NATIONAL OPEN UNIVERSITY OF NIGERIA

SCHOOL OF SCIENCE AND TECHNOLOGY

COURSE CODE: ESM 421

COURSE TITLE: ELEMENTS OF SURVEYING

ESM 421 ELEMENTS OF SURVEYING

Course Title: Elements of Surveying

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ESM 421: ELEMENT OF LANDS SURVEYING

1.0 Introduction

This lesson will provide an overview of elements of surveying. It is aimed at introducing the students to the content of the course. Surveying is practical oriented hence students musts must be prepared to go beyond studying in the classroom to collecting data in the field and using the data to draw maps and plans. This course will aim at demystify surveying which by now most students have had little knowledge about. An overview of the course is provided below.

1.0 Course aim and objectives

The course aims at introducing the students to the elements of surveying. After going through this course, a student should be able to achieve the following objectives:

a. Define surveying and state the main objectives and relevance of surveying.
b. Examine the major classification, principles and processes of surveying.
c. Appreciate chain surveying, its relevance, equipments and processes of chain surveying.
d. Give an account of compass surveying and its relevance.
e. State the meaning , principles and strategies of levelling.
f. Explain the principles and methods of pain tabling.

2.0 Course content

The course is divided into 5 Modules, each of which is y divided into Units as follows:

MODULE 1 INTRODUCTION TO SURVEYING

Unit 1: Overview and Introduction to Surveying

Unit 2: Classification of surveying

Unit 3: The basic principles and process surveying

MODULE 2 CHAIN SURVEYING

Unit 1 Meaning, purpose, suitability and equipments

Unit 2 Errors and overcoming obstacles in Chain survey.

MODULE 3 COMPASS SURVEY

Unit 1 Meaning and types of Compass Survey

Unit 2 Back and Fore bearing; and Traversing and plotting with prismatic compass.

MODULE 4 LEVELING

Unit 1 Meaning, equipment and principles

Unit 2 Booking and Calculation of Reduced levels.

MODULE 5 PLANE TABLING

Unit 1 Meaning and instruments

Unit 2 Methods of plane tabling

4. 0: **Textbooks and References**

Agor, R. (1993). Textbook of Surveying and Leveling, Khanna. Publishers, India.

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MODULE 1 INTRODUCTION TO SURVEYING

Unit 1: Overview and Introduction to Surveying

1.0 Introduction

Most scientists do not spend all their working hours inside air conditioned rooms but in most cases depend on information and data gathered in the field to enable them do their work successfully. Surveying is one of those courses whose practitioners depend on data gathered either by themselves or their agents to enable them take vital decisions that will make the society function properly.

2.0 objectives

g. to introduce the students to the meaning and definition of surveying

h. to help the students understand the main objectives and relevance of surveying.

i. To expose the students to the primary divisions of surveying.

3.0 Main Body

3.1 Meaning / Definition of surveying

Surveying is the art and science of measuring distances, direction and elevation to determine the relative positions of features on the earth's surface and their representation in the form of maps, plans and charts.

3.2 Object of Surveying

The main object of surveying is the gathering of data and the preparation of plans, maps and charts of a specific area with such data. From ancient times man had been interested in demarcating and recording property boundaries hence early surveying efforts were directed towards that direction. In contemporary times, modern life is made possible by the efforts of surveyors and the plans, maps and charts they help to create. For an example, the first step for the execution of most projects, is surveying. Hence, before the construction of roads, building, railways, etc, the surveyor makes detailed measurements in the field and prepares the detailed plans and charts that help the engineers to layout the alignments of such projects.

It should be noted that since surveying developed from ancient times the science, methods and instruments of surveying have been greatly influenced by the level of technological development of any era. Because of the importance of surveying to modern man, the training of

engineers, environmentalists (planners, Architects, Geographers, etc) is not complete without instructions on various aspects of surveying.

3.3 **Primary Divisions of Surveying**

The curative of the surface of the earth, based on its being close to ellipsoid in shape forms the basis to surveying being divided into;

(a) **Plane Surveying**

Plane surveying is survey in a small extent hence the earth's surface is assumed to be a plane and the curvature of the earth is ignored. As only small areas are involved, the lines connecting any 2 points on the surface of the earth are treated on straight lines and the angles between them as plane angles. Plane surveying involves areas that are up to 260 square km to determine the relative position of individual features at a sufficiently large scale.

Surveys for engineering projects falls under plane surveying. Knowledge of plane geometry and trigonometry are necessary for plane surveying.

(b) **Geodetic Surveying**

Geodetic surveying takes place in a national scale which takes into consideration the curvature of the earth. It requires higher levels of accuracy in linear and angular observations than plane surveys hence used to provide widely spaced control points for subsequent detailed plane surveys.

Geodetic surveys extend our large areas of 1000km^2 and above hence lines connecting any two points are treated as arcs and not straight lines and the angles as spherical angles.

4. 0; **Textbooks and References**

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Unit 2: Classification of surveying

1. 0. Introduction

For easy understanding of surveying and the various components of the subject, we need a deep understanding of the various ways of classifying it.

2.0 Objective

- to enable the students have understanding of the various ways of classifying surveying

3.0 Main Body

3.1 Classification Of Surveying

Surveying is classified based on various criteria including the instruments used, purpose, the area surveyed and the method used.

3.1.1 Classification on the Basis of Instruments Used.

Based on the instrument used; surveys can be classified into;

i) Chain tape surveys

ii) Compass surveys

iii) Plane table surveys

iv) Theodelite surveys

3.1.2 Classification based on the surface and the area surveyed

i) **Land survey**

Land surveys are done for objects on the surface of the earth. It can be subdivided into:

(a) **Topographic survey:** This is for depicting the (hills, valleys, mountains, rives, etc) and man made features (roads, houses, settlements…_ on the surface of the earth.

(b) **Cadastral survey** is used to determining property boundaries including those of fields, houses, plots of land, etc.

(c) **Engineering survey** is used to acquire the required data for the planning, design and execution of engineering projects like roads, bridges, canals, dame, railways, buildings, etc.

(d) **City surveys:** The surveys involving the construction and development of tows including roads, drainage, water supply, sewage street network, etc, are generally referred to as city survey.

(2) **Marine or Hydrographic Survey:** Those are surveys of large water bodies for navigation, tidal monitoring, the construction of harbours etc. The taking of soundings on shares aid banks aid the determination of water depths helps in the production of topographic maps and the survey of batty – metric controls.

(3) **Astronomical Survey:**

Astronomical survey uses the observations of the heavenly bodies (sun, moon, stars etc) to fix the absolute locations of places and gratiscules (lines of longitude and (attitude) on the surface of the earth.

3.1.3 CLASSIFICATION ON THE BASIS OF PURPOSE

i) **Engineering survey** (see 4.1.2c)

ii) **Control Survey:**

Control survey uses geodetic methods to establish widely spaced vertical and horizontal control points.

iii) **Geological Survey**

Geological survey is used to determine the structure and arrangement of rock strata. Generally, it enables me know the composition of the earths const.

iv) **Military or Defence Survey** is carried out to map places of military and strategic importance

iv) **Archeological survey** is carried out to discover and map ancient/relies of antiquity.

3.1.4 Classification Based On Instrument Used

i. **Chain/Tape Survey:** This is the simple method of taking the linear measurement using a chain or tape with no angular measurements made.

ii. **Compass Survey:** Here horizontal angular measurements are made using magnetic compass with the linear measurements made using the chain or jape.

iii. **Plane table survey:** This is a quick survey carried out in the held with the measurements and drawings made at the same time using a plane table.

iv. **Leveling**

This is the measurement and mapping of the relative heights of points on the earth's surface showing them in maps, plane and charts as vertical sections or with conventional symbols.

