1. Acquaintance with Chain Survey Equipment

Aim: To study and acquaint with various equipment used in chain survey

A. Instruments Used for Measuring Distances

1. Chain
2. Tape

B. Instruments used for Setting Right Angles

1. Cross-staff
2. Optical square

C. Instruments used for Marking Survey Stations

1. Arrows
2. Ranging rod
3. Offset rod
4. Pegs
5. Laths and whites
6. Plumb bob

Description of the equipment

1. Chain: The chains are made of galvanized mild steel wire of straight in length. These wires are bent into small rings at the ends and joined each other by three small circular or oval type wire rings. These wires are called links. The ends of chains are provided with brass handle with swivel joint to avoid twisting of the chain. The length of al link is the distance between the centers of two consecutive middle rings.The length of chain is measured from the outside of one handle to the outside of there handle at the end.

   Types of chains

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

Metric chain is more commonly used in measuring distances in a agricultural farm. However, the revenue chain is still in use by the officials at village level

Metric chain

Metric chains are available in lengths of 20m and 30m. The brass tallies are provided to read the fractions of the chain length. These are provided at 5m interval in 20m and 30m standard metric chain. The brass rings are provided at every meter length of chain. A groove is provided outside the brass handle to facilitate holding of arrows in position with the handle of chain. The tallies used for recording distances in metric chain are provided with letters 'm' or 'mee' to distinguish from non-metric chains. The length of a chain is engraved on the handle. Each length of link is 0.2m (20cm) in metric chain. However, the number of links vary with the length of chain whether it is 20 m chain (100 links) or 30 m chain (150 links). The construction details of the metric chain of 20 m length are given in Fig 1.1.

2. Tapes

Tapes are used for more accurate measurements and classified according o the material with which they are made of Different types of tapes are:

i. Cloth or Linen tape
ii. Metallic tape
iii. Steel tape
iv. Invar tape

i. Cloth or Linen tape

Cloth tape is made of woven linen cloth having 12 to 15 mm width. It is varnished to resist moisture. These tapes are light, flexible and may be used for taking comparatively rough and subsidiary measurements such as offsets. The cloth tape is available in 10 m, 20 m, 25 m and 30 m lengths. The end of tape is provided with small brass or steel ring whose length is included in total length of the tape.

Disadvantages

a) It is susceptible to shrinkage when used in moist or dampness conditions
b) It's length is altered by stretching
c) It is likely to twist and tangle
d) It is not strong

Precaution

Before winding up the tape in cover case after use, it should be cleaned and dried.

ii. Metallic tape

A metallic tape is made of varnished strip of water proof linen inter woven with small brass, copper or bronze wires. These are available in 2 m, 5 m, 10 m, 20 m, 30 m, and 50 m, in length. A metallic (brass or steel) ring is attached to the outer end, having same width as that of tape (Fig. 1.2). In addition to ring, the outer ends are reinforced by a strip of leather or plastic material of same width as tape, up to a length of 20 cm . The tape are supplied in metal or leather case fitted with winding device.

Advantages

a) They are useful in cross-sectioning and topographic surveys due to their flexibility and light weight.

B) The measurements made by metallic tapes are more accurate over cloth tapes.

Precaution:

The tape should be cleaned and dried if it used on moist surfaces.

ii. Steel tape:

Steel tape consists of light steel strip of width ranging from 6 mm to 10 mm and is more accurately graduated. It is available in 1 m, 2 m, 10 m, 20 m, 30 m, and 50 m lengths the brass or steel ring is provided at the outer end of tape. The ring is fastened to tape end by metallic strip of same width as that of tape. The length of tape includes the length of metal ring.

Advantages:

a) It is superior over cloth and metallic tapes
b) It is strong and can long last when compared to above tapes
c) The measurements are more accurate and precise over the cloth and metallic tapes

Disadvantages:

a) It is costlier than the cloth and metallic tapes
b) The tape must be provided with corrosion resistant metal case or well sewn leather for winding purpose
c) It is delicate and light. Hence, it can not withstand rough usage in the field

Precaution:

a) The should be wiped clean and dry after using
b) It may be oiled with mineral oil so that it does not get rusted.

iii. Invar tape:

Invar tapes are used for linear measurements of a very high degree of precision like measuring baseline in chain triangulation and cross-staff survey. It is made of an alloy of nickel (36%) and steel. It possesses a very low thermal co-efficient of expansion of 1.22×10^{-7} per 1^{o} C. It has a width of 6 mm and it is available in 20 m, 30 m, 50 m, and 100 m lengths.

Advantages:

a) They can be used more rapidly and conveniently while measuring base lines of greater distance.
b) They can give more accurate results with high precision

c) It can be used conveniently in dry weather due to its very low thermal co-efficient of expansion.

Disadvantages:

a) They are more expensive over other types
b) They are subjected to creep resulting in small increase in length of tape
c) They are easily bent and damaged when compared to steal tapes

Precaution:

The tape must be kept on reels of large diameter as invar is very delicate material.

3.Arrows:

Arrows are also called as marking pins. They are made of steel wire, having 4 mm dia and it is black painted. The length of arrow varies from 25 to 50 cm. One end of arrow is made sharp to drive into ground and other end is provided with loop or circle to facilitate handling. As per Indian standards, the length of arrow is fixed at 40 cm generally, 10 arrows are provided with chain. While chaining, as arrow is inserted into ground after every chain length is measured on ground.

4. Ranging rods:

Ranging rods are made of well seasoned straight grained timber or cast iron hallow pipe. They are circular or octagonal in cross section having 3 cm dia. They are available in 2 m and 3 m lengths. 2 m lengths are commonly used. They are shod at bottom with heavy iron point. They are painted in alternative bands of either black and white or red and white or black, red and white in succession. Each band is 20 cm deep so that rod can be used for rough measurement of short lengths. They are used for marking intermediate stations in a survey line. They are invisible at a distance of 200 m. If the distance exceeds 200 m, red or white or yellow flag is tied at the top of the rod. The flag dimension is 30 to 50 cm square.

