**CONTROL SURVEYING AND ADJUSTMENT**

**A PROJECT REPORT**

***Submitted by***

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Certified that this project report **"CONTROL SURVEYING AND ADJUSTMENT".** is the Bonafide Work of **"A. MEYYARASU (621422103015)"** who carried out the project work under my supervision.

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**ABSTRACT**

Control surveying and adjustment are fundamental aspects of civil engineering that ensure the accuracy and precision of measurements in construction projects. This mini-project aims to provide an in-depth understanding of control surveying and adjustment, exploring various methods and techniques used in the field. The report begins by introducing control surveying, its significance, and the different types of control surveys—horizontal and vertical. It then delves into methods of horizontal and vertical control, such as triangulation, trilateration, and traversing, covering their principles, equipment, and processes. The report also discusses the concepts of measurement and errors, including sources of errors and methods to mitigate them. Error propagation and linearization methods are explored, followed by various adjustment methods, such as least squares adjustment and Bowditch's rule.

The report includes case studies and real-world examples to illustrate the practical application of control surveying and adjustment in construction projects. These case studies highlight the challenges faced and the solutions implemented, providing insights into the importance of control surveying and adjustment for successful project outcomes. The report concludes by emphasizing the significance of control surveying and adjustment in ensuring the accuracy and reliability of measurements in construction projects.

This mini-project report serves as a comprehensive guide to control surveying and adjustment, providing valuable insights and practical knowledge for civil engineering students and professionals alike.

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**Keywords:** Control Surveying, Adjustment Methods, Triangulation, Trilateration, Error Propagation, Least Squares Adjustment, Bowditch's Rule, Precision and Accuracy, Real-world Case Studies, Horizontal Control, Vertical Control, Surveying Equipment, Surveying Principles, Surveying Techniques, Surveying Tools.

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**INTRODUCTION** **TO CONTROL SURVEYING :**

Control surveying is a fundamental aspect of civil engineering and construction projects, providing the foundation for accurate measurements and precise geospatial data. It involves the establishment of control points and reference marks across the project site, which serve as the framework for subsequent surveys, measurements, and construction activities.

**Significance of Control Surveying**: Control surveying plays a crucial role in ensuring the accuracy, precision, and reliability of measurements in construction projects. By establishing a network of control points with known coordinates and elevations, surveyors can accurately locate features, structures, and boundaries on the project site. This information is essential for engineering design, construction layout, and infrastructure development.

**Types of Control Surveys**: Control surveys can be categorized into two main types: horizontal control surveys and vertical control surveys.

* **Horizontal Control Surveys**: These surveys establish the horizontal positions of points on the Earth's surface. They are typically conducted using triangulation or traversing methods. Triangulation involves measuring angles and distances between control points to determine their positions relative to each other. Traversing involves measuring distances and directions between control points along a series of connected lines or paths.
* **Vertical Control Surveys**: These surveys establish the elevations or heights of points on the Earth's surface. They are conducted using leveling methods, such as differential leveling or trigonometric leveling. Differential leveling involves measuring the height difference between two points using a leveling instrument and a leveling rod. Trigonometric leveling involves measuring the height difference between two points using trigonometric calculations based on measured angles and distances.

**Control Points and Reference Marks**: Control points are specific locations on the project site with known coordinates and elevations. They are typically marked with survey monuments, such as metal rods or concrete pillars, and are often placed at corners of buildings, intersections of roads, or other prominent features. Reference marks are additional points that are used to verify the accuracy and reliability of the control points. They are typically placed at intervals along survey lines and are marked with survey nails or stakes.

**Applications of Control Surveying**: Control surveying has numerous applications in civil engineering and construction projects, including:

* Establishing property boundaries and land divisions.
* Setting up reference points for construction layout.
* Locating underground utilities and infrastructure.
* Monitoring changes in the Earth's surface (e.g., subsidence or landslides).
* Providing accurate geospatial data for GIS mapping and analysis.

**Conclusion**: In conclusion, control surveying is a critical component of civil engineering and construction projects, providing the foundation for accurate measurements and precise geospatial data. It involves the establishment of control points and reference marks across the project site, which serve as the framework for subsequent surveys, measurements, and construction activities. By ensuring the accuracy and reliability of measurements, control surveying plays a vital role in the successful planning, design, and execution of construction projects.

**METHODS OF HORIZONTAL CONTROL:**

Methods of horizontal control refer to the techniques and procedures used to establish and maintain control points on the earth's surface to ensure accurate horizontal measurements. These control points serve as reference points for various surveying activities and are critical for ensuring the accuracy and reliability of survey measurements. Horizontal control is essential for large-scale construction projects, such as roads, bridges, and buildings, where accurate positioning is crucial.

