# Superelevation Design Guide

Roadway Design Division

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# Table of Contents

# Part 1: Superelevation Quick Guide

**Roadway Design Guidelines**

Details on Superelevation design can be found in Roadway Design Guidelines, Chapter 2-101.01

**Standard Roadway Drawings**

- RD01-SE-2
- RD01-SE-3
- RD11-SE-1
- RD11-SE-2
- RD11-SE-2A
- RD11-SE-3
- RD11-SE-3A

**TDOT Roadway Design Training Classes**

- GEOPAK Road Course Guide
  - Exercise 13: How to use MicroStation and GEOPAK to set up superelevation controlled shapes
  - Exercise 14: How to apply the superelevation shapes to the cross sections
  - Exercise 22: How to apply the superelevation shapes to the creation of the final TIN process.
- Roadway Design Manual
  - Chapter 8: How to create the superelevation shapes and applying it to cross sections

**TDOT Roadway Design Reference Documents**

- Roadway Design R.O.W. Checklist
- Roadway Design Construction Checklist

**Roadway Design Plans**

In a standard roadway plan set, superelevation is included on the following sheets:

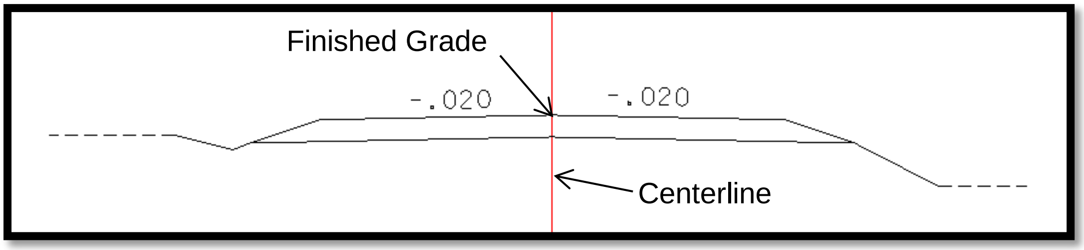
- Typical Sections Sheet: If a project has superelevation, a typical section and the station ranges of superelevation must be shown on this sheet.
- Proposed Profile: A superelevation diagram must be added to the Proposed Profile sheet.
- Cross Sections: The superelevation should be seen on the cross sections where superelevation is present.

**Other Helpful Material**

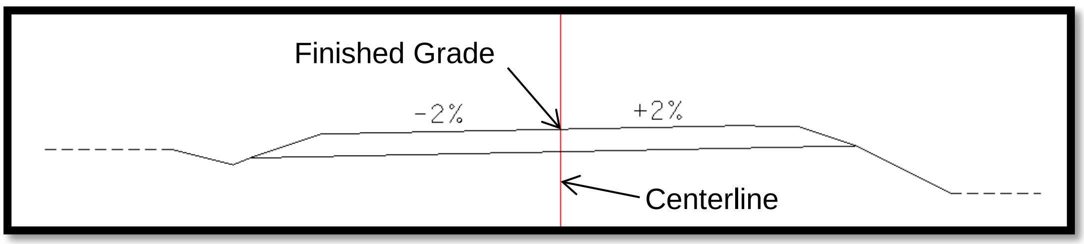
- Green Book (2011)

# Part 2: Superelevation Calculation Guide

Superelevation is defined as the rate of cross slope on a curved section of roadway in which the outer edge is banked higher than the inner edge. The Standard Roadway Drawings provide information for Urban Superelevation Details (RD01-SE-2) and Rural Superelevation Details (RD01-SE-3). Within the drawings, there are illustrations for a 2 lane and 4 or 6 lane road transition in superelevation. The following documentation will explain the log file created by running Superelevation in Geopak Road. It will also explain how to check information in the log file by performing calculations to find the stations where the lanes on each side of the centerline are at normal crown (-0.02) and where one of the lanes has transitioned from normal crown (-0.02) to straight surface or reverse crown (+0.02). Calculations will also be shown for the lane where maximum transition occurs from normal crown to a positive cross slope to identify the station where zero percent slope occurs.




Normal Crown




Reverse crown

The curve information that will be used for this example is for a rural 2 lane road based on the "E MAX = 0.08 Desirable" table on Standard Roadway Drawing RD01-SE-3 with v = 30 mph., degree of curve 13º- 00', maximum superelevation of 0.068, and transition length of 160.00'. When a horizontal alignment is added in Geopak Road, information for the curve can be found in Geopak Road by opening Coordinate Geometry>Navigator>Chain. Also, when the proposed horizontal alignment is displayed in the alignment file, the curve data will be part of the display. The curve data matches what is found in the Standard Roadway Drawing for Superelevation. The horizontal alignment and curve data are shown in *Figure 1- Horizontal Alignment Curve D1*. The SE, design speed, and transition length are all filled in by the user from the data in the standard drawing.

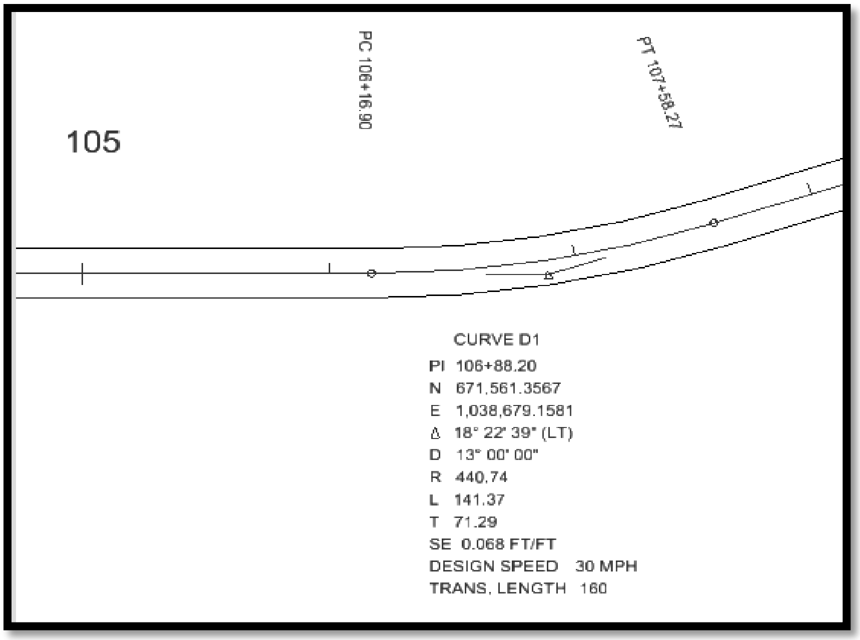



*FIGURE 1 – HORIZONTAL ALIGNMENT CURVE D1*

Notice the P.I. of the curve is to the right of the radius and the way the curve is laid out in *Figure 1- Horizontal Alignment Curve D1*. The transition from normal crown to full superelevation will begin on the right lane of the centerline first because that side goes from negative to positive cross slope while the other side remains negative.

The superelevation log file from Geopak Road contains information for the left and right lanes of the road as shown below. Because the transition begins on the right lane of the road, the right lane is listed first in the log file.

| **Left** | **Right** |
|---|---|
| ROADNAME 8.0000 | ROADNAME -8.0000 |
| filler line station / slope | filler line station / slope |
| 100+00.000000 -2.0000 | 100+00.000000 -2.0000 |
| 106+00.315956 -2.0000 | 105+27.588683 -2.0000 |
| 106+87.588683 -6.8000 /* Curve D1 */ | 106+87.588683 6.8000 /* Curve D1 */ |
| 107+74.861410 -2.0000 | 108+47.588683 -2.0000 |
| 112+03.385413 -2.0000 | 112+03.390000 -2.0000 |

The first entry line lists the road name and maximum superelevation rate from the “E MAX = 0.08 Desirable” table. The beginning and ending stations on the proposed horizontal alignment will always be listed for both the left and right lanes of the road. For this alignment, the beginning and ending stations are 100+00.00 and 112+03.39. The output shows that full super occurs at station. 106+87.588683. The curve is only in full super for this station. This is because this station is at the midpoint of the curve** and begins to transition back down to normal crown. If the curve remained in full superelevation for more than a station, there would be an additional entry. For example, if the curve was in full superelevation for 100', there would be an additional entry of 107+87.588683 6.8000 /* Curve D1 */, and the remaining stations would adjust accordingly.

Compare the output for the last station with normal crown listed on the right lane of the road (105+27.588683) prior to the full superelevation station with the last station with normal crown listed on the left lane of the of the road (106+00.315956). The station on the right precedes the station on the left because it has a longer transition. The same occurs after the full superelevation station where the station on the right (108+47.588683) follows the station of the left (107+74.861410) due to the longer transition length needed.

** In Figure 1, the length of the curve is shown to be 141.37.

141.37/2 = 70.69.

10616.90 (P.C.Sta.) +70.69 = 10687.59 = Station 106+87.59

This station (106+87.59) is the point on the curve with full superelevation.

The log file carries the numbers out 6 decimal places, but for the figures and calculations, only 2 decimal places will be used. When performing the calculations, there might be a slight difference in the 3rd decimal place due to rounding. Also, within the calculations, the plus sign in stations will be removed for clarity but will be shown in each result.

Verification and calculations for superelevation station:

For this example, the length of transition (160' from RD01-SE-3) is longer than the length of curve (141.37' from Geopak). Generally, one-half the transition length is before the PC and the other one-half is after the PC where maximum superelevation begins. Maximum superelevation continues to one-half the transition length before the PT and ends one-half the transition length after the PT. When the

Verification and calculations for stations will be shown for the right lane first:

**Right**

ROADNAME -8.0000

filler line station / slope

100+00.000000 -2.0000

105+27.588683 -2.0000

106+87.588683 6.8000 /* Curve D1 */

108+47.588683 -2.0000

112+03.390000 -2.0000

## NORMAL CROWN BEFORE FULL SUPERELEVATION (RIGHT LANE)

To verify the last station where the right lane is at normal crown before it starts transitioning to full superelevation, subtract the transition length from the full superelevation station.

- Station of full Superelevation - Transition Length

  10687.5887 - 160 = **105+27.5887**

## TRANSITION RATE

The transition rate for a curve is found for the lane of the road with the most change in cross slope, the right lane in this example. To find the transition rate, the maximum change in cross slope is divided by the known transition length for the curve.

- Transition Rate = $\frac{\text{Maximum Change in Cross Slope}}{\text{Known Transition Length of Curve}}$

  $= \frac{(0.068 - (-0.02))}{160'} = \frac{0.088}{160'} = 0.00055$

This Transition Rate will be used in other calculations.

**ZERO PERCENT BEFORE FULL SUPERELEVATION (RIGHT LANE)**

Since the right lane of the road goes from a negative slope (normal crown slope of -0.02) to a positive slope at full super (+0.068), there is a station where the cross slope for the right lane is at zero percent (0.00). This is an area of concern because of drainage issues and should be analyzed by the designer to ensure no ponding occurs.

To find the station where zero percent cross slope occurs for the right lane of the road before reaching full superelevation, reverse the formula used to calculate the transition rate. Using the known transition rate and the change in cross slope, find the length needed to transition from normal crown cross slope to zero percent cross slope. Add the length to the last station where normal crown occurred.

- $\text{Length} = \dfrac{\text{Change in Cross Slope}}{\text{Transition Rate}}$

$$= \frac{0.00 - (-0.02)}{0.00055} = \frac{0.020}{0.00055} = 36.36'$$

Zero percent cross slope is reached at 10527.5887 + 36.36' = **105+63.95**

Another way to perform the calculation would have been to find the length of transition from zero percent cross slope to full superelevation cross slope and subtract from the superelevation station

- $\text{Length} = \dfrac{\text{Change in Cross Slope}}{\text{Transition Rate}}$

$$= \frac{(0.068 - 0.00)}{0.00055} = \frac{0.068}{0.00055} = 123.64'$$

Zero percent cross slope is reached at 10687.5887 – 123.64' = **105+63.95**

**REVERSE CROWN BEFORE FULL SUPERELEVATION (RIGHT LANE)**

To find the station where reverse crown (+0.02) occurs for the right lane of the road before reaching full superelevation, use the same calculations as previously described. Find the length needed to transition from normal crown cross slope to reverse crown and add the length to the last station where normal crown occurred.

- $\text{Length} = \dfrac{\text{Change in Cross Slope}}{\text{Transition Rate}}$

$$= \frac{0.02 - (-0.02)}{0.00055} = \frac{0.040}{0.00055} = 72.72'$$

OR

Double the number found in calculation #4 since it was calculated for a 0.02 change in cross slope, and this is a 0.04 change. (36.36' X 2) = 72.72'

Reverse crown cross slope is reached at 10527.5887 + 72.72' = **106+00.32**

This station matches the station shown in the log file for the left lane of the road at the last station where normal crown occurs.

Once the right lane transitions from -0.20 to +0.20, both lanes will rotate at the same rate until full superelevation of 0.068 is reached (+0.068 for the right and -0.068 for the left).

## FULL SUPERELEVATION

To verify the station where full superelevation is reached divide the curve length in half and add the result to the to the P.C. station.

P.C. Station + Curve Length /2 =

10616.90 + (141.37/2) = 106+87.59

Since the curve is only at full superelevation for one station, the station can be also be checked by using the P.T. station. To verify the station superelevation is reached, divide the curve length in half and subtract the result from to the P.T. station.

P.T. Station – Curve Length/2 =

10758.27 - (141.37/2) = 106+87.59

## REVERSE CROWN AFTER FULL SUPERELEVATION (RIGHT LANE)

To find the station where reverse crown (+0.02) occurs for the right lane of the road after full superelevation, use the same concept as previously described except use the station listed after the full superelevation where the cross slope has transitioned back to normal crown and subtract the calculated length (72.72') for a 0.04 change in cross slope.

Reverse crown cross slope is reached at 10847.5887 - 72.72' = **107+74.86**

This station matches the number shown in the log file for the left lane of the road for the last station where the left lane is at normal crown.

**ZERO PERCENT AFTER FULL SUPERELEVATION (RIGHT LANE)**

To find the station where zero percent cross slope occurs for the right lane of the road after reaching full superelevation, use the same concept as previously described except use the station after the superelevation where the cross slope has transitioned back to normal crown. Subtract the calculated length (36.36) for a 0.02 change in cross slope

Zero percent cross slope is reached at 10847.5887 – 36.36' = **108+11.23**

Check: Full superelevation station plus length found for change from 0.00 to 0.068.

10687.5887 + 123.64' = **108+11.23**

**NORMAL CROWN AFTER SUPERELEVATION (RIGHT LANE)**

To verify where the right lane transitions back to normal crown after full superelevation is reached, add the transition length to the full superelevation station.

- Full Super + Transition Length

10687.5887 + 160 = **108+47.5887**

The next few steps will verify stations that are generated for the left lane of the road. The left lane of the road transitions from -0.02 to -0.068 so there is not a station for zero percent cross slope or reverse crown.

**Left**

ROADNAME 8.0000

filler line station / slope

100+00.000000 -2.0000

106+00.315956 -2.0000

106+87.588683 -6.8000 /* Curve D1 */

107+74.861410 -2.0000

112+03.385413 -2.0000

## NORMAL CROWN BEFORE FULL SUPERELEVATION (LEFT LANE)

The full transition length of 160' is not needed on the left lane. The transition rate that was calculated for the right lane will be used to find the transition length needed to normal crown to superelevation. To verify the last station for normal crown prior to superelevation for the left lane, find the length needed for the change in cross slope from normal crown to full superelevation and divide by the known transition rate for the right lane. Subtract this length from the full superelevation station.

- $\text{Length} = \dfrac{\text{Change in Cross Slope}}{\text{Transition Rate}}$

$$= \frac{-0.068 - (-0.02)}{.00055} = \frac{0.048}{.00055} = 87.27$$

Full Super minus Length

10687.5887 - 87.27 = **106+00.32**

This station matches the station calculated for reverse crown for the right lane.

## NORMAL CROWN AFTER FULL SUPERELEVATION (LEFT LANE)

To find the station where the left lane transitions back to normal crown, add the length calculated for the left lane to the full superelevation station.

- Full Super + Length

10687.5887 + 87.27 = **107+74.86**

This station matches the station calculated for reverse crown for the right lane.

Below is a figure for the entire curve with all the stations and cross slopes.

