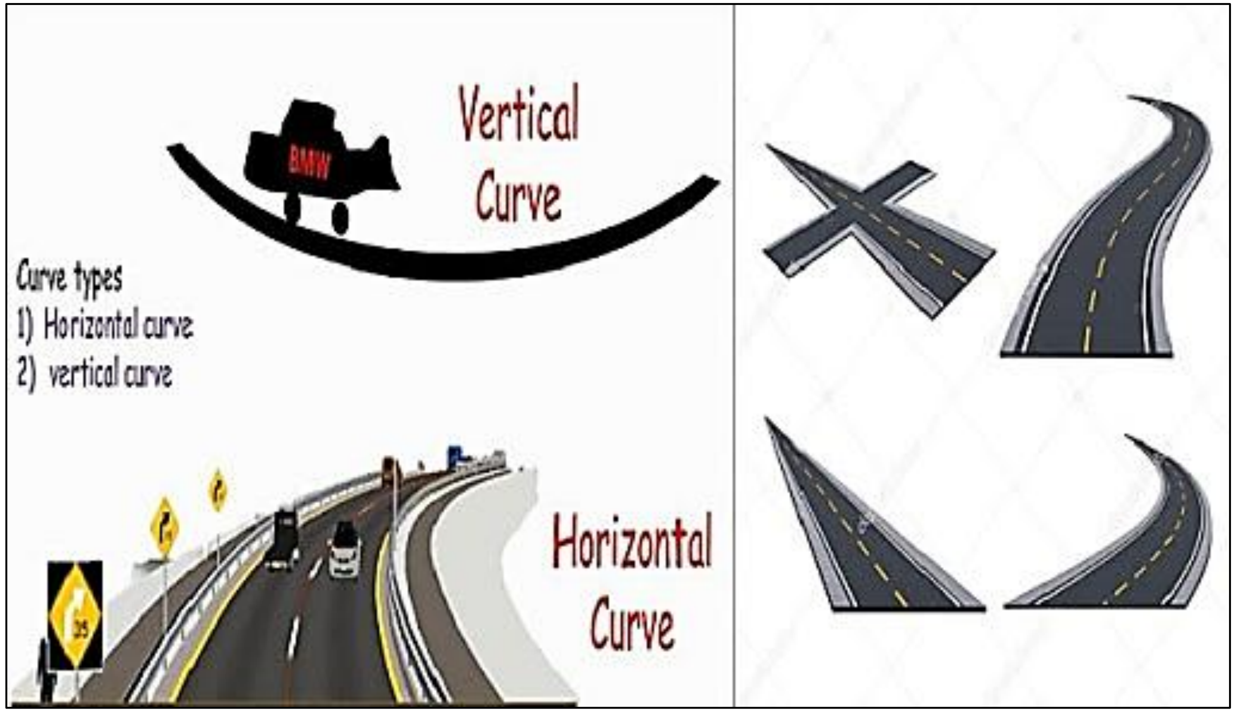
Republic of Iraq
Ministry of Higher Education & Scientific Research
Al-Mustaqbal University College
Department of Building & Construction Engineering

"APPLIED SURVEYING" 2nd Stage

((Vertical Curves المنحنيات الرأسية))



Prepared by The Senior Lecturer: Mr. Tameem Mohammed Al Musawi

1. Vertical Curves

A vertical curve provides a smooth transition between two tangent grades. There are two types of vertical curves: crest vertical curves and sag vertical curves. The profiles of crest and sag vertical curves are shown in Figure 1 with the initial grade G1; final grade G2; and their signs.

