# MINE SURVEY III (TH-II)

## Weisbach Method of correlation :

The weisbach method of correlation is usually preferred when only one shaft is available. The method consists of suspending two plumb wises which form a plumb plane and azimuth of the same is determined at the surface and taken U/G at the shaft inset and thereafter transferred to the U/G base or reference line.

Two plane wires A & B made of anticorrosive crucible steel 0.1 cm diameter having breaking strength of 150" g and to avoid king on a small drums fitted with brake or ratchet to hold them in any desired position are lowered down the shaft tin washers are passed down by the wires from the surface & they are free of obstruction. The smaller plummets are then replaced by symmetrically shaped finned plumb bobs made of lead. When the wires hang vertically each plumb bobs immersed in a barred of water to cut down oscillation due to (i) simple pendulum motion, (ii) Irregular mass in strata, (iii) air current, (iv) dropping water. The longer the wire is left in suspension it will reduce the oscillation and will eventually come to rest. It may be necessary to raise the plumb bob from time to time to allow for the stretch of the wires.

From the surface traverse, station R and R1 fixed as surface base RR1 whose azimuth is very carefully determined. The theodolite is set at T1 at surface as closed to the near wire B as focusing will allow and almost in the with the plumb plane AB produce and connecting to the surface base. The small angle BT1A should be only few minutes of arc. The triangle ABT1 is known as weisbach triangle.

To measure the small angle BT1A1 the theodolite is setup at T1 and all the temporary adjustments are made. The telescope is directed to wire B and the angle BT1R is observed. In the usual manner, taking at least three round of readings on each face of the instrument the mean value is the correct value of the angle, In a smaller manner the value of angle AT1R is obtained and difference between the two angles thus obtained is the correct value of the angle BT1A.

## Continuous Azimuth Method :

Let it is required to make a closed theodolite traverse of the lines joining the section points A B C D E.

The instrument is setup as station A and usual temporary adjustments are made for centering leveling & removing parallel.

The body is clamped and the vernier clamp is released the instrument is turned in a clockwise direction to sight the fore station and the vernier is clamped & the station point is accurately bisect by the vernier tangent. Now record the bearing of line AB.

If the bearing of the cone AB is already know be fore hand, the vernier reading B to be set according before taking any sight from station B.

The instrument is next setup at B. the reading on the vernier is the fore bearing of AB. Body clamp B and station is bisected using the body clamp is tightened in this position.

The telescope is now transited, vernier circulated and station C is sighted. The vernier clamp is tightened & final bisection of the station point being obtained by means of vernier tangent screw. The instrument now records the bearing of BC directly.

Thus when similar operations are replaced at each station the forward azimuth of each draft is automatically recorded by the instrument.

To check accuracy of work after the traverse the instrument should be set up at station A and the bearing of the first draft AB should be taken whether is give the correct known bearing.

Advantages :

1. Bearing are obtained directly.
2. Field work is expendious.
3. Calculation are simplified.
4. Booking on simple.
5. Checking for magnetic bearing is possible at any iron free station.

Disadvantages :

1. Any accidental shifting of the instrument at any stage affect the reading recorded.
2. double transisting at each station gives rise to error if the collimation adjustment is not perfect.
3. The amount of error being twice the error is collimation.
4. If a closing angular error is discovered these is no sure way to ascertain whether it is cumulative.

**Double foresight method :**

In this method the bearing of initial line and the horizontal clockwise angle between adjacent lines are measured. The Azimuth of all other lines are reduced by calculate.

Let it is required to make a closed traverse of the line joining station A B C D E by this method.

The instrument is set up at A and usual temporary adjustments are made. The A vernier is set at zero & the instrument is directed towards the meridian as shown by the compass provided with body clamp and tangent. The body is clamped and the vernier is released. The telescope is now directed towards station B and final bisection of the station is made by the vernier tangent screw. The bearing of the line AB recorded.

The instrument is set up at B. The temporary adjustment having been made the telescope is sighted to station A. Both plates being clamped, the two vernier are read and reading recorded. The usual practice is to set the A vernier to zero, through this is not essential.

Advantages :

1. any error in the line of collimation does not seriously affect the result.
2. Any number of observation of each angle by the method of repetation.

Disadvantages :

The only draw back to this method for regular and extensive work is that it adds to the burned of office computation, which however is often warranted by the higher degree of accuracy attainable.

**Precise Magnetic correlation :**

Principle : In this method the magnetic bearing of surface & U/G base line are determined and then a traverse is carried out from each to a single plum wire suspended in the shaft. The magnetic azimuth of each line is determine and the difference applied to the grid bearing of the surface base will give the grid azimuth of the U/G base. The traverse will give the co-ordinate of the U/G.