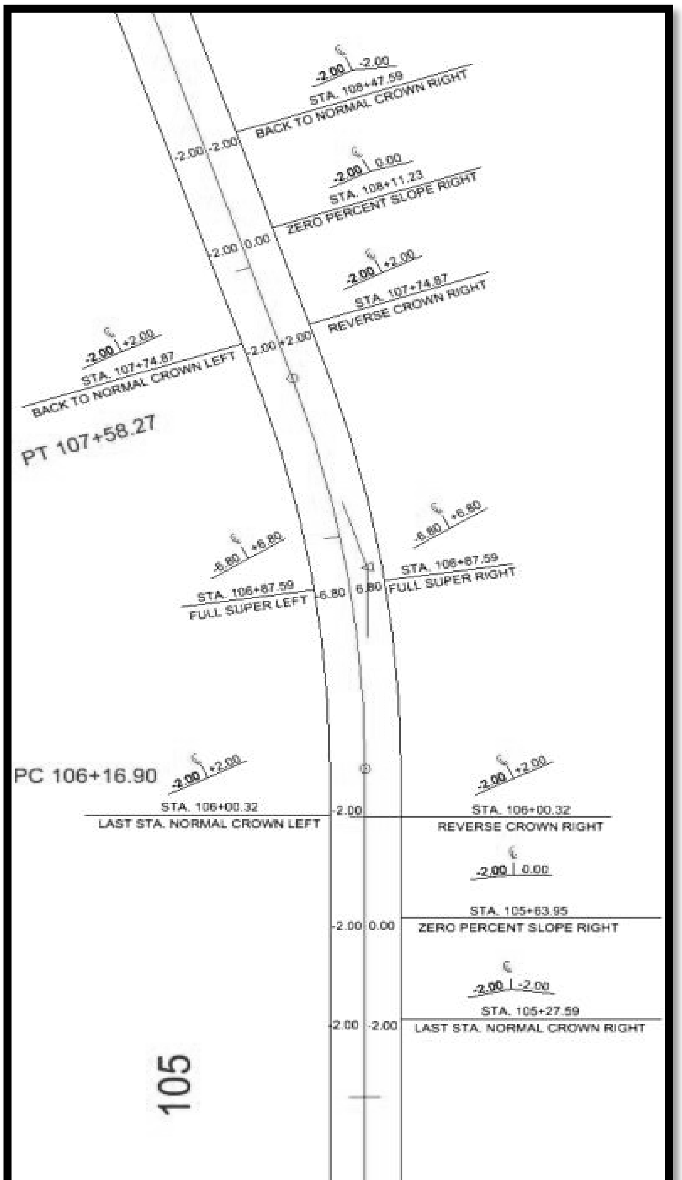



*FIGURE 2 – STATIONS AND CROSS SLOPES*

For clarity, the *Figure 2, Stations and Cross Slopes* has been split into two separate figures representing the stations before and after full superelevation.

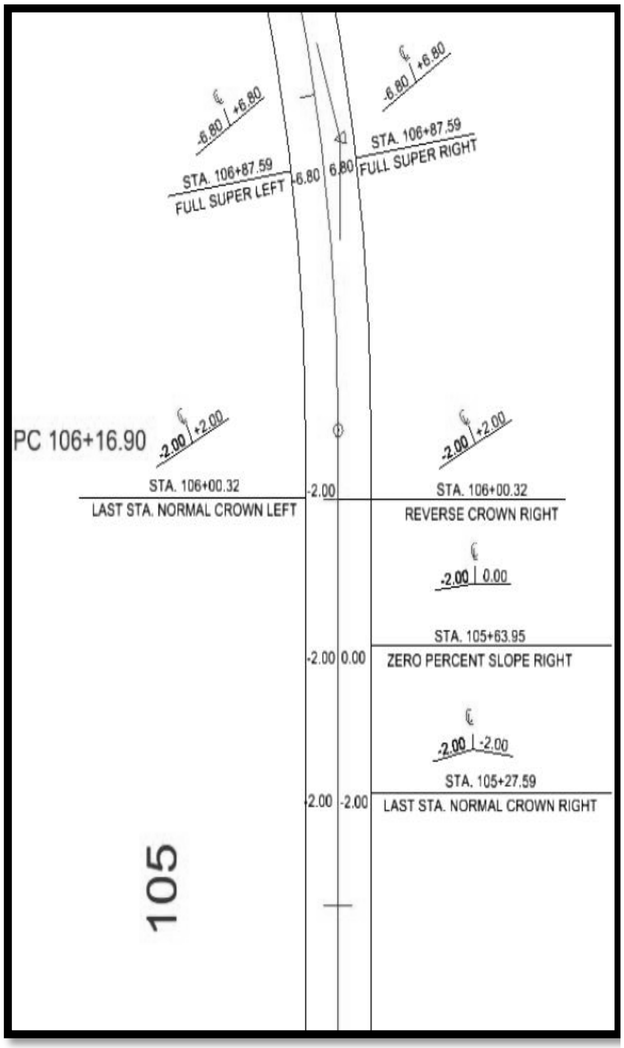



*FIGURE 3 – STATIONS AND CROSS SLOPES BEFORE FULL SUPERELEVATION*

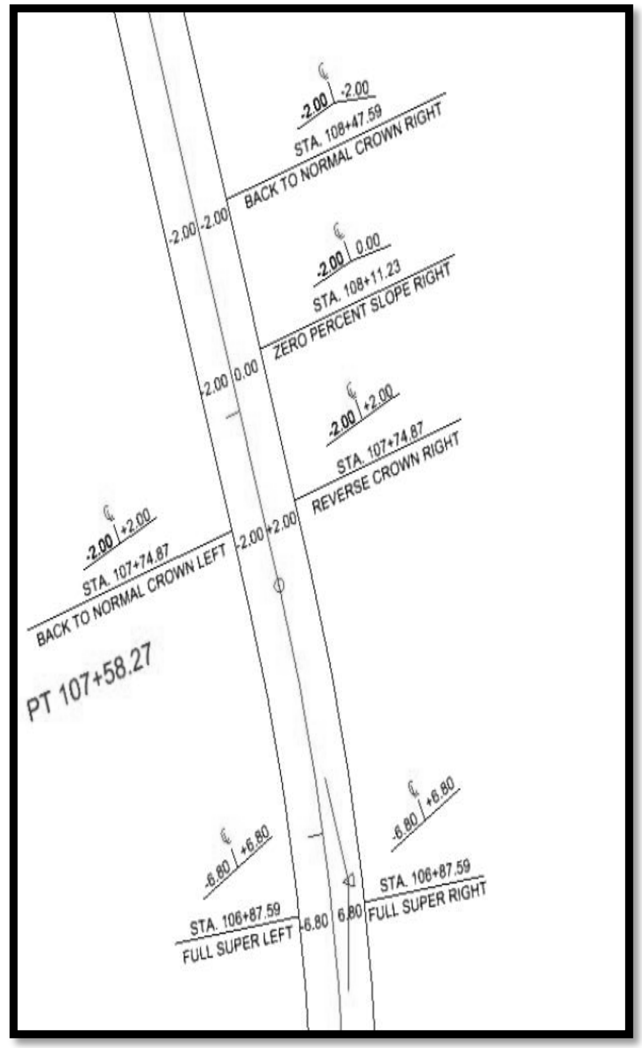



*FIGURE 4 – STATIONS AND CROSS SLOPES AFTER FULL SUPERELEVATION*

# Part 3: Superelevation Calculation (RD11 Series)

Horizontal curves will no longer be identified by degree, they will be identified by radius only. Standard Drawings RD11-LR-1 (Urban) and RD11-LR-2 (Rural) contain tables for different design speeds, and number of lanes, showing the superelevation rate ($e_d$) associated with curve radius. One important thing to note that is different from the earlier standards is that for a specific $e_d$, the radius shown is the <u>minimum</u> radius that can be used. Also, for a given radius, only use the corresponding $e_d$.

③

| $e_d$ | V = 20 (MPH) | | | | | | R |
|---|---|---|---|---|---|---|---|
| | R | Number of lanes | | | | | |
| (%) | MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | MIN (FT. |
| NC | 1640 | 0 | 0 | 0 | 0 | 0 | 237 |
| 2 | 1190 | 32 | 40 | 49 | 57 | 65 | 172 |
| 2.2 | 1070 | 36 | 44 | 54 | 62 | 72 | 155 |
| 2.4 | 959 | 39 | 48 | 58 | 68 | 78 | 140 |
| 2.6 | 872 | 42 | 52 | 63 | 74 | 85 | 128 |
| 2.8 | 796 | 45 | 57 | 68 | 79 | 91 | 117 |
| 3 | 730 | 49 | 61 | 73 | 85 | 98 | 107 |
| 3.2 | 672 | 52 | 65 | 78 | 91 | 104 | 985 |
| 3.4 | 620 | 55 | 69 | 83 | 96 | 111 | 911 |
| 3.6 | 572 | 58 | 73 | 88 | 102 | 117 | 845 |
| 3.8 | 530 | 62 | 77 | 92 | 108 | 124 | 784 |
| 4 | 490 | 65 | 81 | 97 | 114 | 130 | 729 |
| 4.2 | 453 | 68 | 85 | 102 | 119 | 137 | 678 |
| 4.4 | 418 | 71 | 89 | 107 | 125 | 143 | 630 |
| 4.6 | 384 | 75 | 93 | 112 | 131 | 150 | 585 |
| 4.8 | 349 | 78 | 97 | 117 | 136 | 156 | 542 |

For example, given a radius of 730 ft., the corresponding super rate is 3%. If the $e_d$ is to remain at 3%, any radius greater than 730 can be used. If the radius is to remain at 730, no other $e_d$ than 3% can be used.

The numbers that appear under the number of lanes are runoff lengths ($L_R$). Runoff Length ($L_R$) is the distance that is required to transition from zero (flat) superelevation to full superelevation. The total transition length (L) is the length at which the transition from Normal Crown (NC) to full super ($e_d$) takes place.

The formula for the total transition length is found on Standard Drawing RD11-SE-1.

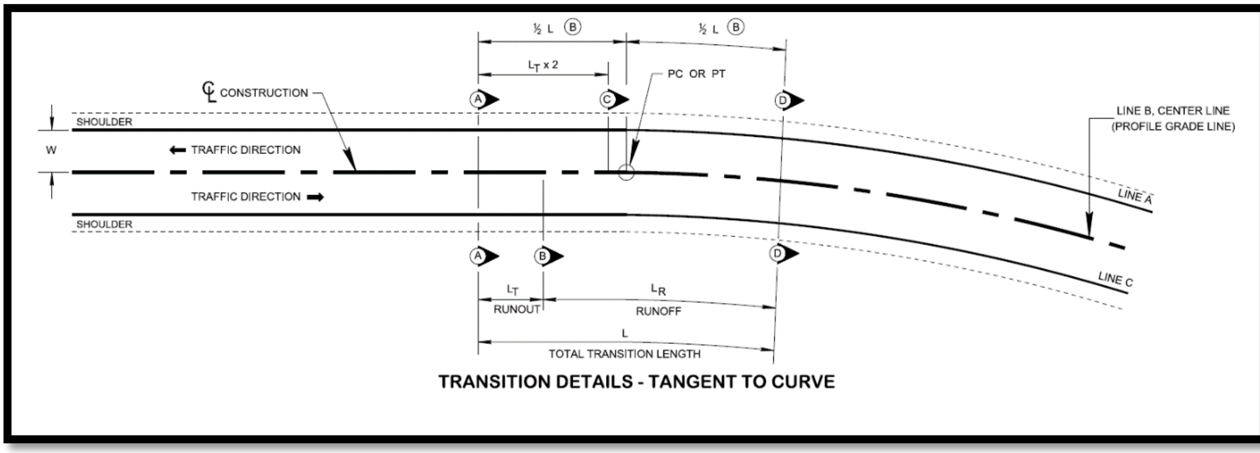
**SUPERELEVATION TRANSITION EQUATIONS**

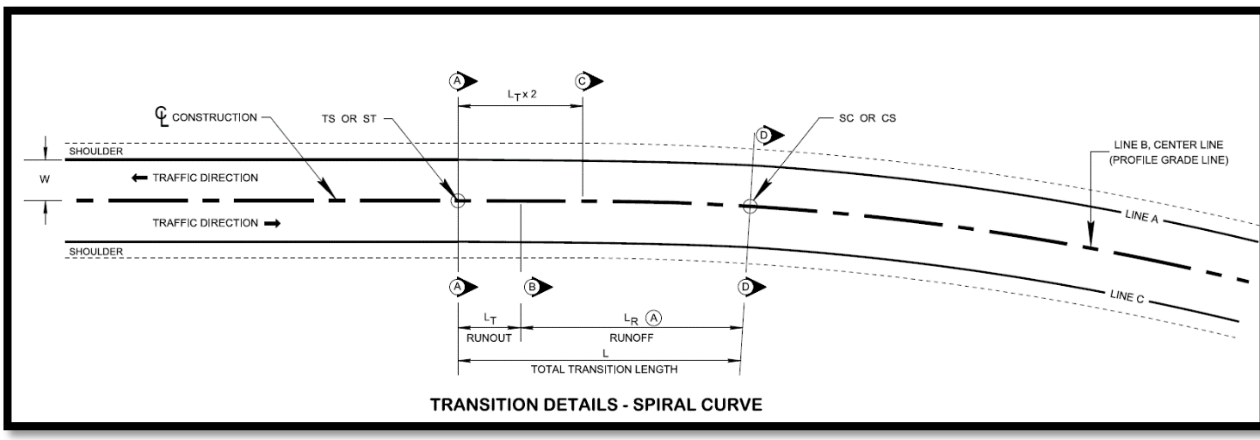
$$L = L_R + L_T$$

$$L_R = \frac{(W n 1)\, e_d}{\Delta \%}(b_w)$$

$$L_T = \frac{NC}{e_d} L_R$$

Standard Drawing RD11-SE-2 shows the relationship of L to the begin and end points of the horizontal curve.

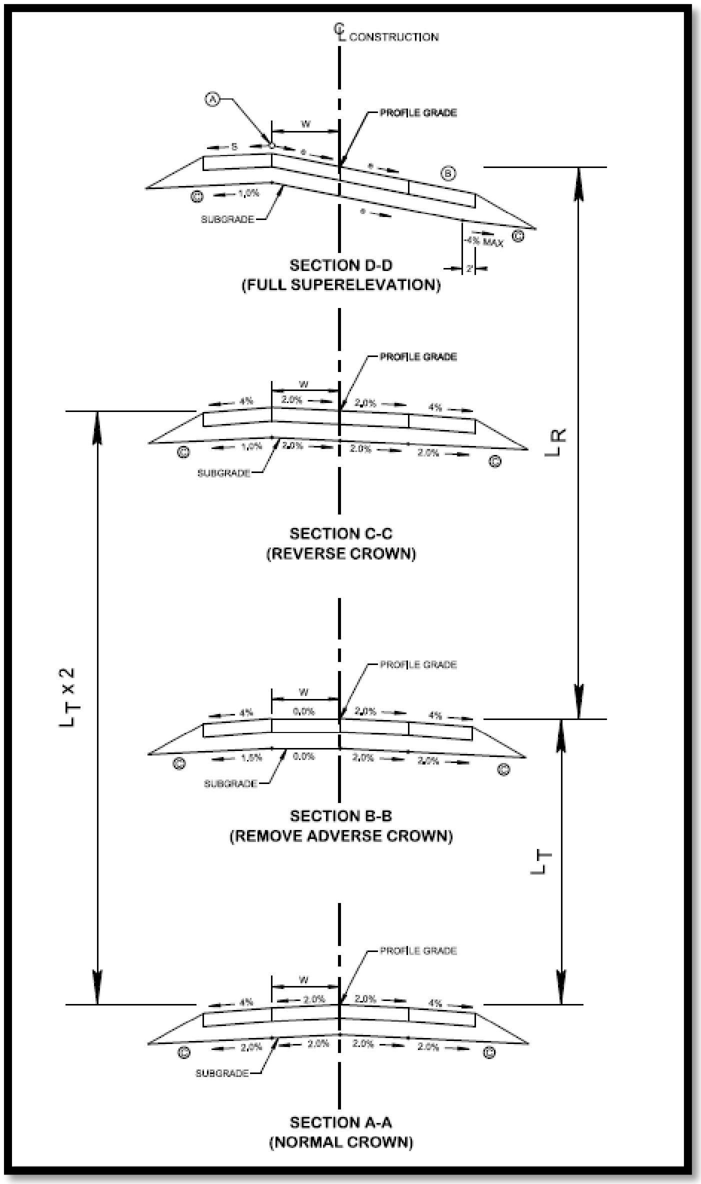



For a simple curve half of the transition length is before and half after the P.C. or P.T.

For a spiral curve L is the same as the length of the spiral.

Standard Drawing RD11-SE-2A shows the lengths at which key points occur within the transition length.




NOTE: Standard Drawings RD11-SE-3 and 3A contain the same information as RD11-SE-2 and 2A, except for divided highways.

Example 1

- 2 lane rural design
- Design Speed 50 MPH
- Curve Radius 2280 ft.

According to Standard Drawing RD11-LR-2 (Minimum Runoff Lengths for Rural Highways), the superelevation rate ($e_d$) for this curve is 4.6% (.046 ft./ft.). 2280 ft. is the minimum radius that can be used with this rate. This also means that for a particular $e_d$ rate a higher radius can be used.

