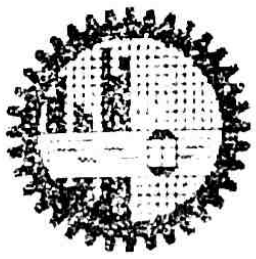

Lecture Note on

CE103
Surveying

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Note: Students are directed to read reference books given at the end of this lecture note. Please note that lecture note can be used as a guideline for this lecture.

1) Suitability of chain surveying.
2) Purpose of checkline and baseline and tie line
3) Purposes of reconnaissance in chain surveying
4) Considerations for fixing a station
5) Obstacles in chain surveying
6) Sources of errors
7) Principles of chain surveying
8) Steps in the field work
9) Problems in chaining
10) Diff. betⁿ Traverse & Chain Surveying

AFIA JAHIN
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* Class Test – 01
09.02.2014 (Sunday)
Chain Surveying (Pg-1-45)

* Class Test – 03
(Pg 94-114)
Tues/Wed – 01.04.14

* Extra class
Tuesday → 4:00pm

** Distinguish bet^{n} M·M & T·M →

Magnetic Meridian	True Meridian
(1) M·M does not pass through the true N & S always.	Always passes through the true N & S.
(2) Magnetic meridian sometimes acts as a true meridian if there is no magnetic attraction.	True meridian can never act as a magnetic meridian
(3) Freely floating and balanced magnetic needle is used to determine the M·M.	No magnet is used to determine the T·M.
(4) Magnetic meridian at a place changes with time.	True meridian does not change with time.
(5) Direct^{n} of magnetic meridian can be established by a magnetic compass.	The direct^{n} of true meridian can be established by astronomical observations.

** Distinguish bet^{n} True bearing & Magnetic bearing :—

True Bearing	Magnetic Bearing
(1) The true bearing of a line is always constant.	The Magnetic bearing of a line varies with time & place.
(2) No magnetic compass is used.	Magnetic compass is used to measure magnetic bearing.
(3) Horizontal angle makes with the true meridian.	Horizontal angle makes with the magnetic meridian.

Chapter 1: Fundamental Definitions and Concepts

1.1 Surveying
Leveling

1.2 Survey
- Plane Survey → Mean Surface of the earth is considered plane
- Geodetic Survey → Shape of the earth is taken into account

1.3 Classification

A) Based upon Nature of Field
1) Land Survey
   i) Topographic Surveys → Horizontal and Vertical Locations
   ii) Cadastral Surveys
   iii) City Surveying
2) Hydrographic or Marine Survey
3) Astronomical Survey

B) Based on Object
1) Engineering Survey
2) Military Survey
3) Mine Survey
4) Geological Survey
5) Archeological Survey

C) Instrument used
1) Chain Survey
2) Theodolite Survey
3) Traverse Survey
4) Triangulation Survey
5) Tacheometric Survey
6) Plane Table Survey
7) Photogrammetric Survey
8) Aerial Survey

* Balancing the traverse—

① Bowditch's Method:—

The basis of this method is on the assumptions that the errors in linear measurements are proportional to $\sqrt{l}$ and the errors in angular measurements are inversely proportional to $\sqrt{l}$ where,

l = length of a line.

The Bowditch's rule also termed as **Compass rule**, is mostly used to balance a traverse where linear & angular measurements are of equal precision.

The total errors in latitude & departure are distributed in proportion to the length of the sides.

The Bowditch's rule is —

$$\text{Correction to latitude (or departure) of any side} = \text{Total error in latitude (or departure)} \times \frac{\text{Length of that side}}{\text{Perimeter of traverse}}$$

Thus, If,

C_L = correction to latitude of any side
C_D = " " departure " " "
ΣL = total error in latitude
ΣD = " " Departure
Σl = length of perimeter

We have, $C_L = \Sigma L \times \frac{l}{\Sigma l}$

and $C_D = \Sigma D \times \frac{l}{\Sigma l}$

1.4 Principles of Survey

1) Location of a point by measurement from two points of reference
2) Working from whole to part

Chapter 2: Accuracy and Errors

Accuracy and Errors

2.1 Accuracy Depends on:
1) Precise Instruments
2) Precise Methods
3) Good Planning

2.2 Sources of Errors
1) Instrumental
2) Personal
3) Natural

2.3 Kinds of Error
1) Mistakes
2) Systematic Errors (Cumulative Errors)
3) Accidental Errors

Chapter 3: Linear Measurements

3.1 Different Methods
3.2 Direct Measurements: 1) Pacing; 2) Measurement with passometer; 3) Measurement with pedometer
4) Measurement by odeometer and speedometer; 5) Chaining

** Comparison among diff. types of traversing :-

Basis	Chain Traversing	Chain & Compass	Transit Tape	Plane Table
(1) Instrument	Chain & tape	Chain or tape & a compass	Theodolite & compass	a drawing board, tripod stand, alidade, trough compass, plumb bob, U fork, spirit level, chain or tape, drawing sheets.

Chain Surveying

Prof. Dr. M. Shariful Islam

** Most of the geometrical shape have —

i) Length &

ii) Angle

** Only square & triangles need only length.

** For surveying we can do —

1) Only Linear Measurement

2) " Angular "

3) Both Linear & Angular "

**Q. Compare chain surveying with traverse surveying.

Basis	Chain Sur.	Traverse Sur.
(1) Suitability	For small projects.	For large projects
(2) Measurement	Only Linear measurement.	Both linear & angular measurement.
(6) Geo. figure	requires a particular geo. figure	requires no particular geo. figure
(3) Accuracy	Less accurate	More accurate
(7) Check line	Check line is necessary.	Check line is not necessary.
(4) Instrument	Chain or tape	Compass or theodolite
(5) Classification	No classification	Classified in two groups

** Advantages, Disadvantages & Limitations of Chain Surveying.

** Disadvantages are not Limitations.

** In surveying two things are imp. —

(1) Mistake — unintentionally done

(2) Errors — intentionally done / we know about it / it is predicted to be happened.

e.g. Chain is metallic. suppose — a chain is 20' long at 20°C. But with the increase or decrease in temp., the length of the chain will be more or less. This is called errors.

** Using mathematical calculation → errors can be prevented.

** Being cautious, careful, physically & mentally sound → mistakes can be minimized.

* For surveying a project, we can select a particular method, one combination of methods or a part of a method.

SURVEYING

Q. What is surveying? What are the main objectives?

Surveying is the art of determining the relative position of points on, above or beneath the surface of the earth by means of direct measurements of distance, direction or elevation. It also includes the art of establishing points by predetermined angular and linear measurements. The application of surveying requires skill as well as the knowledge of mathematics, physics and some astronomy.

** The main objective of surveying is to prepare the map of the surroundings of the projects.

** The success & unsuccess of any project depends on surveying.

** In any project → 1st step = surveying
2nd " = preparing map

** Engineering purpose is to make any project ECONOMIC & SUSTAINABLE.

** That type of design of any project is perfect which is OPTIMUM & ECONOMIC.
e.g. For protecting 6.0 richter earthquake, the designed building should only be perfect for 6.0 richter, not more or less than that.

Based on the instruments or methods employed:

1. Chain Surveying
2. Theodolite Surveying
3. Traverse Surveying
4. Triangulation Surveying
5. Tacheometric Surveying
6. Marine or Hydrographic Survey
7. Photographic Surveying
8. Ariel Surveying

❖ **Definition:** (chain Surveying)

Chain surveying is that type of surveying in which only linear measurements are made in the field. with the help of chain or tape.

❖ **Suitability:**

Q. For what type of projects chain surveying is suitable??

This type of surveying is suitable for surveys of small extent on open ground to secure data for exact description of the boundaries of a piece of land or to take simple details. It is not suitable for crowded or risky area.

❖ **Principle:**

Q. Compare the principle of chain & traverse surveying.

Q. Why only triangles ?? → Here we must use linear measurement & Δ is the only shape which we can plot by measuring length only.

The principle of chain survey is to provide a skeleton or framework consisting of a number of connected triangles, as triangle is the only figure that can be plotted from the lengths of its sides measured in the field. To get good results in plotting, the framework should consist of triangles which are as nearly equilateral as possible.

Squares can also be plotted by measuring only length but it is not suitable for every case.

Q. Why are there so many different methods of surveying??

Instruments for Chaining:

The various instruments used for the determination of the length of line by chaining are as follows:

I. Chain
II. Tape
III. Pegs
IV. Arrows
V. Ranging rods
VI. Offset staff/rod
VII. Optical square
VIII. plumb Bob

Q. What are the factors for choosing type of surveying?
— There are 4 imp factors for choosing types of surveying —
1) Size of the project
2) Importance
3) Time Available
4) Cost / Budget

Q. What is ranging ??

Q. Write down the uses of the instruments of chain surveying.

** In case of surveying, objects around that particular place will also be located

While measuring, if the length of the survey line is less than the length of the chain, there will be no difficulty. If, however, the length of the line exceeds the length of the chain, some intermediate points will have to be established in line with the two terminal points before starting chaining. The process of fixing such intermediate points is called RANGING.

Uses and working principle of the these instrument are following.

I. CHAIN:

* Straight links of galvanized mild steel
* three circular or oval wire rings at the end
* Brass handle with swivel joint.

Chains are formed of (2) straight links of galvanised mild steel wire bent into rings at the ends and joined each other by three (3) small circular or oval wire rings. These rings offer flexibility to the chain. The ends of the chains are provided with brass (5) handle at each end with swivel joint, so that the chain can be turned without twisting. The length of a link is the distance between the centres

How measured

* length of a link → distance bet^n the centers of 2 consequtive middle rings.
# length of chain → the outside of one handle to the outside of the other.

of two consecutive middle rings, while the length of the chain is measured from the outside of one handle to the outside of the other handle.

There are various types of chains in common use.:
They are -

i. Metric chains
ii. Gunter's chain or Surveyor's chain
iii. Engineer's chain
iv. Revenue chain
v. Steel band or band chain.

i. Metric chains -

Metric chains are generally available in lengths of 5, 10, 20 and 30 meters. Fig shows 5, 10, 20, 30 meter chains.

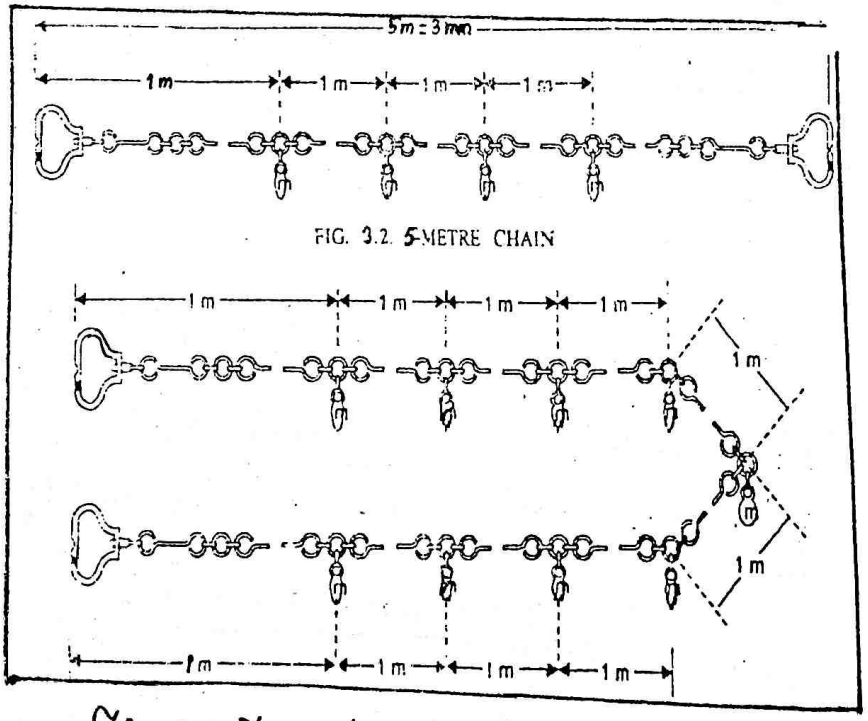


FIG. 3.2. 5-METRE CHAIN

Fig: 5-metre and 10-metre chain

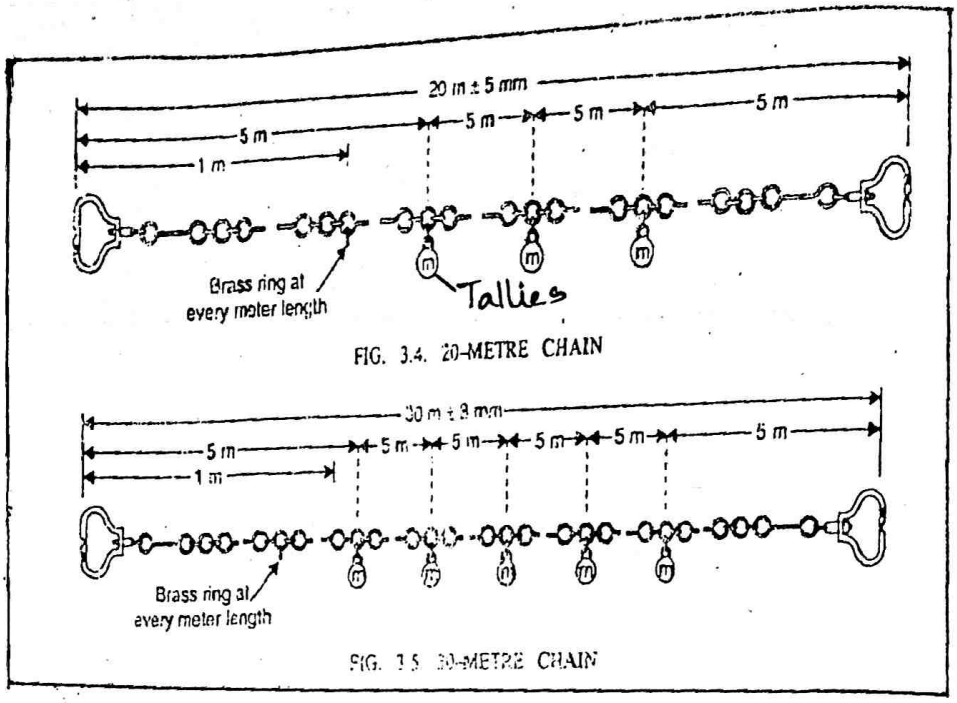


Fig: 20-metre and 30-metre chain

* For 5 & 10 m Length → tallies are every meter length

To enable the reading of fractions (1) of a chain without much difficulty, tallies are fixed at every meter length for chains of 5m and 10m lengths and at every five metre length for chains of 20m and 30m lengths. In the case of 20m and 30m chains, (2) small brass rings are provided at every meter length, except where tallies are attached. The shapes of tallies for chains of 5 and 10 m lengths for different positions are shown in fig. To facilitate holding of arrows in position with the handle of the chain, a groove is cut on the outside surface of the handle. The tallies used for marking distances in the metric chains are marked with the letter 'm'

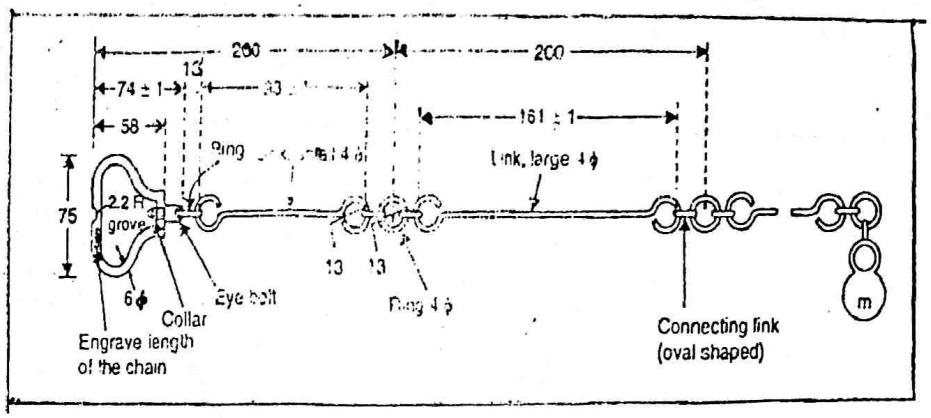
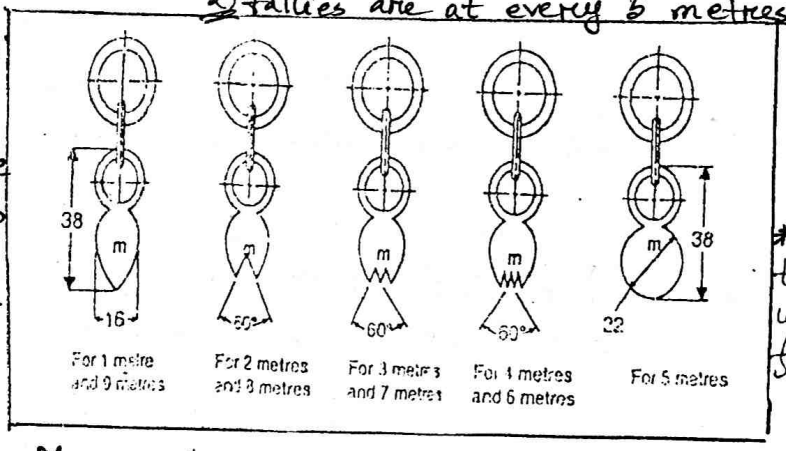


Fig: Details of a metric chain

in order distinguish them from non-metric chains. The length of chain, 5m., 10m, 20m. or 30 m as the case may be., are engraved on both the handles to indicate the length and also to distinguish the chains from non-metric chains.

* For 20 & 30 m length → 1) small brass rings at every meter except tally's place.
2) tallies are at every 5 metres length.

** Groove → it is cut on the outside surface of the handle → it's use is to hold arrows in position with the handle of the chain.



* Tallies are used for marking distances.
** In metric chain tallies are marked with "m" for diff. from non-metric chain.

Fig: Shapes of tallies for 5m and 10m chains

**66' long → 100 links → each link is 0.6'/7.92".
**66 is convenient for land measurement

ii. **Gunter's chain or Surveyor's Chain –**

A gunter's chain or surveyor's chain is 66 ft long and consists of 100 links each link being 0.6 ft or 7.92 inches long. The length of 66 ft was originally

** 10 square chains = 1 acre
** 10 Gunter's chain = 1 furlong
** 80 " " = 1 mile
** 8 furlong = 1 mile

adopted for convenience in land measurement since 10 square chains are equal to 1 acre. Also, when linear measurments are required in furlongs and miles, it is more convenient since 10 Gunter's chain = 1 furlong and 80 Gunter's chains = 1 mile.

iii. **Engineer's Chain** –

** total 100' long → 100 links → each link is 1' long.
** Brass tags → at every 10 links → indicates the no. of 10 link segments bet^n the tag & end of the chain.

The engineer's chain is 100 ft long and consists of 100 links, each link being 1 ft long. At every 10 links, brass tags are fastened with notches on the tags indicating the number of 10 link segments between the tag and end of the chain. The distance measured are recorded in feet and decimals.

** distance measured → recorded in feet & decimals.

iv. **Revenue Chain** –

** 33' long → 16 links → each link $2\frac{1}{16}$' long
** mainly used for "CADASTRAL SURVEY."

The revenue chain is 33 ft long and consists of 16 links, each link being $2\frac{1}{16}$ ft long. The chain is mainly used for measuring fields in cadastral surve

v. **Steel band or band chain** –

** long narrow strip of blue chain — width 12 to 16 mm — thickness 0.3 to 0.6 mm.

The steel band consists of a long narrow strip of blue steel, of uniform **width of 12-16 mm** and **thickness of 0.3 to 0.6 mm.** Metric steel bands are available in

**availabale length → 20/30m ; **brass studs at every 20 cm & numbered at every metre.
**1st & last links are subdivided into cm & mm.

lengths of 20 or 30 m. It is divided by brass studs at every 20 cm and numbered at every metre. The 1st and last links are subdivided into cm and mm. Alternatively, in the place of putting brass studs, a steel band may have graduation etched as meters, decimeters and centimeters on one side and 0.2 m links on the other. For convenience in handling and carrying, steel bands are almost invariably wound on special steel crosses or metal reels from which they can be easily unrolled.

**main disadvantage is — it is easily broken and difficult to repair.

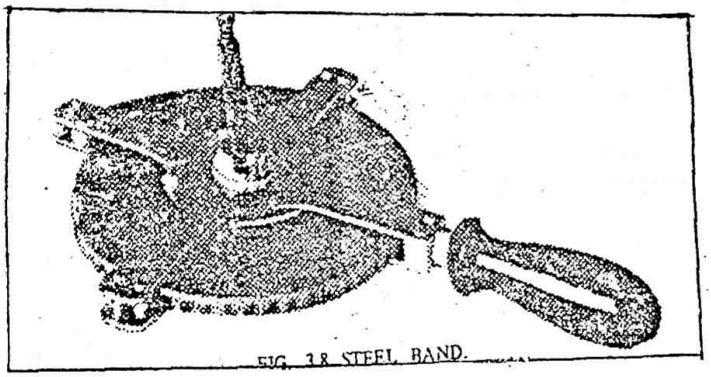


Fig: Steel Band.

For accurate work, the steel band should always be used in preference to the chain; but it should only be placed in the hands of careful chainmen. A steel band is lighter than the chain and easier to handle. It is practically unalterable in length, and is not liable to kinks when in use. Its chief disadvantage is that it is easily broken and difficult to repair.

II. **TAPES :** → are used for more accurate measurement.

Tapes are used for more accurate measurements and are classed according to the material of which they are made, such as follows :

i. cloth or linen type tape.
ii. metallic tape
iii. steel tape
iv. invar tape

i. **Cloth or linen tape :** ** used for taking comparatively rough & subsidiary measurements such as OFFSETS.

cloth tapes of closely woven linen, **12 to 15 mm wide varnished to resist moisture**, are light and flexible and may be used for taking comparatively rough and subsidiary measurements such as offsets. A cloth tape is commonly available in lengths of 10 meters, 20, 25 and 35 metres, and in 33 ft, 50 ft, 66 ft and 100 f

The end of the tape is provided with small brass ring whose length is included in the total length of the tape.

ii. **Metallic tape :** ** made of varnished strip of water proof linen interwoven with small brass, copper or bronze wires and does not stretch as easily as a cloth tape.

A metallic tape is made of varnished strip of water-proof linnen interwoven with small brass, copper

or bronze wires and does not stretch as easily as a cloth tape. [Usefulness/Advantage:- Since metallic tapes are light and flexible and are not easily broken, they are particularly useful in cross-sectioning and in some method of topography where small errors in length of the tape are of no consequence.] Metallic tapes are made in lengths of 2, 5, 10, 20. 30 and 50 metres In the case of tapes of 10, 20, 30 and 50 m lengths of a metal ring is attached to the outer ends and fastened to it by a metal strip of the same width as the tape

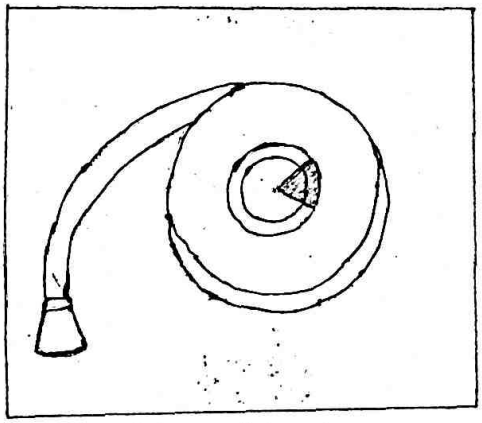


Fig: Metallic tape

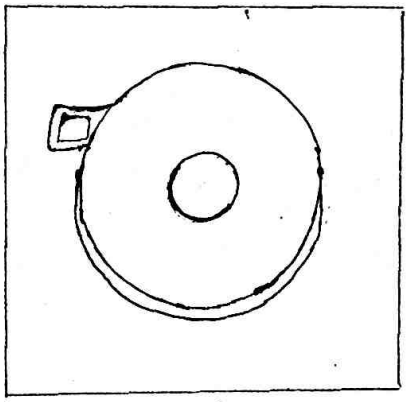


Fig: Steel tape

iii. **Steel tape:**

Steel tapes vary in quality and accuracy of graduation. A steel tape consists of a light strip of width 6 to 10 mm and is more accurately graduated.

