Nilachal Polytechnic

Estd. - 1997

Bhubaneswar

Sem. : 4th sem [redacted] **Subject: Surveying I**

Branch : Civil Engg. **NOTE**

Name of the Faculty: T. Dalai **Sec: A** **Sec: B**

Text Book to be followed by Student / Faculty

Book-1 : N. N. Basak (Ch No.- 1)

Ch. No.: 01 Name: Introduction to Surveying, Linear Measurements

1. Learning objective

i) Handle various survey instruments for a particular survey work.
ii) To determine the relative position of any objects or points of the earth.
iii) To determine the distance and angle between different objects.
iv) To prepare a map or plan to represent an area on a horizontal plan.
v) Apply checks for errors elimination
vi) Solve measurement problems in an optimal way.

2. Essential Questions (Fundamental Question)

i) What do you mean by Surveying?
ii) What is the principle of surveying?
iii) what are the different types of survey?
iv) What do you mean by linear measurement?
v) Which plane used for surveying?

3. Hours Required

Theory	**1hr**
Problems	**30min**
Question & Answer Theory	**30min**
Total	**2hr**

4. Question for Teaching / Assignment / Self Practice

	02 Marks	05 Marks	10Marks
Teaching	**03**	**02**	**02**
Assignment	**02**	**02**	**02**
Self Practice	**02**	**01**	**02**
Total	**07**	**05**	**06**

5. Lesson Description (Abstract of the Chapter):

- Surveying is defined as taking a general view of, by observation and measurement determining the boundaries, size, position, quantity, condition, value etc. of land, estates, building, farms mines etc. and finally presenting the survey data in a suitable form.
- This covers the work of the valuation surveyor, the quantity surveyor, the building surveyor, the mining surveyor and so forth, as well as the land surveyor.
- Surveying is the art of making measurements of objects on, above or beneath the ground to show their relative positions on paper. The relative position required is either horizontal or vertical.
- This part of the definition is important as it indicates the need to obtain an overall picture of what is required before any type of survey work is undertaken. In land surveying, this is achieved during the reconnaissance study.
- This part of the definition denotes the next stage of any survey, which in land surveying constitutes the measurement to determine the relative position and sizes of natural and artificial features on the land.
- The data collected in any survey must be presented in a form which allows the information to be clearly interpreted and understood by others. This presentation may take the form of written report, bills of quantities, datasheets, and drawings and in land surveying maps and plan showing the features on the land.

Enclosed:

1. **Course Material.**

CHAPTER-1
INTRODUCTION

Surveying

Surveying is the art of determining the relative position of different objects on the surface of the earth by means of measurements of distances, directions and elevations and then, preparing a map to any suitable scale.

Technical terms:

(i) *Plan*: A plan is a geographical representation of the features on the earth surface or below the earth surface as projected on horizontal plane. This may not necessarily show its geographical position on the globe. On a plan horizontal distances and directions are shown.

(ii) *Map*: The representation of earth surface on a small scale is called a map. The map must show its geographical position on the globe.

(iii) *Topographical map*: The maps which are on sufficiently large scale to enable the individual features shown on the map to be identified on the ground by their shapes and positions are called topographical map.

(iv) *Geographical map*: The maps which are on such a small scale that the features shown on the map are suitably generalized and the map gives a picture of the country as a whole and not a strict representation of its individual features, are called geographical maps.

Aim and objectives of surveying

The aim of surveying is to prepare a map to show the relative positions, horizontal distances, and elevation of the objects on the surface of the earth. The map is drawn to some suitable scale. It shows the natural features of a country, such as towns , villages , roads , railways , river etc. The objectives of surveying can be stated as follows.

(i) Collect and record data on the relative positions of points on the surface of the earth.

(ii) Compute areas and volumes using this data,required for various purposes.

(iii) Prepare the plans and maps required for various activities.

(iv) Lay out, using survey data, the various engineering works in correct positions.

(v) Check the accuracy of laid out lines, built of structure.

Classification of surveying

(1) Primary classification

Surveying is primarily classified as:

(i) Plane surveying

(ii) Geodetic surveying

(i) *Plane surveying*:

In plane surveying the curvature of the earth is not taken into consideration. This is because surveying is carried out over a small area so the surface of the earth is consider as plane .Plane surveying is done on an area of less than 250 km^2.

