**SURVEYING PROJECT**

**ABSTRACT**

There is a growing interest in our built heritage, the subject matter ranging from  
prehistoric monuments and historic townships to more modern military or industrial  
sites. Studying a subject can include carrying out documentary research and looking  
at extant remains. The planning and design of all Civil Engineering projects such as construction of highways, bridges, tunnels, dams etc are based upon surveying measurements. Moreover, during execution, project of any magnitude is constructed along the lines and points established by surveying. Thus, surveying is a basic requirement for all Civil Engineering projects. In this report our project deals with survey of an area consisting of leveling, shifting benchmark to the site and contouring .

**Company details:**

We are hereby making our project in **Sri Satyam Constructions** to successfully complete our project as per standard specification.

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**1. INTRODUCTION** CIVIL ENGINEERING is considered as the first discipline of the various branches of engineering after military engineering, and includes the designing, planning, construction, and maintenance of the infrastructure. The works include roads, bridges, buildings, dams, canals, water supply and numerous other facilities that affect the life of human beings. Civil engineering is intimately associated with the private and public sectors, including the individual homeowners and international enterprises. It is one of the oldest engineering professions, and ancient engineering achievements due to civil engineering include the pyramids of Egypt and road systems developed by the Romans.  
**Civil Engineering In Daily Life:-** Civil engineering has a significant role in the life of every human being, though one may not truly sense its importance in our daily routine. The function of civil engineering commences with the start of the day when we take a shower, since the water is delivered through a water supply system including a well designed network of pipes, water treatment plant and other numerous associated services. The network of roads on which we drive while proceeding to school or work, the huge structural bridges we come across and the tall buildings where we work, all have been designed and constructed by civil engineers. Even the benefits of electricity we use are available to us through the contribution of civil engineers who constructed the towers for the transmission lines. In fact, no sphere of life may be identified that does not include the contribution of civil engineering. Thus, the importance of civil engineering may be determined according to its usefulness in our daily life.  
**Sub-disciplines of Civil Engineering:-** Civil engineering is a multiple science encompassing numerous sub-disciplines that are closely linked with each other. The various sub-disciplines of civil engineering are mentioned below:  
**Structural Engineering**:-   
This discipline involves the design of structures that should be safe for the users, be economical, and accomplish the desired functions. The design and analysis should initially identify the loads that act on the structures, stresses that are created due to loads, and then design the structure to withstand these loads. It includes steel structures, buildings, tunnels, highways, dams, and bridges.  
**Geotechnical Engineering**:- Geotechnical engineering deals with soils, rocks, foundations of buildings and bridges, highways, sewers and underground water systems. Technical information obtained from the sciences of geology, material testing, and hydraulics is applied in the design of foundations and structures to ensure safety and economy of construction.  
**Water Resources Engineering:-** This discipline of civil engineering concerns the management of quantity and quality of water in the underground and above ground water resources, such as rivers, lakes and streams. Geographical areas are analyzed to forecast the amount of water that will flow into and out of a water source. Fields of hydrology, geology, and environmental science are included in this discipline of civil engineering.  
**Environmental Engineering**:- It is related to the science of waste management of all types, purification of water, cleaning of contaminated areas, reduction of pollution, and industrial ecology. Technical data obtained due to environmental engineering assists the policy makers in making decisions related to environmental issues.  
**Other Disciplines**:- Some of the other disciplines included in civil engineering include coastal engineering, construction engineering, earthquake engineering, materials science, transportation engineering, and surveying.  
**Future of Civil Engineering:-** Civil engineering utilizes technical information obtained from numerous other sciences, and with the advancement in all types of technologies, the civil engineering has also benefited tremendously. The future of civil engineering is expected to be revolutionized by the new technologies including design software, GPS, GIS systems and other latest technical expertise in varied fields. Technology will continue to make important changes in the application of civil engineering, including the rapid progress in the use of 3-D and 4-D The history of civil engineering can be traced back to 4000 BC when the sole means of construction was human labor, lacking any sophisticated equipment. With advancement in all spheres of technology, civil engineering has also developed tremendously.  
**Manual Labor :- ( the First Engineering Tool)** Civil engineering involves the design, construction, and maintenance of works such as roads, bridges, and buildings. It's a science that includes a variety of disciplines including soils, structures, geology, and other fields. Thus the history of civil engineering is closely associated with the history of advancement in these sciences. In ancient history, most of the construction was carried out by artisans, and technical expertise was limited. Tasks were accomplished by the utilization of manual labor only, without the use of sophisticated machinery, since it did not exist. Therefore, civil engineering works could only be realized with the utilization of a large number of skilled workers over an extended period of time.  
**Prehistoric and Ancient Civil Engineering Structures:-** It might be appropriate to assume that the science of civil engineering truly commenced between 4000 and 2000 BC in Egypt when transportation gained such importance that it led to the development of the wheel. According to the historians, the Pyramids were constructed in Egypt during 2800-2400 BC and may be considered as the first large structure construction ever. The Great Wall of China that was constructed around 200 BC is considered another achievement of ancient civil engineering. The Romans developed extensive structures in their empire, the physical sciences concerning civil engineering was implemented by Archimedes in the third century BC, by utilizing the Archimedes Principle concerning buoyancy and the Archimedes screw for raising water.  
**The Roles of Civil and Military Engineer in Ancient Times:-** As stated above, civil engineering is considered to be the first main discipline of engineering, and the engineers were in fact military engineers with expertise in military and civil works. During the era of battles or operations, the engineers were engaged to assist the soldiers fighting in the battlefield by making catapults, towers, and other instruments used for fighting the enemy. However, during peace time, they were concerned mainly with the civil activities such as building fortifications for defense, making bridges, canals, etc.  
