# ECE
# Surveying
# Unit 2.2

# Linear Measurements

## Syllabus

- **Linear measurements**:

  Methods, Instruments used in chaining; Chain surveying, Ranging, Errors in chaining, Conventional symbols.

## Introduction

- The determination of the distance between two points on the surface of the earth is one of the basic operations of surveying. Measurements of horizontal distances or measuring linear measurements is required in chain surveying, traverse surveying and other types of surveying. In surveying the distance between two points means a horizontal distance. As the map is potted on a horizontal plane, the distance are measured in surveying, these are always reduced to the equivalent horizontal distances for mapping purposes.

## Methods

- There are three methods of making linear measurements.
- **Direct method**
- **Optical methods**
- **EDM methods**
- In **direct method** the distance is actually measured during field work using a chain or a tape. This is most commonly used method for linear measurements.
- In the **optical methods**, principles of optics are used. The distance is not actually measured in field but it is computed indirectly. The instruments used for making observations is called tacheometer.
- **Electromagnetic Distance Measuring (E.D.M)** instruments have been quite recently.
- These are practically replacing the measurement of distances using chains or tapes. There is a large variety of such instruments and depending upon the precision required, a particular EDM instrument should be used.

# Direct Method

# Optical Method
# Tacheometer

# EDM

# EDM

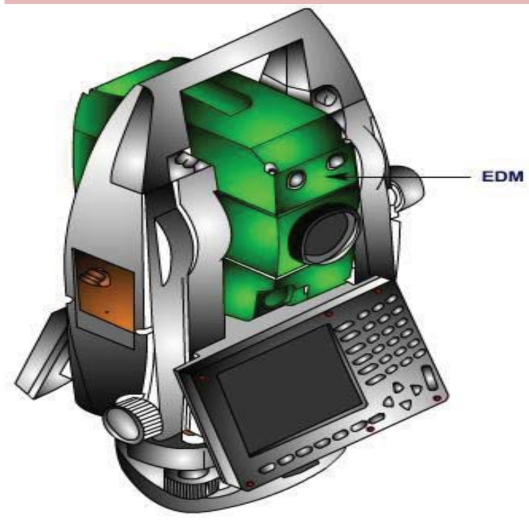



Figure 10.1 Total Station

# Approximate methods

- The methods given below may be used in reconnaissance or for detecting major mistakes in linear measurements obtained with a chain or tape.
- **Pacing:** A distance between two points can approximately be determined by counting number of paces and multiplying it with average length of the pace.
- **Passometer:** It is small instruments which counts the number of paces.
- Pedometer: This instrument directly gives the distance by multiplying the number of paces with the average pace length of the person carrying the instrument.
- **Odometer:** An odometer is a simple device which can be attached to the wheel of a bicycle or any such vehicle. The odometer registers the number of revolutions made by the wheel. The distance covered is equal to the product of the number of revolutions and the perimeter of the wheel.
- **Speedometer:** This is used in automobiles for measuring distances.
- **Measuring wheel:** It is a wheel fitted with a fork and handle. The wheel is graduated and shows a distance per revolution. There is a dial which records the number of revolutions. Thus the distance can be computed.

# Approximate Methods

Passometer
(Step counter)

Measuring
Wheel

Odometer

# Instruments Used in Chaining

- The following instruments are used while chaining:
- Chain
- Tapes
- Arrows
- Ranging rods and offset rods
- Pegs
- Plumb-bob etc.

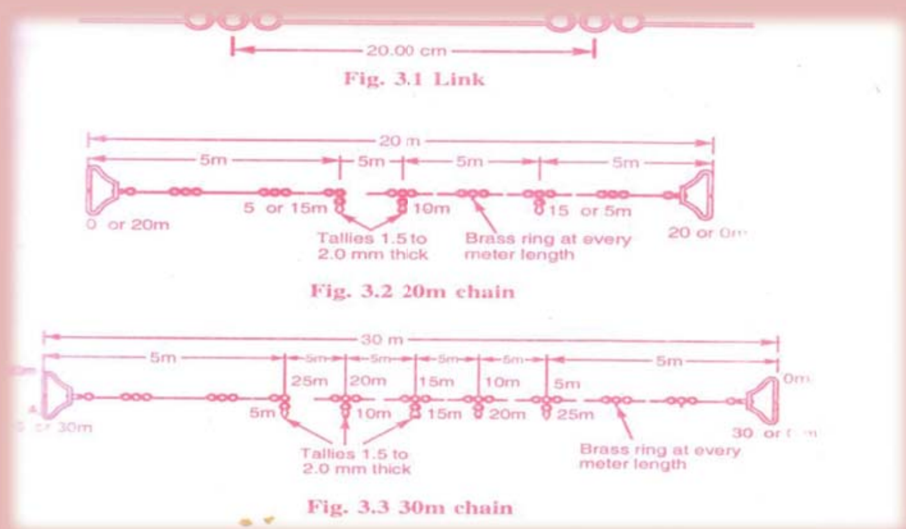
# Chains

- Various types of chains used in surveying are:
- Metric chain
- Gunter's chain or Surveyor's chain
- Engineer's chain
- Revenue chain
- Steel band or band chain

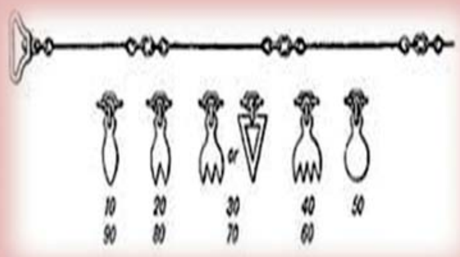
# Metric Chain

- Normally, this chain consists of galvanized mild steel wire of 4mm diameter known as link. The ends of the links are bent into loop and connected together by means of three oval circular rings which provide flexibility to the chain and make it less liable to kinking. Both ends of the chain have brass handles with swivel joint so that the chain can be turned around without twisting. The length of the chain is considered from outside surface of one handle to the outside surface of the other handle at the ends. Similarly the length of link is the length between the centres of the two central rings provided at both ends of the chain. In metric chain length of one link is 20 cm. At every one meter length of chain, a small brass ring is provided. Brass tallies are also provided at every 5m length of chain. Each tally has different shape which indicates either 5m, 10 m, or 15 m from any one end of the chain. Metric chain are also available in the length of 20 m and 30 m. As the length of one link is 20 cm, a 20 m chain consists of 100 such links, while 30 cm chain consists of 150 links. Length of the chain is embossed on the brass handles of the chain.

# Metric Chain




# Metric Chain




# Gunter's Chain or Surveyor's chain

- A 66 feet long chain consists of 100 links, each of 0.66 ft, is known as Gunter's chain.
- Here, 10 chains are equal to 1 acre,
- 10 chains= 1 furlong and 8 furlong (80 chains)= 1 mile
- This chain is suitable for taking length in miles and areas in acre.

# Gunter's Chain or Surveyor's Chain (66 ft. Chain)

| MEASUREMENTS TO REMEMBER | |
|---|---|
| 1 LINK | 7.92 INCHES |
| 25 LINKS | 1 ROD/POLE/PERCH 16 1/2 FEET |
| 100 LINKS | 1 CHAIN OR 66 FEET |
| 10 CHAINS | 1FURLONG OR 220 YARDS |
| 80 CHAINS | 1 MILE OR 5280 FEET |
| 10 SQUARE CHAINS | 1 ACRE |

# Engineer's Chain

- A 100 ft long chain consists of 100 links each of 1 foot is known as Engineer's chain. Brass tags are fastened at every 10 links. This chain is used to measure length and area in square yards.

# Engineer's Chain (100 ft.)

# Revenue Chain

- Revenue chain is 33 ft long chain consisting of 16 links. This chain is used for distance measurements in feets & inches for smaller areas.

# Steel Band or Band Chain

- Steel band are preferred than chains because they are more accurate, but the disadvantage is that they get broken easily and are difficult to repair in the field. They are 20 m and 30 m long, 12 to 16 mm wide and 0.3 to 0.6 mm thick. They are numbered at every metre and divided at every 20 cm.

# Steel Band or Band Chain

# Testing and Adjustment of Chain

- During continuous use, the length of a chain gets altered, its length is shortened chiefly due to bending of links. Its length is elongated either due to stretching of the links and joints and opening out of the small rings. For accurate work it is necessary to test the chain time to time. The chain can be thus tested by a steel tape or by a standard chain. Sometimes, it is convenient to have a permanent test gauge established where the chain is tested.
- When the length of a chain is measured at a pull of 8 kg at 20 $^0$ C, the length of the chain should measure 20 m + 5 mm and 30 m + 8mm for 20 m and 30 m long chain respectively. In addition to this, every m length of the chain shall be accurate to within 2 mm. Following measures are taken to adjust the length of a chain.

# Testing and Adjustment of Chain


Fig. 3.5(b) Testing of chain

# If the chain is found to be too long

- Closing up the joints of the rings if found to be open out.
- Reshaping the elongated ring.
- Replacing elongated rings
- Removing one or more small rings
- Adjust the links at the ends

# If the chain is found to be too short:

- It can be adjusted by:
- Straightening the bent links.
- Opening the joints of the links.
- Replacing one or more smaller circular rings by bigger ones.
- Inserting new rings where necessary.
- Adjusting the links at the ends.
- The adjustment should as far as possible be symmetrical in either side of the middle point so that the position of the centre tag remains unchanged.

# Tapes

- Tapes are used for more accurate measurements. The tapes are classified based on the material of which they are made of such as :
- Cloth Tape
- Fiber Tape
- Metallic Tape
- Steel Tape
- Invar Tape

# Tapes

- **Cloth or Linen tape:**
- Linen tapes are closely woven linen and varnished to resist moisture. They are generally 10 m, 20 m, 25 m and 30 m long length and 12 to 15 mm wide. They are generally used for offset measurements. These tapes are light and flexible.
- **Fiber tape**:
- These tapes are similar to linen and plastic coated tapes but they are made of glass fibre. The tapes are quite flexible, strong and non-conductive. These can even be used in the vicinity of electrical equipment. These tapes do not stretch or shrink due to change in temperature or moisture. These tapes are available in lengths of 20 m, 30 m, and 50 m lengths.

# Tapes

*Linen Tape*

*Fiber Tape*

# Tapes

- **Metallic tape**:
- A linen tape reinforced with brass or copper wires to prevent stretching or twisting of fibres is called a metallic tape. As the wires are interwoven and tape is varnished. These wires are visible to naked eyes. This is supplied in a lather case with a winding device. Each metre length is divided into 10 parts (decimetres) and each part is further sub-divided into 10 parts ( centimetres). It is commonly used for taking offsets in chain surveying.

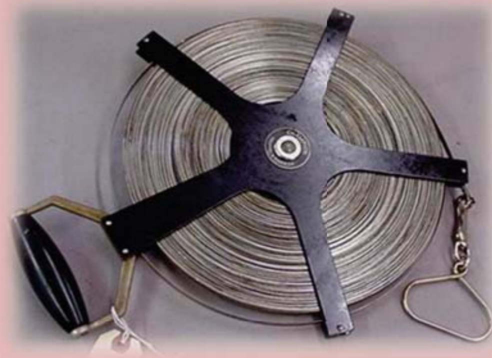
# Metallic tape

# Tapes

- **Steel Tape:**
- The steel tape is made of steel ribbon of width varying from 6 mm to 16 mm. The commonly available length are 10 m, 15 m, 20 m, 30 m, and 50 m. It is graduated in metres, decimetres, and centimetres. Steel tapes are used for accurate measurements of distances.
- **Invar Tape:**
- Invar tape are made of an alloy of nickle 36 % and steel 64 % having very low co-efficient of thermal expansion. These are 6 mm wide and generally available in lengths of 30 m, 50 m, and 100m. It is not affected by change of temperature therefore, it is used when high degree of precision is required.