(ii) *Geodetic surveying*:

In geodetic surveying the curvature of the earth is taken into consideration. It is extended over a large area. It is carried out over an area exceeding 250 km^2.

(2) Secondary classification

(i) Chain surveying
(ii) Compass surveying
(iii) Plane table surveying
(iv) Theodolite surveying
(v) Tachometric surveying

General principle of surveying

The two basic principles of surveying need to be followed for accurately locating points on earth.

(i) *To work from the whole to part*:

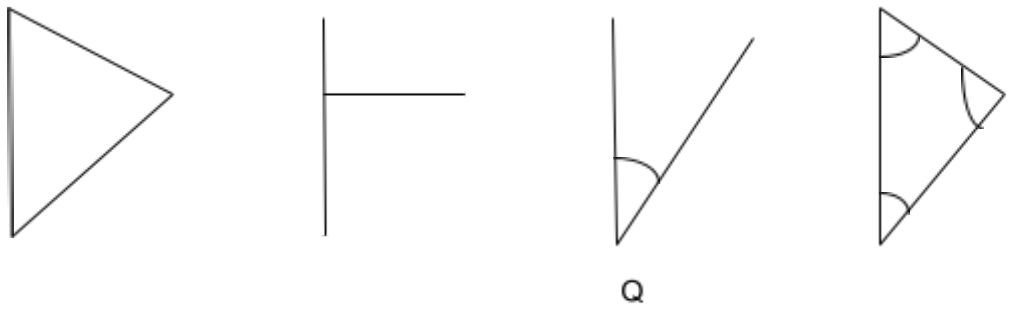
The main principle of surveying is to work from whole to part whether it is plane or geodetic surveying. To achieve this in actual practice, a sufficient number of primary control points are established with higher precision in and around the area to be detail surveyed. Minor control points in between the primary control points are then established with less precise method. Further details are surveyed with the help of these minor control points by adopting any of the survey methods. The main idea of working from whole to part is to prevent accumulation of errors and localize minor errors within the frame work of control points. On the other hand if survey is carried out from part to whole, the errors would expand to greater magnitudes and the scale of the survey will be distorted beyond control.

In general practice the area is divided into a number of large triangles and the positions of their vertices are surveyed with greater accuracy, using sophisticated instruments. These triangles are further divided into smaller triangles and their vertices surveyed with less accuracy.

(ii) *To locate a new station by at least two measurements from fixed reference points / control points*.

The reference points / control points are selected in the area and distance between them, is measured accurately. The line is then plotted to a convenient scale on a drawing sheet. In case, the control points are co-ordinated, their locations may be plotted with the system of coordinates (Cartesian or spherical). The location of the required point may then be plotted by making two measurements from the given control points as explained below.

Let P and Q be two given control points. Any other point R can be located with reference to these points, by any of the following methods.



(a) (b) (c) (d)

Fig.1

(i) *By measuring distances PR and QR*:- The distances PR and QR may be measured and the location of R may be plotted by drawing arcs to the same scale to which line PQ has been drawn as shown in Fig 1 (a).

(ii) *By dropping a perpendicular from R on PQ*:- A perpendicular RT may be dropped on the line PQ. Distances PT, TQ and RT are measured and the location of R may be plotted by drawing the perpendicular RT to the same scale to which line PQ has been drawn (Fig. 1 (b)).

The above two principles are generally used in “Chain surveying”.

(iii) *By measuring the distance QR and angle PQR*:- The distance QR and the angle PQR equal to α are measured and location of R may be plotted either by means of a protractor or trigonometrically (Fig 1 (c)),

This principle is used in “Theodolite traversing”.

(iv) *By measuring the interior angles of the triangle PQR*:- The interior angles P,Q and R of the triangle PQR are measured with an angle measuring instrument such as theodolites. The length of sides PR and QR are calculated by solving the triangle PQR and coordinates of R are calculated in the same terms as those of P and Q. Even without calculating the co-ordinates, or sides the location of R can be obtained by plotting the angles PQR and QPR (Fig 1(d).

This principle is used in the method of 'Triangulation'.

LINEAR MEASUREMENTS
INTRODUCTION

There are two main methods of determining the distances between points on the surface of earth:

(i) *Direct Measurement*: In this method, distances are actually measured on the earth surface by means of **chains, tapes** etc.