5. Offset rods:

They are round wooden rods with a length of 3 m. One end of the rod is provided with pointed iron shoe and notch or hook at other end. The hook or notch on top of rod facilities pulling or pushing the chain through hedges and other obstructions. They are used for measrui9ng offsets. Also, they have two narrow slots at centre perpendicular to each other at the eye level for aligning the offset lines.

6. Cross-staff:

There are three types of cross-staff namely, i. Open ii. French and iii. Adjustable cross-staff. The first one is commonly used.

i. Open Cross Staff:

It consists of two parts. One is head and the other is leg. The head is made up of 4 cm deep with two fine saw cuts at right angles to each other. The head is furnished with two pairs of vertical slits at the end of saw cuts, providing two lines of sight perpendicular to each other. The head is fixed to the top of an iron-shod wooden staff or iron pole whose dia and lengths are 2.5 cm and 1.2 to 1.5 m long respectively. The leg is driven into ground surface while setting right angles to survey line. It is used for setting perpendicular offsets from chain line.

7. Optical square:

It is an accurate instrument for setting right angles to a survey line when compared to cross-staff. It consists of circular box with three slits at E, F and G. In line with the openings E and G, a glass silvered at the top and unsilvered at the bottom, is fixed facing the opening E. A silver coated mirror is fixed at "A" opposite to the opening F. These two mirrors are fixed at 45^{o} inclimation to each other. A ray from the ranging rod at 'Q' passes through the lower unsilvered portion of the mirror at 'B' and is seen directly by eye at the slit 'E'. Another ray from the object at 'P' is received by the mirror at 'A' and is reflected towards and mirror at 'B' which reflects it towards the eye. Thus, the images of P and Q are visible at 'B'. If both images are in the same veratical line as shown in Fig. 1.7 the PD and QD will be at right angles to each other.

To set a right angle on a survey line, the instrument is held on the line with it's centre on the point at which perpendicular is to be erected. The slits F and G are directed towards the ranging rod fixed at the end of the survey line. The surveyor holding the instrument then directs a person holding ranging rod, approximately perpendicular position to survey line to move till the two images of ranging rods coincide.

8. Pegs:

Pegs are made of timber wood and used to mark the positions of survey station or terminal points of survey line. They are made with square cross section (2.5 x 2.5 cm^2 or 3 x 3 cm^2) and 15 cm long (Fig./1.8). One end of it is tapered and the other end is sharpened. They are driven into ground with the help of wooden hammer.

9. Laths and Whites:

In open level ground, intermediate paints on a line may also be lined out with straight laths. They are made of softwood with length varying from ½ to 1 m (Fig.1.9). They are light both in color and weight. Laths are also useful for ranging out a line when crossing depression from which the forward rod is invisible.

Whites are pieces of sharpened thin sticks and are used for the same purposes as the laths. They are sharpened at one end and split with knife at the top. The pieces of white paper are inserted in the clefts in under to make them more visible when stuck up in grass. They are also useful in cross-sectioning or in temporary marking of contour points.

10. Plumb bob:

It is used while chaining along sloping ground, to transfer the points to ground surface. It serves the purpose of making ranging poles vertical and to transfer points from a line ranger to the ground. It can also be used as centering aid in theodolites, compass, plan table and a variety of other surveying instruments.

2. To calculate the distance between two points by pacing

Aim: To find the distance between two points by pacing

Principle of pacing:

Measurement of distances by pacing is chiefly confined to the reconnaissance surveys. It is quick and used to check the distances measured by chains and tapes. The method of pacing consists of counting the number of paces between two points of a line. The length of line can be computed by knowing the average length of pace. A length of pace is nearly that of one's natural step of walking. The accuracy could be maintained is 1 to 100 if it is done on level and unobstructed ground. The length of pace depends on.

- i. Physique of individual
- ii. Nature of ground and its slope
- iii. Speed of pacing

Equipment required

Metric chain of 20 m or 30 m.

Procedure

1. Fix the known distance of 30 between two points A and B
2. Walk over AB line with one's natural step and count the number of steps (paces)
3. Calculate pace length by using the equation.

$$\text{Pace length (m)} = \frac{\text{Length of AB}}{\text{No. of paces}} \qquad (1.1)$$

4. Replicate step (2) and (3) at least three times and calculate average pace length and enter the reading in observation sheet.
5. Now walk across the line CD whose distance has to be found and note down the no of paces.
6. Now multiply the no of paces with pace length you will get the distance between the points C and D.

Precautions:

i. One shouldn’t run over the selected length of line AB and use his natural step.

ii. The ground surface selected for conducting exercised is as plain as possible.

iii. It is only an average method which gives and approximate distance.

Result:

3 RANGING AND MEASUREMENT OF OFFSETS

Aim: i. To locate intermediate stations by direct ranging

ii. To measure offsets from the chain line

Principle:

A. Ranging:

Ranging is the process of fixing or establishing intermediate stations in a survey line in order to maintain straight measurement between two end stations of survey line. There are two types of ranging.

v. Direct Ranging: It is done when two ends of survey line are intervisible. This can be done either by eye or line ranger (optical instrument).

vi. Indirect Ranging: It is called as reciprocal ranging. It is done when two end points are too far or not intervisible due to obstruction.

B. Offsets:

Offset is the lateral distance of an object or ground feature measured from a survey line. By way of offsets, an object is located by measuring distance and angle from a point on the chain line. When the angle is 90º, it is perpendicular offset and if angle is other than 90º, it is oblique offset as shown in Fig. 2. 1a & b.

Equipment required: Metric chain, tape, arrows, ranging rods and cross-staff.

Procedure

A. Direct ranging:

1. Fix any two end points A and B of survey line. As show in Fig. 2.2.
2. Errect two ranging rods at both A and B
3. The survey or then directs his assistant to go with another ranging ord and establish the rod at a point approximately in line with AB at a distance not more than one chain length.
4. The survey or standing behind the ranging rod at A, signals the assistant to move transverse to the chain line till he is in line with A and B as show in /fig. 2.2 and establishes intermediate station P
5. Similarly, any number of intermediate stations can be established between two end stations.