Procedure : The method used the tabular compass attached to the theodolite to determine the magnetic bearing of the lines. Two theodolites will be used. One on the surface and the other U/G. The location of the surface base line and the U/G base line have got to be chosen with great care.

If it is all possible the surface base line should be vertically above the U/G base. The station where the observation are to be taken must free from local disturbances. On the surface it is fairly easy to see whether there are disturbing influences very difficult to find around which is free from local attraction due to pipe lines, power cables and use of steel below ground.

The time of observation should be chosen carefully because of the vibration of the magnetic needle.

The two theodolites are set up on the stations and magnetic observation must be taken simultaneously on the surface & U/G the observation are replaced at fixed interval graphs are plotted of the observation. The following day the position of the two theodolites is reversed and the observation repeated.

<u>Advantages:</u>

1. The method entails little of no disorganization of the colliery routine.
2. If there are several base lines in different levels these can all be oriented with little trouble.
3. If sufficient care is taken it gives fairly good result.

<u>Disadvantages:</u>

1. A minor irregularity in the magnetic needle itself after the result serious.
2. The results of the correlation are vitiated if the work is carried out magnetically disturbed day.
3. Besides the irregular variation, the secure & diurnal variation have direct influence over magnetic readings.
4. There is possibility of change in the instrument contact during the period of transference form the surface to the U/G base.
5. The stations where the magnetic observations are to be made must be free from local attraction.

**<u>Weisbach Triangle</u> :**

When transferring ground level azimuth U/G by suspensions of two wires down a shaft. It is difficult to set up the theodolite exactly in line with them. In addition one wire being nearer obscures. The wire beyond leading to an inaccurate bisection. In weisbach method the theodolite is set up slightly out of line forming a small triangle with the two wires. This triangle is known as weisbach triangle & the azimuth of the line joining the two wires is found by solution of the triangle of formed. .α is obtained form the triangle W1 TW1 by the sine rule

$$\sin \alpha = \frac{\alpha \sin \beta}{b} \qquad e = c.\sin\alpha$$

In a weisbach triangle W2 TW1 called the weisbach angle β & the ratio c/b must be very small for which the theodolite station (T) should be very near to the wire (W1). If the weisbach angle is less than 25 minutes. There is no necessary of measuring sides. The angle should be measured very accurately to avoid any error.

**<u>Purpose of correlation survey</u> :** The various purposes of correlation of surface and U/G.

1. To determine with high degree of accuracy the relative positions of the U/G roadway & faces may be correctly laid down on the working plan.
2. To fix the boundary of the mine for limiting the extent of U/G working.
3. To fix the positions of railways, road and important building or structures on mine plans.
4. To mark the river, lake, tank, pond etc. on mine plans so as to take adequate precautions against inundation.

5. To select suitable site for proposed pits drifts or boreholes to connect with U/G working.

**Explain correlation survey. Define different method of U/G survey. What should be accuracy.**

Correlation survey : Correlation in surveying is the method of surveying by which the surface survey are U/G survey are connected to the same base.

Different methods : The method employed for correlation surveys are controlled to a large extent by the conditions at the mine the different methods are

1. Direct traversing when working are reached by adits or drifts.
2. Shaft plumbing methods when access is by means of vertical shaft.
    (a) One wire in each of two shafts.
    (b) Two or more wires in a single shaft by
        (i) Coplaining or exact alignment method.
        (ii) Approximate alignment or method of weisbach triangles.
        (iii) Methods of weis quadrilateral.
3. Optical method or direct transference of azimuth sown a shaft by a transit theodolite.
4. Magnetic methods.
    (a) By tabular compass.
    (b) By magnetic theodolite.
5. Gyro-theodolite method.

Accuracy : The permissible angular error for correlation 18 $\pm$ 2 minutes or arc. Therefore the accuracy in correlation survey should not exceed the maximum permissible angular error.

**Explain triangulation survey. Describe principle involved in triangulation survey. What are the points to be fixing the position for triangulation station.**

Triangulation survey : The process of measuring the angle of a series of indercounted angles by a no of st mark on the surface on the earth is called triangulation survey.

Principle : On the surface, where the country is comparatively open, the survey is performed by triangulation. It is based on the trigonometric proposition that if only one side and all side are three angles of a triangle be known then the remaining sides can be calculated by the sine-rule. Suitable triangulation station from the vertices of a series of mutually connected triangles of the triangulation system. In this system on side called the base line and all the angles are very carefully measured and the length of all other lines in the system are then computed and all the angles being known. The direction of each line relative to some standard direction may be determined. The position of each triangulation station with reference to a predetermined point in the area surveyed can be computed.

