Engineering Surveying
3rd Stage

Vertical Curve

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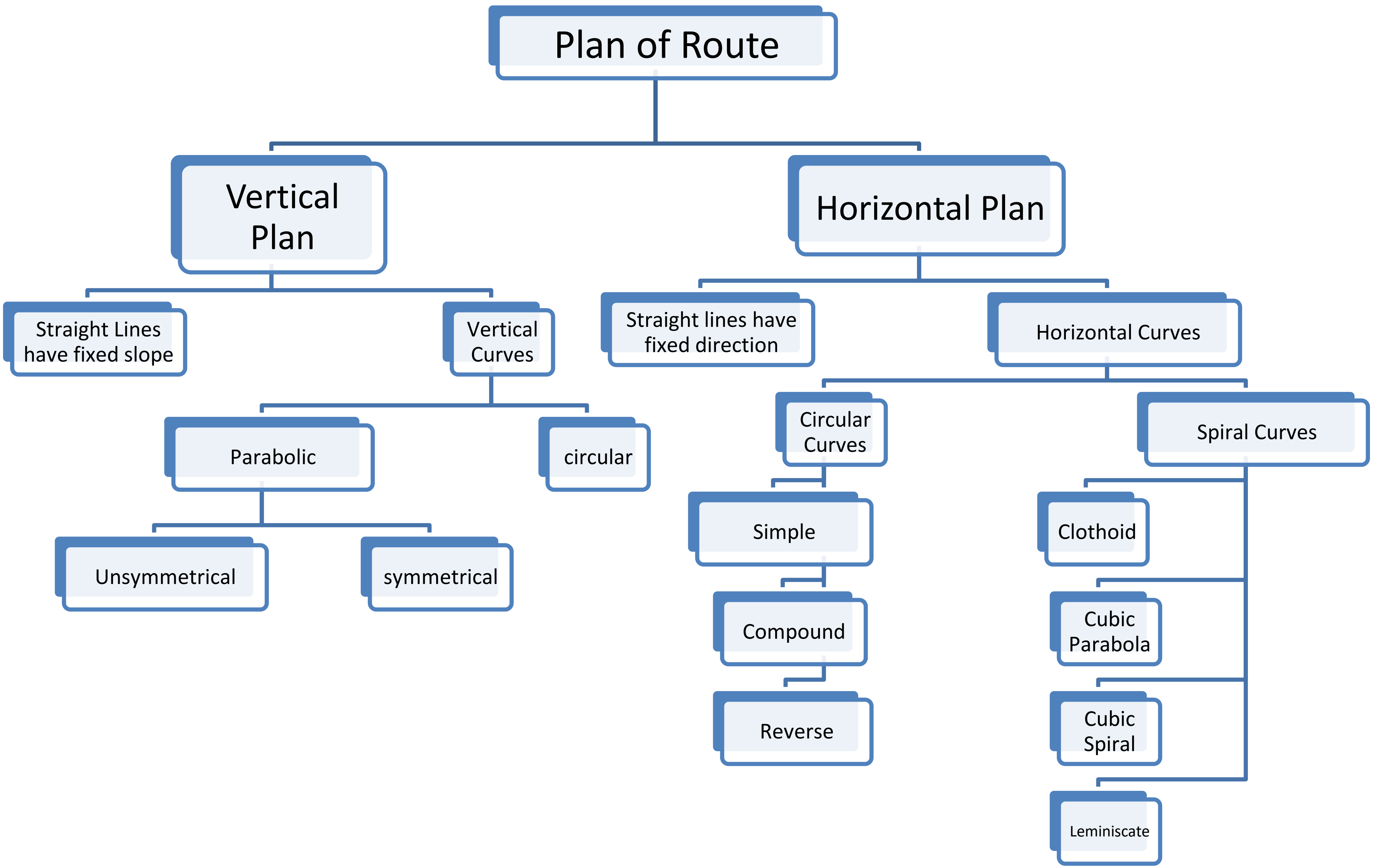
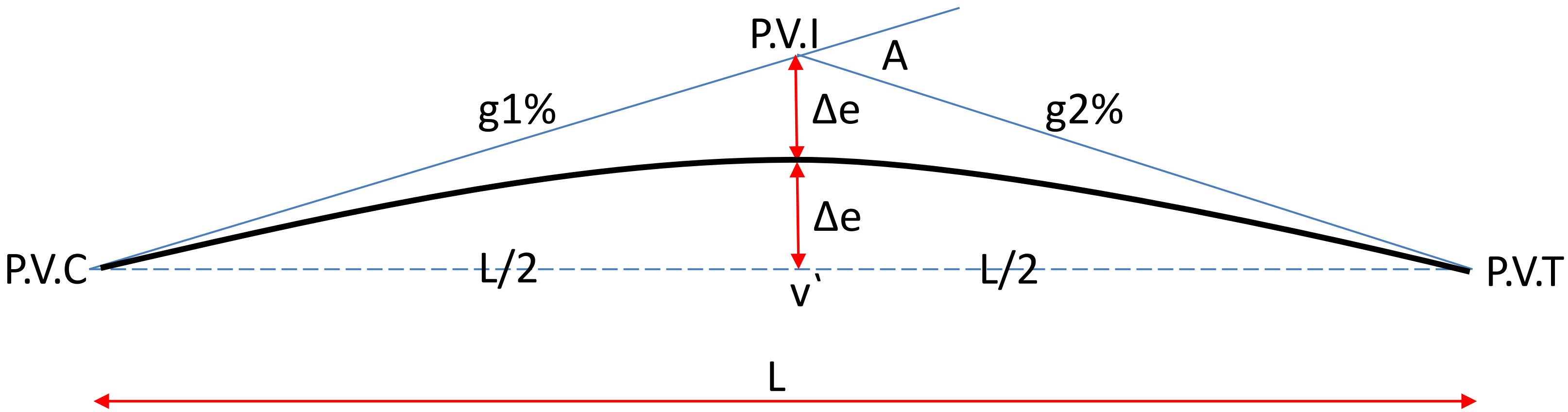
Plan of Route