6. Measure the distance between A and B and record it in observation sheet.

B. Measurement of offsets:

1. Locate two or three objects lying by the side of survey line.
2. Errect cross-staff vertically on chain line and ensure that one pair of opposite slit bisect the ranging rod fixed at one end of survey line. Then, by viewing through another pair of slits on cross-staff, move cross-staff forward or backward on chain line till the line of sight bisects the object. Locate that point i.e foot of perpendicular offset on chain line.
3. Measurde perpendicular offset and record it in field note book
4. Follow the step (ii) and (iii) similarly and measure the offsets.

C. Indirect ranging:

1. Select two end points A and B which are far apart as shown in Fig. 2.3 and erect two ranging rods.
2. Select two intermediate points M1 and N1 very near to chain line such that from M1, both N1, and B are visible and from N1, both M1, and A are visible.
3. Place two surveyors with ranging rods at both M1 and N1.
4. The surveyor at M1 then directs another surveyor at N1 to move to N2 position in line with M1B as shown in Fig 2.3.
5. The surveyor at N2 then directs surveyor at M1 to move to M2 in line with N2A
6. The above process is repeated till the points M and N are located in suce a way that the person at M finds a person at N in line with MB and a person at N finds a person at M in line with NA.

Result:

2. CHAIN TRIANGULATION

Introduction to Chain Survey

Chain survey include measurement of distances and calculation of areas, etc., Basically, the distances are measured by using chain which is the most accurate method in surveying. In chain survey, two men are required one is follower and other is leader. The chainman at the forward end of chain is called leader, while the chainnm at the rear end of chain is known as follower.

A. Duties of leader:

a) To drag the chain forward
b) To insert arrows at the end of every chain length and
c) To obey the instructions of follower

B. Duties of follower:

a) To place the leader in line with ranging rod
b) To call out instructions to the leader
c) To carry rear handle in his hand and not to allow handle to drag on the ground
d) To pick up arrows inserted by leader.

C. Field note book:

The distances measured by chain are recorded in field note book. Field book may be single line or double line, drawn at the centre of page. For larger surveys, single line field book is used and double line field book is used for ordinary survey works. The date is entered in field note book as given below.

i. All the distances along the chain line are entered in the space between two ruled lines.
ii. The offsets are entered either to the left or right of chain line as the case may be
iii. Offsets are entered in the order as they appear at chain line
iv. Every chain line must be started from a fresh page
v. The data is entered from bottom of page to top of page
vi. Starting and ending of survey line must be indicated with oval or triangle.
vii. Name of survey line must be entered. Eg: line ‘AB’
viii. Details of any other line meeting at the starting point must be written.

The field note book must contain date of survey, name of surveyor, index sketch and details of survey lines.

Code of signals for Ranging:

The signals given by surveyor are to be followed by the assistant are tabulated below

Table 3.1: Signals to be followed in ranging:

S.No.	Signal by the surveyor	Action by the assistant
1.	Rapid sweep with a) Right hand b) Left hand	Move Considerably a) To the right b) To the left
2.	Slow sweep with a) Right hand b) Left hand	Move slowly a) To the right b) To the left
3.	Extended arm a) Right arm b) Left arm	Continue to move a) To right b) To left
4.	Right arm up and moved	Plump the rod to the to right right
5.	Left arm up and moved to the left	Plumb the rod to the left
6.	Both hands above Head and then brought down	Correct
7.	Both arms extended forward horizontally and the hands depressed briskly.	Fix the rod

3. Chain Triangulation

Aim: To calculate the area of a given field by using chain triangulation survey

Principle

Chain triangulation chiefly consists of dividing the whole area of field into net work of triangles as it is simplest geometric figure. Then, the distances of each side of a triangle are measured by the chain. The area of triangle can be calculated by using the following formula:

i. When three sides of a triangle are known:

$$A = \sqrt{s(s-a)(s-b)(s-c)} \quad \ldots \quad (3.1)$$

Where

A = area of triangle, m^2

$$s = \frac{a+b+c}{2},$$ half of the triangle perimeter, 'm'

a,b,c, = triangle side lengths, m

ii. When base length and perpendicular height are known (Right angle triangle)

$$A = \tfrac{1}{2} * \text{Base } (b) * \text{ Height } (h) \quad \text{---} \quad (3.2)$$

Equipment required: Metric chain, arrows and ranging rods.

Procedure:

1. Draw an index sketch of given field in field note book.
2. Identify north direction with which base line is positioning by compass.
3. Identify the base line, which is the longest line of all survey lines in the index sketch and divide index sketch of field into network of triangles over the base line. Designate the vertices of triangles by alphabets.
4. Fix the base line in the actual field as per index sketch with respect to north and measure the distance of base line and enter it in field note book.
5. From the net work of triangles in the field by fixing ranging rods at vertices of triangle and measure the sides.

6. Record the distance of each side of a triangle on separate page of field note book.
7. Calculate the area of each triangle by using the formula given and find out the total area of the field.
8. Draw an index sketch and enter the area calculations in the observation sheet.

