LEARNING MATERIALS

SEMESTER-4TH SEM.

BRANCH-MINING ENGG.

SUBJECT-MINE SURVEY-II(TH-2)

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MINE SURVEY – II

1.0 MINE'S DIAL :

1.1 Define Dip, Declination, Variation.

DIP : If a magnetic needle is suspendal freely at its centre of gravity, the needle will turn and point in the direction of the magnetic meridian and it will also dip downward (except) at the magnetic equator at an angle to horizontal plane. This vertical angle made by the magnetic force with the earth,s surface is called the dip. The angle of dip is different for different positions on the earth's surface. In the northern hemisphere, the north end of the needle dips downwards, whereas in the southern hemisphere, the south end of the needle dips downwards. At the magnetic poles, the dip's 90°, the needle becomes vertical. As the ll\ine of force are parallel to the surface of the earth at the magnetic equator, the needle remain horizontal and the dip is zero. AT any other place on the surface of the earth, the dip varies from 0 to 90°, depending upon the lines of force at that point.

1.2 Explain loose needle method of survey & calculate bearings.

This method of surveying may be (i) ordinary loose needle method, when the area to be surveyed is free from local attraction and the other. (ii) Candle'r system, also known as Reciprocal bearing method or correcting deflection method is applied when there are sources of level attraction in the vicinity.

Ordinary loose Needle survey : The alternate station method is most common in practice when there is no local attraction to affect the needle. The procedure is ilfustrated in the sketch. The route of the traverse being A to H via

B.C etc. The direction of magnetic meridian is shown by the arrow.

The bearing of the line AB is first taken for this prupoe the dial is set up B and after usual centering and leveling the magnetic needle is allowed to swing freely until it comes to rest in the magnetic meridian. S-end of the dial is now directed towards the plumb line at A. The plumb line can be made clearly visible by holding a piece of tracing paper behind it, and a lamp behind the paper. The N-end is kept in the forward direction. The North end of needle will now indicated the bearing of AB (not BA). The reading is booked and checked again. Let it is N 80° E.

Equipment Required : A miner's dial with tripod stand. A chain and a tape. Two or three plumb lines, brass hooks, lamp and tracing paper chalk, paint, survey book, pencil etc.

Arrow and ranging rod will be required in place of lamps if the traverse is made at the surface.

Precautions required in ordinary loose needle surveying : The station where the magnetic bearing are determined must be free from magnetic disturbances. Under present day condition in the mine it is unlikely that sufficient stations can be found which are free from local attraction, since, tubs, tracks, conveyors, pipes, electrical conductor, steel supports and other mining mechineries are now wide-spread throughout the working. Consequently, this system of surveying is not used belowground to any great extent. However for reasonable accuracy in the result the following precautions should be observed in loose needle surveying :

1. The dial should be in proper adjustment.
2. A tested chain should be used.
3. Sources of local attractionfrom the vivinity should be removed.
4. The dial should be set firm.
5. proper centering and leveling of the dial over or under the station must be carried out.
6. North sight of the dial should always be kept in the forward direction of the survey.
7. Bearing should be read from the nend of the needle.
8. Distances should be measured with great care using the chian taut and straight.
9. A clear manner of booking with necessary details should be maintained.

BEARING : This represent one system of designating direction of lines. The bearing of a line is the horizontal angle subtended between the line concerned and some standard line of reference, termed a meridian. The meridian may be either (1) the geographical or true meridian. (2) The magnetic meridian. (3) An artificial meridian. (4) An assumed meridian. The bearing may be stated either as (a) Quadrant bearing measured from wither end of the meridian according to circumstances or (b) whole circle bearing measured from one end of the meridian.

2.0 LEVELLING :

2.1 Define benchmark, M.S.L. Dumpy level.

BENCH MARK : the bench marks are fixed point of reference whose elevation above the datum is known. The bench marks may be of following types.

(a) Great Trigonometrical Survey Bench Marks : The bench marks, known as G.T.S. Bench marks are fixed with high precision at regular intervals throughout the country by the survey of India department with reference to mean sea level at Karachi. The position and reduced level bench marks are published by the department.

