Updates to *Indiana Design Manual* Ch. 305 – Horizontal Alignment

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- Standards Reminders ❤️
- Horizontal Curve Statistics
- Summary of Revisions
- Questions

Communication

How Do We Notify Designers?

What Do We Communicate?

How To Subscribe?

- Email notification via listserv

  "Design Consultant"

- Design Memos - changes to design guidance and design procedures, yearly Standard Drawings publication, RSPs that affect designers
- Training opportunities, surveys

- Links available from multiple webpages: Indiana Design Manual, Active Design Memos, Designers https://cloud.subscription.in.gov/signup?depid=546006753

Design Memos

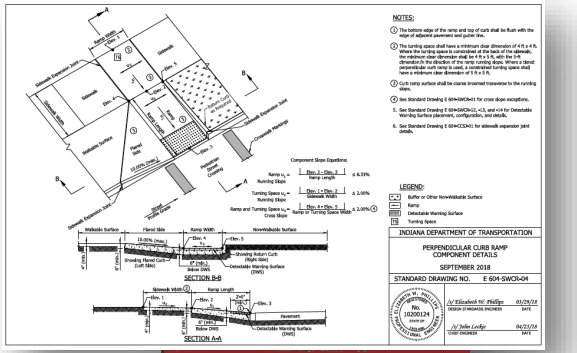
- Published the second week of each month
- Associated revisions to the IDM are incorporated concurrently, unless otherwise stated. Link in memo.
- Memos remain active for year and are then “Archived”
- Superseded memos are archived immediately
- Memos that include guidance that has not been incorporated into the IDM or other INDOT publication may remain active
- Memos that are integral to applying a recurring special provision (RSP) or recurring plan detail (RPD) may remain active

Standards Publication Dates

The Standard Drawing Index can be filtered to show changes from previous year

Revisions from the previous spec book are posted on-line

- **2025** *Standard Drawings*
  - Effective **September 2025** (online now!)
  - Published every year
- **2026** *Standard Specifications* (CM Div.)
  - Effective **September 2025** (preprint online now!)
  - Published every other year
- Recurring Special Provisions Menu (CM Div.)
  - Published Feb, May, Aug, Nov
  - Applicable menu is based on contract letting date. Available from the *Recurring Special Provisions and Plan Details* webpage



Menu and Basis for Use	Expected Publication Date	For Lettings
MAY 2025 MENU	Posted 05/01/25	September, October, and November 2025

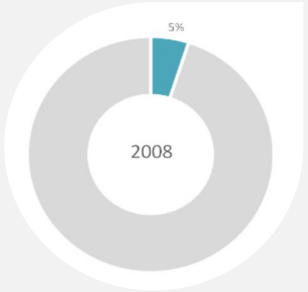
Feedback from Contract Administration

What is the #1 issue for INDOT Technical Writers?

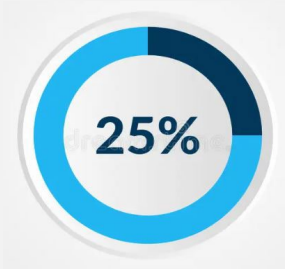
- Receiving the wrong RSP menu for the contract letting date.

Designers: you may need to resubmit the menu if you turn your Final Tracings in early or the letting date moves.

Statistics for Horizontal Curves



Horizontal curves comprise about 5% of the nation's roadway system.



Nationally more than 25% of fatal crashes are associated with a horizontal curve.

Crash rate for curves is approximately 3 times higher than tangent segments.

Sources: US DOT Federal Highway Administration, Roadway Departure Safety webpage
Handbook for Designing Roadways for the Aging Population

Statistics for Horizontal Curves (MnDOT)

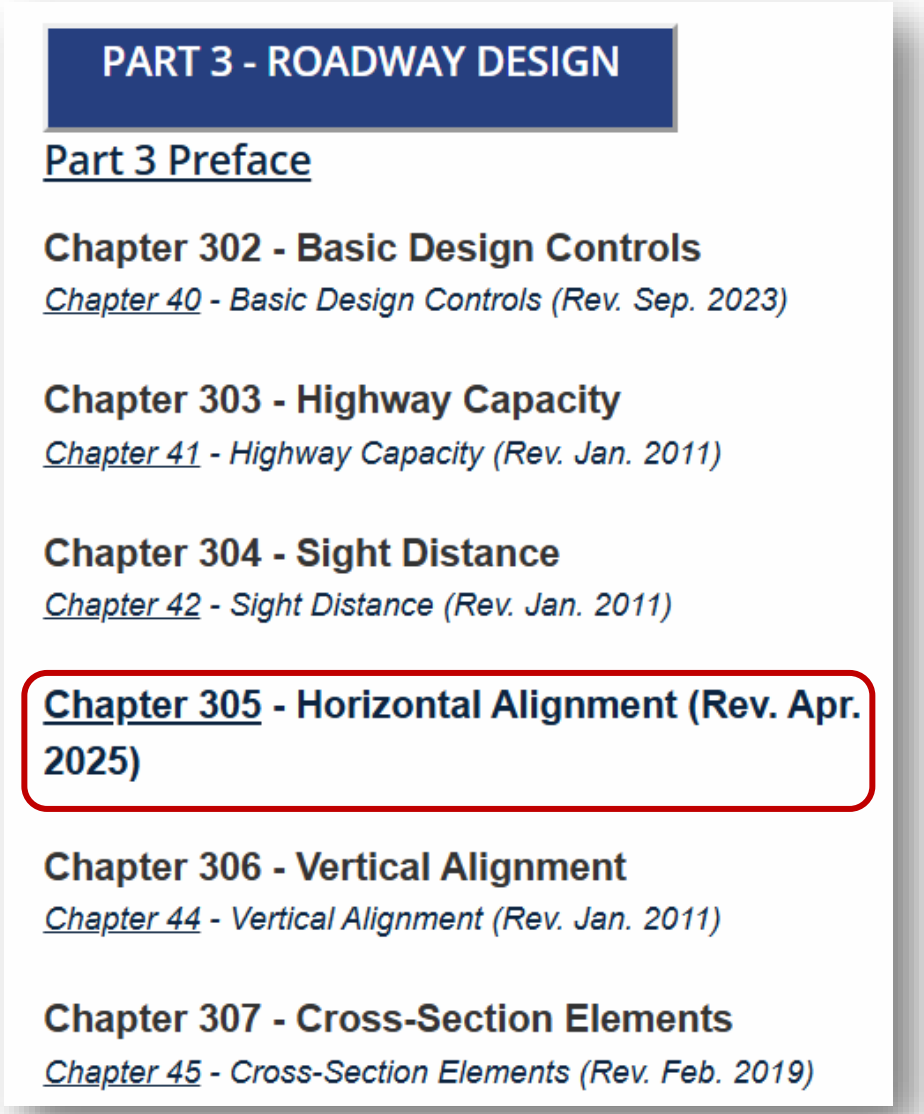
- Crash rates on horizontal curves increased as radius decreased.
- Radius ≥ 2000 ft, crash rate = statewide average for all two-lane highways.
- **Radius = 1500 ft**, crash rate = **2x** statewide avg.
- **Radius = 1000 ft**, crash rate = **5x** statewide avg.
- **Radius = 500 ft**, crash rate = **11x** statewide avg.

~90% of the fatal crashes and 75% of injuries occurred on curves with a radius < 1500 ft.

Source: MnDOT/Minnesota Local Road Research Board

General Revisions

- Chapter 43 renumbered to Chapter 305
  - IDM webpage: Remaining Part 3 chapters updated accordingly
- Ancillary changes
  - Ch 48 (Interchanges) revised to reflect change in e_{max}
  - Ch 40 (Basic Design Controls) updated design speed definition
  - Other chapters updated for new chapter and section callouts



Design Speed

305-1.0 DEFINITIONS

6. Design Speed (V). The selected speed used to determine the various geometric design features of the roadway, such as horizontal curve radius and sight distance. See Chapter 40 for additional information on speed.
   a. High speed is considered $V \geq 50$ mph.
   b. Low speed is considered $V \leq 45$ mph.