DESIGN RUNOFF LENGTHS ( $L_R$ ) ①

E MAX = 0.08 DESIRABLE

| ③ e d (%) | V = 20 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | V = 25 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC | 1640 | 0 | 0 | 0 | 0 | 0 | 2370 | 0 | 0 | 0 | 0 | 0 |
| 2 | 1190 | 32 | 40 | 49 | 57 | 65 | 1720 | 34 | 43 | 51 | 60 | 69 |
| 2.2 | 1070 | 36 | 44 | 54 | 62 | 72 | 1550 | 38 | 47 | 57 | 66 | 76 |
| 2.4 | 959 | 39 | 48 | 58 | 68 | 78 | 1400 | 41 | 51 | 62 | 72 | 83 |
| 2.6 | 872 | 42 | 52 | 63 | 74 | 85 | 1280 | 45 | 55 | 67 | 78 | 90 |
| 2.8 | 796 | 45 | 57 | 68 | 79 | 91 | 1170 | 48 | 60 | 72 | 84 | 96 |
| 3 | 730 | 49 | 61 | 73 | 85 | 98 | 1070 | 51 | 64 | 77 | 90 | 103 |
| 3.2 | 672 | 52 | 65 | 78 | 91 | 104 | 985 | 55 | 68 | 82 | 96 | 110 |
| 3.4 | 620 | 55 | 69 | 83 | 96 | 111 | 911 | 58 | 73 | 87 | 102 | 117 |
| 3.6 | 572 | 58 | 73 | 88 | 102 | 117 | 845 | 62 | 77 | 93 | 108 | 124 |
| 3.8 | 530 | 62 | 77 | 92 | 108 | 124 | 784 | 65 | 81 | 98 | 114 | 131 |
| 4 | 490 | 65 | 81 | 97 | 114 | 130 | 729 | 69 | 85 | 103 | 120 | 138 |
| 4.2 | 453 | 68 | 85 | 102 | 119 | 137 | 678 | 72 | 90 | 108 | 126 | 145 |
| 4.4 | 418 | 71 | 89 | 107 | 125 | 143 | 630 | 75 | 94 | 113 | 132 | 152 |
| 4.6 | 384 | 75 | 93 | 112 | 131 | 150 | 585 | 79 | 98 | 118 | 138 | 159 |
| 4.8 | 349 | 78 | 97 | 117 | 136 | 156 | 542 | 82 | 102 | 123 | 144 | 165 |
| 5 | 314 | 81 | 101 | 122 | 142 | 163 | 499 | 86 | 107 | 129 | 150 | 172 |
| 5.2 | 284 | 84 | 105 | 126 | 148 | 169 | 457 | 89 | 111 | 134 | 156 | 179 |
| 5.4 | 258 | 88 | 109 | 131 | 153 | 176 | 420 | 93 | 115 | 139 | 162 | 186 |
| 5.6 | 236 | 91 | 113 | 136 | 159 | 183 | 387 | 96 | 120 | 144 | 168 | 193 |
| 5.8 | 216 | 94 | 117 | 141 | 165 | 189 | 358 | 99 | 124 | 149 | 174 | 200 |
| 6 | 199 | 97 | 121 | 146 | 170 | 196 | 332 | 103 | 128 | 154 | 180 | 207 |
| 6.2 | 184 | 101 | 125 | 151 | 176 | 202 | 308 | 106 | 132 | 159 | 186 | 214 |
| 6.4 | 170 | 104 | 129 | 156 | 182 | 209 | 287 | 110 | 137 | 165 | 192 | 221 |
| 6.6 | 157 | 107 | 133 | 161 | 187 | 215 | 267 | 113 | 141 | 170 | 198 | 227 |

| e d (%) | V = 30 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | V = 35 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC | 3240 | 0 | 0 | 0 | 0 | 0 | 4260 | 0 | 0 | 0 | 0 | 0 |
| 2 | 2370 | 36 | 45 | 55 | 64 | 73 | 3120 | 39 | 48 | 58 | 68 | 78 |
| 2.2 | 2130 | 40 | 50 | 60 | 70 | 80 | 2800 | 43 | 53 | 64 | 75 | 86 |
| 2.4 | 1930 | 44 | 54 | 65 | 76 | 88 | 2540 | 46 | 58 | 70 | 81 | 93 |
| 2.6 | 1760 | 47 | 59 | 71 | 83 | 95 | 2320 | 50 | 63 | 75 | 88 | 101 |
| 2.8 | 1610 | 51 | 63 | 76 | 89 | 102 | 2130 | 54 | 67 | 81 | 95 | 109 |
| 3 | 1480 | 55 | 68 | 82 | 95 | 110 | 1960 | 58 | 72 | 87 | 102 | 117 |
| 3.2 | 1370 | 58 | 72 | 87 | 102 | 117 | 1820 | 62 | 77 | 93 | 108 | 124 |
| 3.4 | 1270 | 62 | 77 | 93 | 108 | 124 | 1690 | 66 | 82 | 99 | 115 | 132 |
| 3.6 | 1180 | 65 | 81 | 98 | 115 | 132 | 1570 | 70 | 87 | 105 | 122 | 140 |
| 3.8 | 1100 | 69 | 86 | 104 | 121 | 139 | 1470 | 74 | 92 | 110 | 129 | 148 |
| 4 | 1030 | 73 | 91 | 109 | 127 | 146 | 1370 | 77 | 96 | 116 | 135 | 156 |
| 4.2 | 955 | 76 | 95 | 115 | 134 | 153 | 1280 | 81 | 101 | 122 | 142 | 163 |
| 4.4 | 893 | 80 | 100 | 120 | 140 | 161 | 1200 | 85 | 106 | 128 | 149 | 171 |
| 4.6 | 834 | 84 | 104 | 125 | 146 | 168 | 1130 | 89 | 111 | 134 | 156 | 179 |
| 4.8 | 779 | 87 | 109 | 131 | 153 | 175 | 1060 | 93 | 116 | 139 | 163 | 187 |
| 5 | 727 | 91 | 113 | 136 | 159 | 183 | 991 | 97 | 120 | 145 | 169 | 195 |
| 5.2 | 676 | 95 | 118 | 142 | 165 | 190 | 929 | 101 | 125 | 151 | 176 | 202 |
| 5.4 | 627 | 98 | 122 | 147 | 172 | 197 | 870 | 105 | 130 | 157 | 183 | 210 |
| 5.6 | 582 | 102 | 127 | 153 | 178 | 205 | 813 | 108 | 135 | 163 | 190 | 218 |
| 5.8 | 542 | 105 | 131 | 158 | 185 | 212 | 761 | 112 | 140 | 168 | 196 | 226 |
| 6 | 506 | 109 | 136 | 164 | 191 | 219 | 713 | 116 | 145 | 174 | 203 | 233 |
| 6.2 | 472 | 113 | 140 | 169 | 197 | 227 | 669 | 120 | 149 | 180 | 210 | 241 |
| 6.4 | 442 | 116 | 145 | 175 | 204 | 234 | 628 | 124 | 154 | 186 | 217 | 249 |
| 6.6 | 413 | 120 | 149 | 180 | 210 | 241 | 590 | 128 | 159 | 192 | 224 | 257 |

| e d (%) | V = 40 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | V = 45 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NC | 5410 | 0 | 0 | 0 | 0 | 0 | 6710 | 0 | 0 | 0 | 0 | 0 |
| 2 | 3970 | 41 | 52 | 62 | 72 | 83 | 4930 | 44 | 55 | 67 | 78 | 89 |
| 2.2 | 3570 | 46 | 57 | 68 | 80 | 91 | 4440 | 49 | 61 | 73 | 86 | 98 |
| 2.4 | 3240 | 50 | 62 | 74 | 87 | 100 | 4030 | 53 | 66 | 80 | 93 | 107 |
| 2.6 | 2960 | 54 | 67 | 81 | 94 | 108 | 3690 | 58 | 72 | 87 | 101 | 116 |
| 2.8 | 2720 | 58 | 72 | 87 | 101 | 116 | 3390 | 62 | 77 | 93 | 109 | 125 |
| 3 | 2510 | 62 | 77 | 93 | 109 | 125 | 3130 | 67 | 83 | 100 | 117 | 134 |
| 3.2 | 2330 | 66 | 82 | 99 | 116 | 133 | 2900 | 71 | 89 | 107 | 124 | 143 |
| 3.4 | 2170 | 70 | 88 | 106 | 123 | 141 | 2700 | 76 | 94 | 113 | 132 | 152 |
| 3.6 | 2020 | 74 | 93 | 112 | 130 | 150 | 2520 | 80 | 100 | 120 | 140 | 161 |
| 3.8 | 1890 | 79 | 98 | 118 | 138 | 158 | 2360 | 84 | 105 | 127 | 148 | 170 |
| 4 | 1770 | 83 | 103 | 124 | 145 | 166 | 2220 | 89 | 111 | 133 | 156 | 179 |
| 4.2 | 1660 | 87 | 108 | 130 | 152 | 175 | 2080 | 93 | 116 | 140 | 163 | 188 |
| 4.4 | 1560 | 91 | 113 | 137 | 159 | 183 | 1960 | 98 | 122 | 147 | 171 | 197 |
| 4.6 | 1470 | 95 | 118 | 143 | 167 | 191 | 1850 | 102 | 127 | 153 | 179 | 205 |
| 4.8 | 1390 | 99 | 124 | 149 | 174 | 200 | 1750 | 107 | 133 | 160 | 187 | 214 |
| 5 | 1310 | 103 | 129 | 155 | 181 | 208 | 1650 | 111 | 138 | 167 | 194 | 223 |
| 5.2 | 1230 | 108 | 134 | 161 | 188 | 216 | 1560 | 116 | 144 | 173 | 202 | 232 |
| 5.4 | 1160 | 112 | 139 | 168 | 196 | 225 | 1480 | 120 | 149 | 180 | 210 | 241 |
| 5.6 | 1090 | 116 | 144 | 174 | 203 | 233 | 1390 | 124 | 155 | 187 | 218 | 250 |
| 5.8 | 1030 | 120 | 149 | 180 | 210 | 241 | 1320 | 129 | 160 | 193 | 226 | 259 |
| 6 | 965 | 124 | 155 | 186 | 217 | 250 | 1250 | 133 | 166 | 200 | 233 | 268 |
| 6.2 | 909 | 128 | 160 | 192 | 224 | 258 | 1180 | 138 | 172 | 207 | 241 | 277 |
| 6.4 | 857 | 132 | 165 | 199 | 232 | 266 | 1110 | 142 | 177 | 213 | 249 | 286 |
| 6.6 | 808 | 137 | 170 | 205 | 239 | 274 | 1050 | 147 | 183 | 220 | 257 | 295 |

| e d (%) | V = 50 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | V = 55 (M… R MIN. (FT.) | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|
| NC | 8150 | 0 | 0 | 0 | 0 | 0 | 9720 | 0 | 0 |
| 2 | 5990 | 48 | 60 | 72 | 84 | 96 | 7150 | 51 | 64 |
| 2.2 | 5400 | 53 | 66 | 79 | 92 | 106 | 6450 | 56 | 70 |
| 2.4 | 4910 | 58 | 72 | 86 | 101 | 116 | 5870 | 61 | 76 |
| 2.6 | 4490 | 62 | 78 | 94 | 109 | 125 | 5370 | 66 | 83 |
| 2.8 | 4130 | 67 | 84 | 101 | 118 | 135 | 4950 | 71 | 89 |
| 3 | 3820 | 72 | 90 | 108 | 126 | 145 | 4580 | 77 | 95 |
| 3.2 | 3550 | 77 | 96 | 115 | 134 | 154 | 4250 | 82 | 102 |
| 3.4 | 3300 | 82 | 102 | 122 | 143 | 164 | 3970 | 87 | 108 |
| 3.6 | 3090 | 86 | 108 | 130 | 151 | 174 | 3710 | 92 | 114 |
| 3.8 | 2890 | 91 | 114 | 137 | 160 | 183 | 3480 | 97 | 121 |
| 4 | 2720 | 96 | 120 | 144 | 168 | 193 | 3270 | 102 | 127 |
| 4.2 | 2560 | 101 | 125 | 151 | 176 | 203 | 3080 | 107 | 134 |
| 4.4 | 2410 | 106 | 131 | 158 | 185 | 212 | 2910 | 112 | 140 |
| 4.6 | 2280 | 110 | 137 | 166 | 193 | 222 | 2750 | 117 | 146 |
| 4.8 | 2160 | 115 | 143 | 173 | 202 | 232 | 2610 | 123 | 153 |
| 5 | 2040 | 120 | 149 | 180 | 210 | 241 | 2470 | 128 | 159 |
| 5.2 | 1930 | 125 | 155 | 187 | 218 | 251 | 2350 | 133 | 165 |
| 5.4 | 1830 | 130 | 161 | 194 | 227 | 260 | 2230 | 138 | 172 |
| 5.6 | 1740 | 134 | 167 | 202 | 235 | 270 | 2120 | 143 | 178 |
| 5.8 | 1650 | 139 | 173 | 209 | 244 | 280 | 2010 | 148 | 184 |
| 6 | 1560 | 144 | 179 | 216 | 252 | 289 | 1920 | 153 | 191 |
| 6.2 | 1480 | 149 | 185 | 223 | 260 | 299 | 1820 | 158 | 197 |
| 6.4 | 1400 | 154 | 191 | 230 | 269 | 309 | 1730 | 163 | 203 |
| 6.6 | 1330 | 158 | 197 | 238 | 277 | 318 | 1650 | 169 | 210 |

For instance, according to the table, a radius of 4400 ft. can be used with a superelevation rate of 4.6%.

In the table, the runoff lengths are given. For a rate of 4.6% and R = 2280, the runoff length ($L_R$) is 110 feet for 2 lanes.

| | V = 50 (MPH) R MIN. (FT.) | 2 | 3 | 4 | 5 | 6 | R MIN. (FT.) |
|---|---|---|---|---|---|---|---|
| 5 | | | | | | | |
| ) | 8150 | 0 | 0 | 0 | 0 | 0 | 972C |
| 9 | 5990 | 48 | 60 | 72 | 84 | 96 | 715C |
| 8 | 5400 | 53 | 66 | 79 | 92 | 106 | 645C |
| )7 | 4910 | 58 | 72 | 86 | 101 | 116 | 587C |
| 16 | 4490 | 62 | 78 | 94 | 109 | 125 | 537C |
| 25 | 4130 | 67 | 84 | 101 | 118 | 135 | 495C |
| 34 | 3820 | 72 | 90 | 108 | 126 | 145 | 458C |
| 43 | 3550 | 77 | 96 | 115 | 134 | 154 | 425C |
| 52 | 3300 | 82 | 102 | 122 | 143 | 164 | 397C |
| 51 | 3090 | 86 | 108 | 130 | 151 | 174 | 371C |
| 70 | 2890 | 91 | 114 | 137 | 160 | 183 | 348C |
| 79 | 2720 | 96 | 120 | 144 | 168 | 193 | 327C |
| 38 | 2560 | 101 | 125 | 151 | 176 | 203 | 308C |
| 97 | 2410 | 106 | 131 | 158 | 185 | 212 | 291C |
| )5 | 2280 | 110 | 137 | 166 | 193 | 222 | 275C |
| 14 | 2160 | 115 | 143 | 173 | 202 | 232 | 261C |
| 23 | 2040 | 120 | 149 | 180 | 210 | 241 | 247C |
| 32 | 1930 | 125 | 155 | 187 | 218 | 251 | 235C |

In Standard Drawing RD11-SE-1, the total transition length (L) is equal to $L_R + L_T$, where $L_T$ is the Tangent Runout Length.

