I.C.2.2: PROCESSING DATA OF CIVIL STRUCTURES

2.2.1: **DOWNLOADING DATA**

In modern civil engineering, the management and analysis of data are critical for the design, construction, and maintenance of structures such as bridges, buildings, dams, and roads. **Downloading data refers to the process of transferring information from monitoring systems, sensors, databases, or software applications to local devices for analysis, reporting, or archiving**.

This process enables engineers and project managers to make informed decisions, ensure safety, and optimize performance

material is used to store data?

- Diskettes
- Optical discs
- Compact discs (CDs) and
- Digital video discs (DVDs
- Hard disk drives (HDD)
- Flash drives and solid-state drives (SSD)
- Network-based storage allows multiple computers to access it through a network, making it better for data sharing and collaboration

Steps of download data depend on the instrument used while recording data

Data conducting surveying work commonly required:

- Cable
- Hard discs
- Batteries charge where it required
- Computer
- Data
- Instrument

2.2.3: UPLOADING DATA

If you upload data, you transfer it from a computer or phone to another device or to the internet

2.2.4: CLEANING DATA

Data cleaning is the process of fixing or removing incorrect, corrupted, incorrectly formatted, duplicate, or incomplete data within a dataset. When combining multiple data sources, there are many opportunities for data to be duplicated or mislabele

How to Clean Data

1. Identify data discrepancies using data observability tools. ...
2. Remove unnecessary values. ...
3. Remove duplicate data. ...
4. Fix structural errors. ...
5. Address any missing values. ...
6. Standardize data entry and formatting. ...
7. Validate and correct values against a known list of entities. ...
8. Develop a data quality strategy.

Types of Dirty Data and How do you Clean Them?

- Insecure Data.
- Data security and privacy laws are being established left and right
- Inconsistent Data. ...
- Too Much Data. ...
- Duplicate Data. ...
- Incomplete Data. ...
- Inaccurate Dat

2.2.5: ANALYSING DATA

Data analysis in surveying civil structures involves systematically collecting and analyzing data related to the design, construction, and performance of structures. Here are key components and considerations specific to this field:

Key Components

1. **Data Collection**:
    - **Surveying Techniques**: Utilize methods like total stations, GPS, and laser scanning to gather precise measurements of the site.
    - **Material Properties**: Collect data on materials used, such as concrete strength and soil characteristics.
2. **Types of Data**:
    - **Geometric Data**: Coordinates, elevations, and angles of structures.
    - **Environmental Data**: Site conditions, including topography, weather, and soil stability.
    - **Performance Data**: Monitoring structural health over time, including deflection and vibration measurements.
3. **Data Processing**:
    - **Data Cleaning**: Ensure accuracy by checking for measurement errors or anomalies.
    - **Data Transformation**: Convert raw data into a usable format (e.g., from field data to CAD drawings).
4. **Analysis Techniques**:
    - **Statistical Analysis**: Analyze trends in structural behavior, such as load responses and settlement patterns.
    - **Finite Element Analysis (FEA)**: Simulate structural responses under various loads and conditions.
    - **Geospatial Analysis**: Use GIS tools to analyze spatial data related to the structure and its surroundings.
5. **Visualization**:

  - **Mapping**: Create topographical maps and 3D models to visualize the data.
  - **Graphs and Charts**: Use visual tools to communicate findings effectively, such as load vs. deflection curves.

Common Challenges

- **Data Accuracy**: Ensuring that all measurements are precise and reliable.
- **Complexity of Analysis**: Integrating various data types and ensuring compatibility between datasets.
- **Interpreting Results**: Accurately interpreting structural behavior and performance metrics.

Best Practices

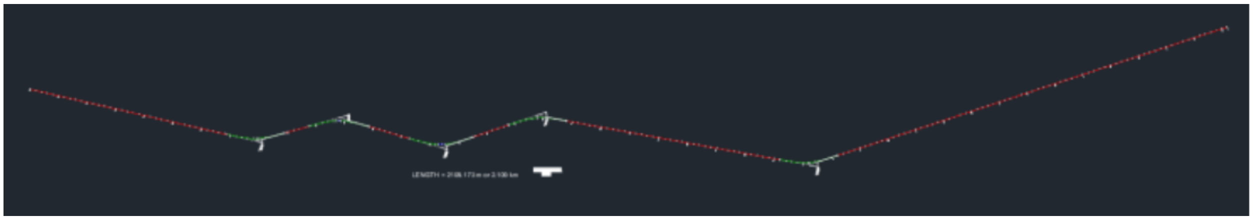
- **Standardization**: Follow industry standards and protocols for data collection and analysis.
- **Documentation**: Keep detailed records of methods, data sources, and analytical techniques used.
- **Collaboration**: Work closely with engineers, architects, and stakeholders to ensure comprehensive understanding and application of data

2.3: DESIGNING CIVIL STRUCTURES

2.3.1: Road horizontal alignment

Horizontal alignment deals with the design of the directional transition of the road in a horizontal plane. The plan view gives the horizontal alignment of a road. The length of the highway is measured along the plan view, on a horizontal plane.