40-3.01 Definitions (previous language)

1. Design Speed. Design speed is the maximum safe speed that can be maintained over a specified section of highway if conditions are so favorable that the design features of the highway govern. A design speed is selected for each project which will establish criteria for design elements including horizontal and vertical curvature, superelevation, and sight distance.

Design Considerations – 305-2.0

- Previously grouped as Design Controls and Procedure
- Added context and priority for horizontal alignment through an intersection and coordination between horizontal and vertical alignments.

Coordination with Vertical Alignment

Intersection

Direction

Use of Min. Radius

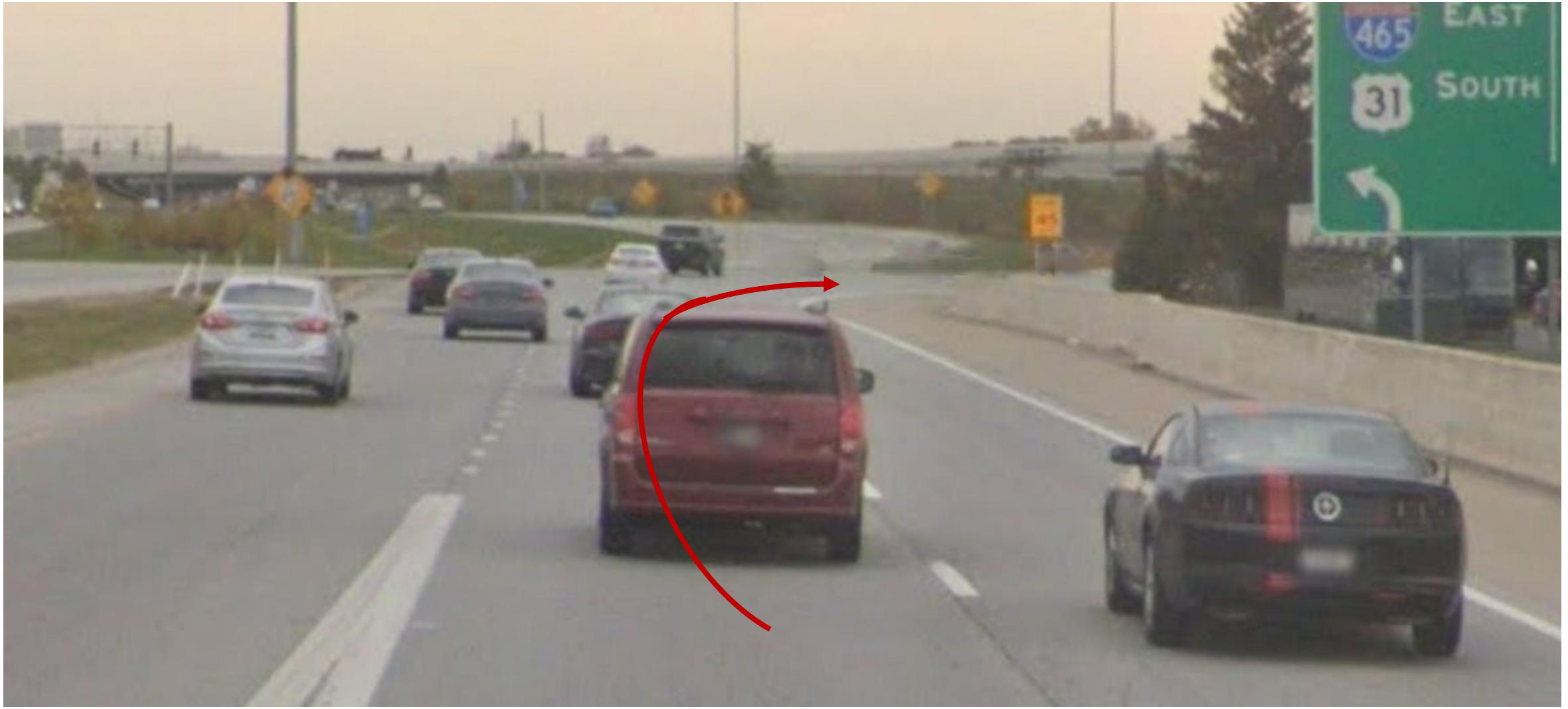
Consistency

Coordination with Natural/Man-made Features

Environmental Impact

Design Considerations – Visual Trap

Design Considerations – Visual Trap



Design Considerations – Visual Trap at Intersection

- If addressing an existing layout, enhance with mitigation measures
  - Signage
  - Pavement Markings
  - Other?

Minimum Length of Curve

305-3.02 Length of Curve

High-speed Limited Access: 30V, 15V min.

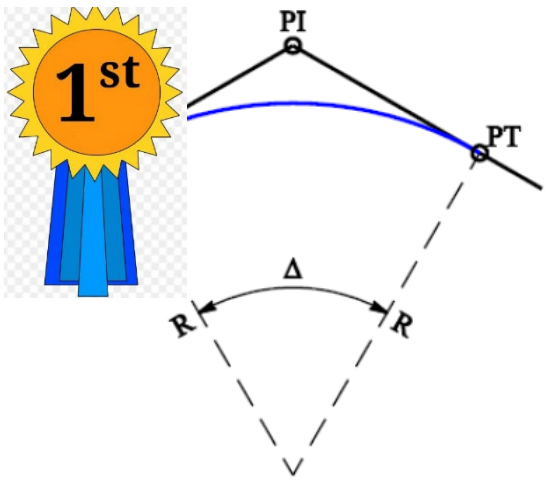
Other High-speed Facilities: 15V min.

Low-speed Facilities: 15V where practical.
RAB and urban facilities < 15 V expected.

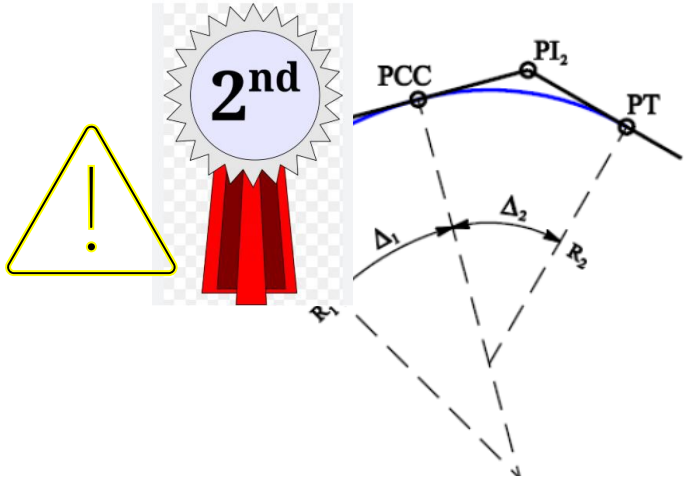
Δ (deg)	Minimum Curve Length (ft)
≤ 1	100
1 < Δ ≤ 2	200
2 < Δ ≤ 3	300
3 < Δ ≤ 4	400
4 < Δ ≤ 5	500
> 5	Calculated Length

*"For small deflections angles, curves should be sufficiently long to avoid the appearance of a kink. Curves should be at least 500-ft long for a central angle of 5 degrees, and the minimum length should be **increased** 100 ft for each 1-degree **decrease** in the central angle."*