# Steel Tape

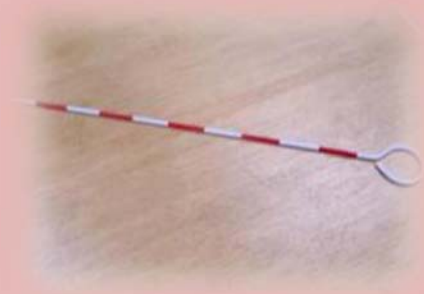
# Invar Tape



# Arrows

- Arrows are made of tempered steel wire of dia 4 mm. One end of the arrow is bent into a ring of diameter 50 mm and other end is pointed. Its overall length is 400 mm. Arrows are used for counting the number of chains while measuring a chain line. An arrow is inserted into the ground after every chain length measured on the ground.

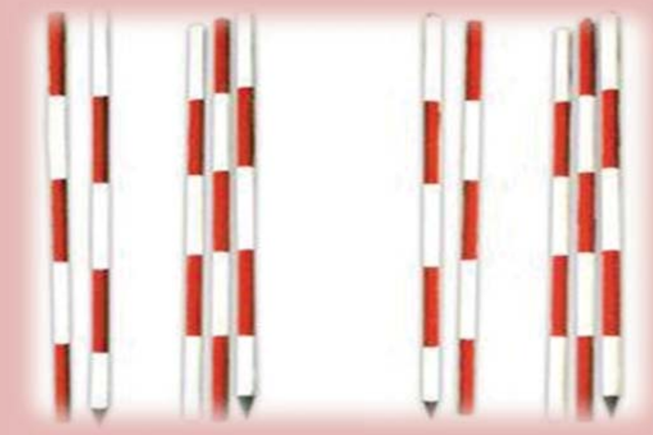
# Arrows



# Ranging Rods and Offset Rods

- Ranging rods are used for ranging some inermediate points on the survey line. Ranging rods are generally 2 to 3 m in length and are painted with alternate color bands of black and white or red and white colors with length of each equalizing 20 cm. The location of any survey station can be known from long distances only by means of ranging rods. If the distance is too long, a rod of length 4.0 m to 6.0 m is used called as ranging poles.
- The offset rod is similar to the ranging rod with the exception that instead of the flag, a hook is provided at the top for pushing and pulling the chain or the tape. It is also used for measuring small offsets.

# Ranging Rods



# Pegs

- Pegs are made of timber or steel and they are used to mark the position of the stations or terminal points of a survey line. Wooden pegs are 15 cm long and are driven into the ground with the help of a hammer.

# Pegs

# Plumb-Bob

- Plumb –bob is used to transfer points on the ground. It is also used for fixing instruments exactly over the station point marked on the ground by checking the centre of the instrument whether coincides with the centre of the peg or station or not, by suspending the plumb-bob exactly at the centre of the instrument under it. Plumb bob is thus used as centering aid in theodolites and plane table.

# Plumb-Bob

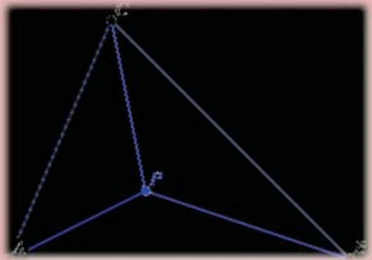
# Chain Surveying

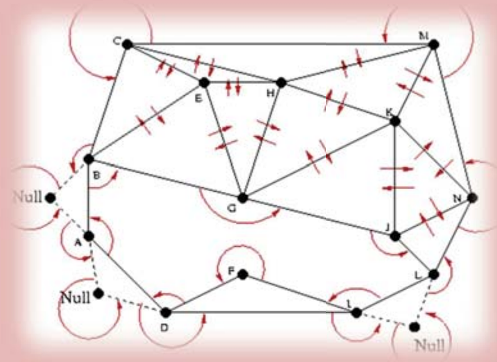
- Chain surveying is that type of surveying in which only linear measurements are taken in the field. This type of surveying is done for surveys of small extent to describe the boundaries of plots of land and to locate the existing features on them.
- It is the method of surveying in which area is divided into network of triangles and the sides of the various triangles are measured directly in the field with a chain or tape and no angular measurements are taken.

# Principle of Chain Surveying

- The principles of chain survey is to divide the area into a number of triangles of suitable sides. As triangle is the only simple plane geometric figure which can be plotted from the lengths of the three sides even if angles are not known. A network of triangles is preferred to in chain surveying. Thus triangulation is the principle of chain surveying. If the area to be surveyed is triangle in shape and if the length and sequence of its sides are recorded, the plan of the area can be easily drawn.

# Principle of Surveying (Triangulation)

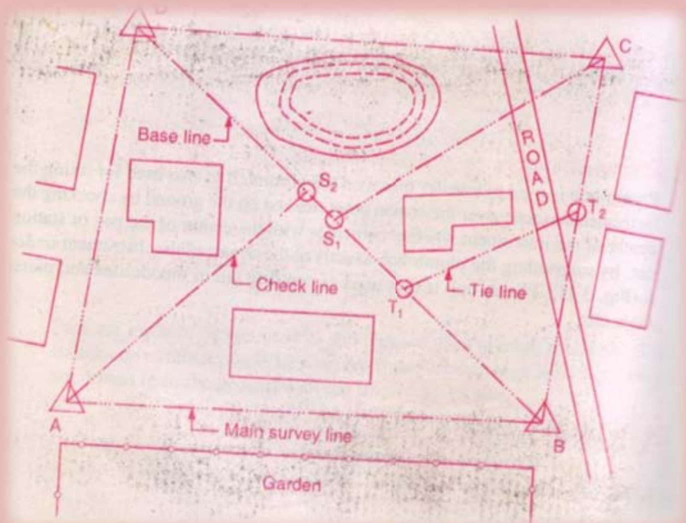





# Terms related with Chain Surveying

- **Survey Stations:** Survey stations are the points at the beginning and at the end of a chain line. They may also occur at any convenient position on the chain line. Such stations may be:
- Main Stations
- Subsidiary Stations
- Tie Stations

# Terms related with Chain Surveying



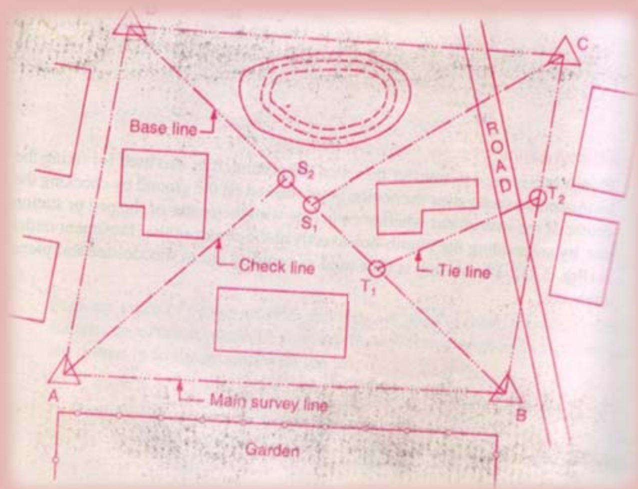

# Terms related with Chain Surveying

- **Main Stations:** Stations taken along the boundary of an area as controlling point are known as ‘ main stations’. The lines joining the main station are called ‘ main survey lines’/ The main survey line should cover the whole area to be surveyed. The main Stations are denoted by with letter A, B, C, D, etc.
- **Subsidiary Stations:** Stations which are on the main survey lines or any other survey lines are known as ‘ subsidiary stations’. These stations are taken to run subsidiary lines for dividing area into triangles. For checking the accuracy of triangles and for locating interior details. These stations are denoted by ‘O’ with letter $S_1$, $S_2$, $S_3$ etc.
- **Tie Stations:** these are also subsidiary stations taken on the survey lines. Lines joining the tie station are known as ‘ tie lines’. The lines are taken to locate interior details. The stations are denoted by ‘ ‘ with letter $T_1$, $T_2$, $T_3$, etc.

# Terms related with Chain Surveying

- **Main Survey lines:**
- The line joining the main stations are called ‘ main survey lines’ or chain lines. In fig AB, BC, CD, DA are the main survey lines.
- **Base Line:** The line on which the framework of survey is built is known as the’ base line’. It is the most important line of the survey. Generally, the longest of the main survey lines is considered as the base line. This line should be taken through fairly level ground, and should be measured very carefully and accurately. In fig , B is the base line.
- **Check line:** The line joining the apex point of a triangle to some fixed points on its base is known as the ‘ check line’. It is taken to check the accuracy of triangles. Some times this lines helps to locate interior details. In fig $CS_1$, $AS_2$, are the check lines.
- **Tie Line:**
- A line joining tie stations is termed as a tie line. It is run to take the interior details which are far away from the main lines and also to avoid long offsets. It can also serve as check line. In fig $T_1$ $T_2$ is the tie line.

# Terms related with Chain Surveying




# Selection of Survey Stations

- The following points should be considered while selecting survey stations
- The stations should be intervisible.
- Survey lines should be minimum as far as possible.
- Stations should form well conditioned triangles.
- Stations points should be so located that tie line, check line, base line, etc. can be formed.
- Station points should be selected within the boundary of the area to be surveyed.
- The survey lines should be taken through fairly level ground as far as practicable.

# Operations in Chaining

- The following operations are involved in chain survey.
- Chaining
- Ranging
- Offsetting
- These three operations are done simultaneously during chain surveying.

# Chaining on Level Ground

- The method of taking measurements with the help of a chain or a tape is termed as chaining.
- Chaining involves following operations:
- Fixing the stations
- Unfolding the chain
- Ranging
- Measuring the distance (Survey Lines)
- Folding the chain
- Stations are first of all marked with pegs and ranging rods to make them visible. There is a typical method of folding and unfolding the chain to prevent the problem of knot formed while unfolding the chain, after unfolding the chain the it is laid straight between the station to measure the correct length of the line. If the length of the survey line is greater than one chain length, intermediate points are located, in order that the chain is pulled along a straight line. This is known as ranging a line.

# Chaining on Level Ground

- After fixing the station points and intermediate points if required, a chain is stretched between two points. The follower holds the zero end of the chain whereas the leader fixes up an arrow at the end of one chain length. The leader pulls the chain for measuring further distance. The leader goes on fixing the arrows at the other ends of each and every chain length. At last, the follower collects all the arrow fixed by the leader while moving forward. At the end of the work , as a check the number of arrows are multiplied by the chain length which is total length measured Finally at the end of work, the chain is folded and tied up with a coir thread.