(b) Permanent Bench Mark : the bench mark which are fixed by the government Agencies such as Public Works Department (P.W.D.) or Military Engineering Services (M.E.S.) are known as permanent bench marks. Such bench marks take the form of a board arrow pointing upward to a horizontal line and are chiseled on some clearly well defined permanent point such as culvert or bridge, kilometer stone, building or other permanent landmark. They are of permanent nature, Their value is written and their position is recorded for future reference.

(c) Arbitary Bench Mark : When leveling operations is carried out the whole work may not be completely in a day. In such cases, at the end of days work some reference points are fixed, the reduced levels of which are known or calculated. The work is again resumed with reference to such points. These points are known as Temporary bench marks.

M.S.L. : (Mean Sea Level) It is the average height of the sea water for all stages of the tides. At a place it is the average of hourly tide height for a loan period of 19 years.

DUMPY LEVEL : The instrument is essentially, a spirit level attached to a telescope which is rigidly mounted on to a vertical centre bearing and at right angles to it. It depends for its accuracy on the verticality of the axis. The dumpy level may be fitted with a three or four screw leveling arrangement.

The instrument consist of a telescope with an adjustable eye-piece at one end and an object glass at the other end. The telescope is fitted with an internal diaphragm near to the eye piece and which may consist of cross hairs or fine lines on glass. The body of the telescope consist of two tubes. One sliding within the other and the movement operated by the milled wheel mounted on the side of the telescope. On top or on the side of the telescope a long spirit level is fitted by means of capstan screws or hinge and adjustable screw which allows for the adjustment of the level with respect to the telescope and vertical axis of the instrument.

The telescope tube and the vertical spindle are cost in one piece. The spindle revolves in the socket of the leveling head or tri branch. The solid design gives greater rigidity and stability and reduces the overall height of the instrument. The telescope in some forms of dumpy Level is connected by adjustable straps or callars to a horizontal for or stage placed beneath the telescope. A quick leveling arrangement based on the principle of ball and socket principle to enable the instrument for aaproximent can be accurately leveled by means of three leveling screws. On some older type of leveling arrangement consists of two parallel plates plate of a four leveling scres. The lower parallel plate of a dumpy leveling screws. The lower parallel plate of a dumpy level is bored and threaded for mounting it on its tripod.

Parts of dumpy level :-

1) Telescope,	2) Eye-piece,	3) Object-glass,
4) Diaphragm,	5) Milled Head,	6) Vertical Spindle
7) Spirit Level	8) Adjustable screw	9) Transverse Spirit level
10) Levelling screws,	11) Tribranch stage	12) Trivet stage.

2.2 Adjust dumpy level, modern levels, precise staff.

ADJUST DUMPY LEVEL : In a dumpy level the telescope is rigidly fixed to the spindle. Therefore parts requiring adjustment are the cross hairs and level tube. The adjustment are :

1. To make the axis of the bubble tube perpendicular to the vertical axis. (known as bubble adjustment)
2. To make the line of the collimation parallel to the axis of the bubble tube. (known as collimation adjustment)

1. To make the axis of the bubble tube perpendicular to the vertical axis.

OBJECT : The object of this adjustment is to make the vertical axis truly vertical and to ensure that once the temporary adjustment of the instrument is done, the bubble should remain in the centre of its run for all positions of the telescope.

ADJUSTMENT :

i. Note the deviation of the bubble from the centre, say 2n divisions. Bring the bubble half way back i.e. ‘n’ division by the third foot screw.
ii. The remaining half is removed by raising or lowering the one end of the level tube by tuning the capstan headed nuts provided at one end of the level tube.
iii. Turn the telescope through 90° anticlock wise. The telescope will be now parallel to a pair of foat screw. Bring the bubble in the centre of its run by these foot screws if not central.
iv. Again turn the telescope through 90° clockwise and see wheather the bubble remains central or not. If not repeat the steps ii and iii. Three or four trials are necessary.
v. As a final check the bubble should remain central for all positions of the telescope when the bubble tube is finally adjusted.