**Civil Engineering in the 18th - 20th Century:-** Until the recent era, there was no major difference between the terms civil engineering and architecture, and they were often used interchangeably. It was in the 18th century that the term civil engineering was firstly used independently from the term military engineering. The first private college in the United States that included Civil Engineering as a separate discipline was Norwich University established in the year 1819 Civil engineering societies were formed in United States and European countries during the 19th century, and similar institutions were established in other countries of the world during the 20th century. The American Society of Civil Engineers is the first national engineering society in the United States. In was founded in 1852 with members related to the civil engineering profession located globally. The number of universities in the world that include civil engineering as a discipline have increased tremendously during the 19th and the 20th centuries, indicating the importance of this technology.  
**Modern Concepts in Civil Engineering:-** Numerous technologies have assisted in the advancement of civil engineering in the modern world, including high-tech machinery, selection of materials, test equipment, and other sciences. However, the most prominent contributor in this field is considered to be computer-aided design (CAD) and computer-aided manufacture (CAM). Civil engineers use this technology to achieve an efficient system of construction, including manufacture, fabrication, and erection. Three-dimensional design software is an essential tool for the civil engineer that facilitates him in the efficient designing of bridges, tall buildings, and other huge complicated structure. To accomplish their objective, **surveyors** use elements of geometry, engineering,  
trigonometry, mathematics, physics, and law. Surveying has been an essential element in the development of the human environment since the beginning of recorded history (about 5,000 years ago). It is required in the planning and execution of nearly every form of construction. Its most familiar modern uses are in the fields of transport, building and construction,  
communications, mapping, and the definition of legal boundaries for land ownership.  
**1.1 GENERAL**  
**Surveying techniques** Historically, distances were measured using a variety of means, such as with chains having links of a known length, for instance a Gunter's chain, or measuring tapes made of steel or invar. To measure horizontal distances, these chains or tapes were pulled taut according to temperature, to reduce sagging and slack. Additionally, attempts to hold the measuring instrument level would be made. In instances of measuring up a slope, the surveyor might have to "break" (break chain) the measurement- use an increment less than the total length of the chain. Historically, horizontal angles were measured using a compass, which would provide a magnetic bearing, from which deflections could be measured. This type of instrument was later improved, with more carefully scribed discs providing better angular resolution, as well as through mounting telescopes with reticles for moreprecise sighting atop the disc (see theodolite). Additionally, levels and calibrated circles allowing measurement of vertical angles were added, along with verniers for measurement to a fraction of a degree—such as with a turn-of-the-century transit. The simplest method for measuring height is with an altimeter — basically a  
barometer — using air pressure as an indication of height. But surveying requires greater precision. A variety of means, such as precise levels (also known as differential leveling), have been developed to do this. With precise leveling, a series of measurements between two points are taken using an instrument and a measuring rod. Differentials in height between the measurements are added and subtracted in a series to derive the net difference in elevation between the two endpoints of the series. With the advent of the Global Positioning System (GPS), elevation can also be derived with sophisticated satellite receivers, but usually with somewhat less accuracy than with traditional precise leveling. However, the accuracies may be similar if the traditional leveling would have to be run over a long distance.  
Triangulation is another method of horizontal location made almost obsolete by GPS. With the triangulation method, distances, elevations and directions between objects at great distance from one another can be determined. Since the early days of surveying, this was the primary method of determining accurate positions of objects for  
topographic maps of large areas. A surveyor first needs to know the horizontal distance between two of the objects. Then the height, distances and angular position of other objects can be derived, as long as they are visible from one of the original objects. High-accuracy transits or theodolites were used for this work, and angles between objects were measured repeatedly for increased accuracy.  
**Surveying equipment** As late as the 1990s, the basic tools used in planar surveying were a tape measure for determining shorter distances, a level to determine height or elevation differences, and a theodolite, set on a tripod, to measure angles (horizontal and vertical), combined with the process of triangulation. Starting from a position with known location and elevation, the distance and angles to the unknown point are measured. A more modern instrument is a total station, which is a theodolite with an electronic distance measurement device (EDM). A total station can also be used for leveling when set to the horizontal plane. Since their introduction, total stations have made the technological shift from being optical-mechanical devices to being fully electronic. Modern top-of-the-line total stations no longer require a reflector or prism (used to return the light pulses used for distancing) to return distance measurements, are fully robotic, and can even e-mail point data to the office computer and connect to satellite  
positioning systems, such as a Global Positioning System. Though real-time  
kinematic GPS systems have increased the speed of surveying, they are still horizontally accurate to only about 20 mm and vertically accurate to about 30–40 mm. Total stations are still used widely, along with other types of surveying instruments. However, GPS systems do not work well in areas with dense tree cover or constructions. One-person robotic-guided total stations allow surveyors to gather precise measurements without extra workers to look through and turn the telescope or record data. A faster but expensive way to measure large areas (not details, and no obstacles) is with a helicopter, equipped with a laser scanner, combined with a GPS to determine the position and elevation of the helicopter. To increase precision, surveyors place beacons on the ground (about 20 km (12 mi) apart). This method reaches precisions between 5–40 cm (depending on flight height).[5]  
**Surveying as a career** The basic principles of surveying have changed little over the ages, but the tools used by surveyors have evolved tremendously. Engineering, especially civil engineering, depends heavily on surveyors. Whenever there are roads, railways, reservoir, dams, retaining walls, bridges or residential areas to be built, surveyors are involved. They establish the boundaries of legal descriptions and the boundaries of various lines of political divisions. They also provide advice and data for geographical information systems (GIS), computer databases that contain data on land features and boundaries. Surveyors must have a thorough knowledge of algebra, basic calculus, geometry, and  
trigonometry. They must also know the laws that deal with surveys, property, and  
contracts. In addition, they must be able to use delicate instruments with accuracy and precision.  
