

ERRATA for
A Policy on Geometric Design of Highways and Streets

October 2019

Dear Customer:

Recently, we were made aware of some technical revisions that need to be applied to the 2018 *A Policy on Geometric Design of Highways and Streets*, 7th Edition.

Please replace the existing text with the corrected text to ensure that your edition is both accurate and current. Additional copies of this erratum can be downloaded from AASHTO's online bookstore at

<http://downloads.transportation.org/GDHS-7-Errata.pdf>

AASHTO staff sincerely apologizes for any inconvenience to our readers.

Page	Existing	Corrected
Chapter 2		
2-52	In Section 2.6.3, paragraph 1, the reference callout is incorrect.	In Section 2.6.3, paragraph 1, changed the reference callout from “(24)” to “(25).”
2-96	In Section 2.11, reference entry 12, there is a slash where a hyphen should be in the publication number. In Section 2.11, reference entry 14, there is an equal sign where a hyphen should be in the publication number.	In Section 2.11, reference entry 12, changed “FHWA/SA-90-017” to “FHWA-SA-90-017.” In Section 2.11, reference entry 14, changed “FHWA-SA=14-015” to “FHWA-SA-14-015.”
Chapter 3		
3-38	U.S. Customary Equation 3-11 shows a multiplier of “1.15” in the denominator: $R_{PI} = \frac{V_R^2}{1.15e_{\max}}$	In U.S. Customary Equation 3-11, changed multiplier in the denominator to “0.15”: $R_{PI} = \frac{V_R^2}{0.15e_{\max}}$
3-49	For $e_{\max} = 12\%$, $e = 5.8\%$, and $V = 45$ mph, Table 3-12 shows a radius of 1,920 ft.	In Table 3-12, for $e_{\max} = 12\%$, $e = 5.8\%$, and $V = 45$ mph, changed the radius from 1,920 ft to 1,620 ft.
3-66 through 3-69	In Table 3-16 U.S. Customary and metric, table values were not updated to match the gradient change.	In Table 3-16 U.S. Customary and metric, updated table values to match the gradient change.
3-83	In Figure 3-8(c), object B and its centerline(s) are slightly out of position.	In Figure 3-8(c), corrected positioning of object B and its centerline.
3-85	In Section 3.3.8.7, paragraph 1, some values are inconsistent with text elsewhere in the chapter. In Section 3.3.8.7, paragraph 1, second to last sentence, metric values should be listed second.	Revised to read “Even when the maximum relative gradient is used to define runoff length, the length of vertical curve does not need to be large to conform to the 0.67 percent break at the 30-mph [50-km/h] design speed (see Figure 3-8) and 0.50 percent break at design speeds of 50 mph [80 km/h] and higher. Where the traveled way is revolved about an edge, these grade breaks are doubled to 1.33 percent for the 30-mph [50-km/h] design speed and to 1.00 percent for design speeds of 50 mph [80 km/h] and higher.” Revised to read “For an approximate guide, however, the minimum vertical curve length in feet [meters] can be used as numerically equal to the design speed in miles per hour [0.2 times the design speed in kilometers per hour].”
3-93	In both the U.S. Customary and metric versions of Equation 3-33, the square root symbol extends too far, including “–R” as part of the square root expression.	Corrected both the U.S. Customary and metric versions of Equation 3-33 so that “–R” is not part of the square root expression.

Page	Existing	Corrected
3-96	U.S. Customary Equation 3-34 shows “0.1” just after the equal sign: $Z = 0.1(V / \sqrt{R})$	In U.S. Customary Equation 3-34, deleted “0.1” just after the equal sign: $Z = (V / \sqrt{R})$
3-99	The first row of Table 3-24a has one cell too many highlighted.	In the first row of Table 3-24a, for $R = 7000$ ft, removed the highlighting from the next to last cell on the right, where the value is 2.0.
3-123	In paragraph 3, second to last sentence, the percentage upgrade is incorrect in “maintain a minimum speed of 50 mph [80 km/h] on a 3 percent upgrade.”	In paragraph 3, second to last sentence, changed the percentage upgrade to read “maintain a minimum speed of 50 mph [80 km/h] on a 2 percent upgrade.”
3-124	Metric Figure 3-15 is incorrectly positioned.	Rotated metric Figure 3-15 by 90 degrees.
3-125	Metric Figure 3-16 has a y axis label of “mph.”	Changed metric Figure 3-16’s y axis label to “km/h.”
3-126	In paragraph 1, all figure callouts are incorrect.	Changed figure callouts as follows: “3-16” to “3-15,” “3-17” to “3-16,” “3-18” to “3-17,” and “3-19” to “3-18.”
3-140	In the last paragraph, the callout is “Figure 3-18.”	Changed the callout from “Figure 3-18” to “Figure 3-17.”
3-184	In Figure 3-40(C), the label “Preferred” has been separated from its arrow, which has been separated from its point of interest: the dashed line.	In Figure 3-40(C), moved the label “Preferred” and the arrow to indicate the dashed line.
3-185	In Figure 3-40(H), the label “Minimum Curve...” is set on top of the arrow. In Figure 3-40(I), “conves” is a typographical error. In Figure 3-40(J), “Verticles” is a typographical error. In Figure 3-40(L), “shrot” is a typographical error.	In Figure 3-40(H), moved the label “Minimum Curve...” into the clear. In Figure 3-40(I), changed “conves” to “convex.” In Figure 3-40(J), changed “Verticles” to “Vertices.” In Figure 3-40(L), changed “shrot” to “short.”
Chapter 4		
4-89	In Section 4.21, reference entry 18, the publication number and year are incorrect.	In Section 4.21, reference entry 18, changed “FHWA-SA-96-078” to “FHWA-NHI-10-009” and the publication year from 1996 to 2009.
4-92	In Section 4.21, reference entry 37, hyphens are missing from the publication number.	In Section 4.21, reference entry 37, changed “FHWA NHI 01-002” to “FHWA-NHI-01-002.”
Chapter 5		
5-40	In Section 5.7, reference entry 7, the title is incomplete.	In Section 5.7, reference entry 7, changed the title from “ <i>Drainage Manual</i> ” to “ <i>AASHTO Drainage Manual</i> .”