Fixing Triangulation station :

1. All available surface plans of the area should be made for fixing probably positions of triangulation station.
2. The station points each triangle are inter visible & the height available ground should be inter visible.
3. They should be well conditioned triangle.
4. All station should be easily accessible.
5. The base line should be located on flat ground so that well shaped triangles can be formed in connecting the end of station of the base to the main triangulation system.
6. They are so located that the cost of clearing obstruction from the line of sight is minimum.
7. they should be useful detail surveys important surface features such as shafts, inclines bunkers, important building etc. should be located near the triangulation station.

8. They should be fixed on firm ground avoiding sand or loose earth and two stations should not be use one triangle.
9. When angle or U/G obstructs the line between the two stations, stations may be raised by erecting wooden scaffold so as to clear the greater part of the obstruction avoided and the remainder cleared at small cost.

**Principle of Tri-alteration :**

The principle of tri-alteration is based on the trigonometrical proposition that of the three sides of a triangles are known then all the angles of the triangle can be computed from the following trigonometric formula.

The other angles B & C can be determined in the same way.

**Purpose of triangulation method :** Triangulation method carried out for.

1. Establishment of accurate control points for plane.
2. Establishment of accurate control point for photo grammatic surveys of large areas.
3. Accurate location of engineering works.

**Classification of Triangulations :**

On the basis of quality, accuracy and purpose triangulation are classified as.

1. Primary triangulation or first order triangulation.
2. Secondary or second orders triangulation.
3. Tertiary triangulation or third order triangulation.

1. Primary Triangulation : It is the highest order of triangulation system which is employed for the determination of the shape and size of the earth surface. The primary triangulation system embraces the vast area. Every precaution is taken in making linear & angular measurement and in performing the reductions. The following are the general specification of the primary triangulation.

(i) Maximum triangle closure, less than 1 sec.
(ii) Maximum triangle closure, not more than 3 sec.
(iii) Length of the line, 5 to 15 km.
(iv) Length of the sides of triangles, 30 to 150 km.
(v) Actual error of base, 1 in 3000000.
(vi) Probable error of base, 1 in 1000000.
(vii) Discrepancy between two measure of a section : 10 mm √km.

2. Secondary triangulation : It consists of a number of point fixed within the frame work of primary triangulation. The stations are fixed at close intervals. The general specification of secondary triangulation are.

(i) average triangle closure : 3 sec.
(ii) Maximum triangle closure : 8 sec.

(iii) Length of base line : 1.5 to 5 km.
(iv) Length of sides of triangles : 8 to 65 km.
(v) Actual error of base : 1 in 150000.
(vi) Probable error of base : 1 in 500000
(vii) Discrepancy between two measures of a section : 20 mm √km.

3. Third-order or tertiary triangulation : It consists of a number of points fixed within the frame work of secondary triangulation and forms the immediate control for detained engineering and other survey. The specifications for a third-order triangulation are as follows.
(i) Average triangle closure : 6 sec.
(ii) Maximum triangle closure : 12 sec.
(iii) Length of base line : 0.5 to 3 km.
(iv) Length of sides of triangles : 1.5 to 10 km.
(v) Actual error of base : 1 in 75000.
(vi) Probable error of base : 1 in 250000
(vii) Discrepancy between two measures of a section : 25 mm √km.

**Define curve. Classification of curve. State the elements of simple circular curve.**

Curve : Gradual & smooth change of direction from one straight to another is known as curve. The curves are generally circular arcs. Curve are generally used on highway and railways where it is necessary to change the direction of motion.

Classification of curve :

1. Simple Curve : A simple is the one which consists of a single arc of a circle. It is tangential to both the straight line T1 and T2.
2. Compound curve : A compound curve consists of two or more simple area turn the same direction and join at common tangent points.
3. Reverse curve : It is also known as agree or serpentine curve. It is composed of two arcs of equal or different radius bending in opposite direction with a common tangent and with their centers on opposite side of the curves.