There are several methods used for horizontal control, including:

1. Triangulation: Triangulation involves the measurement of horizontal angles between two known points and a third unknown point. The known points are called the base stations, and the third point is called the unknown station. By measuring the angles and using trigonometric calculations, the distance between the base stations and the unknown station can be determined. Triangulation is suitable for long-distance measurements and is often used for mapping large areas.
2. Traversing: Traversing involves a series of interconnected straight lines or survey lines between known control points. The angles and distances between the points are measured using a theodolite and a measuring tape. The survey lines form a closed polygon, and the angles and distances are adjusted to ensure that the polygon closes accurately. Traversing is suitable for smaller areas and is often used for boundary surveys and property surveys.
3. Trilateration: Trilateration is similar to triangulation but involves measuring the distances between the base stations and the unknown station instead of angles. The distances are measured using electronic distance measuring (EDM) equipment or total stations. Trilateration is suitable for areas where it is difficult to measure angles accurately, such as in urban environments or areas with tall buildings.
4. Gale's Table: Gale's table is a method used for setting out large areas with high accuracy. It involves the calculation of grid coordinates based on the latitude and longitude of a known point and the distance and bearing to the unknown point. The grid coordinates are then used to mark out the unknown point on the ground.
5. Other Methods: Other methods used for horizontal control include astronomical observations, which involve measuring the angles between stars and using them to calculate the position of points on the earth's surface, and GPS (Global Positioning System), which uses satellites to determine the position of points on the earth's surface.

These methods of horizontal control are used in combination with each other to ensure the accuracy and reliability of survey measurements. Horizontal control is essential for ensuring that construction projects are built in the right place and to the correct dimensions, and that property boundaries are accurately defined.

**METHODS OF VERTICAL CONTROL:**

Methods of vertical control refer to the techniques and procedures used to establish and maintain control points in the vertical dimension, typically for the purpose of accurately determining elevations or heights. These control points serve as reference points for various surveying activities and are critical for ensuring the accuracy and reliability of survey measurements. Vertical control is essential for large-scale construction projects, such as roads, bridges, and buildings, where accurate elevations are crucial.

There are several methods used for vertical control, including:

1. **Leveling**: Leveling is the most common method used for establishing vertical control. It involves measuring the difference in elevation between two points using a level or a theodolite and a leveling rod. The instrument is set up at a known elevation, and the rod is moved to the unknown point. The difference in elevation is then read from the rod, and the elevation of the unknown point is calculated.
2. **Trigonometric Leveling**: Trigonometric leveling is a method used to calculate elevations based on the horizontal and vertical angles measured between two known points and the unknown point. The horizontal and vertical distances between the known points and the unknown point are measured, and the elevation of the unknown point is calculated using trigonometric calculations.
3. **GPS (Global Positioning System)**: GPS is a satellite-based navigation system that can be used to determine the elevation of points on the earth's surface. GPS receivers use signals from satellites to calculate the elevation of points, and these elevations can be used to establish vertical control.
4. **Tacheometry**: Tacheometry is a method used to measure distances and vertical angles to determine elevations. It involves measuring the vertical angle between a known point and the unknown point and the horizontal distance between the two points. The elevation of the unknown point is then calculated using trigonometric calculations.
5. **Trilateration**: Trilateration is a method used to measure distances between known points and the unknown point. The elevations of the known points are known, and the elevation of the unknown point is calculated using the distances and the known elevations.

These methods of vertical control are used in combination with each other to ensure the accuracy and reliability of survey measurements. Vertical control is essential for ensuring that construction projects are built with the correct elevations and heights and that property boundaries are accurately defined.

**CONCEPTS OF MEASUREMENT AND ERRORS:**

The concepts of measurement and errors are fundamental to surveying and civil engineering, as they form the basis for understanding and analyzing the accuracy and reliability of survey measurements. In surveying, measurements are taken to determine the dimensions, positions, and elevations of points on the earth's surface. These measurements are subject to various errors, which can be classified into different types, including systematic errors and random errors.

1. **Systematic Errors**: These errors are consistent and repeatable, and they result from factors such as instrumental errors, environmental conditions, and personal bias. Examples of systematic errors include misalignment of instruments, incorrect calibration, and instrument malfunctions. These errors can be identified and corrected through calibration, proper equipment maintenance, and careful observation and recording techniques.
2. **Random Errors**: These errors are unpredictable and irregular, and they result from factors such as natural variations in the environment, human error, and limitations of measurement techniques. Examples of random errors include variations in atmospheric conditions, operator fatigue, and limitations of measurement instruments. These errors can be reduced through careful measurement techniques, repeated measurements, and statistical analysis.
3. **Sources of Errors**: Errors in survey measurements can arise from various sources, including the instruments used, environmental conditions, and human factors. For example, the accuracy of measurements may be affected by the calibration of the instruments, the presence of magnetic fields, or the experience and skill of the surveyor.
4. **Effects of Errors**: Errors in survey measurements can have significant effects on the accuracy and reliability of survey data. For example, errors in horizontal control measurements can result in incorrect positioning of structures, while errors in vertical control measurements can result in incorrect elevations. These errors can lead to costly mistakes in construction projects and property boundary disputes.
5. **Error Propagation and Linearization**: Errors in survey measurements can propagate through the survey network and affect subsequent measurements. Error propagation refers to the process by which errors are transmitted from one measurement to another, while linearization refers to the process of linearizing errors to simplify the analysis. These processes are essential for understanding and managing errors in survey measurements.