Vi. **Theodolite Survey:**

Theodolite survey takes vertical and horizontal angles in order to establish controls

3.1.5 CLASSIFICATION BASED ON THE METHOD USED

1. **Triangulation Survey**

In order to make the survey, manageable, the area tube survey is first covered with series of triangles. Lines re first run round the perimeter of the plot, then the details fixed in relation to the established lines. This process is called triangulation. The triangle is preferred as it is the only shape that can completely over an irregularly shaped area with minimum space left.

ii. **Traverse survey:**

If the bearing and distance of a place of a known point is known: it is possible to establish the position of that point on the ground. From this point, the bearing and distances of other surrounding points may be established. In the process, positions of points linked with lines linking them emerge. The traversing is the process of establishing hese lines, is called traversing, while the connecting lines joining two points on the ground. Joining two while bearing and

distance is known as traverse. A traverse station is each of the points of the traverse, while the traverse leg is the straight line between consecutive stations. Traverses may either be open or closed.

- **Open Traverse**

An open traverse terminates in a point that is not predetermined as it neither returns to its starting station nor closes on any point while bearing and height is known as show in Fig. 1.

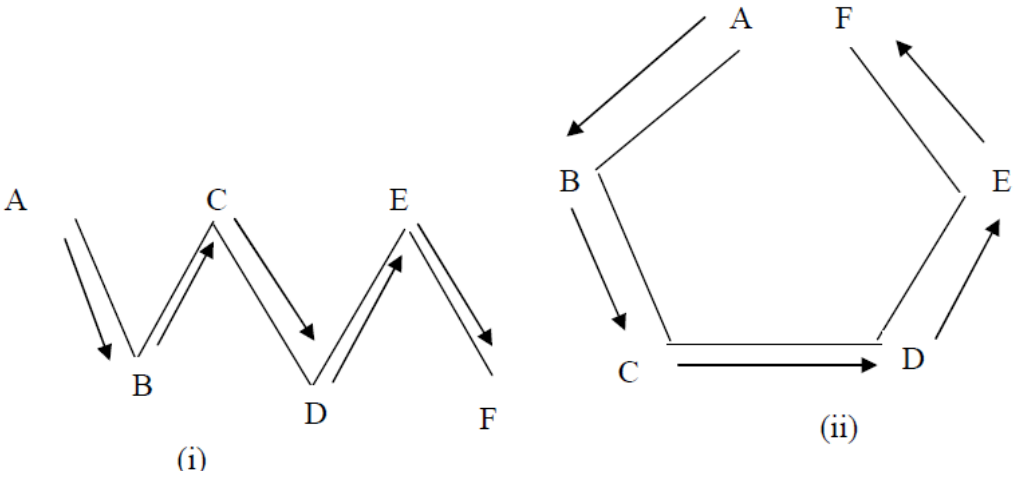

Fig. 1.1: Open Traverse – A and F are positions of unknown coordinates and heights in (i) and (ii).

- **CLOSED TRAVERSE**

In a closed traverse, a traverse cogitates from a point whose bearing and height are known and terminates in another point whose bearing and height are also known. The terminal point may either be its starting point (Fig.1.2i) or any point of known coordinate (Fig. 1.2ii).

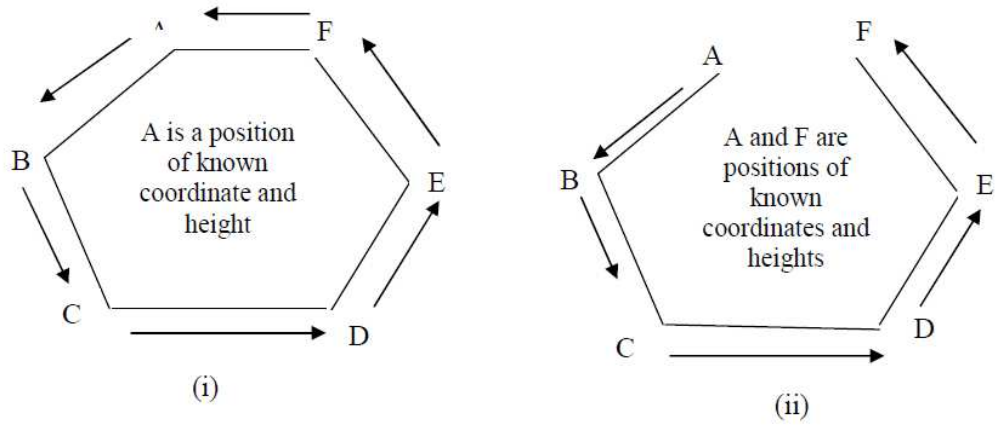

Fig. 1.2: Close Traverse – (i) and (ii)

4. 0; **Textbooks and References**

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Unit 3: The basic principles and process surveying

3.1 Introduction

So far in this module, we have discussed the meaning, object and maor classifications of surveying. In this unit, we move further to discus the basic principles and process of surveying.

2. 0 objectives.

- To enable students understand the basic principles of surveying.
- To expose the students to the process of surveying.

3.0 Main Body

3.1 Basic Principles of Surveying

Surveying is based on simple fundamental principles which should be taken into consideration to enable one get good results.

(a) Working from the whole to the part is achieved by covering the area to be surveyed with a number of spaced out control point called primary control points called primary control points whose pointing have been determined with a high level of precision using sophisticated equipments. Based on these points as theoretic, a number of large triangles are drawn. Secondary control points are then established to fill the gaps with lever precision than the primary control points. At a more detailed and less precise level, tertiary control points at closer intervals are finally established to fill in the smaller gaps. The main purpose of surveying from the whole to the parts is to localize the errors as working the other way round would magnify the errors and introduce distortions in the survey.

In partial terms, this principle involve covering the area to be surveyed with large triangles. These are further divided into smaller triangles and the process continues until the area has been sufficiently covered with small triangles to a level that allows detailed surveys to be made in a local level. Error is in the whole operation as the vertices of the large triangles are fixed using higher precision instruments.

(b) Using measurements from two control parts to fix other points. Given two points whose height and bearings have been accurately determined, a line can be drawn to join them hence surveying as control reference points. The locations of various other points and the lines joining them can be fixed by measurements made from these two points and the lines joining them. For an example, if A and B are the control points, the following operations can be performed to fix other points.

i) Using points A and B as the centers, ascribe arcs and fix (where they intersect.

ii) Draw a perpendicular from D along AB to a point C.

iii) To locate C, measure distance AB and use your protractor to equally measure angle ABC.

iv) To locate C the interior angles of triangle ABC can be measured. The lengths of the sides AC and BC can be calculated by solving the triangle.

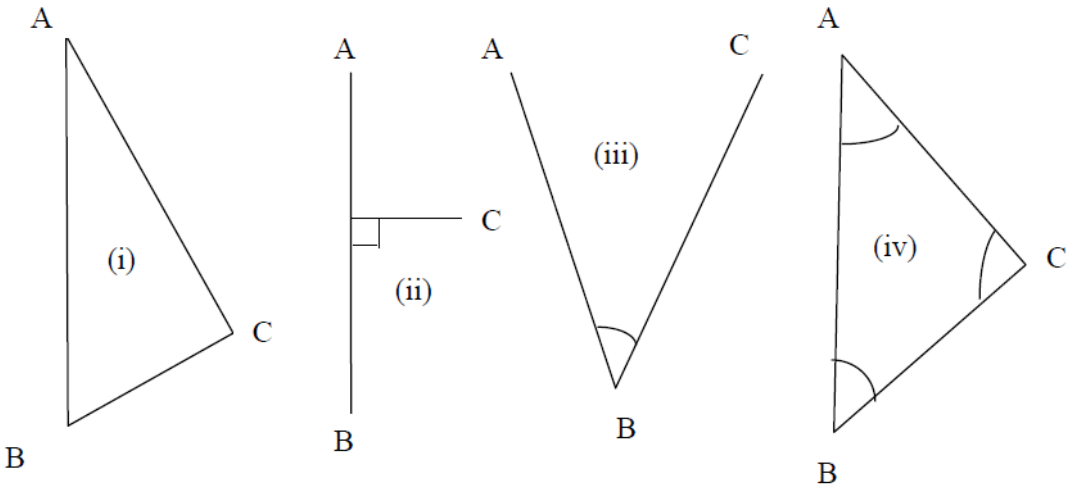

Fig. 1.3: Fixing the third points using two points

3.1 The process of surveying:

The survey process passes through 3 main phases – the reconnaissance, field work and measurements, and, the office work.