Horizontal alignment is the backbone of roadway design and ensures a pleasant driving experience. Stripped to basics, it generally consists of a horizontal arc and two transition curves forming a curve that joins two tangents

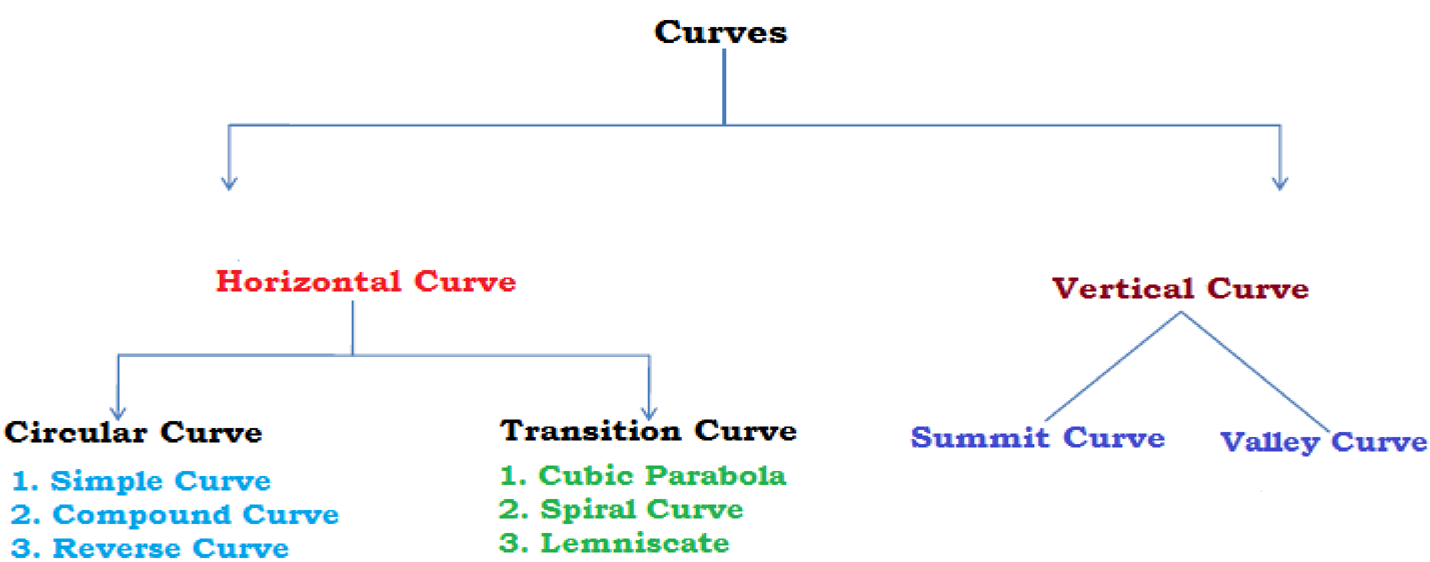


Horizontal road alignment

components of horizontal alignment include:

1. **Tangents**: Straight sections of road that allow for uninterrupted travel.
2. **Curves**: Circular or spiral sections that change the direction of the road. Curves must be designed considering factors like radius, superelevation (banking), and sight distance to enhance safety and comfort.
3. **Transitions**: Areas that gradually change from straight to curved sections, helping vehicles adjust to changes in direction.

THE TYPES OF ROAD CURVES ARE CLASSIFIED AS FOLLOWS:



2.3.1.1:A horizontal curve

Curves used in horizontal planes to connect two straight tangent sections are called horizontal curves

A curve can be described by its radius or by its degree of curvature.