**SUPERELEVATION TRANSITION EQUATIONS**

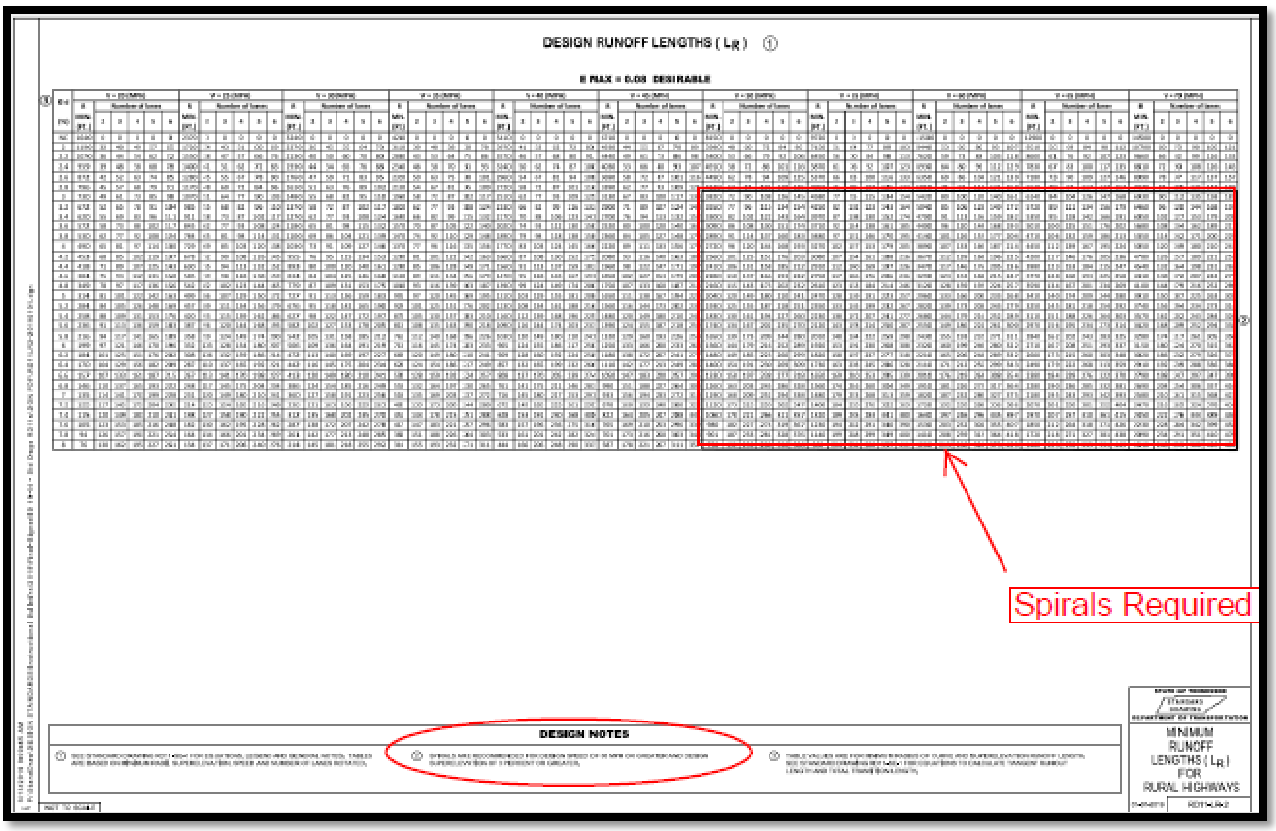
$$L = L_R + L_T$$

$$L_R = \frac{(W\ n\ 1)\ e_d}{\Delta\ \%}(b_w)$$

$$L_T = \frac{NC}{e_d} L_R$$

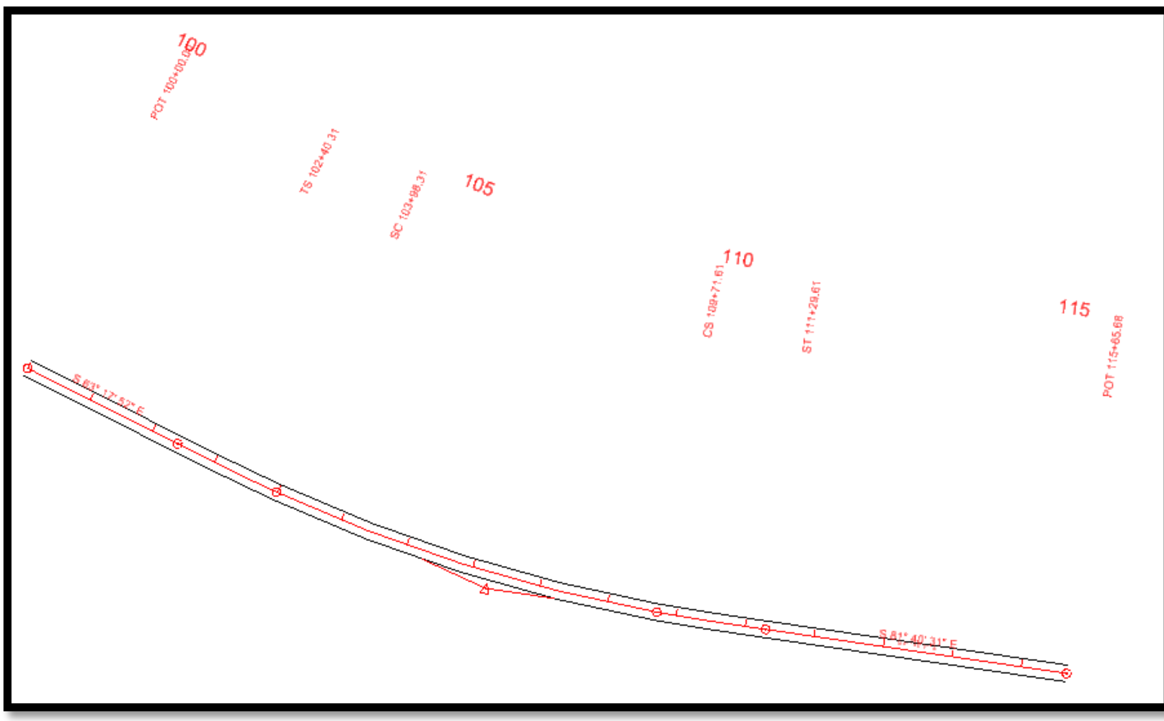
According to the equation on RD11-SE-1, $L_T$ equals to 47.83 (2/4.6 x 110), and the total transition length (L) would be 110 + 47.83 = 157.83, rounded to 158 ft.

Going back to RD11-LR-2, note #2 at the bottom of the sheet says that spirals are recommended for design speeds of 50 MPH or greater and superelevation of 3% or greater. So, in our example L is also equal to spiral length.



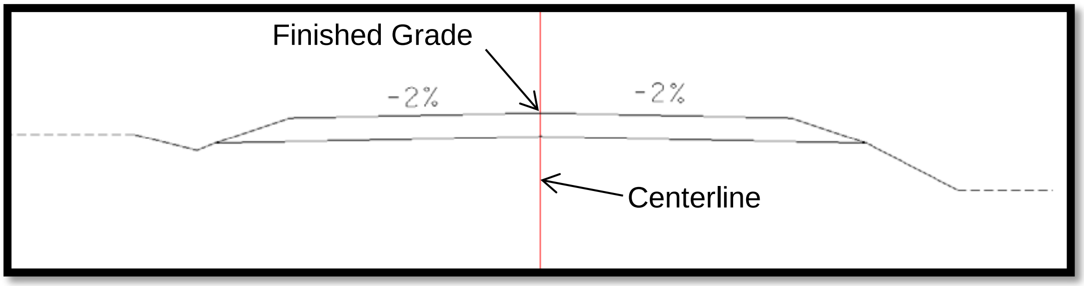
Plan view of proposed alignment

| | |
|---|---|
| Station 100+00 | Alignment Begins |
| Station 102+40.31 | T.S. of the curve |
| Station 103+98.31 | S.C. of the curve |
| Station 109+71.61 | C.S. of the curve |
| Station 111+29.61 | S.T. of the curve |
| Station 115+65.68 | Alignment Ends |



Normal Crown

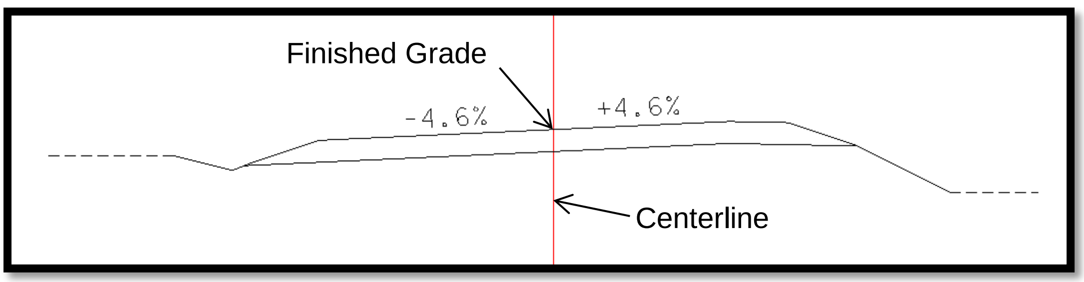
The alignment starts out at normal crown at station 100+00.




Full Superelevation

The transition to superelevation will begin at the T.S. point, station 102+40.31.

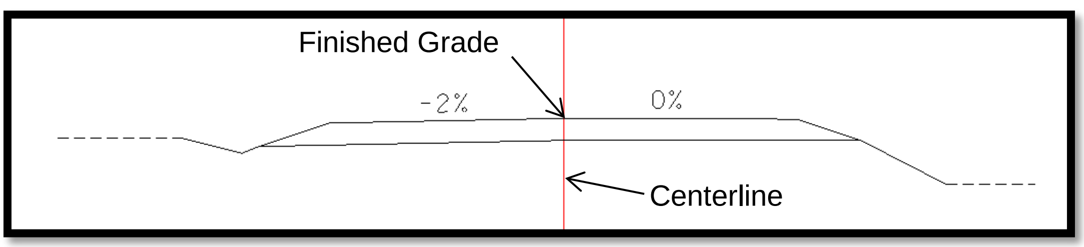
The transition ends at the S.C. point, station 103+98.31. This in the station at which full superelevation begins.




Remove Adverse Crown

In the transition area a couple of key points to know are the Reverse Crown station and the Remove Adverse Crown station.

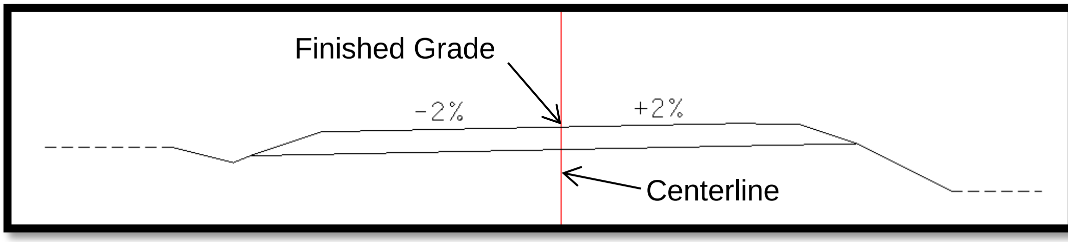
Going from Normal Crown to Full Super the point Remove Adverse Crown point will occur first.



Reverse Crown

Since the roadway curves to the left, the pavement transitions from a negative cross slope to a positive cross slope only on the right side, therefore zero cross slope would only be on the right side.  According to RD11-SE-2A, this point occurs at the distance $L_T$ from the T.S. station, or

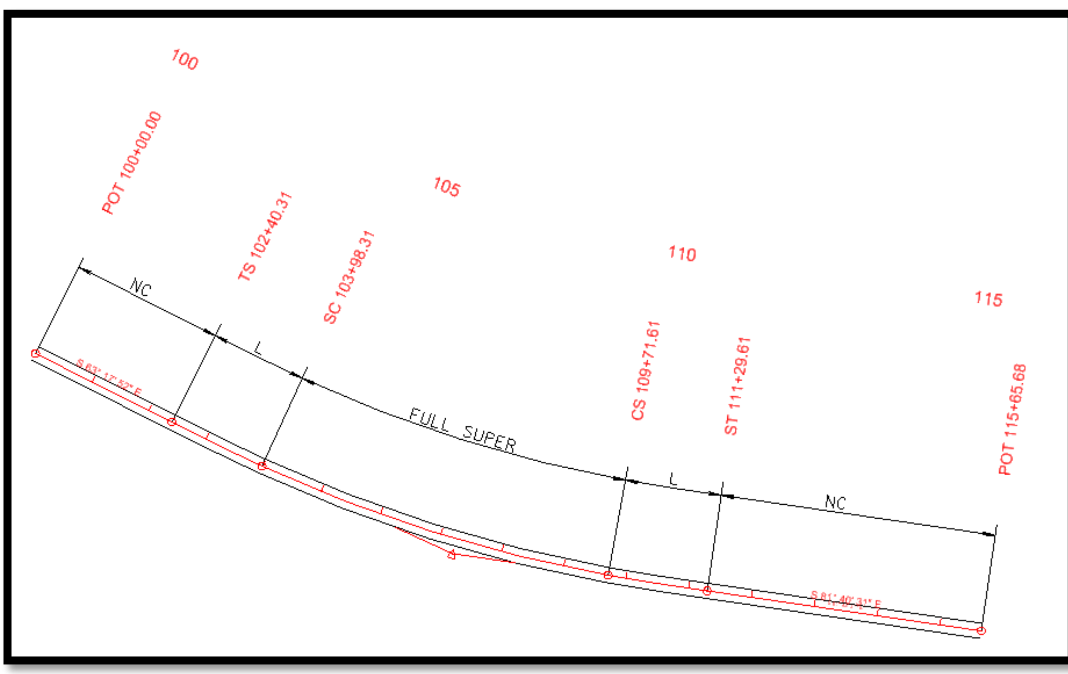
10240.31 + 47.83 = 10288.14, or station 102+88.14




Also, from RD11-SE-2A, Reverse Crown occurs at T.S. + ($L_T$ x 2), or

10240.31 + (47.83 x 2) =10335.97, or station 103+35.97

At the other end of the curve the alignment transitions from full super back to normal crown.  The transition begins at the C.S. point (station 109+71.61) and ends at the S.T. point (station 111+29.61). The Reverse Crown and Zero Cross Slope stations would be calculated in the same manner as for the first transition and would occur in reverse order.



Now let's pick some random stations and calculate the superelevation:

103+00

This station occurs in the spiral portion of the alignment which is in the transition.

The rate of change in superelevation is found by dividing the difference between normal crown and full super by the transition length.

For this example, $\frac{[.046 - (-.020)]}{158} = \frac{.066}{158} = .0004177$

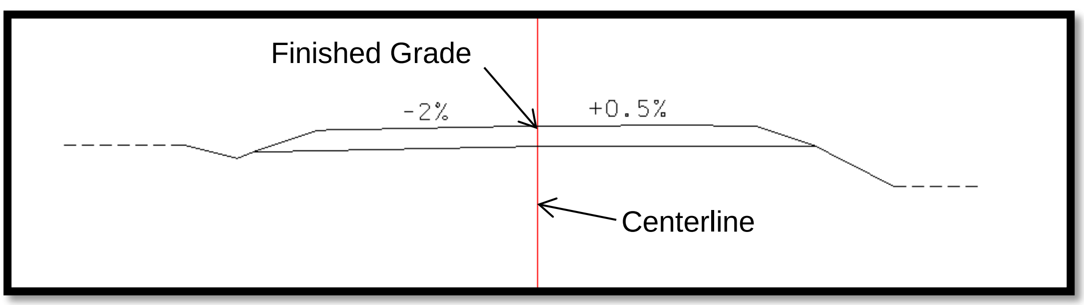
L= 10300 – 10240.31 = 59.69

59.69 x .0004177 =.025, or 2.5%

This number is added to the cross slope at the beginning transition station, 102+40.31, which is normal crown (-2%)

2.5% + (-2%) = + 0.5%

Since this number is less than + 2%, and has not yet reached reverse crown, the other side will be - 2%




107+00

Station 107+00 is in the full super area, between the S.C and C.S.  + 4.6% in this example.

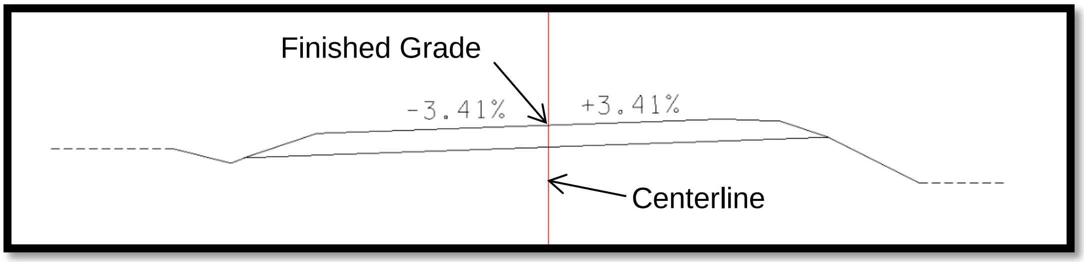
110+00

This station is in the transition from full super to normal crown (109+71.61 - 111+29.61), so subtract the beginning station of the transition

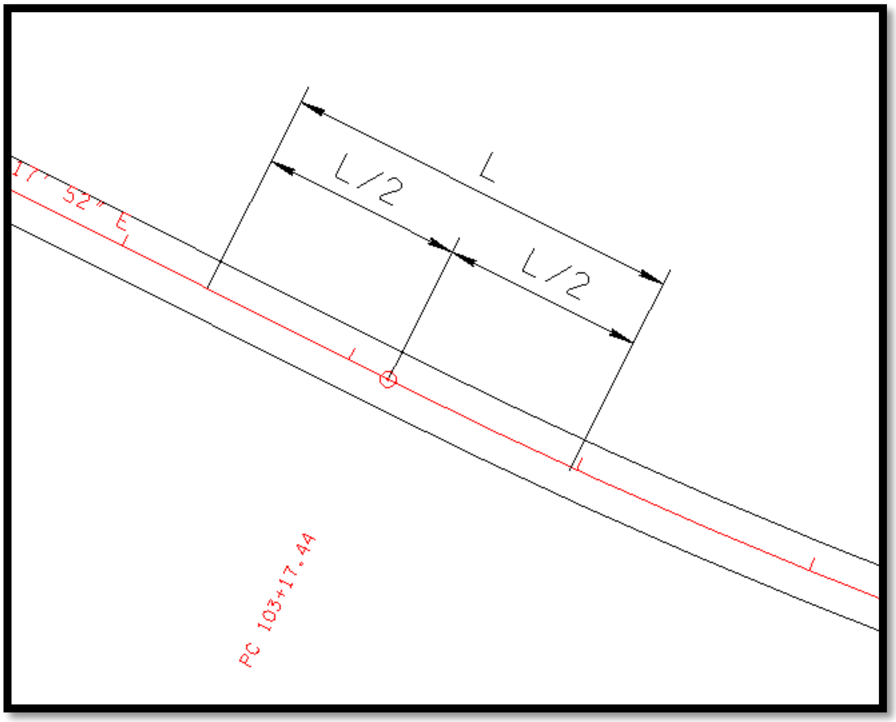
11000 – 10971.61 = 28.39. The rate of change is the same as for the transition at the beginning end of the curve (.0004177).

28.39 x .0004177 = .0119, or 1.19%

This number is subtracted from the full super rate at 109+77.61, 4.6 -1.19 = 3.41%




For curves where a spiral is not required, the calculation methods are the same.  The calculated transition lengths are spaced so that the P.C. and P.T. points are at the halfway point of L.



Example 2

- 4 lane rural design
- Design Speed 30 MPH
- Curve Radius 261 ft.

Find L

Use Standard Drawing RD11-LR-1, Minimum Runoff Lengths for Urban Highways, $E_{max}$ = 0.04.

From the Table, $e_d$ =3%. This is the minimum superelevation rate for this radius.

According to the table on RD11-LR-1, $L_R$ is 82 feet.

According to the Superelevation Transition equation on RD11-SE-1, $L_T$ is 54.67

$L = L_R + L_T$ = 82 + 54.67 = 136.67, rounded to 137 feet

A spiral curve is not required for this design speed so half of L is on either side of the P.C. or P.T. as shown on the previous page.