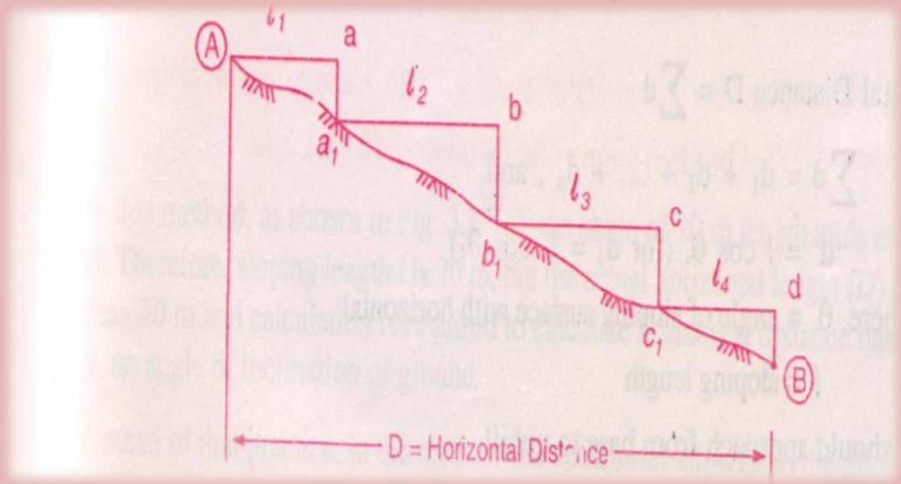
# Chaining on Sloping Ground

- The object of a survey is to prepare a plan or map. In the plan or a map the distances plotted between any two points is always a straight horizontal distance between them. Even if the chaining is done on a sloping ground, this sloping distance is converted into horizontal distance while plotting. There are two methods of finding out horizontal distance while chaining on a sloping ground.
- Direct method
- Indirect method

# Chaining on Sloping Ground

- **Direct method**:
- This method is also called as method of stepping in this method, the distance is measured in small horizontal stretches. A suitable length of chain or tape say $l_1$ is taken. The follower holds the rear end of the tape at a point on the top of the hill or slopping ground. i.e. at point (A) The tape is stretched horizontally from (A) and at small step length ($l_1$) of 3 to 5 m, the point at the end of $l_1$ is dropped and marked on the ground as a1. From $a_1$, again tape is stretched exactly in a horizontal plane at a convenient step $l_2$, and drop end of $l_2$ on the ground as $b_1$. Likewise entire length of line on the sloping ground is measured.
- Finally, the total length of line AB, i.e. D is obtained.
- $D= l_1+ l_2+\ldots\ldots. l_n$
- Where, ln= the last step for the given survey line.
- Here, it should be noticed that, stepping down the hill is convenient than stepping up.

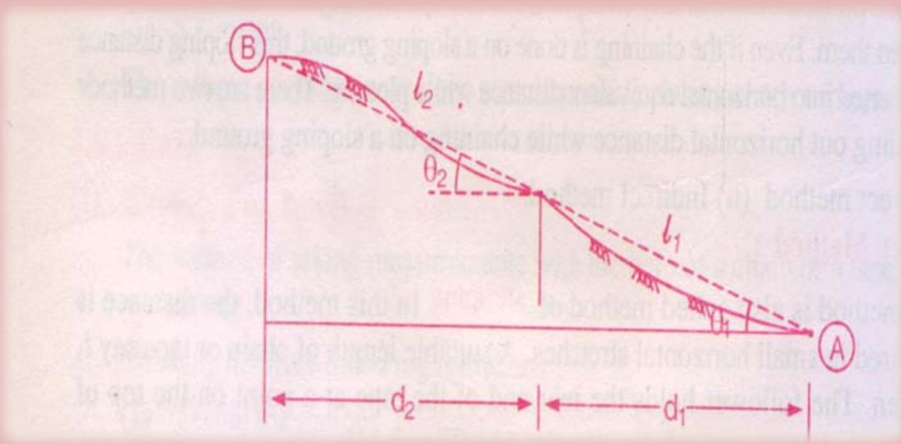
## Chaining on Sloping Ground




## Chaining on Sloping Ground

- **Indirect method:**
- Indirect methods involve calculation from the directly measured lengths. These methods are briefly explained here.
- **Method 1**: Horizontal distance of the segment is calculated by knowing sloping length of the segment and angle of inclination of that with the horizontal.
- The angle of the sloping surface with horizontal can be known by a simple handy instrument called Abney's Level.
- Total Distance D= $\sum$ d
- $\sum d = d_1 + d_2 + \ldots.. dn$, and
- D= lcos Θ. (for $d_1 = l_1 \cos \Theta_1$)
- Where Θ= angle of sloping surface with horizontal
- L= sloping length
- It should approach from base to uphill.

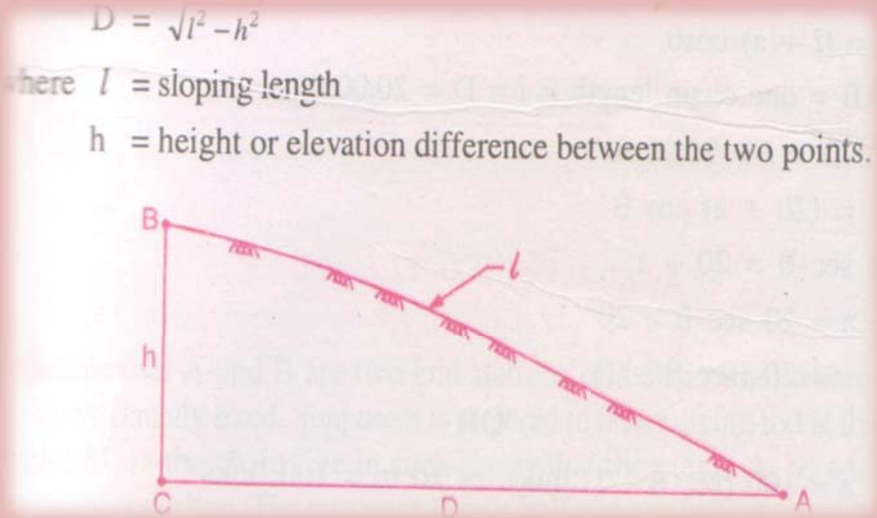
## Chaining on Sloping Ground




## Method 2

- If the elevation difference between two terminal points and the sloping distance between the two terminal points is known, the horizontal distance D can be calculated as,
- $D = \sqrt{l^2 - h^2}$
- Where l= sloping length
- H= height or elevation difference between the two points.

# Method 2



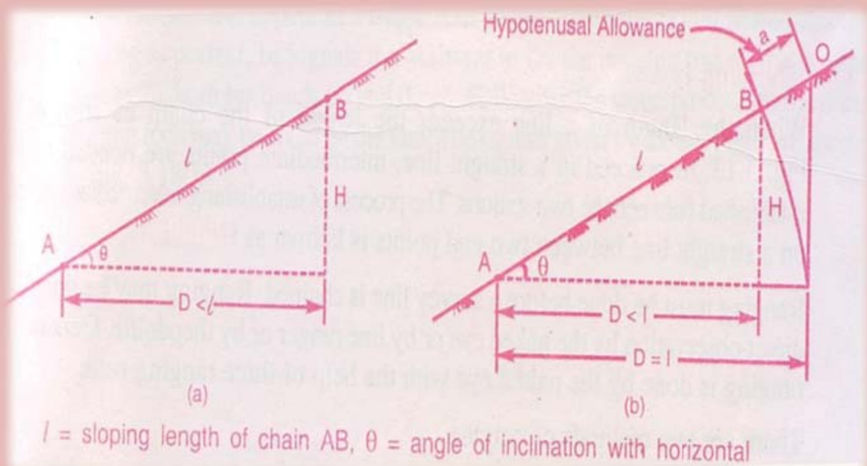

# Method 3

- This method is also called the hypotenusal allowance method. The chaining is done on the sloping ground, but instead of putting the end arrow at actual end of chain, it I put at some advanced distance and that point is considered as the end of one chain length as shown in fig
- In this method, the chain of 20 m length ends at point B, Therefore, sloping length l= 20 m, but the actual horizontal length (D) is less than 20 m and calculation is required to calculate horizontal distance based on Θ, an angle of inclination of ground.
- Instead of that practice, in the method of hypotenusal allowance, the allowance in advance of end of the chain is made in such a way that the total distance, i.e. the length of chain on sloping ground plus allowance, is directly equal to 20 m horizontal distance between those two points as shown in fig

# Method 3

- From figure, the horizontal distance D= (l+a) cos Θ
- Where D is intended to make equal to one chain length
- Therefore , D= (l+a)cos Θ,
- Here, AB= one chain length= l=D= 20m
- Therefore put D= l= 20 m
- Therefore 20 = (20 +a) cos Θ
- Therefore 20 sec Θ = 20 + a
- a= 20 sec Θ- 20
- = 20(sec Θ-1)
- Or
- a= 100 (sec Θ-1) links, as 20m= 100 links
- Where, a= hypotenusal allowance for 20 m long chain
- For the chain other than 20 m, length.
- A= l(sec Θ-1) where, l= length of chain in m
- Thus, the arrow is inserted at (l+a) distance on the ground instead of at the end of the chain. Thus, the horizontal distance for this sloping distance on ground is equal to one chain length (l)

# Method 3



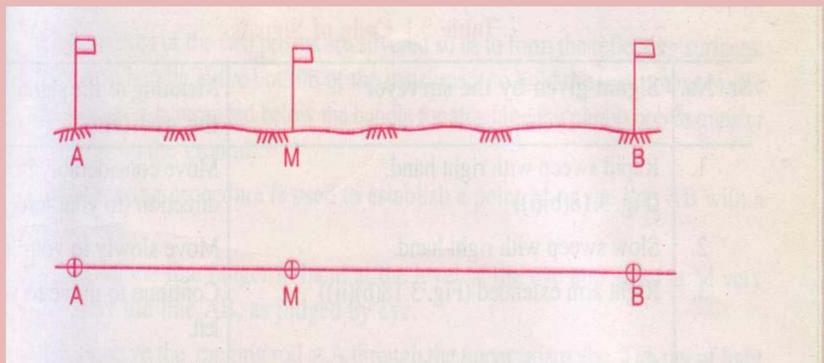
# Ranging

- When the length of a line exceeds the length of the chain as shown in fig to proceed in a straight line, intermediate points are needed to be established between the two stations. The process of establishing intermediate points on a straight line between two end points is known as ranging.
- Ranging must be done before a survey line is chained. Ranging may be done by direct observation of naked eye or by line ranger or by theodolite. Generally, ranging is done by the naked eye with the help of three ranging rods.
- There are two methods of ranging:
- Direct Ranging
- Indirect Ranging or Reciprocal Ranging.