(ii) *Computative Measurement*: In this method distances are determined by calculation as in tachometry and triangulation.

Instruments for measuring distances

(i) Tapes
(ii) Steel Bands
(iii) Chains
(iv) Arrows
(v) Pegs
(vi) Ranging Rods
(vii) Ranging Poles
(viii) Offset Rods
(ix) Plumb Bobs

Tapes:

Depending upon the material tapes are classified as

(i) Cloth or linen tape
(ii) Metallic tape
(iii) Steel tape
(iv) Invar tape

(i) *Cloth or linen tape*: Linen tapes are closely woven linen and varnished to resist moisture. They are generally 10 metres to 30 metres in length and 12mm to 15 mm in width. Cloth tapes are generally used for measuring offset measurements only due to following reasons :

(i) It is easily affected by moisture and shrunk.
(ii) Its length gets altered by stretching.
(iii) It is likely to twist and tangle.
(iv) It is not strong as a chain or steel tape.
(v) It is light and flexible and it does not remain straight in strong wind.
(vi) Due to continuous use, its figures get in-distinct.

(ii) *Metallic Tape*: A linen tape reinforced with brass or copper wires to prevent stretching or twisting of fibers is called a metallic tape. As the wires are interwoven

and the tape is varnished, these wires are not visible to naked eyes. These tapes are available in different lengths but tapes of 20m and 30m lengths are very common. These are supplied in leather case with winding machine. Each metre is divided into decimeters and each decimeter is sub-divided into centimeters.

(iii) *Steel Tape*: Steel tapes are available with different accuracy of graduation. Steel tapes are available in different lengths but 10m, 20m, 30m and 50m tapes are widely used in survey measurements. At the end of the tape a brass ring is provided. The length of metal ring is included in the length of tape. A steel tape of lowest degree of accuracy is generally superior to a metallic or cloth tape for linear measurements.

(iv) *Invar Tape*: Invar tapes are made of an alloy of nickel (36%) and steel (64%) having very low co-efficient of thermal expansion (0.000000122 per 1ºC). These are 6mm wide and are available in length of 30m, 50m and 100m. These tapes are used for high degree of precision required for base measurements.

Chains:

The different types of chains are used in surveying and are given below.

(1) *Gunter's chain*: It is 66ft. long and divided into 100 links. Each link measures 0.66 ft.

(2) *Engineer's chain*: It is 100ft. long and divided into 100 links. Each link measures 1 ft.