If the P.C. is at station 103+17.44:

Transition begins at 10317.44 – (137/2) = 10248.94, station <u>102+48.94</u>

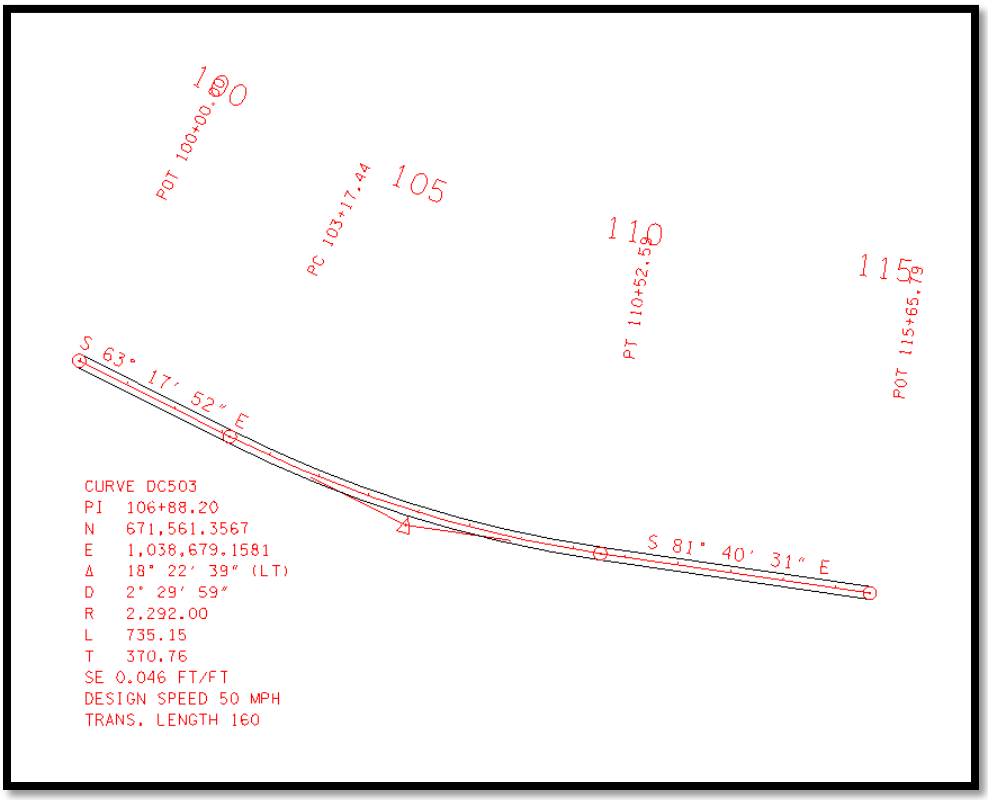
Remove Adverse Crown is 10248.94 + $L_T$ = 10248.94 + 54.67 = 10303.61, station <u>103+03.61</u>

Reverse Crown is 10248.94+ 2 x $L_T$ = 10248.94 + 109.34 = 10358.28, station <u>103+58.28</u>

# Part 4: Superelevation Calculation (RD01 Series)

Example:

- 2- lane rural design
- Design speed 50 MPH
- 2° 30’ curve (R = 2,292’)




Plan view of proposed alignment

The alignments begin and end stations are 100+00 and 115+65.79.

The P.C of the curve is at station 103+17.44.

The P.T. of the curve is at station 110+52.59.

MINIMUM LENGTH OF

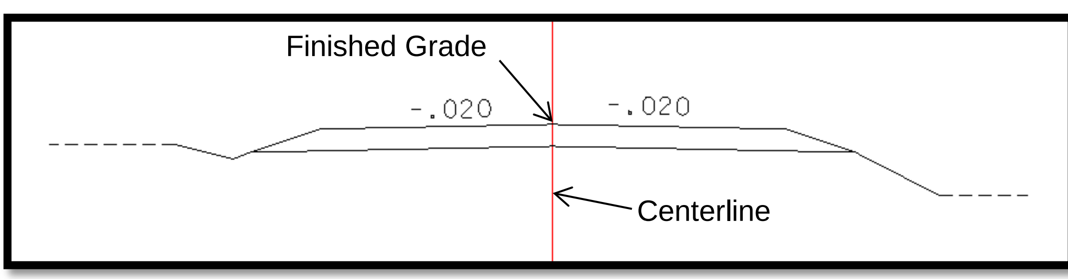
E MAX=0.08 DESIRABLE

| D | R (FT.) | V=20(MPH) | | | | V=30(MPH) | | | | V=40(MPH) | | | | V=50(MPH) | | | | V=60(MPH) | | | | V=70(MPH) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | e F/F | L(FT.) 2-LN | 4-LN | 6-LN | e F/F | L(FT.) 2-LN | 4-LN | 6-LN | e F/F | L(FT.) 2-LN | 4-LN | 6-LN | e F/F | L(FT.) 2-LN | 4-LN | 6-LN | e F/F | L(FT.) 2-LN | 4-LN | 6-LN | e F/F | L(FT.) 2-LN | 4-LN | 6-LN |
| 0°-15' | 22,918 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 |
| 0°-30' | 11,459 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | RC | 175 | 175 | 215 | RC | 200 | 200 | 240 |
| 0°-45' | 7,639 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | RC | 150 | 150 | 195 | .022 | 175 | 175 | 225 | .028 | 200 | 220 | 290 |
| 1°-00' | 5,730 | NC | 0 | 0 | 0 | NC | 0 | 0 | 0 | RC | 125 | 130 | 170 | .021 | 150 | 150 | 200 | .029 | 175 | 200 | 265 | .036 | 200 | 255 | 340 |
| 1°-30' | 3,820 | NC | 0 | 0 | 0 | RC | 100 | 110 | 145 | .021 | 125 | 130 | 175 | .030 | 150 | 180 | 240 | .041 | 175 | 245 | 325 | .051 | 215 | 320 | 430 |
| 2°-00' | 2,865 | NC | 0 | 0 | 0 | RC | 100 | 110 | 145 | .027 | 125 | 150 | 200 | .038 | 150 | 210 | 280 | .051 | 190 | 285 | 380 | .065 | 255 | 385 | 510 |
| 2°-30' | 2,292 | NC | 0 | 0 | 0 | .021 | 100 | 115 | 150 | .033 | 125 | 170 | 225 | .046 | 160 | 240 | 320 | .061 | 220 | 325 | 435 | .075 | 285 | 430 | 570 |
| 3°-00' | 1,910 | RC | 65 | 100 | 130 | .025 | 100 | 125 | 165 | .038 | 125 | 185 | 245 | .053 | 180 | 265 | 355 | .068 | 235 | 355 | 470 | .080 | 300 | 450 | 600 |
| 3°-30' | 1,637 | RC | 65 | 100 | 130 | .028 | 100 | 130 | 175 | .043 | 135 | 200 | 265 | .058 | 190 | 285 | 375 | .074 | 255 | 380 | 505 | D(MAX)=3°-00' | | | |
| 4°-00' | 1,432 | RC | 65 | 100 | 130 | .031 | 100 | 140 | 185 | .047 | 145 | 215 | 285 | .063 | 200 | 300 | 400 | .078 | 265 | 395 | 525 | | | | |
| 5°-00' | 1,146 | .021 | 70 | 100 | 135 | .038 | 105 | 160 | 210 | .055 | 160 | 240 | 315 | .071 | 220 | 330 | 440 | D(MAX)=4°-45' | | | | | | | |
| 6°-00' | 955 | .025 | 75 | 110 | 145 | .043 | 115 | 175 | 230 | .062 | 175 | 260 | 345 | .077 | 235 | 350 | 470 | | | | | | | | |
| 7°-00' | 819 | .028 | 80 | 120 | 155 | .048 | 125 | 185 | 245 | .067 | 185 | 275 | 370 | .080 | 240 | 360 | 480 | | | | | | | | |
| 8°-00' | 716 | .031 | 85 | 125 | 165 | .053 | 135 | 200 | 265 | .071 | 195 | 290 | 385 | D(MAX)=7°-30' | | | | | | | | | | | |
| 9°-00' | 637 | .035 | 90 | 135 | 180 | .056 | 140 | 210 | 275 | .075 | 200 | 300 | 400 | | | | | | | | | | | | |
| 10°-00' | 573 | .037 | 95 | 140 | 185 | .060 | 145 | 220 | 290 | .078 | 210 | 310 | 415 | | | | | | | | | | | | |
| 11°-00' | 521 | .040 | 100 | 145 | 195 | .063 | 150 | 225 | 300 | .079 | 210 | 315 | 420 | | | | | | | | | | | | |
| 12°-00' | 477 | .043 | 105 | 155 | 205 | .065 | 155 | 230 | 310 | .080 | 210 | 315 | 420 | | | | | | | | | | | | |
| 13°-00' | 441 | .045 | 105 | 160 | 210 | .068 | 160 | 240 | 320 | D(MAX)=12°-15' | | | | | | | | | | | | | | | |
| 14°-00' | 409 | .047 | 110 | 165 | 215 | .070 | 165 | 245 | 325 | | | | | | | | | | | | | | | | |
| 16°-00' | 358 | .051 | 115 | 175 | 230 | .074 | 170 | 255 | 340 | | | | | | | | | | | | | | | | |
| 18°-00' | 318 | .054 | 120 | 180 | 240 | .077 | 175 | 265 | 350 | | | | | | | | | | | | | | | | |
| 20°-00' | 286 | .057 | 125 | 185 | 250 | .079 | 180 | 270 | 360 | | | | | | | | | | | | | | | | |
| 22°-00' | 260 | .060 | 130 | 195 | 260 | .080 | 180 | 270 | 360 | | | | | | | | | | | | | | | | |
| 24°-00' | 239 | .062 | 135 | 200 | 265 | D(MAX)=22°-45' | | | | | | | | | | | | | | | | | | | |
| 28°-00' | 205 | .067 | 140 | 210 | 280 | | | | | | | | | | | | | | | | | | | | |
| 32°-00' | 179 | .070 | 145 | 220 | 290 | | | | | | | | | | | | | | | | | | | | |
| 36°-00' | 159 | .074 | 155 | 230 | 305 | | | | | | | | | | | | | | | | | | | | |
| 40°-00' | 143 | .076 | 155 | 235 | 310 | | | | | | | | | | | | | | | | | | | | |
| 44°-00' | 130 | .078 | 160 | 240 | 315 | | | | | | | | | | | | | | | | | | | | |
| 48°-00' | 119 | .079 | 160 | 240 | 320 | | | | | | | | | | | | | | | | | | | | |
| 52°-00' | 110 | .080 | 160 | 240 | 320 | | | | | | | | | | | | | | | | | | | | |
| | | D(MAX)=53°-30' | | | | | | | | | | | | | | | | | | | | | | | |

| LEGEND | |
|---|---|
| D | DEGREE OF CURVE |
| R | RADIUS OF CURVE |
| V | ASSUMED DESIGN SPEED |
| e | RATE OF SUPERELEVATION |
| L | MINIMUM LENGTH OF TRANSITION |
| NC | NORMAL CROWN |
| RC | REMOVE ADVERSE CROWN, SUPERELEVATE AT NORMAL CROWN SLOPE |

The 0.08 max superelevation table from Standard Drawing RD01-SE-3 shows the required rate to be .046 ft/ft with a transition length of 160 ft. for the two-lane design.

On this example roadway, the alignment starts out at normal crown at station 100+00.




Normal Crown

Begin Transition (End Normal Crown)

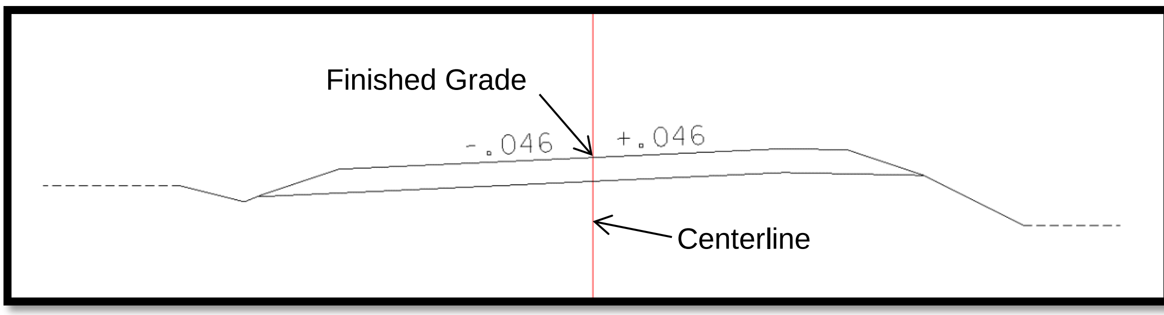
The station at which the roadway begins transition from normal crown to full super is half the transition length in advance of the P.C. station, 103+17.44.

In this example that would be:

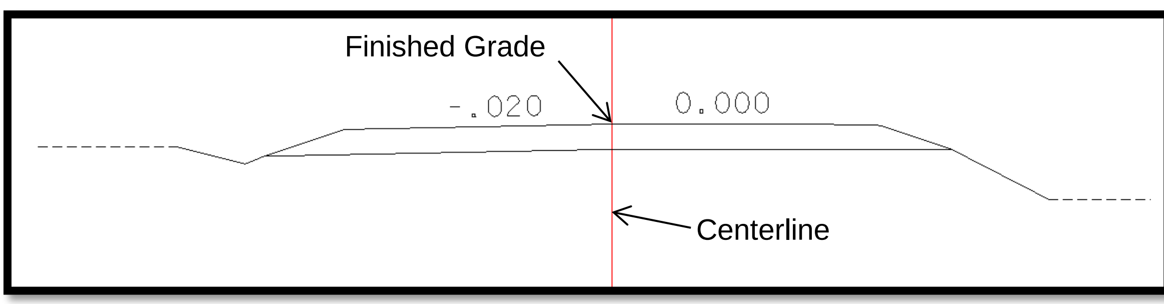
10317.44 – 80 = 10237.44 (station 102+37.44)

End Transition (Begin Full Super)

The station at which full super begins is 10237.44 + 160 = 10397.44 (station 103+97.44)




Zero cross slope:




Since the roadway curves to the left, the pavement transitions from a negative cross slope to a positive cross slope only on the right side, therefore zero cross slope would only be on the right side.

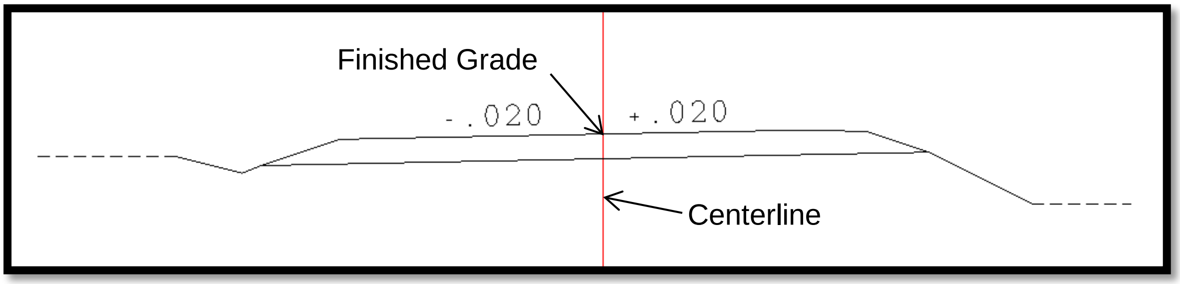
The rate of change in superelevation is found by dividing the difference between normal crown and full super by the transition length.

For this example, [.046 – (-.020)]/160 = .066/160 = .0004125

To go from normal crown to zero, the difference is [0.000 – (-.020)] = .020, then

.020/.0004125 = 48.48 feet, zero slope station is 10237.44 + 48.48 = 10285.92 (102+85.92)

Reverse crown:

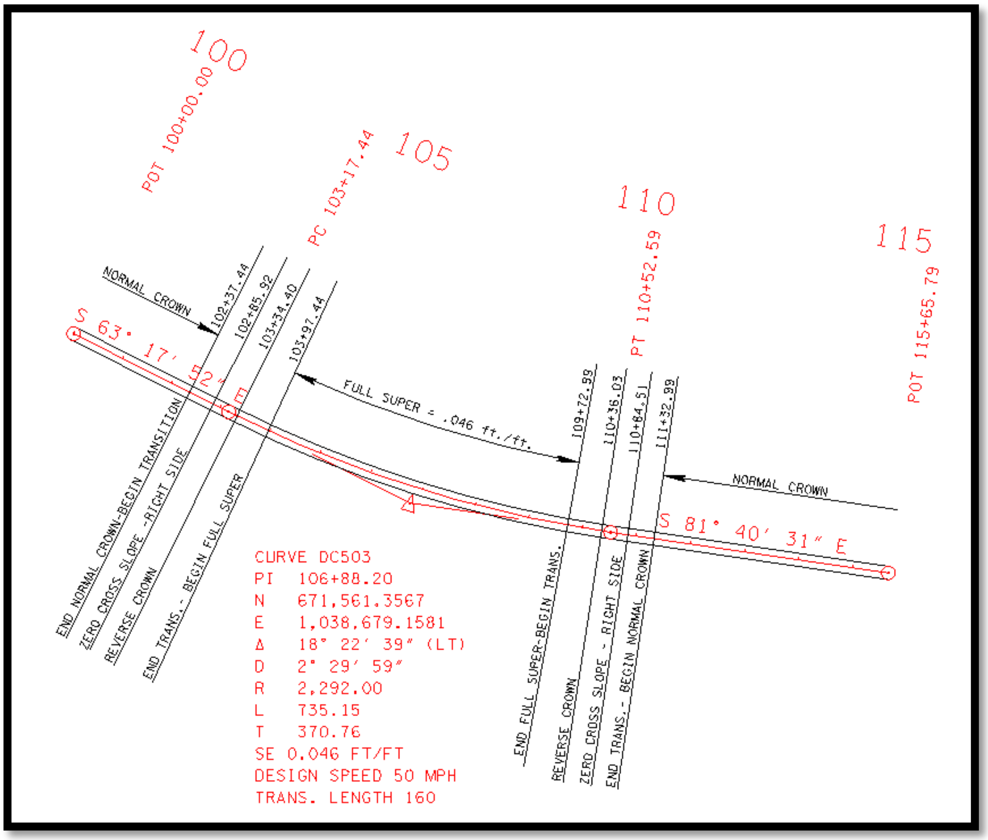



.020 - (-.020) = .040

.040/.0004125 = 96.96

10237.44 + 96.96 = 10334.40 (station 103+34.40)

At the other end of the curve (P.T.) the alignment transitions from full super back to normal crown. The transition begins at station 109+72.99 (11052.99 – 80) and ends at station 111+32.99 (10972.99 + 160). The Reverse Crown and Zero Cross Slope stations would be calculated in the same manner as for the first transition.