(a) **Reconnaissance survey**

This is a pre-field work and measurement phase. It requires taking an overall inspection of the area to be surveyed to obtain a general picture before commencement of any serious survey. Walking through the site enables one understand the terrain and helps in determining the survey method to be adopted, and the scale to be used. The initial information obtained in this stage helps in the successful planning and execution of the survey.

(b) **Field work and measurement:**

This is the actual measurements in the field and the recordings in the field notebook. To get the best results in the field, the surveyor must be acquainted with the functions of the equipments and take good care of them.

(c) **Office work:** This is the post field work stage in which data collected and recordings in the field notebooks are decoded and used to prepare the charts, planes and maps for presentation to the clients and the target audience.

4. 0; **Textbooks and Refences**

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MODULE 2: CHAIN SURVEY

Unit 1 Meaning, purpose, suitability and equipment of chain survey

1. 0 Introduction

In this module, we begin an in-depth study of the various types of survey. The different type of survey depends on the equipment used and the desired level of accuracy.

2. 0 Objectives

- To enable students understand the meaning, purpose, suitability and equipments of chain survey.
- To expose the students to the various equipments used in chain survey.

3.0 Main Body

3.1 Definition/Meaning

This is the simplest form of survey where only the linear measurements are made while the angular, measurements are ignored. It is named after the principal instrument previously in used for survey operations – the chain. Although a more flexible tape now replaces the chain, the name is still community used to refer to the type of survey that explains the taking of linear measurements in the field. Chain survey is suited for small areas that need the filling of geographical details.

3. 2 **Purpose , suitability and unsuitability of chain survey:**

Agor (1993) examines the purpose, suitability and unsuitability of chain survey as follows:

Purpose: Chain survey is carried out to: obtain data further accurate description of property boundaries; to prepare an accurate plan of a plot of law and determine its area; to delineate the boundary of a piece of land in a previously surveyed location; to share a piece of land into smaller units; to obtain data for engineering project l(e.g. road and rail alignment).

Suitability: Chain survey is suitable on an open and well level piece of land with non-simple details; where large scale plans/maps are need (e.g. site of a housing estate); and, where the area is small in extent.

Unsuitability: Chain survey is not suitable for large areas that are crowded with many details and wooded and undulating areas.

3.3. **Principles of Chain Survey:**

Chain survey is mainly concerned with the measurement of distances hence the main equipment used include:

a) Chain

b) Tape

c) Arrows

d) Ranging poles

e) Plumb bob

f) Trough compass

a) **Chain**

A chain is made up of steel or iron pieces of wire known as links which are joined together with circular or oval rings that make for flexibility. It has a brack handle at both ends which is part and parcel of the total length of the chain known as chain length. A typical chain is made up of 100 links and has a bran tag at every 10th link called a teller. This makes for operating of length as the letters are numbered and differentiated from the next one for easy identification.

Different kinds of chains exist including Equnter’s chain, Engineers chain and metric chains.

Generally, chains have been replaced with chains for linear surveys. Chains are now being studied to get the historical perspective of the development of survey equipments over the years.

b) **Tape**

Tapes have replaced chains in recent years because they are light, portable and flexible. Different types of tapes exist aid they are classified according to the materials they are made of hence we have cloth or line tape, metallic tape, steel tape and in car take.

i) **Cloth Tape or Linen Tape:**

Generally between 10m to 30m in length, these are made of linen cloths that are varnished to resist moisture. It aspiring at the end of the tape that has its length included in the total length of the tape.

The main limitation of cloth tape is that it stretching of the length can introduce errors in measurements. It is not as heavy and strong as chain or steel tape hence is likely to twist and tangle and does not remain straight in strong winds. Continuous usage can erase the figures.

ii) **Metallic Tape:** These are more durable them cloth tapes as they are made up of cloth that are reinforced with bran or copper wires.

Usually, between 20 to 30m, they come in a leather cases with winding mechanism. They can be used to take accurate measurement as each meter is divided into decimeters which is equally sub divided into centimeters.

iii) **Steel Tape:**

This is a fine steel ribbon used to provide measurement of superior accuracy than cloth or metallic tapes. With a bring ring at the end, whose length is included in the length of the tape, steel tapes are available in lengths of 10, 20, 30 and 50 meters.

iv) **Invar Tape:** This is made up of used primarily to obtain a high degree of precision, invar tapes are more expensive and softer than steel tapes. Also, it needs to be handled with great core to avoid bending.

v) **Steel Bands:**

Also called a band chain, it is made up of ribbon of steel with brass swivel handle at each end. The steel band is wound on either an open cross of metal reel. The steel band is used to obtain accurate measurements, it is lighter to handle than the chain, and its length is not stretched due to usage. However, it requires proper care as it can easily break. Also it must be oiled and cleared regularly to avoid rust.

(3) **Arrows or Chain Pins**

An arrow is a piece of steel and iron of about .4 - .5 meters in length bent at the top into a circle and with a posited end allow for easy penetration into the ground. It is used primarily for marking the end of chaining and temporary stations.

(4) **Ranging Pole as Rod:**

This is a pole of about 2 meters in length alternatively painted white and red and is pointed at one end. They are used stations and for ranging (is getting out straight lines). To do this two poles are fixed at the 2 stations or points and this enables one to measure along straight lines by placing a series of ranging poles along the route in order to get the straight lines.

(5) **Optical Squares:** This is an optical instrument used to take offsets at right angles from the chain lines. Offsets are measurements made from outside the survey line of triangulation or traverse skeleton to a property boundary or fence or wall offsets enable one fix points details in relation to the chain line.

(6) **Cross Staff:** This is a simple form of optical squares used for the same purpose of fixing offsets. Constructed in the form of a wind vane, consisting of a cross with vertical ends with slits. Offsets are taken using the lines of sight which cross at right angles.

(7) **Trough Compass:** To determine the North – South line.

4. 0; **Textbooks and References**

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Unit 2 Processes of Chain Survey and sources of error

1.0 Introduction

In this unit we move ahead to show the processes involved in a chain survey operation , then explain the main sources of errors and waus of overcoming them.

2. 0. Objectives.

- To enable students understand the processes of chain surveying
- To help students identify and explain the sources of error of chain surveying and ways of overcoming them

3.0 Main Body

3.1 **Processes of Chain Survey**

The chain survey process follows the procedure already explained in Module 1. These include: -

Reconnaissance survey , - Field work , and - Office work

In this section, the procedure will be explained under the following headings:

a) Reconnaissance

b) Ranging

c) Running of a chain line

d) Measurement of offset

e) Booking drying chaining

a) **Reconnaissance Survey**

This is the preliminary inspection of the area to be surveyed and in the process closing the main triangles by taking note of corners and intersections. Furthermore, secondary lines of the survey framework are noted. Also, the scale is determined by getting an estimate of the maximum dimensions of the area by pacing and measurements.

b) **Ranging:** Ranging involves placing ranging poles along the route to be measures so as to get a straight line. The poles are used to mark the stations and in between the stations.

c) **Running a chain line:**

As explained earlier, the use of tapes have now replaced the chain, the chaining is still being used to mean the process of measurement of the sides of the triangles. To measure, two team leaders called a leader and a follower are chosen. Taking a number of arrows and holding the handle of the tape, the leader starts the chaining process by walking along the line towards the end of the line learning behind the follower holding the tape, with signals from the follower, the leader extends the tape along the line, aid places an arrow where the tape ends. The procedure is continued until the whole line is coursed.

d) Measurement of offsets

As the chaining progresses, the leader leaves the tape on the ground for the offset and booking teams to do their work.

Offsets are measurements made outside the main survey line. Where the appropriate equipments are not available, a simple method of taking measurements along the survey line at two points to the object is used.

e) **Booking**

In order to avoid confusion after the measurements in field care must be taken to record neatly in a field notebook where the original field notebook cannot be accessed, an improvised version can be made by ruling 2 lines about 1cm apart in the middle of an ordinary exercise book. Booking takes place measurement is done along the line from the bottom of the page to the top. Right and left enters on the page is made to correspond with the right and left measurements on the ground. It is advisable that each chain lien should be recorded in a separate page.

3.2 Sources of Errors in Chain Survey and Their Correction

The errors can be divided into three groups:

- Cumulative (systematic) errors
- Compensating (accidental) errors
- Gross Errors

3.2.1 **Cumulative Errors:**

Cumulative errors are said to be systematic errors as they are one-directional hence keep on accumulating as the survey progresses. If not checked they have serious implications to the accuracy of the survey. Errors in this class include incorrect length of the tape, page of the tape or the tape not being in line. Since the sources of these errors are known, they can be eliminated. They can either be positive or negative errors. While positive errors shortens the measurement (e.g. where the tape length is shorter than what it should be) while negative errors elongates the measurements (e.g. where the tape is longer than what it should be). Checking the equipment can eliminate these errors.

3.2.2 **Compensating Errors:**

Compensating errors are said to be accidental errors hence cancel out and does not pose serious problem to the accuracy of the survey. They arise as a result of not being perfect in the use of the equipment or in the whole survey process. For example, if the pull exerted on the tape in either more than or less than what should be the case, faulty results be gotten. The effect can either be positive or negative.

3.2.3. **Gross Errors :**

These are mistakes that can be attributed to the inexperience of the team leaders. These are very serious errors which although are random in accordance may lead to faulty plans and maps if not checked. They include discontinuing the chain length (e..g where some arrows are cost or misplaced); misreading of the tape; reading tape upside down (e.g. taking 6 to be 9), etc. By taking the necessary precautions, these errors can be corrected.

3.3 **Overcoming obstacles during chaining**

Agor (1993) classified the various types of obstacles encountered in the course of chaining into three:

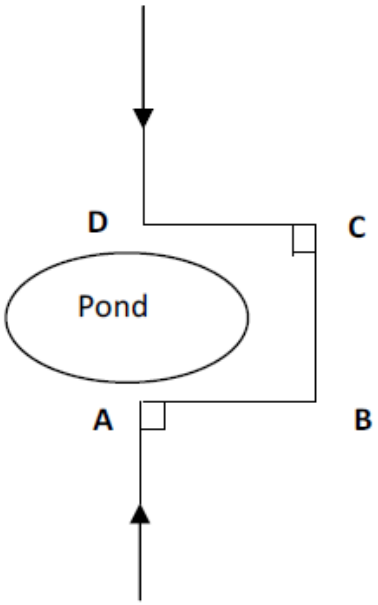
- Obstacles which obstruct ranging but not chaining
- Obstacles which obstruct chaining but not ranging
- Obstacle which obstruct both ranging and chaining

Obstacles that obstruct ranging but not chaining

Here, there is lack of inter-visibility between the ends of a chain line. This occurs in an undulating terrain.

Obstacles which obstruct chaining but not ranging. Water bodies like lakes, ponds and rivers are typical examples of obstacles in this category. It is possible to chain around these obstacles by using the following methods.

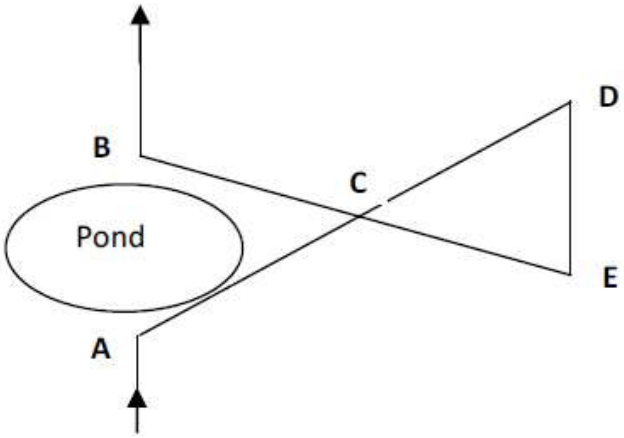
i. By constructing rectangles: Chaining had reached A and encountered an obstacle. To get to B, mark A and B with an arrow. Set of perpendiculars AC and BD high enough to clear the obstacles. Join and measure DC which now equals AB. This allows chaining to continue from B.



ii. By constructing similar triangles:

To continue chaining from B, fix a point C away from the obstacle. Range a pole at D to align with AC hence AC = CD. In line with BC range another point E in line with BC. Hence BC = CE.

Measure ED which equals AB hence chaining can continue from B.



3. **Obstacles which obstruct both ranging and chaining**

Chaining has reached B from A where an obstacle like a building has been reached. Erect equal perpendiculars AC and BD from A and B along the chain line. Along CD, range E and F beyond the obstacle. Set off perpendiculars EG and FH from E and F equal to AC. AS G and H are in line with AB, then CE equals AG.

By constructing similar triangles

Chaining had reached A and there is the need to overcome the obstacle created by the stream to really B.

Set out a perpendicular AC and mark the midpoint E. Set out another perpendicular CD so that D, E and B are in a straight line. The 2 triangles created are congruent hence CD = AB which is the required length hence chaining can now proceed from B.

4. 0; **Textbooks and Refences**

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MODULE 3 COMPASS SURVEY

Unit 1 Meaning and types of Compass Survey

1.0 Introduction

Another type of survey instrument that forms the subject of this section is the compass. Here, we will explain the meaning, types of compass survey and also introduce and discus the concept of bearing.

2.0 Objectives

- To introduce the students to the meaning and types of compass survey
- To enable students understand the concept of bearing.

3.0 Main Body

3.1 Meaning and types of compass survey

In compass survey, the direction of the survey line is measured by the use of a magnetic compass while the lengths are by chaining or taping. Where the area to be surveyed is comparatively large, the compass survey is preferred, whereas if the area is small in extent and a high degree of accuracy is desired, then chain survey is adopted. However, where the compass survey is used, care must be taken to make sure that magnetic disturbances are not present.

The compass the 2 major primary types of survey compass are: the prismatic compass and surveyors compass

3.2 Prismatic Compass

Invented in 1814, the prismatic compass consists of a small circular box of about 100m. It can either be used as a hand instrument or mounted on a tripot; and is very useful in a situation where rough surveys are needed i.e. where the accuracy of the survey is not the main consideration but the speed. The main parts of a prismatic compass are: compass box, lifting lever, needle, Agate cap, Glass cover, magnetic needle, graduated ring, prism, prism cap, sighting slit, lifting pin, coloured glasses, focusing screw, object hair – vane; horse hair, reflecting mirror, brake pin and spring brake.

Prismatic compass is useful for filling in details in a survey and in places where the ground does not allow the use of chaining. It is used by the military for reconnaissance survey, might motility and for sketching along roads or rivers.