**Land surveyor** A common use of a survey is to determine a legal property boundary. The first stage in such a survey is to research relevant title records such as deeds, survey monumentation (marks on the ground), and any public or private records that provide relevant data. In order to properly establish the position for survey markers, the surveyor must then take measurements. To do this, the surveyor usually places a total station over various points on the ground and records distances taken with the EDM. The surveyor analyses the data and makes comparisons with existing records to determine evidence that can be used to establish boundary positions. The surveyor calculates the bearing and distance of lines between the boundary corners and total station positions and uses them to set out and mark the corners in the field. He may check measurements by measuring directly between places using a flexible tape.  
1.2 **The History Of Surveying And Survey Equipment** Surveying has been an essential element in the development of the human environment since the beginning of recorded history (ca. 5000 years ago) and it is a requirement in the planning and execution of nearly every form of construction. Its most familiar modern uses are in the fields of transport, building and construction, communications, mapping, and the definition of legal boundaries for land ownership. Historically, angles and distances were measured using a variety of means, such as chains with links of a known length, for instance a Gunter's Chain (see Edmund Gunter), or measuring tapes made of steel or invar. In order to measure horizontal distances, these chains or tapes would be pulled taut, to reduce sagging and slack. Additionally, attempts to hold the measuring instrument level would be made. In instances of measuring up a slope, the surveyor might have to "break" the measurement that is, raise the rear part of the tape upward, plumb from where the last measurement ended. Historically, horizontal angles were historically measured using compasses, which would provide a magnetic bearing, from which deflections could be measured. This type of instrument was later improved upon, through more carefully scribed discs, providing better angular resolution, as well as through mounting telescopes with reticles for more precise sighting atop the disc (see theodolite). Additionally, levels and calibrated circles allowing measurement of vertical angles were added, along with verniers for measurement down to a fraction of a degree such as a turn-of-the-century Transit (surveying). The simplest method for measuring height is with an altimeter (basically a barometer) using air pressure as an indication of height. But for surveying more precision is needed. Toward this end, a variety of means, such as precise levels have been developed, which are calibrated to provide a precise plane from which differentials in height between the instrument and the point in question, typically through the use of a vertical measuring rod. The basic tool is a theodolite, set on a tripod, with which one can measure angles (horizontal and vertical), combined with triangulation. Starting from a benchmark, a position with known location and elevation, the distance and angles to the unknown point are measured. A more modern instrument is a total station, which is basically a theodolite with an **electronic distance measurement** device (**EDM**). Still more modern is the use of satellite positioning systems, such as a Global Positioning System (GPS). Though GPS systems have increased the speed of surveying, they are still only accurate to about 20 mm. As well GPS systems do not work in areas with dense tree cover. It is because of this that EDMs have not been completely phased out. Robotics allows surveyors to gather precise measurements without extra workers to look through and turn the telescope or record data. A faster way to measure (no obstacles) is with a helicopter with laser echolocation, combined with GPS to determine the height of the helicopter. To increase precision, beacons are placed on the ground (about 20 km apart). This method reaches a precision of about 5 cm. With the triangulation method, first, one needs to know the horizontal distance to the object. If this is not known or cannot be measured directly, it is determined as explained in the triangulation article. Then the height of an object can be determined by measuring the angle between the horizontal plane and the line through that point at a known distance and the top of the object. In order to determine the height of a mountain, one should do this from sea level (the plane of reference), but here the distances can be too great and the mountain may not be visible. So it is done in steps, first determining the position of one point, then moving to that point and doing a relative measurement, and so on until the mountaintop is reached.  
**Triangulation** In trigonometry and elementary geometry, **triangulation** is the process of finding a distance to a point by calculating the length of one side of a triangle, given measurements of angles and sides of the triangle formed by that point and two other reference points. Some identities often used (valid only in flat or euclidean geometry): The sum of the angles of a triangle is pi rad or 180 degrees. The law of sines - The law of cosines - The Pythagorean theorem Triangulation is used for many purposes, including surveying, navigation, metrology, astrometry, binocular vision and gun direction of weapons. Many of these surveying problems involve the solution of large meshes of triangles, with hundreds or even thousands of observations. Complex triangulation problems involving real-world observations with errors require the solution of large systems of simultaneous equations to generate solutions.  
  
**2. THEORY OF SURVEYING**  
**Definition:-** Surveying is defined as the science of making measurements of the earth specifically the surface of the earth. This is being carried out by finding the spatial location (relative / absolute) of points on or near the surface of the earth. Different methods and instruments are being used to facilitate the work of surveying. The primary aims of field surveying are:  
• To measure the Horizontal distance between points.  
• To measure the Vertical elevation between points.  
• To find out the Relative direction of lines by measuring horizontal angles with reference to any arbitrary direction.  
• To find out Absolute direction by measuring horizontal angles with reference to a fixed direction. These parameters are utilized to find out the relative or absolute coordinates of a point location.  
**2.1 Importance of Surveying to Civil Engineers:-** The planning and design of all Civil Engineering projects such as construction of highways, bridges, tunnels, dams etc are based upon surveying measurements. Moreover, during execution, project of any magnitude is constructed along the lines and points established by surveying. Thus, surveying is a basic requirement for all Civil Engineering projects.  
**Other principal works in which surveying is primarily utilized is:-**  
• To fix the national and state boundaries  
• To chart coastlines, navigable streams and lakes  
• To establish control points.  
• To execute hydrographic and oceanographic charting and mapping.  
• To prepare topographic map of land surface of the earth.  
**2.2 Objectives of surveying**:-  
• To collect field data;  
• To prepare plan or map of the area surveyed;  
• To analyse and to calculate the field parameters for setting out operation of actual engineering works.  
• To set out field parameters at the site for further engineering works.  