Now let's pick some random stations and calculate the superelevation:

103+00

This station is in the transition area (102+37.44 – 103+97.44)

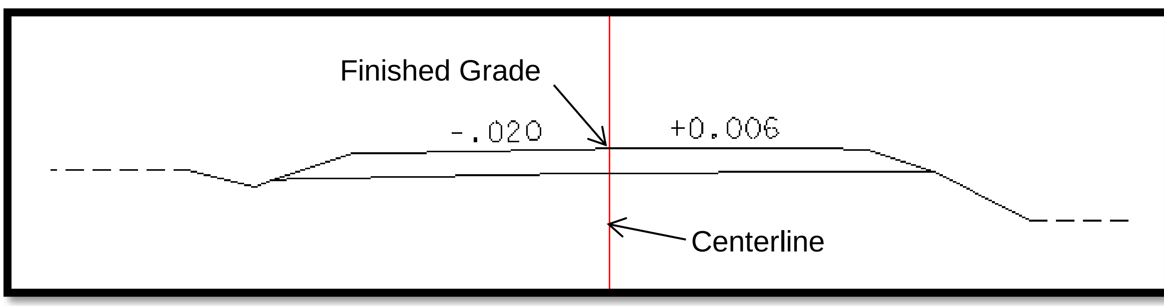
10300 - 10237.44 = 62.56

62.56 x .0004125 =.026

This number is added to the cross slope at the beginning transition station, 102+37.44, which is normal crown (-.020)

.026 + (-.020) = +.006

Since this number is less than +.020, and has not yet reached reverse crown, the other side will be -.020




107+00

Station 107+00 is in the full super area, between stations 103+97.44 and 109+72.99, 0.046 ft/ft in this example.

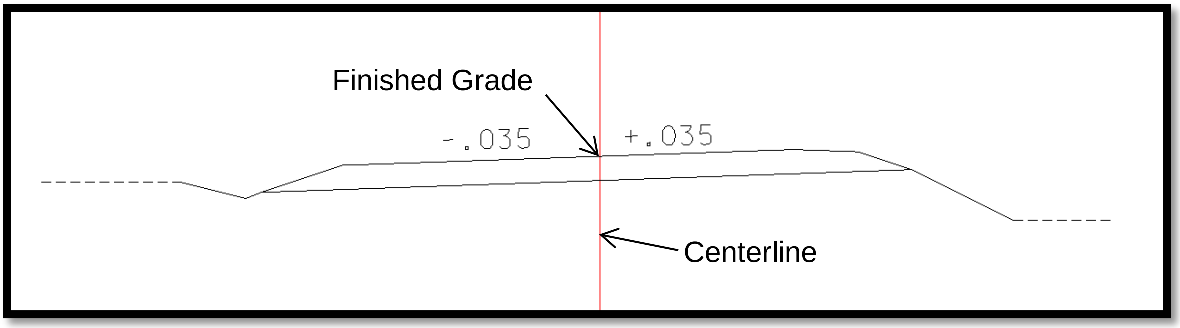
110+00

This station is in the transition from full super to normal crown (109+72.99 - 111+32.99), so subtract the beginning station of the transition

11000 – 10972.59 = 27.41. The rate of change is the same as for the transition at the P.C. end of the curve (.0004125).

27.41 x .0004125 = .011

This number is subtracted from the full super rate at 109+72.99, .046 -.011 = .035

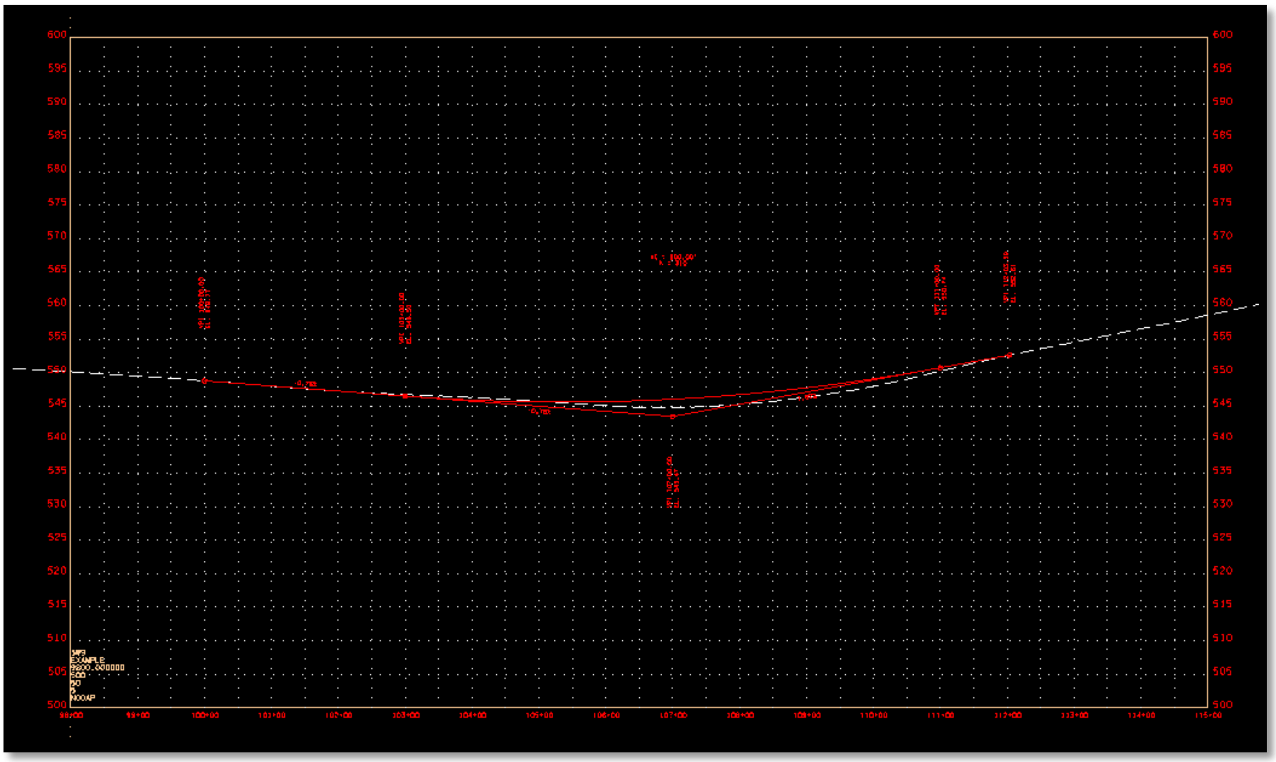

Finished Grade
-.035
+.035
Centerline

# Part 5: Superelevation Profile Diagram

The purpose of this section is to provide the designer information to draw the superelevation diagram. This diagram is important to show so that it is easily seen where superelevation changes take place.

## Superelevation Diagram Placement

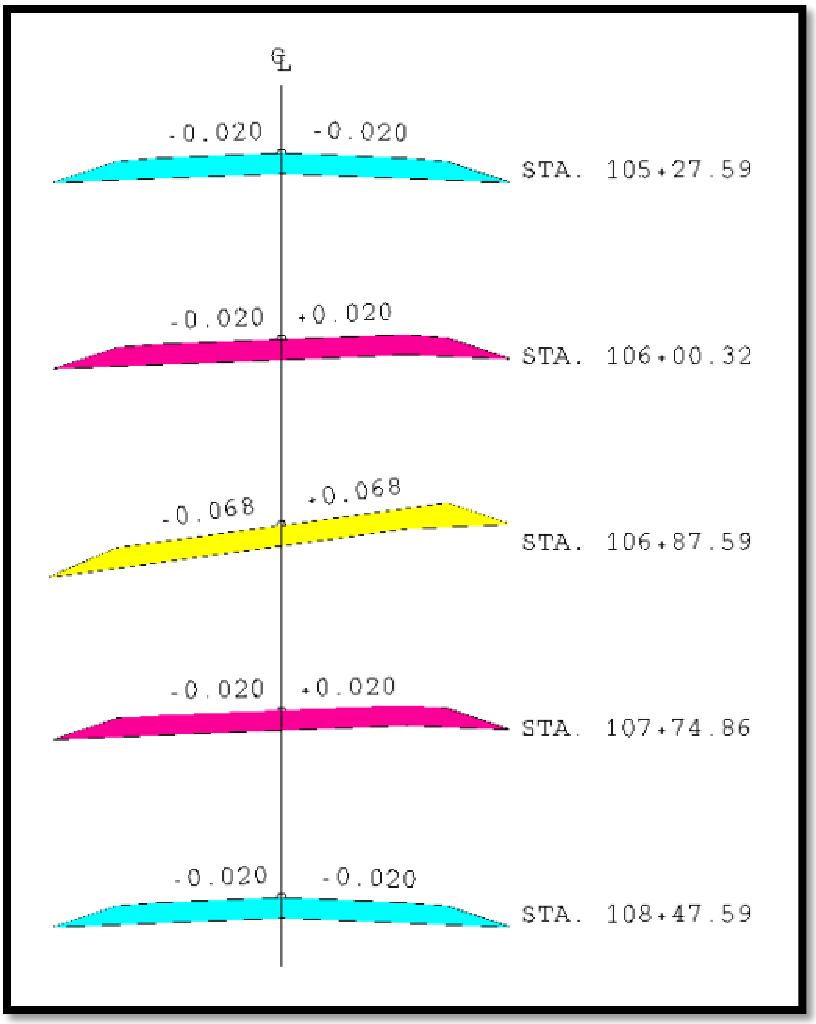
The best place to draw the superelevation diagram is in the alignment file. If you have displayed the proposed vertical alignment and a profile grid (See GEOPAK v8i Road Course Guide), the diagram should go in the lower portion of this area.



## Determining Critical Superelevation Stations

From the Superelevation Calculations tutorial (.inp file created when "Generate Superelevation Transitions" operation is performed in GEOPAK), the stations where superelevations change are as follows:

| Left | Right |
|---|---|
| ROADNAME 8.0000 | ROADNAME -8.0000 |
| filler line station / slope | filler line station / slope |
| 100+00.000000 -2.0000 | 100+00.000000 -2.0000 |
| 106+00.315956 -2.0000 | 105+27.588683 -2.0000 |
| 106+87.588683 -6.8000 /* Curve D1 */ | 106+87.588683 6.8000 /* Curve D1 */ |
| 107+74.861410 -2.0000 | 108+47.588683 -2.0000 |
| 112+03.385413 -2.0000 | 112+03.390000 -2.0000 |



## Drawing the Profile Diagram

Using the 510-elevation line on the grid, draw a line representing the finished grade which has a slope of 0% or 0 ft/ft.

Use the following symbology settings:

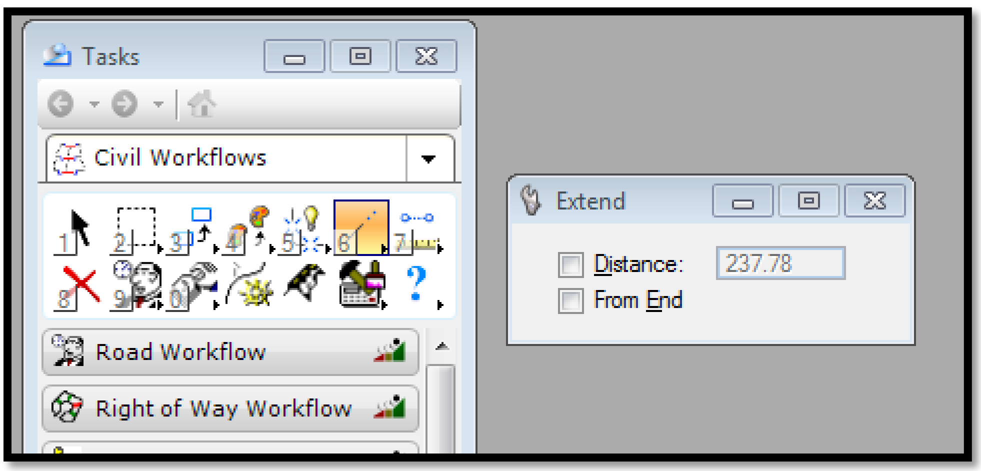
LV: DESIGN-CENTERLINE-Proposed Text

CO: 6

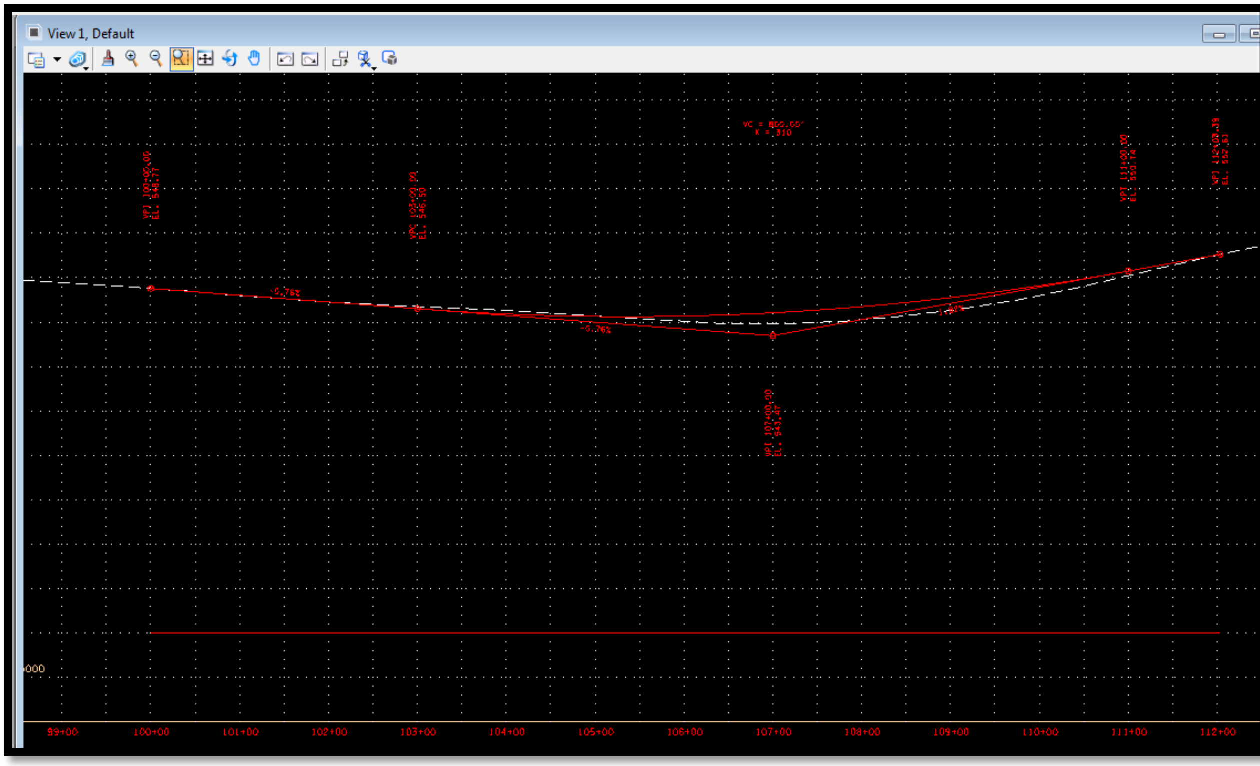
LC: 0

WT:10

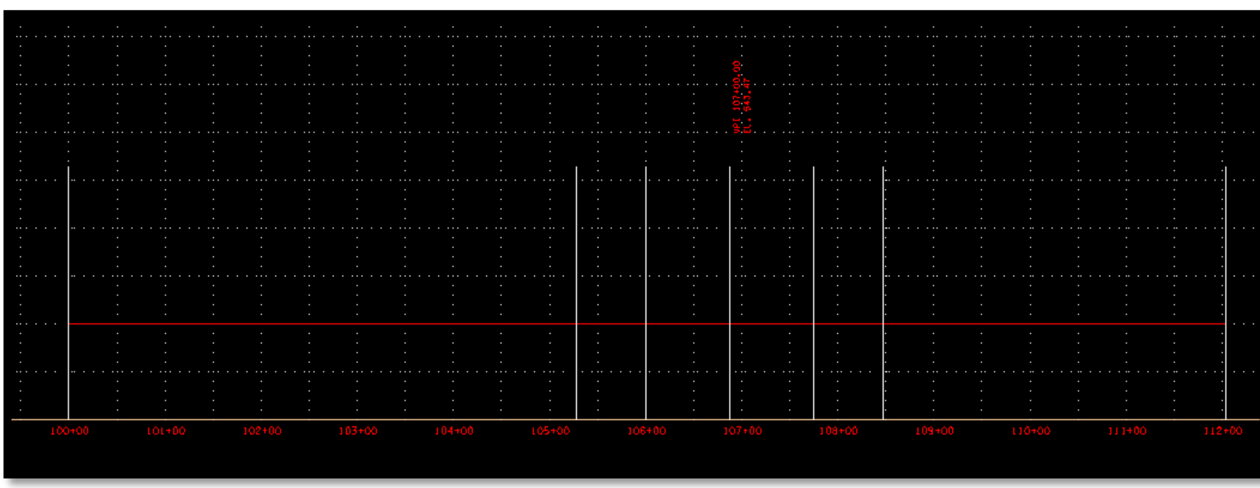
Make sure the line limits are the same as the proposed vertical grade. For this example, sta. 100+00 and sta. 112+03.39.