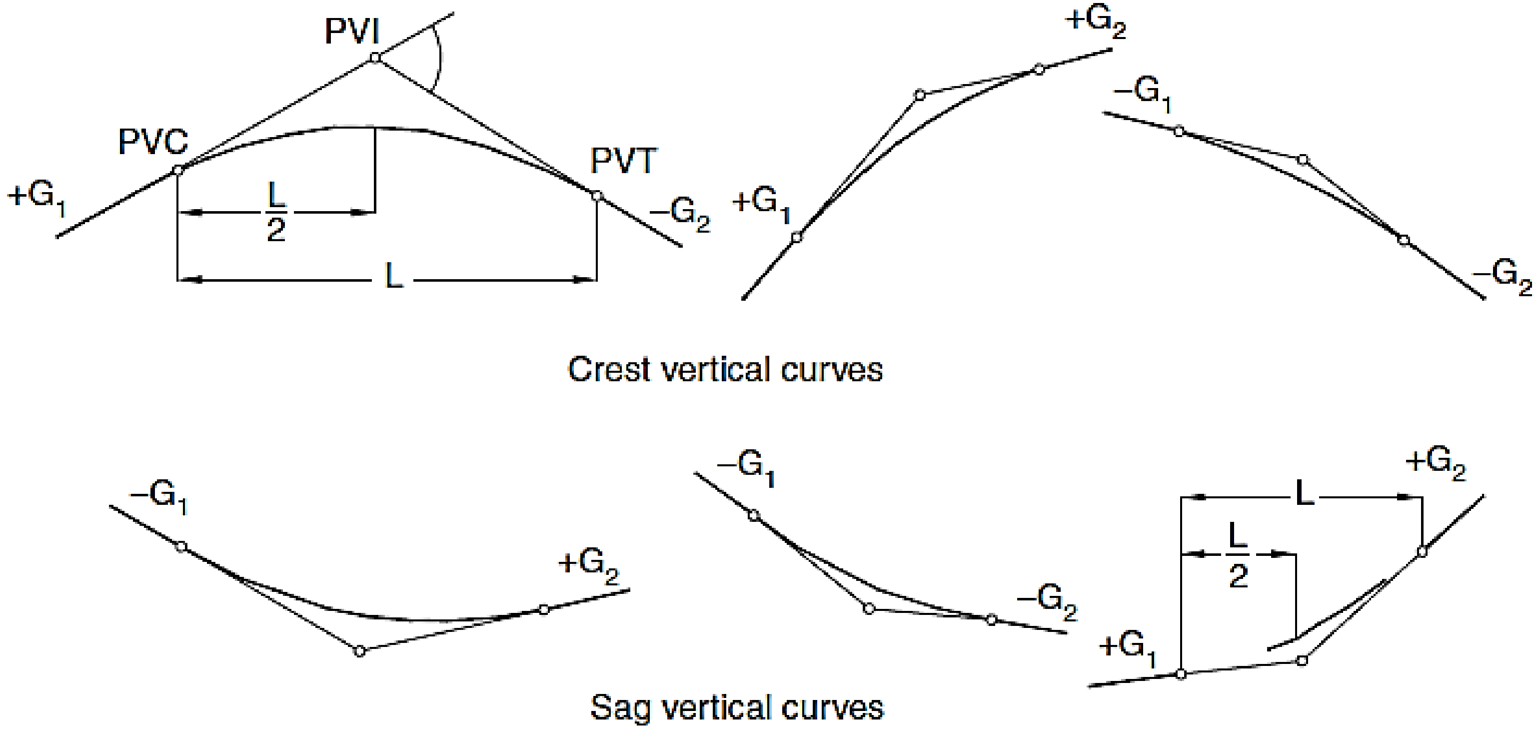
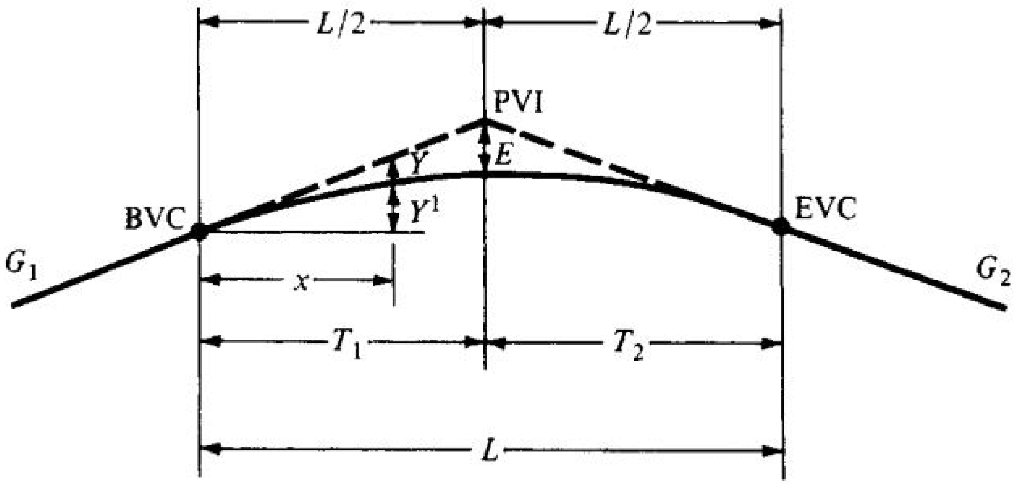