# Direct Ranging

- When intermediate ranging rods are fixed on a straight line by direct observation from end stations, the process is known as direct ranging. Direct ranging is possible when the end stations are intervisible. The following procedure is adopted for direct ranging.
- Assume that A and B are two end stations of a chain line, where two ranging rods are directly fixed. Suppose it is required to fix a ranging rod at the intermediate point M on the chain line in such a way that the points A, M, B are in same straight line. The surveyor stands half a meter behind the ranging rod at A by looking towards the line AB. The assistant holds a ranging rod at M vertically at arm's length. The rod should be held lightly by thumb and for-finger. Now, the surveyor directs the assistant to move the ranging rod to the left or right until the three ranging rods comes exactly in the same straight line. To check the verticality of the rods, the surveyor looks through the bottom of the rods. The ranging is perfect, when the three ranging rods coincide and appear as a single rod. When the surveyor is satisfied that the ranging is perfect, he signals the assistant to fix the ranging rod on the ground by waving both his hands up and down. Following the same procedure, the other ranging rods may be fixed on the line. The signal given by the surveyor are shown in fig

# Direct Ranging




# Direct Ranging

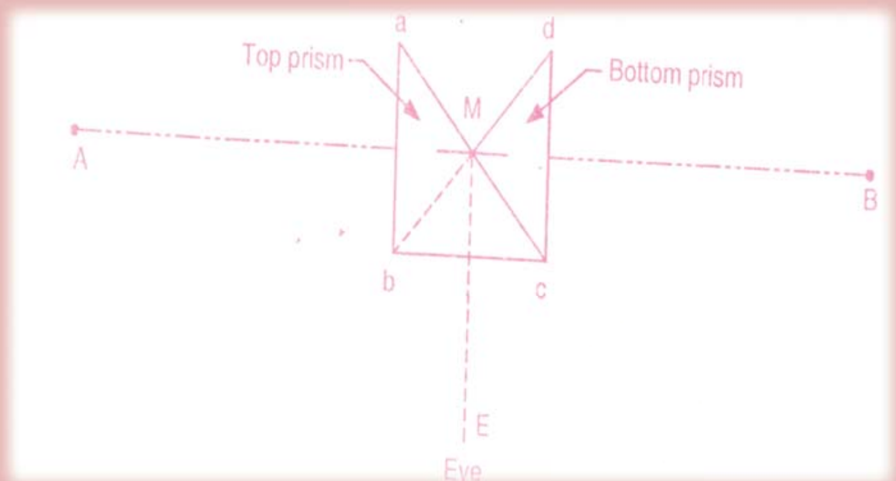
## Direct Ranging with a line ranger

- A line ranger consists of two right angled isosceles triangular prisms placed one above the other. The diagonals of the two prism are silvered so as to form the reflecting surfaces. There is a handle at the bottom of the instrument to hold the instrument in one hand. A hook is provided below the handle for attaching the plumb bob to transfer the point on the ground.

## Direct Ranging With A Line Ranger

- The following procedure is used to establish a point M on the line AB with a line ranger.
- Hold the line ranger in handle at the level on the eye and stand at M very near the line AB, as judged by eye.
- Observe the ranging rod at A through the upper prism, ABC. The ray of light from A enters the upper prism, gets reflected from the silvered diagonal ac and enters the eye at right angle to the line AB, as the incident ray makes an angle of 45 0 with the reflecting surface.
- Also observe the ranging rod at B through the lower prism dbc. The ray of light from B enters the prism, goes reflected from the silvered diagonal db and enters the eye at right angle to the line AB.
- Check whether the image of the ranging rods at A and b are seen in one vertical line or not. If the point at which the line ranger is held is not exactly on the line AB, the two images appear separated.
- Move the instrument slightly backwards or forwards, at right angles to the line AB until the two images appear exactly one over the another.
- Transfer the point to the ground by hanging a plumb bob from the hook on the handle. The point M so transferred is exactly below the intersection of the two diagonals
- Like wise other points can be established.

## Direct Ranging with a line Ranger




## Indirect or Reciprocal Ranging

- When the end stations are not intervisible due to there being high ground between them, intermediate ranging rods are fixed on the line in an indirect way. The method is known as indirect ranging or reciprocal ranging. The following procedure is adopted for indirect ranging.

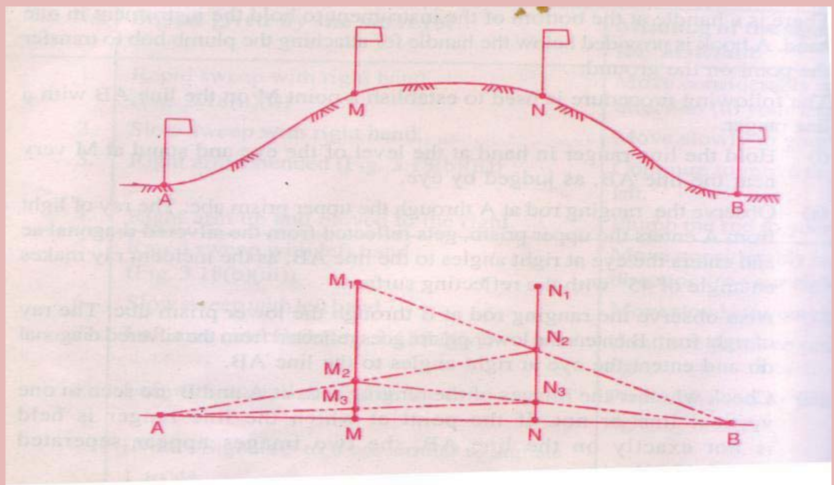
# Indirect or Reciprocal Ranging

- Suppose A and B are two end stations which are not intervisible due to high ground existing between them. Suppose it is required to fix intermediate points between A and B, two chain men take up positions as $M_1$ and $N_1$ with ranging rods in their hands, The chainmen at $M_1$ stands with his face towards B so that he can see the ranging rod at $M_1$ and A. Then the chainmen proceed to ranging the line by directing each other alternately. The chainmen at $M_1$ directs the chainmen at $N_1$ to come to the position $N_2$ so that $M_1$, $N_1$ and B are in the same straight line. Again, the chairmen at $N_2$ directs the chainmen at $M_1$ to move to the position at $M_2$ so that $N_2$, $M_2$ and A are in the same straight line.

# Indirect or Reciprocal Ranging

- The two chainmen are now at $M_2$ and $N_2$ which are nearer to the chain line than the position $M_1$and $N_1$. The process is repeated till the other points M and N are located in such a way that the chainmen at M finds the chainman at N in line with MB and the chainmen at N finds the chainmen at M in line with NA, Thus the points A, M, N and B are in the same straight line.

# Indirect or Reciprocal Ranging




# Indirect or Reciprocal Ranging

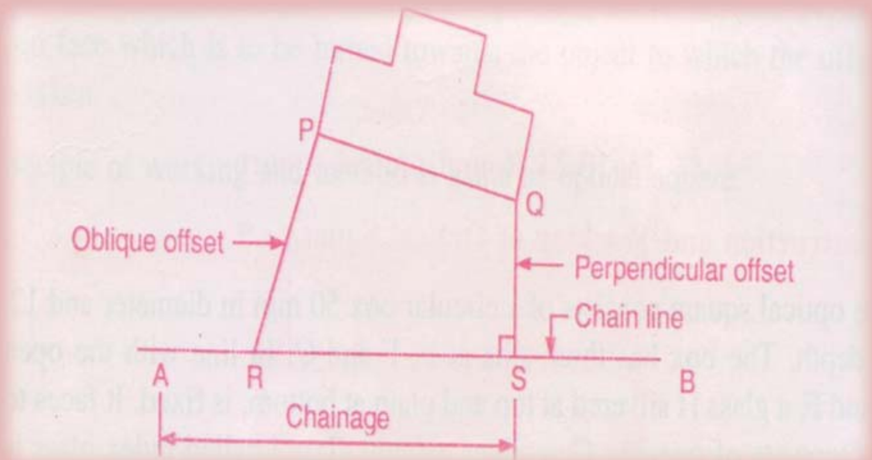
# Offsetting

- The method of taking perpendicular distance from the chain line to the objects which are to be plotted is known as offsetting. Thus, the distance measured from object to chain line is termed as an offset.
- It is done to locate objects from chain line. Offsets are either taken on one side of the chain or both sides of the chain.

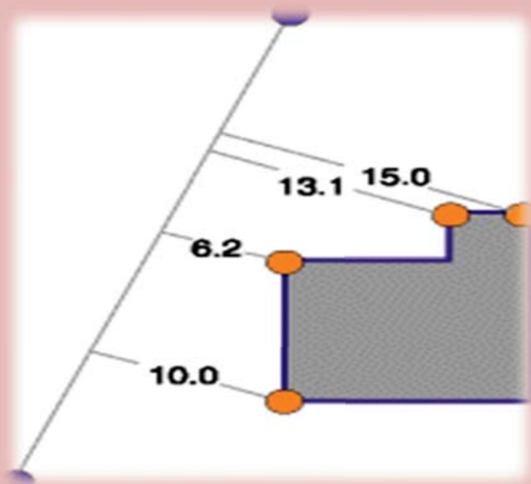
# There are two types of offsets

- Perpendicular offsets
- Oblique's offsets:
- **Perpendicular Offsets:**
- The offsets which are taken perpendicular to the chain line are termed as perpendicular offsets. These offsets are taken by holding zero ends of the tape at the object and swinging the tape on the chain line. The shortest distance whatsoever measured from object to the chain line is always a perpendicular offset.
- **Oblique Offsets:** Oblique distance is always greater than the perpendicular distance. All the offsets which are not taken at right angle to chain line are know as oblique's offsets.
- The distance to the chain line at which the foot of the offset is taken is known as a chainage.
- According to length, the offset having length greater than or equal to 15 m are termed as long offsets and the offsets of length less than 15 m are known as short offsets. Short offsets are more accurate than long offsets.

# Oblique Offsets




# Perpendicular Offsets



# Instruments for laying offsets

- Offsets are set of instruments such as
- Optical Square
- Indian Optical square
- Open Cross staff
- Prism Square

# Optical Square

- This instrument is used for perpendicular offset only.
- Principle of Optical Square
- The angle between the incident ray and the reflected ray is twice the angle between the mirrors.
- Construction and working of optical square
- The optical square consists of a circular box 50 mm in diameter and 12.5 mm in depth. The box has three slits at E, F, and C. in line with the opening at E, and f, a glass H silvered at top and plain at bottom, is fixed. It faces towards E. opposite of opening C, a silvered painted glass I called index glass is fixed so that the inclined edge of glass I and inclined face of glass H makes angle of 45 $^0$. When opening C face towards object for offset, the image will strike to the index glass I and reflected to horizon glass H. from this horizon glass H, the image received from glass I will be reflected and received by a surveyor holding the instrument and looking through opening E.

# Setting up the perpendicular by optical Square

- The observer should stand on the chain line and approximately at the position where the perpendicular is to be set up.
- The optical square is held by the arm at the eye level. The rod at the forward section B is observed through the unsilvered portion on thee lower part of the horizon glass.
- Then the observer looks through the upper silvered portion of the horizon glass to see the image of the object P
- Suppose the observer finds that the ranging rod B and the image of object P does not coincide, then he should move forward or backward along the chain line until the ranging rod B and the image P exactly coincide.
- At this position the observer marks a point on the ground to locate the foot of the offset for the given object.

# Optical Square

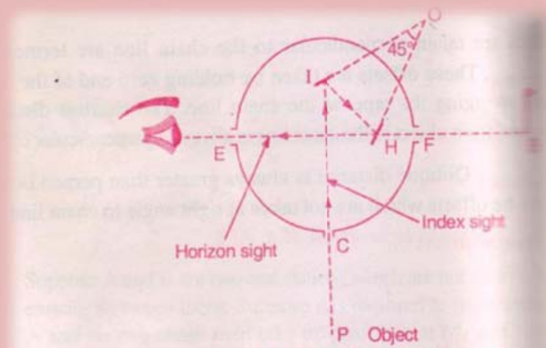



Fig. 3.23 Round optical square

# Indian Optical Square

- It is brass wedge shaped hollow box of about 5 cm sides and 3 cm deep with a handle 8 cm long fixed underneath.
- $M_1$ and $M_2$ are two mirrors fixed to the inclined sides of the box at an angle of 45 $^0$; abs and cod are two rectangles openings above mirrors. PQRS is the open face which is to be turned towards the object to which the offset is to be taken.
- Principle of working and method is same as optical square.