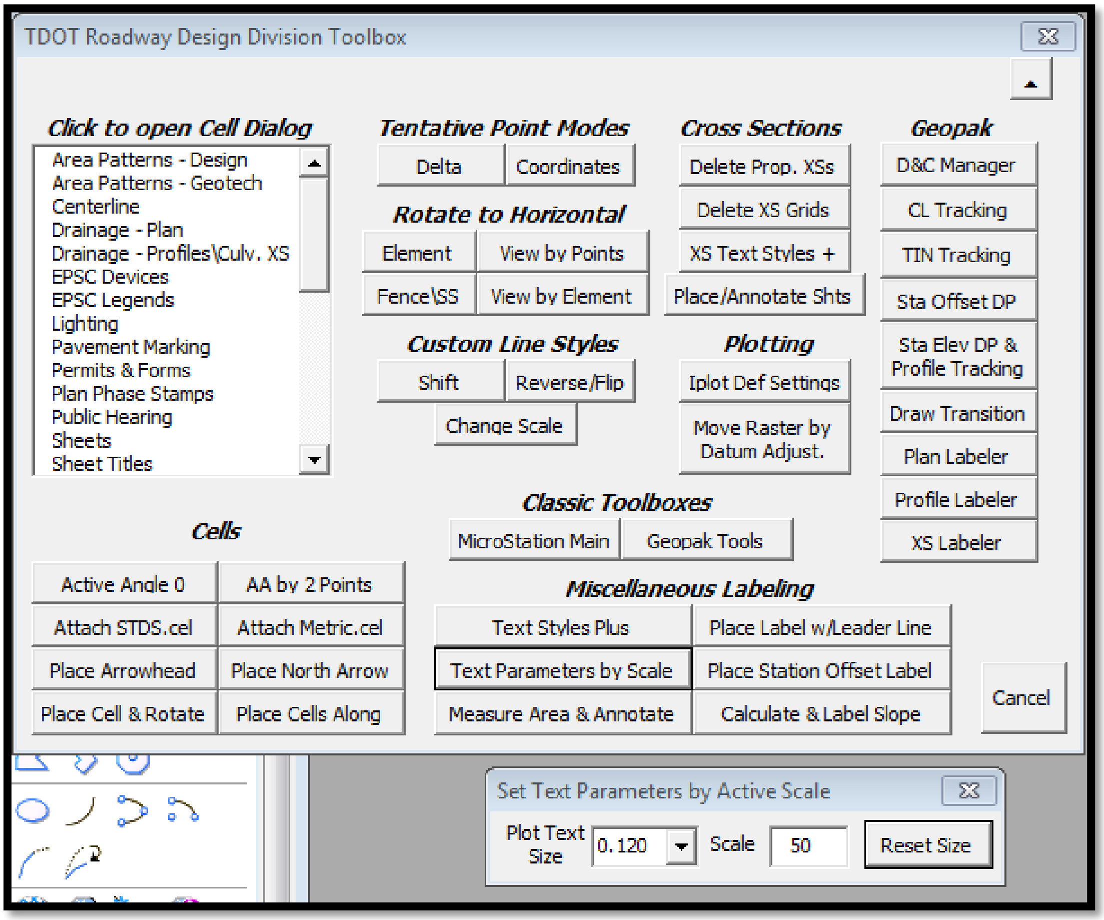

Use “Extend Line” and snap to each end of the profile.

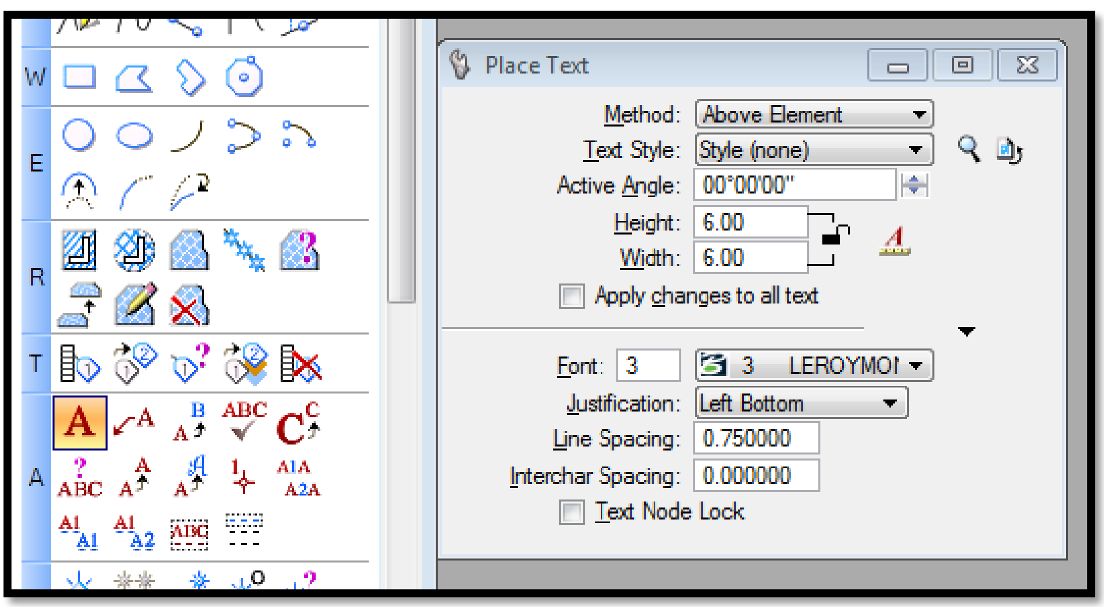


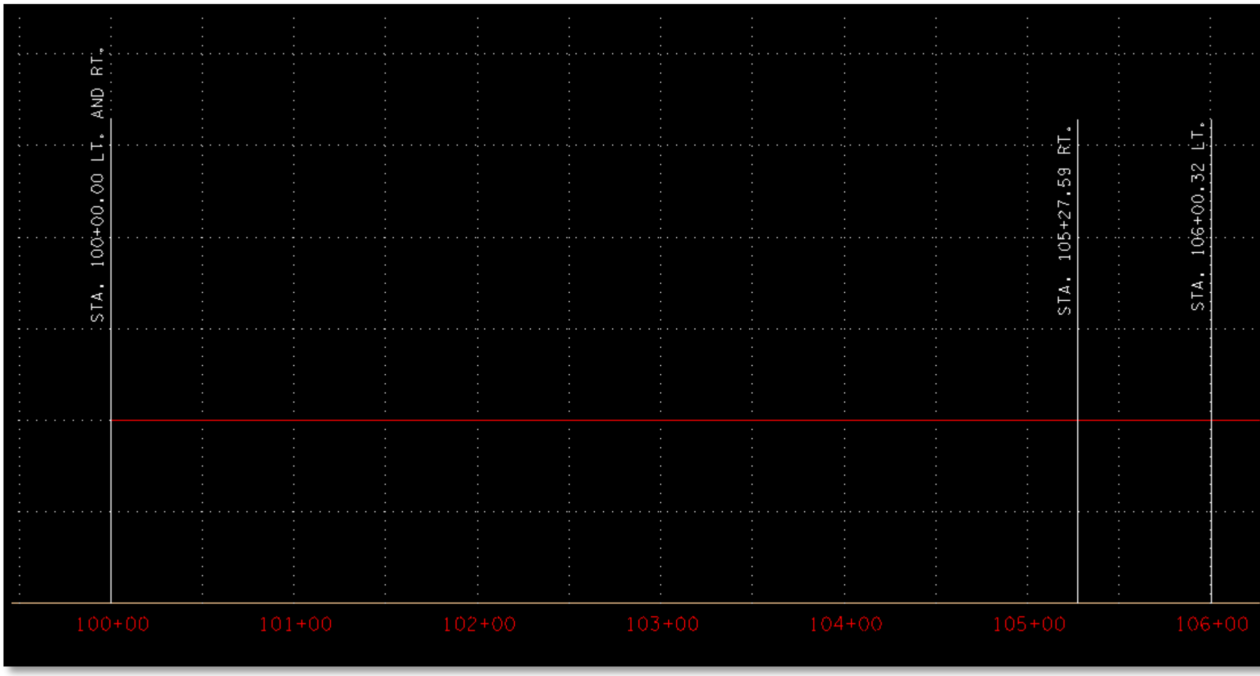

Change line symbology settings WT to 4 and CO to 0, draw vertical lines to represent the superelevation change stations listed on page 2 for both the right and left.

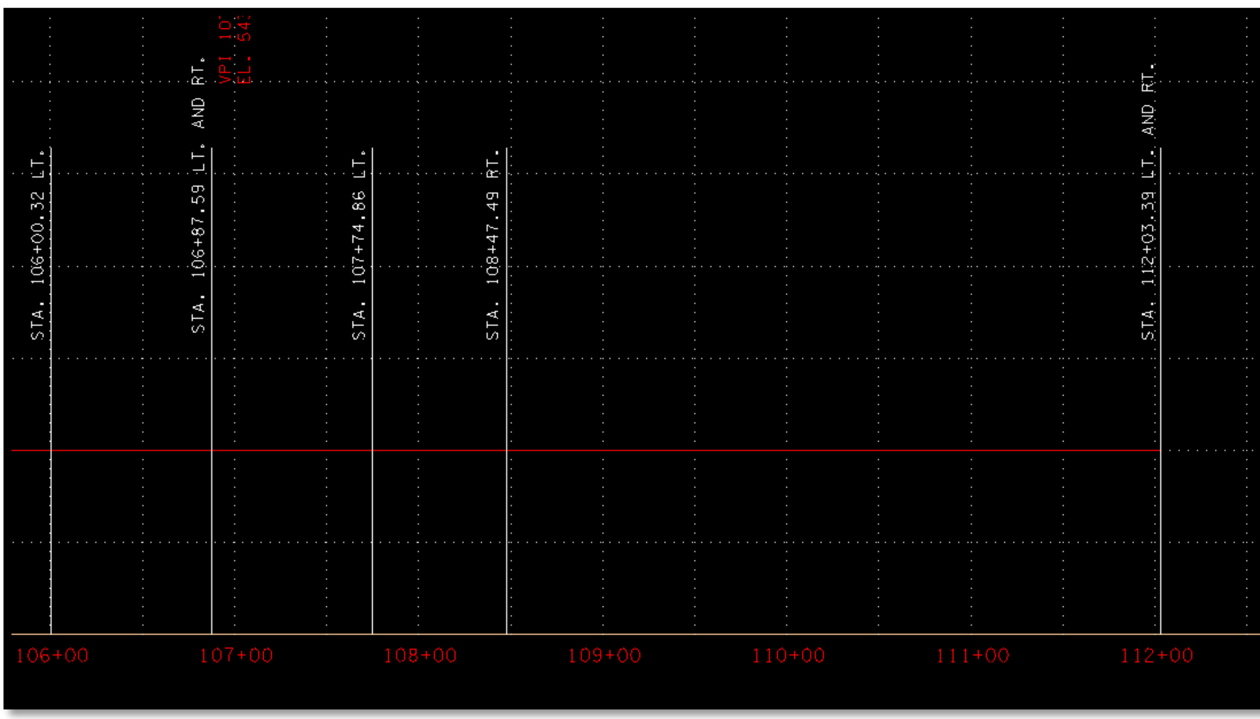


Make text settings as follows and label each vertical line as shown below:




STA. 100+00.00 LT. AND RT.
STA. 105+27.59 RT.
STA. 106+00.32 LT.
100+00
101+00
102+00
103+00
104+00
105+00
106+00


STA. 106+00.32 LT.
STA. 106+87.59 LT. AND RT.
STA. 107+74.86 LT.
STA. 108+47.49 RT.
STA. 112+03.39 LT. AND RT.
106+00
107+00
108+00
109+00
110+00
111+00
112+00

**Draw the Left Profile Diagram**

To distinguish between the left and right diagrams, they should be drawn in different colors. For the left diagram, use the following settings:

LV: DESIGN-CENTERLINE-Proposed Text

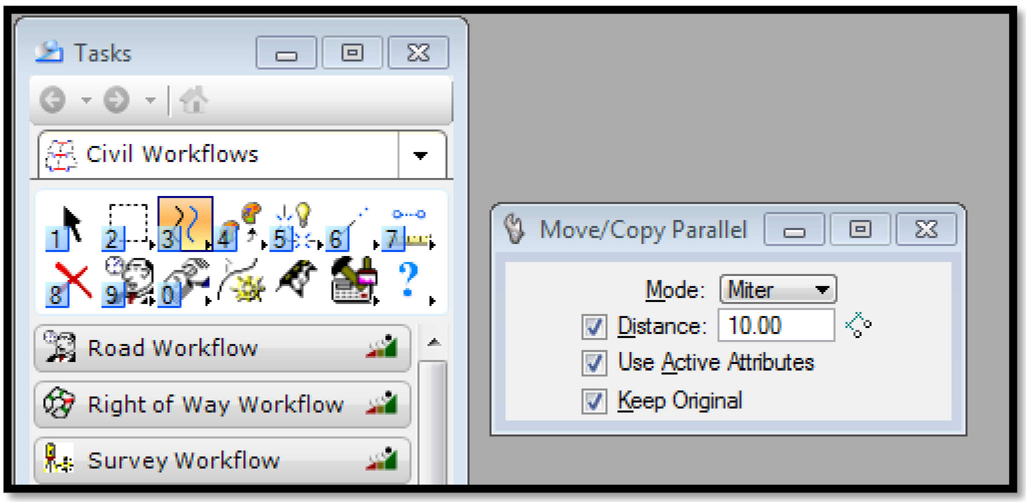
CO: 7

WT: 10

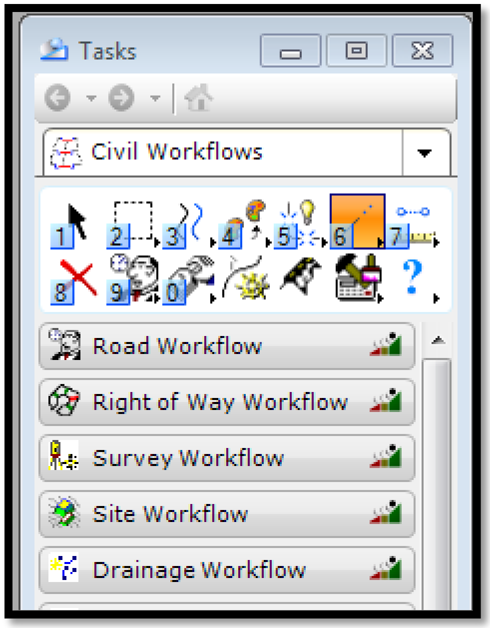
From sta. 100+00 to 106+00.32, the cross slope is a constant -2.00%, or -.020 ft/ft. To draw the diagram proportionally, set one vertical grid, 50 ft, equal to a maximum superelevation of 0.10 ft/ft. Therefore,

$$0.020 \text{ ft/ft} \times \frac{(50 \text{ ft})}{0.100 \text{ ft/ft}} = 10 \text{ ft}$$

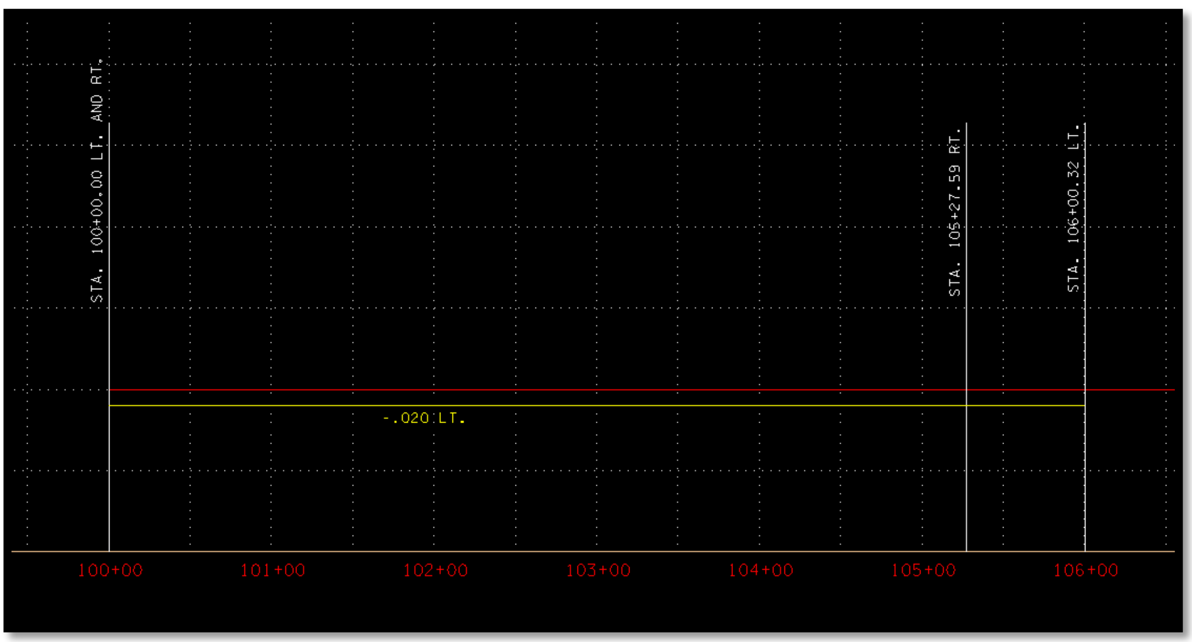
The line representing -.020 ft/ft superelevation for the left side can be drawn by copying parallel the red line drawn earlier using the settings:



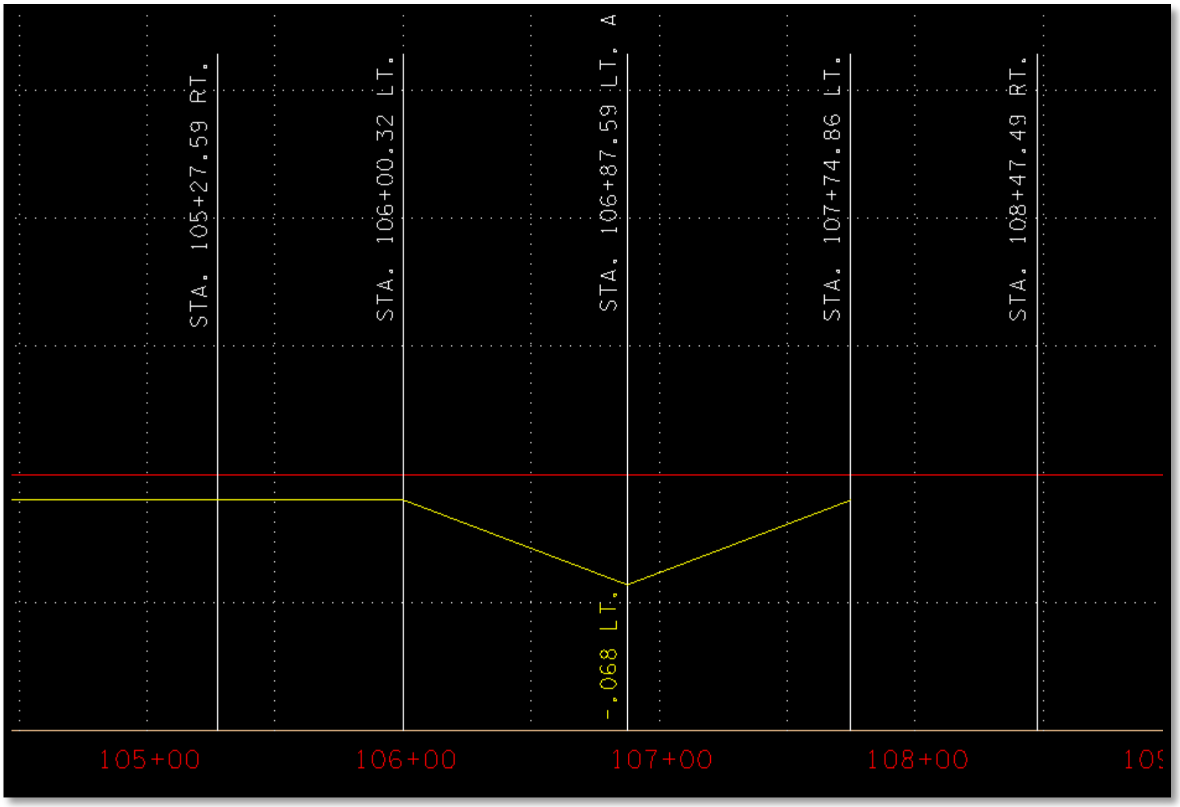

Make sure line ends at the sta. 106+00.32 line by using the "Lengthen or Shorten element to element" command:



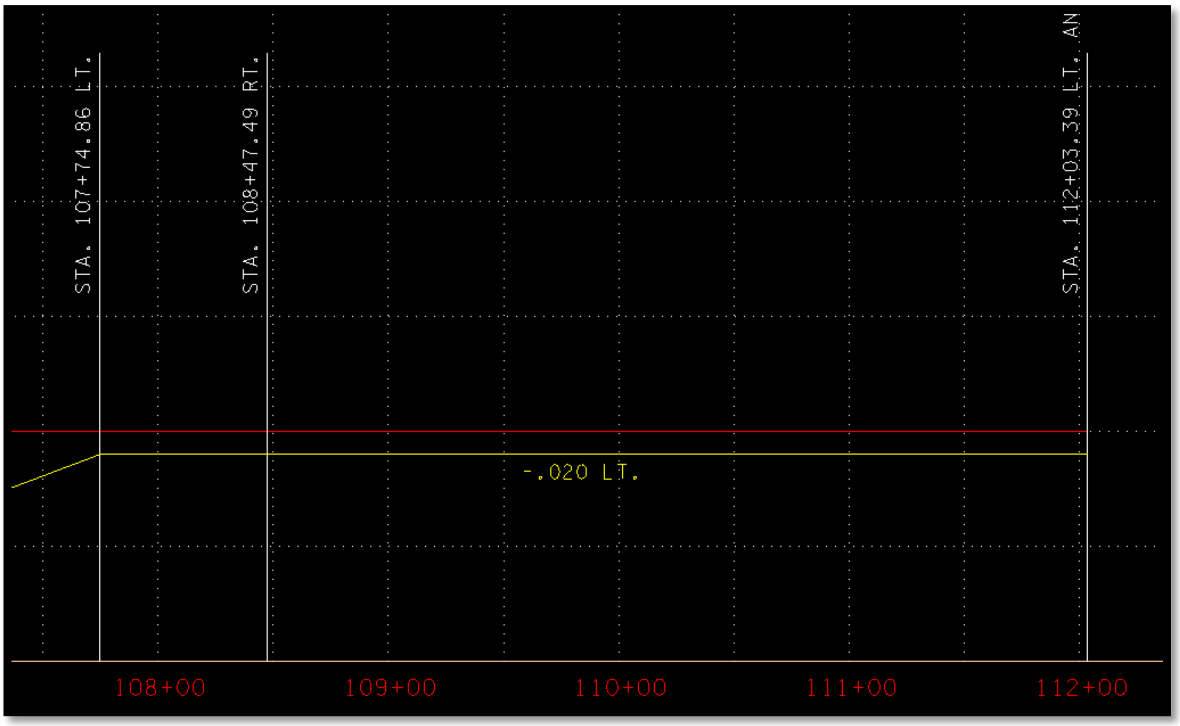

Label line as shown below using “Place text Under Element” option:



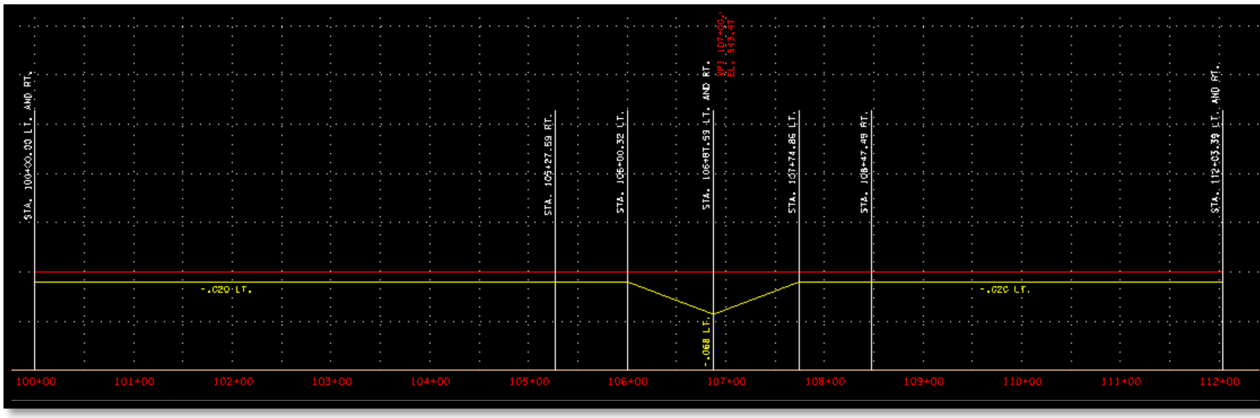

The next segment transitions from -.020 ft/ft at sta. 106+00.32 to -.068 ft/ft at sta.106+87.59, then back to -.020 ft/ft at sta. 107+74.86. Using the same conversion on page 6, -0.068 ft/ft converts to 34 ft. below the red line. Label superelevation at sta. 106+87.59 as shown below using text settings as shown on page 5.




The last segment, from sta. 107+74.86 to sta. 112+03.39, has a constant slope of -0.020 ft/ft. Draw this segment and label similar to the first segment.



The diagram for the left side should look as shown:




## Draw the Right Profile Diagram

Use the following symbology settings:

LV: DESIGN-CENTERLINE-Proposed Curve Text

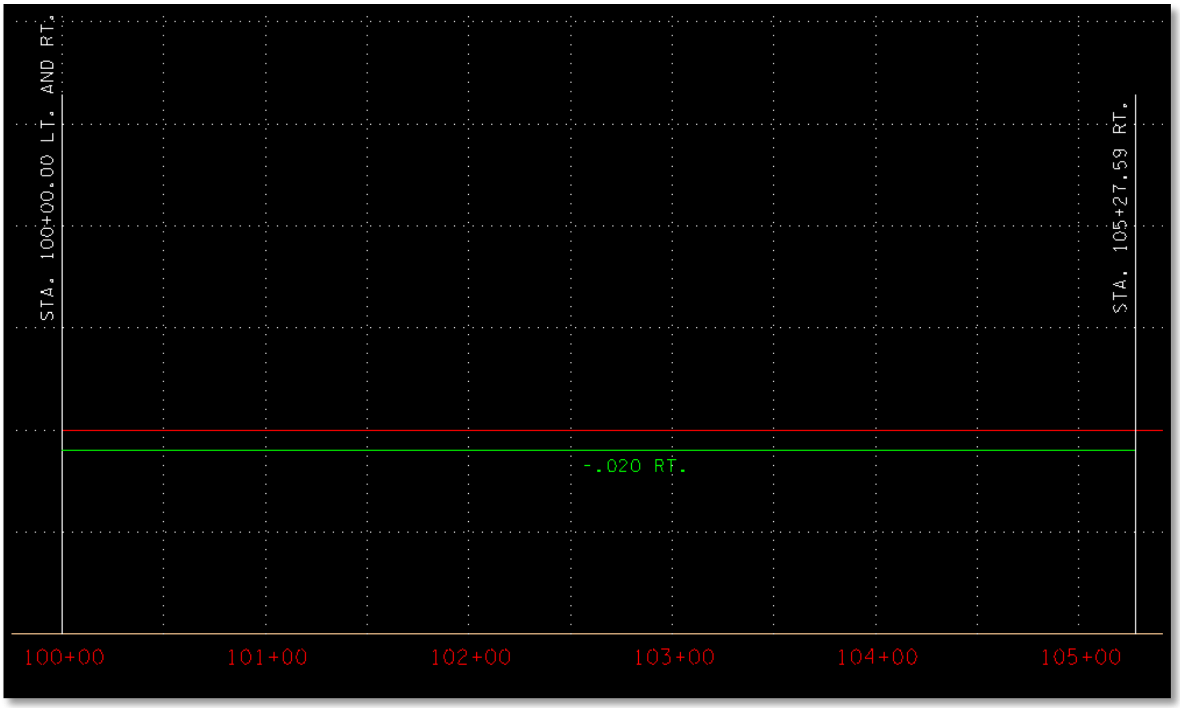
CO: 8

WT: 10

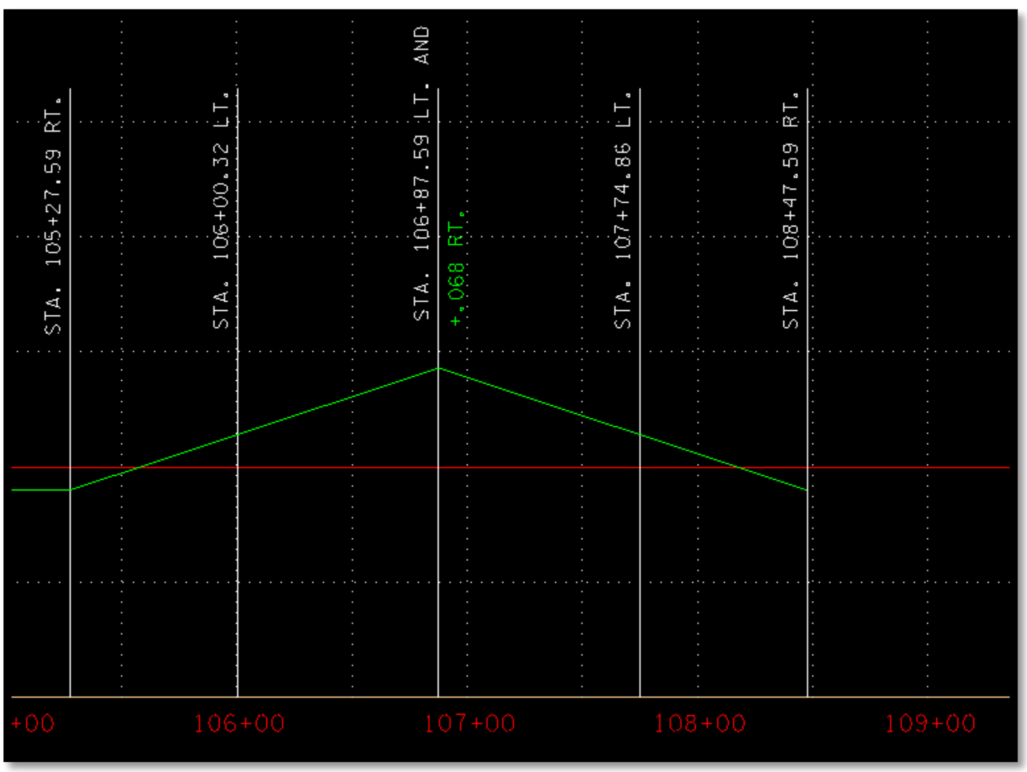
Before drawing the right-side diagram, turn off the level “DESIGN – PROFILE – Proposed Text”, which was used for the left side diagram.

From sta. 100+00 to 105+27.59, the cross slope is a constant -0.020 ft/ft.

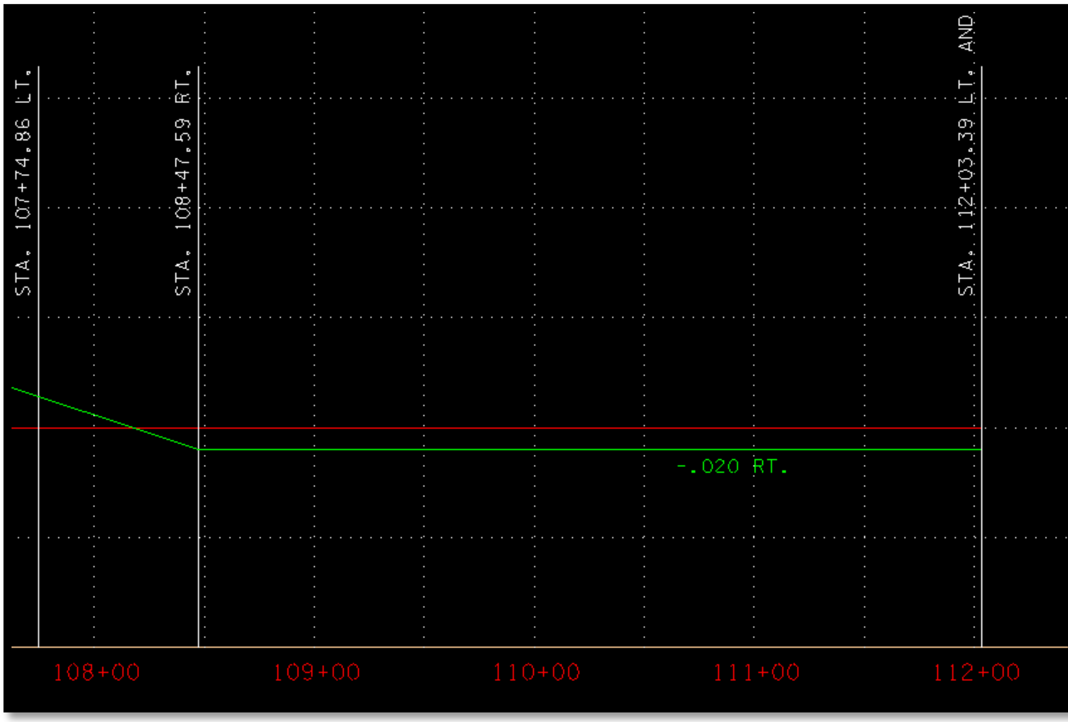
Similar to the left side diagram, copy parallel the line representing finished grade 10 ft below itself. Modify the new line to end at sta. 105+27.59.




The next segment transitions from -.020 ft/ft at sta. 105+27.59 to +.068 ft/ft at sta.106+87.59, then back to -.020 ft/f at sta. 108+47.59. Using the same conversion on page 6, +0.068 ft/ft converts to 34 ft. above the red line. Label superelevation at sta. 106+87.59 as shown below using text settings as shown on page 5.



The last segment, from sta. 108+47.59 to sta. 112+03.39, has a constant slope of -0.020 ft/ft. Draw this segment and label similar to the first segment




Turn the level “DESIGN-PROFILE-Proposed Text” back on and the finished product should look like this: