

Geometric Design of the track

4- Types of Cants

The cants are further divided on the bases of speed:

- Equilibrium cant
- Cant deficiency (Cd)
- Cant excess (Ce)

Equilibrium cant

The cant or super elevation as given by equation $e = (GV^2/1.27R)$ using equilibrium speed (**weighted average speed of the trains or average speed of the trains**).

The weighted average speed of different trains at different speeds is calculated from equation.

$$\text{weighted average speed} = \frac{n_1V_1 + n_2V_2 + n_3V_3 + n_4V_4}{n_1 + n_2 + n_3 + n_4}$$

$$\text{average speed} = \frac{V_1 + V_2 + V_3 + V_4}{4}$$

Where:

n_1, n_2, n_3, n_4 = Number of trains

V_1, V_2, V_3, V_4 = Speed of trains in kmph

Cant excess (C_e)

Cant excess (C_e) occurs when a train travels around a curve at a speed lower than the equilibrium speed. **It is the difference between the actual cant provided and the cant required for such a low speed.**

Cant deficiency (C_d)

The equilibrium cant is provided on the basis of equilibrium speed (average speed, or weighted average speed of different trains). But this equilibrium cant or superelevation falls short of that required for the high speed trains. This shortage of cant is called "cant deficiency ".

In other words, **cant deficiency is the difference between the cant necessary for the maximum permissible speed on a curve and the actual cant provided.**

This cant deficiency is limited due to two reasons:-

- i- Higher cant deficiency gives rise to higher discomfort to passengers.
- ii- Higher cant deficiency means higher would be the balanced centrifugal forces and hence extra pressure and lateral forces on outer rails. This will require strong track and fastenings for stability.

Limits of cant deficiency

| Gauge | Cant deficiency for speeds up to 100 kmph | Cant deficiency for speeds higher than 100 kmph |
|--------------|--------------------------------------------------|--------------------------------------------------------|
| B.G. | 7.6 cm (7.5 cm approx.) | 10.0 cm |
| M.G. | 5.1 cm (5.0 cm approx.) | Not specified |
| N.G. | 3.8 cm | Not specified |

Negative superelevation:

When the main line is on a curve and has a turnout of contrary flexures leading to a branch line (as shown in Fig. 1) the superelevation necessary for the average speeds of trains running over the main line cannot be provided.

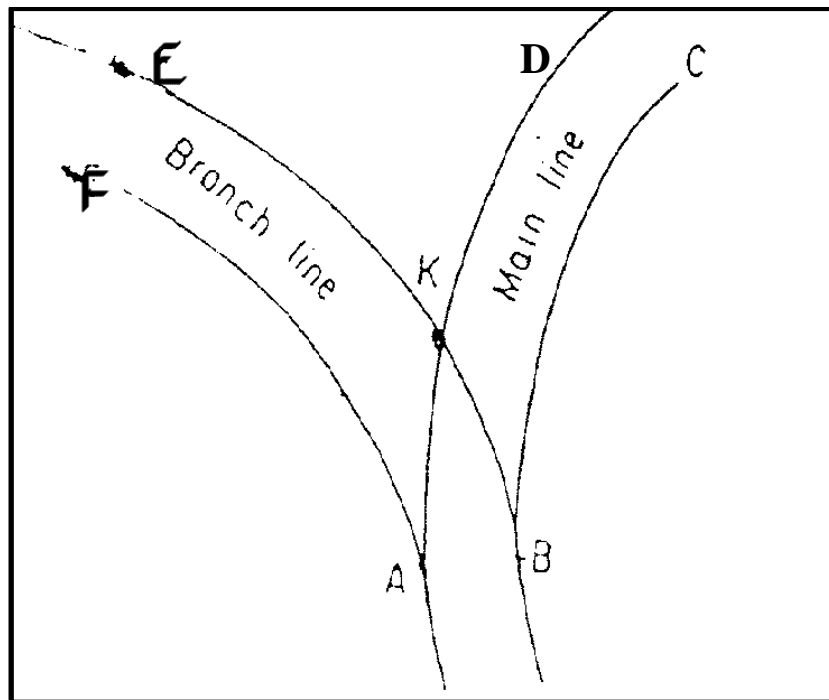


Fig. 1 **Negative superelevation**

AD which is the outer rail of the main line curve must be higher than inner rail BC or in other words, the point A should be higher than point B

For the branch line, however, BE should be higher than AF or the point B should be higher than point A.

These two contradictory conditions cannot meet within one layout. So instead of outer rail BE on branch line being higher, it is kept lower than the inner rail AF. In such cases, the branch line curve has a negative superelevation and therefore speeds on both tracks must be restricted, particularly on branch line.

The method, of working out the speeds on main line, branch line and negative superelevation on branch line, will be clear from the following steps:-

- 1- The theoretical superelevation or cant on branch line is calculated by formula (e), after assuming a max. speed on branch line.
- 2- The permissible cant deficiency deducted from the theoretical cant as obtained in step (1).
- 3- The difference obtained (theoretical cant – permissible cant deficiency) will give the negative superelevation to be used on the branch line.
- 4- This negative superelevation is also equal to the maximum superelevation permitted on the main curved track.
- 5- The restricted speed on curved track is obtained by adding permissible deficiency to maximum cant on the main track and applying the formula (e).