Page	Existing	Corrected
Chapter 6		
6-25	In Section 6.4, reference entry 7, the title is incomplete.	In Section 6.4, reference entry 7, changed the title from “ <i>Drainage Manual</i> ” to “ <i>AASHTO Drainage Manual</i> .”
Chapter 7		
7-71	In Section 7.4, reference entry 11, the publication number has a zero where a hyphen should be.	In Section 7.4, reference entry 11, changed “FHWA-HEP017-024” to “FHWA-HEP-17-024.”
Chapter 8		
8-4	Section 8.2.4 did not allow narrower shoulders in mountainous terrain as is allowed in the Interstate standard.	Added the following paragraph to Section 8.2.4: When necessary for freeways in mountainous terrain, the paved right shoulder may be reduced to 8 ft [2.4 m]. On four- or six-lane freeways, the paved left shoulder width may be reduced to 4 ft [1.2 m]. On freeways with eight or more lanes in mountainous terrain, the paved left and right shoulders should be at least 8 ft [2.4 m].
Chapter 9		
9-30	Figure 9-13, Typical Single-Lane Roundabout, is out of date.	Replaced Figure 9-13, Typical Single-Lane Roundabout.
9-31	Figure 9-14, Typical Multilane Roundabout, is out of date.	Replaced Figure 9-14, Typical Multilane Roundabout.
9-38	In Section 9.5.2.2, paragraph 1, sentence 3 is incomplete.	In Section 9.5.2.2, paragraph 1, added the following language to the end of sentence 3: “from which stopped vehicles may enter or cross a major road on which traffic is not required to stop.”
9-97	In both the U.S. Customary and metric versions of Equation 9-3, the variable “ t_c ” in the denominator is incorrect.	In both the U.S. Customary and metric versions of Equation 9-3, changed the variable “ t_c ” in the denominator to “ t_f .”
9-144	Figure 9-61, Basic Geometric Elements of a Roundabout, is out of date.	Replaced Figure 9-61, Basic Geometric Elements of a Roundabout.
9-148	Figure 9-62, Roundabout Lane Configuration Example, is out of date.	Replaced Figure 9-62, Roundabout Lane Configuration Example.
9-156	In Section 9.11.4, the last reference callout is incorrect.	In Section 9.11.4, changed the last reference callout from “(50)” to “(51).”
Chapter 10		
10-92	In Figure 10-55(B1), the outside edges of lane lines are missing.	In Figure 10-55(B1), replaced the missing outside edges of lane lines.

derpasses may be potential crime areas, lessening their usage. The FHWA publication entitled *Informational Report on Lighting Design for Midblock Crosswalks* (24) provides information on nighttime visibility needs for pedestrians crossing roadways at nonintersection locations.

A pedestrian's age is an important factor that may explain behavior that leads to collisions between motor vehicles and pedestrians. Very young pedestrians are often careless in traffic from either inexperience or exuberance, whereas older pedestrians may be affected by limitations in sensory, perceptual, cognitive, or motor skills. Driver behavior, such as turning right on red without coming to a complete stop or parking too close to an intersection, may result in collisions with pedestrians. Pedestrian collisions can also be related to the lack of sidewalks, which may force pedestrians to share the traveled way with motorists. Therefore, sidewalk construction should be considered as part of any street improvement in the suburban, urban, and urban core contexts.

Measures with the potential to reduce vehicle–pedestrian crashes and increase pedestrian comfort in the walking environment:

- Use simple designs that minimize crossing widths and minimize the use of more complex elements such as channelization and separate turning lanes.
- Provide curb extensions (bulb-outs) at intersections.
- Assume lower walking speeds.
- Provide median refuge islands of sufficient width at wide intersections.
- Provide lighting and eliminate glare sources at locations that demand multiple information gathering and processing.
- Consider the traffic control system in the context of the geometric design to provide compatibility and adequate advance warning or guide signs for situations that could surprise older drivers or pedestrians or increase their crash frequencies.
- Use accessible pedestrian signals to provide audible and vibrotactile information.
- Consider increasing sign letter size and retroreflectivity to accommodate individuals with decreased visual acuity.
- Use advance yield/stop signs.
- Provide enhanced markings and delineation.
- Use repetition and redundancy in design and in signing.

For further information on older pedestrians and drivers, refer to the FHWA publications, *Handbook for Designing Roadways for the Aging Population* (14) and *Pedestrian Safety Guide and Countermeasure Selection System* (22).

2.6.3 Walking Speeds

Air temperature, time of day, trip purpose, age, gender, ability, grade, and presence of ice and snow all affect pedestrian walking speeds. Typical pedestrian walking speeds range from approximately 3.0 to 4.0 ft/s [0.9 to 1.2 m/s] (25). Older people will generally walk at speeds in the lower end of this range. To accommodate most pedestrians, a walking speed of 3.5 ft/s [1.1 m/s] is used, with a walking speed of 3.0 ft/s used where older pedestrians are expected.

Intersection design can be directly affected by the assumed walking speed, particularly where pedestrian crossings are controlled by pedestrian signals. The *Manual on Uniform Traffic Control Devices* (MUTCD) (20) establishes a two-fold process for calculating pedestrian crossing times and distances. First, the pedestrian clearance time (Flashing Don't Walk) is based on a walking speed of 3.5 ft/s [1.1 m/s] measured from curb to curb. Second, the total pedestrian crossing phase (Walk plus Flashing Don't Walk) is calculated using a walking speed of 3.0 ft/s [0.9 m/s] for a crossing measured from the top of the sidewalk ramp to the far curb. These pedestrian walking speeds used in the MUTCD have implications for geometric design because shortening the crossing distance by using curb bulb-outs or narrower lanes can reduce the time for the pedestrian walk phase, thereby increasing the time available for opposing vehicular travel.

2.6.4 Walkway Level of Service

Walking speeds decrease as the pedestrian density of the walkway increases. As with roadway capacities, there is an optimum speed and density under which the walkway will carry the largest volume. The width used for walkway calculations should be reduced where parking meters, hydrants, newsstands, litter barrels, utility poles, or similar obstructions preclude the use of the full walkway. For a more detailed analysis of sidewalk, stairway, and crosswalk design and capacities, see the *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* (2) and the *Highway Capacity Manual* (43).

2.6.5 Intersections

When pedestrians encounter an intersection, there is a major interruption in pedestrian flow. The sidewalk should provide sufficient storage area for those waiting to cross as well as an area for pedestrian cross traffic to pass.