Vertical Curve



L: Length of Vertical Curve measured horizontally in meter or in stations
g1,g2: Slope of Tangents
A: Algebraic difference in grades
r: Rate of change of grade per station
(P.V.C) or (B.V.C): Point of Vertical Curvature (Beginning of V.C)
(P.V.I) or (V): Point of Vertical Intersection or (Vertex)
(P.V.T) or (E.V.C): Point of Vertical Tangency (End of V.C)
Δy: Difference in elevation between tangent and curve
Δe: Difference in elevation at (P.V.I)
X: Horizontal distance in stations from (P.V.C) or (P.V.T) to the required point
Y: Elevation of point on the curve

Vertical Curve

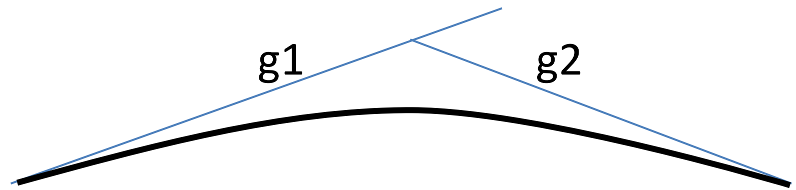
- A= g2- g1
- r= $\frac{A}{L}$ (L in station)
- Δy=($\frac{r}{2}$)* X^2
- Δy= $(\frac{X}{L/2})^2$ * Δe
- Δy= $4\Delta e(\frac{X}{L})^2$
- Δe= ($\frac{r}{2}$)* $(\frac{L}{2})^2$
- Δe= ($\frac{A*L}{8}$)
- Elev. of v`= $\frac{elev(P.V.C)+elev(P.V.T)}{2}$
- Δe= $\frac{\frac{elev(P.V.C)+elev(P.V.T)}{2}-elev(P.V.I)}{2}$
- y= ($\frac{r}{2}$)* X^2 + g1(X) + Elev. of (P.V.C)

Vertical Curve

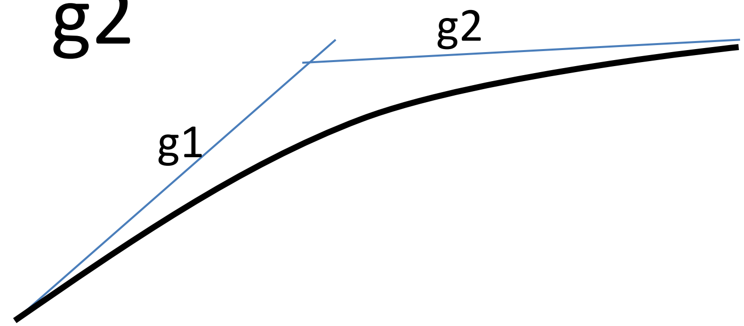
- Stat. (P.V.I)= Stat. (P.V.C)+$\frac{L}{2}$
- Stat. (P.V.T)= Stat. (P.V.I)+$\frac{L}{2}$
- Elev. (P.V.I)= Elev. (P.V.C)± g1($\frac{L}{2}$)
- Elev. (P.V.T)= Elev. (P.V.I) ± g2($\frac{L}{2}$)
- $X_{\circ}= \frac{-g1}{r}$
- $y_{\circ}= (\frac{r}{2})* (X_{\circ})^2 + g1(X_{\circ})$ + Elev. of (P.V.C)