2. To make the line of collimation parallel to the axis of the bubble tube.

OBJECT : The object of the adjustment is to set the line of collimation also at right angles to the vertical axis when the bubble is centered.

TEST & ADJUSTMENT : the collimation error is tested and adjusted by the following method known as Two-peg method.

Test :

i. Set two pegs A and B on a fairly level ground 100 m apart set up the level at C exactly midway A and B and do the temporary adjustment.

ii. Take staff reading by keeping the staff first at A and then at B, taking care that the bubble should remain central while taking the reading let the staff reading A and B are h1 and h2 respectively. Fine out the difference as the level is set midway even if the line of sight is inclined.

iii. Shift the level at a point D in line AB about 10 metres away from B. After doing the temporary adjustment again take staff reading at A and B with the bubble central. Let the staff reading on A and B are h3 and h4 respectively. Calculate the qppartment difference of level.

IV.If the difference found in step I tallies with the difference in level of step ii. The instrument is in adjustment, if not it means that the line of collimation is inclined and needs adjustment.

ADJUSTMENT :

1. The true difference of level =h1 =h2 or h2-h1 as the peg A is lower than peg B or the peg A is at a rise than Peg B. Thus find whether the peg A at a fall or at a rise.
2. Now find out the reading on the for peg A by adding or subtracting the true difference in the reading of peg B as the peg is at a fall or at a rise. Let the reading by h5 a.

   h5 = h4± true difference (+ve sign for fall and –ve sign for rise).
3. Now compare the calculate reading h5 with the observed one h3, if h3 is greater than h5 the line of collimation is inclined upwards and if h3 is less than h5 the line of collimation is inclined downward. The collimation error thus will be equal to either h5-h3 or h3-h5 in a distance AB=100 m.
4. Now find the correction to be applied to the reading on both the pegs.

PRECISE STAFF : The term precise staff is intended to convey the idea that a high degree of precision may be attained in making a leveling of the boundary of polygon, in leveling from one sation to another is establishing bench marks at widely distributed points, or in recording mining subsidence.

Instrument required :

1. A high grade level equipped with tilting screw, stadia wires, coincidence level and tilting screw, stadia wires, coincidence level and optical micrometer adjusted before use.
2. Two invar precision staves reading up to 1/1000 m with the optical micrometer, spot bubble on back or attachment of plumb bob.
3. Bolts 30 cm long with round heads.
4. Pegs.
5. Shield for the instrument.

2.3 Describe methods of leveling – Rise & Fall method, height of instrument.

RISE & FALL METHOD : In this method, the difference between consecutive points is calculated by comparing each point after the first with that immediately preceding if a staff reading is greater than at the preceding point. Then there is a fall on the other hand if the staff reading of the following point is smaller than the preceding point, the difference in reading is a rise.

The reduced level of each point is then found out by adding rise or subtracting fall to or from the R.L. of the preceding point.

Arithmetic check : The difference between the sum of back sight and sum of fore sight be equal to the difference between the sum of rise and the sum of fall and should also be equal to the difference between the R.L. of last and first point. Thus

$$\Sigma BS - \Sigma FS = \Sigma Rise - \Sigma fall = Last\ R.L. - First\ R.L.$$

This provides a complete check on the interne dilate sights also. The arithmetic check would only fail in the unlikely, but possible, case of two more errors occurring in such a manner as to balance each other.

Advantage and Disadvantages : the method has three checks for arithmetical accuracy. But it is more laborious as it involves more calculation work in finding rise and fall of each point. The mistake done is calculating the R.L. of one point will be carried forward.

The rise and fall method is used for calculating precise leveling operations and for earth work calculation work

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

Arithmetic check : The difference between the sum of back sights and the sum of fore sight should be equal to the difference between the last and the first R.L. Thus.

$$\Sigma BS - \Sigma FS = \text{Last RL} - \text{First RL}$$

The method affords a check for the HI and RL of turning point but not for the intermediate points.