**2.3 Divisions of surveying:-** The approximate shape of the earth can best be defined as an oblate tri-axial overlaid . But, most of the civil engineering works, concern only with a small portion of the earth which seems to be a plane surface. Thus, based upon the consideration of the shape of the earth, surveying is broadly divided into two types. Geodetic Surveying Plane Surveying  
**2.3.1 Geodetic Surveying:-** In this branch of surveying, the true shape of the earth is taken into consideration. This type of surveying is being carried out for highly precise work and is adopted for surveying of large area.  
**2.3.2 Plane Surveying**:- In this method of surveying, the mean surface of the earth is considered to be a plane surface. This type of survey is applicable for small area (less than 200 square kilometer). Thus for most of the Civil Engineering projects, methods of plane surveying are valid. This course is restricted to the different aspects of plane surveying. Henceforth, in this course work, the word surveying implies plane surveying.  
**Fundamental Assumptions in Plane Surveying:-**  
• All distances and directions are horizontal.  
• The direction of the plumb line is same at all points, within the limits of survey   
• All angles (both horizontal and vertical) are plane angles  
• Elevations are with reference to a datum.  
**2.4 Classification of surveying:-** Based on the purpose (for which surveying is being conducted), Surveying has been classified into:  
**• Control surveying:** To establish horizontal and vertical positions of control points.  
**• Land surveying:** To determine the boundaries and areas of parcels of land, also known as property survey, boundary survey or cadastral survey.  
**• Topographic survey:** To prepare a plan/ map of a region this includes natural as well as and man-made features including elevation.  
**• Engineering survey:** To collect requisite data for planning, design and execution of engineering projects. Three broad steps are  
**1) Reconnaissance survey:** To explore site conditions and availability of infrastructures.  
**2) Preliminary survey:** To collect adequate data to prepare plan / map of area to be used for planning and design.  
**3) Location survey:** To set out work on the ground for actual construction / execution of the project.  
• **Route survey:** To plan, design, and lying out of route such as highways, railways, canals, pipelines, and other linear projects.  
• **Construction survey:** Surveys which are required for establishment of points, lines, grades, and for staking out engineering works (after the plans have been prepared and the structural design has been done).  
• **Astronomic surveys:** To determine the latitude, longitude (of the observation station) and azimuth (of a line through observation station) from astronomical observation.  
• •  
**Mine surveys:** To carry out surveying specific for opencast and underground mining purposes.  
**1. OPERATIONS IN SURVEYING**  
**I.** Planning  
**II.** Field Observation  
**III.** Office Works  
**IV.** Setting Out Works.  
**3.1 Planning:-** To decide,  
• The methods to be adopted for surveying;  
• The resources (instruments & personnel) to be used;  
• The control points / stations to be used (those already available and/ or to set up). The planning operation needs a-priori field visit and this is known as reconnaissance.  
**3.2 Field Observation:-** It involves  
• Collection of field data by making necessary measurements;  
• Recording of observed data in a systematic manner. Before starting any field observation, the permanent adjustments of all the instruments need to be checked thoroughly by trained personnel and if required, it must be adjusted.  
**3.3 Office Work:-** It involves  
• Processing, analyzing and calculation of observed data;  
• Preparation of necessary data (for making plan or map of the area);  
• Making of a plan or map of the area;  
• Computation of relevant field parameters as per design for setting out engineering works at site.  
**3.4 Setting Out Works:-** To locate and establish different parameters / dimensions at the site as per design for further engineering works. This surveying method is used to determine the difference in elevation between two or more points.  
**Establishing A Benchmark** When both benchmarks cannot be reached from one instrument position, turning points must be used.Because a turning point is a temporary benchmark, it must be a stable structure. A backsight is taken on BM1.The 4.31 is added to the elevation of the bench mark to find the height of the instrument (104.31).  
⦁ A turning point is established and a foresight is recorded (4.92).  
⦁ The foresight is subtracted from the height of instrument to determine the elevation of the turning point (99.39)  
⦁ Then the instrument is moved to a point between the turning point and the next station.  
⦁ In this example the next station is BM2.  
⦁ A backsight is taken on the turning point (4.22).  
⦁ The backsight is added to the elevation of the turning point to find the new instrument height (103.61).  
⦁ The instrument is rotated and a foresight is recorded on BM2.  
⦁ The foresight on BM2 (2.35) is subtracted from the instrument height to determine the elevation of BM2 (101.08)  
⦁ Tables are an excellent way of organizing numbers.  
⦁ Surveyors have developed a standard table for differential leveling.  
**Differential Leveling Table** Five columns are used. STA = Station Identification BS = Backsight HI = Instrument Height FS = Foresight ELEV = Elevation The table for this example:  
  
**Table 3.1** STA BS HI FS ELEV BM1 4.31 104.31 100.0 TP 4.22 103.61 4.92 99.39 BM2 2.53 101.08 101.08 - 100.0 = 1.08  
**BM2 is 1.08 feet higher than BM1**  
**4. CHECKS IN CLOSED TRAVERSE**  
**Three Checks For Error**  
1. Closing the loop  
2. Note check  
3. Allowable error check  
**4.1Closing the loop**  
**Closing the Loop Example**  
⦁ The steps are the same.  
⦁ The instrument is moved and a backsight is recorded for BM2 (3.27).  
⦁ The instrument is rotated.  
⦁ A foresight is recorded on TP2 (2.21) .  
⦁ The instrument is moved between TP2 and BM1  
⦁ A BS is recorded on TP2 (3.29).  
⦁ The instrument is rotated.  
⦁ The loop is closed by recording a foresight on BM1 (5.42).  
**Table 4.2 Note check**  
**Table 4.1: Check for closing error**  
❖ When the closing data is entered into table it is complete and the first error check is completed.  
❖ The second check for error is called the note check.  
