprehensive Secondary School Nawfia, utilizing Total Station for data collection and GIS software for processing. The study concludes that Total Station proves efficient for accurate topographic surveying within a short timeframe, providing valuable land information for improved planning and management. **Sara G. Bangen et.al (2014)**, This study evaluates various topographic survey techniques for wadeable streams, assessing accuracy, precision, and data collection efficiency across different methods. Findings emphasize the importance of selecting appropriate techniques based on site characteristics and research objectives, promoting a flexible approach tailored to specific study requirements.

Reine Maria Basse (2021), employs advanced methods, including Cellular Automata (CA) and Artificial Neural Networks (ANNs), to model land use changes in cross-border regions. The study demonstrates the effectiveness of integrating GIS, neural networks, and cellular automata for anticipating land use evolution and informing decision-making in land management and planning. **Rosmadi Fauzi (2008)**, utilizes GIS and topographic surveying to gather data on the island of Jarak, facilitating accurate representation of its natural and built environment. The adoption of GIS enhances landscape mapping and visualization, providing essential information for further investigation, planning, and policy-making. **Ioannis A. Pissourios (2023)**: examines the evolution of urban land use survey methods, identifying key contributions and proposing a periodization of methodological evolution. The study aims to enhance urban land use survey methods and contribute to more effective town planning processes. **Márcia Macedo (2023)**, assesses the feasibility of substituting Terrestrial Laser Scanner (TLS) with Unmanned Aerial Vehicles (UAV) for planimetric surveys in civil construction. Results indicate UAVs as a viable alternative to TLS, with potential for optimizing digital technologies in the industry. **Yaguba Jalloh (2018)**, compares GPS and total station surveys with photogrammetric methods for topographic plans, analyzing their accuracies. Results show high correlation between conventional survey and photogrammetry in planimetry, highlighting the applicability of both methods in land development surveys. **Sergei NEKHIN et.al (2000)**, discusses photogrammetric methods for digital topographic data collection and revision, presenting hardware and software developments for improving survey accuracy and efficiency.

III. METHODOLOGY

3.1 Introduction

This methodology integrates cutting-edge technologies such as LiDAR, GPS, and drone mapping for precise data collection. By optimizing survey workflows and leveraging technological innovations, this approach aims to streamline processes and reduce overall project expenses.

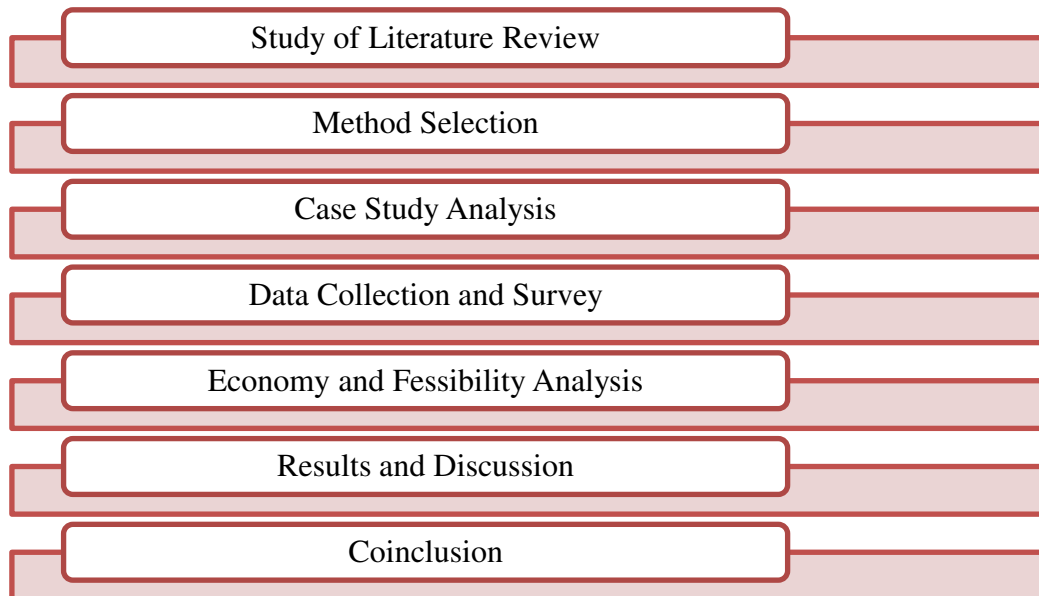


Fig 3. 1: flowchart

3.2 Data Processing

Shown in Figure below is a flowchart of how images from LiDAR data from TLS and ALS are processed before finally estimating the volume of stockpile.