Two types are used: circular arcs and spirals. Both are readily laid out in the field with surveying equipment

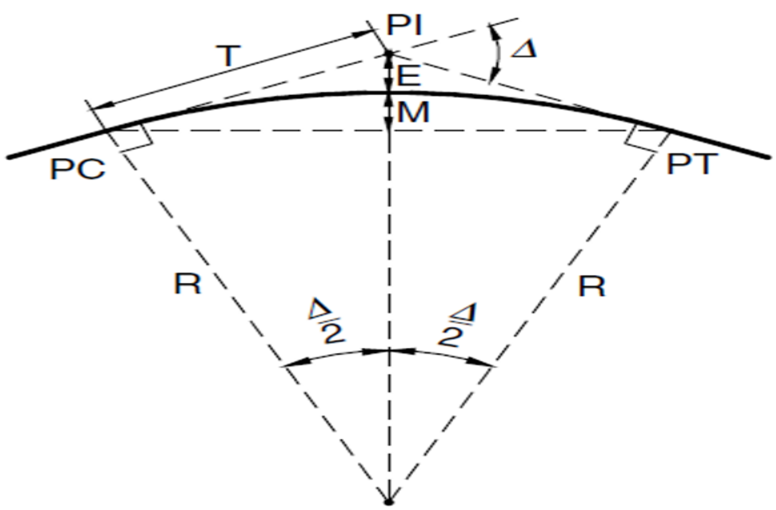


Figure: horizontal curve

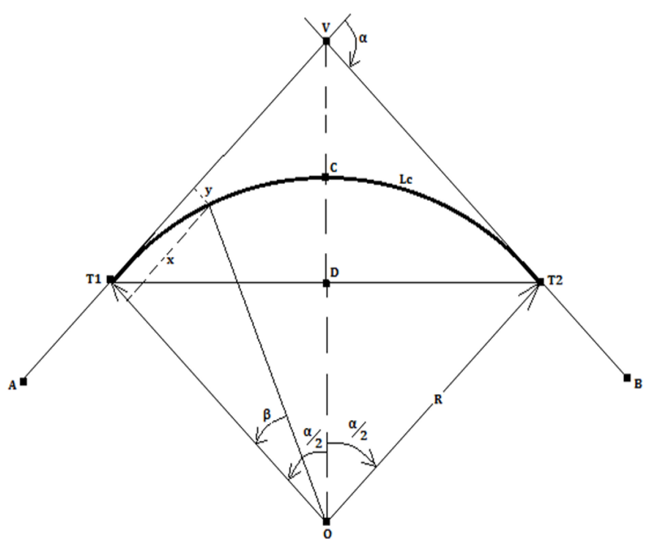
A curve may be *Circular, Parabolic* or *Spiral* and is always connect two straight directions (tangents). Circular curves are divided into three types from which the simple circular curve is only to be discussed. The remaining types are *Compound* and *Reversing circular curves.*

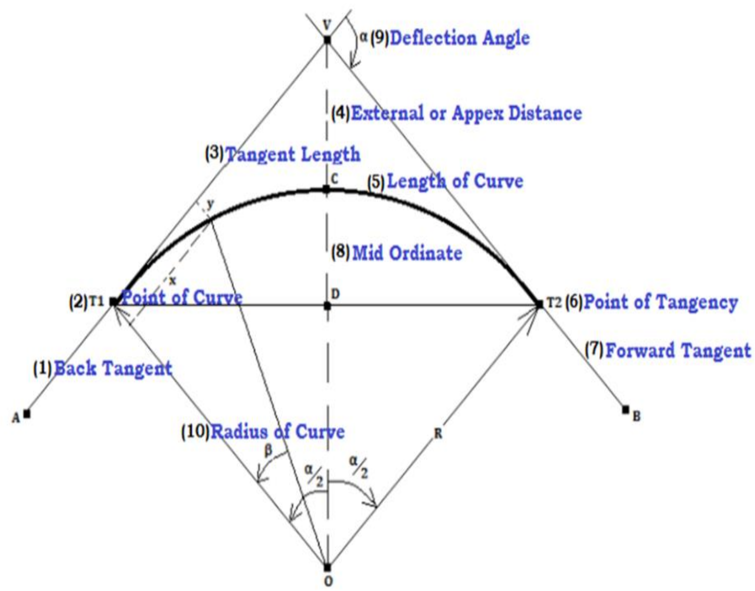
- **Simple circular curve** is the one which consists of a single arc of a circle. It is tangential to both the straight lines (tangents).

- **Compound circular curve** consists of two or more simple arcs that turn in the same direction and join at common tangent points.