# Indian Optical Square

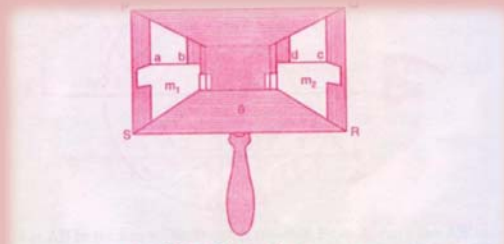
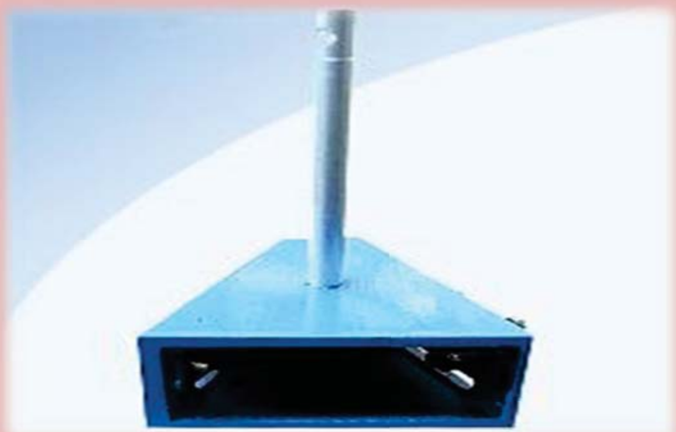



Fig. 3.24 Indian optical square

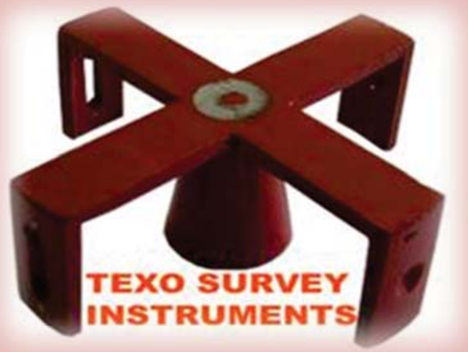
# Indian Optical Square



# Open Cross Staff

- This Instrument is the simplest form among all and consists of four metal arms with vertical slits for sighting through at right angles to each other
- Two persons are required for this instrument. One pair of vertical slit is to be bisect ranging rod at the end of the given chain line by standing on the chain line and other pair of vertical slit is required to be inline with a ranging rod at object for perpendicular offset. If this happens. The point on the chain line is the base of the perpendicular offset from object to chain line. The vertical point is marked on the chain line to measure perpendicular offset and chain age.

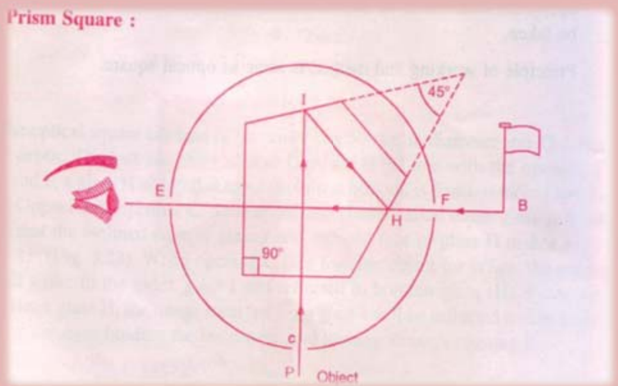
# Open Cross Staff




# Prism Square

- This works on the same principle of optical square. Instead of two mirrors or reflecting surface, a prism is used which has two reflecting surfaces I and H fixed at $45^0$. The ranging rod at B is seen directly through a peep hole on the top of the prism. The ranging rod at P on a line at right angle to the line AB is seen below B after reflection from the faces I and H. In a prism square, there is no provision of adjustment of reflecting surfaces. However, a prism square is more precise than an optical square.
- The prism square is used for taking offsets and setting out the perpendicular, like an optical square.

# Prism Square




# Prism Square

# Obstacles

- Obstrucles like ponds, buildings, rivers, hedges, etc, prevent the direct measurement of the length, width etc. between two stations or objects. In these cases it is necessary to overcome such obstrucles to get required length/ measurements
- The obstrucles may be of following types.
- When chaining is free but vision is obstructed
- When chaining is obstructed but vision is free
- When chaining and vision both are obstructed.

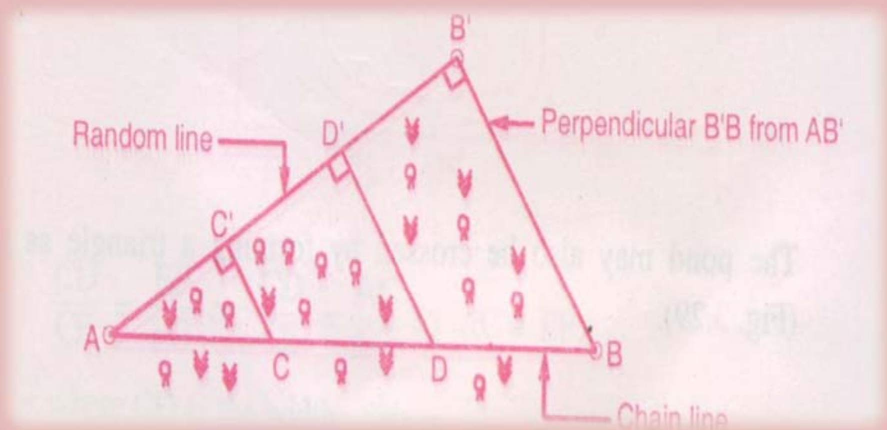
# When Chaining Is Free But Vision Is Obstructed

- Such a problem arise when a rising ground or a jungle area interrupts the chain line. Here the end stations are not intervisible. Here two cases may arise.
- Both ends may be visible from any intermediate point lying on the line such as in the case of hill, the obstacle may be overcome by the method of reciprocal ranging as explained earlier.
- Both ends may not be visible from any intermediate point such as in the case of a jungle or dense plantation. This kind of obstrucles may be crossed over by ‘ Random line method’.
- Let AB be the line whose length is required. From a, run a line AB’ called a random line, in the approximate convenient direction of AB and continue it until point B is visible from B’. Chain the line BB’, where BB’ is always taken as perpendicular to AB’. Measure AB’ and BB’
- Then, AB= $\sqrt{(AB')^2 + (BB')^2}$

# When Chaining Is Free But Vision Is Obstructed

- Any Intermediate points can be located as C and D on the chain line AB by taking perpendicular offsets from the chain line AB’.
- Here, C’C= B’B x $\frac{AC'}{AB'}$ and D’D= B’B x $\frac{AD'}{AB'}$

# Chaining Is Free But Vision Is Obstructed



## Case -2
## When Chaining Is Obstructed But Vision Is Free

- **Case (a)** It is possible to chain round the obstacle
- In this case any one of the following methods can be adopted.
- (a) when the ponds interrupts the chain line, it is possible to go round the obstruction.
- Suppose AB is the chain line. Two points C and D are selected on it on opposite banks of the pond. Equal perpendiculars CM and DN are erected at C and D. The distance MN is measured.
- The pond may also be crossed by forming a triangle as shown in fig.
- A point C is selected on the chain line. The perpendicular CM is set out at C and a line MD is suitably taken. The distance CM and MD are measured. So,
- $CD = \sqrt{(MD)^2 - (CM)^2}$

## Case -2
## When Chaining Is Obstructed But Vision Is Free

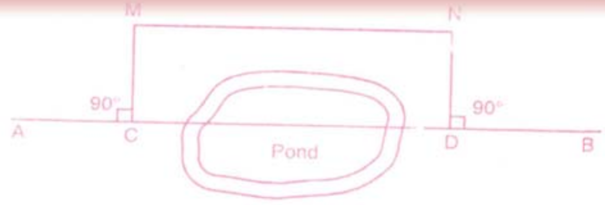
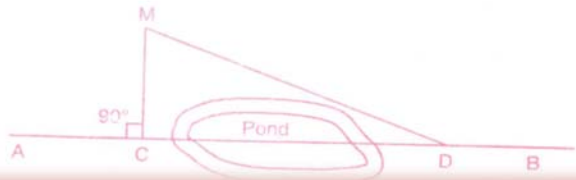
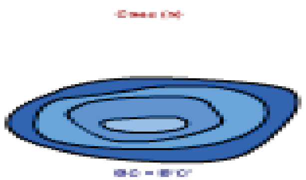



Fig. 3.28

The pond may also be crossed by forming a triangle as shown in (Fig. 3.29).




## When Chaining Is Obstructed But Vision Is Free



## When Chaining Is Obstructed But Vision Is Free

## Case -2
## When Chaining Is Obstructed But Vision Is Free

- **Case-b** When, it is not possible to chain round the obstacle, e.g. in case of continuous long obstacles like river, valley etc.
- (a) Select point C and D on opposite banks of the river on the river on the line AB. As shown in fig, width of the river can be calculated as under.
- From C draw a perpendicular CE of convenient length. Establish point G in line with DE beyond E by ranging so that a line AG is perpendicular to AB at A. Form a line EF parallel to CA so that F is on line AG.
- Measure AC, CE and FG. Here Δ EFG and Δ DCE are similar triangles
- Therefore $\frac{CD}{CE} = \frac{EF}{FG}$ or $\frac{CD}{CE} = \frac{AC}{FG}$

## Case -2
## When chaining is obstructed but vision is Free

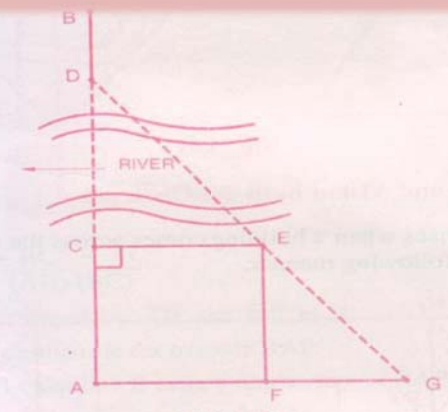



Fig. 3.30

$$\therefore \quad \frac{CD}{CE} = \frac{EF}{FG} \text{ or, } \frac{CD}{CE} = \frac{AC}{FG} \quad (\because AC = EF),$$

where CD is the width of river.

## Case -2
## When Chaining is Obstructed but Vision is Free

- Where CD is the width of river.
- (b) Select two points A and B on the line on either side of the river as shown in fig.. Set a perpendicular AC and mark its mid point D. From C, establish E to form CE perpendicular to AC such that E, D and B are in the same line.
- From triangle BAD and ECD
- EC= AB
- The distance EC is measured and thus the distance is obtained indirectly.