Convex Vertical Curve

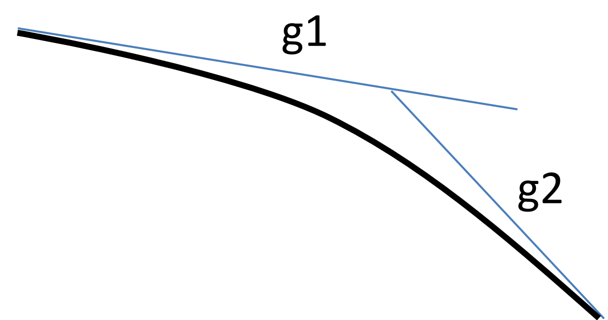
- + g1 -g2



- + g1 +g2 g1 > g2

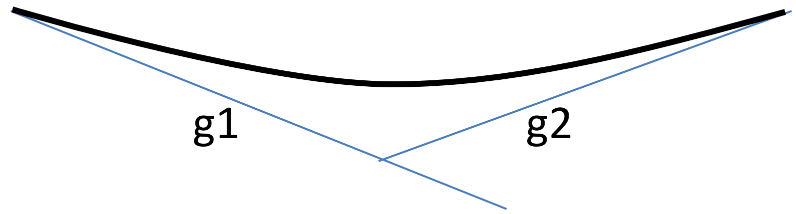


- - g1 -g2 g1 < g2

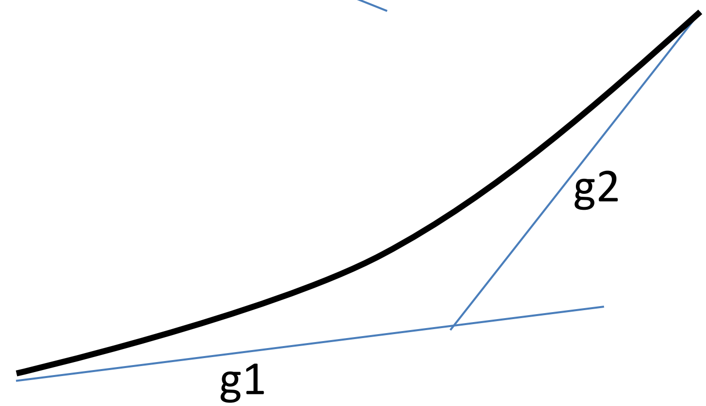


Concave Vertical Curve

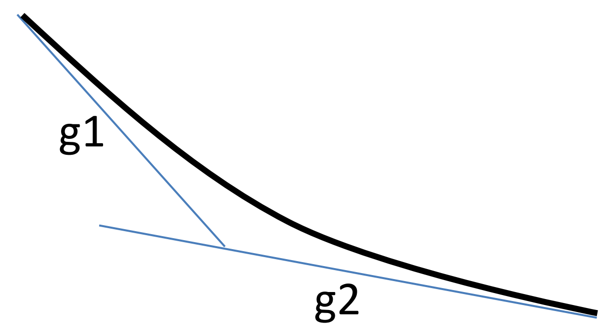
- - g1 +g2



- + g1 +g2 g1 < g2



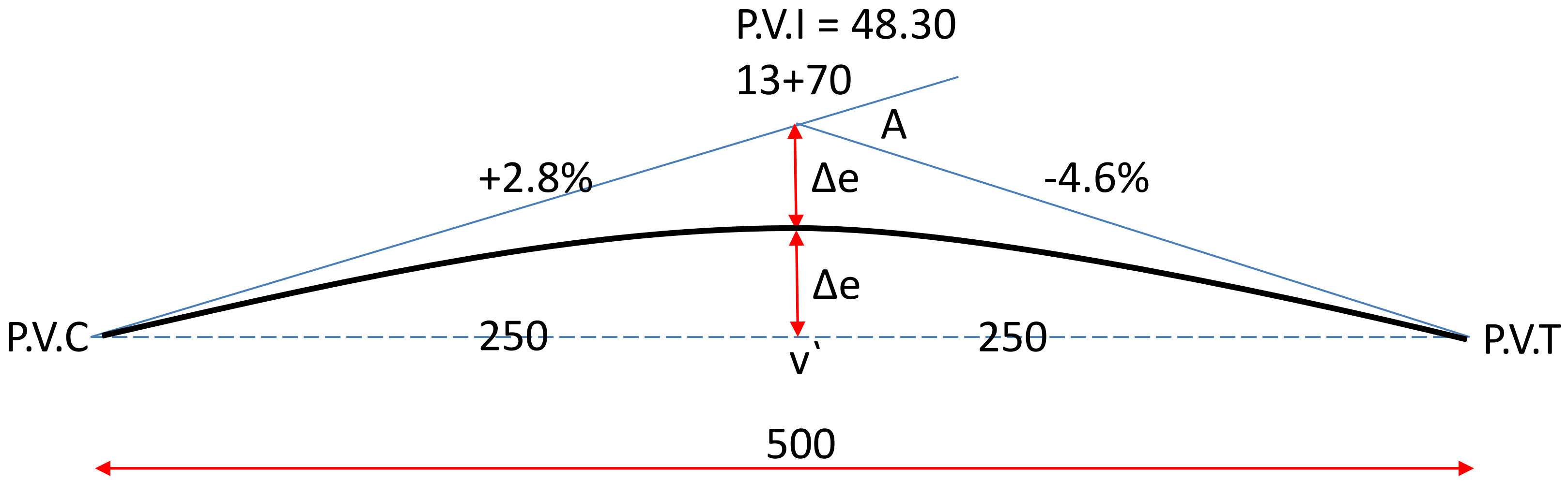
- - g1 -g2 g1 > g2



Example

- In the symmetric vertical curve of length 500m. ,$g1$= +2.8% ,$g2$= -4.6% , the elevation and station of (P.V.I)= 48.30m ,13+70 Compute the elevation of complete station by elevation of tangent method and check elevation of two points by equation method then compute elevation and station of highest point on the curve.

Solution



- A= g2- g1= -4.6-(+2.8)= -7.4   convex curve
- r= $\frac{A}{L}$ (L in station) = $\frac{-7.4}{5}$ = -1.48% per station

$\frac{r}{2}$ = -0.74

Solution

- Stat. (P.V.C)= Stat. (P.V.I)- $\frac{L}{2}$ =(13+70) – (2+50)= (11+20)
- Stat. (P.V.T)= Stat. (P.V.I)+$\frac{L}{2}$ =(13+70) + (2+50)=(16+20)
- Elev. (P.V.C)= Elev. (P.V.I)- g1($\frac{L}{2}$) = 48.30 - $\frac{2.8}{100}$ (250)= 41.30 m.
- Elev. (P.V.T)= Elev. (P.V.I) - g2($\frac{L}{2}$) = 48.30 - $\frac{4.6}{100}$ (250)= 36.80 m.
- Δe= ($\frac{A*L}{8}$) = ($\frac{-7.4*5}{8}$)= -4.62 m.
- Δy=($\frac{r}{2}$)* X^2 (X in station)