Reverse circular curve is the one which consists of two circular arcs of same or different radii, having their centres to the different sides of the common tangent. Both the arcs thus bend in different directions with a common tangent at their junction

THE SIMPLE CIRCULAR CURVE:





$$T = R\tan\left(\frac{\Delta}{2}\right)$$

The middle ordinate M is

$$M = R\left[1 - \cos\left(\frac{\Delta}{2}\right)\right]$$

The external distance E is

$$E = R\left[\frac{1}{\cos\left(\frac{\Delta}{2}\right)} - 1\right]$$

The degree of curvature D is the central angle subtended by a L=100 m arc of the curve.

$$D = \frac{100\ m * \left(\frac{180}{\pi}\right)}{R} = \frac{5729.6}{R}$$

The length of the curve L is

$$L = DR\frac{\pi}{180}$$

716 HORIZONTAL CURVES

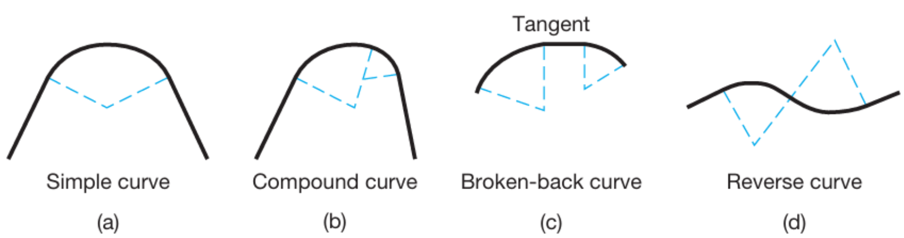


Figure 24.1
Circular curves.

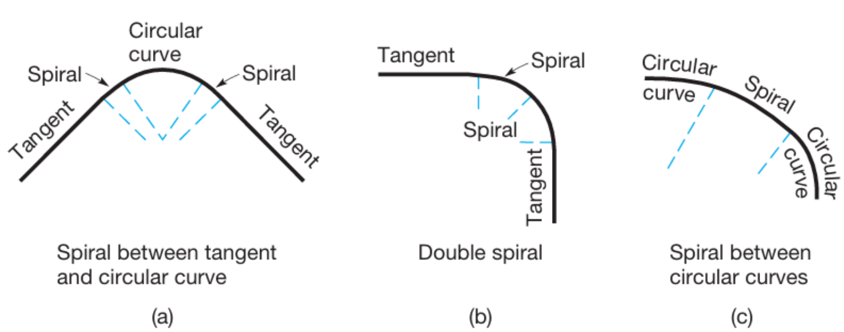


Figure 24.2
Use of spiral transition curves.

GENERAL PROCEDURE OF CIRCULAR CURVE LAYOUT BY DEFLECTION ANGLES

Except for unusual cases the radii of curves on route surveys are too large to permit swinging an arc from the curve center. Circular curves are therefore laid out by more practical methods, including

(1) deflection angles

(2) coordinates

(3) tangent offsets

(4) chord offsets,

(5) middle ordinates

(6) ordinates from

METHODS OF ROAD CURVE SETTING OUT.

Linear Methods:

Offsets or ordinate from the long chord
Successive bisection of arcs or chords
Offsets from the tangents;
Offsets from the chord produced

Angular Method

Rankine method of tangential angles Or One theodolite method
Two theodolite method.

Coordinate method:

Use of DGPS;
Use of total station.

a) DEFINITIONS AND NOTATIONS:

1. **Length of tangent** or **Tangent Distance (T):** Is the distance between the Point of the Curve (T_1) or the Point of Tangency (T_2) and the Vertex (Point of Intersection).
2. **Back tangent:** Also called "**First tangent**" is the tangent (AT_1) previous to the curve.
3. **Forward tangent:** Also called "**Second tangent**" is the tangent (T_2B) following the curve.
4. **Vertex (V)** or **Point of intersection (PI):** If the back and forward tangents are produced, they will meet in a point called Vertex or Point of Intersection.

5. **Point of curvature (T_1):** Is the beginning of the curve, where the alignment changes from a tangent to a curve.
6. **Point of tangency (T_2):** It is the end of the curve, where the alignment changes from a curve to a tangent.
7. **Intersection angle (α):** or **External deflection angle** between two tangents. Is the angle between "AV" produced and "VB".
8. **Deflection angle:** Deflection angle to any point on the curve is the angle at T_1, between the back tangent and the chord from T_1 to point on the curve.
9. **External** or **Apex distance (E):** It is the distance from the mid-point of the curve to the vertex (V).
10. **Length of the curve:** It is the total length of the curve from T_1 to T_2.
11. **Long chord:** It is the chord joining T_1 and T_2.
12. **Midi-chord:** It is a half the long chord.
13. **Normal chord:** It is a chord between two successive regular stations on a curve.
14. **Sub-chord:** Any chord shorter than normal curve.
15. **Mid-ordinate** It is the ordinate from the mid-point of the long chord to the mid-point of the curve
16. **Right hand curve:** It is the curve that deflects to the right of the direction of road user.
17. **Left hand curve:** It is the curve that deflects to the left of the direction of road user.