## Case -2
## When Chaining is Obstructed but Vision is Free

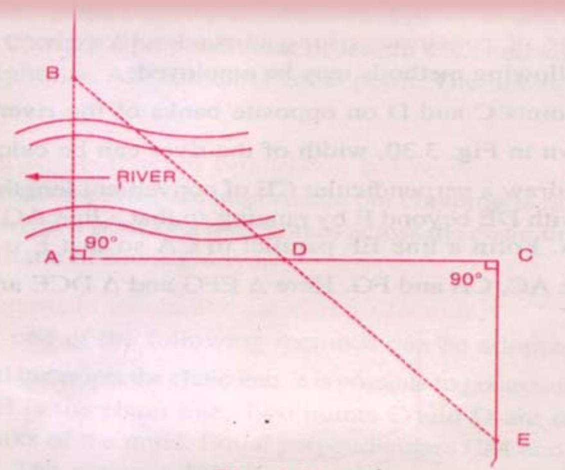
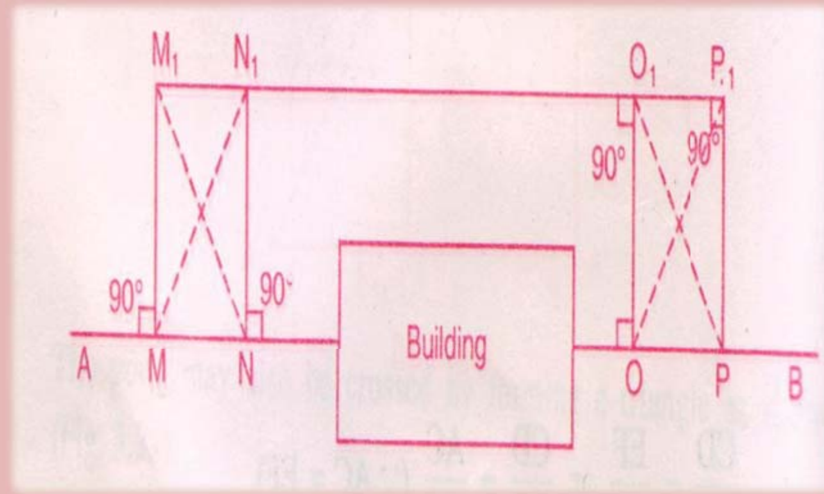



Fig. 3.31

# When Chaining And Vision Both Are Obstructed:

- Such a position when a building comes across the chain line. It is solved in the following manner.
- Suppose AB is the chain line. Two points m and N are selected on it at one side of the building. Equal perpendiculars $MM_1$ and $NN_1$ are erected. The line $M_1N_1$ is extended until the building is crossed. On the extended line, two points $O_1$ and $P_1$ are selected. Then perpendiculars $O_1O$ and $P_1P$ are so erected that
- $O_1O = P_1P = N_1N = M_1M$
- Thus, the points M, N, O and P will be on the same straight line AB. Here, $NO = N_1 O_1$
- The distance $N_1O_1$ is measured and is equal to the required distance NO.

# When Chaining And Vision Both Are Obstructed




# When Chaining And Vision Both Are Obstructed

# Errors in Chaining

| Reasons for Occurrence of Error | Effect | Nature |
|---|---|---|
| 1. Erroneous length of chain/tape | +ve/–ve | cumulative |
| 2. Bad Ranging | +ve | cumulative |
| 3. Careless holding & marking | +ve/–ve | compensating |
| 4. Bad straightening | +ve | cumulative |
| 5. Non-horizontality | +ve | cumulative |
| 6. Sag in chain / tape | +ve | cumulative |
| 7. Variation in temperature | +ve/–ve | cumulative |
| 8. Variation in Pull | +ve/–ve | compensating or cumulative |
| 9. Personal mistakes | +ve/–ve | compensating |

# Errors in Chaining

- The nature of error is either cumulative or compensating. Thus, errors are classified as compensating errors and cumulative errors.
- **Cumulative Errors:**
- The errors, which occur in the same direction and tend to accumulate are called cumulative errors. These errors effects on accuracy of survey works.
- **Compensating Errors:**
- The errors which occur in either direction and tends to compensate are called compensating errors. These have minor final effects at the end.

# Errors in Chaining

- Sources of Errors in Chaining are:
- **A) Instrumental Errors**
- **B) Natural Errors**
- **C) Personal Errors**
- Errors occurring due to faulty adjustments or imperfections of the instruments or devices such as chains or tapes are called instrumental errors. It may be too long or too short.
- Errors occurring due to variation in phenomenon of nature such as temperature, moisture, nature of terrain etc. are called natural errors.
- Errors due to chain or tape not being straight or working with faulty methods or mistakes done while writing measurements etc are termed as personal errors.
- The errors in chaining are regarded as +ve or –ve which are according to they make the result too great or too small.

# Errors due to Incorrect Chain

- If the length of the chain used for measuring distance is found incorrect, then corrections has to be applied to the measured distance to find the correct distance.
- If the chain is too long measured distance will be less and the correction to be applied is positive. But if the chain is too small, the measured distance will be more and correction to be applied is negative as shown in fig given below:
- If the length is measured with too long chain, then, the end of the chain which measures 20 m will be in advance of actual 20.00 distance on ground and at point on ground which is exactly 20.00 m from starting point will measure 19.9 or so for the too long chain and gives too short distance.
- Correction is applied to get actual length
- Therefore, **Correct length of line= L' x measured length**
- **L**
- (Actual length on the field)
- Where
- L'= Incorrect or actual length of the chain
- L = Designated or standard length of the chain

# Error Due to Incorrect Chaining

- For Area,
- True Area of field= $\left(\frac{L'}{L}\right)^2$ x measured area
- For Volume,
- True volume of field= $\left(\frac{L'}{L}\right)^3$ x measured area and

## Examples

**A 20 m chain was found to be 8 cm too long at the end of day's work after measuring 4000m. If the chain was correct before the commencement of the work, find the correct length of the line.**

**Solution:**

The Increase of 8 cm length should be taken as gradual.

Therefore Mean In-correct length of the chain

$L' = \frac{20.00+20.08}{2}$

= 20.04 m

L= 20 m.

Measured Length= 4000m.

Therefore Correct Length = $\frac{L'}{L}\ x\ Measured\ Length$

$= \frac{20.04}{20}\ x\ 4000$

**= 4008 m. Ans.**

## Examples

**A Chain was tested before starting the survey and was found to be exactly 20.00 m. After measuring 350 m, it was again tested and was found to be 5.0 cm too long. After a total measurement of 600 m, again the chain was tested and was found to be 10.00 cm too long. Calculate actual length of the line.**

**Solution:**

Initially, the chain was perfectly correct. Length of chain was 20.00m as denoted or designated length of chain. After measuring 350 m, it was found 5 cm too long. i.e. elongated and length of chain was increased by 5.0 cm and measuring 20.05 m instead of 20.00 m.

Thus, assuming uniform change in length of chain from 20.00 m at 0.0 m to 20.05 m at the end of 350.0 m the average elongation should be taken.

$L' = \frac{20.00+20.05}{2} = 20.25\ (Incorrect\ length\ of\ the\ chain)$

L= 20.00 (Correct/ Designated length of the chain)

Measured length of line= 350.00 m.

Therefore, Correct length of line up to 350.00m = $\frac{20.025}{20}\ x\ 350$

= 350.4375 m (a)

After measuring 600.00 m, i.e. for remaining 600-350 = 250 m measurement of length, the chain was found measuring 20.10 i.e. 10 cm too long.

## Examples (Cont..)

Initially, at 350 m chain was only 5.0 cm too long and measuring 20.05 m while at the end i.e. at 600 m, 20.10, i.e. 5 cm and thus average length of chain can be taken as 20.075 m for the measurement of length from 350.00 m to 600.00 m

Therefore,

$L' = \frac{20.05+20.10}{2} = 20.075$ m

L= 20.00 m

Measuring length = 250.00 m (600-350 = 250 m)

Therefore, Actual length= $\frac{20.075}{20.00}\ x\ 250$

= 250.9375 m (b)

Therefore correct/ Actual length of line= 350.4375 + 250.9375

= 601.375 m

## Example

**Example A 20 m chain was found to be 10 cm too long after chaining a distance of 1500 m. It was found to be 18 cm too long at the end of one day's work after chaining the total distance of 3900 m. Find the true distance if chain was correct before the commencement of work.**

Solution:

First Part: L= 20 m

$L' = \frac{20.00+20.10}{2}$ $(considering\ mean\ elongation)$

= 20.05 m

Measured Length= 1500 m

True Length= ?

$TL = \frac{L'}{L}\ x\ ML$

$= \frac{20.05}{20}\ x\ 1500$

= 1503.75 m

# Example (Cont…)

Second Part: L = 20 m

$L' = \frac{20.05+20.18}{2}$

ML= 20.14 m

$TL = \frac{L'}{L}\ x\ ML$

$= \frac{20.14}{20}\ x\ 2400$

= 2416.80 m

True Distance = 1503.75 + 2416.80

= 3920.55 m

# Example

**The length of a survey line measured with a chain was found to be 350 m. Calculate the true length of the line if The length was measured with a 30 m chain was 10 cm too long, and The Length of chain was 30 m in the beginning and 30.10 m at the end of work.**

**Solution**: Measured Length = 350 m.

True length of chain L = 30 m

Incorrect or actual length of the chain used L'= 30.10 m.

Chain was 10 cm too long in the beginning and the chain was not tested at the end of work. So, there is no average elongation but 10 cm too long length is considered through the measurement.

True Length of Line = $\frac{L'}{L}\ x\ meaured\ length$

$= \frac{30.10}{30}\ x\ 350$

= 351.166 m.

Chain was 30 m in the beginning and at the end of work 30.10 m. So, average elongation is considered.

$L' = \frac{30.00+30.10}{2} = 30.05\ m.$

True Length of line = $\frac{L'}{L}\ x\ measured\ length$

$= \frac{30.05}{30}\ x\ 350$

**= 350.583 m.**

# Example

**A Road actually 2860 m long was found to be 2850 m when measured with a defective chains. How much corrections do the chains need if ?**
**Length of Chain = 20 m, Length of Chain = 30 m**

**Solution:**

Length of chain = 20 m

True length= $\frac{L'}{L}\ x\ measured\ length$

Therefore, $2860 = \frac{L'}{20}\ x\ 2850$

Therefore, L' = 20.07 m

The chain is 0.07 (7 cm) too long

**Correction = -7 cm (Ans.)**

Length of Chain = 30 m

True Length= $\frac{L'}{L}\ x\ measured\ length$

$2860 = \frac{L'}{30}\ x\ 2850$

Therefore, L' = 30.10 m

The Chain is 0.1 (10 cm) too long

Therefore **Correction = -10 cm (Ans.)**

# Examples

**The distance between two stations measured between two stations was measured with a 20 m chain and found to be 1200 m. The same distance was measured with a 30.00 m chain and found to be 1195.40 m. if the 20.0 m chain was 5.0 cm too short, what was the error in the 30.00 m chain ?**

**Solution:**

By 20 m long chain L= 20.00 m

L = 20-0.05 (Chain was 5 cm too short in the beginning)

= 19.95 m

Measured Length= 1200.00 m

Actual Length of line = $\frac{L'}{L}\ x\ ML$

Therefore, $1197 = \frac{L'}{30.00}$ x 1195.40

$L' = \frac{30.00+1197.00}{1195.40} = 30.04m$

Therefore error in 30.00 m long chain = 0.04 m

i.e. **4 cm too long… (Ans.)**

# Examples

**A Chain of 30 m nominal length was used to measure are of a rectangular field. Length of the longer side was measured to be 110.0m and chain was found to be 2.00 cm too long. Further the work was continued and shorter side of the rectangular was measured to be 80.00 m and at that stage was 4.00 cm too long. Find true area of the field in square metre and in hectares.**