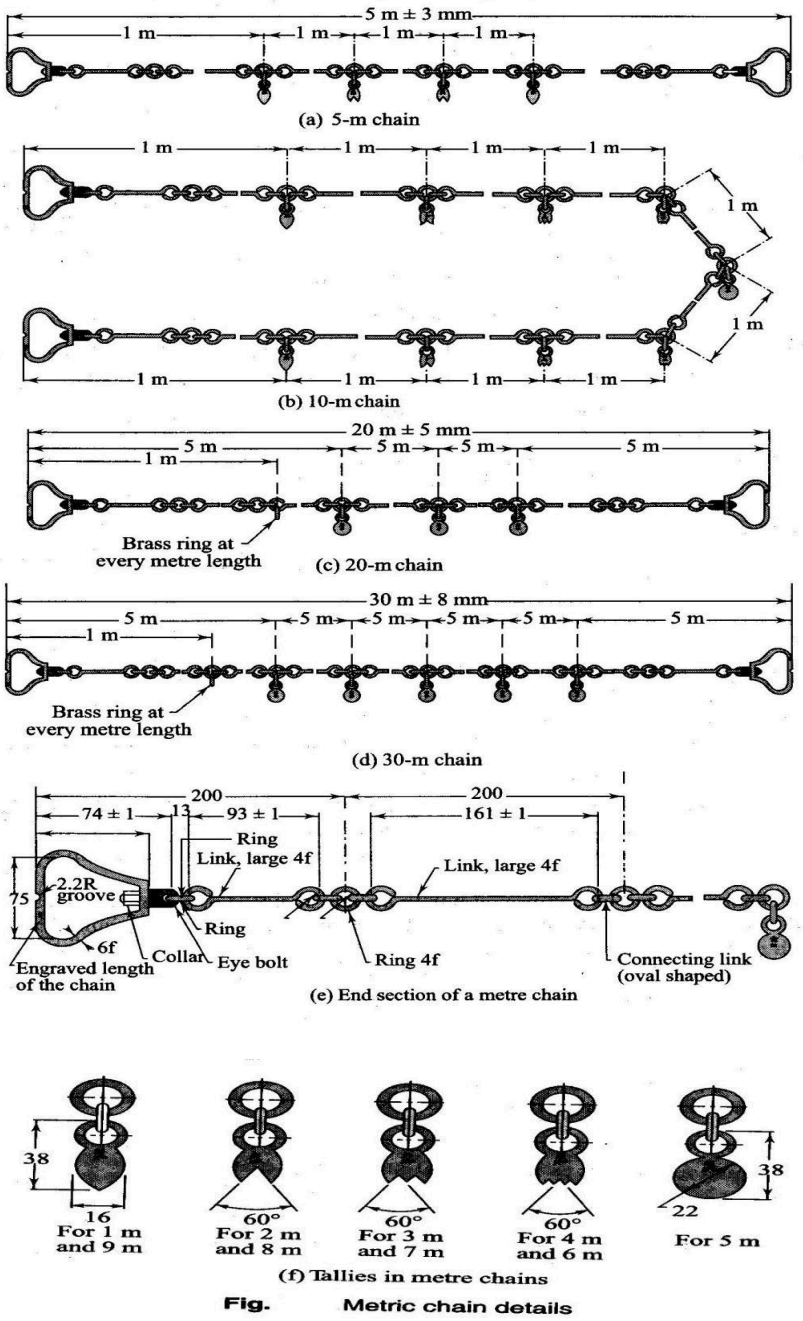


Fig. **Metric chain details**

Fig. 2.1

(3) *Metric Chain*: A metric chain is prepared with 100 or 150 pieces/ links of galvanized mild steel wire of diameter 4mm. The ends of the pieces are bent to form loops and connected together by means of three oval shaped rings which gives flexibility to the chain. Two brass handles are provided at the two ends of the chain with swivel joints so that chain can be turned round without twisting. The outside of the handle is the zero point or the end point of the chain. The length of the chain is measured from the outside of one handle to the outside of the other. The length of a link is the distance between the centres of the two consecutive middle rings as shown in the Fig. 2.1. The end links include the length of handle. Tallies are provided for marking 5m, 10m, etc are marked with letter “m” to distinguish the metric chain from non-metric chain. The length of chain whether 20m 0r 30m is indicated on the handle for easy identification.

Suitability of Chains: The chains are suitable for the following cases.

(i) It is suitable for ordinary or preliminary works as its length alters due to continuous use.

(ii) Its length gets shortened due to bending of links and gets lengthened by flattening of the rings.

(iii) Being heavier, a chain gets sagged considerably when suspended at the ends.

(iv) It can be easily repaired in the field.

(v) Measurement readings can be taken very easily.

(vi) It is only suitable for rough works.

Merits of Chains:

(i) They can be read easily and quickly

(ii) They can withstand wear and tear

(iii) They can be easily repaired or rectified in the field.

Demerits of Chains:

(i) They are heavy and take too much time to open or fold.

(ii) They become longer or shorter due to continuous use.

(iii) When the measurement is taken in suspension the chain sags excessively giving incorrect measurements.

Arrows: Arrow are made of tempered steel wire of diameter 4mm.One end of the arrow is bent into a ring of diameter 50 mm and the other end is pointed. Its overall length is 400mm. Arrows are used for counting the number of chains while measuring a chain line. Generally 10 arrows accompany a chain.

Ranging rods: Rods, which are used for ranging a line are known as ranging rod. Such rods are made of seasoned timber or seasoned bamboo. Sometimes GI pipes of 25mm/ 30mm diameter are also used as ranging rods. They are generally circular in section of diameter 25mm/30mm and length 2m / 3m.The rod is divided into equal parts of 20cm each and the divisions are painted black and white or red and white alternatively so that the rod is visible from a long distance. The lower end of the rod is pointed or provided with an iron shoe.

Ranging poles: These are similar to ranging rods except that they are heavier in section of length 4m to 6m. They are used for ranging very long lines in undulating ground.

Offset rods: These are similar to ranging rods and o 3m long. The top is provided with an open hook for pulling or pushing a chain through obstruction like bushes etc.It is used for aligning the offset line and measuring short offsets.