b) CALCULATION OF SIMPLE CIRCULAR CURVE ELEMENTS:

i) **Length of tangent:** $\boldsymbol{T} = TV = OT_1 * tan\frac{\propto}{2} = \boldsymbol{R * tan\frac{\propto}{2}}$

ii) **External distance** or **Apex distance:** $\boldsymbol{E} = VC = VO - CO = R * sec\frac{\propto}{2} - R = \boldsymbol{R\,(sec\frac{\propto}{2} - 1)}$

iii) **Length of the curve:** $\boldsymbol{Lc} = T_1CT_2 = 2 * \pi * R\frac{\alpha}{400} = \boldsymbol{\pi * R\frac{\alpha}{200}}$

iv) **Long chord:** $\boldsymbol{Ch} = T_1T_2 = 2 * OT_1 * sin\,\frac{\alpha}{2} = \boldsymbol{2 * R * sin\,\frac{\alpha}{2}}$

v) **Mid-ordinate:** $\boldsymbol{M} = CD = CO - DO = R - R * cos\,\frac{\propto}{2} = \boldsymbol{R\,(1 - cos\,\frac{\propto}{2})}$

vi) **Other points on the curve:** Let XA and YA be respectively abscissa and ordinate of the point A on the curve or any other point to set out the curve. Thus: $\boldsymbol{XA = R * sin\,\beta}$ and $\boldsymbol{YA = R\,(1 - \cos\,\beta)}$

Exercises

1. *Two horizontal tangents meet at central angle of 172 grades. Calculate all necessary data to connect two tangents with the 500m radius of curvature.*

2.3.1.2VERTICAL CURVES

A vertical curve is a curve or succession of curves, normally parabolic, in profile. It is used to join two intersecting grade lines of roadway to smooth out the change in vertical motion. For simplicity of
calculation work, the simple parabola is normally used to provide a constant rate of change of curvature
and hence, the visibility along its length.

It has the following form: Y = X2/2R

Where:

Y = Vertical distance from the grade line to the curve (m).

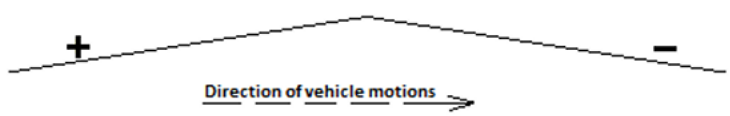
X = Horizontal distance from start of vertical curve (m).

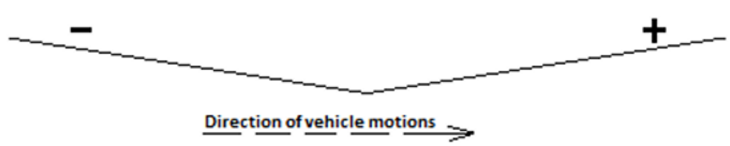
R = Radius of circular curve that is approximated by the parabola (m).

The vertical alignment of the road has a strong influence upon: construction cost, the operation cost and
on the number of accidents. The two major elements of vertical alignment are the gradient which is
related to the vehicle performance and level of service, and the vertical curve which is governed by sight
distance and comfort criteria.

1.2.1. Tangent gradient

The gradient (grade) or grade is said to be upgrade or **(positive slope)** when elevations along the direction of motion increase; and downgrade or **(negative slope)** when they decrease





2.3.2. Types of vertical curves

a) Sag curve: It is also named "Concave" and it can be presented by:

i. A downgrade followed by an upgrade **(- and +)**

ii. An upgrade followed by another upgrade **(+ and +)**

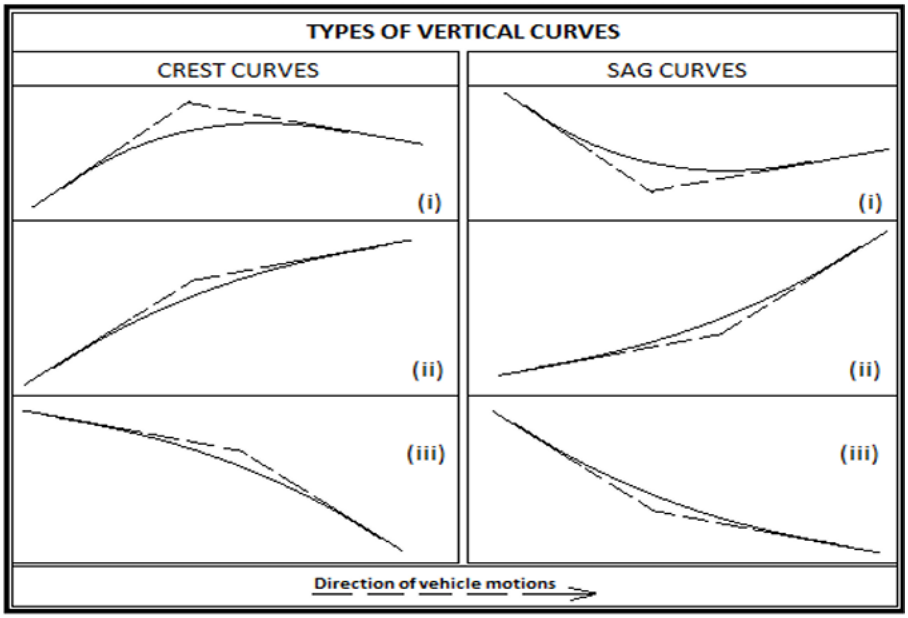
iii. A downgrade followed by another downgrade **(- and -)**

b) Crest curve: It is also named "Summit" or "Convex" and it can be formed by:

i. An upgrade followed by a downgrade **(+ and -)**

ii. An upgrade followed by another upgrade **(+ and +)**

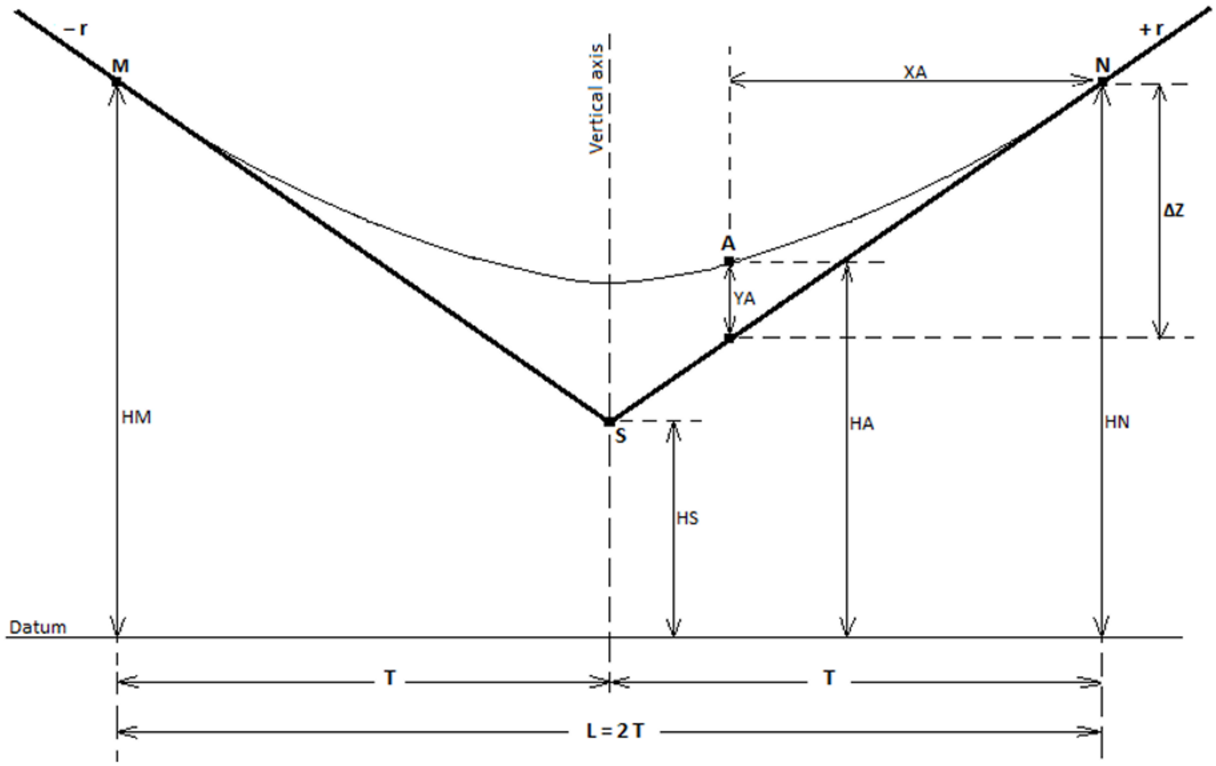
iii. A downgrade followed by another downgrade (- and -)



2.3.3. Setting a sag curve:

a) First method: ($|-\mathbf{r}| = |+\mathbf{r}|$) Taking a difference between cumulative distances of the point "M" and "N", the maximum value of "X" is obtainable. Replacing the obtained value in the parabola equation "Y=x2/2R", a value of "Y" is also determined.