Result:

4. CROSS-STAFF SURVEY

Aim: To calculate the area and to locate boundary of a give field by using cross staff survey

Principle

In cross staff survey, the entire field is divided into a network of right angle triangles and trapezoids by measuring perpendicular offsets to the boundary and chainage along the base line. The formulae used for calculating area are:

i. Area of right angle triangle (A) = ½ x b x h ------------------- (4.1)

Where

B = base of a triangle (chainage) in m

H = Perpendicular offset, (height) m.

ii. Area of trapezium (At) = ½ (a+b) h ---------------- (4.2)

Where

Ab = Perpendicular offsets of a trapezium, m

H = Chainage between two perpendicular offsets a and b, m

Equipment required: Two metric chains, cross-staff, arrows and ranging rods

Procedure

1. Draw index sketch of field and identify the base line with respecxt to north direction in the field note book.
2. Fix the chainage interval say 5 m, 10 m, 15 m, or 20 m based on the area fro taking perpendicular offsets. More the number of offsets, more will be the accuracy in calculating area.
3. Measure the base line with the help of metric chain by doing direct ranging.
4. While measuring base line, fix the cross-staff vertically at a fixed interval of chainage for measuring perpendicular offsets.
5. Keep one pair of opposite slits parallel to chain line by turning cross-staff. Then, sight through another pair of slits on cross-staff and direct assistant holding ranging rod to move along the boundary till the line of sight bisects the ranging rod. Fix the ranging rod at that point.
6. Measure the perpendicular distance between cross-staff on chain line and ranging rod fixed at the boundary. If the distance is less than 10m,

tape may be used. Other wise metric chain is used for measuring offsets.

7. Continue steps (4), (5) and (6) and complete the measurement of base line and offsets on both sides of base line. Enter all the data in the field note book.
8. Calculate area of right angle triangle and trapeziums formed in the field by using the data in step (7) and compute total area of the field.
9. Record all the areas in observation sheet with index sketch.

Result:

5. PLOTTING OF A CHAIN SURVEY

Introduction

Chain survey involves recording data in the field note book about the measured distances, identifying survey stations and all the information about ground features in a given area. This type of data storage in the field note book is temporary and does not provide any idea about shape and size of the surveyed field. Hence, the transformation of field data recorded in field note book into a graphical form on drawing sheet by way of plotting is necessary. This type of graphical representation of field data including ground distances, stations and ground features on drawing sheet is called as plan or map. However, the plan and map can be distinguished by a scale. The scale of plan or map is the fixed proportion which every distances on the map or plan be4arsd to the corresponding distance on the ground. If the scale is large, the graphical representation is called plan and if the scale is small, it is map.

Representation of Scale:

i. Numerical scale: One 'cm' on the plan represents some whole number of meters (m) 0n the ground.
   Eg: 1 cm = 10 m 0r 1 cm = 20 m etc.
   This type of representation of scale is called engineer's scale.

ii. Representative factor (R.F): One unit of length of the plan represents some number of same units of length on the ground as ration. This ratio of map distance to the corresponding ground distance is independent of units of measurements. This is known as representative factor.
   Eg: Given engineer's scale 1 cm = 50 m, the corresponding R.F is (1/50 x 100) = 1/5000

2. Graphical scale: It is a horizontal bar sub-divided into plan distance corresponding to convenient units of length of the ground.

Plotting Procedure of Chain Survey

1. Before commencement of plotting on drawing sheet, a suitable scale should be selected based on the linear measurements and space available on the drawing sheet (A1 size: 594 mm x 841 mm).
2. Convert ground measurements into plan distances in the field note book as per scale selected.

3. Fix the drawing sheet to the drawing board with the help of clamps or pins so that to edge of paper is parallel to the crony edge of the square when tee square head is kept against the sliding edge of divulging board.
4. Draw the border lines on the drawi9ng sheet with 4 cm as left margin and 2.5 cm as the margin of the remaining sides. Draw the rectangular box in right hand corner of drawing sheet with the dimensions as given in Fig 5.1b for writing personal information.
5. In the rectangular so drawn, the position of survey, north line, scale, title etc., should be arranged so that the plan will appear to be systematic and proper.
6. The survey should be plotted facing north direction only.

Lettering in Drawing Sheet:

1. Any writing within drawing sheet should be with pencil and scale only. No free hand writing is allowed.
2. Gothic plain style of English alphabets and numerals with vertical or slanting at 70^{o} should be used.
3. Main title of the plotting should be written with the letter of 10 x 10 mm size on top of the drawing sheet. See that the title is placed properly with respect to plotting.
4. Scale should be written with letter size of 7.5 x 7.5 mm below the main title at the Eg: SCALE: 1 CM = 10 M
5. The remaining writing on drawing sheet like distances, units, alphabets. Filling personal information etc., should be done with letter size of 5 x 5 mm only.
6. North line must be written vertically on top right side corner of drawing paper. It may be ordinary or ornamental writing.

Folding of Drawing Sheet

1. Fold the bottom side of drawing sheet to the opposite side of front page width wise to a width of 80 mm from border line.
2. Reverse the above folding width wise to the same width of folding (Fig. 5.2a).
3. Folding the extreme right portion of drawing sheet length wise in opposite direction to a width of 180 mm folding.
4. Reverse the folding in step (3) length wise till the first folding edge touches the 4 cm margin line in the left of drawing sheet (Fig. 5.2b).

Conventional Symbols:

Symbols are used to identify various ground features in the plan. On a small scale, it is usual to represent fences, hedges and walls by a solid line, but on large scale, these are differentiated. The most commonly used symbols are given in Fig. 5.3.

6. PLOTTING OF CHAIN TRIANGULATION

Aim: To prepare a plan of the field surveyed by the method of chain triangulation.

Principle

Plotting of chain triangulation involves constructing the network of triangles built over the base line, location of interior details of the field and boundary of the field on the drawing sheet.

Materials required

Drawing paper (A1 size), T.square, squares, instrument box and drawing clips or pins.

Procedure

1. Select a suitable engineer’s scale
2. Fix the drawing sheet to drawing board and draw the boundaries as explained in chapter 5
3. Draw the base line with respect to north direction as per the selected scale.
4. Construct the triangles over the base line by looking into index sketch and data in the field note book.
5. After completing drawing, write done title, scale, distances on survey lines, designating letter at vertices of triangles, north direction etc. as explained in chapter 5
6. Draw the table given in the observation sheet of chapter 3 with the calculated areas of each triangle and write total area of the field. This table should be drawn to the right side of plotting figure.
7. All survey lines measured by chain must be identified with dotted line as given in the conventional symbols of Fig. 5.3
8. Fold the drawing sheet as per the procedure given in the chapter (5) and file it in a folder.

Result:

7. PLOTTING OF CROSS STAFF SURVEY

Aim: To prepare a plan of the field surveyed by the cross-staff survey

Principle

Plotting of cross-staff survey involves construction of right angle triangles and trapezium over the base line as per the chainages noted in the field note book white doing cross-staff survey.

Materials required:

Drawing paper (A1 size), set squares, t-square, instrument box and drawing clips.

Procedure:

1. Select a suitable engineer's scale
2. Fix the drawing paper to the drawing board with the help of clips. Draw boundaries and personal information box as per the dimension given in chapter (5).
3. Draw the base line as per the scale with respect to north direction.
4. Draw the perpendicular offsets as per the chainages noted in the field note book offset may be drawn as dotted lines.
5. Base line must be represented as chain line.
6. Draw the boundary lines as thick lines.
7. After completing drawing, write the title, scale, north direction, offset measurements, chainnages etc., as per procedure given in chapter (5).
8. Draw the table given in the observation sheet of chapter (4) to the right side of plotting in drawing paper. Enter areas of all different geometric figures. Indicate the total area of field below the table.
9. Fold the drawing paper and file it in a folder.

Result:

8. STUDY OF LEVLLING EQUIPMENT

Aim: i. To acquaint with leveling instruments

iii. To practice temporary adjustments in a dumpy level and to record staff reading.

Chain survey deals with measurement of horizontal distances in a horizontal plane. Levelling deals with vertical distances in a vertical plane. The objectives of leveling are (i) to find the elevations of given points with respect to given or assumed datum and (ii) to establish points at a given elevation or at different elevations with respect to a given or assumed datum.

Levelling Instruments

The instruments commonly used in leveling are a level and a leveling staff.

A. Level

The purpose of level is to provide a horizontal line of sight. A level primarily consists of the following parts.

i. A telescope : It provides line of sight

ii. A level tube: It is to make the line of sight horizontal

iii. A leveling head: It bring the bubble in the centre of bubble tube.

iv. A tripod: It provides support to the level instrument.

There are four types of levels. They are Dumpy level, Wye level, Reversible level and Tilting level. Dumpy level is commonly used instrument for agricultural surveys among the above four levels.

Dumpy Level

The dumpy level was originally designed by GRAVATT. It consists of a telescope tube firmly secured in two collars, fixed by two adjusting screws to the stage.The stage is carried by vertical spindle and a long bubble tube is attached on top of the telescope as shown in Fig(8.1). The important parts of dumping level and their functions are:

1. Telescope provides line of sight
2. Eye piece provides imaginary image of the object large than that of real image.
3. Ray shade provides protection to object lense from sun rays.
4. Object lense provides real image of the object infront of the eye piece i.e on the diaphragm of cross hairs.
5. Longitudinal bubble makes the line of sight truly horizontal.

6. Focussing screw s to adjust the distance between eye pieceand object lense so as to have the real image of the object on the diaphragm.
7. Foot screws are to bring spirit bubble at the centre of longitudinal bubble tube.

8.Upper parallel plate (Tribrach) and Foot plate (Trivet stage): The foot screws are arranged in between upper parallel and foot plates. Upper plate is provided to keep the line of sight truly horizontal in any plane of rotation of telescope.

9. Diaphram and Bubble gtube adjusting screws: The adjusting screws of diapharam are provided to keep the diapharam at the common focal length of eye piece and object lences. Similarly, the adjusting screws are provided to bubble tube for keeping the bubble intact inside the tube and bubble tube as horizontal over the telescope.
10. Transverse bubble tube is provided at perpendicular position to the longitudinal bubble tube so as to check the horizontality of telescope in that direction.

B. Leveling Staff

Telescopic staff (Sop with pattern) is commonly used in levelling work as gauging staff. Its construction details are given below.

i. Telescopic staff is made of well seasoned timber or Aluminum.
ii. It's total length is 4 m when it is fully extended.
iii. The solid top length of 1.25 m slides into the central box of 1.25 m length, which intern slides into lower end of length 1.5 m. The cross section of wooden box is 10 x 5 cm.
iv. Each length of solid box when pulled out to its full length, is held in position by means of a brass spri8ng catch. The staff made of Aluminum has push button type lock.
v. Each meter on the staff is divided into 200 sub-divisions. The minimum staff reading that could be read is 5 mm or 0.0005 m.
vi. The graduations on the staff appear inverted or straight and vertical depending upon the type of glasses or lences used in the dumping level, when sighted through telescope.

Equipment for leveling: The equipment required for leveling are Dumping level, Levelling staff, Chain or Taoe and Level field note book. Before taking out the instrument from the box, mark the positions of object glass eyepiece lampand tangent screws so that the level is placed properly without any difficulty after the work is completed.

C. Temporary Adjustments of a Dumpy Level

Levelling instrument needs two types of adjustment. One is temporary adjustments and other is permanent adjustments.

Temporary adjustments are also called as station adjustments. These are made at each setting of instrument and preparatory for taking objservations with the instrument. The temporary adjustments for a dumpy level consist of the following steps.

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

1. Setting up the level: This step includes.

i. Fixing the instrument on stand

ii. Levelling the instrument approximately by leg adjustments

For fixing level to tripod, the clamp is released and instrument is held in right hand. Thus, the level is fixed on tripod by turning round the lower part with left hand. The tripod legs are so adjusted that the instrument is at convenient height and tribrach is approximately horizontal.

2. Levelling up

After ensuring approximate leveling, accurate leveling is done with the help of foot screws and with reference to plate levels. The purpose of leveling is to make vertical axis of instrument truly vertical, thereby ensuring the line of sight truly horizontal. The step by step procedure is given below for three foot screw head.

i. Loosen the clamp. Turn the telescope parallel to line joining any two of the foot screws A & B as shown in Fig. 8.3a.

ii. Hold the foot screws (leveling screws) between the thumb and first finger of each hand and turn them uniformly in a single direction (either clockwise or anticlock wise) until the bubble is at centre. It should be noted that the bubble will move in the direction of movement of left thumb.

iii. Turn the telescope through 90º i.e. until the axis on the level passes over the position of third leveling screw 'C' as shown in Fig. 8.3b. Turn the foot screw at 'C' till the bubble comes to centre of bubble tube.

iv. Return the telescope through 90º to its original position and repeat step (ii) till the bubble is at centre.

v. Turn back telescope again through 90º over 'C' and repeat step iii.

vi. Repeat steps (ii) & (iii) till the bubble is at centre in both the directions.

vii. Now, rotate the telescope through 180º. The bubble should remain in the centre of its run, provided it is in correct adjustment. The line of sight will then be truly horizontal.

3. Elimination of parallax

Parallox is a condition arising when the image formed by the objective glass is not in the plane of cross-hairs. Unless the parallax is removed, accurate sighting of an object is impossible. This can be eliminated in two steps.

i. Focussing the eye piece: To focus the eye-piece for distinct vision of cross-hairs, hold a sheet of white paper in front of objec lense of telescope. Then, move the eye-piece in or out till the cross-hairs. Unless the parallax is removed, accurate sighting of an object is impossible. This can be eliminated in two steps.

ii. Focussing the object lense: The telescope is now directed towards the staff and the focusing screw2 is turned till the image appears clear and sharp on diapharam. The image is so obtained now in the plane of cross hairs. Then, record the staff reading.

D. Recording the staff readings in level field note book

1. The readings should be entered in the respective columns and in the order of their observation.

2. The first entry on the page is always a back sight and last one always a fore sight in a single set up of instrument.

3. The fore and back sights of change point should be written in the same horizontal line.

4. The reduced level of the plane of collimation should be written in same horizontal line opposite to back sight.

5. The bench mark, change points and other important points should be briefly noted down in 'REMARKS' column of field note book.

9.DIFFERENTIAL LEVELLING

Aim: To determine the elevation difference between two points which are far apart

Principle

Differential leveling is also known as fly leveling. It is followed when the distance between two end stations is very large or two end points are not intervisible due to obstruction in between two stations. In such, a case, the distance between two stations is divided into various segments and the readings are taken by installing dumpy level at the centre of each segment. At the end of each segment, the level instrument is shifted and the staff readings are recorded. So, there are many change points in differential leveling.

Equipment required

Dumpy level, leveling staff and tripod

Procedure

1. Fix two end stations at a given place such that the two stations are spaced far apart .
2. Divide the distance between two stations into suitable segments as shown in Fig.9.1
3. Fix the level instrument approximately at the centre of first segment and take readings with leveling staff on bench mark and two end stations of segment. Enter these readings in level field note book.
4. Shift the instrument into second segment and take the staff readings at end points.
5. Repeat the step (4) till the readings in all segments are completed.
6. Each end point of a segment is change point except the end point of last segment. The last end station reading is entered as fore sight.
7. Calculate the reduced levels of all stations by Rise and fall method.
8. Perform the arithmetic check and calculate the difference in elevation between two end stations.

Result:

10. PROFILE LEVELLING

Aim: i. To determine the elevations of points along a given line at fixed interval of distance.

ii.To study the nature of the profile of ground surface along a given line.

Principle:

Profile leveling is the process of determining the elevations of points at fixed intervals along a fixed line such as centre line of a farm road, railways, canal etc. The fixed line may be a single straight line or it may consist of succession of straight lines. It is also known as longitudinal sectioning. With the help of profile leveling, the engineer can estimate the cut and fill at different points between the existing ground surface and the levels of proposed construction in the direction of its length.

Equipment required:

Dumpy level, metric chain (30 m) or tape (30 m), leveling staff (4 m) and tripod

Procedure

1. Select a suitable site where a farm road is proposed to be laid.
2. Fix up the longitudinal line t the centre of proposed site.
3. Select a suitable interval of either 10 m or 20 m and mark the stations along longtitudional line.
4. Set up the dumpy level at a suitable place such that all readings can be taken with the help of a single set up. If the longitudinal line is too long, it is better to select two or three change points.
5. Complete the temporary adjustments of dumpy level after setting up the level at a chosen place.
6. Take the first reading on a permanent structure like culvert or big out crop or plinth of a building etc., and treat it as bench mark. Enter the first reading as back sight in the level page of field note book.
7. Enter all the readings observed by gthe dumpy level between first reading and last reading in the first set up of instruments as intermediate sights in level page.
8. Enter the last reading of the set up as foresight in level page.
9. If the change points are selected, then ask the staff man to stay firmly at the change point where the shifting of instrument is taking place. Take another reading on the same point after the instrument is set up at new place. Enter

this reading as back sight in the same line of level page. Indicate the change point in remarks column of field note book.

10. Cumulative distances must be recorded in the distance column o field note book starting from first point to end point of longitudinal line.
11. Calculate the reduced levels of the stations along longitudional line by using Height of Instrument method or Rise and Fall method. Do the arithmetic check as:

    Arithmetic check: Σ B.S - ΣF.S = Σ Rise - Σ Fall

    = R.L of last point - R.L of first point
12. Determine the gradient of longitudinal line and enter them in the observation sheet.

Result:

11. PLOTTING OF PROFILE LEVELLING

Aim: To represent the reduced levels graphically with respect to distance.

To estimate the depth of cut and fill by drawing formation line

Principle

Plotting of profile leveling involves drawing XY graph `by taking reduced levels of different points on Y-axis and the corresponding distances on X-axis to a suitable scale. The graphical representation of profile gives an idea to construction engineer such that the amount of earth work can be estimated and its cost while doing any construction exercise along the length of profile. Also, it gives clear idea of relative position of different stations along longitudional line of profile.

Equipment required: Drawing paper, instrument box, T-square and set-squares.

Procedure

A. Procedure to draw profile:

1. Fix the drawing paper to the board and draw the necessary boundaries and personal information box as per standard measurements.
2. Select a suitable scale to represent distance along X-axis.
3. Select a suitable vertical scale to represent reduced levels along Y-axis such that the vertical scale is 10 times larger than the horizontal scale selected in step (2), which will magnify the difference in elevation between two consecutive stations along a profile.
4. Assume the reduced level of datum line for XY-graph such that the R.L. of datum is less than the least value of /R.L. reading in profile leveling. For eg, if the least reading is 93.5 m, the R.L. of datum for XY-graph may be selected as 90 m or 85 m etc., so that all the readings can be represented above the datum line.
5. Draw X Y lines in a drawing paper with HB pencil. Fix the points on X-axis as per the horizontal scale selected in step (2). Then, draw very light vertical line at each point on X-axis with set squares.
6. Draw five horizontal lines below the X-axis as shown in Fig. 11.1 so as to write down the numerical values of ground levels, formation levels, depth of cut, depth of fill and distance.
7. Mark the R.Ls of different points along vertical lines as per the4 vertical scale selected in step (3). Draw profile by connecting all the points in XY graph.

B. Procedure to draw formation line

1. Calculate the average value of reduced levels of various points along longitudinal line of profile.
2. Fix the average value as formation level at the centre of longitudinal line of profile.
3. Keep the gradient of formation line as 0.1 per cent. However, the gradient of formation line depends on the natural slope of the profile.

4(a) If the gradient of formation line is down ward from left to right:

i. Find out elevation difference of the formation line between two consecutive stations. That is, if formation slope is 0.1 per cent and interval between two consecutive stations is 10 m, then the elevation difference (ΔE) between two consecutive points of formation line is 0.01 m [(0.1/100) x 10 = 0.10].

ii. The ΔE has to be added cumulatively to the average elevation towards left and ΔE has to be deducted cumulatively from average value towards right of formation line.

iii. Then, mark all the points with formation levels and draw a formation line.

iv. If the ground elevation is less than the formation level, it is called as fill and if ground level is more than formation level, it is called as cut.

v. For every station, cut or fill has to be calculated and enter it either in the row of cut or fill (Ground level – Formation level = +ve indicates cut or-ve indicates fill).

b) If the gradient of formation line is up ward from left to right, the calculation in the above step (ii) in 4 (a) has to be changed i.e., ΔE has to be added cumulatively towards right from average value. All other steps will remain same for this case also.

5. Draw the formation line by conneting the first and last formation levels obtained as per above procedure.
6. Identify cut and fill by hatching and by dots respectively in the profile.
7. Write down the title, scale (Horizontal and Vertical), legend identifying formation line profile, cut and fill along with personal information
8. Give the replica of profile with details in observations sheet.

Result:

12 CONTOURSURVEY

4Aim: To find out grid levels by using grid method

Principle

Contour survey helps in preparing topographic maps in which both horizontal and vertical position of different points are shown. Contours have both contour interval and horizontal interval. Contour interval is the difference in the elevation of two consecutive contours, where as horizontal interval is the horizontal distance between two consecutive contours. The contour interval should be inversely proportional to the scale. If the scale is small, the contour interval should be large and vice versa. The values of contour interval for different purposes are given in Table. 12.1

Table 12.1: Contour intervals for different purposes of contour survey

S.No.	Purpose of contour survey	Scale	Interval (m)
1.	Building sites	1 CM = 10 M or Less	0.2 to 0.5
2.	Town planning schemes, Reservoirs etc.,	1CM = 50 M to 100 M	0.5 to 2
3.	Location surveys	1 CM = 100 to 200 m	2 to 3

In general, Grid method is used to locate contours by interpolating the elevation of grid points over the distance. It is also called as indirect method of locating contours in topographic map. Grid method involves dividing the given area into number of squares or rectangles. The size of square may vary from 5 to 20 m depending upon the nature of contour and contour interval. This method is adopted when area to be surveyed is small and the ground is not much undulating.

Equipment required

Dumpy level, leveling staff, tape (30 m) tripod, arrows, cross staff and ranging rods.

Procedure

1. Prepare index sketch of the given field and determine whether it is of square or rectangular shape. Identify north direction.
2. Accordingly as in step (1), locate the square or rectangle with the help of cross staff and fix the ranging rods at four corner points.

3. Select a suitable grid size (10 or 20 m) such that one can complete the work in a given time.
4. Fix the dumpy level at a suitable place where all the readings can be taken from a single set up and perform temporary adjustments.
5. Divide the whole area into number of squares (grids) as per the size selected in step (3).
6. Take the reading at each grid corner either column wise or row wise and enter them in field note book according to the sequence of row or columns.
7. Find out the reduced levels of all grid corners by Rise and Fall or Height of Instrument method. Do the arithmetic check.
8. Give the grid levels in the observation sheet and find out the elevation difference between maximum and minimum reduced levels.

Result:

13. PLOTTING OF CONTOUR SURVEY

Aim: To prepare a contour map or topographic map of given area.

Principle

Plotting procedure in contour survey involves the selection of suitable contour interval, number of contours and identifying the contour points in between two grid corners by interpolation either by the method of estimation or arithmetic calculation. All these contour points will be jointed by a smooth hand curve. Also, contour map thus prepared provides information on drawing of section, intervisibility of two points, location of route, measurement of drainage area, calculation of reservoir capacity and land slope etc.,

Equipment required

Drawing paper, instrument box, T-square and set squares.

Procedure

1. Draw the borders on drawing paper along with personal information box as per the standard dimensions.
2. Select a suitable scale for drawing.
3. Plot the field and divide the field into grids as per scale in (2). Write down grid levels at each corner of grid.
4. Fix the contour elevations by selecting a suitable contour interval from minimum reduced and maximum reduced levels obtained in contour survey. For eg, if the maximum and minimum reduced levels are 99.0 m and 93.5 m respectively, the maximum elevation difference is 5.5 m (99.0 – 93.5 m). If the selected contour interval is 0.5 m, then the contour values will be 94.0 m, 94.5 m, 95.0 m, 95.5 m etc.,
5. After arriving contour values, interpolate between two grid levels over the grid distance by arithmetic calculation and locate the contour point. All such contour points should be located throughout the grid points, wherever it exists.
6. Join all the contour points located in plan with a smooth hand curve. The contour will end at borders of plan only if it is plain surface.
7. Identify the contours by writing their values in circular loops at both ends of contour.
8. Finish the drawing after writing title, scale, north direction, grid size and personal information.
9. Give the replica of drawing in observation sheet.

