# CVL203 - Practice Problems - Vertical Curves

## Problem 1

Grades g1 of -2.5% and g2 of +2.5% meet at the VPI at station 4+200 and elevation 293.585 m. Compute and tabulate full-station elevations for the equal-tangent vertical curve having a length of 300-m (Use 60-m stationing). Determine the location and elevation of the lowest point.

(1) Determine the station of the BVC:

$$Sta_{BVC} = Sta_{VPI} - \frac{L}{2} = (4+200) - \left(\frac{300}{2}\right)$$

$$= (4+200) - (0+150)$$

(0 → km, 150 → m)

$$\boxed{Stat_{BVC} = 4+50.000}$$

(2) Determine Elevation of BVC:

$$Elev_{BVC} = Elev_{VPI} - g_1\left(\frac{L}{2}\right)$$

$$= 293.585 - (-2.5)\left(\frac{150}{100}\right)$$

↳ Divide by 100 to convert to units of (100 m)

$$\boxed{Elev_{BVC} = 297.335\ m}$$

(3) Determine Station of EVC:

$$Stat_{EVC} = Stat_{VPI} + \frac{L}{2} = (4+200) + (0+150)$$

$$\boxed{Stat_{EVC} = 4+350.000}$$

④ Determine the elevation of EVC:

$$Elev_{EVC} = Elev_{VPI} + g_2\left(\frac{L}{2}\right)$$

$$= 293.585 + 2.5\left(\frac{150}{100}\right)$$

$$\boxed{Elev_{EVC} = 297.335\ m}$$

⑤ Write the general equation to use in order to determine the elevations at different stations:

$$Y = Y_{BVC} + g_1 X + \frac{r}{2} X^2$$

$$r = \frac{g_2 - g_1}{L} = \frac{(2.5)-(-2.5)}{300/100} = \frac{5}{3}$$

$$\Rightarrow \boxed{Y = 297.335 - 2.5X + \frac{5}{6} X^2}$$

⑥ Find the next station to stake after the BVC

* Divide the station of BVC by 60 (increment)

$$\Rightarrow \frac{4050}{60} = 67.5$$

* Round up to next number $\Rightarrow$ 68

* Multiply that number by 60

$$\Rightarrow 68 \times 60 = 4080$$

* The next station after the BVC that is evenly divisible by 60 is (4+ 80.000)

⑦ Tabulate your results:

| | Station | X (m) | X (100 m) | Elevation (m) |
|---|---|---|---|---|
| (BVC) | 4+ 050.000 | 0 | 0 | 297.335 |
| | 4+080.000 | 30 | 0.3 | 296.660 |
| | 4+140.000 | 90 | 0.9 | 295.760 |
| | 4+200.000 | 150 | 0.15 | 295.460 |
| | 4+260.000 | 210 | 0.21 | 295.760 |
| | 4+320.000 | 270 | 0.27 | 296.660 |
| | 4+350.000 | 300 | 0.30 | 297.335 ✓ |

Same value we calculated for $Elev_{EVC}$!

(8) The location of the lowest point is given by the equation:

$$X = \frac{g_1 L}{g_1 - g_2} \quad \text{or} \quad X = \frac{-g_1}{r}$$

$$X = \frac{-(-2.5)}{5/3} = 1.5 \quad (\text{unit } 100\text{ m})$$

The station of the lowest point is

$\Rightarrow (4 + 50.000) + (0 + 150.000) = \underline{4 + 200.000}$

The elevation of the lowest point is

$\underline{295.460\text{ m}}$

**Problem 2**

Grades g1 of +3.0% and g2 of -2.0% meet at the VPI at station 2+175 and elevation 157.830 m. Compute and tabulate full-station elevations for the equal-tangent vertical curve having a length of 150-m (Use 60-m stationing). Determine the location and elevation of the heighest point.

① Determine the station of the BVC

$$Stat_{BVC} = Stat_{VPI} - \frac{L}{2} = (2+175) - \left(\frac{150}{2}\right)$$

$$= (2+175) - (0+075)$$

$$\boxed{Stat_{BVC} = 2+100.000}$$

② Determine elevation of BVC:

$$Elev_{BVC} = Elev_{VPI} - g_1\left(\frac{L}{2}\right)$$

$$= 157.83 - (3)\left(\frac{150/2}{100}\right)$$

$$\boxed{Elev_{BVC} = 155.580\ m}$$

③ Determine the station of EVC:

$$Stat_{EVC} = Stat_{VPI} + \frac{L}{2} = (2+175) + (0+075)$$

$$\boxed{Stat_{EVC} = 2+250.000}$$

④ Determine the elevation of EVC:

$$Elev_{EVC} = Elev_{VPI} + g_2\left(\frac{L}{2}\right)$$

$$= 157.83 - 2\left(\frac{75}{100}\right)$$

$$\boxed{Elev_{EVC} = 156.330\ m}$$

(5) Determine the equation to use to calculate elevations at different stations:

$$Y = Y_{BVC} + g_1 X + \frac{r}{2} X^2$$

$$r = \frac{g_2 - g_1}{L} = \frac{-2-3}{(150/100)} = -\frac{10}{3}$$

$$\boxed{Y = 155.580 + 3X - \frac{10}{6} X^2}$$

(6) Determine the stations for stakeout:

1st station after BVC:

$\frac{2100}{60} = 35$ → Round up to the next integer

→ 36

→ Multiply by 60

$36 \times 60 = 2160$

→ 1st station is (2+160.000)

⑦ Tabulate the Results:

| | Station | X (m) | X (100 m) | Elevation (m) |
|---|---|---|---|---|
| BVC - | 2+100.000 | 0 | 0.000 | 155.580 |
| | 2+160.000 | 60 | 0.600 | 156.780 |
| | 2+220.000 | 120 | 0.120 | 156.780 |
| EVC - | 2+250.000 | 150 | 0.150 | 156.330 |

⑧ The station of the heighest point is found using the equation:

$$X = \frac{-g_1}{r} = \frac{-(3)}{\frac{-10}{3}} = 0.9 \ (90\,m)$$

$$\text{Station}_{\text{heighest}} = (2+100) + (0+090)$$

$$= \underline{2+190.000}$$

The elevation of the heighest point is:

$$\underline{156.930\ m}$$