This means that the curve will be found taking different values of "X" which is not greater than its maximum.



Elevation of point "A" is calculated by: **HA = HN –ΔZ + YA**

Before calculating the elevation of "A", the following value should be calculated:

ΔZ = XA*r → where "**r**" is the tangent gradient.

In the formula "HA = HN –ΔZ + YA", signs depend on tangent direction and curve type.

b) ***Second method:*** (|−**r**| ≠ |+**r**|)

- For a downgrade (g) followed by an upgrade (h):

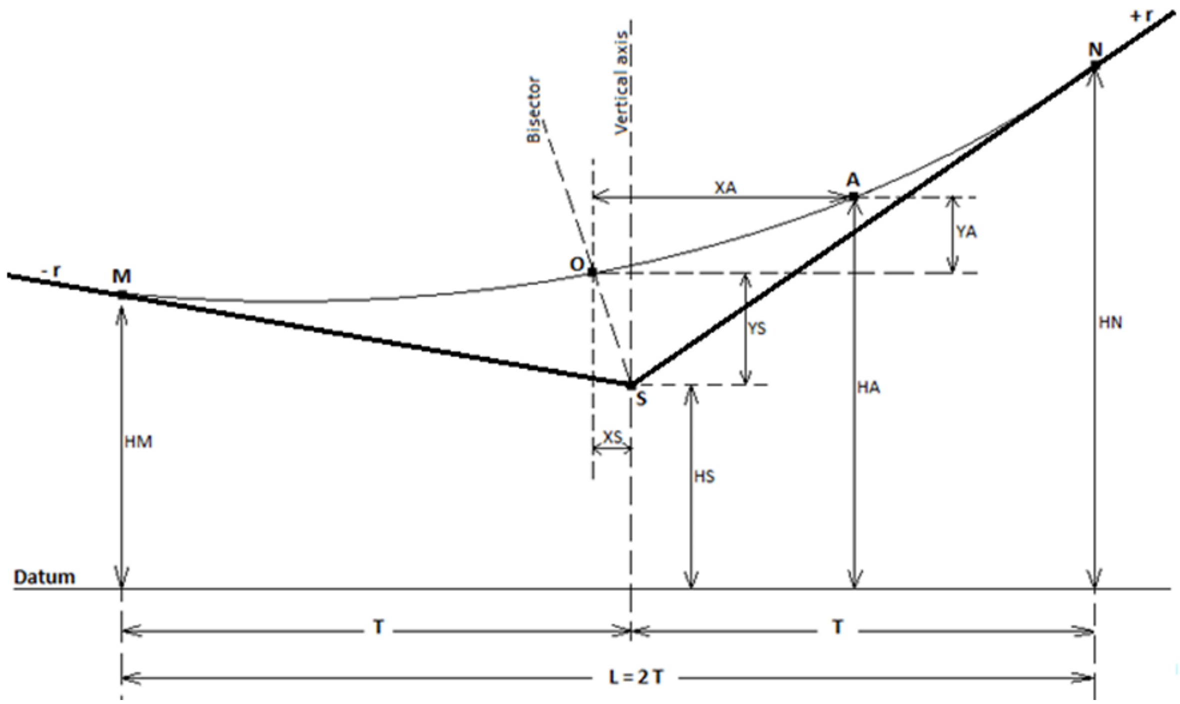
  $\mathbf{XS = \frac{R}{2}(g - h)}$ and $\mathbf{YS = \frac{R}{2}(g * h)}$

- For an upgrade (h_1) followed by another upgrade (h_2) :

  $\mathbf{XS = \frac{R}{2}(h_1 + h_2)}$ and $\mathbf{YS = \frac{R}{2}(h_1 * h_2)}$

- For a downgrade (g_1)followed by another downgrade (g_2):

  $\mathbf{XS = \frac{R}{2}(g_1 + g_2)}$ and $\mathbf{YS = \frac{R}{2}(g_1 * g_2)}$



Elevation of origin “O” is equal to “HS + YS”, its cumulative distance being “S ± XS”. Thus, coordinates

of intermediate points can easily be calculated by assuming “XA” which is equal to the difference

between the origin “O” and the point to calculate on the curve.