Advantage and Disadvantages :

The HI method provides considerable saving of labour as this method dispasses with finding rises and Falls in the other method. It is less tedious, more rapid and involves less calculations. The error in calculating the RL of any point is not carried forward because the RL are calculated from the height of collimation. The main advantage is when a large number of intermediate sights, have to be observe from each setting of the instrument. Another application of this method may be where certain points have to be set out at specified levels above datum. In this case it is very simple matter to calculate the required staff reading to fix a particular reduced level. The system is generally used in setting out for construction works.

Plot level section, errors in ordinary leveling, undergropund leveling in an incline by straight edge & spirit level.

PLOT LEVEL SECTION : In plotting the longitudinal section, a horizontal line is drawn as datum line, and chain ages of the staff points are market along with this line to a convenient scale. AT these plotted points, perpendiculars are erected and on each of these lines, the respective levels are set off. The plotted points are then joined by straight lines to obtain the out lines of the ground surface. The horizontal scale used of the plan but the vertical scale in plotting the levels should be larger so as to mark the ground inequalities more apparent.

The plotted plan shows the features of the original surface, the formation levels of new work, the proposed gradient, the depth of cutting and height of filling, and any other information which may be useful during construction of the work.

ERROR IN LEVELLING :

1. Instrumental errors may arise due to
    a. Defect in construction of instrument and its bubble
    b. Imperfect adjustment.
    c. Loose joints of tripod stands
    d. Inaccurate division of the staff.
    e. Defective joints and foot plates of staff.

2. Error in manipulation may be due to
    a. Careless leveling.
    b. Bubble not in the centre of its run at the time of taking staff reading.
    c. Imperfect focusing causing parallax.
    d. Staff not being held truly vertical.
    e. Staff section not pulled out.
3. Error due to displacement or settlement of staff and level due to
    a. Setting on loose ground.
    b. Movement of change point.
    c. Working near the instrument.
    d. Resting hand on tripod.
4. Errors due to natural cause may arise due to
    a. effect of curvature of earth which increases staff reading.
    b. Refraction which decreases staff reading.
    c. change of staff length with variation in temperature.
5. Error in reading due to :
    a. Sights too long.
    b. Reading upward instead of cownwards.
    c. Reading downwards during inverted staff reading.
    d. Reading against stadia hairs.
    e. Reading wrongly omitting zero from decimals or noting the whole number wrongly.
6. Error in booking includes
    a. Entering reading in wrong column
    b. Noting a reading with digits interchanged.
    c. Entering a wrong distance.

d. omitting an entry.

PRECAUTION TO ELIMINATING ERROR IN LEVELLING :

1. The instrument should be firmly set on solid ground. Its leveling screws should not be excessively tightened and each leveling screw must be in contact with the lower plate or bar.
2. A length of sight which may cause staff-gradation indistinct should be avoided.
3. Sight should not be long and the back and fore sight should be of equal length to eliminate error due to instrument imperfections and errors due to curvature and refraction.
4. The telescope should accurately focused and parallax eliminated.
5. The bubble must always be brought exactly to the centre of its run.
6. Error from unstable supports can be avoided by using a heavy firm stand and repeating the leveling in the opposite direction and by taking the mean of the results.
7. If a slide of the staff is drawn out, it must be drawn out fully.
8. Foot of the staff should be kept from dirt.
9. When velocity of wind exceeds 12-15 km per hour work must be kept in abeyance.
10. During heated atmosphere work should be proceeding with short sight only.
11. Care should be taken in reading and booking of staff reading.

UNDERGROUND LEVELING IN AN INCLINE BY STRAIGHT EDGE AND SPIRIT LEVEL .

A flying level is carried out from the temporary bench mark at the shaft bottom to the permanent bench mark previously established

Accuracy : The survey work will be considered satisfactory if the limits of error are within the following

Ranges :

Surface leveling : not to exceed 2 cm per km.

Shaft Measurment : not to exceed 1 in 5000 of depth measured.

Underground leveling : not to exceed 4 cm per km.