**Solution:**

The average incorrect length of chain over 110 m length with 2.00 cm too long chain,

$L' = \frac{30.00+30.02}{2} = 30.01\ m$

L' = 30.00 m

Measured length = 110 ( Longer Side)

Therefore, correct longer side= $\frac{30.01}{30}\ x\ 110 = 110.0366\ m$

For Shorter Side,

$L' = \frac{30.02+30.04}{2} = 30.03\ m$

L= 30.00 m

Therefore, correct length on field = $\frac{30.03}{30}\ x\ 80 = 80.08\ m.$

Therefore Correct area of Rectangular Plot = Longer side x Shorter Side

= 110.0366 x 80.08

= 8811.73 $m^2$

**As 10000 $m^2$ = 1 hectare, 8811.73 $m^2$ = 0.881173 hectares**

# Tape Corrections

- Precise linear measurements are made by means of a steel or invar tape. Before use, it is desirable to ascertain its actual length by comparing it with standard of known length. Since the tape is not used on the field under standard condition of temperature, pull etc., it is necessary to apply the following correction to the measured length of a line in order to obtain its true length.
- Correction for absolute length
- Correction for temperature
- Correction for pull
- Correction for sag
- Correction for slope

# Correction for absolute (Actual) Length

- Nature of correction ( +ve or –ve cumulative)
- If the absolute length (or actual length) of the tape is not equal to its nominal length or designated length, a correction will have to be applied to the measured length of the line. If the absolute length of the tape is greater than the nominal or designated length, the measured distance will be too short and the correction will be additive. If the absolute length of the tape is lesser than the nominal length the measured distance will be too great and the correction will be substractive
- Thus, $C_a = \frac{L.C}{l}$

# Correction for absolute (Actual) Length

- Where, $C_a$= Correction for absolute length
- L= Measured length of a line
- C= correction per tape length
- L= Designated length of a tape
- Ca will be of the same sign as that of C

# Correction for Temperature

- **Nature of Correction is +ve or –ve**
- It is necessary to apply this correction sice measurements are not made at the same temperature at which the tape is standardized. The length of a tape increases or decreases with the increase or decrease in temperature than the standard temperature.
- If $C_t$= Correction for temperature in m
- α= Co-efficient of thermal expansion
- $T_m$= mean temperature during measurement
- $T_s$= Standard temperature for tape
- L= Length of tape in m.
- Then, $C_t = \alpha (T_m - T_s) L$
- The average value of co-efficient of thermal expansion for steel and invar tape are taken as $12 \times 10^{-6}$ and $0.9 \times 10^{-6}$ per degree Celsius respectively
- The unit of $C_t$ will be the same as that of L, $C_t$ will be positive if Tm□ Ts and negative if $T_m$ □ $T_s$

# Correction for Pull

- **Nature of correction is +ve or –ve cumulative**
- The correction for pull is necessary when the pull applied during measurement differs from that at which the tape is standardized.
- If Cp= Correction for pull
- Pm= Pull applied during measurement in N
- Ps= Pull at which the tape is standardized in N
- L= Length of Tape in m
- A= C/s area of the tape in $mm^2$ or $cm^2$
- E= modulus of Elasticity of the tape material.
- Then $C_p = \frac{(P_m - P_s) L}{AE}$
- Where, E may be taken as,
- $E = 2.1 \times 10^7 N/cm^2$ for steel and
- E= 1.5 x 10 7 $N/cm^2$ for invar tape

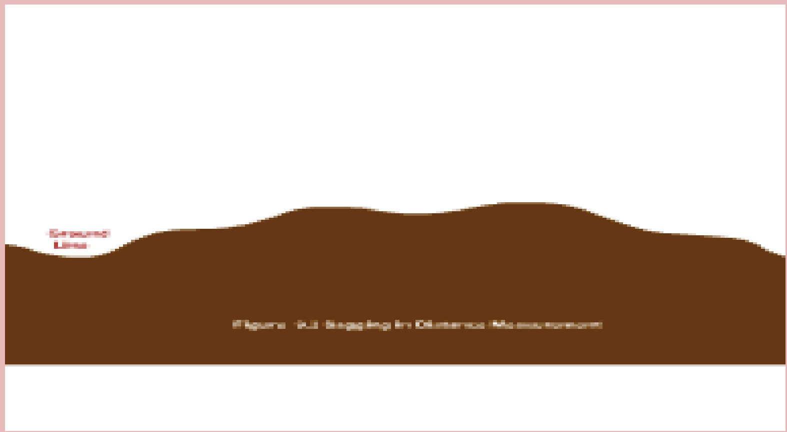
# Correction for Sag

- **Nature of correction is –ve cumulative**.
- When a tape is stretched between two supports, it takes the form of a centenary (sag) which is assumed to be a parabolic curve. The correction for sag is the difference in length between the arc and the subtending chord. It is required only when the tape during measurement is kept suspended. Since the effect of sag is to make the measured length too great, this correction is always –ve.

# Correction for Sag

- If $C_{sg}$= Correction for sag in m
- $l_1$= distance between supports in m
- W= weight of the tape in N/m
- Pm= Pull applied in N
- $Csg = \frac{l_1 (wl_1)^2}{24 (Pm)^2}$
- (Units of w and Pm should be same, both in terms of N or Kg)

# Correction for Sag



# Normal Tension

- The tension or pull at which effect of pull and sag are neutralized is called the normal tension. It may be obtained by equating the correction for pull and sag.

# Correction for slope

- The correction for slope is required when the points of supports are not at the same level.
- If Θ= angle of slope
- h= height difference between two ends
- Lm= measured length on slope
- $C_{sl}$= Correction for slope
- Then, $Cs_l = \frac{h^2}{2\ Lm}$
- $Cs_l = _{hm}$ (1-cos Θ)
- = Lm Versine Θ
- The Correction is always substractive from measured length.

# Correction for slope

# Examples

**A Line was measured with a steel tape which was exactly 30 m long at 18 $^0$ C and found to be 452.343 m. The temperature during measurement was 32 $^0$ C. Find the true length of line. Take coefficient of expansion of the tape per $^0$ C= 0.0000117. Find the true length of line. Take coefficient of expansion of the tape per $^0$ C = 0.0000117.**

Solution

Here,

Measured length on field

Lm= 452.343 m.

Standard Temperature of tape

Ts= 18 $^0$ C

Field Temperature Tm= 32 $^0$ C

α = 0.0000117/ $^0$ C

The correction for temperature per 30 m tape length:

Ct= α (Tm- Ts) L

Therefore, Ct= 0.0000117 ( 32 $^0$ – 18 $^0$) x 30

Ct= 0.004914 m.

Since Tm > Ts the correction is positive. Length of tape is increased due to temperature.

Therefore,

L' = 30.00+ 0.004914

= 30.004914 m

Therefore, True length of line = $\frac{L'}{L}\ x\ Lm$

= $\frac{30.004914}{30}\ x$ 452.343

= **452.41709 m. (Ans.)**

•

# Examples

**A Steel Tape was standardized as 30.00 m at 18 $^0$ C temperatures. A line was measured as 480.0 m at mean temperature of day as 30 $^0$ C. Calculate the true length of line, if coefficient of thermal expansion for steel is 0.000012 per $^0$ C rise in temperature.**

Here, L= 30.00 m

Measured length on the field Lm= 480 m.

Field mean Temperature Tm= 30 $^0$ C.

Standard Temperature of tape Ts= 18 $^0$ C.

α= 0.000012 per $^0$ C.

The correction for temperature per 30 m tape length:

Ct= α (Tm-Ts) L

Therefore, = 0.000012(30 $^0$ C- 18 $^0$ C) x 30.00

= 0.00432 (+ve)

Since, Tm> Ts,

The correction is positive

Length of tape is increased due to temperature

Therefore, L' = 30.00 + 0.00432

= 30.00432 m.

Therefore True Length of Line

= $\frac{L'}{L}\ x\ Lm$

= $\frac{30.00432}{30.00}\ x$ 480.00

**= 480.06912 m (Ans)**

# Example

**A line was measured with a steel tape which is exactly 30.00 m at a pull of 5 kg and the measured length was 230.00 m The pull applied during measurement was 12 kg and the tape was uniformly supported. Find the true length of the line if the cross-section area of the tape was 0.02 cm2 and the modulus of elasticity = 2.1 x 10 $^6$ kg cm$^2$.**

**Solution:**

The Correction for pull, Cp= $\frac{(Pm-Ps)L}{AE}$ *(per 30 m tape length)*

Here,

Standard length of tape, L= 30.00 m

Pull applied during measurement, Pm= 12.00 Kg.

Standard Pull while standardized, Ps= 5 kg

Measured length on field, Lm= 230.00m

C/S Area of Tape, A = 0.02 cm $^2$

Modulus of Elasticity of steel, E= 2.1 x 10 $^6$ kg/ cm$^2$

Cp= $\frac{(12-5) x\ 30.00}{0.02\ x\ 2.1\ x\ 10\ 6}$

= 0.005 m (+ve)

As applied pull is more than standard pull, the correction is positive. The length of tape is increased by applied pull as Cp.

Therefore,

L' = L + Cp

= 30.00 + 0.005

= 30.005

Therefore True length of line = $\frac{L'}{L}\ x\ Lm = \frac{30.005}{30}\ x$ 230.00

= **230.038831 m (Ans.)**

# Example

**A line was measured with a steel tape which was exactly 30 m at 18 $^0$ C and a pull of 50 N and the measured length was 459.2 m. Temperature during measurement was 28 $^0$ C and the pull applied was 100 N. The tape was uniformly supported during the measurement. Find the true length of the line if the Cross- Section area of the tape was 0.02 cm $^2$, the coefficient of expansion per $^0$ C = 0.0000117 and modulus of elasticity = 21 x 10 $^6$ N/ cm $^2$.**

**Solution:**

Correction to be applied are (per 30 m tape length)

Correction for temperature Ct= α (Tm- Ts) L

Where α= 0.0000117 / $^0$ C

Tm= 28 $^0$ C

Ts= 18 $^0$ C

L= 30.00 m (Length of Tape)

Therefore, Ct= 0.0000117 (28 $^0$ – 18 $^0$) x 30

= **0.00351 m (+ve)**

Correction for pull Cp= $\frac{(Pm-Ps)L}{AE}$

Where,

Pm= 100 N

Ps= 50 N

L = 30.00 m

A= 0.02 $cm^2$

E= 21 x $10^6$

Cp= $\frac{(100-50)x\,30}{0.02\,x\,21\,x\,10\,6}$

**= 0.00357 m (+ve)**

Correction for Sag

Csg = $\frac{l1\,(wl1)2}{24\,9Pm)2}$

(The tape was uniformly supported during the measurement at every 30 m, hence sag correction must be applied)

$l_1$ = 30 m

Pm= 100 N

W= w $l_1$ = weight of tape for 30 m length

Here,

W= weight of tape= V x Δ and V= A x $l_1$

$l_1$ = 30 m= 3000cm

Cross-Section area of tape= 0.02 $cm^2$

V= $l_1$ X A = 0.02 x 3000 = 60 $cm^3$

Δ= 0.077 N/$cm^3$ (Assumed)