❖ The note check uses an equation:  
| BS - FS |=| BM1i - BM1c |   
❖ If the equation is true, there is no math error in the notes.  
❖ If the equation is not true, the notes have a math error.  
STA BS HI FS Elev  
BM1 4.31 104.31 100  
TP1 4.22 103.61 4.92 99.39  
BM2 3.27 104.35 2.53 101.08  
TP2 3.29 105.43 2.21 102.14  
BM1 5.42 100.01  
**4.2 Note Check**  
BM1  
i  
BM1  
c  
STA BS HI FS Elev  
BM1 4.31 104.31 100.00  
TP1 4.22 103.61 4.92 99.39  
BM2 3.27 104.35 2.53 101.08  
TP2 3.29 105.43 2.21 102.14  
BM1 5.42 100.01  
15.09 - 15.08  
0.01 = 0.01  
OK  
BM1  
i  
BM1  
c  
⦁ The note check statement is true.  
⦁ The 0.01 difference in the elevation of BM1i and BM1c is not caused by a math error in the notes  
**4.3 Allowable Error of Closure**  
⦁ The third check for error is called the allowable error.  
⦁ Early surveyors realized that the sources of error were so large that it would be impossible to control for all of them.  
⦁ It is common practice for the agency/individual contracting the work to specify the acceptable level of error.  
⦁ or professional standards  
⦁ Many different standards for acceptable error are used.  
⦁ A simple one is called the allowable error and it is based on an equation:  
AE = k M  
k = 1.0 to 0.01  
M = Distance surveyed (miles)  
⦁ For the differential example we pace the distance between BM1 and BM2 and record a distance of 1.100 feet.  
⦁ A k value of 0.1 is acceptable for general work.  
AE = k M = 0.1 1,100 x 2  
5280  
= 0.1 x 0.417 = 0.04 The actual error was 0.01 and the allowable error is 0.04, therefore the survey is acceptable.0.01<0.04  
**Table 4.3 Allowable Error of Closure**  
STA BS HI FS Elev  
BM1 4.31 104.31 100.00  
TP1 4.22 103.61 4.92 99.39  
BM2 3.27 104.35 2.53 101.08  
TP2 3.29 105.43 2.21 102.14  
BM1 5.42 100.01  
15.09 - 15.08  
0.01 = 0.01  
OK  
AE = k M = 0.1 1100 x 2  
5280 = 0.04  
0.1 < 0.4  
**Allowable Error**  
⦁ In this example the actual error was less than the allowable error.  
⦁ When the actual error is greater than than the allowable error the date has excessive error, it is destroyed and the survey must be done again.  
**Leveling instruments:** The instruments commonly used in leveling are: 1. A level 2. A leveling staff  
Level:  
To provide a horizontal line of sight .  
Consisting of 1. Telescope 2. Level tube 3. Leveling head 4. tripod  
**Elevations Determined by Transit and Leveling Rod**  
**Booking & Calculations**  
**Staff readings**: level book / booking form Processed **readings** -> RL’s Use hand-held calculator / notebook with spreadsheets  
⦁ Compute all rises & falls  
⦁ Start at a BM with known RL  
To get RL of next station:  
⦁ add rise to previous RL, or  
⦁ subtract fall from previous RL  
Repeat for all subsequent stations  
**Rise & fall method**  
**3.729**  
**CP2**  
**CP1**  
**BM**  
**4.212 0.718**  
**2.518**  
**4.153 0.556**  
**Fig**  
**Table 4.4 Rise and fall method**  
**Station BS FS Rise Fall RL Remarks**  
**BM 4.212 23.918**  
**CP1 4.153 0.718 3.494 27.412**  
**CP2 2.518 0.556 3.597 31.009**  
**B 3.729 1.211 29.798**  
**Total = 10.883 5.003 7.091 1.211 29.798**  
**minus 5.003 1.211 23.918**  
**= 5.880 5.880 5.880**  
**B**  
**3.729**  
all all  
BS FS = Total rise – total fall = Last RL – first RL i. check equalities in last row, Table ii. discrepancy -> arithmetic mistake(s) (unrelated to accuracy of measurements).  
A rule often used in construction leveling with many (n) instrument stations:  
Maximum permitted closure error E :  
E = Dn  
1/2  
(2.10)  
D = 5 mm & D = 8 mm: commonly adopted  
**A construction project requires four kinds of surveys for its**  
**completion:** (1) A property or boundary survey by a registered land surveyor to establish the location and dimensions of the property. (2) A survey to determine the existing conditions such as contours, man-made and natural features, streams, sewers, power lines, roads, nearby structures, and so on. This work may also be done by the land surveyor along with the boundary survey. (3) The construction surveys which determine the position and elevation of the features of the construction work. These surveys include the placing of grade stakes, alignment stakes and other layout control points. (4) Finally there are the surveys which determine the positions of the finished structures．These are the ―as-built‖ surveys and they are used to check the  
contractor’s work and show locations of structures and their components (water lines, sewers, etc.) which will be needed for future maintenance, changes, and new construction  
**Sources of Errors in Measurement:-**  
Natural Errors  
Instrumental Errors  
Personal Errors  
**Types of Errors:-**  
Gross Error  
Systematic Error  
Cumulative Error  
Compensating Error  
Random Error  
**Important definitions in Surveying**:-  
**Horizontal Angle**:- An angle measured between two intersecting lines in a horizontal plane, is defined as a horizontal angle.  
**Control Points**:- Stations having known position.  
**Plan**:- Orthographic representation of features on or near the surface of the earth in Large Scale on a horizontal plane.  
**Map**:- Graphical representation of features on or near the surface of the earth in small scale on a horizontal plane and is constructed using a projection system other than orthographic.  
**Oblate (spheroid):-** An oblate (spheroid) is a surface of revolution obtained by rotating an ellipse about its minor axis i.e., having equatorial radius greater than the polar radius.  