- Tangent (1)Elev. = Elev. (P.V.C) ± $\frac{g1}{100}$*(distance)
- Tangent (2)Elev. = Elev. (P.V.I) ± $\frac{g2}{100}$*(distance)

Solution

Station	X in station	Tangent Elevation in m.	$\Delta y=(\frac{r}{2})* X^2$ (X in station)	Elevation in m. On the curve
11+20		41.30	0	41.30
12+00	0.8	Elev. (P.V.C) ± $\frac{g1}{100}$*(distance) 41.30+ $\frac{2.8}{100}$*(80)=43.54	$(-0.74)*(0.8)^2$ = -0.47	43.07
13+00	1.8	43.54+ $\frac{2.8}{100}$*(100)=46.34 41.30+ $\frac{2.8}{100}$*(180)=46.34	$(-0.74)*(1.8)^2$ = -2.40	43.94
13+70	2.5	48.30	Δe = -4.62	43.68
14+00	2.2	Elev. (P.V.I) ± $\frac{g2}{100}$*(distance) 48.30 - $\frac{4.6}{100}$*(30)= 46.92	$(-0.74)*(2.2)^2$ = -3.58	43.34
15+00	1.2	46.92- $\frac{4.6}{100}$*(100)= 42.32 48.30 - $\frac{4.6}{100}$*(130)= 42.32	$(-0.74)*(1.2)^2$ = -1.06	41.26
16+00	0.2	37.72	$(-0.74)*(0.2)^2$ = -0.03	37.69
16+20		36.80	0	36.80

Solution

- y= ($\frac{r}{2}$)* X^2 + g1(X) + Elev. of (P.V.C)
- Elevation at station 15+00
- y= -0.74* $(3.80)^2$ + (+2.8)(3.80) + 41.30= 41.26 m.
- X○= $\frac{-g1}{r}$ = $\frac{-(+2.8)}{-1.48}$= 1.8919 in station 1+89.19
- Station of highest point on the curve= (11+20)+(1+89.19)= 13+09.19
- y○= ($\frac{r}{2}$)* $(X○)^2$ + g1(X○) + Elev. of (P.V.C)
- y○= -0.74* $(1.8919)^2$ + (+2.8)(1.8919) + 41.30 = 43.95 m.