Therefore, W $l_1$ = weight of tape

W= V x Δ

= A x $l_1$ x Δ

= 0.02 x 30000 x 0.0077

= **4.62 N**

Csg = $\frac{l1\,(wl1)2}{240m\,2}$

= $\frac{30\,x\,(4.62)2}{24(100)2}$

= **0.00267 m (-ve)**

- Therefore correction to be applied per tape length
- $C_T = C_t + C_p - C_{sg}$
- = 0.00351 + 0.00357 + 0.00267
- = 0.00441m
- Therefore, Actual length of tape
- L'= L + $C_T$
- = 30 + 0.00441
- = 30 00441 m
- Corrected length of line measured on the ground
- = $\frac{30.00441}{30}$ x 459.2
- **459.2675. (ans.)**

**A Steel tape was exactly 30.00 m long at 20 $^0$C and when supported throughout its length under a pull of 9 kg. A line was measured with a tape under a pull of 14.00 kg and found to be 1800.m The mean temperature during the measurement was 36 $^0$ C. Assuming the true length of the line, given that cross- section area of the tape= 0.05 cm $^2$ . The Weight of 1cm $^3$ of tape is 0.0087 kg.**

**The co-oefficient of expansion= 0.000012 per 1 $^0$ C and modulus of elasticity = 2.1 x 10 $^6$ kg / cm $^2$. Find the corrected measured length.**

**Solution :**

Correction to be applied are ( per 30 m tape length)

Correction for Temperature

Ct= α (Tm- Ts) L

Where, α= 0.000012 per $^0$ C

Tm= 36 $^0$ C

Ts= 20 $^0$ C

L= 30.00 m ( length of the tape)

Therefore, Ct= 0.000012 (36 $^0$C – 20 $^0$C) x 30

= 0.00576 m (+ve)

Correction for pull

$$Cp= \frac{(Pm-Ps) x L}{AE}$$

Where, Pm= 14 kg

Ps= 9 kg

L= 30 m

A= 0.05 cm $^2$

E= 2.1 x 10 6 kg/ cm$^2$

$$Cp= \frac{(14-9) x 30}{0.05 \ x \ 2.1 \ x \ 10 \ 6}$$

= 0.00143 (+ve)

Correction for Sag $C_{sg} = \frac{l1 \ (wl1) \ 2}{24 \ 9Pm)2}$

(The tape was uniformly supported during the measurement at every 30 m, hence sag correction must be applied)

$l_1$ = 30 m

Pm= 14 kg

W= $wl_1$= weight of tape for 30 m length

Here,

W= weight of tape= V x Δ and V= A x $l_1$

$l_1$ = 30 m= 3000cm

Cross-Section area of tape= 0.05 cm $^2$

V= $l_1$ X A = 0.05 x 3000 = 150 cm $^3$

Δ= 0.0087 N/cm$^3$ (Assumed)

Therefore, W $l_1$ = weight of tape

W= V x Δ

= A x $l_1$ x Δ

= 0.05 x 3000 x 0.0087

= 1.305 kg

$$C_{sg} = \frac{l1 \ (wl1)2}{24Om \ 2}$$

$$= \frac{30 \ x \ (1.305)2}{24(14)2}$$

= 0.010867 m (-ve)

Therefore correction to be applied per tape length

$C_T = C_t + C_p - C_{sg}$

$= 0.00576 + 00014 + 0.00267$

$= -0.00367$ (-ve)

$L' = L + C_T$

$= 30 - 0\ 00367$ m

$= 29.99633$

Corrected length of line measured on the ground

$= \frac{L'}{L} \times Lm$

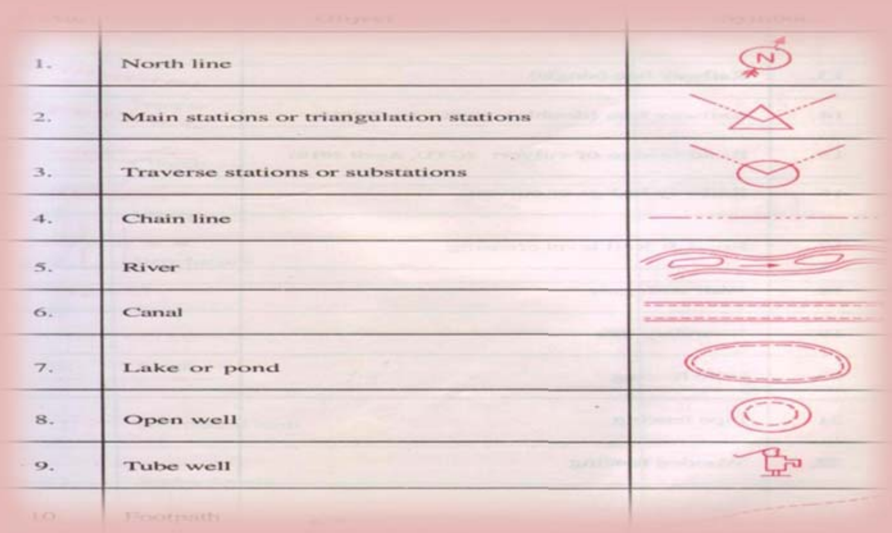
$= \frac{29.996}{30} \times 1800$

$=$ **1799.7798.m.(Ans.)**

# Conventional Symbols

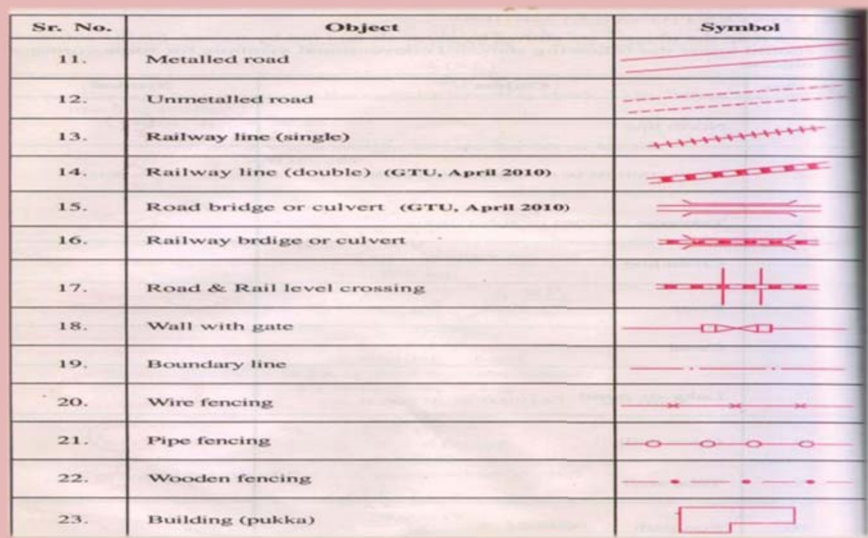
- In a map the objects are shown by symbols and not by names. So the surveyor should know the conventional symbols of some common objects

# Conventional Symbols



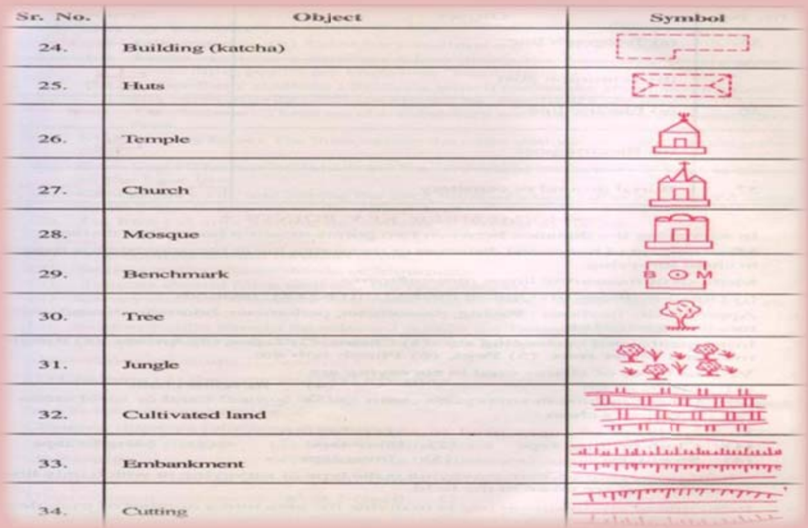
| | | |
|---|---|---|
| 1. | North line | |
| 2. | Main stations or triangulation stations | |
| 3. | Traverse stations or substations | |
| 4. | Chain line | |
| 5. | River | |
| 6. | Canal | |
| 7. | Lake or pond | |
| 8. | Open well | |
| 9. | Tube well | |

# Conventional Symbols



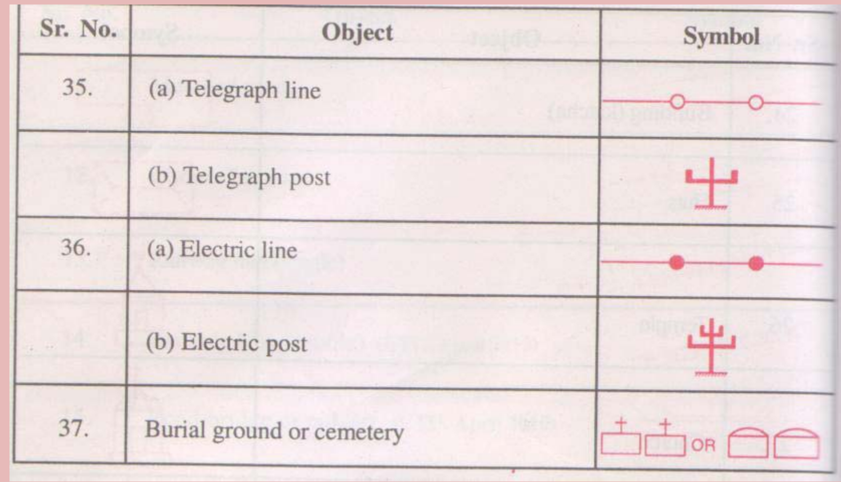
| Sr. No. | Object | Symbol |
|---|---|---|
| 11. | Metalled road | |
| 12. | Unmetalled road | |
| 13. | Railway line (single) | |
| 14. | Railway line (double) (GTU, April 2010) | |
| 15. | Road bridge or culvert (GTU, April 2010) | |
| 16. | Railway brdige or culvert | |
| 17. | Road & Rail level crossing | |
| 18. | Wall with gate | |
| 19. | Boundary line | |
| 20. | Wire fencing | |
| 21. | Pipe fencing | |
| 22. | Wooden fencing | |
| 23. | Building (pukka) | |

# Conventional Symbols



| Sr. No. | Object | Symbol |
|---|---|---|
| 24. | Building (katcha) | |
| 25. | Huts | |
| 26. | Temple | |
| 27. | Church | |
| 28. | Mosque | |
| 29. | Benchmark | |
| 30. | Tree | |
| 31. | Jungle | |
| 32. | Cultivated land | |
| 33. | Embankment | |
| 34. | Cutting | |

# Conventional Symbols



| Sr. No. | Object | Symbol |
|---|---|---|
| 35. | (a) Telegraph line | |
| | (b) Telegraph post | |
| 36. | (a) Electric line | |
| | (b) Electric post | |
| 37. | Burial ground or cemetery | OR |

# References


- Elements of Civil Engineering- By Prof R.B.Khasiya
- NPTEL
- Internet websites


# Thanks