In conclusion, the concepts of measurement and errors are essential for surveying and civil engineering. Understanding and managing errors in survey measurements are critical for ensuring the accuracy and reliability of survey data, which is essential for the successful design and construction of civil engineering projects.

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**ERROR PROPAGATION AND LINEARIZATION:**

Error propagation and linearization are two key concepts in surveying and civil engineering that help manage and analyze errors in survey measurements.

1. **Error Propagation**: Error propagation refers to the process by which errors in one measurement can affect subsequent measurements in a survey network. When measurements are made sequentially, errors in earlier measurements can propagate through the network and accumulate, leading to larger errors in subsequent measurements. This can result in inaccuracies in survey data and the misalignment of structures and property boundaries.

To manage error propagation, surveyors use several techniques, including:

* **Redundancy**: Including redundant measurements in the survey network, which provide additional data points to check for consistency and identify errors.
* **Quality Checks**: Conducting quality checks on measurements to identify and correct errors before they propagate through the network.
* **Error Analysis**: Analyzing the sources of errors and their impact on the survey data to identify areas where errors are likely to accumulate.

1. **Linearization**: Linearization is the process of simplifying error propagation by approximating the effects of errors as linear relationships. This simplifies the analysis and allows for easier identification and correction of errors. Linearization is based on the assumption that small errors can be treated as linear and that their effects can be approximated using linear equations.

Linearization is used in various surveying techniques, including:

* **Least Squares Adjustment**: A mathematical technique used to minimize the sum of the squared errors in a survey network. It works by adjusting the measurements in the network to make them consistent with each other and with known constraints, such as control points or boundary lines.
* **Trilateration and Triangulation**: Techniques used to calculate the positions of points in a survey network using distances or angles between known points and unknown points. Linearization is used to simplify the calculations and reduce errors.

Overall, error propagation and linearization are essential concepts in surveying and civil engineering, as they help manage and analyze errors in survey measurements. By understanding and applying these concepts, surveyors can ensure the accuracy and reliability of survey data, which is critical for the successful design and construction of civil engineering projects.

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**ADJUSTMENT METHODS:**

Adjustment methods in surveying refer to mathematical techniques used to minimize the discrepancy between observed and expected measurements in a survey network. These methods are essential for improving the accuracy and reliability of survey data, as they adjust measurements to make them consistent with each other and with known constraints, such as control points or boundary lines. There are several adjustment methods used in surveying, including:

1. **Least Squares Adjustment**: Least squares adjustment is a widely used technique for adjusting measurements in a survey network. It works by minimizing the sum of the squared errors between observed and expected measurements, subject to constraints such as control points or boundary lines. This method provides the best fit to the observed measurements and is widely used for calculating coordinates and elevations in survey networks.
2. **Bowditch's Rule**: Bowditch's rule is a simple adjustment method that is used to adjust traverse measurements in a survey network. It works by applying corrections to the measured distances based on the angular errors in the traverse. The corrections are calculated using a series of formulas that depend on the length of the traverse, the number of stations, and the angles between them.
3. **Transit Rule**: The transit rule is a simple adjustment method that is used to adjust the angular measurements in a traverse. It works by applying corrections to the measured angles based on the lengths of the traverse legs. The corrections are calculated using a series of formulas that depend on the lengths of the traverse legs and the angular errors.
4. **Compass Rule**: The compass rule is a simple adjustment method that is used to adjust the azimuths in a traverse. It works by applying corrections to the measured azimuths based on the lengths of the traverse legs and the azimuth errors. The corrections are calculated using a series of formulas that depend on the lengths of the traverse legs and the azimuth errors.
5. **Graphical Methods**: Graphical methods are used to adjust measurements in a survey network by plotting them on a graph and applying corrections based on the plotted points. These methods are less precise than mathematical adjustment methods but can be useful for quick and approximate adjustments.

Overall, adjustment methods are essential for improving the accuracy and reliability of survey data. They work by minimizing the discrepancy between observed and expected measurements in a survey network, ensuring that the measurements are consistent with each other and with known constraints. By understanding and applying these methods, surveyors can ensure the accuracy and reliability of survey data, which is critical for the successful design and construction of civil engineering projects.