Figure 1 Vertical curves

The vertical alignment of a transportation facility consists of tangent grades (straight lines in the vertical plane) and the parabolic vertical curves that connect these grades. Vertical alignment is documented by the profile. The profile is a graph that has elevation as its vertical axis and distance, measured in stations along the center line or other horizontal reference line of the facility, as its horizontal axis. Vertical curves are used to provide a gradual change from one tangent grade to another so that vehicles may run smoothly as they traverse the highway. These curves are usually parabolic in shape. The expressions developed for minimum lengths of vertical curves are therefore based on the properties of a parabola. The design of the vertical alignment therefore involves the selection of suitable grades for the tangent sections and the appropriate length. Vertical tangents with different grades are joined by vertical curves such as the one shown in the figure below (figure 2). Vertical curves are normally parabolas centered about the point of intersection (VPI) of the vertical tangents they join. Hence, the method used for computing elevations of points on the vertical curve relies on the properties of the parabola.



PVI = point of vertical intersection

BVC = beginning of vertical curve (same point as PVC)

EVC = end of vertical curve (same point as PVT)

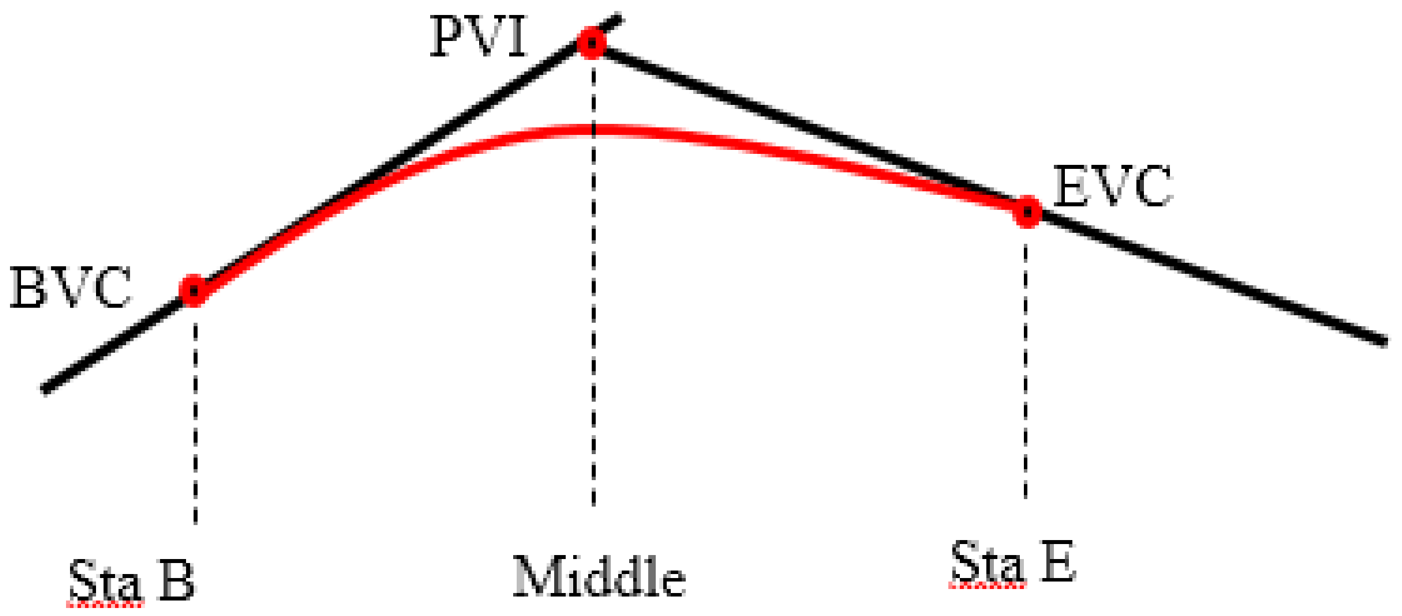
E = external distance

G_1, G_2 = grades of tangents (%)

L = length of curve

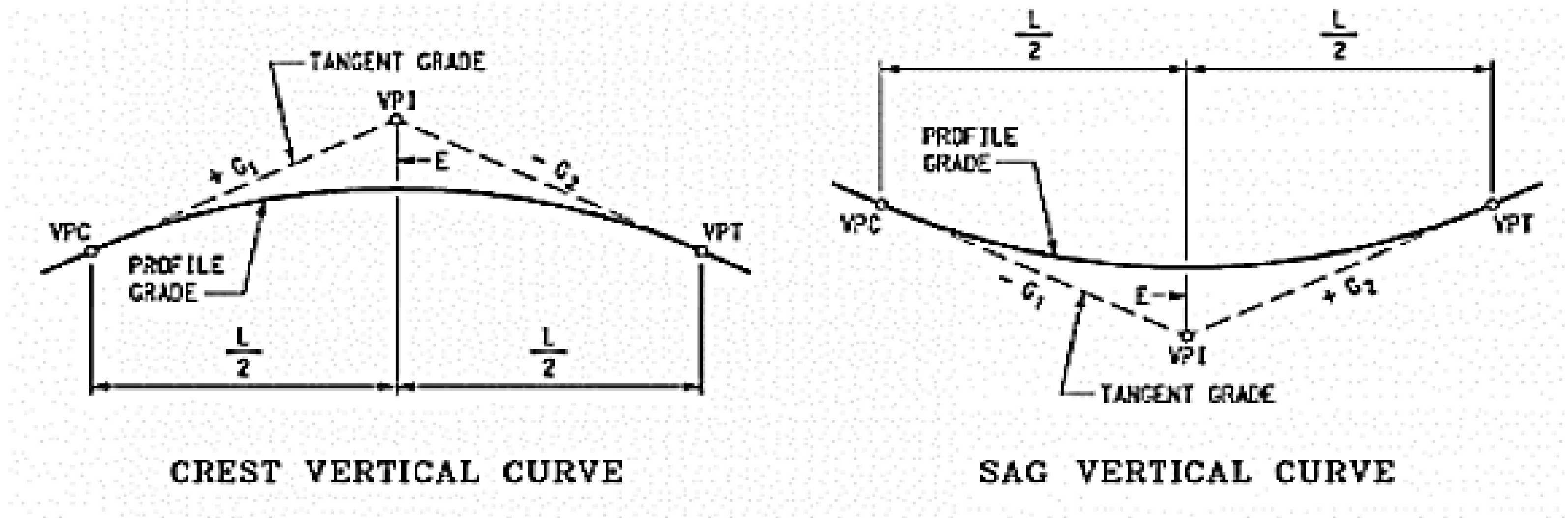
Figure 2 Vertical curve components

PVI station in the middle between BVC & EVC



Elv. BVC = Elv. PVI ± g_1 (x)

Elv. EVC = Elv. PVI ± g_2 (x)



The location of highest or lowest point:

$X_{H/L} = - g_1 L / g_2 - g_1$ or $= - g_1/2a$

$a = r/2$

$r = g_2 - g_1 /L$ (rate of change in grade)

Elevation of any point on the curve:

$E_p = E_{BVC} + g_1 x + a x^2$

x = any distance at the curve

Example:

1. A 2.5% grade is connected at +1.0% grade by means of 180m vertical curve. The PI elevation is 100.0m above sea level. What are the station and elevation of the lowest point on the vertical curve.

Sol:

Rate of grade change:

$$r = \frac{g2 - g1}{L} = \frac{1.0\% - (-2.5\%)}{1.8\ sta} = 1.944\%\ sta$$

$$X_L = \frac{-g1}{2a} = \frac{-g1}{r} = -\left(\frac{-2.5}{1.944}\right) = 1.29 = 1 + 29\ sta$$

Elv. BVC = Elv. PVI $\pm$ g_1 (x) = 100 + 2.5 (0.9) = 102.25 m

Elevation of lower point:

$$E_P = E_{BVC} + g1x + ax^2 = 102.25 + (-2.5\%)(1.29sta + \frac{1.944sta \times (1.29sta)^2}{2} =$$

100.64 m