Plumb bob: It is used to transfer the end points of the chain onto ground while measuring distances in hilly terrain. It is also used for testing verticality of ranging poles, ranging rods.

Pegs: Wooden pegs usually 2.5cm square and 15cm deep are used to mark the position of survey stations.

Adjustment of chain:

Chains are adjusted in the following ways-

(1) When the chain is too long, it is adjusted by

(a) Closing up the joints of the rings

(b) Hammering the elongated rings

(c) Replacing some old rings by new rings

(2) When the chain is too short, it is adjusted by

(a) Straightening the bent links

(b) Opening the joints of the rings

(c) Replacing the old rings by some larger rings

Errors in linear measurements / chaining

Errors in chaining may be caused due to variation in temperature and pull, defects in instruments etc. They may be classified into two categories.

(i) Compensating errors

(ii) Cumulative error

(i) *COMPENSATING ERRORS*: Errors, which may occur in both directions (that is both positive and negative) and which finally tend to compensate are known as compensating errors.

(ii) *CUMULATIVE ERRORS*: Errors, which may occur in the same direction and which finally tend to accumulate are said to be cumulative. They seriously affect the accuracy of the work and are proportional to the length of the line (L).The errors may be positive or negative.

I. *Positive Cumulative Error*: The error, which make the measured length more than the actual is known as positive cumulative error.

Sources: (a) The length of chain / tape is shorter than its standard length due to

- Bending of links
- Removal of too many rings due to adjustment of its length.
- Knots in connecting links.
- The field temperature is lower than that at which the tape was calibrated.
- Shrinkage of tape when moist
- Clogging of rings with mud.

(b) The slope correction is ignored while measuring along slopping ground.

(c) The sag correction, if not applied when chain / tape is suspended at its ends.

(d) Incorrect alignment.

II. *Negative Cumulative Error*: The error, which make the measured length less than the actual is known as negative cumulative error.

Sources: (a) The length of chain / tape is longer than its standard length due to

- Flattening of connecting rings.
- Opening of the ring joints.
- The field temperature is higher than that at which the tape was calibrated.

Mistakes:

Errors occurring due to the carelessness of the chainman are called mistakes. Following are a few common mistakes:

(1) Once an arrow is withdrawn from the ground during chaining it may not be replaced in proper position, if required due to some reason.

(2) A full chain length may be omitted or added. This happen when arrows are lost or wrongly counted.

(3)The number may be read from the wrong direction; for instance a 6 may be read as a 9.

(4) Some number may be called wrongly. For example 50.2 may be called as fifty two without the decimal point being mentioned.

Precautions against errors and mistakes:

(1) The point where the arrow is fixed on the ground should be marked with a cross(×).

(2) The zero end of the chain or tape should be properly held.

(3) During chaining the number of arrows carried by the follower and leader should always tally with the total number of arrows taken.

(4) The chainman should call the measurement loudly and distinctly and the surveyor should repeat them while booking.

(5) Ranging should be done accurately.

(6) No measurement should be taken with the chain in suspension.

Errors in measurement due to incorrect chain / tape length:

Due to usage of chain over rough ground, its oval shaped rings get elongated and thus the length of chain gets increased. On the other hand, sometimes some of the links get bent and consequently the length of the chain gets decreased. Thus, the lengths obtained by chaining with a faulty chain are either too long or too short than the length which would be obtained with a chain of standard length. *If the chain is too long the measured distance will be less and if the chain is too short the measured distance will be more.*

Let *L* be the true length of chain and *L'* be the faulty length of chain.

Then, *the true length of a line* = $\frac{L'}{L} \times measured\ length$

Corrections in linear measurements

(i) Correction for standard length

(ii) Correction for alignment

(iii) Correction for slope

(iv) Correction for tension

(v) Correction for temperature

(vi) Correction for sag

(i) *Correction for standard length*: Before using a tape, its actual length is ascertained by comparing it with a standard tape of known length. The designated nominal length of a tape is its designated length e.g. 30m or 100m. The absolute length of a tape is its actual length under specified conditions.

Let L= measured length of a line

C_a = correction for absolute length

l = nominal designated length of tape

C = correction be applied the tape

Then, $$C_a = \frac{L.C}{l}$$

The sign of the correction C_a will be the same as that of C.