Elements of simple circular curves : The elements of a simple circular curve the following definition are

1. Straight : The two portions of railway line or roadway which are to be connected by a curve of radius R are the straights AT and BT. In the figure are the two straights.
2. Tangent points : These are the ends of the curve where the alignment changes from a curve to a tangent. These are the beginning and end points of a curve, point T and T1 are tangent points.
3. Back tangent : The tangent AT previous to the curve is called back tangent or first tangent.
4. Forward tangent : The tangent TB following the curve is called the forward tangent or second tangent.
5. Point of intersection : If the two tangents AT & BT are produced, they will meet in a poin called the point of intersection or vertex. The point X of the point of intersection.
6. Long chord : The chord joining the two tangent points is the long chord (T T1)

7. Intersection angle : The angle YXT1 = Q between the tangents AX produced and XT1 is called the intersection tangents. This angle θ is equal to the angle TOT1 subtended at the centre of curvature O by the arc of curvature TFT1. The angle O indicates the amount of deviation given by the curve.
8. Apex angle : It is the angle at the apes of the curve made by the two tangents. The apes angle TXT1 = Q = 180° - Q.
9. Tangent distance : It is the distance from the tangent point T or T1 to the point of intersection.
10. Apex distance : The distance apex from the mid point of the curve to the point or intersection is apex distance.
11. Rise : The distance EF between the mid point of the long chord to the mid point of the curve is the rise of curve. It is known as middle ordinate or versed sine of the curve.

**Satelite Station :** It sometimes happens, when church spires, temples, towers or other remarkable objects are selected as stations for the continuation of triangulation that the theodolite can not be placed over the pt occupied by the axis of the signal or the rays from the station are obstructed of a scaffold may have to be erected for the purpose.

In all such cases the necessary observation may be taken from some other convenient station a short distance away and this station is known as satellite of supplementary station. The observation can be adjusted to agree with these which would have been made from the main triangulation station.

**Routine of triangulation survey :** The routine of triangulation survey generally consists of the following operations.

1. Reconnaissance.
2. Erection of signals and towers.
3. Measurement of base line.
4. Measurement of horizontal angle.
5. Astronomical observation.
6. Computations.

Since the basic principle of surveying is working from whole to part reconnaissance is very important in all types of surveys. The following operations are required for an efficient reconnaissance.

1. Examination of the country to be surveyed.
2. Selection of suitable sites for base lines.
3. Selection of suitable positions for triangulation station.
4. Determination of inter visibility & height of station.
5. Collection of miscellaneous information regarding communication of water, food, labour & guides etc.

Whenever possible help should be taken from the existing maps. The reconnaissance survey requires great skill, experience & judgment on the part of the party chief.

The following instruments are generally used for the survey.

1. A theodolite and sextant for measuring of angles.
2. Prismatic compass for measurement of bearing.
3. Aneroid barometer for ascertaining elevations.
4. Steel tape.
5. Good telescope or powerful field glass.
6. Helecot ropes for testing inter visibility.
7. Drawing instrument and materials.
8. Gayed ladders, ropes, creepers etc for climbing trees.

**Selection of triangulation station :**

1. The stations should be inter visible.
2. They should from well shaped triangles. As far as possible the triangles should be either isosceles with base angles of about 56° or equilateral. No angle should be smaller than 30° or greater then 120°.
3. The station should be easily accessible supplies of food and water are easily available and camping ground or nearest suitable accommodation is available.
4. The length of sight should neither be too small nor too large. Small length of sight results in errors due to centering & bisection. While large line of sight makes the signal too indistinct for accurate bisection.
5. In heavily wooden country the station should be located that the cost of clearing & cutting of building towards are minimum.
6. The station should be situated so that lines of sight do not pass over towns factory fence etc nor graze any obstruction. So that the effects of irregular atmospheric refraction is avoided.

**EDM :** It means electronic distance measuring device. A major advance in surveying in recent year has been the development of EDM devices, to determine the length base upon the time. It takes electromagnetic energy to travel from one end of a line to the other and return with modern EDM devices; distances are automatically displayed in digital from in feet or meter several. EDM instrument also measure angles to a few seconds of arc can be attached to theodolite so that both angular linear measurements can be obtained with the same instrument from one setting. The various instrument are used under electronic method are geodimeter, based on the propagation of light waves and Tellurometer based on radio waves.

**Sag Correction :** A tape sags the points of supports. The correction for sag is the difference in length between the arc and its chord. The effect of sag on the tape is to make the measured length too long and so this correction is always negative.

$$\text{Correction} = \frac{L(WL)^L}{24\ P^2}$$

Where
L = Distance between support in meters.
W = Weight of tape in kg per meter run.
P = Applied pull in kg.