**Ovaloid:-** A pear shaped figure having dimension of one hemisphere larger than the other for earth, southern hemisphere is larger than the northern.  
**Plumb line:-** The direction of the lines of force of earth's gravity field. In field surveying, it is defined by the direction of a freely suspended plumb-bob.  
**Elevation:**- The vertical distance of a point from a datum.  
**Datum**:- A leveled surface taken as reference for the determination of elevations of points.  
**Latitude:-** The angular distance measured along a meridian above or below the plane of the equator.  
**Longitude:-** The angular distance measured in the plane of the equator east or west of the Greenwich Meridian.  
  
**5. LEVELLING**  
**Definition:-** It is a method of surveying to determine the relative elevation of the point on the surface of the earth.  
**5.1 Object of Leveling**: 1) To establish point at desired elevation with respect to the given datum. 2) To determine the elevation of given points with respect to the given datum. Leveling deals with the measurement in a vertical plane. Leveling is a very much useful in the initial stage of the design of the project as well as during the execution of the project. Leveling is an important method of surveying for many engineering works and construction of the projects. Leveling is a very much useful for the purpose of design of railways, highways, canals, dams, sewers etc. Leveling is required for estimating the capacities, for locating the gradient line and for the layout of construction of projects, for locating the execution levels and for the control of various buildings, dams, bridges etc. The drainage characteristics of the area can be obtained by leveling.  
**5.2 Methods of Leveling**:-  
**Barometric leveling**:- Barometric leveling makes use of the phenomenon that difference in elevation between two points is proportional to the difference in atmospheric pressure at these points.  
**Trigonometric Leveling:-** Trigonometric leveling or indirect leveling is the process of leveling in which the elevation of the points are computed from the vertical angles and horizontal distance measured in the field, just as the length of any triangle can be computed from proper trigonometric relations.  
**Spirit Leveling (direct leveling):** It is the branch of leveling in which the vertical distance with respect to horizontal line may be used to determine the relative difference in elevation between two adjacent points. A horizontal plane of sight tangent to level surface is readily established by means of a spirit level.  
**Theory of Direct leveling**:- A level provides horizontal line of sight i.e. a line tangential to a level surface at the point where the instrument stands. The difference in elevation between two points is the vertical distance between two level lines. We have only level line of sight. Neglect the curvature of earth and refraction with a level setup in any place, the difference in elevation between any two points within proper lengths of sight is given by the difference between the rod readings taken on these points.  
**Special methods of Spirit leveling**:-  
**(i) Differential Leveling**:- It is the method of direct leveling the object of which is solely to determine the difference in elevation of two points regardless of the horizontal positions of the points w.r.t each other. When the points are far apart, it may be necessary to setup the instrument several times. This type of leveling is also known as fly leveling.  
**(ii) Profile Leveling**:- It is the method of direct leveling the object of which is to determine the elevations of points at measured intervals along a line in order to obtain a profile of the surface along that line.  
**(iii) Cross section**:- Cross section leveling is the process of taking levels on each side of a main line at right angles to that line, in order to determine a vertical cross-section of the surface of the ground or the both.  
**(iv) Reciprocal leveling**:- It is the method of leveling in which the different in elevation between two points is accurately determined by two sets of reciprocal observations when it is not possible to setup the level between the two points.  
**(v) Precise Leveling**:- It is the leveling in which the degree of precision required is too great to be attained by ordinary methods, and all possible errors have to be avoided.  
**Important definitions in Leveling:-**  
**Line of Collimation or line of sight:-** The line joining the point of intersection of the cross wires of the diaphragm to the optical centre of the objective and its imaginary continuation.  
**Reduced Level:-** The vertical distance measured above or below the mean sea level or benchmark is called as reduced level.  
**Benchmark:-** It is a permanent reference point whose elevations or reduced levels are known. All the leveling operations start from benchmark.  
**Back sight reading:** The reading taken by leveling instrument on a leveling staff held on a point whose elevation is known. It is very first reading taken on the benchmark after setting up the instrument.  
**Fore sight reading:-** The reading taken on the point whose elevation is to be found out. It is the last reading before shifting the instrument.  
**Intermediate sight:** Any other staff reading taken on a point of unknown elevation from the same setup of the instrument. All sights which are taken between back-sight or fore-sight or intermediate sight.  
**Change point:-** It is a point on which fore-sights and back-sight are taken.  
**The leveling instruments essentially consist of the following:-** 1) Leveling head with three foot screws which enables to bring the bubble at its centre. 2) Telescope that provides line of sight to bisect distinct objects. 3) A bubble tube to make the line of sight horizontal either mounted on top or side of the telescope. 4) A tripod for supporting the leveling instrument.  
  
**6. CONTOURING**  
**Definition:-** Contouring is the science of representing the vertical dimension of the terrain on a two dimensional map. We can understand contouring by considering a simple example.  
**Example**:- Let us assume that a right circular cone of base 5m diameter and vertical height 5m is standing upright on its base. Let the base be resting on a horizontal plane at zero level At zero level, the outline of the cone will be a circle of 5m diameter. This circle is the contour line at 0m elevation for the cone. We draw this first contour line on paper to a convenient scale. Let us now slice the cone at 1m height from the base. This will produce another circular outline corresponding to the diameter of the cone at 1m elevation. Let us draw this second circle on our contour map using the same scale. The second circle being smaller in diameter than the first will appear as a concentric circle within the first circle. Similarly, we continue to draw the outline of the cone at 2m, 3m, 4m and 5m levels on our contour map. Our contour map for the conical object is now ready. The circles on the map are called contour lines.  
**Contour Line:-** A Contour line is an imaginary outline of the terrain obtained by joining its points of equal elevation. In our example of the cone, each circle is a contour line joining points of same level.  
**Contour Interval (CI):-** Contour interval is the difference between the levels of consecutive contour lines on a map. The contour interval is a constant in a given map. In our example, the contour interval is 1m.  
**Horizontal Equivalent (HE):-** Horizontal equivalent is the horizontal distance between two consecutive contour lines measured to the scale of the map  
**Gradient:-** Gradient represents the ascending or descending slope of the terrain between two consecutive contour lines. The slope or gradient is usually stated in the format 1 in S, where 1 represents the vertical component of the slope and S its corresponding horizontal component measured in the same unit. The gradient between two consecutive contour lines can also be expressed in terms of TanQ(theta) as follows:  
**Tan Q (theta) = CI / HE** … both measured in the same unit.  
**Differences between contour interval and horizontal equivalent:-** There are three main differences between contour interval and horizontal equivalent as follows:  
**Table 6.1**  
**Contour Interval Horizontal Equivalent** 1 It is based on vertical levels Represents horizontal distance 2 No measurement or scaling is required since the contour levels are indicated on the contour lines The distance must be measured on the map and converted to actual distance by multiplying with the scale of the map 3 In a given map the contour interval is a constant The horizontal equivalent varies with slope. Closer distance indicates steep slope and wider distance gentle slope  
**Table 6.2 Factors governing selection of Contour Intervals:-**  
**S.No Factor Select High CI like**  
**1m, 2m, 5m or more**  
**Select Low CI like**  
**0.5m, 0.25m, 0.1m**  
**or less** 1 Nature of ground If the ground has large variation in levels, for instance, hills and ponds If the terrain is fairly level 2 Scale of the map For small scale maps covering a wide area of varying terrain For large scale maps showing details of a small area 3 Extent of survey For rough topographical map meant for initial assessment only For preparation of detailed map for execution of work 4 Time and resources available If less time and resources are available If more time and resources are available The survey leader has to decide an appropriate contour interval for his project before start of survey work. The above factors govern the selection of contour interval for a project.  
**6.1 Characteristics of Contours**:- Contours show distinct characteristic features of the terrain as follows: i) All points on a contour line are of the same elevation. ii) No two contour lines can meet or cross each other except in the rare case of an overhanging vertical clif for wall. iii) Closely spaced contour lines indicate steep slope. iv) Widely spaced contour lines indicate gentle slope. v) Equally spaced contour lines indicate uniform slope. vi) Closed contour lines with higher elevation towards the centre indicate hills. vii) Closed contour lines with reducing levels towards the centre indicate pond or other depression. viii) Contour lines of ridge show higher elevation within the loop of the contours. Contour lines cross ridge at right angles. ix) Contour lines of valley show reducing elevation within the loop of the contours. Contour lines cross valley at right angles. x) All contour lines must close either within the map.  
**6.2 Uses of Contours**: Contour maps are very useful since they provide valuable information about the terrain. Some of the uses are as follows: i) The nature of the ground and its slope can be estimated ii) Earth work can be estimated for civil engineering projects like road works, railway, canals, dams etc. iii) It is possible to identify suitable site for any project from the contour map of the region. iv) Inter-visibility of points can be ascertained using contour maps. This is most useful for locating communication towers. v) Military uses contour maps for strategic planning, boundary or outside.  
**6.3 Methods of Contouring** Two methods of Contouring are:- i) DIRECT METHOD ii) INDIRECT METHOD  
**6.3.1 DIRECT METHOD:-** In direct method, the points of equal elevation on the terrain are physically located and then plotted on map. This is a very tedious process and requires more time and resources than the indirect method.  
**6.3.2 INDIRECT METHOD:-** In the indirect method of contouring one of these three methods are adopted:- (i) Cross section Method (ii) Squares or Grid Method (iii) Tachometric Method  
**Cross Section Method**:- Cross section method is most suitable for preparing contour maps for road works, rail work canals etc. Typically, this type of land has a very long strip but narrow width.  
**The steps involved are as follows:** i) the centre line of the strip of land is first marked ii) Lines perpendicular to the longitudinal strip are marked dividing the strip into equal sections iii) The perpendicular lines are divided into equally spaced divisions, thus forming rectangular grids. iv) Levels are taken at the intersection of the grid lines to obtain the cross-section profile of the strip of land. v) Contour map is plotted in the office by interpolating points of equal elevation based on the levels taken at site  
**Squares or Grid Method**:- Squares or grid method is suitable for contouring of plains or gently sloping grounds.  
**The steps adopted are as follows:-** i) Mark square grids on the land to be surveyed. The grid size would depend on the extent of survey. Generally a 1m x 1m grid is selected for small works and a larger grid size for large works ii) Levels are taken at all the corners of the square and the intersection of the diagonal. iii) Levels taken on the intersection of diagonals are used for verification of the interpolation. vi) Contour map is plotted in the office by interpolating points of equal elevation based on the levels taken on the corners of the square.  
**Tachometric Method:-** Tachometric method is adopted for contouring of very steep hills.  
**The steps are as follows:-** i) Set up the tachometers at the top of the steep hill. Tachometer is a theodolite fitted with stadia diaphragm. The stadia diaphragm has three horizontal parallel hairs instead of one as found in a conventional cross hair diaphragm. ii) With the help of a tachometer it is possible to determine the horizontal distance of the point from the telescope as well its vertical level. iii) The steep hill is surveyed at three levels – the base of the hill, the mid-level of the hill and the top level of the hill. iv) Using the tachometer reading is taken all around the hill at equal angular intervals on all these three levels. v) The radial plot thus obtained is worked in the office to interpolate points of equal elevation for contour mapping.  