(ii) *Correction for alignment*: Generally a survey line is set out in a continuous straight line. Sometimes, it becomes necessary, due to obstruction to follow a bent line which may be composed of two or more straight portions subtending an angle other than 180º as shown in Fig.2.2.

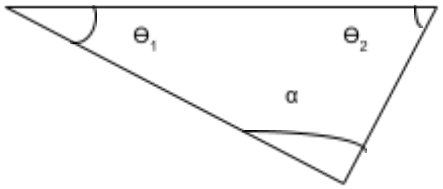


Fig.2.3. Correction for alignment

Let AC=l_1; CB= l_2

Angle BAC = Θ_1; Angle BAC = Θ_2

Length AB= $l_1 \cos \Theta_1 + l_2 \cos \Theta_2$

The required correction = $(l_1 + l_2)-(l_1 \cos \Theta_1 + l_2 \cos \Theta_2)$

(iii) *Correction for slope*: The distance measured along the slope between two stations is always greater than the horizontal distance between them. The difference in slope distance and horizontal distance is known as slope correction which is always substractive.

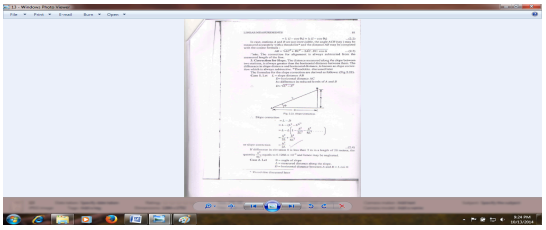


Fig. 2.4 Slope Correction

Let L = slope distance AB

D = horizontal distance AC

h=difference in reduced levels of A and B

$$D = \sqrt{\left(L^2 - h^2\right)}$$

Slope Correction = $L - D = \frac{h^2}{2L}$

(iv) *Correction for pull/ tension (C_P)*:

During measurement the applied pull may be either more or less than the pull at which the chain or tape was standardized. Due to the elastic property of materials the strain will vary according to the variation of applied pull and hence necessary correction should be applied. This correction is given by the expression

$$C_P = ((P-P_0)xL)/(AxE)$$

where, P= Pull or tension applied during measurement in Newtons

A= Cross-sectional area of the tape in square cm.

L= Length of the measured line

P_0 = Standard pull

E = Modulus of Elasticity of the tape

If the applied pull is more, tension correction is positive, and if it is less, the correction is negative.

(v) *Temperature correction (C_t)*:

This correction is necessary because the length of the tape or chain may be increased or decreased due to rise or fall of temperature during measurement. The correction is given by the expression as mentioned below.

$C_t = \alpha(T_m - T_0)L$

where C_t = correction for temperature

α=coefficient of thermal expansion

T_m=temperature during measurement in degrees centigrade

T_0=temperature at which the tape was standardized in degrees centigrade

L=length of tape

(vi) *Correction for sag* (C_s)

This correction is necessary when the measurement is taken with the tape in suspension. It is given by the expression as mentioned below.

$$C_s = \frac{L}{24}\left(\frac{W}{P}\right)^2$$

where W= total wt of the tape; L= horizontal distance between the supports

P = pull applied during measurement

Problem 1. The length of a survey line measured with a 30m chain was found to be 631.5m. When the chain was compared with a standard chain, it was found to be 0.1m too long. Find the true length of the survey line.

Solution

The true length of a line = $\frac{L'}{L} \times measured\ length$

L' = 30.1m. L = 30m

and measured length of the survey line = 631.5m

Thus, true length of the survey line = $\frac{30.1}{30} \times 631.5$ = 633.603 m. Ans.

Problem 2. *A 20m chain was found to be 4 cm too long after chaining 1400m. It was 8 cm too long at the end of day's work after chaining a total distance of 2420m. If the chain was correct before commencement of the work, find the true distance.*

Solution

The correct length of the at commencement = 20m

The length of the chain after chaining 1400m = 20.04 m.

The mean length of the chain while measuring = (20+20.04)/2 = 20.02m

The true distance for the wrong chainage of 1400m = (20.02/20)x1400 = 1401.4 m

The remaining distance = 2420-1400 = 1020m

The mean length of chain while measuring the remaining distance = (20.08+20.04)/2 = 20.06m

The true length of remaining 1020m = (20.06/20)x 1020 =1023.06m

Hence, the total true distance = 1401.4 + 1023. 06 = 2424.46 m Ans.