However, while making observation with a prismatic compass care must be taken to avoid local attractions. Also, keys, pins and other metallic substances must not be brought near the compass.

3.3 Surveyor's Compass

Similar to the prismatic compass but with few modifications, the surveyors compass is an old form of compass used by surveyors hence the name. it is used to determine the magnetic bearing of a given line and is usually used in connection with the chain or compass survey.

3.4 Bearing

The bearing is the angular direction measured clockwise starting from North with reference to the observer. The reference North may be true or magnetic. While the true bearing is the

angular direction measured in a place with the direction of true or geographical north; the magnetic bearing is the angle which it makes with the direction of Magnetic North measured in the clockwise direction.

3.4.1 Difference between The Prismatic And Compass Bearing

The difference can be shown as follows:

Prismatic Compass	Surveyors Compass
1. The magnetic needle and the graduated dial are attached together while the prism and the box rotate	1. The magnetic needle remains stationary while the graduated dial rotates with respect to the needle.
2. Readings are taken by looking through the prism eye hole from the south end of the compass	1. Readings are taken by looking on the dial immediately between the North end of the magnetic needle.
3. The graduations are graduated in clockwise direction.	3. The graduations are method so as to increase in the counter clockwise direction.
4. The zero of the graduated scale is marked.	4. The zero is fixed below the North end.
5. The position of the East and West are in their correct positions	5. The positions of East amd West are interchanged.
6. It gives whole circle bearings	6. The surveyor's compass usually indicates the reduced bearings.

Source: Okoroigwe (2002)

4. 0 **Textbooks and References**

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Unit 2 Back and Fore bearing; and Traversing with compass survey

1.0 Introduction

In this section, we will examine the back and fore bearing; and the steps to be taken when traversing with compass survey.

2.0 Objectives

- To enable students demonstrate back and fore bearing.
- To expose the students to traversing with compass survey.

3.0 Main Body

3.1 Back and fore bearing

Fore bearing is the compass bearing of a place taken from a status to the other in the direction that the survey is being carried out. The back bearing in the other hand is the bearing in the opposite direction i.e. the bearing taken backwards from the next station to its preceding station that the fire bearing was taken. The difference between BB and FB is always 180^0.

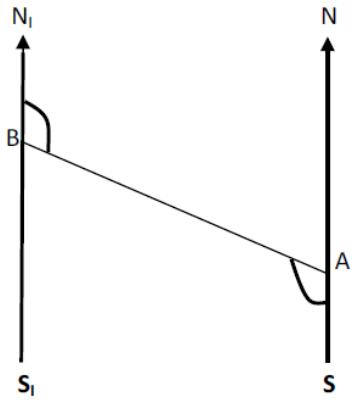

Fig. 3: 1 Back and fore bearing

If B is sighted from an observer at A, and the N/S and N_1S_1 are the magnetic NS lines, then

Forward bearing (FB) = < N A S + < S A B

Back bearing BA = < N_1 B A

:. Back Bearing BA = Forward Bearing AB - 180^0

If the observer relocates to B and observers B, then forward bearing (FB) BA = < N_1 BA and back bearing (AB) = < NAS + SAB. Hence, we can conclude that Forward Bearing = N_1 B A + 180^0. As a general rule, if the Fore Bearing is less than 180^0, add 180^0 to get the Back. Bearing, and if the Fore Bearing is greater than 180^0, then subtract 180^0 to get the Back Bearing. Traversing and plotting with the prismatic compass.

3.2 **Traversing and plotting with the compass survey**

Traversing with the compass involves taking the bearing along a series of connecting straight lines and in the same time measuring the distances with the tape. The compass is read at each

point and a back bearing is equally taken to serve as a check. This continues until the traverse class.

Choosing a suitable scale, the traverse is then plotted taking into consideration the general shape of the area.

3.2 Error of Closure

A closed traverse when plotted from field observations, many not close due to some errors including that of observation, measurements or drawings. Hence, the last station does not coincide with the starting point. This discrepancy is called error of closure of closing error. This can be adjusted using the following procedure derived from Agor (1993).

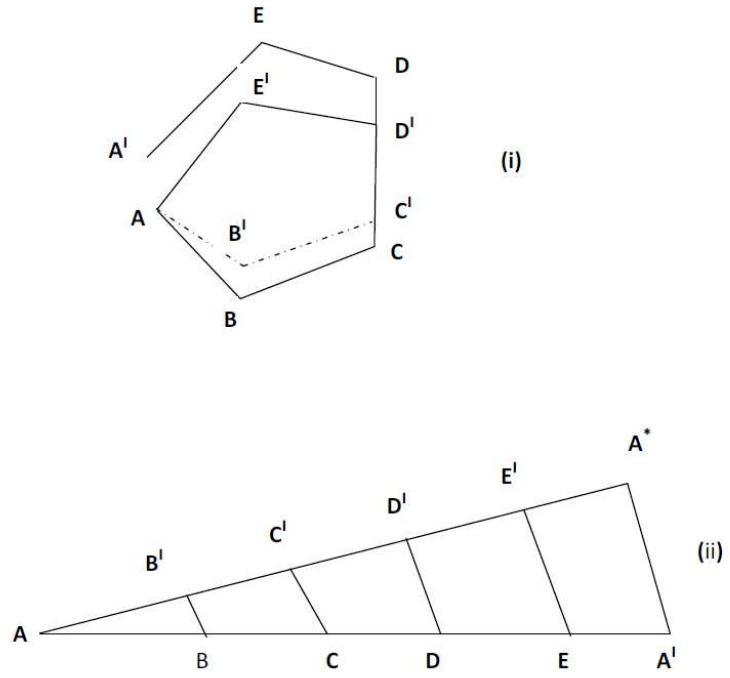

Fig. 3: 2 Error of Closure – the error (i) and Correction (ii)

Procedure:

1. Draw a straight lien A A^1 equal to the perimeter of the traverse to any suitable scale. Set off along it the distances AB, BC, CD, DE and EA^1 equal to the lengths of the sides of the traverse.

2. Draw A^1 A* parallel and equal to the closing error A ^{1}A.

3. Draw parallel lines through points B, C, D, and E to meet A A* at B^1, C^1, D^1 and E^1.

4. Draw parallel lines through the plotted stations B, C, D, E and plot the errors equal to B B^1, CC^1, DD^1 in the direction A^1 A.

5. Join the points A B C^1 D^1 E^1 A to get the adjusted traverse.

4. 0; **Textbooks and Refences**

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MODULE 4: LEVELING

Unit 1 Meaning, equipments and principles.

1.0 Introduction

We have so far been dealing with survey in an horizontal scale. We know that phenomena in space also exist in a vertical scale. In this module, we will examine leveling which enables us survey in a vertical scale.

2.0 Objectives

- To enable students comprehend the meaning and equipments used in leveling.
- To help students explain the basic principles of and terms used in leveling.

3.0 Main Body

3.1 Meaning of leveling

From most engineering surveys title road or rail construction, it is necessary to measure the elevation of points along the project. The act of establishing the elevation of points on or below the surface of the earth is called leveling. Leveling is therefore surveying is a vertical plane. An elevation of a point on the surface of the earth is actually the difference in attitude

between the point and some datum or base level. Hence, leveling makes use of a base level to determine the height of any point the sea level is the base level of topographic maps.

3.2 The Instruments

3.2.1 **The level**

The level is an instrument used to accurately determine the difference in elevation between two points on the earth's surface. By itself, it does not read or register heights but gives a horizontal line of sight so that in looking along it, places lying along the same height can be seen, varieties of levels exist and their difference lines in the level of complexity. Examples include water level and surveyor's level (Dumpy level).

The water level is made up of 2 glass tubes half filled with coloured water fitted ant a tripot when the two water levels are in line and one looks along a horizontal line of sight passing through the water surfaces, any thing are sees along this line are of the same level with one's eye and the water surface.

The surveyor's level consists of a bubble tube with a telescope attached.

3.2.2 Leveling Staff: This is a graduated wooden staff for reading vertical heights. Different types exist. Generally, the bottom of the staff represents the zero reading. The type of staff where that allows readings to be read directly is called the self-reading staff; while the long type that allows a more accrete reading to be made but which is long and cumbersome to handle (about 3m) is called solid staff. The folded or hinged are double 2m long staff that are hinged or folded together.

3.3 Principles of Leveling

The principle of leveling is based on the fact that if a level is placed between 2 points A and B. measurements obtained on a staff placed on these two points would mean the difference in height between the two points. This is because the readings are made from the same position along the same line of sight.

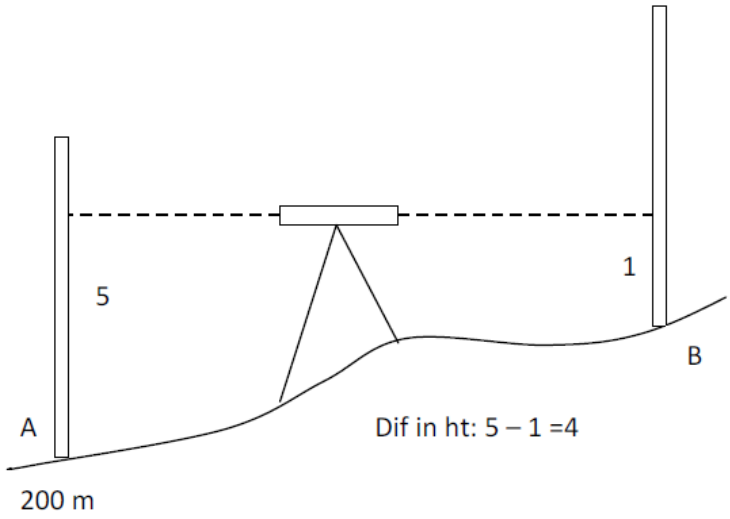

Fig.4.1: Principles of leveling (1)

In this case, the difference is 4m (5-1). Lower readings are usually made at higher grounds while higher figures are made at lower grounds. If the distances between the two points are long, it means the reading of the staff will not be done once but in stages. If A is 200m above sea level, B will be 200 + 4 = 204m.

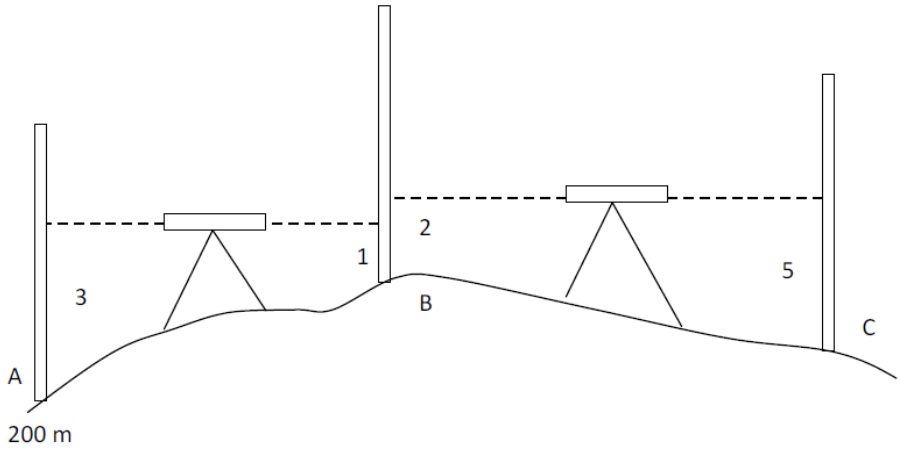

Fig. 4.2: Principles of leveling (2)

If the level is set between points A and B, the difference in height is 2m (i.e. 3-1m). The height of point B is then 200 + 2 (202) as B is in a higher elevation than A. One can remove the level and place it in between B and C. The new height of the staff is now 2m rat B and 5m at C. making it a difference of 3m. If means that the height of point C will be height of B (202m) – dif in height = 202 – 3m = 199m.

3.4 Major Terms

(1) **Datum or Datum:** This is an imaginary level surface to which all elevations are measured or referred to. The sea level is often used as the datum

(2) **Bench Mark (B.M):** This is mark of a point of known elevation which serves as a starting point of determining the elevation of other places. It is usually points that have been correctly surveyed and approved by appropriate government agencies. It is indicated by the letters BM and the height in meters (e.g. B.M. 203) cut in fixed materials.

(3) **Backsight:** This is the first reading on the staff placed on a benchmark at the commencement of levelling operation. It is first reading taken to a point whose height is either known or can be calculated.

(4) **Foresight:** Foresight is the reading taken at a point where the elevation is not yet known. It is the reading taken at a point whose height is required in order for the leveling operation to continue.

(5) **Reduced Level:** This is also called reduced height and is the calculated elevation of a place above or below sea level.

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Unit 2 Booking and Calculation of Reduced levels.

1.0 Introduction

This module concludes by examining the booking and calculation of reduced levels.

2.0 Objectives

- To enable students understand the procedure of booking and calculation of reduced levels.

3.0 Main Body

3.1 Booking and Calculation of Reduced Levels

Two methods are used to book and calculate the reduced level. These are: Rise and Fall Method; and, Height of Instrument or collimation method.

3.1.1 Rise and Fall Method

The rise and fall method uses differences in level between two consecutive points to obtain the rise or fall in elevation at that point.

In the diagram supposing the level is set up not X between points A and B. If A is located at a located at a point 200 meters above level and the difference in height is 2m, then the location B is 202m the covered. To book and calculated the level in a level notebook, 6 columns are drawn for the station, backsight, foresight, rise, fall reduced level and remarks. The calculation is performed step by step a shown hence the level at D is 201m.

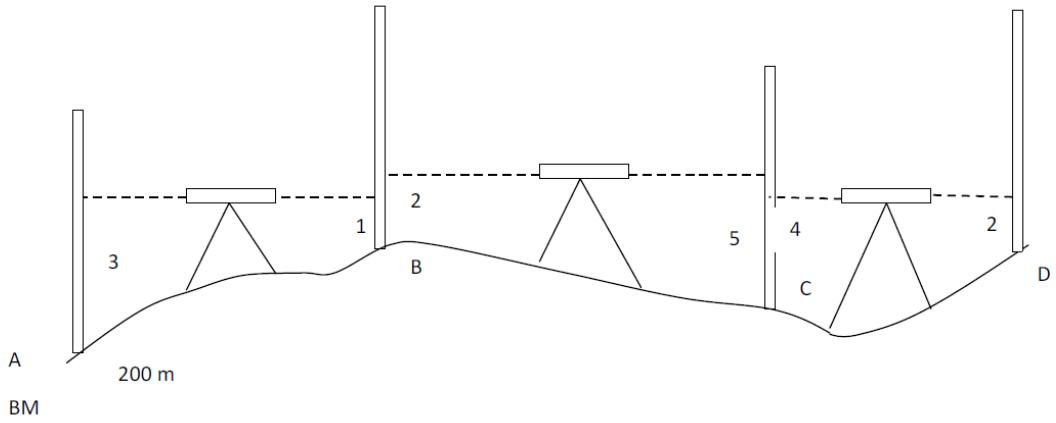

Fig. 4.3: Reduced Levels

Stations	**(BS)** **Back sight**	**(FS)** **Foresight**	**(R) Rise**	**(F)** **Fall**	**(RL)** **Reduced level**	**Remarks**
A	3	-	-	-	200	BM
B	-	1	2	-	202	-
C	2	5	-	3	199	-
D	4	2	2	-	201	End of line

To check the accuracy of the tabulation the formulae is used as follows:

$\sum BS - \sum FS = \sum R - \sum F =$ First Reduced Level – Last reduced level

= 9 – 8 = 4-3 = 200-201

= 1 = 1 = 1

NOTE: The sum of the back sight mines the sum of the foresight must be equal to the sum of the rise mine sum of fall must be equal to first reduced level mine last reduced level. In the above example, they are all equal meaning that the table was correctly compiled.

3.1.2 Collimation (Height of Instrument Method)

In this method, the back sight is added to the known elevation of the point to get the height of instrument. The foresight of the second point is then subtracted from the height of the instrument to obtain the reduced level or the elevation of the second point.

Level Station	BS	FS	Height of Instrument	RL(M)	Remark
A	3	-	203	200	BM
B	- 2	1 -	- 204	201 -	
C	- 4	5 -	- 203	199 -	
D	-	2	-	201	End of station

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MODULE 5: PLANE TABLING

Unit 1 : Meaning, Instruments and Operation of Plane Tabling

1.0 Introduction

So far, we have dealt with survey methods in which measurements and recordings are done in the field, with transcription and drawings being done in the office. In plane tabling the map is plotted in the field the same time measurements are done.

2. 0 Objectives

- To enable students understand the meaning of plane tabling and major instruments used to carry it out.
- To expose students to plane table operation.

3.0 Main Body

3.1 Meaning of Plane Tabling

In this method of surveying, observations and the plotting are done simultaneously on a plane table. The plane table combines a sighting device with a plotting scale.

Agor (1993) defines plane tabling as a graphical construction of straight lines, angles and triangles for plotting the ground detail points. It is based on the principle that the lines that join points on the plane table can be made to lien parallel to the corresponding lines that join points on the ground.

A plane tabling eliminates the field notebook and it is suitable for putting in details in a survey where the survey methods have been accurately fixed using theodolite or any other survey methods.

3.2 Instruments For Plane Tabling Survey

The following are the main instruments used for plane tabling.

3.2.1 Drawing Board or plane table:

A plane table is a wooden drawing board mounted on a tripod in such a way that it can be rotated in its vertical axis and can also be clamped into any required position. Plane tables come in different shapes and sizes but most have some refinements for leveling the table and a

compass. The plane table equally comes with a plumbing fork used for accurately centering the table on a location.

3.2.2 Sight rule or Alidade:

This is a straight edge fitted with sighting device that allows one have the line of sight. It is used for sighting objects and drawing rays along the edges. Two types of alidade are commonly is use: Plain Alidade and Telescopic Alidade. Plain Alidade is made up of a wooden or metallic rule of about 50-75cm day, with vanes at the ends. While, one of the vanes has a narrow slit, the other is open with a fine wire or horse hair. The Alidade sometimes comes with a circular bubble attachment for leveling the table.

The Alidade that comes with a telescope to increase the accuracy and the range of sighting is called telescopic Alidade.

3..2.3 **Others:** Drawing paper, compass

3.3 Plain Table operation

The tripod is unfolded and the plane table is clamped safely on it. The table is then set up using the following operational steps:

3.3.1 Leveling: Here, the table is placed and leveled over the station with the legs of the tripod spread out although eye estimate can be used for leveling for rough and small scale work, a spirit level is needed for accurate and large scale work.

3.3.2 Orientation: In this operation, the table is placed in such away that all the lines of the paper are parallel and corresponds to the lines on the ground. This is achieved by the use of a magnetic needle and by back-sighting.

3.3.3 Centering: The operation which allows the point on the paper representing the station is made to be vertically over the point on the ground is called centering. Centering may not be necessary in a rough and of the table is only required to be over the ground position.

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Unit 2 Methods of plane tabling

1.0 Introduction

We now conclude this module by examining the various methods of plane tabling.

2.0 Objectives

- To enable the students demonstrate the various methods of plane tabling.

3.0 Main Body

3.1 Methods of Plane Table Surveying

Four classes of plane tabling surveys are recognized: Radiation method; Intersection method; 3. Traversing method, and, Resection method.

3.1.2 Radiation Method

Here, the plane table is set up at one station which allows the other station to be accessed. The points to be plotted are then located by radiating rays from the plane table station to the points. After reducing the individual ground distances on the appropriate scale, the survey is then

plotted. This method is suitable for small area surveys. It is rarely used to survey a complete project but is used in combination with other methods for filing in details within a chain length.

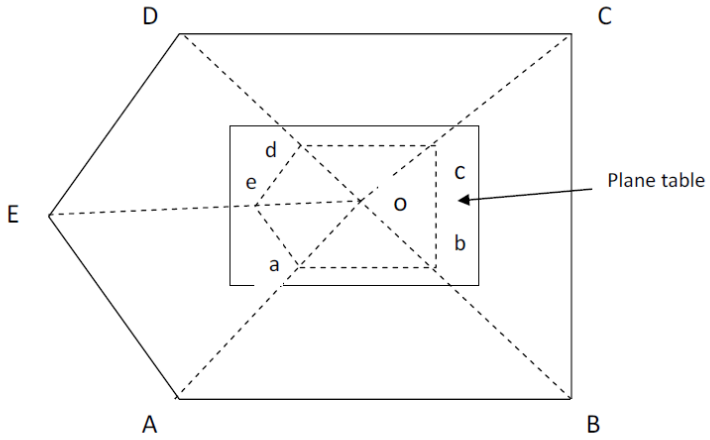

Fig. 5.1: Plane Tabling using Radiation Method

The following steps are taken:

1. Select at point O such that all the points are visible

2. Set up and level the instrument at O

3. From O align the Alidade and draw radial lines towards. The stations A, B, C, D and E.

4. Measure the distances OA, OB, OC, OD and OE: scale and draw Oa, Ob, Oc, Od and Oe on the paper.

5. Join the point a, b, c, d, and to give the outline of the survey.

3.1. 2 Intersection Method

In this method, two instrument stations are used with the distance between them called based line serving as the base to measure and plot the other locations:

1. 2 points A and B are selected from which the rest of the stations can be seen.
2. Set up and level the plane table at A and mark it as a in the paper to coincide with A on the ground.
3. Sight B, C, D and E with the Alidade from a and draw rays forwards them.
4. Measure AB, AC, AD and AE and using appropriate scale draw the corresponding paper distance.
5. Remove the equipment from A to B and repeat the procedure using B as the measuring station.

