INTRODUCTION:

Tacheometric is a branch of surveying in which horizontal and vertical distances are determined by taking angular observation with an instrument known as a tachometer. Tacheometric surveying is adopted in rough in rough and difficult terrain where direct leveling and chaining are either not possible or very tedious. The accuracy attained is such that under favorable conditions the error will not exceed 1/100. and if the purpose of a survey does not require accuracy, the method is unexcelled. Tacheometric survey also can be used for Railways, Roadways, and reservoirs etc. Though not very accurate. Tacheometric surveying is very rapid, and a reasonable contour map can be prepared for investigation works within a short time on the basis of such survey.

Uses of Tachometry

Tachometry is used for preparation of topographic map where both horizontal and vertical distances are required to be measured;

survey work in difficult terrain where direct methods of measurements are inconvenient;

reconnaissance survey for highways and railways etc; Establishment of secondary control points.

Instruments used in tachometric surveying

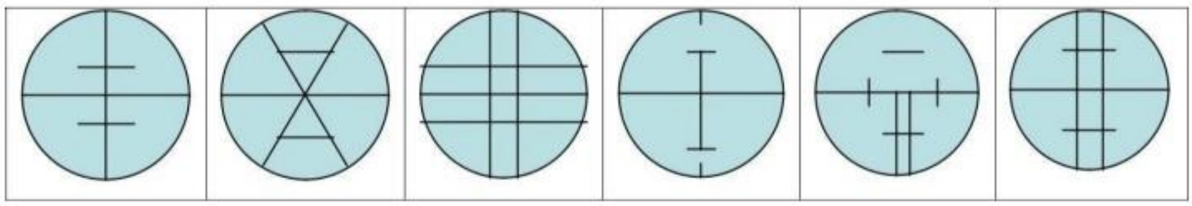
An ordinary transits theodolite fitted with a stadia diaphragm is generally used for tacheometric surveying. The stadia diaphragm essentially consists of one stadia hair above and the other an equal distance below the horizontal cross hair, the stadia hair being mounted in the same ring and in the same vertical plane as the horizontal and vertical cross-hair.

The telescope used in stadia surveying are three kinds, The Simple external focusing telescope.

The external focusing anal lactic telescope (porro's telescope).

The internal focusing telescope.

The first type is known as stadia theodolite, while the second type is known as tacheometer. The tacheometer has the advantage over the first and third type due to fact that the additive constant of the instrument is zero.



The instruments employed in tachometry are the engineer's transit and the levelling rod or stadia rod, the theodolite and the subtense bar, the self-reducing theodolite and the levelling rod, the distance wedge and the horizontal distance rod, and the reduction tacheometer and the horizontal distance rod.

Features of tacheometer or Characteristic of tacheometer

The multiple constant (f/i) should have a normal value of 100 and the error contained in this value should not exceed 1 in 1000.

The axial horizontal lines should be exactly midway between the other two lines. The telescope should be fitted with an anallatic lens to make the additive constant (f + d) exactly to zero.

The telescope should be truly analectic.

The telescope should be powerful having a magnification of 20 to 30 diameters. The Aperture of the object should be 35 to 45 mm in diameter.

Levelling and Stadia Staff Rod

For short distances, ordinary levelling staves are used. The levelling staff normally 4m long, and it can be folded with here parts. The graduations are so marked that a minimum reading of 0.005 or 0.001m can be taken.

Different systems of Tacheometric Measurement

The various systems of tacheometric survey may be classified as follows, The Stadia Method

i. Fixed Hair Method and

ii. Movable Hair Method

The Tangential System

Measurements by means of special instruments.

The principle is common to all system is to calculate the horizontal distance between two points A and B their deference in elevation, by observing 1) the angle at the instrument at A subtended by known short distance along a staff kept at B and 2) the vertical angle to B from A

Stadia systems

In this systems staff intercepts, at a pair of stadia hairs present at diaphragm, are considered. The stadia system consists of two methods:

a) Fixed-hair method and

b) Movable-hair method

Fixed-hair method

In this method, stadia hairs are kept at fixed interval and the staff interval or intercept (corresponding to the stadia hairs) on the leveling staff varies. Staff intercept depends upon the distance between the instrument station and the staff.

Movable- hair method

In this method, the staff interval is kept constant by changing the distance between the stadia hairs. Targets on the staff are fixed at a known interval and the stadia hairs are adjusted to bisect the upper target at the upper hair and the lower target at the lower hair. Instruments used in this method are required to have provision for the measurement of the variable interval between the stadia hairs. As it is inconvenient to measure the stadia interval accurately, the movable hair method is rarely used.

Non-stadia systems

This method of surveying is primarily based on principles of trigonometry and thus telescopes without stadia diaphragm are used. This system comprises of two methods:

(i) Tangential method and

(ii) Subtense bar method. Tangential method

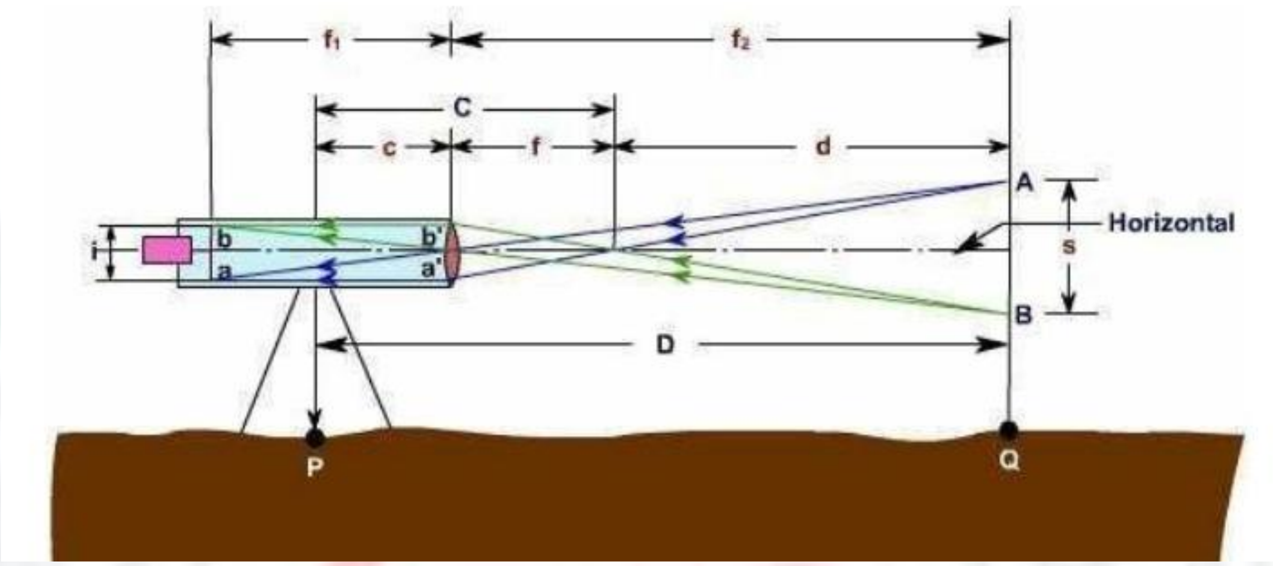
In this method, readings at two different points on a staff are taken against the horizontal cross hair and corresponding vertical angles are noted.

Subtense bar method.

In this method, a bar of fixed length, called a subtense bar is placed in horizontal position. The angle subtended by two target points, corresponding to a fixed distance on the subtense bar, at the instrument station is measured. The horizontal distance between the subtense bar and the instrument is computed from the known distance between the targets and the measured horizontal angle.

Principles of Stadia Method

A tacheometer is temporarily adjusted on the station P with horizontal line of sight. Let a and b be the lower and the upper stadia hairs of the instrument and their actual vertical separation be designated as i. Let f be the focal length of the objective lens of the tacheometer and c be horizontal distance between the optical centre of the objective lens and the vertical axis of the instrument. Let the objective lens is focused to a staff held vertically at Q, say at horizontal distance D from the instrument station.



By the laws of optics, the images of readings at A and B of the staff will appear along the stadia hairs at a and b respectively. Let the staff interval i.e., the difference between the readings at A and B be designated by s. Similar triangle between the object and image will form with vertex at the focus of the objective lens (F). Let the horizontal distance of the staff from F be d. Then, from the similar Ds ABF and a' b' F,

$$\frac{AB}{d} = \frac{a'b'}{f}$$

$$\text{Or, } d = \frac{AB}{a'b'} \times f = \frac{s}{i} \times f$$

$$\therefore d = \frac{f}{i} \times s$$

as a' b' = ab = i. The ratio (f / i) is a constant orf a particular instrument and is known as stadia interval factor, also instrument constant. It is denoted by K and thus

d = K.s --------------------- Equation (23.1)

The horizontal distance (D) between the center of the instrument and the station point (Q) at which the staff is held is d + f + c. If C is substituted for (f + c), then the horizontal distance D from the center of the instrument to the staff is given by the equation

$D = Ks + C$ ---------------------- Equation (23.2)

The distance C is called the stadia constant. Equation (23.2) is known as the stadia equation for a line of sight perpendicular to the staff intercept.

Theory of Stadia Tacheometry

The following is the notation used in stadia tacheometry

O = Optical centre of object Glass

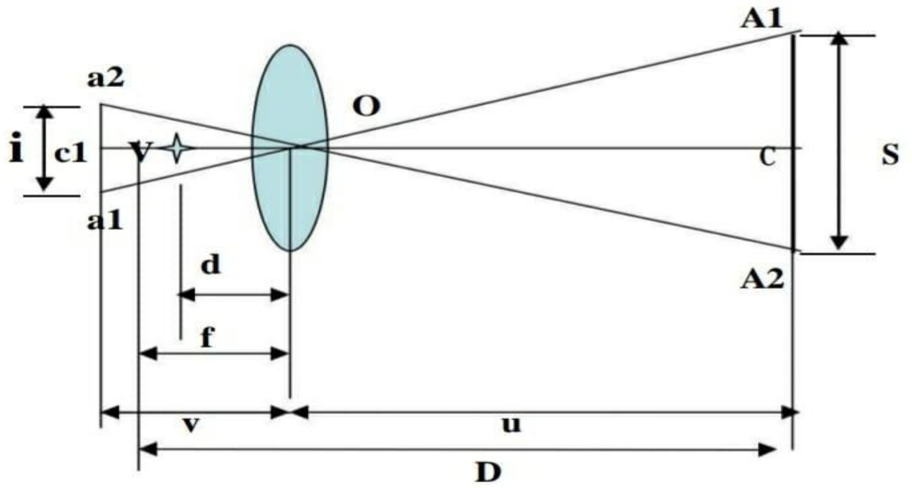
A1, A2, C = Reading of staff cut by three hair

a1,a2, C = Bottom Top Central hair of diaphragm

a1,a2 = i = Length of image

A1, A2 = S = Staff Intercept

V = Vertical axis of Instrument



f =Focal length of a object glass

d =distance between optical centre and vertical axis of instrument

u=distance between optical centre and staff

v=distance between optical centre and image.

For similar triangles $a_1, O a_2$ and A_1, OA_2,

$$\frac{i}{s} = \frac{v}{u} \quad \text{or} \quad v = \frac{iu}{s} \qquad (1)$$

From the properties of length,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f} \qquad (2)$$

Putting the value of v in Eq. (2)

$$\frac{1}{iu/s} + \frac{1}{u} = \frac{1}{f}$$

Or

$$\frac{s}{iu} + \frac{1}{u} = \frac{1}{f}$$

Or

$$\frac{1}{u}\left\{\frac{s}{i} + 1\right\} = \frac{1}{f}$$

Or

$$u = \{\frac{s}{i} + 1\} f$$

But,

$$D = u + d \text{ ---------------------------- (3)}$$

$$D = \{\frac{s}{i} + 1\} f + d$$

$$\frac{s}{i} \times f + f + d = \{\frac{f}{i}\} \times s + (f + d)$$

The quanta ties (f/i) and (f + d) are known as techeometric constants. (f/i) is called the multiplying constant, as already stated, and (f + d) the additive constant. by adopting an anal latic lens in the telescope of a tacheometric, the multiplying constant is made 100, and the additive constant zero. However, in some tacheometers the additive constants are not exactly zero, but vary from 30 cm to 60 cm

Inclined Stadia Measurements

It is usual that the line of sight of the tacheometer is inclined to the horizontal. Thus, it is frequently required to reduce the inclined observations into horizontal distance and difference in elevation.

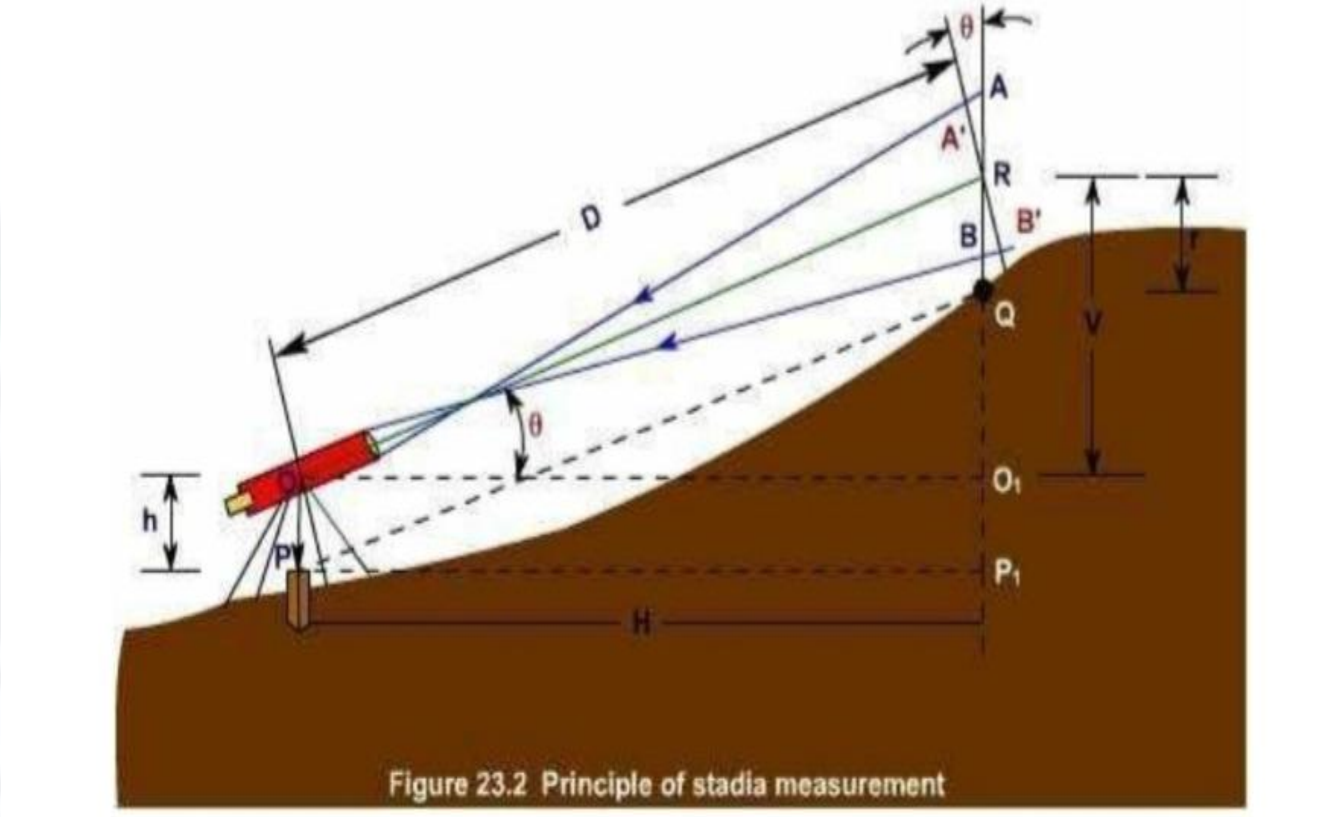


Figure 23.2 Principle of stadia measurement

Let us consider a tacheometer (having constants K and C) is temporarily adjusted on a station, say P (Figure 23.2). The instrument is sighted to a staff held vertically, say at Q. Thus, it is required to find the horizontal distance PP1 (= H) and the difference in elevation P1Q. Let A, R and B be the staff points whose images are formed respectively at the upper, middle and lower cross hairs of the tacheometer. The line of sight, corresponding to the middle cross hair, is inclined at an angle of elevation q and thus, the staff with a line perpendicular to the line of sight. Therefore A'B' = AB cos q = s cos q where s is the staff intercept AB. The distance D (= OR) is C + K. scos q (from Equation 23.2). But the distance OO1 is the horizontal distance H, which equals OR cos q. Therefore the horizontal distance H is given by the equation.

$$H = (Ks \cos q + C) \cos q$$

Or $H = Ks \cos 2\, q + C \cos q$ ---------------- Equation (23.3)

in which K is the stadia interval factor (f / i), s is the stadia interval, C is the stadia constant (f + c), and q is the vertical angle of the line of sight read on the vertical circle of the transit.

The distance RO1, which equals OR sin q, is the vertical distance between the telescope axis and the middle cross-hair reading. Thus V is given by the equation

$$V = (K\, s \cos q + c) \sin q$$

$V = Ks \sin q \cos q + C \sin q$ ---------------- Equation (23.4)

[redacted] Equation (23.5)

Thus, the difference in elevation between P and Q is (h + V - r), where h is the height of the instrument at P and r is the staff reading corresponding to the middle hair.

Uses of Stadia

The stadia method of surveying is particularly useful for following cases:

1. In differential leveling, the back sight and foresight distances are balanced conveniently if the level is equipped with stadia hairs.

2. In profile leveling and cross sectioning, stadia is a convenient means of finding distances from level to points on which rod readings are taken.

3. In rough trigonometric, or indirect, leveling with the transit, the stadia method is more rapid than any other method.

4. For traverse surveying of low relative accuracy, where only horizontal angles and distances are required, the stadia method is a useful rapid method.

5. On surveys of low relative accuracy - particularly topographic surveys-where both the relative location of points in a horizontal plane and the elevation of these points are desired, stadia is useful. The horizontal angles, vertical angles, and the stadia interval are observed, as each point is sighted; these three observations define the location of the point sighted.

Errors in Stadia Measurement

Most of the errors associated with stadia measurement are those occur during observations for horizontal angles (Lesson 22) and differences in elevation (Lesson 16). Specific sources of errors in horizontal and vertical distances computed from observed stadia intervals are as follows:

1. **Error in Stadia Interval factor**

This produces a systematic error in distances proportional to the amount of error in the stadia interval factor.

2. **Error in staff graduations**

If the spaces on the rod are uniformly too long or too short, a systematic error proportional to the stadia interval is produced in each distance.

3. **Incorrect stadia Interval**

The stadia interval varies randomly owing to the inability of the instrument operator to observe the stadia interval exactly. In a series of connected observations (as a traverse) the error may be expected to vary as the square root of the number of sights. This is the principal error affecting the precisio

2nd CHAPTER
CURVES

INTRODUCTION:

The center line of a road consists of series of straight lines interconnected by curves that are used to change the alignment, direction, or slope of the road. Those curves that change the alignment or direction are known as horizontal curves, and those that change the slope are vertical curves. The initial design is usually based on a series of straight sections whose positions are defined largely by the topography of the area. The intersections of pairs of straights are then connected by horizontal curves. Curves can be listed under three main headings, as follows:

(1) Horizontal curve

(2) Vertical curves

HORIZONTAL CURVES

When a highway changes horizontal direction, making the point where it changes direction a point of intersection between two straight lines is not feasible. The change in direction would be too abrupt for the safety of modem, high-speed vehicles. It is therefore necessary to interpose a curve between the straight lines. The straight lines of a road are called tangents because the lines are tangent to the curves used to change direction.

The smaller the radius of a circular curve, the sharper the curve. For modern, high-speed highways, the curves must be flat, rather than sharp. The principal consideration in the design of a curve is the selection of the length of the radius or the degree of curvature. This selection is based on such considerations as the design speed of the highway and the sight distance as limited by headlights or obstructions (see Fig. 1). The horizontal curve may be a simple circular curve or a compound curve.

For a smooth transition between straight and a curve, a transition or easement curve is provided. The vertical curves are used to provide a smooth change in direction taking place in the vertical plane due to change of grade.

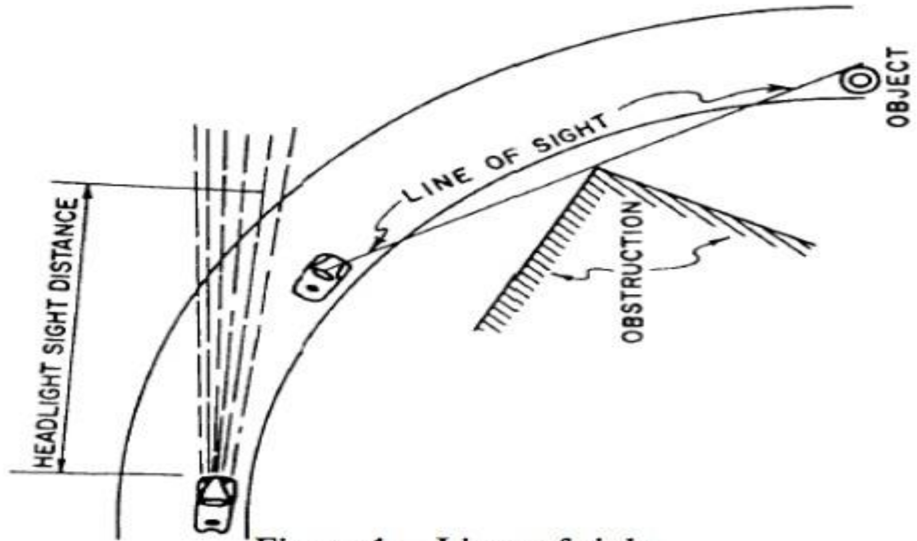


Figure 1.—Lines of sight.

Types of Horizontal Curves There are four types of horizontal curves. They are described as follows:

A. SIMPLE.

The simple curve is an arc of a circle (view A, fig. 2). The radius of the circle determines the sharpness or flatness of the curve.

B. COMPOUND.

Frequently, the terrain will require the use of the compound curve. This curve normally consists of two simple curves joined together and curving in the same direction (view B, fig. 2).

C. Reverse. A reverse curve consists of two simple curves joined together, but curving in opposite direction. For safety reasons, the use of this curve should be avoided when possible (view C, fig. 2).

D. Spiral. The spiral is a curve that has a varying radius. It is used on railroads and most modem highways. Its purpose is to provide a transition from the tangent to a simple curve or between simple curves in a compound curve (view D, fig. 2).

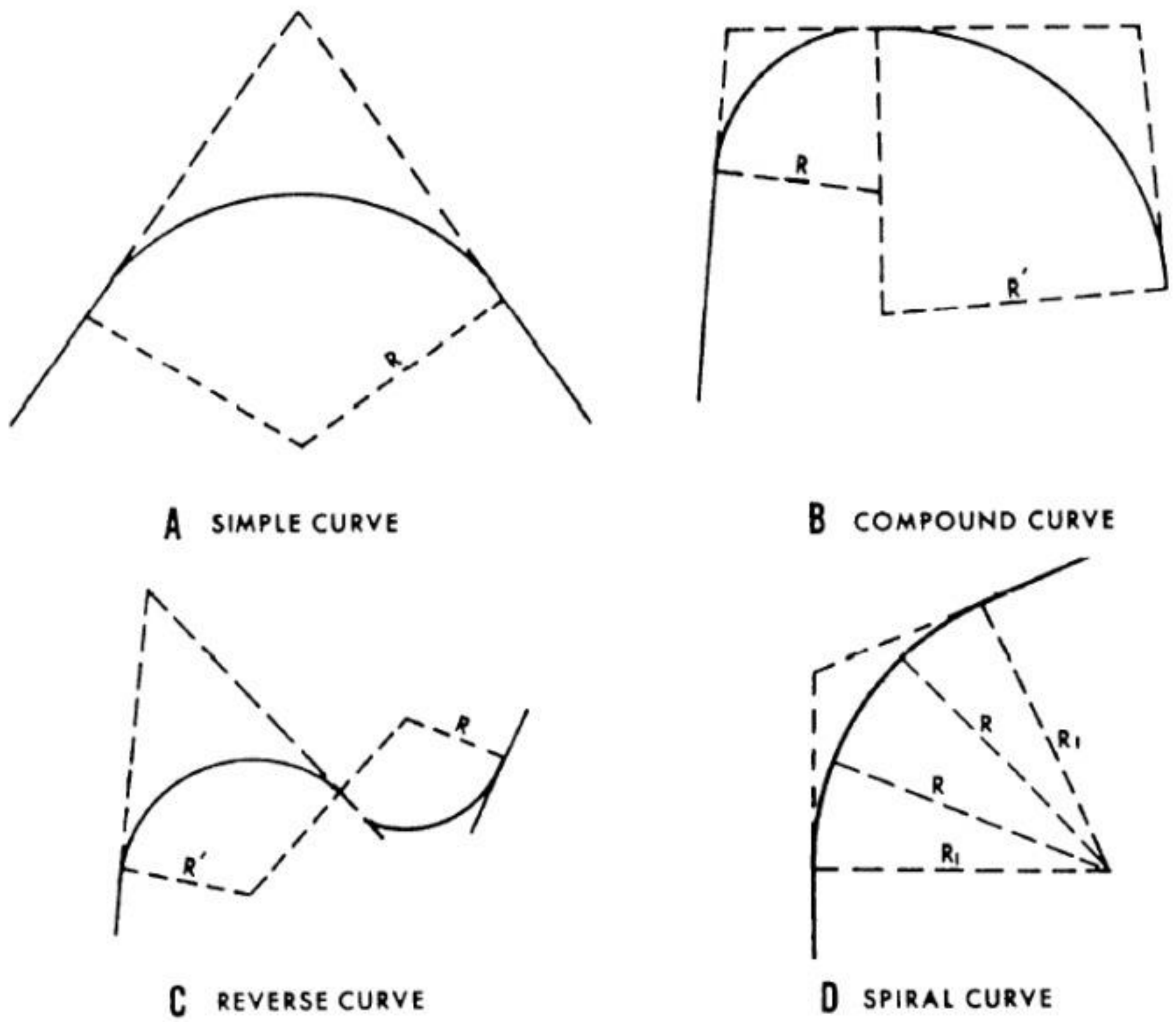


Figure 2.—Horizontal curves.

(A) HORIZONTAL CURVE OR CIRCULAR CURVES OF CONSTANT RADIUS.

A simple circular curve shown in Fig., consists of simple arc of a circle of radius R connecting two straights lines, intersecting at PI, called the point of intersection (P.I.), having a deflection angle △. The distance E of the midpoint of the curve from P I is called the external distance. The arc length from T1 to T2 is the length of curve, and the chord T1T2 is called the long chord. The distance M between the midpoints of the curve and the long chord, is called the mid-ordinate. The distance T1 PI which is equal to the distance P IT2, is called the tangent length.

ELEMENTS OF HORIZONTAL CURVES

The elements of a circular curve are shown in figure 3. Each element is designated and explained as follows: Point of Intersection (PI). The point of intersection is the point where the back and forward tangents intersect. Sometimes, the point of intersection is designated as V (vertex). Deflection Angle ( ). The central angle is the angle formed by two radii drawn from the center of the circle (O) to the PC and PT. The value of the central angle is equal to the I angle. Some authorities call both the intersecting angle and central angle either I or A. Radius (R). The radius of the circle of which the curve is an arc, or segment. The radius is always perpendicular to back and forward tangents. Point of Curvature (PC). The point of curvature is the point on the back tangent where the circular curve begins. It is sometimes designated as BC (beginning of curve) or TC (tangent to curve). Station P.C.= P.I. – T Point of Tangency (PT), The point of tangency is the point on the forward tangent where the curve ends. It is sometimes designated as EC (end of curve) or CT (curve to tangent). Station P.T. = P.C.+ L Point of Curve. The point of curve is any point along the curve. Length of Curve (L) . The length of curve is the distance from the PC to the PT, measured along the curve.

$$L = \Delta \times R \frac{2\Pi}{360}$$

TANGENT DISTANCE (T).

The tangent distance is the distance along the tangents from the PI to the PC or the PT. These distances are equal on a simple curve.

$$T = R \tan \frac{\Delta}{2}$$

LONG CORD (C).

The long chord is the straight-line distance from the PC to the PT. Other types of chords are designated as follows: C The full-chord distance between adjacent stations (full, half, quarter, or one tenth stations) along a curve. C1 The subchord distance between the PC and the first station on the curve.

C2 The subchord distance between the last station on the curve and the PT.

$$C = 2R \sin \frac{\Delta}{2}$$

EXTERNAL DISTANCE (E).

The external distance (also called the external secant) is the distance from the PI to the midpoint of the curve. The external distance bisects the interior angle at the PI.

$$E = R\left[\left[\text{Sec}\frac{\Delta}{2} - 1\right]\right]$$

MIDDLE ORDINATE (M).

The middle ordinate is the distance from the midpoint of the curve to the midpoint of the long chord. The extension of the middle ordinate bisects the central angle.

$$M = R\left|1 - \cos\frac{\Delta}{2}\right|$$

Degree of Curve. The degree of curve defines the sharpness or flatness of the curve.

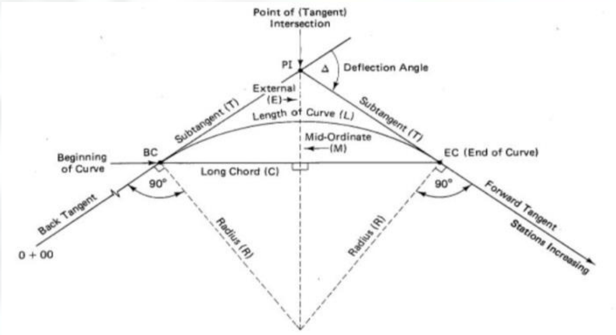


Figure 3 Elements of a Circular Curve

Rectangular Offsets From The Tangent /Coordinate/ Method

This method is also suitable for short curve and, as in the previous method, no attempt is made to keep the chord of equal lengths.

$R^2 = AB^2 + AO^2$ (Pythagoras' theorem),
$= y^2 + (R - x)^2$

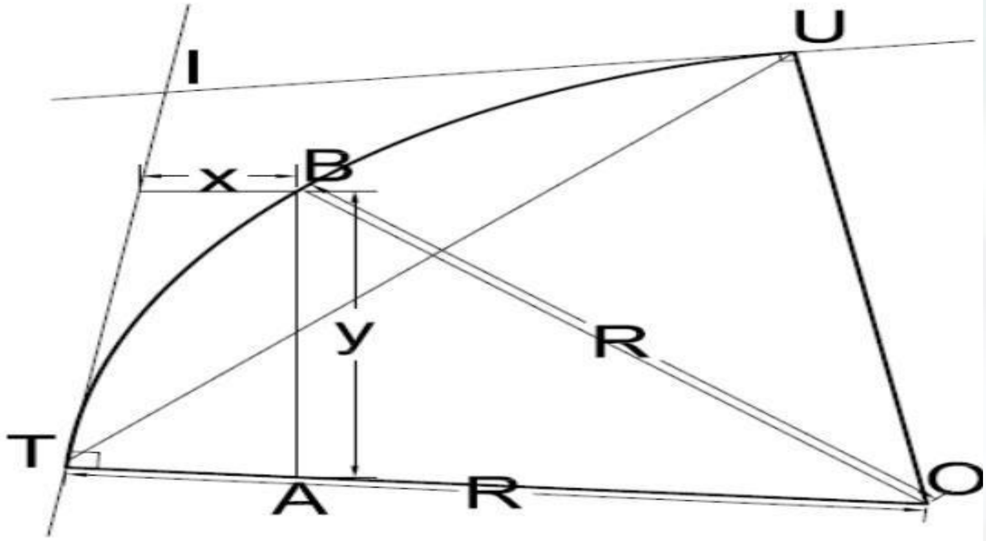
There fore $x = R - \sqrt{(R^2 - y^2)}$

$= R - R(1 - y^2/R^2)^{1/2}$

Expand $(1 - y^2/R^2)^{1/2}$ using Binomial theorem

Then $x = R - R(1 - 1/2\, y^2/R^2 + \ldots)$

$= y^2/2R$ Approximately



(B) POLAR STAKING / DEFLECTION METHOD

Polar staking methods have become increasingly popular, especially with the availability of electronic tachometers. A simple method can be derived using the starting point of the circle Є is equal to the angle between the tangents and chord. For equal arc lengths the polar staking elements are determined with respect to the tangent.

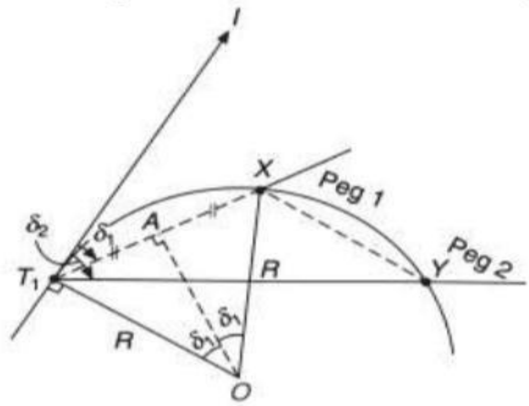


Figure 5 Polar Staking

By radians, arc length $T_1X = R2\delta_1$

$$\therefore \delta_1 \text{ rad} = \frac{\text{arc } T_1X}{2R} \approx \frac{\text{chord } T_1X}{2R}$$

$$\therefore \delta_1^\circ = \frac{\text{chord } T_1X \times 180^\circ}{2R \cdot \pi} = 28.6479\frac{\text{chord}}{R} = 28.6479\frac{C}{R}$$

VERTICAL CURVES

Once the horizontal alignment has been determined, the vertical alignment of the section of highway can be addressed. Again, the vertical alignment is composed of a series of straight-line gradients connected by curves, normally parabolic in form. These vertical parabolic curves must therefore be provided at all changes in gradient. The curvature will be determined by the design speed, being sufficient to provide adequate driver comfort with appropriate stopping sight distances provided.

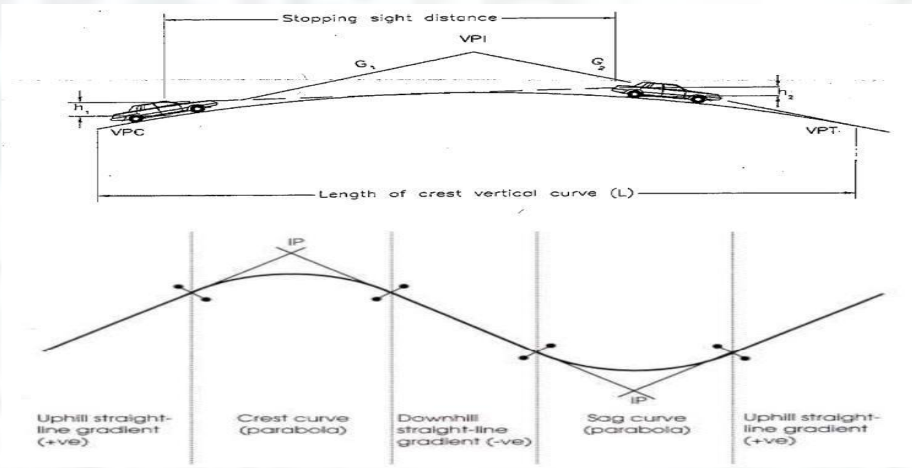


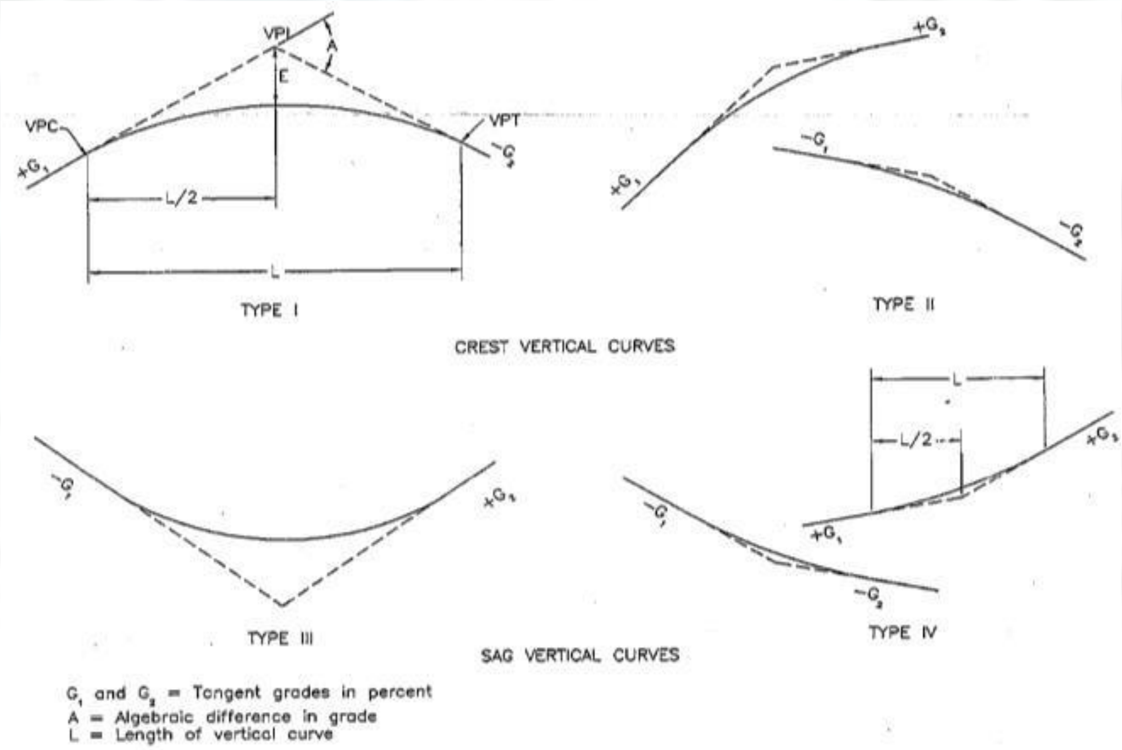
Figure 6: Example of typical vertical alignment

Vertical curves should be simple in application and should result in a design that is safe and comfortable in operation, pleasing in appearance, and adequate for drainage.

The major control for safe operation on crest vertical curves is the provision of ample sight distance for the design speed; while research has shown that vertical curves with limited sight distance do not necessarily experience safety problems, it is recommended that all vertical curves should be designed to provide at least stopping sight distances. Wherever practical, more liberal stopping sight distances should be used. Furthermore, additional sight distance should be provided at decision points.

For driver comfort, the rate of change of grade should be kept within tolerable limits. This consideration is most important in sag vertical curves where gravitational and vertical centripetal forces act in opposite directions. Appearance also should be considered in designing vertical curves. A long curve has a more pleasing appearance than a short one; short vertical curves may give the appearance of a sudden break in the profile due to the effect of foreshortening.

The vertical offset from the tangent grade at any point along the curve is proportional of the vertical offset at the VPI, which is AL/800. The quantity L/A, termed "K", is useful in determining the horizontal distance from the Vertical Point of Curvature (VPC) to the high point of Type I curves or to the low point of type III curves.



1.2.1 Elements of Vertical Curves

Figure 8 shows the elements of a vertical curve. The meaning of the symbols and the units of measurement usually assigned to them follow:

PVC Point of vertical curvature; the place where the curve begins.

PVI Point of vertical intersection; where the grade tangents intersect.

PVT Point of vertical tangency; where the curve ends.

POVC Point on vertical curve; applies to any point on the parabola.

POVT Point on vertical tangent; applies to any point on either tangent.

g_1 Grade of the tangent on which the *PVC* is located; measured in percent of slope.

g_2 Grade of the tangent on which the *PVT* is located; measured in percent of slope.

G The **algebraic difference** of the grades:

$$G = g_2 - g_1$$

Where in plus values are assigned to uphill grades and minus values to downhill grades.

L Length of the curve, the **horizontal** length measured in 20- 100 meters stations from the *PVC* to the PVT. This length may be computed using the formula ***L = G/r,*** where *r* is the rate of change (usually given in the design criteria).

When the rate of change is not given, *L* (in stations) can be computed as follows: for a summit curve, **L = 125** x G/4; for a sag curve, **L = 100** x G/4. If *L* does not come out to a whole number of stations using these formulas, then it is usually extended to the nearest whole number.

l_1 Horizontal length of the portion of the *PVC* to the *PVI;*

l_2 Horizontal length of the portion of the curve form the *PVI* to the *PVT;*

e Vertical (external) distance from the *PVI* to the curve. This distance is computed using the formula ***e* = LG/8,** where

L is the total length in stations and G is the algebraic difference of the grades in percent.

x The Horizontal distance from the *PVC* to any *POVC* or *POVT* back of the *PVI,* or the distance from the PVT to any *POVC* or *POVT* ahead of the *PIV,* measured in feet.

Y Vertical distance (offset) from any *POVT* to the corresponding *POVC,* measured in feet; which is the fundamental relationship of the parabola that permits convenient calculation of the vertical offsets.

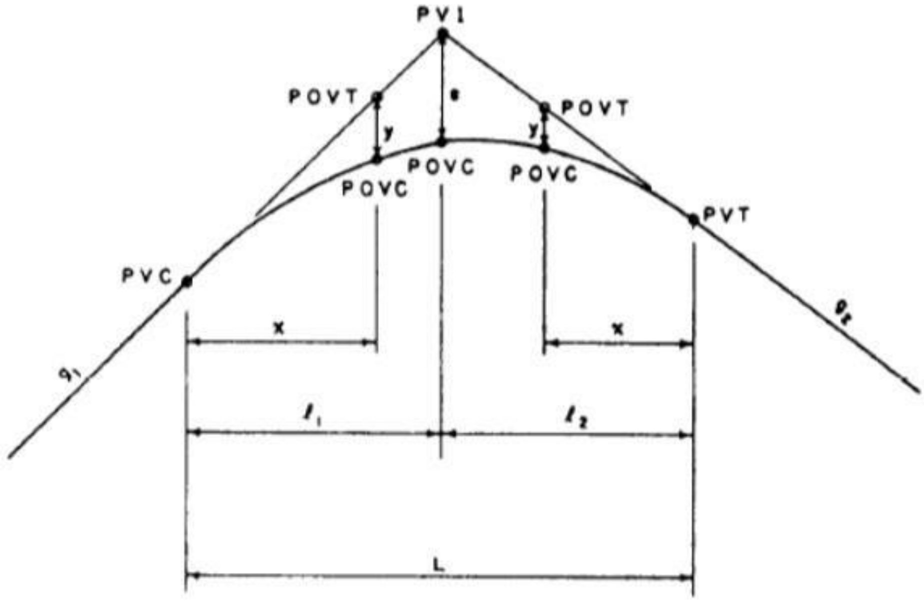


Figure 8.—Elements of a vertical curve.

Parabolic formula:

Referring to Fig. 8, the formula for determining the co-ordinates of points along a typical vertical curve is:

$$y = \left[\frac{G2 - G1}{2L}\right]x^2 \qquad \text{(a)}$$

Where: G1and G2 are the gradients of the two straights being joined by the vertical curve in question.

- *L is the vertical curve length*
- X and y are the relevant co-ordinates in space

Proof:

If Y is taken as the **elevation** of the curve at a point x along the parabola and k is a constant, then:

$\frac{d^2Y}{dx^2} = k$ Integrating this equation gives: $\frac{dY}{dx} = kx + C$ (b)

Examining the boundary conditions: When x = 0: $\frac{dY}{dx} = G1$ (c)

(G1 being the slope of the first straight line gradient) $\frac{dY}{dx} = G2$

Therefore: G1 = C and when x = L, (d)

(G2 being the slope of the second straight line gradient)

$G2 = kL + C = kL + G1$ and rearranging this equation

$k = (G2\text{-}G1)/L$ (e)

Substituting Equations (d) and (e) in to equation (b):

$$\frac{dY}{dx} = \left[\frac{G2 - G1}{L}\right]x + G1 \quad (f)$$

Integrating Equation (f);

$$Y = \left[\frac{G2 - G1}{L}\right]\frac{x^2}{2} + G1x$$

From figure 2: $G1 = (y+Y)/x$

Which gives $$Y = \left[\frac{G2 - G1}{L}\right]\frac{x^2}{2} + (y + Y)$$

and rearranging this equation gives

$$y = -\left[\frac{G2 - G1}{2L}\right]x^2$$

Where x is the distance along the curve measured from the start of the vertical curve and y is the vertical offset measured from the continuation of the slope to the curve.

At the intersection point VPI: $x = L/2$

Therefore; $$e = -\left[\frac{G2 - G1}{2L}\right]\left(\frac{L}{2}\right)^2 = y$$

$$= -(G2\text{-}G1)\,L/8$$

The co-ordinates of the highest/lowest point on the parabolic curve, frequently required for the estimation of minimum sight distance requirements, are:

$$x = \frac{L * G1}{G1 - G2} \qquad y = \frac{L * G1^2}{2(G1 - G2)}$$

FIELD STAKEOUT OF VERTICAL

Cures The stakeout of a vertical curve consists basically of marking the finished elevations in the field to guide the construction personnel. The method of setting a grade stake is the same whether it is on a tangent or on a curve, so a vertical curve introduces no special problem. As indicated before, stakes are sometimes set closer together on a curve than on a tangent. But that will usually have been foreseen, and the plans will show the finished grade elevations at the required stations. If, however, the field conditions do require a stake at an odd plus on a curve, you may compute the needed POVC elevation in the field using given on the plans and the computational explained in this chapter.

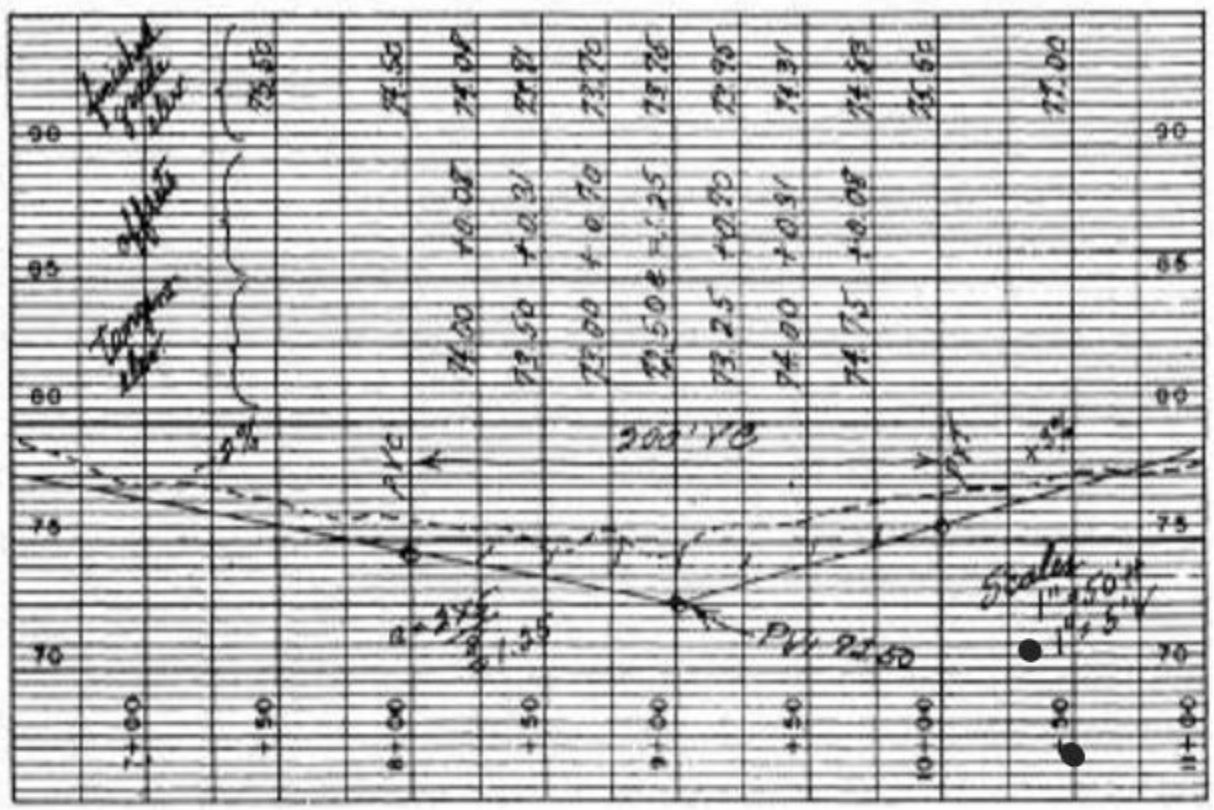


Figure 9 Profile work sheet.

3RD CHAPTER

BASICS OF SCALES & BASICS OF MAP

SCALES:

The ratio between the two points on map, plane or the photograph & the actual distance between the same two point on ground is called scale.

REPRESENTATIVE FRACTION OR RATIO SCALE OR FRACTION SCALE:

- A representative fraction indicates ratio between the number of units on the map to the number of units on the ground.
- RF is generally shown in fraction because show how much the real world is required to fit on the map.
- Ex.- Fraction of 1:24,000 show that 1 unit of length on map represent 24,000 of the same length on the ground i.e. mm, cm, inch.

LINEAR SCALE:

- A linear scale, also called a bar scale, scale bar, graphic scale, or graphical scale, is a means of visually showing the scale of a map, nautical chart, engineering drawing, or architectural drawing.
- A linear scale is a type of rating system that uses numbers to quantify feelings, levels of satisfaction, attitudes, and perceptions.
- It is divided in to primary & secondary scales.

MAP:

- A map is a symbolic representation of selected characteristics of a place, usually drawn on a flat surface. Maps present information about the world in a simple, visual way. They teach about the world by showing sizes and shapes of countries, locations of features, and distances between places. Maps can show distributions of things over Earth, such as settlement patterns. They can show exact locations of houses and streets in a city.

MAP SCALE:

- Map scale refers to the relationship (or ratio) between distance on a map and the corresponding distance on the ground. For example, on a 1:100000 scale map, 1cm on the map equals 1km on the ground.
- Map scale is often confused or interpreted incorrectly, perhaps because the smaller the map scale, the larger the reference number and vice versa. For example, a 1:100000 scale map is considered a larger scale than a 1:250000 scale map.
- On the basis of scales, map is divided in two types.
    - SMALL SCALE MAP
    - LARGE SCALE MAP

SMALL SCALE MAP:

A small scale map is a type of map in which a very large area like the whole country or continent or even the entire world can be represented on one sheet of paper. Scale of an actual region is reduced to a greater extent. For example: World map.

LARGE SCALE MAP:

Large scale maps show a smaller amount of area with a greater amount of detail. The geographic extent shown on a large scale map is small. A large scaled map expressed as a representative scale would have a smaller number to the right of the ratio. For example, a large scale map could have a RF scale of 1 : 1,000.

MAP PROJECTION:

- Map projection is the method of transferring the graticule latitude and longitude on a plane surface. It can also be defined as the transformation of spherical network of parallels and meridians on a plane surface. As you know that, the earth on which we live in is not flat.
- The globe is divided into various segments by the lines of latitude and longitude. The horizontal lines represent the parallels of latitude and the vertical lines represent the meridians of the longitude. The network of parallels and meridians is called graticule. This network facilitates drawing of maps. Drawing of the graticule on a flat surface is called projection.
- The need for a map projection mainly arises to have a detailed study of a region, which is not possible to do from a globe. Similarly, it is not easy to compare two natural regions on a globe.

HOW MAP CONVEY LOCTION & EXTENT:

- A map is a collection of map elements laid out and organized on a page. Common map elements include the map frame with map layers, a scale bar, north arrow, title, descriptive text, and a symbol legend. The primary map element is the map frame, and it provides the principal display of geographic information. Within the map frame, geographical entities are presented as a series of map layers that cover a given map extent—for example, map layers such as roads, rivers, place names, buildings, political boundaries, surface elevation, and satellite imagery. The following graphic illustrates how geographical elements are portrayed in maps through a series of map layers. Map symbols and text are used to describe the individual geographic elements.
- Map layers are thematic representations of geographic information, such as transportation, water, and elevation.
- Map layers help convey information through:

  - Discrete features such as collections of points, lines, and polygons
  - Map symbols, colors, and labels that help to describe the objects in the map
  - Aerial photography or satellite imagery that covers the map extent

- Continuous surfaces such as elevation which can be represented in a number of ways—for example, as a collection of contour lines and elevation points or as shaded relief.

SPECTICAL RELATIONSHIP IN A MAP:

Maps help convey geographic relationships that can be interpreted and analyzed by map readers. Relationships that are based on location are referred to as spatial relationships. Here are some examples.

- Which geographic features *connect* to others (for example, Water Street connects with 18th Ave.)
- Which geographic features are *adjacent* (contiguous) to others (for example, The city park is adjacent to the university.)Which geographic features are *contained within* an area (for example, The building footprints are contained within the parcel boundary.)
- Which geographic features *overlap* (for example, The railway crosses the freeway.)
- Which geographic features are *near* others (proximity) (for example, The Courthouse is near the State Capitol.)
- The feature geometry *is equal to* another feature (for example, The city park is equal to the historic site polygon).
- The *difference* in elevation of geographic features (for example, The State Capitol is uphill from the water.)
- The feature is *along* another feature (for example, The bus route follows along the street network.).

Within a map, such relationships are not explicitly represented. Instead, as the map reader, you interpret relationships and derive information from the relative position and shape of the map elements, such as the streets, contours, buildings, lakes, railways, and other features. In a GIS, such relationships can be modeled by applying rich data types and behaviors (for example, topologies and networks) and by applying a comprehensive set of spatial operators to the geographic objects (such as buffer and polygon overlay).

CLASSIFICATION OF MAPS:

PHYSICAL MAP:

- A physical map is one that documents landscape features of a place. These maps generally show things like mountains, rivers, and lakes.

Bodies of water are commonly shown in blue. Mountains and elevation changes are sometimes shown with different colors and shades to show elevation. On physical maps, greens usually indicate lower elevations while browns usually indicate higher elevations.

- This map of Hawaii is a physical map. Low elevation coastal regions are shown in dark green, while the higher elevations transition from orange to dark brown. Rivers are shown in blue

TOPOGRAPHICAL MAP:

- A topographic map is similar to a physical map in that it shows different physical landscape features. Unlike physical maps, though, this type of map uses contour lines instead of colors to show changes in the landscape.
- Contour lines on topographic maps are normally spaced at regular intervals to show elevation changes (e.g. each line represents a 100-foot elevation change). When lines are close together, it means the terrain is steep.

THEMATIC MAP:

- A thematic map is a map that focuses on a particular theme or special topic. These maps are different from the six aforementioned general reference maps because they do not just show features like rivers, cities, political subdivisions, elevation, and highways. If these items appear on a thematic map, they are background information and are used as reference points to enhance the map's theme.
- This Canadian map, for example, which shows changes in population between 2011 and 2016, is a good example of a thematic map. The city of Vancouver is broken down into regions based on the Canadian Census. Changes in the population are represented by a range of colours ranging from green (growth) to red (loss) based on the degree of change.

POLITICAL MAP:

- A political map does not show topographic features like mountains. It focuses solely on the state and national boundaries of a place. These maps also include the locations of cities large and small, depending on the detail of the maps.
- A typical example of a political map would be one showing the 50 U.S. states and their borders along with the United States' international borders.

ROAD MAP:

- A road map is one of the most widely used map types. These maps show major and minor highways and roads (depending on the degree of detail), as well as things like airports, cities, and points of interest such as parks, campgrounds, and monuments. Major highways on a roadmap are generally shown with thick, red lines, while minor roads are lighter in color and drawn with narrower lines.
- A road map of California, for example, would depict Interstate highways with a wide red or yellow line, while state highways would be shown in a narrower line in the same color. Depending on the level of detail, the map may also show county roads, major city arteries, and rural routes. These would be depicted in shades of gray or white.

CLIMATE MAP:

- A climate map shows information about the climate of an area. These maps can show things like the specific climatic zones of an area based on the temperature, the amount of snow an area receives, or the average number of cloudy days. These maps normally use colors to show different climatic areas.
- This climate map for Australia uses colors to show differences between the temperate area of Victoria and the desert region in the center of the continent.

ECONOMIC OR RESOURCE MAPS:

- An economic or resource map shows the specific types of economic activity or natural resources present in an area through the use of different symbols or colours depending on what is being depicted.
- This economic activity map for Brazil, for example, uses colours to show different agricultural products of given areas, letters for natural resources, and symbols for different industries.

4th CHAPTER
SURVEY OF INDIA
MAP SERIES

Survey Of India (SOI) brings out two series of map through the national map policy, 2005.

OPEN SERIES MAPS (OSM):

OSMs are brought out exclusively by SOI, primarily for supporting development activities in the country.

DEFENCE SERIES MAPS (DSM):

These topographical maps (on Everest/WGS-84 Datum and Polyconic/UTM Projection) are on various scales (with heights, contours and full content without dilution of accuracy). These maps mainly cater for defence and national security requirements. This series of maps (in analogue or digital forms) for the entire country are classified by the Ministry of Defence.