Problem No.3. A line was measured with a steel tape which was exactly 30 meters at 20 $^{\circ}C\ ^{\circ}C$ at a pull of 100N (or 10kgf), the measured length being 1650.00 meters. The temperature during measurement was 30 $^{\circ}\ ^{\circ}$ C and the pull applied was 150N (or 15kgf). Find the length of the line, if the cross-sectional area of the tape was 0.025 sq.cm. The co-efficient of expansion of the material of the tape per 1 ºC =3.5x $10^{-6}\ 10^{-6}$ and the modulus of elasticity of the material of the tape=2.1x $10^5\ 10^5$ N/m $^{m^2}\ ^{m^2}$ (2.1x $10^6\ 10^6$ kg/c $^{m^2}\ ^{m^2}$).

Solution:

(i) Correction of temperature per tape length

$$= \alpha(Tm - To)L\ \alpha(Tm - To)L$$

$$= 0.0000035(30 - 20)X\ 30$$

= 0.00105m (+ve)

(ii) Correction for pull per tape length

= C_P =((P-P_0)xL)/(AxE)=((150-100)x30)/(2.5x2.1x10^5) 10^5)

=0.00286m (+ve)

Combined correction = 0.00105+0.00286=0.00391m

True length of the tape = 30+0.0039=30.0039m

True length of the line = (30.0039x1650.00)/30

=1650.21m. Ans.

2. **Question Set.**

Short Questions (2mark)

1. A chain line 120 m is represented by 4 cm. what is the R. F?
2. What is cadastral surveying?
3. What do you mean by RF?

Assignment Questions

4. What do you mean by Surveying?[*A]
5. What do you mean by geodetic surveying? [*A]

Self-Assessment

6. Based upon the nature of the field what are the different types of survey?[*SA]
7. What is cardinal principle in surveying? [*SA]

Long Questions (5mark)

1. What is meant by positive cumulative errors and negative cumulative errors?
2. Explain steel bands.
3. What is the classification of survey based on nature of field?

Assignment Question

4. What is the classification of surveying? Describe. [*A]

Self-Assessment

5. How chains are superior to tapes? Explain five different chains commonly used in field measurement. [*A]
6. What are the different accessories used for linear measurements? [*SA]

Long Questions (10mark)

1. The length of a survey line measured with a 30m chain was found to be 315. 4m. afterwards it was found that the chain was 5cm too long. What is the correct length of the line?
2. A line was measured by a 20m chain which was accurate before starting the day's work. After chaining 900, the chain was found to be 6cm too long. After chaining a total distance of 1575m, the chain was found to be 14cm too long. Find the true distance of the line.

Assignment Question

3. A steel tape 20m long, standardized at 15ºC with a pull of 10kg, was used to measure distance along a slope of 4º. If the mean temperature during measurement was 25ºC and the pull applied 16kg, determine the correction required per tape length. Assume co-efficient of expansion as 112x10-7 per ºC, cross-sectional area of tape – 0.08cm2. E = 2. 1x106 kg/cm2. [*A]
4. To measure a base line, a steel tape 30m long standardized at 15º C with a pull of 15kg was used. Find the correction per tape length, if the temperature at the time of measurement was 20ºC and

the pull exerted was 20kg weight of 1 cubic cm of steel is 7.86 gm, wt of tape = 0.8kg, E=2.1x106 kg/cm2 co-efficient of expansion of the tape per 1º C = 7.1 x10-7. [*A]

Self-Assessment

5. A 30m steel tape was standardized at a temperature of 20ºC and under a pull 5kg. The tape was used in catenary at a temperature of 25ºC and under a pull of P kg. The cross-sectional area of the tape is 0.02cm^2, its weight per unit length is 22g/m. Young's modulus = 2x10^{-6}Kg/cm^2, α=11x10^{-6}/ºC. Find the correct horizontal distance, if P is equal to (i) 5kg and (ii) 11kg. [*SA]
6. A tape 20m long, standardized at 15ºC with a pull of 10kg, was used to measure distance along a slope of 4º. If the mean temperature during measurement was 25ºC and the pull applied 16kg, determine the correction required per tape length. Assume co-efficient of expansion as 112x10-7 per ºC, cross-sectional area of tape – 0.08cm2. E = 2. 1x106 kg/cm2.[*SA]

Faculty **HOD** **Principal**