**Comparison between Direct and Indirect Methods:-**  
**Table 6.3**  
**S No Direct Method Indirect Method** 1 Very tedious Not tedious 2 Accurate Less accurate 3 Slow Fast 4 Requires more resources Requires less resources 5 Suitable for contouring of small area. Suitable for large areas 6 Points are physically located on the Ground Points are interpolated in the office  
**7. PRACTICAL WORK**  
**Aim:-** Survey contour work s for the proposed area.  
**Location:-** Hafeezpet, near railway station.  
**Instruments used**:- Dumpy level Cross staff Staff Tape Tripod stand Pegs  
**Procedure**:-  
⮚ Standard benchmark (BM) is taken as railway track near ―K‖ gate.  
⮚ Benchmark are transferred to the stations mentioned below:-  
• Ground  
• Tar road  
• Cross road  
• Road towards maayabazar  
• On electric pole at sight  
⮚ Survey has been done using ―square or grid method‖.  
⮚ The given plot of 450x90 meters is divided into grids. Each grid is of size 15x15 meters.  
⮚ The levels are taken at every point using staff and dumpy level.  
⮚ Calculating those readings contour map is drawn.  
**Observations:**  
**Table (i):-** These readings were taken by using dumpy level. 00 15 30 45 60 75 90 15 2.80 3.07 3.08 X 2.47 30 2.84 3.08 2.75 3.24 3.85 45 2.98 2.35 3.46 3.21 3.98 60 2.69 3.18 2.66 3.35 3.90 75 2.47 3.28 3.05 3.12 3.71 90 2.23 2.99 2.84 1.90 2.90 105 2.11 2.68 2.01 X 1.82 120 2.48 1.65 1.84 X 2.80 135 1.61 1.59 1.70 2.65 X 150 1.33 1.34 1.35 2.40 2.68 165 1.24 0.70 1.12 2.00 2.38 180 1.07 0.98 1.59 1.69 1.81 195 0.89 0.81 X 1.40 1.70 210 0.62 0.79 1.03 1.29 1.45 225 1.96 1.38 1.57 1.87 2.32 240 1.65 1.36 1.74 1.86 2.23 2.15 3.25 255 0.98 1.27 1.62 1.71 1.98 1.92 3.35 270 0.87 1.25 1.43 1.62 1.55 1.83 3.40 285 0.75 1.13 1.31 1.50 1.45 1.76 3.10 300 0.60 0.81 1.16 1.20 1.25 1.54 3.20 315 0.45 0.61 0.69 1.10 1.45 1.68 2.87 330 0.38 0.54 0.43 1.00 1.40 1.42 2.75 345 0.31 0.30 0.15 0.93 1.20 1.15 2.55 360 0.20 0.24 0.06 0.69 0.90 0.95 2.47 375 0.00 0.16 0.20 0.35 0.50 0.74 2.20 390 1.16 1.40 1.70 1.44 1.78 2.15 2.03 405 1.13 1.45 1.24 1.37 1.50 1.55 1.51 420 0.94 0.81 0.75 0.85 1.43 1.65 1.32 435 0.85 0.81 0.69 1.08 1.38 1.45 1.14 450 0.83 0.63 0.15 0.18 0.40 1.20 1.30  
**Table 7.1**  
❖ Railway track is taken as a standard bench mark, which is near to the site.  
❖ Standard bench mark of railway track is 556.50.  
**Calculations:-** Benchmark of railway track 556.50 Back sight (+)0.98 557.48 Fore sight (-)2.31 Benchmark at mud road 555.17 Back sight (+)0.01 555.18 Fore sight (-)3.57 Benchmark at tar road 551.61 Back sight (+)0.60 552.21 Fore sight (-)2.53 Benchmark at cross road 549.68 Back sight (+)0.00 549.68 Fore sight (-)2.45 Benchmark at road 547.23 Back sight (+)o.98 548.21 Fore sight (-)0.96  
547.25  
**Table 7.2**  
**Table (ii):-** These readings are after deducting the above values from height of collimation. 00 15 30 45 60 75 90 15 546.55 546.28 546.27 X 546.38 30 546.51 546.27 546.60 546.11 545.50 45 546.37 547.00 545.89 546.14 545.32 60 546.66 546.17 546.69 546.00 545.45 75 546.88 546.07 546.30 546.23 545.64 90 547.12 546.36 546.51 547.45 546.45 105 547.24 546.67 547.34 546.48 547.53 120 546.87 547.70 547.51 X 546.55 135 547.74 547.76 547.65 546.70 X 150 548.02 548.01 548.00 546.95 546.67 165 548.11 548.62 548.23 547.32 546.97 180 548.28 548.37 547.76 547.66 547.54 195 548.46 548.54 X 547.95 547.65 210 548.73 548.56 548.32 548.06 547.90 225 548.87 548.65 548.46 548.16 547.71 547.70 240 548.98 548.67 548.29 548.23 547.80 547.88 548.14 255 549.05 548.76 548.41 548.32 548.05 548.11 548.04 270 549.16 548.78 548.60 548.41 548.48 548.20 547.99 285 549.20 548.90 548.72 548.49 548.58 548.27 548.29 300 549.43 549.22 548.93 548.79 548.78 548.49 548.19 315 549.58 549.42 549.34 548.89 548.58 548.35 548.52 330 549.65 549.49 549.60 549.03 548.63 548.61 548.64 345 549.72 549.73 549.98 549.10 548.83 548.88 548.84 360 549.83 549.79 550.03 549.34 549.13 548.08 548.92 375 550.03 549.93 549.83 549.68 549.53 549.08 549.19 390 550.23 549.99 549.69 549.92 549.64 549.24 549.36 405 550.26 549.94 550.15 549.82 549.89 549.84 549.88 420 550.35 550.58 550.64 550.54 549.96 549.74 550.07 435 550.44 550.58 550.70 550.31 550.01 549.94 550.28 450 550.46 550.76 551.24 551.21 550.99 550.19 550.09  
**Table 7.3**  
  
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