Setting a crest curve:

(Case of an upgrade (r_1) followed by another upgrade (r_2))

- Tangent length: $\mathbf{T = \frac{R}{2}(r_1 - r_2)}$
- Origin “O” coordinates: $\mathbf{XS = \frac{R}{2}(r_1 \pm r_2)}$ and $\mathbf{YS = \frac{R}{2}(r_1 * r_2)}$
- Coordinates of any point “A” on the curve: $\mathbf{YS = (XA)^2/2R}$

Where: “XA” is the assumed distance which should not be greater than “XS + T”.

Examples:

1. For a sag curve of longitudinal profile, it is required to connect a horizontal line with a gradient and an upward slope (r2) of 4% by a parabolic curve. If the tangent length T=40m:

a) Calculate the total length of connecting

b) Calculate the coordinates Xs and Ys of summit of the parabolic curve.

c) Calculate the ordinate Y of point A set at 30m from summit of the parabolic curve.

2. Calculate the necessary data to connect an upgrade of 4% followed by another upgrade of 1% with

a parabolic curve, if the normal curve radius is 2000m. With the help of drawing, detail the connecting procedure.

3. It is provided to connect an upward slope (r1) of 4% and a downward slope (r2) of 6% for a parabolic curve to set. The origin of this parabola is M and the end is N. The length of tangent is T=60m. a) What is the length of connecting? b) Find the coordinates Xs and Ys of summit of the parabolic curve. c) For X1 =10m and X2 =20m, find the ordinates Y1 and Y2 respectively.

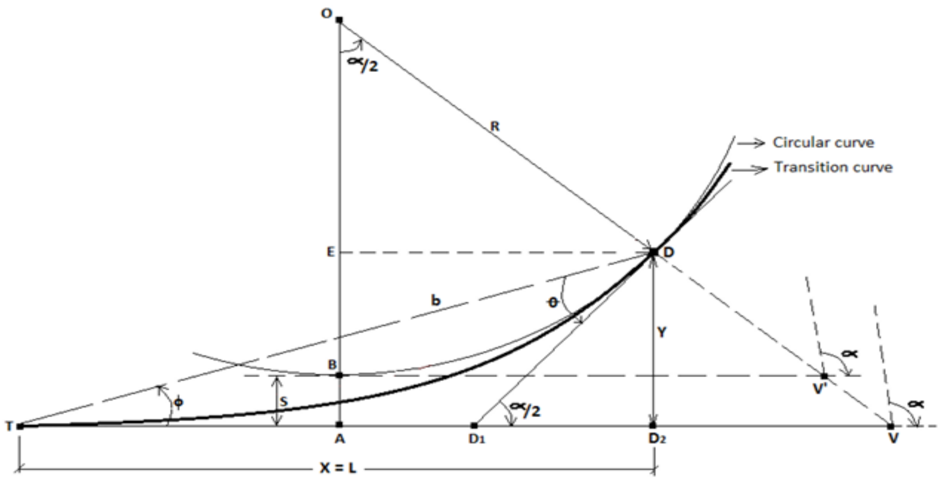
2.3.4. BERNOULLI'S LEMNISCATE CURVE Bernoulli's lemniscate is commonly used in road work where it is required to have the curve transitional throughout having no intermediate circular curve. It is used in preference to the spiral for the following reasons:

¬ Its radius of curvature decreases more gradually

¬ Its rate of increase of curvature diminishes towards the transition curve. Thus fulfilling an essential condition.

¬ It corresponds to an autogenously8 curve of an automobile For the lemniscate

The following is the most important property of the lemniscate: θ = Φ + α 2 Where: ∝ 2 = 3 Φ = Deviation angle (angle between the tangent to the curve at "D" and the initial tangent "TV") Φ = Polar deflection angle θ = Angle between the polar ray "b" and the tangent "DD1" to the curve at "D".



The polar equation of Bernoulli's lemniscate is: **b=** $\mathbf{K\sqrt{sin\ 2\theta}}$; where **b=** polar ray "TD"; and "**k**" being a coefficient. **"K"** coefficient can be approximated from the following formula according to Nördling's cubic parabola equation as follow:

$Y=X^3/6RL = kX^3 \rightarrow \mathbf{k}= \frac{\mathbf{1}}{\mathbf{6RL}} = \frac{1}{6PL}$ and P=R= OD: *Here,* $L = X = TD_2 = TA + D_2A = TA + R \sin\frac{\alpha}{2}$

Also, the abscissa of transition curve "L" can be estimated as follow:

$\mathbf{L} = \frac{\mathbf{100000}}{\mathbf{R}}$ when $R \geq 750m$ or $\mathbf{L} = \sqrt{\mathbf{24(R-13)}}$ when $R < 750m$

2.3.1.2ROUND ABOUT