SWAMI VIVEKANANDA SCHOOL OF ENGINEERING & TECHNOLOGY

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LECTURE NOTES

ON

MINE SURVEY-II

YEAR & SEMESTER:2ND YEAR & 4TH SEMESTER

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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.

$\Sigma BS - \Sigma FS$ = Last RL – 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.

2.5 Explain reciprocal leveling, subsidence leveling, setting out gradient, trgonometric leveling, geometrical leveling, physical leveling.

RECIPROCAL LEVELING : 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.

Procedure: 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 CONTOURING :

3.1 Explain different methods of contouring, contour lines.

In general, there are mainly two field method of determining contouring :
(a) Direct Method. (b) Indirect Method.

(1) Direct Method : 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
(ii) Horizontal control : Survey of those points.

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

(2) Indirect Method : 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.