**Two Theodolite :**

This method, although giving very accurate results is rarely used because the area on which the curve is to be set out has to be completely unobstructed theodolites are set up at both tangent points T & T1. the theodolite at R is set to the first tangent angles α and thus pt in the direction of the first pt B. Mean while the second theodolite and T1 has been clamped with vernier reading zero to bisect the single at T. The plates are unclamped the vernier set to the value of the first tangential angle α and the telescope will be pointing in the direction T1B. The pt of intersection of the line of sight of the two instrument B fixed by an assent. Who moves surveying pole under the direction of the instrument until its image is bisected by the cross-wires of both instrument. To determine the second & succeeding pt C D etc. both instrument are set to the second third etc. tangential angles and the corresponding pt on the curve are fixed as before.

The process of fixing a pt on the curve until it is bisected by both telescope is some what radius, but cumulative error is eliminated.

Preparation : For setting out a curve with two theodolite the following steps are involved.

1. Prepare a table of deflection angles for the first sub chord normal at chord and the last sub-chord.
2. Setup one theodolite at T1 and other theodolite at T2.
3. Theodolite at T1 should be directed towards the point. Theodolite at point T2 should be directed towards T1.
4. The vernier of both the theodolite should read zero.
5. Set the first deflection angle the both theodolites so that their telescopes are in the direction T1 and T2 respectively.
6. Ask the attendant to move in the line of sight of the theodolite with a ranging rod. The position of the ranging rod is the required location on the curve.
7. Set the second value of the deflection on the both the theodolite and repeat the steps 6 get the location b on the curve.
8. Continue the process for obtaining the location of other points in a similar manner.

**Define stadia method and its principle .**

Let O be the optical centre ACB be the top axial & bottom hair BCA be the points on the shaft cuts by the three hairs.
c – The interval between the stadia line.
b – The shaft intercept.
f – focal length of the object.
f1 – Horizontal distance of the shaft from the optical center of the object.
f2 – The horizontal distance from the optical center to the image of the staff.
d – horizontal distance from the optical center to the vertical axis of the tacheoletric.
D – Horizontal distance from the vertical axis of the instrument to the staff.
Let us consider Δ A’OB’ and Δ AOB and similar

then $\frac{AB}{A'B'} = \frac{OC}{OC'}$

But from the formula of the lences.

Now multiplying both side by f1 in equation (2) we get

Now multiplying both side by f in equation (3) we get

We know that D = f1 + d ------------------(4)
Substuting the value of f1 in equation (4)

**Tacheometer :** a tacheometer which is essentially nothing more than a theodolite fitted with stadia hairs is generally used for tacheometric surveying.
**Errors in tacheometric :** The various sources of errors in tacheometric are.

1. The instrument error.
2. error due to maniculation and sighting.
3. Error due to natural causes.

**Tacheometric contouring :**

1. Contour is an imaginary line on the ground joining the point of equal elevation or decression.
2. It is a line in which the surface of the ground is intercept by a level.
3. A contour line is a line on the map representing a contour.

**Diaphragm :** The stadia diaphragm consists of one stadia hair above and the other at equal distance below the horizontal cross hair.

**Tangential Method :** The method is used when the telescope is not fitted with a stadia diaphragm. The horizontal and vertical distance of the staff station from the instrument station may be computed from observation taken to two vanes on the staff at a known distance a part usually 3mt.
Case 1: when both the observed angles are angles of elevation.
Let, A = The instrument station.
A1 = The position of the instrument axis.
P = The staff station.
BA1K = $\alpha 1$ = the vertical angle to the upper vane.
CA1K = $\alpha 2$ = the vertical angle to the lower vane.
KC = V = the vertical distance from the instrument axis to the lower vanes.
BC = S = the distance between the vanes.
A1K = D = the horizontal distance from the instrument station A to the staff station P.
PC = h = the height of the lower vane above the foot of the staff.
BK = A1K tan BA1K
V + S = D tan $\alpha 1$ ------------(1)
Again from $\Delta$ CKA1 we get CK = A1K tan CA1K
V = D tan $\alpha 2$ -----------------(2)

Subtracting equation (2) from (1)

S = D (tan $\alpha 1$ – tan $\alpha 2$

Elevation of staff station P = elevation of the instrument axis V-h.

<u>Case 2</u>: When both the observed angles are angles of depression.
In triangle CKA1
KC = A1K tan KA1C
V = D tan $\alpha 2$ -------------(1)
Again in triangle BKA1
KB = A1K tan BA1K
V = D tan $\alpha 1$ -------------(2)
Subtracting equation (2) from equation (1)
S = D (tan $\alpha 2$ – tan $\alpha 1$)

Elevation of the staff station P
Elevation of the instrument axis V-h

<u>Case 3</u> : when one of the observed angles is an angle of elevation and the other an angle of depression.
Let $\alpha 1$ be the angle of elevation and $\alpha 2$ be the angle of depression.
Now V =D tan $\alpha 2$ -------------(1)
S – V = D tan $\alpha 1$ --------------(2)
Adding equation (1) and (2) we get
S = D (tan $\alpha 1$ + tan $\alpha 2$)

Elevation of the staff station P
Elevation of the instrument axis V – h.

**Moveable Hair method :**
In this method the staff intercept is kept constant where as the distance between the hairs is variable, instrument used in this method are a theodolite with a special type of diaphragm and a staff provided with two targets at a known distance.

1. Diaphragm of the theodolite : In this type of diaphragm the central or axial wire is fixed in the plane of the telescope. The stadia hairs are moved in vertical plane. The total distance through which stadia wires move is equal to the sum of the micro meter readings.
2. The staff targets : If the distance between the instrument station and staff position is within 200 m an ordinary leveling staff may be used. For distance exceeding 200m. It becomes difficult to read graduations. In such cases two graduations. In such cases two vanes or targets fixed at a known distance. The third target is fixed at the mid point of the two targets.

**Reconnaissance :** Since the basis principle of surveying working reconnaissance is very important in all types of survey. The reconnaissance survey requires great skill experience and judgment on the part of the party chief, since the economic and accuracy of the whole triangulation system depends upon an efficient reconnaissance. It includes the following operations.

1. Examination of the country to be surveyed.
2. Selection of suitable sites for base lines.
3. Selection of suitable positions for triangulation stations.
4. Determination of inter visibility and high of stations.

**Describe methods of measuring angle types of theodolite in triangulation survey.**
Method of measuring angle : there are two general methods of measuring angle in triangulation.
(1) The repetition method, (2) the Direction method.
The method of repetition : To measure the angle PQR at the station Q the following procedure is followed.

1. Set the instrument at Q and level it with the help of upper clamp and tangent screw, set 0° reading on vernier A note the reading of vernier B.
2. Loose the lower clamp and direct the telescope towards the point P clamp the lower clamp and bisect point P accurately by lower tangent screw.
3. Unclamp the upper clamp and turn the instrument clockwise toward point R clamp the upper clamp and bisect R accurately with the help of upper tangent screw. Note the reading of verniers A and B to get the approximate value of the angle PQR.

The direction method :
In the direction method the signals are bisected successively & a value is obtained for each direction. Let A be adopted as

the initial station to measure the angles AOB, BOC, COD, at O with instrument having more than ore micrometer.

**<u>Sighting and making triangulation station point</u> :**

The selection of triangulation station point is based upon the following consideration.

1. The triangulation stations should be inter visible for this purpose. They should be placed upon the most elevated ground.
2. They should form well-shaped triangles.
3. The station should be easily accessible.
4. They should be so selected that the length of sight is neither to small not too large.
5. They should be in commanding situation.
6. In heavily wooden country.

**<u>Tape corrections</u> :**

After having measured the length the correct length of the base is calculated by applying the following corrections.

1. Correction for absolute length.
2. Correction for temperature.
3. Correction for pull or tension.
4. Correction for sag.
5. Correction for slope.
6. Correction for alignment.
7. Reduction to sea level.

**<u>Describe the methods of base line measurement –EDM.</u> :**

There are two methods of base line measurement of EDM.

(1) Measurement on wheelers method by wheeler base line apparatus, (2) Jaderin's method.

<u>Wheeler's base line apparatus</u> :

- The making stakes are driven on the line with their tops above 50cm above the surface of the ground.
- Supporting stakes are also provided at a interval of 5 to 15m with their faces in the line.
- The points of supports are set either on a uniform grade or at the same level.
- A weight is attached to the other and of the straining tripod to apply a uniform pull.
- To measure the length the rear and of the tape is connected to the straining pole and the following end of the spring balance to the tape is adjusted to coincide with the zinc strip by adjusting screw.
- The thermometers are also observed and the working is thus continued.

Jaderin's method :

- In this method, the measuring tripods are aligned and set a distance nearly equal to the length of the tape.
- The ends of the tape is attached to the straining tripods to which weights are attached.
- The rear mark of the tape is adjusted to coincide with the mark on rear measurement tripod.
- The mark on the forward measuring tripod is then set of forward mark on the tape.
- The leveling observation are made by a level and light staff.
- The tension applied should not be less than 20 times the weight of the tape.

**Direct correlation by traversing :**

In comparatively shallow mines, where the workings are connected to the surface by a drift or adit, the surface survey is simply connected to a convenient underground base line by a traverse as shown in figure.

- As the traverse line may exceed the inclinations normally meet with on the surface or underground. Special care must be taken in the measurement of the horizontal angles.
- It should be possible to use there or more tripod system.
- The probable angular error should not exceed $\pm$ 5 sec per instrument setting.

**Direct orientation by optical method :**

- These method involved sighting either up or down the mine shaft with a theodolite.
- It consisted of a high powered telescope without circles mounted on an open tribrach.
- To ensure strict practicality of the telescope an artificial horizon, consisting a mercury was placed below the instrument and just in focus.
- The mercury gave a perfectly horizontal surface on which a reflection of the telescope is appeared.

**Describe orientation by wires in two shafts :**

Condition of application : This method can be employed at mines which have two vertical shafts and the principles involved are simple diagram.

Figure shows a single wire suspended in each shaft.

- The national gird co-ordinates of the connecting them directly or indirectly to the local colliery triangulation stations.
- A traverse is then made underground between the two wires and their co-ordinates calculated be reference to an assumed meridian.
- The bearing of the plumb plane as calculated from the surface co-ordinates of the wires, is taken as its true value and composed with the bearing of the plumb\plane calculated from the co-ordinates of the underground traverse.
- This difference in bearing is taken to be the error in direction of the assumed underground meridian.

**Explain correlation by mines in a vertical shafts :**

- When only one vertical shaft is available. The problem of accurate correlation becomes rather more difficult. Two wires suspended in the shaft will from plumb plane will rarely be more than 20ft in width.
- The azimuth of this surface and taken of underground at the inset level or levels.
- There are three main methods of observation the plumb plane for azimuth namely.

(a) Exact alignment or coplaning.
(b) Approximate alignment or the method of weisbach triangles and.
(c) The method of weis quadrilaterals.

**Purpose of stope surveying :**

1. To determine the amount of ground remove in a given period of a time.
2. To determine the position of stope faces relative to each other to the shaft.
3. To calculate the ore reserve.
4. To comply with the requirement of mine regulation.

**Tape Triangulation :**

- As the face advances, new stations are established nearer the face to facilities off setting.
- Suitable positions are selected near the face from which at least two stations in connection are visible.
- Direct measurements are made between survey pegs and selected stations.

**Instrumental survey :**

- It is same that tedious but required for check survey.
- Specially when the ore body is irregular from the station of the theodolite traverse are calculated and their positions are plotted on a horizontal projection which are converted to the plane of the ore body.
- Peg to peg distances are measured by still tape horizontal & vertical angle by theodolite.

**Determine Stope face :**

A 30 mt tape is held between two stope station with its 0 at the starting station near the face and right angle. Offset from the tape to the successive points at the face are measured and booke. If the offsets are less than 1.2 mt the graduated rod may be used instead of the 15 mt tape.

The tag line should be closer to the face. It may some times be necessary for convient to hold the tape with its 0 at the station peg & a mark on the face. The station thus omitted may be often by measuring and a check right angle measurement may be made in addition.

In order to often and average stope width a no. of measurement from the hanging wall to the foot wall are taken during the survey.

**Co-planning or alignment :**

To co-planning or direct alignment method consists of setting of theodolite in the place of two plumb lines in one shaft at the surface and underground and thus transferring the bearing of surface survey directly below ground.

- From the surface traverse, two station R1 and R2 are fixed at the surface base.
- The theodolite is set at station T1 read the shaft. The instrument is leveled in exact line with the wires.
- The angle AT, R2 is measured.
- Then the theodolite is setup at R2 and the angle R1 R2 T1 is measured and the distance R2 T1, T1 A and AB are measured.
- The azimuth of the plumb plane AB and the co-ordinates at A and B and surface base station R1R2 are calculated.

Similarly the theodolite is set at station T2 & the angles B T2 R3 and T2 R3 R4 are measured. Distances BT2 T2 R3 & R3 R4 are calculated.

**Weis-quadrilateral method :**

If the layout of the shaft either at the surface or underground the method of weis-quadrilateral is applied.

- From the figure, the weis quadrilateral is formed by the wires and two instrument stations X and Y.
- The angle 1 & 2 and angle YXR are measured at station X.
- The angle 3 & 4 and angle XYR are measured carefully at station Y.
- The sides and diagrams are also measured.
- The angle at R & XY and XRR1 & YRR1 are measured at R.
- The angle 5 & 6 are measured at B and the angle 7 & 8 are measured at A.

**Setting out of curves by angle tangent :**

The offsets from the tangents may be either perpendicular or radial.

Perpendicular offsets :

Let any point M on the back tangent of the curve of radius R be at distance of X from T1 length of the offset ME to the curve perpendicular to the TI be Y.

Draw EN perpendicular to OT.

Now $OE^2 = EN^2 + ON^2$

$R^2 = X^2 + (OT1 - TN)^2$

$R^2 = X^2 + (R - Y)^2$

$(R - Y)^2 = R^2 - X^2$

$R - Y = \sqrt{R^2 - X^2}$

$Y = R - \sqrt{R^2 - X^2}$ (exact)

**<u>Radial offsets</u> :**

Let M be any point on the tangent at a distance X from the point of commencement T1. Y be the radial offsets from M to the curve. R be the radius of the curve with O as its centre.

Now

$$(R + Y)^2 = R^2 + X^2$$

$$R + Y = \frac{\sqrt{R^2 + X^2}}{X^2 + Y - R}$$

$$= X - Y$$

<u>Field Operation</u> : The following steps are followed.

1. Fix the ranging rod at T1 I T2 and O.
2. Measure a distance as long T1 I and point M.
3. From M join a line to O.
4. Similarly locate the other points on the first half of this curve.

**<u>Offset from long chord</u> :**

Let T1 and T2 be the point of commencement and point tangency of the curve radius of the circular curve is R having O as centre.

<u>Construction</u> : Join T1 T2 drive T1 T2 at D join ID which intersects the curve at B. The maximum length of the offsets from the long chord T1 T2 is BD.

Let

ND = X

EN = Y

BD = Z

T1 T2 = L & T1 D = L/4

Where Z is the ordinate at the mid-point of the long chord.

<u>Field operation</u> : The following steps are followed.

1. Exact ranging rod & at T1 D & T2.
2. Divides The long chord T1 T2 in equal part of suitable length.
3. Calculate the length of BD.
4. Perpendicular with the help of optical square and measure the calculated offsets.

**Super Elevation :** When a vehicle moves from astraight to a curve it is acted upon by centrifugal force in addition to its own height. In order to balance this force, outer rail on railway or outer edge of highways is raised above the inner one. The difference in top level of outer of inner rails is known as super elevation.

**Transition curve :** A curve of varying radius introduced between a straight & circular curve is called transition curve.

**Dip :** An imaginary line which shows the direction of slope of a plane is known as dip. Dip direction always makes an angle with the horizontal.

**True dip :** It is the direction of maximum slope of strata from horizontal which is known as true dip.

**Apparent dip :** It is the direction slope of strata other than the maximum slope is known as apparent dip.

**Strike line :** It is an imaginary line which is at right angles to true dip is known as strike line. It is only one line.

**Rectangular Co-ordinates :** An alternative method of plotting a survey involves the use of rectangular co-ordinates of each point in the survey. The methods enables a survey to be plotted with great precision, each point may be plotted quite independently of any other point in the survey, the bearing and length of the closing line may be calculated to any required degree of accuracy consistent with the accuracy of the angular points. The use of rectangular co-ordinate must therefore be resorted to all important surveys.

**Closing error :** If a closed traverse is plotted according to the field measurement the end point of the traverse will not consider exactly with the starting point owing to the error in the field measurement of the angle and distance. Such error is known as closing error.

In a closing traverse the algebraic sum of the latitudes should be zero and the algebraic sum of the departure should be zero.

**Base line :** In a triangulation survey the base is of prime importance. Since the accuracy of the computed sides of the whole triangulation system fully depends upon the accuracy of measurement of the base line.

The length of the base line depends upon the grades of the triangulation system.

Apart from the mine base line several other check bases are also measured at some suitable intervals.

In India ten bases were used the length of nine bases vary from 6.4 to 7.8 miles and that of the tenth base is 1.7 miles.

**EDM uses in mine surveying :** The electronic distance measuring devices are a new development in the field of surveying. The first such instrument Geodimeter was available to the general surveying and engineering profession in the early 1950. the model employed a modulated light beam for determining distances. It was followed afterwards by the Tellurometer which employed modulated microwave. The advantage of microwave instruments is their operability in fog or moderate rain, day or night, as well as their generally longer range. The development and perfection of small light emitting diodes in the mid 1960 as well as miniaturization of electronics using solid state components caused a revolution in the design of EDM's which are more portable, take less power and simpler to operate and read. The latest generation of EDM's employing highly coherent laser light has been brought the instruments to perfection in recent years.

**Uses of EDM in modern mine surveying :**

The uses of electronic distance measuring instruments may be summarized as follows.

1. Establishment of control points by triangulation that is by the measurement of the length of sides of triangle only.
2. Measuring the base line and stiffening a triangulation network.
3. Rapid establishment of ground control points for photogrammetry.
4. Measurement of traverse line precisely within a very short period.
5. Measuring the depth of shaft.