Example 1:

If a 8° curve track diverges from a main curve of 5° in an opposite direction in the layout of a B.G. yard, calculate the superelevation and the speed on the branch line, if the maximum speed permitted on the main line is 45 kmph.

Solution:-

- 1- Equilibrium cant required for speed 45 kmph by equation (e):

$$e = \frac{GV^2}{1.27R}$$

G=1.676 for B.G , V=45 kmph

D=1720/R R=1720/5 =344 m

$$e = 1.676 * 45 * 45 / 1.27 * 344$$

$$e = 7.78 \text{ cm.}$$

2- For broad gauge the cant deficiency for the main line = 7.6cm permitted from table

3- So the cant for main track = $7.78 - 7.6 = 0.18\text{cm}$

4- Therefore the cant to be provided for branch track = -0.18 .

5- With cant deficiency of 7.6 cm which is permissible the speed of the train will be for a cant of $7.6 + (-0.18) = 7.42\text{cm}$

Hence permissible speed on branch line can be worked out from formula (e).

$$7.42 = 1.676 * V^2 / 1.27 * 215$$

$$V^2 = 7.42 * 1.27 * 215 / 1.676$$

$$= 1210$$

$$V = 34.7 \text{ kmph}$$

This is theoretical speed on branch line, because the maximum speed on branch line should not be more than 24 kmph.

Example no. 2:

Find the speed for which superelevation is to be maintained if the speeds of several trains running on a main curve track are as follows:

- i- 15 trains at speed of 50 kmph.
- ii- 10 trains at speed of 60 kmph.
- iii- 5 trains at speed of 70 kmph.
- iv- 2 trains at speed of 80 kmph.

Solution:

The " weighted average " of different trains at different speeds is calculated from equation.

$$\text{weighted avg.} = \frac{n_1v_1 + n_2v_2 + n_3v_3 + n_4v_4}{n_1 + n_2 + n_3 + n_4}$$

$$\text{weighted avg.} = \frac{15 * 50 + 10 * 60 + 5 * 70 + 2 * 80}{15 + 10 + 5 + 2}$$

$$\text{weighted avg.} = \frac{750 + 600 + 350 + 160}{32}$$

$$= 58.125 \text{ kmph}$$

Example no. 3:

What would be the equilibrium cant on a M.G curved track of 7° for an average speed of trains 50 kmph ? also calculate the max. Permissible speed after allowing the maximum cant deficiency.(cant deficiency for M.G =5.0 cm).

Solution:

1- Equilibrium cant for M.G.

$$e = \frac{GV^2}{1.27R}$$

$$R = 1720 / 7$$

$$e = 1.0 * 50 * 50 * / 1.27 * 245.71$$

$$e = 8.01 \text{ cm.}$$

2- Theoretical cant = actual cant + cant deficiency

$$= 8.01 + 5.0 = 13.01 \text{ cm}$$

3- Therefore, the max. permissible speed when theoretical cant of 13.01cm

$$13.01 = \frac{1.0 * V^2}{1.27 * 245.71}$$

$$V = \sqrt{\frac{13.01 * 245.71 * 1.27}{1.0}}$$

$$V = \sqrt{4060}$$

$$V = 63.718 \text{ kmph}$$

4- According to railway board speed formula

$$V = 4.4 \sqrt{R - 70}$$

$$V = 4.4 \sqrt{245.71 - 70}$$

$$V = 58.324 \text{ kmph}$$

So the maximum speed permissible for the train (lower of the two values)
= 58.324 kmph

Example no. 4:

Calculate the maximum permissible speed on curve of high speed B.G. track having the following particulars:

- i- Degree of the curve = 1°
- ii- Amount of superelevation = 8.0 cm
- iii- Length of transition curve = 130 m
- iv- Max. speed of the section likely to be sanctioned = 165 kmph

Solution:

Radius of the curve = $1720 / 1 = 1720$ m.

- i- Safe speed on the curve (for high speed)

$$\begin{aligned}V &= 4.58 \sqrt{R} \\ &= 4.58 \sqrt{1720} \\ &= 190 \text{ kmph}\end{aligned}$$

- ii- Speed from superelevation

Actual superelevation = 8.0 cm

Max. cant deficiency for high speed B.G. track = 10.0 cm

Theoretical superelevation = $8.0 + 10.0 = 18.0$ cm

Max. speed for this superelevation

$$18 = \frac{1.676 * V^2}{1.27 * 1720}$$

V = 153 kmph

iii- Speed of the length of transition curve

$$V_{max} \frac{198 \cdot L}{e} \quad e = 8.0 \text{ cm} = 80 \text{ mm}, \quad L = 130 \text{ m}$$

$$V_{max} = 320 \text{ kmph} \quad \text{or}$$

$$V_{max} \frac{198 \cdot L}{D} \quad D = 10 \text{ cm} = 100 \text{ mm}, \quad L = 130 \text{ m}$$

$$V_{max} = 257 \text{ kmph}$$

The max. permissible speed on the curve is the minimum of the following:

- 1- 190 kmph
- 2- 153 kmph
- 3- 257 kmph
- 4- 165 kmph,

Therefore max. permissible speed = 153 kmph say 150 kmph