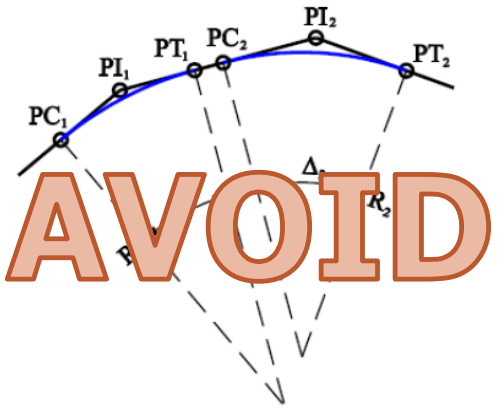
Horizontal Curve Types



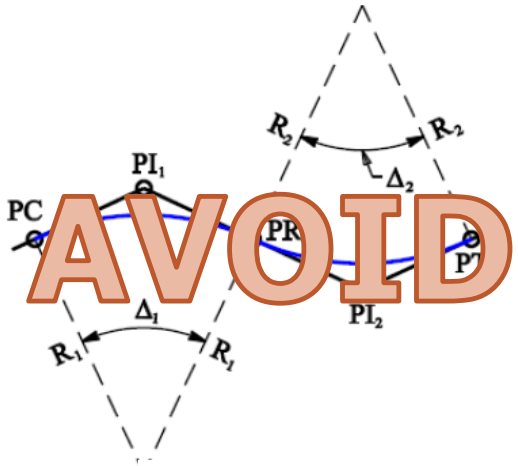
Simple Curve



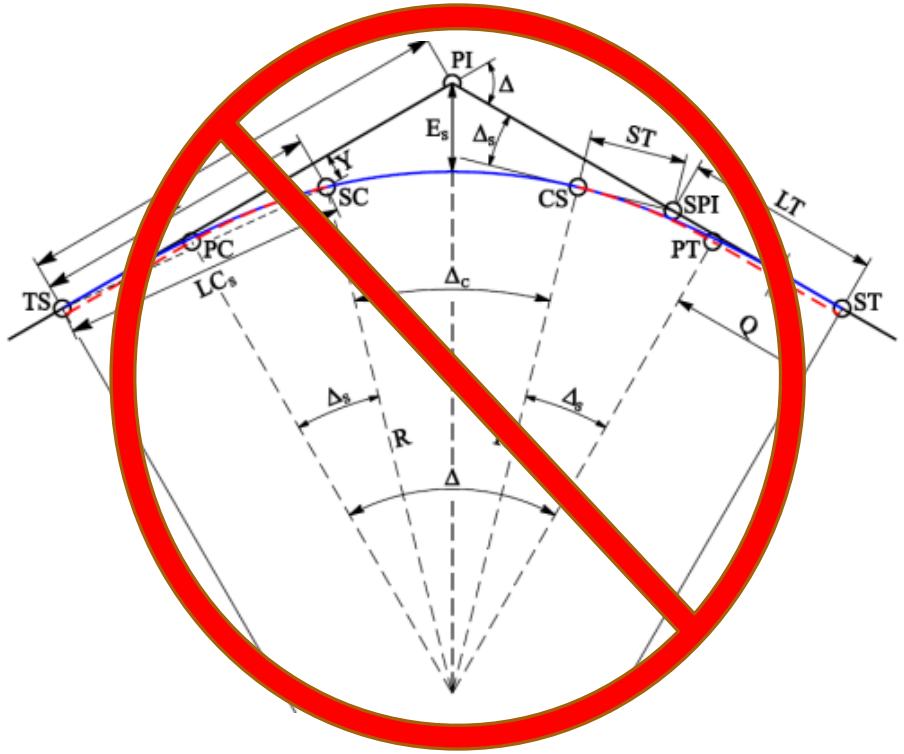
Compound Curve



Broken-Back Curve



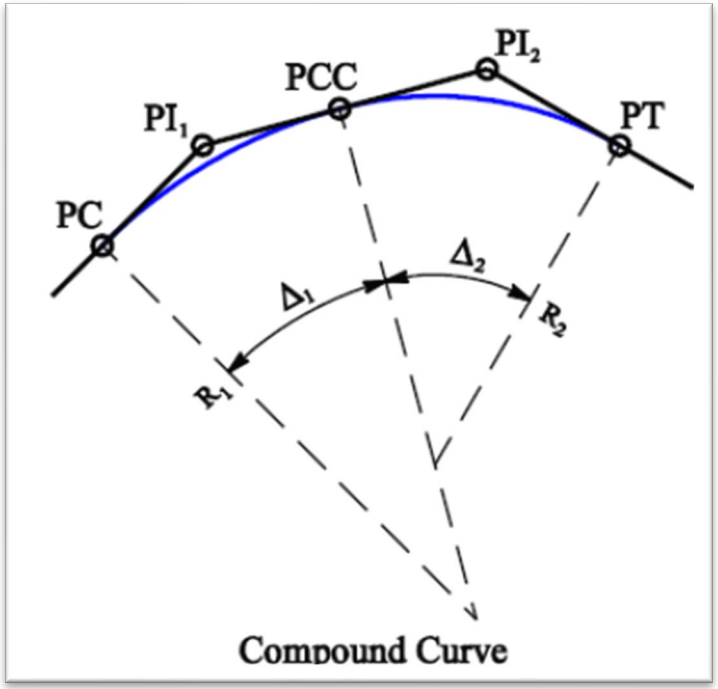
Reverse Curve



Spiral Curve

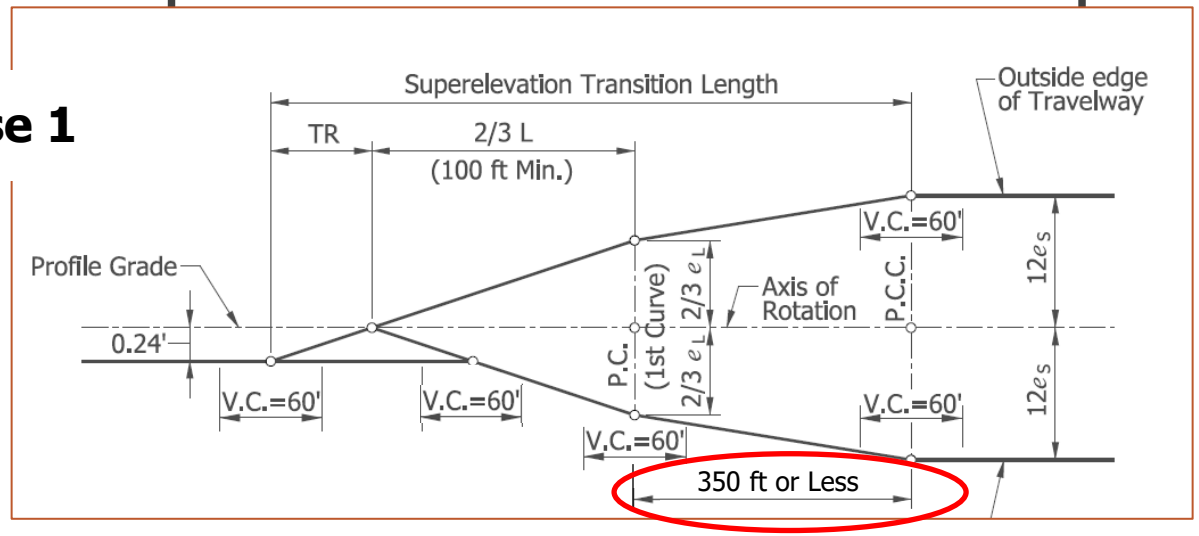
Compound Curves

- Definition: a series of two or more simple curves with deflections in the same direction immediately adjacent to each other.
- Should not be used on interstate/freeway mainline or exit ramps.
- Curve Ratio (flatter radius to sharper radius):
  - High-speed facilities: 1.25:1 not to exceed 1.5:1.
  - Low-speed facilities: 1.75:1 not to exceed 2:1.
  - Not to exceed 2:1 at intersections and turning roadways with a design speed ≤ 40 mph.
- Minimum Length Curve: criteria applicable to the total arc length of the compound curves.