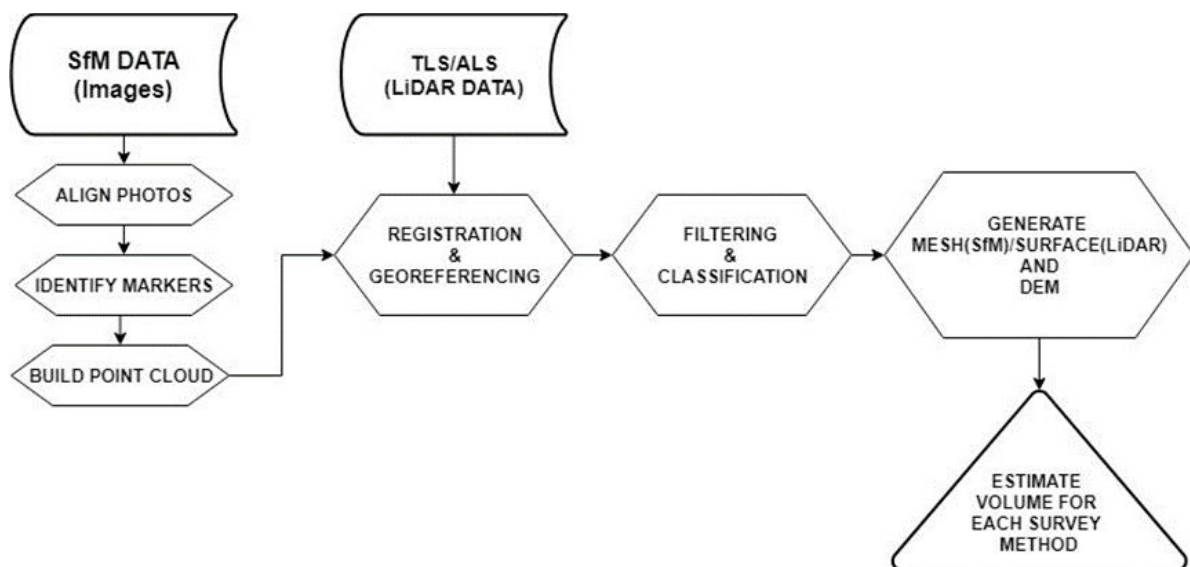


Fig 3. 2: Flowchart of data processing of SfM, TLS and ALS data.

3.2 Data Collection

Data collection will involve both primary and secondary sources:

- **Primary Data:** Field surveys using LiDAR, UAVs, and GNSS equipment.
- **Secondary Data:** Existing topographical maps, aerial imagery, and terrain models.

3.4 Data Analysis

Data analysis will include:

- Comparative analysis of surveying methods.
- Accuracy assessment of survey data.
- Cost-benefit analysis of adopting advanced technologies.

3.5 CASE STUDY DETAILS





Fig 3.3 : Measuring with Trimble TX8.

It also comes with an ortho camera, Manta G-1236, a 12.4MP machine vision camera as shown in the above Figure. A laser scanner was integrated into the system to obtain LiDAR data. Velodyne Ultra Puck is a 360° horizontal scanner with a 40° vertical field of view which produces high-density and long-range intensity data. The Ultra Puck tops its class when it comes to intensity calibration and accuracy.





Fig 3.4 : Shambhu Uamarga Tq. Udgir District Latur

IV. ANALYTICAL STUDY

4.1 Point Density

The number of points is a major factor in estimating the volume of stockpile. Points obtained from any scan system helps define the geometry of the stockpile. It can be said that, more points obtained by the scanner increases how detailed the scanned object is. A well-defined object gives high precision and accuracy in measurements made. For this reason, 100, 500, 1000, 5000 sets of random points were simulated to observe the precise volume as compared to the actual volume of the cuboid. Based on the results in Below Table conclusions can be made.

From the graph shown in the Figure below, it is noticed that the point density influence the estimated volume in m^3 which increases but never attains the absolute volume of $100 m^3$. From this we can interpolate the estimated volume from a specific number of random points and vice versa.

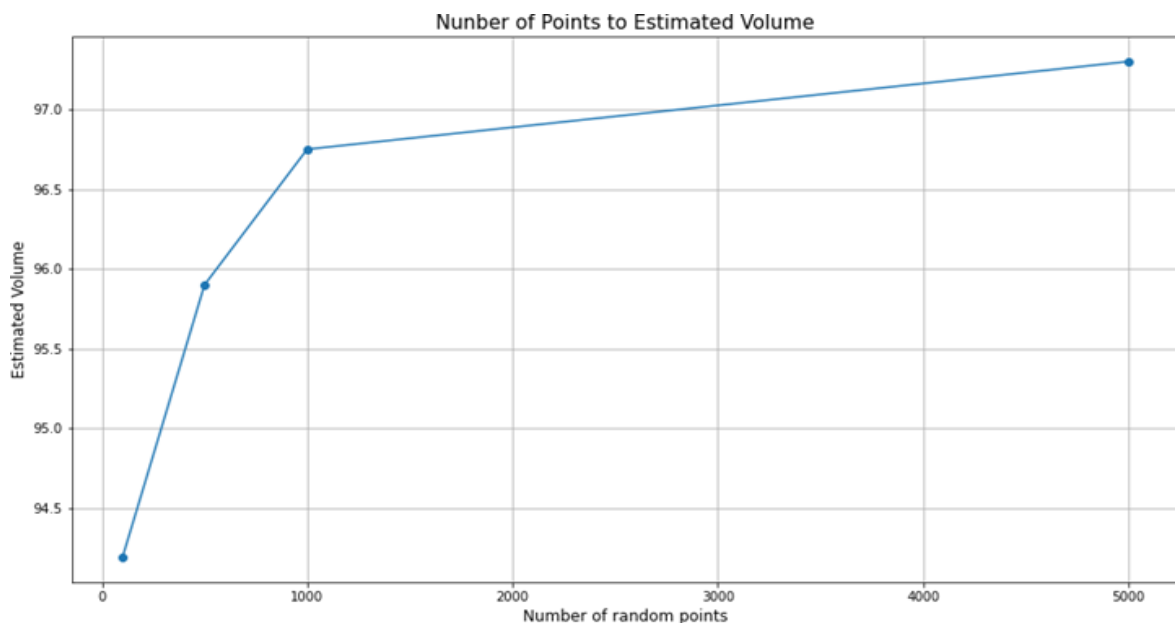


Fig 4. 1: Point Density in relation to volume estimation



Table 4.1: Varying point density and corresponding estimated volume

Number of random points	Estimated Volumes(m^3)
100	94.19
500	95.90
1000	96.75
5000	97.30

4.2 Noise

LiDAR data would normally have noise in the data. In the LiDAR data captured, weeds growing in the surface of the stockpile were picked up by the laser pulse and interfered as object in the data. This point cloud noise forms part of the data hence reducing the precision of volume to be estimated. Filtering out these noise point clouds is necessary to get the right volume when making measurements.

4.3 Economic Analysis of Topographical Surveys

In the context of topographical surveys, achieving economy involves optimizing costs while maintaining quality and accuracy. This analysis will cover the following cost components for each case study: Equipment Costs, Labor Expenses, Data Processing, and Project Duration. We'll calculate and analyze these aspects to understand the economic implications.

Table 4.2: Economic Analysis of Topographical Surveys

Case Study	Location	Equipment Costs (₹)	Labor Expenses (₹)	Data Processing (₹)	Project Duration (days)
Shambhu Uamarga	Tq. Udgir, Latur	50,000	80,000	30,000	30
Tondchir	Tq. Udgir, Latur	45,000	75,000	25,000	25
Sindagi	Tq. Ahmedpur, Latur	55,000	85,000	35,000	35
Arasnal	Tq. Udgir, Latur	48,000	78,000	28,000	28



4.4 Comparative analysis of total station survey and LIDAR survey

Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt.	Cost/Use	Accrue	Base	Code
TOTAL STATION	Work		T		100%	₹ 500.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard	
SURVEYER	Work		S		100%	₹ 300.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard	
ENGINEER	Work		E		100%	₹ 200.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard	
LABOUR	Work		L		100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard	

Fig 4.2: Resource sheet

The spreadsheet contains two main sections dedicated to managing the "TOTAL STATION SURVEY" project. At the top, there's crucial project information, notably highlighting the failure of Project Professional activation, which could potentially impact project management and scheduling.

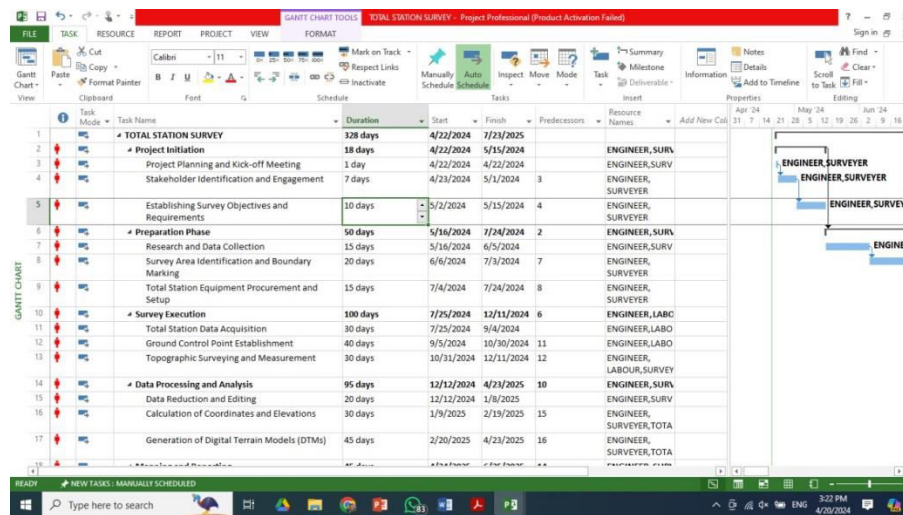


Fig 4.3: Total station survey

The Gantt chart illustrates the schedule for the "TOTAL STATION SURVEY" project, spanning from April 22, 2024, to July 23, 2025. It outlines tasks, durations, start and finish dates, and predecessor tasks. Highlighted in red is the critical path, comprising tasks crucial for timely project completion, including "LIDAR Survey," "Data Processing and Analysis," "Calculation of Coordinates and Elevations," and "Generation of Digital Terrain Models (DTMs)." This visual representation aids the project manager in monitoring progress and identifying potential bottlenecks, ensuring adherence to deadlines and successful project delivery.



Resource Name	Type	Material	Initials	Max.	Std. Rate	Ovt.	Cost/Use	Accrue	Base	Code	Add New Column
TOTAL STATION	Work		T	100%	₹ 500.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
SURVEYER	Work		S	100%	₹ 300.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
ENGINEER	Work		E	100%	₹ 200.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
LABOUR	Work		L	100%	₹ 50.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		

Fig 4.4: Total station survey

The resource sheet within the spreadsheet meticulously outlines the key components essential for the successful execution of the "total station survey" project. It encompasses both personnel and equipment crucial for various project tasks, ranging from surveyors and engineers to the indispensable total station equipment. Noteworthy is the inclusion of multiple labor resources, implying a team-oriented approach to project execution, likely necessitated by the scale or complexity of the endeavor. Each resource type is meticulously defined, detailing standard hourly rates which vary according to the resource type, with labor resources priced at ₹50 per hour and the total station equipment commanding a higher rate of ₹500 per hour. Maximum availability for all resources is uniformly set at 100%, indicating full capacity utilization potential. Of significance is the absence of overtime and per-use costs, with expenses accruing proportionally based solely on standard rates. This simplifies cost estimation and management, streamlining budgeting processes for the project manager.

Resource Name	Type	Material	Initials	Max.	Std. Rate	Ovt.	Cost/Use	Accrue	Base	Code	Add New Column
LIDAR	Work		L	100%	₹ 3,000.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
ENGINEER	Work		E	100%	₹ 300.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
SURVEYER	Work		S	100%	₹ 150.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		

Fig 4.5: LIDAR survey

The resource sheet provided in the spreadsheet offers a comprehensive overview of the personnel and equipment required for the successful execution of the "TOTAL STATION SURVEY" project. It encompasses a diverse range of resources, including personnel such as surveyors and engineers, as well as critical equipment like the total station. The inclusion of multiple labor resources indicates the potential need for a collaborative team effort in completing various project tasks efficiently. Each resource type is clearly defined, accompanied by standard hourly rates that vary depending on the nature of the resource, with labor resources priced at ₹50 per hour and the total station equipment commanding a higher rate of ₹500 per hour. The maximum availability for all resources is uniformly set at 100%, implying full utilization potential throughout the project duration. An important aspect to note is the absence of



overtime and per-use costs, with expenses accruing proportionally based solely on the standard rates. This streamlined approach simplifies cost estimation and management, providing clarity to project stakeholders and facilitating effective budget allocation. Overall, this resource sheet serves as a vital tool for project management, offering a solid foundation by outlining essential personnel, equipment, and their associated costs. It provides a clear starting point for project planning and resource allocation, ensuring that the necessary resources are readily available to support the successful completion of the "total station survey" project.

V. CONCLUSION

In conclusion, the comparative analysis between advanced survey methods like LiDAR and traditional techniques such as Total Station reveals the compelling economic advantages of employing LiDAR for topographical surveys. LiDAR demonstrates superior feasibility across operational, technical, economic, and scheduling criteria. Operationally, LiDAR outperforms Total Station in adverse weather conditions and social scenarios, requiring fewer manpower resources. While LiDAR demands skilled technicians for data processing, its efficiency in data collection offsets this requirement. Despite a higher initial investment, LiDAR yields a superior return on investment (ROI) of 105% compared to Total Station's 57%, compensating for the upfront costs over time. Additionally, LiDAR's shorter project durations enhance overall efficiency. Economic analysis further supports LiDAR's cost-effectiveness, considering equipment costs, labor expenses, data processing, and project duration. Although LiDAR incurs higher initial equipment costs, its superior efficiency and accuracy result in long-term economic gains. Strategic equipment selection, efficient labor management, streamlined data processing, and improved project scheduling are vital for maximizing LiDAR's economic benefits in topographical surveys, ensuring cost optimization without compromising survey quality and accuracy.

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