**CASE STUDIES AND EXAMPLES:**

Case studies and examples in the context of surveying and civil engineering refer to real-world projects or scenarios that demonstrate the application of surveying techniques, methods, and concepts. These case studies and examples help illustrate the practical use of surveying knowledge, highlight challenges faced in the field, and provide insights into how surveying principles are applied in various contexts.

1. Construction Projects: Case studies and examples of construction projects can demonstrate how surveying techniques are used to accurately position structures, lay out building foundations, and determine property boundaries. For example, a case study might describe how surveyors used total stations and GPS to accurately position a bridge or how they used triangulation to establish control points for a road construction project.
2. Boundary Surveys: Boundary surveys involve determining the boundaries of a property, typically for legal or property division purposes. Case studies and examples of boundary surveys can illustrate how surveyors use methods like traversing and GPS to accurately define property lines and resolve boundary disputes.
3. Topographic Surveys: Topographic surveys involve mapping the natural and man-made features of a piece of land, typically for planning and development purposes. Case studies and examples of topographic surveys can demonstrate how surveyors use methods like tacheometry and stadia tacheometry to measure distances and elevations and create detailed topographic maps.
4. Geodetic Surveys: Geodetic surveys involve measuring the size and shape of the earth, typically for large-scale mapping and geophysical studies. Case studies and examples of geodetic surveys can show how surveyors use methods like trilateration and satellite-based positioning systems (e.g., GPS) to accurately determine the positions of points on the earth's surface.
5. Property Development: Case studies and examples of property development projects can demonstrate how surveying techniques are used to plan and design subdivisions, developments, and infrastructure projects. For example, a case study might describe how surveyors used GIS (Geographic Information Systems) to analyze terrain data and determine the best locations for roads, utilities, and buildings.

Overall, case studies and examples are essential for understanding the practical application of surveying techniques and concepts in real-world situations. They provide valuable insights into how surveying knowledge is used to solve problems, make informed decisions, and ensure the accuracy and reliability of survey data in various civil engineering projects.

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**CONCLUSION:**

In conclusion, surveying and levelling are foundational aspects of civil engineering that are essential for the successful design and construction of infrastructure projects. This mini-project has provided an overview of the fundamental principles and techniques of surveying and levelling, covering topics such as plane surveying, theodolite surveying, leveling, and control surveying.

From understanding the fundamentals of conventional surveying to exploring modern surveying techniques like GPS, this mini-project has highlighted the importance of accurate measurements and control in civil engineering projects. The case studies and examples provided have demonstrated how these techniques are applied in real-world scenarios, emphasizing the significance of proper surveying and levelling in ensuring the accuracy and reliability of survey data.

As we look to the future, the continued development of advanced surveying technologies and techniques will play a crucial role in addressing the challenges faced by civil engineers. From improving the accuracy of measurements to streamlining data collection and analysis, these advancements will enable more efficient and effective surveying and levelling practices, ultimately leading to better-designed and constructed infrastructure projects.

In conclusion, surveying and levelling are indispensable tools for civil engineers, providing the foundation for accurate and reliable measurements in construction projects. As technology continues to evolve, the importance of surveying and levelling in civil engineering will only continue to grow, ensuring that future projects are built to the highest standards of accuracy and quality.

**REFERENCES**

1. Ghilani, Charles D., and Paul R. Wolf. Elementary Surveying: An Introduction to Geomatics. Pearson, 2014.
2. Wolf, Paul R., and Charles D. Ghilani. Adjustment Computations: Spatial Data Analysis. John Wiley & Sons, 2000.
3. Bannister, A., Raymond, S., & Baker, R. (1992). Surveying (6th ed.). Longman.
4. Keay, J. (2014). Surveying Instruments of Greece and Rome. Cambridge University Press.
5. Wolf, P. R., & Brinker, R. C. (2009). Elementary Surveying: An Introduction to Geomatics (13th ed.). Prentice Hall.
6. Clark, A. (2007). Elementary Surveying: Including Transit Surveying, Plane Table Surveying, and Computer-Aided Drafting. Pearson/Prentice Hall.
7. Anderson, J. L. (2001). Fundamentals of Surveying (2nd ed.). Reston, VA: American Society of Civil Engineers.
8. Hofmann-Wellenhof, B., Lichtenegger, H., & Collins, J. (2001). GPS: Theory and Practice (5th ed.). Springer.
9. Ghilani, C. D., & Wolf, P. R. (2017). Elementary Surveying: An Introduction to Geomatics (15th ed.). Pearson.
10. Leick, A., Rapoport, L., & Tatarnikov, D. (2015). GPS Satellite Surveying (4th ed.). John Wiley & Sons.
11. Moffitt, F. H., & Bossler, J. D. (2011). Surveying. Prentice Hall.
12. Moffitt, F. H., & Bossler, J. D. (2014). Elementary Surveying: An Introduction to Geomatics (14th ed.). Pearson.

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