14. CENTRIFUGAL PUMPING SYSTEM AND WATER MEASURING DEVICES

Aim: i. To calculate the discharge rate of the pump and its power requirement

ii. To calculate the discharge rate using water measuring devices

Equipment required

Jute rope of 15 m length and tape

Procedure

1. Observe the specific data given on the name plate of electric motor with respect to BHP rpm etc.,
2. Measure the dia of both suction and delivery pipes. Also, measure both suction and delivery heads with the help of rope.
3. Note down the type of fittings used in the entire pumping system.
4. Check whether centrifugal pump is required priming or not. If required, remove air with in suction and casing by pouring water through delivery pipe.
5. After priming is over switch on the motor and measure the discharge rate by co-ordinate method.
6. Calculate the head loss due to friction in the pipe line and its fittings and also the velocity head losses in both suction and delivery.
7. Calculate the total head available in the pumping system.
8. Calculate WHP, BHP and IHP and convert IHP into energy units into kilowatts by multiplying it with the factor 0.746.
9. Compare the calculated energy in the pumping system with the observed reading energy meter installed in the pumpshed.
10. Enter all above readings and calculations in the given observation sheet.
11. Measure the head of the flow over the crust of weir from the gauge fixed in the weir pond.
12. Calculate the discharge rate by using concerned formula.

15.UNIFORMITY OF WATER APPLICATION IN DRIP AND SPRINKLER IRRIGATION SYSTEMS

Aim: To estimate the uniformity co-efficient of water application is both drip and sprinkler irrigation systems.

Principle

A. Drip Irrigation system

Uniformity of water application is an important parameter in the design of irrigation systems. In the drip irrigation system, it depends on presur variations with pipe net work and field and manufacturing variations within emission points (Emitters). For better rield performance of drip irrigation system, the discharge variations should not exceed 10 per cent and the pressure variations must be within 20 per cent. For field evaluation of drip system, uniformity is defined by the emission uniformity which is a measure of the uniformity of discharge ratio from all emitters in the entire system. Emission uniformity is given by the formula.

$$EU = \frac{qn}{qa} \times 100$$

Where,

EU = field test emission uniformity, %

qn = average discharge rate of the lowest one fourth of the field data of emitter discharge readings, l/hr

qa = average discharge rate of all the emitters checked in the field, l/hr.

B. Sprinkler Irrigation System

The uniformity of water application in sprinkle irrigation system is defined by the distribution uniformity (DU). The DU indicates the uniformity of water application throughout the field and is calculated by:

$$DU = \frac{\text{Average low-quarter depth of water received}}{\text{Average depth of water received}} \times 100 \quad \text{---- (16.2)}$$

The average low-quarter depth is the average of the lowest one-quarter of the measured. Another parameter widely used for field evaluation of sprinkler system is Christianson uniformity co-efficient (CD) which is given by:

$$CU = 100 \left(1.0 - \left(\frac{\Sigma/z - m/}{Mm}\right)\right) \qquad \text{---- (16.3)}$$

Where,

CU = co-efficient of uniformity

Z = individual depth of catch observations from uniformity Test, mm

M = mean depth of observations (Z)/n, m

N = number of observations

From CD, DU value can be computed by using the formula

$$DU = 10 - 1.59 (100 - CU) \qquad \text{------} \qquad (16.4)$$

If the co-efficient of uniformity of water application obtained from field evaluation is greater than or equal to 80%, it is acceptable design to irrigator.

Equipment required: Pressure gauge connected to pivot tube, 60 nos catch containers (1 litre capacity), stop watch, measuring cylinder and metallic tape (30 M).

1.. **Drip Irrigation System**

1. Select suitable drip irrigation system installed in the field
2. Observe the size of lateral pipes, sub mains and main pips, spacing of laterals, emitter spacing and their rated discharge with operating pressure.
3. Switch on the system and allow it to run for 10 to 15 min. for the pressured development in the system and to remove the entrapped air in the pipe net work.
4. Keep the operating pressure at rated value given by the manufacturer for that set of emitters and their discharge rate used in the system..
5. Keep the catch containers below the emission points (emitter) along a lateral and collect the water for time period of 10 to 15 min.

6. Measure the quantity of water collected in the catch containers by usi9ng measuring cylinder.
7. Calculate discharge rate of emitters and enter them in observation sheet.
8. Repeat steps 5, 6 and 7 for all laterals existing in the system.
9. Pickup the lowest one-quarter discharge rate readings from measured data (For, eg of 20 readings are taken, five valves have to be picked up from the lowest values of the readings)
10. Calculate the average of these lowest one quarter readingts and average of all discharge rates.
11. Calculate emission uniformity from eqn (16.1) and enter in the observation sheet.

I. Sprinkler Irrigation System

1. Select a suitable sprinkler lateral with three sprinkler heads installed in the field
2. Note down the size of main pipe, lateral pipe, sprinkler spacing, wind speed and its direction of flow etc.,
3. Operate the system at required pressure and allow it to run for 10 to 15 minuts to develop pressure in the system.
4. Measure the pressure available at the sprinkler nozzles used pressure gauge connected to pivot tute.
5. Calculate the application rate of the sprinkler nozzle by diverting water through hose pipe into the known volume of container and time.
6. Measure the wetted circle diameter and place the catch containers in the grid form in between three sprinklers as shown in Fig (16.1)
7. Switch on the system and operate it for know time.
8. Put off the system and measure the depth of water collected in each container by pouring into measuring cylinder.
9. Calculate the CU and DU by using eqns (16.3) and (16.4) and enter them in the observation sheet.

Result: