NARAYANI INSTITUTE OF ENGINEERING & TECHNOLOGY
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4th Semester, Mining Engineering

Theory – 2

Sub: - Mine Survey-II

Chapter – Curves

CURVES

INTRODUCTION

Curves are generally used on highway and railway where it is necessary to change the direction of motion.

When two straights of a highway or railway are at same angle each other, a curve is introduced between them to avoid an abrupt change in direction and to make the vehicle move safely, smoothly and comfortably. A curve is provided at the intersection of the two straights to effect a gradual change in the direction. This change in direction of the straights may be in a horizontal or a vertical plane, resulting in the provision of a **horizontal** or a **vertical** curve, respectively.

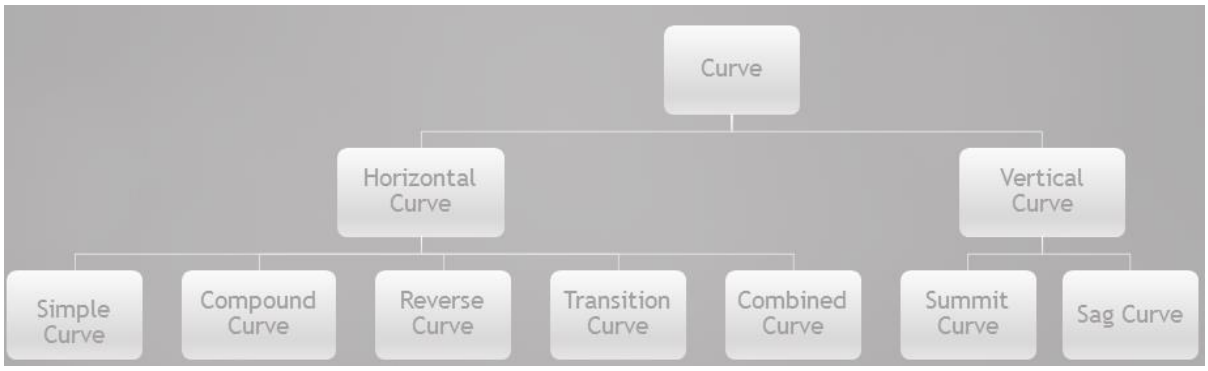
HORIZONTAL CURVE

A horizontal curve is provided at the point where the two straight lines intersect in the horizontal plane. When the curve is provided in the horizontal plane, it is known as a horizontal curve. The horizontal curves are further classified as simple circular, compound, reverse, transition and combined curves.

VERTICAL CURVE

A vertical curve is provided at the point where the two straight lines at different gradients intersect in the vertical plane. In such a case, a parabolic curved path is provided in the vertical plane in order to connect the gradients for easy movement of the vehicles. Vertical curves are usually parabolic and are classified as summit and sag vertical curve.

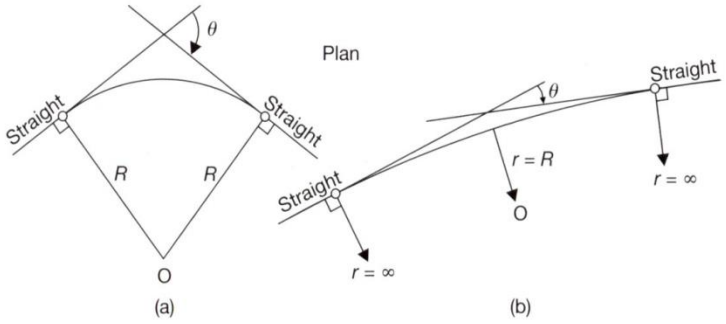
Different Forms of Curves



- **There are mainly two types of horizontal curves :**

1. circular curves - curves of constant radius.

2. Transition curves - curves of varying radius.



Horizontal curves: (a) circular curve; (b) transition curve.

CIRCULAR CURVES :

There are 3 basic types of circular curves:

1. Simple Circular Curves :

A simple circular curve consists of one are of constant radius R, these are the most commonly used type of curves

2. Compound Circular Curves :

These consist of two or more consecutive simple circular curves of different radii without and intervening straight section.

3. Reverse Circular Curves :

These consist of two consecutive curves of the same or different radii with any intervening straight section and with their centres of curvature falling on opposite sides of their common tangent point (TC).

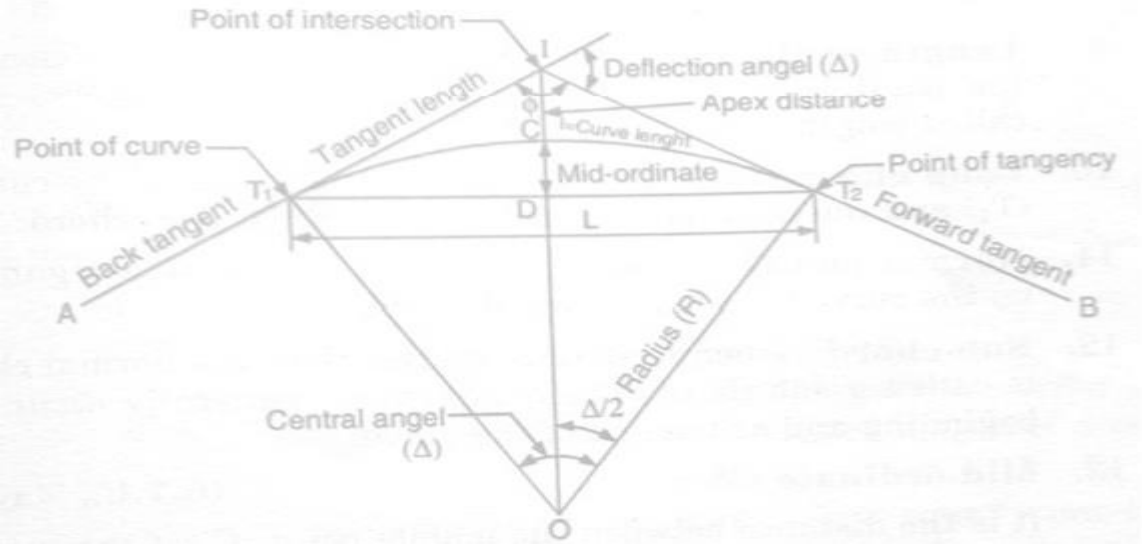
Designation of curve :

The sharpness of the curve is designated by two ways.

(1) By radius (R)

(2) By Degree of Curvature (D)

Notations for curve :



1) Back tangent or First Tangent - AT_1 – Pervious to the curve

2) Forward Tangent or Second tangent- B T_2 - Following the curve.

3) Point of Intersection (P.I.) or Vertex. (v)

If the tangents AT_1 and BT_2 .are produced they will meet in a point called the point of Intersection

4) Point of curve (P.C.) –Beginning Point T_1 of a curve. Alignment changes from a tangent to curve.

5) Point of Tangency - PT – End point of curve (T_2) is called..

6) Intersection Angle (Ø) - The Angle AVB between tangent AV and tangent VB is called...

7) Deflection Angle (Δ) The angle at P.I. between tangent AV and VB is called..

8) Tangent Distance – It is the distance between P.C. and P.I.

9) External Distance – CI -The distance from the mid point of the curve to P.I. It is also called the apex distance.

10) Length of curve – l -It is the total length of curve from P.C. to P.T.

11) Long chord : – It is the chord joining P.C. to P.T., T_1 T_2 is a long chord.

12) Normal Chord: A chord between two successive regular station on a curve is called normal chord. Normally , the length of normal chord is 1 chain (2o mt).

13) Sub chord -The chord shorter than normal chord (shorter than 20 mt) is called sub chord)

14) Versed sine – Distance CD- The distance between mid point of long chord (D) and the apex

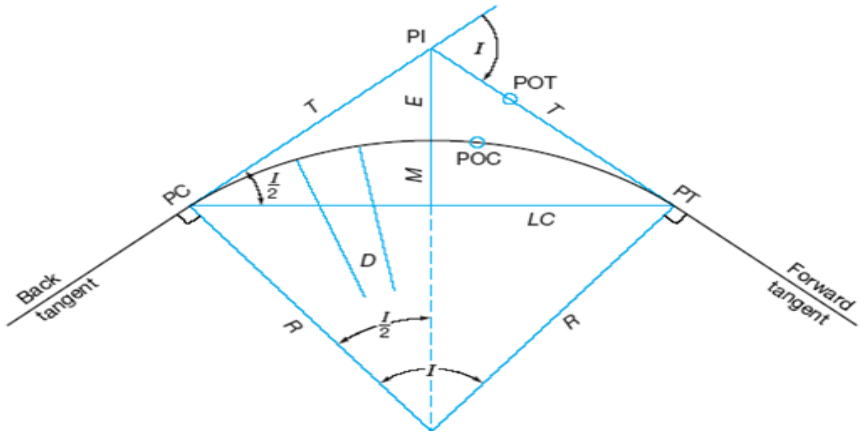
point C, is called versed sine. It is also called mid- ordinate (M).

15) Right hand curve: If the curve deflects to the right of the direction of the progress of survey.

16) Left hand curve-If the curve deflects to the left of the direction of the progress of survey.

OR

Simple Circular Curve



Elements of a simple circular curve

1. **Back tangent :** The tangent line before the beginning of the curve is called the back tangent or the rear tangent. The line AT1 is the back tangent.
2. **Forward tangent :** The tangent line after the end of the curve is called the forward tangent. The line T2B is the forward tangent.
3. **Point of Intersection (PI) :** The point I where the back tangent when produce forward and forward tangent when produced backward meet, is called the point of intersection.
4. **Intersection angle (I) :** The angle between the back tangent AT1 and the forward tangent T2B at I is called the intersection angle.
5. **External distance (E) :** It is the distance between the point of intersection and the middle point of the curve.
6. **Angle of Deflection (Δ) :** The angle Δ through which the forward tangent deflects is called deflection angle of the curve. It may be either to the left or the right.
7. **Point of curvature (P.C.) :** It is the point on the back tangent at the beginning of the curve, where the alignment changes from a tangent to a curve. The point of curvature is also called the point of curve. (T1)
8. **Point of Tangency (P.T.) :** It is the point on the forward tangent at the end of the curve where the alignment changes from a curve to a tangent. (T2)
9. **Tangent distance (T) :** It is the distance between the point of curvature (T1) and the point of inter
10. **Length of the curve (*l*) :** The total length of the curve from the point of curvature (T_1) to the point of tangency (T_2), is called length of curve.
11. **Long chord (L) :** The chord joining the point of the curvature (T_1) and the point of tangency (T_2), is called a long chord.
12. **Normal chord :** A chord between two successive regular pegs on the curve, is called a normal chord.

13. Sub-chord : When a chord is shorter than the normal chord, it is called a sub-chord.
14. **Mid-ordinate (M) :** it is the distance between the middle point (C) of the curve and the middle point (D) of the long chord.
15. **Right-hand curve :** If the curve deflects to the right of the direction of the progress of survey, it is called the right-hand curve.
16. **Left-hand curve :** If the curve deflects to the left of the direction of the progress of survey, it is called the left-hand curve.

Location Of Tangent Points

- Before setting out the curve, the surveyor is always supplied with a working plan upon which the general alignment of the tangent is marked.
- Knowing offsets to certain points on the both the tangents, the tangents can be staked on the ground by the tape measurements
- Both the tangents AV and BV, intersect at point V, known as the point of intersection.
- Set the theodolite at V and measure angle AVB = Φ.
- Therefore Deflection angle = Δ = 180 – Φ , Or angle Δ can be directly measured by theodolite.
- Calculate the tangent length= T = R tan Δ/ 2
- Now select point T1 on line AV at distance T from V, Similarly, select point T2 on line BV at distance T from V.

Chainage Of Tangents

- The Distance of any point from the beginning of the chain line is called chainge of that point.
- Point A Is the starting point of chain line. Chainage of Points, V, B, D are mesured from point A.
- Chainage of T1 = chainage of V – T (Tangent Length)
- Chainage of T2 = chainage of T1 + length of curve (l), l = R*Δ*Π/ 180

Normal Chord And Sub Chord

- On the alignment of curve, at a certain distance interval pegs are driven into the ground. The distance between two pegs is normally kept equal to 20 m. The distance is known as peg interval.
- If pegs are driven at 20 m interval, the peg stations are called main peg stations.
- The chord joining the tangent point T1 and the first main peg station is called first sub chord.
- All the chords joining adjacent peg stations ate called full chord or normal chord.
- The length of the normal chord is generally taken equal to 20 m.
- The chord joining last main peg station and the tangent point T2 is called last sub chord.

Method of setting out simple circular curves :

There are two type of methods for setting out simple circular curves based on the instrument used in method :

1. Linear method.
2. Angular method.

Setting out Circular Curves by linear Methods :

There are 4 methods by which pegs on the centreline of circular curves can be set out:

1. Offsets from chords produced.
2. Offsets from the tangent lengths.
3. Offsets from the long chord.
4. Method of successive bisection of arcs or chords.

2. By offsets from the tangents :

There are two types for sitting out simple circular curves by method of offsets from the tangents :

1. RADIAL OFFSET. & 2. PERPENDICULAR OFFSET.

Angular method : Used when length of curve is large

- More accurate than the linear methods.
- Theodolite is used

The angular methods are:

1) Rankine method of tangential angles.
   OR
   One theodolite method
2) Two theodolite method.

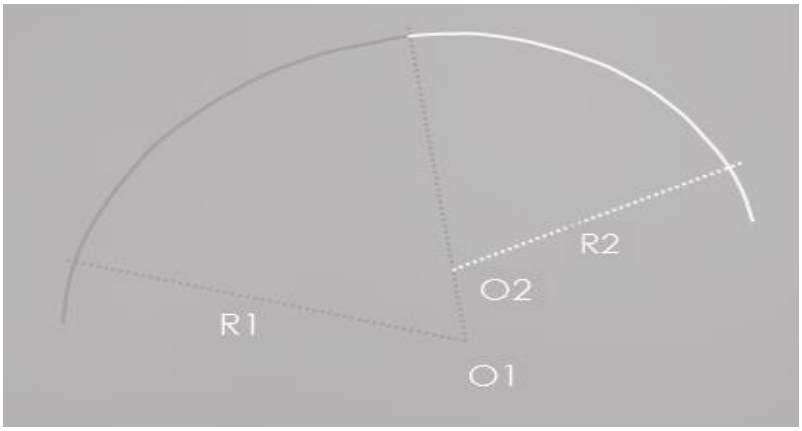
Obstacles in setting out simple curves :

- Case –I -When P.I. is inaccessible
- Case –II -When P.C. is inaccessible
- Case –III -When P.T. is inaccessible
- Case –IV - When both P.C. and P.T. Is inaccessible.
- Case –V - When obstacles to chaining.

COMPOUND CURVE

A compound curve consists of two or more circular arcs of different radii with their centres of curvature on the same side of the common tangent. Compound curves are required when space restrictions preclude a single circular curve and when there are property boundaries.

- Combination of two or more simple circular curves of different radius having their curvature in the same direction



REVERSE CURVE

A reverse curve consists of two circular arcs of same or different radii having their centres on the opposite sides of the common tangent at the point of reverse curvature. The reverse curve is also tangent at the point of reverse curvature. The reverse curve is also known as a serpentine curve or S-curve because of their shape.

Reverse curves are generally used to connect two parallel roads or railways lines, or when two lines intersect at a very small angle. These are used in hilly terrains and in railways siding as crossovers. These are also used on highways and railways designed for low speed. As far as possible, they should not be used on main highways and railways designed for high speed.

- Consider a simple circular curve
- It may join with a second circular curve of opposite curvature

TRANSITION CURVE

A transition curve is a horizontal curve of varying radius. The radius of such a curve varies from infinity to a certain fixed value. The transition curve provides a gradual change from the straight line to the circular curve and again from the circular curve to the straight line. A transition curve is provided on both ends of a circular curve. The curvature varies from zero at the tangent point to a definite value just at the junction with the circular curve. A transition curve is also provided between two branches of a compound curve or a reverse curve so that the changes in curvature are gradual. Transition curves are provided in railways tracks to ensure safe running of trains. Transition curves are required on roads and railways to lessen discomfort at the junction of a straight line and a curve. On railways, transition curves are used invariably. On highways, they are seldom used.

Advantages of a Transition curve

- To avoid overturning of the train. It reduces the chances of overturning of the vehicles at the junction of the straight and the curve.
- The chances of side slipping of the vehicles and the derailment of trains are also reduced considerably.
- It provides comfort to the passengers while vehicles negotiating a curve.
- The super elevation is introduced gradually in proportion to the rate of change of curvature.
- It permits higher speeds at curves.
- It reduces the wear and tear of rail section due to unusual friction at point of turning.
- It has lower rate of change of curvature which is an advantage for heavy vehicles.

Requirements of a Transition curve

- It should be tangential to the straight, and meet the circular curve also tangentially at the junction.
- Its curvature should be zero at the origin on junction with the circular curve.
- Its curvature should be equal to that of the circular curve at the rate of increase of super elevation.
- The rate of increase of curvature along the transition curve should be such that full cant or super elevation is attained at the junction with the circular curve.

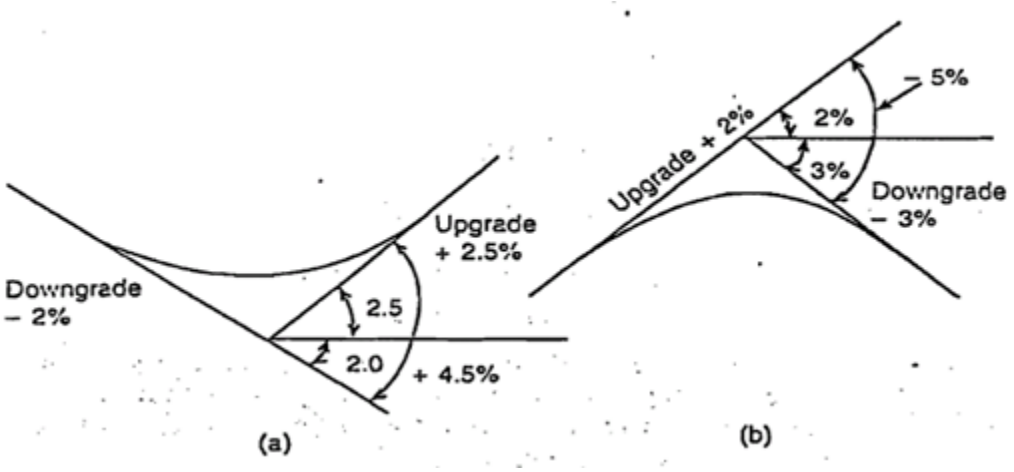
COMBINE CURVE

Combine curves are a combination of simple circular curve and transition curves and are preferred in railways and highways.

When transition curves are introduced at both ends of a circular curve, the resulting curve is known as a combined or composite curve.

VERTICAL CURVE

Vertical curves are provided when a highway or a railway crosses a ridge or a valley. When the grade line of a highway or railway changes grade such as while crossing low ridges or valleys, provision must be made for a vehicle to negotiate this transition smoothly and to provide vision over the crest of a hill for enough ahead to give the driver of the vehicle ample time to react to a dangerous situation. A curve used to connect two different grade lines of railways or highways is called a **Vertical Curve**. Such a curve is introduced to round off the angle and to obtain a gradual change in the gradient so that the vehicle passing over it may not experience a shock or a sudden jerk. It also keeps the gradients of the roads within certain limits and provides a minimum sight distance. A parabola is most commonly used as a vertical curve.



- **Summit Curves** : If a vertical curve has its convexity upwards, it is called a summit curve.
- **Sag or Valley Curves** : If a vertical curve has its convexity downwards or when it is concave upwards it is called a sag or valley curve.