LEVELING WITH STRAIGHT EDGE : The usual forms of level and staff may be used belowground in precisely by same way as they are used on the surface, except that the sight will generally be much shorter. When the gradient exceeds 1 in 5 it becomes exceedingly difficult to do good work on account of the short shots obtained at each setting of the instrument and the difficult of focusing the telescope on the staff at short range. When the gradient is moderate, say 1 in 10, it is hardly possible to got sight more than about 12 meters long in roads 1.8 meter high. The leveling for steep inclined roadway cannot, therefore be done satisfactorily with the dumpy level, and recourse must be had either to trigonometrically leveling or necessitates the use of an expensive instrument and a knowledge of trigonometry, whereas the straight edge leveling only requires instrument that can be readily obtained and calculation of simplest kind are involved. The straight edge leveling gives only approximate result.

Leveling with straight edge.

The straight edge or stave should be well seasoned timber about 2.5 cm wide and 5 to 8 cm deep. Its depends upon the gradient and height of the roadway. The steeper the roadway and the less the available height, the shorter must be the straight edge in the length. Thus if the roadway dips 1 in 2 and its height is 2 meters. The maximum length of straight edge would be 4 meters. But this would be inconvient required are spirit level, plumb bob, leveling staff, steel tape etc.

As the accuracy of the leveling with a straight edge depends on the stave. It must be checked for length, straightness and parallelism of the edges. The accuracy of the spirit level must also be tested. The length of the straight edge must be compared with standard steel rule or steel tape in good condition. To test straightness, lay the stave flat on a plane surface and draw a fine line close to one edge turn the stave over with the other flat side uppermost and adjust the ends of the same edge carefully to the end of the line. Draw another line along this same edge. If the stave is truly straight, the two lines will coincide. But if it is curved or crooked, there will be two lines instead of one and the extend of inaccuracy will be shown doubled.

It will be noted that the back sight is constant as the depth of the straight edge. Had the traveling being done uphill, i.e upward direction then the for sight would have been constant.

25 <u>Explain reciprocal leveling, subsidence leveling, setting out gradient, trgonometric leveling, geometrical leveling, physical leveling.</u>

<u>RECIPROCAL LEVELING :</u> In ordinary leveling, where the sight are comparatively short the effect of refraction is usually ignored and the equalization of back sight and foresights will eliminate curvature and refraction errors. If the route of leveling has to cross a river it may be impossible to equalize back sights and fore sight. In such a case, the eliminated by adopting the procedure known as reciprocal leveling.

<u>Procedure:</u> The procedure, which is a method of reversion, is used in making adjustment of level and transits let the difference of level between two points P and Q on opposites bank of a river is to be found out. In such case it is not possible to set up the level midway between the points.

The instrument is set up very near to P its height a1 is measured with a staff at P and a reading b1 is taken to a staff held at Q.

The instrument is set up very near Q and again two readings from the staff held at P and Q are noted. Let these are a2 and b2 respectively

If –d = true difference of level between P and Q.

e = total error (curvature + refraction + collimation)

Then correct reading on Q in the first setting + b1 – e, and correct reading on P in secong setting = a1 –e. from the first setting of the level, we get ..

True fall from P to Q = d = (b1 – e) –a1

$= (b1 – a1) – e$

Again, from the second setting of the level we get.

True fall from P to Q = d = b2 – (a2 –e)

$= (b2 – a2) = e.$

Averaging the two result we get.

Advantages:

1. It may be used when it is not possible to set up the level midway between the two point in case of river, valley etc.
2. The error due to curvature and refraction may be entirely eliminated.
3. Error due to maladjusted line of collimation may be eliminated.

SUBSIDENCE LEVELING : The term subsidence means the lowering of the surface when an underground opening is established due to extraction of a coal seam or ore body, the original equilibrium of strata is disturbed with resultant stress concentration. It causes effect on the surface where particles suffer vertical and horizontal displacement, creating subsidence basin trough which flattens out to sides until it is level with the existing ground. The area of the surface affected above a goaf depends on the angle of draw, which is the angle between a vertical line from the edge of the goaf and a line extended toa point at which subsidence tails out to zero. The angle of draw varies with depth, nature and inclination of the strata, and other geological feature.

Aims of subsidence measurement : If ground movement observation are carried out in a scientific manner, following every depillaring operation and the observation data are kept properly maintained many valuable, angle of draw, rate of subsidence, etc.

A correct subsidence record is a mass of precisely observed data which helps to devise method of forecasting, or recalculating, subsidence and this gives result sufficiently accurate to enable some of the problem and costs of surface damage to be alleviated.

On the basic of subsidence survey carried out for the horizontal and vertical surface movements, the five parameters of subsidence may be ascertained. These are :

1. Vertical subsidence.
2. Differential change in the ground slope.
3. Change in the surface curvature,
4. Horizontal displacement of different surface point.
5. Horizontal strain.

TRIGONOMETRIC LEVELING : When the inclined distance between two point is known the relative attitudes and the horizontal displacement of the point may be determined by reading with the vertical circle of the theodolite the angle of elevation or depression of the line joining the point. This method of finding attitudes is known as trigonometrically leveling. This method is suitable in steep gradients where the dumpy level is inconvenient to set and where extreme accuracy is not required, only an approximate difference in level between two point is urgently required.

Equipment required: A theodolite or a modern mining dial, leveling staff, steel band or tape, plumb bob, field book, pencil etc.

Procedure : Let the vertical displacement of two points P and Q is required. The instrument is set up carefully over station P and leveled. The height of the axis of the telescope above the floor is measured. The staff is held by an assistant on station Q and the telescope is directed to mark on the staff at the same height as the instrument at P. The vertical angle is noted. The measurement of the angle is repeated on the other face of the instrument. The mean of the reading is taken as correct. The inclined distance between P and Q is also measured for long sight the inclined distance may be measured by means of station reading.

Now if the distance along the slope = PQ

The vertical angle = θ

Then the vertical displacement = PQ X Sinθ

The horizontal equipment of PQ = PQ X Cosθ

In this method the instrument is set up at alternate station for subsequent reading. To ensure maximum accuracy. The vertical angle must be measured at least twice on each face the attitude bubble being carefully centered of each pointing.

Advantages :

1. It is important in the underground working of seams inclined at angles of 10 to 12 degree or upwards. Where the use of ordinary level would be inconvenient by reason of the shortness of sights for restricted height.
2. This method of leveling is suitable for leveling hilly and mountainous regions where ordinary leveling with a dumpy level is difficult and time taking.
3. It is preferred for leveling steep gradient and when distance involves are large.
4. In conjunction with stadia measurements this method is used for contouring in hilly areas.
5. As the inclined length is measured along the floor any error in measurement due to tape sagging can be avoided.

Disadvantages:

1. The degree of accuracy attainable by this method is low in comparison to that attainable by leveling with a dumpy level.
2. Profile of the ground may not be parallel with the inclined line of sight. The line measurement along the ground in such cases can never be equal to the inclined distance.
3. The accuracy is entirely dependent upon the linear measurement vertical angles and the

ground profile.

4. The method is preferred only when extreme accuracy is not required.

GEOMETRICALLY LEVELING : The geometrical leveling comprise the direct measurement of the vertical distance between points whose levels are required and a horizontal line or plane set out by means of a spirit level. Normally, it involves the use of a suitably mounted telescope, generally a Dumpy level, for setting out the horizontal lines and a graduated staff for measuring the vertical height, and with these instrument the method is capable of giving the highest degree of accuracy. The dumpy level, however is not suitable for steep gradients, but in the absence of an angular instrument, the work may be carried out by means of a wooden straight edge, a mason's spirit level and a tape or staff. The method is also known as direct leveling.

PHYSICAL LEVELING : In this method, difference of level are reduced from the reading of a barometer or of boiling point thermometer, the method is based on the fact that the atmosphere pressure varies inversely as the height of any place. The result however are approximate only and the method is of little use in mine surveying.

LEVELING INSTRUMENT : The instrument commonly used in direct leveling are

A. Level

1. A telescope to provide line of sight.
2. A level tube to make the line of sight horizontal.
3. A leveling head to bring the bubble in centre of its run.
4. A tripod stand to support instrument.

B. Leveling Staff.

1. Self reading staff and

2. Target staff.

3.0 <u>CONTOURING :</u>

3.1 <u>Explain different methods of contouring, contour lines.</u>

In general, there are mainly two field method of determining contouring :

(a) Direct Method. (b) Indirect Method.

<u>(1)</u> <u>Direct Method :</u> The method in which contouring of the point of required elevation are directly located on the ground with the help of leveling instrument is called Direct Method of contouring. The position of hese point are surveyed by chain and offset method or by a plane table. The contours of required elevation are drawn by joining the respective point. The method is accurate, but it is slow and tedious as lot of time is consumed in tracing the point of the same elevations on the ground.

The field work is two fold :

(i) Vertical control : Location of points on the contour and

(i) Horizontal control : Survey of those points.

<u>Vertical Control :</u> The point on the contours are traced either with the help of a level and staff or with the help of a hand level.

<u>Horizontal Control :</u> After having located the point on various contours, they are to be surveyed with a suitable control system. The system to be adopted depends mainly on the type and extend of areas. For small area, chain surveying may be used and the point may be located by offsets from the survey lines. In a work of larger nature, a traverse may be used.

<u>(2)</u> <u>Indirect Method :</u> The method in which spot level taken on already fixed points over the entire

area their respective R is written against each point on the plan drawn to scale and contour lines are drawn by interpolation is called Indirect Method of contouring.

In this method the slop levels are taken on points fixed along series of lines laid out over the area to be contoured. The slop levels so taken are not necessarily on the contour lines slop levels at several representative points, representing ridge and valley lines, hills and depressions and important changes in the slope on the sheet where the elevation written against each point. The contours of required elevation are then drawn by interpolation. The method is used in all kind of surveys being cheaper, quick and less tedious compared to direct method of contouring.

Contouring by indirect method is done by any of the following method.

1. By square method.
2. By cross section method.
3. By tachometric method.

(1) By Square Method : The method is used when the area to be surveyed is small and the ground is not very much undulating. The area to be surveyed is divided into a number of squares.

(2) By Cross Section : In this method, cross section are run transverse, to the centre line of a road, railway or canal etc. The method is most suitable for railway route surveys.

(3) By Tachometric Method : In the case of hilly terrain, the tachometric method may be used with advantages. A tachometric is a the odolite fitted with stadia diaphragm so that staff readings against all the three hairs may be taken.

CONTOUR LINES : A contour line is the intersection of a level surface with surface of the ground it is an imaginary line connecting the point of equal elevation above or below a given datum. A contour is represented in nature by the shore line of a body of still water. Since the contour lines on a plan or map are drawn in their true horizontal position with respect to the ground surface, a plane containing contour lines shown not only the elevations of point on the ground, but also the shapes of the various topographic feature, such as hills, villages ridges, etc. Contours give a maximum amount of information without obscuring other detail portrayed on the map or plan.

3.2 Describe various characteristics of contours.

The following are the characteristic \s of the contour line :

1. All point in one contour line have the same reduced level.
2. Every contour line closes on it self, either within or beyond the limit of the map.
3. Contour lines are equally spaced when the ground is uniformly sloping and where the ground is plane they are straight and parallel.
4. Contour lines run close together near the top of the hill, representing very steep ground, and wide apart at the flat ground.
5. Contours never split nor do two contour run into one, nor cross each other, except in the rare instance of an overhanging cliff.
6. Contour lines dross ridge lines or valley lines at right angles. A ridge line is shown when the higher values are inside the loop or bend in the contour, while in the case of a valley line, the lower values are inside the loop. The same contour appears on either side of a ridge or valley.
7. A series of closed contours on the map indicates a depression or a summit, according as the lower or higher values are inside them. Depressions between summits are called saddles.
8. The direction of the steepest slope at a point on contour is at right angles to the contour.

3.3 Evalute contour gradient.

Contour gradient is a line throughout on the surface of all ground and preserving a constant inclination to the horizontal. If the inclination of such a line is given, its direction from a point may be easily located either on the map or on the ground. The method of locating the contour gradient on map is discussed in the next article. The method of locating the contour gradient on map is discussed in the next article. To locate the contour gradient in the field, a clinometers, a theodolite or a level may be used. Let it be required to trace a contour gradient of inclination 1 in 100, starting from a point A, with the help of a clinometers. The clinometers is held at A and its line of sight is clamped at an inclination of 1 in 100. Another person having a target at a height equal to the height of the observer's eye is directed by the observer to move up or down the slope till the target is bisected by the line of sight. The point is then pegged on the ground. The clinometers is then moved to the point so obtained and another point is obtained in a similar manner. The line between any two pegs will be parallel to the line of sight.

If a level is used to locate the contour gradient. It is not necessary to set the level on the contour gradient. The level is set at a commanding position and reading on the staff kept at the first point is taken. For numerical example, let the reading be 1.21 meters. The reading on another peg B (say) distant 20 meters from A, with a contour gradient of 1 in 100, will be 1.21 + 0.20= 1.41 meters. To locate the point B, the staff man holds the 20 meters end of chain or tape (with zero meter end at A) and moves till the reading on the staff is 1.41 meters. Thus from one single instrument station several points at a given gradient can be located. The method of calculating the staff reading for several pegs has been explained through numerical example of leveling.

3.4 Describe the use of contour plan.

The following are the some of the important uses of contour plan :

1. Contour lines convey when delineated upon a plan, an approximate representation of configuration of the surface of the ground, the degree of approximation depending on the

proximity of contours. Any change in level, flat or inclined seams, anticlinal or synclinal structures, domes or basins etc can be esily ascertained from a contour map.

2. A contour line is a line of strike and the direction and amount of dip can be calculated.

3. Work planning scheme can be drawn up with due regard to all dip of the seam.

4. Proper position of shafts, inclines etc can be located so as not to be affected by highest flood level.

5. Gradient of proposed road or railway lines at surface or haulage road below ground can be determined.

6. Static pumping head can be determined at any point.

7. Layout of stowing pipe range can be planned.

8. Area liable to flooding can be seen at a glance and proper drainage scheme can be drawn up.

9. Indivisibility of two stations can be ascertained from a contour map.

10. The thickness of cover over a coal seam can be determined from stratum contour or underground levels and surface contour lines isopachs can be found out for use in quary works.

11. Quantity of earthwork can be computed.

12. Capacity of a reservoir can be determined.

3.5 Define stratum contour, isopachs.

STRATUM CONTOUR : These are contour lines drawn on the surface of a bed or coal seam and are the same as the strike lines. In case of uniformly sloping bed or seam these lines are equally spaced and may form straight lines if the direction of dip is constant in the area.

ISOPACHY : These are lines showing equal vertical thickness of strata, say, between the floor of two seams. Such lines are obtained by showing the contours of two seams on the same plan in correct relationship to each other. Where these contours of the seams cross one another, the thickness of the intervening strata is obtained simply by deducting the value of the contour of the lower seam from that of the upper seam. If one joins the point where these difference give the same value, a curved line is produced, known as Isopachyte Line.

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.

Advantages:

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.

Disadvantages:

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.

Weisbach Triangle :

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.

Purpose of correlation survey : 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.

<u>Sag Correction</u> : 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.

$$\text{Correction} = \frac{L(WL)^{L}}{\quad\quad\quad}$$

Where

L = Distance between support in meters.

W = Weight of tape in kg per meter run.

P = Applied pull in kg.

<u>Two Theodolite</u> :

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 α1------------- (1)

Again from Δ CKA1 we get CK = A1K tan CA1K

V = D tan α2 ------------------(2)

Subtracting equation (2) from (1)

S = D (tan α1 – tan α2

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 α2 --------------(1)

Again in triangle BKA1

KB = A1K tan BA1K

V = D tan α1 --------------(2)

Subtracting equation (2) from equation (1)

S = D (tan α2 – tan α1)

Elevation of the staff station P

Elevation of the instrument axis V-h

Case 3 : 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.

Sighting and making triangulation station point :

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.

Tape corrections :

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.

Describe the methods of base line measurement –EDM. :

There are two methods of base line measurement of EDM.

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

Wheeler's base line apparatus :

- 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 ± 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)

Radial offsets :

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

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

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

$= X - Y$

Field Operation : 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.

Offset from long chord :

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.

Construction : 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.

Field operation : 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.