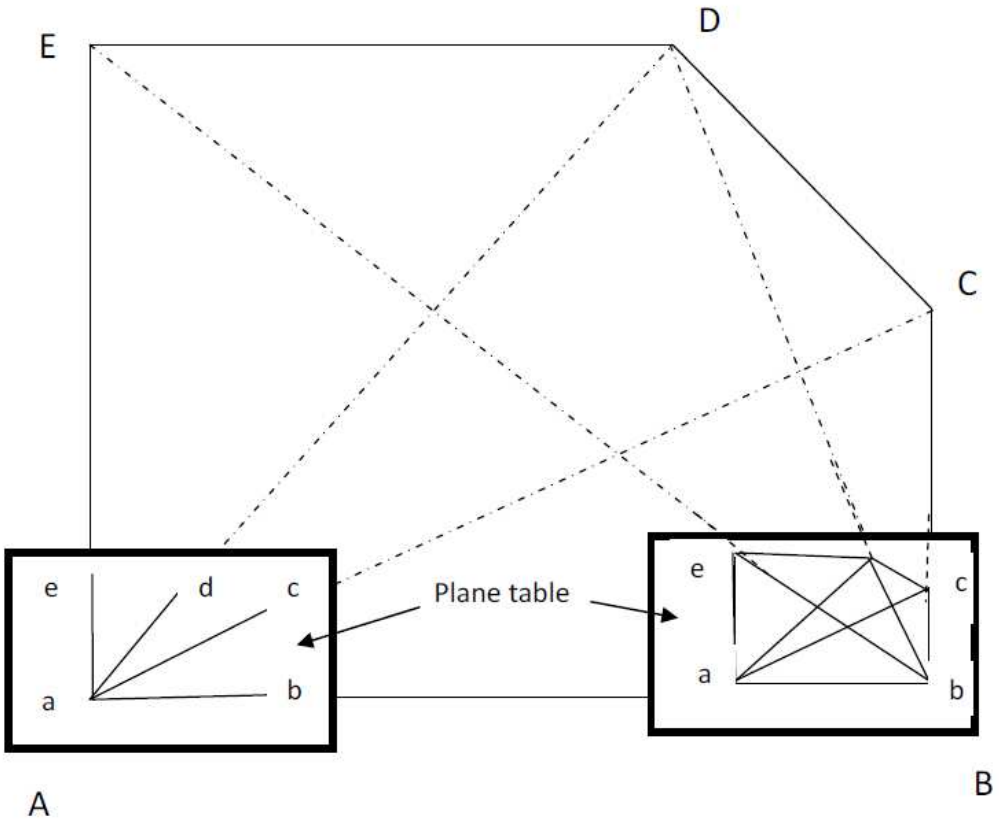

Fig. 5.2: Plane Tabling using Intersection Method

3.1.3 Traversing Method

This method resembles the compass traversing in which the plane table is set up at each successive and the back sight taken station until all the stations are covered.

PROCEDURE:

1. Set up the plane table over station A

2. With the Alidade at a sight B, measure AB and using appropriate scale draw the distance ab to correspond with ground distance AB.

3. Transfer the table to B and position b to B. from b sight, measures scale AB and insert as ab on the paper.

4. Relocate the station to C and sight D from there. Continue the procedure until all the stations are covered as shown in the diagram.

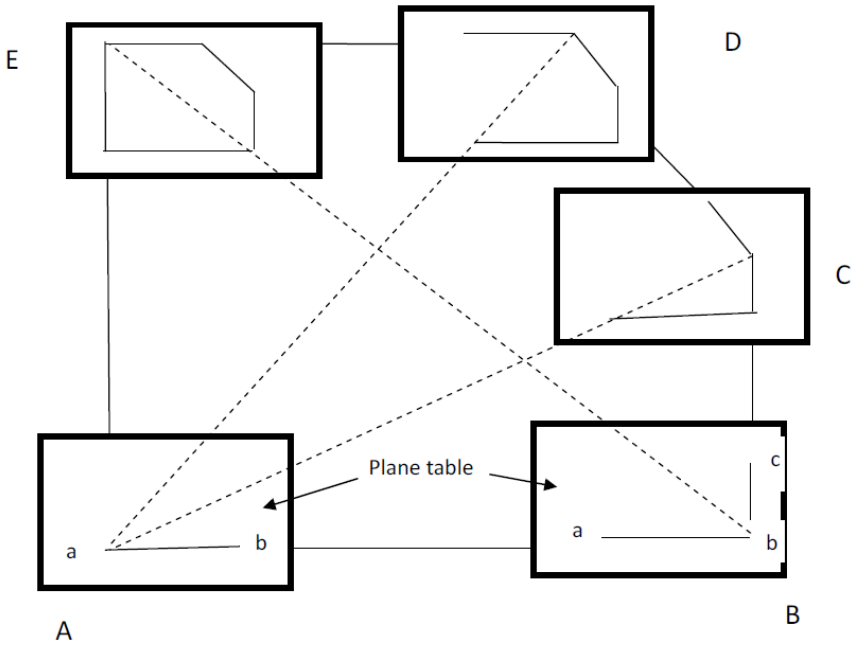

Fig. 5.3: Plane Tabling using Traversing Method

3.1.4. Resection Method

The resection method is used for locating the station points by means of drawing rays from the stations whose locations have already been plotted on the sheet. This carried out using various procedures:

* In the simplest method, select a base line AB on the ground, measure and plot ab on paper. Set up the plane table at B in a position where b corresponds to B.

* From b sight C and draw a ray to represent the approximate location of C locate this position as C.

* Set up the instrument at C and draw a ray to A, the tone position of C is the point of intersection made between the ray and that made from b.

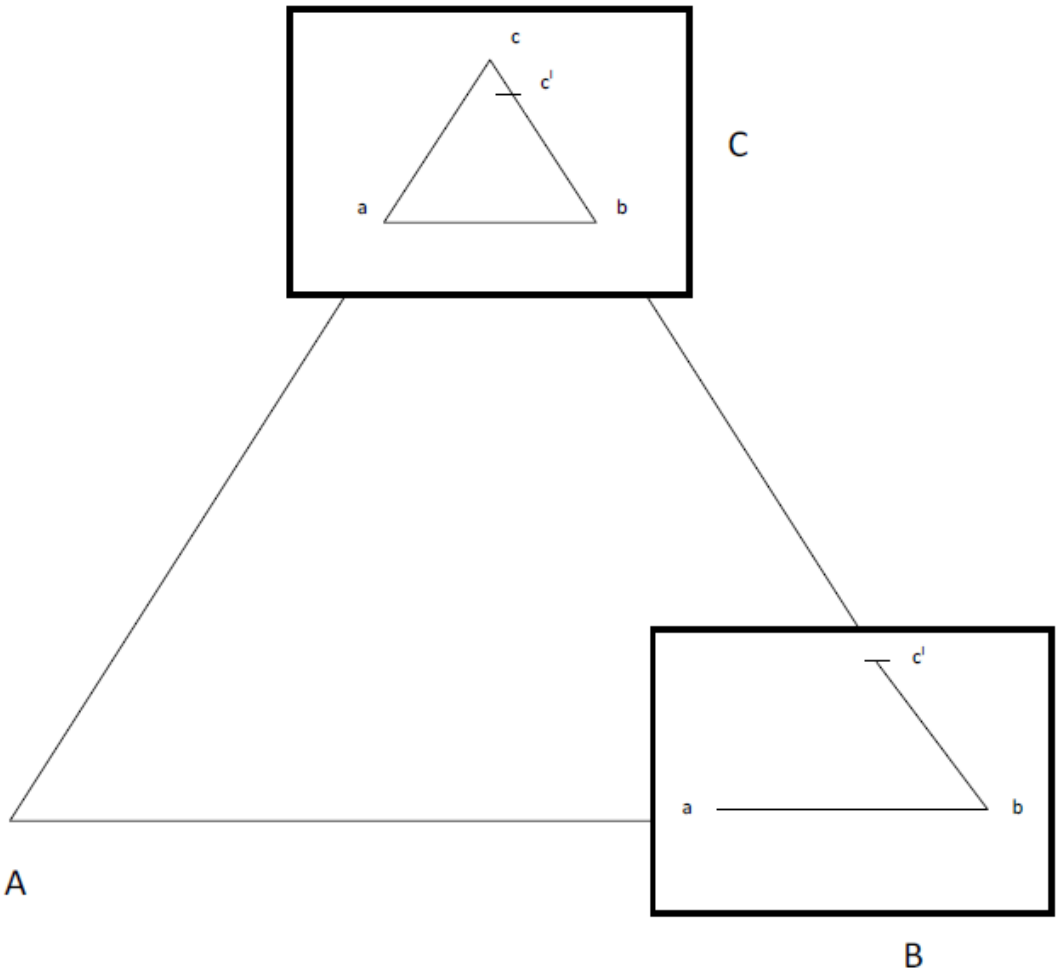

Fig. 5.4 Plane Tabling using Resection Method

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