QUADRANGLE

The word quadrangle is **formed from two-word parts: the prefix quad–, meaning four, and –angle**. Quadrilateral and quadrangle are synonyms in geometry. Quadrilateral is also Latin, but it means "four sides." A very different word, tetragon, comes from Greek origins but also means a four-sided shape.

LATITUDE, LONGITUDE, UTM's

- Latitudes are horizontal lines that measure distance north or south of the equator. Longitudes are vertical lines that measure east or west of the meridian in Greenwich, England. Together, latitude and longitude enable cartographers, geographers and others to locate points or places on the globe.
- UTM Provides a constant distance relationship anywhere on the map. In angular coordinate systems like latitude and longitude, **the distance covered by a degree of longitude differs as you move towards the poles and only equals the distance covered by a degree of latitude at the equator**.
- **Instead of using latitude and longitude coordinates**, each 6° wide UTM zone has a central meridian of 500,000 meters. This central meridian is an arbitrary value convenient for avoiding any negative easting coordinates.

CONTOUR LINE:

A contour line of a function of two variables is a curve along which the function has a constant value, so that the curve joins points of equal value. It is a plane section of the three-dimensional graph of the function f parallel to the-plane.

Magnetic Declination

At most places on the Earth's surface, the compass doesn't point exactly toward geographic north. The deviation of the compass from true north is an angle called "declination" (or "magnetic declination").

PUBLIC LAND SURVEY SYSTEM:

The Public Land Survey System (PLSS) is the surveying method developed and used in the United States to plat, or divide, real property for sale and settling. Also known as the Rectangular Survey System, it was created by the Land Ordinance of 1785.

There are two separate and distinct systems of land surveys in the United States:

- System of metes and bounds in which each parcel of land is individually described and bounded
- System of rectangular surveys under which the land is divided basically into equal-sized townships, sections, and fractions thereof.

FIELD NOTES:

Field notes are prepared to record all pertinent information, measurements, calculations, sketches, and observations made by the surveyor during the course of a survey. These notes become the permanent record of the survey.

5TH CHAPTER

BASICS OF AERIAL PHOTOGRAPHY, PHOTOGRAMMETRY, DEM AND ORTHO IMAGE GENERATION

AERIAL PHOTOGRAPHY:

An aerial photograph, in broad terms, is **any photograph taken from the air**. Normally, air photos are taken vertically from an aircraft using a highlyaccurate camera.

aerial photographs are classified into the following types :

- **Vertical photographs**
- **Low oblique photographs**
- **High oblique photographs**

We are familiar with photographs taken with normal cameras. These photographs provide us with a view of the object similar to the way we see them with our own eyes. In other words, we get a horizontal perspective of the objects photographed. For example, a photograph of a part of settlement will provide us a perspective the way it appears to us when we look at it.

Suppose we want to take a 'bird's eye view' of similar features, then we have to place ourselves somewhere in the air. When we do so and look down, we get a very different perspective. This perspective, which we get in aerial photographs, is termed as aerial perspective. The photographs taken from an aircraft or helicopter using a precision camera are termed aerial photographs.

GLOSSARY

Aerial Camera : A precision camera specifically designed for use in aircrafts.

Aerial Film : A roll film with high sensitivity, high intrinsic resolution power and dimensionally stable emulsion support.

Aerial Photography : Art, science and technology of taking aerial photographs from an air-borne platform.

Aerial Photograph : A photograph taken from an air-borne platform using a precision camera.

Fiducial Marks : Index marks, rigidly connected at the central or corner edges of the camera body. When the film is exposed, these marks appear on the film negative .

Forward Overlap : The common area on two successive photographs in the flight direction. It is usually expressed in per cent.

Image Interpretation : An act of identifying the images of the objects and judging their relative significance.

Nadir Point : The foot of the perpendicular drawn from the camera lens centre on the ground plane.

Principal Point : The foot of the perpendicular drawn from the camera lens centre on the photo plane.

Principal Distance : The perpendicular distance from the perspective centre to the plane of the photograph. Perspective Centre : The point of origin (perspective centre) of the bundle of light rays.

Photogrammetry : The science and technology of taking reliable measurements from aerial photographs.

Photogrammetry Photogrammetric surveying or photogrammetry is **the branch of surveying in which maps are** prepared from photo-graphs taken from ground or air stations. O With anadvancement of the photogrammetric techniques, photographs are also being used for the interpretation of geology, classification of soils and crops,etc.

CLASSIFICATION OF PHOTOGRAMMETRY

Two general types of photogrammetry exist:

- aerial (with the camera in the air)
- terrestrial (with the camera handheld or on a tripod)

AERIAL PHOTOGRAMMETRY

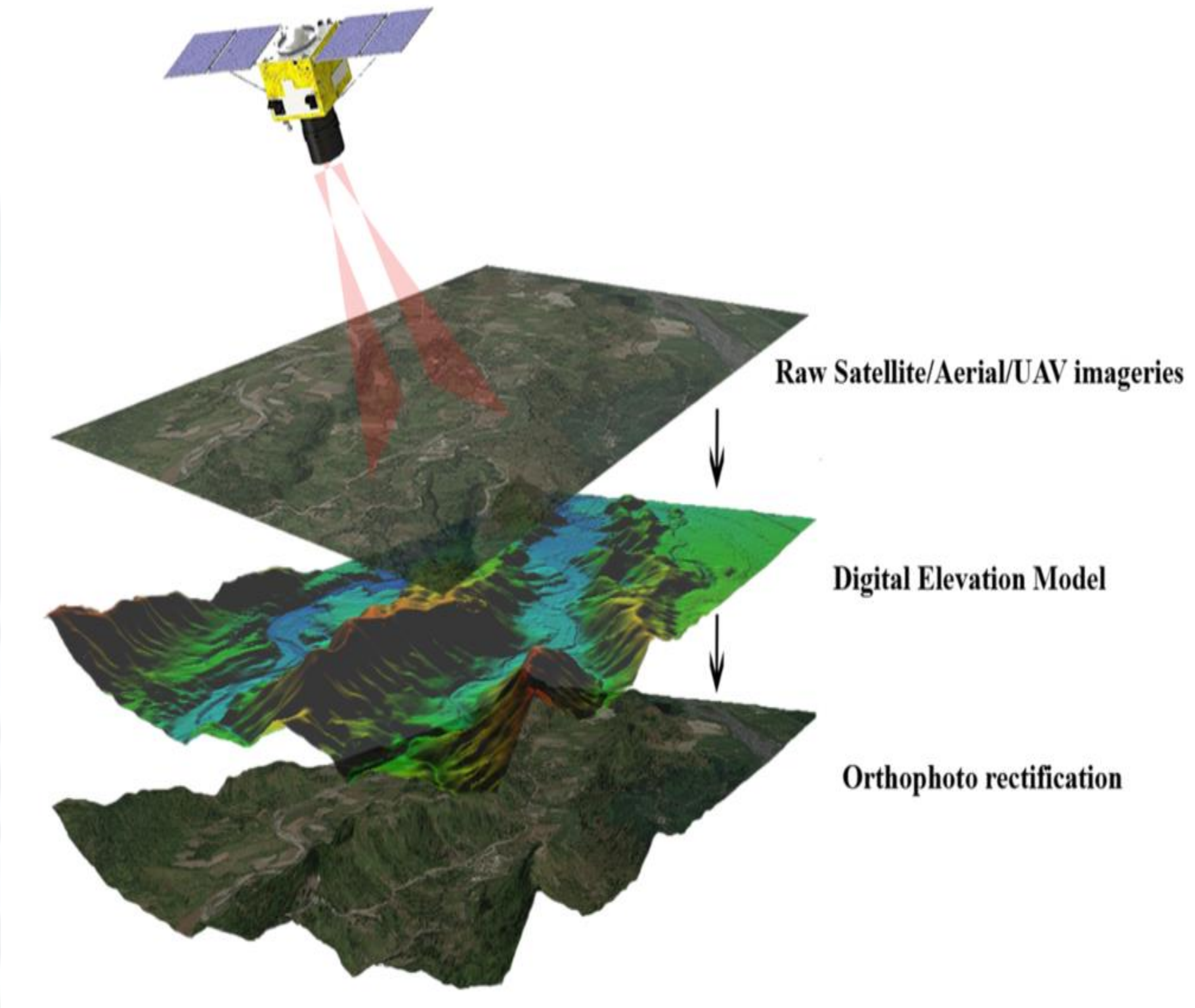
Aerial surveying, also known as photogrammetry, is a method used to survey land that would be impossible or impractical to survey on the ground. In recent decades, advancements in GPS tracking and photoimaging technology have allowed this practice to flourish.

TERRESTRIAL PHOTOGRAMMETRY

The purpose of the terrestrial photogrammetric survey is to provide precise data on the shape, size and position of a specific structure or monument, at a given time, for evaluating its actual conditions and architectonic aspects. There can be differentiated two types of surveys: General surveys and detailed surveys.

ORTHO IMAGE GENERATION

An orthophoto, orthophotograph or orthoimage is an aerial photograph /satellite images/drone images or image geometrically corrected ("orthorectified") such that the scale is uniform: the photo has the same lack of distortion as a map. Unlike an uncorrected aerial photograph, an orthophotograph can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

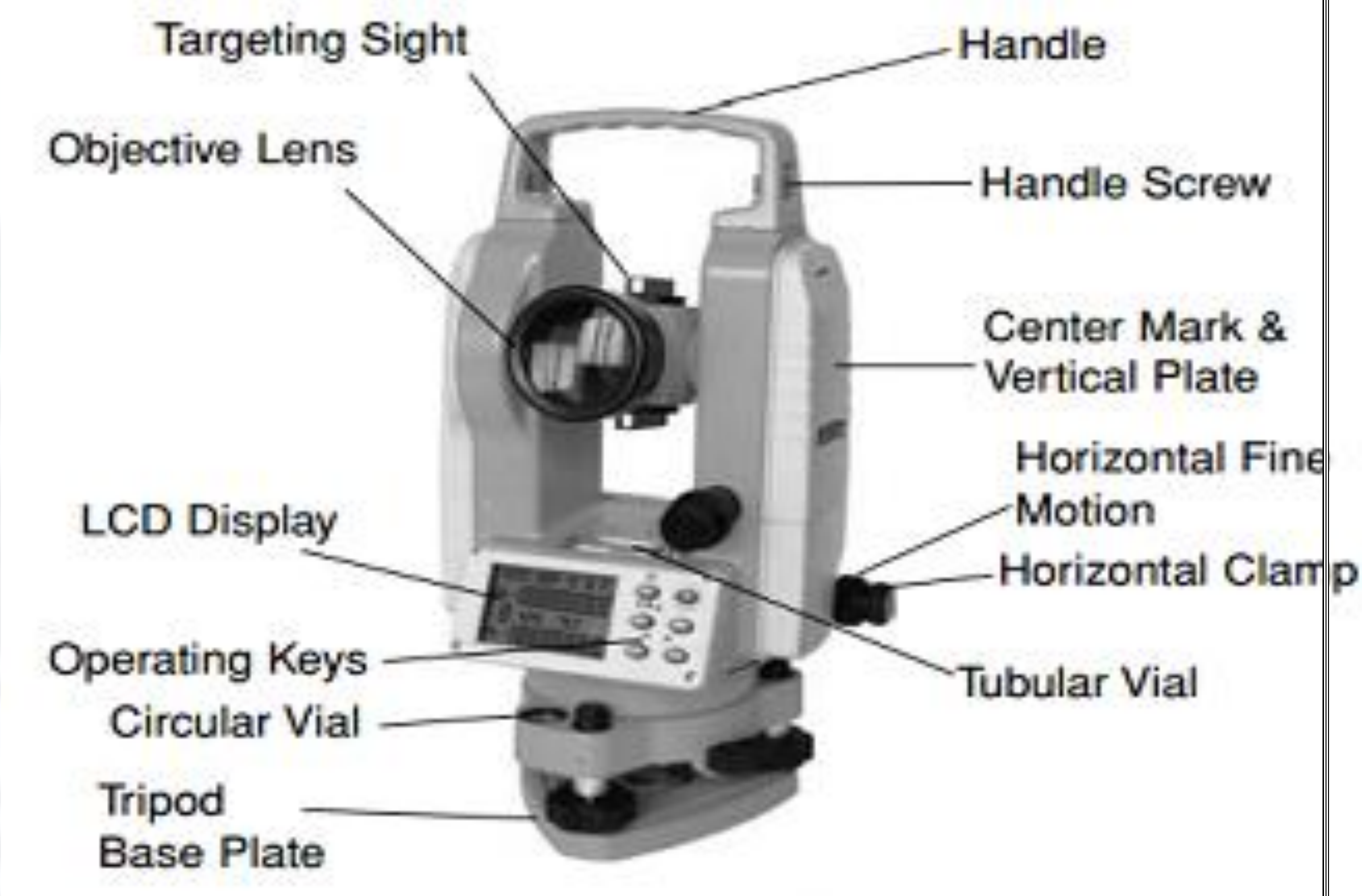

Raw Satellite/Aerial/UAV imageries
Digital Elevation Model
Orthophoto rectification

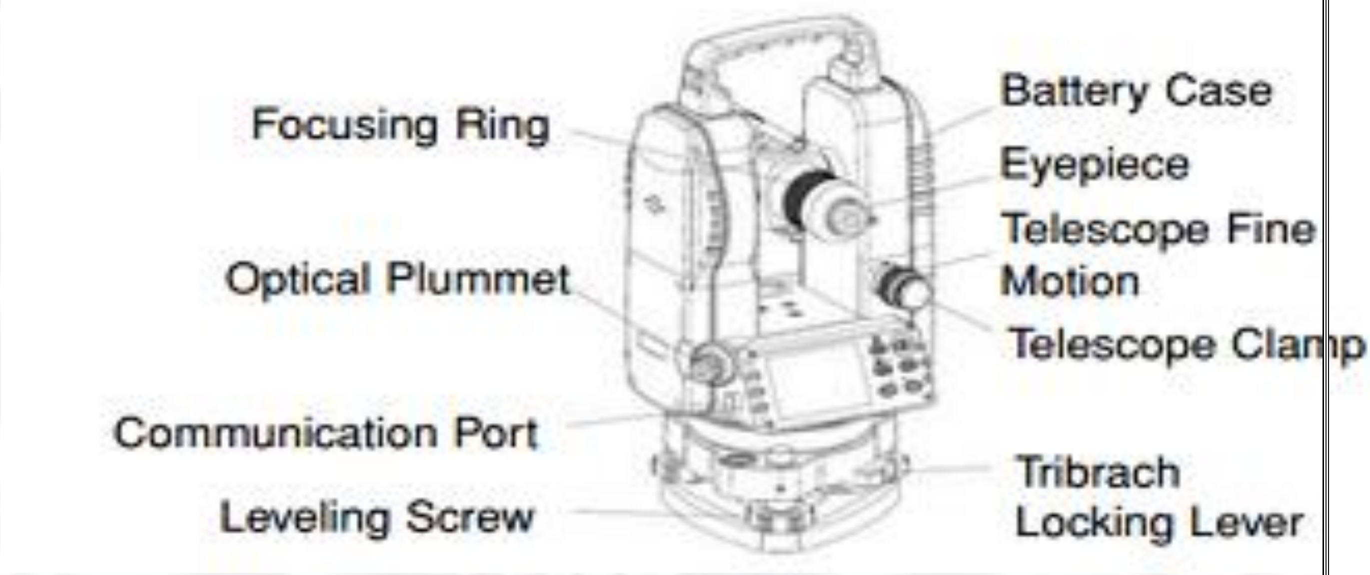
6^{TH} CHAPTER

MODERN SURVEYING METHODS

TOTAL STATION:

This is an electronic instrument. In this instrument, all the parameters required to be observed during surveying can be obtained. The value of observation gets displayed in a viewing panel. The precision of this type of instrument varies in the order of 0.1" to 10". Total station surveying - defined as the use of electronic survey equipment used to perform horizontal and vertical measurements in reference to a grid system. It is also a form of an electronic theodolite combined with an electronic distance measuring device (EDM).





- These instruments can record horizontal and vertical angles together with slope distance and can be considered as combined EDM plus electronic theodolite. The microprocessor in TS can perform various mathematical operations such as averaging, multiple angle and distance measurements, horizontal and vertical distances, X, Y, Z coordinates, distance between observed points and corrections for atmospheric and instrumental corrections.

- Due to the versatility and the lower cost of electronic components, future field instruments will be more like total stations that measure angle and distance simultaneously having:
    - all capabilities of theodolites
    - electronic recording of horizontal and vertical angles
    - Storage capabilities of all relevant measurements (spatial and non-spatial attribute data) for manipulation with computer.
    - Nowadays surveying systems are available which can be use in an integrated manner with Global Positioning System (GPS). Hence, future theodolites/total stations may have integrated GPS receivers as part of the measurement unit.

ADVANTAGES OF TOTAL STATION:

- Relatively quick collection of information
- Multiple surveys can be performed at one set-up location.
- Easy to perform distance and horizontal measurements with simultaneous calculation of project coordinates (Northings, Eastings, and Elevations).
- Layout of construction site quickly and efficiently.
- Digital design data from CAD programs can be uploaded to data collector.
- Daily survey information can also be quickly downloaded into CAD which eliminates data manipulation time required using conventional survey techniques.

DISADVANTAGES OF TOTAL STATION:

- Vertical elevation accuracy not as accurate as using conventional survey level and rod technique. Horizontal coordinates are calculated on a rectangular grid system.
- However, the real world should be based on a spheroid and rectangular coordinates must be transformed to geographic coordinates if projects are large scale. Examples: highways, large buildings, etc.
- As with any computer-based application "Garbage in equals Garbage out". However, in the case of inaccurate construction surveys "Garbage in equals lawsuits and contractors claims for extras."

FIELD TECHNIQUES WITH TS:

Various field operations in TS are in the form of wide variety of programs integrated with microprocessor and implemented with the help of data collector. All these programs need that the instrument station and at least one reference station be identified so that all subsequent stations can be identified in terms of (X, Y, Z).

Typical programs include the following functions:

- Point location
- Slope reduction
- Missing line measurement (MLM)
- Resection
- Azimuth calculation
- Remote distance and elevation measurement
- Offset measurements
- Layout or setting out operation
- Area computation

FUNCTIONS PERFORMED BY TOTAL STATIONS

Total Stations, with their microprocessors, can perform a variety of functions and computations, depending on how they are programmed. The capabilities vary with different instruments, but some standard computations include:

- Averaging multiple angle and distance measurements.
- Correcting electronically measured distances from prism constant, atmospheric pressure, and temperature. Making curvature and refraction corrections to elevations determine by trigonometric levelling.
- Reducing slope distances to their horizontal and vertical components. Calculating point elevations from the vertical distance components (supplemented with keyboard input of instrument and reflector heights). Computing coordinates of survey points from horizontal angle and horizontal distance.
    - Averages multiple angle measurements.
    - Averages multiple distance measurements.
    - Computes horizontal and vertical distances.
    - Corrections for temp, pressure and humidity.
    - Computes inverses, polars, resections.
    - Computes X, Y and Z coordinates.

APPLICATIONS OF TOTAL STATION

- There are many other facilities available, the total station can be used for the following purposes.
- Detail survey i.e., data collection.
- Control Survey (Traverse).
- Height measurement (Remove elevation measurement- REM).
- Fixing of missing pillars (or) Setting out (or) Stake out.

- Resection.
- Area calculations, etc.
- Remote distance measurement (RDM) or Missing line measurement (MLM).

7TH CHAPTER
BASICS ON GPS & DGPS AND ETS

GPS:

The global positioning system (GPS) is a network of satellites and receiving devices used to determine the location of something on Earth. Some GPS receivers are so accurate they can establish their location within one centimeter (0.4 inches). GPS receivers provide location in latitude, longitude, and altitude.

THERE ARE FIVE MAIN USES OF GPS:

- Location — Determining a position.
- Navigation — Getting from one location to another.
- Tracking — Monitoring object or personal movement.
- Mapping — Creating maps of the world.
- Timing — Making it possible to take precise time measurements.

THE TYPES OF GPS SYSTEMS INCLUDE:

- A-GPS. Assisted GPS (A-GPS) is a type of GPS that allows receivers to get information from local network sources, which helps in the location of satellites. ...
- S-GPS. ...
- D-GPS. ...
- Non-differential GPS. ...
- Mapping and non-mapping GPS.

WORKING PRINCIPLE OF GPS,GPS SIGNALS:

- The system of GPS consists of three main parts, including the GPS satellites, the control system, and the control system.

- The satellites have covered virtually every corner of the earth.No matter where you are,at least four GPS satellites can be visible at any time.
- Everyone regularly transmits information about their location and real-time. These signals that are traveling at the speed of light are intercepted by the GPS receiver, and the GPS receiver calculates the distance of each satellite from us based on the length of time the information arrives.
- What a GPS receiver does is locate the four or more satellites and calculate the distance between each one of them. Using this information the GPS tracking system in our car or other devices finds out its current location. The information is presented as maps, latitude And longitude specification, etc.
- Once you have information about the distance between you and the three satellites, the GPS receiver can use a method called trilateration to determine your position. It is easy to understand this for the people who have learned math.

THE APPLICATION OF GPS TECHNOLOGY

- GPS technology can be applied to many fields, such as car navigation, military weapons and security.
- To learn more about the application of GPS technology, you can read the article: https://grindgis.com/gps/50-uses-or-applications-of-gps
  You will know 50 Uses or Applications of GPS technology
- *GPS tracker is also the one of application of GPS technology ,which is a combination of software technology and GPS technology.*

HOW TO SOLVE THE PROBLEM OF WEAK GPS SATELLITE SIGNALS

- As we use GPS technology more and more in our daily lives, many derivative technologies have been born.
- Now we can solve this problem of weak GPS satellite signals very well , we can install the GPS receiver where the GPS signal is weak.
- GPS receiver can enhance the ability to receive GPS signals. So It can capture the very weak GPS signals.

Disadvantages of GPS:

Even though GPS technology brings us greater convenience, it still has some limitations.

GPS satellite signals are too weak when compared to phone signals, so it doesn't work as well indoors, underwater, under trees, etc. The highest accuracy requires line-of-sight from the receiver to the satellite, this is why GPS doesn't work very well in an urban environment.

8TH CHAPTER
BASICS OF GIS AND MAP PREPARATION USING GIS

GEOGRAPHICAL INFORMATION SYSTEM (GIS)

Introduction: A large variety of information systems are available for various applications. Figure given below describes different types of such systems. This module will focus on Geographical Information System (GIS), one of the important spatial information systems with a capability to handle spatial information (information distributed in space).

DEFINITIONS

- A powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world.
- A system for capturing, storing, checking, manipulating, analysing, and displaying data which are spatially referenced to earth.
- An information technology which stores, analyses, and displays both spatial and nonspatial data.
- An automated set of functions that provides professionals with advanced capabilities for the storage, retrieval, manipulation and display of geographically located data.
- An institutional entity, reflecting an organisational structure that integrates technology with a database, expertise, and continuing financial support over time.
- A decision support system involving the integration of spatially referenced data in a problem solving environment
- An information system that is designed to work with data referenced by spatial or geographic co-ordinates. In other words, a GIS is both a database system with specific capabilities for spatially-referenced data,

as well as a set of operations for working with the data. In a sense, a GIS may be thought of as a higher-order map.

- A system of hardware and software that links mapped objects with text information that describes them and provides tools for the storage, retrieval and manipulation of both types of data.
- A system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis, and display of spatially referenced data for solving complex planning and management problems.
- A system that contains spatially referenced data that can be analysed and converted to information for a specific set of purposes, or application. The key feature of a GIS is the analysis of data to produce new information.

WHY GIS IS REQUIRED:

Use of GIS is advocated on account of following observations:

- Poorly maintained geospatial data
- Out of date maps and statistics.
- Inaccurate data and information.
- Absence of data retrieval service.
- Absence of data sharing.
- Digital format data is compact and large quantities can be maintained and retrieved at a greater speed and lesser cost.
- Planning scenarios, decision models and interactive process are normal functions of GIS.
- Ability to perform complex spatial analysis rapidly.
- Ability to manipulate different types of data efficiently.

BENEFITS OF GIS:

- Geospatial data better maintained in a standard format.
- Revision and updating easier.
- Geospatial data and information easier to search, analyze and represent.
- Value added products can be generated.
- Geospatial data can be shared and exchanged freely.
- Productivity and efficiency of staff is improved.
- Saving in time and money.
- Better decisions making

APPLICATION OF GIS:

1. GIS IN MAPPING: Mapping is a central function of Geographic Information System, which provides a visual interpretation of data. GIS store data in database and then represent it visually in a mapped format. People from different professions use map to communicate. It is not necessary to be a skilled cartographer to create maps. Google map, Bing map, Yahoo map are the best example for web based GIS mapping solution.

2. TELECOM AND NETWORK SERVICES: GIS can be a great planning and decision making tool for telecom industries. GDi GISDATA enables wireless telecommunication organizations to incorporate geographic data in to the complex network design, planning, optimization, maintenance and activities. This technology allows telecom to enhance a variety of application like engineering application, customer relationship management and location based services.

3. ACCIDENT ANALYSIS AND HOT SPOT ANALYSIS: GIS can be used as a key tool to minimize accident hazard on roads, the existing road network has to be optimized and also the road safety measures have to be improved. This can be achieved by proper traffic management. By identifying the accident locations,

remedial measures can be planned by the district administrations to minimize the accidents in different parts of the world. Rerouting design is also very convenient using GIS.

4. URBAN PLANNING: GIS technology is used to analyze the urban growth and its direction of expansion, and to find suitable sites for further urban development. In order to identify the sites suitable for the urban growth, certain factors have to consider which is: land should have proper accessibility, land should be more or less flat, land should be vacant or having low usage value presently and it should have good supply of water.

5. TRANSPORTATION PLANNING: GIS can be used in managing transportation and logistical problems. If transport department is planning for a new railway or a road route then this can be performed by adding environmental and topographical data into the GIS platform. This will easily output the best route for the transportation based on the criteria like flattest route, least damage to habitats and least disturbance from local people. GIS can also help in monitoring rail systems and road conditions.

6. ENVIRONMENTAL IMPACT ANALYSIS: EIA is an important policy initiative to conserve natural resources and environment. Many human activities produce potential adverse environmental effects which include the construction and operation of highways, rail roads, pipelines, airports, radioactive waste disposal and more. Environmental impact statements are usually required to contain specific information on the magnitude and characteristics of environmental impact. The EIA can be carried out efficiently by the help of GIS, by integrating various GIS layers, assessment of natural features can be performed.

7. AGRICULTURAL APPLICATIONS: GIS can be used to create more effective and efficient farming techniques. It can also analyze soil data and to determine: what are the best crop to plant?, where they should go? how to maintain

nutrition levels to best benefit crop to plant?. It is fully integrated and widely accepted for helping government agencies to manage programs that support farmers and protect the environment. This could increase food production in different parts of the world so the world food crisis could be avoided.

8. DISASTER MANAGEMENT AND MITIGATION: Today a well-developed GIS systems are used to protect the environment. It has become an integrated, well developed and successful tool in disaster management and mitigation. GIS can help with risk management and analysis by displaying which areas are likely to be prone to natural or man-made disasters. When such disasters are identified, preventive measures can be developed.

9. LANDSLIDE HAZARD ZONATION USING GIS: Landslide hazard zonation is the process of ranking different parts of an area according to the degrees of actual or potential hazard from landslides. The evaluation of landslide hazard is a complex task. It has become possible to efficiently collect, manipulate and integrate a variety of spatial data such as geological, structural, surface cover and slope characteristics of an area, which can be used for hazard zonation. The entire above said layer can well integrate using GIS and weighted analysis is also helpful to find Landslide prone area. By the help of GIS we can do risk assessment and can reduce the losses of life and property.

10. DETERMINE LAND USE/LAND COVER CHANGES: Land cover means the feature that is covering the barren surface .Land use means the area in the surface utilized for particular use. The role of GIS technology in land use and land cover applications is that we can determine land use/land cover changes in the different areas. Also it can detect and estimate the changes in the land use/ land cover pattern within time. It enables to find out sudden changes in land use and land cover either by natural forces or by other activities like deforestation.

11. NAVIGATION (ROUTING AND SCHEDULING): Web-based navigation maps

encourage safe navigation in waterway. Ferry paths and shipping routes are identified for the better routing. ArcGIS supports safe navigation system and provides accurate topographic and hydrographic data. Recently DNR, s Coastal Resources Division began the task of locating, documenting, and cataloging these no historic wrecks with GIS. This division is providing public information that make citizens awareness of these vessel locations through web map. The web map will be regularly updated to keep the boating public informed of these coastal hazards to minimize risk of collision and injury.

12. FLOOD DAMAGE ESTIMATION: GIS helps to document the need for federal disaster relief funds, when appropriate and can be utilized by insurance agencies to assist in assessing monetary value of property loss. A local government need to map flooding risk areas for evaluate the flood potential level in the surrounding area. The damage can be well estimate and can be shown using digital maps.

13. NATURAL RESOURCES MANAGEMENT: By the help of GIS technology the agricultural, water and forest resources can be well maintain and manage. Foresters can easily monitor forest condition. Agricultural land includes managing crop yield, monitoring crop rotation, and more. Water is one of the most essential constituents of the environment. GIS is used to analyze geographic distribution of water resources. They are interrelated, i.e. forest cover reduces the storm water runoff and tree canopy stores approximately 215,000 tons carbon. GIS is also used in afforestation.

14. GIS SOLUTIONS IN BANKING SECTOR: Today rapid development occurs in the banking sector. So it has become more market driven and market responsive. The success of this sector largely depends on the ability of a bank to provide customer and market driven services. GIS plays an important role providing planning, organizing and decision making.

15. SOIL MAPPING: Soil mapping provides resource information about an area.

It helps in understanding soil suitability for various land use activities. It is essential for preventing environmental deterioration associated with misuse of land. GIS Helps to identify soil types in an area and to delineate soil boundaries. It is used for the identification and classification of soil. Soil map is widely used by the farmers in developed countries to retain soil nutrients and earn maximum yield.

16. GIS BASED DIGITAL TAXATION: In Local Governments, GIS is used to solve taxation problems. It is used to maximize the government income. For example, for engineering, building permits, city development and other municipal needs, GIS is used. Often the data collected and used by one agency or department can be used by another. Example Orhitec ltd can supply you with a system to manage property tax on a geographic basis that can work interactively with the municipal tax collection department. Using GIS we can develop a digital taxation system.

17. LAND INFORMATION SYSTEM: GIS based land acquisition management system will provide complete information about the land. Land acquisition managements is being used for the past 3 or 4 years only. It would help in assessment, payments for private land with owner details, tracking of land allotments and possessions identification and timely resolution of land acquisition related issues.

18. SURVEYING: Surveying is the measurement of location of objects on the earth's surfaces. Land survey is measuring the distance and angles between different points on the earth surface. An increasing number of national and governments and regional organizations are using GNSS measurements. GNSS is used for topographic surveys where a centimeter level accuracy is provided. These data can be incorporated in the GIS system. GIS tools can be used to estimate area and also, digital maps can prepared.

19. WETLAND MAPPING: Wetlands contribute to a healthy environment and

retain water during dry periods, thus keeping the water table high and relatively stable. During the flooding they act to reduce flood levels and to trap suspended solids and attached nutrients. GIS provide options for wetland mapping and design projects for wetland conservation quickly with the help of GIS. Integration with Remote Sensing data helps to complete wetland mapping on various scale. We can create a wetland digital data bank with spices information using GIS.

20. GIS APPLICATIONS IN GEOLOGY: Geologists use GIS in a various applications. The GIS is used to study geologic features, analyze soils and strata, assess seismic information, and or create three dimensional (3D) displays of geographic features. GIS can be also used to analyze rock information characteristics and identifying the best dam site location.

21. DETECTION OF COAL MINE FIRES: GIS technology is applied in the area of safe production of coal mine. Coal mine have developed an information management system, the administrators can monitor the safe production of coal mine and at the same time improve the abilities to make decisions. Fire happens frequently in coal mines. So it can assessed spontaneous combustion risk using GIS tools.(Kun Fang, GIS Network Analysis in Rescue of Coal Mine)

22. ASSETS MANAGEMENT AND MAINTENANCE: GIS helps organizations to gain efficiency even in the face of finite resources and the need to hold down the cost. Knowing the population at risk enables planners to determine where to allocate and locate resources more effectively.

23. GIS FOR PLANNING AND COMMUNITY DEVELOPMENT: GIS helps us to better understand our world so we can meet global challenges. Today GIS technology is advancing rapidly, providing many new capabilities and innovations in planning. By applying known part of science and GIS to solve unknown part, that helps to enhance the quality of life and achieve a better future. Creating and applying GIS tools and knowledge allow us integrating

geographic intelligence into how we think and behave.

24. GIS IN DAIRY INDUSTRY: Geographic Information System is used in a various application in the dairy industry, such as distribution of products, production rate, location of shops and their selling rate. These can be monitored by using GIS system. It can be also possible to understand the demand of milk and milk products in different region. GIS can prove to be effective tool for planning and decision making for any dairy industry. These advantages has added new vistas in the field of dairy farm and management.

25. TOURISM INFORMATION SYSTEM: GIS provides a valuable toolbox of techniques and technologies of wide applicability to the achievement of sustainable tourism development. This provide an ideal platform tools required to generate a better understanding, and can serve the needs of tourists. They will get all the information on click, measure distance, find hotels, restaurant and even navigate to their respective links. Information plays a vital role to tourists in planning their travel from one place to another, and success of tourism industry. This can bring many advantages for both tourist and tourism department.

26. IRRIGATION WATER MANAGEMENT: Water availability for irrigation purposes for any area is vital for crop production in that region. It needs to be properly and efficiently managed for the proper utilization of water. To evaluate the irrigation performance, integrated use of satellite remote sensing and GIS assisted by ground information has been found to be efficient technique in spatial and time domain for identification of major crops and their conditions, and determination of their areal extent and yield. Irrigation requirements of crop were determined by considering the factors such as evapotranspiration, Net Irrigation Requirement, Field irrigation Requirement, Gross Irrigation Requirement, and month total volume of water required, by organizing them in GIS environment.