Once pedestrians are given the walk indication, the crosswalk width and length become important. Crosswalks should be wide enough to accommodate the pedestrian flow in both directions within the duration of the pedestrian signal phase. The wider the street, the longer it takes a pedestrian to cross and proportionately less green signal time will be available for the primary street movements. Additionally, the longer the pedestrian crossing time, the longer the exposure to potential pedestrian-vehicular conflicts.

method in the first edition of the HSM does not address every facility type and design feature of potential interest and does not consider potential interactions between design features. Still, the HSM represents an important step toward a performance-based project development process. The FHWA IHSDM (21) provides a software tool to implement the HSM Part C procedures.

2.10 ENVIRONMENT

A roadway has wide-ranging effects in addition to providing traffic service to users. It is essential that the highway be considered as an element of the total environment. The term “environment,” as used here refers to the totality of humankind’s surroundings: social, physical, natural, and synthetic. It includes the human, animal, and plant communities and the forces that act on all three. The roadway can and should be located and designed to complement its environment and serve as a catalyst to environmental improvement.

The area surrounding a proposed road or street is an interrelated system of natural, synthetic, and sociologic variables. Changes in one variable within this system cannot be made without some effect on other variables. The consequences of some of these effects may be negligible, but others may have a strong and lasting impact on the environment, including sustaining and improving the quality of human life. Because roadway location and design decisions affect the development of adjacent areas, it is important that environmental variables be given full consideration. Also, care should be exercised so that applicable local, state, and Federal environmental requirements are met.

2.11 REFERENCES

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3. AASHTO. *Strategic Highway Safety Plan—A Comprehensive Plan to Substantially Reduce Vehicle-Related Fatalities and Injuries on the Nation’s Highways*, SHSP-2. American Association of State Highway and Transportation Officials, Washington, DC, 2004.
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Volume 1: A Guide for Addressing Aggressive-Driving Collisions, 2003

Volume 2: A Guide for Addressing Collisions Involving Unlicensed Drivers and Drivers with Suspending or Revoked Licenses, 2003

Volume 3: A Guide for Addressing Collisions with Trees in Hazardous Locations, 2003

Volume 4: A Guide for Addressing Head-On Collisions, 2003

Volume 5: A Guide for Addressing Unsignalized Intersection Collisions, 2003

Volume 6: A Guide for Addressing Run-off-Road Collisions, 2003

Volume 7: A Guide for Reducing Collisions on Horizontal Curves, 2004

Volume 8: A Guide for Reducing Collisions Involving Utility Poles, 2004

Volume 9: A Guide for Reducing Collisions Involving Older Drivers, 2004

Volume 10: A Guide for Reducing Collisions Involving Pedestrians, 2004

Volume 11: A Guide for Increasing Seatbelt Use, 2004

Volume 12: A Guide for Reducing Collisions at Signalized Intersections, 2004

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Volume 15: A Guide for Enhancing Rural Emergency Medical Services, 2005

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3.3.4.2 Superelevation

Method 5, described previously, is recommended for the distribution of e and f for all curves with radii greater than the minimum radius of curvature on highways in rural areas, freeways in urban areas, and high-speed streets in urban areas. Use of Method 5 is discussed in the following text and figures.

3.3.4.3 Procedure for Development of Method 5 Superelevation Distribution

The side friction factors shown as the solid line on Figure 3-4 represent the maximum f values selected for design for each speed. When these values are used in conjunction with the recommended Method 5, they determine the f distribution curves for the various speeds. Subtracting these computed f values from the computed value of $e/100 + f$ at the design speed, the finalized e distribution is thus obtained (see Figure 3-6).

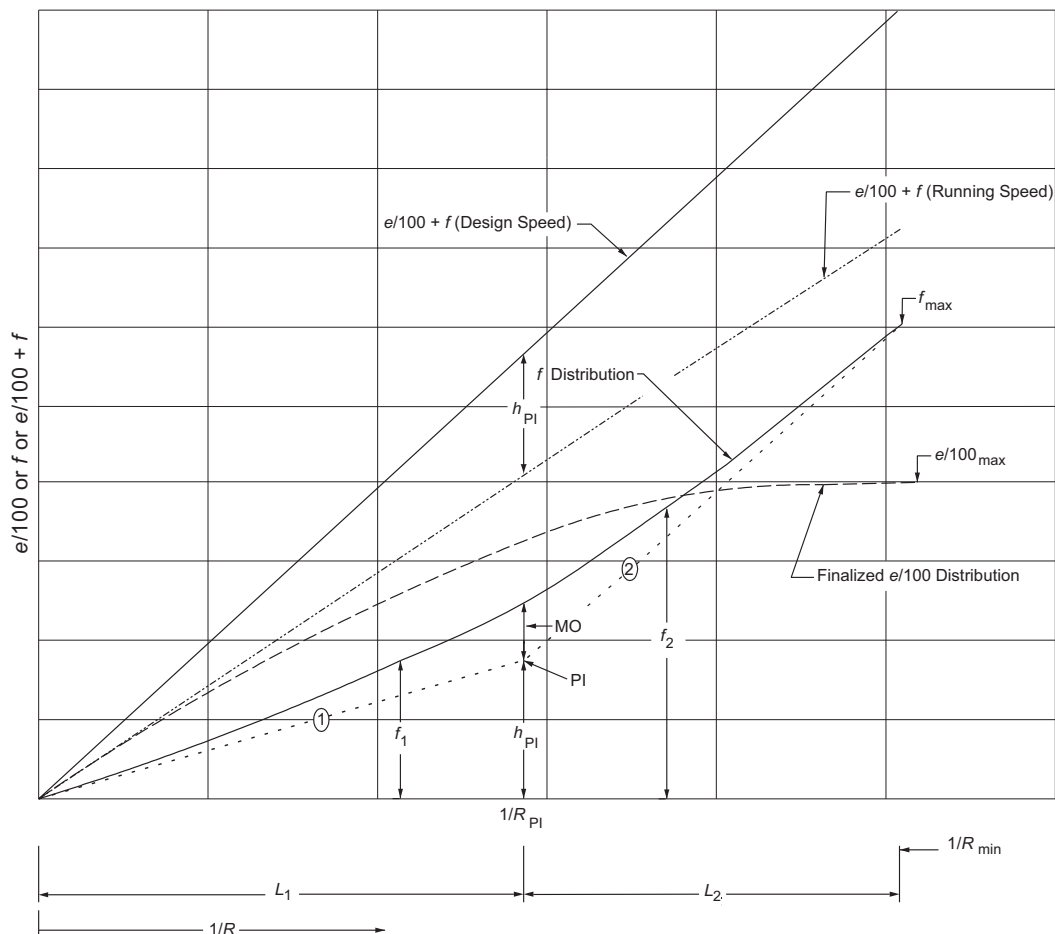


Figure 3-6. Method 5 Procedure for Development of the Superelevation Distribution

The e and f distributions for Method 5 may be derived using the basic curve equation, neglecting the $(1 - 0.01ef)$ term as discussed earlier in this chapter, using the following sequence of equations:

U.S. Customary	Metric	
$0.01e + f = \frac{V^2}{15R}$ where: $V = VD$ = design speed, mph $e = e_{\max}$ = maximum superelevation, percent $f = f_{\max}$ = maximum allowable side friction factor $R = R_{\min}$ = minimum radius, ft then: $R_{\min} = \frac{V_D^2}{15(0.01e_{\max} + f_{\max})}$ and where: $V = V_R$ = running speed, mph $R = R_{PI}$ = radius at the Point of Intersection, PI, of legs (1) and (2) of the f distribution parabolic curve (= R at the point of intersection of $0.01e_{\max}$ and $(0.01e + f)_R$) then: $R_{PI} = \frac{V_R^2}{0.15e_{\max}}$ Because $(0.01e + f)_D - (0.01e + f)_R = h$, at point R_{PI} the equations reduce to the following: $h_{PI} = \frac{(0.01e_{\max}) V_D^2}{V_R^2} - 0.01e_{\max}$ where h_{PI} = PI offset from the $1/R$ axis. Also: $S_1 = \frac{h_{PI}(R_{PI})}{5729.58}$	$0.01e + f = \frac{V^2}{127R}$ where: $V = VD$ = design speed, km/h $e = e_{\max}$ = maximum superelevation, percent $f = f_{\max}$ = maximum allowable side friction factor $R = R_{\min}$ = minimum radius, m then: $R_{\min} = \frac{V_D^2}{127(0.01e_{\max} + f_{\max})}$ and where: $V = V_R$ = running speed, km/h $R = R_{PI}$ = radius at the Point of Intersection, PI, of legs (1) and (2) of the f distribution parabolic curve (= R at the point of intersection of $0.01e_{\max}$ and $(0.01e + f)_R$) then: $R_{PI} = \frac{V_R^2}{1.27e_{\max}}$ Because $(0.01e + f)_D - (0.01e + f)_R = h$, at point R_{PI} the equations reduce to the following: $h_{PI} = \frac{(0.01e_{\max}) V_D^2}{V_R^2} - 0.01e_{\max}$ where h_{PI} = PI offset from the $1/R$ axis. Also: $S_1 = h_{PI}(R_{PI})$	(3-9) (3-10) (3-11) (3-12) (3-13)

Table 3-12. Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{\max} = 12\%$

U.S. Customary														
e (%)	$V_d = 15$ mph	$V_d = 20$ mph	$V_d = 25$ mph	$V_d = 30$ mph	$V_d = 35$ mph	$V_d = 40$ mph	$V_d = 45$ mph	$V_d = 50$ mph	$V_d = 55$ mph	$V_d = 60$ mph	$V_d = 65$ mph	$V_d = 70$ mph	$V_d = 75$ mph	$V_d = 80$ mph
	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)
NC	950	1690	2460	3370	4390	5580	6910	8370	9990	11800	13200	14800	16400	18100
RC	700	1250	1820	2490	3260	4140	5130	6220	7430	8740	9840	11000	12300	13600
2.2	631	1130	1640	2250	2950	3750	4640	5640	6730	7930	8920	9980	11200	12400
2.4	574	1030	1500	2060	2690	3420	4240	5150	6150	7240	8160	9130	10200	11300
2.6	526	936	1370	1890	2470	3140	3900	4730	5660	6670	7510	8420	9380	10500
2.8	484	863	1270	1740	2280	2910	3600	4380	5240	6170	6960	7800	8700	9660
3.0	448	799	1170	1620	2120	2700	3350	4070	4870	5740	6480	7270	8110	9010
3.2	417	743	1090	1510	1970	2520	3130	3800	4550	5370	6060	6800	7600	8440
3.4	389	693	1020	1410	1850	2360	2930	3560	4270	5030	5690	6390	7140	7940
3.6	364	649	953	1320	1730	2220	2750	3350	4020	4740	5360	6020	6740	7500
3.8	341	610	896	1250	1630	2090	2600	3160	3790	4470	5060	5700	6380	7100
4.0	321	574	845	1180	1540	1980	2460	2990	3590	4240	4800	5400	6050	6740
4.2	303	542	798	1110	1460	1870	2330	2840	3400	4020	4560	5130	5750	6420
4.4	286	512	756	1050	1390	1780	2210	2700	3240	3830	4340	4890	5490	6120
4.6	271	485	717	997	1320	1690	2110	2570	3080	3650	4140	4670	5240	5850
4.8	257	460	681	948	1260	1610	2010	2450	2940	3480	3960	4470	5020	5610
5.0	243	437	648	904	1200	1540	1920	2340	2810	3330	3790	4280	4810	5380
5.2	231	415	618	862	1140	1470	1840	2240	2700	3190	3630	4110	4620	5170
5.4	220	395	589	824	1090	1410	1760	2150	2590	3060	3490	3950	4440	4980
5.6	209	377	563	788	1050	1350	1690	2060	2480	2940	3360	3800	4280	4800
5.8	199	359	538	754	1000	1300	1620	1980	2390	2830	3230	3660	4130	4630
6.0	190	343	514	723	960	1250	1560	1910	2300	2730	3110	3530	3990	4470
6.2	181	327	492	694	922	1200	1500	1840	2210	2630	3010	3410	3850	4330
6.4	172	312	471	666	886	1150	1440	1770	2140	2540	2900	3300	3730	4190
6.6	164	298	452	639	852	1110	1390	1710	2060	2450	2810	3190	3610	4060
6.8	156	284	433	615	820	1070	1340	1650	1990	2370	2720	3090	3500	3940
7.0	148	271	415	591	790	1030	1300	1590	1930	2290	2630	3000	3400	3820
7.2	140	258	398	568	762	994	1250	1540	1860	2220	2550	2910	3300	3720
7.4	133	246	382	547	734	960	1210	1490	1810	2150	2470	2820	3200	3610
7.6	125	234	366	527	708	928	1170	1440	1750	2090	2400	2740	3120	3520
7.8	118	222	351	507	684	897	1130	1400	1700	2020	2330	2670	3030	3430
8.0	111	210	336	488	660	868	1100	1360	1650	1970	2270	2600	2950	3340
8.2	105	199	321	470	637	840	1070	1320	1600	1910	2210	2530	2880	3260
8.4	100	190	307	452	615	813	1030	1280	1550	1860	2150	2460	2800	3180
8.6	95	180	294	435	594	787	997	1240	1510	1810	2090	2400	2740	3100
8.8	90	172	281	418	574	762	967	1200	1470	1760	2040	2340	2670	3030
9.0	85	164	270	403	554	738	938	1170	1430	1710	1980	2280	2610	2960
9.2	81	156	259	388	535	715	910	1140	1390	1660	1940	2230	2550	2890
9.4	77	149	248	373	516	693	883	1100	1350	1620	1890	2180	2490	2830

Table 3-12. Minimum Radii for Design Superelevation Rates, Design Speeds, and $e_{\max} = 12\%$
(Continued)

U.S. Customary														
e (%)	$V_d = 15$ mph	$V_d = 20$ mph	$V_d = 25$ mph	$V_d = 30$ mph	$V_d = 35$ mph	$V_d = 40$ mph	$V_d = 45$ mph	$V_d = 50$ mph	$V_d = 55$ mph	$V_d = 60$ mph	$V_d = 65$ mph	$V_d = 70$ mph	$V_d = 75$ mph	$V_d = 80$ mph
	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)	R (ft)
9.6	74	142	238	359	499	671	857	1070	1310	1580	1840	2130	2440	2770
9.8	70	136	228	346	481	650	832	1040	1280	1540	1800	2080	2380	2710
10.0	67	130	219	333	465	629	806	1010	1250	1500	1760	2030	2330	2660
10.2	64	124	210	320	448	608	781	980	1210	1460	1720	1990	2280	2600
10.4	61	118	201	308	432	588	757	951	1180	1430	1680	1940	2240	2550
10.6	58	113	192	296	416	568	732	922	1140	1390	1640	1900	2190	2500
10.8	55	108	184	284	400	548	707	892	1110	1350	1600	1860	2150	2460
11.0	52	102	175	272	384	527	682	862	1070	1310	1560	1820	2110	2410
11.2	49	97	167	259	368	506	656	831	1040	1270	1510	1780	2070	2370
11.4	47	92	158	247	351	485	629	799	995	1220	1470	1730	2020	2320
11.6	44	86	149	233	333	461	600	763	953	1170	1410	1680	1970	2280
11.8	40	80	139	218	312	434	566	722	904	1120	1350	1620	1910	2230
12.0	34	68	119	188	272	381	500	641	807	1000	1220	1480	1790	2130

Metric												
e (%)	$V_d = 20$ km/h	$V_d = 30$ km/h	$V_d = 40$ km/h	$V_d = 50$ km/h	$V_d = 60$ km/h	$V_d = 70$ km/h	$V_d = 80$ km/h	$V_d = 90$ km/h	$V_d = 100$ km/h	$V_d = 110$ km/h	$V_d = 120$ km/h	$V_d = 130$ km/h
	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)	R (m)
NC	210	459	804	1130	1540	2030	2510	3040	3720	4280	4990	5440
RC	155	338	594	835	1150	1510	1870	2270	2770	3190	3740	4080
2.2	139	306	536	755	1040	1360	1690	2050	2510	2900	3390	3710
2.4	127	278	488	688	942	1250	1550	1880	2300	2650	3110	3400
2.6	116	255	448	631	865	1140	1420	1730	2110	2440	2860	3140
2.8	107	235	413	583	799	1060	1320	1600	1960	2260	2660	2910
3.0	99	218	382	541	742	980	1220	1490	1820	2110	2480	2720
3.2	92	202	356	504	692	914	1140	1390	1700	1970	2320	2550
3.4	86	189	332	472	648	856	1070	1300	1600	1850	2180	2400
3.6	81	177	312	443	609	805	1010	1230	1510	1750	2060	2270
3.8	76	166	293	417	573	759	947	1160	1420	1650	1950	2150
4.0	71	157	276	393	542	718	896	1100	1350	1560	1850	2040
4.2	67	148	261	372	513	680	850	1040	1280	1490	1760	1940
4.4	64	140	247	353	487	646	808	988	1220	1420	1680	1850
4.6	60	132	234	335	436	615	770	941	1160	1350	1600	1770
4.8	57	126	222	319	441	586	734	899	1110	1290	1530	1700
5.0	54	119	211	304	421	560	702	860	1060	1240	1470	1630

The superelevation runoff lengths given in Table 3-16 are based on 12-ft [3.6-m] lanes. For other lane widths, the appropriate runoff length should vary in proportion to the ratio of the actual lane width to 12 ft [3.6 m]. Shorter lengths could be applied for designs with 10- and 11-ft [3.0- and 3.3-m] lanes, but considerations of consistency and practicality suggest that the runoff lengths for 12-ft [3.6-m] lanes should be used in all cases.

Table 3-16a. Superelevation Runoff L_r (ft) for Horizontal Curves

U.S. Customary																				
e (%)	Number of Lanes Rotated. Note that 1 lane rotated is typical for a 2-lane highway; 2 lanes rotated is typical for a 4-lane highway, etc. (See Table 3-15.)																			
	$V_d = 15$ mph	$V_d = 20$ mph	$V_d = 25$ mph	$V_d = 30$ mph	$V_d = 35$ mph	$V_d = 40$ mph	$V_d = 45$ mph	$V_d = 50$ mph	$V_d = 55$ mph	$V_d = 60$ mph	$V_d = 65$ mph	$V_d = 70$ mph	$V_d = 75$ mph	$V_d = 80$ mph	$V_d = 85$ mph					
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2				
	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)				
1.5	23	34	23	34	25	37	40	29	44	32	47	34	51	36	54	36	54	36	54	
2.0	30	45	30	45	33	50	36	54	39	42	63	45	68	48	72	48	72	48	72	
2.2	33	50	33	50	36	54	40	59	43	46	69	50	74	53	79	53	79	53	79	
2.4	36	54	36	54	40	59	43	65	47	70	50	76	54	81	58	86	58	86	58	86
2.6	39	59	39	59	43	64	47	70	51	76	55	82	59	88	62	94	62	94	62	94
2.8	42	63	42	63	46	69	50	76	55	82	59	88	63	95	67	101	67	101	67	101
3.0	45	68	45	68	50	74	54	81	59	88	63	95	68	101	72	108	72	108	72	108
3.2	48	72	48	72	53	79	58	86	62	94	67	101	72	108	77	115	77	115	77	115
3.4	51	77	51	77	56	84	61	92	66	100	71	107	77	115	82	122	82	122	82	122
3.6	54	81	54	81	59	89	65	97	70	105	76	113	81	122	86	130	86	130	86	130
3.8	57	86	57	86	63	94	68	103	74	111	80	120	86	128	91	137	91	137	91	137
4.0	60	90	60	90	66	99	72	108	78	117	84	126	90	135	96	144	96	144	96	144
4.2	63	95	63	95	69	104	76	113	82	123	88	132	95	142	101	151	101	151	101	151
4.4	66	99	66	99	73	109	79	119	86	129	92	139	99	149	106	158	106	158	106	158
4.6	69	104	69	104	76	114	83	124	90	135	97	145	104	155	110	166	110	166	110	166
4.8	72	108	72	108	79	119	86	130	94	140	101	151	108	162	115	173	115	173	115	173
5.0	75	113	75	113	83	124	90	135	98	146	105	158	113	169	120	180	120	180	120	180
5.2	78	117	78	117	86	129	94	140	101	152	109	164	117	176	125	187	125	187	125	187
5.4	81	122	81	122	89	134	97	146	105	158	113	170	122	182	130	194	130	194	130	194
5.6	84	126	84	126	92	139	101	151	109	164	118	177	126	189	134	202	134	202	134	202
5.8	87	131	87	131	96	144	104	157	113	170	122	183	131	196	139	209	139	209	139	209
6.0	90	135	90	135	99	149	108	162	117	176	126	189	135	203	144	216	144	216	144	216
6.2	93	140	93	140	102	154	112	167	121	181	130	195	140	209	149	223	149	223	149	223
6.4	96	144	96	144	106	158	115	173	125	187	135	202	144	216	154	230	154	230	154	230
6.6	99	149	99	149	109	163	119	178	129	193	139	208	149	223	158	238	158	238	158	238
6.8	102	153	102	153	112	168	122	184	133	199	143	214	153	230	163	245	163	245	163	245

Table 3-16a. Superelevation Runoff L_r (ft) for Horizontal Curves (Continued)

U.S. Customary																																
e (%)	Number of Lanes Rotated. Note that 1 lane rotated is typical for a 2-lane highway; 2 lanes rotated is typical for a 4-lane highway, etc. (See Table 3-15.)																															
	$V_d = 15$ mph		$V_d = 20$ mph		$V_d = 25$ mph		$V_d = 30$ mph		$V_d = 35$ mph		$V_d = 40$ mph		$V_d = 45$ mph		$V_d = 50$ mph		$V_d = 55$ mph		$V_d = 60$ mph		$V_d = 65$ mph		$V_d = 70$ mph		$V_d = 75$ mph		$V_d = 80$ mph		$V_d = 85$ mph			
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	L_r (ft)	
7.0	105	158	105	158	116	173	126	189	137	205	147	221	158	236	168	252	168	252	168	252	168	252	168	252	168	252	168	252	168	252	168	252
7.2	108	162	108	162	119	178	130	194	140	211	151	227	162	243	173	259	173	259	173	259	173	259	173	259	173	259	173	259	173	259	173	259
7.4	111	167	111	167	122	183	133	200	144	217	156	233	167	250	178	266	178	266	178	266	178	266	178	266	178	266	178	266	178	266	178	266
7.6	114	171	114	171	125	188	137	205	148	222	160	240	171	257	182	274	182	274	182	274	182	274	182	274	182	274	182	274	182	274	182	274
7.8	117	176	117	176	129	193	140	210	152	228	164	246	176	263	187	281	187	281	187	281	187	281	187	281	187	281	187	281	187	281	187	281
8.0	120	180	120	180	132	198	144	216	156	234	168	252	180	270	192	288	192	288	192	288	192	288	192	288	192	288	192	288	192	288	192	288
8.2	123	185	123	185	135	203	148	221	160	240	172	258	185	277	197	295	197	295	197	295	197	295	197	295	197	295	197	295	197	295	197	295
8.4	126	189	126	189	139	208	151	227	164	246	177	265	189	284	202	302	202	302	202	302	202	302	202	302	202	302	202	302	202	302	202	302
8.6	129	194	129	194	142	213	155	232	168	252	181	271	194	290	206	310	206	310	206	310	206	310	206	310	206	310	206	310	206	310	206	310
8.8	132	198	132	198	145	218	158	237	172	258	185	277	198	297	211	317	211	317	211	317	211	317	211	317	211	317	211	317	211	317	211	317
9.0	135	203	135	203	149	223	162	243	176	263	189	284	203	304	216	324	216	324	216	324	216	324	216	324	216	324	216	324	216	324	216	324
9.2	138	207	138	207	152	228	166	248	180	269	193	290	207	311	221	331	221	331	221	331	221	331	221	331	221	331	221	331	221	331	221	331
9.4	141	212	141	212	155	233	169	254	183	275	198	296	212	317	226	338	226	338	226	338	226	338	226	338	226	338	226	338	226	338	226	338
9.6	144	216	144	216	158	238	173	259	187	281	202	303	216	324	230	346	230	346	230	346	230	346	230	346	230	346	230	346	230	346	230	346
9.8	147	221	147	221	162	243	176	264	191	287	206	309	221	331	235	353	235	353	235	353	235	353	235	353	235	353	235	353	235	353	235	353
10.0	150	225	150	225	165	248	180	270	195	293	210	315	225	338	240	360	240	360	240	360	240	360	240	360	240	360	240	360	240	360	240	360
10.2	153	230	153	230	168	253	184	275	199	299	214	322	230	344	245	367	245	367	245	367	245	367	245	367	245	367	245	367	245	367	245	367
10.4	156	234	156	234	172	257	187	281	203	304	219	328	234	351	250	374	250	374	250	374	250	374	250	374	250	374	250	374	250	374	250	374
10.6	159	239	159	239	175	262	191	286	207	310	223	334	239	358	254	382	254	382	254	382	254	382	254	382	254	382	254	382	254	382	254	382
10.8	162	243	162	243	178	267	194	291	211	316	227	340	243	365	259	389	259	389	259	389	259	389	259	389	259	389	259	389	259	389	259	389
11.0	165	248	165	248	182	272	198	297	215	322	231	347	248	371	264	396	264	396	264	396	264	396	264	396	264	396	264	396	264	396	264	396
11.2	168	252	168	252	185	277	201	302	219	328	235	353	252	378	269	403	269	403	269	403	269	403	269	403	269	403	269	403	269	403	269	403
11.4	171	257	171	257	188	282	205	308	222	334	240	359	257	385	274	410	274	410	274	410	274	410	274	410	274	410	274	410	274	410	274	410
11.6	174	261	174	261	191	287	209	313	226	340	244	366	261	392	278	418	278	418	278	418	278	418	278	418	278	418	278	418	278	418	278	418
11.8	177	266	177	266	195	292	212	318	230	345	248	372	266	398	283	425	283	425	283	425	283	425	283	425	283	425	283	425	283	425	283	425
12.0	180	270	180	270	198	297	216	324	234	351	252	378	270	405	288	432	288	432	288	432	288	432	288	432	288	432	288	432	288	432	288	432

Table 3-16b. Superelevation Runoff L_r (m) for Horizontal Curves

e (%)	Metric															
	Number of Lanes Rotated. Note that 1 lane rotated is typical for a 2-lane highway, 2 lanes rotated is typical for a 4-lane highway, etc. (See Table 3-15.)				$V_d = 20$ km/h				$V_d = 30$ km/h				$V_d = 40$ km/h			
	1	2	1	2	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)
1.5	7	10	7	10	12	9	13	9	14	11	16	11	16	11	16	11
2.0	9	14	9	14	16	12	18	13	19	14	22	14	22	14	22	14
2.2	10	15	10	15	18	13	19	14	21	16	24	16	24	16	24	16
2.4	11	16	11	16	19	14	21	15	23	17	26	17	26	17	26	17
2.6	12	18	12	18	21	15	23	16	25	19	28	19	28	19	28	19
2.8	13	19	13	19	23	16	25	18	26	20	30	20	30	20	30	20
3.0	14	20	14	20	24	18	26	19	28	22	32	22	32	22	32	22
3.2	14	22	14	22	26	19	28	20	30	23	35	23	35	23	35	23
3.4	15	23	15	23	28	20	30	21	32	24	37	24	37	24	37	24
3.6	16	24	16	24	29	21	32	23	34	26	39	26	39	26	39	26
3.8	17	26	17	26	31	22	33	24	36	27	41	27	41	27	41	27
4.0	18	27	18	27	32	23	35	25	38	29	43	29	43	29	43	29
4.2	19	28	19	28	34	25	37	26	40	30	45	30	45	30	45	30
4.4	20	30	20	30	36	26	39	28	42	32	48	32	48	32	48	32
4.6	21	31	21	31	37	27	40	29	43	33	50	33	50	33	50	33
4.8	22	32	22	32	39	28	42	30	45	35	52	35	52	35	52	35
5.0	23	34	23	34	40	29	44	32	47	36	54	36	54	36	54	36
5.2	23	35	23	35	42	30	46	33	49	37	56	37	56	37	56	37
5.4	24	36	24	36	44	32	47	34	51	39	58	39	58	39	58	39
5.6	25	38	25	38	45	33	49	35	53	40	60	40	60	40	60	40
5.8	26	39	26	39	47	34	51	37	55	42	63	42	63	42	63	42
6.0	27	41	27	41	49	35	53	38	57	43	65	43	65	43	65	43
6.2	28	42	28	42	50	36	54	39	59	45	67	45	67	45	67	45
6.4	29	43	29	43	52	37	56	40	60	46	69	46	69	46	69	46
6.6	30	45	30	45	53	39	58	42	62	48	71	48	71	48	71	48
6.8	31	46	31	46	55	40	60	43	64	49	73	49	73	49	73	49

Table 3-16b. Superelevation Runoff L_r (m) for Horizontal Curves (Continued)

e (%)	Metric																			
	Number of Lanes Rotated. Note that 1 lane rotated is typical for a 2-lane highway, 2 lanes rotated is typical for a 4-lane highway, etc. (See Table 3-15.)																			
	$V_d = 20$ km/h	$V_d = 30$ km/h	$V_d = 40$ km/h	$V_d = 50$ km/h	$V_d = 60$ km/h	$V_d = 70$ km/h	$V_d = 80$ km/h	$V_d = 90$ km/h	$V_d = 100$ km/h	$V_d = 110$ km/h	$V_d = 120$ km/h	$V_d = 130$ km/h	$V_d = 140$ km/h							
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)	L_r (m)
7.0	32	47	32	47	35	52	38	57	41	61	66	50	76	50	76	50	76	50	76	50
7.2	32	49	32	49	36	53	39	58	42	63	68	52	78	52	78	52	78	52	78	52
7.4	33	50	33	50	37	55	40	60	43	65	70	53	80	53	80	53	80	53	80	53
7.6	34	51	34	51	38	56	41	62	44	67	72	55	82	55	82	55	82	55	82	55
7.8	35	53	35	53	39	58	42	63	46	68	74	56	84	56	84	56	84	56	84	56
8.0	36	54	36	54	40	59	43	65	47	70	76	58	86	58	86	58	86	58	86	58
8.2	37	55	37	55	41	61	44	66	48	72	77	59	89	59	89	59	89	59	89	59
8.4	38	57	38	57	42	62	45	68	49	74	79	60	91	60	91	60	91	60	91	60
8.6	39	58	39	58	43	64	46	70	50	76	81	62	93	62	93	62	93	62	93	62
8.8	40	59	40	59	44	65	47	71	52	77	83	63	95	63	95	63	95	63	95	63
9.0	41	61	41	61	45	67	49	73	53	79	85	65	97	65	97	65	97	65	97	65
9.2	41	62	41	62	46	68	50	74	54	81	87	66	99	66	99	66	99	66	99	66
9.4	42	63	42	63	47	70	51	76	55	83	89	68	102	68	102	68	102	68	102	68
9.6	43	65	43	65	48	71	52	78	56	84	91	69	104	69	104	69	104	69	104	69
9.8	44	66	44	66	49	73	53	79	57	86	93	71	106	71	106	71	106	71	106	71
10.0	45	68	45	68	50	74	54	81	59	88	95	72	108	72	108	72	108	72	108	72
10.2	46	69	46	69	51	76	55	83	60	90	96	73	110	73	110	73	110	73	110	73
10.4	47	70	47	70	51	77	56	84	61	91	98	75	112	75	112	75	112	75	112	75
10.6	48	72	48	72	52	79	57	86	62	93	100	76	114	76	114	76	114	76	114	76
10.8	49	73	49	73	53	80	58	87	63	95	102	78	117	78	117	78	117	78	117	78
11.0	50	74	50	74	54	82	59	89	64	97	104	79	119	79	119	79	119	79	119	79
11.2	50	76	50	76	55	83	60	91	66	98	106	81	121	81	121	81	121	81	121	81
11.4	51	77	51	77	56	85	62	92	67	100	108	82	123	82	123	82	123	82	123	82
11.6	52	78	52	78	57	86	63	94	68	102	110	84	125	84	125	84	125	84	125	84
11.8	53	80	53	80	58	88	64	96	69	104	112	85	127	85	127	85	127	85	127	85
12.0	54	81	54	81	59	89	65	97	70	105	113	86	130	86	130	86	130	86	130	86

3.3.8.2.2 Minimum Length of Tangent Runout

The length of tangent runout is determined by the amount of adverse cross slope to be removed and the rate at which it is removed. To achieve a smooth edge of pavement profile, the rate of removal should equal the relative gradient used to define the superelevation runoff length. Based on this rationale, the following equation should be used to compute the minimum tangent runout length:

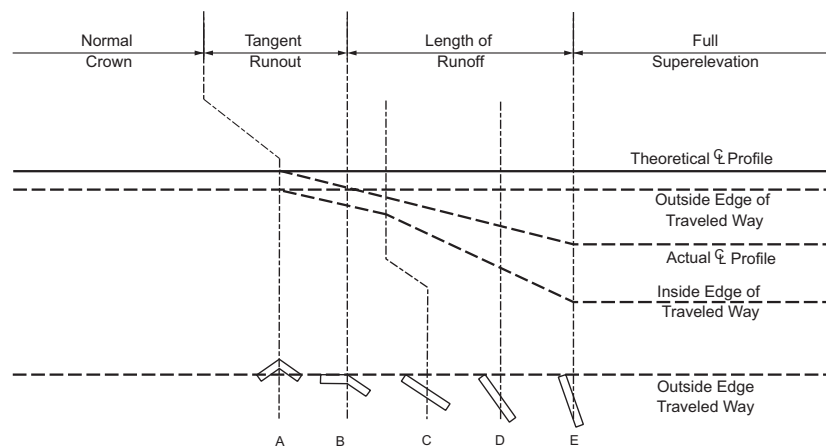
U.S. Customary	Metric
$L_t = \frac{e_{NC}}{e_d} L_r$ where: L_t = minimum length of tangent runout, ft e_{NC} = normal cross slope rate, percent e_d = design superelevation rate, percent L_r = minimum length of superelevation runoff, ft	(3-24) $L_t = \frac{e_{NC}}{e_d} L_r$ where: L_t = minimum length of tangent runout, m e_{NC} = normal cross slope rate, percent e_d = design superelevation rate, percent L_r = minimum length of superelevation runoff, m

The tangent runout lengths determined with Equation 3-24 are listed in Table 3-16 in the 2.0 percent row.

3.3.8.2.3 Location with Respect to End of Curve

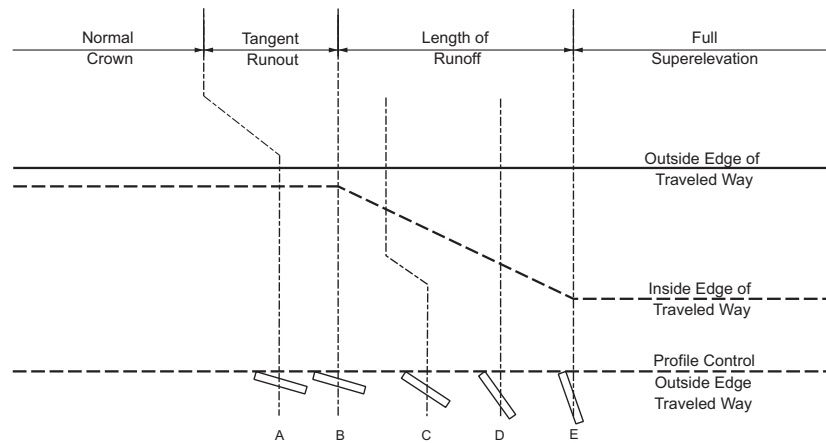
In the tangent-to-curve design, the location of the superelevation runoff length with respect to the Point of Curvature (PC) needs to be determined. Normal practice is to divide the runoff length between the tangent and curved sections and to avoid placing the entire runoff length on either the tangent or the curve. With full superelevation attained at the PC, the runoff lies entirely on the approach tangent, where theoretically no superelevation is needed. At the other extreme, placement of the runoff entirely on the circular curve results in the initial portion of the curve having less than the desired amount of superelevation. Both of these extremes tend to be associated with a large peak lateral acceleration.

Experience indicates that locating a portion of the runoff on the tangent, in advance of the PC, is preferable, in order to limit the peak lateral acceleration and the resulting side friction demand. The magnitude of side friction demand incurred during travel through the runoff can vary with the actual vehicle travel path. Observations indicate that a spiral path results from a driver’s natural steering behavior during curve entry or exit. This natural spiral can be assumed to be distributed equally around the PC; as a result, the lateral acceleration incurred at the PC should theoretically be equal to 50 percent of the lateral acceleration associated with the circular curve. Most evidence indicates that the length of this natural spiral ranges from 2- to 4-s travel time; however, its length may also be affected by lane width and the presence of other vehicles.



Crowned
Traveled Way Revolved about Outside Edge

— C —



Straight Cross Slope
Traveled Way Revolved about Outside Edge

— D —



Note: Angular breaks to be appropriately rounded as shown (see text)

Figure 3-8. Diagrammatic Profiles Showing Methods of Attaining
Superelevation for a Curve to the Right (Continued)