Steel tapes are available in lengths of 1, 2, 10, 20, 30 and 50 metres. The tapes of 10, 20, 30 and 50 metre lengths are provided with a brass ring at the outer end, fastened to it by a metal strip of the same width as the tape. The length of the tape includes the metal ring. It is wound in a well-sewn leather case or a corrosion resisting metal case, having a suitable winding device. Tapes of longer length are wound on metal reel.

iv. **Invar tape:** **used for linear measurement of a very high degree of precision i.e. measurement of BASE LINES.

Invar tapes are used mainly for linear measurements of a very high degree of precision, such as measurement of base lines. The invar tape is made of alloy of nickel and steel, and has very low coefficient of thermal expansion. Another great advantage of invar is that bands and wires made of invar enable base lines to be measured very much more rapidly and conveniently.

** made of alloy of NICKEL & STEEL; very low coefficient of thermal expansion.

** great advantage — bands and wires made of invar enable to measure base lines much more rapidly & conveniently.

3. PEGS :

Wooden pegs are used to mark the position of the stations or terminal points of a survey line. They are made of stout timber, generally 2.5 cm or 3 cm square and 15 cm long, tapered at the end. They are driven in the ground with the help of a wooden hammer and kept about 4 cm proper projecting above the surface.

4. ARROWS :

** made of stout steel wire & generally 10 arrows are supplied with a chain.

Arrows or marking pins are made of stout steel wire and generally 10 arrows are supplied with a chain. An arrow is inserted into the ground after every chain length measured on the ground. Arrows are made of good quality hardened and tempered steel wire 4 mm in diameter. The length of arrow may vary from 25 cm – 50 cm. One end of the arrow is made sharp other is bent into a loop.

** Arrows — made of good quality hardened & tempered steel wire 4mm in diameter.
** Length → may vary from (25 – 50) cm.
** One end of the arrow is made sharp.

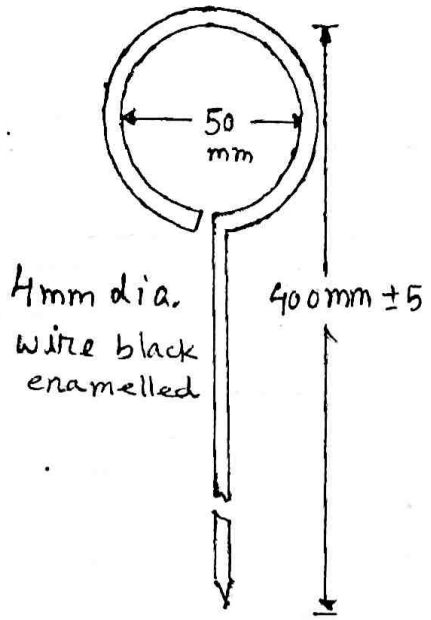


Fig: Arrow

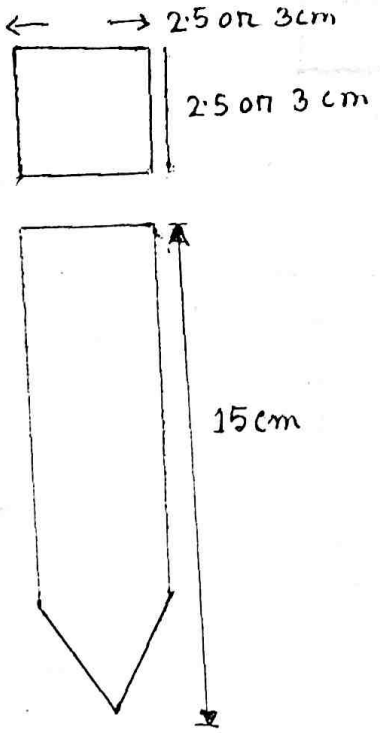


Fig: Wooden peg

5. RANGING RODS

Ranging rods have a length of either 2m or 3m, 2m height is being more common. They are shod at the bot with a heavy iron point and are painted in alternative bands, each band being 20cm deep so that on occasion the rod can be used for rough measurement of short lengths. Ranging rods are used to range some intermediate points in the survey line. They are circular or octagonal in cross section of 3cm nominal diameter. The rods are almost invisible at a distance of about 200 meters, hence when used

on long lines each rod should have a red, while or yellow flag.

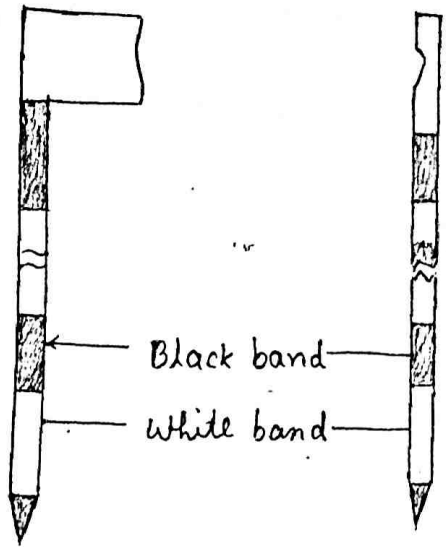


Fig: Ranging rod

Fig: offset staff

6. OFFSET STAFF / rod:

An offset staff is similar to a ranging rod and has a length of 3m. They are round wooden rods, shod with pointed iron shoe at one end, and provided with a notch or a hook at the other. The hook facilities pulling and pushing the chain through hedges and other or obstructions. The rod is mainly used for measuring rough offset nearby. It has also two narrow slots passing through the centre of the section and set at right angles to one another. at the eye level. for aligning o the offset line

7. PLUMB BOB:

While chaining along sloping ground, a plumb-bob is required to transfer the points to the ground. It is also used to make ranging poles vertical and to transfer points from a line ranger to the ground. In addition it is used as centering aid in theodolites, compass, plane table and a variety of other surveying instrument

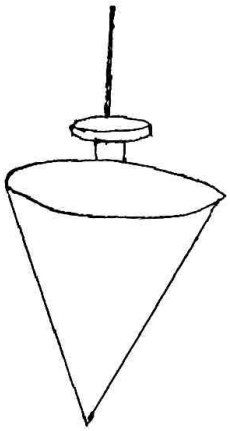


Fig: Plumb Bob

8. OPTICAL SQUARE:

Optical square is somewhat more convenient and accurate instrument than the cross staff for setting out a line at right angles to another line. Fig 4 illustrates the principle on which it works.

It consists of a circular box with three slits at E, F and G. In line with the openings

E and G1, a glass silvered at the top and unsilvered at the bottom, is fixed facing the opening E. Opposite to the opening F, a silvered glass is fixed at A making an angle of 45° to the previous glass. A ray from the ranging rod at Q passes through the lower

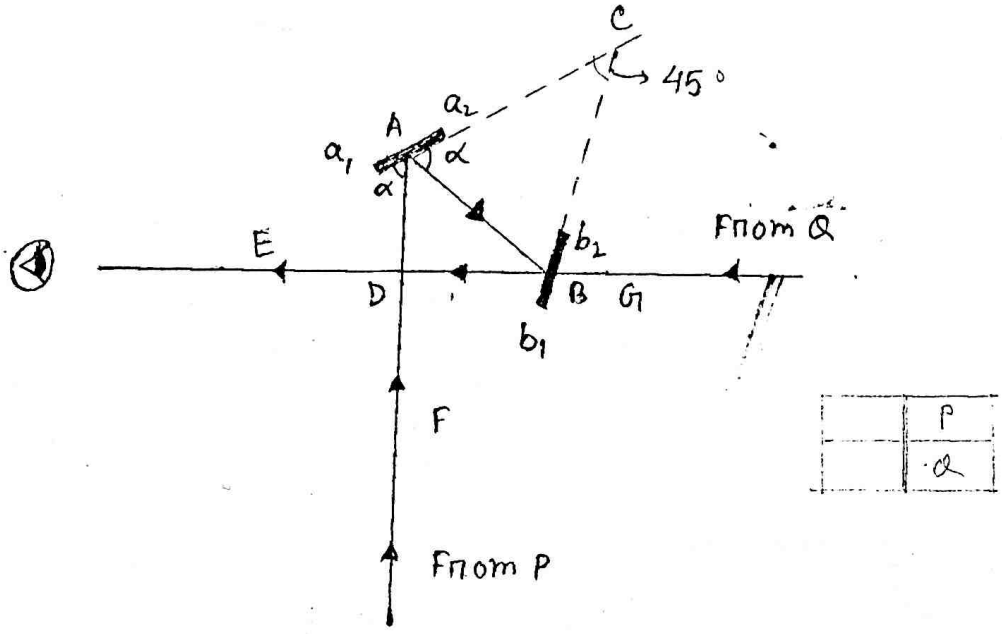
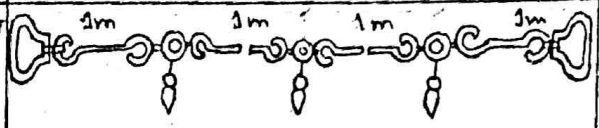
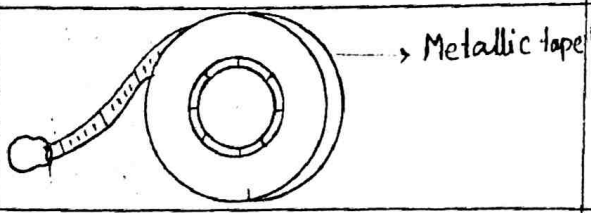
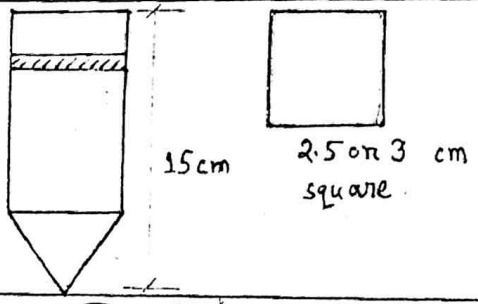
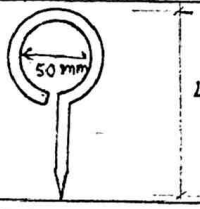
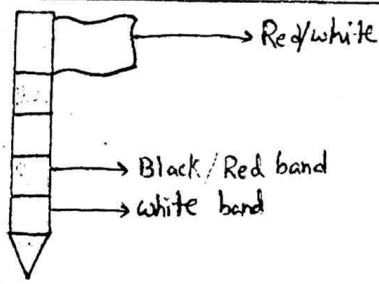
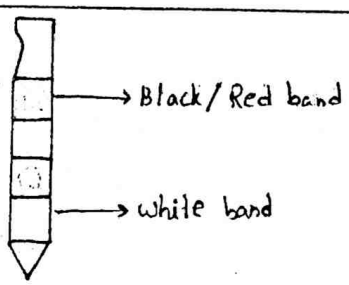
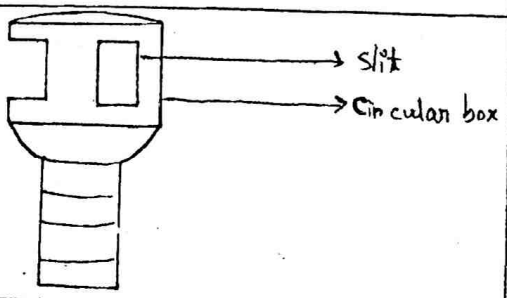
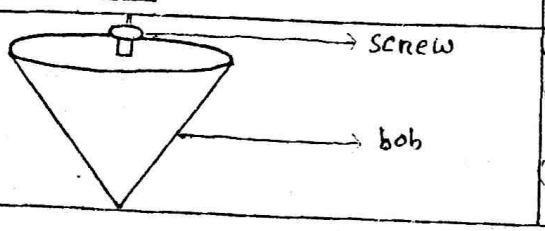


Fig: Optical Square.

unsilvered portion of the mirror at B, and is seen directly by eye at the slit.

Instruments under chain surveying

Name	Diagram	Purpose
1. Metric chain **Chain** 2. Surveyor's chain 3. Engineer's chain	 4- Meter chain	(i) to measure the distance of two points. (ii) to measure the area of land. (iii) to measure the angle between two lines.
Tape i) Cloth tape ii) Metallic tape iii) Steel tape iv) Invar tape		(i) can be used as a chain but its measurement is more accurate.
Pegs		(i) to mark the position of the stations or terminal points of a survey line.
Arrows		(i) can be inserted after every points of chain length which is measured on the ground.
Ranging rods		(i) to range some intermediate points in the survey line.
Offset staff		(i) for measuring rough offset nearly. (ii) the hook at one end of this staff facilities pulling and pushing chain through obstacles.
Optical square		(i) for setting out a line at right angle to another line.
Plumb bob		(i) to make ranging poles vertical (ii) can be used as centering aid in theodolite, compass etc. (iii) to transfer the points to the ground, while chaining in sloping ground

❖ Procedure:

The entire operation of chain survey can be divided into three major groups namely –

i. Field work
ii. Keeping of records in the field book
iii. Plotting of data to prepare maps

❖ Field Work:

It includes –

a) Reconnaissance
b) Marking and Fixing survey stations
c) Running survey lines.

Reconnaissance → its purpose is to get a general idea about the sight.

– A quick survey using simple instruments to know:

a) Topography
b) Probable alignments
c) Obligatory areas i.e. schools, mosques etc...which can't be uprooted.
d) Soil and drainage condition
e) Highest flood level
f) Availability of construction materials and labors
g) Land value for acquisition
h) Time required for construction
i) Slope of hills

Q. What are the purposes of reconnaisance?? (general)

Q. " " " " " " in a particular method??

(a) **Reconnaisance**

The first principle of any type of surv-ying is to work from whole to part. Before startin the actual survey measurements, the surveyor should walk around the area to fix best position of survey lines and survey stations. During reconnaisance, a refe-rence sketch of the ground should be prepared an general arrangement of lines, principal features suc as buildings, roads, canals, ditches, culverts etc. sh be shown. Before selecting the sta-tions, the surveyor should examine the intervisibility of stations and should note the position of bui-dings, roads, streams etc. He shou also investigate various difficulties that may arise and think of their solution.

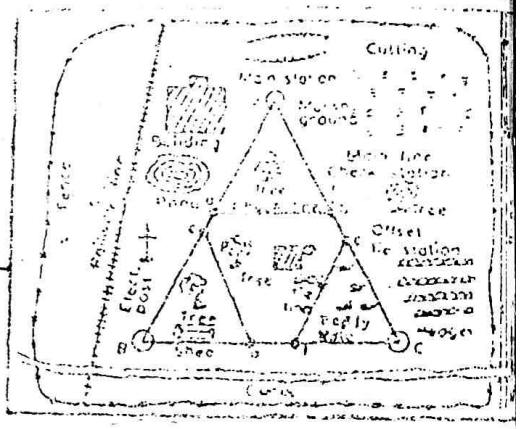


Fig. 2.1

Q. Write down the considerations for choosing survey stations.

(b) **Marking and fixing survey stations:**

The requirements for selection of survey stations, they should be marked to enable

them to be easily discovered during the progress of the survey. The marking of a station depends upon the following considerations:

(1) The triangle should be a well-defined one i.e. nearly equilateral triangle.

(2) Every main station should be visible from the other two.

(3) There should be minimum number of obstacles in ranging and chaining.

(4) The chain line should run near the boundary of the plot.

(5) The chain line should be as few as possible.

(6) The chain line should be over an approximately levelled ground.

(7) In case of chaining along the road, it is always better to run chains at one side of the roads so as to avoid ~~in~~ interruption of vehicles. It is better not to cross road frequently.

(8) In soft ground, wooden pegs should be driven, leaving a small projection above the ground. The name of the station may be written on the top

(b) Offsets should not exceed one chain.

(c) Check and tie lines should be provided in sufficient number so that all the main lines, offsets and other details can be checked thoroughly.

© **Running Survey lines:**

In fig. 2.6 the main station 'A' is located with respect to three permanent objects and a ranging rod is fixed on the station. One ranging rod is fixed at main station B and another at an intermediate point in between A & B. The three rods will be in a straight line when only the intermediate rod is visible if a man looks from A to B. Now, measurement of line AB is taken by chain. The chain should be properly stretched so that there is no sag in it. As the measurements proceeds, offsets are taken on both sides of the line AB and recorded in the field book (shown in fig. 2.6). In this way all the lines including tie and check lines are measured and offsets taken and recorded in the field book.

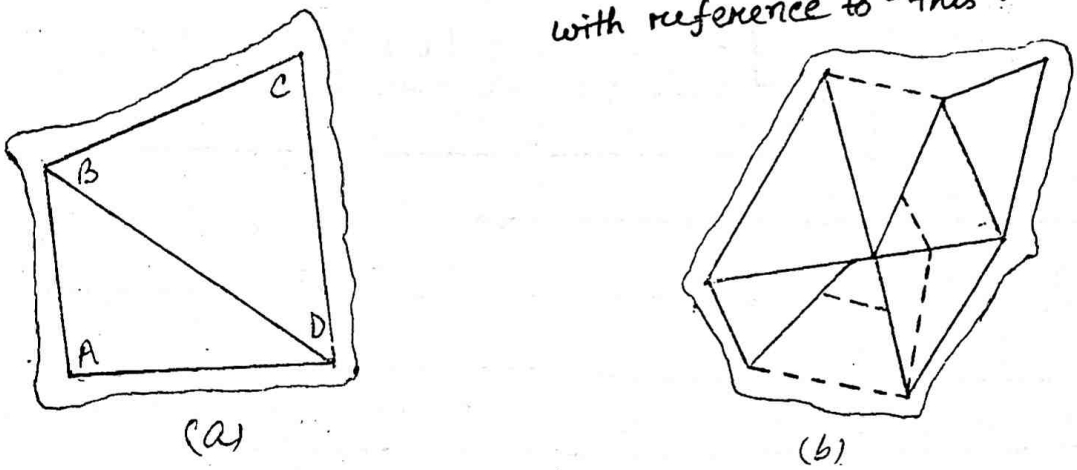
Survey station

A survey station is a prominent point on the chain lines and can either at the beginning of the chain line or at the end. Such stations known as main staion.

Survey Lines: → lines joining the main survey stations.

The lines joining the main survey stations are called main survey lines. The biggest of the main survey lines is called the **base line** and the various survey stations are plotted with reference to this. If the area to be surveyed has more than three straight boundaries, the field measurements must be so arranged that they can be plotted by laying down the triangles as shown in fig. 4.1 (a) and (b)

* Base Line — The biggest of the main survey lines
The various survey stations are plotted with reference to this.



(a) (b)

Fig. 4.1

Proof Lines

Check lines: → Lines run in the field to check the accuracy of the work.

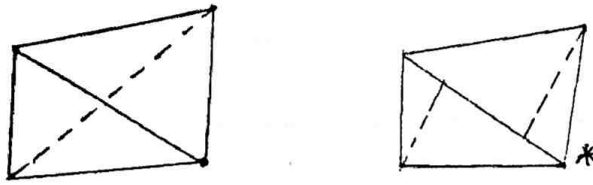
Check lines or **proof lines** are the lines which are run in the field to check the accuracy of the work. The length of the check line measured in the field must agree with its length on the

plan. A check line may be laid by joining the apex of the triangles to any point on the opposite side or by joining two points on any two sides of a triangle. Each triangle must have a check line. Fig 4.2 (a), (b), show the check lines by dotted lines.

***Each triangle must have a check line.

** Offset:- An offset is the lateral distance of an object or ground feature measured from a survey line.

*angle of offset → ⊥ offset is 90°



(a) (b)

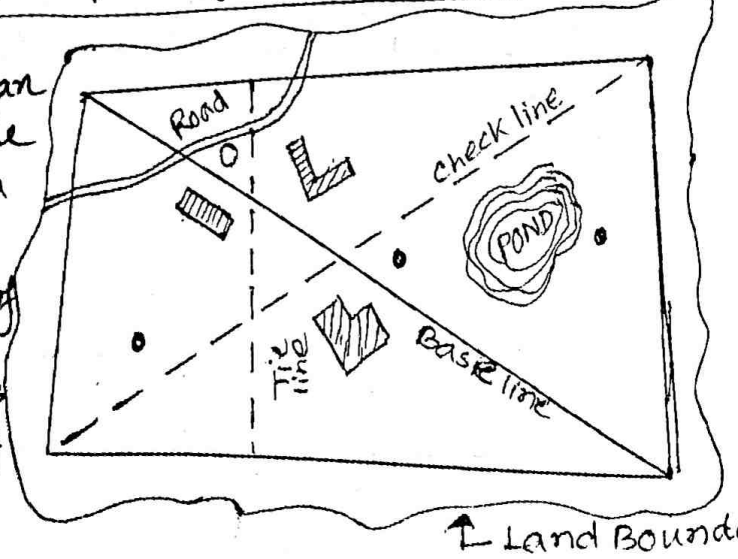
Fig. 4.2

Tie lines: → line joining the subsidiary/ tie stations on the main line.

A tie line is a line which joins subsidiary or tie stations on the main line. The main object of running a tie line is to take the details of nearby objects but it also serves the purpose of a check line. The accuracy in the location of the objects depends upon the accuracy in laying the tie line. A frame may have one or more tie lines depending upon the circumstances fig (4.3)

***Tie line can also serve the purpose of a check line.

*Main object of tie line → to take the details of the nearby object.



Base Line

• Biggest of the main chain line.

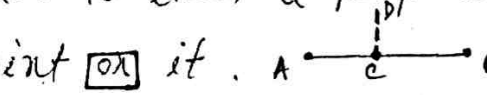
Offset

Fig. 4.5 Punmia Vol. 1

Basic problems in chaining:

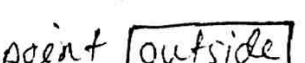
There are four Basic problem in chaining. such as →

(A) To erect a perpendicular to a chain line from a point on it.



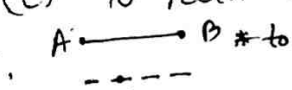
* to draw AB⊥CD is the problem.

(B) To drop a perpendicular to a chain line from a point outside it.



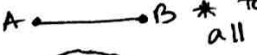
* to draw a ⊥ through C.

(C) To run a parallel to chain through a given point.



* to draw a ∥ through C.

(D) To run a parallel to a given inacce-ssible line through a given point.



* to draw a ∥ through C i.e inaccessible.

Description: All the methods from Book

(A) To erect a perpendicular to a chain line from a point on it:

(1) The 3-4-5 method: ** Other methods (from pan Pia)

Let it be required to erect a perpendicular to the chain line at a point C in it [Fig. 4.20(a)]. A point E is established at a distance of 3m from C. 'O' is put at the end of the tape (10m) long at E and the 10m end at C. The 5m and 6m marks are brought together to form a loop of 1m. The tape is now stretched tight by fastening the ends E and C. The point D is thus established. Angle DCE will be 90°. One person can set out a right angle by this method.

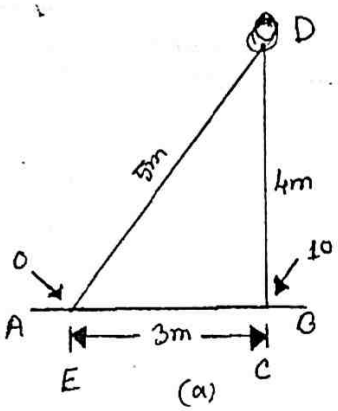
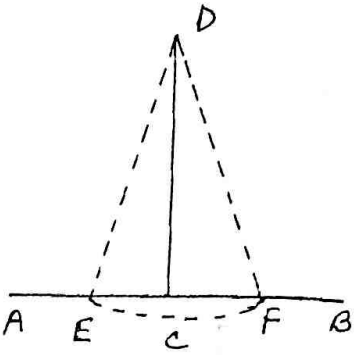


Fig. 4.20.

(B) To drop a perpendicular to a chain line from a point outside it.

Method:

Let it be required to drop a perpendicular to a chain line AB from a point D outside it.

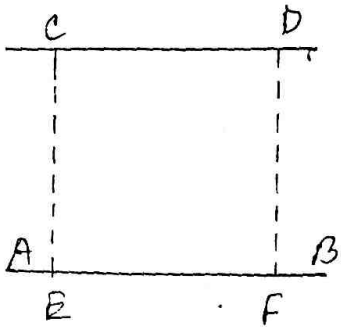


Any point E is selected on the line. With D as centre and DE as radius, an arc to cut chain line in E is drawn in F. Then EF is bisected at C. CD will be perpendicular to AB.

(C) To run a parallel to chain line through a given point:

Let it be required to run a parallel to a chain line AB through a given point C.

Method:



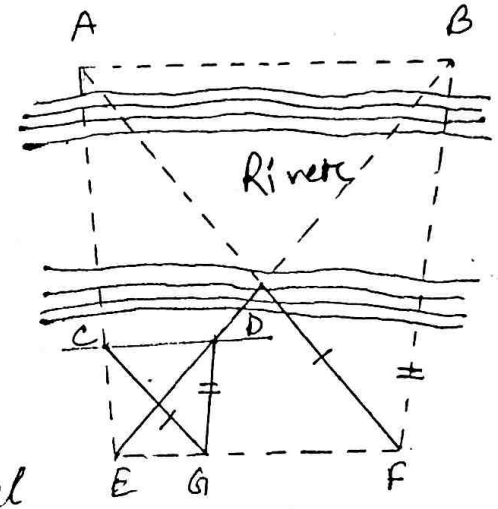
Through C, a perpendicular CE to the chain line is dropped. CE is measured. Any other point F on line is selected and a perpendicular FD is erected. FD = EC is made and C, D are joined. Line CD ∥ AB

(Extra Page)

(D) To run a parallel to a given inaccessible line through a given point.

Let AB be the given inaccessible line and C be the given point through which the parallel is to be drawn.

Method:



Any point E is selected in line with A and C. Similarly Any other convenient point F is selected. E, F are made join. Through C, a line CG parallel to AF is drawn. Through G, a line GD parallel to BF, is drawn, cutting BE in D. CD will be then the required line.

In $\triangle AEF$, $AF \parallel CG$
$\therefore EG : GF = EC : CA$
or, $\frac{EG}{GF} = \frac{EC}{CA}$

In $\triangle EBF$, $GD \parallel FB$
$\therefore \frac{EG}{GF} = \frac{ED}{DB}$

$\therefore$ We get — $\frac{EC}{CA} = \frac{ED}{DB}$

$\therefore$ In $\triangle ECD$ & $\triangle AEB$
$\frac{EC}{CA} = \frac{ED}{DB}$ $\therefore$ CD ∥ AB

Please prove that CD ∥ AB

**CD ∥ AB, But অন্য পাড়ে যাওয়া যাবে না। সে পাড়ে যেতে হবে সেই পাড়েই থাকতে হবে।

or, In case (d), we have to stay fixed. We can't go to the other point where the parallel should be drawn.

Obstacles in chaining :

Obstacles to chaining prevent chainman from measuring directly between two points and give rise to a set of Problems in which distance are found by indirect measurements. Obstacles to chaining are of three kinds :

(a) obstacles to ranging (→ to straighten both stations)
(b) obstacles to chaining
(c) obstacles to both chaining and ranging.

(a) Obstacles to ranging -

This type of obstacle, in which the ends are not intervisible, is quite common except in flat country. There may be two cases of this obstacle.

(i) Both ends of the line may be visible from intermediate points on the line.

(ii) Both ends of the line may not be visible from intermediate points on the line.

case (i) : (Assignment → from book (description) must) Method of reciprocal ranging may be used.

case (ii) : In the following figure, let AB be the line in which A and B are not visible from intermediate point on it. Through A, a random line ABi is drawn in any convenient direct

but as nearly towards B as possible.

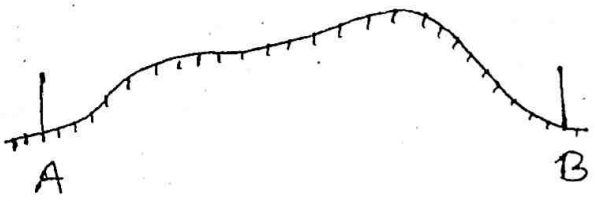


Fig : Case(i)

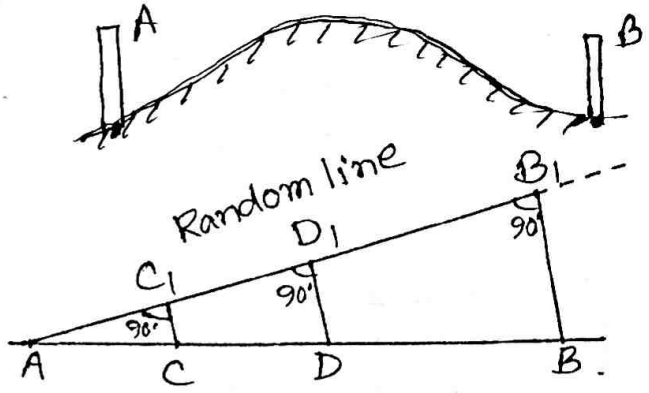


Fig : case(ii)

The point B_1 should be so chosen that (i) B_1 is visible from B (ii) BB_1 is (ii) BB_1 is perpendicular to the random line.

BB_1 be measured and points C_1 and D_1 be selected on the random line and erect perpendicular CC and D_1D on it.

$$CC_1 = \frac{AC_1}{AB_1} BB \text{ and } DD_1 = \frac{AD_1}{AB_1} \cdot BB_1$$

C and D be joined and prolong.

(6) Obstacle to chairig :

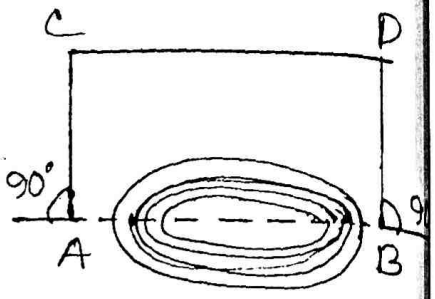
There may be two cases of this obstacle :

(i) when it is possible to chain round the obstacle, i.e. a pond, hedge etc.

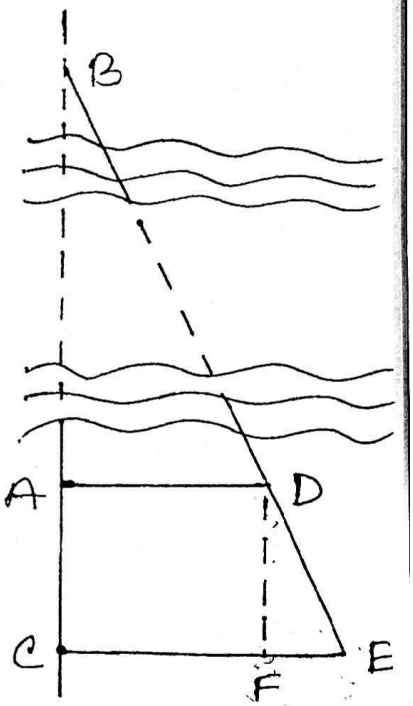
(ii) when it is not possible to chain round the obstacle, e.g. a river.

(P.T.O)

Case (I) Two Points A and B is selected on either side. Equal Perpendiculars AC and BD are set out. CD is measured. Then CD = AB.



Case (II): Point B is selected on one side and A and C are selected on other side. AD and CE are erected as Perpendiculars to AB and B, D and E are ranged in one line. AC, AD and CE are measured. If DF is drawn Parallel to AB, cutting CE in F Perpendicularly, then tringles ABD and FDE will be similar.



$$\therefore \quad \frac{AB}{AD} = \frac{DF}{FE}$$

But $FE = CE - CF = CE - AD$

and $DF = AC$.

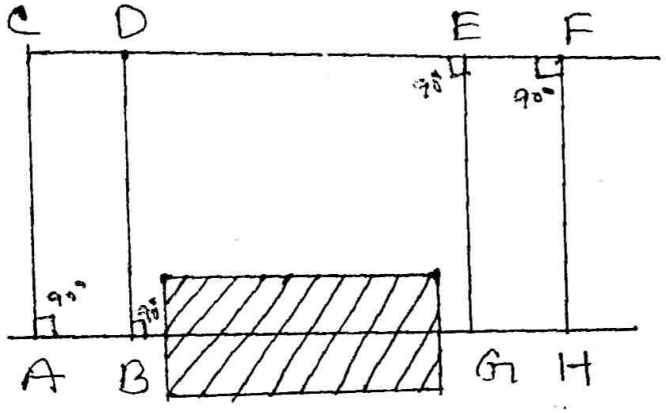
$$\therefore \quad \frac{AB}{AD} = \frac{AC}{CE - AD}$$

From which $$AB = \frac{AC \times AD}{CE - AD}$$

© Obstacles to Both Chaining and Ranging:

A building is the typical example of this type of obstacle. The problem lies in prolonging the line beyond the obstacle and determining the distance across it.

Method:



Steps:

- Chosing two points A and B to one side and erecting perpendiculars AC and BD of equal length.
- Joining CD and Prolonging it Past the obstacle.
- Choosing two points E and F on CD and erecting perpendiculars FG and FH equal to that AC or BD.
- Joining GH and Prolonging it.
- Measuring DE

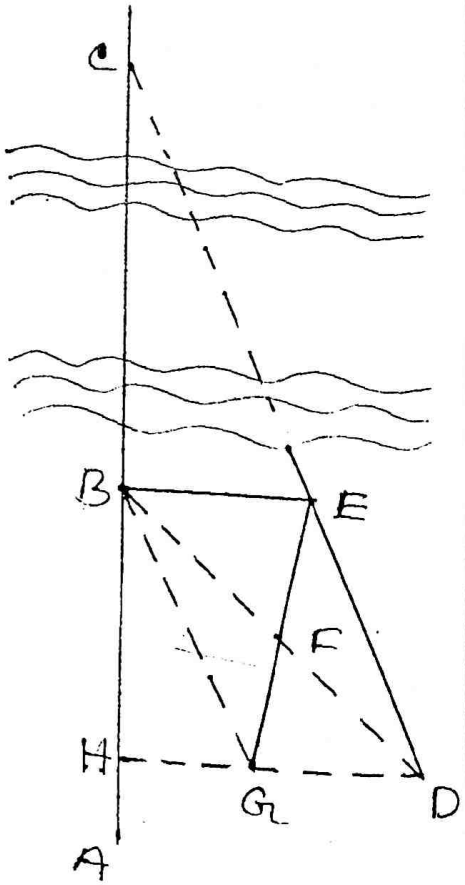
Therefore, **BG = DE**

Similar Problems & Examples from Pan Hin

*Problem-এ figure must draw করতে হবে।
*Question-এ figure থাকে।

Example 4.9

A survey line ABC cuts the banks of a river at B and C and to determine the distance BC, a line BE, 60 m long was set out roughly parallel to the river. A point D was then found in CE produced and middle point F of DB determined. EF was then produced to G, making FG equal to EF, and DG produced to cut the survey line in H. GH and HB were found to be 40 and 80 metres long respectively. Find the distance from B to C.



Solution:

In BEDG, DF = FD

and GF = FE

Hence BEDG is a Parallelogram.

Hence, GD = BE = 60m

$$HD = HG + GD$$
$$= 40 + 60$$
$$= 100\ m$$

From Similar triangles CHD and CBE, we get

$$\frac{CB}{CH} = \frac{BE}{HD}$$

or, $$\frac{CB}{CB + BH} = \frac{BE}{HG + GD}$$

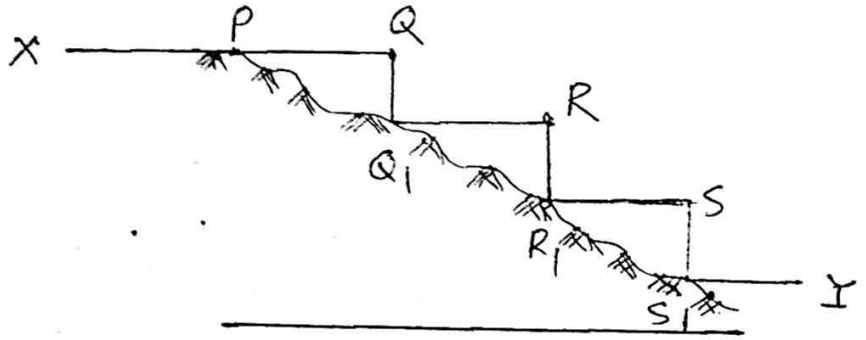
or, $$\frac{CB}{CB + 80} = \frac{60}{40 + 60} = 0.6$$

$\therefore CB = 0.6CB + 48$

$\therefore CB = 120\ m.$

Chaining along sloping ground:

During chaining along a sloping surface, the horizontal projection or a chain line is found by the process shown in the following figure(1). In this method, a portion of the chain, 15ft to 30 ft is generally used. The length of the chain, ofcourse, depends upon the steepness of the sloping surface.



The chain is held horizontally with zero end of it at 'P' on the ground, while the point 'Q_1' vertically below the other end of the chain at 'Q' is found by means of a drop-arrow shown in fig(2). The next step is commenced from point 'Q_1' and the process is continued until the whole horizontal distance is measured.

This method is also known as "stepping".

* Field book-এ alltime নিচ থেকে উপরে লিখতে হবে।
যত বার reading নিবে figure draw করা যাবে তত বার

Record Keeping:

All the details including a rough sketch of different types of stations, offsets etc in the field are recorded in a book called "Field Book". It is an important book or document which should be maintained carefully. It is 9" x 5" in size with two Parallel lines ruled longitudinally in the centre of the every Page. These two parallel lines are imaginary lines representing the chain line and the space in between has no existence in the field.

The record keeping starts from the bottom of the end page of the field book. A rough sketch of the plot is drown before hand on the last Page for reference.

At the beginning of a Particular Chain survey, the following details must be given-

(i) Date of survey and names of surveyors (weather recording-এর জন্য date imp এবং chain length depend করে)
(ii) General sketch of the layout of survey lines.
(iii) Details of survey lines.
(iv) Page index of survey lines.
(v) Location sketches of survey stations.

(P.T.O)

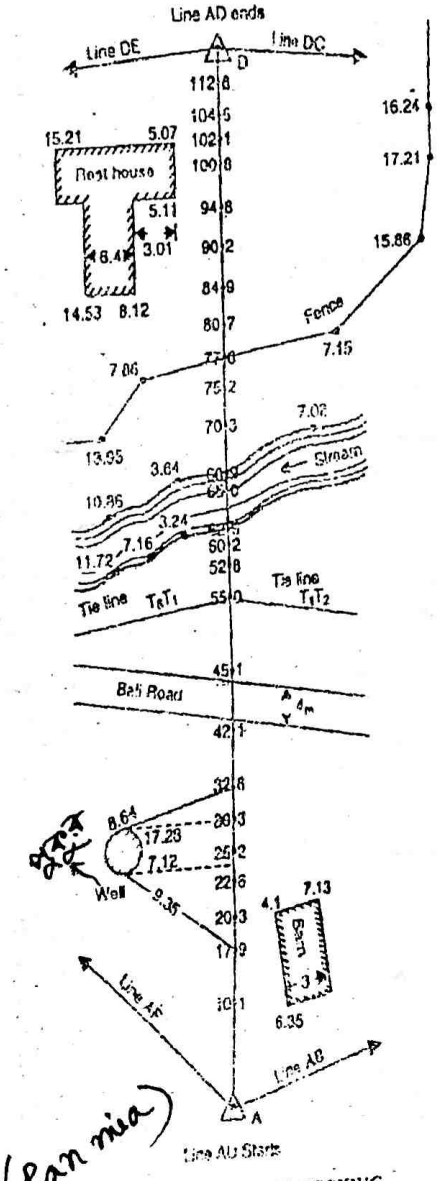
At the starting of a chain or survey lines, the following details should be given:

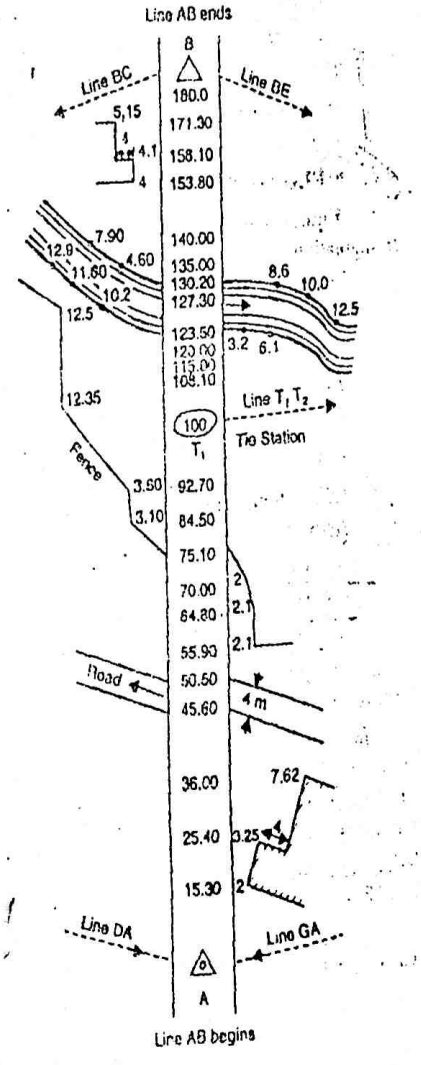
(i) Name of the line

(ii) Name of the stations marked either by an oval or by a triangle.

(iii) Bearing of the line

(iv) Details of any other line meeting at the starting Point of the survey line.





Recording of stations, chain lines and other details are shown in the above figures. Neat figures and sketches with clearness in representing points to which offsets are taken should be properly maintained.

Plotting a chain survey:

Generally, the scale of plotting a survey is decided before the survey is started. In general, the scale depends on (1) the purpose of survey (2) the extent of survey and (3) the finance available.

The plan must be so oriented on the sheet that the north side of the survey lines towards the top of the sheet and it is centrally placed. The way to achieve this, is to first plot the skeleton on a tracing paper and rotate it on the drawing paper. After having oriented it suitably, the points may be pricked through. To begin with, base line is first plotted. The other triangles are then laid by intersection of arcs. Each triangle must be verified by measuring the check line on the plan and comparing it with its measured length in the field.

If the discrepancy is not within the limits, measurements may be taken again. If it is less, the error may be adjusted suitably.

After having drawn the skeleton consisting a number of triangles, offsets may be plotted. There are two methods of plotting the offsets. In the

• (1) In the first method, the chainages of the offsets are marked on the chain line and perpendicular to the chain line are erected with the help of a set-square. In the other method

• (2) In the other method, the plotting is done with the help of an offset scale. A long scale is kept parallel to the chain line and a distance equal to half the length of the offset scale. The offset scale consists of a small scale having zero mark in the middle. The zero of the long scale is kept in line with the zero of the chain line. Chainages are then marked against the working edge of the offset scale and the offsets are measured along its edge. Thus, the offset can be plotted to both the sides of the line.

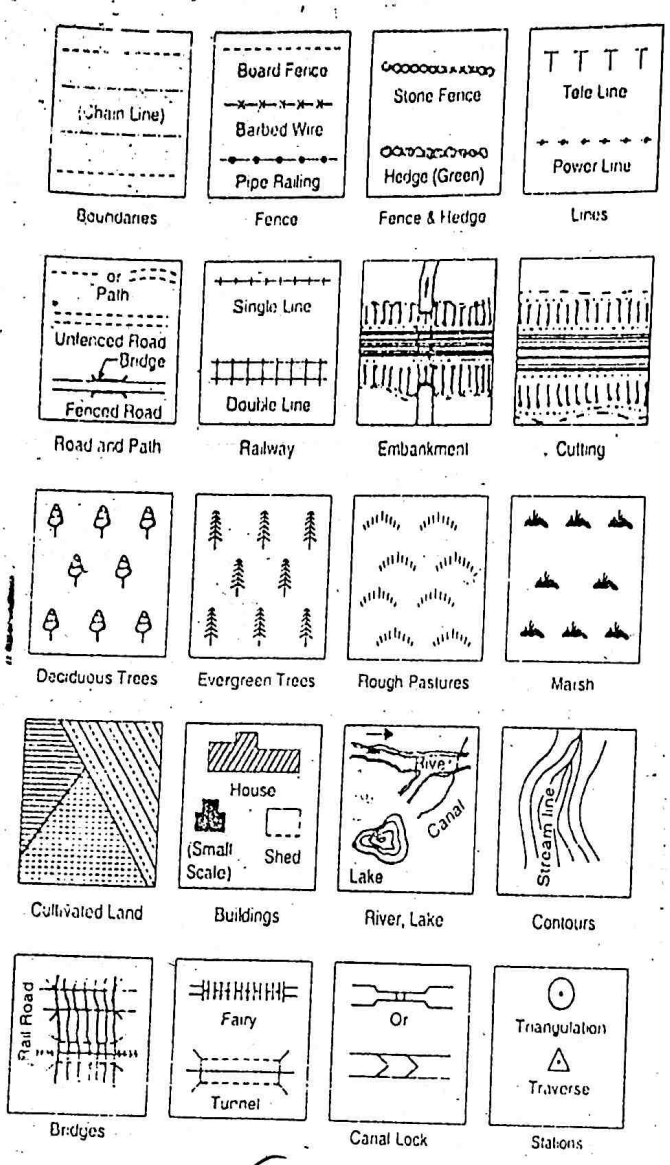


FIG 4.33. CONVENTIONAL SYMBOLS

(should be memorized)

Fig-1

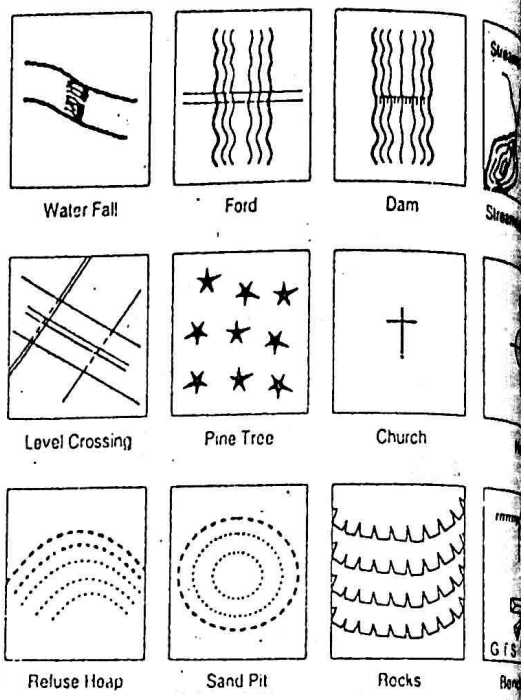


FIG. 4.34. CONVENTIONAL SYMBOLS.

Fig-2

Different features on the ground are rep by different symbols. Fig-1 and Fig-2 sh some conventional symbols commonly use

Example 3.12

A steel tape 20m long standardised at 55°F with a pull of 10 kg was used for measuring a base line. Find the correction per tape length, if the temperature at the time of measurement was 80°F and pull exerted was 16 kg. Weight of 1 cubic cm of steel = 7.86 g, Wt. of tape = 0.8 kg and $E = 2.109 \times 10^6$ kg/cm^2. Coeff. of expansion of tape per 1°F = 6.2×10^{-6}.

We know,

Pull correction,

$$C_p = \frac{L(F_s - F_f)}{AE} \quad \text{---(i)}$$

Given,

$E = 2.109 \times 10^6$ kg/cm^2

$\alpha = 6.2 \times 10^{-6}$ /°F

$t_s = 55$°F ; $t_f = 80$°F

$F_s = 10$ kg

$F_f = 16$ kg

$W = 0.8$ kg

Now, $C_t = L \times \alpha (t_f - t_s) = 20 \times 6.2 \times 10^{-6} (80 - 55)$

$= 0.0031$ m (Additive)

Weight of tape,

$W = AL \times 7.86 \times 10^{-3}$

or, $0.8 = A \times 20 \times 100 \times 7.86 \times 10^{-3}$

$\therefore A = 0.051$ sq.cm.

$\therefore$ From (i) $\rightarrow$

$$C_p = \frac{20(16-10)}{0.051 \times 2.109 \times 10^6} = 0.00112 \text{ m (Additive)}$$

Again, sag correction, $C_s = \frac{w^2 L}{24 F_f^2} = \frac{(0.8)^2 \times 20}{24 \times (16)^2} = 0.00208$ m (Substractive)

$\therefore$ Total Correction $= C_t + C_p - C_s$

$= (0.0031 + 0.00112 - 0.00208)$ m

$= \boxed{+0.00214 \text{ m}}$

Errors in Chaining:

It is always very difficult Practically to measure length accurately. The error in chaing may happen in various ways.

- Mistake
- Compensating
- Cumulative

Mistake:

This kind of error arises from inattention, inexperience, poor judgeme serious personal error or confusion in reading the tallies such as 30 and 70.

Try to avoid

Compensating:

Accidental error caused by reason beyond the ability of the observer to control.

Example: Stretching chain alway not . Assumed to obey the law of probability / chance, errors which cancel one another and finally tot effects remaining approximately.

Cumulative:

Cumulative errors are these which may either go on increasin or decreasing when a chain is shorter or longer than its standard

Advantages of Chain Survey:

- This type of survey work is suited for a small plain ground. (Suitability but not advantage)
- It requires simple instruments.
- Plotting of map is very simple and easy.

Disadvantages of Chain Survey:

- This type of surveying is not suitable for undulation land where chaining operation is tedious and subject to errors.
- This method is not generally recommended for a crowded city with large number of buildings and obstacles because it cannot be divided into well conditioned triangles.
- In case of route surveying. the survey work of a road, irrigation canel. railways. water and sewer lines, tunneling etc. this method is not recommended at all.

length. When the chain is too short. the measured length of the line is to great. i.e. greater than its true length and therefore, the error (1) is positive and the correction is negative. Agai when the chain is too long. the measured length is too short. i.e. less than its true length. so the error is (2) negative and correction is Positive.

See problems related to correction

2. **Chain Survey**

The students will form a triangle in the field, after selecting proper stations. They will measure the lines and take offsets of different objects in the field. In chain survey the students will use tie lines, check lines and enter the data in the field book. They will plot the details in a drawing sheet.

References

1. A Text Book of Surveying, Third Edition, 1982.
   -M. Shahajahan & M. A. Aziz

2. Surveying, Vol. 1, Sixteenth Edition, 2005.
   -B.C. Punmia, Ashok, K. Jain & Arun K. Jain

(For problem solving)

Cumulative Error: Cumulative errors are those which my either goes on increasing or decreasing when a chain is shorter or longer than its standard.

Corrections:

- Particularly for cumulative error
- Mainly focus on chain length

Correction to chain/tape:

+ve /-ve

(to find actual length of chain)

1. Correction for errors due to incorrect chain length:

L_c = correct length of chain

L_e = incorrect length of chain

L' = Measured distance using incorrect chain

Correct Distance, $L = \frac{L_e L'}{L_c} = \left(\frac{L_e}{L_c}\right) * L'$ $\quad L = \frac{Le}{Le} \times L'$

Corrected Area, $A = \left(\frac{L_e}{L_c}\right)^2 . A'$ $\quad A = \left(\frac{Le}{Le}\right)^2 \times A'$

$V = \left(\frac{Le}{Le}\right)^3 \times V'$

Corrected volume, $V = \left(\frac{L_e}{L_c}\right)^3 . V'$

2. Correction for pull:

Correction, where, $c_p = \frac{L(F_f - F_s)}{AE}$ $\quad C_p = \frac{L}{AE}(F_f - F_s)$

L= length of tape,

A = cross-sectional area of tape,

F_f = pull applied in the field,

F_s = pull at standard condition,

E = Young's modulus of Elasticity.

May be positive or negative

If pull is more than standard correction is: +ve.

If pull is less than standard correction is: -ve.

3. Correction for sag: Always negative

Correction, $c_s = \frac{w^2 L}{24 F_f^2}$ $\quad C_s = \frac{w^2 L}{24 F_f^2}$

where, w = wt. of the tape in lb

L = Length of the tape in ft

F_f = Pull applied in the field in lb

Since the effect of sag on tape is to make the measured length too large, the correction is always negative.

4. Temperature correction:

Correction, $c_t = \alpha (t_f - t_s) * L$ $C_t = \alpha (t_f - t_s) \times L$

Where, L = measured length in ft,

t_s = temp. at which the tape was standardized

t_f = temp. at which the tape is used in the field

α = Coeff. of thermal expansion

The steel tapes are generally standardized 65°F.

Example: A distance was measured using a 100ft chain to be 1840 ft. standard pull a standard temperature for the chain 30lb and 85° F, respectively. However, the chain w pulled with pull of 20lb. field temperature was 75°F, calculate the correct distance.

Example: The road from Dhaka to Mirpur is actually 25320 ft long. This distance w measured by an Engineer's defective chain and was found to be 25270 ft. how mu correction does the chain need?

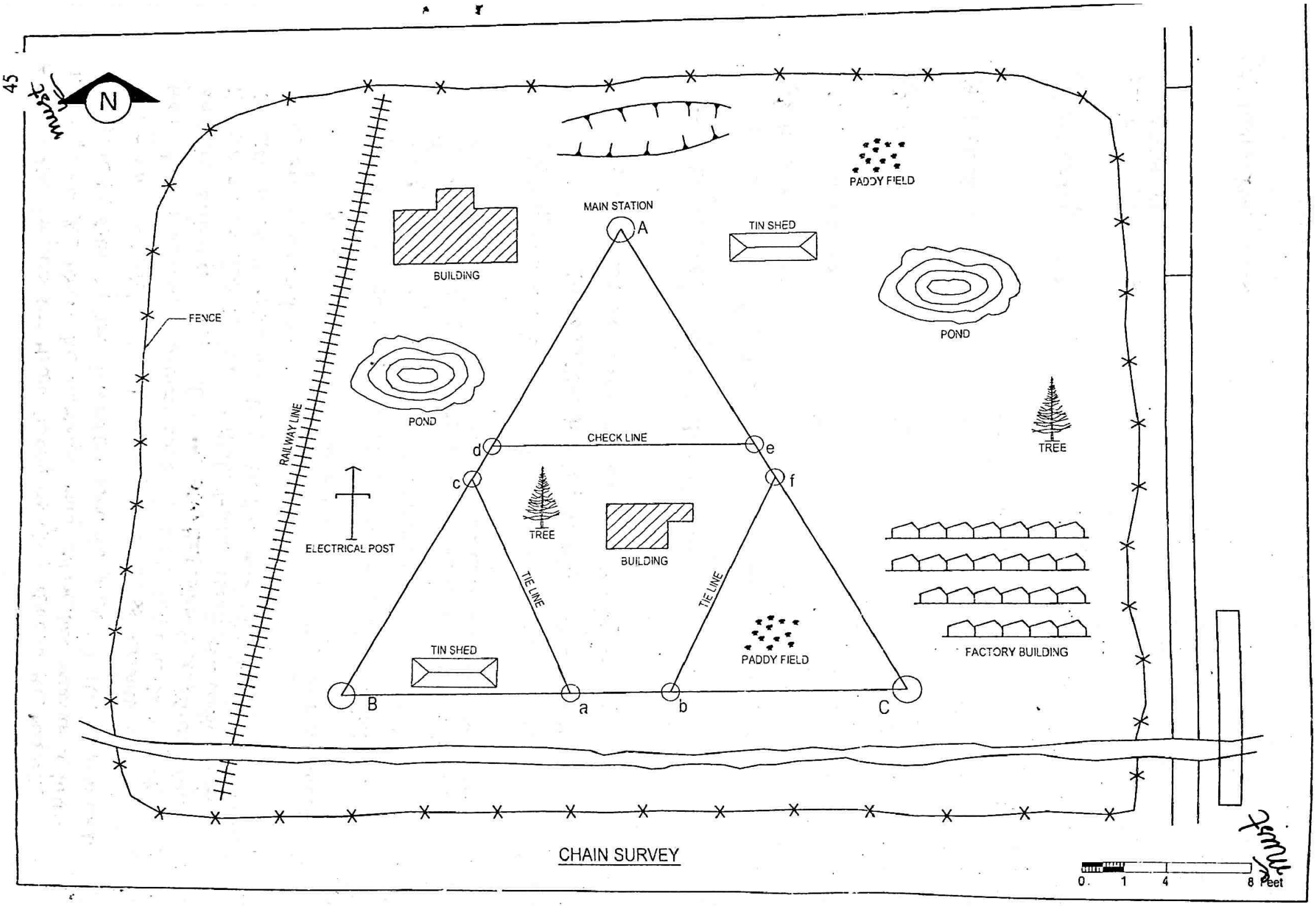
Solution:

$$L = \frac{L_e}{L_c} \times \text{measured incorrect length}$$

$$L_e = \frac{L \times L_e}{\text{measured length}}$$

$$= \frac{25320 \times 100}{25270} = 100.197 \text{ ft}$$

Therefore, the chain should be shortened by 0.197 ft.



CHAIN SURVEY

* Magnetic Compass :— Magnetic compass gives directly the magnetic bearings of the lines. The bearings may either be measured in the W.C.B or in Q.B. system depending upon the form of the compass used. The general principle of all magnetic compass depends upon the fact that if a long narrow strip of steel or iron is magnetized and is suitably suspended on pivoted about a point near its centre so that it can oscillate freely about the vertical axis, it will tend to establish itself in the magnetic meridian at the place of observation.

The most essential features of magnetic compass are—

(a) Magnetic needle : to establish the magnetic meridian.

(b) A line of sight : to sight the other end of the line

(c) A graduated circle : either attached to the box or to the needle, to read the directions of the lines.

(d) Compass box : to house the above parts.

In addition to this, a tripod or suitable stand can be used to support the box.

* Distinguish bet^{n} compass & theodolite :—

Bassis	Compass	Theodolite
(1) Measurement →	Only horizontal angle	Both vertical & horizontal angle
(2) Suitability →	for short projects	for large projects
(3) User →	unskilled users can use.	only skilled users can use.
(4) Range →	the range of vision is less than theodolite	The range of vision is more than compass.
(5) Accuracy →	less accurate	More accurate.
(6) Local Attraction →	There is a possibility of local attraction.	No possibility of local attraction.
(7) Mechanism →	Angle measured with the help of a magnet	No magnet is used here.

Q: Write down the difference bet^n surveyors & prismatic compass.

Basis	Prismatic Compass	Surveyor's Compass
1. Magnetic Needle	The needle is of 'broad needle' type. The needle does not act as index.	The needle is of 'edge bar' type. The needle acts as the index also.
2. Reading	(i) The reading is taken with the help of a prism provided at the eye slit.	(i) The reading is taken by directly seeing through the top of the glass.
	(ii) Sighting & reading taking can be done symultaneously.	(ii) Sighting & reading taking can not be done symultaneously.
3. Tripod	Tripod may or may not be provided. The instrument can be used even by holding in hand.	The instrument can not be used without a tripod.
4. Graduated Cared	(i) The graduated card ring is attatched with the needle. The ring does not rotate along with the line of sight.	(i) The graduated cared is attatched to the box & not to the needle. The cared rotates along with the line of sight.
	(ii) The graduations are in W.C.B system — having 0° at S, 90° at W, 180° at N and 270° at E.	(ii) The graduations are in S.B. system — having 0° at N & S and 90° at E & W.
	(iii) The graduations are engraved inverted.	(iii) The graduations are engraved erect.

Compass, Theodolite Traverse Surveying

Q: How to plot chain & compass traversing ??

— There are two methods of plotting a traverse survey:

(1) Angle & Distance Method.

& (2) Co-ordinate method.

Angle & distance method is of three types —

(a) By protractor
(b) By the tangent of the angle
(c) By the chord of the angle

Q. Why we need to study compass & theodolite before traverse surveying ??

— Here we need angular measurement for which we need compass & theodolite. They are critical instruments & so we should study them first.

** Chain & tap are very simple instruments and so we need not study them particularly.

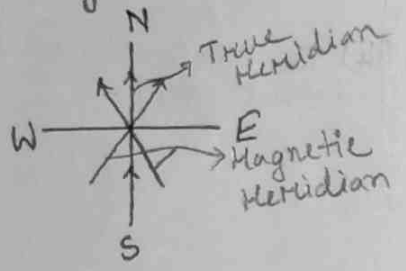
** For angular measurement, we will use compass and theodolite.

** Line - না reference না point. e.g.

** But angle should be measured with a reference of line.

True Meridian → it is the real N–S line.

Magnetic Meridian → In the compas, north should be exactly to the north, but all time it should not be. There may be a deviation through slightly left or right.
It occurs due to some magnetic attraction. If there is no such matter, M.M is the same of T.M.



** Magnetic meridian sometimes acts as true meridian.

** Traverse surveying —

1) Open traverse — starting & end point same

2) Close " — " & " different

** Compass can be used by anyone because it is easy to use. It is suitable for short projects.
But theodolite is not so.

** Figure of all bearing.

Bearing:

The bearing of a line (Survey line) is the angle which the line makes with a reference direction on meridian in the clockwise direction.

* normally north-south direct^{n} কে reference ধরা হয়।
যেই N-S direct^{n}- কে বলা হয় MERIDIAN

True Meridian:

True Meridian through a point is the line in which a plane, passing that point and the north and south poles, intersects with surface of the earth Thus, it passes through the true north and south poles.

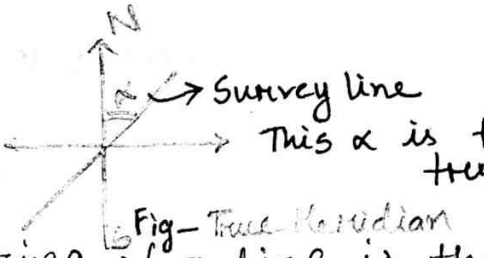


Fig- True Meridian

True Bearing:

The true bearing of a line is the horizontal angle which it makes with the true meridian through one of the extremities of the line.

Magnetic Meridian:

Magnetic meridian through a point is the direction shown by a freely floating and balanced magnetic ~~ne~~ needle free from all other attractive forces.

DESIGNATION OF BEARINGS:

(a) The Whole Circle/Circuit System (W.C.B): (Azimuthal system)

In this system, the bearing of a line is measured with magnetic north (or with south) in clockwise direction. The value of these bearing thus varies from 0° to 360°. Prismatic compass is graduated on this system.

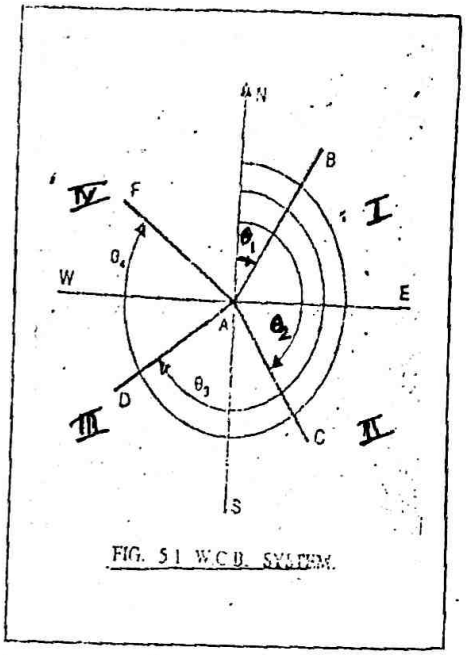


FIG. 5.1 W.C.B. SYSTEM.

*All the angles are measured from North and clockwise.

**the limit is 0°-360°

Reffering to figs 5.1, the W.C.B of AB is θ_1, of AC is θ_2, of AD is θ_3 and of AF is θ_4.

(b) The Quadrantal Bearing system (Q.B): (Reduced B)

**limit will be 0°-90°.

The bearing of a line in this system is measured eastward or westward from north or south, whichever is nearer. Both North and

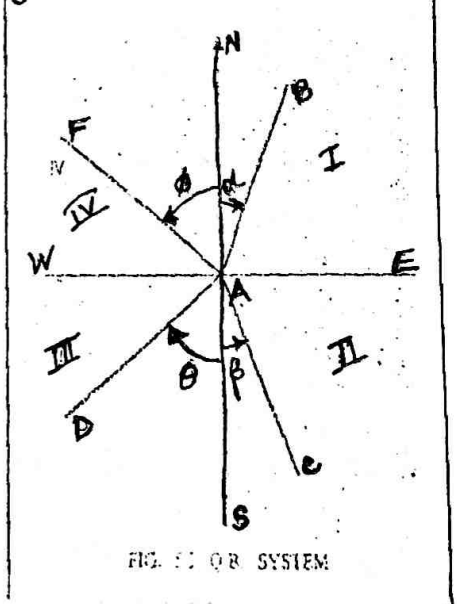


FIG. 5.2 Q.B SYSTEM

Line	W.C.B between	Rule for R.B	Quadrant
AB	0° and 90°	R.B = W.C.B	NE
AC	90° and 180°	R.B = 180° − W.C.B	SE
AD	180° and 270°	R.B = W.C.B − 180°	SW
AF	270° and 360°	R.B = 360° − W.C.B	NW.

Similarly, referring to Fig., the conversion of R.B into W.C.B can be expressed in to the following table:

Conversion of R.B into W.C.B

Line	R.B	Rule for W.C.B	W.C.B between.
AB	N α E	W.C.B = R.B	0° and 90°
AC	S β E	W.C.B = 180° − R.B	90° and 180°
AD	S θ W	W.C.B = 180° + R.B	180° and 270°
AF	N ϕ W	W.C.B = 360° − R.B	270° and 360°.

* 2 things of direct^{n} is very imp →
  (1) Either W.C.B or R.B
  (2) Whether the angles are clockwise or anticlockwise

FORE AND BACK BEARING :

The bearing of line differs according as the observation is made from one end of the line or from the other, whether expressed in W.C.B or in Q.B system.

The fore or forward bearing of a line is the bearing in the direction of progress of survey. And

The backward bearing is the bearing in the reverse direction of the progress of survey.

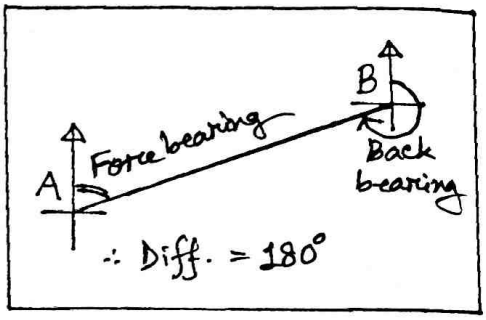


Fig-3

In the fig.3 if the bearing of the line AB is measured from A towards B then it is fore bearing (F.B) and if measured from B towards A then it is back bearing (B.B).

** fore bearing must be forward bearing

Example 5.1 Convertion of whole circle bearings to quadrantal bearing

Example 5.2 conversion of fore-bearing to back bearing

Example 5.3 Calculation of interior angle.

Problem: Example → 5.4 (from book) (Imp)

The following interior angles were measured with a sextant in a closed traverse. The bearing of the line AB was measured as 60°00′ with prismatic compass. Calculate the bearings of all other line if ∠A = 140°10′; ∠B = 99°8′; ∠C = 60°22′ ∠D = 69°20′

$\theta_2 = \theta_1 + \alpha' - 180^\circ$ Prove it (H.W)

Solution:

Fig-4 shows the plotted traverse.

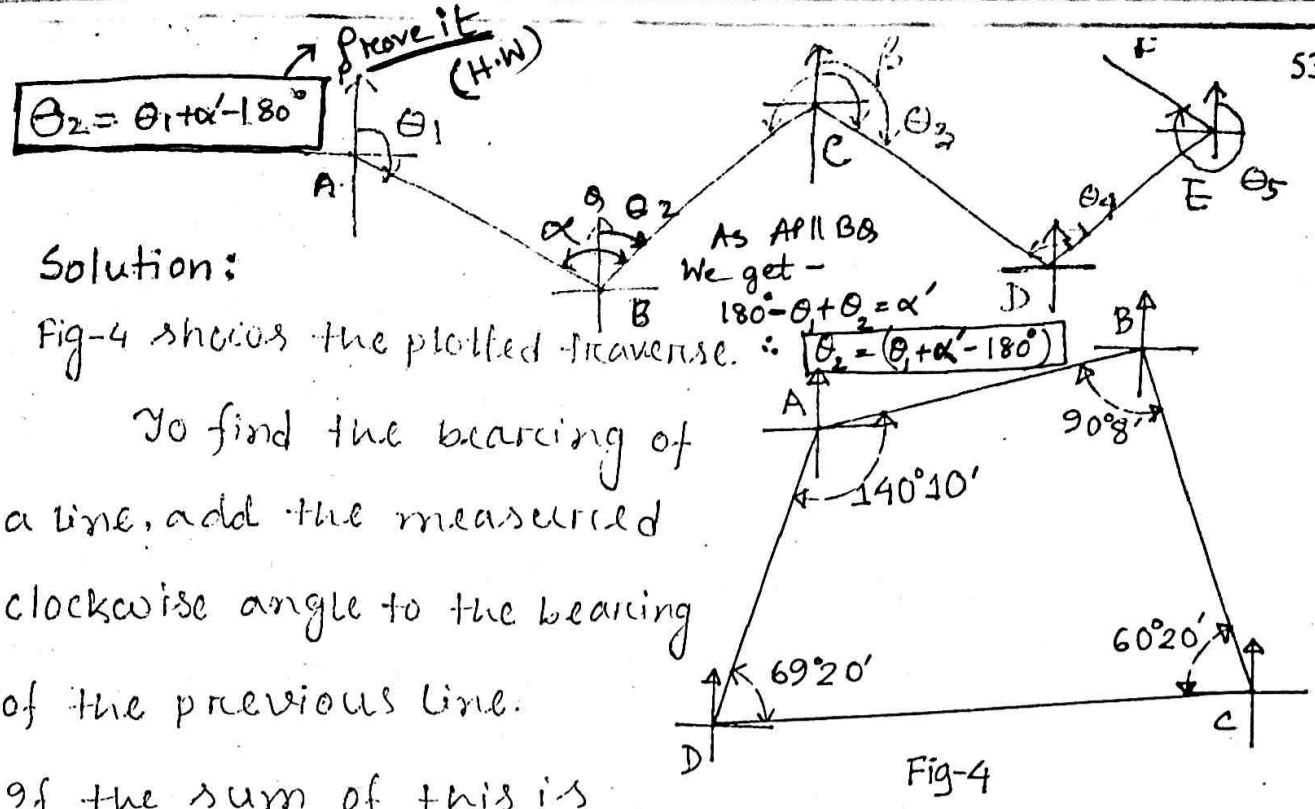


Fig-4

To find the bearing of a line, add the measured clockwise angle to the bearing of the previous line. If the sum of this is more than 180°, deduct 180°. If the sum is less than 180°, add 180°.

Clockwise angles will be obtained if we proceed in the anticlockwise direction round the traverse.

Starting with A and proceeding toward D, C, B etc. we have

Bearing of AD = Bearing of BA + 140°10' - 180°

$= (180^\circ + 60^\circ) + 140^\circ 10' - 180^\circ = 200^\circ 10'$

$\therefore$ Bearing of DA = 20°10'

Bearing of DC = Bearing of AD + 69°20' - 180°:

$= 200^\circ 10' + 69^\circ 20' - 180^\circ = 89^\circ 30'$

$\therefore$ Bearing of CD = 269°30'

Bearing of CB = Bearing of DC + 60°22′ + 180°

= 89°30′ + 60°22′ + 180° = 329°52′

∴ Bearing of BC = 149°52′

Bearing of BC = Bearing of CB + 90°8′ − 180°

= 329°52′ + 90°8′ − 180° = 240°

∴ Bearing of AB = 60° (check).

(The compass Chapter 5)

THE PRISMATIC COMPASS :-

Prismatic compass is the most convenient and portable form of magnetic compass which can either be used as a hand instrument or can be fitted on a tripod → ত্রিপদী leg set করে ব্যবহার

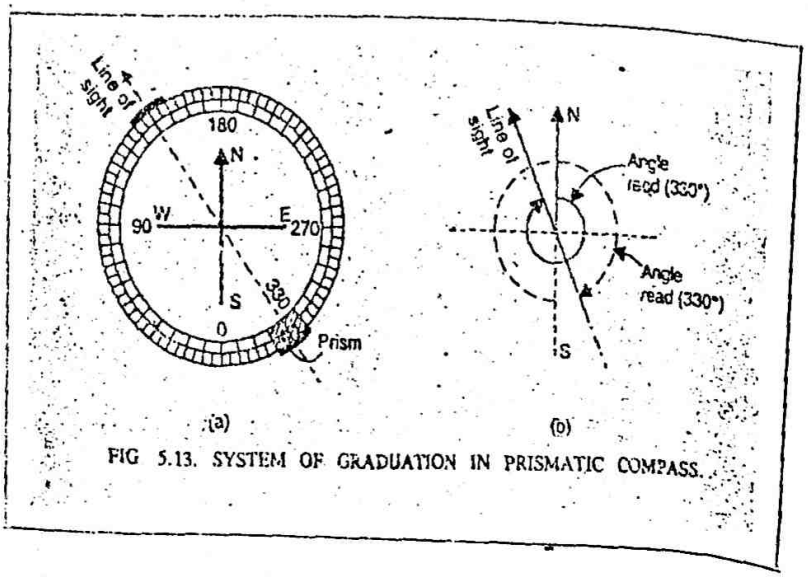


FIG 5.13. SYSTEM OF GRADUATION IN PRISMATIC COMPASS.

case. Generally, a tripod is provided with ba
and socket arrangement with the help of wh
the top of the box can be levelled.

(ii) **Focusing the Prism:**

The prism attachment is slided u
or down for focusing till the readings are
seen to be sharp and clear.

(b) Permanent Adjustments:

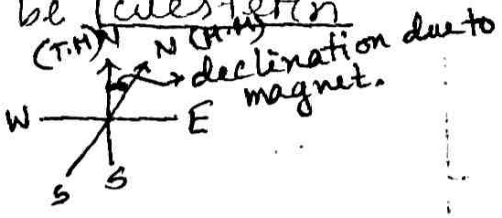
The permanent adjustments of prismatic compass are almost the same as that of the surveyor's compass except that there are no bubble tubes to be adjusted and the needle cannot be straightened. The sight vanes are generally not adjust

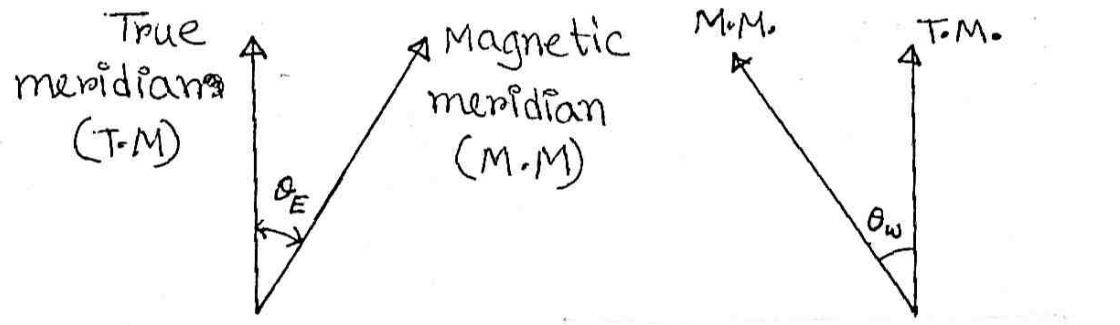
V. V. Imp

MAGNETIC DECLINATION: → two causes 1) for earth's magnetism 2) for another magnetic matters.

Magnetic declination at a place
the horizontal angle between the true merid

and the magnetic meridian shown by the needle at the time of observation]. If the magnetic meridian is to the right side (or eastern side) of the true meridian, declination is said to be (1) eastern or positive if it to be the left side (or western side) then is said to be western or negative. (2)





(a) Declination east (b) Declination west

Fig: MAGNETIC DECLINATION

Variations in Declination: → a chart is available for this variation.

The value of declination at a place never remains constant but changes from time to time. There are four types of variations of declination.

1. **Diurnal Variation:** (diff. times of a day)

The diurnal variation or daily vari is the systematic departure of the declination from its mean value during a period of 24 hou It generally varies with the phase of the sunspot period. It depends upon the following factors —

(i) The locality
(ii) Season of the year
(iii) time
(iv) The amount of daily variation changes from year to year.

2. **Annual Variation:** (every year)

[The variation which has a yearly period is known as annual variation.] The declination has a yearly swing of about 1′ or 2′ in amplitude. It varies from place to place.

3. **Secular Variation:** (over the years)

The variation which appears to be of periodic character and follows roller-coaster

observed magnetic bearing by the following relation:

True bearing = magnetic bearing ± declination

Use **plus sign** if the declination is **to the East** and **minus sign** if it is **to the west**. The above rule is valid for **whole circuit bearings only**.

Problem:

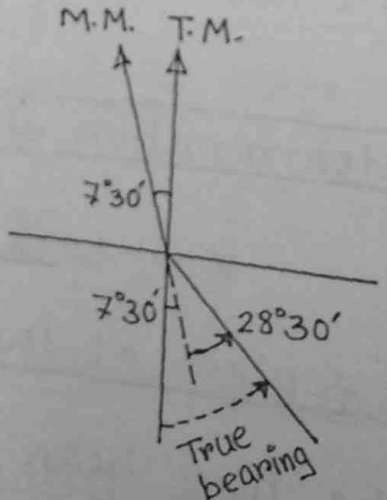
Do example 5·5, 5·7, 5·8.

Example→5·6

The magnetic bearing of a line AB is S 28°30 E. Calculate the true bearing if the declination is 7°30′ west.

Solution:

The positions of true meridian, magnetic meridian and the line have been shown in fig. 5·20. Since the



Fig→ 5·20.

declination is to be west, the magnetic meridian will be to the West of true meridian.

Hence.

True bearing = S 28°30' E + 7°30'

= S 36°00' E

(Answers are in points)

Q. What is local attraction?

Q. What are the reasons?? How can it be detected??

Q. What's the elimination??

LOCAL ATTRACTION:

Local attraction is a term used to denote any influence such as, the magnetic needle may be attracted and prevented from indicating the true magnetic meridian when it is in proximity to certain magnetic substances, which prevents the needle from pointing to the magnetic North in a given locality.

It is caused due to the influence of iron, steel structures, rails, electric posts and cables, keys, steel-boned spectacles, metal buttons, axes, chains, steel tapes, underground pipelines etc.

Q: Describe the first/2nd/special method of Local attraction elimination.
or, Q Write short note on Local attraction elimination.

V.V.Imp.

Elimination of Local Attraction: (point পড়তে হবে)

If there is local attraction at a station all the bearings measured at that place will be incorrect and the amount of error will be equal in all the bearings.

There are two methods for eliminating the effects of local attraction:

First Method: The bearings of the lines are calculated on the basis of the bearing of that line which has a difference of 180° in its fore and back bearings. It is assumed that there are no observational and instrumental errors. The amount and direction of error due to local attraction at each of the affected stations is found. If, there is no such line in which the two bearings differ by 180°, the corrections should be made from the mean value of the bearing of that line in which there is least discrepancy between the back sight and fore sight readings.

must be used by skilled workers in large projects.

Theodolite: Chapter 6: The Theodolite

The Theodolite is the most precise instrument with which both the horizontal and verticle angles can be measured. It has wide applicability in surveying such as: (1) Locating points on line, (2) Laying off horizontal angles, (3) Prolonging survey lines, (4) establishing slope, (5) determining difference in elevation (Levelling), (6) ranging curves and (7) traversing.

Theodolites are of two types such as:

(i) Transit theodolite (rotable)

(ii) Non-transit theodolite (not rotable)

The theodolite in which the line of sight can be reversed by revolving the telescope through 180° in the verticle plane about its horizontal axis, is transit theodolite. On the other hand in non-transit theodolite the telescope cannot be transited.

(For practical)

The essential parts of the Transit Theodolite:

(1) The Telescope

(2) The Verticle Circle

(12) The Compass

(13) Striding Level.

(14) The Azimuth and Plate Bubble Tubes

Some Definitions: (Imp for definitions in exam.)

[1] Horizontal Axis (Transverse or Trunnion Axis):

This is the axis about which the telescope and the vertical circle rotate in vertical plane.

[2] Vertical Axis:

This is the axis about which the telescope is rotated in a horizontal plane.

[3] Telescope Axis:

This is the line joining the optical centre of the objective and the centre of the eyepiece.

[4] Line of Collimation (Line of Sight): (V.V. Imp.)

The imaginary line passing through the intersection of the cross-hairs of the diaphragm

and the optical centre of the objective and its extension upto infinity is known as the line of collimation.

The imaginary line passing through the intersection of the horizontal & vertical cross-hairs and the optical centre of the object glass and its continuation upto infinity is known as the **Line of Collimation**

[5] Diaphragm:

It is a ground glass ring consisting of cr hairs. This is fitted in the telescope tube. The cr hairs may be of spider webs, lines or glass a platinum wires. The diaphragm may be mov vertically or horizontally by means of screws.

[6] Face Left and Face Right Observation:

If the face of the vertical circle is to t left of the observer while taking a reading, the position is termed as face left. When the vertical circle of the theodolite lies on the right of the observer, the position is face right. And the corresponding observations are called face l and face right observations.

[13] Telescope Normal and reversed or inverted:

When the position of the bubble tube is on the top of the telescope, it is called telescope normal. When the telescope is transited, the position of the bubble tube is at the bottom and the vertical circle is to the right which is called telescope reversed or inverted.

*** যেখানে Meridian, bearing etc আলোচনার প্রয়োজন নাই সে ক্ষেত্রে Magnet use হয় না। → Theodolite

Adjustment of Theodolite

If adjusted some conditions are full-filled.

Two types of adjustments:

(1) **Temporary Adjustments**

Temporary adjustments or station adjustments are those which are made at every instrument setting and preparatory to taking observations with the instrument. The temporary adjustments are,

(i) Setting over the station

(ii) Levelling up.

Q. Write down the processes of the adjustments of theodolite. — (temporary & permanent তিনটা হবে)

(iii) Elimination parallax

(2) ** There are six permanent adjustments in a transit theodolite —

Adjustment of →
(a) parallel plate bubble tubes
(b) horizontal (transverse) axis of the telescope
(c) the line of collimation vertically.
(d) " " " laterally
(e) the bubble tube on the telescope on T-frame
(f) determination of the index error of the vertical circle.

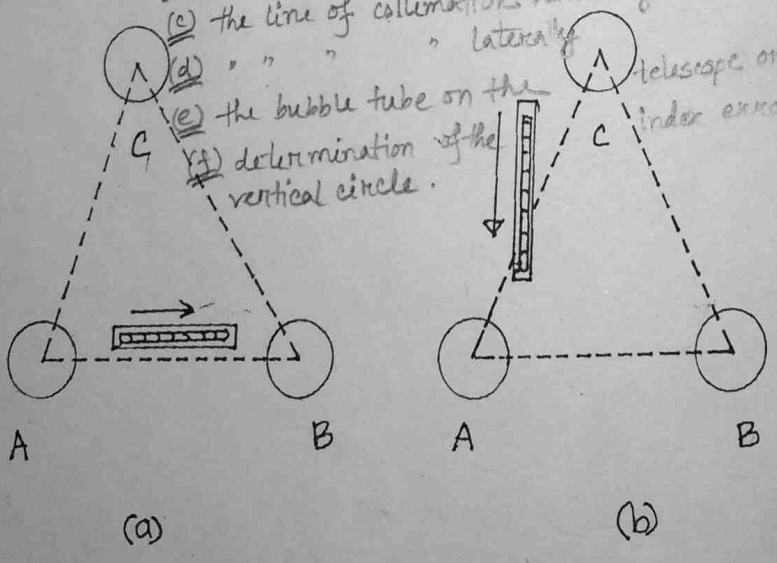


Fig: Levelling up with three foot screw

(2) P82-83

Permanent adjustment. (book)

- Read from Book.

Definition

Traversing is that type of survey in which a number of connected survey lines form the framework and the directions and lengths of the survey lines are measured with the help of an angle measuring instrument and a tape or chain respectively.

Types of traversing

There are two types of traverse surveying. They are:

(i) **Closed traverse**: when the lines form a circuit which ends at the starting point it is known as closed traverse.

(ii) **Open traverse**: when the lines from a circuit ends elsewhere except starting point, it is said to be an open traverse.

Suitability

Imp.

Q. For what type of project traverse surveying is suitable??

** normally roads are open traverse, but in special cases it can be closed. eg. metro rail.

The **closed traverse** (1) is suitable for locating the boundaries (1) of lakes (2), woods (3) etc and for the survey of large areas.

The **open traverse** (2) is suitable for surveying a long narrow strip of land as required for a road (1) or canal (2) or the coast (3) line.

It should be written in a classified way

Difference between chain and traverse surveying.

Traverse survey differes from chain surveying in that the arrangement of the survey lines is not limited to any particular geometrical figure as in chain surveying, where a system of connected triangles forms the fundamental basis of the skeleton. Also, check lines etc. are not necessary in traversing as the traverse lines may be arranged near the details. The details etc. are directly located with respect to the survey lines either by offsetting or by any other method.

Q. Differentiate bet^n diff. methods of traversing.

Methods of Traversing

There are several methods of traversing, depending on the instruments used in determining the relative directions of the traverse lines. The following are the principal methods

(i) Chain traversing (1)

(ii) Chain and compass traversing (2)

(iii) Transit tape traversing : (3)

(a) By tape needle method (i)

(b) By measurement of angles between the lines. (ii)

(iv) Plane table traversing (4)

Chain Traversing → Practical (1)

The method in which the whole of the work is done with the chain and tape is called chain traversing. No angle measuring instrument is used and the directions of the lines are fixed entirely by linear measurements. Angles fixed by linear or tie measurements are known as chain angles.

The method is unsuitable for accurate work and is generally not used if an angle measuring instrument such as a (1) compass, (2) sextant or (3) theodolite is available.

Chain and compass traversing (2)

In chain and compass traversing, the magnetic bearings of the survey lines are measured by a compass and the lengths of the lines are measured either with a chain or with a tape. The direction of magnetic meridian is established at each traverse station independently. The method is also known as free or loose needle method.

3(c)

Traversing by fast needle method — 3(i)

The method in which the magnetic bearings of traverse lines are measured by a theodolite fitted with a compass is called traversing by fast needle method. The direction of the magnetic meridian is not established at each station but instead, the magnetic bearings of the lines are measured with reference so that direction of magnetic meridian established at the first station. There are three methods of observing the bearings of lines by fast needle method.

(a) Direct method with transiting

(b) Direct method without transiting

(c) Back bearing method.

3(ii) By measurement of angles bet^n the lines :—

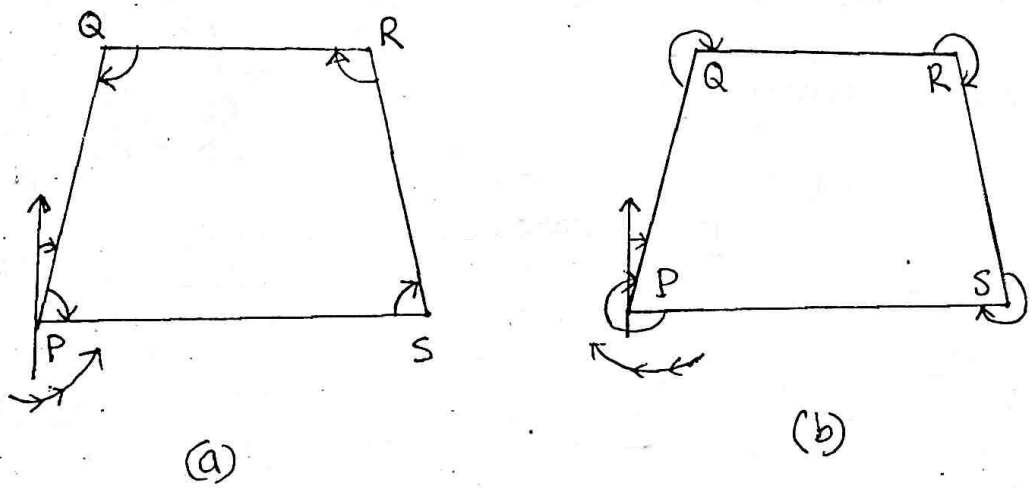
Traversing by direct observation of angles

In this method, the angles between the lines are directly measured by a theodolite. The magnetic bearing of any one line can be measured and the magnetic bearing of other lines can be calculated in this method. The angles measured at different stations may be either (i) included angles and (ii) deflection angles.

polygon-এর ক্ষেত্রে ব্যবহার করা হয়।

Traversing by included angles

An included angle at a station is either of the two angles formed by the two survey lines meeting there and this angles should be measured clockwise. The method consists simply in measuring each angle directly from a backsight on the preceding station. The angles may also be measured by repetition. The angles measured from the back station may be interior or exterior depending upon the direction of progress.



In the Fig (a) the direction of progress is counter-clockwise and so the angles measured clockwise are the interior included angles.

In Fig (b) the direction of progress is clockwise and so the angles measured clockwise are exterior excluded angles.

Traversing by deflection angles (2)

A deflection angle is the angle which a survey line makes with the prolongation of the preceding line. It is designated as right (R) or left (L) according as it is measured clockwise or anti-clockwise from the prolongation of the previous line.

This type of traversing is more suitable for survey of roads, railways, pipe-lines etc where the survey lines make small deflection angles.

Checks in Traverse surveying :— two types.

* Checks in traverse surveying —
  1) Closed traverse
     - length check
     - Angle "
       $(2n-4)\frac{\pi}{2}$
       $(2n+4)\frac{\pi}{2}$

(1) Checks in closed traverse

The errors involved in closed traversing are two kinds: (i) linear and (ii) angular. The most satisfactory method of checking the linear measurements consists in chaining each survey line a second time, preferably in the reverse direction on different dates and by different parties. The following are the checks for the angular work:

(i) Linear :—

(ii) Angular :—

1) Traverse by included angles :

(a) The sum of measured interior angles (clockwise) should be equal to $(2N-4)\frac{\pi}{2}$ where N = number of sides of the traverse

(b) If the exterior angles (clockwise) are measured, their sum should be equal to $(2N+4)\frac{\pi}{2}$

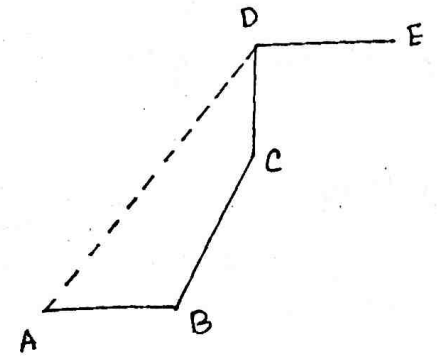
* Uses of fore & back bearing —
1) to check accuracy of the measurement
2) " " local attraction.

2) **Traverse by deflection angles:** the algebraic sum of the deflection angles should be equal to 360°, taking the right-hand deflection angles as positive and left-hand angles as negative.

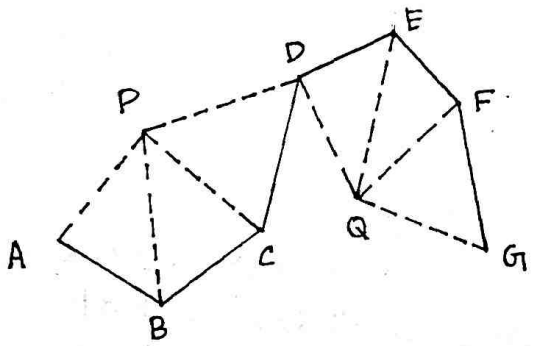
3) **Traversing by direct observation of bearings:** the fore bearing of the last line should be equal to its back bearing ± 180° measured at the initial station.

Checks in open traverse: In open traverse there are two types of checks — (i) linear & (ii) angular (i) linear check → same as before
(ii) No direct check of angular measurement is available. So indirect checks can be made.

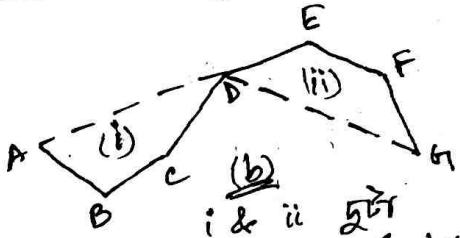
As illustrated in the fig (a) the addition to the observation of bearing of AB at station A, bearing of AD can also be measured, if possible. Similarly, at D, bearing of DA can be measured and check applied. If the two bearings differ by 180°, the work may be accepted as correct.



Another method, which furnishes a check when the work is plotted is as shown in fig: b and consists in treading the bearing to any prominent point P from each of the consecutive stations. The check in plotting consists in laying off the lines AP, BP, CP etc and noting whether the lines pass through one point.



(b)



(b)

i & ii 2टा closed traverse. So, by included/excluded fore & back bearing म diff. find measure गर्न.

Plotting a traverse survey (only name)

There are two principal methods of plotting a traverse survey:

(1) Angle and distance method: this method is of ~~two~~ three types

(a) By protractor

(b) By the tangent of the angle

(c) By the chord of the angle

(2) Co-ordinate method.

Traverse computations

H.W [+ & - sign দিয়ে উত্তর দিবে]

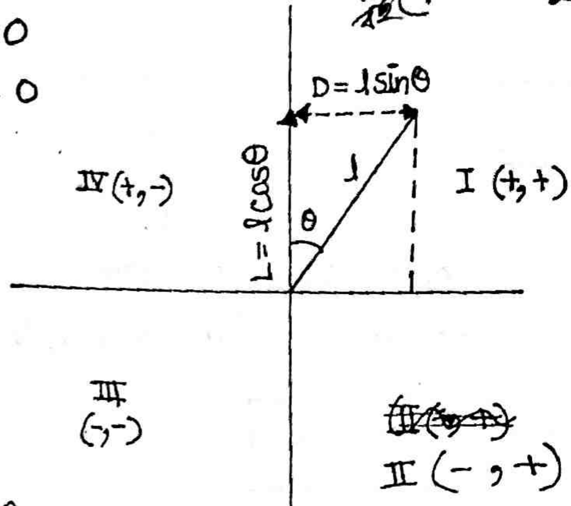
v.v.IMP. * In closed traverse —

$\Sigma L = 0$

& $\Sigma D = 0$

** এখানে cosθ & sinθ কোন quadrant-এ +/- হবে অনুযায়ী L & D এর sign হবে। কারণ? convention use হবে।

In the figure, the latitude and departure of the line AB of length l and reduced bearing θ are given by



$$L = +\,l\cos\theta \quad \text{and} \quad D = +\,l\sin\theta$$

* [L = Lattitude → distance through y-axis
D = Departure → " covered " x-axis]

To calculate the latitude and departure of the traverse lines, it is first essential to reduce the bearing in the quadrantal system. The sign of latitude and departures will depent upon the reduced bearing of the line. The following table gives signs of latitudes and departures.

Table – 1

W.C.B	R.B and Quadrant	Sign of Latitude	Sign of Departure
0° to 90°	N θ E ; I	+	+
90° to 180°	S θ E ; II	−	+
180° to 270°	S θ W ; III	−	−
270° to 360°	N θ W ; IV	+	−

Thus, latitude and departure co-ordinates of any point with reference to the preceding point are equal to the latitude and departure of the line joining the preceding point to the point under consideration. Such co-ordinates are also known as consecutive co-ordinates or dependent co-ordinates.

Q. 1) What is consecutive co-ordinates?

Q. 2) " " dependent co-ordinates?

Closing Error

If a closed traverse is plotted according to the field to measurement, the end point of the traverse will not coincide exactly with the starting point, owing to the errors in the field measurements of angles and distances. Such error is known as **closing error**. In a closed traverse, the algebraic sum of the latitudes and the algebraic sum of the departures should be zero.

In the figure,

closing error $e = AA'$

$$= \sqrt{(\Sigma L)^2 + (\Sigma D)^2}$$

The direction of closing error is given by

$$\tan\delta = \frac{\Sigma D}{\Sigma L}$$

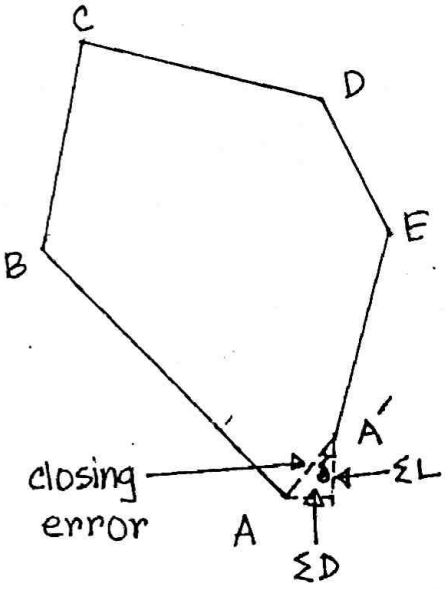


Fig-1

The sign of ΣD and ΣL will be defined by the quadrant in which the closing error lies. The relative error of closure, thr is

$$\frac{\text{Error of closure}}{\text{Perimeter of traverse}} = \frac{e}{P} = \frac{1}{P/e}$$

Balancing The Traverse

The term 'balancing' is generally applied to the operation of applying corrections to latitudes and departures so that $\Sigma L = 0$ and $\Sigma D = 0$. This applies only when the survey forms a closed polygon. The following are common methods of adjusting a traverse. (4 methods)

① Bowditch's method — Read. [From book]

② Transit method

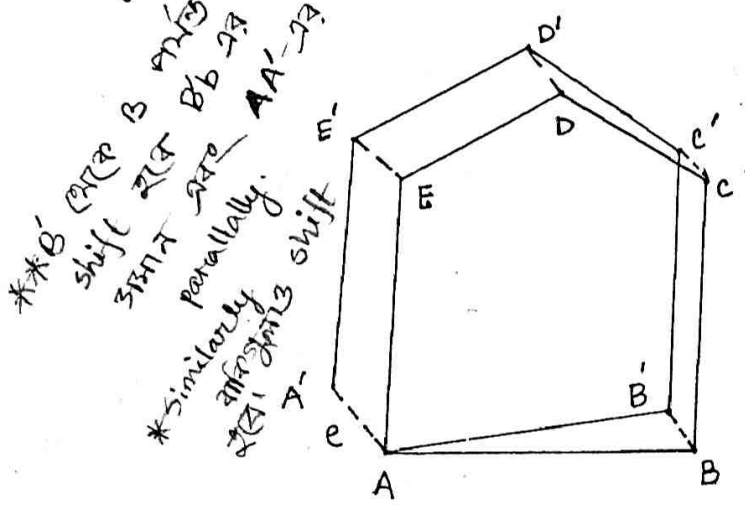
③ Graphical method

④ Axis method.

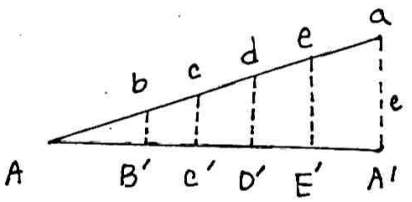
Q. Why the graphical method is preferable in balancing the traverse??

Graphical Method

V. Imp Line According to the (Ans) graphical method, it is not necessary to calculate latitudes and departures. Before plotting the traverse directly from the field notes, the angles or bearings may be adjusted to satisfy the geometric conditions of the traverse.



(a)



(b)

=> In fig-a, polygon AB'C'D'E'A represents an unbalanced traverse having a closing error equal to A'A since the first point A and the last point A' are not coinciding

=> The total closing error AA' is distributed linearly to all the sides in proportion to their AB', B'C', C'D' etc. represent the length of the sides of the

**xm-A graph বলা না থাকলে আঁকতে হবে না।
traverse-এ যা থাকবে না / বের করতে হবে
Parvia Chp-8 *Ommitted measurement

Example 8.2

A closed traverse was conducted round an obstacle and the following observations were made. Work out the missing quantities:

*Fixed Bearing এলে থাকলে Azimuth-এ convert করতে হবে।
*Direction বলা নাই এলে (WCB) Bearing

Side	Length (m)	Azimuth
AB	500	98° 30′
BC	620	30° 20′
CD	468	298° 30′
DE	?	230° 0′
EA	?	150° 10′

Solution

The affected sides are adjacent. Figure-1 shows the traverse ABCDE in which DA is closing line of the polygon ABCD. The latitude and departure of the closing line DA can be calculated. The calculations are shown in the tabular from below.

Problem:— Assume the magnetic bearing of a line AB read in 1889 was N 26°15′ E. The declination at the time and place was 7°15′ W. In 2014, the declination is 4°13′ E. Determine the magnetic bearing in 2014.

In 1889, from figure-1 — we get —

$T.B. = 26°15' - 7°15'$

$= 19°$

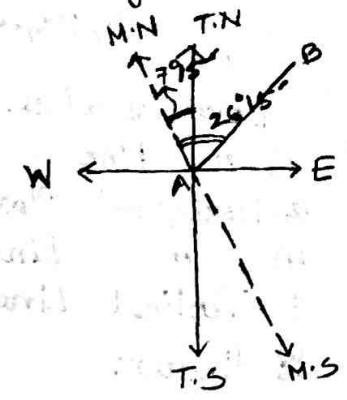


Fig1 - In 1889

From fig-2, we get, in 2014, the M·B of the line is —

$MB = 19° - 4°13'$

$= N14°47'E$

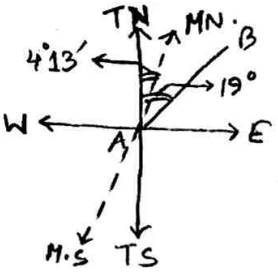


Fig2 — In 2014

Traverse Computation:— (Def^{n}s)

(1) Lattitude:— The lattitude of a survey line may be defined as its co-ordinate length measured parallel to an assumed meridian direction (i.e. true N or magnetic N or any other assumed direct^n).

(2) Departure:— The departure of survey lines may be defined as its co-ordinate lengths measured at right angles to the meridian direct^n.

Lattitude:

+ve → measured northward (upward) → called Northing

-ve → " southward (downward) → " Southing

Departure:

+ve → measured eastward → called Easting

-ve → " westward → " Westing

Levelling and Contouring

(3) Consecutive Co-ordinate:— Lattitude and departure co-ordinate of any point with reference to the preceeding point are equal to the Lattitude & departure of the line joining the preceeding point to the point under consideration.

(4) Independent Co-ordinate:— The total lattitude and departure of any point with respect to a common origin are known as independent co-ordinates / total co-ordinates.

**Generally the most westerly station is chosen for the two reference axes.

Imp. Definitions:—

1) Level Surface
2) " Line
3) Horizontal Plane
4) " Line
5) Vertical Line
6) Datum
7) Elevation
8) Mean Sea Level
9) Bench Mark

** As chain & traverses are suitable for small projects, so, we neglected the curvature of the earth.

** As level line - is curved & it is drawn with respect to Datum, So, Datum is also a curved line.

** Mean Sea Level is a datum, it is not the only datum, but it is the mostly used datum.

** Elevation fixed করতে চাইলে MEAN SEA LEVEL লাগবে।
but diff. of elevation চাইলে " " " লাগবে না।

* Purpose / Objective of levelling —
  1) to fix the elevation
  2) to know " "

9

* যেকোন point-এর elevation depends on — datum এর।
* Datum → the particular reference point

Levelling

Levelling Purpose

1) To find elevations → for design
2) To establish points → setting out engg. works.

9.1. DEFINITIONS (Ref. Fig. 9.1)

Levelling. Levelling is a branch of surveying the object of which is (1) to find the elevations of given points with respect to a given or assumed datum, and (2) to establish points at a given elevation or at different elevations with respect to a given or assumed datum. The first operation (1) is required to enable the works to be designed while the second (2) operation is required in the setting out of all kinds of engineering works. Levelling deals with measurements in a vertical plane → most imp

Level Surface. A level surface is defined as a curved surface which at each point is perpendicular to the direction of gravity at the point. The surface of a still water is a truly level surface. Any surface parallel to the mean spheroidal surface of the earth is, therefore, a level surface.

Level Line. A level line is a line lying in a level surface. It is, therefore, normal to the plumb line at all points.

Horizontal Plane. Horizontal plane through a point is a plane tangential to the level surface at that point. It is, therefore, perpendicular to the plumb line through the point.

→ curved surface

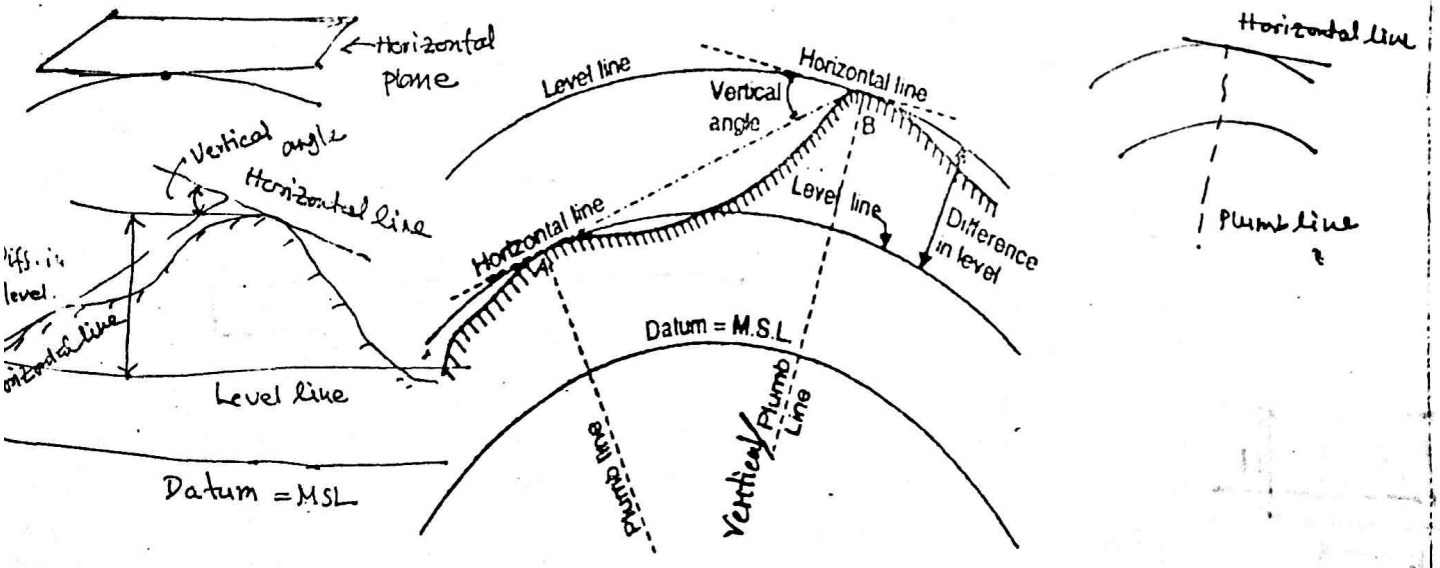


FIG. 9.1 H.W (to draw it in cW copy)

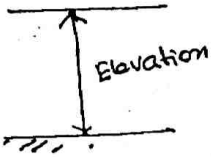
Dr. Mohammad Shariful Islam
Associate Professor
Department of Civil Engineering
BUET, Dhaka-1000, Bangladesh

Horizontal Line It is straight line tangential to the level line at a point. It is also perpendicular to the plumb line.

Vertical Line It is a line normal to the level line at a point. It is commonly considered to be the line defined by a plumb line.

Datum. Datum is any surface to which elevations are referred. The *mean sea level* affords a convenient datum world over, and elevations are commonly given as so much above or below sea level. It is often more convenient, however, to assume some other datum, specially if only the relative elevations of points are required.

Elevation. The elevation of a point on or near the surface of the earth is its vertical distance above or below an arbitrarily assumed level surface or datum. The *difference in elevation* between two points is the vertical distance between the two level surfaces in which the two points lie.



Vertical Angle Vertical angle is an angle between two intersecting lines in a vertical plane. Generally, one of these lines is horizontal.

Mean Sea Level Mean sea level is the average height of the sea for all stages of the tides. At any particular place it is derived by averaging the hourly tide heights over a long period of 19 years.

Bench Mark Bench Mark is a relatively permanent point of reference whose elevation with respect to some assumed datum is known. It is used either as a starting point for levelling or as a point upon which to close as a check.

9.2. METHODS OF LEVELLING

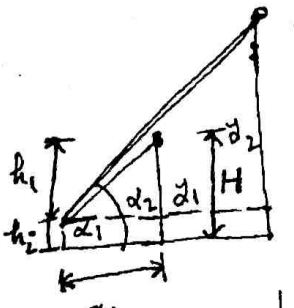
Three principal methods are used for determining difference in elevation, namely, *barometric* levelling, *trigonometric* levelling and *spirit* levelling.

(1) Barometric levelling. Barometric levelling makes use of the phenomenon that difference in elevation between two points is proportional to the difference in atmospheric pressures at these points. A barometer, therefore, may be used and the readings observed at different points would yield a measure of the relative elevations of those points.

At a given point, the atmospheric pressure does not remain constant in the course of the day, even in the course of an hour. The method is, therefore, relatively inaccurate and is little used in surveying work except on reconnaissance or exploratory surveys.

(2) Trigonometric Levelling (Indirect levelling) :

Trigonometric or Indirect levelling is the process of levelling in which the elevations of points are computed from the vertical angles and horizontal distances measured in the field, just as the length of any side in any triangle can be computed from proper trigonometric relations. In a modified form called *stadia levelling*, commonly used in mapping, both the difference in elevation and the horizontal distance between the points are directly computed from the measured vertical angles and staff readings.



(3) Spirit Levelling (Direct Levelling) :

It is that branch of levelling in which the vertical distances with respect to a horizontal line (perpendicular to the direction of gravity) may be used to determine the relative difference in elevation between two adjacent points. A horizontal plane of sight tangent to level surface at any point is readily established by means of a spirit level or a level vial. In spirit

(1) only rough idea পাওয়া যাবে।
একই level line এর bottom-এ, $p_1 = h_1 \rho g$ & top এ $p_2 = h_2 \rho g$.
$\therefore p_2 - p_1 = h_2 - h_1$
but, ρ & g temp. dependent. Height বাড়লে temp. diff. হবে। So, ρ & g const. হবে না।

(2)

LEVELLING

levelling, a spirit level and a sighting device (telescope) are combined and vertical distances are measured by observing on graduated rods placed on the points. The method is also known as *direct levelling*. It is the most precise method of determining elevations and the one most commonly used by engineers.

9.3 LEVELLING INSTRUMENTS

The instruments commonly used in *direct levelling* are :

(1) A level

(2) A levelling staff.

1. LEVEL

The purpose of a level is to provide a horizontal line of sight. Essentially, a level consists of the following four parts :

(*a*) A *telescope* to provide line of sight

(*b*) A *level tube* to make the line of sight horizontal

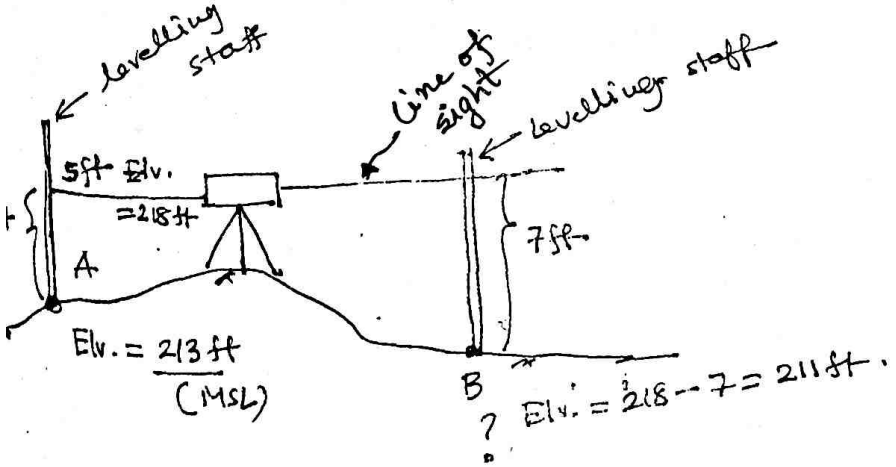
(*c*) A *levelling head* (tribrach and trivet stage) to bring the bubble in its centre of run

(*d*) A *tripod* to support the instrument.

There are the following chief types of levels

(i) Dumpy level
(ii) Wye (or Y) level
(iii) Reversible level
(iv) Tilting level.

Digital Law Theodolite
Auto level CE / 1 mm. staff reading
2 mm accuracy.



{ Longitudinal section
cross section.

1) Dumpy level

- Telescope and vertical spindle are cast as one piece.
- Telescope and bubble tube are mounted directly on the upper parallel plate.
- When permanent adjustments are achieved, the line of sight will be horizontal in all directions of the telescope.
- In spite of this advantage, dumpy level is not so popular compared to tilting or automatic levels, because of the time required to adjust the level and possibility of dislevelment with use.

Setting up: (Temporary)

- Drive legs firmly into ground so that approximate levelling is achieved,
- Using footscrews, with several trials bring the level tube bubble to center for two perpendicular directions of telescope.
- Focus eyepiece.(view cross hairs)
- Create staff image (no parallax)

Permanent adjustment:

- For dumpy level two permanent adjustments need to be checked.

1. Check if bubble tube axis is perpendicular to the vertical axis. If this condition is satisfied, the vertical axis will remain vertical and the bubble will remain at the center for all directions of the telescope .

Align bubble tube along a pair of footscrews and bring bubble to center. Turn telescope 180°. If bubble goes out of center, adjustment is required. Half of the bubble movement is corrected using the same footscrews, the other half using bubble tube adjusting capstan nuts. The same procedure is followed in the perpendicular direction. The total procedure is repeated several times till the desired objective is obtained.

2. Check if line of sight is parallel to the bubble tube axis. If this condition is satisfied, line of sight will be horizontal when the bubble tube is at center.

- Perform two peg test.
- If further adjustment is required, change the line of collimation by raising or lowering the horizontal cross hair using diaphragm adjusting screws. Note that the bubble tube has already been positioned in the first adjustment.

2)Tilting Level

- Telescope can be tilted with respect to the vertical spindle using tilting screw.
- Vertical axis need not be exactly vertical, since line of sight is not perpendicular to the vertical axis.
- Tilting levels are capable of highest accuracy and is in common use for both ordinary and precise levelling work.

It is convenient to use the tilting screw for obtaining horizontal line of sight but you have to use tilting screw again and again as you change direction of telescope.

Setting up:

- Drive legs firmly into ground so that approximate levelling with respect to circular bubble is achieved.
- Using footscrews, with several trials bring the circular bubble to center for two perpendicular directions of telescope.
- Focus eyepiece.(view cross hairs)
- Create staff image (no parallax)

Permanent adjustment:

- Permanent adjustment needs to be checked at suitable time intervals and not at every setting.
- For tilting level only one permanent adjustment needs to be checked.
- Check if line of sight is parallel to bubble tube axis. If this condition is satisfied, with the bubble at center, line of sight will be horizontal.
- Perform two-peg test
  - ❖ Take readings with level at M equi-distant from two staff positions A & B.
  - ❖ Since error due to inclined line of sight is proportional to distance, the errors would and the difference in above readings would give true difference in elevation..
  - ❖ Take readings at A,B from another level station N at unequal distances. If the difference in these staff readings is not equal to true difference, adjustment is required.

- The telescope has greater magnifying power.
- Levelling procedure and levelling staff for precise levelling are also different compared to ordinary levelling.
- Adjustments of levels are tested daily.

5) Hand level

- Hand levels are small (about 6 inches long) pocket sized levels used for approximate levelling.
- The level is held approximately horizontally with the hand by viewing the bubble inside the level tube.
- There is normally no magnification (no telescope) and the maximum probable distance for viewing is about 50 ft.
- It is handy and can be used where accurate levelling is not necessary.

Barometric Levelling

- Barometer is used to measure the atmospheric pressure.
- Barometric pressure decreases with increase in altitude. From known relations between pressure and altitude, elevation is determined. Average reading of barometer at MSL is 30 inch and decreases by about 1 inch for every 900 ft above MSL.
- This type of Levelling is not very accurate and is, thus, used in approximate and exploratory surveys. It is also used in surveys of hilly areas.
- There are two types of barometer in use. Although (1) mercury column barometer is more accurate, the aneroid (2) barometer is more portable and convenient and is normally used in surveying.
- Barometer readings are affected by weather (temperature, humidity) changes. Some means of corrections for these must be made.
- It is fast, no adjustment required, no staff required.

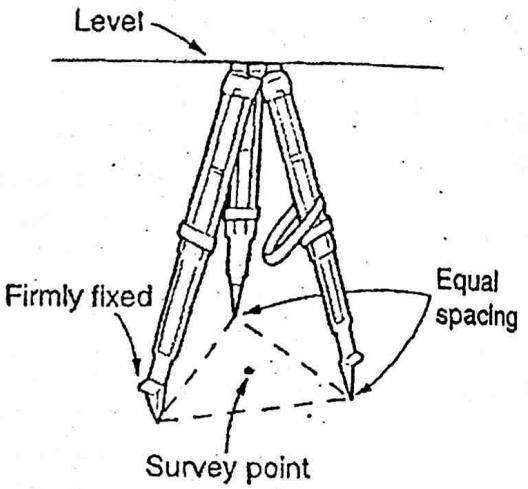
6. SETTING UP THE INSTRUMENT

- Mount the battery in the instrument before performing this operation because the instrument will tilt sightly if the battery is mounted after leveling.

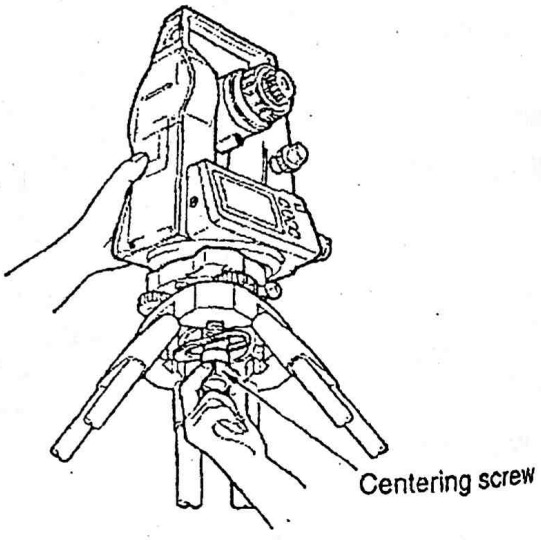
6.1 Centering

PROCEDURE

1. **Set up the tripod.**
   Make sure the legs are spaced at equal intervals and the head is approximately level.
   Set the tripod so that the head is positioned over the surveying point.
   Make sure the tripod shoes are firmly fixed in the ground.

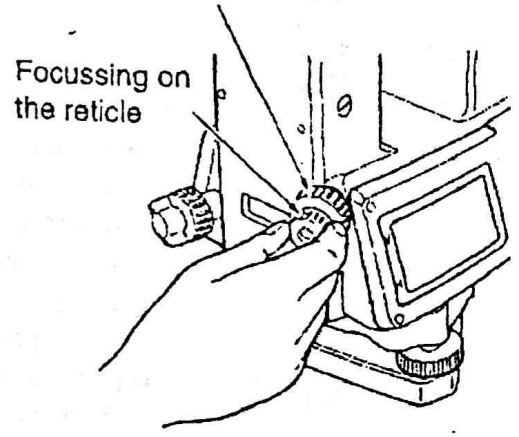


2. **Install the instrument.**
   Place the instrument on the tripod head.
   Supporting it with one hand, tighten the centering screw on the bottom of the unit to make sure it is secured to the tripod.



3. **Focus on the surveying point.**
   Looking through the optical plummet eyepiece screw, turn the optical plummet eyepiece to focus on the reticle. Turn the optical plummet focusing ring to focus on the surveying point.

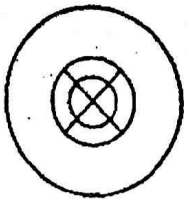
Focussing on the survey point



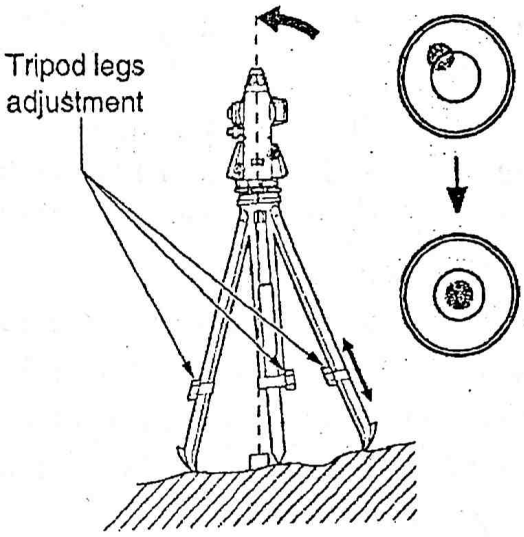
6.2 Leveling

PROCEDURE

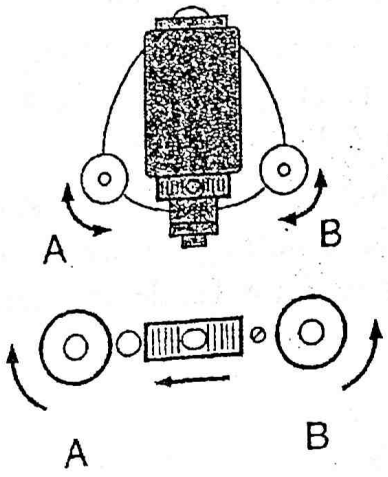
1. **Center the surveying point in the reticle.**
   Adjust the leveling foot screws to center the surveying point in the optical plummet reticle.



2. **Center the bubble in the circular level.**
   Center the bubble in the circular level by either shortening the tripod leg closest to the off-center direction of the bubble or by lengthening the tripod leg farthest from the off-center direction of the bubble. Adjust one more tripod leg to center the bubble.



3. **Center the bubble in the plate level.**
   Loosen the horizontal clamp to turn the upper part of the instrument until the plate level is parallel to a line between leveling foot screws A and B.
   Center the air bubble using leveling foot screws A and B.
   The bubble moves towards a clockwise rotated leveling foot screw.



Almost same as theodolite

9.6. TEMPORARY ADJUSTMENTS OF A LEVEL

Each surveying instrument needs two types of adjustments : (1) temporary adjustments, and (2) permanent adjustments. *Temporary adjustments or Station adjustments* are those which are made at every instrument setting and preparatory to taking observations with the instrument. *Permanent adjustments* need be made only when the fundamental relations between some parts or lines are disturbed (See Chapter 16).

The temporary adjustments for a level consist of the following :

(1) Setting up the level (2) Levelling up (3) Elimination of parallax.

1. Setting up the Level. The operation of setting up includes (*a*) fixing the instrument on the stand, and (*b*) levelling the instrument approximately by leg adjustment. To fix the level to the tripod, the clamp is released, instrument is held in the right-hand and is fixed on the tripod by turning round the lower part with the left hand. The tripod legs are so adjusted that the instrument is at the convenient height and the tribrach is approximately horizontal. Some instruments are also provided with a small circular bubble on the tribrach.

2. Levelling up. After having levelled the instrument approximately, accurate levelling is done with the help of foot screws and with reference to the plate levels. The purpose of levelling is to make the vertical axis truly vertical. The manner of levelling the instrument by the plate levels depends upon whether there are three levelling screws or four levelling screws.

(a) Three Screw Head

1. Loose the clamp. Turn the instrument until the longitudinal axis of the plate level is roughly parallel to a line joining any two (such as *A* and *B*) of the levelling screws [Fig. 9.29 (*a*)].

2. Hold these two levelling screws between the thumb and first finger of each hand and turn them uniformly so that the thumbs move either towards each other or away from each other until the bubble is central. *It should be noted that the bubble will move in the direction of movement of the left thumb* [see Fig. 9.29 (*a*)].

sighting is impossible. Parallax can be eliminated in two steps : (*i*) by focusing the eye-piece for distinct vision of the cross-hairs, and (*ii*) by focusing the objective to bring the image of the object in the plane of cross-hairs.

(*i*) ***Focusing the eye-piece***

To focus the eye-piece for distinct vision of the cross-hairs, point the telescope towards the sky (or hold a sheet of white paper in front of the objective) and move eye-piece in or out till the cross-haris are seen sharp and distinct. In some telescopes, graduations are provided at the eye-piece so that one can always remember the particular graduation position to suit his eyes. This may save much of time.

(*ii*) ***Focusing the objective***

The telescope is now directed towards the staff and the focusing screw in turned till the image appears clear and sharp. The image so formed is in the plane of cross-hairs.

9.1. THEORY OF DIRECT LEVELLING (SPIRIT 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. Strictly speaking, therefore, we must have a level line of sight and not a horizontal line of sight ; but the distinction between a level surface and a horizontal plane is not an important one in plane surveying.

Neglecting the curvature of earth and refraction, therefore, the theory of direct levelling is very simple. With a level set up at 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. By a succession of instrument stations and related readings, the difference in elevation between widely separated points is thus obtained.

SPECIAL METHODS OF SPIRIT LEVELLING

(*a*) **Differential Levelling.** It is the method of direct levelling the object of which is solely to determine the difference in elevation of two points regardless of the horizontal positions of the points with respect of each other. When the points are apart, it may be necessary to set up the instruments serveral times. This type of levelling is also known as *fly levelling.*

(*b*) **Profile Levelling.** It is the method of direct-levelling the object of which is to determine the elevations of points at measured intervals along a given line in order to obtain a profile of the surface along that line.

(*c*) **Cross-Sectioning.** Cross-sectioning or cross-levelling 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 of underlying strata, or of both.

(*d*) **Reciprocal Levelling.** It is the method of levelling in which the difference in elevation between two points is accurately determined by two sets of reciprocal observations when it is not possible to set up the level between the two points.

(*e*) **Precise Levelling.** It is the levelling in which the degree of precision required is too great to be attained by ordinary methods, and in which, therefore, special, equipment or special precautions or both are necessary to eliminate, as far as possible, all sources of error.

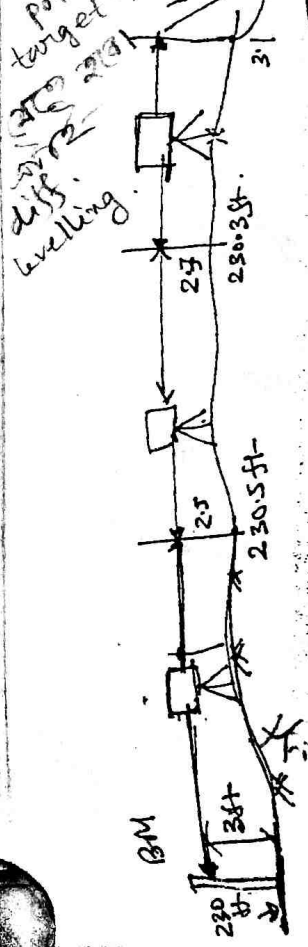


Fig → Diff. Levelling

TERMS AND ABBREVIATIONS

(*i*) **Station.** In levelling, a station is that point where the level rod is held and not where level is set up. It is the point whose elevation is to be ascertained or the point that is to be established at a given elevation.

(*ii*) **Height of Instrument** (H.I.) For any set up of the level, the height of instrument is the elevation of plane of sight (line of sight) with respect to the assumed datum. It does not mean the height of the telescope above the ground where the level stands.

(*iii*) **Back Sight (B.S.).** Back sight is the sight taken on a rod held at a point of *known elevation*, to ascertain the amount by which the line of sight is *above* that point and thus to obtain the height of the instrument. *Back sighting* is equivalent to measuring *up* from the point of known elevation to the line of sight. It is also known as a *plus sight* as the back sight reading is always added to the level of the datum to get the height of the instrument. *The object of back sighting is, therefore, to ascertain the height of the plane of sight.*

(*iv*) **Fore Sight (F.S.).** Fore sight is a sight taken on a rod held at a point of unknown elevation, to ascertain the amount by which the point is *below* the line of sight and thus to obtain the elevation of the station. *Fore sighting* is equivalent to measuring *down* from the line of sight. It is also known as a *minus* sight as the fore sight reading is always subtracted (except in speical cases of tunnel survey) from the height of the instrument to get the elevation of the point. *The object of fore sighting is, therfore, to ascertain the elevation of the point.*

(*v*) **Turning Point (T.P.).** Turning point or *change point* is a point on which both minus sight and plus sight are taken on a line of direct levels. The minus sight (fore sight) is taken on the point in one set of instrument to ascertain the elevation of the point while the plus sight (back sight) is taken on the same point in other set of the instrument to establish the new height of the instrument.

(*vi*) **Intermediate Station (I.S.).** Intermediate station is a point, intermediate between two turning points, on which only one sight (minus sight) is taken to determine the elevation of the station.

STEPS IN LEVELLING (Fig. 9.31)

There are two steps in levelling : (*i*) to find by how much amount the line of sight is above the bench mark, and (*ii*) to ascertain by how much amount the next point is below or above the line of sight.

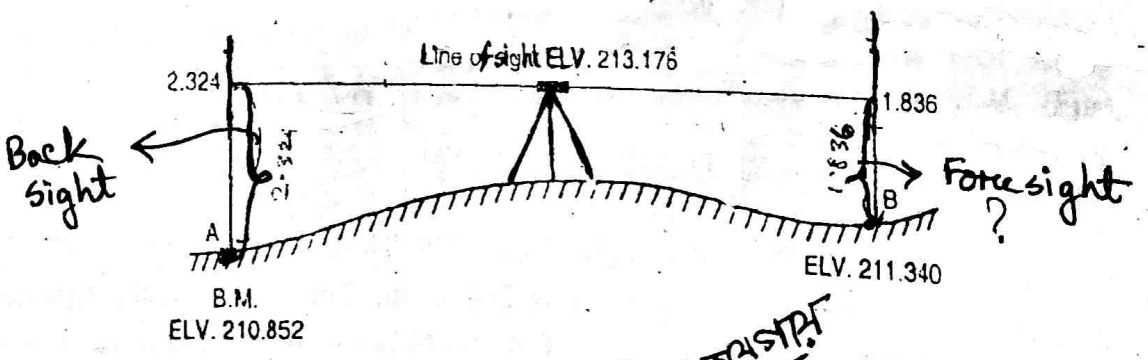


FIG. 9.

A level is set up approximately midway between the bench mark (or a point of known elevation) and the point, the elevation of which is to be ascertained by direct levelling. A back sight is taken on the rod held at the bench mark. Then

$$H.I. = Elv.\ of\ B.M. + B.S. \quad \text{---} (i) \qquad \ldots(1)$$

Turning the telescope to bring into view the rod held on point B, a foresight (minus sight) is taken. Then

$$Elv. = H.I. - F.S. \quad \text{---} (ii) \qquad \ldots(2)$$

For example, if elevation of $B.M.$ = 210.852 m, $B.S.$ = 2.324 m and $F.S.$ = 1.836 m.

Then $H.I.$ = 210.852 + 2.324 = 213.176 m

and Elv. of B = 213.176 − 1.836 = 211.340 m.

It is to be noted that if a back sight is taken on a bench mark located on the roof of a tunnel or on the ceiling of a room with the instrument at a lower elevation, the back sight must be subtracted from the elevation to get the height of the instrument. Similarly, if a foresight is taken on a point higher than the instrument, the foresight must be added to the height of the instrument, to get the elevation of the point.

9.8. DIFFERENTIAL LEVELLING

The operation of levelling to determine the elevation of points at some distance apart is called *differential levelling* and is usually accomplished by direct levelling. When two points are at such a distance from each other that they cannot both be within range of the level at the same time, the difference in elevation is not found by single setting but the distance between the points is divided in two stages by turning points on which the staff is held and the difference of elevation of each of succeeding pair of such turning points is found by separate setting up of the level.

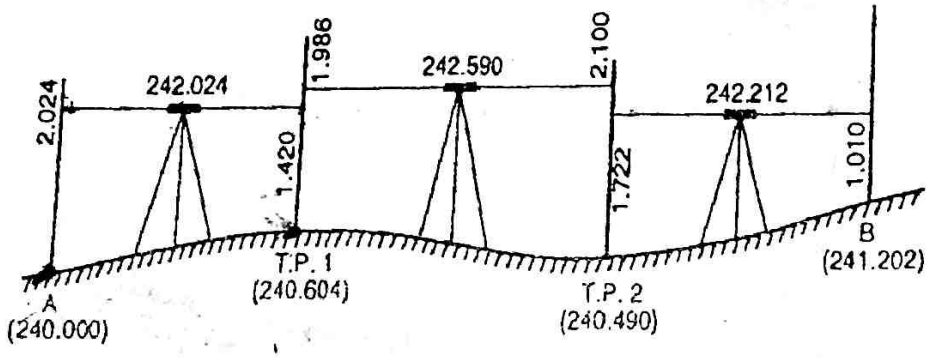


FIG. 9.32

Referring to Fig. 9.32, A and B are the two points. The distance AB has been divided into three parts by choosing two additional points on which staff readings (both plus sight and minus sight) have been taken. Points 1 and 2 thus serve as *turning points*.

The $R.L.$ of point A is 240.00 m. The height of the first setting of the instrument therefore = 240.00 + 2.024 = 242.024. If the following $F.S.$ is 1.420, the $R.L.$ of $T.P.$ 1 = 242.024 − 1.420 = 240.604 m. By a similar process of calculations, $R.L.$ of $T.P.$ 2 = 240.490 m and of B = 241.202 m.

9.9. HAND SIGNALS DURING OBSERVATIONS

When levelling is done at construction site located in busy, noisy areas, it becomes difficult for the instrument man to give instructions to the man holding the staff at the other end, through vocal sounds. In that case, the following hand signals are found to be useful (Table 9.1 and Fig. 9.33)

TABLE 9.1. HAND SIGNALS

Refer Fig. 9.33	*Signal*	*Message*
(a)	Movement of left arm over 90°	Move to my left
(b)	Movement of right arm over 90°	Move to my right
(c)	Movement of left arm over 30°	Move top of staff to my left
(d)	Movement of right arm over 30°	Move top of staff to my right
(e)	Extension of arm horizontally and moving hand upwards	Raise height peg or staff
(f)	Extension of arm horizontally and moving hand downwards	Lower height peg or staff
(g)	Extension of both arms and slightly thrusting downwards	Establish the position
(h)	Extension of arms and placement of hand on top of head.	Return to me

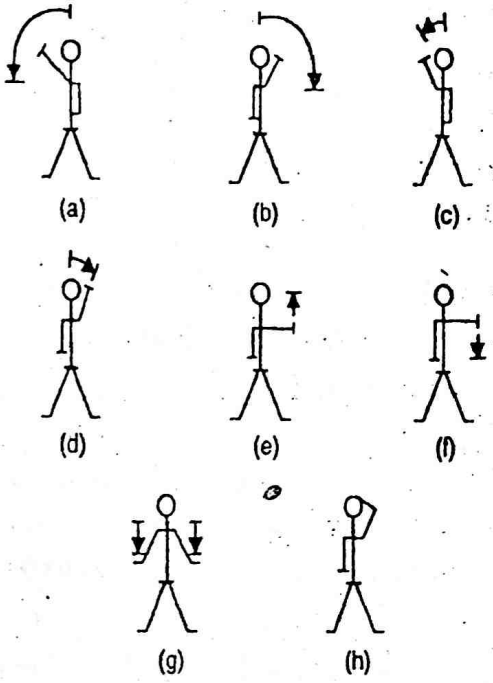


FIG. 9.33. HAND SIGNALS.

9.10. BOOKING AND REDUCING LEVELS

There are two methods of booking and reducing the elevation of points from the observed staff readings : *Collimation or Height of Instrument* method ; *Rise and Fall* method.

(1) HEIGHT OF INSTRUMENT METHOD

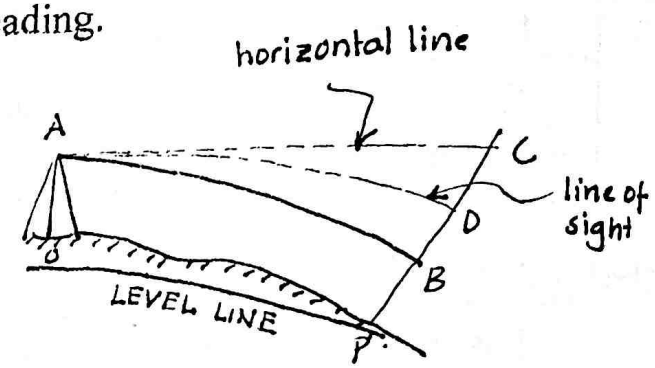
In this mehtod, the height of the instrument (*H.I.*) is calculated for each setting of the instrument by adding back sight (plus sight) to the elevation of the *B.M.* (First point). The elevation of reduced level of the turning point is then calculated by subtracting from *H.I.* the fore sight (minus sight). For the next setting of the instrument, the *H.I.* is obtained by adding the *B.S* taken on *T.P.* 1 to its *R.L.* The process continues till the *R.L.* of the last point (a fore sight) is obtained by subtracting the staff reading from height of the last setting of the instrument. If there are some intermediate points, the *R.L.* of those points is calculated by subtracting the intermediate sight (minus sight) from the height of the instrument for that setting.

EFFECT OF CURVATURE AND REFRACTION ON LEVELLING:

Q: Derive the formula for curvature correction.

Effect of curvature:

- Deviation of level surface from horizontal plane increases with distance.
- This deviation is negligible for short distances, but must be considered for large distances.
- Effect of curvature is to increase staff reading.



$OA = HI$

ΔOAC:

$$OC^2 = AC^2 + OA^2$$

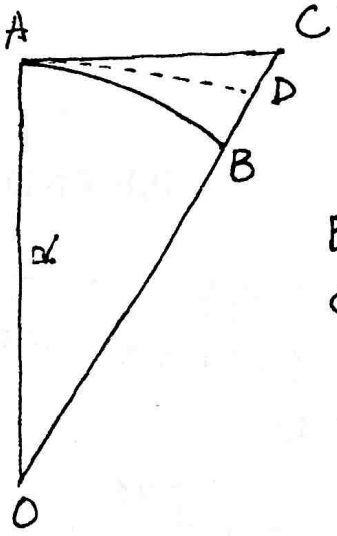
$$(R + h_c)^2 = l^2 + R^2$$

$$h_c = \frac{l^2}{2R + h_c}$$

Since $R >> h$, $h_c = \frac{l^2}{2R}$

$\therefore h_c = 2/3\, l^2$ ft when l is in miles

$h_c = 0.07857 l^2$ m when l is in k.m.



$BC = h_c$

$CD = h_r$

Effect of Refraction:

- With denser air underlying lighter air, ray of light refracts downwards.
- Under average atmospheric conditions this path is circular with a radius of approximately 7R.
- Effect of refraction is to reduce staff reading.
- In a similar manner it may be proved that $h_r = 2/21\, l^2$ ft when l is in miles $= 0.01122\, l^2$ m when l is in KM

Total correction:

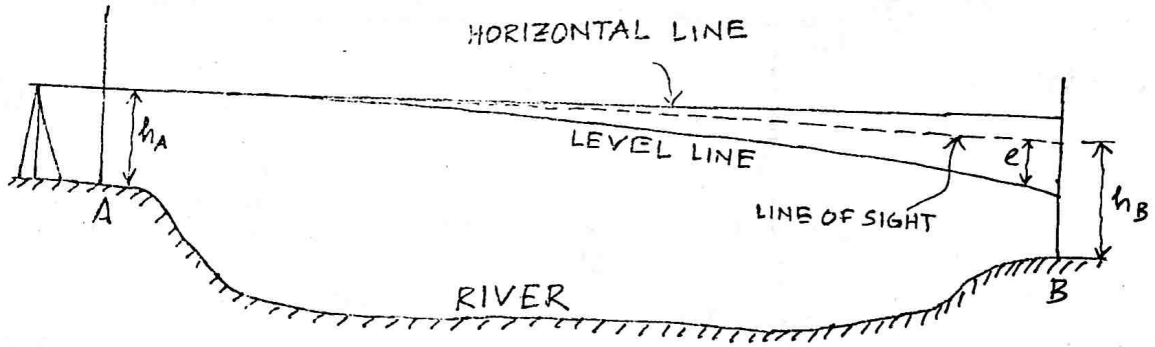
$h_{cr} = h_c - h_r = 0.572 l^2$ feet [l in miles] or, $0.06735 l^2$ m [l in KM]

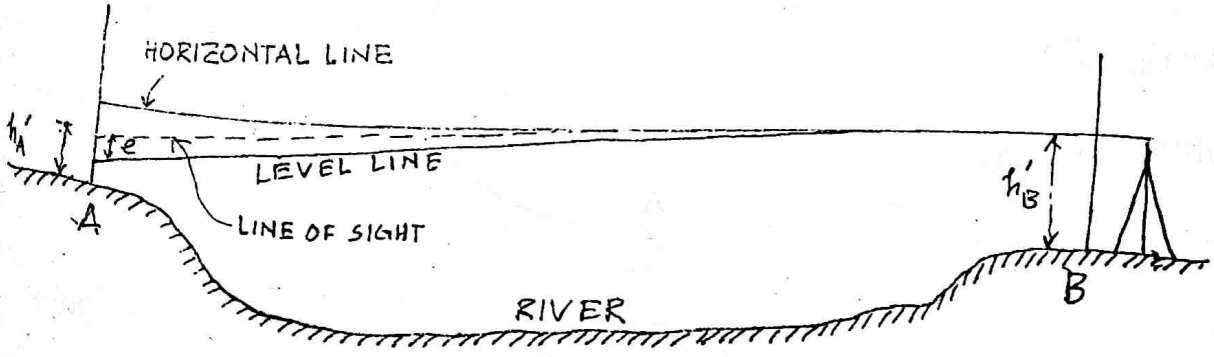
Corrected staff reading = Observed reading - h_{cr}

RECIPROCAL LEVELLING (short notes)

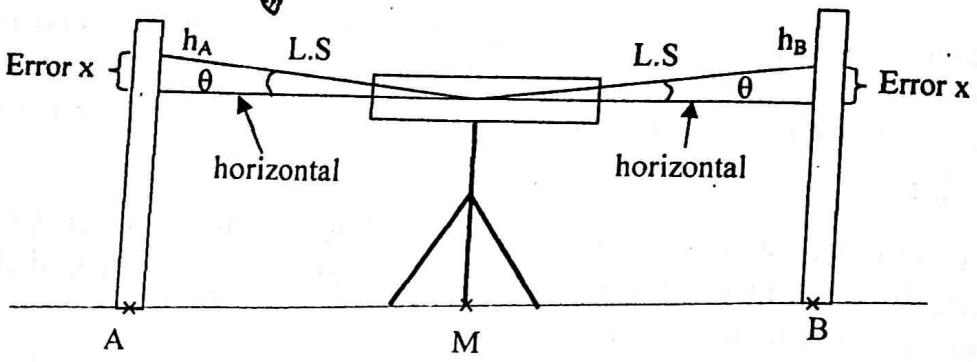
- By means of reciprocal Levelling, the need for applying corrections due to instrument collimation error or curvature refraction effects can be avoided without placing the level at equal distances between two far-apart points.
- This is required when performing Levelling across a river or ravine requiring long sight readings, where the level cannot be placed midway between the two points.
- Staff readings (h_A, h_B) are taken near the level point A and on staff located on the other bank (point B). staff readings (h_A', h_B') are again taken on the same two points but with level on the other bank near staff position B.

True difference in elevation between A and B: = ½ [(h_A - h_B) + (h_A' - h_B')]





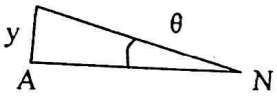
TWO-PEG TEST



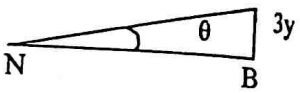
True difference in elevation between A & B = $(h_A - x) - (h_B - x)$

$= h_A - h_B$

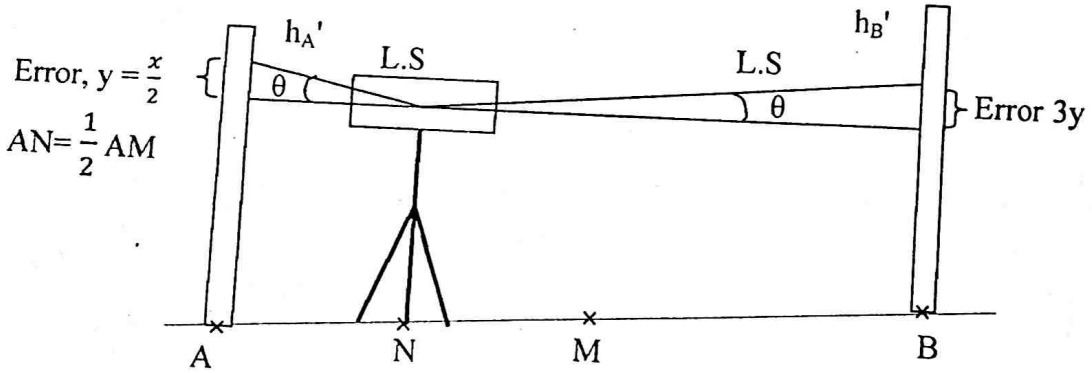
Error & distance



$\tan^{-1}\theta = \frac{y}{AN}$



$\tan^{-1}\theta = \frac{3y}{NB}$



(AN = NM) NB = 3AN

True difference in elevation between A & B

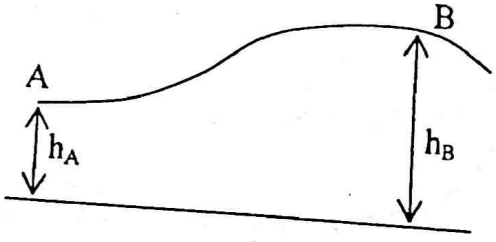
$= (h_A' - y) - (h_B' - 3y) = h_A - h_B$

y=? { +ve (L.S. inclined up); − ve (L.S. inclined down)

$\theta = \tan^{-1}(\frac{y}{AN})$

$hA' - y - hB' + 3y = h_A - h_B$

$\Rightarrow hA' - hB' + 2y = h_A - h_B$

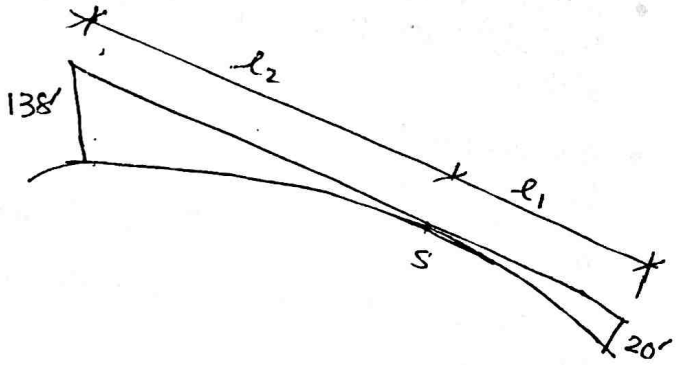


Example 9.6, Page 224

Punmia

Prob: An observer standing on the deck of a ship just sees a lighthouse. The height of the lighthouse is 138 feet above MSL and the height of the observer's eye is 20 feet above MSL. Find the distance between observer and lighthouse.

Example 9.12 BC Punmia



Prob:

Level at	Staff reading (ft) at	
	P	Q
P	5.98	9.01
Q	3.05	5.27

PQ = 3312.8 ft
R.L. of P = 414.55 ft
Find (a) True R.L. of Q
(b) h_{cr}
(c) collimation error (if any)

(a) True difference in elevation =

True R.L. of Q =

(b) h_{cr} =

(c) with level at P, correct staff reading at Q =

Due to h_{cr} effect, reading at Q should be =

But the actual reading at Q =

Collimation error =

Line of collimation is inclined

Inclination =

Q: Write down the errors in levelling.
— Tabular form - Q first
left side → errors
right " → sol^{n}s

ERRORS IN LEVELLING:

(1) Instrumental:

- *Imperfect adjustment*: Errors at turning points eliminated by quality of backsight and foresight distances, but error will remain at intermediate sights.
- *Sluggish Bubble*: check bubble before and after reading for slow moving bubbles.
- *Incorrect marking on staff*: check marking by a steel tape.
- *Defective joint of extendable staff due to wear or accumulation of dirt:* Repair
- *Wear at staff bottom*: consider only if both normal and inverted staff readings are taken.
- *Misalignment of telescope in external focusing telescopes*: Repair
- *Accumulation of dirt on base of staff*: Clean

(2) Natural:

- *Curvature of earth*: Adopt curvature correction
- *Refraction*: Adopt refraction correction.

May neglect the above two corrections for short distances. Also no correction needed when balancing backsight and foresight, and in reciprocal Levelling.

- *Temperature*: On hot sunny days, irregular refraction causes apparent vibration of staff and affects accuracy of staff reading. As a partial remedy, sight distances should be reduced. Also, unequal heating may cause distortion of instrument which may be important only for precise Levelling work. Use shade.
- *Wind*: strong winds may cause difficulty in holding staff vertical and also may cause vibration of level. Avoid using extended staffs and make sure that tripod is firmly supported on ground. May need to partially shelter the level from wind.
- *Soft ground*: Avoid soft ground where level or staff is kept for some time and may settle.

* For a particular map, contour interval is same.
* But for diff. map, contour interval may vary.

Dr. Tahseen M. Al-Hussaini

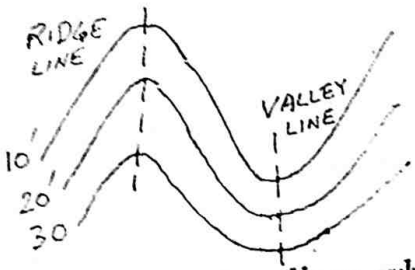
CONTOURING

Contours: Imaginary lines joining points of equal elevation (R.L.)

Contour Interval: Elevation difference between successive contours

Characteristics of Contours: (10.3)

1. Contour lines of different elevation do not cross each-other except in the case of an overhanging cliff or cave (Fig. 10.2)
2. Contour lines of different elevation do not touch each-other except in the case of a vertical surface.
3. Closely spaced contour lines represent steep slope, while far apart contour lines represent gentle slope.
4. If contours are uniformly spaced, they represent uniform slope. If they are straight uniformly spaced and parallel, they represent sloping plane surface.
5. The direction of steepest slope at a point on a contour is at right angles to the contour.
6. A contour must close itself or go off the map.
7. Contour lines cross a ridge line or water-shed line at right angles with the concave side facing higher ground.
8. Contour lines cross a valley line at right angles with the concave side facing lower ground.



Contour Map: Map containing contour lines, which may be used for:

- Assessment of topography of the site.
- Drawing vertical section of ground surface along any direction.
- Determination of intervisibility between triangulation stations.
- Locating a route (highway, railway, canal) with a certain vertical gradient following the local topography.
- Measurement of drainage area.
- Determination on plan of the boundary for a proposed earthwork.
- Calculation of earthwork (volume) for grading work, embankment construction, excavation work for roadway or canal.
- Determination of capacity of reservoir.

TACHEOMETRY

- A branch of angular surveying.
- Horizontal distances and heights/vertical distances are determined form instrument readings. Tape or chain is not required.
- Rapid and convenient method.
- Very useful where obstacles such as stretches of water or swamp roads, steep ground, ravines, crops etc. occur.
- Widely used in preparing contour maps of large scale.
- Accuracy is not very high, varying from about 1 in 10000 for more accurate subtense systems.

SYSTEMS: Q. 3 টি system description করতে বলবে এখান থেকে নিবে।

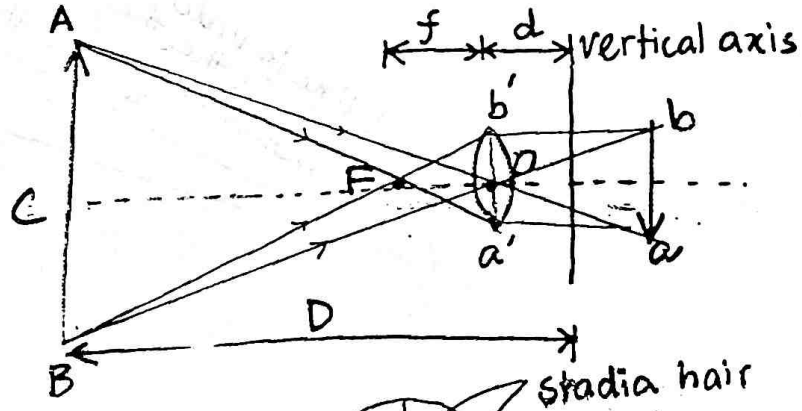
1.Stadia system 2.Subtense system 3.tangential system 4.Specialized instruments

*Instruments:—
1) Theodolite 2) Level staff 3) stadia hair

STADIA SYSTEM

- Relatively cheap and easy method of optical distance measurement system.
- Uses standard theodolite with stadia hair and leveling staff.
- **Basic theory:**

Staff is normal to the line of sight.
AB = Staff intercept, s ab = Stadia interval, i
D = Horizontal distance of staff from the vertical axis of the instrument
f = focal length of the objective
d = horizontal distance of the optical center of O from the vertical axis



Similar triangles
ΔAFB and Δa'Fb'

$$FC = FO \frac{AB}{a'b'}$$

$$= f \cdot \frac{s}{i}$$

Distance, $D = \left(\frac{f}{i}\right) s + f + d$

$$\therefore D = K.s + C$$

Q. Derive this eqn.

multiplying constant — additive constant

If K=100 & C=0, then calculation becomes much simpler.

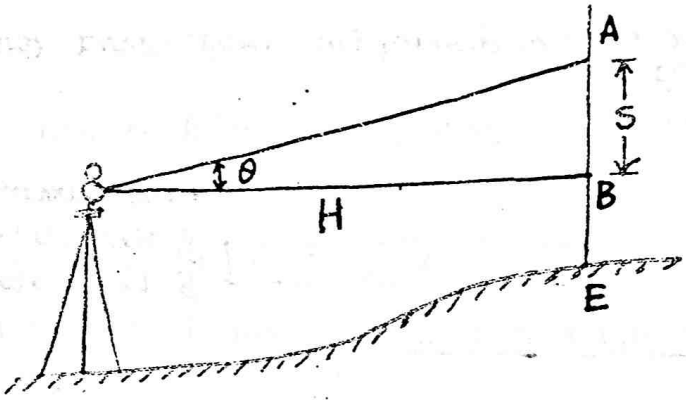
Instruments :—
1. theodolite
2. Level staff

THE TANGENTIAL SYSTEM

(i.e. stadia hair is not used)

- Distances and elevations may be deduced from staff readings taken by a theodolite without any additional fittings whatever.

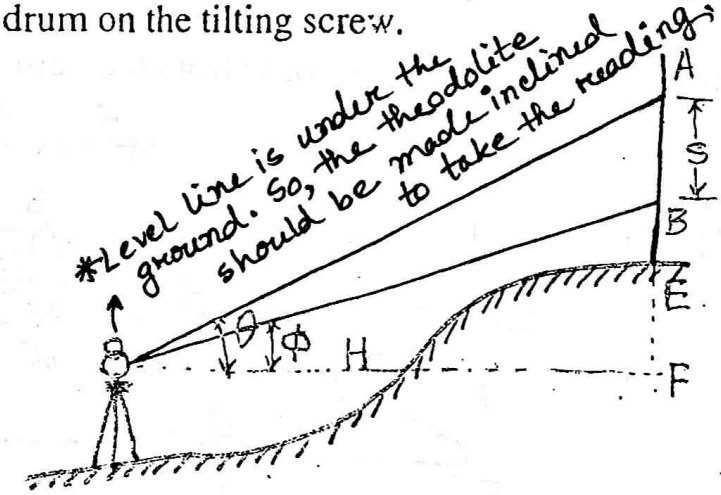
Case-(1) If the ground is sufficiently level, the staff may be read with a horizontal line of sight. The reading at B is observed with the telescope leveled, and that of A by means of a sight inclined at θ to the horizontal. The elevation of E is derived from the reading B as in ordinary leveling.



$$H = S \cot\theta$$

Q: Derive the formula

Case-(2) If the situation is such that a horizontal sight cannot be taken, the intercept between the two elevations (or depressions) can be observed. A similar procedure can be carried out with a tilting level having a graduated drum on the tilting screw.



$$S = AF - BF = H\tan\theta - H\tan\phi$$

$$\therefore H = \frac{S}{\tan\theta - \tan\phi}$$

Q: Derive the formula.

FIELD METHOD OF STADIA TACHEOMETRY:

- Set up instrument
- Determine height of instrument.
- Orient instrument
- Take readings along radial lines:

  (a)W.C.B. (b) Stadia hair and middle hair readings (c) vertical angle
- Take readings at next instrument station
- Shift instrument to new position, take readings at previous position.
- Take readings along radial lines.

PRINCIPAL SOURCES OF ERROR IN STADIA TACHEOMETRY:

- *Uncertainty in staff reading and hence staff intercept 's'*. Effect of multiplying constant. (K=100). Maximum length of sight should not generally exceed 100 m. Keep lower stadia reading above 1m.
- *Non-verticality of staff*: Use circular bubble fitted to staff. Keep vertical angle within ±10°.
- *Error in vertical angle*: this error is small compared to other errors if normal procedure is followed.

PHOTOGRAMMETRIC SURVEYING / PHOTOGRAMMETRY

*satellite, helicopter or plane থেকে surveying করা হয়।

- Obtaining accurate measurements by use of photographs

Purposes:

1) the construction of planimetric and topographic maps
2) classification of soils
3) interpretation of geology
4) acquisition of military intelligence and
5) the preparation of composite pictures of the ground.

The photographs are taken either from the air or from stations on the ground.

Two types →

1) *Terrestrial photogrammetry:* is that branch of photogrammetry wherein photographs are taken **from a fixed position on or near the ground.**

2) *Aerial photogrammetry:*
The photographs are taken by a camera mounted in an aircraft flying over the area.

** As different parts of photographs should be matched together, so the resolution, angle, speed etc should be same which is very difficult.

TERRESTRIAL PHOTOGRAMMETRY

- Photographs are taken with the camera supported on the ground
- by means of a phototheodolite, which is a combination of a camera and a theodolite. It can be fixed or from moving vehicles. Records of horizontal angle/bearings and take photograph viewed from that angle.
- Maps are then compiled from the photographs. imp

Q. Show the essential parts in photogrammetric surveying. (Def^n - w figure must)

Camera Axis

Camera axis is the line passing through the centre of the camera lens perpendicular both to the camera plate (negative) and the picture plane (photograph). The optical axis coincides with the camera axis in a camera free from manufacturing imperfections.

Picture Plane

Picture plane is the plane perpendicular to the camera axis at the focal distance in front of the lens. It is represented by the positive contact print or *photograph* taken from a plate or film.

Principal Point

Principal point (*k* or *k'*) is defined by the intersection of the camera axis with either the picture plane (positive) or the camera plate (negative).

Focal Length

Focal length (f) is the perpendicular distance from the centre of the camera lens to either the picture plane or the camera plate. It satisfies the following relation:

$$f = \frac{uv}{u+v}$$

where, u and v are conjugate object and image distances.

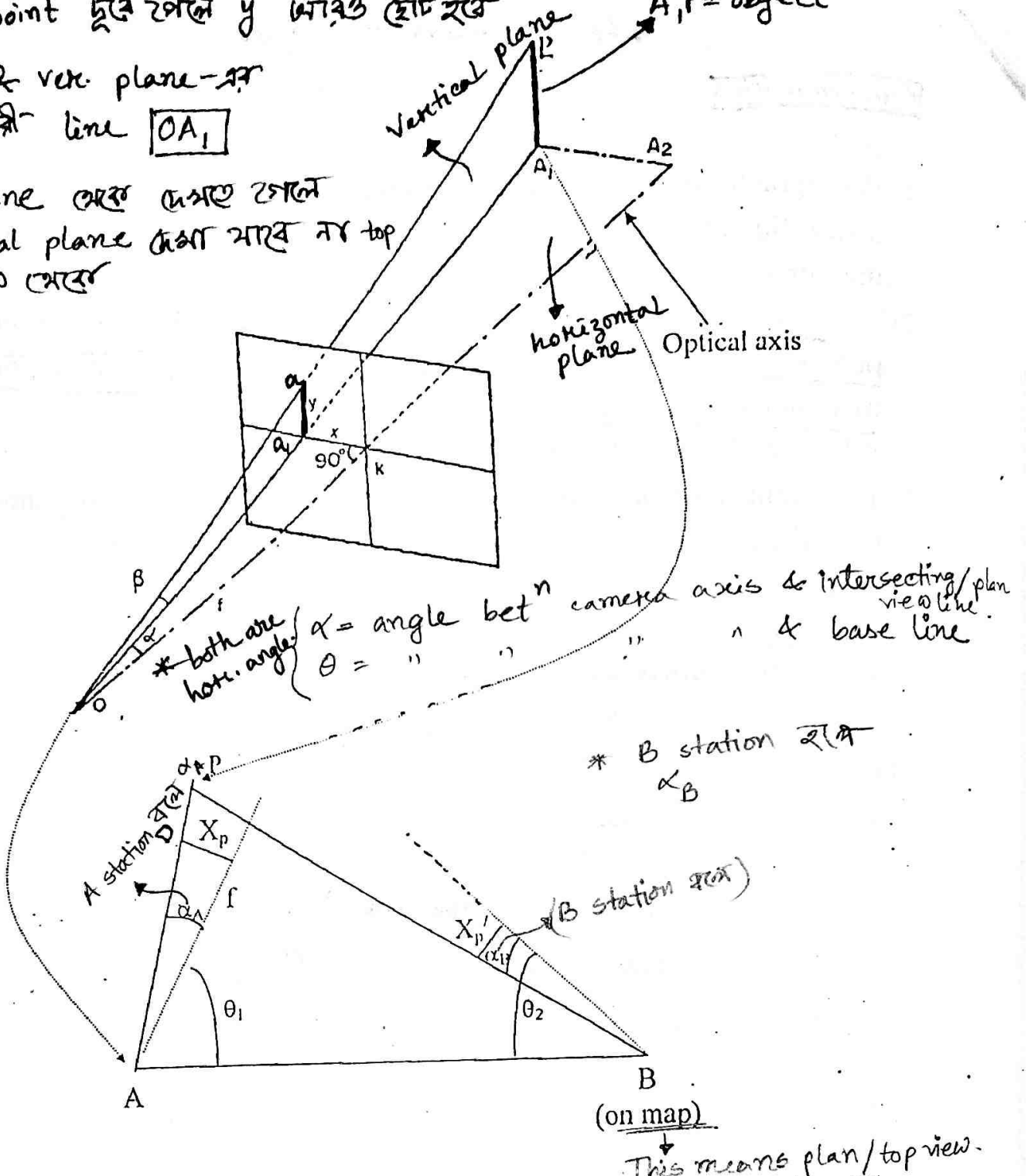
Focal Plane (Image Plane)

Focal plane is the plane (perpendicular to the axis of the lens) in which images of points in the object space of the lens are focused.

* O point দুরে গেলে y আরও ছোট হবে

∴ Hori. & vert. plane-এর ছেদরেখা line OA_1

**plaine থেকে দেখলে গেলে vertical plane দেখা যাবে না top view থেকে



Calculation of Distance, direction and elevation: Distance, bearings, RL

$\tan \alpha_A = X_p/f \Rightarrow \alpha_A = ?$, similarly $\tan \alpha_B = X_p'/f \Rightarrow \alpha_B = ?$

Solve triangle PAB for length and bearing in horizontal plane

- Height of P: $\frac{h(=PA')}{y_p} = \frac{AP}{AD}$ $\quad AD = f \sec\alpha_A$ or $\sqrt{f^2 + X_p^2}$

$\tan \beta_A = \frac{y_p}{AD}$

18. Horizon point

Horizon point is the intersection of the principal line with the horizontal line through the perspective centre, such as point *h* in Figure. In a near vertical or tilted photograph, this point is generally outside the photograph. In a high oblique photograph, however, it is in the photograph.

19. Axis of tilt

Axis of tilt is a line in the plane of the photograph and is perpendicular to the principal line at the isocentre such as $i_1 i i_2$ in Figure. The plane of the photograph is tilted to the horizontal about this axis The axis of tilt is a horizontal line, as are all line perpendicular to the principal line. It is also known as *isometric parallel.*

PROCEDURE FOR AERIAL PHOTOGRAMMETRY

Aerial photogrammetry consists of four operations:

1) Flying
2) Photography
3) Ground Control
4) Compilation or mapping

* 10^{-6} sec-ল photo নিতে হবে i.e. speed is very high.

To match the photos { same height, " speed, " resolution.

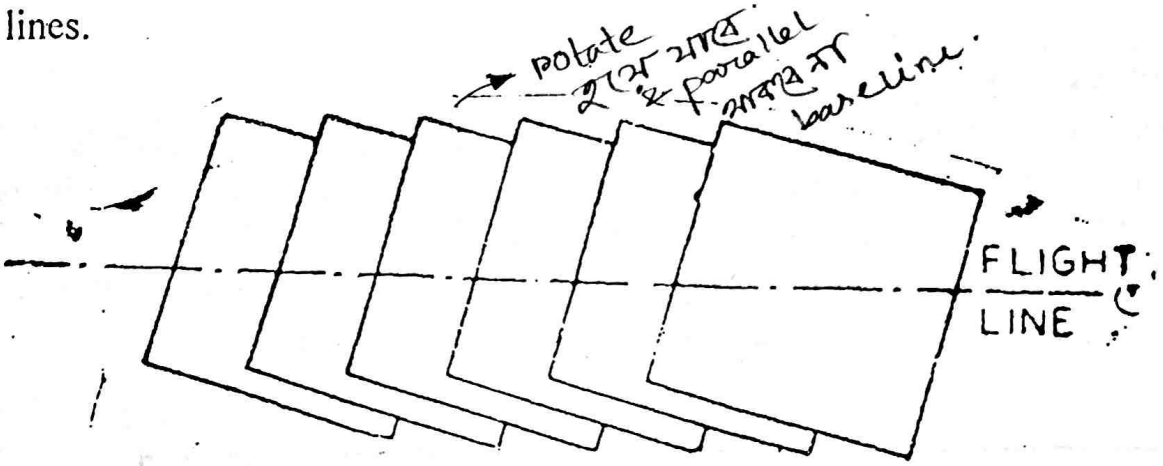
FLYING: Aeroplane should fly
- at an uniform rate
- on a straight course in a given direction
- at constant height

CRAB

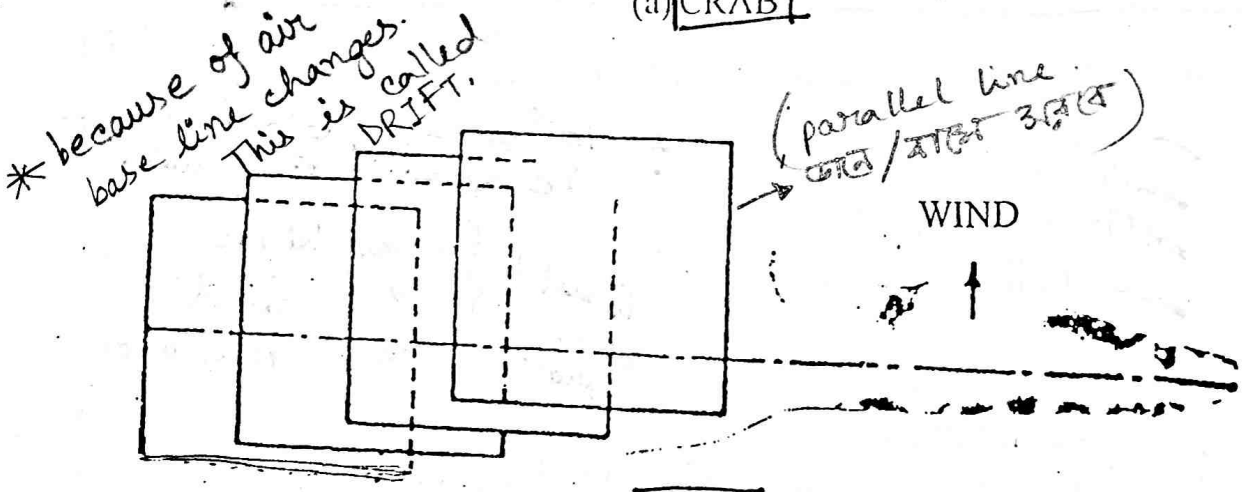
Crab is the term used to designate the angle formed between the flight line and the edges of the photograph in the direction of flight. At the instant of exposure, if the focal plane of the camera is not square with the direction of flight, the crab is caused in the photograph. The arrangements are always made to rotate the camera about the vertical axis of camera mount. Crabbing should be eliminated since it reduces effective coverage of the photograph.

DRIFT

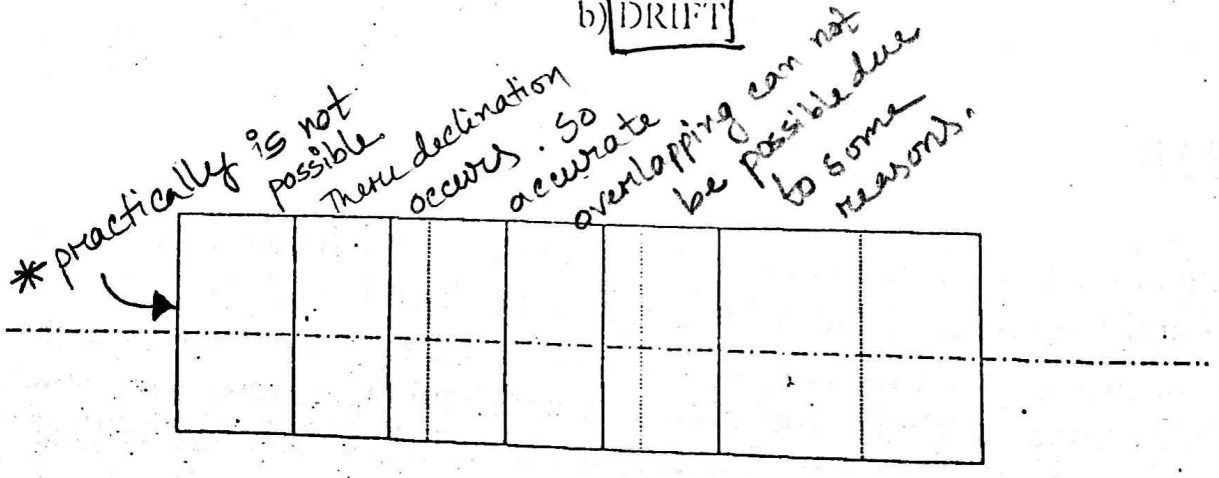
Drift is caused by the failure of the photograph to stay on the predetermined flight line. If the aircraft is set on its coarse by compass without allowing for wind velocity, it will drift from its course. If the drifting from the predetermined flight line is excessive, reflights will have to be made because of serious gapping between adjacent flight lines.



(a) CRAB



b) DRIFT



(c) Navigation in correct course