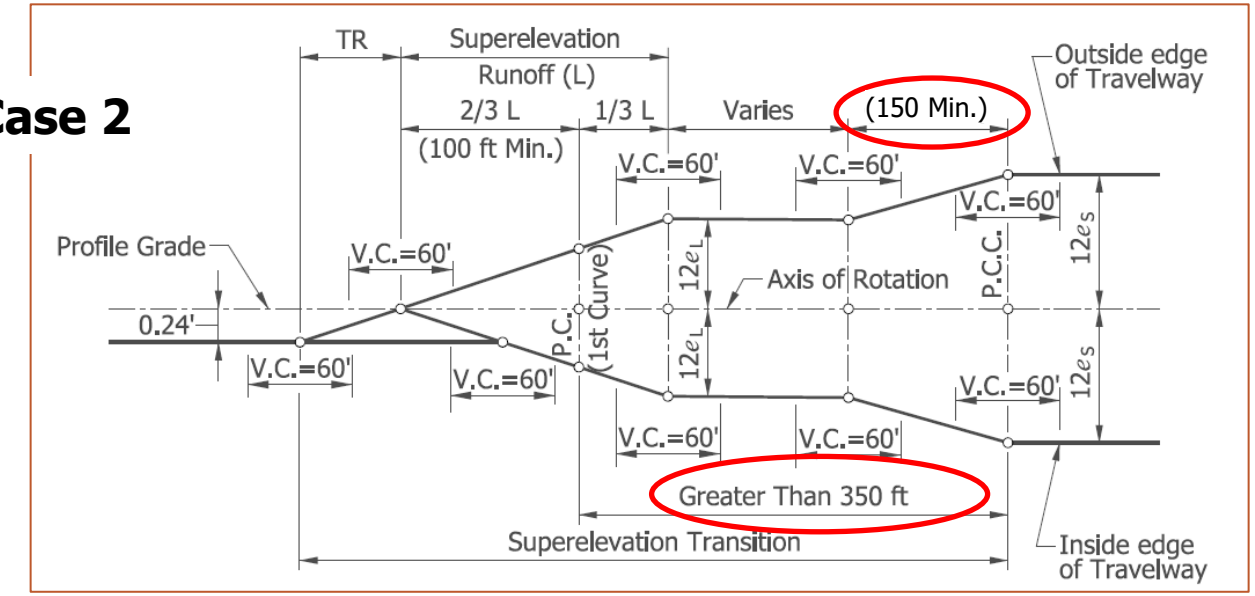


Compound Curves - Superelevation

Case 1



Case 2



SUPERELEVATION OF COMPOUND CURVES
(Two Lane Roadways)

Figure 305-4I

Case 1: The distance between the PC of larger radius curve to the PCC is 350-ft or less.

Case 2: The distance between the PC of larger radius curve to the PCC is greater than 350-ft.

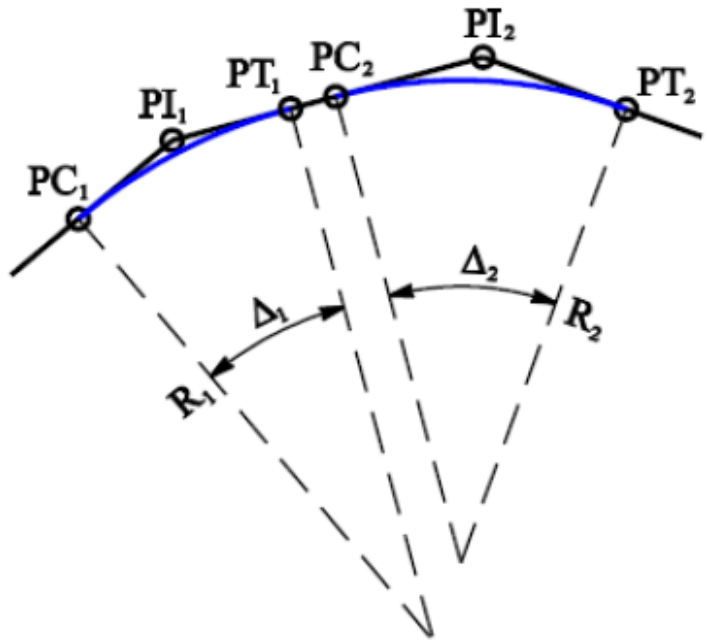
L = Superelevation Transition Length

e_s = Superelevation rate for small radius curve

e_L = Superelevation for large radius curve

Broken Back Curves

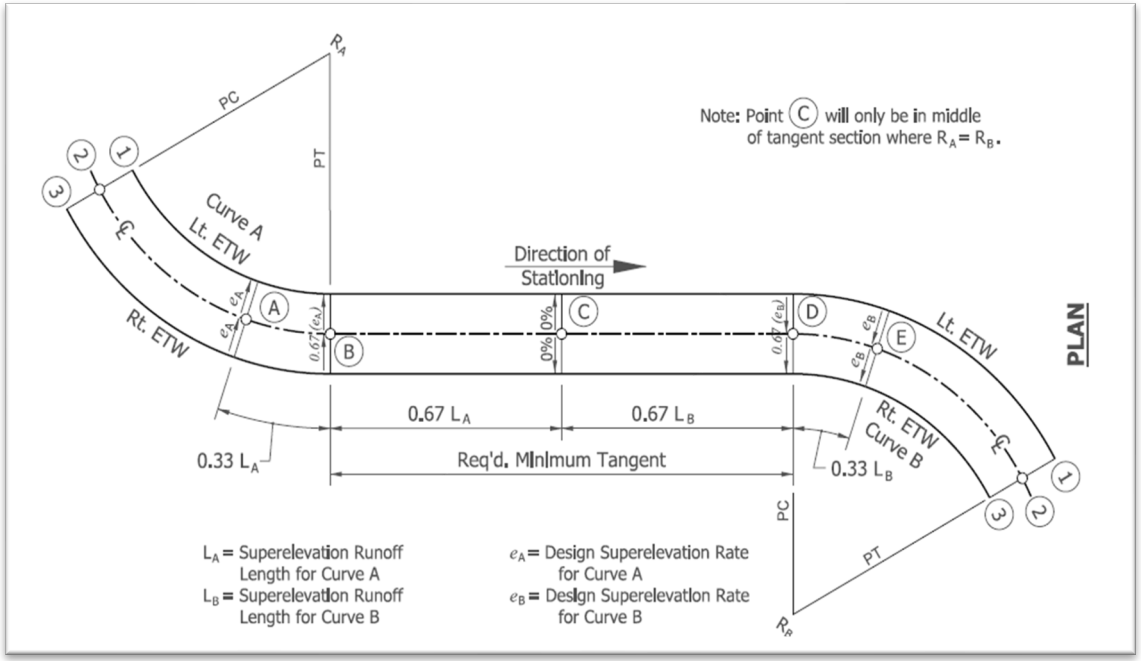
- Definition: Successive curves turning in the same direction separated by short tangent.
- Avoid using. The alignment violates the driver's expectancy.
- The length of curve criteria applies to each curve, not the total length of both curves and tangent.
- Minimum tangent lengths between the PT and PC of the adjacent curves
  - Freeways and Interstates: 1500 ft
  - All other facilities: 15V. In low-speed urban applications this distance may not be practical.



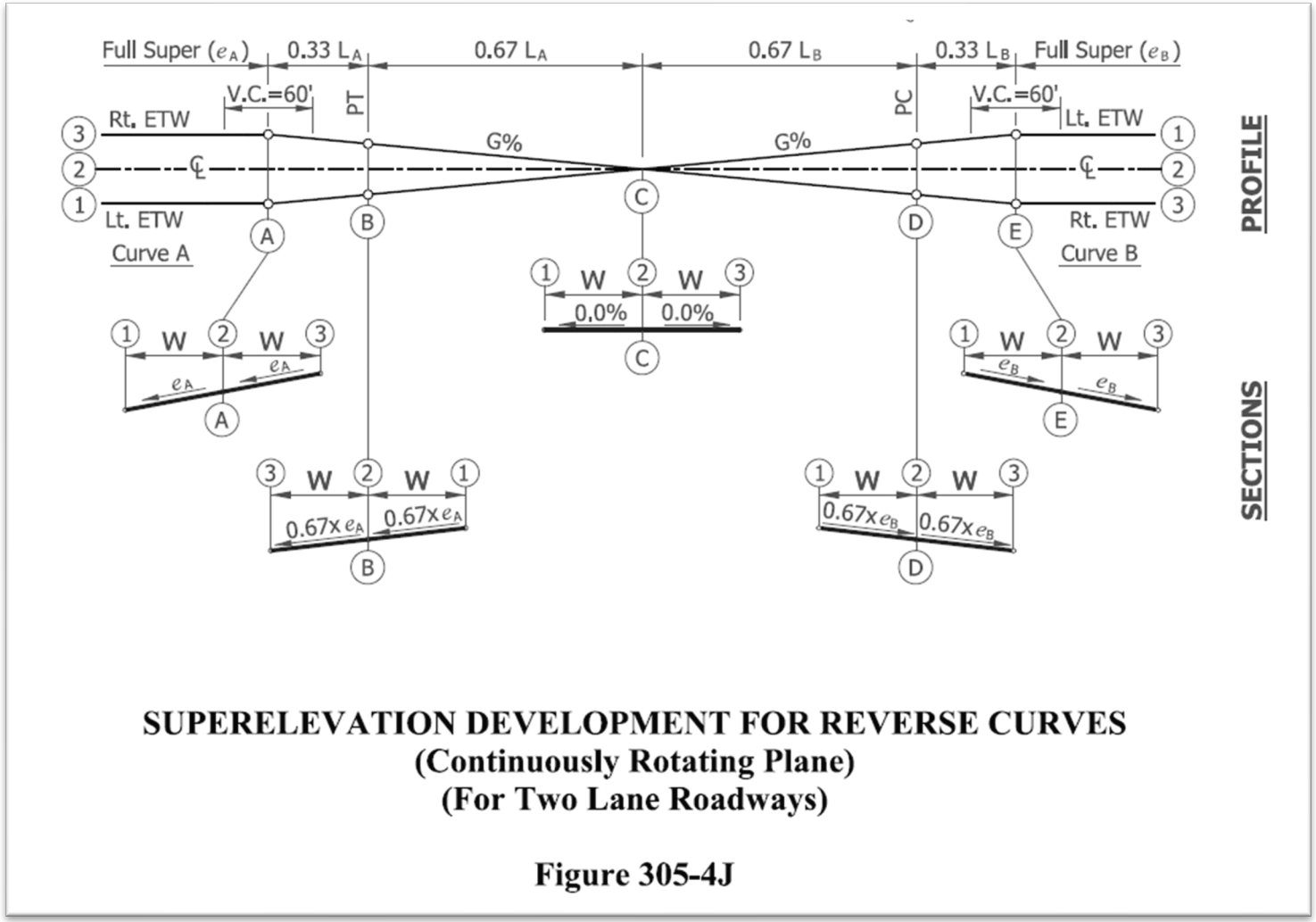
Broken-back Curve

Reverse Curves

- Definition: Two simple curves with deflections in opposite directions.
- Avoid using. Abrupt reversals make it difficult for drivers to stay in their lane.
- Normal Crown. Superelevation transition length should be met for both curves to achieve normal crown between curves.
- Continuously Rotating Plane. Distance between the PT and PC should be the sum of the respective 2/3 of superelevation runoff lengths, not, not less than 300 ft.



Reverse Curves - Superelevation

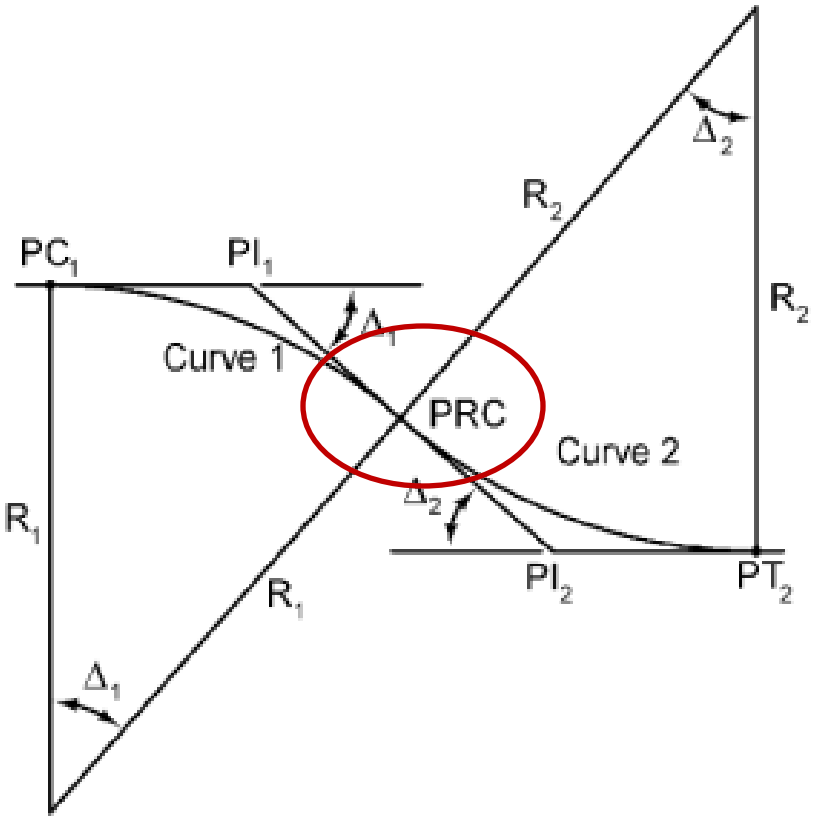


SUPERELEVATION DEVELOPMENT FOR REVERSE CURVES
(Continuously Rotating Plane)
(For Two Lane Roadways)

Figure 305-4J

Point of Reverse Curvature

- Point of Reverse Curvature is where two reverse curves are joined at a common point, the Point of Reverse Curvature (PRC).
- Reminder: PRC (no length of tangent) limited to very low speed facilities (V < 30 mph) in urban settings
  - Explicitly prohibited for interchange ramp design – IDM 48-5.03(02)
- When two curves are superelevated in the opposite direction and connected at the PRC, one of the following two scenarios happen (neither is good)
  - The PRC is not super elevated going in or out of a curve.
  - The PRC will have super elevation in the wrong direction going in or out of one of the curves.



Superelevation Rate

- New figure for selection of e_{max}
- Rural facilities, high-speed urban, and system interchange ramps.
  - e_{max} = 6% (8% may be retained for reconstruction)
- Limitations added for use of minimum radius/maximum superelevation.

Type of Facility		Design Speed	e_{max}
Rural		All Speeds	6% (1)
Rural Frontage Roads		All Speeds	8%
High-Speed Urban		V ≥ 50 mph	6% (1)
Low-Speed Urban, except ramps		V ≤ 45 mph	Varies, Method 2 (2)
Turning Roadway		V ≤ 45 mph	Varies, Method 2 (2)
Ramps	System	All Speeds	6% (3)
	Service	All Speeds	6% or 8%
Last Curve of Exit Ramp to Stop- or Signal-Controlled Terminal at Crossroad		V = 30 mph	4% or 6%

SELECTION OF e_{max}

Figure 305-4A

1400	1730	2110	2490	2910
1330	1650	2010	2380	2790
1260	1560	1910	2280	2690
1190	1480	1820	2180	2580
1120	1400	1720	2070	2470
1060	1320	1630	1970	2350
980	1230	1530	1850	2230
901	1140	1410	1720	2090
758	960	1200	1480	1810

here unusual design circumstances dictate.

NC = Normal Crown, RC = Remove (Adverse) Crown

MINIMUM RADII (R) for DESIGN SUPERELEVATION RATE (e), DESIGN SPEED (V), e_{max} = 8%
(Open Roadway Conditions)
Figure 305-4D

Superelevation Runoff – Distribution

305-4.04(03) Applying Superelevation Runoff

1. Simple Curve. The superelevation runoff length (L) should be distributed **2/3 L on the tangent and 1/3 L on the curve…**may be adjusted incrementally down to **50% on the tangent and up to 50% on the curve**.

   *For multi-lane roadways, an adjustment factor (b_w) should be applied rather than adjusting the distribution percentages.

V (mph)	Number of Lanes Rotated			
	1	1.5	2 or 2.5	3 or 3.5
15 - 45	80%	85%	90%	90%
50 - 70	70%	75%	80%	85%

PORTION OF SUPERELEVATION RUNOFF ON TANGENT, %

Figure 43-3F

(NCHRP Rpt 774)…*placing too great a proportion of the runoff length on the approach tangent develops excessive superelevation prior to the PC and results in negative side friction through much of the transition. With negative side friction, drivers are required to correctively steer uphill against the developing superelevation in order to maintain position in their lane.*

Research incorporated into GB 7th Ed. To achieve a balance between the lateral acceleration and negative side friction, most agencies are using 67% on the tangent.

Superelevation Runoff – Adjustment Factor, b_w

Number of Lanes Rotated	Adjustment Factor, b_w	
	Route on the State Highway System	Routes off the State Highway System and Restricted Locations (1)
1	1.0	1.0
1.5	1.0	0.83
2	1.0	0.75
2.5	1.0	0.70
3	1.0	0.67
3.5	1.0	0.64

(1) Where physical constraints, e.g., bridge, ramp terminals, etc. do not allow the full transition length to be provided, adjustment factors should be used instead of modifying runoff distribution percentages to place more of the runoff on the curve.

Adjustment Factor

MAXIMUM RELATIVE GRADIENT AND ADJUSTMENT FACTORS

Figure 305-4F

Now has restrictions for application

Number of Lanes Being Rotated*	b_w
1	1.0
1½	0.83
2	0.75
2½	0.70
3	0.67
3½	0.64

* *This column refers to the number of lanes being rotated on either side of the axis rotation. Select the higher value.*

bw VALUES
(Superelevation Runoff Lengths, Multilane Highways)

Figure 43-3G

Effect of b_w on the Gradient

Design Speed	Required G_{max}	Number of Lanes Rotated (b_w factor)							
		1.5(0.83)		2(0.75)		2.5(0.70)		3(0.67)	
MPH	%	G_r	V_r	G_r	V_r	G_r	V_r	G_r	V_r
40	0.58	0.70	25	0.77	16	0.83	<15	0.87	<15
45	0.54	0.65	31	0.72	23	0.77	16	0.81	<15
>50	0.50	0.60	37	0.67	29	0.71	24	0.75	19

G_r = Resultant Gradient

V_r = Equivalent Speed (mph)

$$L_r = \frac{wne_d(b_w)}{G}$$

Design Speed (mph)	Maximum Relative Gradient, G (%)
15	0.78
20	0.74
25	0.70

Superelevation Runoff – Max. Gradient

Design Speed (mph)	Maximum Relative Gradient, G (%)
15	0.78
20	0.74
25	0.70
30	0.66
35	0.62
40	0.58
45	0.54
≥ 50	0.50

Maximum Relative Gradient
(Outside Edge of Traveled Way)

MAXIMUM RELATIVE GRADIENT AND ADJUSTMENT FACTORS

Figure 305-4F

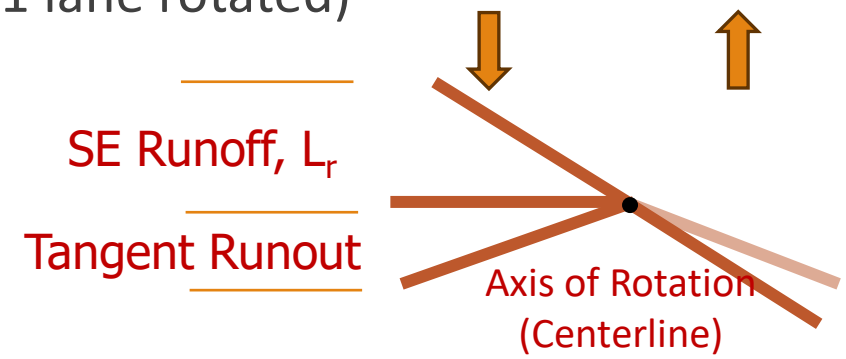
Design Speed (mph)	Equivalent Max. RS	Edge-of-Travelway Slope Relative to Centerline G_{max} (%)
15	128	0.78
20	135	0.74
25	143	0.70
30	152	0.66
35	161	0.62
40	172	0.58
45	185	0.54
50	200	0.50
55	213	0.47
60	222	0.45
65	233	0.43
70	250	0.40

RELATIVE LONGITUDINAL SLOPES
(Two-Lane Roadway)

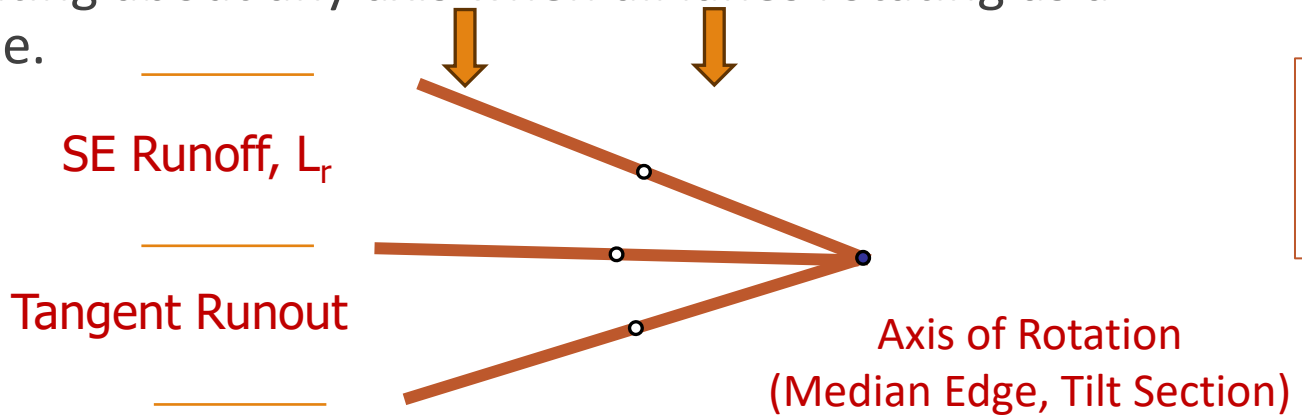
Figure 43-3E

Superelevation Development

- Rotating about the centerline for two-lane, two-way roadway (1 lane rotated)



- Rotating about any axis when all lanes rotating as a plane.



$$L_r = \frac{wn_1eb_w}{G}$$

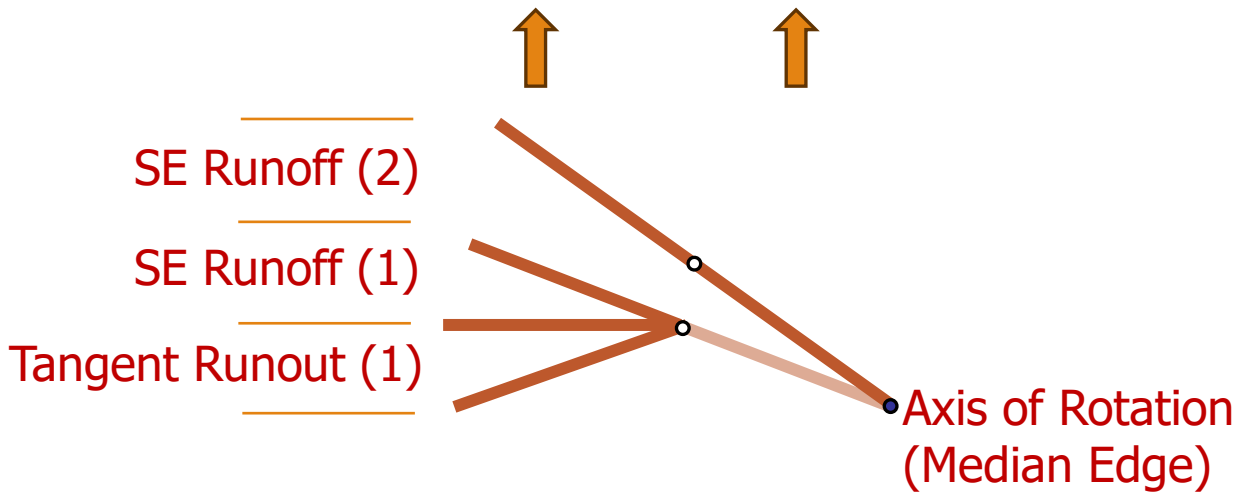
$$TR = \frac{L_r(S_{\text{normal}})}{e}$$

SUPERELEVATION RUNOFF LENGTHS

Figure 305-4G

Superelevation Development – Multi-lane Divided

- Rotating a crown section about the median edge is an incremental calculation.

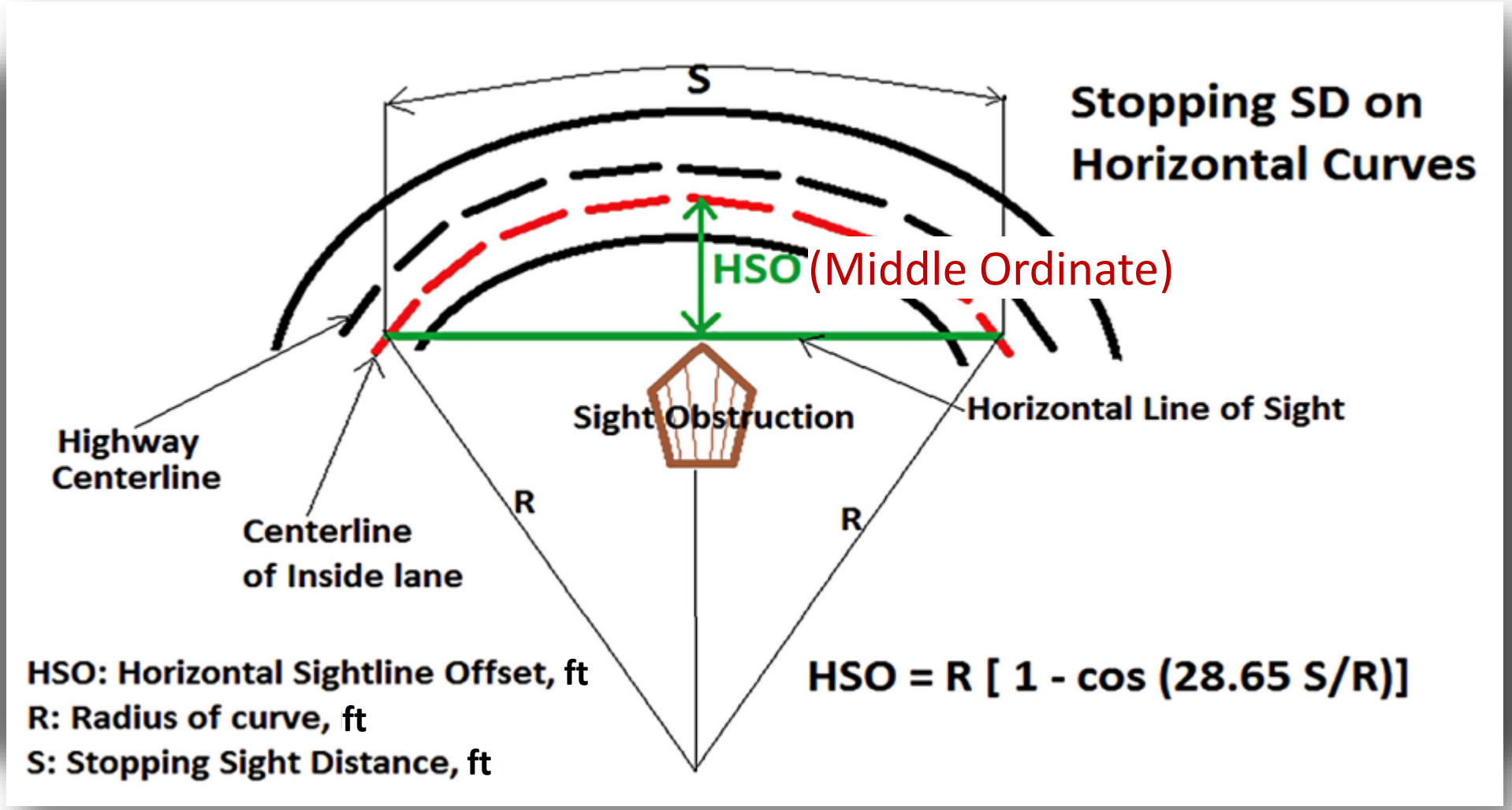


n_{RC} = # lanes rotated to remove adverse crown

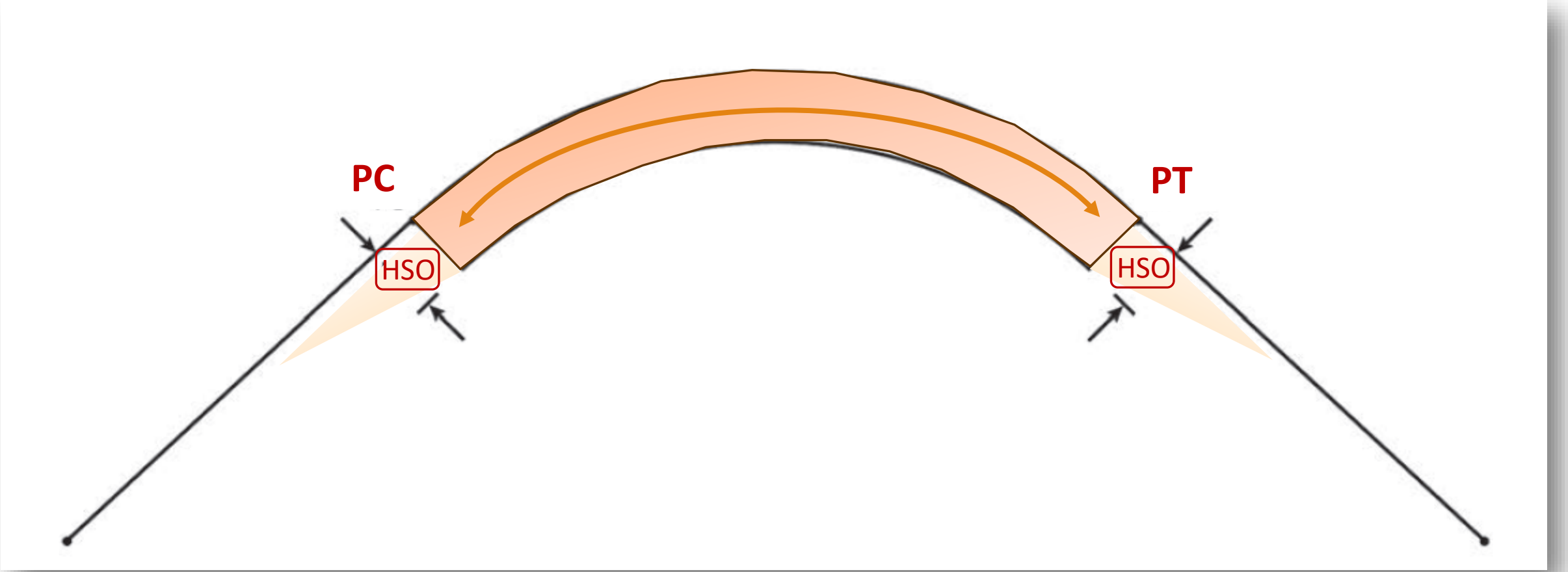
$$TR_{ML} = \frac{(S_{normal})(n_{RC})(w)}{G}$$

$$L_r = \frac{wn_1eb_w}{G}$$

Stopping Sight Distance – Horizontal Curves



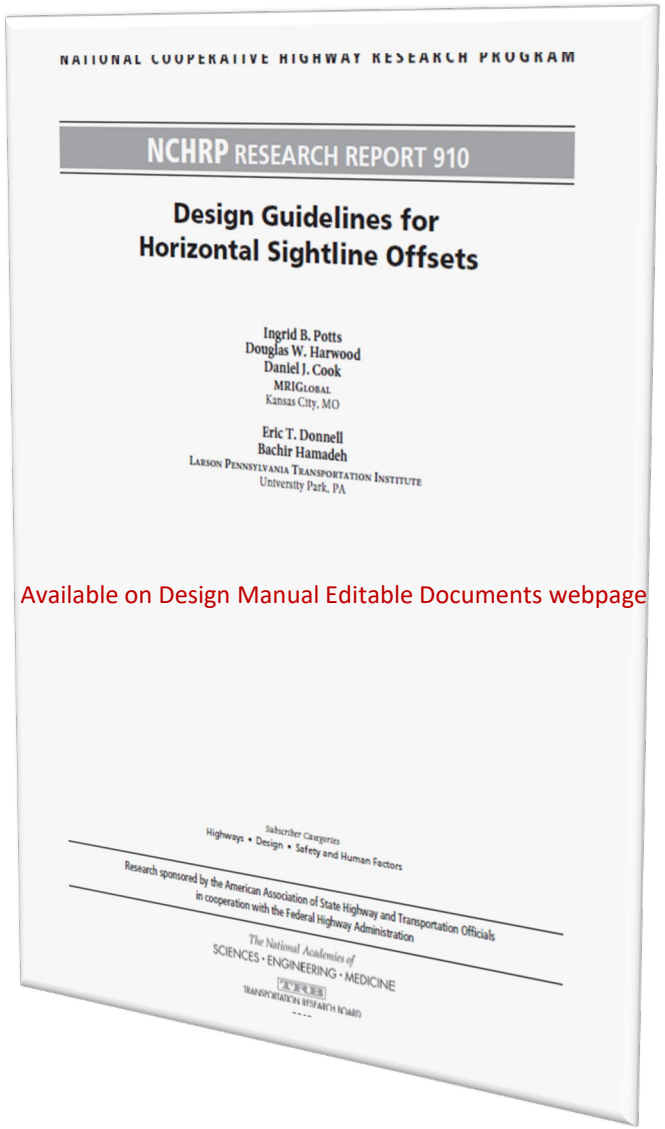
Stopping Sight Distance – Horizontal Curves



Calculate the horizontal sightline offset and ensure there are no sight obstructions within that offset from the PC to the PT.

Evaluating Stopping Sight Distance

- NCHRP Report 910 – Design Guidelines for Horizontal Sightline Offsets.
- No definitive CMFs that quantify the effect of SSD on crashes in either the AASHTO *Highway Safety Manual* or on the FHWA CMF Clearinghouse
- Limited SSD is far more likely to result in a collision at some locations (hidden features) than at others.
- Research suggests correcting or mitigating limited SSD may be more critical in some highway situations than others.
- Developed a reliability analysis model and spreadsheet tool
- Guidance to assess whether horizontal sight restrictions on particular horizontal curves should be removed or mitigated.*
- **guidance is a framework for decision-making, not right or wrong.*



Available on Design Manual Editable Documents webpage

(Available on Design Manual Editable Documents webpage)

Reliability Analysis Spreadsheet Tool

Use the pull down to select the facility type/number of lanes

Estimating the relative frequency of opportunities for crashes – This is not crash prediction

INPUT DATA

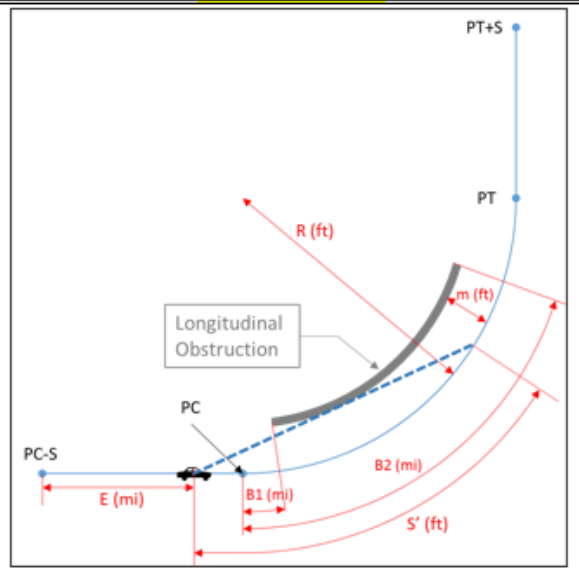
Facility Type	
Rural freeway (4 lanes)	
Number of lanes in analysis direction	2
Average lane width (ft)	12.0
AADT (one direction, veh/d)	20000

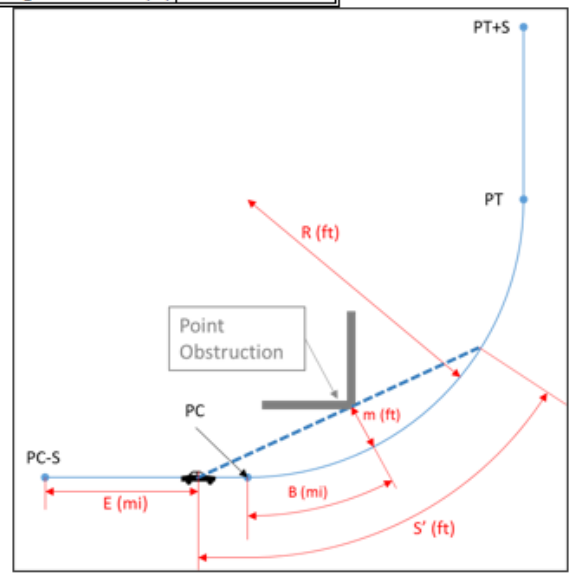
RESULTS	Lane 1	Lane 2			Total
Minimum available sight distance (ft)	400.2	595.6			
Length of sight-restricted roadway (mi)	0.360	0.000			
Total Number of potentially affected vehs per yr	733.10	0.00			733.10
Total number of vehicles passing site per year	5,840,000	1,460,000			7,300,000
Percent potentially affected	0.013%	0.000%			0.010%
Time and date of last analysis	5/12/2025 17:24		AASHTO design stopping sight distance (ft)		495

Calculate

- ○ Point obstruction
- ◉ Continuous obstruction, straight grade
- ○ Continuous obstruction, vertical curve present

Direction of Curve
To the left





Horizontal Curve and Obstruction Data Input	
Curve Radius, R (ft)	2000.0
Curve Length, L (mi)	0.372
Design or Operating Speed (mi/h)	55
Longitudinal distance from PC to beginning of continuous obstruction, B1 (mi)	-0.100
Longitudinal distance from PC to end of continuous obstruction, B2 (mi)	0.372
Offset from edge of traveled way to sight obstruction, m (ft)	4.0
Height of obstruction above edge of traveled way (ft)	3.8

Profile Data	
Roadway grade (%)	2.50

Opportunity to consider alternatives to AASHTO values

Advanced Options		AASHTO values	Alternative values
Analysis increment, x (ft)	50	Eye height (ft)	3.5	3.5
○ Use AASHTO values		Object in road height (ft)	2.0	3.5
◉ Use alternative values		Distance from left edge of lane to driver (ft)	6.0	6.0

NOTE: B, B1, and B2 should be entered as negative values if they occur prior to the PC

Remember This (TLDR)

- ✓ Ensure the RSP menu is correct for the letting date
- ✓ September 2025 lettings for 2025 standard drawings and 2026 *Standard Specifications*.
- ✓ Consider the context of horizontal alignments
- ✓ Updated minimum length of curve requirements
- ✓ Additional design guidance for compound, broken back, and reverse curves
- ✓ Limit maximum superelevation rate to e_{max} = 6% for high-speed facilities
- ✓ Superelevation transition distribution 2/3 – 1/3
- ✓ New range for maximum gradient
- ✓ New limits for using minimum radius/maximum superelevation.
- ✓ NCHRP Report 910 is a resource for evaluating horizontal stopping sight distance.

Road Design Questions?

RoadReviewTeam@indot.in.gov

General Questions?

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INDOT HIGHWAY DESIGN CONFERENCE 2025

UPDATES TO IDM CHAPTER 305 – HORIZONTAL ALIGNMENT