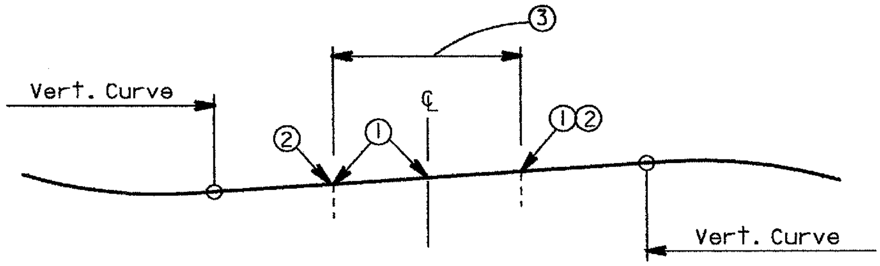
CROSSROAD PROFILE SIGNALIZED INTERSECTION	401-4
	REFERENCE SECTION 401.44

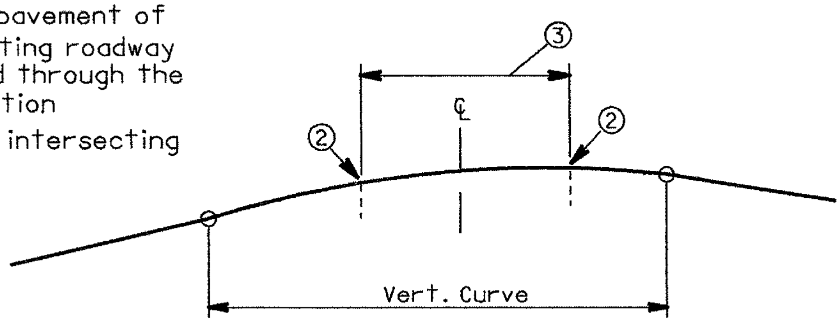


Example A - Crossroad Profile Tangent through Intersection

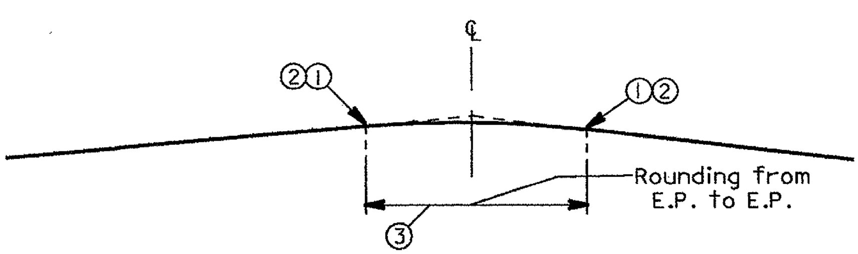
① Location of permissable grade break per Fig. 203-2

② Edge of pavement of intersecting roadway extended through the intersection

③ Width of intersecting roadway

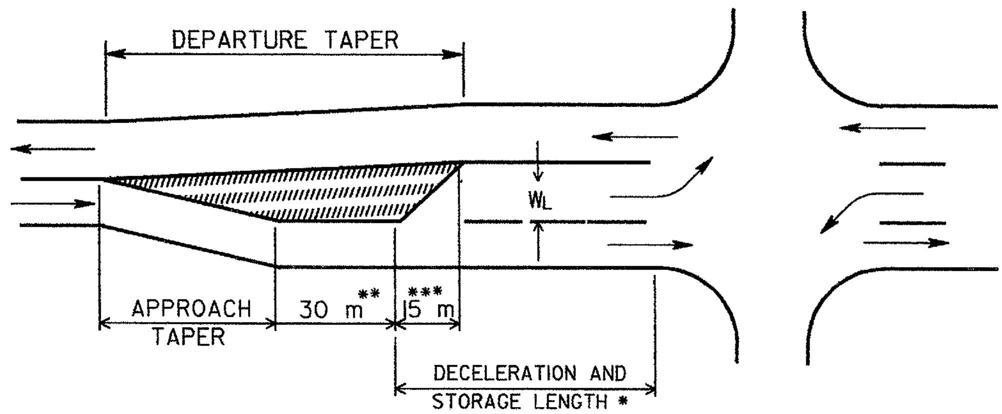


Example B - Crossroad Profile on Vertical Curve through Intersection

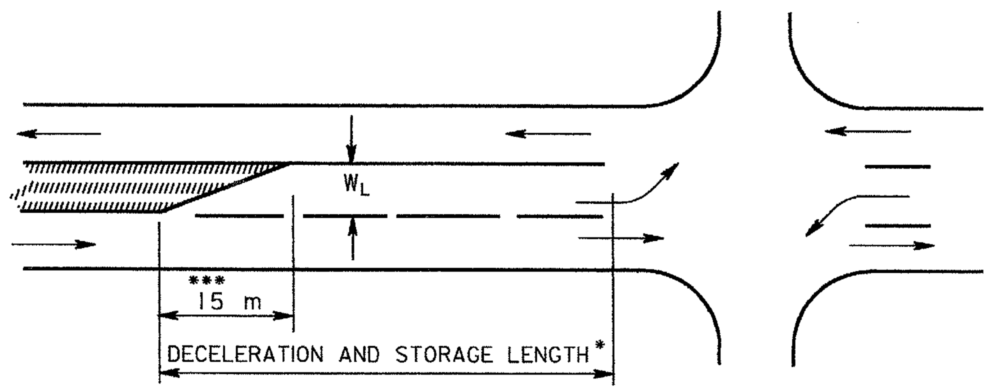


Example C - Crossroad Profile Fitted to a Normal Crown on the Mainline Road

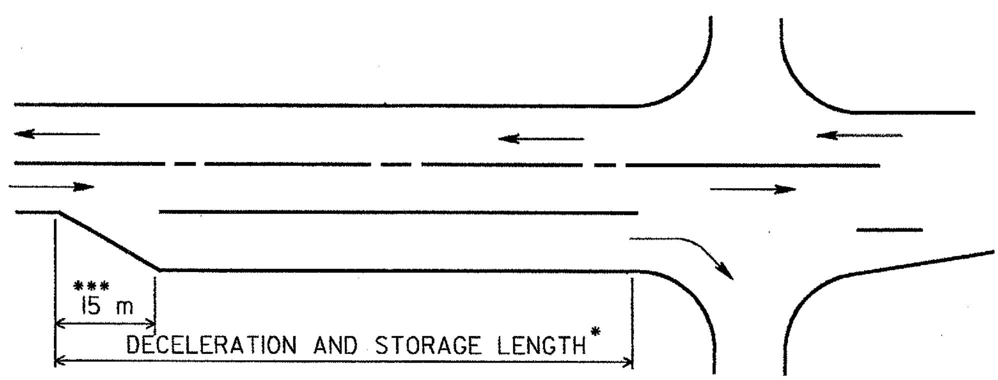
TURNING LANE DESIGN	401-5
	REFERENCE SECTION
	401.71, 401.73



LEFT TURN LANE-NO MEDIAN OR MEDIAN WIDTH < W_L



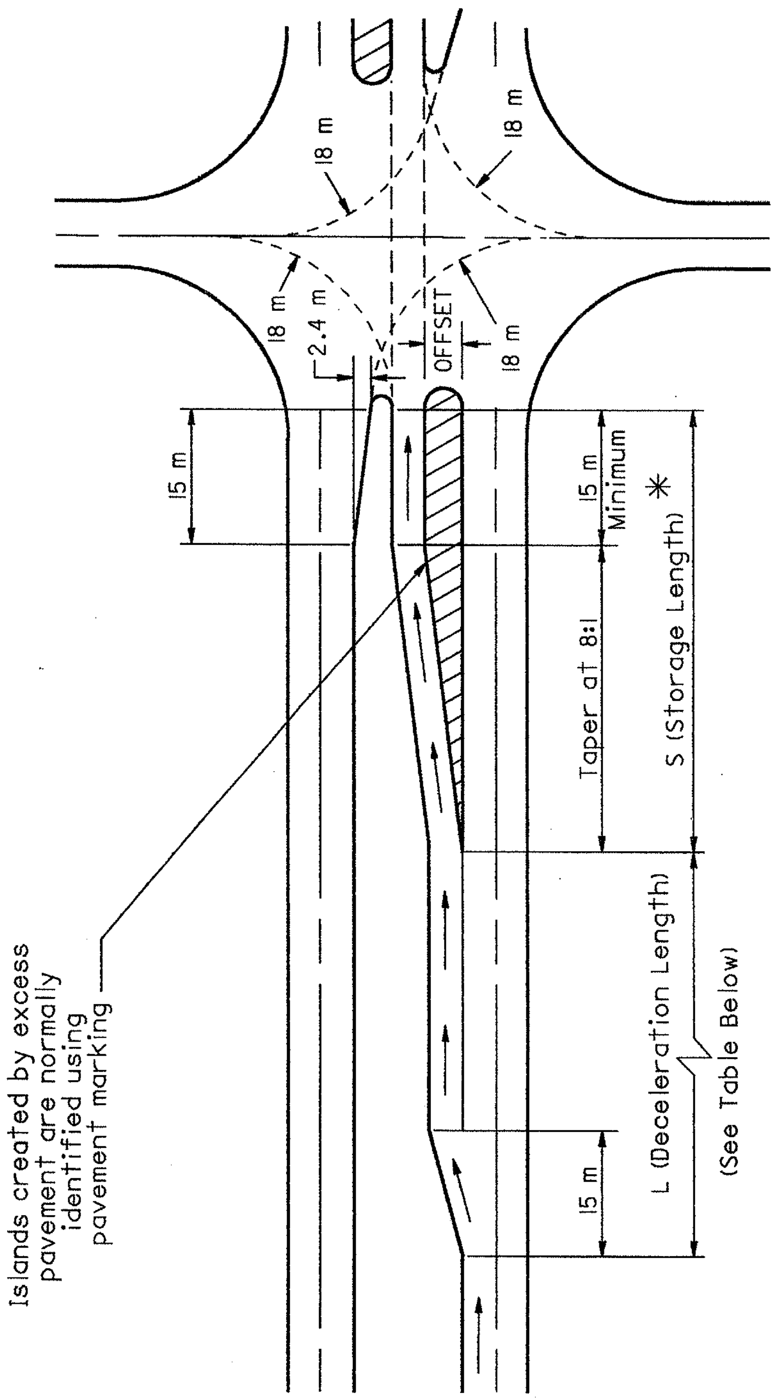
LEFT TURN LANE - - MEDIAN WIDTH ≥ W_L



RIGHT TURN LANE

* See 401-7 and 401-8 to compute length.
** May be reduced or eliminated in urban areas if intersection spacing or storage length is constraining.

OFFSET LEFT TURN LANE	401-6
	REFERENCE SECTION 401.71



*Use Figure 401-7 to determine length. Minimum storage length equals 8 x offset + 15 m.

Design Speed (km/h)	L (meters)
70	50
80	70
90	90
100	110

BASIS FOR COMPUTING LENGTH OF TURN LANES

401-7

REFERENCE SECTION 401.71

TYPE OF TRAFFIC CONTROL	DESIGN SPEED (km/h)					
	50 - 60		70		80 - 100	
	TURN DEMAND VOLUME					
	HIGH	LOW*	HIGH	LOW*	HIGH	LOW*
SIGNALIZED	A	A	** B or C	** B or C	** B or C	** B or C
UNSIGNALIZED STOPPED CROSSROAD	A	A	A	A	A	A
UNSIGNALIZED THROUGH ROAD	A	A	C	B	** B or C	B

* LOW is considered 10% or less of approach traffic volume.
**Whichever is greater

CONDITION A STORAGE ONLY

Length = 15 m (diverging taper) + Storage Length (Fig. 401-8)

CONDITION B HIGH SPEED DECELERATION ONLY

Design Speed	Length (Including 15 m Diverging Taper)
70 km/h	50 m
80	70
90	90
100	110

CONDITION C MODERATE SPEED DECELERATION AND STORAGE

Design Speed	Length (Including 15 m Diverging Taper)
70 km/h	37 m + Storage Length (Fig. 401-8)
80	44 "
90	51 "
100	58 "

For Explanation, See Turn Lane Design Example

STORAGE LENGTH AT INTERSECTIONS

401-8

REFERENCE SECTION 401.71, 401.73

* AVERAGE No. OF VEHICLES/CYCLE	REQUIRED LENGTH	* AVERAGE No. OF VEHICLES/CYCLE	REQUIRED LENGTH
1	15 m	17	180 m
2	30 m	18	190 m
3	45 m	19	200 m
4	55 m	20	210 m
5	65 m	21	220 m
6	75 m	22	230 m
7	85 m	23	240 m
8	95 m	24	245 m
9	105 m	25	250 m
10	115 m	30	295 m
11	125 m	35	340 m
12	135 m	40	385 m
13	145 m	45	430 m
14	155 m	50	475 m
15	160 m	55	520 m
16	170 m	60	565 m

$$*\text{AVERAGE VEHICLES/CYCLE} = \frac{\text{DHV (TURNING LANE)}}{\text{CYCLES/HOUR}}$$

IF CYCLES/HOUR ARE UNKNOWN, ASSUME:
UNSIGNALIZED OR 2 PHASE - 60 CYCLES/HR
3 PHASE - 40 CYCLES/HR
4 PHASE - 30 CYCLES/HR

Example - Turn Lane Design
Using Figures 401-7 and 401-8

Problem

Calculate the length of an exclusive left-turn lane on a signalized intersection approach of a rural arterial highway (Design Speed - 90 kilometers per hour). The intersection approach has 3 approach lanes comprised of an exclusive left turn lane and 2 through lanes with 200 left turning vehicles and 680 through vehicles, respectively. The traffic signal has a 90 second cycle length.

Determine Lane Length

Refer to the matrix in Figure 401-7. First, using the given design speed of 90 km/h, enter the column with the design speed "80-100". Next, determine if the left turn demand volume is "high" or "low". "Low" is considered 10% or less of the approach traffic flow. The demand is 200/(680+200) = 22.7%. Therefore, the left turn demand is considered "high". Based on a "signalized" intersection, the matrix indicates that Method B or C (whichever is greater) should be used to calculate the length of the left turn lane.

Method B, for the 90 km/h design speed, requires a left turn lane length of 90 meters.

Method C is calculated by adding the 51 meters (for the 90 km/h design speed) to the storage length determined from Figure 401-8. To determine the storage length, first, calculate the number of cycles/hour (3600 second/hour x 1 cycle/90 seconds = 40 cycles/hour). Next divide the hourly left turn approach volume by the number of cycles/hour (200 left turning vehicles/40 cycles/hour = 5. Using Figure 401-8, the required storage length is 65 m. Adding the 65 m (storage length) to the 51 m (Moderate speed deceleration length) noted above, equals 116 m. A comparison of the values from Method B and Method C yields 90 m and 116 m, respectively. Therefore, use the greater value of 116 m.

Check Length for Backup

Next, check to determine if backups from the through movements will block left turning vehicles from entering the left turn lane. Figure 401-8 is also used for this purpose. Using the value of 40 cycles/hour (determined above), calculate the average number of through vehicles per cycle (680/40 = 17). Based on Figure 401-8, this will result in backups of 180 m in a single lane. However, since the through traffic volume is in 2 through lanes, the backup of through vehicles is only half the 180 m, or 90 m. Therefore, the through vehicle backup of 90 m per lane will not block left turning vehicles desiring to enter the left turn lane which extends back 116 m.

Notes For Figure 401-9
Double Left Turn Lanes

1. Notice that the single left turn lane at the top of the page has been laterally offset from the through lanes in order to prevent conflicts between opposing turning paths.

2. Opposing turning paths should always be checked to verify that there is no conflict (See dimension "G").

3. The double right turn lane design follows the same criteria as the double left turn lane for expanded throat width.

4. The pavement width of the receiving lanes for a double left turn at an intersection needs to be checked to see if design vehicles can complete their turns within the pavement area. This is especially important where the radius returns are curbed. Turning radius templates can sometimes be used to check for pavement overruns, but usually are designed for minimum radius. Use the following formula to estimate a need for widening the pavement at the receiving throat:

$$F = \frac{W-7.2}{2}$$

where W is the maximum expanded throat width from the table on Figure 401-9. Then use the following guidelines:

If $F < 0.6$, no widening is required

If $F =$ 0.6 to 1.1, use a 12.0 m by 1.2 m taper

If $F =$ 1.2 to 1.7, use a 13.5 m by 1.8 m taper

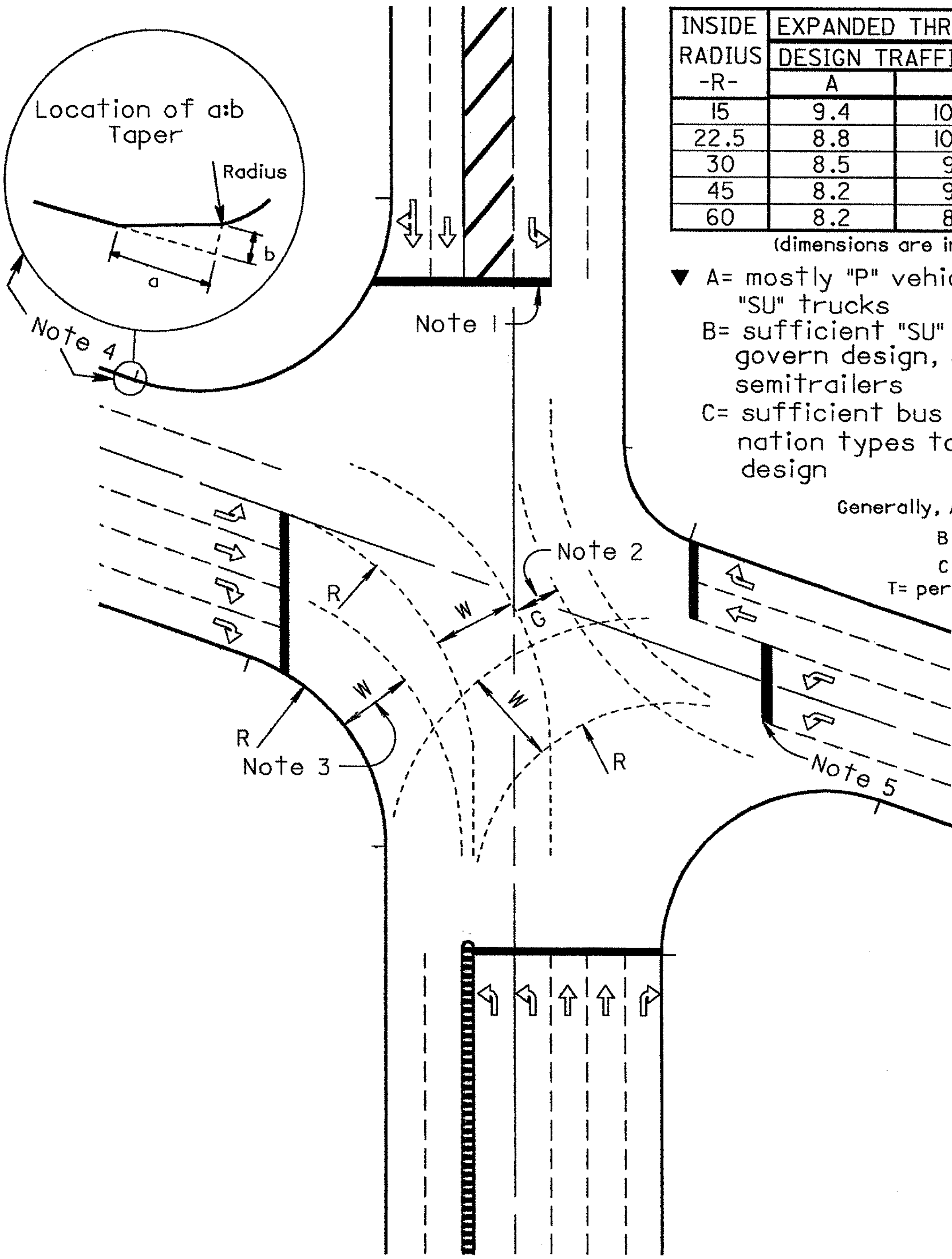
If $F =$ 1.8 to 2.7, use a 15.0 m by 2.4 m taper

The taper dimensions are represented by a:b in Figure 401-9.

See Figure 404-5 for examples of how these tapers are used at radius returns.

5. Stop bar locations may need to be adjusted to the inside radius return of the left turn movement.

DOUBLE LEFT TURN LANES	401-9
	REFERENCE SECTION
	401.72 & 401.74



INSIDE RADIUS -R-	EXPANDED THROAT WIDTH -W-		
	DESIGN TRAFFIC CONDITION▼		
	A	B	C
15	9.4	10.7	12.8
22.5	8.8	10.1	11.3
30	8.5	9.4	10.7
45	8.2	9.1	10.1
60	8.2	8.8	9.4

(dimensions are in meters)

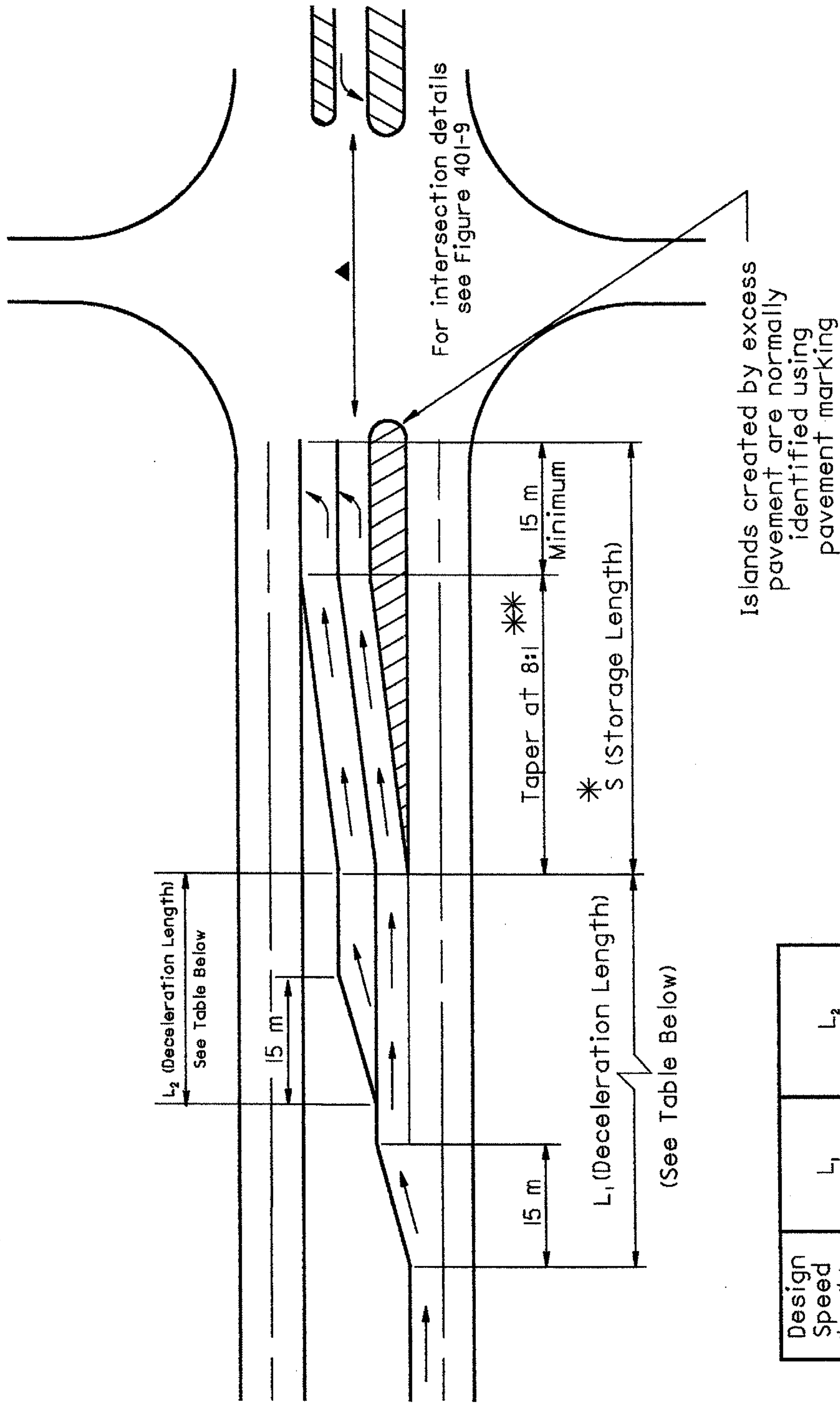
▼ A= mostly "P" vehicles, some "SU" trucks
B= sufficient "SU" trucks to govern design, some semitrailers
C= sufficient bus and combination types to govern design

Generally, A is when T < 5%
B is when T = 5-10%
C is when T > 10%
T= percentage of type B and C trucks in Design ADT

DEVELOPMENT OF DUAL LEFT TURN LANES

401-10

REFERENCE SECTION 401.72



✱ Use Figure 401-8 to determine storage length. For offset left turn lanes, minimum storage length equals 8 x offset + 15 m.

✱✱ Taper is used when dual left turn lanes are offset.

▲ If opposite approach has one left turn lane, these lanes should line up.

Design Speed (km/h)	L_1	L_2
70	50 m	37 m
80	70 m	44 m
90	90 m	51 m
100	110 m	58 m

RAMP DESIGN SPEED GUIDE

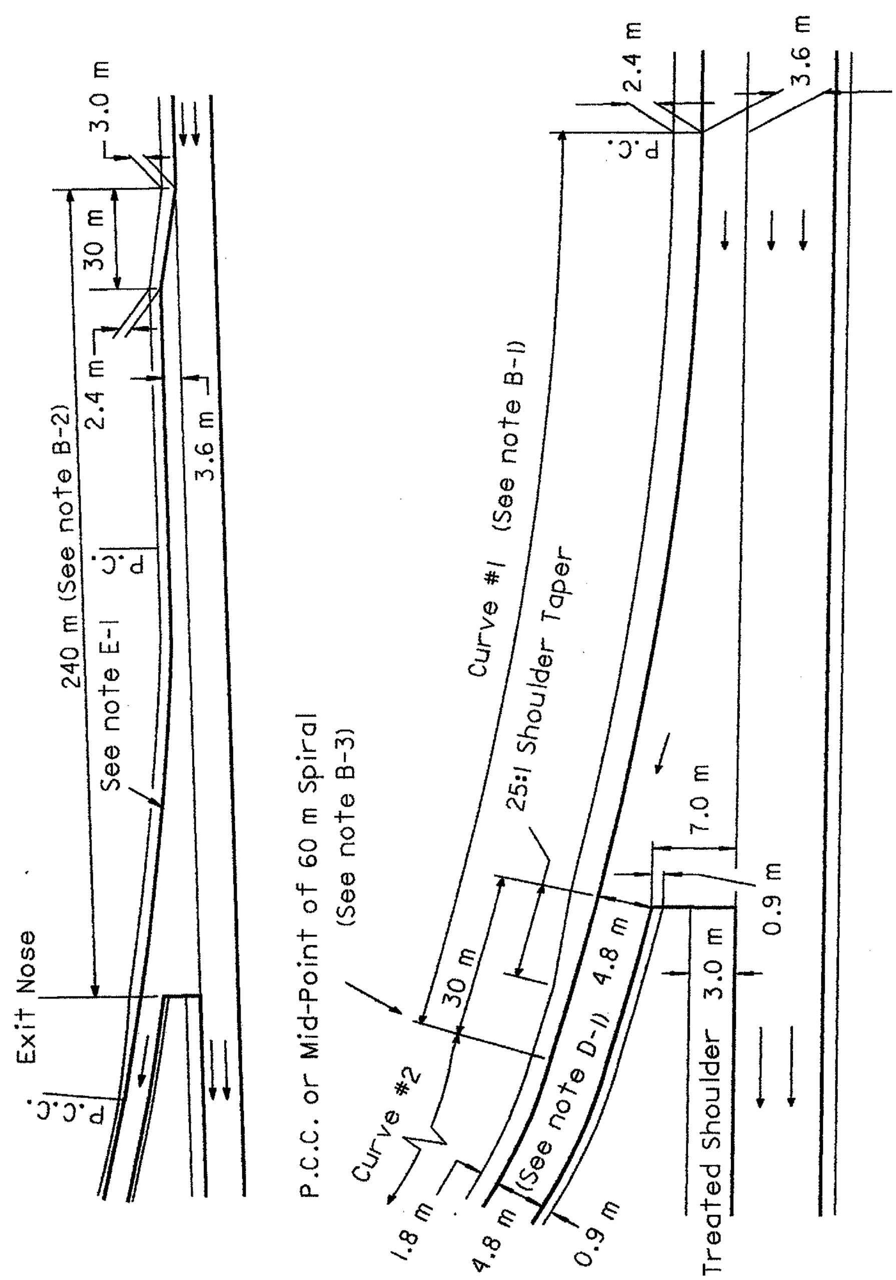
404-1

REFERENCE SECTION 404.2

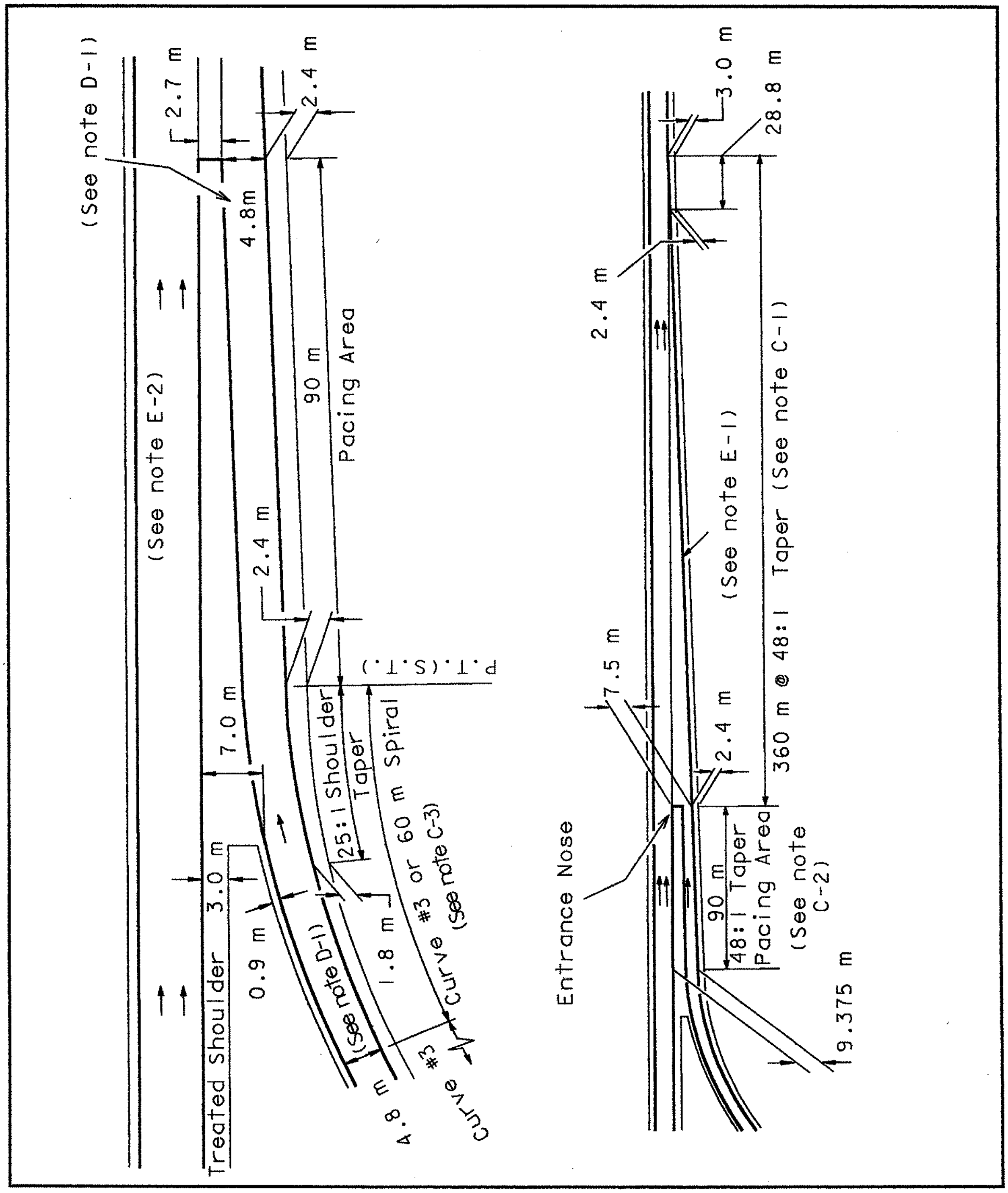
RAMP DESIGN SPEED \ MAINLINE DESIGN SPEED	50	60	70	80	90	100	110	120
UPPER RANGE	40	50	60	70	80	90	90	100
MIDDLE RANGE	30	40	50	60	60	70	80	80
LOWER RANGE	20	30	30	40	40	50	50	60

ALL SPEEDS ARE IN km/h.

CLASS I EXIT TERMINALS	404-2A
	REFERENCE SECTION 404.31



CLASS I ENTRANCE TERMINALS	404-2B
	REFERENCE SECTION 404.31



Notes for Class I Entrance & Exit Terminals
Figures 404-2A and 404-2B

A. GENERAL

1. Class I Terminals are intended for use on all Rural Interstate Highways. They will be used on such other Limited Access facilities as may be approved by the Bureau of Location and Design.

B. EXIT TERMINAL

1. Exit Curve #1 shall have a minimum radius of 1250 meters where the mainline is on tangent alignment. Where the mainline is on a curving alignment, the relationship between the radius of Curve #1 and that of the mainline curve shall be as shown in the following tables.

Mainline Curve	Ramp Curve Range
Right 3500 m	Right 1250 m to Right 900 m
Right 1750 m	Right 900 m to Right 700 m
Right 1250 m	Right 700 m to Right 600 m
Right 900 m	Right 600 m to Right 500 m
Right 700 m	Right 500 m to Right 450 m
Right 600 m	Right 450 m to Right 400 m
Right 500 m	Right 400 m to Right 350 m
Right 450 m	Right 350 m to Right 325 m
Right 400 m	Right 325 m to Right 300 m
Right 350 m	Right 300 m to Right 275 m
Right 325 m	Right 275 m to Right 250 m
Right 300 m	Right 250 m to Right 225 m

Mainline Curve	Ramp Curve Range
Left 3500 m	Right 3500 m to Right 1750 m
Left 1750 m	Right 3500 m to Right 1750 m
Left 1250 m	Left 3500 m to Right 1750 m *
Left 900 m	Left 1750 m to Left 3500 m
Left 700 m	Left 1250 m to Left 1750 m
Left 600 m	Left 900 m to Left 1250 m
Left 500 m	Left 700 m to Left 900 m
Left 450 m	Left 600 m to Left 700 m
Left 400 m	Left 500 m to Left 600 m
Left 350 m	Left 450 m to Left 500 m
Left 325 m	Left 400 m to Left 450 m
Left 300 m	Left 350 m to Left 400 m

* Avoid a tangential exit alignment in this situation.

2. The 240 m deceleration lane length may be reduced (180 m minimum length) if such reduction would eliminate the need for bridge widening.

3. When Ramp Curve #2 has a radius of 225 m or greater, Exit Curve #1 may be compounded directly with Curve #2 at a PCC 30 m beyond the nose. When the radius of Curve #2 is less than 225 m, a 60 m spiral should be placed between Curve #1 and Curve #2 and the beginning of the spiral (CS) should be at the exit nose.

Notes for Class I Entrance & Exit Terminals

C. ENTRANCE TERMINAL

1. The acceleration lane shall be a uniform taper (48:1) relative to the mainline pavement edge for either tangent or curving alignment.

2. The right edge of the 90 m pacing area shall be a rearward extension of the right edge of the acceleration lane (i.e. on a 48:1 taper relative to the mainline).

3. When Ramp Curve #3 has a radius of 225 m or greater, the PT shall be at the beginning of the 90 m pacing area. When the radius of Curve #3 is less than 225 m, a 60 m spiral shall be placed between Curve #3 and the pacing area.

D. RAMP WIDTH

1. Normally single lane ramps will have a width of 4.8 m. The width shall be increased to 5.4 m when the ramp radius is less than 60 m. When a 5.4-meter wide ramp is used, the 11.8-meter exit and 7.5-meter entrance terminal widths shall be retained and the 7.0-meter and 2.7-meter widths reduced by 0.6 m.

E. TREATED SHOULDER

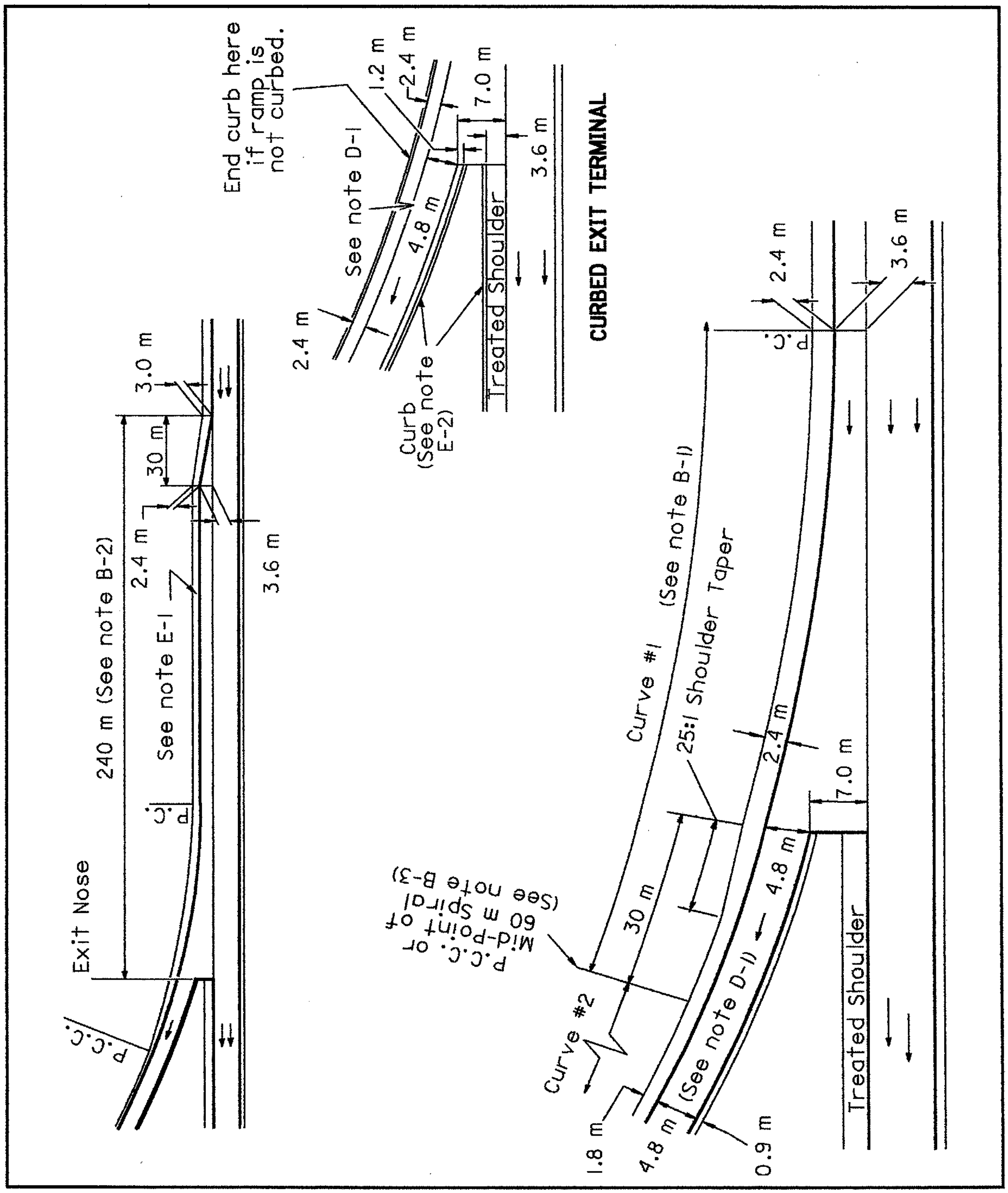
1. If the treated shoulder is less than 2.4 m in width along the mainline, this lesser width shall be used along the speed change lanes.

2. The 2.7 m to 7.0 m variable width treated shoulder of the entrance terminal shall be sloped for 3.0 m as required for mainline design (usually a rate of 0.04), except for the last 30 to 60 m at the 2.7 m end, which is to be sloped as required for proper terminal grading.

F. LEFT SIDE TERMINALS

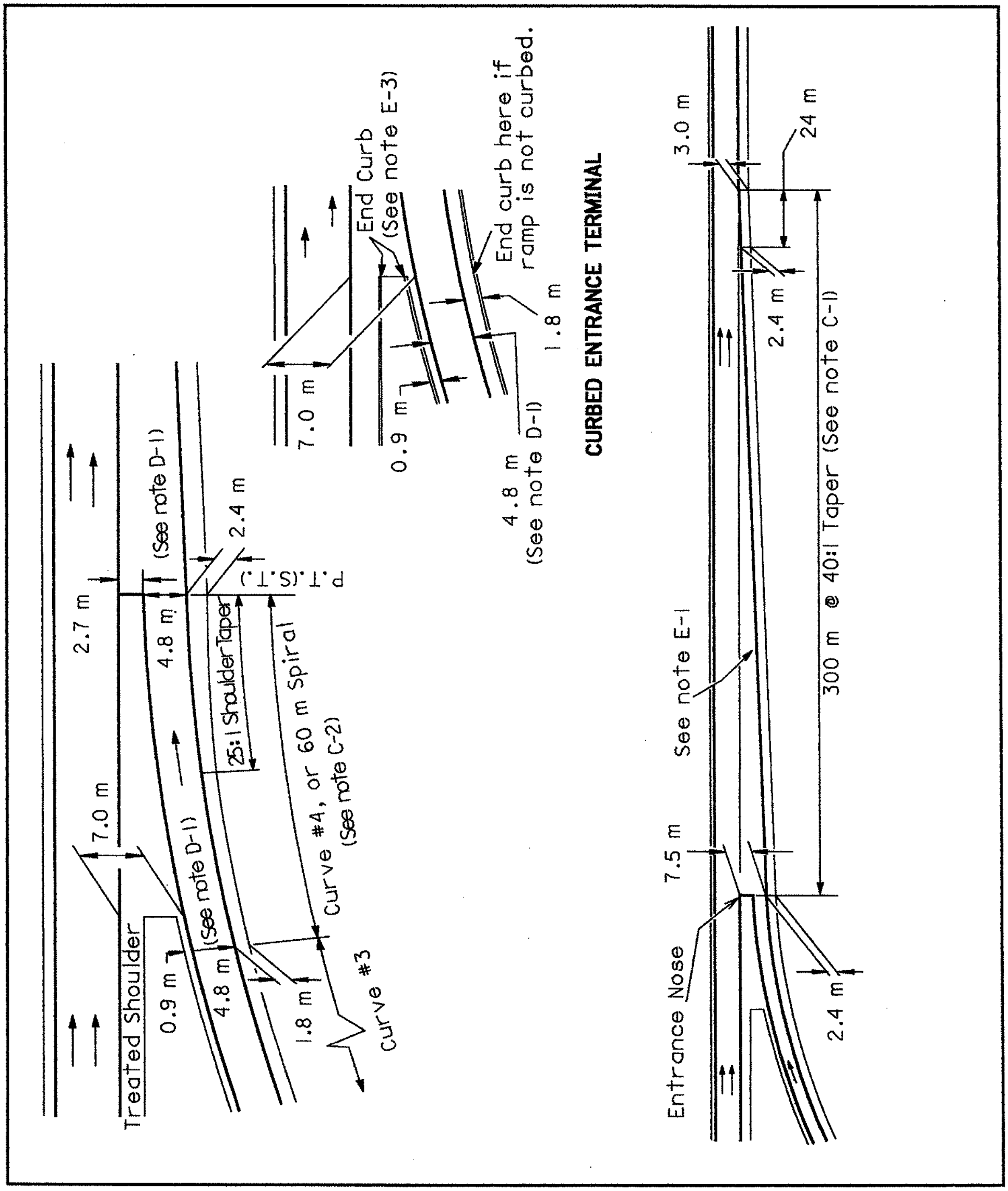
1. A Left Side Exit or Entrance Terminal shall be designed similarly to the drawing shown, but of opposite hand. Treated shoulder widths shall be in accord with Notes E-1 and E-2.

CLASS II EXIT TERMINALS	404-3A
	REFERENCE SECTION 404.31



For notes, see adjacent sheet

CLASS II ENTRANCE TERMINALS	404-3B
	REFERENCE SECTION 404.31



For notes, see adjacent sheet

Notes for Class II Entrance & Exit Terminals
Figures 404-3A and 404-3B

A. GENERAL

1. Class II Terminals are intended for use on all Urban Interstate Highways and all other limited access facilities where the use of Class I is not designated or required.

B. EXIT TERMINAL

1. Exit Curve #1 shall have a minimum radius of 450 meters where the mainline is on tangent alignment. Where the mainline is on a curving alignment, the relationship between the radius of Curve #1 and that of the mainline curve shall be as shown in the following tables.

Mainline Curve	Ramp Curve Range
Right 3500 m	Right 1250 m to Right 400 m
Right 1750 m	Right 900 m to Right 350 m
Right 1250 m	Right 700 m to Right 325 m
Right 900 m	Right 600 m to Right 300 m
Right 700 m	Right 500 m to Right 275 m
Right 600 m	Right 450 m to Right 250 m
Right 500 m	Right 400 m to Right 225 m
Right 450 m	Right 350 m to Right 225 m
Right 400 m	Right 325 m to Right 200 m
Right 350 m	Right 300 m to Right 190 m
Right 325 m	Right 275 m to Right 180 m
Right 300 m	Right 250 m to Right 170 m

Mainline Curve	Ramp Curve Range
Left 3500 m	Right 3500 m to Right 500 m
Left 1750 m	Right 3500 m to Right 600 m
Left 1250 m	Left 3500 m to Right 700 m *
Left 900 m	Left 1750 m to Right 900 m *
Left 700 m	Left 1250 m to Right 1250 m *
Left 600 m	Left 900 m to Right 1750 m *
Left 500 m	Left 700 m to Right 1750 m *
Left 450 m	Left 600 m to Right 1750 m *
Left 400 m	Left 500 m to Left 3500 m
Left 350 m	Left 450 m to Left 1750 m
Left 325 m	Left 400 m to Left 1250 m
Left 300 m	Left 350 m to Left 900 m

* Avoid tangential exit alignments in these situations.

2. The 240 m deceleration lane length may be reduced (180 m minimum length) if such reduction would eliminate the need for bridge widening.

3. When Ramp Curve #2 has a radius of 225 m or greater, Exit Curve #1 may be compounded directly with Curve #2 at a PCC 30 m beyond the nose. When the radius of Curve #2 is less than 225 m, a 60 m spiral should be placed between Curve #1 and Curve #2 and the beginning of the spiral (CS) should be at the exit nose or on the ramp.

Notes for Class II Entrance & Exit Terminals

C. ENTRANCE TERMINAL

1. The acceleration lane shall be a uniform taper (40:1) relative to the mainline pavement edge for either tangent or curving alignment.

2. The design of the entrance terminal curvature shall be based on the following:

(a) Ramp Curve #3 of 225 m or Greater Radius

When the mainline is on a tangent or a curve to the right, Curve #4 shall be a 60 m long simple curve of a radius such that the differential between it and the mainline will not exceed those values listed in the table below. When the mainline is on a curve to the left, a 60 m tangent shall be substituted for Curve #4.

Mainline Curve	Ramp Curve Range
Tangent	Right 1750 m to Right 450 m
Right 3500 m	Right 1250 m to Right 400 m
Right 1750 m	Right 900 m to Right 350 m
Right 1250 m	Right 700 m to Right 325 m
Right 900 m	Right 600 m to Right 300 m
Right 700 m	Right 500 m to Right 275 m
Right 600 m	Right 450 m to Right 250 m
Right 500 m	Right 400 m to Right 225 m
Right 450 m	Right 350 m to Right 225 m
Right 400 m	Right 325 m to Right 225 m
Right 350 m	Right 300 m to Right 225 m
Right 325 m	Right 275 m to Right 225 m
Right 300 m	Right 250 m to Right 225 m

(b) Ramp Curve #3 Less than 225 m Radius

A 60 m spiral shall be substituted for Curve #4. When the mainline is on a curve to the left, a 30 m tangent shall be inserted between the 60 m spiral and the entrance nose.

D. RAMP WIDTH

1. Normally single lane ramps will have a width of 4.8 m. The width shall be increased to 5.4 m when the ramp radius is less than 60 m. When a 5.4-meter wide ramp is used, the 11.8-meter exit and 7.5-meter entrance terminal widths shall be retained and the 7.0-meter and 2.7-meter widths reduced by 0.6 m.

E. TREATED SHOULDER

1. If the treated shoulder is less than 2.4 m in width along the mainline, this lesser width shall be used along the speed change lanes.

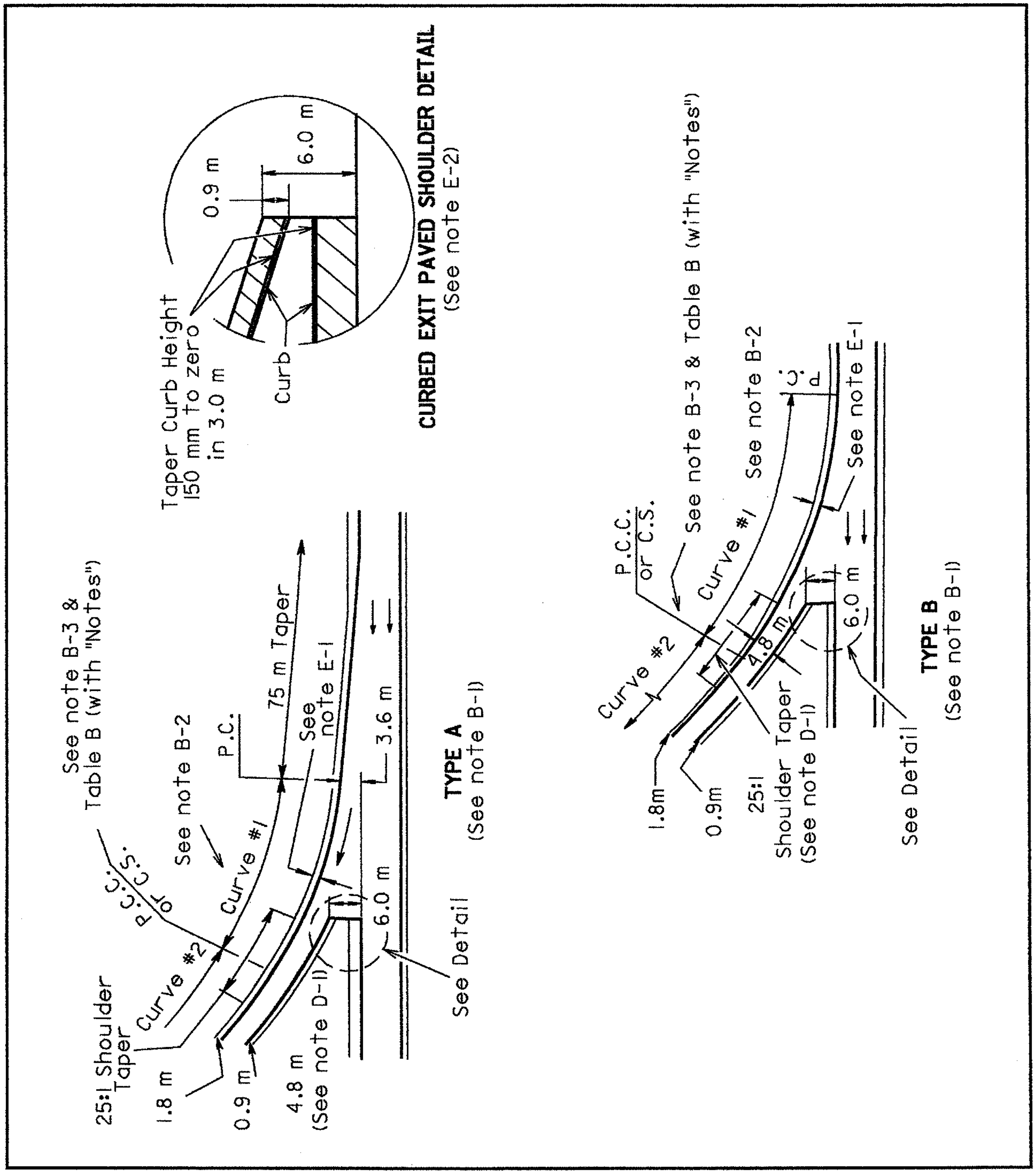
2. When needed, taper curb to required offset along ramp or mainline pavement using a 25:1 taper.

3. At all curb ends use a 150 millimeter to zero height reduction in 3.0 m.

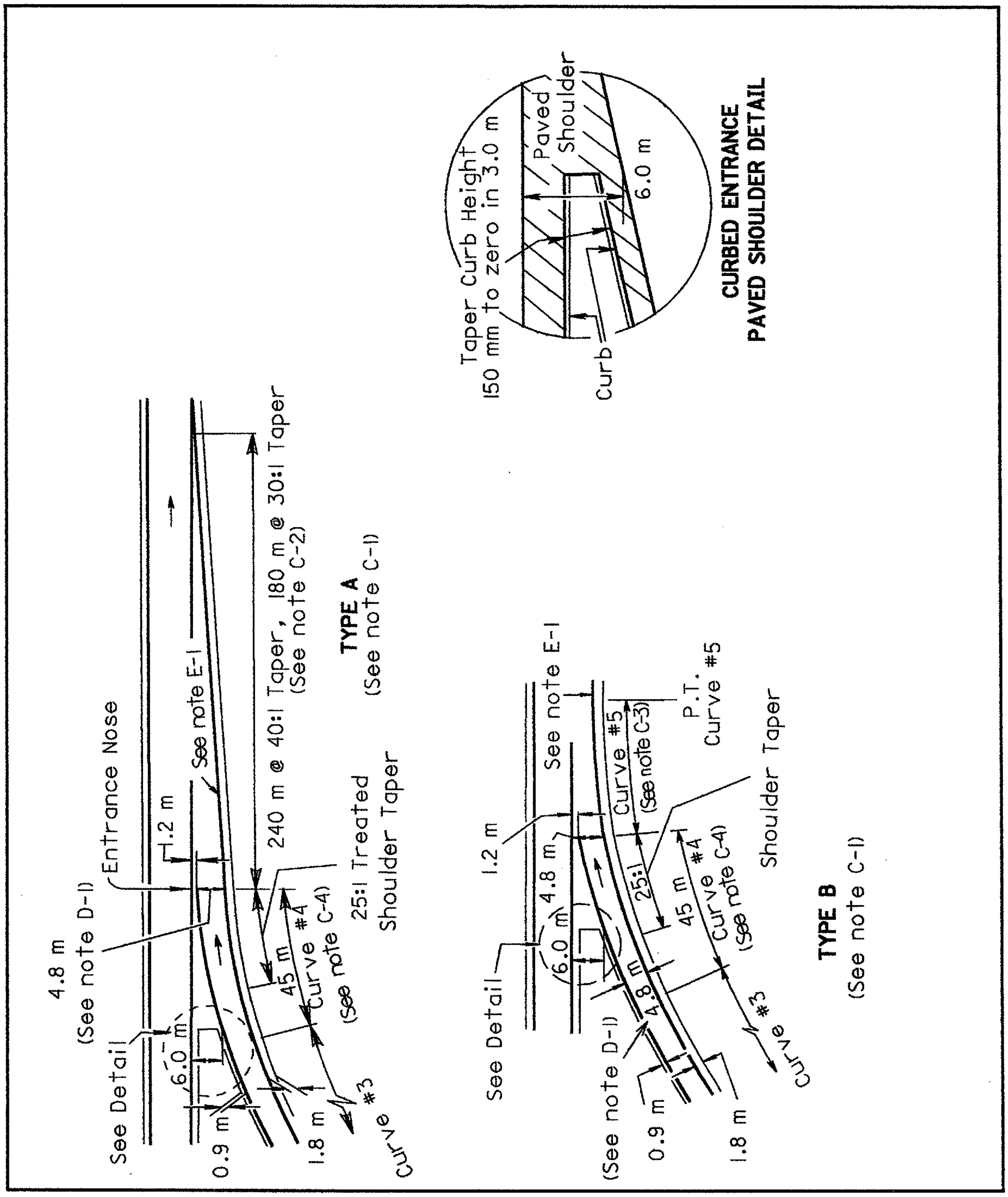
F. LEFT SIDE TERMINALS

1. A Left Side Exit or Entrance Terminal shall be designed similarly to the drawing shown, but of opposite hand. Treated shoulder widths shall be in accord with Note E-1.

CLASS III EXIT TERMINALS	404-4A
	REFERENCE SECTION 404.31



CLASS III ENTRANCE TERMINALS	404-4B
	REFERENCE SECTION 404.31



Notes for Class III Entrance & Exit Terminals
Figures 404-4A and 404-4B

A. GENERAL

1. Class III Terminals are intended for use on highways which have little or no access control except through an interchange area. Many of the features of Class III Terminals are applicable to a terminal of one ramp with another ramp in a freeway interchange.

B. EXIT TERMINAL: TYPE A & TYPE B

1. Type A shall normally be used on highways (including off-system highways) having design speeds of 80, 90 or 100 kilometers per hour; however, Type B may be used where substantial savings in bridge or right-of-way cost would result. Type B shall normally be used on a highways having design speeds of 70 km/h or less.

2. The alignment differential between the through roadway and exit Curve #1 shall be as shown in Table A, below.

3. Exit Curve #1 may be either compounded or spiraled into ramp Curve #2. To determine the treatment between Curve #1 and Curve #2 Table B shall be used.

TABLE A

Case 1 - Through Roadway 100 km/h, Nose Design Speed 70 km/h

Mainline Curve	Ramp Curve Range
Left 450 m	Tangent to Right 900 m *
Left 900 m	Right 900 m to Right 450 m
Tangent	Right 450 m to Right 300 m
Right 900 m	Right 300 m to Right 225 m
Right 450 m	Right 225 m to Right 180 m

Case 2 - Through Roadway 80 km/h, Nose Design Speed 60 km/h

Mainline Curve	Ramp Curve Range
Left 300 m	Left 900 m to Right 900m *
Left 450 m	Tangent to Right 450 m *
Left 900 m	Right 900 m to Right 300 m
Tangent	Right 450 m to Right 225 m
Right 900 m	Right 300 m to Right 180 m
Right 450 m	Right 225 m to Right 150 m
Right 300 m	Right 180 m to Right 130 m

Notes for Class III Entrance & Exit Terminals

Case 3 - Through Roadway 60 km/h, Nose Design Speed 50 km/h

Mainline Curve	Ramp Curve Range
Left 150 m	Left 225 m to Right 1750 m *
Left 180 m	Left 300 m to Right 600 m *
Left 225 m	Left 450 m to Right 350 m *
Left 300 m	Left 900 m to Right 250 m *
Left 450 m	Tangent to Right 190 m *
Left 900 m	Right 900 m to Right 160 m
Tangent	Right 450 m to Right 130 m
Right 900 m	Right 300 m to Right 120 m
Right 450 m	Right 225 m to Right 100 m
Right 300 m	Right 180 m to Right 90 m
Right 225 m	Right 150 m to Right 80 m
Right 180 m	Right 130 m to Right 75 m
Right 150 m	Right 110 m to Right 75 m

Case 4 - Through Roadway 50 km/h, Nose Design Speed 40 km/h

Mainline Curve	Ramp Curve Range
Left 150 m	Left 225 m to Right 160 m *
Left 180 m	Left 300 m to Right 130 m *
Left 225 m	Left 450 m to Right 120 m *
Left 300 m	Left 900 m to Right 100 m *
Left 450 m	Tangent to Right 90 m *
Left 900 m	Right 900 m to Right 80 m
Tangent	Right 450 m to Right 75 m
Right 900 m	Right 300 m to Right 70 m
Right 450 m	Right 225 m to Right 65 m
Right 300 m	Right 180 m to Right 60 m
Right 225 m	Right 150 m to Right 55 m
Right 180 m	Right 130 m to Right 55 m
Right 150 m	Right 110 m to Right 50 m

* Avoid tangential exit alignments in these situations.

Notes for Class III Entrance & Exit Terminals

TABLE B

Location of P.C.C. or C.S. and Spiral Requirements Between Curves #1 and #2..

Thru Roadway Design Speed (km/h)	Curve #2 Radius > Curve #1 Radius		Curve #2 Radius					
			>95 m		95 m to 70 m		< 70 m	
	PCC	Ls	PCC	Ls	PCC or CS	Ls	PCC or CS	Ls
90-100	At Nose	0	30 m Beyond Nose	0	At Nose	60 m	At Nose	60 m
80	At Nose	0	25 m Beyond Nose	0	At Nose	45 m	At Nose	45 m
60-70	At Nose	0	At Nose	0	At Nose	0	At Nose	45 m
50	At Nose	0	At Nose	0	At Nose	0	At Nose	0

C. ENTRANCE TERMINAL: TYPE A & TYPE B

1. Type A is preferred and shall normally be used; however, when a ramp enters as an added lane or as a combined acceleration-deceleration lane, Type B may be used if its use would result in a substantial savings in cost (i.e. reduced bridge width).

2. The acceleration lane of Type A shall be a uniform taper relative to the through pavement edge for either tangent or curving alignment. A 40:1 taper shall be used for design speeds of 80, 90 or 100 km/h and a 30:1 taper shall be used for design speeds of 70 km/h or less.

3. The differential between the radius of the through roadway and that of the entrance Curve #5 of Type B shall be as follows:

Mainline Curve	Ramp Curve
Left 150 m	Left 225 m
Left 180 m	Left 300 m
Left 225 m	Left 450 m
Left 250 m	Left 600 m
Left 300 m	Left 900 m
Left 350 m	Left 1750 m
Left 450 m	Tangent
Left 600 m	Right 1750 m
Left 900 m	Right 900 m
Left 1750 m	Right 600 m
Tangent	Right 450 m
Right 1750 m	Right 350 m
Right 900 m	Right 300 m
Right 600 m	Right 250 m
Right 450 m	Right 225 m
Right 300 m	Right 180 m
Right 225 m	Right 150 m
Right 180 m	Right 130 m
Right 150 m	Right 110 m

Notes for Class III Entrance & Exit Terminals

4. The design of Curves #3 and #4 of the entrance terminal shall be based on the following:

(a) Ramp Curve #3 of 225 m or Greater Radius

When the through roadway is on a tangent or a curve to the right, Curve #4 shall be a 45-meter long simple curve of a radius such that the differential between it and the through roadway is in accordance with the table below.

Mainline Curve	Ramp Curve Range
Tangent	Right 1750 m to Right 450 m
Right 1750 m	Right 900 m to Right 350 m
Right 900 m	Right 600 m to Right 300 m
Right 600 m	Right 450 m to Right 250 m
Right 450 m	Right 350 m to Right 225 m
Right 350 m	Right 300 m to Right 225 m
Right 300 m	Right 250 m to Right 225 m
Right 250 m	Right 225 m

When the through roadway is on a curve to the left, a 45-meter tangent shall be substituted for Curve #4.

(b) Ramp Curve #3 Less than 225 m Raidus

A 45-meter spiral shall be substituted for Curve #4.

D. RAMP WIDTH

1. Normally single lane ramps will have a width of 4.8 m. The width shall be increased to 5.4 m when the ramp radius is less than 60 m. When a 5.4-meter wide ramp is used, the 10.8-meter exit and 6.0-meter entrance terminal widths shall be retained and the 6.0-meter and 1.2-meter widths reduced by 0.6 m.

E. TREATED SHOULDER

1. If the treated shoulder is less than 2.4 m in width along the mainline, the lesser width shall be used along the speed change lanes.

2. If the ramp or through roadway has a curb offset greater than 1.8 m (or 0.9 m) the greater width shall be used at the terminal. Retain the 6.0 m width.

F. LEFT SIDE TERMINALS

1. Left side entrance and exits shall be designed similarly to the drawing shown, but of opposite hand.

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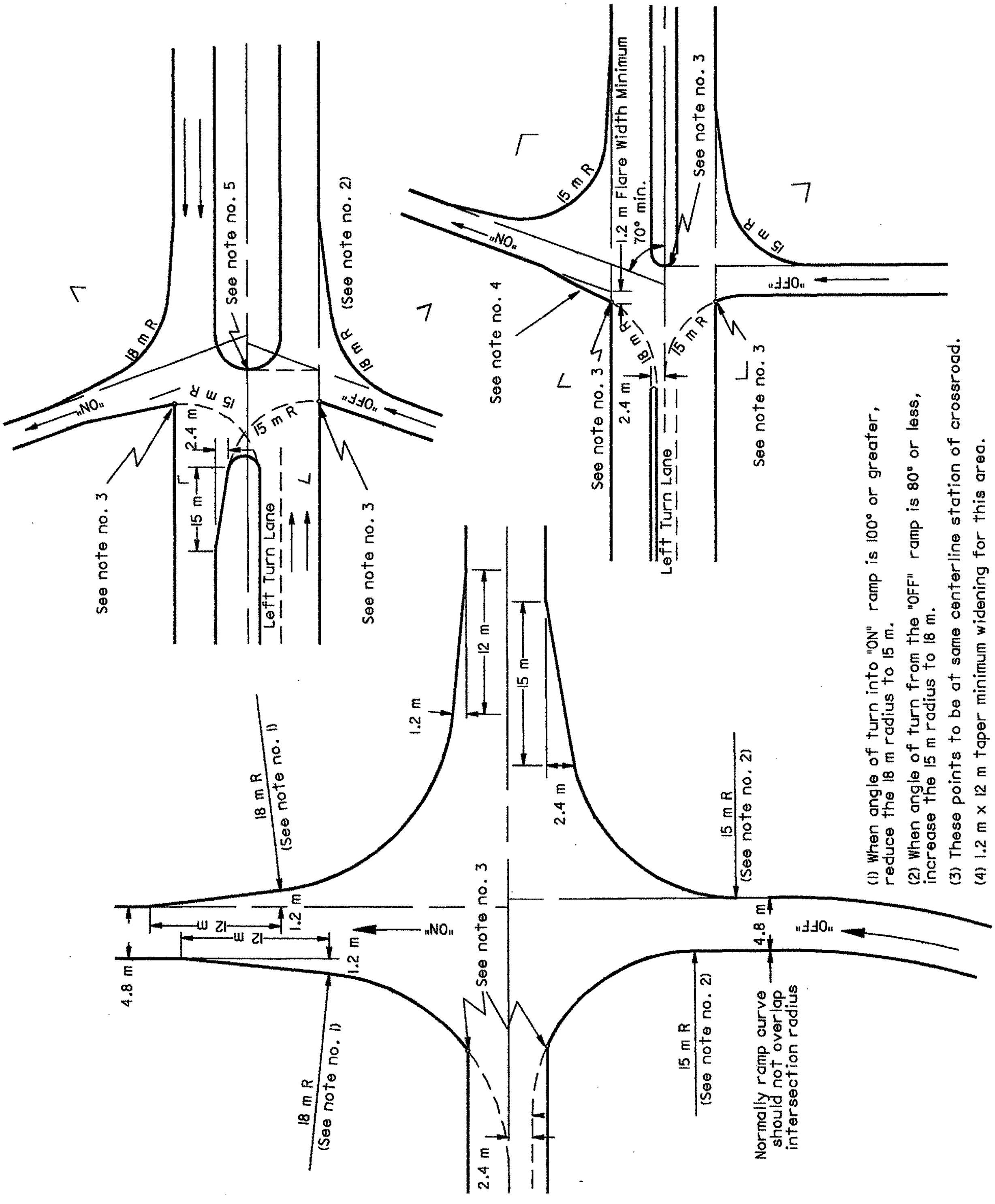
UNCURBED RAMP INTERSECTION	404-5
	REFERENCE SECTION 404.4



(1) When angle of turn into "ON" ramp is 100° or greater, reduce the 18 m radius to 15 m.

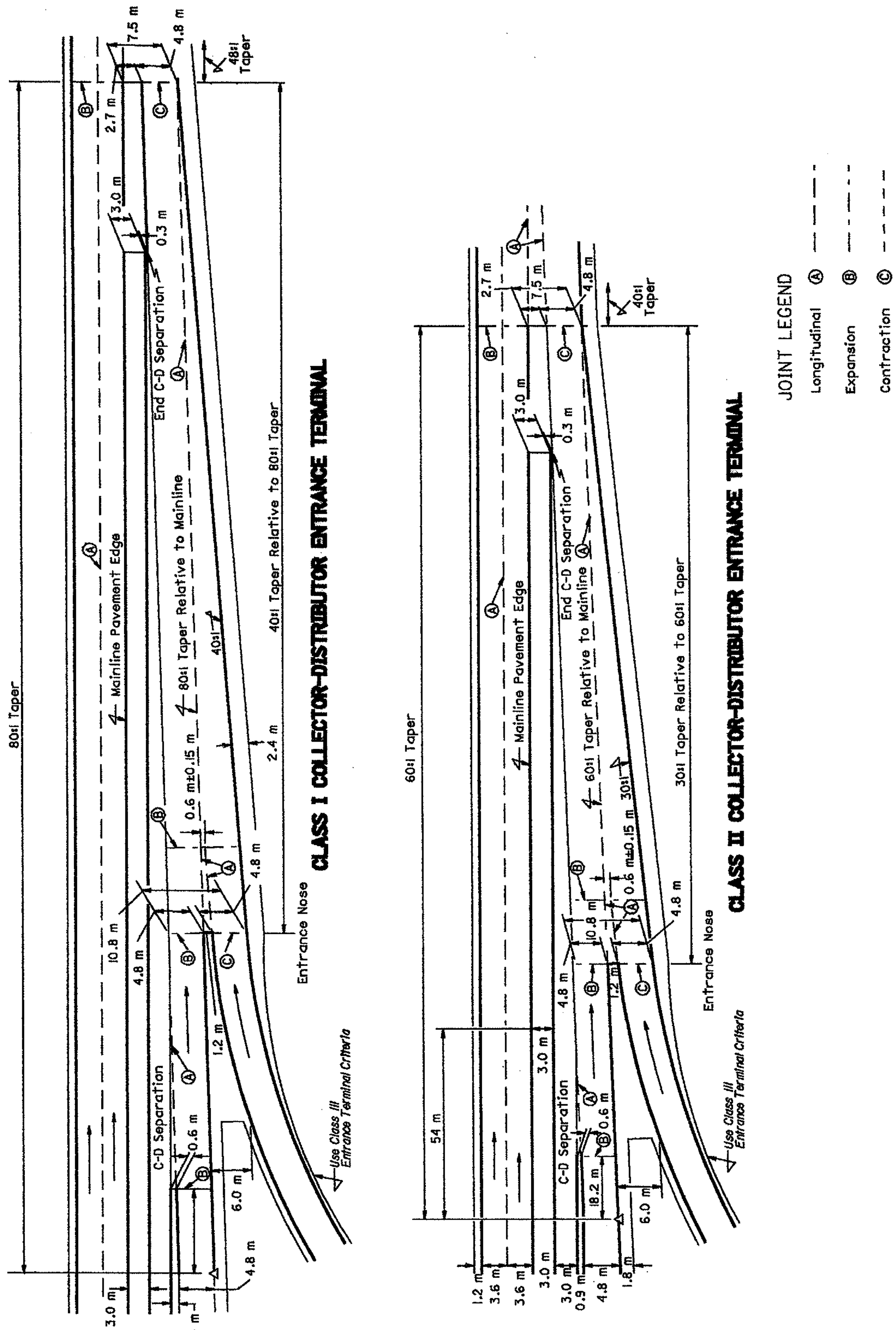
(2) When angle of turn from the "OFF" ramp is 80° or less, increase the 15 m radius to 18 m.

(3) These points to be at same centerline station of crossroad.

(4) 1.2 m x 12 m taper minimum widening for this area.

(5) Where ramps intersect a divided highway, the median opening should be designed to discourage improper turns into off ramps.

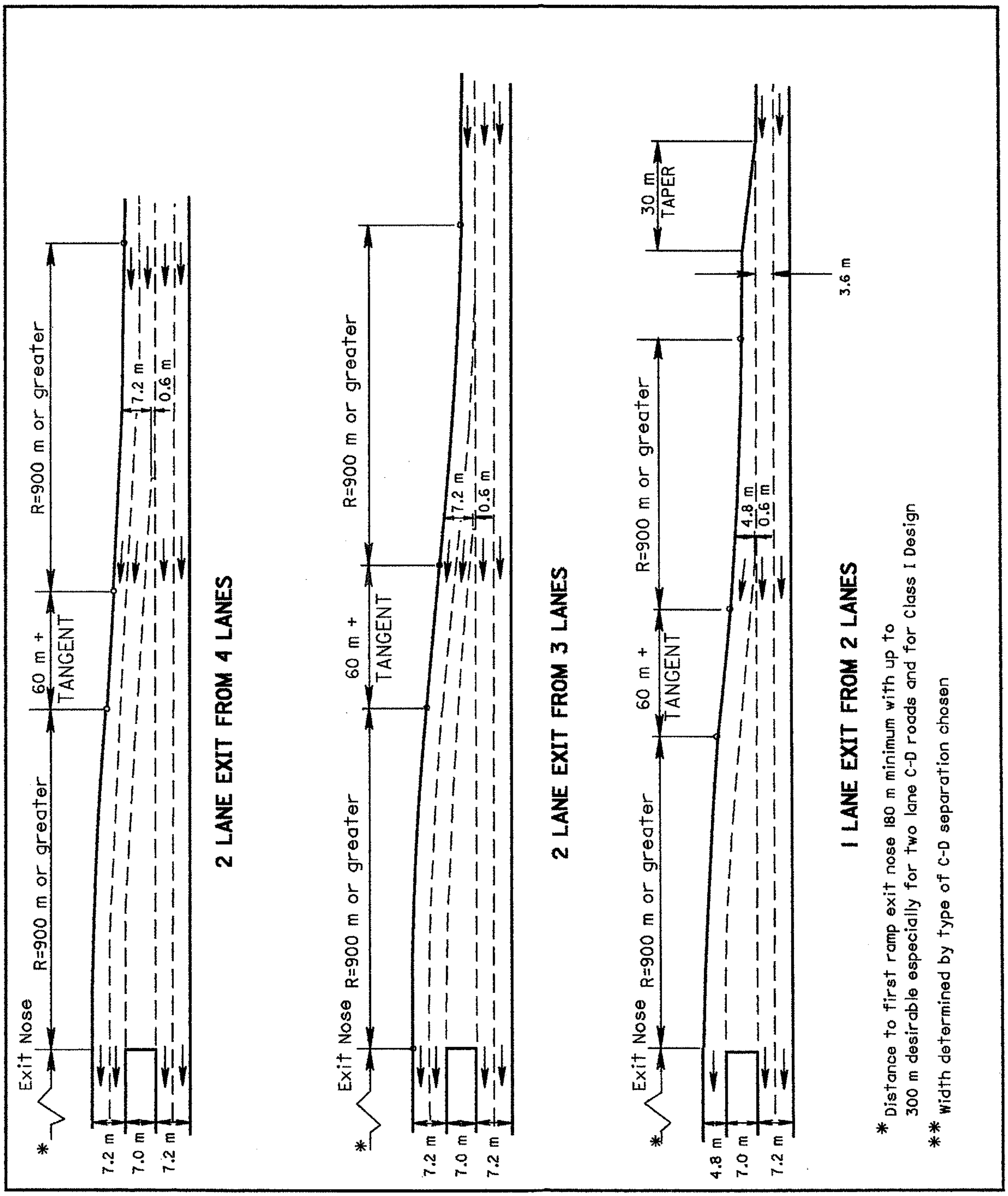
COLLECTOR-DISTRIBUTOR ENTRANCE TERMINALS	405-1
	REFERENCE SECTION 405.3



COLLECTOR-DISTRIBUTOR EXIT TERMINALS

405-2

REFERENCE SECTION 405.3



MULTI-LANE ENTRANCE RAMPS AND CONVERGING ROADWAYS

406-1

REFERENCE SECTION 406.1

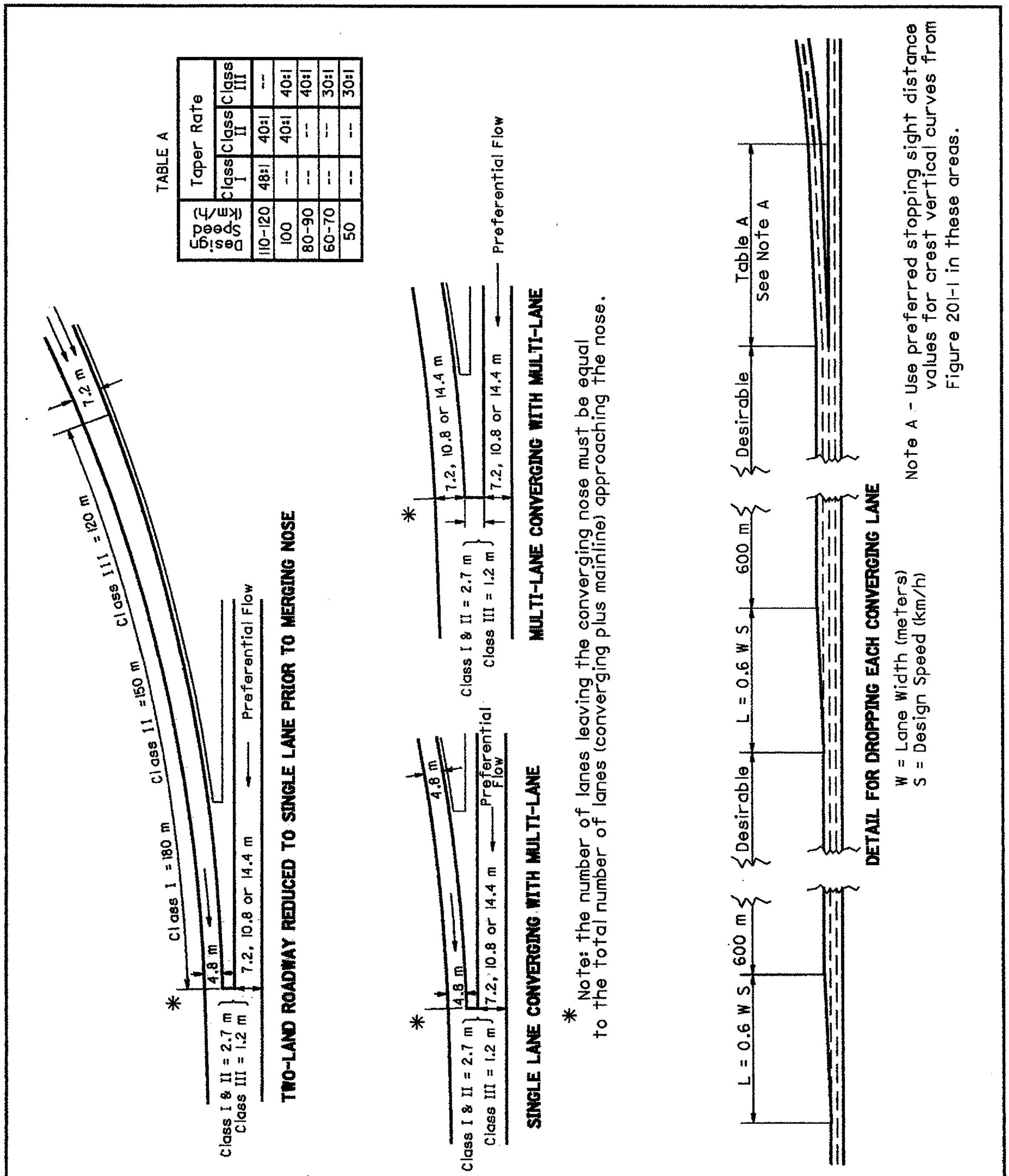


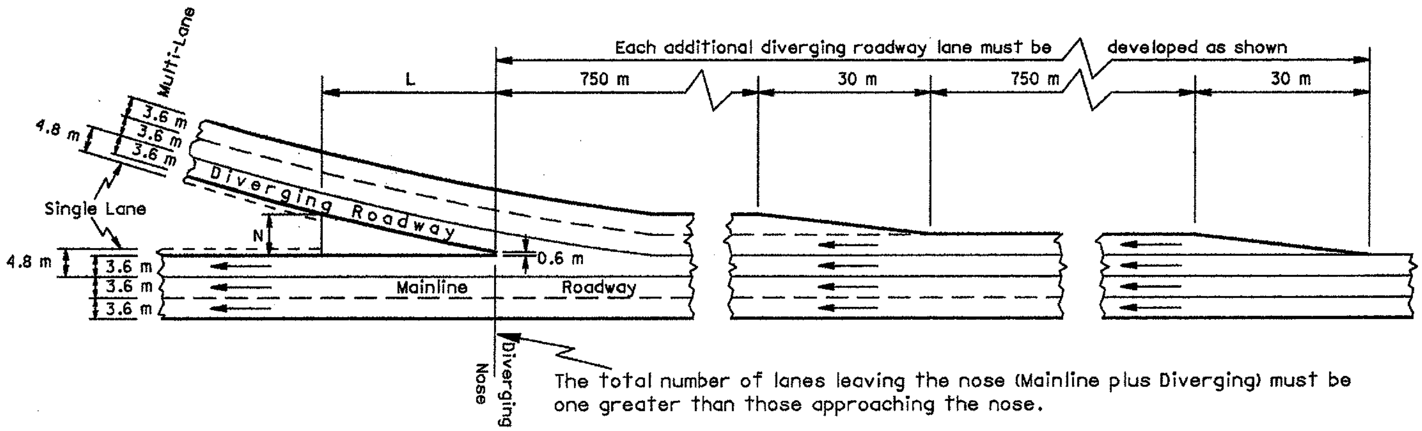
TABLE A

Design Speed (km/h)	Taper Rate Class I	Taper Rate Class II	Taper Rate Class III
110-120	48:1	40:1	--
100	--	40:1	40:1
80-90	--	--	40:1
60-70	--	--	30:1
50	--	--	30:1

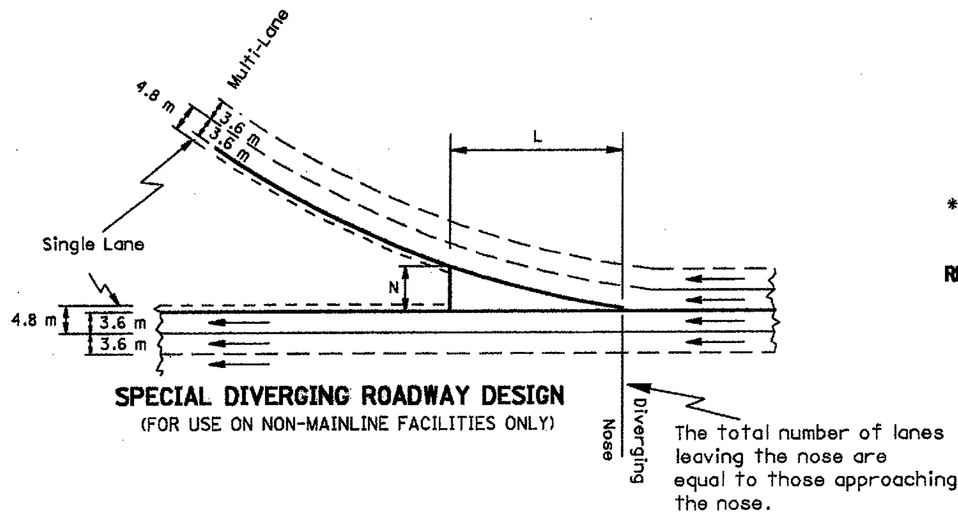
MULTI-LANE EXIT RAMPS AND DIVERGING ROADWAYS

406-2

REFERENCE SECTION **406.2**



DIVERGING ROADWAY OR MULTI-LANE EXIT RAMP DESIGN



SPECIAL DIVERGING ROADWAY DESIGN
(FOR USE ON NON-MAINLINE FACILITIES ONLY)

TABLE A

Design Speed (km/h)	"L" Gore Length (m)			"N" Nose Width (m)		
	Class I	Class II	Class III	Class I	Class II	Class III
110-120	135	105		10	7	
100		90	75		7	7
80-90			60			7
60-70			45			7
50			30			7

* N dimension includes 1.2 m of a 4.8 m lane

TABLE B
RECOMMENDED DIVERGING CURVATURE (See Sec. 406.24)

Design Speed of Approaching Roadway (km/h)	DIVERGING CURVATURE (Radius) Total Lanes Beyond Diverging Nose Equals					
	Approach Lanes			Approach Lanes +1		
	Class I	Class II	Class III	Class I	Class II	Class III
110-120	1750 m	1750 m		3500 m	3500 m	
100		1165 m	775 m		2620 m	1750 m
80-90			500 m			1165 m
60-70			270 m			700 m
50			145 m			290 m

TRANSITIONS FOUR LANE DIVIDED ROADWAY TO TWO LANE ROADWAY	406-3
	REFERENCE SECTION 406.3

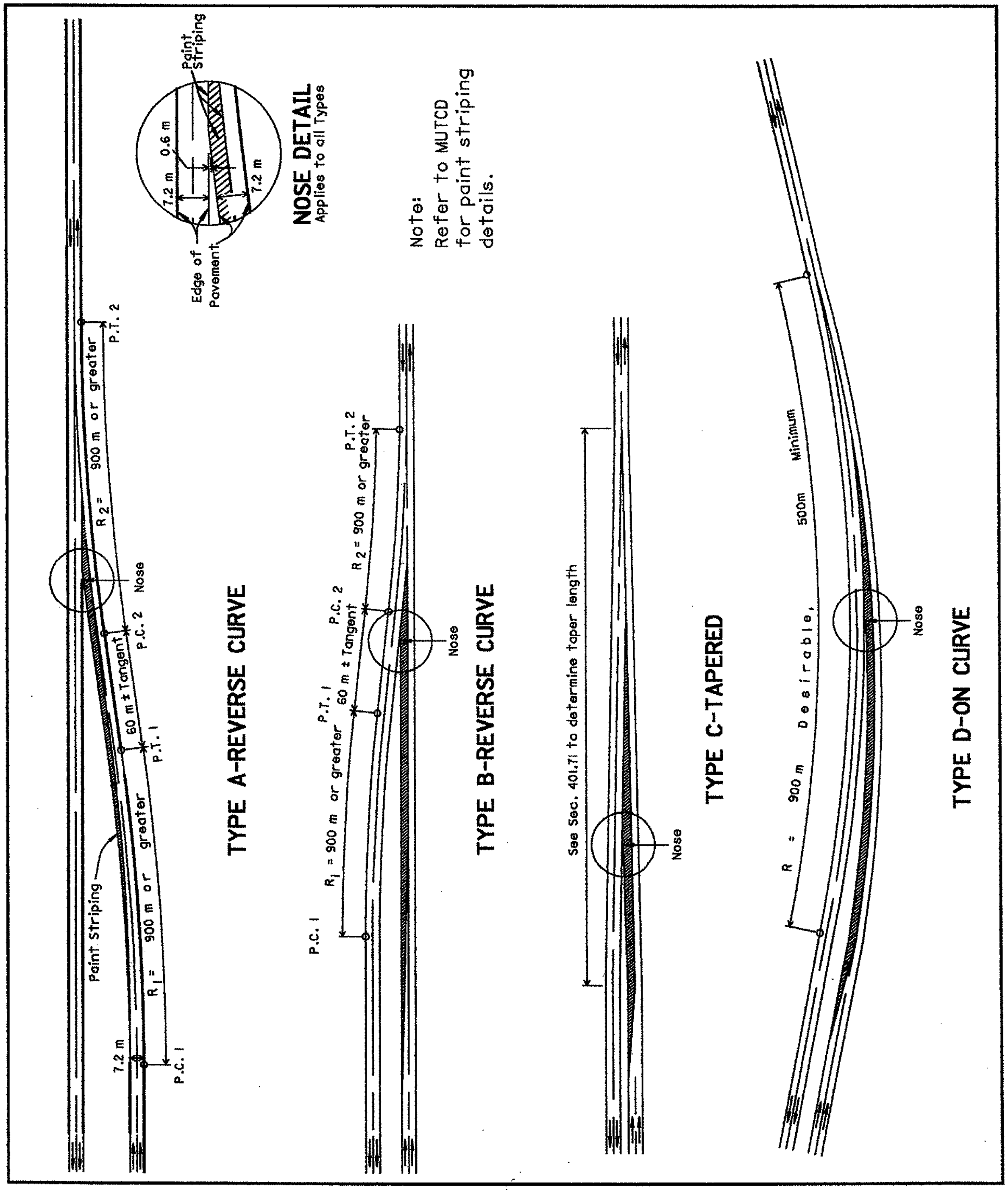


Table of Contents

500 Maintenance of Traffic

500.1 Introduction

Maintenance of traffic operations are one of the most important aspects of a construction project. Much time and effort should be spent in preparing maintenance of traffic plans to ensure that the safest, most efficient schemes possible are developed.

This section discusses many of the normal approaches to maintaining traffic safely through or around construction work zones. It provides concepts to be considered in determining whether a detour or maintenance of traffic on the existing facilities should be used and provides guidelines for considering detours and preparing maintenance of traffic plans. The designer must, however, keep in mind that traffic maintenance must be studied and designed based on project-specific circumstances.

The objective of work zone traffic maintenance is to safely and efficiently move traffic through or around the work zone at normal, or near normal speeds. Each work zone should be designed to eliminate conditions which may be created during construction and be potentially hazardous to the highway user. Keeping the travelling public informed, through the use of the media and other measures, is also essential.

500.2 Supplemental Material

In addition to these guidelines, other Departmental material must be utilized in designing maintenance of traffic plans. The "Ohio Manual of Uniform Traffic Control Devices", distributed by the Bureau of Traffic, and the MT-series of Standard Construction Drawings, with their corresponding guidelines and designer's notes, distributed by the Bureau of Design Services are vital in preparing plan details.

It is intended that this section be used in conjunction with the above mentioned supplemental material to provide one uniform set of guidelines for preparing maintenance of traffic plans. Any discrepancies among these materials should be questioned with the appropriate agencies.

500.3 Corridor Traffic Management Program

As part of the Corridor Traffic Management Program (Directive No. H-P-101), both the District | and Urbanized Area Corridor Traffic Management Planning (CTMP) Team's functions include early traffic management planning, analysis of corridor and project specific maintenance of traffic strategies, selection of conceptual work zone maintenance of traffic schemes and monitoring ongoing activities.

The designer shall work in conjunction with the appropriate CTMP Team to. incorporate the recommended traffic management strategies into construction plans.

500.4 Detour/Maintain Traffic

The decision on whether to maintain traffic on the existing facility or to utilize a detour must be made early in the planning process. Many items must be considered in determining whether to detour or to maintain traffic on a project. Some of these are listed below.

- Type of project
- Length of project
- Duration of project
- Volume of traffic
- Type of Traffic
- Length of detour
- Condition of detour
- Delays/backups
- Geometric requirements
- Effect on local activities and residents
- Economics

In general, detours shorten construction time, are less expensive, and are safer for construction personnel. On the other hand, maintaining traffic generally is more convenient for the user and has a less detrimental effect on local activities. The process for determination of need and further detour details are discussed in Directive PH-O-209. |

501 Detours

501.1 General

If the decision has been made that detouring traffic is required or preferred, provisions must be made for erecting adequate detour signing and any other appropriate traffic control devices. Normally for projects on the state highway system, detour traffic control off the project site is provided by the District Traffic department. On local or other projects where these provisions cannot be made, the plans shall specify all necessary detour traffic control in accordance with the OMUTCD. All project plans should, however, specify the appropriate detour traffic control treatment on the project site as well as at the last crossroad prior to the project site in each direction.

Consideration should be given to other projects, traffic patterns, local activities and special events when planning detour installations.

502 Maintaining Traffic

502.1 General

This section provides guidelines and references used in designing the Maintenance of Traffic portion of a highway construction plan. If traffic is to be maintained on the existing facility during construction, the construction plan must include a maintenance of traffic plan that shows details, notes, MT-series Std. Const. Drwgs., sequences, procedures, limitations, equipment, materials and other items required to maintain traffic.

Capacity constraints are vital considerations in preparing maintenance of traffic plans. In the following sections, capacity constraints are discussed for various types of facilities. The traffic volumes used in each discussion of capacity are maximum values for which the corresponding lane closures can be used. Where traffic exceeds the constraining volumes, consideration must be given to using detours, shoulders as traffic lanes and/or providing alternate routes. See other appropriate sections for further discussion on these considerations.

In preparing Maintenance of Traffic details, the designer must use engineering judgment in combining these guidelines with site- specific conditions to create a safe and efficient work zone environment.

502.11 Sequence of Operations

The Maintenance of Traffic notes should include a sequence of construction operations to coordinate the use of the developed Maintenance of Traffic details, especially on complex projects. The sequence should include any planned stages, phases or steps as well as particular procedures if appropriate.

502.12 Lane Closure Restrictions

The designer shall, in conjunction with the appropriate Corridor Traffic Management Planning Team, investigate the use of lane closure restrictions during holiday and other significant peak periods.

In rural areas on Interstates or freeways, the plan shall contain adequate plan notes requiring the contractor to have all existing lanes (a number of traffic lanes equal to the existing highway) open to traffic during specifically designated periods. Exceptions will be considered by the Director on a case-by-case basis, upon submittal of a written request by the District CTMP Team.

In urban areas on Interstates or freeways, lane closure restrictions discussed for rural areas do not automatically apply, but should receive serious consideration. Some urban routes, such as radial freeway segments leading to a central business district, carry less traffic during holiday weekends. An analysis of traffic patterns within urban freeway sections shall be made to determine whether or not it is appropriate to restrict lane closures for designated periods including holiday weekends.

The designated "lane closure restriction" periods shall be identified in the plan and may include, but are not limited to:

1. National Holidays and Holiday weekends:

    Christmas
    New Years
    Memorial Day
    Fourth of July
    Labor Day
    Thanksgiving

2. Weekends with greater than normal travel:

Mother's Day
Easter
Other weekends or periods when regional travel is significant

3. Periods involving local events having attendance greater than 75,000 persons per day or event.

4. Periods when snow accumulation is probable. During these periods daily isolated lane closures may be used during non-peak hours, weather permitting.

A "holiday weekend", for traffic maintenance purposes, begins at noon on the last normal weekday preceding the weekend and ends at noon on the first normal weekday following the holiday. A day between the holiday and Saturday or Sunday is considered part of the weekend.

On long projects, it is undesirable for lane closures to extend considerable distances when work is concentrated in a small area. The designer should consider, based on the type of work and sequence of operations, specifying length restrictions on lane closures.

502.13 Speed Limit Reductions

On those types of projects discussed below, the plans shall specify speed limits reductions through the work zone.

1. Construction projects on rural Interstate highways or other freeways having speed limits of 65 mph shall have the speed limit reduced to 55 mph.

2. Projects on urban Interstate highways, urban non-interstate freeways, rural expressways and rural 4 or more lane highways having speed limits of 55 mph shall be reduced to 45 mph.

The speed limit for rural non-Interstate freeways or any other type of facility not discussed above should not be changed.

Speed limit reductions shall only apply to projects lasting 30 consecutive calendar days or more where traffic is to be maintained. They apply to projects of all lengths, but are not intended for use on bridge rehabilitation or repair work.

Whenever a lowered speed limit is to be used within a section which has more than one original posted speed, the lowest temporarily reduced speed required by the above discussion shall apply as the speed limit for the entire length of the project.

Speed limits other than those discussed above (higher or lower) or for project types not discussed must have a justification report prepared and submitted to the Bureau of Location and Design for approval by the Director.

When a speed reduction during construction is required, it shall be accomplished by a statement preceding the Director's signature on the plan title sheet and by plan note. The plan note shall be worded to require that the revised speed limit signs be erected or uncovered no earlier than 4 hours prior to the actual start of work and removed or covered no later than 4 hours following restoration of all lanes to traffic with no restrictions.

If, during a project which lasts more than one construction season, all lanes are open to traffic during the winter months and no restrictions exist, the speed limit shall return to the original posted speed and temporary speed limit signs shall be removed or covered no later than 4 hours following restoration of all lanes to traffic with no restrictions for the winter. Temporary speed limit signs may be re-erected or un-covered no earlier than 4 hours prior to resumption of work.

Temporary speed limit signs shall be placed 500 feet in advance of the lane reduction taper (dual mounted for divided highways), immediately after each entrance ramp within the zone, and every mile for 55 mph zones and every 1/2 mile for 45 mph zones.

502.14 Channelizing Devices

Acceptable channelizing devices for use in maintenance of traffic applications are cones, vertical panels, reflectorized plastic drums, barricades and barriers, including portable concrete barrier.

Channelizing device offsets from the edge of any travel lane in a maintenance of traffic operation should be a minimum of 1.5 feet. Attempts to provide larger offsets should be made whenever possible. See Section 502.22 for additional discussion.

Channelizing devices and their application, shall conform to the OMUTCD and any appropriate MT-series Standard Construction Drawing. Application and use of portable concrete barrier is discussed in further detail in Section 505.

502.15 Work Zone Dropoffs

Treatments for dropoffs in construction work zones are shown on Standard Construction Drawing MC-12. The drawing may be used as a designer's tool for determining the appropriate measures to specify in the plans for treatment or protection of dropoff conditions. (Alternatively, the designer may use it to develop designs or sequences of operations that would avoid or minimize dropoffs.)

Maintenance of traffic notes should address treatment of any anticipated open trench areas. Whenever possible, stipulation should be made that trench excavating operations will not remove any more material than can be replaced by the end of each day's work. In areas where this is not possible or where adverse conditions prevent it, overnight trench openings shall be temporarily backfilled.

502.16 Shoulder Use

Many maintenance of traffic situations require the use of either full or part-width of the paved shoulder as a traffic lane. Capacity, traffic characteristics, bridge width, work area location and existing shoulder characteristics all play a role in determining the extent of modifications and use of paved shoulders.

An investigation of required lane closures, capacity constraints and traffic composition and volumes may lead to considering the use of shoulders as a full traffic lane. Both right and left side shoulders may be utilized in this manner.

When a shoulder is to be used as a full traffic lane certain provisions must be made. Lane width, in accordance with Section 502.22, must be provided. This may require widening the existing shoulder. The designer must also examine structures to ensure that sufficient width and height is available.

During any sequence of operations where traffic is to be maintained within 2 feet of the edge of the paved shoulder, the graded shoulder area adjacent to the paved shoulder should be strengthened. An aggregate base placed 6" deep, or a composition with similar structural characteristics, should be specified for 2 feet beyond the edge of the paved shoulder. This treatment should be placed in conjunction with final graded shoulder treatments when such shoulder use is required on final surface couse pavements.

Part width use of shoulders may be required when either work or channelizing devices encroach on the travel lane adjacent to the shoulder.

Any shoulder use for maintaining traffic requires evaluating the integrity of the shoulder pavement. Engineering judgment should be used in making this evaluation. The designer should consider the percentage of truck traffic and the existing pavement condition, including the composition.

Shoulders used for maintaining traffic which are determined to be of insufficient strength should be removed completely and replaced in accordance with the requirements of Sections 301.2 and 702.

Shoulders used for maintaining traffic which are determined to be structurally sufficient should also provide smooth travel. Provisions should be made to recondition shoulder surfaces which are rutted, raveled or otherwise insufficient.

The designer should evaluate the roadside area for hazardous obstructions. The maintenance of traffic clear zone, as discussed in Section 502.23, should be used in the evaluation. Temporary protection may be required at obstructions which were not previously protected.

Examples of use of the shoulder as a traffic lane are shown on Std. Const. Drwgs. MT-102.10 and MT-102.20.

502.17 Law Enforcement Officers (LEO's)

LEO's with patrol cars are extremely effective for slowing traffic down to a safe speed through work zones. Their use shall be specifically identified in the construction plans.

In general, LEO's should be positioned to direct traffic at the point of lane restriction or road closure. Their primary purpose is to ensure the safe, efficient and orderly movement of traffic. They are not to be used for the convenience of the contractor at the expense of the state.

For lane closures, the use of LEO's should be required during initial set up periods, tear down periods, substantial shifts of a closure point or when new lane closure arrangements are initiated. Use of LEO's is required during the entire advance preparation and closure sequence where complete blockage of traffic is required. LEO's should not be used where the OMUTCD intends that flagmen be used.

Use of LEO's by contractors other than the uses specified above will generally not be permitted at project cost. The plans shall specify that when used during other operations, LEO's shall circulate through the work area, with flashing lights off, to provide a general slowing of traffic.

For projects specifying the use of LEO's by municipalities, the design agency shall contact the cities which are to provide the LEO to ensure that the necessary patrol car(s) will be available. If the municipality cannot guarantee the availability of patrol cars, the plans should be modified to eliminate the need for the LEO.

State Highway Patrolmen may be specified on rural interstate projects. They shall not be used exclusively on other projects where local LEO's are available.

502.18 Contractor Access

Work zones requiring barrier protection of the work area can, if not properly addressed, create circumstances which either prohibit contractor access to the work area or make such access unnecessarily difficult.

When barriers are used in such a capacity for maintaining traffic, designers should address access to the work area, especially when it is perceived that lack thereof could be an unreasonable burden on the contractor.

502.2 Design Speed and Geometrics

502.21 Design Speed

The design speed for traffic maintenance through construction work zones should normally be the posted speed limit. Where maintaining the legal speed limit is not feasible or practical, it is recommended that the design speed not be less than 10 mph below the posted speed, with the minimum design speed being 25 mph. Reductions in design speed should be accomplished gradually, in increments of 10 mph or less. Sudden changes in design speed and the related geometrics should be avoided. Advisory speed signing (see Section 506.13) should be provided in accordance with the OMUTCD. Posted speed reductions are discussed in Section 502.13.

Whenever a speed reduction is to be used, the design of work zone maintenance of traffic items shall use the original posted speed for the design of maintenance of traffic items on the approaches to the work zone. The temporary reduced speed limit shall be used only in designing maintenance of traffic items within the work zone.

502.22 Geometrics

The following discussion of geometrics should be used as a guide where maintenance of traffic is to be accomplished using the existing facility. Geometric criteria to be used in designing and utilizing temporary roads is discussed in Section 504.22.

It is desirable to maintain lane widths at least equal to those on the existing facility. Where width reductions are necessary, widths should not be less than 10 feet, unless lane widths on the existing facility are less than 10 feet. See Figure 502-9 for required lane widths when the degree of horizontal curvature exceeds 10°.

Channelizing device offsets, discussed in Section 502.14, should be provided in addition to lane widths whenever possible.

On spot improvement locations of very short length, such as bridge replacements or bridge reconstruction, (excluding Interstates and freeways) where the clear roadway width criteria stated above cannot be provided and a detour is not feasible, lateral clearance requirements to barriers and channelizing devices may be waived. At no time, however, on such a project shall the distance face-to-face of barrier and/or channelizing devices be less than 10 feet. (See Figure 502-9 for requirements on sharp curves.)

Where the horizontal alignment is to be altered from that of the existing roadway, the maintenance of traffic horizontal alignment shall conform to the criteria in Sections 202.1 and 202.2. The designer should also ensure that the minimum stopping sight distance criteria in Section 201.2 and vertical clearances from Section 302.1 (for existing bridges to remain in place) are satisfied.

502.23 Clear Zone

On projects where maintenance of traffic operations use the paved shoulder as a traffic lane, the designer should evaluate the roadside for obstacles which may require protection. In such a situation the clear zone values for the facility under normal conditions (Section 601.1) may be reduced by 12 feet, but shall never be reduced to less than 2 feet.

502.3 Capacity Considerations

The following capacity restrictions should be evaluated for each project. The values have been developed to assist in identifying when traffic volumes may cause delays and/or backups during construction phases.

When traffic volumes exceed these values, other steps should be considered in preparing maintenance of traffic plans. These include resequencing construction to allow additional lanes to be used, use of shoulders as traffic lanes, providing advance warning signs, use of alternate routes and corresponding signing, use of portable changeable message signs or detours.

The above considerations should be utilized where the following conditions exist:

1. On two-lane highways where the ADT is greater than 6000 (two-way) or where the peak hour traffic is greater than 600 vph (two-way).

2. On multi-lane highways (more than two lanes, divided or undivided) where the directional ADT is greater than 14,000 per lane of traffic being maintained, or where the peak hour traffic is greater than 1400 vph per lane of traffic being maintained.

502.4 Traffic Control Details

502.41 Use of Standard Construction Drawings and Plan Insert Sheets

When designing maintenance of traffic plans, MT-series Standard Construction Drawings and plan insert sheets should be used whenever they are appropriate. Figures 502-1 through 502-8 are flowcharts which may be used as guides for their use.

Plan insert sheets have been developed by the Department for certain specific applications. They may be inserted directly into the plan or modified to fit site-specific conditions. Plan insert sheets are available through the Bureau of Design Services.

502.42 Flagger/Signalized Closures

When a two lane highway qualifies for one-lane flow work zones as set forth in Section 502.31, two methods of lane closure should be considered, flaggers or signal control.

Flaggers may be utilized in closing one lane of a two-lane highway where the lane closure is required during daylight hours only, such as one day only closures or closures which may be removed at the end of each days work. Flaggers may also be used in certain cases where a lane closure must be left in place overnight for up to 4 or 5 days. Flaggers must be provided at all times travel is reduced to one lane and be located in a sufficiently illuminated area to be highly visible.

Signalized lane closures on two lane highways should be used whenever lane closures utilizing flaggers cannot be economically justified.

Plan insert sheets are available through Design Services for treatments of crossroads in signalized closure areas.

Where an existing traffic signal will be close to the temporary signal, they should be coordinated. Where a side road or major drive intersects within the single lane section, consideration of a third signalized movement may be appropriate.

502.43 Closing Left Lane of Five-Lane Highways

Closing the left travel lane of a five lane highway requires detailing the closure in the plans. Details should begin with closing the center turn lane. Once the center turn lane closure occurs, signing and tapers for closing the left travel lane, similar to that shown on Std. Const. Drwg. MT-95.32 can be placed.

All details and procedures used for closing the left travel lane of a five lane highway shall conform to the aforementioned standard drawings and the OMUTCD.

502.44 Closing Inside Lanes on Six or More Lane Highways

On highways having six or more lanes, closing the center lane by itself (traffic maintained on each side) should be avoided. The center lane closure must be incorporated with either a right or left lane closure and use of the shoulder as a traffic lane. Shoulder use as a traffic lane or detours should be considered when traffic exceeds the capacity constraints of Section 502.33.

When closing more than one lane, each lane shall be closed as a separate lane reduction.

502.45 Intersections and Driveways

Within lane closure and/or work areas, provisions must be made to control traffic entering from intersecting streets, roads and driveways. These provisions shall include measures to prevent wrong-way movements and to keep vehicles from entering the work area. Such measures may include:

1. Providing a flagger at each location.

2. Placing a row of drums/cones (min. of 3 per lane) across the closed lane or work area approximately 100' each way from the intersection.

3. Erecting temporary traffic signals.

502.46 Ramps

When construction work must be performed on ramp pavement (excluding acceleration and deceleration lanes), the pavement width and type of work determine the maintenance of traffic operations that can be used.

Where the type of work and ramp pavement width can be combined in a staged sequence which maintains 10.0 foot lane widths, the ramp may be left open to traffic. See Figure 502-9 where ramp curves exceed 10°.

Where these conditions cannot be met, a ramp closure and detour should be used. The plans shall stipulate that a ramp may not be closed until work on that ramp is ready to begin and that work on the ramp shall be continuous to a point where it may once again be opened to traffic. Consideration may also be given to staged construction where segments of the work may be performed while traffic is maintained on the ramp and the remaining work is performed during the ramp closure, therefore minimizing the closure duration.

Ramp shoulders may be used for maintaining traffic.

503 Two Way Operation on One Roadway of a Divided Highway

503.1 Use

A two way maintenance of traffic operation on one roadway of a divided highway should only be used where more customary traffic maintenance methods are not practical, such as where major sections of pavement must be removed or where a concrete overlay or other construction procedures makes it impractical to work in one or two lanes while accommodating traffic in the adjacent lane(s) or shoulder(s).

The two way operation on one roadway should only be utilized if it complies with the capacity constraints discussed for the appropriate facility in Section 502.

Details of the two way operation are shown on Std. Const. Drwgs. MT-95.70, MT-95.80, MT-95.81 and MT-100.00.

503.2 Crossover Design

The design of the temporary crossover is shown in Figures 503-1 and 503-2.. The 3 degree reverse curves are appropriate for rural temporary crossovers. In urban areas the curvature may be increased to 5 degree reverse curves, provided the posted speed is reduced to 45 mph. Superelevation for these curves shall be limited to 0.0156 sloped toward the inside of the curves. Variations in design due to mainline curvature will be considered on a case-by-case basis.

The plans should detail temporary crossovers, including locations, horizontal alignment, typical sections, profiles, and pavement transitions to the existing pavement.

Crossover locations should be very carefully selected with traffic needs being the primary consideration. A tangent section on flat terrain is the most desirable location for constructing a crossover. The designer should field check possible crossover locations to select the optimum site and not necessarily choose the project limits as their location.

All temporary crossover areas shall be illuminated as shown on Std. Const. Drwg. MT-100.00.

All temporary crossovers shall be removed at the completion of the current proposed work unless retention for future use is recommended and justified by the District. Any crossover which is to remain for future use or left in place without use between construction seasons shall be camouflaged with an earth overlay so that the crossover area appears as part of the normal median.

503.3 Traffic Separation

For projects of short length (2000 ft. or less), portable concrete barrier should be used to separate opposing traffic in a two way operation. Standard Construction Drawing MT-95.70 shows two way operation details using portable concrete barrier.

For longer projects (over 2000 ft.), asphalt curb divider may be used to separate opposing traffic in a two way operation. Std. Const. Drwg. MT-95.80 shows two way operation details using the asphalt curb divider.

The use of breaks in the traffic separation runs to permit access should not normally be allowed. For unusual circumstances where breaks are necessary, each end of the barrier shall be protected by an attenuator.

503.4 Length

The length of individual two lane operations on one roadway of a divided highway should not be limited in relatively flat terrains. In rolling to hilly terrain where underpowered vehicles tend to slow traffic flow, the length of two way operations should be limited to 5 miles.

503.5 Barrier Considerations

When a two lane operation on one roadway of a divided highway is to be used, the designer should provide temporary barrier protection for the opposite direction of traffic at obstacles which did not require protection under one-directional conditions. The designer should evaluate the project for locations requiring barrier and/or bridge terminal assemblies and specify the appropriate protection.

504 Temporary Roads

504.1 Justification

Temporary roads include crossovers, runarounds, ramps, entire roadways, etc., whose sole purpose is to temporarily maintain traffic during construction and which are normally removed upon project completion.

Temporary roads are required when the existing roadway is inadequate to properly accommodate both the work and traffic. They may also be required in certain cases where bridge construction or reconstruction does not facilitate part-width construction or realignment to the extent that the existing facility can serve as the temporary road. The use of runarounds and temporary structures in such cases must be evaluated by the designer for cost-effectiveness and public service.

504.2 Design

504.21 Design Speed

The design speed used in designing temporary roads shall be that which is discussed in Section 502.21.

504.22 Geometrics

The geometric design of temporary roads should be commensurate with the chosen design speed.

The horizontal alignment of temporary roads shall conform with the criteria discussed in Sections 202.1 and 202.2. Superelevation of temporary roads is discussed in the following section. Spirals shall not be required.

Crest and sag vertical curves on temporary roads should conform with Section 203.3 using minimum criteria. Maximum allowable grades are the values shown in Fig. 203-1 under hilly terrain for the appropriate design speed.

Stopping sight distances must meet or exceed the minimum criteria discussed in Section 201.2 and pavement cross slopes shall be as discussed in Section 301.15.

The designer shall also ensure that vertical clearances in conformance with Section 302.1 (existing structures to remain) are provided.

504.23 Superelevation

Except as noted in Section 503.2, superelevation on temporary roads should conform to the requirements shown in Fig. 202-11 for design speeds greater than 40 mph and Fig. 202-5 for design speeds equal to or less than 40 mph.

Curve widening should be considered as shown on Figure 502-9.

504.24 Lane Width

Lane widths of temporary roads should conform to the requirements discussed in Section 502.22.

504.25 Guardrail and Sideslopes

The Construction and Material Specifications permits a minimum guardrail offset of 1.5 feet and a maximum side slope of 1-1/2:1. These dimensions are appropriate for absolute minimum design, but design above these values should be provided when feasible. For design speeds over 40 mph, a minimum shoulder width and guardrail offset of 6 feet is desired and 4:1 side slopes are desired where right-of-way is available.

Barrier placement along temporary roads shall conform to the appropriate requirements of Section 600.

504.26 Pavement

The Construction and Material Specifications provides Class A and Class B pavement design for temporary roads. These designs are intended to be specified on projects with large traffic volumes where the proposed project pavement design is stronger than either of these two designs. A temporary road pavement should not normally be stronger than the permanent pavement design of the project.

For a temporary road pavement design that is weaker than Class A or B, the design should be based on the anticipated total equivalent 18-kip single axle-load applications and determined from information contained in Section 700.

For temporary road pavement which is to be used for a short time (less than two months), and by moderate traffic volumes (2000 ADT or less), 410 Traffic Compacted Surface, stabilized with 616, may be provided.

505 Barriers

505.1 General

Barrier use in maintenance of traffic applications should consist of either portable concrete barrier (PCB) or guardrail.

The method used for determining the length of barrier discussed in Section 601.52 should also be used to design the length and location of barrier for maintenance of traffic applications.

505.2 Guardrail

All guardrail used as a temporary barrier in maintenance of traffic applications shall be to the same standards as required for permanent guardrail in Section 601.41. In general, Type 5 guardrail will be used exclusively, except Type 4 may be used for low volume roads which have current traffic volumes less than 400 ADT and the design speed is 40 mph or less.

Guardrail may be installed by any of the standard methods detailed in the current Standard Construction Drawings or other special methods approved by the Engineer of Location and Design on a case-by-case basis.

All guardrail used in maintaining traffic should have a minimum lateral offset from the edge of the travelled lane of 1.5'. A lateral offset of less than 1.5' may be used in rare instances when the project length is short. These exceptions are discussed in Section502.22.

505.3 Portable Concrete Barrier (PCB)

505.31 Justification

The decision on whether to specify the use of PCB is based on characteristics of the work zone and engineering judgment. The use of PCB should be required during construction in any area where penetration or deflection permitted by other traffic control devices cannot be tolerated.

Where the work zone involves dropoff areas, Section 502.15 and Std. Const. Drwg. MC-12 should be used to determine where to use PCB.

PCB should be considered for use where long term work zones will exist, as the possible number of encroachments into the work zone increase over longer periods of time. Also, work zones which will have heavy equipment or dangerous obstacles near the traveled way should be considered for PCB protection.

505.32 End Treatment

Wherever practical, the exposed end of the PCB should be located at a distance from the edge of the traveled way equal to the clear zone distance for the facility as discussed in Section 601.1. For acceptable taper rates of PCB, see Fig. 601-7.

Exceptions may be made when the PCB installation and taper are incorporated with traffic control used for lane closures. These installations should be designed as shown on Fig. 505-1.

505.33 Glare Screen

Glare screen should be considered for use on PCB in accordance with the discussion in Section 602.1.

506 Traffic Control Devices

506.1 Signing

506.11 Advance Warning and Alternate Routes

When lane restrictions or closures are placed on high volume roadways, traffic demands often exceed the capacity of the remaining lane(s) and other maintenance of traffic measures are not feasible. Resulting backups may occur which might extend upstream of the standard warning signs and may, in some cases, require advance warning or indicate the need to provide information about alternate routes to the highway user. The designer shall perform a capacity analysis of each maintenance of traffic phase or scheme to determine if there will be problems of this nature.

Where problems resulting from capacity limitations can be anticipated, additional fixed signing should be utilized to provide additional upstream advance warning. The advance warning signs should be a set of sign configurations as shown on Std. Const. Drwg. MT-95.30. The "Watch for Stopped Traffic" OW-166 sign shown should be placed at a location where the longest projected queue is expected to end. Capacity analysis procedures should be used to estimate maximum probable queue length.

Where capacity problems and queues are expected and alternate routes are available, consideration should be given to implementing diversion schemes. Signing indicating alternate routes around work zone congestion may be erected prior to interchanges with the alternate routes.

506.12 Portable Changeable Message Signs (PCMS)

Portable changeable message signs are trailer-mounted programmable message units which can be utilized to provide advance information about upcoming traffic conditions or diversion routing schemes to drivers. PCMS units are supplemental information devices and shall not be utilized as alternates to standard fixed signing or flashing arrow panels.

On major construction projects, PCMS units, although costly, can provide real benefits to road users. These benefits include increased work zone traffic flow resulting from advance warning of lane closures and improved corridor utilization resulting from diversion schemes implemented in reduced capacity situations.

Due to the high cost of these units, every attempt should be made to provide needed information with fixed signing. Where fixed signing is not adequate or when variable message capacity is needed, PCMS units should be considered.

Generally, PCMS units should be located well in advance of the situation they relate to. In the case of lane closures, the PCMS unit should be located in advance of the longest expected backup. In the case of diversion schemes, the PCMS units should be located in advance of the interchange where the alternate route begins. The desired location(s) for deployment of PCMS units should be established by means of a plan note listing the specific locations where the contractor is to furnish, install, maintain and remove the PCMS unit(s) and the duration the PCMS unit is to function.

When specifying the number of signs required, care should be exercised to require that the contractor furnish the units, on site, for the duration of the phase or the entire project rather than merely having the units available. If standby units are needed, they shall be so specified along with a time interval in which a malfunctioning unit must be replaced.

Sign messages should be limited to a maximum of three sequential displays, each display consisting of a maximum of three, eight- character lines.

506.13 Advisory Speed Signs

Advisory speed construction signs are shown and discussed on many of the maintenance of traffic (MT) Standard Construction Drawings. The signs should be indicated for use in the plan whenever lower speed limits, as discussed in Section 502.13, are not used and the design speed of the maintenance of traffic facility, or a part of it, cannot be designed to the legal speed limit. They should also be specified when conditions exist that may be difficult to maneuver at the posted or design speed, such as crossovers or sharp curves.

Any use of an advisory speed sign in a plan shall also specify the speed to be posted on the sign.

506.14 Overhead Guide Signs

Maintenance of traffic plans frequently require the closure of lanes and/or ramps. When this occurs, the plans typically include standard construction drawings and plan details which provide orange warning signs to inform the motorist of the closures, but often do not consider the existing guide signs in the area, particularly the overhead guide signs. This is especially important when the guide signs establish certain destinations for each lane. When closures will be in effect for more than two days, appropriate modifications to the guide signs should be considered as a portion of the maintenance of traffic plans.

506.2 Temporary Pavement Marking

The use and specification of temporary pavement marking in maintenance of traffic plans shall be according to the Ohio Manual of Uniform Traffic Control Devices, Std. Const. Drwg. MT- 99.10 and any other standard drawing specifying the use of markings that is being used in the maintenance of traffic plan.

Certain MT-series standard drawings state that temporary pavement markings should be used when specified in the plan (For example, the temporary edge line shown parallel to traffic flow on Std. Const. Drwg. MT-95.30). The decision on whether to specify such markings should be based on engineering judgment and include consideration of the length of work, time of closure, sequence of work including any need to remove the line in subsequent phases, encroachment on other lanes or the shoulder, the type of work, the geometrics in the area and the relative cost of materials.

506.3 Delineation

Delineation through the construction work zone, in addition to the normal channelizing devices discussed in Section 502.14, may be provided through pavement marking applications discussed in Section 506.2, temporary barrier reflectors and temporary raised pavement markers.

Temporary barrier reflectors shall be specified for use on all barrier (PCB or guardrail) utilized for maintenance of traffic in accordance with Supplemental Specification 802.

Temporary raised pavement markers are typically used in dense traffic areas and in areas where the traffic patterns are unusual (i.e. tapered lanes, drop lanes, double right or left turn, etc.). Specific uses of temporary raised pavement markers are detailed on various MT-series Construction Drawings.

506.4 Signals

Details of selected uses of traffic signals for maintaining traffic in one-lane, two-way (alternating flow) operations are shown on Std. Const. Drwgs. MT-96.10 and MT-96.11. Signal placement and wiring details are shown on Std. Const. Drwgs. MT-96.20 and MT-96.25 respectively. Other types of temporary signals must be designed and detailed in the plans.

507 Illumination

Illumination of work zone facilities shall be provided in the area of temporary crossovers used for two way operations on one roadway of a divided highway and in conjunction with signalized closures of one lane of a two lane highway.

Temporary illumination may also be helpful at other critical maneuver areas, particularly when high speeds or high volumes are involved.

Lighting setups and details for temporary crossovers are shown on Std. const. Drwg. MT-100.00. Details for providing illumination at signalized closures of one lane of a two lane highway are shown on Std. Const. Drwgs. MT-96.10, MT-96.11 and MT-96.20.

When construction occurs in areas presently lighted, efforts should be made to assure that adequate illumination continues throughout the construction period. This may require the use of temporary circuits, poles, etc. or maintenance of the existing system.

508 Pedestrian Facilities, Bikeways, and Waterways

508.1 Pedestrian Facilities

In addition to vehicular restrictions, construction work zones may also cause conflicts for pedestrian traffic. Pedestrians are susceptible to being endangered by both construction activity and traffic flow. Therefore, whenever construction work zones encroach upon pedestrian facilities, special consideration must be given to pedestrian safety.

Planning and design for maintaining pedestrian traffic should consider both the characteristics of that traffic and the type of construction activities. An analysis of trip origins, destinations and travel paths is useful for providing adequate temporary facilities.

Guidance in design of pedestrian maintenance of traffic facilities with access for the handicapped can be found in the manual "Design Standards: For Handicap Accessibility to Ohio's Rest Areas", published by the Bureau of Design Services. Specifically, Sections 4.2, 4.3, 4.6, 4.7 and 4.8 should be considered.

Design of temporary pedestrian facilities through or around construction work zones should include the following:

- Advance information where facilities are closed, blocked or maintained along routes not obvious to the pedestrian.
- Proper transitions and channelization into the work zone path.
- Guidance through the work zone including delineation and protective devices.
- Guidance in returning pedestrians to normal routes upon exiting bypass or detour facilities.

Plan insert sheets, available from the Bureau of Design Services, can be used for further information and for including in the plan for specific applications.

508.2 Bikeways

When construction work zones are near or upon designated bikeways, maintenance of traffic provisions should be made for the guidance and safety of bicycle traffic.

Additional information on bikeways may be found in the publication "Policy and Procedure for Bicycle Projects," distributed through the Department's Bicycle Transportation Administration.

508.3 Waterways

On projects involving construction or major reconstruction of structures over navigable waterways, provisions should be made to inform and/or guide watercraft traffic through the construction area.

Projects which close rivers or streams for construction purposes should provide a safe portage for light watercraft along with appropriate guide and warning signs in each direction.

Projects which do not close rivers or streams, but alter existing portages or create otherwise hazardous conditions for watercraft passage, should provide adequate guide and warning signs and protection, if appropriate, along the waterway.

Additional information on watercraft traffic and navigable waters can be obtained through the Division of Watercraft, Ohio Department of Natural Resources.

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Section	Existing English Text	Proposed Metric Text
502.13	freeways having speed limits of 65 mph speed limit reduced to 55 mph. highways having speed limits of 55 mph shall be reduced to 45 mph. signs shall be placed 500 feet every mile for 55 mph zones every 1/2 mile for 45 mph zones.	freeways having speed limits of 100 - 110 km/h speed limit reduced to 90 km/h. highways having speed limits of 90 km/h shall be reduced to 70 km/h. signs shall be placed 150 meters every 1.5 kilometers for 90 km/h zones every 800 meters for 70 km/h zones.
502.14	minimum of 1.5 feet.	minimum of 0.5 meters.
502.16	traffic is to be maintained within 2 feet aggregate base placed 6" deep, specified for 2 feet beyond the edge	traffic is to be maintained within 0.6 meter aggregate base placed 150 millimeter, specified for 0.6 meter beyond the edge
502.21	it is recommended that the design speed not be less than 10 mph below the posted speed, minimum design speed being 25 mph. in increments of 10 mph or less.	that the design speed may be below, but within 20 km/h of, the posted speed, minimum design speed being 40 km/h. in increments of 20 km/h or less.
502.22	widths should not be less than 10 feet, existing facility are less than 10 feet. degree of horizontal curvature exceeds 10 degrees channelizing devices be less than 10 feet.	widths should not be less than 3.0 meters, existing facility are less than 3.0 meters. horizontal curve radius is less than or equal to 150 meters channelizing devices be less than 3.0 meters.
502.23	may be reduced by 12 feet, never be reduced to less than 2 feet.	may be reduced by 3.6 meters, never be reduced to less than 0.6 meter.
502.45	work area approximately 100' each way	work area approximately 30 meters each way
502.46	maintain 10.0 foot lane widths, where ramp curves exceeds 10 degrees.	maintain 3.0-meter lane widths, where ramp curves have a radius of less than 150 meters.
503.2	3 degree reverse curves 5 degree reverse curves. posted speed is reduced to 45 mph. limited to 0.0156 sloped toward	600-meter radius reverse curves 350-meter radius reverse curves. posted speed is reduced to 70 km/h. limited to 0.016 sloped toward
503.3	short length (2000 ft. or less), For longer projects (over 2000 ft.),	short length (0.5 kilometers or less), For longer projects (over 0.5 kilometers),
503.4	should be limited to 5 miles.	should be limited to 8 kilometers.
504.23	design speeds greater than 40 mph equal to or less than 40 mph.	design speeds greater than 70 km/h equal to or less than 70 km/h.

CHAPTER 500 - PAGE 2 OF 2

Section	Existing English Text	Proposed Metric Text
504.25	minimum guardrail offset of 1.5 feet For design speeds over 40 mph, guardrail offset of 6 feet	minimum guardrail offset of 0.5 meter For design speeds over 70 km/h, guardrail offset of 1.8 meters
504.26	equivalent 18-kip single axle loads	equivalent 18-kip single axle loads
505.2	design speed is 40 mph or less. edge of the traveled lane of 1.5'. lateral offset of less than 1.5'	design speed is 70 km/h or less. edge of the traveled lane of 0.5 meter. lateral offset of less than 0.5 meter

500 Maintenance of Traffic

List of Figures

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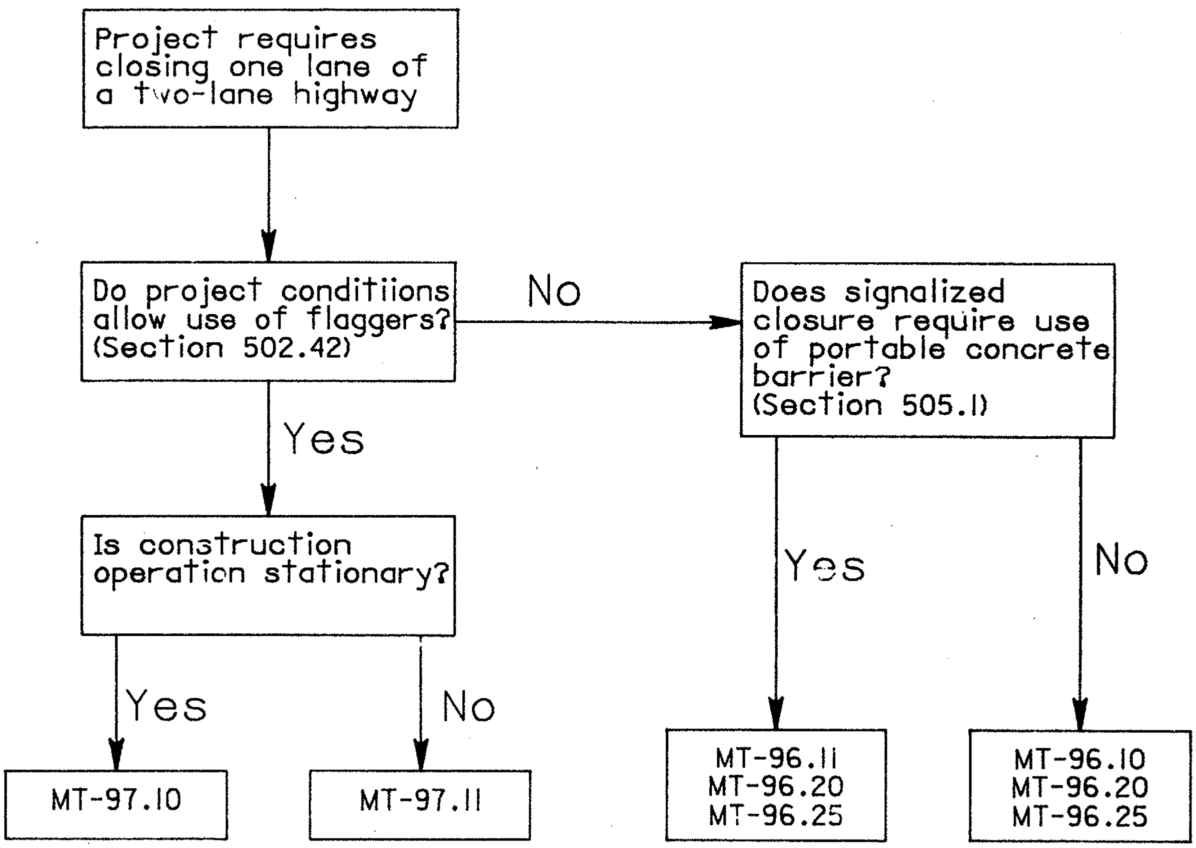
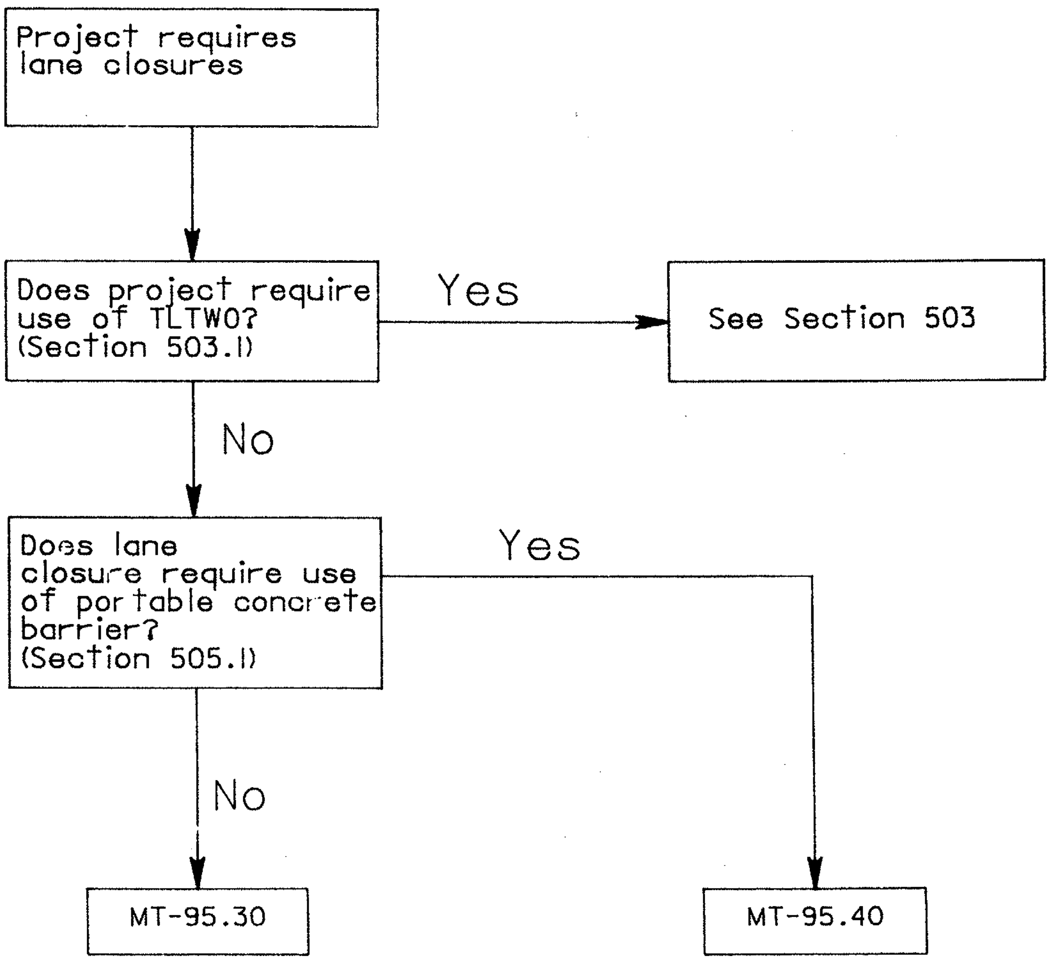
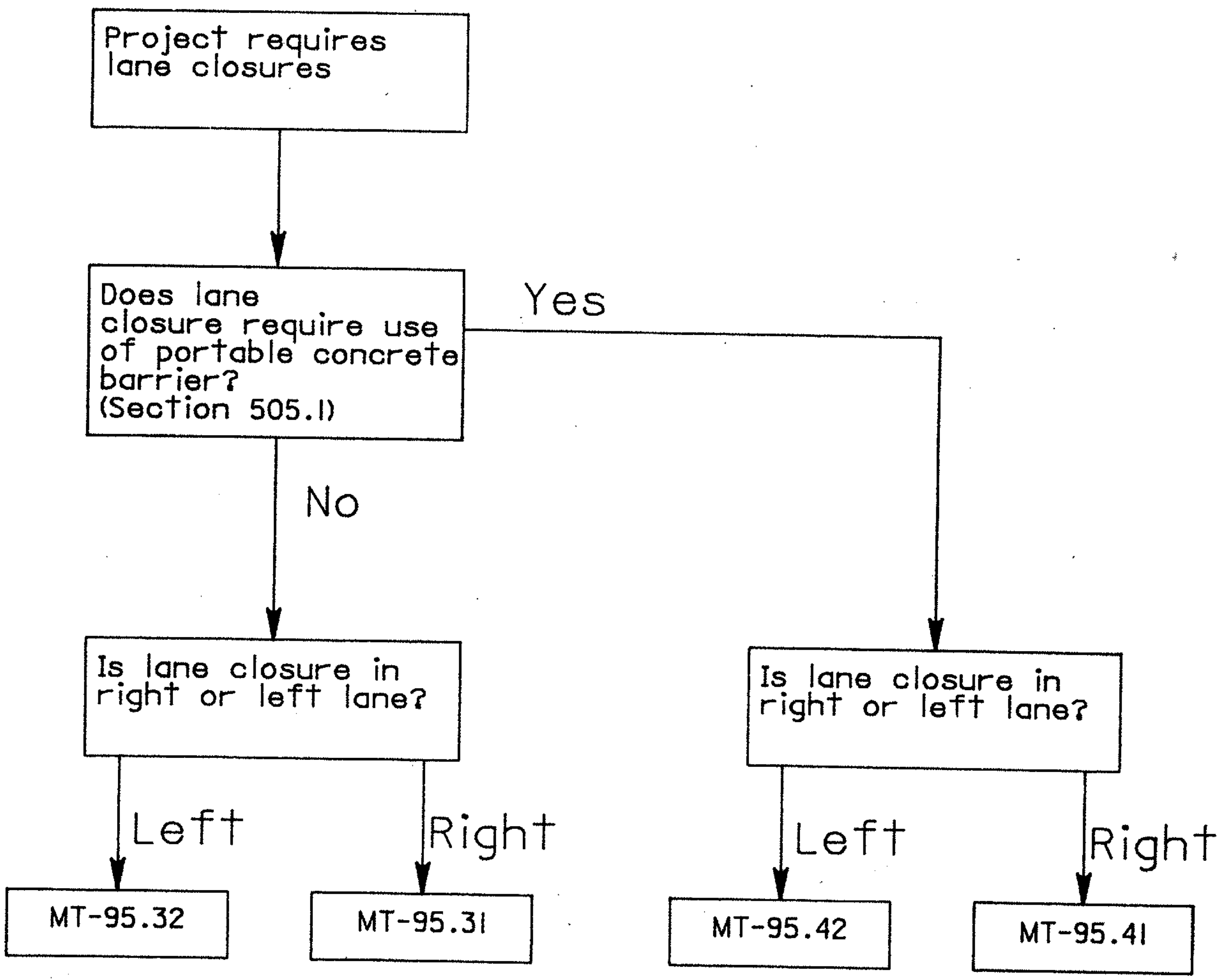
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A TWO-LANE HWY.	502-1
	REFERENCE SECTION 502.41,502.42



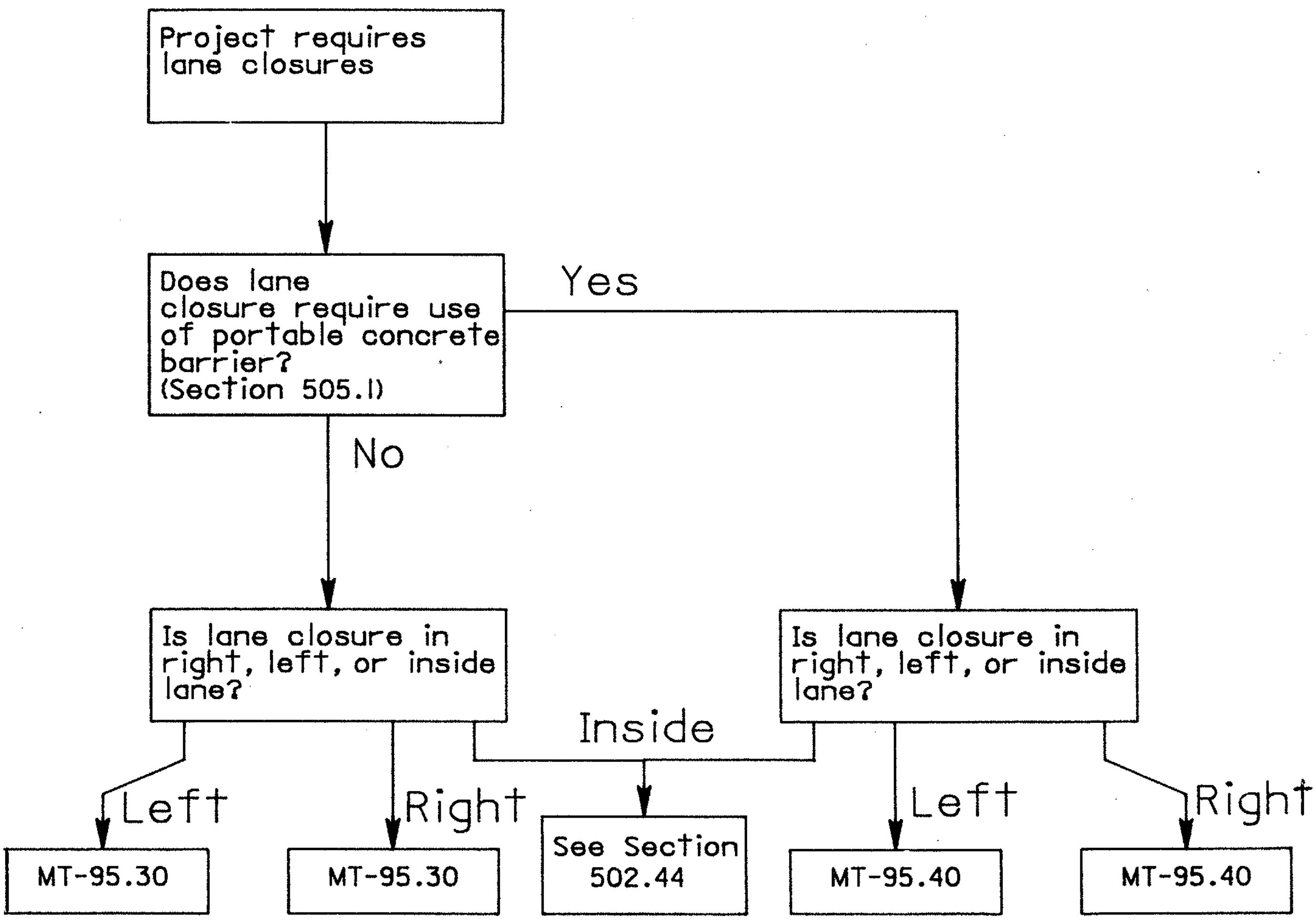
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A FOUR-LANE DIVIDED HIGHWAY	502-2
	REFERENCE SECTION 502.41



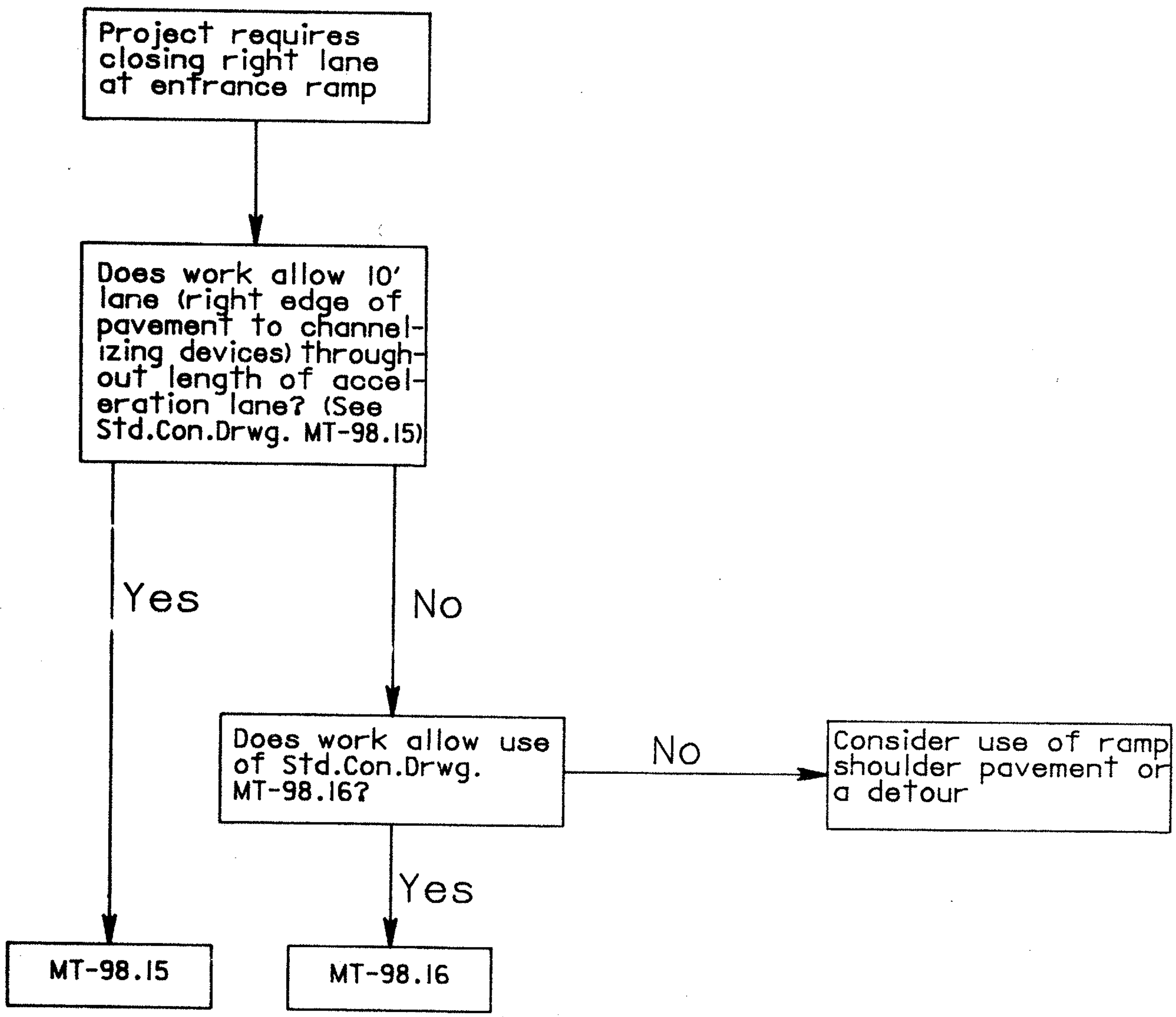
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A FOUR-LANE UNDIVIDED HIGHWAY	502-3
	REFERENCE SECTION 502.41



USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A SIX OR MORE LANE HIGHWAYS	502-4
	REFERENCE SECTION 502.41,502.44

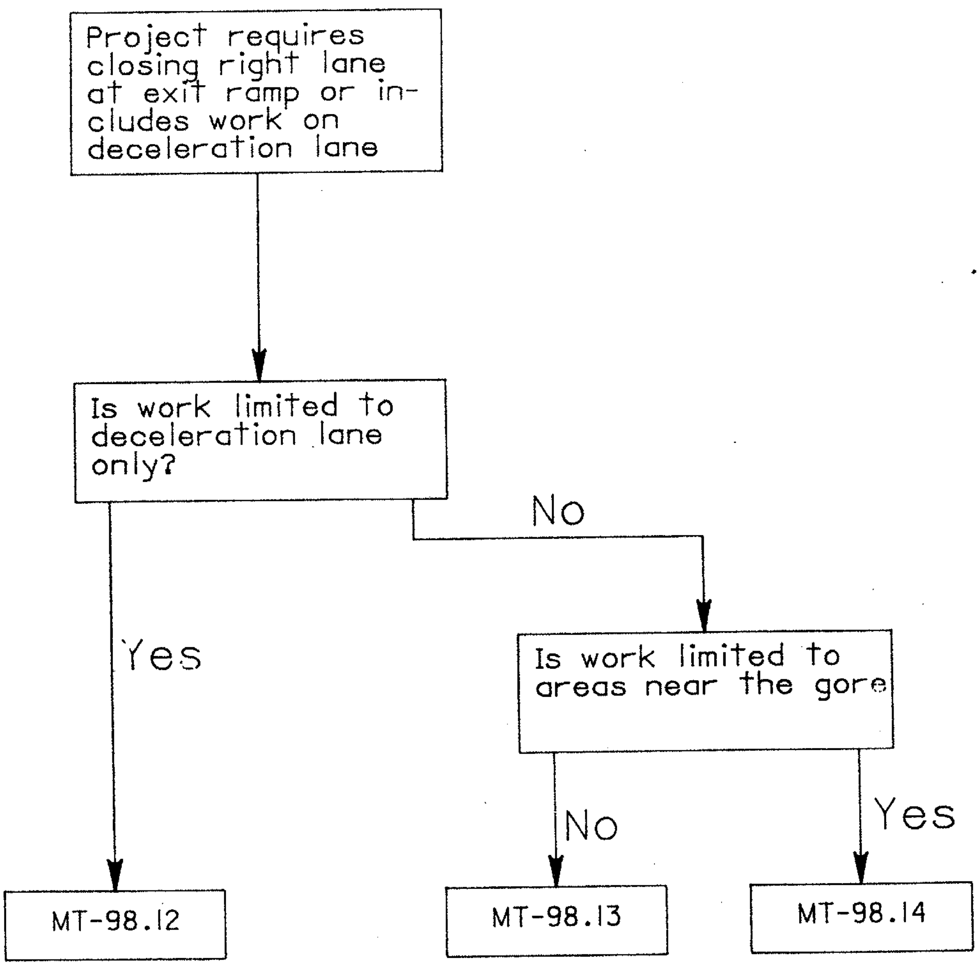


USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON ACCELERATION LANES	502-5
	REFERENCE SECTION 502.41

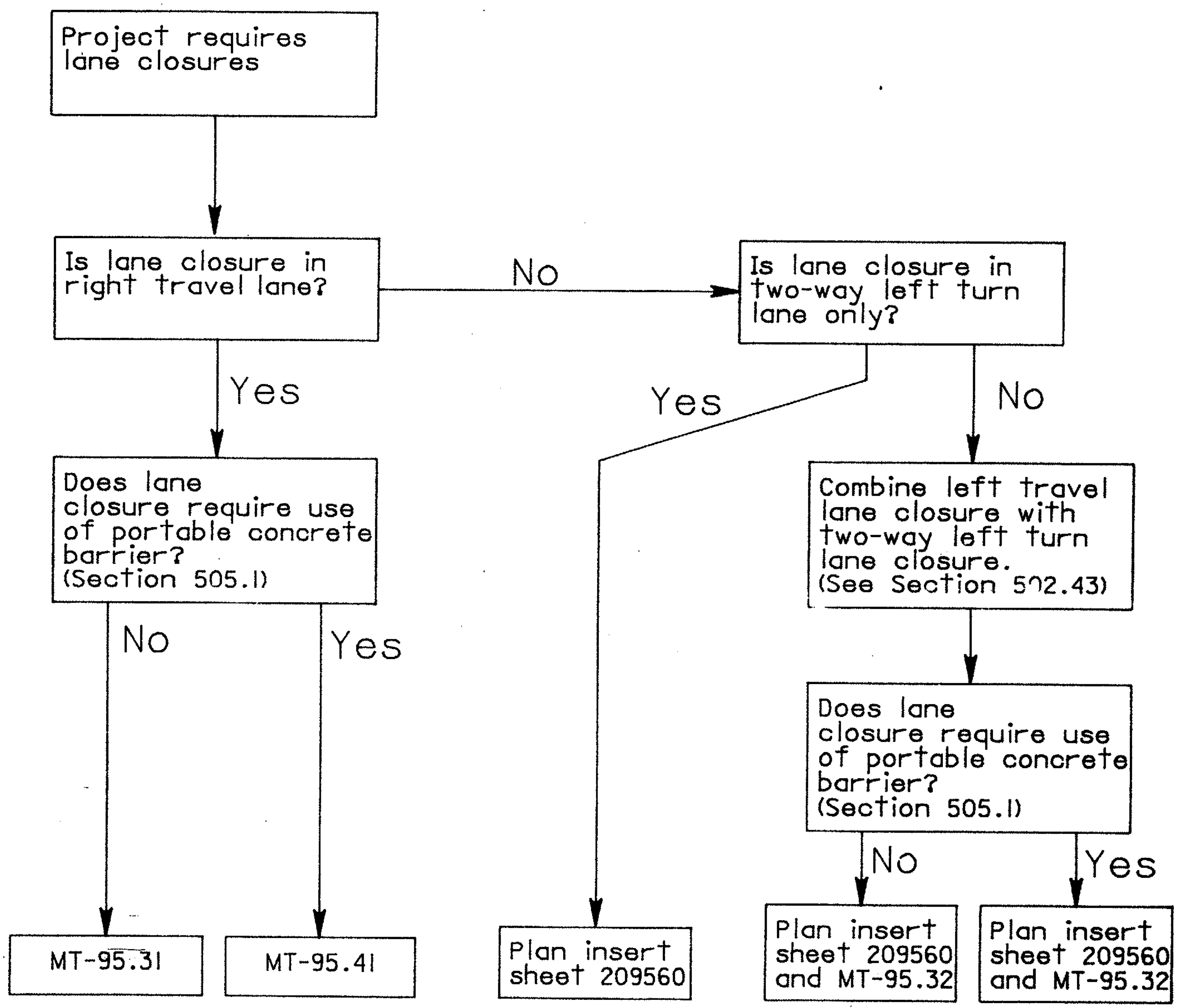


USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON DECELERATION LANES

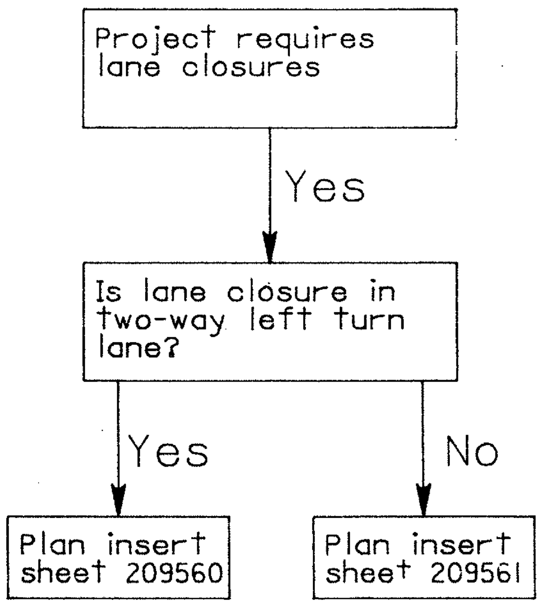
502-6
REFERENCE SECTION 502.41,502.42



USE OF STANDARD CONSTRUCTION DRAWINGS AND PLAN INSERT SHEETS FOR MAINTAINING TRAFFIC ON A FIVE-LANE HWY.	502-7
	REFERENCE SECTION 502.41,502.43



USE OF INSERT SHEETS FOR MAINTAINING TRAFFIC ON A THREE-LANE HWY.	502-8
	REFERENCE SECTION 502.41



MINIMUM PAVEMENT WIDTHS FOR MAINTAINING TRAFFIC ON CURVES WHERE $D_c > 10°$	502-9
	REFERENCE SECTION 502.22, 502.46

Note: Widths shown in excess of 10′ are based on the width of wheel track plus a 1.5′ allowance for maneuverability. Minimum barrier offset in addition to the widths shown is 1.5′. Values marked by an asterisk (*) are those situations where minimum barrier clearance cannot be waived.

	Predominant Traffic Type △		
Radius	Type A	Type B	Type C
>500′	10′	10′	10′
500′	10′	10.5′ *	11.5′ *
300′	10′	11.0′ *	12.5′ *
200′	10′	11.5′ *	13.5′ *
150′	10′*	12.0′ *	14.5′ *
100′	10′*	13.5′ *	17.0′ *

△ Type A - Passenger Cars govern design

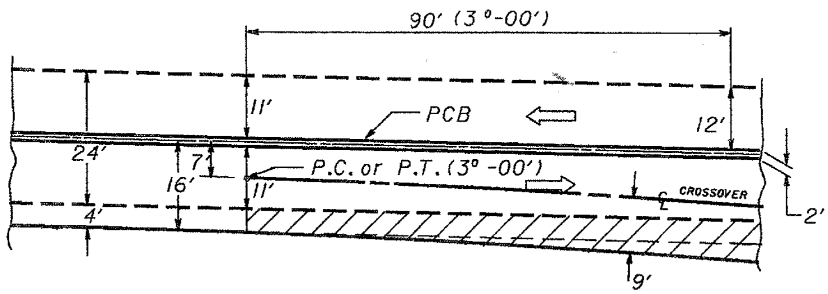
Type B - Single Unit trucks govern design

Type C - Semitrailer vehicles (WB-50) govern design. Larger units may need to be re-routed if their required width cannot be accommodated.

CROSSOVER DESIGN DETAILS

503-1

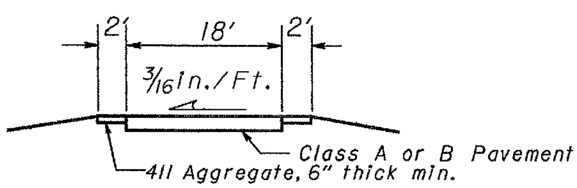
REFERENCE SECTION 503.2



DETAIL A

End of two way operation shown.
Beginning of two way operation opposite hand.

Temporary Pavement

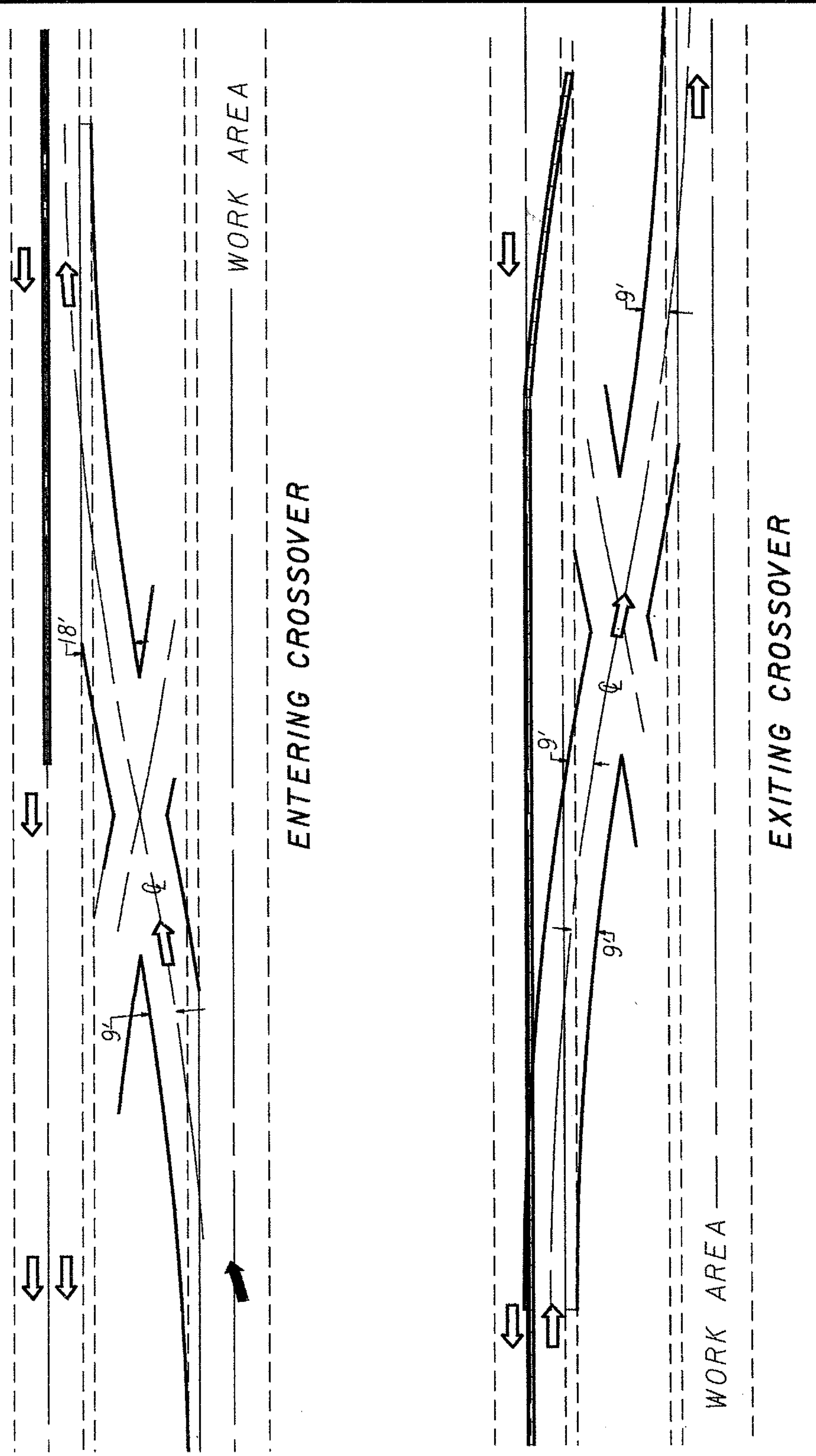


TYPICAL SECTION

		Median Width			
		84′	60′	50′	40′
Dc=3°	Δ	12°-44′-15″	10°-59′-09″	10°-10′-07″	9°-16′-51″
	L	424.58′	366.20′	338.96′	309.36′
	T	213.17′	183.66′	169.93′	155.02′
Dc=5°	Δ	16°-28′-00″	14°-11′-50″	13°-08′-22″	11°-59′-24″
	L	329.33′	283.95′	262.79′	239.80′
	T	165.81′	142.70′	131.97′	120.34′

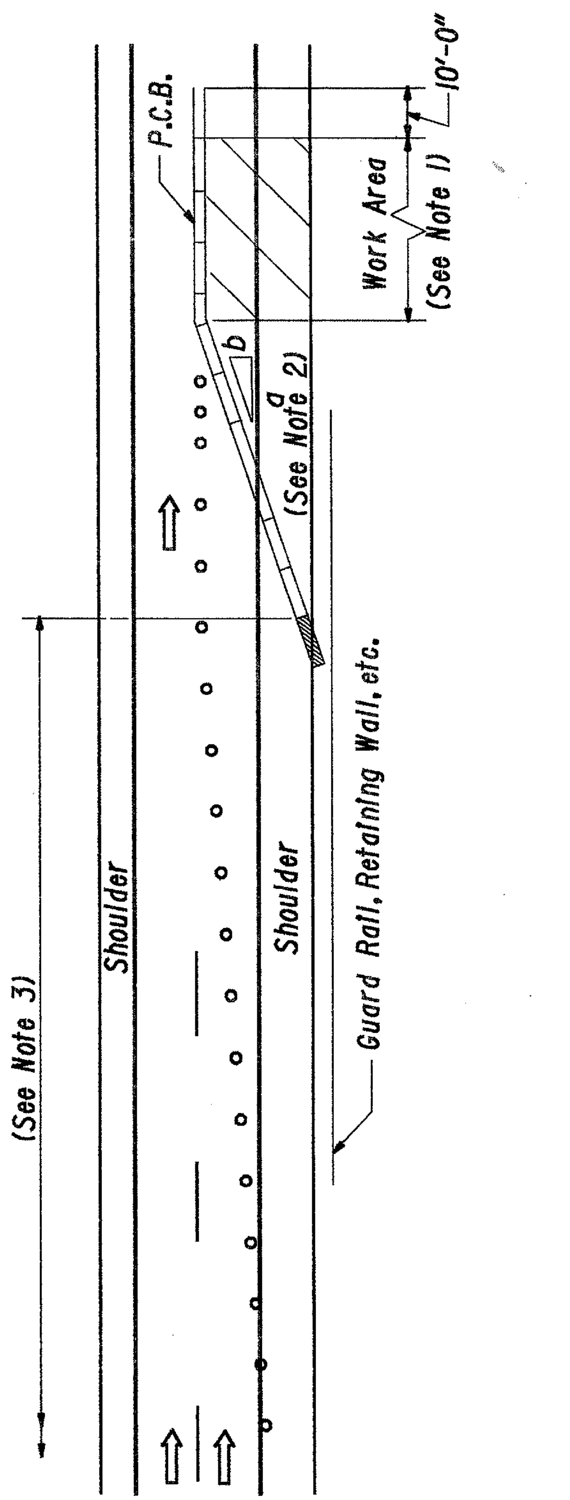
The recommended design is 3°; an alternate 5° design is provided for limited use where physical restrictions prevent using a 3° design in urban areas. Posted speed shall be 45 mph for 5° designs.

CROSSOVER DESIGN PLAN VIEW	503-2
	REFERENCE SECTION 503.2



NOTES:
1.- The minimum pavement width throughout the crossover is 18'
2.- A 2'-0" aggregate shoulder should be provided
3.- See Figure 503-1 for additional details.

PORTABLE CONCRETE BARRIER INSTALLATION WITH ADVANCE LANE CLOSURE ON FOUR-LANE DIVIDED-HIGHWAY	**505-1**
	REFERENCE SECTION
	505.3



10' Tapered End Section

o o o Drums

NOTES:

1. The "Work Area" is defined to include areas where heavy equipement or materials are stored.
2. For P.C.B. taper rates see Figure 601-7
3. The advance lane closure (drum tapers, signing, etc.) shall be as per Std. Const. Drwg. MC-95.30

Exhibit 1028
IPR2018-01202

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List of Metric Figures

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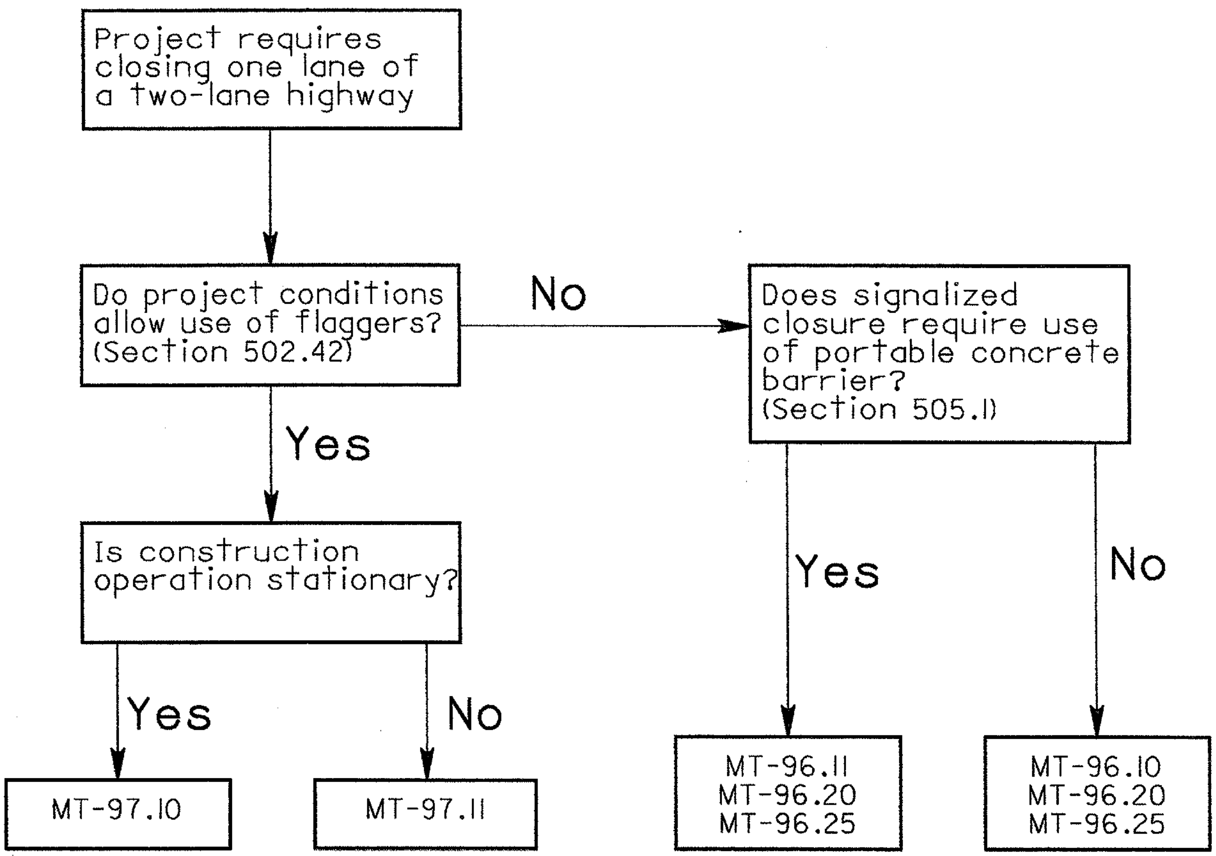
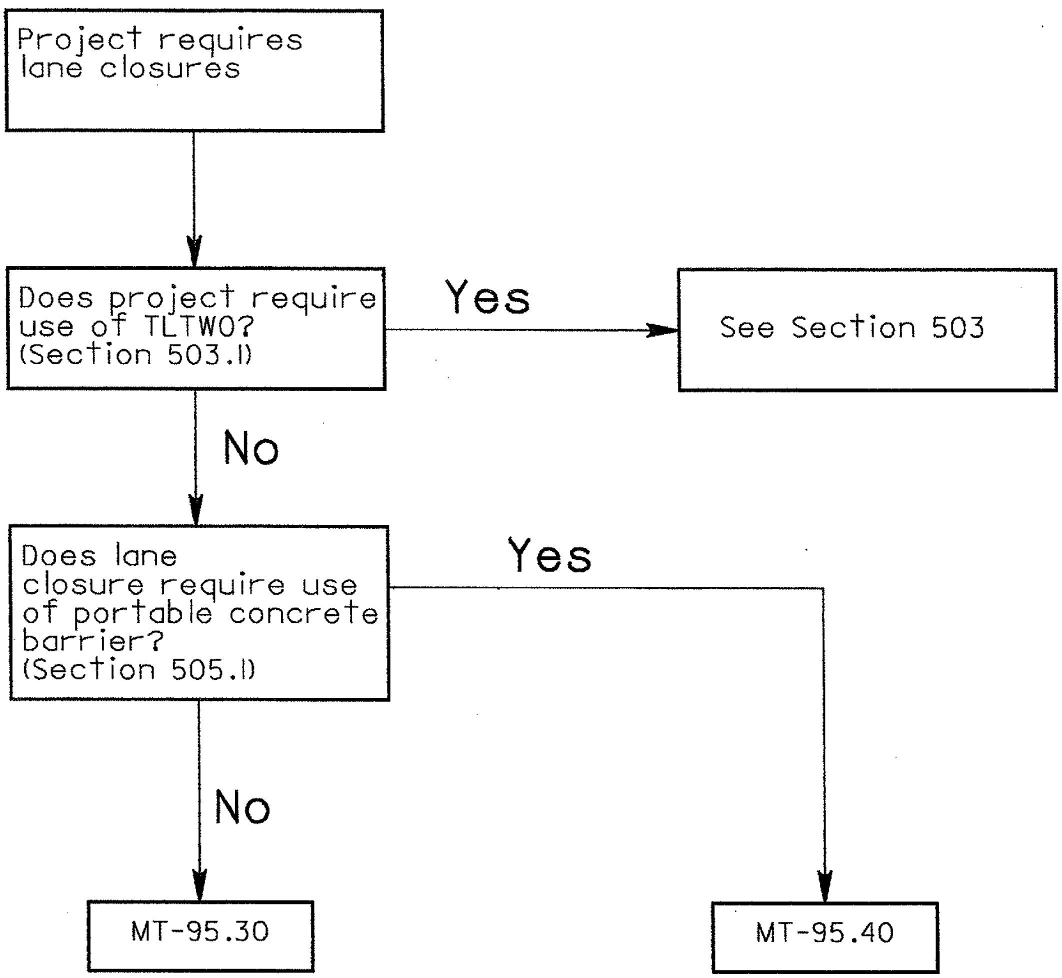
	REFERENCE SECTION
	502.41,502.42



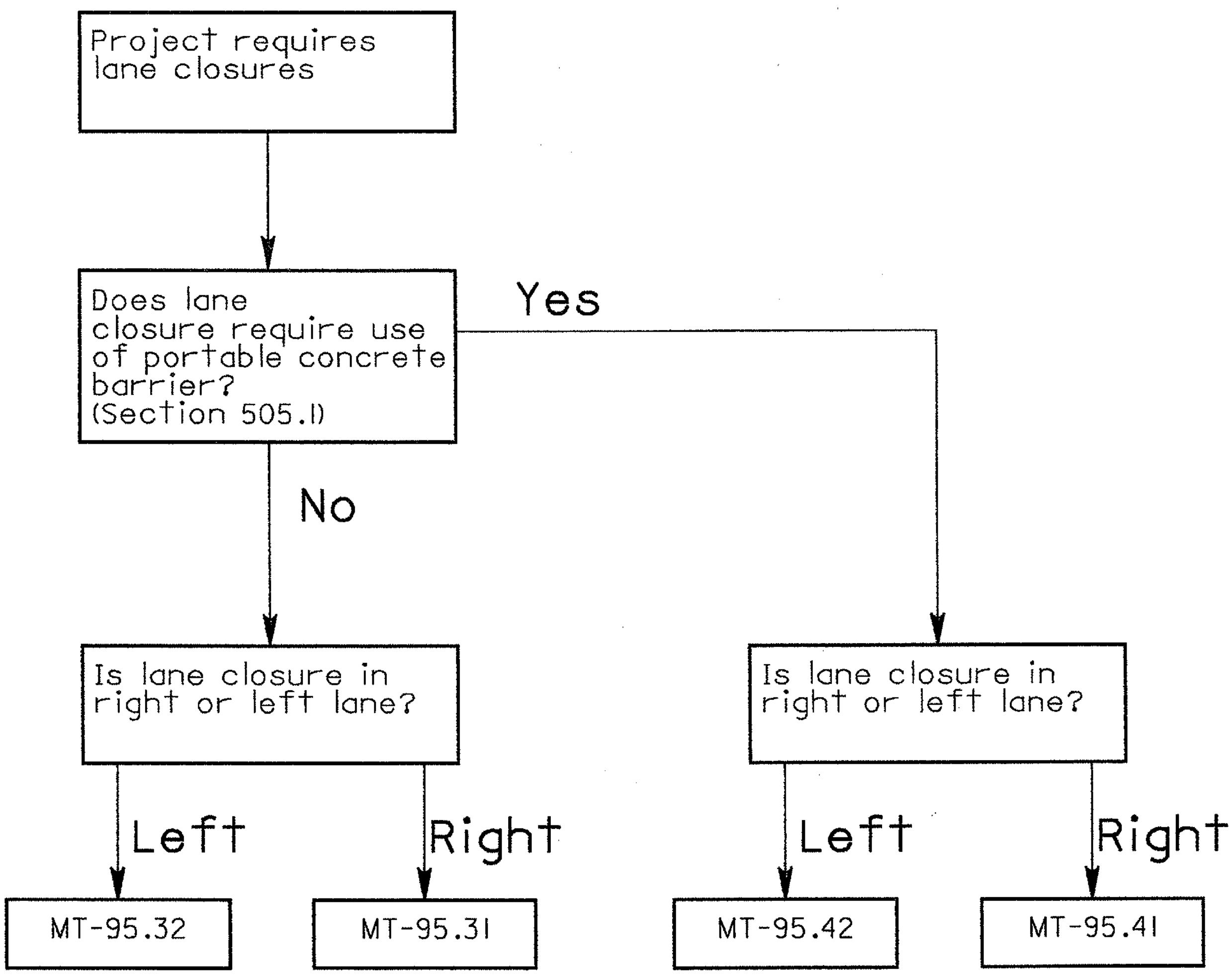
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A FOUR-LANE DIVIDED HIGHWAY

502-2

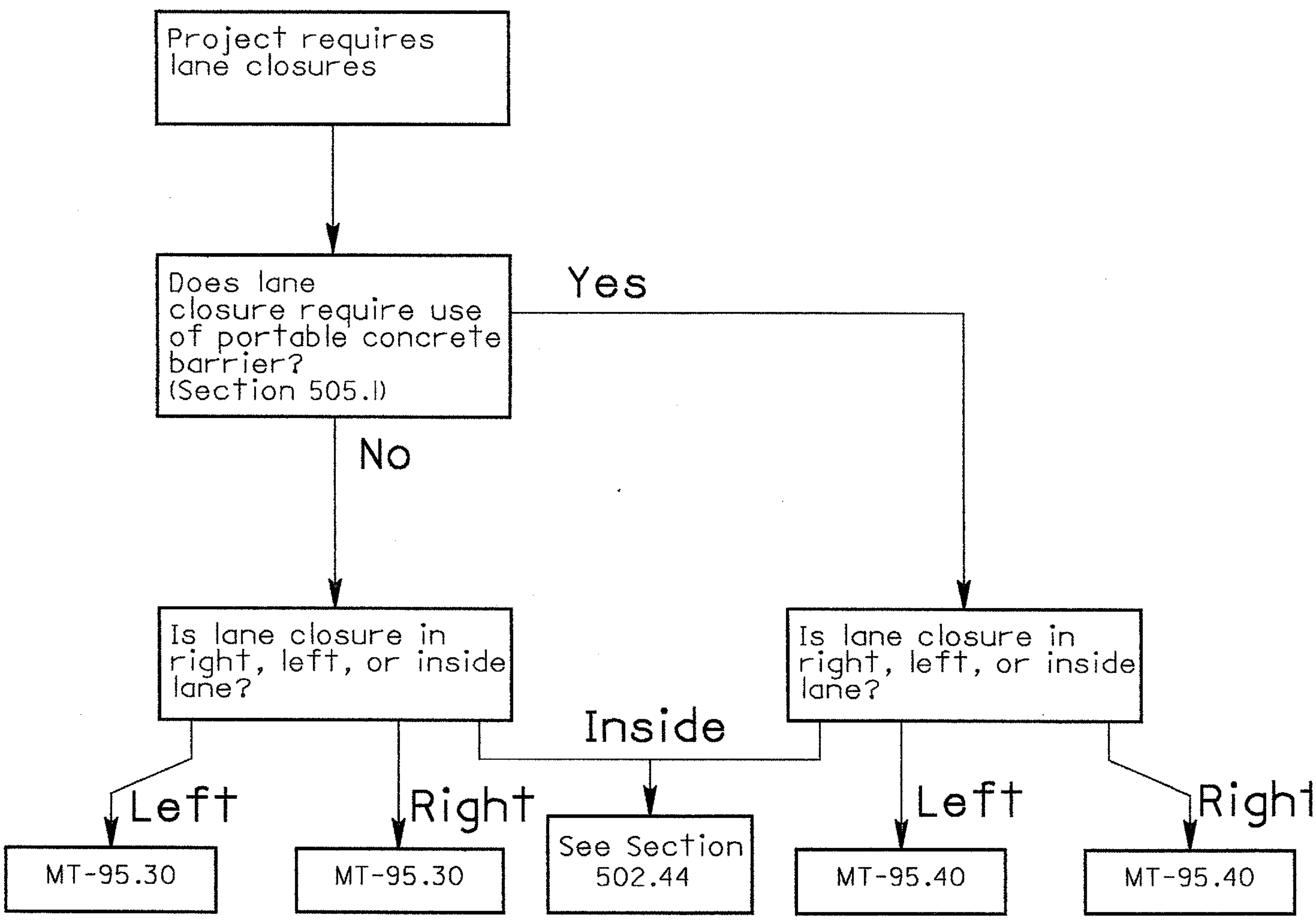
REFERENCE SECTION **502.41**



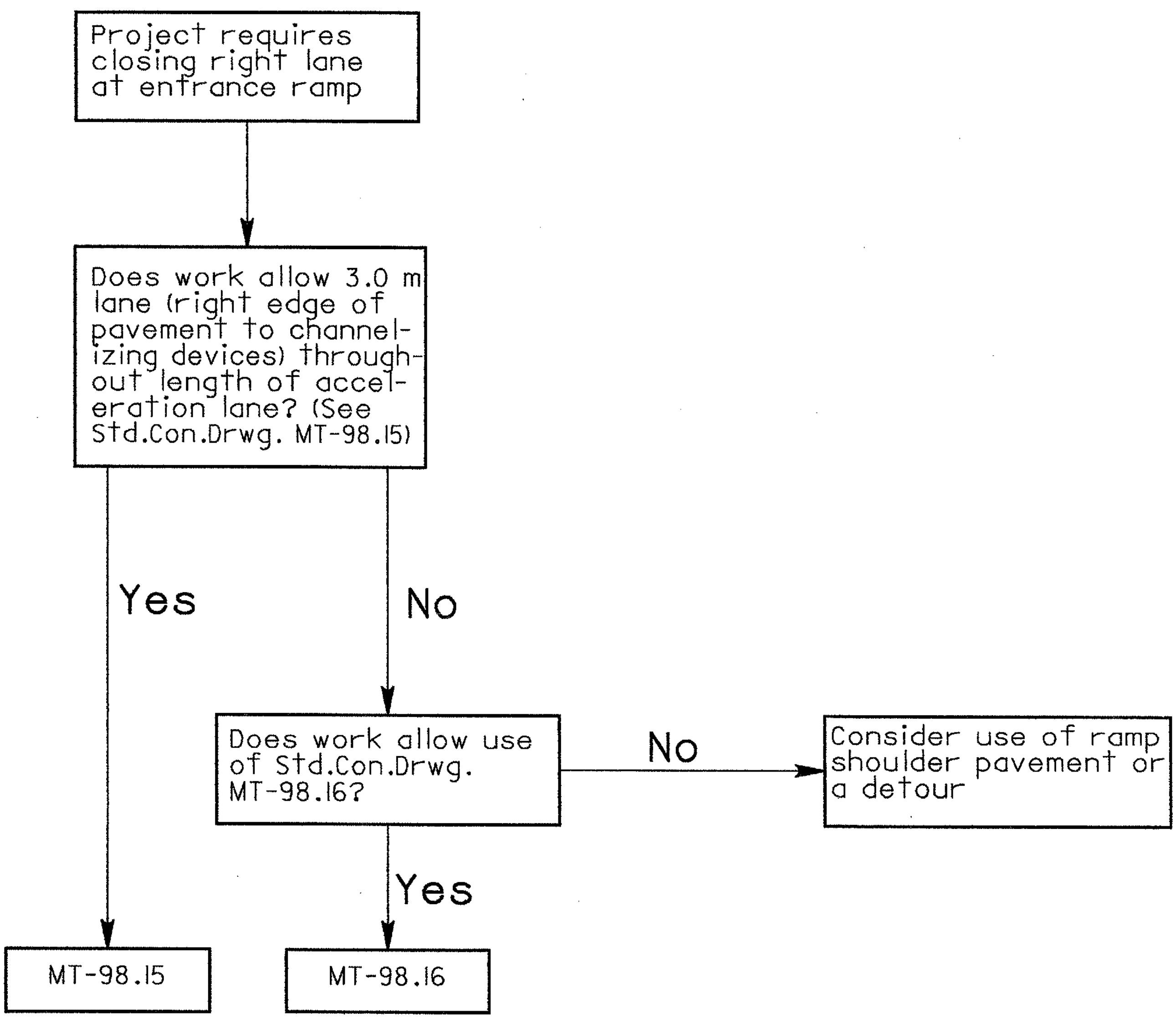
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A FOUR-LANE UNDIVIDED HIGHWAY	502-3
	REFERENCE SECTION 502.41



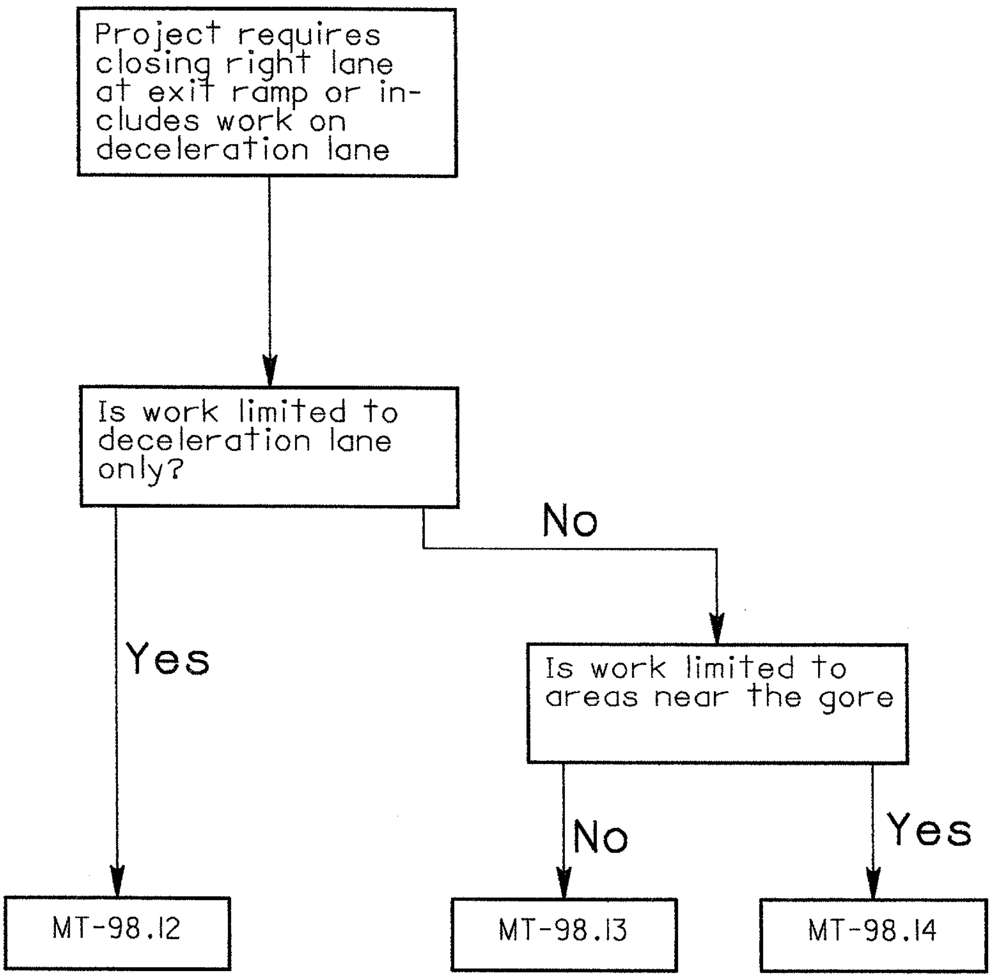
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON A SIX OR MORE LANE HIGHWAYS	502-4
	REFERENCE SECTION
	502.41,502.44



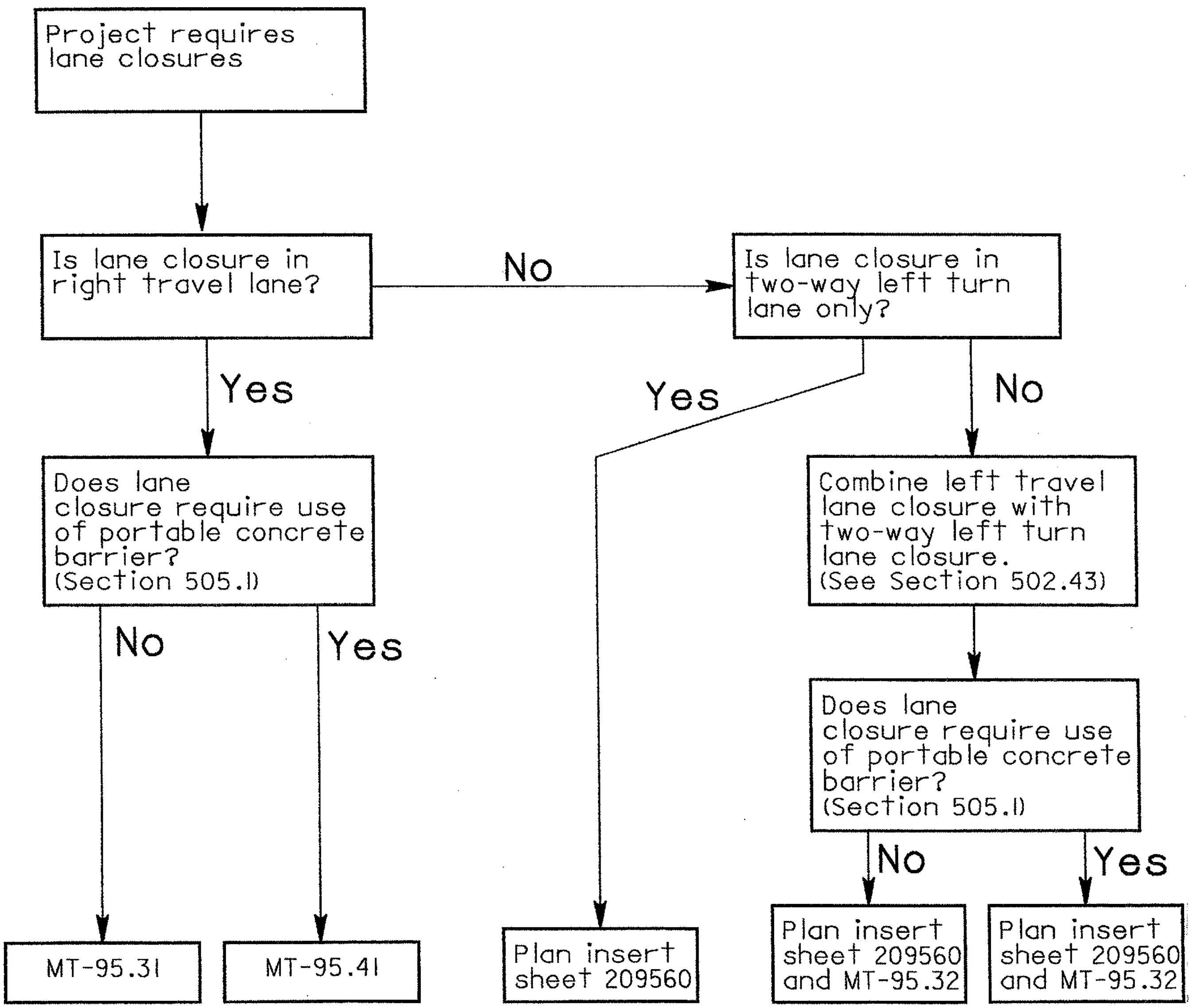
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON ACCELERATION LANES	502-5
	REFERENCE SECTION 502.41



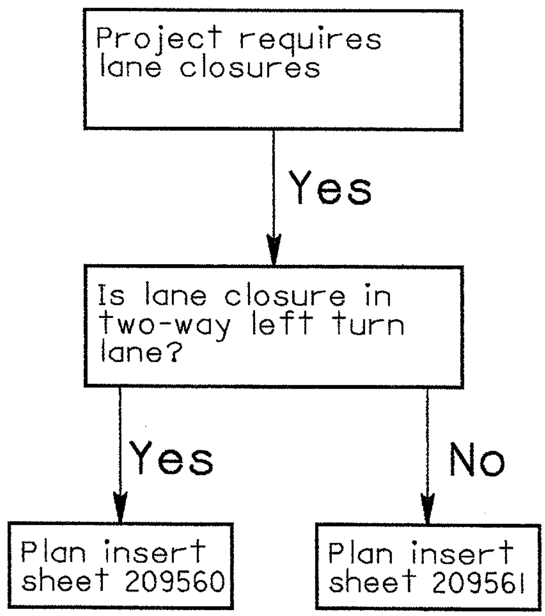
USE OF STANDARD CONSTRUCTION DRAWINGS FOR MAINTAINING TRAFFIC ON DECELERATION LANES	502-6
	REFERENCE SECTION
	502.41,502.42



USE OF STANDARD CONSTRUCTION DRAWINGS AND PLAN INSERT SHEETS FOR MAINTAINING TRAFFIC ON A FIVE-LANE HWY.	502-7
	REFERENCE SECTION
	502.41,502.43



USE OF INSERT SHEETS FOR MAINTAINING TRAFFIC ON A THREE-LANE HWY.	502-8
	REFERENCE SECTION 502.41



MINIMUM PAVEMENT WIDTHS FOR MAINTAINING TRAFFIC ON CURVES WHERE RADIUS ≤ 150 m

502-9

REFERENCE SECTION
502.22, 502.46

Note: Minimum widths shown in excess of 3.0 m are based on the width of wheel track plus a 0.45 m allowance for maneuverability. Minimum barrier offset in addition to the widths shown is 0.5 m. Values marked by an asterisk (*) are those situations where minimum barrier clearance cannot be waived.

	Traffic Condition▲		
Radius	Type A	Type B	Type C
>150 m	3.0 m	3.0 m	3.0 m
150 m	3.0 m	3.15 m*	3.45 m*
90 m	3.0 m	3.3 m*	3.75 m*
60 m	3.0 m	3.45 m*	4.05 m*
45 m	3.0 m*	3.6 m*	4.35 m*
30 m	3.0 m*	4.05 m*	5.1 m*

▲ Type A - Passenger Cars govern design

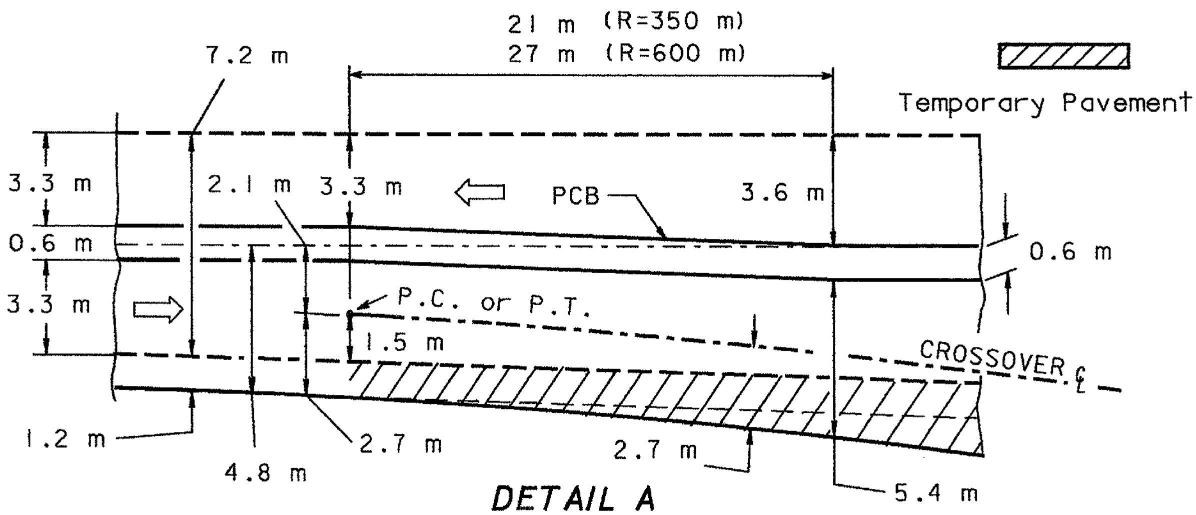
Type B - Single Unit trucks govern design

Type C - Semitrailer vehicles (WB-50) govern design. Larger units may need to be re-routed if their required width cannot be accommodated.

CROSSOVER DESIGN DETAILS

503-1

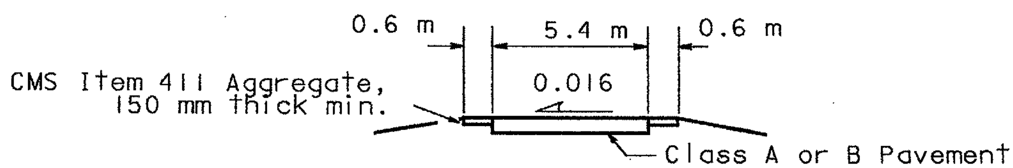
REFERENCE SECTION 503.2



DETAIL A

(Not to scale)

End of two way operation shown.
Beginning of two way operation opposite hand.



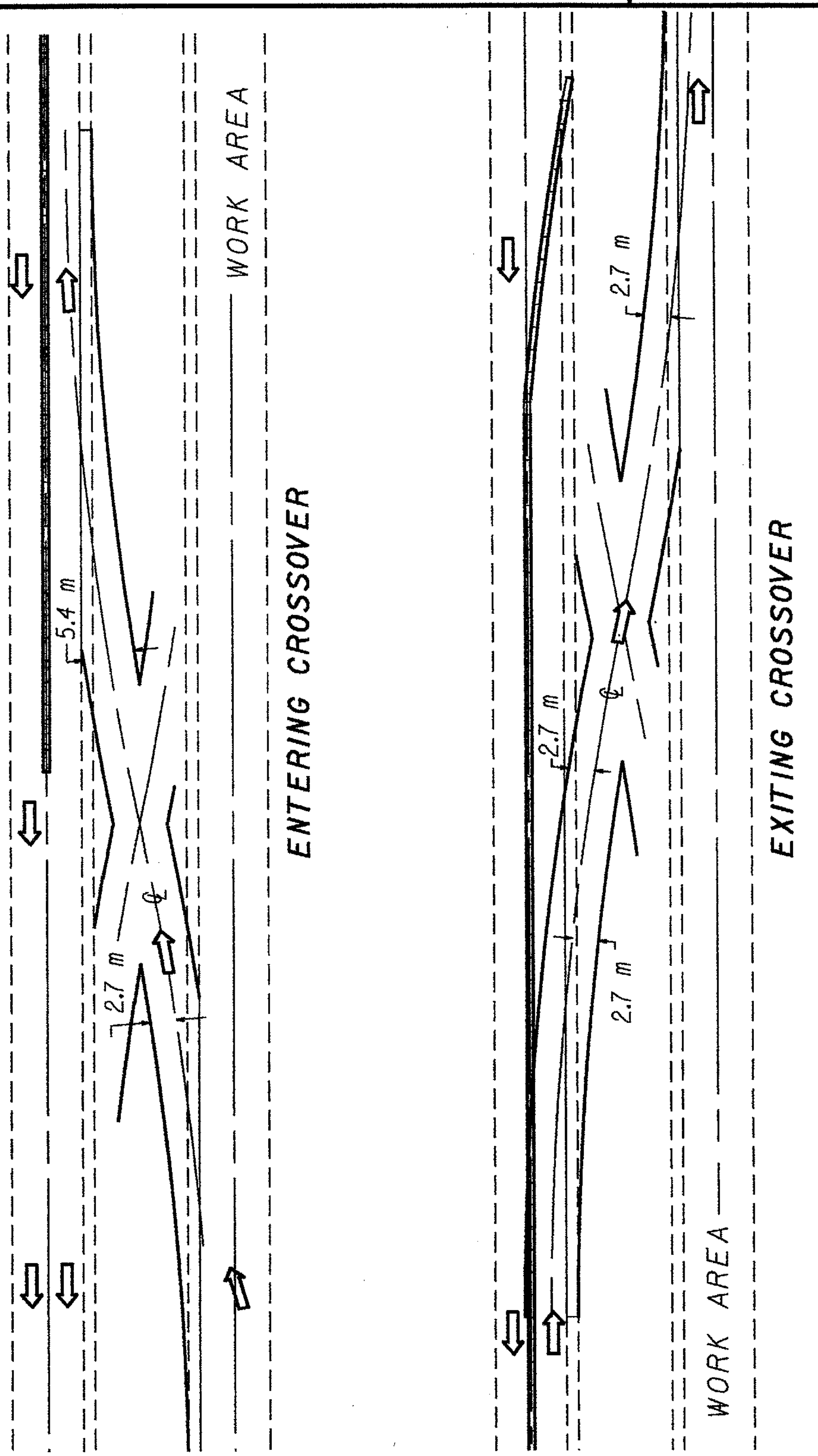
TYPICAL SECTION

		Existing Median Width			
		25.6 m (84 ft.)	18.3 m (60 ft.)	15.2 m (50 ft.)	12.2 m (40 ft.)
R=600 m	Δ	12°-32′-06″	10°-48′-30″	10°-00′-09″	9°-07′-36″
	L	131.27 m	113.18 m	104.75 m	95.47 m
	T	65.90 m	56.76 m	52.51 m	47.89 m
R=350 m	Δ	16°-26′-08″	14°-09′-59″	13°-06′-30″	11°-57′-31″
	L	100.40 m	86.54 m	80.07 m	73.05 m
	T	50.55 m	43.49 m	40.21 m	36.66 m

		Median Width			
		25 m	18 m	15 m	12 m
R=600 m	Δ	12°-24′-05″	10°-44′-05″	9°-56′-11″	9°-04′-07″
	L	129.87 m	112.41 m	104.05 m	94.97 m
	T	65.19 m	56.37 m	52.16 m	47.58 m
R=350 m	Δ	16°-15′-37″	14°-04′-12″	13°-01′-17″	11°-52′-57″
	L	99.33 m	85.95 m	79.54 m	72.59 m
	T	50.00 m	43.19 m	39.94 m	36.42 m

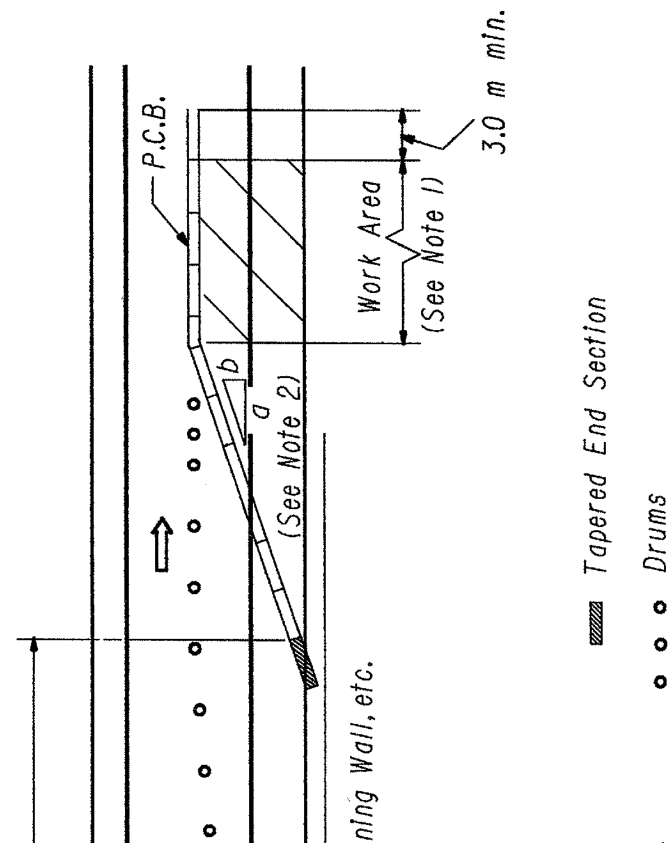
The recommended Radius is 600 m; an alternate R of 350 m is provided for limited use where physical restrictions prevent using R=600 m design in urban areas. Posted speed shall be 70 km/h for R=350 m designs.

CROSSOVER DESIGN PLAN VIEW	503-2
	REFERENCE SECTION 503.2



NOTES:
1. - The minimum pavement width throughout the crossover is 5.4 m.
2. - A 0.6 m aggregate shoulder should be provided.
3. - See Figure 503-1 for additional details.

PORTABLE CONCRETE BARRIER INSTALLATION WITH ADVANCE LANE CLOSURE ON FOUR-LANE DIVIDED-HIGHWAY	505-1
	REFERENCE SECTION 505.3



NOTES:

1. The "Work Area" is defined to include areas where heavy equipement or materials are stored.
2. For P.C.B. taper rates see Figure 601-7
3. The advance lane closure (drum tapers, signing, etc.) shall be as per Std. Const. Drwg. MC-95.30

600 Roadside Design

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600 Roadside Design

600.1 Introduction

This chapter discusses concepts related to roadside safety features that can prevent the occurrence of run-off-the-road accidents and reduce the severity of impact when such an incident does occur. The **1996 AASHTO Roadside Design Guide** contains additional information on roadside design.

Safety devices are themselves fixed objects, and while they may decrease crash severity, they may also increase the total number of impacts. The potential for impacts can be reduced by placing the safety device as close to the shielded object (and as far from the roadway) as permitted by the following standards.

600.2 Clear Zone

Clear Zone refers to the desirable unobstructed area along a roadway, outside the edge of pavement, available for the safe recovery of vehicles that have left the traveled way. Within this area, most motorists will be able to safely regain control of their vehicle. Ideally, there should be no obstructions within the clear zone; however, if an obstruction cannot be removed, then engineering judgement must be used to determine how to treat it.

The ultimate goal on new or reconstructed highways is to eliminate all features that may warrant shielding, such as fixed and non-traversable objects, by using good design practices. On other projects, when a warranting feature cannot be removed, the clear zone distances given in ***Figure 600-1***, may be used as minimum values. These minimum values should not erroneously be interpreted as permitting or encouraging the construction of potential hazards immediately outside the clear zone at what may be deemed a "safe" distance from the edge of the roadway.

Figure 600-1 contains recommended clear zone widths based on design speed, traffic volume, and the combination of foreslopes and backslopes on the typical cross section for the roadway. The clear zone width should be increased if a site investigation indicates that doing so would significantly lessen the potential for accidents. For example, if an obstruction exists just outside the required clear zone in an otherwise obstruction-free area, it should be considered for removal or protection.

For areas with a history of run-off-the-road accidents on the outside of curves with a Dc of 2°-00' or greater [radius of 900 m or smaller], ***Figure 600-1*** also provides a table of adjustment factors based on design speed that should be used to extend the clear zone. In these cases, the designer should ensure that the roadway has proper superelevation before evaluating the curve's effect on the clear zone.

The preferred order of corrective treatment for fixed objects and non-traversable hazards located within the clear zone is as follows:

1. Remove the object or redesign it so that it can be safely traversed.

2. Relocate the object outside the clear zone so that it no longer presents a hazard to motorists.

3. Redesign the object to minimize the potential hazard (e.g., install breakaway devices).

4. Shield the object with a longitudinal barrier or impact attenuator. A barrier should only be installed, however, if the impact resulting from a vehicle striking the barrier will be less severe than an impact with the unshielded object. (See ***Section 601*** for the preferred order of roadside protection.)

5. Delineate the hazard if none of the above options can be implemented.

The overall intent of roadside design is to strive for a forgiving highway. Designing a project exclusively to meet minimum clear zone values may result in a roadside that is not as safe as it could be. On the other hand, the cost of clearing some roadsides may greatly exceed the associated benefits to the traveling public. The optimum solution lies in the judicious application of engineering judgement coupled with a sincere desire to produce safe roadways.

600.2.1 Parallel Embankment Slopes & Ditches

Embankment slopes parallel to the roadway fall into the following categories:

1. Recoverable Slopes - Slopes on which encroaching motorists can generally stop their vehicles or slow down enough to return safely to the roadway. Slopes 4:1 or flatter are considered recoverable.

2. Non-recoverable Slopes - Slopes which may be safely negotiated but are generally too steep for most motorists to stop their vehicles or to return easily to the roadway. Slopes steeper than 4:1 up to and including 3:1 are considered traversable but non-recoverable if they are smooth and free of fixed-object hazards. Since a high percentage of encroaching vehicles will reach the toe of these slopes, a clear runout area at the toe is desirable.

3. Critical Slopes - Slopes steeper than 3:1 on which vehicles are likely to overturn.

Backslopes tend to slow an errant vehicle and are therefore not as critical as foreslopes. They may, under certain conditions, be as steep as 1:1.

Roadside ditches are generally categorized as traversable or non-traversable. ***Figures 307-10 and 307-11*** present preferred designs for ditches with gradual and abrupt slope changes, respectively. Ditches that fall within the shaded areas of these figures are considered traversable and are preferred for use within the clear zone. Ditch sections that fall outside the shaded areas are considered non-traversable and should generally be located outside the clear zone. There are certain conditions, however, under which these sections may be considered for use within the clear zone. 3R projects; projects with limited right-of-way or rugged terrain; and low volume or low speed roads (particularly if the channel bottom and backslopes are free of any fixed objects) may utilize non-traversable ditch sections when traversable ditches are impractical.

In determining a clear zone width, only recoverable foreslopes (4:1 or flatter), traversable ditches, and backslopes 3:1 or flatter may be included. The recovery area includes the clear zone width plus any non-recoverable slope (over 4:1 through 3:1). These relationships are shown in ***Figure 600-2***.

Several examples of clear zone calculations are included after the figures.

600.2.2 Clear Zone on Low Speed Urban Streets

On curbed urban streets where the design speed is 40 mph [70 km/hr] or less, the clearance from the face of curb to an obstruction such as a utility pole, lighting pole or fire hydrant, should be a minimum of 1.5 feet [0.5 m].

601 Warrants

601.1 Roadside Barrier Warrants

A roadside barrier is a longitudinal barrier used to shield motorists from natural or man-made obstacles located on the roadside within the clear zone where impacts are expected on one side of the barrier only. In addition to shielding the motorist from roadside obstacles, some type of roadside barrier is normally required where foreslopes are excessive, and occasionally for the protection of others from vehicular traffic.

601.1.1 Obstacles

Roadside obstacles may be fixed objects or non-traversable terrain.

Roadside obstacles located within the clear zone area may or may not require barrier protection.

Barriers should be considered in the following circumstances:

1. At bridges, piers and abutments.
2. At culverts, pipes and headwalls depending on traffic volumes, and the culvert's size, location and end treatment. (See ***Section 602.6*** for additional details.)
3. At non-breakaway sign and light supports.
4. At rough slopes in cut sections.
5. At utility poles that cannot justifiably be relocated.
6. At bodies of water where the normal depth exceeds one foot [300 mm] depending on the location and likelihood of encroachment.
7. At transverse ditches if the likelihood of a head-on impact is high.
8. At retaining walls if the anticipated maximum angle of impact is 15 degrees. (Estimating an encroaching vehicle's angle of impact is usually done using engineering judgement. In general, higher angles of impact are expected on the outside of curves and at locations where items are flared relative to the roadway.)

Accident experience, either at the site or at a comparable site, will often be the deciding factor with respect to the placement or omission of a barrier. In all cases, the preferred alternative is to keep the entire clear zone free of fixed objects wherever economically feasible.

601.1.2 Slopes

Embankment height and steepness of foreslopes are the basic factors to be considered in determining the need for barrier slope protection. ***Figure 601-1*** should be used to determine roadside barrier warrants for embankments.

601.1.3 Protection of Others

Barriers are sometimes required to protect others (schools, residences, businesses, pedestrians, bicyclists, etc.) from vehicular traffic. Barrier criteria for protection of others from errant vehicles are not as defined as in other barrier warrant cases. Such decisions are normally made using accident experience, either at the site or at comparable locations along with engineering judgement.

601.1.4 Protection on Low Speed Roadways

Barrier protection on city streets and urban type facilities with design speeds of 40 mph [70 km/h] or less is not normally required. However, the designer should specify protection at locations where poor geometric conditions, accident experience or other circumstances indicate that protection may be warranted.

601.2 Median Barrier Warrants

A median barrier is a longitudinal barrier used to separate opposing traffic on a divided highway, where impacts are expected on both sides of the barrier. ***Figure 601-2*** may be used to determine the need for median barriers, which is based on the width of the median and the volume of traffic on the facility. A median barrier may be either Type 5 Barrier Design guardrail or concrete barrier. If the median is wide enough so that the barrier is not likely to be impacted on the opposite side, i.e. it is outside the clear zone of opposing traffic, then roadside barrier warrants should be used.

601.3 NHS Criteria

Highway safety features, including longitudinal barriers, anchor assemblies, bridge terminal assemblies and impact attenuators, installed on the National Highway System (NHS) must demonstrate satisfactory crash worthy performance to be accepted by the **FHWA**. **National Cooperative Highway Research**

Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* is the safety criteria currently used to evaluate these features.

A given feature must be tested to one of six different test levels defined in Report 350. In general, all permanent devices installed on the NHS in Ohio must meet TL-3 requirements. TL-3 devices are tested with an 1800 lb [820C] passenger car and a 4409 lb [2000P] pickup truck traveling at 62.1 mph [100 km/h] with impact angles ranging from 0 - 25 degrees.

Devices in ***Section 603*** designated for use on any roadway are acceptable on the NHS. Devices that are permitted on non-NHS roadways but are not approved for use on the NHS are specifically identified.

602 Site Considerations

Standards and guidelines are presented in this section for certain general site conditions; however, the designer should recognize that each site is unique and should be examined on a case-by-case basis. For example, there may be locations where existing conditions preclude the acquisition and development of additional right-of-way or easements necessary to build the fill slopes required for the most desirable grading. In these situations, it may be advisable to select a terminal that requires less grading or extend a run of guardrail so that the terminal can be placed on more favorable terrain. A site visit is essential to ensure that all design considerations have been addressed.

602.1 Roadside Protection

When a roadside obstacle needs to be shielded, the designer should initially consider the most flexible barrier system installed as far from the traveled way as possible. Subsequent systems should be considered in order of increasing strength and decreasing distance from the roadway. In general, the designer should consider options for roadside protection in the following order:

1. Install flared guardrail and either terminate the end outside the clear zone or bury it into a backslope.
2. Install tangential guardrail and terminate the end with a Type B-98 flared end terminal.
3. Install tangential guardrail and terminate the end with a Type E-98 tangential end terminal.
4. Install concrete barrier according to ***Section 603.1.2*** and terminate the end according to ***Section 603.6***.

602.1.1 Location/Offset

The normal roadside barrier location, with respect to the edge of pavement, is shown in ***Figure 301-3***. Minimum barrier clearances, measured from the face of the barrier to the face of the obstacle, are shown in ***Figure 603-2***. (See ***Section 603.4*** for minimum clearances for impact attenuators.) Although variations from these offsets may occur as a result of reduced graded shoulder width, the face of guardrail should not be located closer than 4 feet [1.2 m] to the edge of the traveled lane. See ***Section 602.1.5*** for guidelines concerning the use of curb with guardrail.

602.1.2 Length of Need on Tangent Alignments

Length of need is the total length of a longitudinal barrier that is needed to shield an area of concern (warranting feature). The length of need point in a gating end terminal or impact attenuator determines how much of the end treatment can be contributed to the length of need for the barrier.

If it is determined that barrier protection is required to shield a fixed object, ***Figure 602-1*** should be used to determine the length of need. The primary variables are the Runout Length (L_R) and the Lateral Extent of the Hazard (L_H). The Runout Length is the theoretical distance needed for an errant vehicle leaving the roadway to come to a stop. The Lateral Extent of the Hazard is the distance from the edge of pavement to the far side of the hazard or to the edge of the clear zone if the hazard extends beyond the clear zone. The other three variables are the Tangent Length of barrier (L_1,) the Lateral Distance from edge of pavement (L_2),and the Flare Rate (a:b).

The formula in ***Figure 602-1*** shown for computing the barrier length of need is appropriate where tangent roadways are involved.

Short runs of barrier should be avoided where economically feasible. Gaps of 300 feet [100 meters] or less between adjacent runs of guardrail should be closed.

Examples of length of need calculations on tangent alignments are included in ***Figure 602-3***.

602.1.3 Length of Need on Curved Alignments

Horizontal curvature of a roadway may have an effect in determining the barrier length of need in roadway design. In general, the length of need for a barrier on the outside of curves with a degree of curvature equal to 2°00' or flatter [radius of 900m or greater] can be calculated as if the barrier was installed tangentially. However, a vehicle leaving the roadway on the outside of a curve sharper than this will generally follow a tangential runout path.

For those cases involving a horizontal curve sharper than the limiting values given above, rather than using the theoretical L_R distance, the tangent line from the curve to the outside edge of the warranting feature (or to the clear zone) should be used to determine the appropriate length of barrier needed. (See ***Figure 602-2***.) The guardrail should not be flared in these locations, since the potential impact angles would generally exceed acceptable design limits.

Lengths of need should not be adjusted on the inside of horizontal curves. These locations should be treated as if they were on a tangent and L_R should be measured along the length of the curve.

Examples of length of need calculations on curved alignments are included in ***Figure 602-3***.

602.1.4 Grading for Barriers & End Treatments

In most cases, longitudinal barriers should not be located on slopes steeper than 10:1. Therefore, where a barrier is located outside the graded shoulder, special grading generally will be required to provide slopes that are 10:1 or flatter. Also, 6:1 slopes are of particular concern due to vehicle ramping effects. Barriers installed on 6:1 slopes should be limited to cases where the barrier is located at least 12' [3.6 m] or more from the edge of the break point for the 6:1 slope to minimize the potential for an errant vehicle to vault over the guardrail. The Buried in Backslope Anchor Assembly is one exception that has been designed specifically for 6:1 or flatter slopes. (See ***Section 603.3.1*** for additional information.)

To function properly, anchor assemblies and impact attenuators also need to be installed with proper grading. The grading is designed to ensure that an impacting vehicle strikes the device at the appropriate height, with all four wheels on the ground. It also helps to reduce the potential for snagging and vehicle rollover during and after impact. Adequate earthwork and excavation should be included in the plans to ensure that all devices have proper grading.

Ideally, the area immediately behind and downstream of all gating terminals should be reasonably traversable and free from fixed objects to the extent practical. A 20' x 75' [6 m x 22.5 m] area with 10:1 maximum slopes is desirable. When this is not practical, the designer should attempt to provide a clear area with recoverable slopes (4:1 or flatter) over the same 20' x 75' [6 m x 22.5 m] area. If a clear runout path is not attainable, this area should be similar in character to the upstream, unshielded roadside area. (See ***Section 603.2.1*** for additional information on gating terminals.)

602.1.5 Guardrail with Curbs

Curbs are generally classified as mountable or barrier curbs. A vehicle can safely traverse mountable curbs. Even though barrier curbs tend to inhibit vehicles from crossing over them, they are not a substitute for longitudinal barriers.

When guardrail must be used in conjunction with a curb the location of the guardrail relative to the curb should be carefully considered to minimize unacceptable post impact vehicle trajectories. When a vehicle strikes a curb, the resulting trajectory may cause the vehicle to impact the guardrail too high. In some cases the vehicle could clear the guardrail altogether.

602.1.5.1 On High Speed Roadways

All guardrail on curbed roadways with a design speed greater than 40 mph [70 km/h] preferably should be located so the face of curb is at the face of guardrail. The guardrail may be located up to 9" [230 mm] behind the face of the curb to avoid interference with subsurface pavement drainage. When curb and gutter is used, the gutter pan width will need to be increased to comply with these guidelines and to maintain a minimum 4' [1.2 m] guardrail offset.

The curb height should be limited to 4" or less when used in conjunction with guardrail on high speed roadways.

602.1.5.2 On Low Speed Roadways

Although guardrail is not normally used on curbed roadways having design speeds of 40 mph [70 km/h] or less (see ***Section 601.1.4***), the same criteria used for roadways with design speeds greater than 40 mph [70 km/h] is recommended. However, since the risk of vaulting is considerably less on low speed roadways, the designer may give more consideration to the location of the guardrail relative to the edge of pavement than to its location relative to the curb.

602.1.5.3 End Treatments in Curbed Sections

None of the approved anchor assemblies or impact attenuators listed in ***Sections 603.3 and 603.4*** have been designed or tested for use with curbs; consequently, the designer should use the guidelines provided for uncurbed sections in addition to engineering judgement and manufacturer's recommendations to select end treatments in curbed sections.

602.2 Median Protection

When a median hazard requires protection, the treatment depends upon the available width of the median. For the purposes of installing barrier, a median is considered wide when the end of a guardrail run installed in the median does not extend into the clear zone of the opposing side of traffic. Conversely, when the end of the guardrail run extends into the clear zone of the opposite side of traffic, the median is considered narrow.

602.2.1 Narrow Median Barrier Installations

Refer to **SCD GR-6.1 and GR-6.2 Design A** for details.

602.2.2 Wide Median Barrier Installations

Refer to **SCD GR-6.1 and GR-6.2 Design B** for details.

602.3 Gore Area Protection

Gore areas are locations where one or more lanes of a road carrying traffic in the same direction diverge away from each other. (Unidirectional traffic exists on both sides of a gore.) Impact attenuators are typically used to terminate the ends of longitudinal barriers located in gores. See ***Section 603.4*** for additional information on impact attenuators.)

602.4 Protection at Drives and Side Roads

When normal mainline guardrail is interrupted by a side road or drive, the opening should be designed as shown in ***Figure 603-3***.

The introduction of barriers at drives and side roads may have an adverse effect on both horizontal and intersection sight distances. These sight distances should be investigated when barriers are used at these locations. (See ***Section 602.6.2*** for additional information.)

602.5 Protection at Bridges

Barrier protection, utilizing Type 5 Guardrail with bridge terminal assemblies, shall be used at the approach end of bridge parapets and other similar fixed objects on all facilities where the design speed exceeds 40 mph [70 km/h]. (See ***SCD GR-6.1***.)

Pier protection in narrow medians and along the roadside is often accomplished using concrete barrier.

602.5.1 Guardrail at Bridges & Large Culverts

Figures 602-1 and 602-2 should be used to calculate the barrier length of need at all bridges and culverts.

Flared guardrail should be provided at overpasses and on safety and clear zone grading projects according to **SCD GR-6.1**.

Flared guardrail should be provided at underpasses or other fixed objects on safety and clear zone grading projects according to **SCD GR-6.2**.

Tangent guardrail should be provided on common grading projects.

There are occasionally areas where the calculated lengths of need are impractical. An example would be where a drive or intersection is located too close to a bridge and cannot be relocated. In such cases, the approach guardrail length may be reduced as necessary. In no case shall the minimum treatment be less than shown in ***Figure 603-4***.

On divided highways, guardrail is not required at either of the bridge parapet trailing ends unless it is warranted because of the lack of clear zone distance, the presence of openings between bridges, or where it is required in conjunction with a bridge railing.

602.6 Protection at Drainage Structures

Adequate drainage is one of the most critical elements in roadway design. A comprehensive drainage design requires consideration of roadside safety as well as hydraulic efficiency.

In general, no part of an unshielded drainage feature within a clear zone graded roadway, excluding curbs, should extend more than 4 inches [100 mm] above the surrounding terrain. (Drainage features that do not comply with this criterion are herein referred to as "protruding.")

(See the **Location and Design Manual, Volume Two** for specific drainage requirements.)

602.6.1 Transverse Drainage

For pipes with spans > 36" [900 mm]:

1. Extend the exposed pipe ends outside the clear zone when practical.
2. When the above option is impractical, shield the ends of the exposed pipe per ***Section 602.5.1***.

For pipes with spans ≤ 36" [900 mm] located in areas where clear zone or safety grading is not provided:

1. Provide standard half-height headwalls at exposed pipe ends.

For pipes with spans ≤ 36" [1000 mm] located in areas where clear zone or safety grading is provided:

1. Extend the exposed pipe ends outside the clear zone when practical and provide standard half-height headwalls.
2. When the above option is impractical, use slope tapered end treatments.

602.6.2 Intersecting Embankments & Parallel Drainage

Intersecting embankments are slopes that are transverse to the roadway. They are usually created by median crossovers, intersecting roadways and driveways. These slopes are typically struck head-on by vehicles that have left the traveled way.

Median crossovers on Interstates/Freeways shall use a 12:1 slope.

Embankment slopes for side roads should be as flat as practical, and drainage pipes underneath side roads should be located outside of the mainline clear zone where practical. This can typically be accomplished with minor adjustments to the ditch profiles.

For driveways on projects with clear zone or safety grading, the intersecting embankment slopes should be as flat as practical and:

1. All protruding drainage appurtenances should be placed outside the mainline clear zone, when practical. Standard half-height headwalls should be provided on all pipe ends located outside the clear zone.
2. If a protruding drainage appurtenance cannot be located outside the clear zone then it should be placed as far from the roadway as practical and treated similarly to drive pipes on projects without clear zone or safety grading.
3. An enclosed drainage system (storm sewer) may also be considered.

For driveways on projects without clear zone or safety grading, the intersecting embankment slopes should be as flat as practical and:

1. Exposed ends of pipes with spans less than or equal to 24" [600 mm] should be miter cut to conform to the prevailing slope.
2. Exposed ends of pipes with spans over 24" [600 mm] should be designed with standard half-height headwalls.
3. An enclosed drainage system may also be considered.

602.6.3 Special End Treatments

End treatments that utilize bars or grates designed as safety treatments for exposed pipe ends are commercially available. However, these end treatments reduce hydraulic efficiency and exhibit a high potential for clogging. This type of end treatment should only be used when all other reasonable options have been exhausted.

602.7 Sight Distance Considerations

The introduction of longitudinal barriers may have an adverse effect on both horizontal and intersection sight distances. The effect on both distances should be investigated at all locations where barriers are used. (See ***Sections 201.22*** and ***201.32*** for additional guidance.)

603 Roadside Safety Devices

The goal of any highway roadside safety device is simply to assist in providing a forgiving roadside for an errant motorist. The goal is met when the feature does one of the following without causing serious injuries to the occupants of the vehicle or to other motorists, pedestrians or work zone personnel:

1. contains or redirects the vehicle away from the hazard,

2. decelerates the vehicle to a stop over a relatively short distance,

3. readily breaks away, fractures or yields,

4. allows a controlled penetration, or

5. allows the vehicle to safely traverse the feature.

National Cooperative Highway Research Program (NCHRP) Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* is the safety criteria currently used to evaluate many of these features. (See ***Section 601.3*** for additional information.)

603.1 Longitudinal Barriers

Longitudinal barriers function by containing and redirecting impacting vehicles. They are typically classified into three types based on relative strength characteristics: flexible, semi-rigid and rigid.

Flexible barriers, such as cable guardrail and weak post w-beam guardrail, resist impact through the development of tension in the rail element. Semi-rigid barriers, like strong post w-beam guardrail, resist impact primarily through beam action between the rails and posts. Rigid barriers resist impacts by transferring the loads directly into the ground and are not designed to yield during impact. This makes them ideal for use in areas with minimal or no space available to accommodate barrier deflections.

The two basic types of barrier used in Ohio are semi-rigid w-beam guardrail and rigid concrete safety shape barrier. Various designs of each are discussed in ***Sections 603.1.1 and 603.1.2*** and shown schematically in ***Figure 603-1***.

Deflection characteristics of a longitudinal barrier system determine the minimum clearances between the face of the barrier and the face of the object it shields. Minimum barrier clearances are listed in ***Figure 603-2*** along with typical applications for the standard types of barrier described in the following sub-sections.

603.1.1 Steel Beam Guardrail

603.1.1.1 Posts and Blockouts

Guardrail posts are designed to support the rail at the appropriate height and provide lateral support during an impact. For most impacts, the posts are designed to rotate through the soil, rather than bend at or near the ground surface. This rotation helps to contribute considerably to the energy absorbed in the collision and helps to prevent contact between the vehicle and the posts. For this reason, paving around posts is not advisable if the thickness of the pavement would prevent this rotation from occurring. Two inches [Fifty millimeters] of asphalt pavement is the maximum allowable thickness for paving under guardrail. See **Sample Plan Note R116 in the L&D Manual Volume Three** for additional information on paving under guardrail.

For guardrail installations to perform properly during an impact, adequate soil support must be provided for the posts in the guardrail run. To ensure this support is provided, 9'-0" [2.75 m] long posts should be specified at locations where the distance from the face of the barrier to the slope break point is less than 2'-0" [0.6 m]. These locations should be specifically identified in the plans.

Blockouts minimize the potential for a vehicle's wheels to snag on the posts and reduce the likelihood of a vehicle vaulting over the barrier. This is accomplished by maintaining the height of the rail as the barrier deflects and rotates downward during an impact.

603.1.1.2 Type 5 & 5A Guardrail

Type 5 guardrail is used primarily for roadside protection on any roadway where a minimum barrier clearance of 5.5' [1.7 m] can be provided. It consists of 12'-6" [3.81 m] long steel w-beam rail elements with either wood or metal posts and wood or recycled plastic blockouts. Posts shall be spaced at 6'-3" [1.905 m].

Type 5A guardrail is used primarily for roadside protection on any roadway where a minimum barrier clearance of 3.5' [1.1 m] can be provided. It consists of the same design for Type 5, except the posts shall be spaced at 3'-1 ½" [952.5 mm].

See **SCD GR-2.1** for additional details.

603.1.1.3 Type 5 Guardrail: Barrier Design

Type 5 barrier design guardrail is identical to standard Type 5 guardrail with the addition of blockouts and rail on the opposite side of the posts. It is used primarily in bi-directional median applications on any roadway where a minimum barrier clearance of 5.5' [1.7 m] can be provided. See **SCD GR-2.1** for additional details.

603.1.1.4 Type 5 Guardrail with Tubular Backup

Type 5 guardrail with Tubular Backup should be specified over new prefabricated structures on non-NHS roadways where lateral deflections of the rail cannot be tolerated. It consists of steel w-beam rail elements, with sections of tubular steel replacing the blockouts, installed on steel posts. The tubular backup shall extend to the first post off the approach and trailing ends of the structure (or past the component of the structure that is being protected). A Type 4 Bridge Terminal Assembly is required at each end of the tubular backup (see ***Section 603.5.5***). See **SCD GR-2.2** for additional details.

603.1.1.5 Long Span Guardrail

The long span guardrail design is the preferred option for spanning across culverts and other structures with depths of cover less than 2'-6" [0.75 m]. It can be used on any roadway where a minimum barrier clearance of 3.5' [1.1 m] can be provided. It consists of Type 5 guardrail with two w-beam rail elements that are nested. A maximum of two posts (spaced at 6'-3" [1.905 m]) can be eliminated to create the clear span. The double rail elements must extend across a minimum of two posts on both sides of the structure. (See **SCD GR-2.4** for additional details.)

603.1.2 Concrete Barrier

Concrete barrier, specifically the New Jersey Safety Shape, is used in locations where barrier deflections cannot be tolerated. Because of its rigidity and shape, it is very effective for small angle impacts and is preferred for use where the chance of impacting it at an angle of 15° or greater is minimal. It also requires less maintenance than steel beam guardrails. The concrete barrier is recommended in most locations where median barriers are warranted.

The 3" [76 mm] vertical portion at the base of the New Jersey barrier plays no significant role in the performance of the barrier, but provides an allowance for future pavement overlays. If additional overlays are required, the existing pavement must be removed and replaced or the barrier must be removed and reconstructed.

At locations where a standard barrier cannot be installed, the face of fixed objects within the clear zone should be designed with the concrete barrier shape. Typical locations are along retaining walls and walls that connect pier columns. On upgrading projects where the face of these fixed objects does not have existing protection, the concrete barrier shape should be provided to shield these objects. See **SCD RM-4.3** for additional details.

603.1.2.1 Types A & A1

Type A concrete barrier is 24" [610 mm] wide at the base and 32" [813 mm] tall. It is used on any roadway in areas where barrier width is restricted.

Type A1 concrete barrier is 24" [610 mm] wide at the base and 50" [1270 mm] tall. It is used on any roadway in areas where barrier width is restricted and glare screening is to be used. The additional height of the barrier in excess of the Type A serves as the glare screen. See ***Section 604*** for additional information on glare screens.

603.1.2.2 Types B & B1

Type B concrete barrier is 30" [763 mm] wide at the base and 32" [813 mm] tall. It is used on any roadway in areas where signs, lighting or other unyielding objects are to be mounted on top of the barrier.

Type B1 concrete barrier is 30" [763 mm] wide at the base and 50" [1270 mm] tall. It is used on any roadway in areas where signs, lighting or other unyielding objects are to be mounted on top of the barrier and where glare screening is to be used. The additional height of the barrier in excess of the Type B serves as the glare screen. See ***Section 604*** for additional information on glare screens.

603.1.2.3 Type C

Type C concrete barrier is used on any roadway in narrow medians where the difference in elevation on either side of the barrier is less than or equal to 24" [610 mm]. The barrier is 30" [763 mm] wide at the base and can vary in height from 32" [813 mm] to 56" [1423 mm].

603.1.2.4 Type D

Type D concrete barrier is 18" [457 mm] wide at the base and 32" [813 mm] tall. It has the safety shape profile on only one side of the barrier; therefore, it can be used on any roadway where impacts are expected on only one side of the barrier. It is often used for the protection of piers and other fixed obstacles. See **SCD RM-4.5** for use at obstructions.

603.2 Characteristics of Anchor Assemblies & Impact Attenuators

Originally end terminals were designed simply to anchor the ends of guardrail runs. However, over the years safety at the ends has become a major concern. As a result, guardrail end terminals (anchor assemblies) have taken on additional functions. An anchor assembly can function by:

1. decelerating a vehicle to a safe stop within a relatively short distance,

2. permitting controlled penetration of the vehicle behind the device,

3. containing and redirecting the vehicle, or

4. a combination of the above.

Anchor assemblies must also be capable of developing the full tensile strength of the rail elements.

Impact attenuators (crash cushions) are designed primarily to safely stop a vehicle within a relatively short distance. Some common uses of impact attenuators are at exit gores, on or under bridges where piers require shielding, and at the ends of roadside and median barriers.

Anchor assemblies and impact attenuators can be either gating or non-gating and redirective or non-redirective.

603.2.1 Gating and Redirection

A <u>non-gating system</u> will bring an impacting vehicle to a controlled stop while a <u>gating system</u> will allow a vehicle impacting the system at an angle to pass through the system along the same general path. The length of need (LON) point in a non-gating system is located at the nose of the system. When using a gating system, the LON point needs to be identified to determine what portion of the system can be used as part of the barrier's LON. (See ***Section 602.1.2*** for additional information on length of need.)

A <u>redirective system</u> will redirect an impacting vehicle away from a fixed object when the system is struck at an angle on the side. A <u>non-redirective system</u> will allow a vehicle to continue in approximately the same direction until it comes to a stop.

A <u>redirective, gating system</u> has redirective capabilities over a portion of its length. The LON point varies from system to system. These devices are almost always anchor assemblies.

A redirective, non-gating system is designed to contain and redirect a vehicle impacting downstream from the nose of the unit. Redirection is provided over the entire length of the device; therefore, the LON is established at the nose of the device.

A non-redirective system is designed to contain and capture a vehicle impacting downstream from the nose of the unit. It provides protection in an end-on collision by absorbing the impacting vehicle's kinetic energy; however, it does not control an angle impact and it may allow pocketing or penetration. (Pocketing is said to have occurred if, upon impact, relatively large lateral displacements happen over a relatively short longitudinal distance.) All non-redirective devices are also gating. LON is established at the rear of the device. Sand barrel arrays are typical non-redirective devices.

603.2.2 Proprietary Products

Many of the following devices are proprietary products, which are subject to change at the manufacturer's discretion. The information provided in this manual is accurate and up-to-date at the time of publication and represents the currently approved versions of these products. New products may be introduced and modifications to existing products may occur, which may or may not be approved by ODOT. Shop drawings of all approved proprietary devices are provided with the standard construction drawings. Every effort will be made to keep this information current. For guidance contact the **Office of Planning, Standards Section**.

Each proprietary end terminal and impact attenuator must be installed according to the manufacturer's recommendations.

603.3 Anchor Assemblies

603.3.1 Buried-In-Backslope

The buried-in-backslope anchor assembly is a flared, redirective, non-gating, non-proprietary, end terminal. The length of this terminal varies depending upon field conditions. It's construction is similar to Type 5 guardrail except the buried-in-backslope terminal uses 8'-0" [2.44 m] long posts and a rubrail. It is installed with 6:1 or flatter foreslopes and backslopes as steep as 1:1.

A vehicle impacting this terminal close to the buried end may be able to climb 2:1 or flatter backslopes and encroach behind the guardrail. Consequently, where backslopes are 2:1 or flatter a 75' [22 m] minimum length of guardrail must be provided upstream between the warranting feature and the intersection of the guardrail with the ditch flowline. Where backslopes are steeper than 2:1 this provision is not applicable.

This anchor assembly may be used as an approach end treatment for guardrail on any roadway. ***Table 603-1*** gives additional information on where to use this anchor assembly. See **SCD GR-4.5** for additional details.

603.3.2 Type B-98

The Type B-98 anchor assembly is a flared, redirective, gating end terminal. Approved devices in this category include the SRT-350 manufactured by SYRO, Inc. and the FLEAT-350 manufactured by Road Systems, Inc. The length of both systems is considered to be 37'-6" [11.43 m], inclusive of three 12'-6" [3.81 m] rail elements.

The SRT-350 is installed with a curved flare while the FLEAT-350 uses a tangent flare, both of which are offset 4'-0" [1.22 m].

For the Type B-98, 25'-0" [7.62 m] may be deducted from the guardrail length of need.

The Type B-98 may be used as an approach end treatment for guardrail on any roadway. The Type B-98 cannot be used where there is a likelihood of an impact occurring on the back side of the device.

The Type B-98 Anchor Assembly requires a recovery area immediately behind the terminal (detailed on **SCD GR-4.3**). Designers should check that this grading is present on existing cross-slopes or otherwise revise the cross-slopes to conform. ***Table 603-1*** provides guidance on where to use this anchor assembly. See **Sample Plan Note R112 in the L&D Manual Volume Three** for additional information.

603.3.3 Type E-98

The Type E-98 anchor assembly is a tangent, redirective, gating end terminal. Approved devices in this category include the ET-2000 (1997) manufactured by SYRO, Inc. and the SKT-350 manufactured by Road Systems, Inc. The length of the ET-2000 (1997) is considered to be 50'-0" [15.24 m], inclusive of two 25'-0" [7.62 m] rail elements. The length of the SKT-350 is considered to be 50'-0" [15.24 m], inclusive of four 12'-6" [3.81 m] rail elements.

For the Type E-98, 37'-6" [11.43 m] may be deducted from the guardrail length of need.

The Type E-98 may be used as an approach end treatment for guardrail on any roadway. The Type E-98 cannot be used where there is a likelihood of an impact occurring on the back side of the device.

The terminal should be offset to minimize the potential for impacts caused by vehicles clipping the portion of the impact head that protrudes in front of the face of the guardrail. The preferred offset method is detailed on **SCD GR-5.3**. The Type E-98 may also be installed with a 50:1 flare over the full length of the terminal or with a 25:1 flare over the first 25'-0" [7.6 m] of the device. ***Table 603-1*** gives guidance on where to use this anchor assembly. See **Sample Plan Note R113 in the L&D Manual Volume Three** for additional information.

Table 603-1

Foreslope	New Construction / Major Reconstruction	3R, HSP and Bridge Replacement
6:1 or flatter	Buried-in-Backslope or Type B-98	Buried-in-Backslope or Type B-98
Steeper than 6:1 up to 4:1	Type B-98	Type E-98
Steeper than 4:1	Type E-98	Type E-98

603.3.4 Type A

The Type A anchor assembly (twisted turned-down end) is a non-proprietary, non-redirective end terminal. It is 25'-0" [7.62 m] long and may be used as an approach or trailing guardrail end treatment in the following situations:

1. On non-NHS arterials, collectors and local roads with a design year ADT of 4000 vpd or less.

2. On any roadway outside the clear zone.

3. On any non-NHS roadway with a design speed of 40 mph [70 km/h] or less.

Since the LON point is at the rear of this device, no portion of the Type A can be included within the guardrail length of need. See **SCD GR-4.1** for additional details.

603.3.5 Type T

The Type T anchor assembly is a non-proprietary, non-redirective end terminal that may be used on any roadway in the following situations:

1. On trailing ends of guardrail runs on multi-lane roadways, where located outside the clear zone of opposing traffic. Since the LON point is at the rear of this device, no portion of the Type T can be included within the guardrail length of need.

2. In guardrail runs where directional changes are made using a radius of less than 25 feet [7.5 meters] (see ***Figures 603-3 and 603-4***).

3. On the ends of guardrail runs on drive approaches (see ***Figure 603-3***).

The Type T is 12'-6" [3.81 m] long.
See **SCD GR-4.2** for additional details.

603.4 Impact Attenuators

603.4.1 Type 1-98

The Type 1-98 is a redirective, gating, proprietary impact attenuator. Approved devices in this category include the C-A-T manufactured by Syro, Inc. and the Brakemaster manufactured by Energy Absorption Systems, Inc. The Type 1-98 can be installed on any roadway in uni-directional and bi-directional configurations, but it must have at least 10 feet [3 meters] of clearance on both sides of the device. A maximum flare of 20:1 is permissible.

See **Sample Plan Note R123 in the L&D Manual Volume Three** for additional information.

603.4.2 Type 2-98

The Type 2-98 is a redirective, non-gating proprietary system that can be installed on any roadway in uni-directional and bi-directional configurations. Currently, the only approved device in this category is the QuadGuard manufactured by Energy Absorption Systems, Inc.

The QuadGuard is available with parallel sides in three widths (2'-0" [610 mm], 2'-6" [762 mm] & 3'-0" [915 mm]) and with flared sides in two widths (5'-9" [1753 mm] & 7'-6" [2286 mm]). It is manufactured in 2- to 12-bay designs depending upon the design speed; however, only designs with 6 bays or more are approved for use on the NHS. (See ***Section 601.3*** for additional information on NHS requirements.)

If cross slopes are steeper than 8% (12:1) or vary by more than 2% over the length of the unit, a leveling pad may be used.

See **Sample Plan Note R124 in the L&D Manual Volume Three** for additional information.

603.4.3 Type 3-98

The Type 3-98 is a redirective, non-gating proprietary impact attenuator that can be installed on any roadway. Approved devices in this category include the 11-bay QuadGuard LMC with the tension strut backup, manufactured by Energy Absorption Systems, Inc. and the REACT 350.9 manufactured by Road Safety Service, Inc. The Type 3-98 should only be used at locations with frequent impacts or where space is limited for the safe accommodation of repair crews.

See **Sample Plan Note R125 in the L&D Manual Volume Three** for additional information.

603.4.4 Sand Barrels

Sand barrel arrays consist of proprietary sand-filled modules of varying sizes arranged in a pattern typically designed to protect wide fixed objects. They are non-redirective systems; consequently, modules at the rear of the array must be carefully placed to minimize the potential for an impact with the corner of the shielded object. Approved devices in this category include Energite Barrels manufactured by Energy Absorption, Fitch Barrels manufactured by Road Safety Service, and TrafFix Sand Barrels manufactured by TrafFix Devices.

Sand barrel arrays are usually designed for a specific site by the manufacturer. All arrays installed on the NHS must meet **NCHRP Report 350** TL3 criteria.

603.5 Bridge Terminal Assemblies

When a less rigid barrier is to be connected to a more rigid barrier, a stiffening transition is needed to make the connection. A transition from a more rigid barrier to a less rigid barrier doesn't require any stiffening unless the barrier can be struck from the opposite direction. Even when the difference in strength is not an issue, a transition is frequently required simply to connect two barrier systems that have different hardware components. Transitions in Ohio are called Bridge Terminal Assemblies because they are typically required where guardrail is warranted in conjunction with bridge parapets/railings. They are also used to connect guardrail to concrete barrier and other similar fixed objects.

At this time, none of the following designs have been tested according to the criteria in **NCHRP Report 350.** There are only four designs that have successfully passed this criteria but none of them are practical for use with our current standards. In the absence of suitable alternatives and until these designs are successfully crash tested, they may be used on all roadways except as noted.

603.5.1 Type 1

The Bridge Terminal Assembly, Type 1 is commonly used to connect Type 5 guardrail to a concrete barrier or a concrete bridge parapet on an undivided bi-directional highway. It uses blocked-out, nested, thrie-beam, guardrail panels attached to a vertical concrete surface to transition to the Type 5 guardrail.

It is generally installed at the following locations:

1. At the approach end of a rigid object.

2. At the trailing end of a rigid object if it is located within the clear zone of opposing traffic.

See **SCD GR-3.1** for additional details.

603.5.2 Type 1 Barrier Design

The Bridge Terminal Assembly, Type 1: Barrier Design is commonly used to connect Type 5 Barrier Design guardrail or a Type 1-98 Impact Attenuator to a concrete median barrier. It uses blocked-out, nested, thrie-beam, guardrail panels attached to a vertical face on both sides of the barrier to transition to the guardrail or attenuator.

See **SCD GR-3.5** for additional details.

603.5.3 Type 2

The Bridge Terminal Assembly, Type 2 is commonly used to connect Type 5 guardrail to the trailing end of a concrete barrier or bridge parapet located outside the clear zone of opposing traffic. It uses standard w-beam guardrail panels attached to a vertical face on the concrete barrier to transition to the guardrail.

See **SCD GR-3.2** for additional details.

603.5.4 Type 3

The Bridge Terminal Assembly, Type 3 is commonly used to connect Type 5 guardrail to a thrie-beam bridge railing on an undivided bi-directional highway. It uses blocked-out, nested, thrie-beam, guardrail panels to transition to the Type 5 guardrail.

It is generally installed at the following locations:

1. At the approach end of a rigid object.

2. At the trailing end of a rigid object if it is located within the clear zone of opposing traffic.

See **SCD GR-3.3** for additional details.

603.5.5 Type 4

The Type 4 Bridge Terminal Assembly is used to connect Type 5 guardrail to the approach and trailing ends of bridges having tubular backup bridge railing. It is also used to transition between Type 5 guardrail and Type 5 guardrail with Tubular Backup.

See **SCD GR-3.4** for additional details.

603.6 Concrete Barrier End Treatment

The end of a concrete barrier may be a hazard if not treated properly. Since a rigid barrier generally does not require end anchorage to develop its strength, the simplest means of providing impact protection for the barrier end may be to terminate the barrier beyond the clear zone. When this approach is used, the flare rate used to offset the barrier should not exceed the flare rates recommended in ***Figure 602-1.*** However, when the end of a concrete barrier is located within the clear zone, a terminal is necessary to protect a vehicle's occupants in an end-on impact.

Acceptable end treatments include the following:

1. Transition to Type 5 guardrail using a bridge terminal assembly and terminate the end of the guardrail run with an anchor assembly.

2. Use an impact attenuator as discussed in ***Section 603.4***.

3. Terminate the concrete barrier directly into a cut backslope.

4. Use a tapered end section per **SCD RM-4.3**, only: (1) when the barrier is terminated outside the clear zone (See ***Figure 603-5***.), or (2) when the barrier is on a non-NHS road with a design speed less than or equal to 40 mph [70 km/h].

604 Glare Screen

Glare screen is used primarily for the shielding of motorists from headlight glare of opposing traffic. It is normally used in the median of divided highways but may be used in other areas where a specific problem exists or is anticipated.

There are locations, other than in the median, where glare screen may be justified. An example would be between a parallel facility and the mainline where geometrics or unusual sources of light cause a glare problem.

604.1 Median Glare Screen

Glare screen is justified based on traffic volumes and median widths in unlighted sections, and on traffic volumes and the number of lanes in lighted sections. ***Figure 604-1*** shows this relationship. Median glare screen may also be justified when glare problems are experienced on isolated sharp curves.

Median glare screen installation should be as continuous as practical. Gaps of approximately 1 mile [1.5 kilometers] or less in length should be avoided.

604.2 Performance Characteristics

Expected performance characteristics of glare screens include the following:

1. Does not penetrate the passenger compartment or present an undue hazard to other traffic when hit.

2. Exhibits predictable impact performance.

3. Effectively reduces glare.

4. Is resistant to damage during impacts.

5. Is easy and economical to repair.

604.3 Glare Screen Options

Glare screening may be accomplished in a number of ways. These include, but are not limited to, the following options (shown in order of preference):

1. Use 50" [1270-mm] concrete barrier.

2. Install a concrete cap to extend the height of existing 32" [813-mm] concrete barrier where barrier thickness is adequate.

3. Attach a paddle or intermittent type of glare screen to the top of 32" [813-mm] tall concrete barrier or steel beam guardrail. These devices shall be designed using a 20-degree cut-off angle measured relative to the centerline of the barrier. They shall be securely fastened to the barrier using the hardware and procedures specified by the manufacturer. Contact the **Office of Materials Management** for a list of approved manufacturers.

4. Install special glare screen fencing fabric used at normal fence locations.

Options 1-3 may only be used in locations where barrier is required. Option 4 should be limited to locations outside the clear zone wherever possible.

605 Rumble Strips

605.1 Shoulder Rumble Strips

A shoulder rumble strip is a pattern of grooves or depressions made in paved highway shoulders to produce an audible and/or vibratory warning to drivers whose vehicles have drifted off the traveled way.

SCD BP-9.1 contains design details and options for the placement of rumble strips on shoulders.

Shoulder rumble strips have proven to be effective in reducing run-off-the-road accidents due to driver inattention, monotony and fatigue. They also may serve as an audible form of roadway edge delineation in adverse weather conditions. Rumble strips are most appropriate for use on higher speed facilities where access is controlled through interchanges or widely-spaced intersections (several miles apart) and are also appropriate for other roadways with a history of run-off-the-road accidents due to driver inattention.

605.1.1 Locations

Shoulder rumble strips should be installed at the following locations:

1. On new, reconstructed, and resurfaced shoulders of all rural fully access-controlled highways (Interstates and freeways).

2. On sections of any highway with a history of run-off-the-road accidents due to driver inattention, fatigue, or sleep. For this purpose, a threshold rate of 0.25 run-off-the-road accidents per million vehicle miles will be used.

Shoulder rumble strips should be considered at the following locations:

1. On new, reconstructed, or resurfaced shoulders of urban fully access-controlled highways and rural partially access-controlled multilane highways.

2. At certain critical locations, such as: in gore areas, ahead of impact attenuators and next to concrete median barriers.

Shoulder rumble strips may be installed at the following locations:

1. At other locations, where deemed to be a safety enhancement, at the discretion of the **District Deputy Director**. This decision should be based on a review and recommendation by the **District Safety Review Team**.

2. On local roads and streets in Federal-aid projects that are not on the NHS, at the discretion of the responsible local agency. (See **SCD BP-9.1** for additional details on the location of shoulder rumble strips.)

605.1.2 Types

Shoulder rumble strips are appropriate for use on either asphalt or concrete shoulders. They can be rolled into new asphalt shoulders (Type 1), milled into existing or new shoulders of either asphalt or concrete pavement (Type 2), or formed into new concrete shoulders (Type 3). (See **SCD BP-9.1** for additional details.)

Type 2 is the most effective of the three types because it produces a noticeable vibratory and audible warning to drivers. It is the preferred treatment for use on most rural roadways. Types 1 and 3 produce little vibratory effect and a less audible warning than the Type 2 pattern and are therefore the recommended treatments for use in most urban areas and in all residential areas to minimize noise levels.

605.1.3 Lateral Clearances for Machinery

The machinery used in the milling process to construct Type 2 rumble strips requires a lateral clearance of at least 2'-10" [875 mm] from the outside edge of the pattern to any obstruction (guardrail, a barrier, curbs, etc.).

605.1.4 Divided Highways

Rumble strips should be installed on both shoulders (right and left) of divided roadways, but individual circumstances may dictate use on only one shoulder.

605.1.5 Existing Shoulders

Rumble strips should only be installed on existing paved shoulders that are in good condition and have the following minimum widths for the specified type of rumble strip:

Minimum Shoulder Width	
Type 1	Types 2 & 3
3'-6" [1 meter]	2'-6" [0.7 meter]

Where existing shoulders are to be resurfaced either permanently or for maintenance of traffic conditions, the existing rumble strip pattern shall be restored on the new shoulder in accordance with this manual.

605.1.6 Bicycle Considerations

Rumble strips generally should not be used on the shoulders of roadways designated as bicycle routes or having substantial volumes of bicycle traffic, unless the shoulder is wide enough to accommodate the rumble strips and still provide a minimum clear path of 4' [1.2 m] from the rumble strip to the outside edge of the paved shoulder or 5' [1.5 m] to adjacent guardrail, curb or other obstacle.

The rumble strip pattern should not be continuous but should consist of an alternating pattern of gaps and strips, each 10' [3-meter] in length. Also, gaps should be provided in the rumble strip pattern ahead of intersections, crosswalks, driveway openings, and at other locations where bicyclists are likely to cross the shoulder.

605.1.7 Residential Areas

In residential areas, noise generated by rumble strips could be objectionable. Rumble strips installed in these areas may be placed further from the edge of the traveled lane than shown on **SCD BP-9.1** to reduce the frequency of contact while still providing some degree of warning to drifting drivers.

The distance from the edge of the traveled lane to the rumble strip pattern should not exceed 2'-0" [600 mm] on the outside shoulder. Also, the use of either Type 1 or Type 3 is preferable to the use of Type 2 in these areas. (See ***Section 605.1.2***.)

605.1.8 Maintenance of Traffic

Where shoulders are to be used for maintenance of traffic purposes, rumble strips should be positioned to adapt to phased construction sequencing. See **SCD BP-9.1**.

605.2 Rumble Strips in Traveled Lanes

Rumble strips in traveled lanes are used to alert drivers of unusual or unexpected traffic conditions or geometrics and to bring the driver's attention to other warning devices. They are not intended for traffic calming and they should only be installed after all other appropriate standard traffic control devices have been utilized and have failed to resolve the problem satisfactorily.

Rumble strips are most effective when they surprise motorists enough to catch their attention. For this reason, they should be used sparingly. (See ***Section 605.2.1*** for typical locations.)

605.2.1 Locations

Typical locations for the installation of rumble strips in a traveled lane are at the following:

1. Rural stop approaches with high accident rates.

2. Signalized intersections with high accident rates.

3. Short exit ramp deceleration lanes or hidden intersections.

4. Approaches to toll booths and narrow bridges.

5. At the approach to work zones and at other locations within the work zone.

Other possible locations include:

1. Locations with abrupt changes in horizontal alignment.

2. Intersections with inadequate stopping sight distance caused by vertical or horizontal alignment.

3. Railroad crossings with sight distance restrictions and a history of accidents.

605.2.2 Types

See ***Section 605.1.2*** for information on acceptable rumble strip types.

606 Fence

606.1 Purpose

Highway fences are a part of the highway facility and are placed within the right-of-way limits of highways having controlled or limited access right-of-way. They act as physical barriers to enforce observance of the acquired access rights. The State or other agency responsible for the maintenance of the facility shall assume the responsibility for the maintenance of these fences.

606.2 Types

It is ODOT's policy to construct only the standard types of fence described below in accordance with the current Standard Construction Drawings and Construction and Material Specifications.

<u>TYPE 47</u> - Woven wire fence with a 47-inch [nominal 1195-mm] fabric, steel line posts, and one strand of barbed wire on the top. (See **SCD F-2.1**.)

<u>TYPE 47RA</u> - Woven wire fence with 47-inch [nominal 1195-mm] fabric, wood line posts, and no barbed wire. (See **SCD F-2.1**.)

<u>TYPE CL</u> - Chain link fence with 60-inch [1525-mm] fabric and top rail. (See **SCD F-1.1**.)

<u>TYPE CLT</u> - Chain link fence with 60-inch [1525-mm] fabric but with a tension wire in lieu of the top rail. (See **SCD F-1.1**.)

606.3 Fence on Freeways

606.3.1 Urban Freeways

Urban freeways shall be continuously fenced. Innerbelts and radials shall use Type CLT. Outerbelts shall use Types CLT or 47 depending upon the adjacent land use.

606.3.2 Rural Freeways

Rural freeways shall be continuously fenced, usually with Type 47 fence; however, Type CLT may be used in areas where there are schools, subdivisions or other developments.

606.3.3 Freeway Fence Design Conditions

1. Where chain link fence is located within the design clear zone, such as along the edge of a roadway shoulder, in a median, or between a frontage road and the mainline, a fence with tension wire, Type CLT, shall be used. Type CL may only be used beyond the clear zone. Type CLT may also be used beyond the clear zone, if desired.

2. Type 47RA fence shall be used to fence rest areas where the highway fence is Type 47. It may also be used in other locations where the aesthetics of the area make this type more desirable.

3. Fence installed across a stream or ditch shall be designed using fence terminals or crossings as shown in **SCDs F-3.3 and F-3.4**, respectively.

4. Where a drainage channel is located parallel to the freeway in a channel easement, the fence shall be located on a bench between the main facility and the channel. Maintenance openings shall be provided at 700' [200-m] maximum intervals where the length of fence between a deep channel and the freeway exceeds 1800' [550 m], unless access can be provided by another means.

5. Fence shall be provided in the median to connect the abutments of all twin bridges on divided highways.

6. All types of fence shall be grounded where a power line passes over them. Fence shall also be grounded where a parallel power line easement is within 50' [15 m] of the fence. For grounding details see **SCD HL-50.11**, published by the **Office of Traffic Engineering**.

7. In the vicinity of some airports, fencing should be non-metallic since it sometimes interferes with airport traffic control radar. The **Federal Aviation Administration** should be contacted to ascertain if metallic fencing will be a problem.

8. Fence should normally be continued behind a noise wall. Sufficient distance should be provided between the fence and the noise wall to permit normal maintenance operations. If there is no critical maintenance responsibility between the noise wall and the right-of-way or limited access line (generally in "cut" sections) the fence may be terminated at each end of the noise wall.

606.3.4 Exceptions to Continuous Freeway Fencing

1. Fence shall be terminated with an end post assembly at an existing ½:1 or steeper slope, measured along the fence centerline. However, if the ground approaching the ½:1 slope is too steep to allow proper fence installation, a Type E fence terminal shall be installed at the edge of the slope. (See ***Figure 606-1 (a) and (b)*** for details.)

2. Fence shall be terminated in a cut section that exceeds 30 feet [10 meters] in vertical height with a backslope of ½:1 or steeper. An End Post Assembly and a Type E fence terminal shall be located as shown in ***Figure 606-1(c)***.

3. Where the fence intersects a crossroad right-of-way line at interchanges, it shall be

constructed along the crossroad to the limits of the limited access right-of-way.

606.4 Fence on Arterials

606.4.1 Urban Arterials

Fence shall be Type CL, CLT or Type 47 depending upon the adjacent land use. Type CL or CLT should be used where there is any doubt that Type 47 would be adequate to prohibit undesired intrusions.

606.4.2 Rural Arterials

Fence should normally be Type 47.

606.4.3 Arterial Fence Design

Fence shall be provided along the limited access right-of-way line on arterials but shall terminate at the end of limited access right-of-way at crossroads or railroads, and at stream banks and driveways. Fence shall be omitted where the highway right-of-way adjoins lateral features which would prevent vehicular access, such as: railroads, streams, deep ditches, swamps, strip mines or other steep slopes. Type CLT and 47RA shall be used on arterials in the same locations as described for freeways in ***Section 606.3.3 (1) and (3)***.

606.5 Fence on Collectors

Fencing of limited access right-of-way on urban or rural Collectors (or lower classifications) with partial access control will be determined on an individual project basis using arterial requirements as a guide.

606.6 Lateral Location of Fence

Section 607.06 of the **Construction and Material Specifications** gives line post and fence location as related to the right-of-way line. Normally, woven wire fence should be placed 2'-0" [0.6 m] inside the right-of-way line and chain link 1'-0" [0.3 m].

When viewed at a flat angle, chain link fencing restricts sight distance. This should be considered when placing fence in interchange areas and intersections.

606.7 Fence Approval

Determination of the type and extent of fencing will be made during the development of the contract plans and will be completed in time for the Stage 3 review.

606.8 Bridge Vandal Protection Fence

For policy and details of vandal protection fence, see the **Bridge Design Manual and SCD VFP-1-90**, both published by the **Office of Structural Engineering**.

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600 Roadside Design

List of English Figures

Sample Calculations

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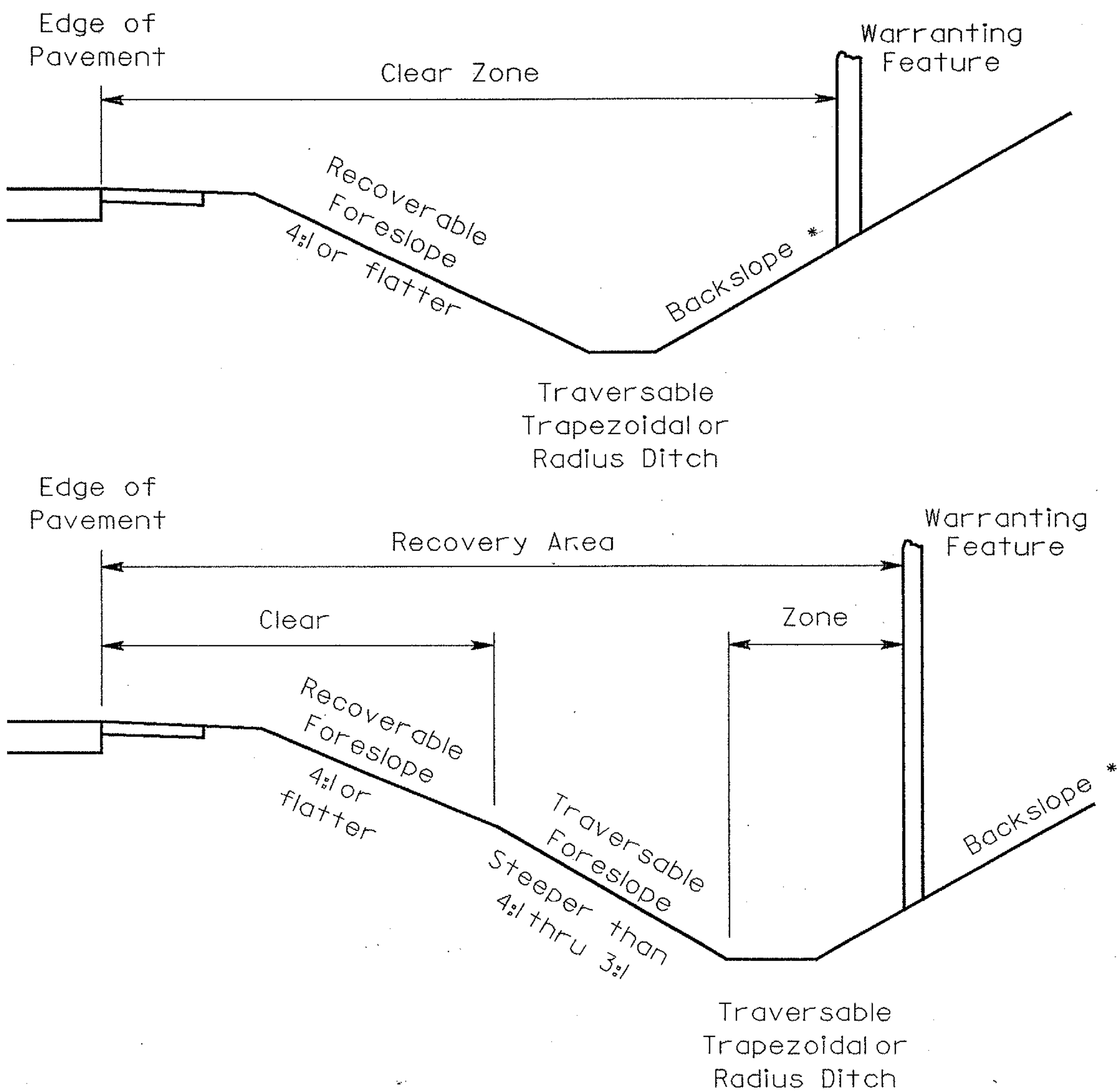
# CLEAR ZONE WIDTHS	600-1
	REFERENCE SECTIONS 600.2

Design Speed	Design ADT	Foreslope		Backslope		
		6:1 or Flatter	Steeper than 6:1 to 4:1	6:1 or Flatter	Steeper than 6:1 to 4:1	Steeper than 4:1
40 mph or less	<750 750-1500 1501-6000 >6000	8 ft 11 13 15	8 ft 13 15 17	8 ft 11 13 15	8 ft 11 13 15	8 ft 11 13 15
45-50 mph	<750 750-1500 1501-6000 >6000	11 13 17 19	13 18 23 26	11 15 17 21	9 13 15 19	9 11 13 15
55 mph	<750 750-1500 1501-6000 >6000	13 17 21 23	16 22 27 29	11 17 21 23	11 15 17 21	9 11 15 17
60 mph	<750 750-1500 1501-6000 >6000	17 22 28 31*	22 29 36* 40*	15 21 25 27	13 17 21 25	11 13 16 21
65-70 mph	<750 750-1500 1501-6000 >6000	19 25 30 32*	23 32* 38* 42*	15 21 27 28	15 19 23 28	11 14 18 23

* Use a **maximum clear zone** of 30 feet unless a site specific investigation or accident history indicates a high potential of continuing accidents. When the potential for continuing accidents is high, the widths in the above chart should be multiplied by the following curve correction factors to extend the clear zone on the outside of curves having a Degree of Curvature of 2 degrees or sharper.

Degree of Curvature	HORIZONTAL CURVE CORRECTION FACTORS						
	Design Speed (mph)						
	40	45	50	55	60	65	70
2.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2.5	1.1	1.1	1.2	1.2	1.2	1.3	1.3
3.0	1.1	1.2	1.2	1.2	1.3	1.3	1.4
3.5	1.1	1.2	1.2	1.3	1.3	1.4	1.5
4.0	1.2	1.2	1.2	1.3	1.4	1.4	
4.5	1.2	1.2	1.3	1.3	1.4	1.5	
5.0	1.2	1.2	1.3	1.4	1.5		
6.0	1.2	1.3	1.4	1.4	1.5		
7.0	1.3	1.3	1.4	1.5			
8.0	1.3	1.4	1.5				
9.0	1.3	1.4	1.5				
10.0	1.4	1.5					
15.0	1.5						

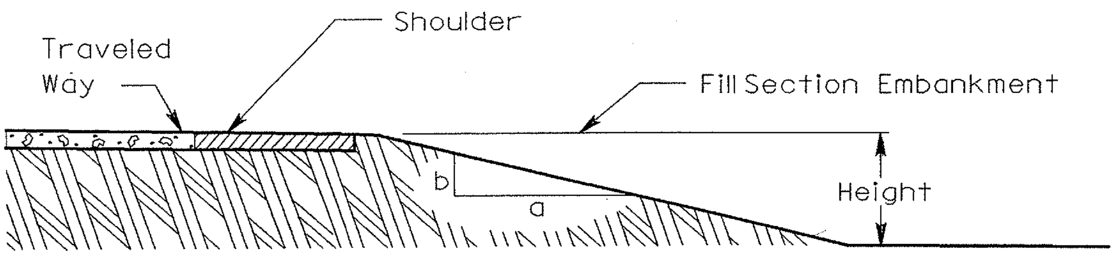
CLEAR ZONE MEASUREMENTS	**600-2**
	REFERENCE SECTIONS 600.2.1

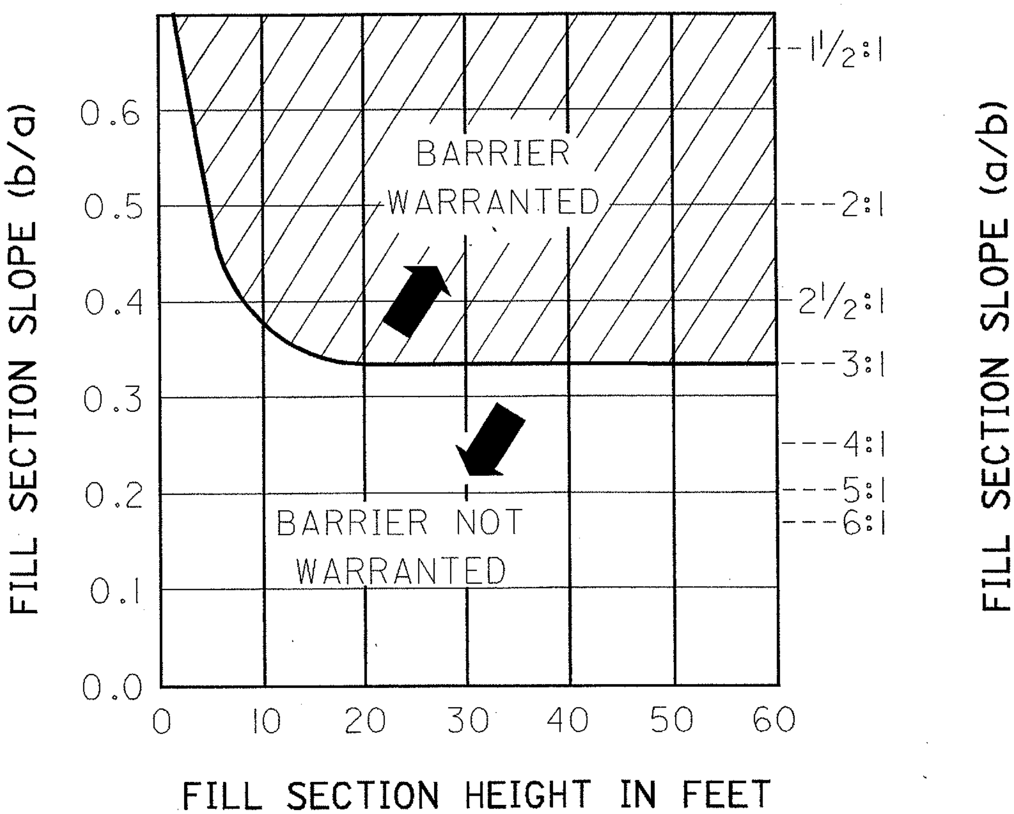


* For acceptable foreslope and backslope combinations that produce traversable trapezoidal and radius ditches, see **Figures 307-3** and **307-2**, respectively.

For clear zone widths, see **Figure 600-1**.
For 3R projects, see **Section 906.1**.

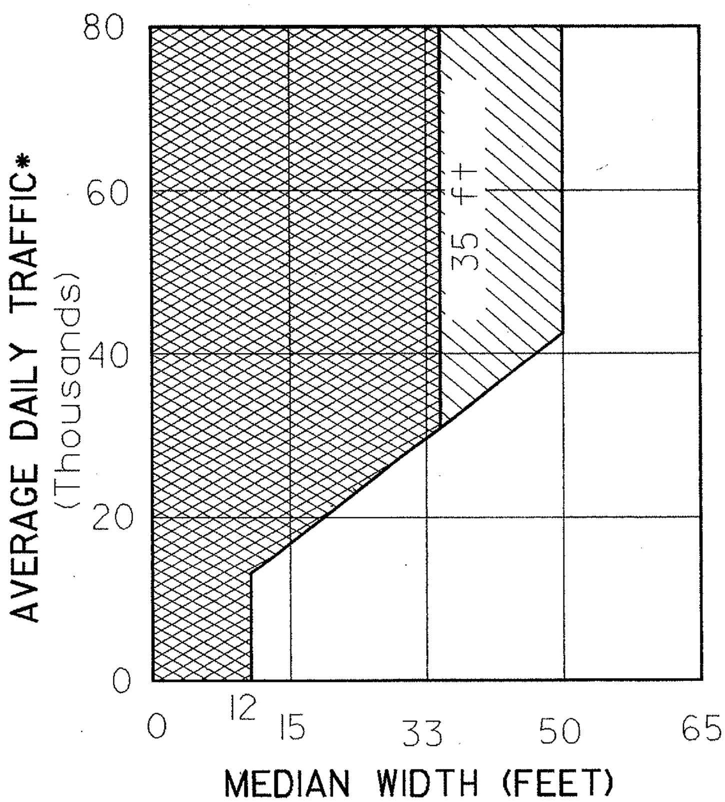
BARRIER WARRANTS FOR EMBANKMENTS	601-1 REFERENCE SECTIONS 601.1.2



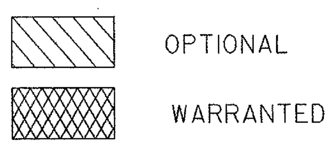


On or below the curve barrier is not warranted for embankment. However, check barrier need for other roadside hazards within the clear zone.

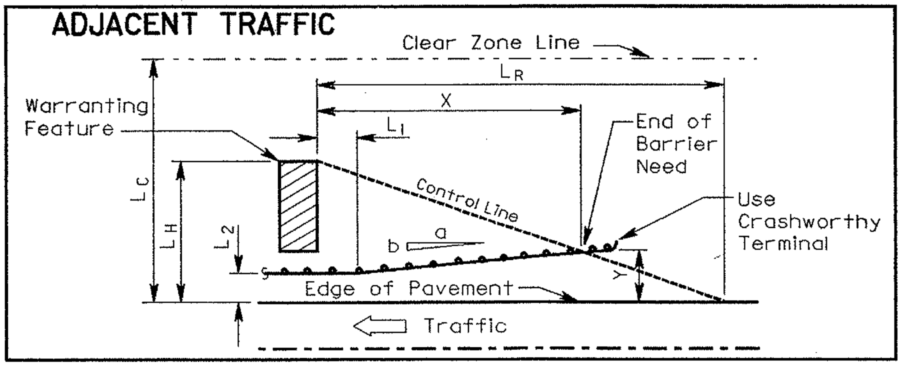
MEDIAN BARRIER WARRANTS	601-2
	REFERENCE SECTIONS 601.2

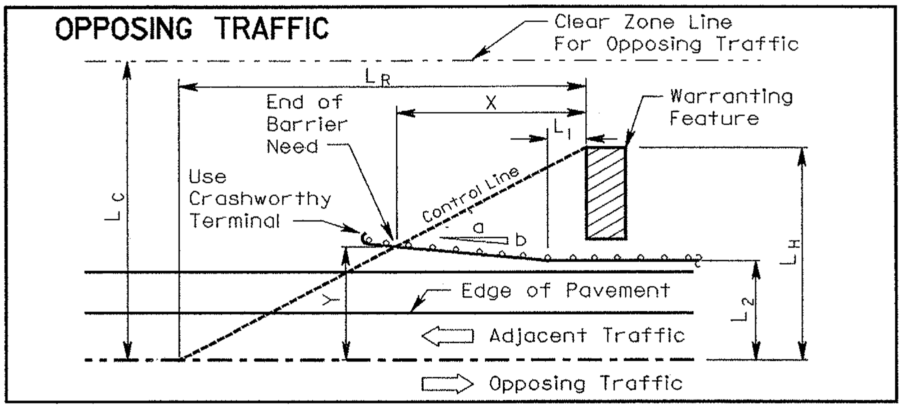


* Based on a 5-year projection



BARRIER LENGTH OF NEED (TANGENT ALIGNMENT)	602-1
	REFERENCE SECTIONS 602.1.2, 602.5.1, 603.6





Design Speed (mph)	Flare Rate (a:b)		Runout Length, L_R (ft)				Formulas
	Concrete Barrier	Steel Beam Guard-rail	Over 6,000 ADT	2000-6000 ADT	800-2000 ADT	Under 800 ADT	
70	20:1	15:1	480	440	400	360	
65	19:1	14:1	440	400	360	330	
60	17:1	13:1	400	360	330	300	
55	16:1	12:1	360	320	290	270	
50	14:1	11:1	320	290	260	240	
45	13:1	10:1	280	250	230	210	
40	11:1	9:1	240	220	200	180	
35	10:1	8:1	200	190	170	150	
30	8:1	7:1	170	160	140	130	

Formulas

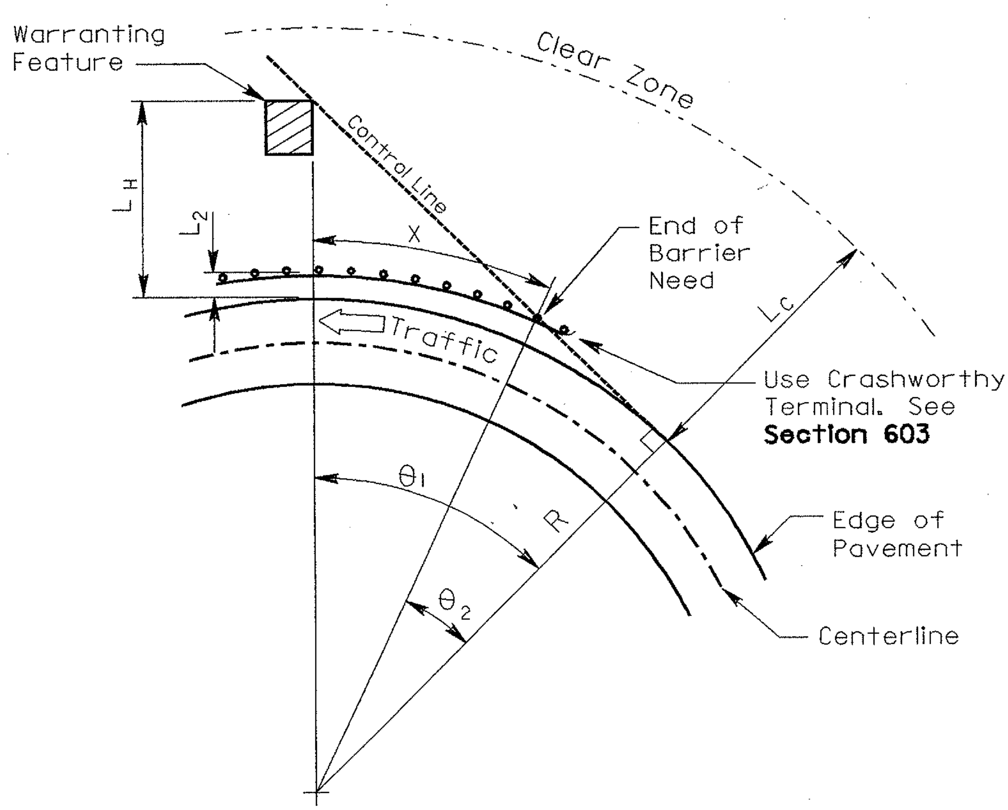
X = Length of Need
L_R = Runout Length
L_C = Required Clear Zone
L_H = Lateral Offset to Back of Warranting Feature
L_2 = Lateral Offset to Face of Barrier (See Figure 301-3.)
L_1 = Varies (Typically measured to the end of a full panel of guardrail.)

If $L_H < L_C$: $X = \dfrac{L_H + (b/a)L_1 - L_2}{(b/a) + L_H/L_R}$

$$Y = L_H - X\,L_H/L_R$$

If $L_H > L_C$: Substitute L_C in the above formulas.

BARRIER LENGTH OF NEED (CURVED ALIGNMENT)	602-2
	REFERENCE SECTIONS 602.1.3, 602.5.1, 603.6



Formulas

X = Length of Need
L_C = Required Clear Zone
L_H = Lateral Offset to Back of Warranting Feature
L_2 = Lateral Offset to Face of Barrier (See **Figure 301-3**.)

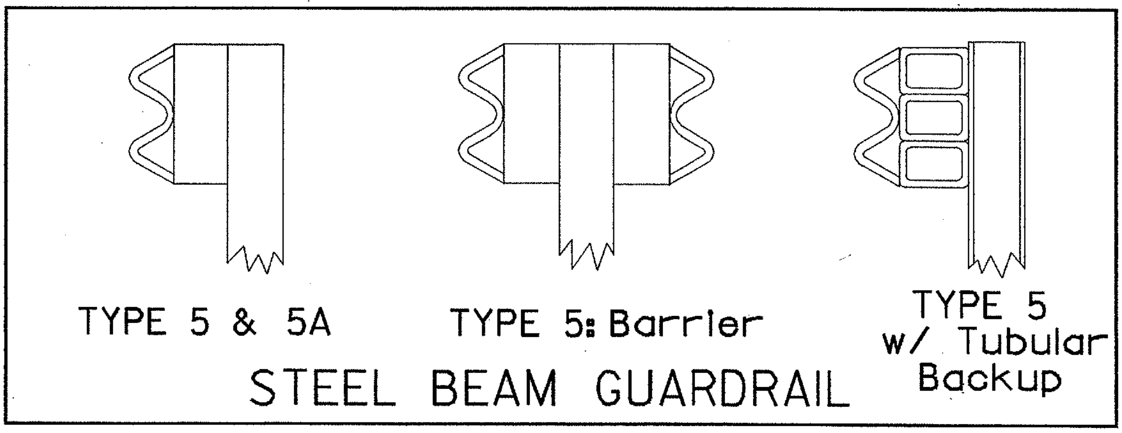
<u>If $L_H < L_C$</u>: $X = (R + L_2)(\theta_1 - \theta_2)$ radians where $\theta_1 = \cos^{-1}(R/(R + L_H))$ and $\theta_2 = \cos^{-1}(R/(R + L_2))$
$R = 5729.58/D_C$ where D_C = decimal degree of curvature
1 degree = $\pi/180$ radians

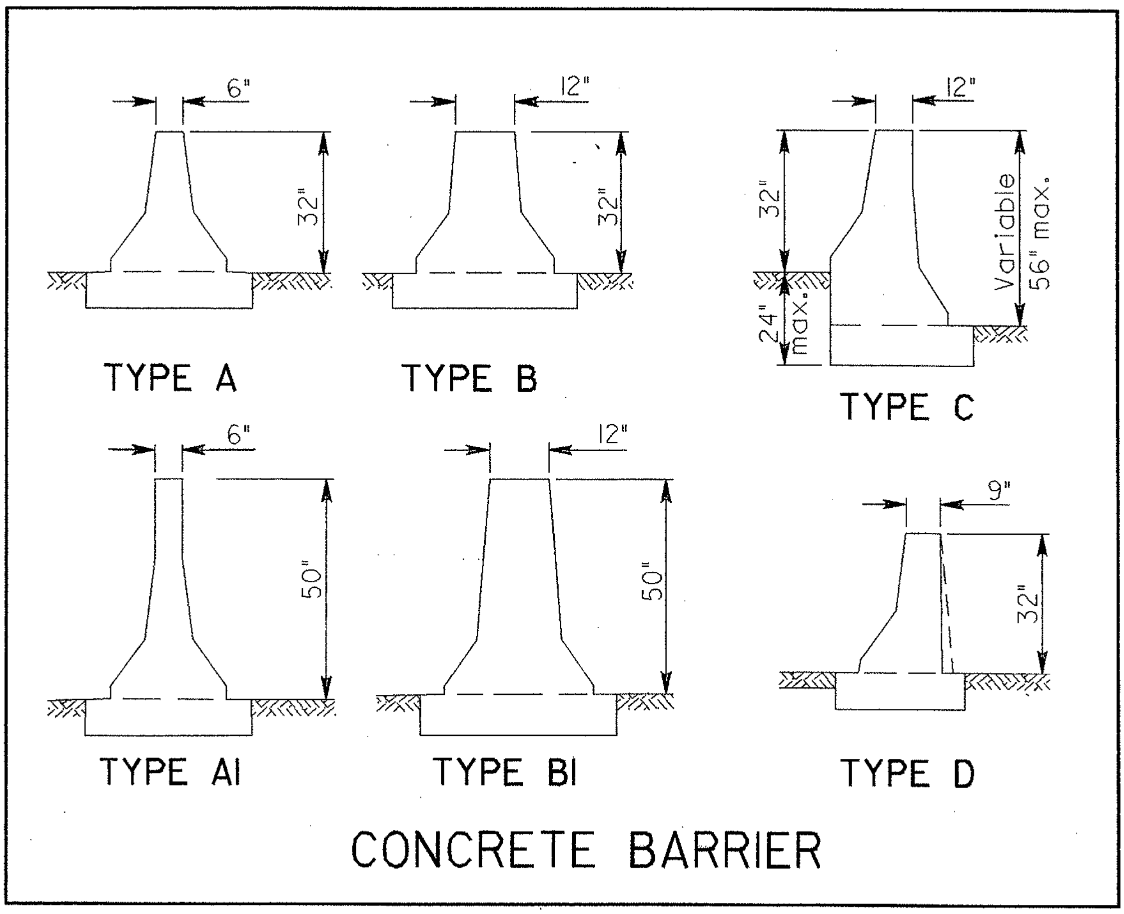
<u>If $L_H \geq L_C$</u>: Substitute L_C in the above formulas.

BARRIER TYPES

603-1

REFERENCE SECTIONS
603.1





TYPICAL BARRIER USES & MINIMUM CLEARANCES

603-2

REFERENCE SECTIONS 602.1.1, 603.1

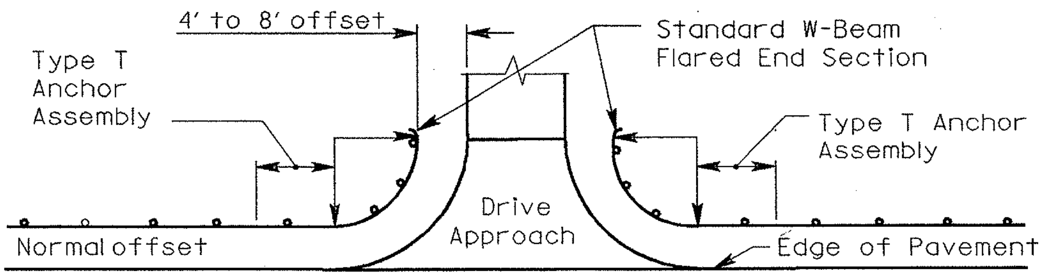
	Barrier Type	Standard Drawing	Minimum Barrier Clearance*	Typical Use
STEEL BEAM GUARDRAIL	Type 5	GR-2.1	5'-6"	Roadside protection. 6'-3" Post Spacing /12'-6" Rails
	Type 5A	GR-2.1	3'-6"	Roadside protection adjacent to fixed objects. 3'-1 1/2" Post Spacing /12'-6" Rails
	Type 5: Barrier	GR-2.1 GR-6.1 GR-6.2	5'-6"	Narrow medians where deflections can be tolerated.
	Type 5 with Tubular Backup	GR-2.2	Width of Barrier 24"	Prefabricated structures where other guardrail system minimum barrier clearances cannot be provided.
	Long Span Across Culvert	GR-2.4	3'-6"	Used primarily to span across precast structures that have limited depths of cover.
CONCRETE BARRIER	Type A	RM-4.3	Width of Barrier 2'-0"	Narrow medians where barrier deflections cannot be tolerated.
	Type A1	RM-4.3	Width of Barrier 2'-0"	Narrow medians where additional height is required.
	Type B	RM-4.3	Width of Barrier 2'-6"	Narrow medians where raceways or median lighting is used.
	Type B1	RM-4.3	Width of Barrier 2'-6"	Narrow medians where additional height is required and raceways are needed.
	Type C	RM-4.3	Width of Barrier 2'-6"	Narrow medians where the difference in shoulder elevation is 24" or less.
	Type D	RM-4.3 RM-4.5	Width of Barrier 18" to 24"	Roadside protection adjacent to fixed obstacles. Areas where impact angles over 15 degrees are unlikely or where maintenance may be difficult/dangerous.

* Measured from the face of the barrier to the obstacle.

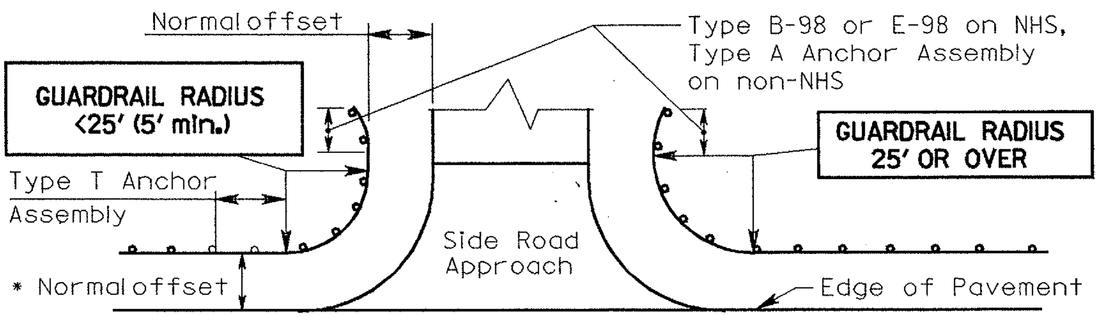
DRIVE AND SIDE ROAD GUARDRAIL OPENINGS

603-3

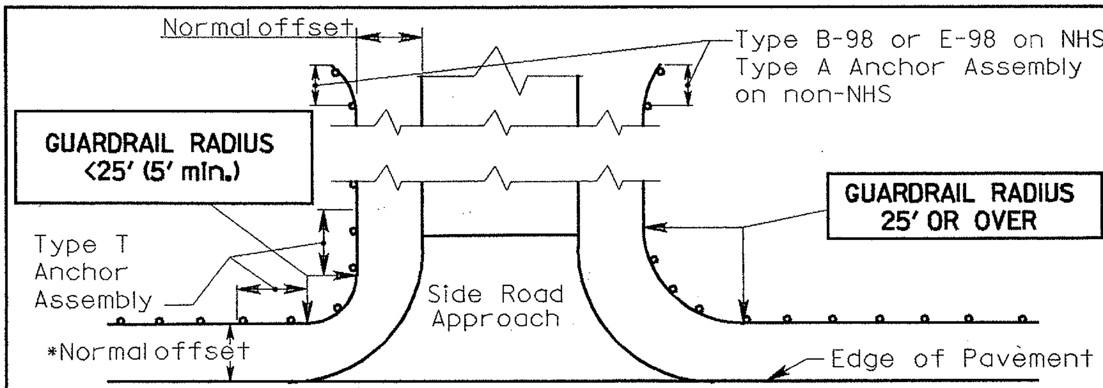
REFERENCE SECTIONS 602.4, 603.3.5



DRIVE GUARDRAIL OPENING



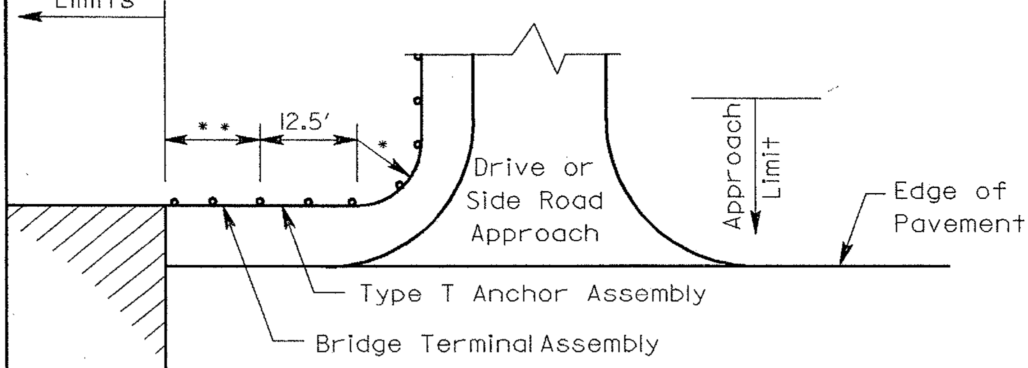
SIDE ROAD GUARDRAIL OPENING



SIDE ROAD GUARDRAIL OPENING WHERE GUARDRAIL EXTENDS ALONG SIDE ROAD

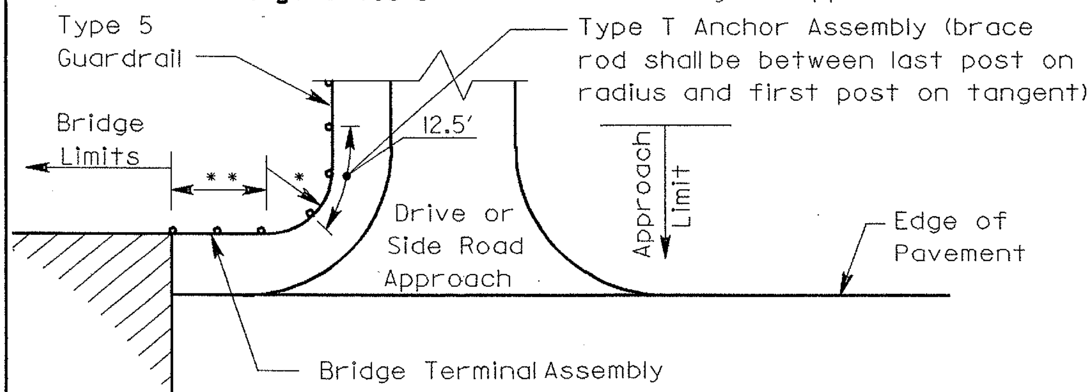
* See **Figure 201-4** for Side Road guardrail offset treatment.

MINIMUM BRIDGE PROTECTION INVOLVING DRIVES OR SIDE ROADS	603-4
	REFERENCE SECTIONS 602.5.1, 603.3.5



PREFERRED MINIMUM APPROACH TREATMENT

See **Figure 603-3** for treatment beyond approach.

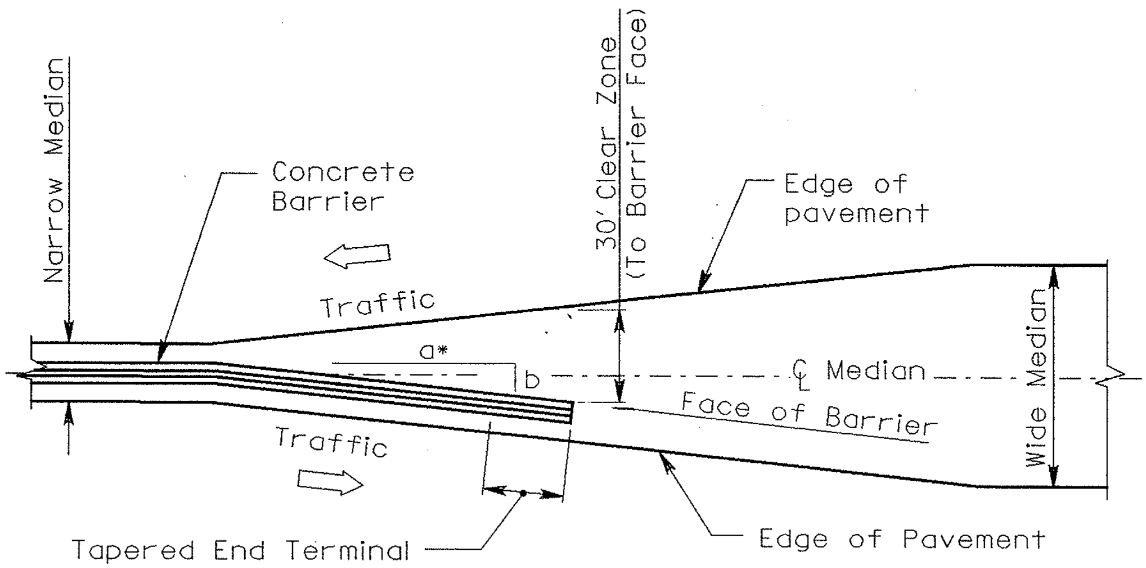


ABSOLUTE MINIMUM APPROACH TREATMENT

* Minimum Guardrail radius is 5'.

** 18'-9" for Type 1 and Type 3 Bridge Terminal Assemblies,
12'-6" for Type 2 and Type 4 Bridge Terminal Assemblies.

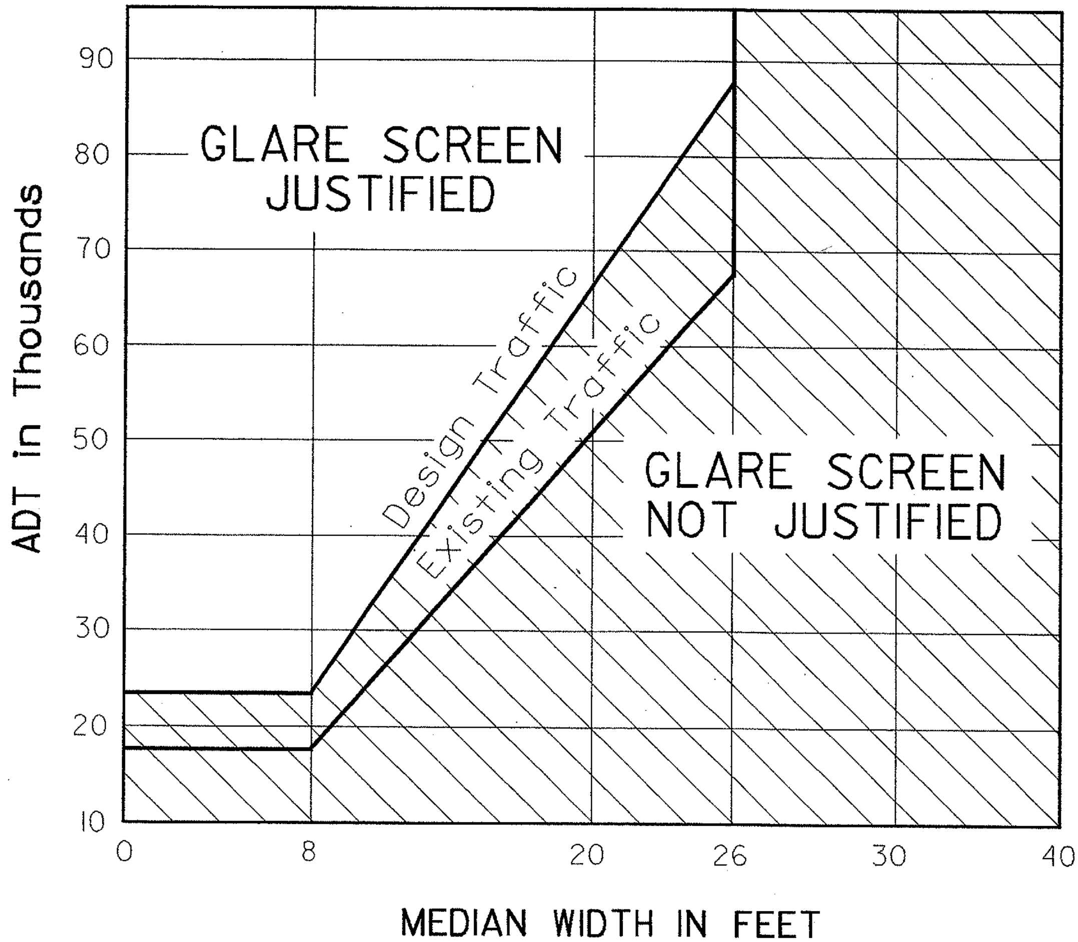
CONCRETE BARRIER MEDIAN TRANSITION	603-5 REFERENCE SECTIONS 603.6



* See **Figure 602-I** for barrier flare rates.

MEDIAN GLARE SCREEN USE GUIDE	604-1
	REFERENCE SECTIONS 604.1

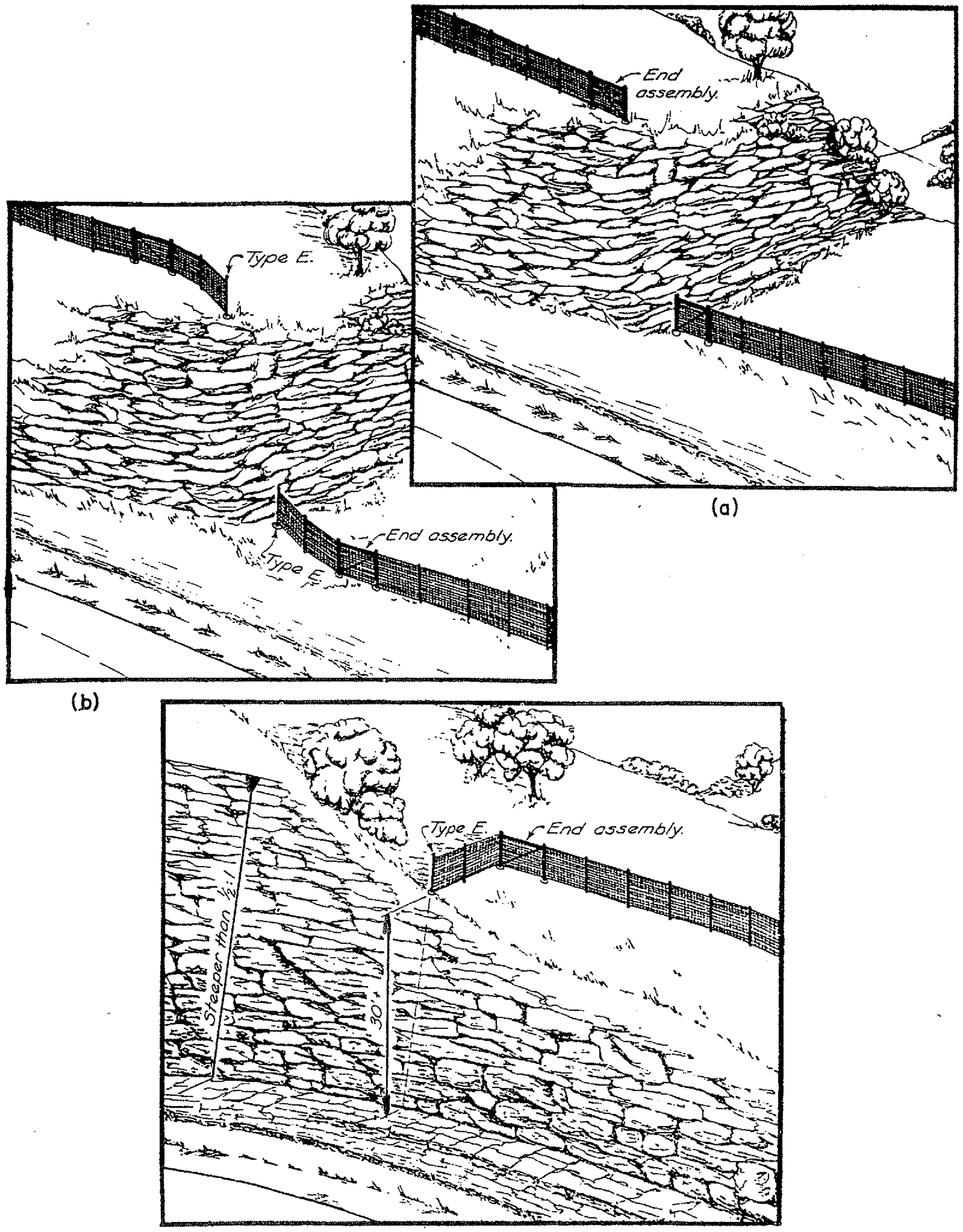
UNLIGHTED HIGHWAYS



LIGHTED HIGHWAYS

TOTAL MAINLINE LANES	GLARE SCREEN JUSTIFIED WHEN ADT (DESIGN OR EXIST) EXCEEDS
4	50,000
6	75,000
8	100,000

EXCEPTION TO CONTINUOUS FREEWAY FENCING	606-1
	REFERENCE SECTIONS 606.3.4



(a) (b) (c)

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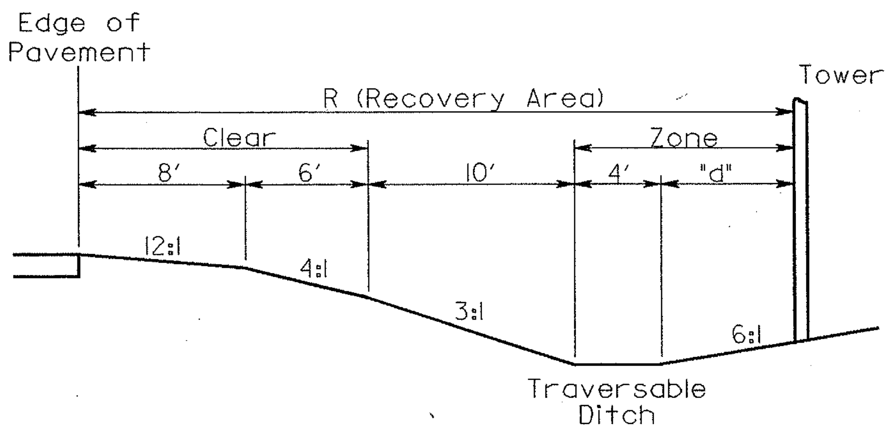
SAMPLE CALCULATIONS	
Ex. 600-1	**Clear Zone Measurement Using Slope Averaging (Traversable Ditch)**

Problem: Compute the safe distance from the edge of pavement to locate a tower for lighting. The project has a design speed of 55 mph, a design year traffic volume of 3,400 ADT and the following cross section in the area where the tower is to be located:



Solution: **Step 1** - Check the foreslope from the edge of pavement to the backslope to determine if all intermediate foreslopes are either recoverable or non-recoverable. (See **Figure 600-2**.)

Since the foreslope has intermediate slopes that are recoverable (12:1 & 4:1) and non-recoverable (3:1), the clear zone may extend into the backslope if necessary.

Step 2 - Determine the weighted average of the foreslope. For sections flatter than or equal to 10:1, use a 10:1 slope. (The 12:1 shoulder slope is typically ignored; however, for this example it is included for illustrative purposes.) Decimal results of 0.5 or greater should be rounded up to the next whole numbered slope while decimal results less than 0.5 should be rounded down to the next whole numbered slope.

First, multiply the width of each slope by the rate of the slope to obtain the weighted average rise for the foreslope. Include half of the ditch bottom in the foreslope.

8' (1/10) + 6' (1/4) + (0*) + 4'/2 (1/10) = 2.5'

* Since the 3:1 foreslope is non-recoverable, it is not included.

(continued)

Next, add the width of each foreslope used above.

8' +6' +4'/2 = 16'

Then, divide the total recoverable width by the weighted average rise to obtain the weighted average of the foreslopes.

16'/2.5' = 6.4 (Rounded to 6:1 slope)

Now, enter **Figure 600-1** (for 6:1 or flatter foreslopes, 55 mph Design Speed and 1,501 < ADT < 6,000) to determine that the required clear zone distance is 21 feet.

Since the required clear zone is 21 feet and only 16 feet of recoverable clear zone exists, additional width must be considered from the backslope.

<u>Step 3</u> - Determine if the ditch section is traversable.

Using **Figure 307-3**, a ditch with a 3:1 foreslope and 6:1 backslope is traversable.

If a non-traversable ditch section had been provided then the designer would have to consider other site conditions to determine whether or not the ditch should be used within the clear zone or if guardrail should be installed.

<u>Step 4</u> - Determine the clear zone using the backslope.

Determine how much of the backslope should be included in the clear zone.

21' - 8' - 6' - 4' = 3'

Therefore, the clear zone must extend 3 feet into the backslope.

The "Recovery Area" includes the clear zone width plus any intermediate widths where the slopes are traversable, but not recoverable.

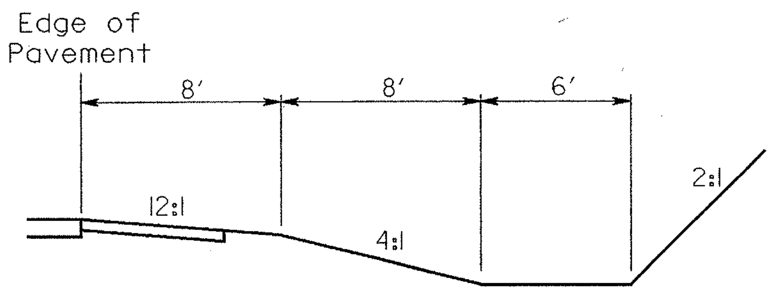
Recovery Area: 8' + 6' + 10' + 4' + 3' = 31'

SAMPLE CALCULATIONS	
Ex. 600-2	**Clear Zone Measurement For A Non-Traversable Ditch**

Problem: a) Determine the required clear zone distance for the following location on a project with a tangent alignment, a design speed of 55 mph and a design year traffic volume of 1,700 ADT.

b) Assuming this cross section occurs on the outside of a 2-Degree, how would this change the above results?

c) Determine the clear zone distance for a Degree of Curve of 3 degrees.



Solution: **a**) - The required clear zone distance (for foreslopes steeper than 6:1 up to 4:1, 55 mph design speed, and 1,501≤ADT≤6,000) is 27 feet. 19 feet of clear distance is available up to the center of the ditch. A trapezoidal ditch with a 4:1 foreslope, 2:1 backslope and a width equal to or greater than 4 feet is a non-traversable design (see **Figure 307-3**) and generally should not be located within the clear zone. However, if the probability of encroachment is low no additional improvement may be needed.

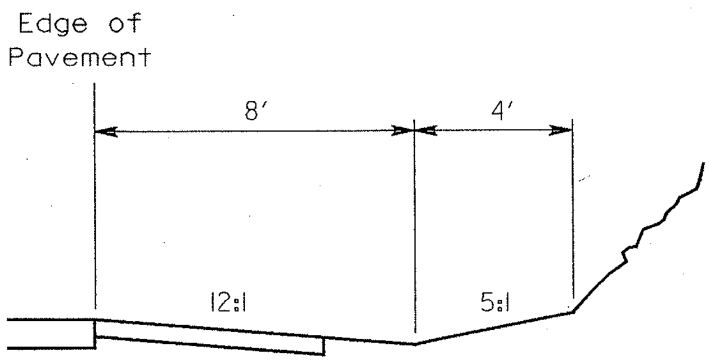
b) - Since this location is on the outside of a curve where the probability of encroachment is high, the designer should consider reshaping the ditch or installing guardrail.

c) - The required clear zone distance determined above for a tangent alignment needs to be increased by a factor or 1.23 for locations on the outside of curves with a curvature of 3 degrees and a design speed of 55 mph. (See **Figure 600-1**.) The adjusted clear zone distance is 27 (1.23) = 33.2'. Since the adjusted value is greater than 30', use 30'.

Since 19 feet or only 63% of the required clear zone distance exists on the outside of this curve, the designer should consider reshaping the ditch or installing guardrail.

SAMPLE CALCULATIONS	
Ex. 600-3	**Clear Zone Measurement For a Cut Slope**

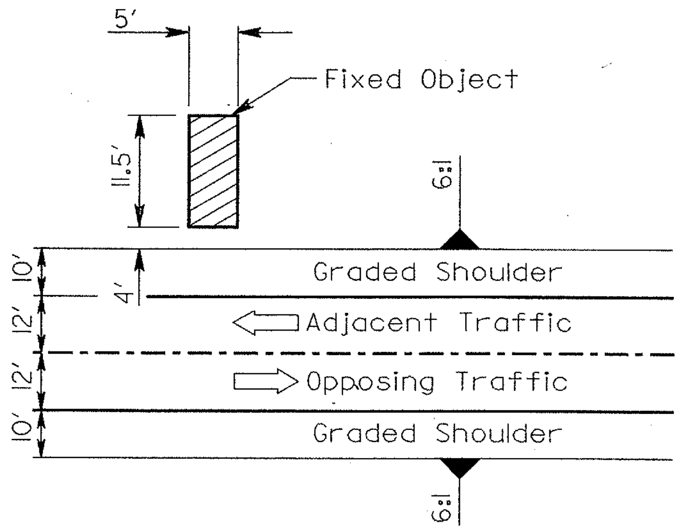
Problem: Determine the required clear zone distance for the following location on a project with a design speed of 45 mph and a design year traffic volume of 1,300 ADT.



Solution: The required clear zone distance (for backslopes steeper than 6:1 up to 4:1, 45 mph design speed and 750≤ADT≤1,500) is 13 feet. (See **Figure 600-1**.) The required clear zone is 13 feet but only 12 feet exist. If this section of roadway has a history of accidents with the cut face then guardrail should be installed.

SAMPLE CALCULATIONS	
Ex. 602-1	**Tangent Barrier Design For a 2-lane Road**

Problem: Design barrier if needed to shield the fixed object located on the two-lane non-NHS rural collector shown below. The project has a design speed of 60 mph, a design year traffic volume of 2,200 ADT, a K factor of 0.10, and a 6:1 foreslope. Assume that the object cannot be removed, relocated or made traversable.



Solution: **Step 1** - Determine whether or not the fixed object is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for 6:1 or flatter foreslope, 60 mph design speed and 1501≤ADT≤6000) to determine that the required clear zone distance is 28 feet.

The available clear area for adjacent traffic is 10' + 4' = 14 ft.

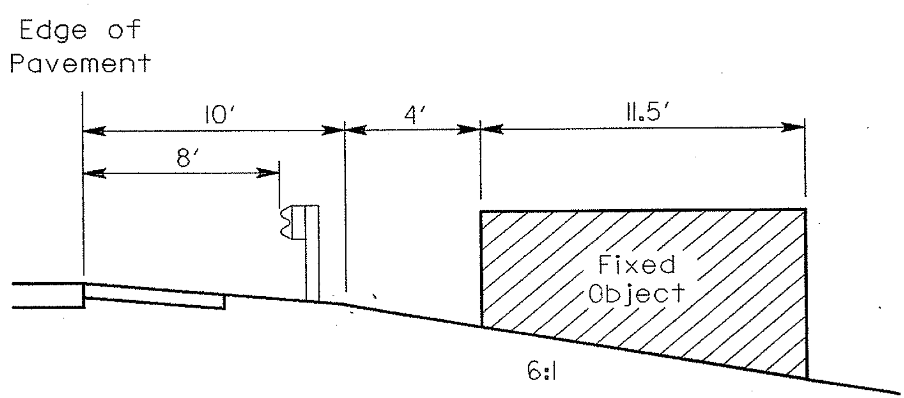
Since the object cannot be removed, relocated or made traversable and it is inside the required clear zone, a barrier should be installed to shield it.

SAMPLE CALCULATIONS

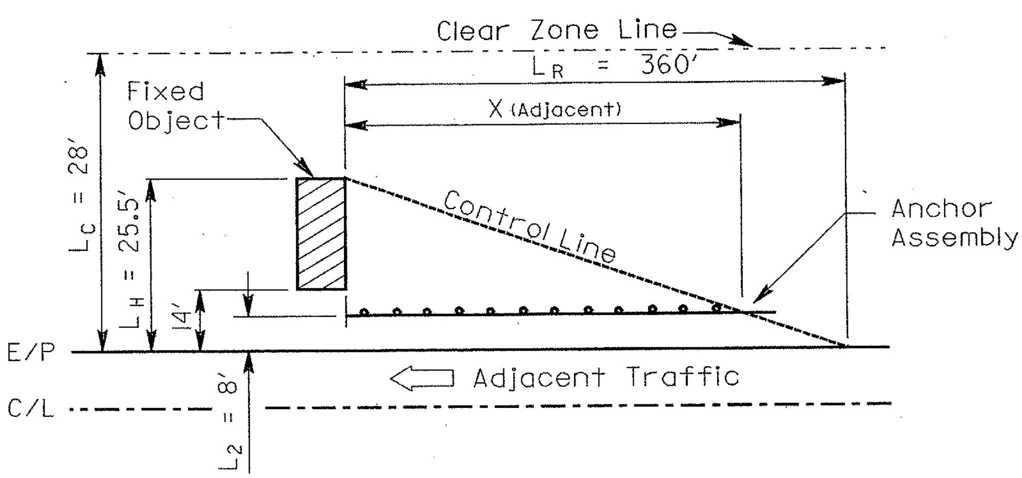
Ex. 602-1 | **Tangent Barrier Design For a 2-lane Road**

(continued)

__Step 2__ - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(2200) = 220. Using **Figure 301-3**, the normal (minimum) barrier offset for a rural collector (201≤DHV≤400) is 8 feet from the edge of pavement. The available barrier clearance at this location is (10' - 8') + 4' = 6 ft; therefore, use Type 5 Guardrail which has a minimum barrier clearance of 5.5 feet. (See **Figure 603-2**.)



__Step 3__ - Calculate the length of need for adjacent traffic. Assume the area along the front of the guardrail cannot be graded to provide 10:1 foreslopes; therefore, the guardrail cannot be installed with a flare.



SAMPLE CALCULATIONS

Ex. 602-1	Tangent Barrier Design For a 2-lane Road

(continued)

From **Figure 602-1**, L_R = 360 ft. (for design speed = 60 mph and 2000≤ADT≤6000). Since the lateral offset to the back of the object (L_H) is less than the required clear zone distance (L_C), use L_H in the LON formula.

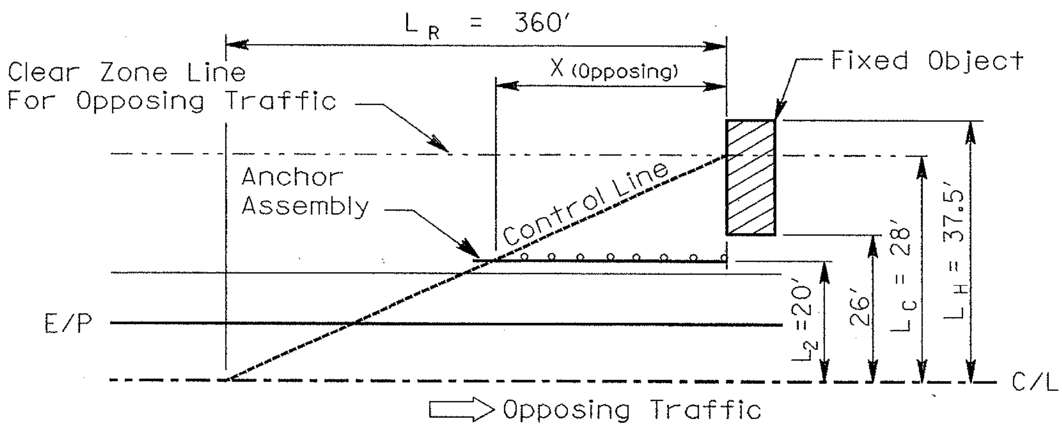
$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$$

Start measuring the length of guardrail needed at the edge of the fixed object. Since the guardrail will not be flared, b/a = 0.

$$x_{(adjacent)} = \frac{25.5 + 0 - 8}{0 + 25.5/360} = 247.05 \text{ ft.}$$

Step 4 - Determine whether or not the fixed object is in the clear zone for opposing traffic. The required clear zone is still 28 feet. The available clear area is 12' $_{(lane\ width)}$ + 14' = 26 ft. Since the object is in the clear zone, calculate the offset to the back of the object, L_H.

L_H = 12' + 14' + 11.5' = 37.5 ft.



Since $L_H > L_C$, protection only needs to be provided up to the clear zone.

$$x_{(opposing)} = \frac{L_C + L_1 b/a - L_2}{b/a + L_C/L_R} = \frac{28' + 0 - 20'}{0 + 28/360} = 102.86 \text{ ft.}$$

SAMPLE CALCULATIONS	
Ex. 602-1	**Tangent Barrier Design For a 2-lane Road**

(continued)

The total length of guardrail required is:

$x_{(adjacent)}$ + width of object + $x_{(opposing)}$ = 247.05' + 5' + 102.86' = 354.91 ft.

The length provided should be a multiple of even 12'-6" panel lengths.

x = 354.91'/12.5' = 28.39 Use 29 panels or 29(12.5') = 362.5 ft.

Note - If the designer had chosen to shield the entire object from opposing traffic instead of providing protection up to the clear zone, then

$$x_{(opposing)} = \frac{L_H - L_2}{L_H/L_R} = \frac{37.5 - 20}{37.5/360} = 168 \text{ ft.}$$

The total length of guardrail needed would have been:

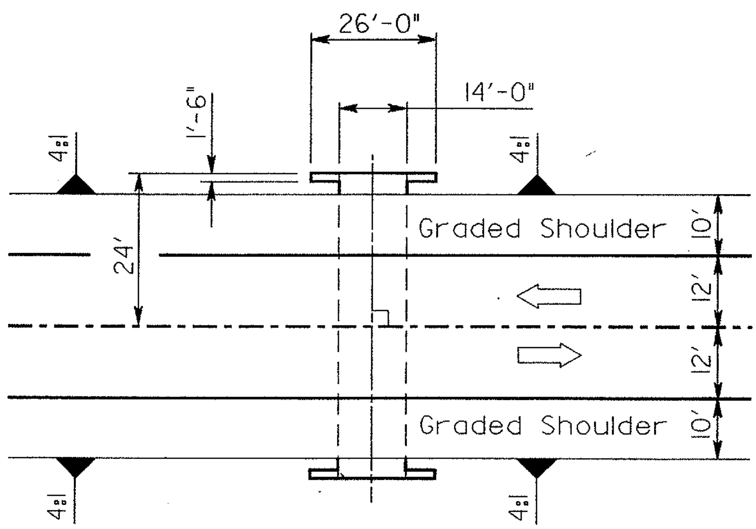
247.05' + 5' + 168' = 420.05 ft. (or 34 panels)

Five additional panels (62.5 feet) of guardrail would be installed. This is approximately 17% more guardrail. In some cases, the designer may choose to shield the entire object even though a portion of it is outside the clear zone; however, in this case it is probably uneconomical to do so.

Step 5 - Select Anchor Assemblies. Since this is a non-NHS collector with a design year ADT≤4000, a Type A Anchor Assembly may be installed on the approach and trailing ends of the guardrail run.

SAMPLE CALCULATIONS	
Ex. 602-2	**Length of Need at a Large Culvert**

Problem: Design barrier if needed to shield the culvert headwalls located on the two-lane NHS rural collector shown below. This bridge replacement project has a design speed of 55 mph, a design year traffic volume of 3,100 ADT, a K factor of 0.10, and 4:1 foreslopes.



Solution

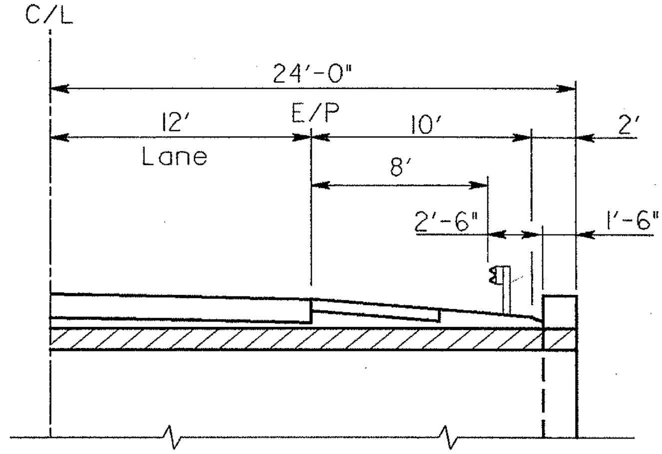
Step 1 - Determine whether or not the headwall is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for foreslopes steeper than 6:1 up to 4:1, 55 mph design speed and 1501≤ADT≤6000) to determine that the required clear zone distance is 27 feet measured from the edge of pavement.

The available clear area for adjacent traffic is 24' - 12' - 1'-6" = 10'-6"

It is impractical to almost double the length of the culvert to get the headwalls outside the clear zone; therefore, barrier should be provided.

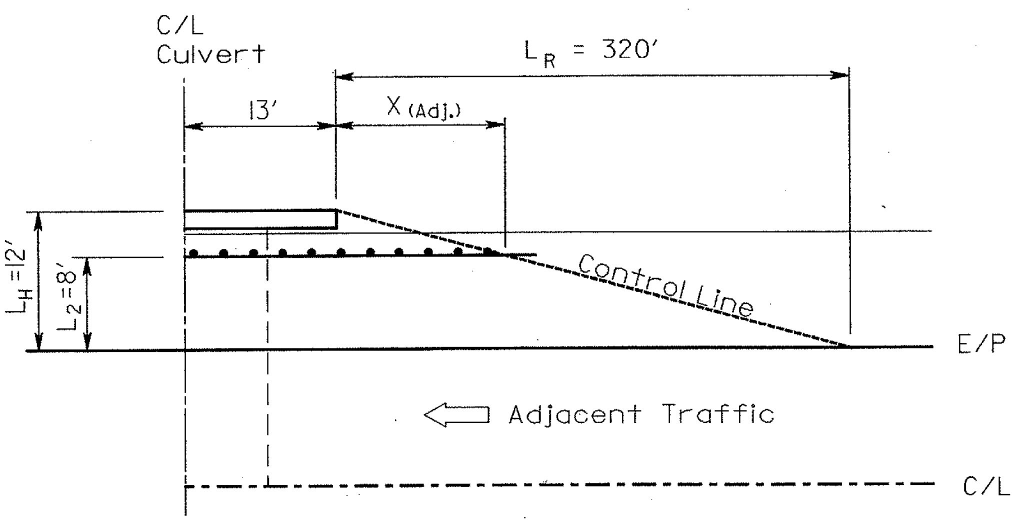
Step 2 - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(3100) = 310. Using **Figure 301-3**, the normal barrier offset for a rural collector (201≤DHV≤400) is 8' from the edge of pavement. The available barrier clearance at this location is (10' - 8') + (2' - 1.5') = 2.5 ft.

(continued)



Since there is not enough clearance available for Type 5 Guardrail, which has a minimum barrier clearance of 5'-6", use Type 5 Guardrail with Tubular Backup, which has a minimum barrier clearance of 24." (See **Figure 603-2**.)

Step 3 - Calculate the length of need for adjacent traffic. Since the foreslope along the face of the guardrail cannot be regraded to 10:1, do not flare the guardrail. (The geometrics of the roadway and the offset to the headwall are the same on both sides of the road; therefore, the lengths calculate for adjacent and opposing traffic for the eastbound lane will be the same as those calculated for adjacent and opposing traffic for the westbound lane.)



(continued)

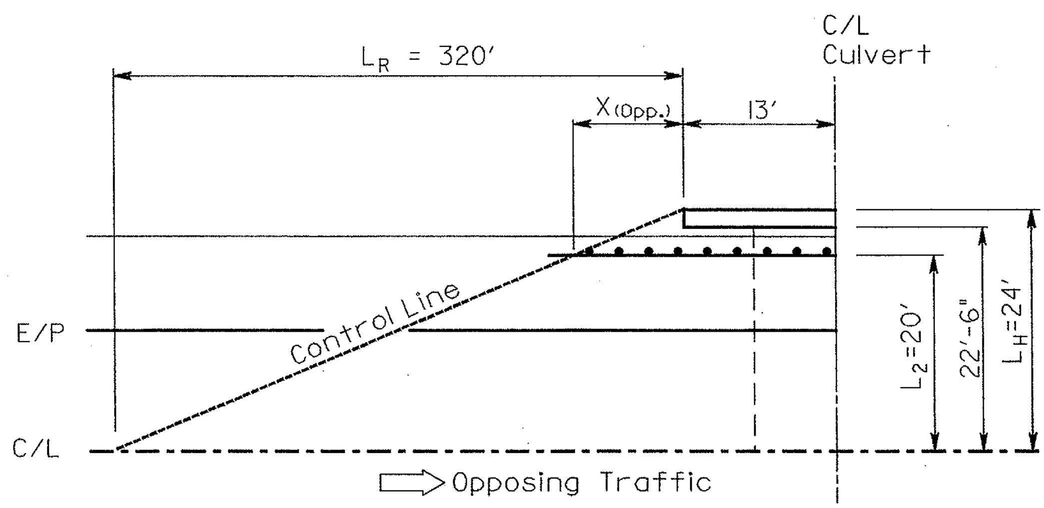
From **Figure 602-1**, L_R = 320 ft. (for design speed = 55 mph and $2000 \leq ADT \leq 6000$). Since the lateral offset to the back of the headwall (L_H) is less than the required clear zone distance (L_C), use L_H in the LON formula.

$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$$

Start measuring the length of guardrail needed at the edge of the headwall. Since the guardrail will not be flared, b/a = 0.

$$x_{(adjacent)} = \frac{12' + 0 - 8'}{0 + 12'/320'} = 106.67 \text{ ft.}$$

Step 4 - Determine whether or not the headwall is in the clear zone for opposing traffic. The required clear zone distance is still 27 feet. The available clear area is 24' - 1'-6" = 22'-6".



Since $L_H < L_C$, $x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$

Start measuring the length of guardrail needed at the edge of the headwall. Since the guardrail will not be flared, b/a = 0.

$$x_{(opposing)} = \frac{24' + 0 - 20'}{0 + 24'/320'} = 53.33 \text{ ft.}$$

(continued)

The total length of guardrail required is:

$x_{(adjacent)}$ + width of headwall + $x_{(opposing)}$ = 106.67' + 26' + 53.33' = 186 ft.

The length provided should be a multiple of even 12'-6" guardrail panel lengths.

x = 186/12.5 = 14.88 Use 15 panels or 15(12.5') = 187.5 ft.

Step 5 - Detail the final installation, including the anchor assemblies. The Type 5 Guardrail with Tubular Backup should extend to the first post off the approach and trailing ends of the structure. In this case, the headwall (not the culvert itself) is the structure that is being protected. The headwall is slightly longer than 2 panels of guardrail so use 3 panels (37'-6"). A Type 4 Bridge Terminal Assembly is required at each end of the Type 5 Guardrail with Tubular Backup. This transition is paid for as a unit and requires 25' of Type 5 Guardrail in order to be installed. If the Tubular Backup is centered about the culvert centerline then the amount of rail needed at the approach end is 106.67' - (37.5' - 26')/2 = 100.92'. This is a little more than 8 panels of guardrail. Rather than add an additional panel, shift the Type 5 Guardrail with Tubular Backup upstream to cover the 0.92' shortage.

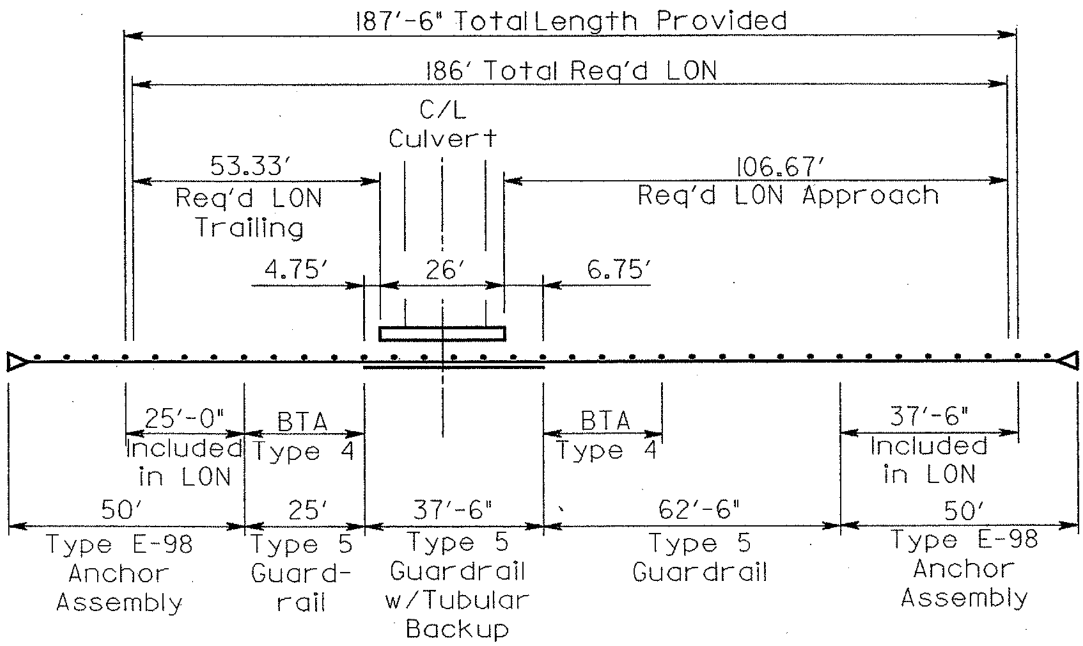
Since this is an NHS route, Type A Anchor Assemblies are not permitted even though the design year ADT$\leq$4000. Refer to **Table 603-1** in **Section 603.3.3** for a Bridge Replacement Project with foreslopes steeper than 6:1 up to 4:1 to determine that a Type E-98 Anchor Assembly should be used on the approach and trailing ends. (It is required on the trailing end because it is within the clear zone for opposing traffic.)

Since up to 37'-6" of the 50' long Type E-98 can be deducted from the guardrail length of need, decrease the amount of rail specified for the approach end by this amount. On the trailing end the amount of barrier needed after the Bridge Terminal Assembly is 53.33' - (25' +4.75') = 23.58'; therefore, only include 25'-0" of the Type E-98 in the amount deducted from the guardrail. (See the following final detail.)

Note: Many large culverts are located in deep channels with steep side slopes. This may necessitate that the designer use $L_H = L_C$ when calculating the required length of need.

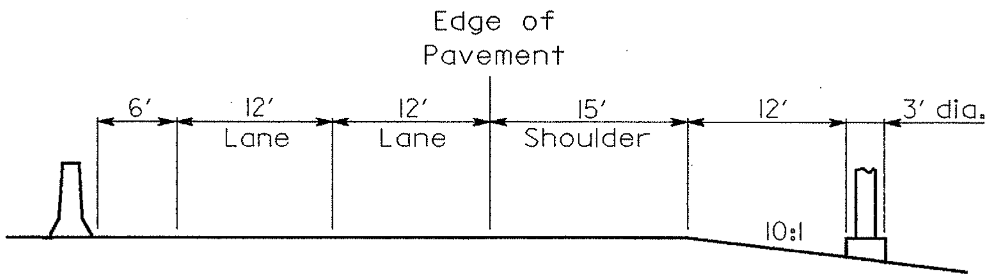
SAMPLE CALCULATIONS	
Ex. 602-2	**Length of Need at a Large Culvert**

(continued)



SAMPLE CALCULATIONS	
Ex. 602-3	**Tangent and Flared Barrier Design For a Divided Highway**

Problem: Design barrier if needed to shield the 3' diameter footing located on the 4-lane, divided, NHS, urban, interstate 3R project shown below. The project has a design speed of 70 mph, a design year traffic volume of 12,000 ADT and 10:1 foreslopes. If barrier is needed calculate how much should be provided if it is installed **a**) at the normal (minimum) barrier offset on a tangent, **b**) at the normal (minimum) barrier offset on a flare, **c**) as close to the footing as permissible on a tangent and **d**) as close to the footing as permissible on a flare.



Solution: **Step 1** - Determine whether or not the footing is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for foreslopes 6:1 or flatter, 70 mph design speed and ADT>6000) to determine that the required clear zone distance is 32 feet measured from the edge of pavement. However, since this is not a high accident area a maximum clear zone distance of 30' should be used.

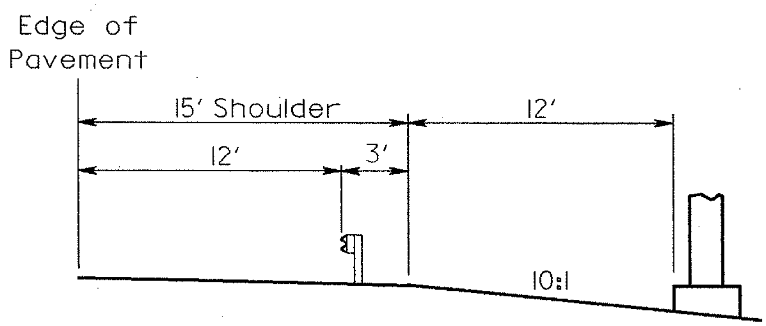
The available clear area for adjacent traffic is 15' + 12' = 27'

Assuming the footing cannot be relocated outside the clear zone, barrier should be provided.

Step 2 - Select the type of barrier to be installed. Using **Figures 301-4 & 301-3**, the normal (minimum) barrier offset for an urban interstate route is 12' from the right edge of pavement. The available barrier clearance at this location is 3' + 12' = 15'; therefore, use Type 5 Guardrail, which has a minimum barrier clearance of 5.5'. (**See Figure 603-2**.)

SAMPLE CALCULATIONS	
Ex. 602-3	**Tangent and Flared Barrier Design For a Divided Highway**

(continued)



Step 3 - Calculate the length of need for adjacent traffic. (A calculation for opposing traffic is unnecessary because the concrete median barrier prevents encroachments by opposing vehicles.)

From **Figure 602-1**, L_R = 480 ft. (for Design Speed = 70 mph and ADT over 6000).

a) For tangent guardrail at the normal (minimum) barrier offset, $L_H=L_C=30'$, $L_2=12'$, and b/a = 0.

$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R} = \frac{30' + 0 - 12'}{0 + 30'/480'} = 288' \quad \text{Use 24 panels.}$$

b) For flared guardrail at the normal (minimum) barrier offset, b/a = 1/15. (See **Figure 602-1**.) Let L_1=12'-6" (one panel length). In this case, this is an arbitrary selection. Site conditions typically control the amount of tangent barrier that should be provided past the warranting feature before a flare is introduced. For instance, where a flared section of Type 5 Guardrail is attached to a tangent section of Type 5A, it is advisable to extend the Type 5A past the warranting feature such that L_1 is at least equal to one panel length. Since Type 5 and 5A have different deflection characteristics, this ensures adequate protection at the edge of the warranting feature.

$$x = \frac{30' + 12.5'(1/15) - 12'}{1/15 + 30'/480'} = \frac{30' + 0.83' - 12'}{0.129'} = 145.97' \quad \text{Use 12 panels.}$$

SAMPLE CALCULATIONS

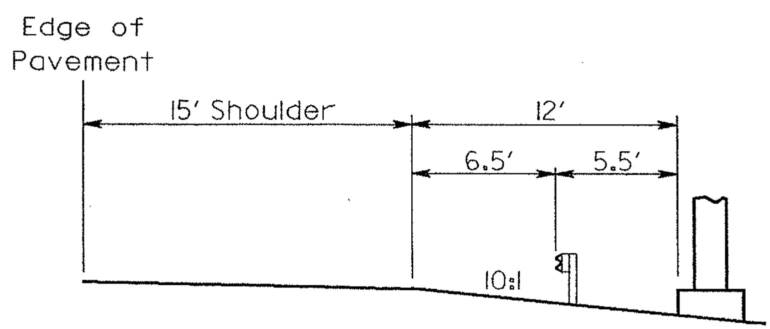
Ex. 602-3	Tangent and Flared Barrier Design For a Divided Highway

(continued)

c) Guardrail can be installed on slopes that are 10:1 or flatter. Since Type 5 Guardrail has a minimum barrier clearance of 5.5' the guardrail can be placed at this distance in front of the footing.

L_2 = 15' + 12' - 5.5' = 21.5'. For tangent guardrail, b/a = 0. L_H is still equal to 30'.

$$x = \frac{30' + 0 - 21.5''}{0 + 30'/480'} = 136' \quad \text{Use 11 panels.}$$



d) For flared guardrail offset at 21.5':

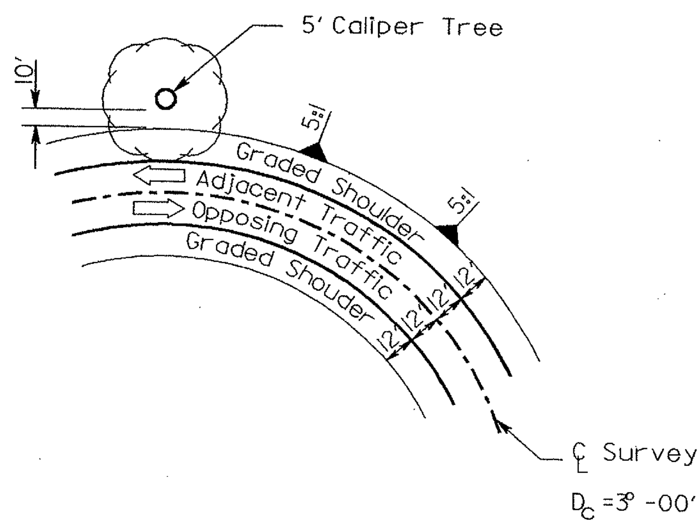
$$x = \frac{30' + 12.5'(1/15) - 21.5'}{1/15 + 30'/480'} = \frac{30' + 0.83' - 21.5'}{0.129'} = 72.32' \quad \text{Use 6 panels.}$$

All of these solutions are correct; however, d) is the best solution because it provides the most recovery area with the least amount of barrier.

__**Step 4**__ - Select Anchor Assemblies. Refer to **Table 603-1** for a 3R project with 6:1 or flatter foreslopes to determine that the approach terminal should be either a Buried in Backslope or Type B-98 Anchor Assembly. There is no backslope so select the Type B-98. Use a Type T Anchor Assembly on the trailing end since it cannot be impacted by opposing traffic.

SAMPLE CALCULATIONS	
Ex. 602-4	**Barrier on the Outside of a Curve**

Problem: Calculate the barrier length of need to shield the 200-yr old 5-ft. diameter tree located on the outside of a 3-degree curve as shown below. The HSP project is on a rural arterial and has a design speed of 55 mph, a design year traffic volume of 3800 ADT, a K factor of 0.10, and 5:1 foreslopes. Assume that the HSP project is needed to address run-off-the-road impacts with the tree and also assume that the tree cannot be removed.



Solution: **Step 1** - Determine whether or not the tree is in the clear zone for adjacent traffic. From **Figure 600-1** (for foreslopes steeper than 6:1 up to 4:1, 55 mph design speed and $1501 \le ADT \le 6000$) the required clear zone distance is 27 feet measured from the edge of pavement. Since the tree is on the outside of a 3-degree curve, the clear zone should be widened by using the curve correction factor for 55 mph design speed (1.23) from the chart at the bottom of **Figure 600-1**.

Required Clear Zone = 1.23 (27') = 33.21 ft.

Do not reduce this value to 30 ft. since this is a high accident location.

The offset to the face of the tree is 12' + 10' = 22 ft. This is less than L_C = 33.21 ft.; therefore, install barrier.

SAMPLE CALCULATIONS

Ex. 602-4	Barrier on the Outside of a Curve

(continued)

Step 2 - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(3800) = 380. Using **Figure 301-3**, the normal (minimum) barrier offset for a rural arterial ($201 \leq DHV \leq 400$) is 10 feet from the right edge of pavement. The available barrier clearance at this location is 12 feet; therefore, use Type 5 Guardrail, which has a minimum barrier clearance of 5.5 feet. (See **Figure 603-2.)**

Step 3 - Calculate the length of need for adjacent traffic. The radius for the 3-degree curve is $R_{centerline} = 5729.58/D_C = 5729.58/3.0 = 1909.86'$.

The radius at the edge of pavement is 1909.86' + 12' =1921.86'.

The lateral offset to the back of the tree is, $L_H = 22' + 5' = 27'$.

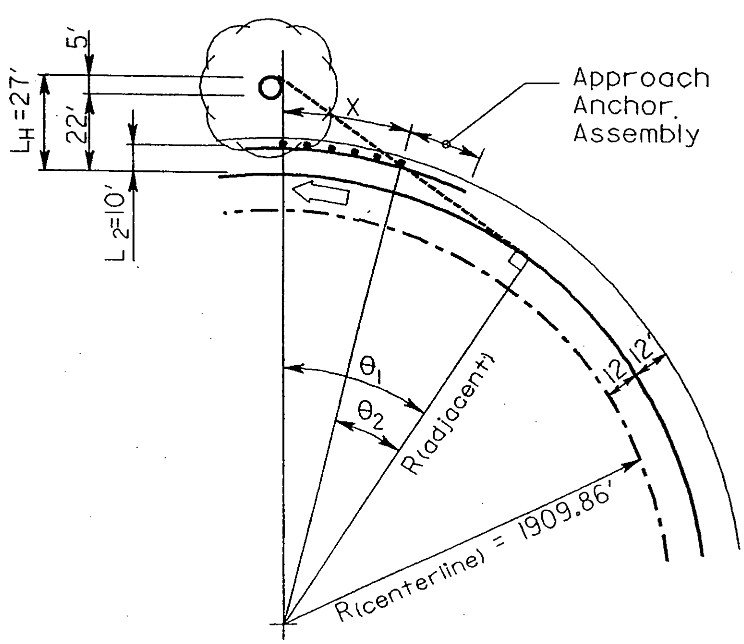
$$\theta_1 = \cos^{-1} (R_{adj} / (R_{adj} + L_H)) = \cos^{-1} (1921.86 / (1921.86 + 27)) = 9.5484°$$

$$9.5484°(\pi/180) = 0.1666 \text{ radians}$$

$$\theta_2 = \cos^{-1} (R_{adj} / (R_{adj} + L_2)) = \cos^{-1} (1921.86 / (1921.86 + 10)) = 5.8323°$$

$$5.8323°(\pi/180) = 0.1018 \text{ radians}$$

$$X = (R_{adj} + L_2) (\theta_1 - \theta_2) \text{ rad.} = (1921.86 +10) (0.1666 - 0.1018) = 125.18'$$



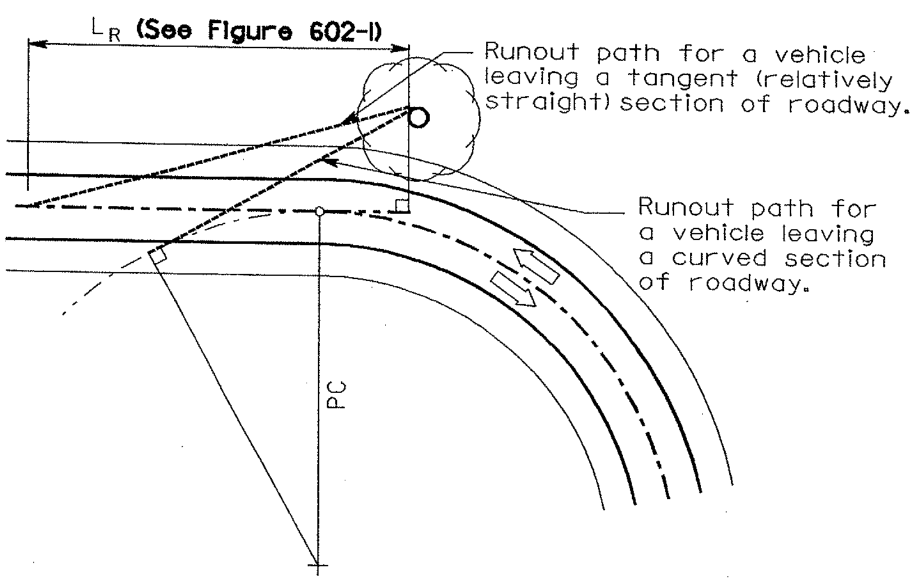
(continued)

Step 4 - Determine whether or not the tree is within the clear zone for opposing traffic. The offset to the face of the tree is 12' + 12' + 10' = 34'. Since this is outside the clear zone, guardrail is not needed past the left side of the tree to shield it from opposing traffic.

The total length of guardrail needed is 125.18' + 5' = 130.18'
Use 11 panels (137.5').

Refer to **Table 603-1** in **Section 603.3.3** to determine the recommended anchor assembly for an HSP project with foreslopes steeper than 6:1 up to 4:1. On the approach end install a Type E-98 Anchor Assembly. Since 37'-6" of the 50' long Type E-98 can be deducted from the guardrail length of need, decrease the amount of rail specified above at the approach end by this amount. (Use 100'.) On the trailing end install a Type T Anchor Assembly because it is outside the clear zone for opposing traffic.

Notes - If a point of curvature exists in the vicinity of the runout path, the curve may need to be extended past the PC or PT (into the tangent portion of the roadway) in order to construct the tangent control line. If this is the case, then the standard runout lengths for tangent roadways should be used to calculate length of need.



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600 Roadside Design

List of Metric Figures

Sample Calculations

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CLEAR ZONE WIDTHS

600-1 (metric)

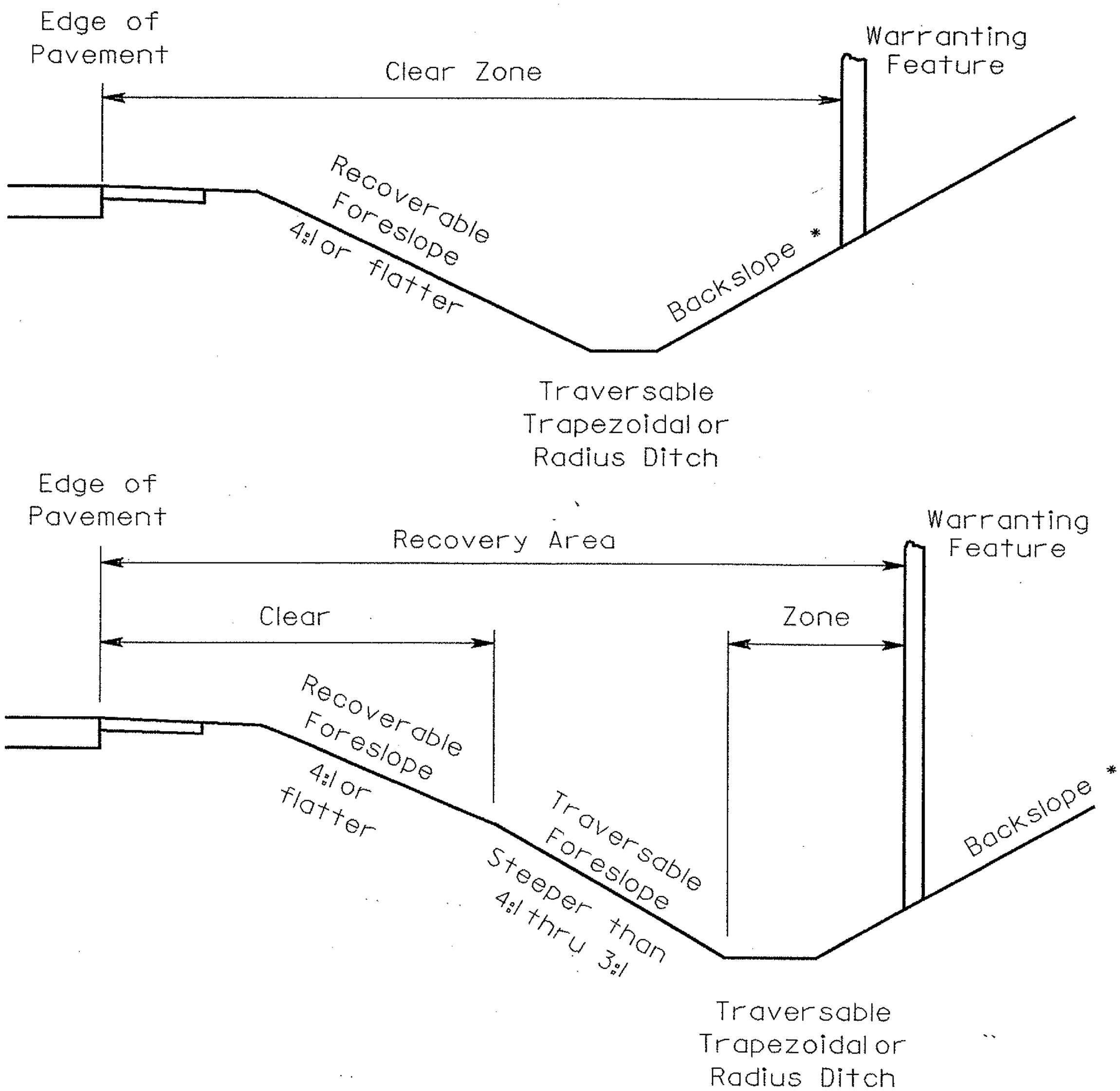
REFERENCE SECTIONS 600.2

Design Speed	Design ADT	Foreslope		Backslope		
		6:1 or Flatter	Steeper than 6:1 to 4:1	6:1 or Flatter	Steeper than 6:1 to 4:1	Steeper than 4:1
60 km/h or less	<750 750-1500 1501-6000 >6000	2.5 m 3.3 4.0 4.8	2.5 m 4.0 4.8 5.3	2.5 m 3.3 4.0 4.8	2.5 m 3.3 4.0 4.8	2.5 m 3.3 4.0 4.8
70-80 km/h	<750 750-1500 1501-6000 >6000	3.3 4.8 5.3 6.3	4.0 5.5 7.0 8.0	3.3 4.8 5.3 6.3	2.8 4.0 4.8 5.8	2.8 3.3 4.0 4.8
90 km/h	<750 750-1500 1501-6000 >6000	4.0 5.3 6.3 7.0	5.0 6.8 8.3 9.0	3.3 5.3 6.3 7.0	3.3 4.8 5.3 6.3	2.8 3.3 4.8 5.3
100 km/h	<750 750-1500 1501-6000 >6000	5.3 6.8 8.5 9.5*	6.8 9.0 11.0* 12.3*	4.8 6.3 7.8 8.3	4.0 5.3 6.0 7.8	3.3 4.0 5.0 6.3
110-120 km/h	<750 750-1500 1501-6000 >6000	5.8 7.8 9.3 9.8*	7.0 9.8* 11.8* 12.8*	4.7 6.3 8.3 8.8	4.8 5.8 7.0 8.5	3.3 4.3 5.5 7.0

* Use a **maximum clear zone** of 9.0 meters unless a site specific investigation or accident history indicates a high potential of continuing accidents. When the potential for continuing accidents is high, the widths in the above chart should be multiplied by the following curve correction factors to extend the clear zone on the outside of curves having a Curve Radius of 900 meters or less.

Curve Radius	HORIZONTAL CURVE CORRECTION FACTORS					
	Design Speed (km/h)					
	60	70	80	90	100	110-120
900 m	1.1	1.1	1.1	1.2	1.2	1.2
700	1.1	1.1	1.2	1.2	1.2	1.3
600	1.1	1.2	1.2	1.2	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	1.5
400	1.2	1.2	1.3	1.3	1.4	
350	1.2	1.2	1.3	1.4	1.5	
300	1.2	1.3	1.4	1.5	1.5	
250	1.3	1.3	1.4	1.5		
200	1.3	1.4	1.5			
150	1.4	1.5				
100	1.5					

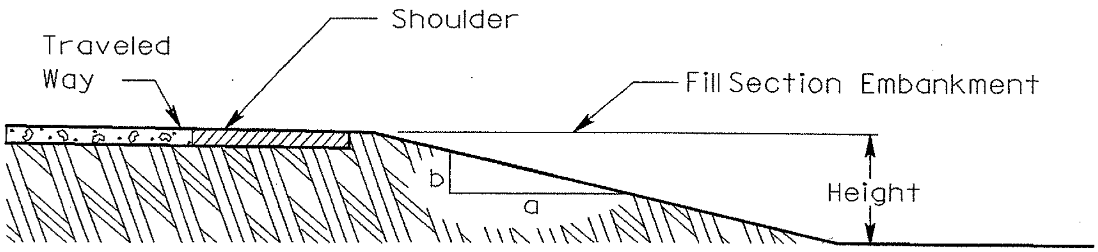
CLEAR ZONE MEASUREMENTS	600-2 (metric) REFERENCE SECTIONS 600.2.1

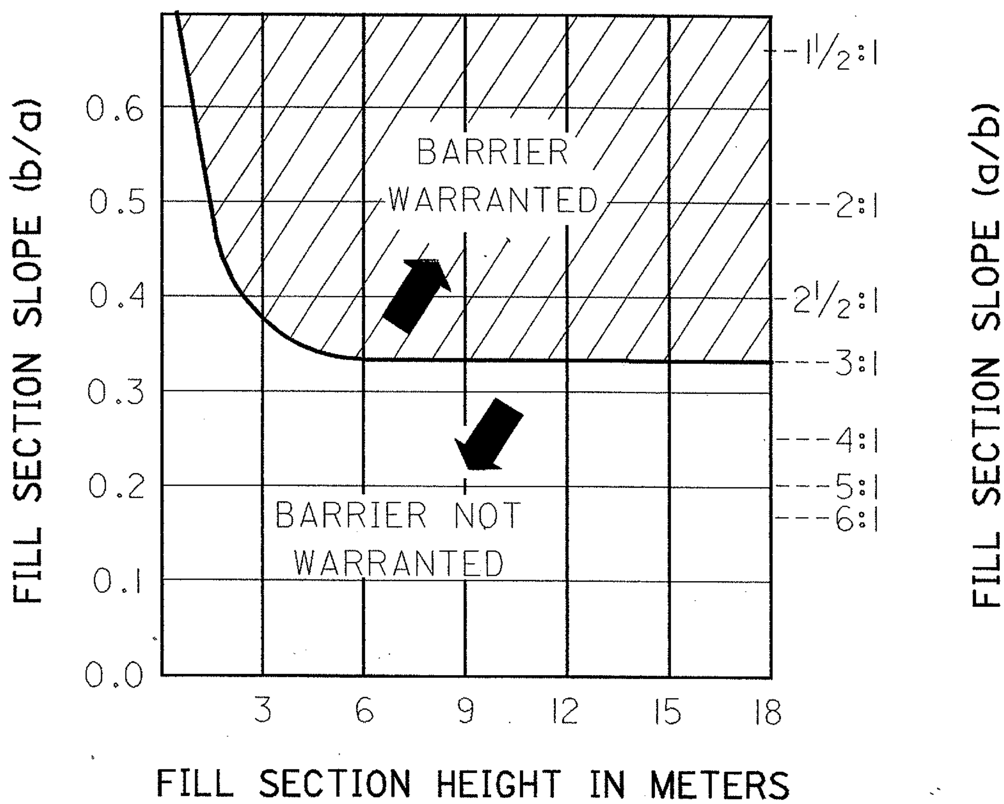


* For acceptable foreslope and backslope combinations that produce traversable trapezoidal and radius ditches, see **Figures 307-3** and **307-2**, respectively.

For clear zone widths, see **Figure 600-1**.
For 3R projects, see **Section 906.1**.

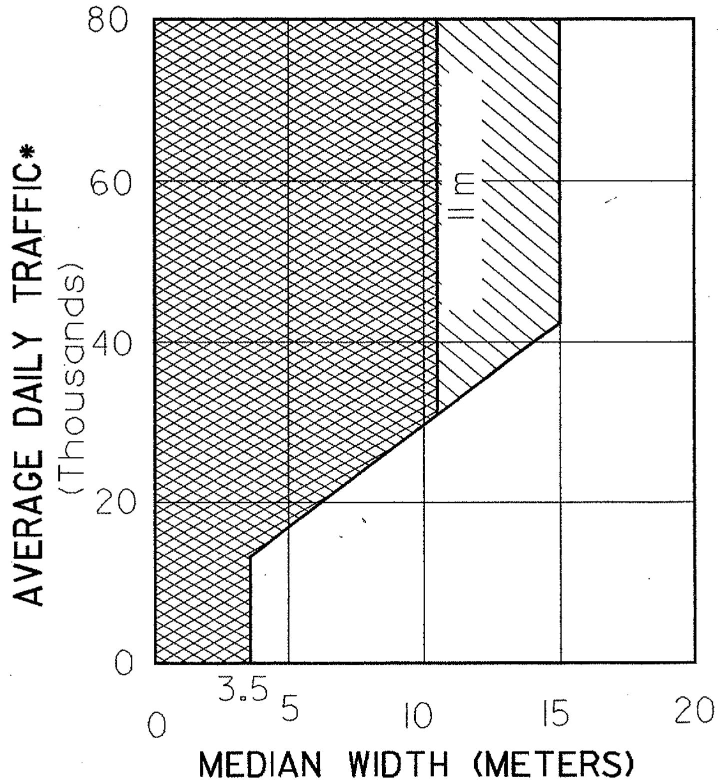
BARRIER WARRANTS FOR EMBANKMENTS	601-1 (metric)
	REFERENCE SECTIONS 601.1.2



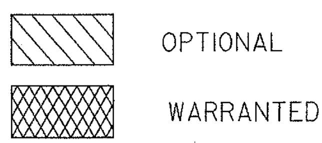


On or below the curve barrier is not warranted for embankment. However, check barrier need for other roadside hazards within the clear zone.

MEDIAN BARRIER WARRANTS	601-2 (metric)
	REFERENCE SECTIONS 601.2



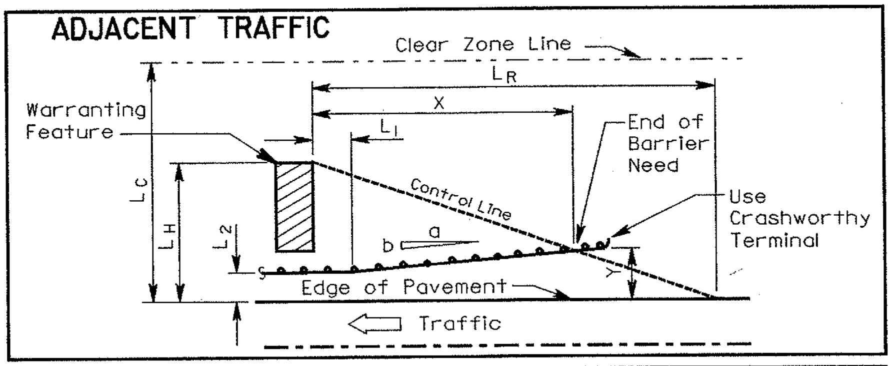
* Based on a 5-year projection

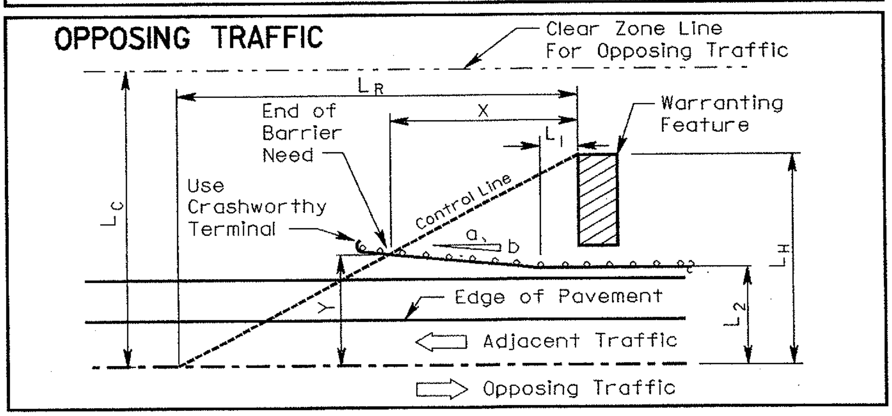


BARRIER LENGTH OF NEED (TANGENT ALIGNMENT)

602-1 (metric)

REFERENCE SECTIONS 602.1.2, 602.5.1, 603.6





Design Speed (km/hr)	Flare Rate (a:b) Concrete Barrier	Flare Rate (a:b) Steel Beam Guard-rail	Runout Length, L_R (m) Over 6,000 ADT	Runout Length, L_R (m) 2000-6000 ADT	Runout Length, L_R (m) 800-2000 ADT	Runout Length, L_R (m) Under 800 ADT
110-120	20:1	15:1	145 m	135 m	120 m	110 m
100	18:1	14:1	130	120	105	100
90	16:1	12:1	110	105	95	85
80	14:1	11:1	100	90	80	75
70	12:1	10:1	80	75	65	60
60	10:1	8:1	70	60	55	50
50	8:1	7:1	50	50	45	40

Formulas

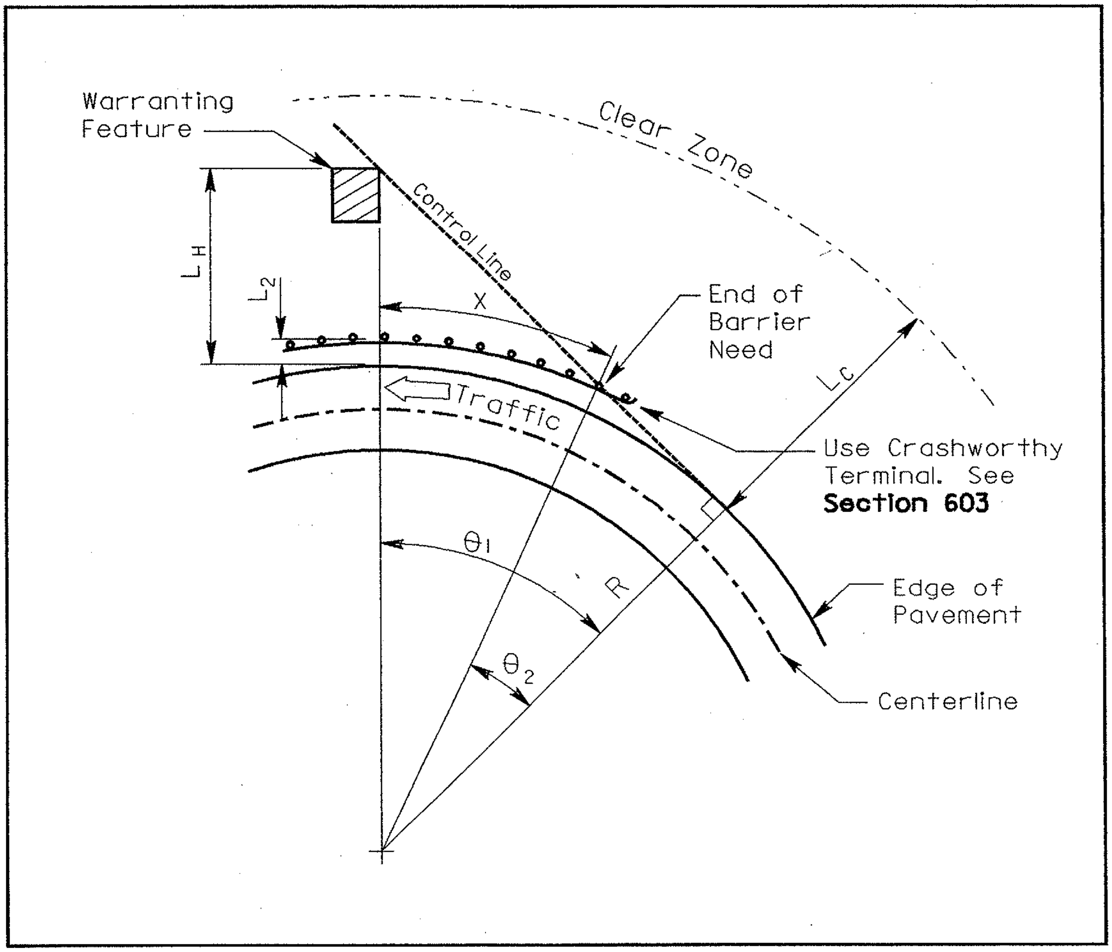
X = Length of Need
L_R = Runout Length
L_C = Required Clear Zone
L_H = Lateral Offset to Back of Warranting Feature
L_2 = Lateral Offset to Face of Barrier (See Figure 301-3.)
L_1 = Varies (Typically measured to the end of a full panel of guardrail.)

If $L_H < L_C$: $X = \dfrac{L_H + (b/a)L_1 - L_2}{(b/a) + L_H/L_R}$

$$Y = L_H - X\,L_H/L_R$$

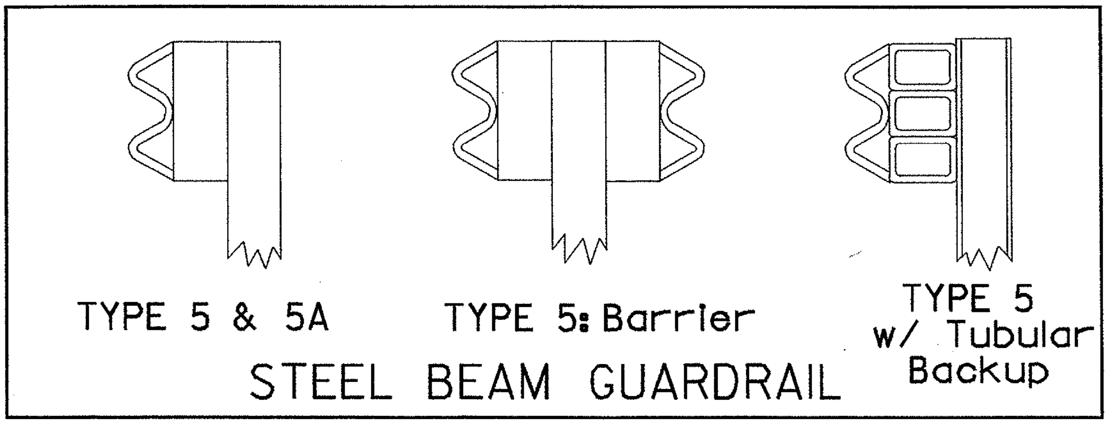
If $L_H > L_C$: Substitute L_C in the above formulas.

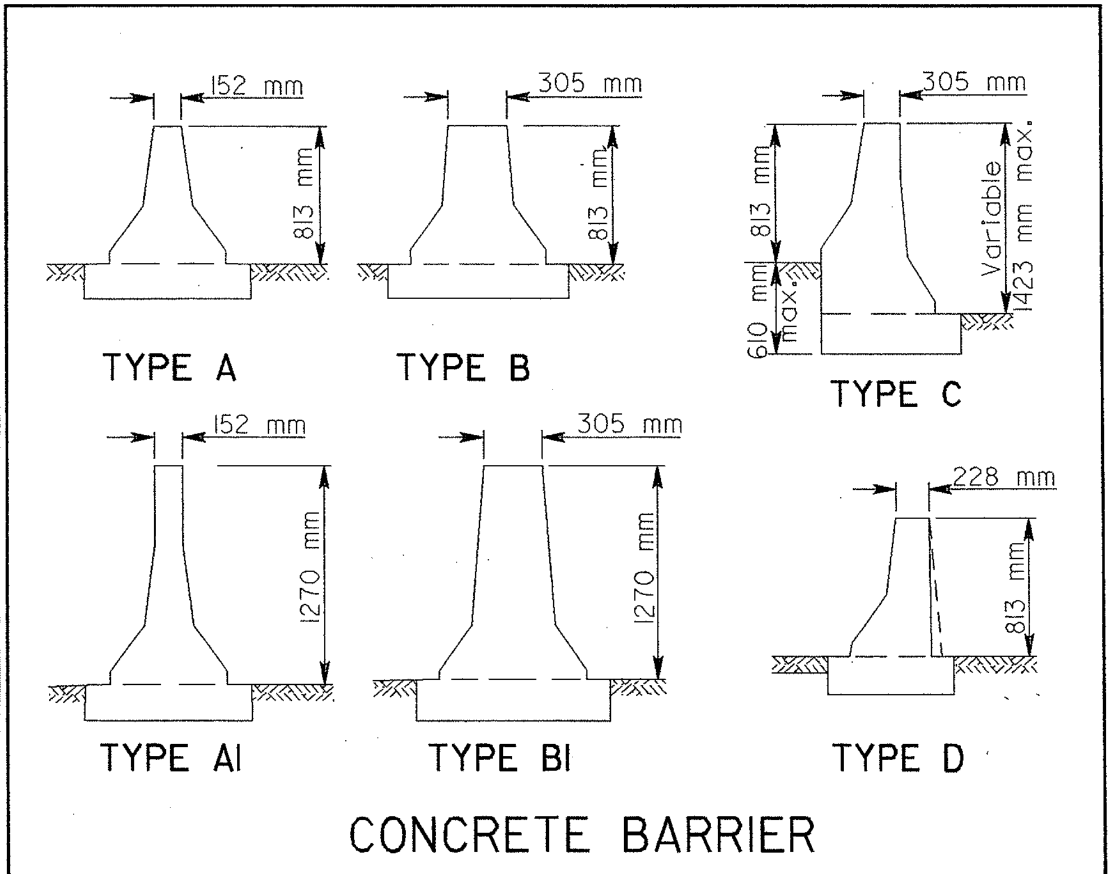
# BARRIER LENGTH OF NEED (CURVED ALIGNMENT)	**602-2 (metric)**
	REFERENCE SECTIONS 602.1.3, 602.5.1, 603.6



Formulas
X = Length of Need L_C = Required Clear Zone L_H = Lateral Offset to Back of Warranting Feature L_2 = Lateral Offset to Face of Barrier (See **Figure 301-3**.) If $\mathbf{L_H < L_C}$: $X = (R + L_2)(\theta_1 - \theta_2)$ radians where $\theta_1 = \cos^{-1}(R/(R + L_H))$ and $\theta_2 = \cos^{-1}(R/(R + L_2))$ 1 degree = $\pi/180$ radians If $\mathbf{L_H > L_C}$: Substitute L_C in the above formulas.

BARRIER TYPES	603-1 (metric)
	REFERENCE SECTIONS 603.1





TYPICAL BARRIER USES & MINIMUM CLEARANCES

603-2 (metric)

REFERENCE SECTIONS 602.1.1, 603.1

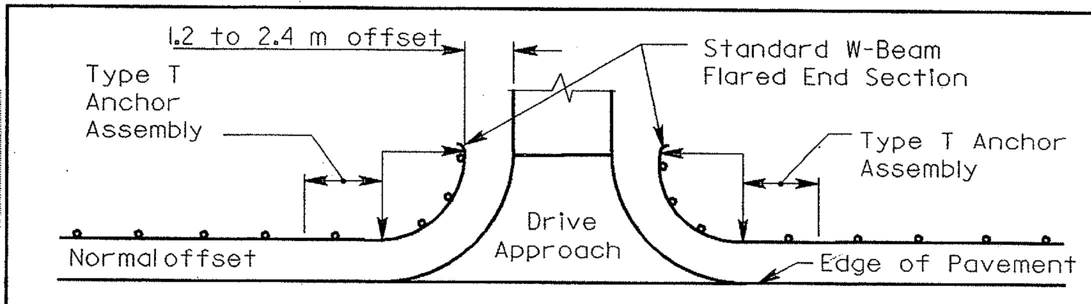
	Barrier Type	Standard Drawing	Minimum Barrier Clearance*	Typical Use
STEEL BEAM GUARDRAIL	Type 5	GR-2.1	1.7 m	Roadside protection. 1.905 m Post Spacing / 3.81-m Rails
STEEL BEAM GUARDRAIL	Type 5A	GR-2.1	1.1 m	Roadside protection adjacent to fixed objects. 952.5 mm Post Spacing / 3.81-m Rails
STEEL BEAM GUARDRAIL	Type 5: Barrier	GR-2.1 GR-6.1 GR-6.2	1.7 m	Narrow medians where deflections can be tolerated.
STEEL BEAM GUARDRAIL	Type 5 with Tubular Backup	GR-2.2	Width of Barrier 610 mm	Prefabricated structures where other guardrail system minimum barrier clearances cannot be provided.
STEEL BEAM GUARDRAIL	Long Span Across Culvert	GR-2.4	1.1 m	Used primarily to span across precast structures that have limited depths of cover.
CONCRETE BARRIER	Type A	RM-4.3	Width of Barrier 610 mm	Narrow medians where barrier deflections cannot be tolerated.
CONCRETE BARRIER	Type A1	RM-4.3	Width of Barrier 610 mm	Narrow medians where additional height is required.
CONCRETE BARRIER	Type B	RM-4.3	Width of Barrier 763 mm	Narrow medians where raceways or median lighting is used.
CONCRETE BARRIER	Type B1	RM-4.3	Width of Barrier 763 mm	Narrow medians where additional height is required and raceways are needed.
CONCRETE BARRIER	Type C	RM-4.3	Width of Barrier 763 mm	Narrow medians where the difference in shoulder elevation is 0.61 m or less.
CONCRETE BARRIER	Type D	RM-4.3 RM-4.5	Width of Barrier 457 mm to 607 mm	Roadside protection adjacent to fixed obstacles. Areas where impact angles over 15 degrees are unlikely or where maintenance may be difficult/dangerous.

* Measured from the face of the barrier to the obstacle.

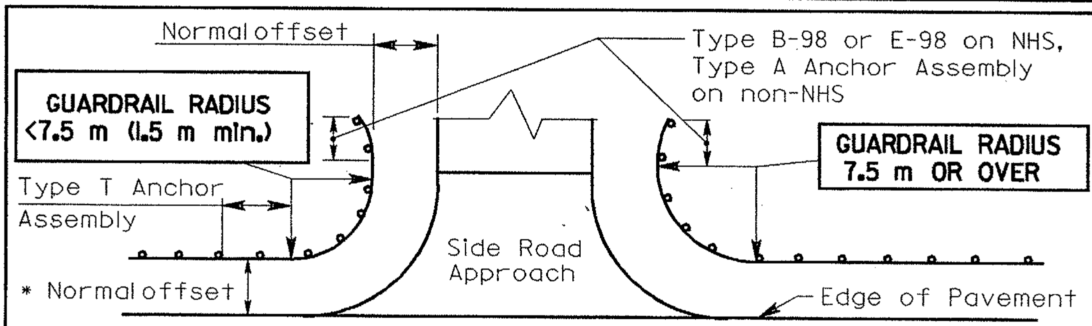
DRIVE AND SIDE ROAD GUARDRAIL OPENINGS

603-3 (metric)

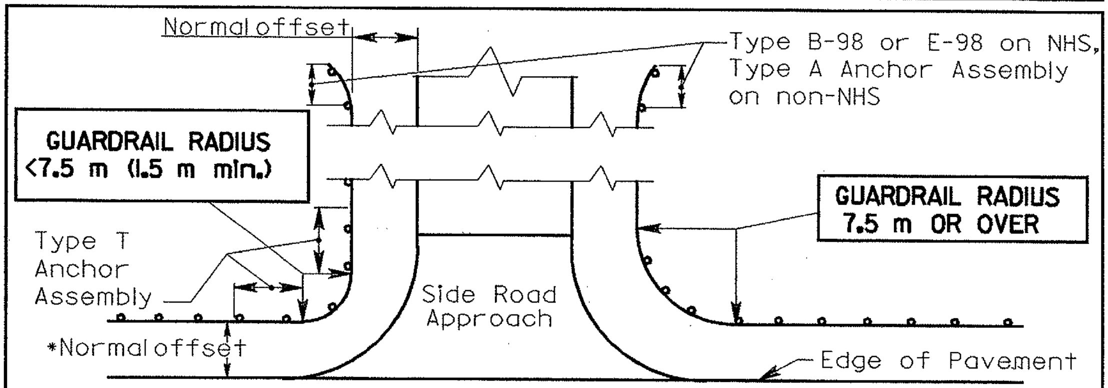
REFERENCE SECTIONS 602.4, 603.3.5



DRIVE GUARDRAIL OPENING



SIDE ROAD GUARDRAIL OPENING



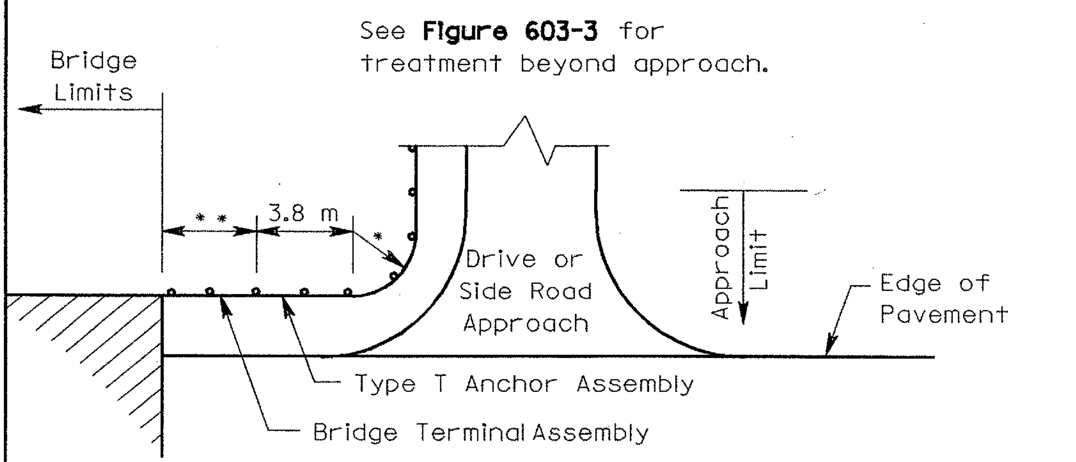
SIDE ROAD GUARDRAIL OPENING WHERE GUARDRAIL EXTENDS ALONG SIDE ROAD

* See **Figure 201-4** for Side Road guardrail offset treatment.

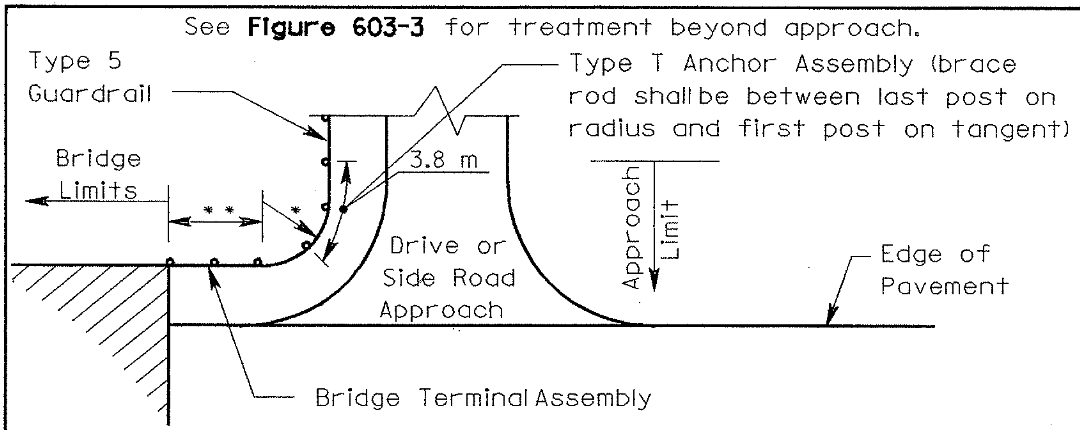
MINIMUM BRIDGE PROTECTION INVOLVING DRIVES OR SIDE ROADS

603-4 (metric)

REFERENCE SECTIONS
602.5.1, 603.3.5



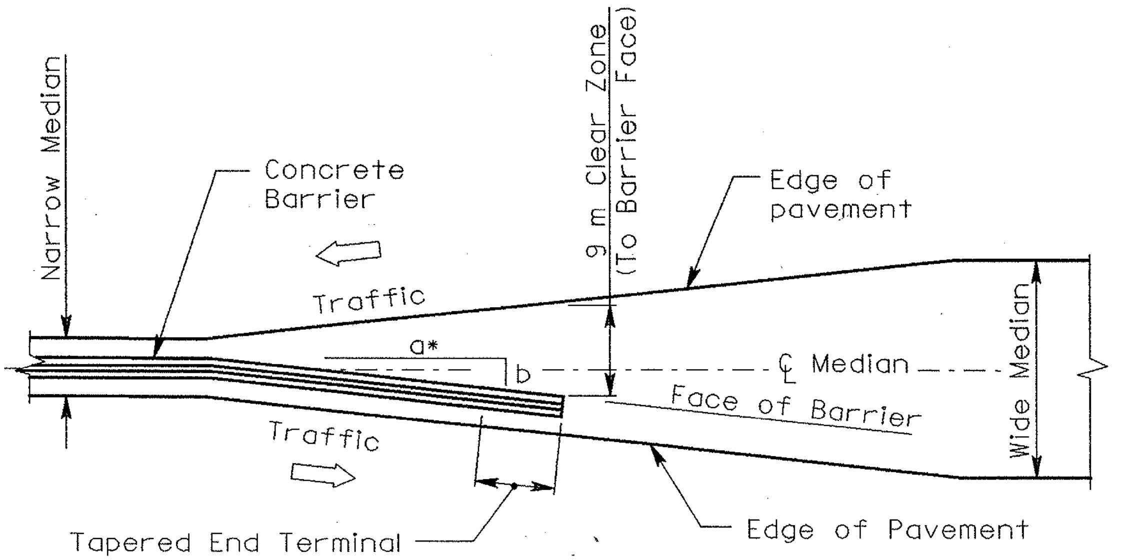
PREFERRED MINIMUM APPROACH TREATMENT



ABSOLUTE MINIMUM APPROACH TREATMENT

* Minimum Guardrail radius is 1.5 m.

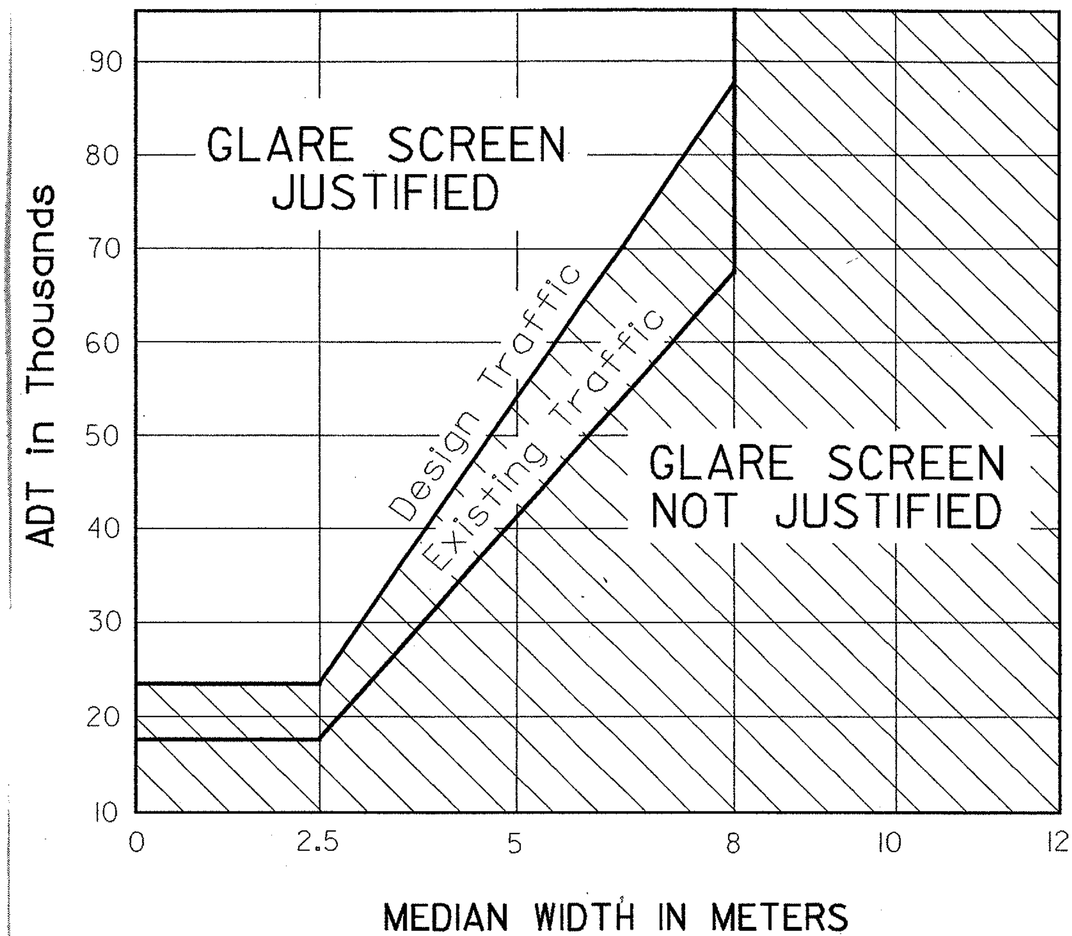
** 5.7 m for Type 1 and Type 3 Bridge Terminal Assemblies,
3.8 m for Type 2 and Type 4 Bridge Terminal Assemblies.



* See **Figure 602-1** for barrier flare rates.

MEDIAN GLARE SCREEN USE GUIDE	604-1 (metric)
	REFERENCE SECTIONS 604.1

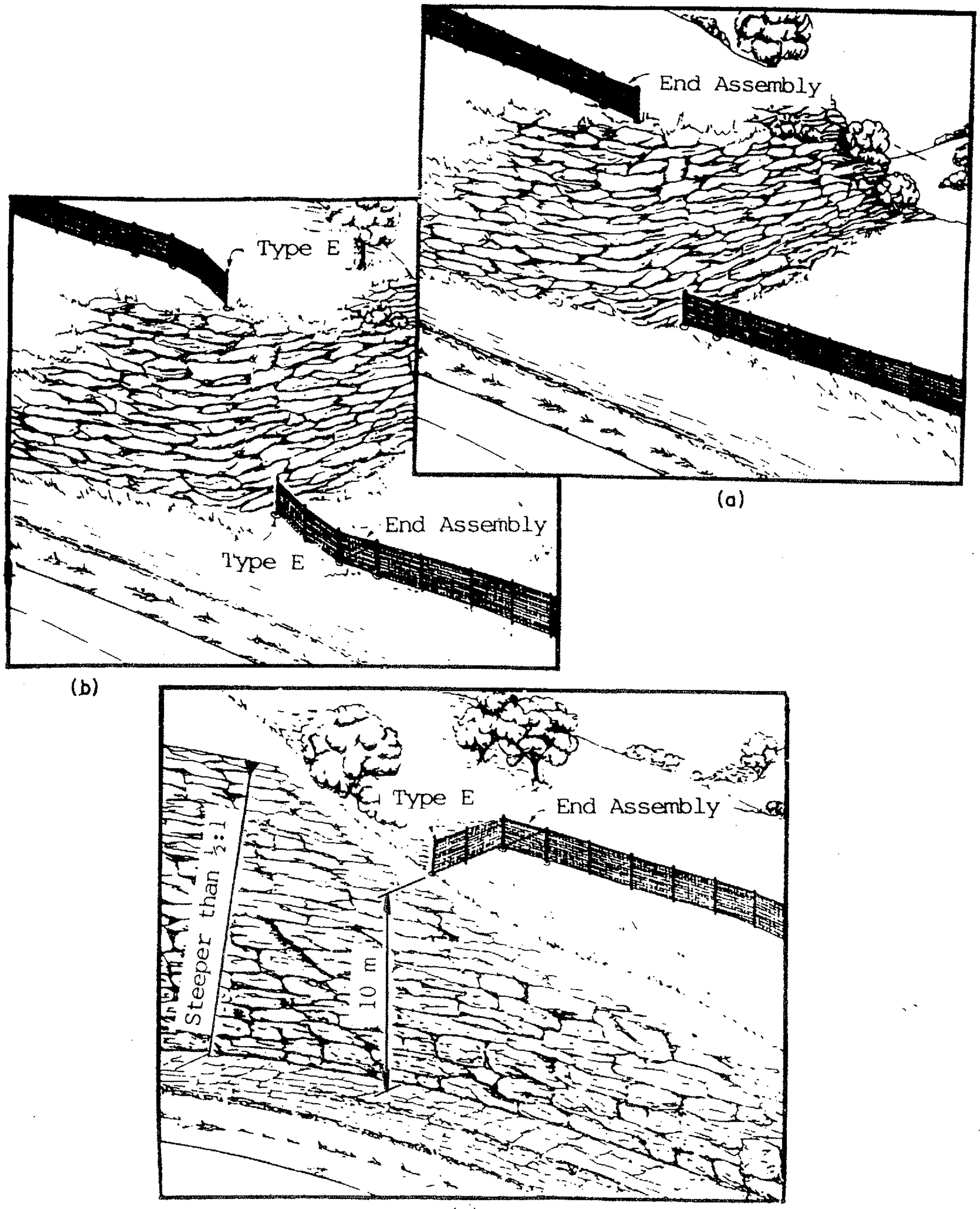
UNLIGHTED HIGHWAYS



LIGHTED HIGHWAYS

TOTAL MAINLINE LANES	GLARE SCREEN JUSTIFIED WHEN ADT (DESIGN OR EXIST) EXCEEDS
4	50,000
6	75,000
8	100,000

EXCEPTION TO CONTINUOUS FREEWAY FENCING	606-1 (metric)
	REFERENCE SECTIONS 606.3.4



(a)

(b)

(c)

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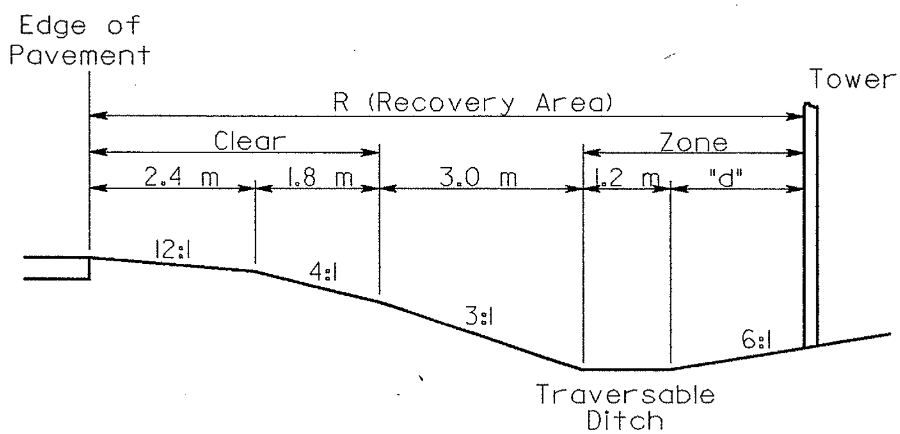
SAMPLE CALCULATIONS

Ex. 600-1 (metric)	Clear Zone Measurement Using Slope Averaging (Traversable Ditch)

Problem: Compute the safe distance from the edge of pavement to locate a tower for lighting. The project has a design speed of 90 km/h, a design year traffic volume of 3,400 ADT and the following cross section in the area where the tower is to be located:



Solution: **Step 1** - Check the foreslope from the edge of pavement to the backslope to determine if all intermediate foreslopes are either recoverable or non-recoverable. (See **Figure 600-2**.)

Since the foreslope has intermediate slopes that are recoverable (12:1 & 4:1) and non-recoverable (3:1), the clear zone may extend into the backslope if necessary.

Step 2 - Determine the weighted average of the foreslope. For sections flatter than or equal to 10:1, use a 10:1 slope. (The 12:1 shoulder slope is typically ignored; however, for this example it is included for illustrative purposes.) Decimal results of 0.5 or greater should be rounded up to the next whole numbered slope while decimal results less than 0.5 should be rounded down to the next whole numbered slope.

First, multiply the width of each slope by the rate of the slope to obtain the weighted average rise for the foreslope. Include half of the ditch bottom in the foreslope.

$$2.4 \text{ m } (1/10) + 1.8 \text{ m } (1/4) + (0^*) + (1.2 \text{ m }/2)(1/10) = 0.75 \text{ m}$$

* Since the 3:1 foreslope is non-recoverable, it is not included.

(continued)

Next, add the width of each foreslope used above.

2.4 m +1.8 m + 1.2 m /2 = 4.8 m

Then, divide the total recoverable width by the weighted average rise to obtain the weighted average of the foreslopes.

4.8/0.75 = 6.4 (Rounded to 6:1 slope)

Now, enter **Figure 600-1** (for 6:1 or flatter foreslopes, 90 km/h design speed, and 1,501 < ADT < 6,000) to determine that the required clear zone distance is 6.3 meters.

Since the required clear zone is 6.3 meters and only 4.8 meters of recoverable clear zone exists, additional width must be considered from the backslope.

Step 3 - Determine if the ditch section is traversable.

Using **Figure 307-3**, a ditch with a 3:1 foreslope and 6:1 backslope is traversable.

If a non-traversable ditch section had been provided then the designer would have to consider other site conditions to determine whether or not the ditch should be used within the clear zone or if guardrail should be installed.

Step 4 - Determine the clear zone using the backslope.

Determine how much of the backslope should be included in the clear zone.

6.3 m - 2.4 m -1.8 m -1.2 m = 0.9 m

Therefore, the clear zone must extend 0.9 meters into the backslope.

The "Recovery Area" includes the clear zone width plus any intermediate widths where the slopes are traversable, but not recoverable.

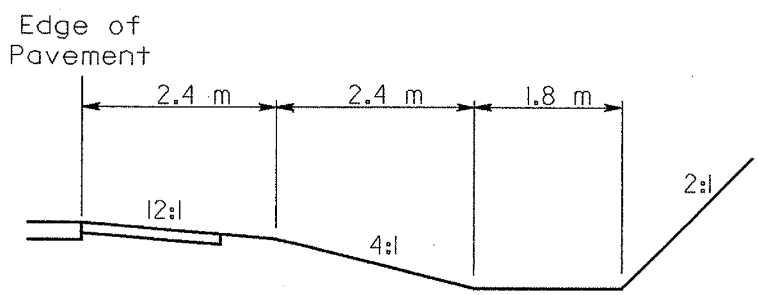
Recovery Area: 2.4 m + 1.8 m + 3.0 m + 1.2 m + 0.9 m = 9.3 m

SAMPLE CALCULATIONS	
Ex. 600-2 (metric)	**Clear Zone Measurement For A Non-Traversable Ditch**

Problem: a) Determine the required clear zone distance for the following location on a project with a tangent alignment, a design speed of 90 km/hr and a design year traffic volume of 1700 ADT.

b) Assuming this cross section occurs on the outside of a curve with a radius of 1000 meters, how would this change the above results?

c) Determine the clear zone distance for a radius of 700 meters.



Solution: a) - The required clear zone distance (for foreslopes steeper than 6:1 up to 4:1, 90 km/hr design speed, and 1501≤ADT≤6000) is 8.3 meters. 5.7 meters of clear distance is available up to the center of the ditch. A trapezoidal ditch with a 4:1 foreslope, 2:1 backslope and a width equal to or greater than 1.2 meters is a non-traversable design (see **Figure 307-3**) and generally should not be located within the clear zone. However, if the probability of encroachment is low no additional improvement may be needed.

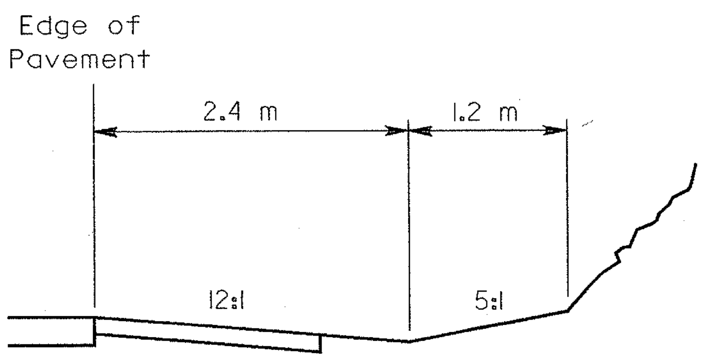
b) - Since this location is on the outside of a curve where the probability of encroachment is high, the designer should consider reshaping the ditch or installing guardrail.

c) - The required clear zone distance determined above for a tangent alignment needs to be increased by a factor or 1.2 for locations on the outside of curves with a radius equal to 700 meters and a design speed of 90 km/hr. (See **Figure 600-1**.) The adjusted clear zone distance is 8.3 (1.2) = 9.96 m. Since the adjusted value is greater than 9.0 m, use 9.0 m.

Since 5.7 meters or only 63% of the required clear zone distance exists on the outside of this curve, the designer should consider reshaping the ditch or installing guardrail.

SAMPLE CALCULATIONS	
Ex. 600-3 (metric)	**Clear Zone Measurement For a Cut Slope**

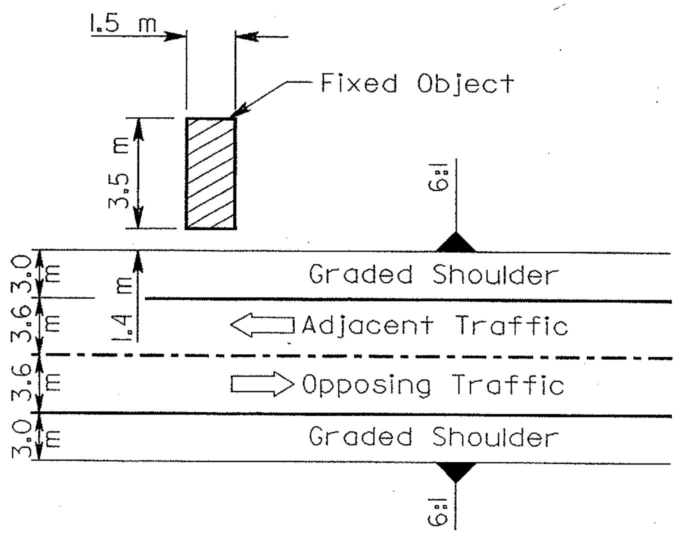
Problem: Determine the required clear zone distance for the following location on a project with a design speed of 70 km/hr and a design year traffic volume of 1300 ADT.



Solution: The required clear zone distance (for backslopes steeper than 6:1 up to 4:1, 70 km/hr design speed and 750≤ADT≤1500) is 4.0 meters. (See **Figure 600-1**.) The required clear zone is 4.0 meters but only 3.6 meters exist. If this section of roadway has a history of accidents with the cut face then guardrail should be installed.

SAMPLE CALCULATIONS	
Ex. 602-1 (metric)	**Tangent Barrier Design For a 2-lane Road**

Problem: Design barrier if needed to shield the fixed object located on the two-lane non-NHS rural collector shown below. The project has a design speed of 100 km/h, a design year traffic volume of 2,200 ADT, a K factor of 0.10, and a 6:1 foreslope. Assume that the object cannot be removed, relocated or made traversable.



Solution: **Step 1** - Determine whether or not the fixed object is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for 6:1 or flatter foreslope, 100 km/hr design speed and 1501≤ADT≤6000) to determine that the required clear zone distance is 8.5 meters.

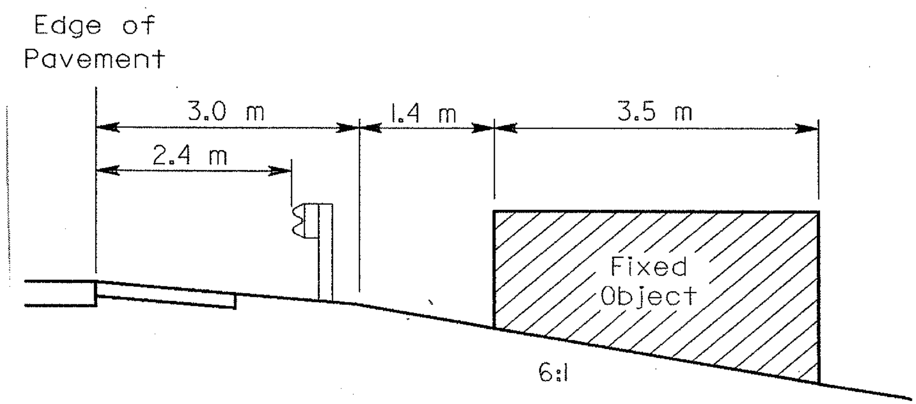
The available clear area for adjacent traffic is 3.0 m + 1.4 m = 4.4 m.

Since the object cannot be removed, relocated or made traversable and it is inside the required clear zone, a barrier should be installed to shield it.

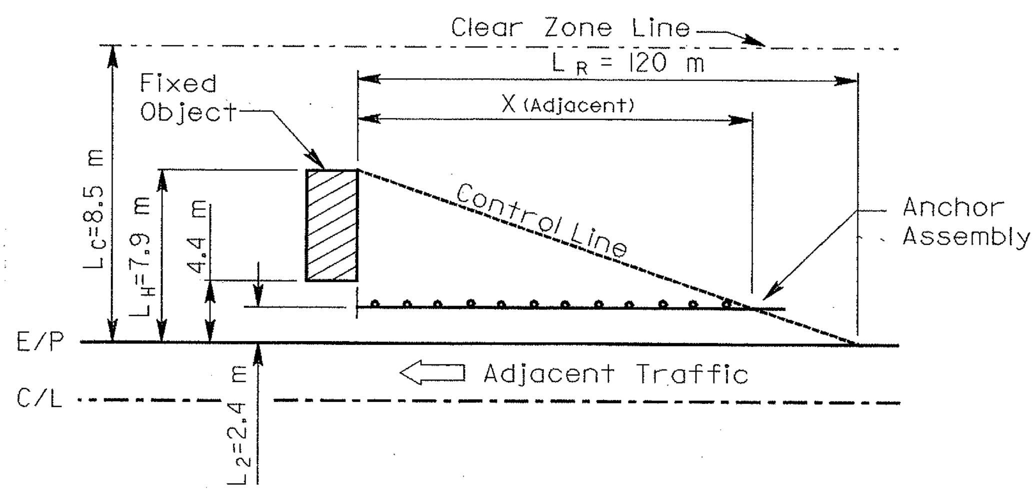
SAMPLE CALCULATIONS	
Ex. 602-1 (metric)	**Tangent Barrier Design For a 2-lane Road**

(continued)

Step 2 - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(2200) = 220. Using **Figure 301-3**, the normal (minimum) barrier offset for a rural collector ($201 \leq DHV \leq 400$) is 2.4 meters from the edge of pavement. The available barrier clearance at this location is (3.0 m - 2.4 m) + 1.4 m = 2.0 m; therefore, use Type 5 Guardrail which has a minimum barrier clearance of 1.7 meters. (See **Figure 603-2**.)



Step 3 - Calculate the length of need for adjacent traffic. Assume the area along the front of the guardrail cannot be graded to provide 10:1 foreslopes; therefore, the guardrail cannot be installed with a flare.



SAMPLE CALCULATIONS	
Ex. 602-1 (metric)	**Tangent Barrier Design For a 2-lane Road**

(continued)

From **Figure 602-1**, L_R = 120 m (for design speed = 100 km/hr and 2000≤ADT≤6000). Since the lateral offset to the back of the object (L_H) is less than the required clear zone distance (L_C), use L_H in the LON formula.

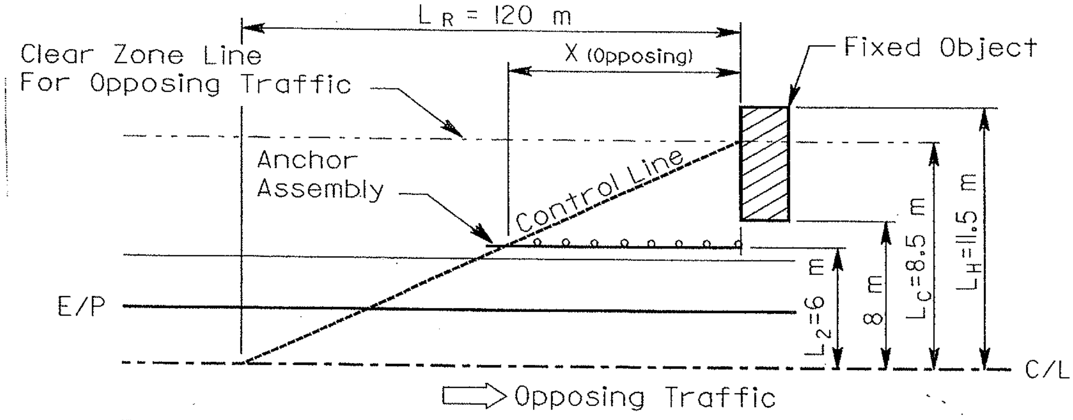
$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$$

Start measuring the length of guardrail needed at the edge of the fixed object. Since the guardrail will not be flared, b/a = 0.

$$x_{(adjacent)} = \frac{7.9 + 0 - 2.4}{0 + 7.9/120} = 83.54 \text{ m.}$$

Step 4 - Determine whether or not the fixed object is in the clear zone for opposing traffic. The required clear zone is still 8.5 meters. The available clear area is 3.6 m $_{\text{(lane width)}}$ + 4.4 m = 8.0 m. Since the object is in the clear zone, calculate the offset to the back of the object, L_H.

L_H = 3.6 + 4.4 + 3.5 = 11.5 m



Since $L_H > L_C$, protection only needs to be provided up to the clear zone.

$$x_{(opposing)} = \frac{L_C + L_1 b/a - L_2}{b/a + L_C/L_R} = \frac{8.5 + 0 - 6.0}{0 + 8.5/120} = 35.29 \text{ m}$$

(continued)

The total length of guardrail required is:

$x_{(adjacent)}$ + width of object + $x_{(opposing)}$ = 83.54 + 1.5 + 35.29 = 120.33 m

The length provided should be a multiple of even 3.81-m guardrail panel lengths.

x = 120.33/3.81 = 31.58 Use 32 panels or 32(3.81) = 121.92 m

Note - If the designer had chosen to shield the entire object from opposing traffic instead of providing protection up to the clear zone, then

$$x_{(opposing)} = \frac{L_H - L_2}{L_H/L_R} = \frac{11.5 - 6.0}{11.5/120} = 57.39 \text{ m}$$

The total length of guardrail needed would have been:

83.54 + 1.5 + 57.39 = 142.43 m (or 38 panels)

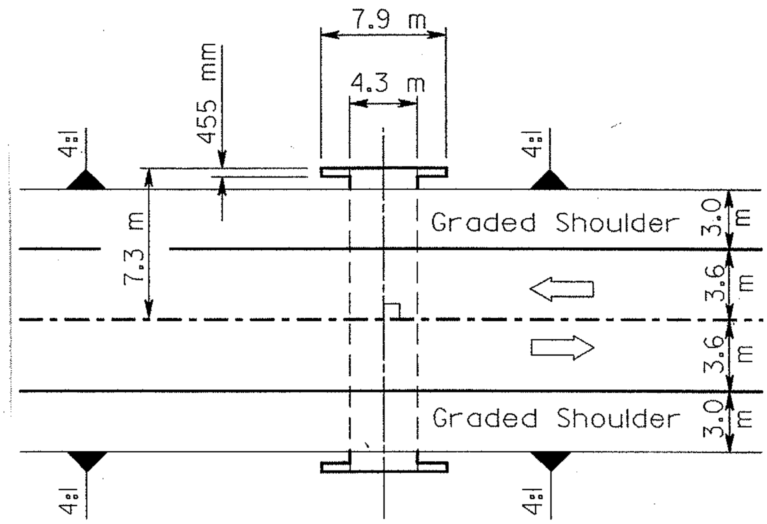
Six additional panels (22.86 meters) of guardrail would be installed. This is approximately 19% more guardrail. In some cases, the designer may choose to shield the entire object even though a portion of it is outside the clear zone; however, in this case it is probably uneconomical to do so.

Step 5 - Select Anchor Assemblies. Since this is a non-NHS collector with a design year ADT≤4000, a Type A Anchor Assembly may be installed on the approach and trailing ends of the guardrail run.

SAMPLE CALCULATIONS

Ex. 602-2 (metric)	Length of Need at a Large Culvert

Problem: Design barrier if needed to shield the culvert headwalls located on the two-lane NHS rural collector shown below. This bridge replacement project has a design speed of 90 km/hr, a design year traffic volume of 3,100 ADT, a K factor of 0.10, and 4:1 foreslopes.



Solution

Step 1 - Determine whether or not the headwall is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for foreslopes steeper than 6:1 up to 4:1, 90 km/hr design speed and 1501≤ADT≤6000) to determine that the required clear zone distance is 8.3 meters measured from the edge of pavement.

The available clear area for adjacent traffic is 7.3 - 3.6 - .455 = 3.24 m.

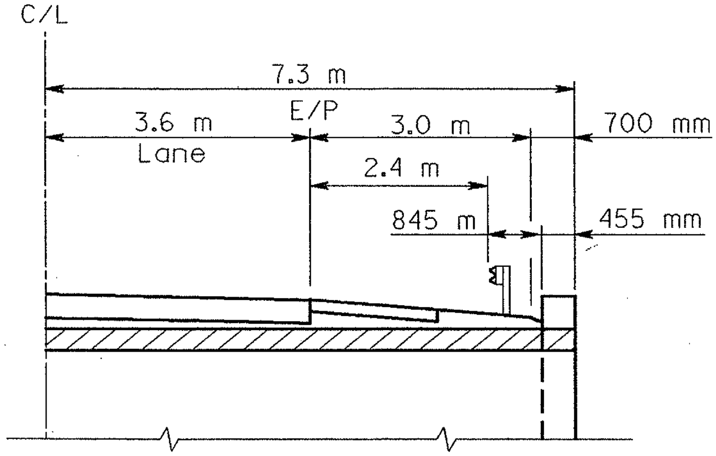
It is impractical to almost double the length of the culvert to get the headwalls outside the clear zone; therefore, barrier should be provided.

Step 2 - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(3100) = 310. Using **Figure 301-3**, the normal barrier offset for a rural collector (201≤DHV≤400) is 2.4 meters from the edge of pavement. The available barrier clearance at this location is (3.0 - 2.4) + (0.7 - 0.455) = 0.845 m.

SAMPLE CALCULATIONS

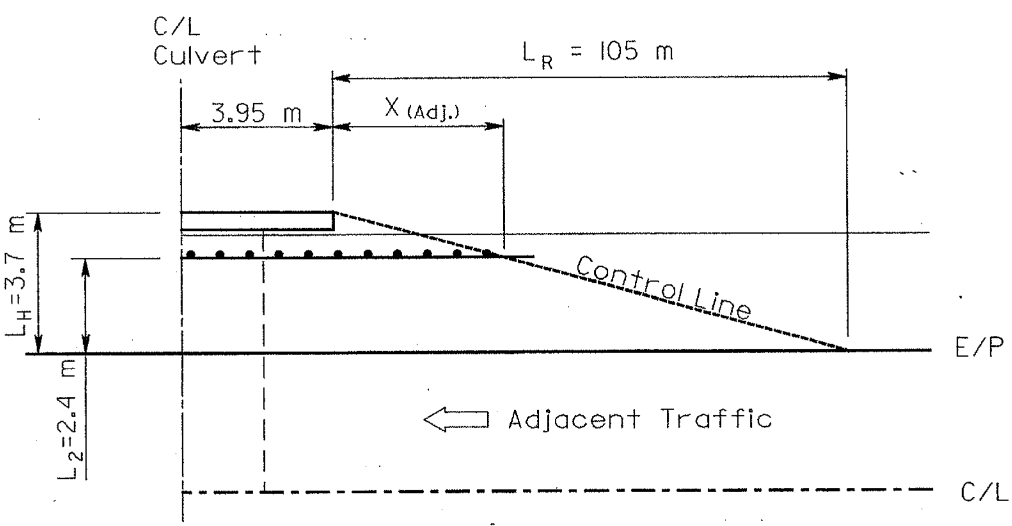
Ex. 602-2 (metric)	Length of Need at a Large Culvert

(continued)



Since there is not enough clearance available for Type 5 Guardrail, which has a minimum barrier clearance of 1.7 m, use Type 5 Guardrail with Tubular Backup, which has a minimum barrier clearance of 610 mm. (See **Figure 603-2**.)

<u>Step 3</u> - Calculate the length of need for adjacent traffic. Since the foreslope along the face of the guardrail cannot be regraded to 10:1, do not flare the guardrail. (The geometrics of the roadway and the offset to the headwall are the same on both sides of the road; therefore, the lengths calculate for adjacent and opposing traffic for the eastbound lane will be the same as those calculated for adjacent and opposing traffic for the westbound lane.)



(continued)

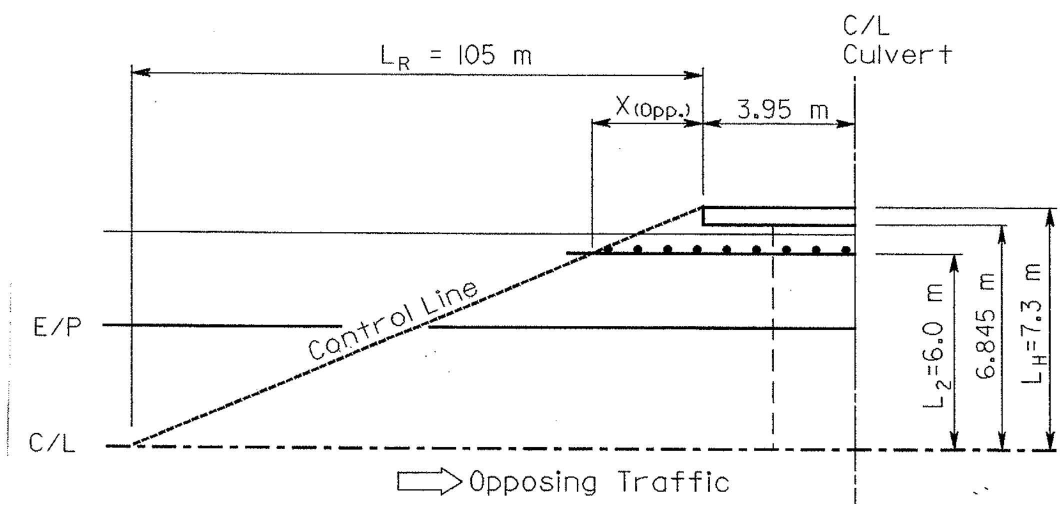
From **Figure 602-1**, L_R = 105 m (for design speed = 90 km/hr and $2000 \leq ADT \leq 6000$). Since the lateral offset to the back of the headwall (L_H) is less than the required clear zone distance (L_C), use L_H in the LON formula.

$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$$

Start measuring the length of guardrail needed at the edge of the headwall. Since the guardrail will not be flared, b/a = 0.

$$x_{(adjacent)} = \frac{3.7 + 0 - 2.4}{0 + 3.7/105} = 36.89 \text{ m}$$

Step 4 - Determine whether or not the headwall is in the clear zone for opposing traffic. The required clear zone distance is still 8.3 meters. The available clear area is 7.3 - 0.455 = 6.845 meters.



Since $L_H<L_C$, $x = \dfrac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R}$

Start measuring the length of guardrail needed at the edge of the headwall. Since the guardrail will not be flared, b/a = 0.

$$x_{(opposing)} = \frac{7.3 + 0 - 6.0}{0 + 7.3/105} = 18.70 \text{ m}$$

SAMPLE CALCULATIONS	
Ex. 602-2 (metric)	**Length of Need at a Large Culvert**

(continued)

The total length of guardrail required is:

$x_{(adjacent)}$ + width of headwall + $x_{(opposing)}$ = 36.89 + 7.9 + 18.70 = 63.49 m.

The length provided should be a multiple of even 3.81-m guardrail panel lengths.

x = 63.49/3.81 = 16.66   Use 17 panels or 17(3.81) = 64.77 m

<u>**Step 5**</u> - Detail the final installation, including the anchor assemblies. The Type 5 Guardrail with Tubular Backup should extend to the first post off the approach and trailing ends of the structure. In this case, the headwall (not the culvert itself) is the structure that is being protected. The headwall is slightly longer than 2 panels of guardrail so use 3 panels (11.43 m). A Type 4 Bridge Terminal Assembly is required at each end of the Type 5 Guardrail with Tubular Backup. This transition is paid for as a unit and requires 7.62 m of Type 5 Guardrail in order to be installed. If the Tubular Backup is centered about the culvert centerline then the amount of rail needed at the approach end is 36.89 - (11.43 - 7.9)/2 = 35.125 m. This is a little more than 9 panels of guardrail. Rather than add an additional panel, shift the Type 5 Guardrail with Tubular Backup upstream to cover the 0.83-m shortage.

Since this is an NHS route, Type A Anchor Assemblies are not permitted even though the design year ADT≤4000. Refer to **Table 603-1** in **Section 603.3.3** for a Bridge Replacement Project with foreslopes steeper than 6:1 up to 4:1 to determine that a Type E-98 Anchor Assembly should be used on the approach and trailing ends. (It is required on the trailing end because it is within the clear zone for opposing traffic.)

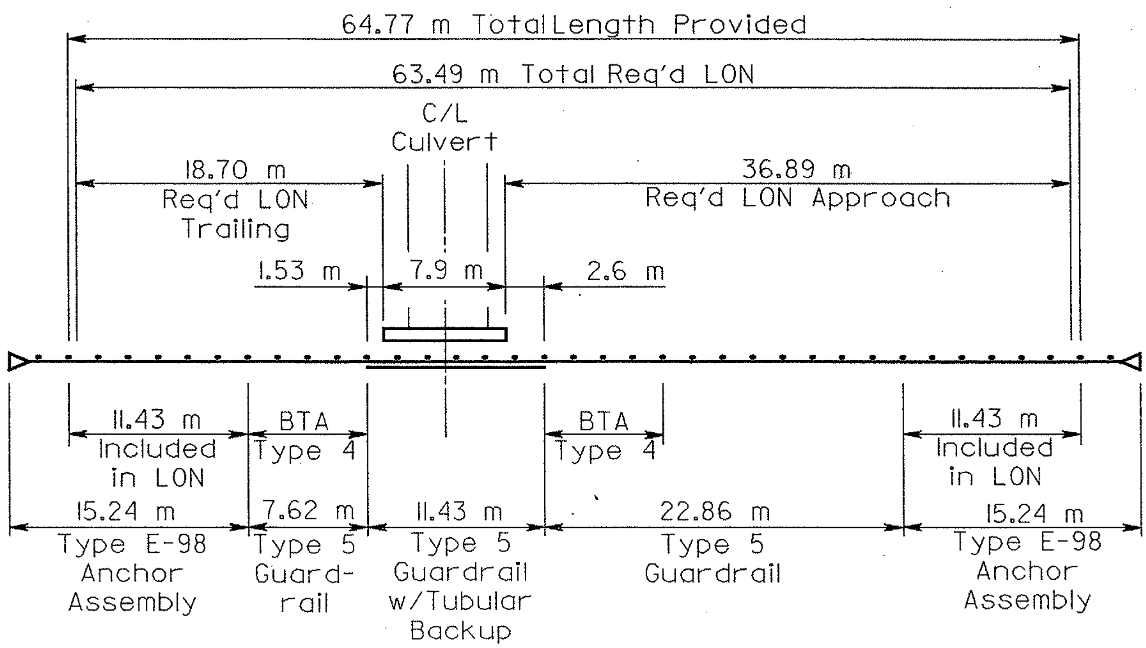
Since up to 11.43 m of the 15.24-m long Type E-98 can be deducted from the guardrail length of need, decrease the amount of rail specified at each end by this amount. See the following final detail.

<u>Note</u>: Many large culverts are located in deep channels with steep side slopes. This may necessitate that the designer use $L_H = L_C$ when calculating the required length of need.

SAMPLE CALCULATIONS

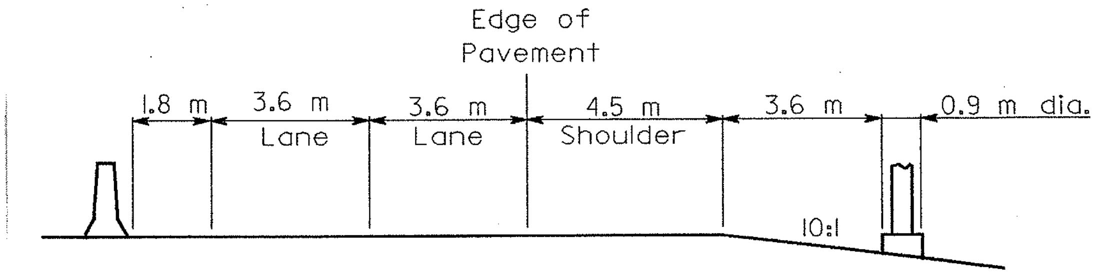
Ex. 602-2 (metric)	Length of Need at a Large Culvert

(continued)



SAMPLE CALCULATIONS	
Ex. 602-3 (metric)	**Tangent and Flared Barrier Design For a Divided Highway**

Problem: Design barrier if needed to shield the 1-meter diameter footing located on the 4-lane, divided, NHS, urban interstate 3R project shown below. The project has a design speed of 120 km/hr, a design year traffic volume of 12,000 ADT and 10:1 foreslopes. If barrier is needed calculate how much should be provided if it is installed **a**) at the normal (minimum) barrier offset on a tangent, **b**) at the normal (minimum) barrier offset on a flare, **c**) as close to the footing as permissible on a tangent and **d**) as close to the footing as permissible on a flare.



Solution: **Step 1** - Determine whether or not the footing is in the clear zone for adjacent traffic. Refer to **Figure 600-1** (for foreslopes 6:1 or flatter, 120 km/hr design speed and ADT>6000) to determine that the required clear zone distance is 9.8 meters measured from the edge of pavement. However, since this is not a high accident area a maximum clear zone distance of 9.0 meters should be used.

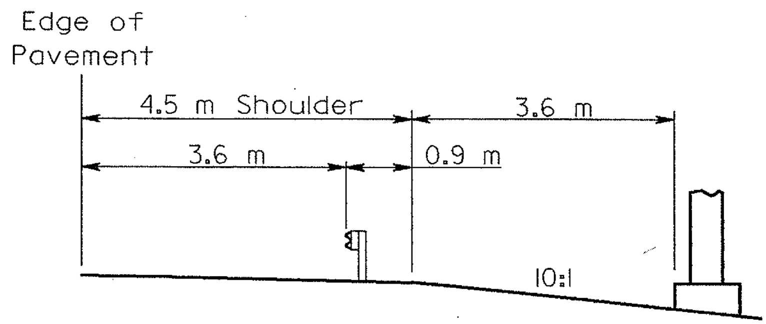
The available clear area for adjacent traffic is 4.5 + 3.6 = 8.1 m.

Assuming the footing cannot be relocated outside the clear zone, barrier should be provided.

Step 2 - Select the type of barrier to be installed. Using **Figures 301-4 & 301-3**, the normal (minimum) barrier offset for an urban interstate route is 3.6 meters from the right edge of pavement. The available barrier clearance at this location is 0.9 + 3.6 = 4.5 m; therefore, use Type 5 Guardrail, which has a minimum barrier clearance of 1.7 m. (**See Figure 603-2.**)

SAMPLE CALCULATIONS	
Ex. 602-3 (metric)	**Tangent and Flared Barrier Design For a Divided Highway**

(continued)



Step 3 - Calculate the length of need for adjacent traffic. (A calculation for opposing traffic is unnecessary because the concrete median barrier prevents encroachments by opposing vehicles.)

From **Figure 602-1**, L_R = 145 m. (for Design Speed = 120 km/hr and ADT over 6000).

a) For tangent guardrail at the normal (minimum) barrier offset, $L_H = L_C$ = 9.0 m, L_2 = 3.6 m, and b/a = 0.

$$x = \frac{L_H + L_1 b/a - L_2}{b/a + L_H/L_R} = \frac{9.0 + 0 - 3.6}{0 + 9.0/145} = 87 \text{ m}$$ Use 23 panels.

b) For flared guardrail at the normal (minimum) barrier offset, b/a = 1/15. (See **Figure 602-1**.) Let L_1 = 3.81 m (one panel length). In this case, this is an arbitrary selection. Site conditions typically control the amount of tangent barrier that should be provided past the warranting feature before a flare is introduced. For instance, where a flared section of Type 5 Guardrail is attached to a tangent section of Type 5A, it is advisable to extend the Type 5A past the warranting feature such that L_1 is at least equal to one panel length. Since Type 5 and 5A have different deflection characteristics, this ensures adequate protection at the edge of the warranting feature.

$$x = \frac{9.0 + 3.81(1/15) - 3.6}{1/15 + 9.0/145} = \frac{9.0 + 0.254 - 3.6}{0.129} = 43.83 \text{ m}$$ Use 12 panels.

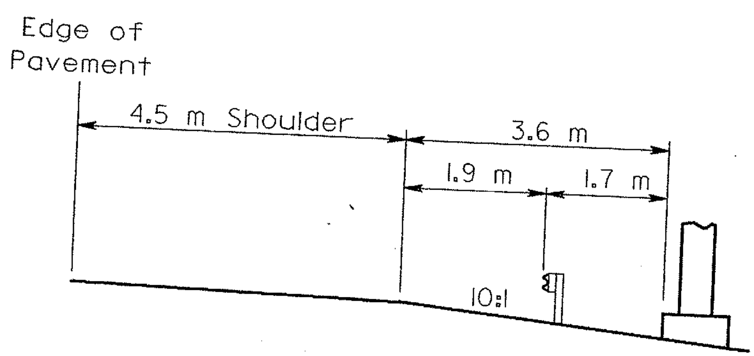
SAMPLE CALCULATIONS	
Ex. 602-3 (metric)	**Tangent and Flared Barrier Design For a Divided Highway**

(continued)

c) Guardrail can be installed on slopes that are 10:1 or flatter. Since Type 5 Guardrail has a minimum barrier clearance of 1.7 meters, the guardrail can be placed at this distance in front of the footing.

$L_2 = 4.5 + 3.6 - 1.7 = 6.4$ m. For tangent guardrail, b/a = 0. L_H is still equal to 9.0 m.

$$x = \frac{9.0 + 0 - 6.4}{0 + 9.0/145} = 41.89 \text{ m}$$ Use 11 panels.



d) For flared guardrail offset at 6.4 m:

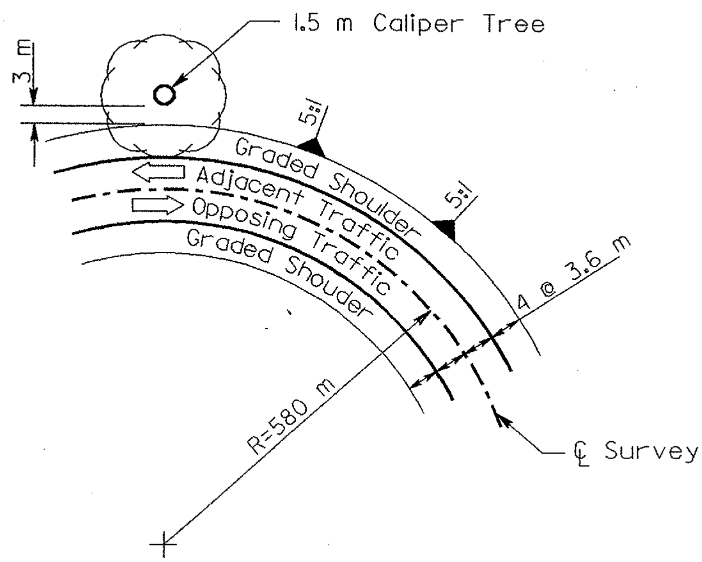
$$x = \frac{9.0 + 3.81(1/15) - 6.4}{1/15 + 9.0/145} = \frac{9.0 + 0.254 - 6.4}{0.129} = 22.12$$ Use 6 panels.

All of these solutions are correct; however, d) is the best solution because it provides the most recovery area with the least amount of barrier.

__Step 4__ - Select Anchor Assemblies. Refer to **Table 603-1** for a 3R project with 6:1 or flatter foreslopes to determine that the approach terminal should be either a Buried in Backslope or Type B-98 Anchor Assembly. There is no backslope so select the Type B-98. Use a Type T Anchor Assembly on the trailing end since it cannot be impacted by opposing traffic.

SAMPLE CALCULATIONS	
Ex. 602-4 (metric)	**Barrier on the Outside of a Curve**

Problem: Calculate the barrier length of need to shield the 200-yr old 1.5-meter diameter tree located on the outside of a curve with a 580-m radius as shown below. The HSP project is on a rural arterial and has a design speed of 90 km/hr, a design year traffic volume of 3800 ADT, a K factor of 0.10, and 5:1 foreslopes. Assume that the HSP project is needed to address run-off-the-road impacts with the tree and also assume that the tree cannot be removed.



Solution: **Step 1** - Determine whether or not the tree is in the clear zone for adjacent traffic. From **Figure 600-1** (for foreslopes steeper than 6:1 up to 4:1, 90 km/hr design speed and 1501≤ADT≤6000) the required clear zone distance is 8.3 meters measured from the edge of pavement. Since the tree is on the outside of a curve with a 580-m radius, the clear zone should be widened by using the curve correction factor for 90 km/hr design speed (1.2) from the chart at the bottom of **Figure 600-1**.

Required Clear Zone = 1.2 (8.3) = 9.96 m.

Do not reduce this value to 9.0 m since this is a high accident location.

The offset to the face of the tree is 3.6 + 3.0 = 6.6 m. This is less than L_C = 9.96 m; therefore, install barrier.

SAMPLE CALCULATIONS	
Ex. 602-4 (metric)	**Barrier on the Outside of a Curve**

(continued)

Step 2 - Select the type of barrier to be installed. DHV = K(ADT) = 0.10(3800) = 380. Using **Figure 301-3**, the normal (minimum) barrier offset for a rural arterial ($201 \leq DHV \leq 400$) is 3.0 meters from the right edge of pavement. The available barrier clearance at this location is 3.6 m; therefore, use Type 5 Guardrail, which has a minimum barrier clearance of 1.7 meters. (See **Figure 603-2.)**

Step 3 - Calculate the length of need for adjacent traffic.

The radius at the edge of pavement is 580 + 3.6 = 583.6 m.

The lateral offset to the back of the tree is, $L_H = 6.6 + 1.5 = 8.1$ m.

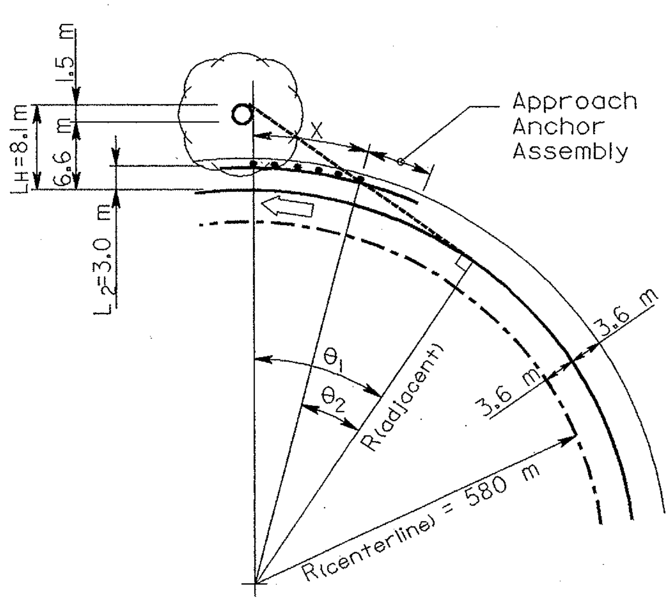
$\theta_1 = \cos^{-1} (R_{adj} / (R_{adj} + L_H)) = \cos^{-1} (583.6 / (583.6 + 8.1)) = 9.4913°$

$9.4913°(\pi/180) = 0.1656$ radians

$\theta_2 = \cos^{-1} (R_{adj} / (R_{adj} + L_2)) = \cos^{-1} (583.6 / (583.6 + 3.0)) = 5.7971°$

$5.7971°(\pi/180) = 0.1012$ radians

$X = (R_{adj} + L_2) (\theta_1 - \theta_2)$ rad. $= (583.6 +3.0) (0.1656 - 0.1012) = 37.78$ m



SAMPLE CALCULATIONS	
Ex. 602-4 (metric)	**Barrier on the Outside of a Curve**

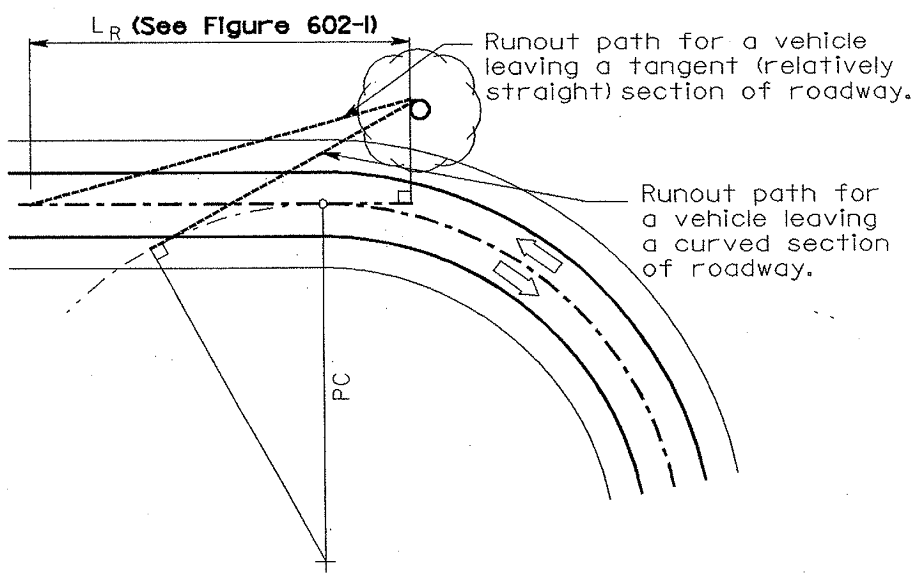
(continued)

__Step 4__ - Determine whether or not the tree is within the clear zone for opposing traffic. The offset to the face of the tree is 3.6 + 3.6 + 3.0 = 10.2 m. Since this is outside the clear zone, guardrail is not needed past the left side of the tree to shield it from opposing traffic.

The total length of guardrail needed is 37.78 + 1.5 = 39.28
Use 11 panels (41.91 m).

Refer to **Table 603-1** in **Section 603.3.3** to determine the recommended anchor assembly for an HSP project with foreslopes steeper than 6:1 up to 4:1. On the approach end install a Type E-98 Anchor Assembly. Since 11.43 m of the 15.24-m long Type E-98 can be deducted from the guardrail length of need, decrease the amount of rail specified above at the approach end by this amount. (Use 30.48 m.) On the trailing end install a Type T Anchor Assembly because it is outside the clear zone for opposing traffic.

__Notes__ - If a point of curvature exists in the vicinity of the runout path, the curve may need to be extended past the PC or PT (into the tangent portion of the roadway) in order to construct the tangent control line. If this is the case, then the standard runout lengths for tangent roadways should be used to calculate length of need.



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700 Multi-Modal Considerations

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700 Multi-Modal Considerations

701 Railroads

701.1 Background

Ohio is interlaced with a network of railroad systems controlled by a multiplicity of local and state laws and regulations. The complexity of railroad operations and regulations requires that special consideration be given to the location of highways with respect to railroad tracks, whether it be the intersection of a highway with a railroad, or the location of a highway adjacent to a railroad facility.

701.2 Crossing At-Grade

701.2.1 General

Highways that cross railroad tracks on a common grade should be located to provide for a minimum of interference to highway traffic and the least amount of adjustment of railroad facilities.

Crossings at-grade will not be permitted on freeways. The creation of new grade crossings where none now exist should be avoided and will require railroad and **Court of Common Pleas** approval. (**Sec. 957.29 et. seq. ORC**).

701.2.2 Railroad Parallel to Highway

When locating a highway parallel to a railroad track, consideration shall be given to the need for space adjacent to railroad tracks for future industrial development. It is desirable to locate the highway a sufficient distance from the railroad to permit rail service to industrial areas without crossing the highway.

Sufficient distance from a railroad to a parallel highway should be provided along crossroads on which traffic must stop before entering the highway, to permit vehicles to stop clear of the railroad track.

701.3 Lateral Clearances

The standard gage of railroad tracks is 4 feet 8½ inches [1.435 meters]. Where two or more tracks are parallel, the normal centerline spacing is 14 feet [4.27 meters].

701.3.1 New Construction

Although minimum lateral clearances vary with railroad ownership, clearance from the centerline of the outside track should normally be at least 18 feet [5.5 meters]. An additional 8 feet [2.5 meters] of lateral clearance should be provided when a railroad off-track equipment road is located parallel to the tracks.

701.3.2 Reconstruction

The above clearances should be provided when replacing an existing structure when such additional work can be accomplished at a reasonable cost. A horizontal clearance less than the existing clearance will not be permitted.

701.4 Vertical Clearance

701.4.1 New Construction

A minimum of 23 feet [7.0 meters] between the top of rail and the bottom of an overpassing structure should be provided. This vertical clearance should extend 6 feet [1.8 meters] on each side of the centerline of the outside tracks. Actual clearance requirements will be determined after the location plan has been submitted.

701.4.2 Reconstruction

Every attempt should be made to increase the minimum vertical clearance to 23 feet [7.0 meters] when such additional work can be accomplished at a reasonable cost. A vertical clearance less than the existing clearance will not be permitted.

701.4.3 Construction Clearances

Construction clearances should also be considered in the design stages since they could be a factor in the location of certain items such as catch basins, headwalls, etc. A minimum of 9 feet 2.75 meters] of lateral clearance should be maintained at all times from the centerline of the track during construction unless this is not possible because of existing conditions.

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801 Access Control

801.1 Access Control Directives

Access policies for highway right-of-way are as set forth in the following directives:

Directive H-P-409 and Standard Operating Procedure PH-P-403- Establishes procedures for processing permit applications and defines permissible uses of right of way for various highway classifications.

Directive H-P-406- Establishes guidelines for access provisions adjacent to major commercial and industrial developments.

It is intended that Section 800 of this manual supplement the above directives with respect to access policies and R/W use permits as well as provide the designer with the criteria necessary to design most types of drives.

801.2 Access Control Policies

The policy of permitting access on highways is summarized below:

801.21 Interstate Limited Access

Direct access to an Interstate Highway will not be permitted. All crossroads and railroad grades shall be separated.

801.22 Limited Access

If a highway is now, or is designated to be an ultimate fully limited access freeway and access rights have been acquired:

A. If the highway has no existing private access points, direct private access to such highway will not be permitted.

B. If the highway has existing private access points and the ultimate freeway design has been determined, temporary access improvements may be permitted. However, at the time the improvement is permitted, the method for deleting the temporary access points must be determined and necessary agreements made with the property owner to facilitate their deletion in the future.

C. If the highway has existing private access points and the ultimate freeway design has not been established, modifications of existing access will not be permitted until the ultimate freeway design has been determined.

D. Provision generally shall be made for future separation of crossroads and railroad grades by purchase of right-of-way as a part of the initial project.

801.23 Controlled Access Highways

Modifications of existing points of access or changes from one location to another within the limits of the applicant's property may be permitted, if such modification or change would be beneficial to both the highway operation and property development. However, new additional points of access will not be permitted. Crossroads and railroads need not be separated unless very high volumes dictate its consideration.

801.24 Non-Limited Access Highways

Access to a non-limited access highway is permissible at any and all points along the highway. However, such access is subject to the conditions prescribed by the Director of Transportation under authority granted by Section 5515.01 of the Ohio Revised Code.

801.25 Interchange Controls

No access shall normally be allowed on intersecting highways adjacent to highway interchanges for a minimum of 600 feet at diamond-type interchanges and 1000 feet at other types of interchanges. This distance applies to each direction along the intersecting highway, measured from the outer-most ramp terminal intersections with the highway. See Figures 801-1 and 801-2 for additional details.

802 Highway Use Permits

802.1 General R/W Use Criteria

802.11 Approvals and Agreements

Permission to use highway R/W is required for fencing, storm sewers, sanitary sewers, public utilities, points of access, or other similar types of work. When a request is made to alter, modify or otherwise use highway R/W, Federal and/or State approvals must be obtained and the necessary agreements or permits between the State and applicant must be completed before any work can be initiated.

802.12 Authority

Permits for the use or occupancy of State Highway right-of-way may be granted, upon formal application, by the Director of Transportation. Such permits, when granted, shall be subject to the policies and regulations set forth herein under authority granted by Section 5515.01 of the Revised Code of Ohio.

802.13 Application Procedures

The procedure for applying for permits is included in Directive H-P-409 and Standard Operating ProcedurePH-P-403.

802.14 Right-of-Way Use Prohibitions

No parking, servicing of vehicles, erection of lights, signs or other advertising devices will be permitted on highway right-of- way. Similarly, no device or structure will be permitted to overhang highway right-of-way. Provisions should be made in the design of driveways or approaches on rural highways so that a vehicle will not be required to back onto the right-of-way or highway pavement to gain access to the highway.

802.15 Future Highway Improvement Controls

When granting permits, consideration should be given to the extent of future highway improvements. The location and design of driveways or public road approaches should then be governed by the general access criteria (Section 802.2) of the future highway facility.

802.16 Drainage Considerations

When any owner or developer of land adjacent to highway R/W proposes to route site drainage into the highway drainage system, the following shall apply and be the responsibility of the owner/developer:

A. There shall be no diversion of flow to the highway.

B. Flow peaks from areas contributing to the highway drainage system shall not be increased, unless the highway drainage system and the drainage system downstream from the highway are of adequate capacity to convey the augmented flow. If downstream capacity is inadequate, flow detention or increased capacity of the downstream system shall be provided.

C. When the owner/developer collects and concentrates surface water, or increases flow peaks or volumes contributing to the highway drainage system, adequate measures to prevent erosion and/or structural damage shall be provided.

D. Adequate erosion control measures shall be provided during construction to minimize downstream sedimentation.

E. Drainage plans and calculations shall be submitted for review by the Department of Transportation prior to the start of construction.

802.2 General Access Criteria

802.21 Highway Access Considerations

The basic considerations that govern the location and design of highway access shall be to facilitate:

A. The safe and expeditious movement of vehicles on the street or highway.

B. The provision of the best service possible to the private or public facility being served by the drive access.

C. The safe movement of pedestrian traffic.

802.22 Median Openings

Median openings are normally not permitted on divided highways. Exceptions may be for public roads or streets or traffic generators such as large shopping centers or industrial plants, if satisfactorily justified and in the public interest.

If a median opening exists prior to the construction of a drive, the opening may be further modified, including relocation, to accommodate the turning movements of the expected traffic. The design modifications shall, however, be consistent with the overall design of the highway.

802.23 Added Highway Lanes

The construction of an additional lane adjacent to the existing highway lanes to serve as an acceleration, deceleration, turning or passing lane may be permitted if benefit to the operation of the through highway will result. The design of any added lane must be consistent with the overall design of the highway.

802.24 Number of Drives Permitted

When adequate frontage is available on a non-limited access highway, two driveways to a property used for a single purpose may be permitted. When a single property is used for two or more purposes and two driveways cannot provide adequate access, then more than two drives may be permitted. Each request for more than two drives must be accompanied by sufficient information to justify the request.

802.25 Joint Drives

A jointly owned drive may be permitted upon joint application by both property owners.

802.26 Location of Drive in Relation to Side Property Line

Figure 802-1 shows the controls for locating drives in relation to side property lines.

A. Controls

(1) 90° Control Line - a line at right angles to the centerline of the highway which extends through the intersection of the side property line with the highway right-of-way line.

(2) 4-foot Control - maximum width of driveway approach flare as measured along the 90° control line from the highway pavement edge.

B. Curbed Highways - the approach radius may begin at the intersection of the 90° control line with the highway pavement edge but may not cross the 90° control.

C. Uncurbed Highways - the approach radius, but not the approach edge extension, may cross the 90° control line within the limits of the 4-foot control.

A permit may be issued for the construction of a driveway which encroaches on the abutting property frontage in excess of the controls set forth above only when written permission from the affected property owner is presented and made a part of the State's record of the permit, and only when such encroachment does not interfere with an existing driveway. It shall be the responsibility of the permit applicant to make all necessary arrangements and agreements with the affected property owners when the relocation of existing driveways is necessary. The expense involved shall be borne by the applicant.

802.27 Location of Drive in Relation to an Intersection

The proximity of a new drive to a highway intersection shall conform to the corner island details shown in Figure 802-2 and to the following:

A. When the intersection radius is:

(1) 40 FEET, OR LESS, the beginning of the approach radius shall be at least 20 feet from the angular bisector as measured along the face of curb or pavement edge, EXCEPT:

(a) Where a sidewalk exists, the beginning of the approach radius shall not begin nearer the roadway intersection than the back edge of the sidewalk.

(2) GREATER THAN 40 FEET, the beginning of the approach radius shall not begin closer to the roadway intersection than a distance equal to one-half the effective intersection radius as measured from the angular bisector along the face of curb or pavement edge, EXCEPT:

(a) When the highway intersection is 120°, or greater, the beginning of the approach radius may begin 20 feet from the angular bisector, as measured along the face of curb or pavement edge.

(b) When the highway intersection radius is greater than 80' the beginning of the approach radius may begin 40' from the angular bisector.

B. AT CHANNELIZED INTERSECTIONS the above conditions shall apply, unless their use would encourage "wrong-way" operation along a directional portion of the intersection. In such case, special drive designs will be required.

802.28 Drive Sight Distance

Wherever possible, drives should be located in accordance with the intersection sight distance criteria in Section 201.3.

802.29 Location of High Volume Drives

Special consideration should be given to the location of drive access to high volume traffic generators such as shopping centers, industrial plants and parks, as well as other types of development having similar traffic characteristics.

A new driveway should not be located where it will create an offset intersection opposite an existing street, highway, or major commercial driveway.

A driveway serving all directions of traffic should be located a minimum of 600 feet from the nearest major highway or street intersection.

803 Drive Geometric Design

803.1 Mailbox Facilities

803.11 Mailbox Supports

Mailbox installations located within the clear zone shall be installed as shown in Figure 803-1 using "breakaway" type supports. Satisfactory supports are as follows:

A. Maximum 4"x4" square or 4½" dia. round timber.

B. Maximum 2" diameter (2-⅜" O.D.) standard strength steel pipe.

C. Any material with breakaway cross section characteristics equivalent to A or B above.

Group mailbox supports should be placed on three foot centers and the turnout lengthened to accommodate the grouping. No more than two mailboxes shall be placed on each post.

Where guardrail exists, mailboxes and their supports should be located behind the guardrail. Supports must still meet the breakaway requirements listed above.

803.12 Mailbox Turnouts

Where the existing or proposed highway shoulder paving is less than 6 feet wide, mailbox turnouts should be provided as shown in Figure 803-1 and Standard Construction Drawing BP-4.1. Mailbox turnouts should be constructed of the same material used in the drive approach and combined with the drive approach where possible.

803.2 Rural Residential and Field Drives

Rural residential drives and field drives should normally conform to the Type 1 design shown in Standard Construction Drawing BP-4.1.

803.21 Drive Intersection Angle

New drives should intersect the highway at an angle between 70° and 90°. However, in some cases, it may be necessary to retain existing drive angles that vary from these desirable angles.

803.22 Drive Widths

If the project involves existing drives, the existing width is normally retained unless it is less than 12 feet. In which case, it should be widened to provide a 12 foot. throat width. In the case of new drives, the width should normally be 12 feet. If the new driveway is a combined drive between two properties, the width should normally not exceed 24 feet. Also, a wider field drive may be used if it will keep the farm equipment operator from encroaching on the opposing traffic lane when entering or exiting the highway.

803.23 Drive Radii

The radii of the Type 1 driveway should normally be 25 feet. The radii. may be increased on field drives if it is deemed that the larger values will improve driveway operation and reduce the hazard to the motorists and farm equipment operator.

803.24 Curbed Drives

Driveways abutting uncurbed highways may be curbed. However, the curb shall not extend closer to the through pavement edge than eight feet or the treated shoulder width, whichever is greater, to avoid curb obstruction for vehicles, snowplows, etc., using the shoulder.

803.3 Urban Residential Drives

Either Type 1 or 2 drives, shown in Standard Construction Drawing BP-4.1, may be used in urban areas. If used in urban areas, the radii and flare dimensions may be reduced so that the apron does not extend past the back of the sidewalk, or past the right-of- way line if there are no sidewalks. The desirable minimum radii for Type 1 drives, when the through highway is curbed, is 15 feet.

Shown on Fig. 803-2 are three methods for designing driveways between the curb line and sidewalk to provide for turning vehicles. Other designs, may be used if they are approved for use by the local governmental agencies responsible for maintenance of the project. Additional details are shown in Figure 803-3 when the tree lawn is less than 6 feet. Residential drives on curbed streets should use a dropped curb as shown in Section B-B on Figure 803-2.

803.4 Service Station Drives

Service station drive approach geometry is probably the most complex of any drive design. Many of the geometric features may be used in the design of other commercial and industrial drives. The following Figures illustrate service station approach designs under varying conditions:

Figure 803-4 - "Uncurbed Roadway/Uncurbed Approach"

Figure 803-5 - "Special Paved Shoulder Detail"

Figure 803-6 - "Uncurbed Roadway/Curbed Approach"

Figure 803-7 - "Curbed Roadway/Curbed Approach"

803.41 Uncurbed Approaches

Figure 803-4 shows the general design for Service Station drives with uncurbed approaches.

When curbing does not exist at the edge of pavement and curbs are not installed along the edges of the approach, the Department of Transportation may install guard posts, within the highway right- of-way, to delineate the approaches.

In rural sections (where no curbing or treated shoulder exists) having a high traffic volume and speed limits in excess of 40 mph, the shoulder may be paved for a distance of 175 feet preceding, and 175 feet following, the entering and.exiting approaches respectively. This paved shoulder shall not be less than eight feet in width and need not be more than ten feet in width, conforming as nearly as possible within these limits to the existing shoulder width. The ends of these paved shoulders shall be tapered from one foot to full width in 75 feet, this taper being included in the overall length. The transverse slope of the paved shoulder shall not be less than 1/4 inch per foot, nor more the 3/4 inch per foot sloping away from the pavement edge. See Figure 803-5.

803.42 Curbed Approaches

Where curbing does not exist along the through pavement, the approaches and islands may be curbed at the option of the permit applicant. (See Figure 803-6). Curbed approaches may be used where the smallest permissible approach radii are required to utilize a small highway frontage.

Where curbing exists along the edge of the through pavement, the edges of the approach shall be delineated by a similar curb through the arc of the radius. Curbing along the entire approach and islands, may be installed at the option of the permit applicant.. (See Figure 803-7). Service station drives on curbed streets should use a dropped curb as shown in Section B-B on Figure 803-2.

803.43 Intermediate Islands

Between all approaches there shall be an intermediate island of a length greater than six (6) feet for curbed islands or islands along curbed roadways, and fifteen (15) feet for uncurbed islands.

To discourage improper use of uncurbed intermediate islands between dual approaches, the island should be seeded or sodded except for a 4-foot wide treated shoulder of stabilized material adjacent to the highway pavement.

803.44 Drive Intersection Angles

The location and angle of an approach in relation to an adjacent highway intersection shall be such that a vehicle entering or leaving the site may turn out of or into the nearest lane of traffic moving in the desired direction and be channeled within this lane before entering the intersection or proceeding along the highway.

The interior angle between the axes of dual approaches and the centerline of the roadway shall fall between 45^o and 90^o. This interior angle shall fall between 70^o and 90^o for single approaches designed for two-way operation.

803.45 Drive Widths

The width of all approaches shall not be greater than 35 feet in the throat of the approach measured at right angles to the axis of the approach.

Where public alleys adjoin the service station property, approaches may begin at the far side of the alley, and if so used, the width of the alley shall be included as part of the approach opening.

803.46 Drive Radii

Approach radii on uncurbed highways shall be as follows:

A. Turning Radii - 15 feet minimum, 25 to 50 feet desirable.

B. Non-turning Radii - 5 feet minimum, 10 feet maximum.

Approach radii on curbed highways shall be as follows:

A. Turning Radii - 3 feet minimum, 15 to 25 feet desirable.

B. Non-turning Radii - 3 feet minimum, 5 feet maximum.

Where the approach radius controls the turning radius of a right turn vehicle entering the service station from the adjacent traffic lane of the roadway, the radius of that edge shall be as long as practical to provide a free and safe movement.

803.47 Safety Curbs at Right-of-Way

Where sidewalks exist, safety curbs of concrete or masonry at least six feet in length for curbed islands or fifteen feet in length for uncurbed islands shall be provided along the right-of-way line between approaches.

803.48 Location of Pump Islands and Other Devices

Pump islands shall not be nearer to the right-of-way line than ten feet. All devices for the servicing of automotive vehicles shall be so located that no part of the vehicle being serviced will extend into the public right-of-way.

No lights, signs or other advertising devices shall be permitted on, or to overhang, highway right-of-way.

803.5 Commercial Drives

The access requirements of most commercial developments can be served by driveways having standard design characteristics. The exceptions are driveways having high traffic volumes, those being used by large vehicles, or those serving businesses which have traffic patterns unique to the business being conducted.

803.51 Standard Commercial Drives (See Fig. 803-8)

A. Radii:

1. 15 foot minimum, when the through highway is curbed.

2. 25 foot minimum, when the through highway is uncurbed.

B. Width - 35 foot maximum

C. A dropped curb should be used on curbed streets as shown in Section B-B on Figure 803-2.

803.52 Exceptions to Standard Commercial Drives

Where access requirements are such that a non-standard driveway is necessary, the design may approximate the design of shopping center driveways as discussed in Sec. 803.6 or public road intersections, Sec. 401.

Specially designed radii and a width greater than 35 feet may be permitted, as necessary, to accommodate the type vehicle using the driveway. (Example: A truck stop may require two one-way driveways or a single drive with width greater than 35 feet and radii as great as 75 feet to facilitate turning movements).

803.6 Shopping Center and Industrial Drives (See Figure 803-9)

This section is intended as a guide for the design of driveways to high volume traffic generators such as shopping centers, industrial plants, industrial parks, and other types of developments having similar traffic characteristics. Many of the design features discussed in Section 401, Intersections At-Grade, will be applicable. Geometric considerations are listed below:

A. Driveways should intersect the highway at an angle between 70° and 90°.

B. Each driveway traffic lane should have a minimum width of 10 feet, with 12 feet preferred.

C. Major driveways in shopping centers should be constructed to prevent cross movement of internal traffic within 100 feet of the entrance approach. This may be accomplished by use of a raised divider, 6 inches high, 6 feet wide (min.) and 100 feet long, and/or by use of curbing, sidewalk or other barrier along the drive edges for a length of 100 feet (See Fig. 803-9).

D. Driveways designed for traffic signal operation should have curbed radii and should provide a minimum of two lanes for vehicles entering the highway.

804 Drive Profile Design

804.1 Drive Profiles (Uncurbed Roadways)

Drive profiles on uncurbed roadways shall slope down and away from the pavement edge at the same slope as the graded shoulder. Any vertical curve should be developed outside the normal graded shoulder width. Vertical curve lengths should be 10 to 20 feet, depending on the grade differential. Under normal circumstances, rural drive grades should not exceed 10 percent with 8 percent considered to be the preferred maximum.

804.2 Drive Profiles (Curbed Roadways)

The design vehicle used to develop the profile criteria of this section is shown on Fig. 803-2. The profile criteria shown provides clearance for this vehicle when its springs are completely compressed. If conditions of a particular driveway do not meet the cross-section criteria listed below, a template of the design vehicle can be used to design the driveway profile.

For tree lawns six feet or wider, the ramp grade from the gutter to the edge of the sidewalk will be one inch per foot or less for normal cross-section design. Fig. 803-2 shows this condition for the following cross-section conditions:

A. Sidewalk and tree lawn slope of 1/4 inch per foot, and

B. 6 inch height of curb with pavement slope of 3/16 inch or 1/4 inch per foot, or

C. Type 2 curb and gutter with pavement slope of 3/16 inch per foot

If the cross-section design does not meet the above conditions (has sharper grade breaks), the profile should be designed using a template of the design vehicle.

For tree lawns less than six feet wide, Fig. 803-3 shows the profile treatment. Clearance for the design vehicle is achieved by depressing the sidewalk 1 inch at the driveway. The sidewalk cross-slope of 1/4 inch per foot is retained. The design may be used directly with curbed highways having cross-section criteria as listed above and the profile conditions of Fig. 803-2. For other cross-sections, a template of the design vehicle may be used to design the profile.

Fig. 803-3 shows an isometric view and profile for a driveway where only a 3-foot tree lawn is available. This design is shown, not because it is desirable, but because right-of-way width and property development may require this type of design. Whenever feasible, the tree lawn should be 8 feet or wider, as discussed in Sec. 306.14 and 306.15.

Where the total width of tree lawn and sidewalk is less than 6 feet, the minimum 3-foot apron designs are inappropriate, and cannot be used, as they extend curb or sharp flares into the sidewalk area. For this condition, the sidewalk and curb are transitioned to meet the drive profile as shown on the lower portion of Fig. 803-3. The profile of the drive meets the one inch depressed grade of the sidewalk as shown in the drive profile of Fig. 803-3.

The tree lawn and walk design shown in Fig's. 803-2 and 803-3 will keep storm water, flowing at the curb design height or less, from flowing over the sidewalk. If it is necessary to lower the curb and sidewalk more than 1 inch, the drainage condition should be checked thoroughly.

804.3 Commercial Drive Profiles (Curbed Roadways)

Commercial drive profiles usually use a dropped curb across the approach. However, some commercial drives serving large traffic generators may be designed as at-grade intersections, without dropped curbs, because of their high traffic volumes.

Shown on Fig. 804-1 are the grade controls for commercial driveways. The grade should be as flat as possible and still meet drainage requirements. The 20-foot length between grade breaks is required by the low clearance and the long axle spacing of the commercial design vehicle (Figure 804-2). Tree lawn profile design should be in accordance with Fig's. 803-2 and 803- 3. The grade break at the face of the curb is critical for some commercial vehicles and the cross-section requirements for residential drives on curbed streets should be used.

805 Drive Pavement Design

805.1 Field Drives

Field driveways should be paved with six inches of 411 or 304 aggregate. They shall be paved from the edge of the pavement or treated shoulders, to a point where the grade of the new driveway intersects the grade of the existing driveway, or on relocated driveways to where the grade of the new driveway intersects the existing ground.

805.2 Residential Drives

Residence driveways shall be paved from the edge of new pavement to the point where the grade of the new driveway intersects the grade of the existing driveway, or on relocated driveways to the point where the geometric limits of the new driveway meet the existing driveway.

Residence driveways having an existing hard surface or an existing aggregate surface shall be replaced with a pavement of a similar type, insofar as practicable, using one of the following designs for the portion beyond the flared apron:

A. 6" 452 Plain Portland cement concrete
B. 2" 404 Asphalt concrete
408 Prime coat at 0.4 gallon per square yard.
6" 304 Aggregate base or 7" 411 Stabilized crushed aggregate
C. 1¼" 404 Asphalt concrete
3¾" 301 Bituminous aggregate base
D. 8" 411 or 304 Aggregate base

In uncurbed areas, the apron pavement design depends on the treated shoulder material as follows:

A. The flared portion of residence driveways adjacent to paved shoulders shall be constructed of the same material and composition as used in the treated shoulder paving.

B. The flared portion of residence driveways adjacent to surface treated aggregate shoulders shall be constructed of the same material as used in the treated shoulder, except it shall be surfaced with two inches of 404 asphalt concrete.

C. The flared portion of residence driveways on projects for which earth shoulders are specified shall be paved with either six inches 452 Plain Portland cement concrete, or with two inches 404, asphalt concrete on six inches of 411 or 304 aggregate.

805.3 Commercial Drives

Commercial driveways shall be paved from the edge of the new pavement to the point where the grade of the new driveway intersects the grade of the existing driveway, or on relocated driveways to the point where the geometric limits of the new driveway meet the existing driveway.

Commercial driveways having an existing hard surface or aggregate surface shall be replaced with a pavement of a similar type insofar as practical, using one of the following designs for the portion beyond the return or apron:

A.	8"	452	Plain Portland cement concrete
B.	1¼"	404	Asphalt concrete
	1¾"	402	Asphalt concrete
		408	Prime coat at 0.4 gallon per sq. yd.
	8"	304	Aggregate base
C.	1¼"	404	Asphalt concrete
	4¾"	301	Bituminous aggregate base
D.	10"	411 or 304	Aggregate base

Additional thicknesses may be provided for the above courses where unusual weights or types of vehicles are expected to use the commercial driveway.

Commercial driveway aprons shall be constructed as previously outlined for residential driveway aprons, except that additional thicknesses should be provided to meet nominal pavement design for commercial driveways.

805.4 Pavement Treatment of Undisturbed Drives

The preceding treatment of driveways does not apply to resurfacing or widening and resurfacing projects when the existing driveway is not disturbed beyond the edge of proposed pavement. Item 411 or 304 aggregate shall be used to adjust aggregate driveways to meet the new pavement surface for widening and/or resurfacing projects. Asphalt concrete shall be used for adjusting bituminous or concrete driveways to meet the new pavement surface, which adjustment shall be accomplished within a reasonable distance from the edge of the pavement. As a general rule, this can be done within the limits of the roadway shoulders.

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Section	Existing English Text	Proposed Metric Text
801.25	600 feet at diamond-type interchanges 1000 feet at other types of interchanges.	180 meters at diamond-type interchanges 300 meters at other types of interchanges.
802.26	(2) 4-foot Control within the limits of the 4-foot control.	(2) 1.2-meter Control within the limits of the 1.2-meter control.
802.27	(1) 40 FEET, OR LESS, shall be at least 20 feet (2) GREATER THAN 40 FEET, approach radius may begin 20 feet intersection radius is greater than 80' approach radius may begin 40' from	(1) LESS THAN OR EQUAL TO 12 METERS, shall be at least 6 meters (2) GREATER THAN 12 METERS, approach radius may begin 6 meters intersection radius is greater than 24 meters approach radius may begin 12 meters from
802.29	be located a minimum of 600 feet	be located a minimum of 180 meters
803.11	A. Maximum 4"x4" square or 4-1/2" dia. B. Maximum 2" diameter (2-3/8" O.D.) standard strength steel pipe.	A. Maximum 100 mm x 100 mm square or 115 mm dia. B. Maximum 60.3 mm O.D. Schedule 40 steel pipe.
803.12	is less than 6 feet wide,	is less than 1.8 meters wide,
803.22	retained unless it is less than 12 feet. widened to provide a 12 foot throat width. width should normally be 12 feet. normally not exceed 24 feet.	retained unless it is less than 3.6 meters. widened to provide a 3.6-meter throat width. width should normally be 3.6 meters. normally not exceed 7.2 meters.
803.23	should normally be 25 feet.	should normally be 7.5 meters.
803.24	eight feet or the treated shoulder width,	2.4 meters or the treated shoulder width,
803.3	through highway is curbed, is 15 feet. tree lawn is less than 6 feet.	through highway is curbed, is 5 meters. tree lawn is less than 2 meters.
803.41	speed limits in excess of 40 mph, distance of 175 feet preceding, and 175 feet following, shall not be less than eight feet in width not be more than ten feet in width, from one foot to full width in 75 feet, shall not be less than 1/4 inch per foot, nor more than 3/4 inch per foot.	speed limits in excess of 70 km/h, distance of 50 meters preceding, and 50 meters following, shall not be less than 2.4 meters in width not be more than 3.0 meters in width, from 0.3 meter to full width in 20 meters, shall not be less than 0.02, nor more than 0.06.
803.43	a length greater than six (6) feet fifteen (15) feet for uncurbed islands. 4-foot wide treated shoulder	a length greater than 2 meters 5 meters for uncurbed islands. 1.2-meter wide treated shoulder

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Section	Existing English Text	Proposed Metric Text
803.45	shall not be greater than 35 feet	shall not be greater than 10.5 meters
803.46	A. Turning Radii - 15 feet minimum, 25 to 50 feet desirable. B. Non-turning Radii - 5 feet minimum, 10 feet maximum.	A. Turning Radii - 5 meter minimum, 8 to 15 meters desirable. B. Non-turning Radii - 2 meters minimum, 3 meters maximum.
	A. Turning Radii - 3 feet minimum, 15 to 25 feet desirable. B. Non-turning Radii - 3 feet minimum, 5 feet maximum.	A. Turning Radii - 1 meter minimum, 5 to 8 meters desirable. B. Non-turning Radii - 1 meter minimum, 2 meters maximum.
803.47	at least six feet in length or fifteen feet in length	at least 2 meters in length or 5 meters in length
803.48	right-of-way line than ten feet.	right-of-way line than 3.0 meters.
803.51	1. 15 foot minimum, 2. 25 foot minimum, B. Width - 35 foot maximum	1. 5 meters minimum, 2. 8 meters minimum, B. Width - 10.5 meters maximum
803.52	and a width greater than 35 feet with width greater than 35 feet radii as great as 75 feet	and a width greater than 10.5 meters with width greater than 10.5 meters radii as great as 23 meters
803.6	10 feet, with 12 feet preferred. internal traffic within 100 feet 6 inches high, 6 feet wide (min.) and 100 feet long, for a length of 100 feet	3.0 meters, with 3.6 meters preferred. internal traffic within 30 meters 150-millimeters high, 2 meters wide (min.) and 30 meters long, for a length of 30 meters
804.1	curve lengths should be 10 to 20 feet,	curve lengths should be 3.0 to 6.0 meters,
804.2	For tree lawns six feet or wider, the ramp grade from the gutter to the edge of the sidewalk will be one inch per foot or less	For tree lawns 2 meters or wider, the ramp cross-slope rate from the gutter to the edge of the sidewalk will be 0.08 or less
	A. Sidewalk and tree lawn slope of 1/4 inch per foot, and B. 6 inch height of curb with pavement slope of 3/16 inch or 1/4 inch per foot, or	A. Sidewalk and tree lawn slope rate of 0.02, and B. 150-millimeter height of curb with pavement slope rate of 0.016 or 0.02, or
	C. Type 2 curb and gutter with pavement slope of 3/16 inch per foot	C. Type 2 curb and gutter with pavement slope rate of 0.016

CHAPTER 800 - PAGE 3 OF 3

Section	Existing English Text	Proposed Metric Text
804.2	For tree lawns less than six feet wide, depressing the sidewalk 1 inch cross-slope of 1/4 inch per foot 3-foot tree lawn the tree lawn should be 8 feet or wider, as discussed in Sec. 306.14 and 306.15. sidewalk is less than 6 feet, minimum 3-foot apron designs one inch depressed grades. sidewalk more than 1 inch,	For tree lawns less than 2 meters wide, depressing the sidewalk 25 millimeters cross-slope rate of 0.02 1.0 meter tree lawn the tree lawn should be 2.5 meters or wider, as discussed in Sec. 306.24 and 306.25. sidewalk is less than 2.0 meters, minimum 1.0 meter apron designs 25 millimeters depressed grades. sidewalk more than 25 millimeters,
804.3	The 20-foot length	The 6-meter length
805.1	paved with six inches of 411 or 304	paved with 150 millimeters of 411 or 304
805.2	A. 6" 452 B. 2" 404 ...0.4 gallon per square yard. 6" 304 Aggregate base or 7" 411 C. 1-1/4" 404 3-3/4" 301 D. 8" 411 or 304	A. 152 mm 452 B. 51 mm 404 ...1.8 liters per square meter. 150 mm 304 Aggregate base or 180 mm 411 C. 32 mm 404 95 mm 301 D. 200 mm 411 or 304
805.2	two inches of 404 either six inches 452 or with two inches 404, on six inches of 411 or 304	51 millimeters of 404 either 152 millimeters 452 or with 51 millimeters 404, on 150 millimeters of 411 or 304
805.3	A. 8" 452 B. 1-1/4" 404 1-3/4" 402 ...0.4 gallon per square yard. 8" 304 C. 1-1/4" 404 4-3/4" 301 D. 10" 411 or 304	A. 203 mm 452 B. 32 mm 404 44 mm 402 ...1.8 liters per square meter. 200 mm 304 C. 32 mm 404 121 mm 301 D. 250 mm 411 or 304

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800 Access Contol, R/W Use Permits and Drive Design

List of Figures

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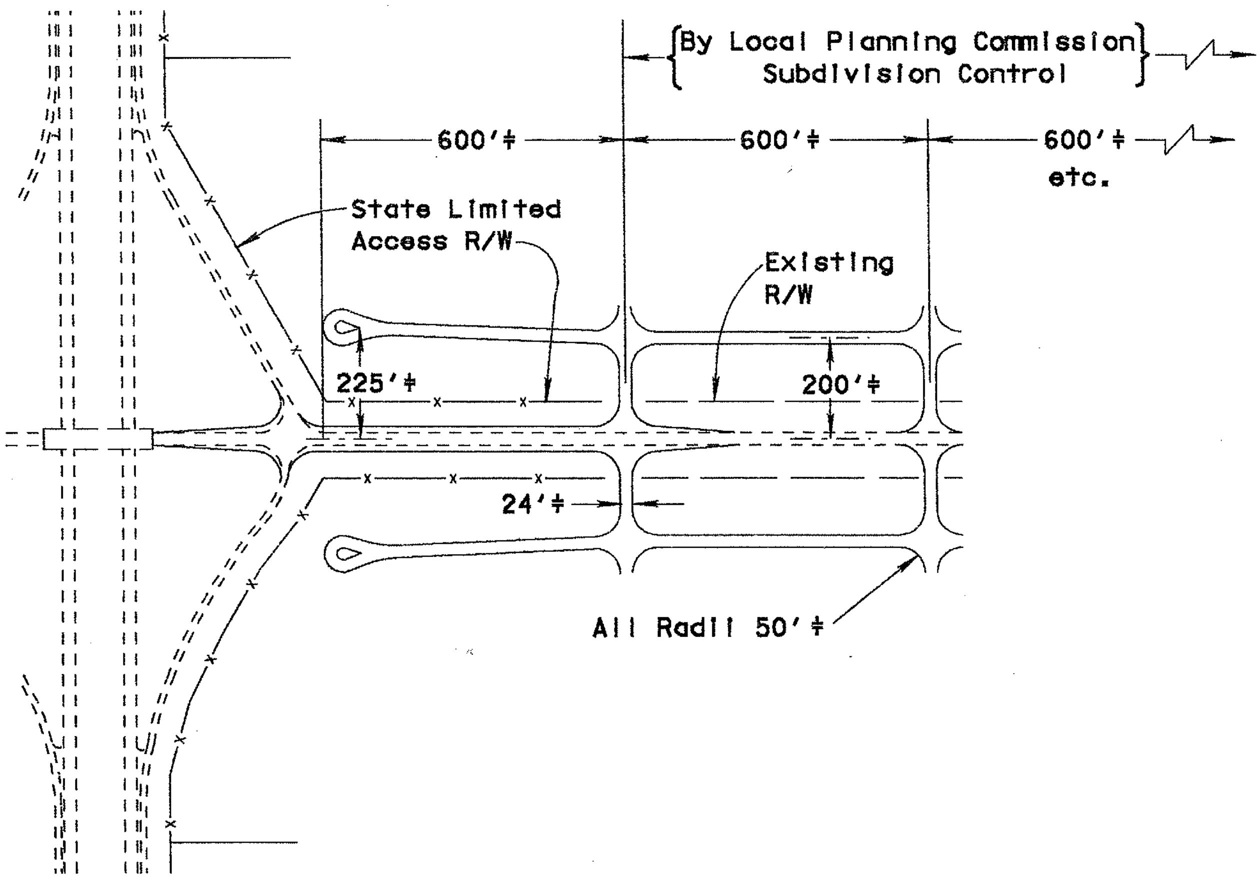
GUIDELINES FOR LIMITATION OF ACCESS AT DIAMOND TYPE INTERCHANGES	801-1
	REFERENCE SECTION 801.25

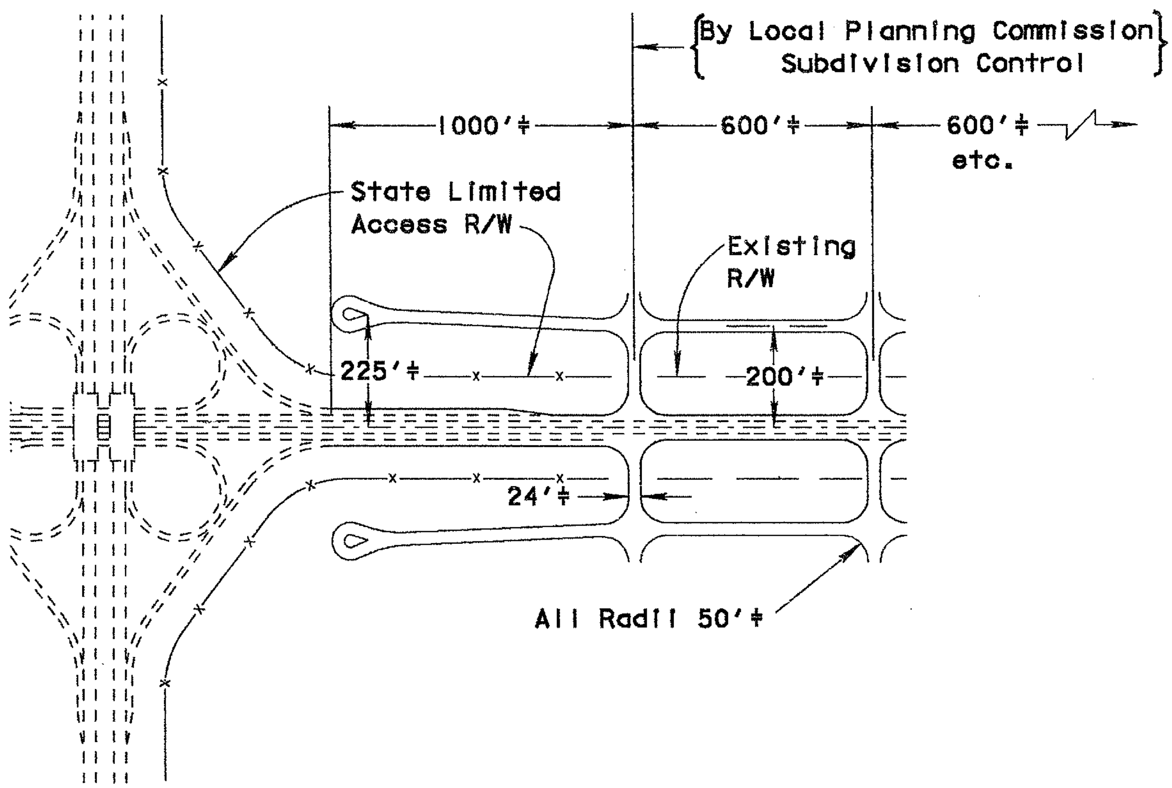


NOTE:
(± symbol indicates desirable minimum)

RURAL INTERCHANGES

The control of developments, adjacent to diamond type interchanges on limited access highways can be effectively controlled by county, regional, or city planning commissions, through subdivision controls and building developments, and in addition by local zoning commissions as to zoning regulations. County commissioners or township trustees may exercise similar controls in the absence of planning and zoning commissions.

GUIDELINES FOR LIMITATION OF ACCESS AT CLOVERLEAF-TYPE INTERCHANGES	801-2
	REFERENCE SECTION 801.25



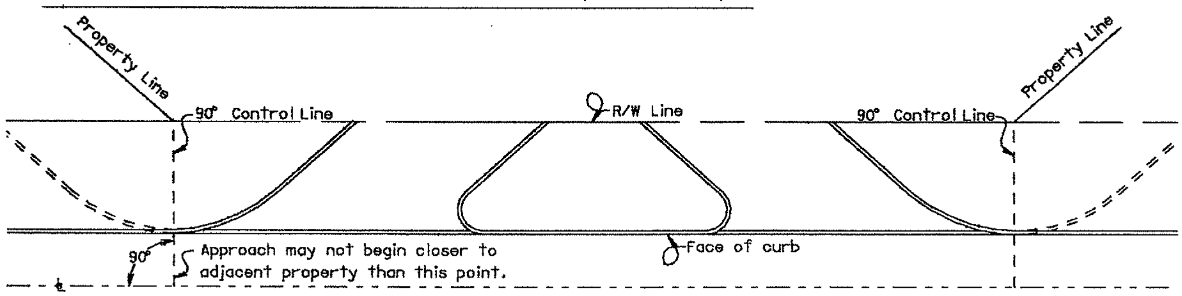
NOTE:
(± symbol indicates desirable minimum)

RURAL INTERCHANGES

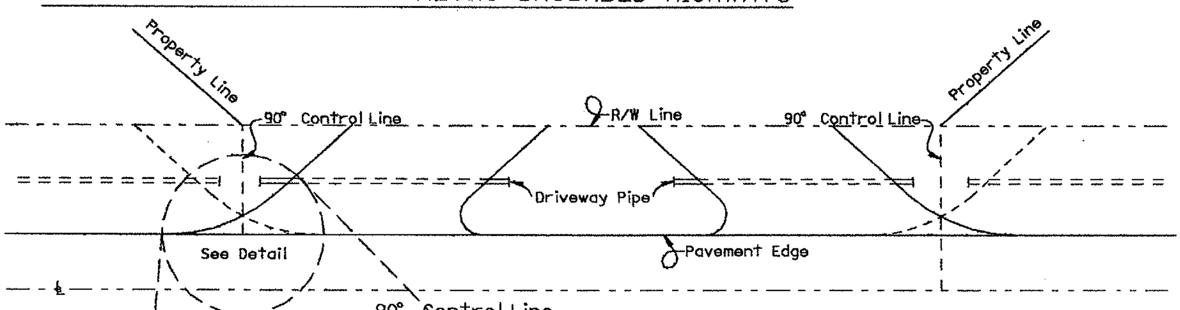
The control of developments, adjacent to cloverleaf type interchanges on limited access highways can be effectively controlled by county, regional, or city planning commissions, through subdivision controls and building developments, and in addition by local zoning commissions as to zoning regulations. County commissioners or township trustees may exercise similar controls in the absence of planning and zoning commissions.

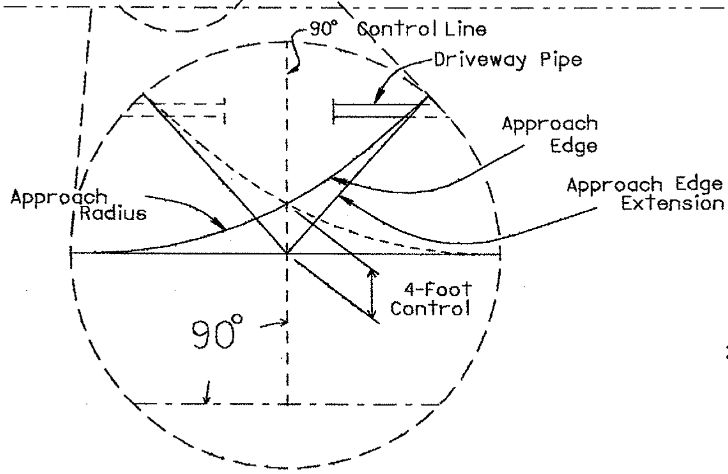
LOCATION OF DRIVES IN RELATION TO PROPERTY LINES	802-1
	REFERENCE SECTION 802.26

LOCATION OF APPROACHES ALONG CURBED HIGHWAYS



LOCATION OF APPROACHES ALONG UNCURBED HIGHWAYS



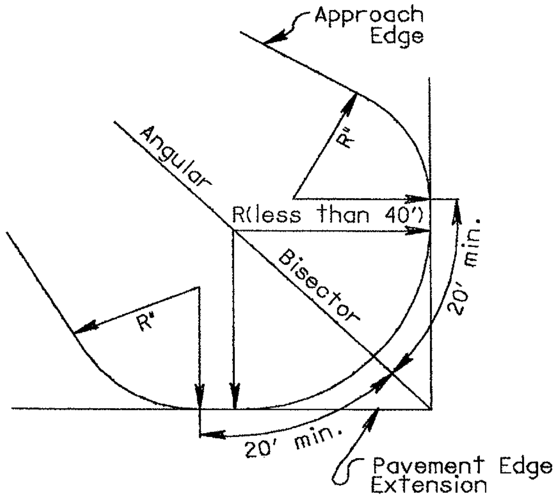


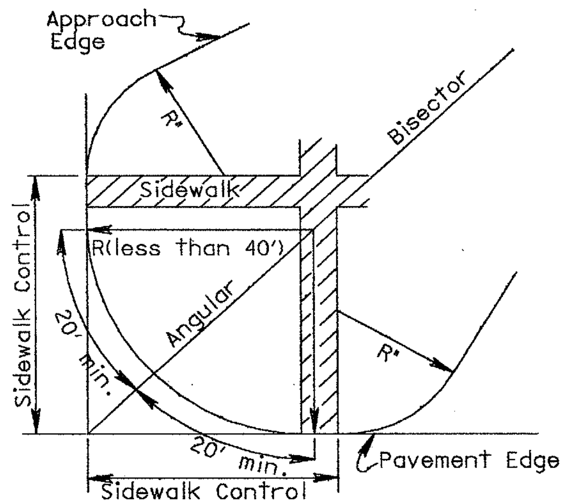
DETAIL FOR DETERMINING MAXIMUM UTILIZATAION OF HIGHWAY FRONTAGE

1. Approach edge extension must not cross the 90° Control Line.
2. Approach Radius may cross the 90° Control line only within the limits of the 4-foot Control

CORNER ISLAND DETAIL	802-2
	REFERENCE SECTION 802.27

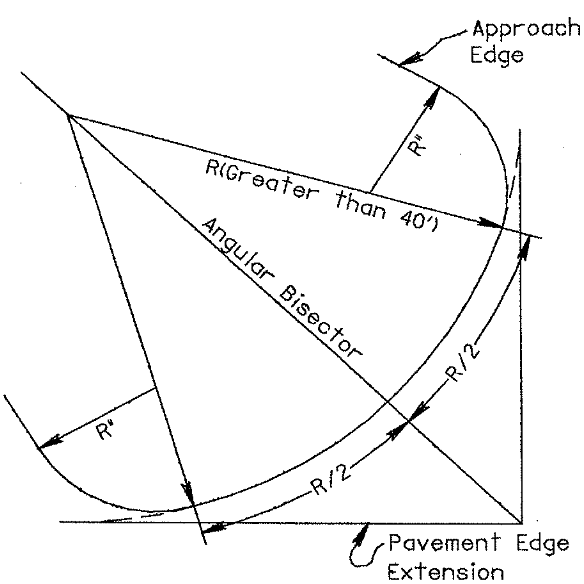
INTERSECTION RADIUS LESS THAN 40 FEET

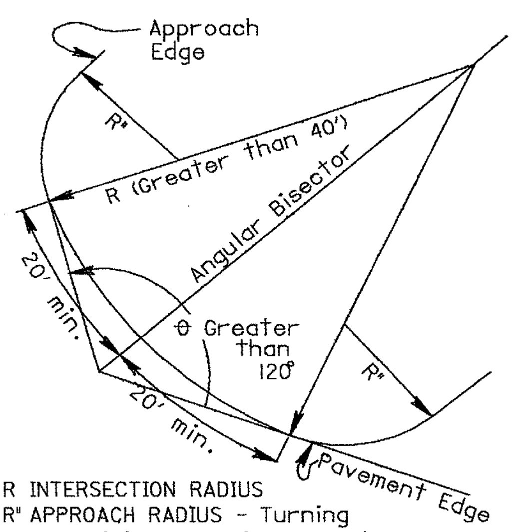




R INTERSECTION RADIUS
R" APPROACH RADIUS- Turning

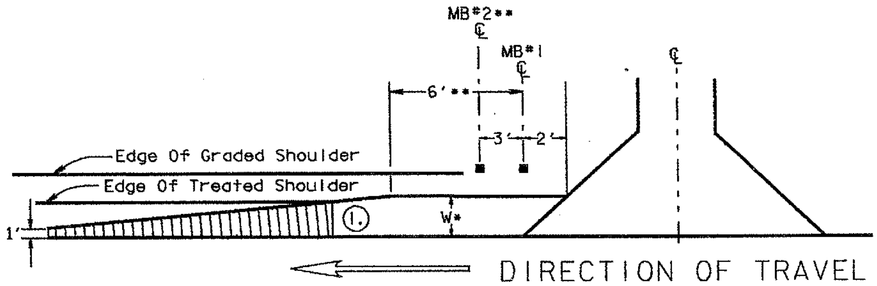
INTERSECTION RADIUS GREATER THAN 40 FEET





R INTERSECTION RADIUS
R" APPROACH RADIUS - Turning
R/2 20'Minimum. Maximum need not be greater than 40'.

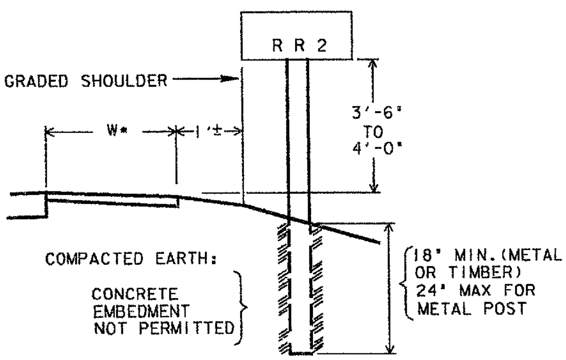
# MAILBOX FACILITIES	803-1
	REFERENCE SECTION
	803.1

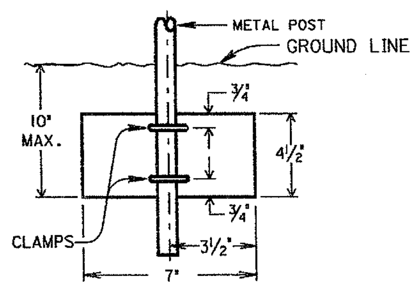


(1.) End mailbox turnout at edge of treated shoulder or 1' which ever is greater

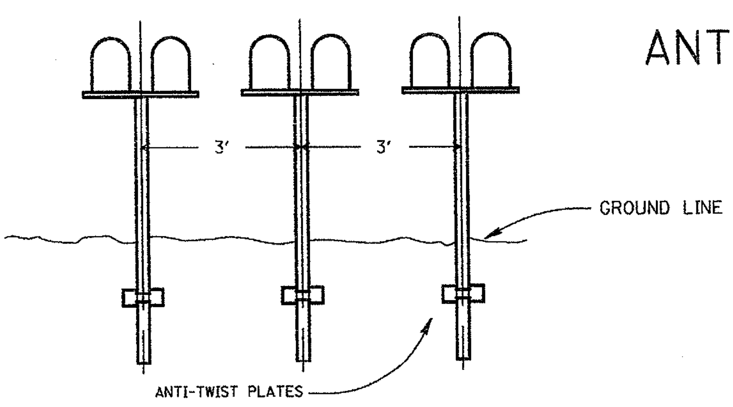
* Where posts are behind guardrail, turnout shall extend to face of guardrail. Where no guardrail is required, turnout width shall be 6' minimum.

** Add 3' for each additional mailbox





ANTI-TWIST PLATE

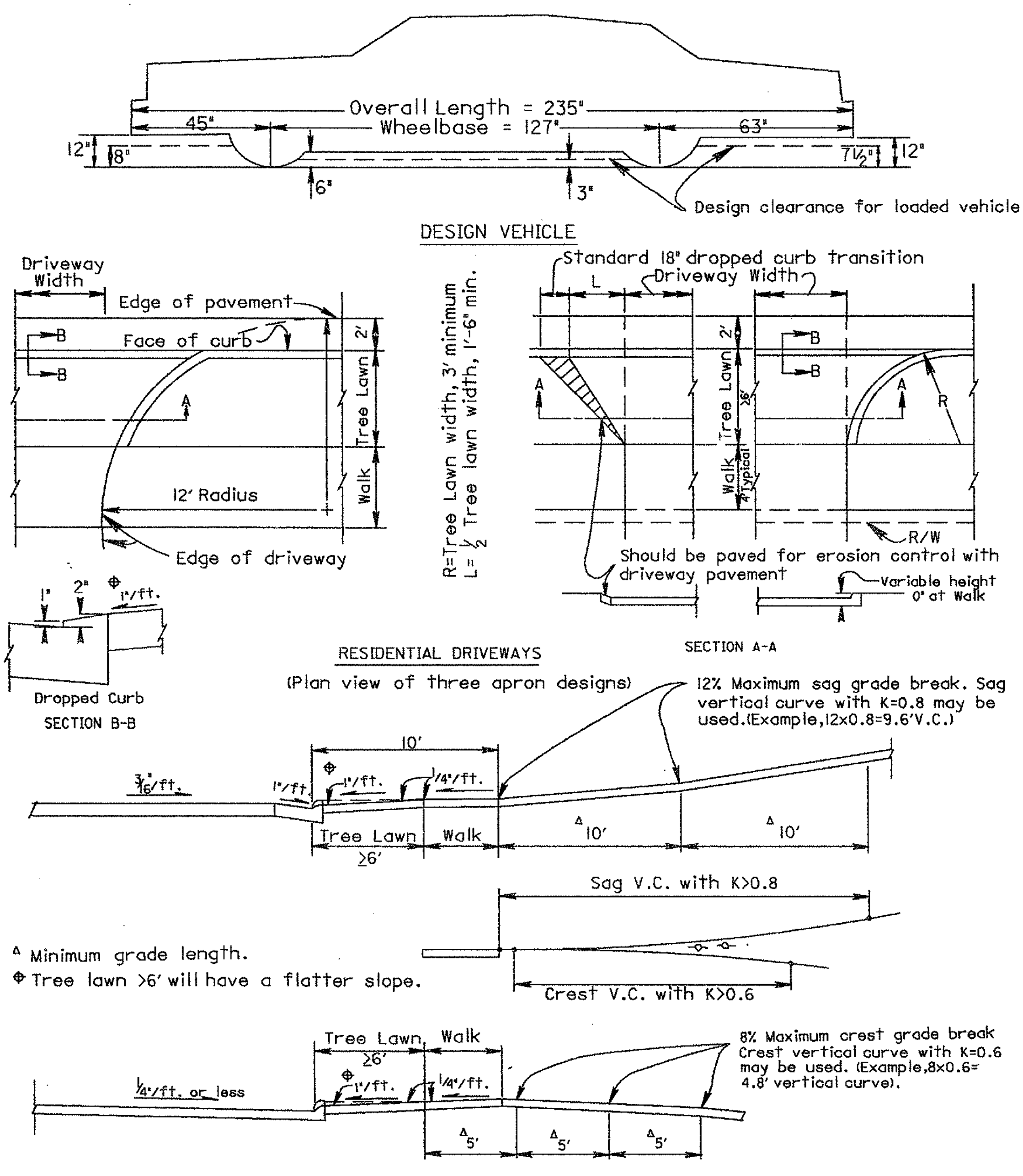


GROUP MAILBOX INSTALLATION

URBAN RESIDENTIAL DRIVE DETAILS

803-2

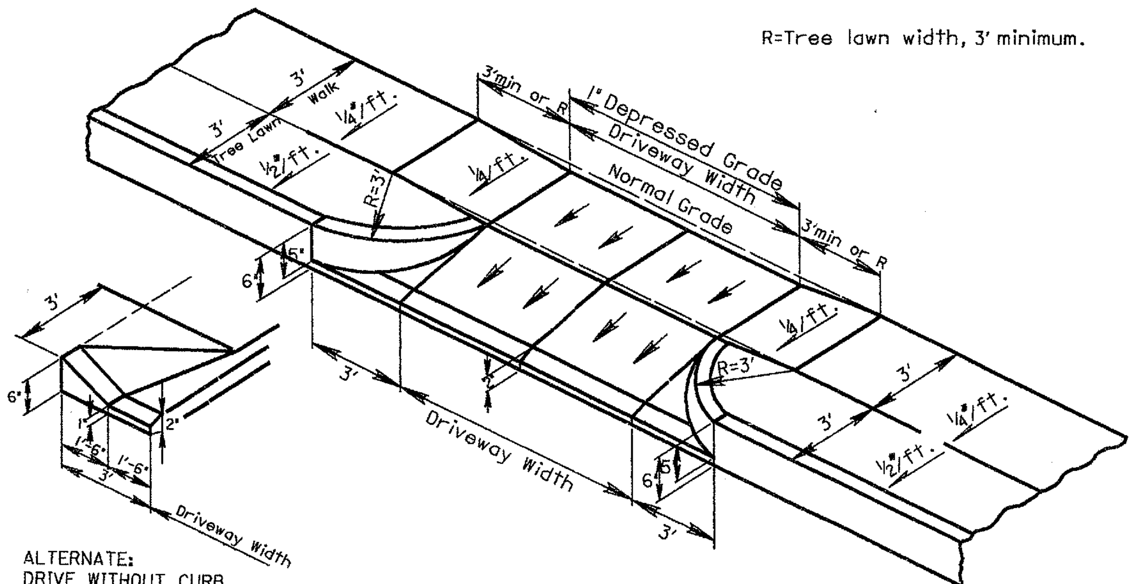
REFERENCE SECTION 803.3 & 804.2



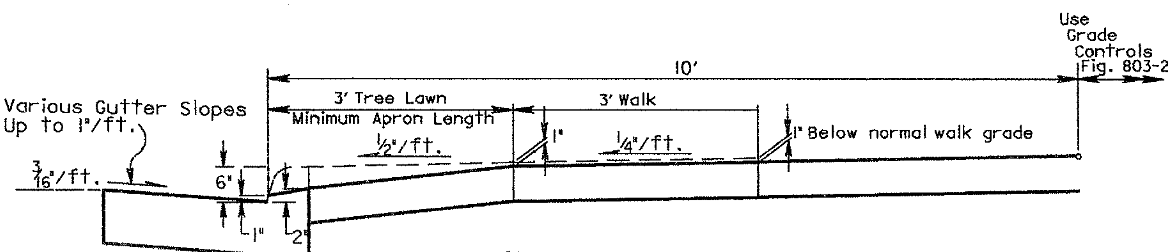
RESIDENTIAL DRIVEWAY PROFILES
6' OR GREATER TREE LAWN

URBAN RESIDENTIAL DRIVE DETAILS	803-3
	REFERENCE SECTION 803.3 & 804.2

R=Tree lawn width, 3' minimum.

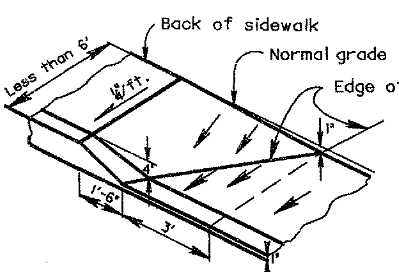


ISOMETRIC VIEW

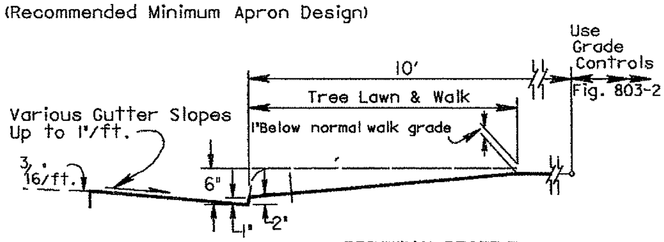


DRIVEWAY PROFILE

EXAMPLE: 3' TREE LAWN WITH 3' WALK DEPRESSED 1"
(Recommended Minimum Apron Design)



ISOMETRIC VIEW



DRIVEWAY PROFILE

EXAMPLE: TREE LAWN AND WALK, LESS THAN 6'
WALK DEPRESSED 1"

RESIDENTIAL DRIVEWAY PROFILES
LESS THAN 6' TREE LAWN

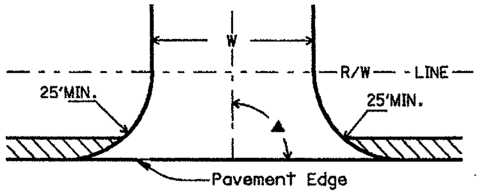
SERVICE STATION DRIVES

UNCURBED ROADWAY / UNCURBED APPROACH

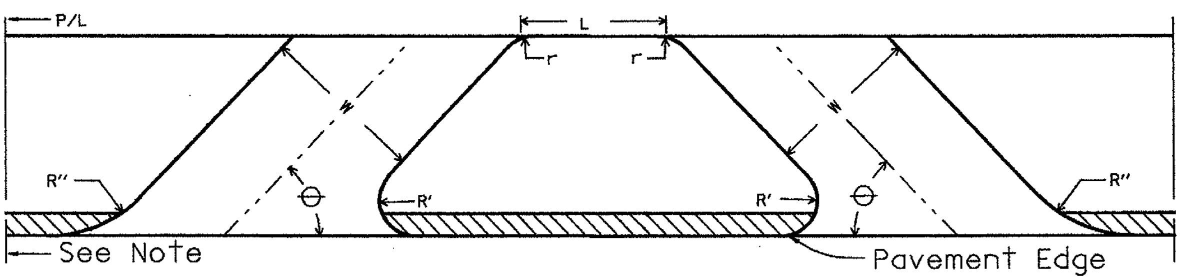
803-4
REFERENCE SECTION
803.41

L 15′ or greater
W 35′ maximum
▲ 70° to 90° (for approach with two-way operation)
⊖ 45° to 90°
R′ Non-Turning Radius, 5′ min. to 10′ max
R″ Turning Radius, 15′ min, 25′ to 50′ Desirable
r Permissible Rounding 15′ max
Treated Shoulder

SINGLE APPROACH

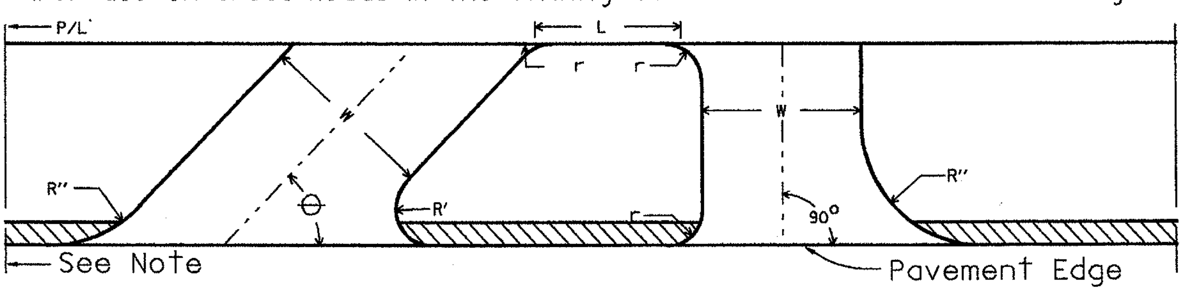


DUAL APPROACHES & INTERMEDIATE ISLAND



DUAL APPROACHES WITH RETURN FLOW & INTERMEDIATE ISLAND

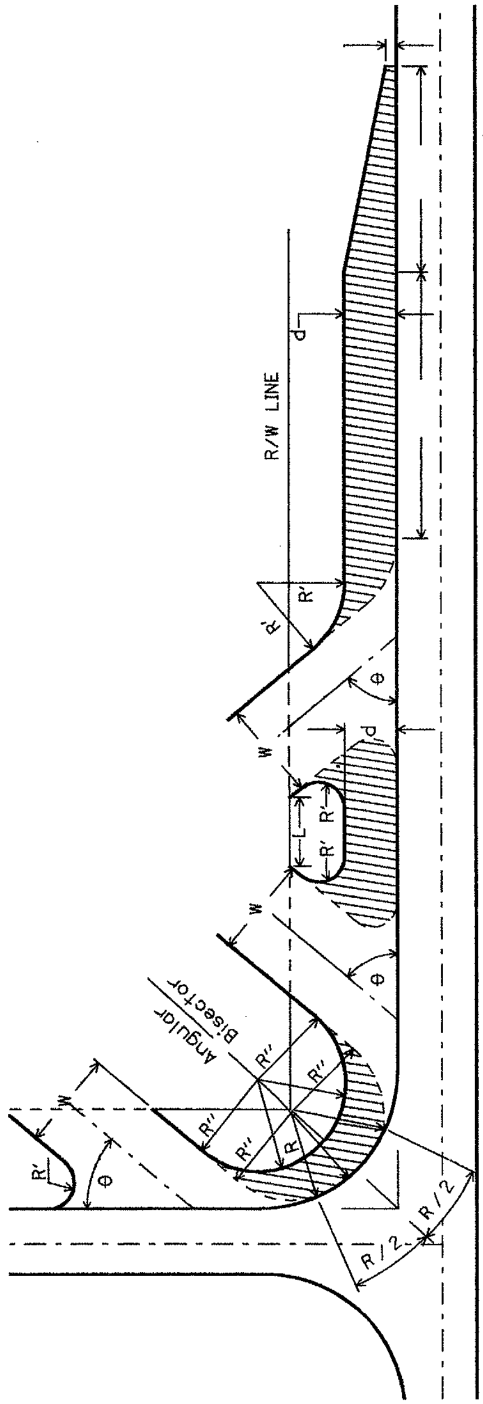
(For use on Cross-Roads in the Vicinity of Interstate Routes or Freeways)



Note: See figure 802-1 for location of drives in relation to property line.

October 1992

SERVICE STATION DRIVES SPECIAL PAVED SHOULDER DETAIL	803-5
	REFERENCE SECTION 803.41



L 15 ft. or greater.

W Not greater than 35ft.

Φ 45° to 90°

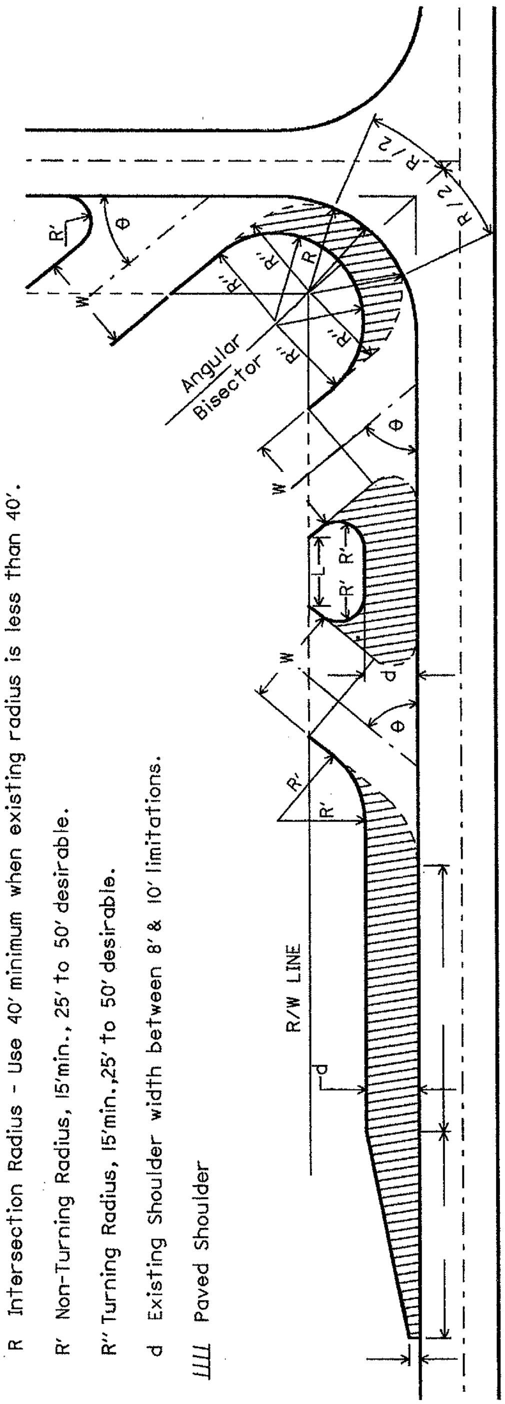
R Intersection Radius - Use 40' minimum when existing radius is less than 40'.

R' Non-Turning Radius, 15'min., 25' to 50' desirable.

R'' Turning Radius, 15'min.,25' to 50' desirable.

d Existing Shoulder width between 8' & 10' limitations.

//// Paved Shoulder

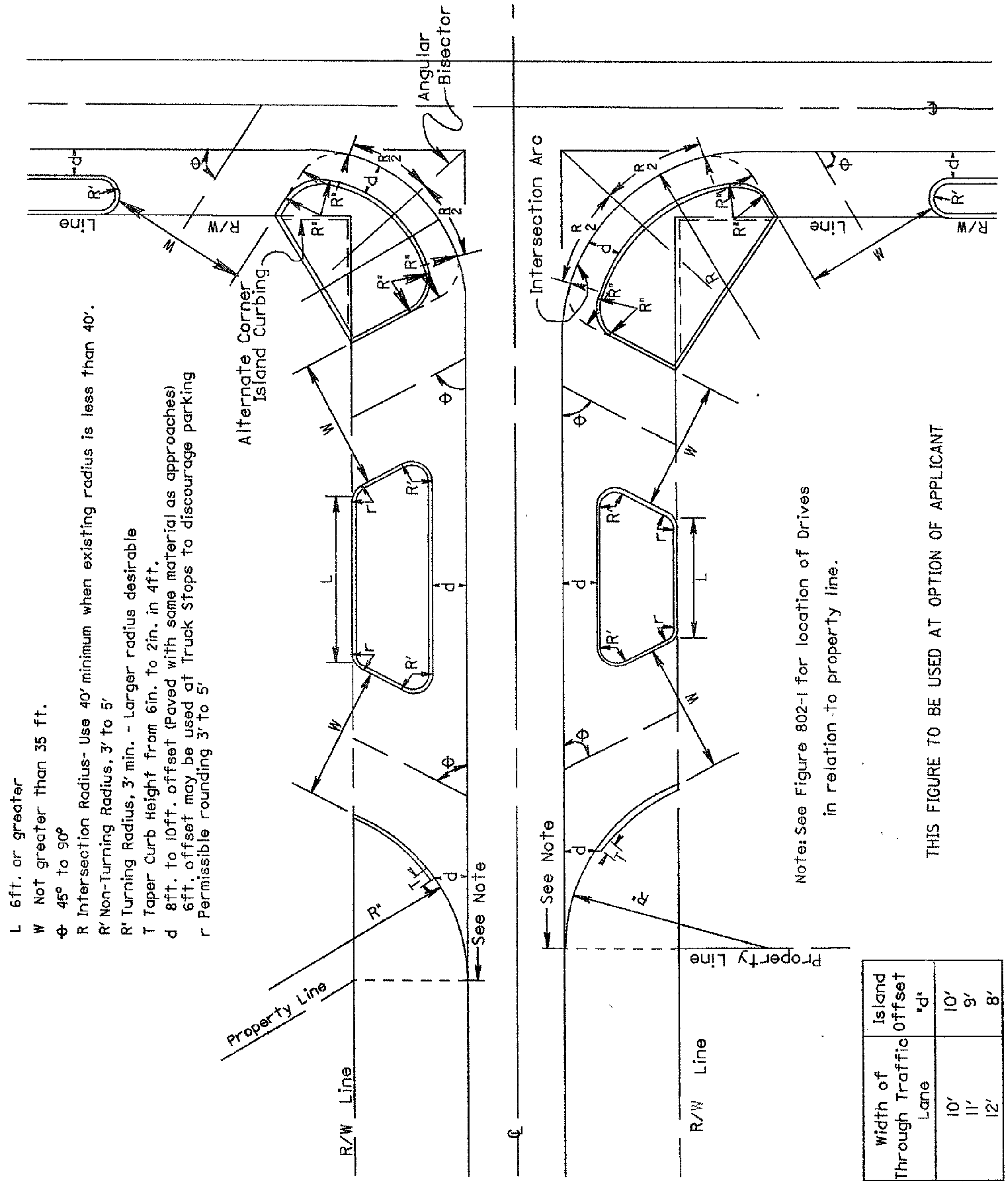


SERVICE STATION DRIVES

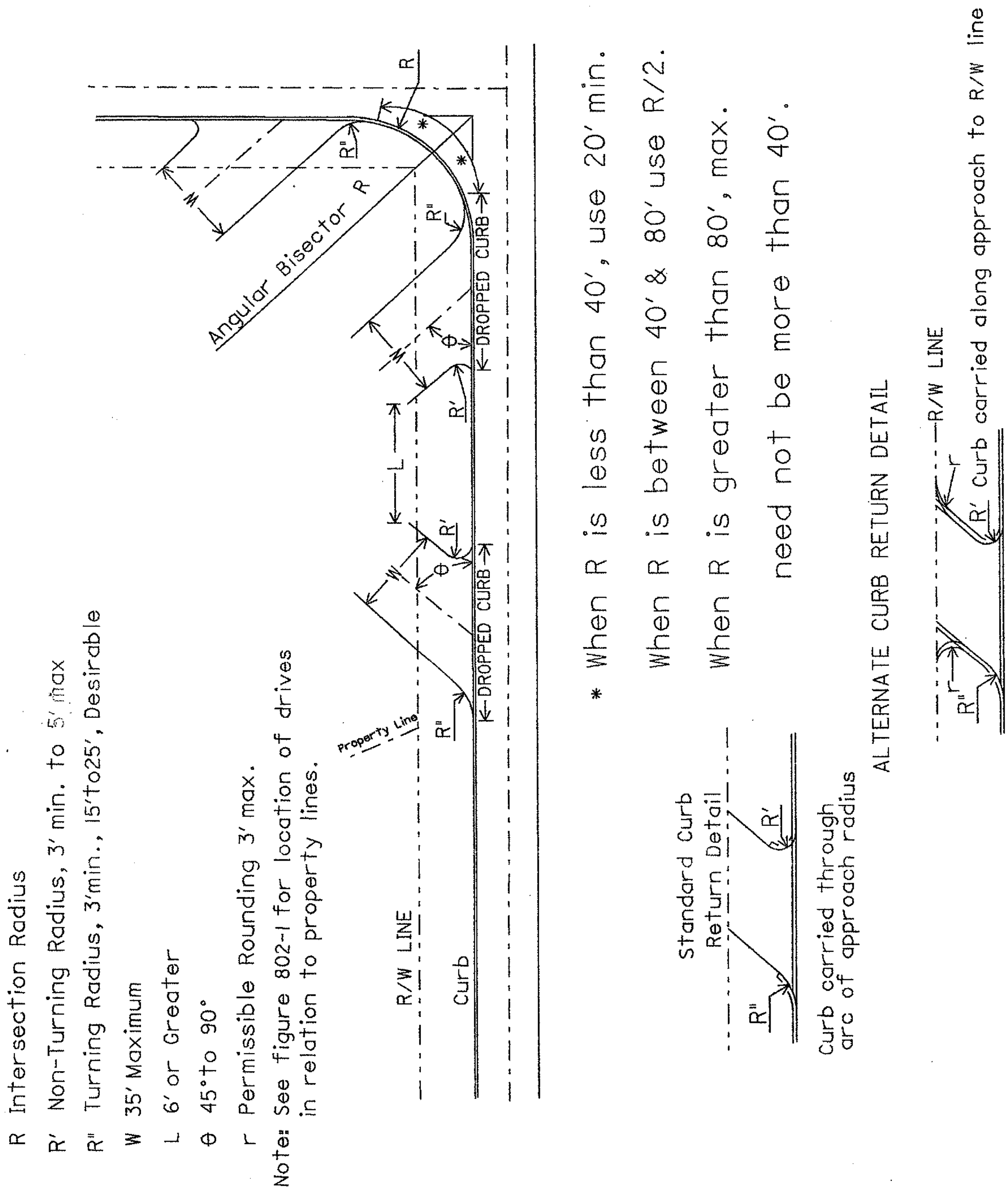
UNCURBED ROADWAY / CURBED APPROACH

803-6

REFERENCE SECTION 803.42

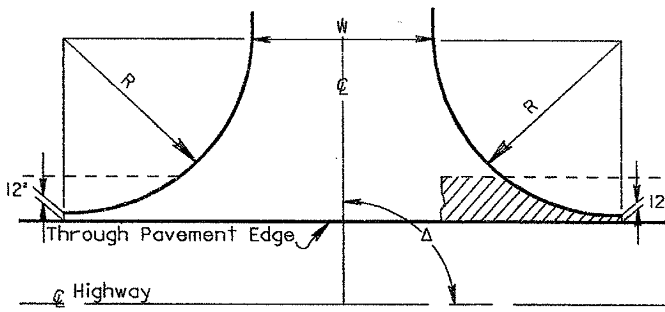


SERVICE STATION DRIVES CURBED ROADWAY / CURBED APPROACH	803-7
	REFERENCE SECTION 803.42

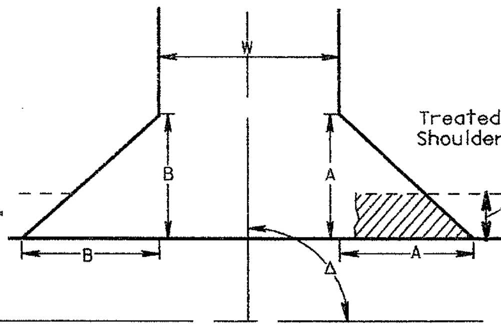


STANDARD COMMERCIAL DRIVE DESIGNS	803-8
	REFERENCE SECTION 803.51

UNCURBED DRIVEWAY ALONG UNCURBED HIGHWAY



TYPE 1 (STANDARD DRAWING BP-4.1)



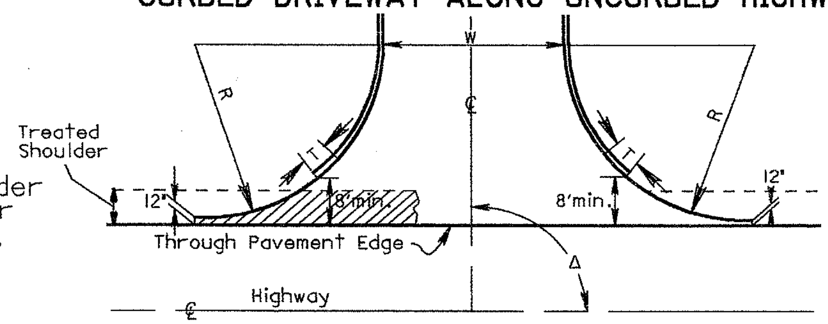
TYPE 2 (STANDARD DRAWING BP-4.1)

W = 35 ft. Maximum
R = 25 ft. Minimum on Uncurbed Highway
15 ft. Minimum on Curbed Highway
T = Taper Curb Height from 6 in. to 2 in.
in. 4 ft.
Δ = 70° to 90° (two-way operation)

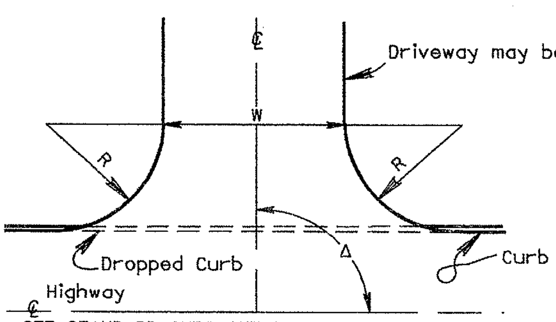
Δ	A	B
85° to 90°	20′	20′
75° to 85°	25′	16′
65° to 75°	28′	13′
55° to 65°	33′	12′

CURBED DRIVEWAY ALONG UNCURBED HIGHWAY

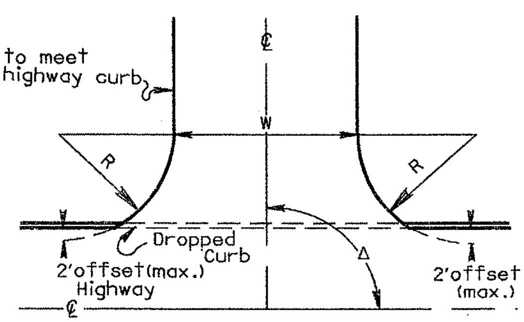
- Do not replace treated shoulder in this portion of drive flare if shoulder has equal or better pavement buildup.



CURBED OR UNCURBED DRIVEWAYS ALONG CURBED HIGHWAY



SEE STANDARD CURB DETAILS
STANDARD DRAWING BP-4.1



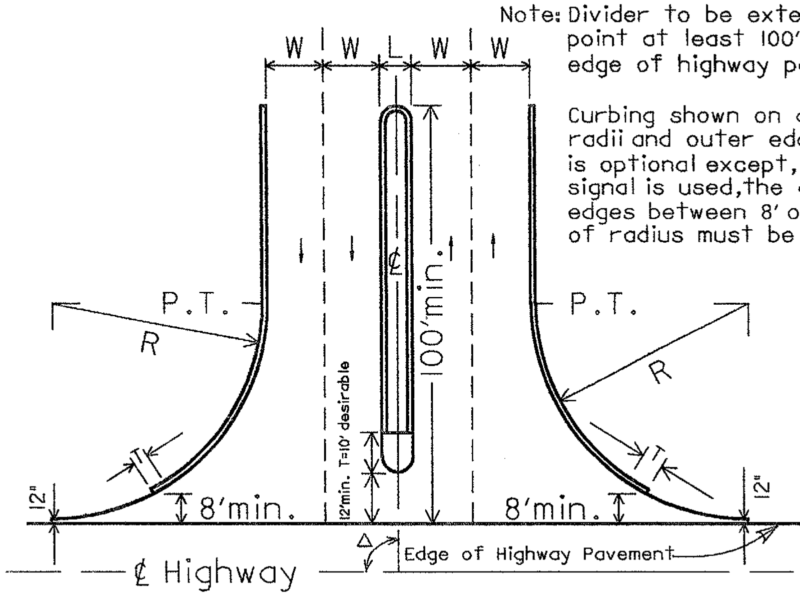
ALTERNATE DESIGN
To be used when smaller curb opening is required.
(or curb and gutter used)

October 1992

SHOPPING CENTER & INDUSTRIAL DRIVE DESIGNS	803-9
	REFERENCE SECTION 803.6

Note: Divider to be extended to a point at least 100' back from edge of highway pavement.

Curbing shown on approach radii and outer edges of drive is optional except, when traffic signal is used, the approach edges between 8' offset and P.T. of radius must be curbed.

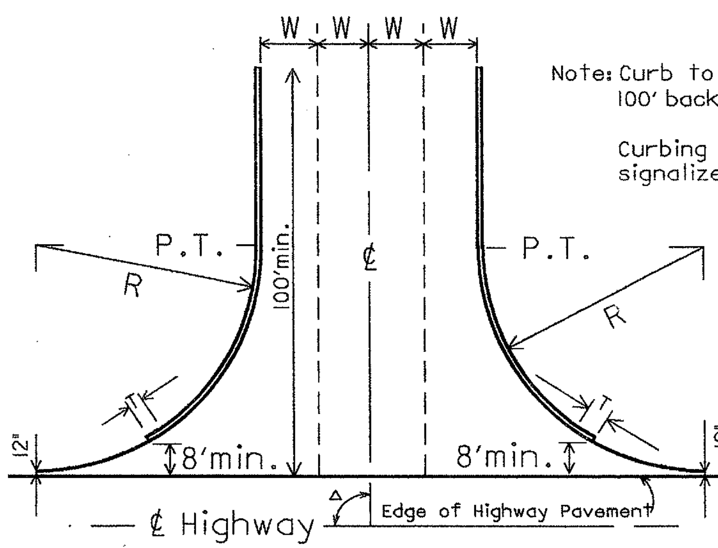


DIVIDED DRIVE

T = Taper Curb Height from 6" to 2" in 4' or greater.
W = 10' to 14' per single traffic lane.
R = 35' Minimum, 50' Desirable.
▲ = 70° to 90°
L = Median Width, 6' Minimum.
(Median must be curbed for 6' to 15' widths)

Note: Curb to be extended to a point at least 100' back from edge of highway pavement.

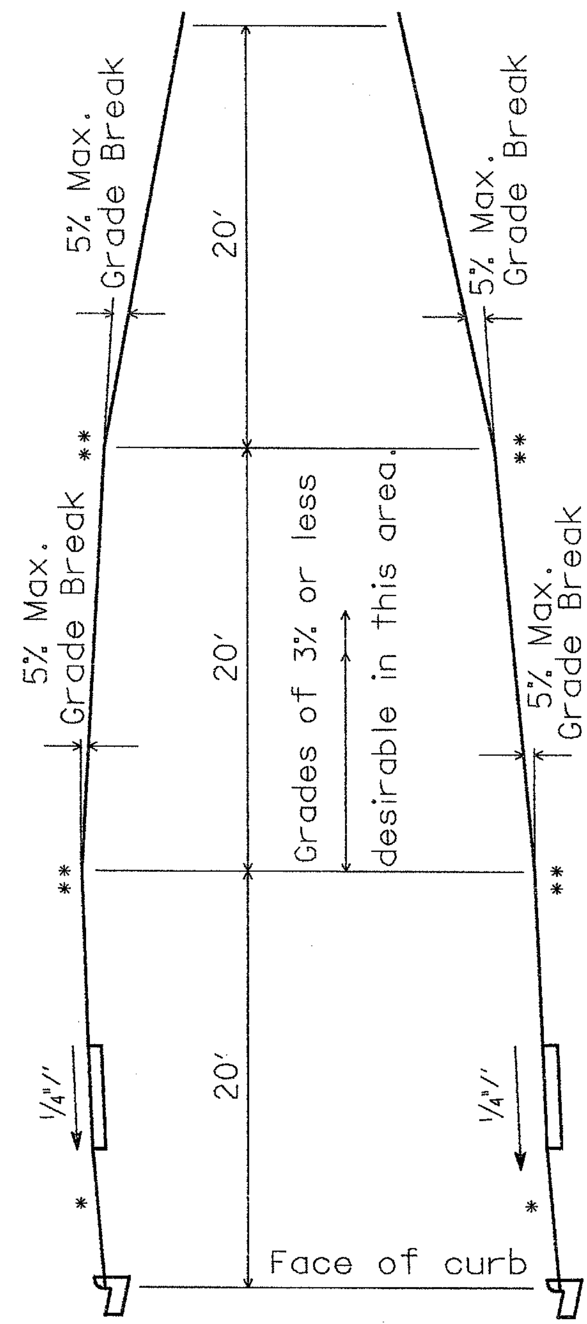
Curbing shown must be used for both signalized and unsignalized driveways.



UNDIVIDED DRIVE

October 1992

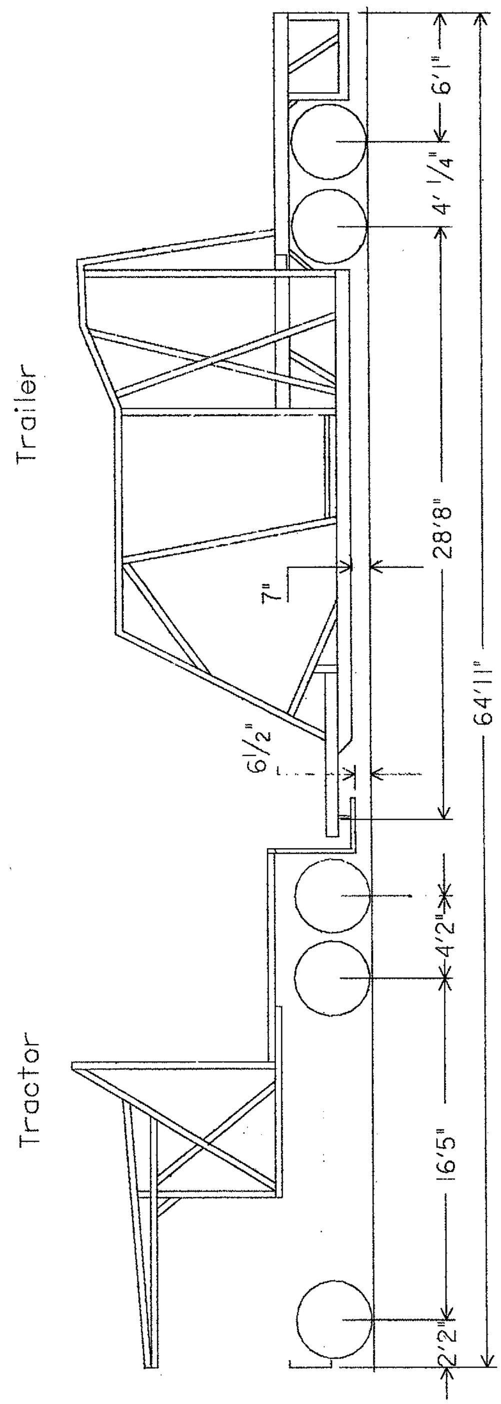
COMMERCIAL DRIVE PROFILE CRITERIA	804-1
	REFERENCE SECTION 804.3



*See Fig. 803-2 & 803-3 for tree lawn and walk treatment.

**Although the use of grade breaks is allowable, a 10' rounding is desirable at these locations.

COMMERCIAL DESIGN VEHICLE	804-2
	REFERENCE SECTION 804.3



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800 Access Contol, R/W Use Permits and Drive Design

List of Metric Figures

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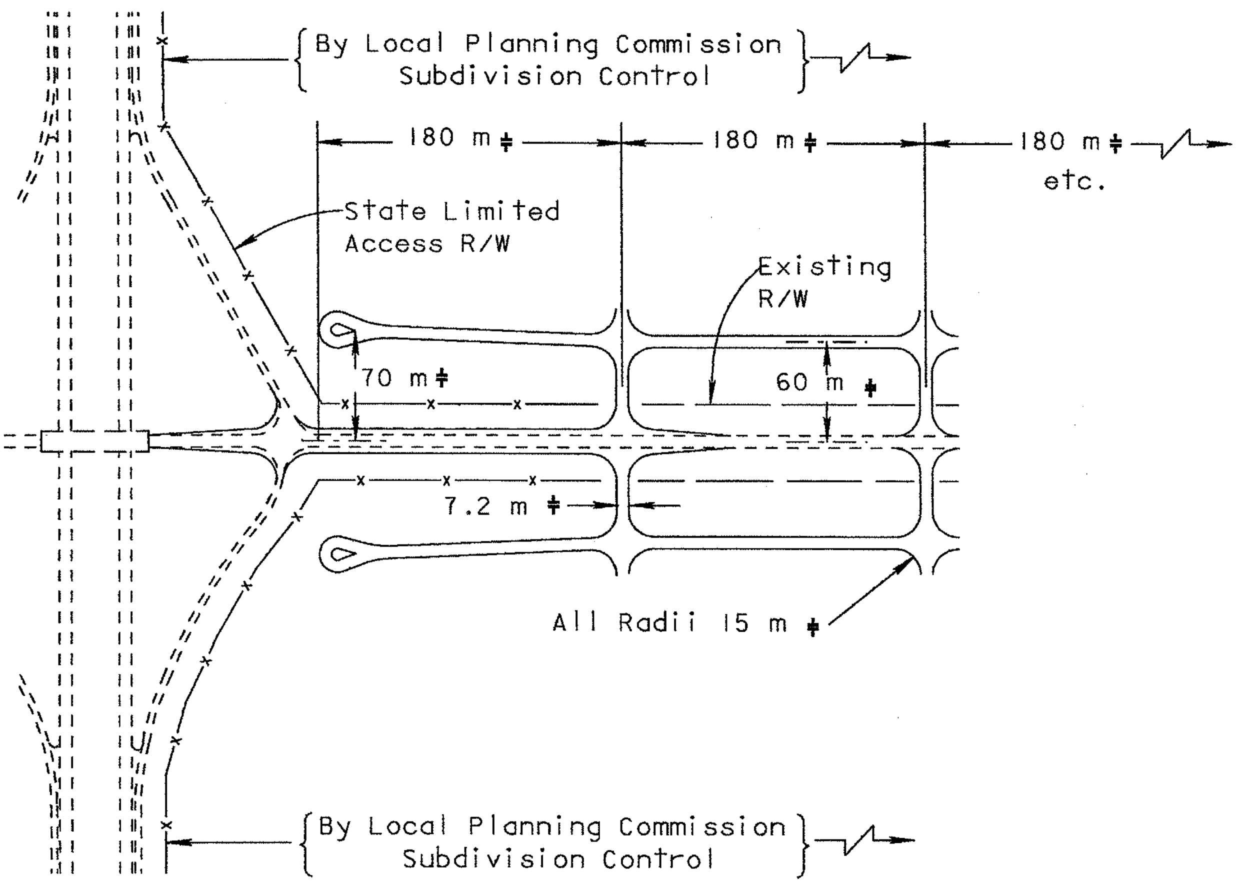
GUIDELINES FOR INTERCHANGE DEVELOPMENT - DIAMOND TYPE INTERCHANGE

801-1

REFERENCE SECTION **801.25**

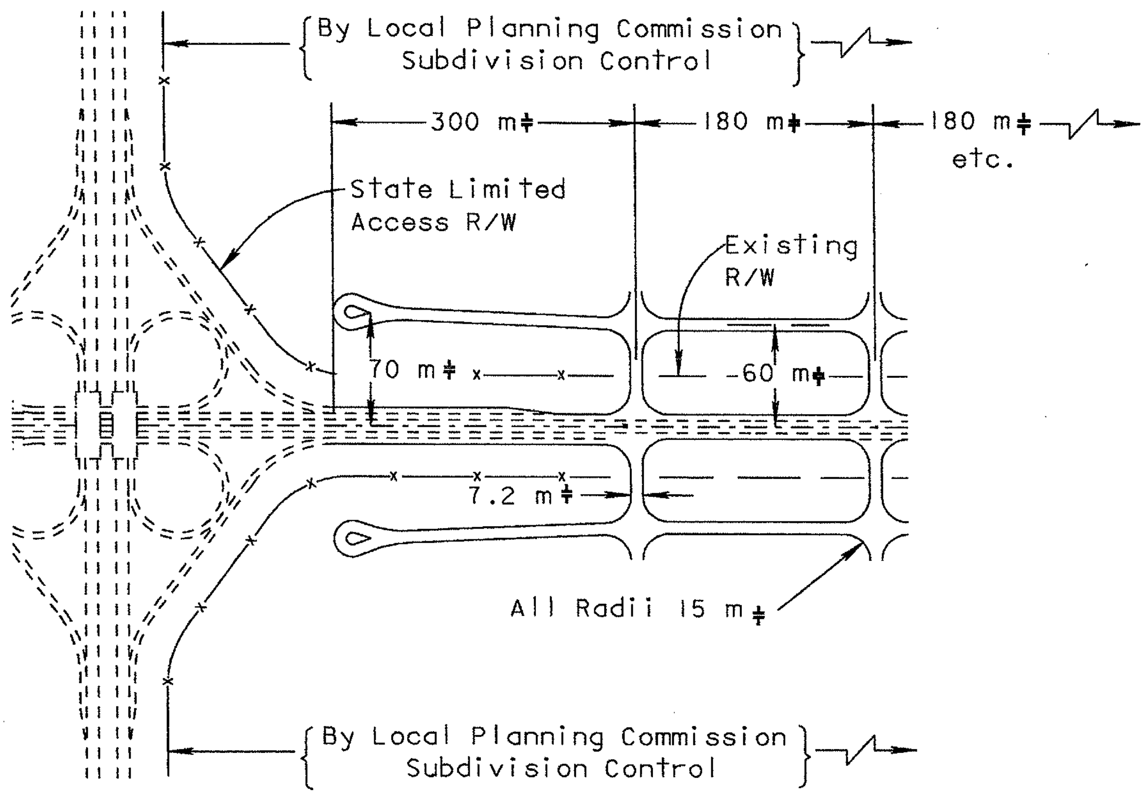


NOTE:
(≑ symbol indicates desirable minimum)

RURAL INTERCHANGES

The control of developments, adjacent to diamond type interchanges on limited access highways can be effectively controlled by county, regional, or city planning commissions, through subdivision controls and building developments, and in addition by local zoning commissions as to zoning regulations. County commissioners or township trustees may exercise similar controls in the absence of planning and zoning commissions.

GUIDELINES FOR INTERCHANGE DEVELOPMENT - CLOVERLEAF TYPE INTERCHANGE	801-2
	REFERENCE SECTION 801.25



NOTE:
(≑ symbol indicates desirable minimum)

RURAL INTERCHANGES

The control of developments, adjacent to cloverleaf type interchanges on limited access highways can be effectively controlled by county, regional, or city planning commissions, through subdivision controls and building developments, and in addition by local zoning commissions as to zoning regulations. County commissioners or township trustees may exercise similar controls in the absence of planning and zoning commissions.

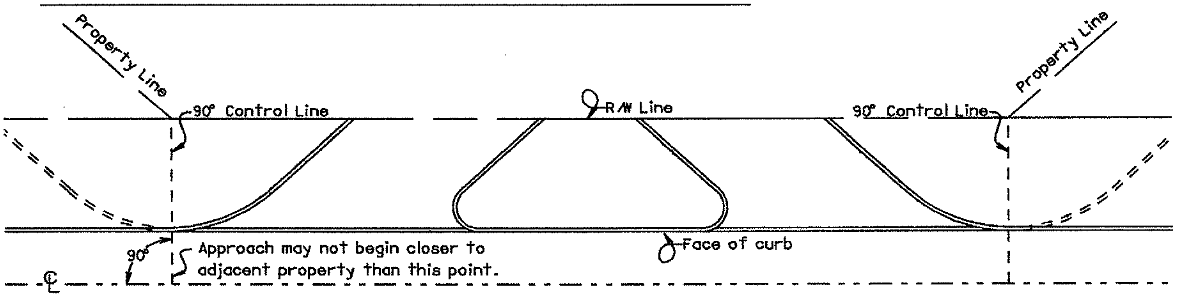
LOCATION OF DRIVES IN RELATION TO PROPERTY LINES

802-1

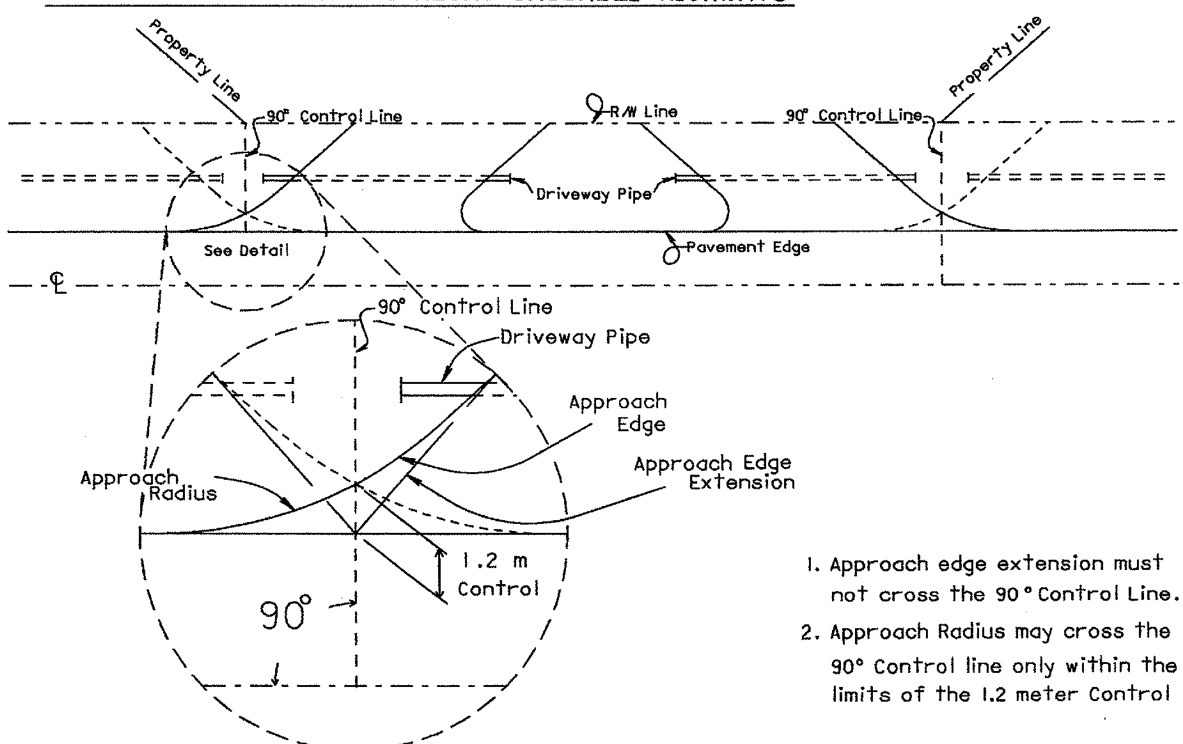
REFERENCE SECTION

802.26

LOCATION OF APPROACHES ALONG CURBED HIGHWAYS



LOCATION OF APPROACHES ALONG UNCURBED HIGHWAYS

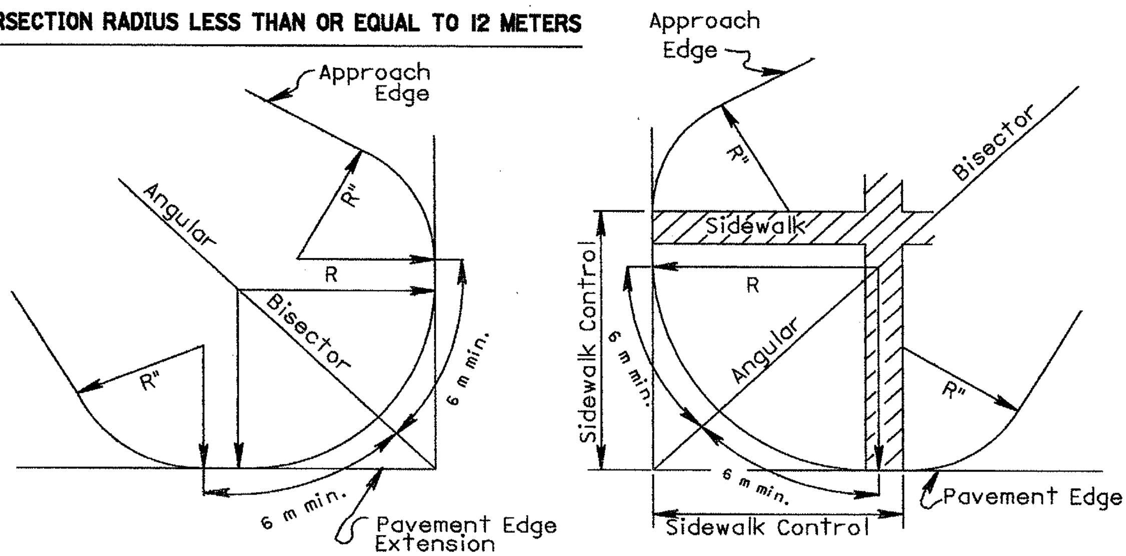


DETAIL FOR DETERMINING MAXIMUM UTILIZATAION OF HIGHWAY FRONTAGE

1. Approach edge extension must not cross the 90° Control Line.
2. Approach Radius may cross the 90° Control line only within the limits of the 1.2 meter Control

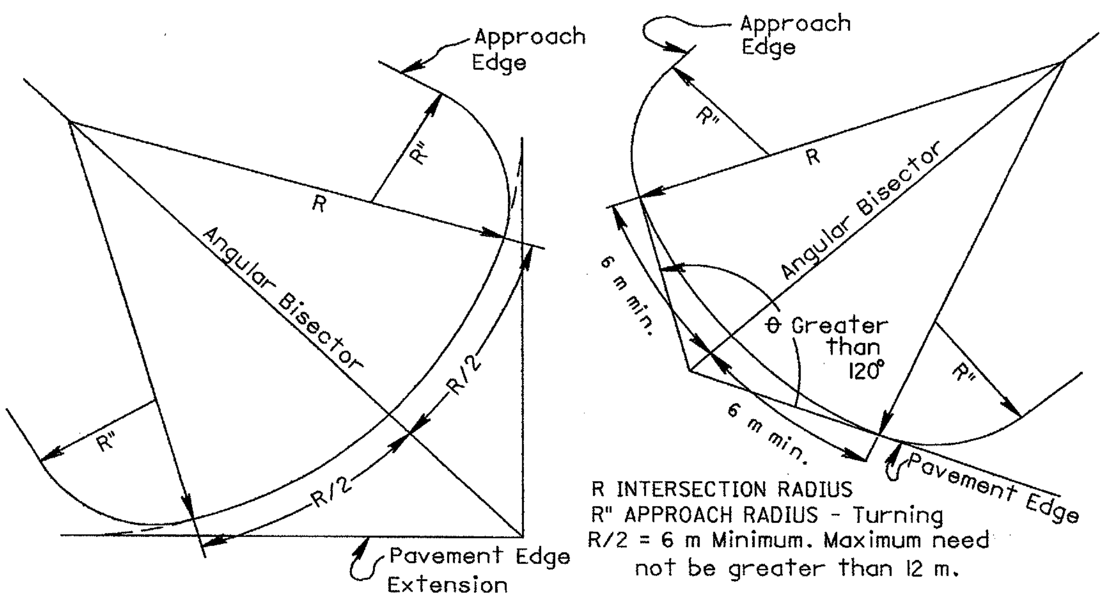
CORNER ISLAND DETAIL	802-2
	REFERENCE SECTION
	802.27

INTERSECTION RADIUS LESS THAN OR EQUAL TO 12 METERS



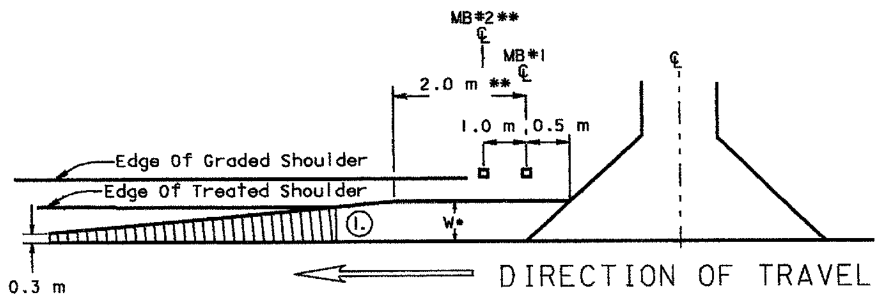
R INTERSECTION RADIUS
R" APPROACH RADIUS- Turning

INTERSECTION RADIUS GREATER THAN 12 METERS



R INTERSECTION RADIUS
R" APPROACH RADIUS - Turning
R/2 = 6 m Minimum. Maximum need not be greater than 12 m.

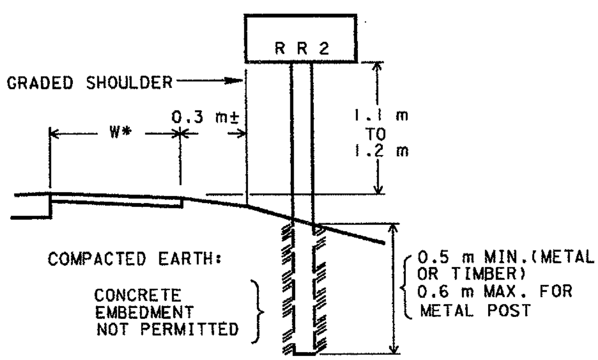
MAILBOX FACILITIES	803-1
	REFERENCE SECTION
	803.1

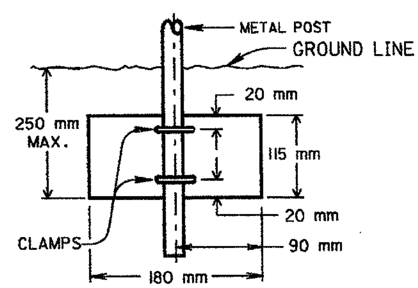


(1.) End mailbox turnout at edge of treated shoulder or 0.3 m which ever is greater.

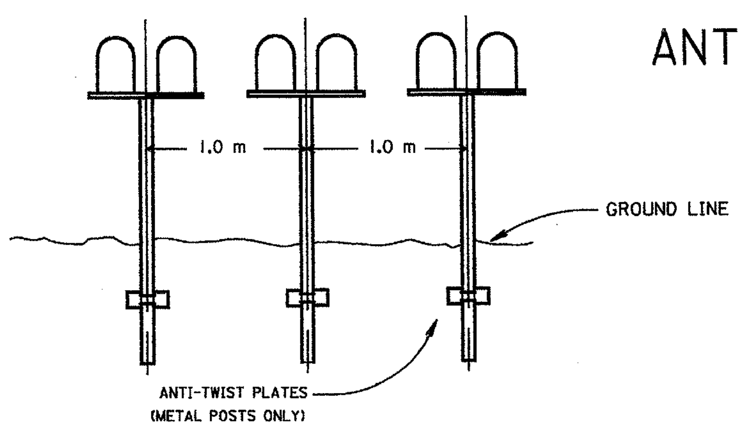
* Where posts are behind guardrail, turnout shall extend to face of guardrail. Where no guardrail is required, turnout width shall be 1.8 m minimum.

** Add 1 m for each additional mailbox.



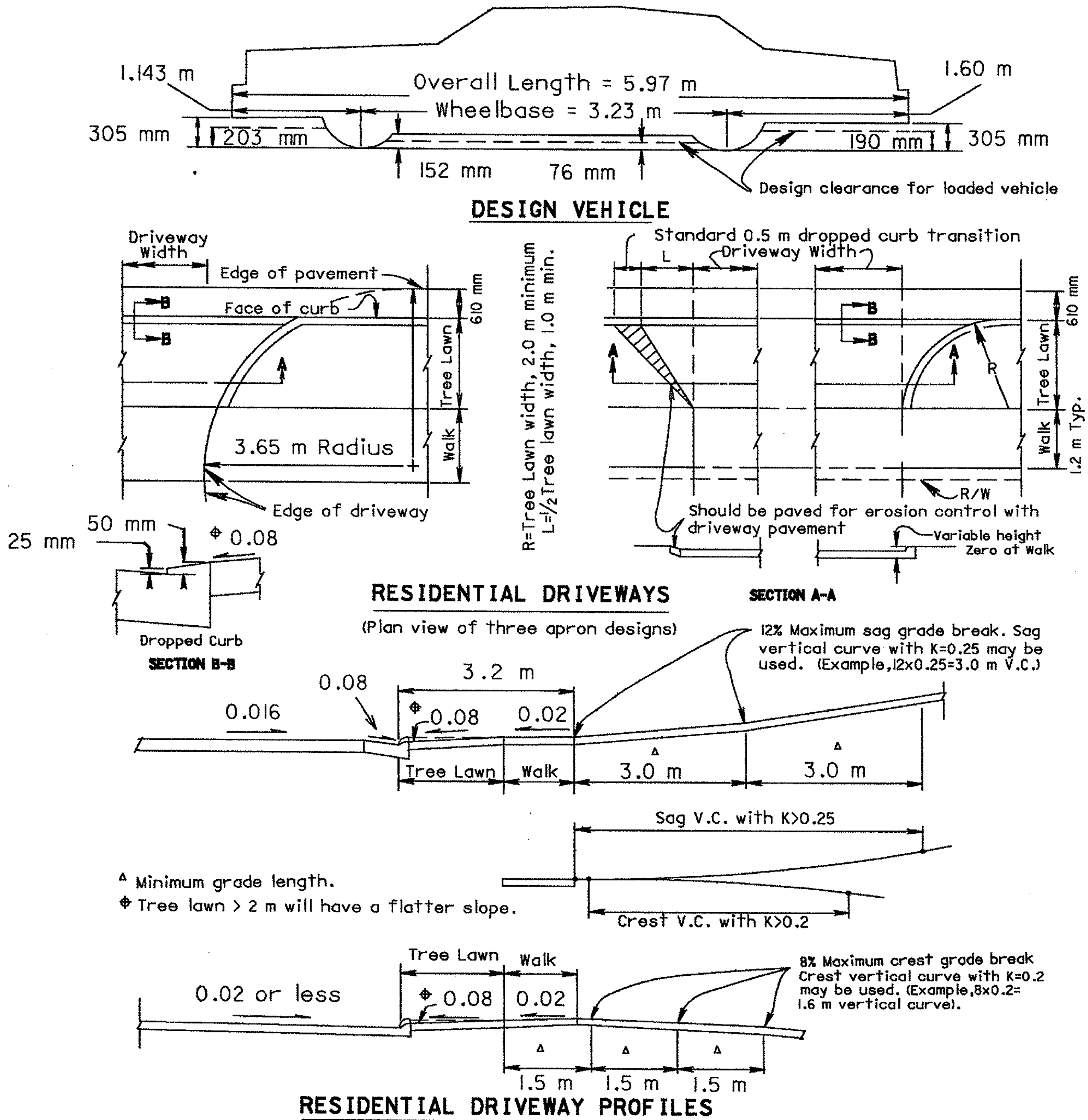


ANTI-TWIST PLATE



GROUP MAILBOX INSTALLATION

URBAN RESIDENTIAL DRIVE DETAILS TREE LAWN ≥ 2 METERS	803-2
	REFERENCE SECTION 803.3 & 804.2

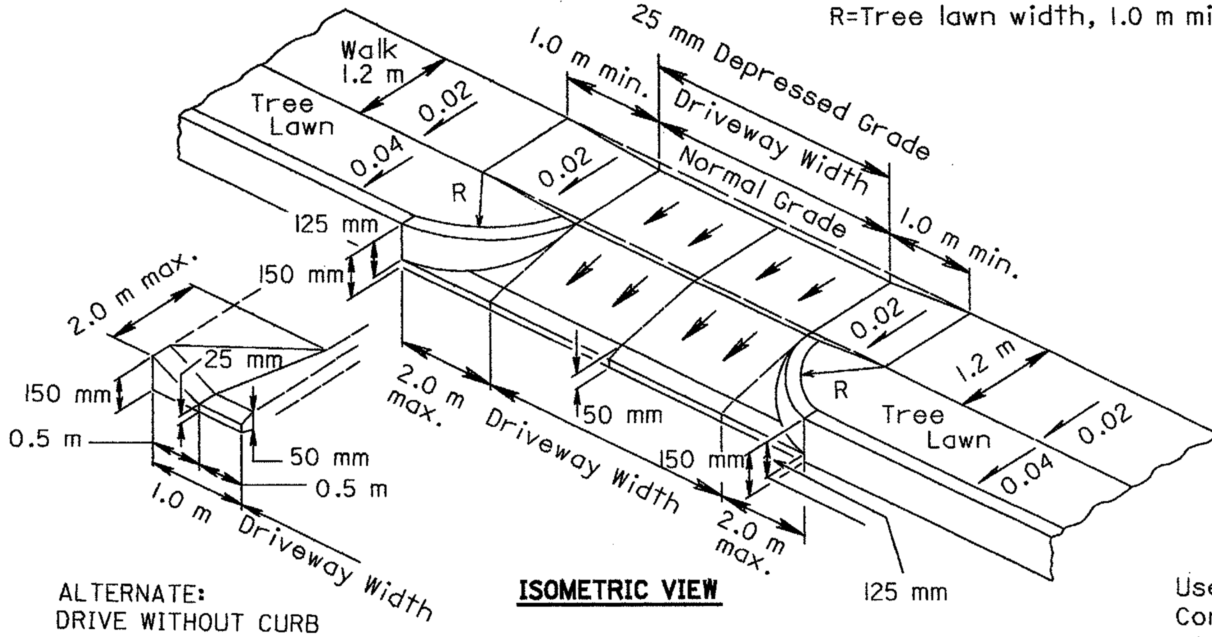


URBAN RESIDENTIAL DRIVE DETAILS TREE LAWN < 2 METERS

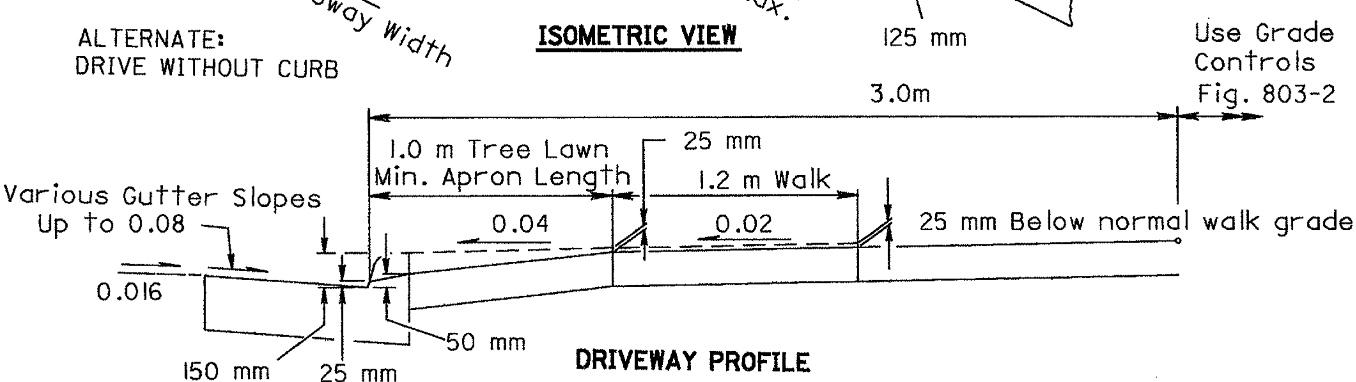
803-3

REFERENCE SECTION 803.3 & 804.2

R=Tree lawn width, 1.0 m minimum.

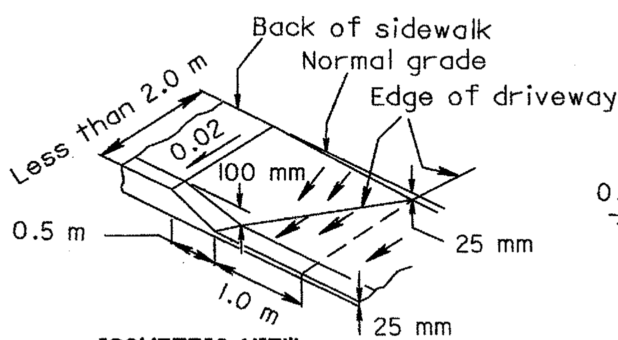


ISOMETRIC VIEW

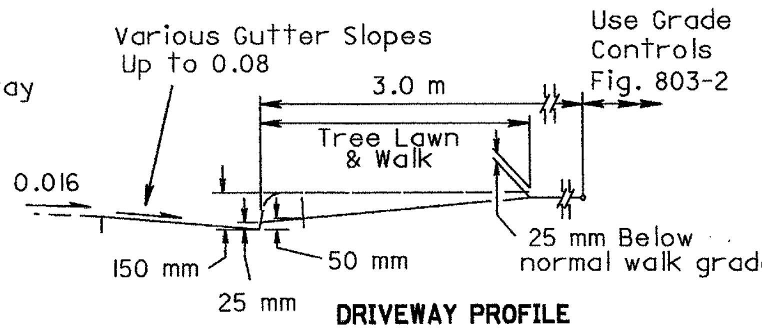


DRIVEWAY PROFILE

EXAMPLE: 1.0 m TREE LAWN WITH 1.2 m WALK DEPRESSED 25 mm
(Recommended Minimum Apron Design)



ISOMETRIC VIEW



DRIVEWAY PROFILE

EXAMPLE: TREE LAWN AND WALK, LESS THAN 2.0 m
WALK DEPRESSED 25 mm

RESIDENTIAL DRIVEWAY PROFILES

SERVICE STATION DRIVES

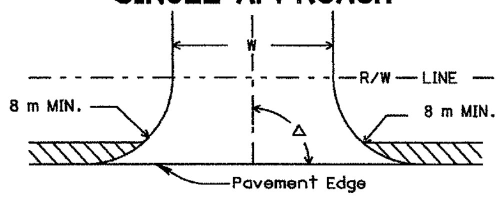
UNCURBED ROADWAY / UNCURBED APPROACH

803-4

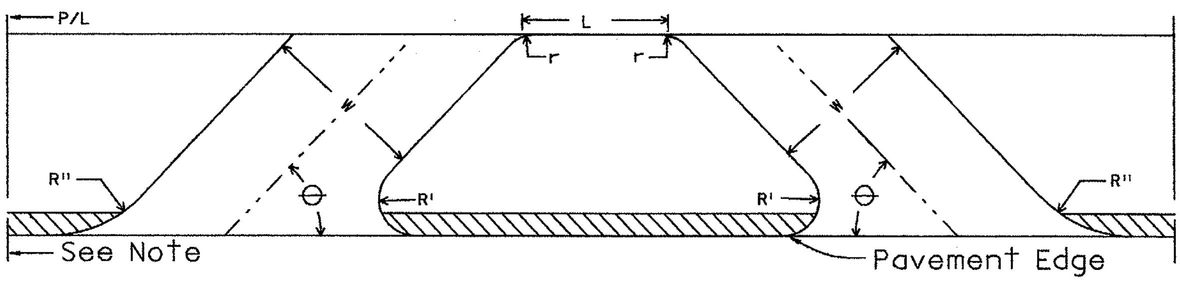
REFERENCE SECTION 803.41

L 5 m or greater
W 10.5 m maximum
△ 70° to 90° (for approach with two-way operation)
θ 45° to 90°
R' Non-Turning Radius, 2 m min. to 3 m max.
R'' Turning Radius, 5 m min, 8 m to 15 m Desirable
r Permissible Rounding 5 m max.
Treated Shoulder

SINGLE APPROACH

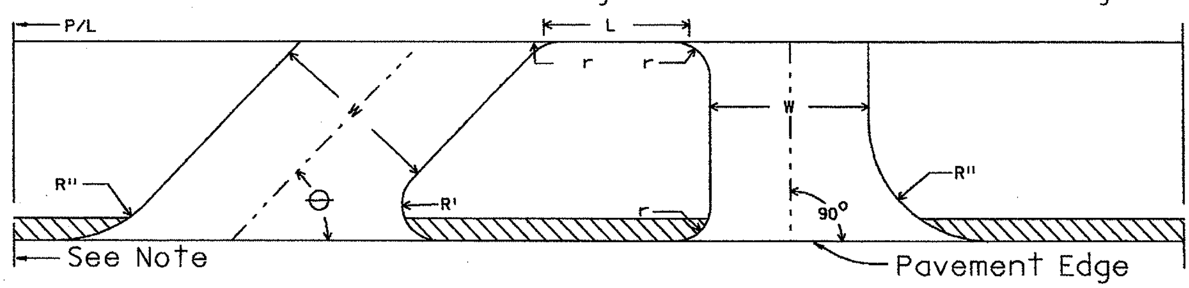


DUAL APPROACHES & INTERMEDIATE ISLAND



DUAL APPROACHES WITH RETURN FLOW & INTERMEDIATE ISLAND

(For use on Cross-Roads in the Vicinity of Interstate Routes or Freeways)

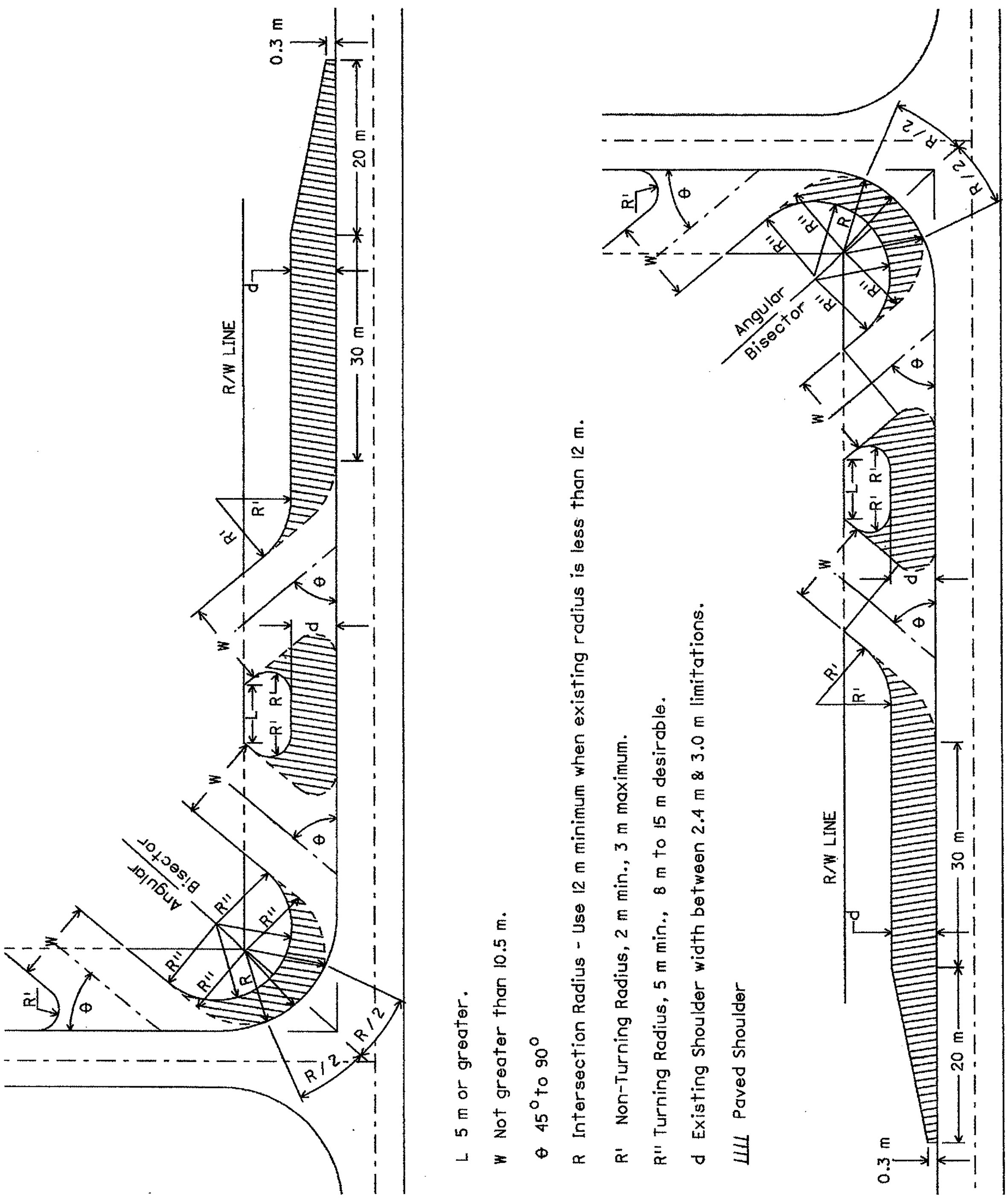


Note: See figure 802-1 for location of drive in relation to property line.

SERVICE STATION DRIVES
SPECIAL PAVED SHOULDER DETAIL

803-5

REFERENCE SECTION **803.41**



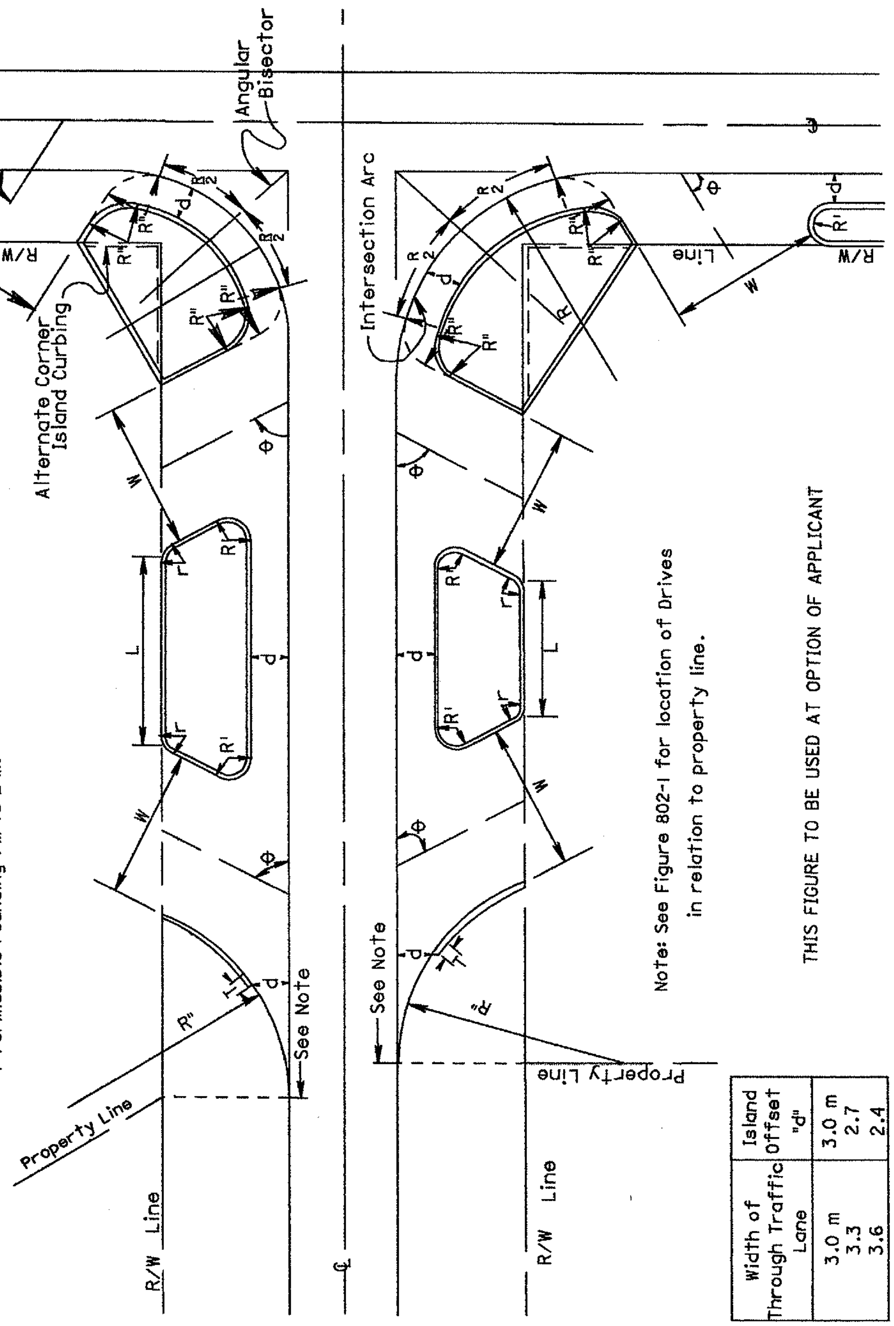
SERVICE STATION DRIVES

UNCURBED ROADWAY / CURBED APPROACH

803-6

REFERENCE SECTION

803.42



L 2 m or greater
W Not greater than 10.5 m.
Φ 45° to 90°
R Intersection Radius - Use 12 m minimum when existing radius is less than 12 m.
R' Non-Turning Radius, 1 m to 2 m.
R" Turning Radius, 1 m min. - Larger radius desirable
T Taper Curb Height from 150 mm to 50 mm in 1 m.
d 2.4 m to 3.0 m offset (Paved with same material as approaches)
1.8 m offset may be used at Truck Stops to discourage parking
r Permissible rounding 1 m to 2 m.

Note: See Figure 802-1 for location of Drives in relation to property line.

THIS FIGURE TO BE USED AT OPTION OF APPLICANT

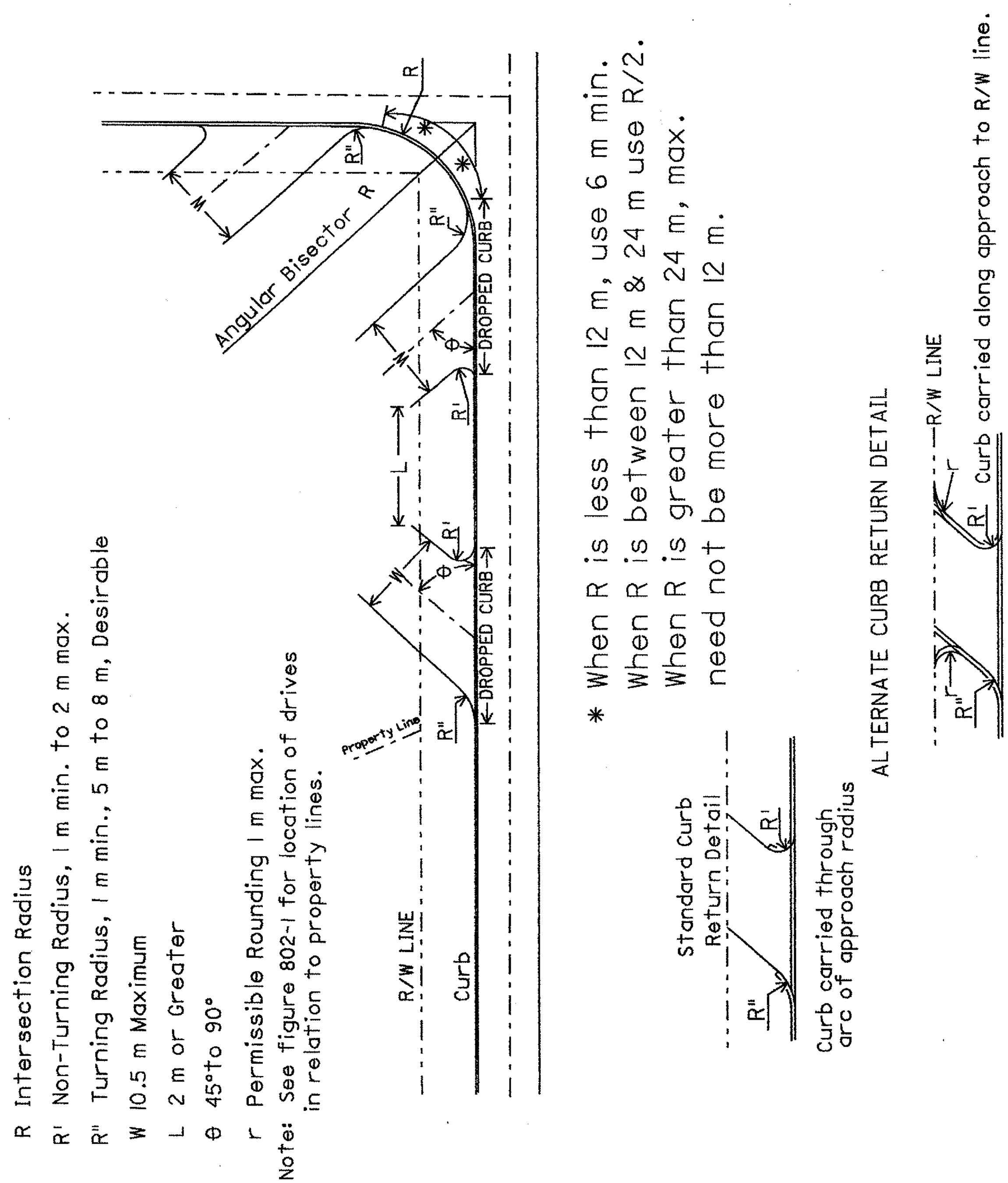
Width of Through Traffic Lane	Island Offset "d"
3.0 m	3.0 m
3.3	2.7
3.6	2.4

SERVICE STATION DRIVES

CURBED ROADWAY / CURBED APPROACH

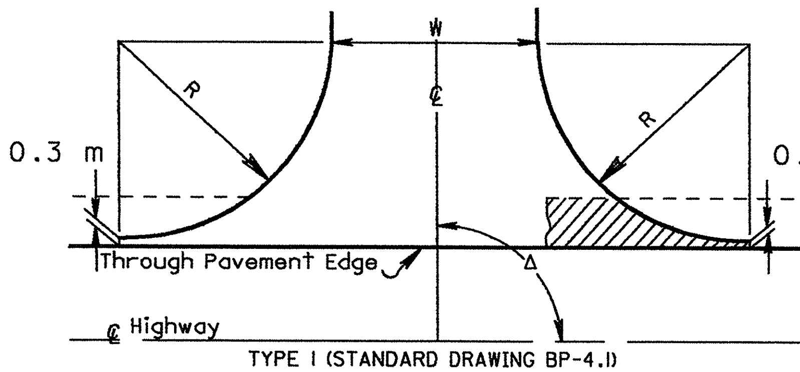
803-7

REFERENCE SECTION 803.42

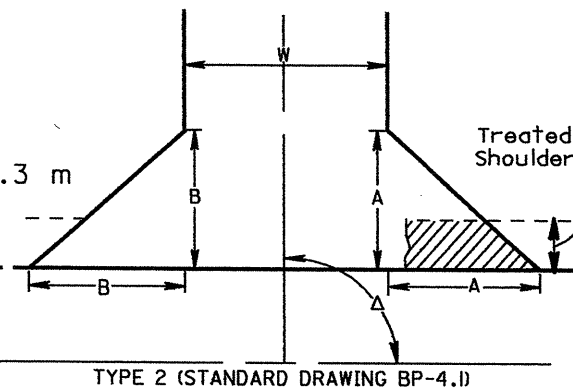


STANDARD COMMERCIAL DRIVE DESIGNS	803-8
	REFERENCE SECTION 803.51

UNCURBED DRIVEWAY ALONG UNCURBED HIGHWAY



TYPE 1 (STANDARD DRAWING BP-4.1)

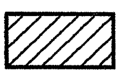


TYPE 2 (STANDARD DRAWING BP-4.1)

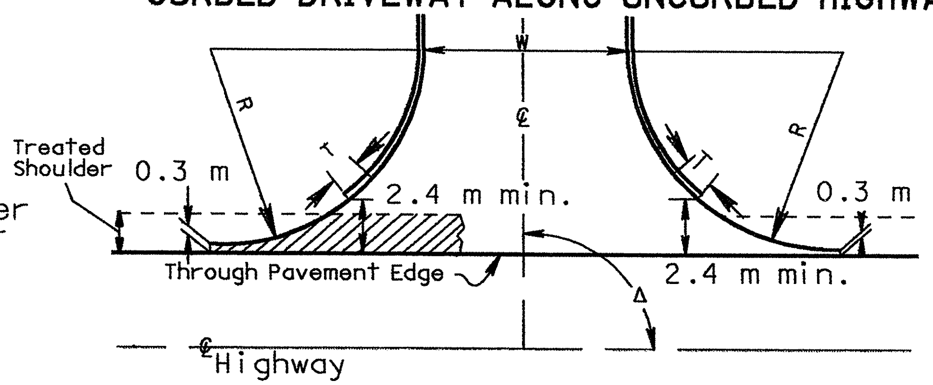
W = 10.5 m Maximum
R = 8 m Minimum on Uncurbed Highway
5 m Minimum on Curbed Highway
T = Taper Curb Height from 150 mm to 50 mm in 1 m.
Δ = 70° to 90° (two-way operation)

Δ	A	B
85° to 90°	6.0m	6.0m
75° to 85°	7.5m	5.0m
65° to 75°	8.5m	4.0m
55° to 65°	10m	3.5m

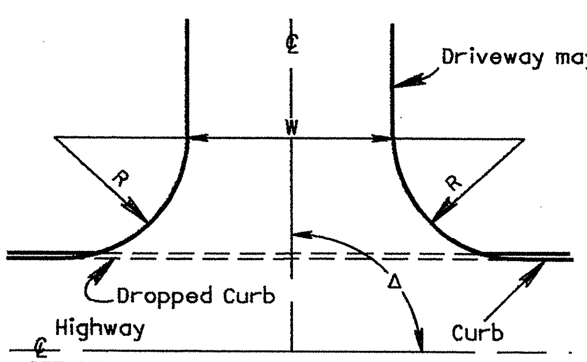
CURBED DRIVEWAY ALONG UNCURBED HIGHWAY



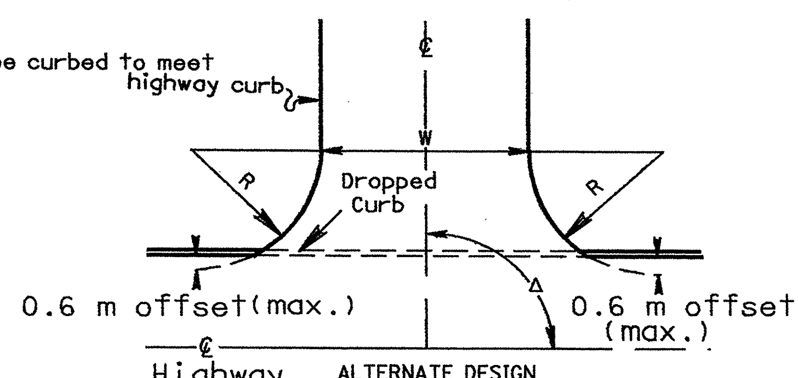
- Do not replace treated shoulder in this portion of drive flare if shoulder has equal or better pavement buildup.



CURBED OR UNCURBED DRIVEWAYS ALONG CURBED HIGHWAY



SEE STANDARD CURB DETAILS
STANDARD DRAWING BP-4.1



ALTERNATE DESIGN
To be used when smaller curb opening is required (or curb and gutter used)

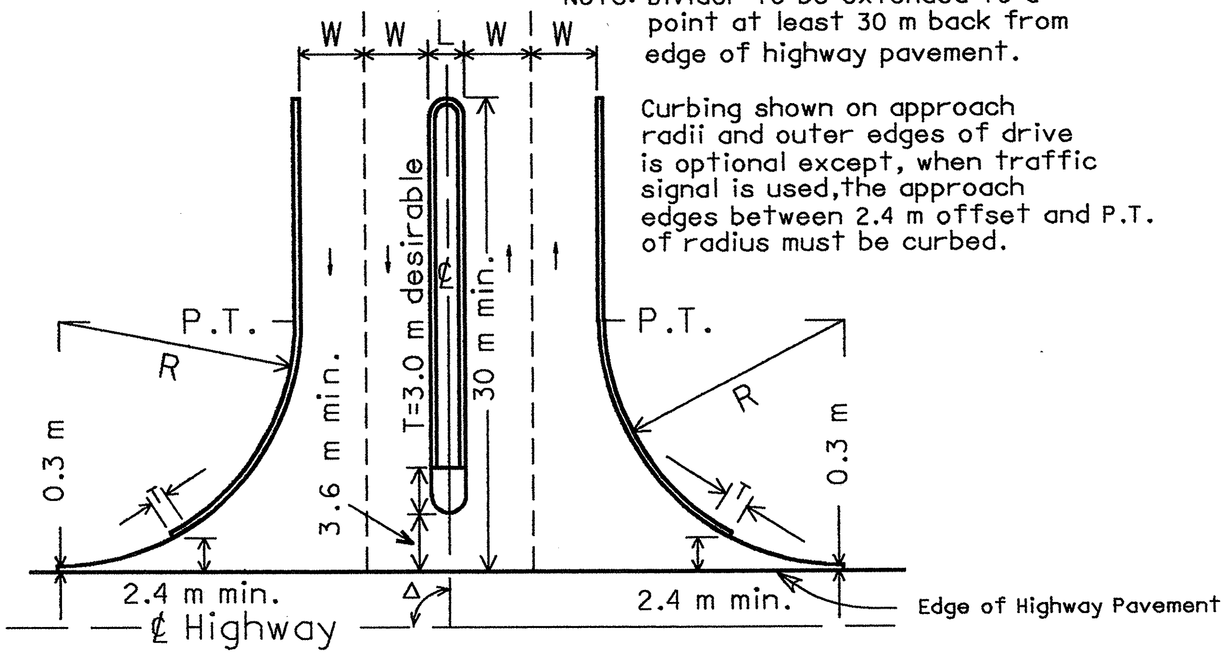
SHOPPING CENTER & INDUSTRIAL DRIVE DESIGNS

803-9

REFERENCE SECTION 803.6

Note: Divider to be extended to a point at least 30 m back from edge of highway pavement.

Curbing shown on approach radii and outer edges of drive is optional except, when traffic signal is used, the approach edges between 2.4 m offset and P.T. of radius must be curbed.

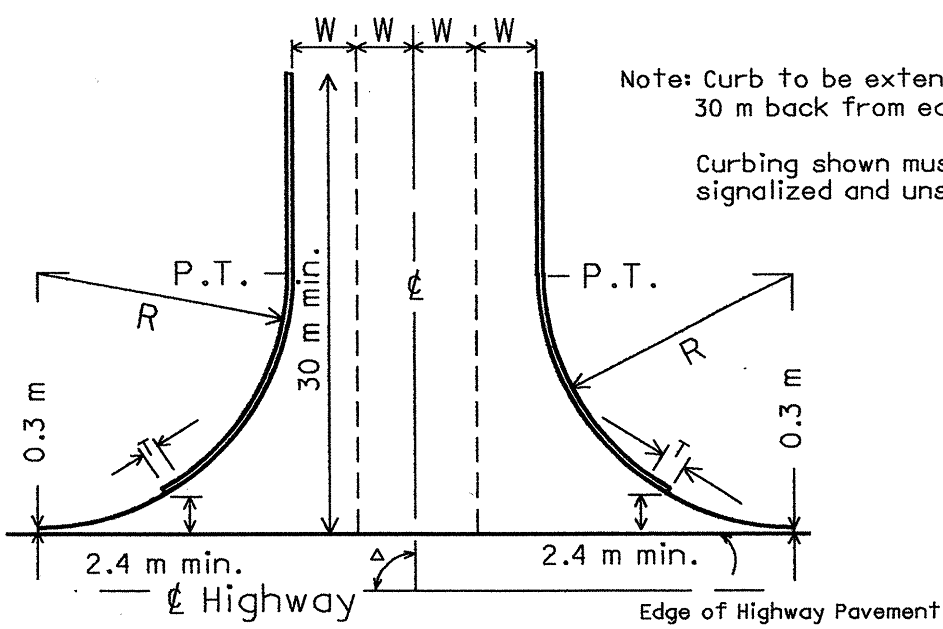


DIVIDED DRIVE

T = Taper Curb Height from 150 mm to 50 mm in 1 m or greater.
W = 3.0 m to 4.2 m per single traffic lane.
R = 10.5 m Minimum, 15 m Desirable.
Δ = 70° to 90°
L = Median Width, 2 m Minimum.
(Median must be curbed for 2 m to 5 m widths)

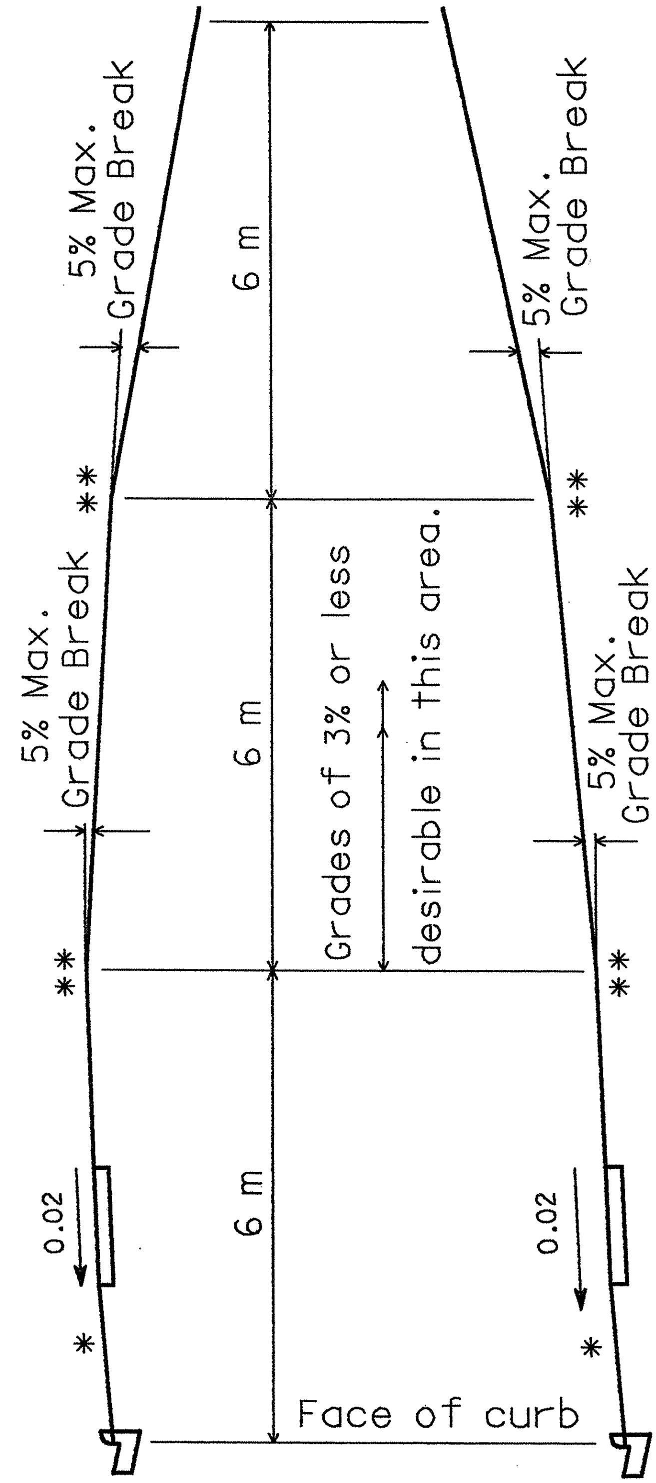
Note: Curb to be extended to a point at least 30 m back from edge of highway pavement.

Curbing shown must be used for both signalized and unsignalized driveways.



UNDIVIDED DRIVE

COMMERCIAL DRIVE PROFILE CRITERIA	804-1
	REFERENCE SECTION 804.3



*See Fig. 803-2 & 803-3 for tree lawn and walk treatment.

**Although the use of grade breaks is allowable, a 3.0m rounding is desirable at these locations.

COMMERCIAL DESIGN VEHICLE	804-2 REFERENCE SECTION 804.3

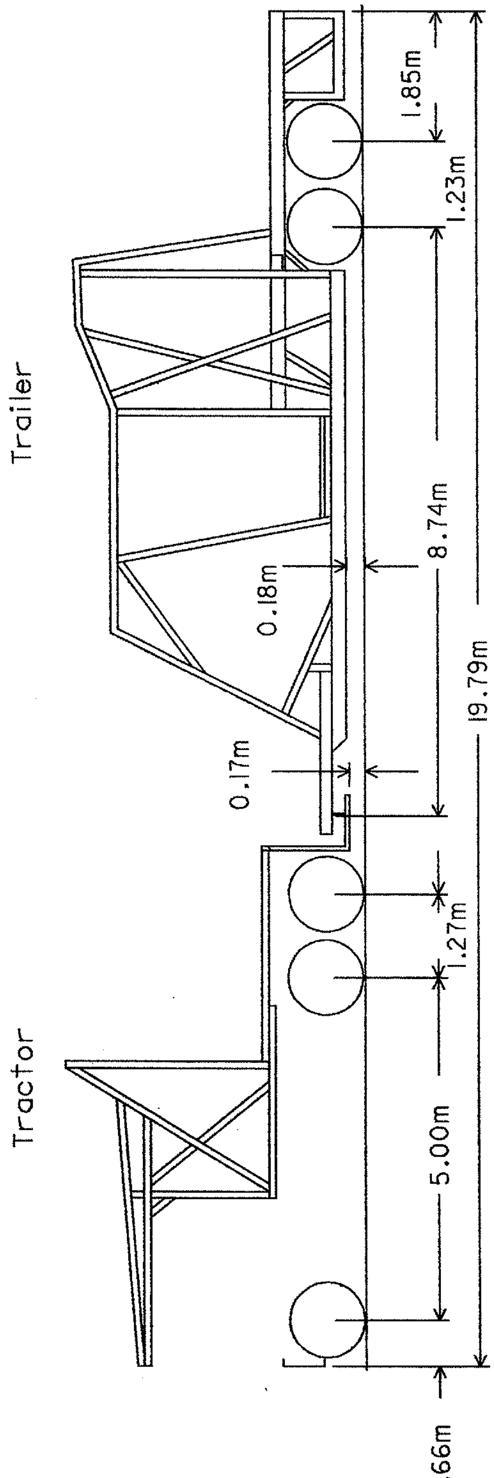


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Table of Contents

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900 Non-Freeway Resurfacing, Restoration and Rehabilitation (3R) Improvements

901 3R Improvements and Values

901.1 3R Improvements

Modification of existing highway facilities requires a different approach to design than the construction of a new facility. The designer is charged with the responsibility of salvaging as much of the existing as possible while, at the same time, updating the facility to improve safety and operation.

A special classification of improvements for non-freeway resurfacing, restoration and rehabilitation projects has therefore been established, referred to as 3R improvements. The purpose of 3R is to preserve and extend the life of existing highways and to enhance safety.

Figure 901-1 outlines the factors which must be considered to determine if a project qualifies as a non-freeway 3R improvement. Obviously, the first factor to consider is the functional classification of the facility. In order to be considered as a non-freeway 3R improvement, the functional classification must be expressway, arterial, collector or local. Interstate or other freeways do not qualify for non-freeway 3R improvements.

The next thing that must be considered is the type of improvement. In order to qualify as a non-freeway 3R improvement, the work to be accomplished must fall into one or more of the following:

A. Resurfacing

B. Pavement structural and joint repair

C. Minor lane (less than a full lane) and shoulder widening

D. Minor alterations to vertical grades and horizontal curves

E. Bridge repair

F. Removal or protection of roadside obstacles

G. Spot safety improvements

Non-freeway functional classification projects meeting the above criteria are considered to qualify as non-freeway 3R improvements. Projects not included in the types of improvements listed above are considered either reconstruction or new construction. 3R improvements may be combined on projects with reconstruction improvements. However, the reconstruction improvement portion of the project must meet the normal design criteria noted in previous sections of the manual and would not qualify for the use of 3R values discussed in Section 901.2. If 3R and reconstruction improvements are combined into one project, the limits of each must be clearly defined in the review process and in the final plans.

901.2 3R Values

Once a project qualifies as a non-freeway 3R improvement, further investigation of accident history is required to determine if special 3R values may be used or if normal design criteria is required. Normal design criteria is considered to be the criteria for new or reconstructed facilities included in previous sections of the manual. The 3R values were developed using the concepts contained in "Special Report 214, Designing Safer Roads, Practices for Resurfacing, Restoration and Rehabilitation", Transportation Research Board, 1987.

As shown in the flow chart on Figure 901-1, an investigation must be made as to whether an accident problem exists. A 3R Safety Study is therefore required to make this determination. Guidelines for completing this Safety Study, as well as sample forms, threshold values and example studies can be found in Volume 3 of the Location and Design Manual. If significant accident problems are identified, a more detailed study is required to determine the type and frequency of the accidents and whether they can be attributed to any substandard condition on the existing facility. Whenever it is determined that existing roadway elements may have contributed to an accident problem, normal design criteria must be used in correcting those specific elements in that portion of a project where the problem exists. Other portions of the same project and other elements which are not contributing to an accident problem may utilize 3R values.

Section 900 includes 3R values for many design features. If a 3R value for a certain feature is not addressed in this section, the designer should refer to other sections of this manual.

901.3 Exceptions to 3R Values

There may be cases on projects eligible for the use of 3R values where existing conditions are less than 3R values. When existing features do not meet 3R values, there are three alternative courses of action which may be taken:

1. Retain existing conditions and obtain a design exception based on normal design criteria.

2. Design to less.than normal design criteria and obtain a design exception based on normal design criteria.

3. Design to normal design criteria..

It is important to remember that, if a design exception is required, the design exception must be based on normal design criteria.

901.4 3R Design Speed

The design speed for 3R improvements shall be the legal speed for the facility.

902 3R Sight Distance

902.1 Stopping Sight Distance

Existing stopping sight distances are considered acceptable (except as discussed in 904.2).

903 3R Horizontal Alignment

903.1 Horizontal Curves

An existing horizontal curve may be retained if:

A. The design ADT is less than 750, or

B. The existing degree of curve provides an actual design speed that is not lower than 15 mph below the design speed of the facility.

903.2 Superelevation

Existing superelevation may be retained if:

A. The design ADT is less than 750, or

B. The roadway is a low speed urban facility (40 mph or less), or

C. For rural and high-speed urban conditions, the combination of existing superelevation and degree of curve provides an actual design speed that is not lower than 15 mph below the design speed of the facility.

See Figures 903-1 and 903-2 for determining the design speed met for an existing curve with an existing maximum superelevation rate. Figure 903-1 is for rural roadways and is based on a maximum superelevation rate of .083 ft/ft. Figure 903-2 is for high-speed urban roadways and is based on a maximum rate of .06 ft/ft.

If an existing horizontal curve is retained, the existing superelevation must be improved to the point where the combination of superelevation and existing degree of curve provides an actual design speed that is not lower than 15 mph below the design speed of the facility. Existing superelevation may be improved beyond this point if it does not meet the criteria discussed in Section 202.41. However, it is suggested that deficient (or excessive) superelevation be corrected by no more than 0.02 feet per foot per each resurfacing unless more is needed to satisfy condition B above.

904 3R Vertical Alignment

904.1 Grades

Existing grades may be retained.

904.2 Crest Vertical Curves

An existing crest vertical curve may be retained if all of the following conditions exist:

A. The design ADT is 1500 or less, and

B. The existing crest vertical curve design speed, based on minimum stopping sight distance, is 20 mph or less below the design speed of the facility, and

C. The existing crest vertical curve does not hide from view a potential problem area, such as: an intersection, a sharp horizontal curve or a narrow bridge.

904.3 Sag Vertical Curves

Existing sag vertical curves may be retained.

905 3R Cross Section Elements

905.1 Roadway Criteria

905.11 Lane Width

The existing lane width may be retained if it meets the values shown in Figure 905-1. The minimum treated shoulder width should be 2 feet of compacted aggregate unless turf shoulders are permitted.

905.12 Shoulder Width

The existing graded shoulder width may be retained if it meets the values shown in Figure 905-1.

905.13 Pavement Cross Slopes

When an existing pavement cross slope does not meet the criteria outlined in Section 301.15, it should be corrected if the project includes resurfacing.

905.2 Bridge Criteria

905.21 Non-Freeway Bridges to Remain

Figure 905-2 contains the minimum criteria to permit non-freeway bridges to remain. The criteria shown is applicable for all non- freeway bridges except those considered to be new or reconstructed (See Figure 302-2).

906 3R Special Considerations

906.1 Clear Zone

The guidelines for clear zone in Section 600 are applicable to new construction or major reconstruction. On 3R improvements, unless accident history, public complaint or site inspections indicate a problem, it may not be cost effective to fully comply with the clear zone requirements in Figure 601-2. Therefore, the clear zone criteria shown in Figure 601-2 may be reduced by 50% on 3R improvements. It is recommended that all obstacles within this clear zone be considered for removal, treatment, or protection. It shall not be a requirement to remove or treat obstacles that are not within the existing R/W. The clear zone width shall not be less than the graded shoulder widths shown on Figure 905-1 for rural sections or 1.5 feet in curbed urban areas, and all obstacles within these zones shall be removed, treated, or protected.

906.2 Barriers

906.21 Adjusting Barrier Height

On pavement overlay projects, existing steel beam guardrail shall be raised to standard height if the top of the rail height would be less than 24 inches. See Standard Construction Drawing GR-2.1 for Raising Guardrail Height.

If the existing guardrail is Type 4 and it is either too low or the current traffic volumes exceed 400 ADT, the Type 4 guardrail should be replaced with Type 5.

Concrete Barrier must be replaced, raised or extended in height whenever the overlay is such that it decreases the effective height of the barrier to less than 29 inches.

906.22 Guardrail Post Soil Support

Where guardrail is to be replaced or installed at new locations on existing facilities, the designer should ensure that the proper soil support is not compromised due to the location of the guardrail installation relative to the embankment slope break point.

Proper soil support is provided under the conditions shown on Figure 906-1 where standard length guardrail posts (6'-0") are depicted. Figure 906-1 also depicts conditions where proper soil support for guardrail posts is not provided, and longer posts should be specified in the plans.

907 Pavement Rehabilitation

907.1 Pavement

907.11 Pressure Relief Joints

On resurfacing projects involving jointed, rigid pavement, Type B or C (Standard Construction Drawing BP-2.4) pressure relief joints shall be installed at all bridge approaches and at about 2000 foot intervals in any pavement that has a history of blowup problems, except that pressure relief joints shall not be installed:

A. In pavements where these type joints now exist.

B. Within 2000 feet of a full depth flexible repair which extends across an entire pavement width.

C. Where the uninterrupted length of the section of rigid pavement is 500 feet or less.

907.12 Rehabilitation and Resurfacing

Design guidelines for minor rehabilitation and resurfacing projects are included in Appendix B.

907.2 Shoulders

907.21 Shoulder Build Up

When a paved shoulder is overlayed, the area outside the paved portion shall be adjusted to grade with Item 617 Compacted Aggregate, Type A, no more than 4" thick and sloped to drain at the rate of 3/4 inch per foot. On projects with overlays requiring more than 4" of material, the top 4 inches next to the paved shoulder is to be Item 617, Compacted Aggregate, Type A, and the remainder constructed using Item 203 Embankment.

907.22 Heavy Overlay Shoulder Treatment

When the overlay of the paved shoulder is too thick to use the treatment described in 907.21, the shoulder area outside the paved portion and slope should be built up to compensate for the additional thickness as shown in Figure 907-1.

CHAPTER 900 - PAGE 1 OF 1

Section	Existing English Text	Proposed Metric Text
903.1	B. The existing degree of curve 15 mph below the design speed	B. The existing radius 25 km/h below the design speed
903.2	(40 mph or less), degree of curve 15 mph below maximum superelevation rate of .083 ft/ft. maximum rate of .06 ft/ft. existing degree of curve 15 mph below superelevation be corrected by no more than 0.02 feet per foot	(70 km/h or less), radius 25 km/h below maximum superelevation rate of 0.08. maximum rate of 0.06. existing radius 25 km/h below superelevation rate be corrected by no more than 0.02
904.2	is 20 mph or less below	is 30 km/h or less below
905.11	2 feet of compacted aggregate	0.6 meter of compacted aggregate
906.1	1.5 feet in curved urban areas,	0.5 meter in curved urban areas,
906.21	less than 24 inches. barrier to less than 29 inches.	less than 610 millimeters. barrier to less than 737 millimeters.
906.22	guardrail posts (6'-0")	guardrail posts (1.8 meters)
907.11	at about 2000 foot intervals B. Within 2000 feet rigid pavement is 500 feet or less.	at about 600-meter intervals B. Within 600 meters rigid pavement is 150 meters or less.
907.21	no more than 4" thick rate of 3/4 inch per foot. 4" of material, the top 4 inches	no more than 100 millimeters thick rate of 0.06. 100 millimeters of material, the top 100 millimeters

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900 Resurfacing, Restoration and Rehabilitation (3R) Projects

List of Figures

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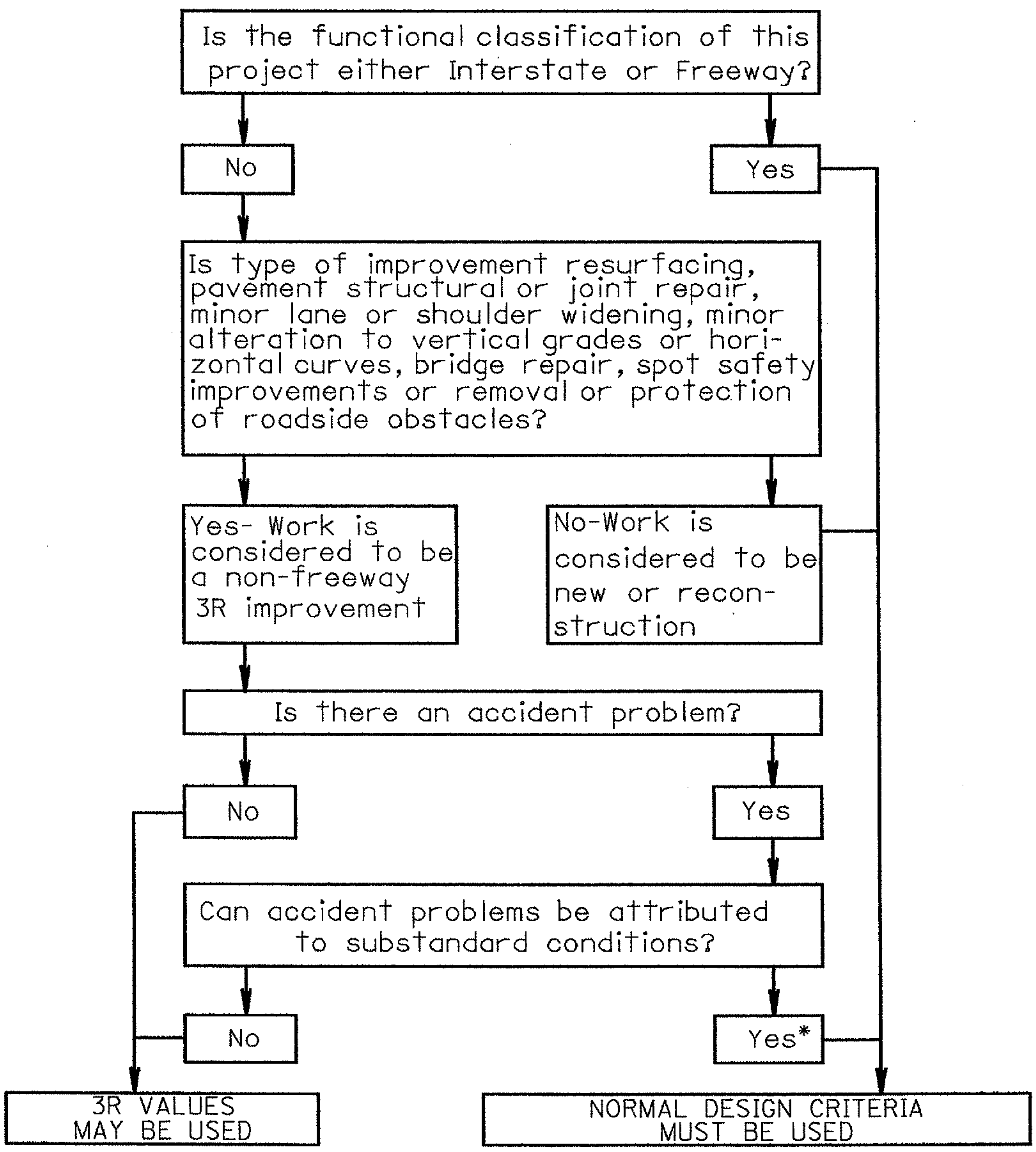
FLOW CHART TO DETERMINE USE OF 3R VALUES

901-1

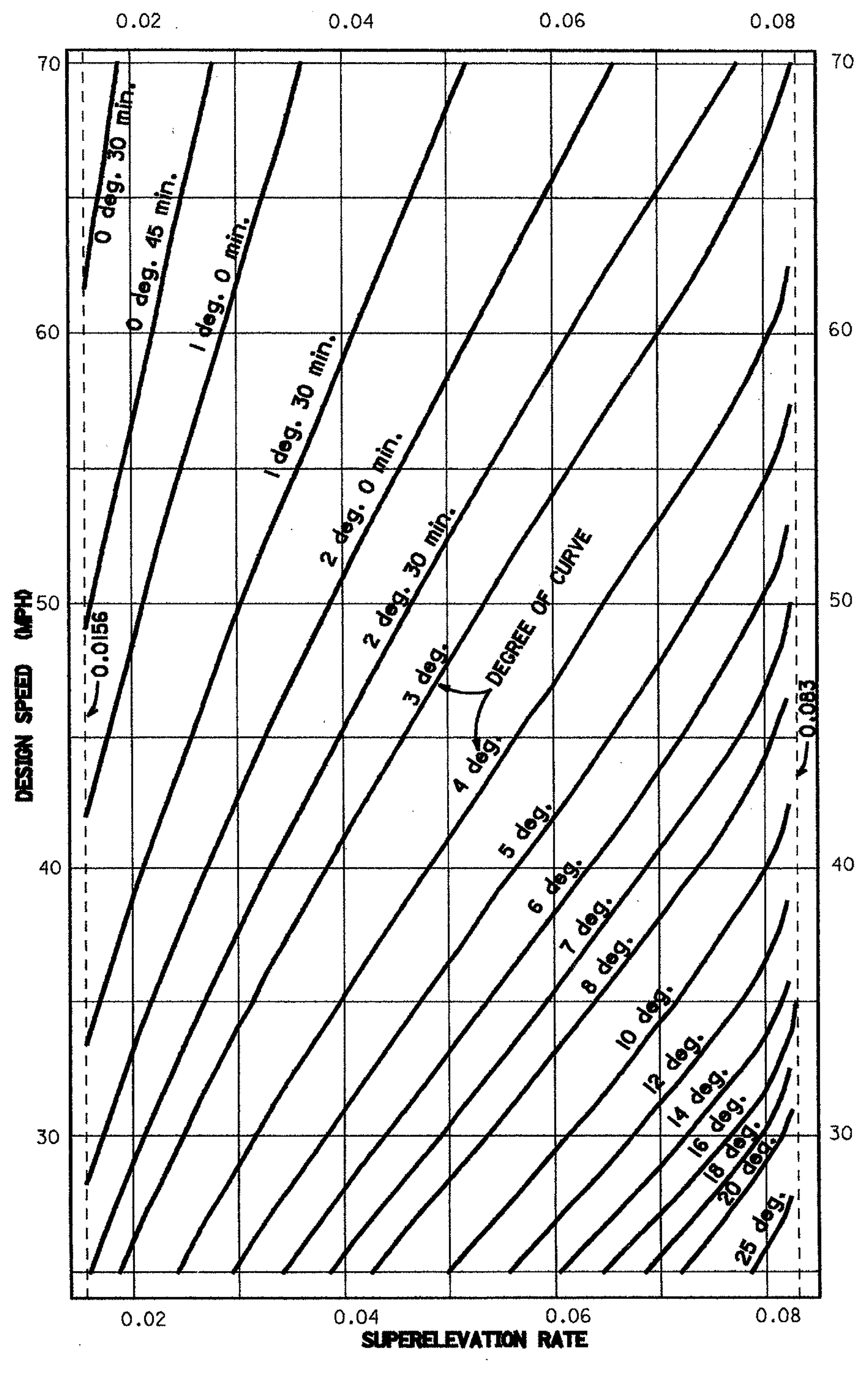
REFERENCE SECTION **901.2**



*See Section 901.2 for additional details

DESIGN SPEED MET BY COMBINATION OF DEGREE OF CURVE AND SUPERELEVATION RATE FOR RURAL HIGHWAYS	903-1
	REFERENCE SECTION 903.2

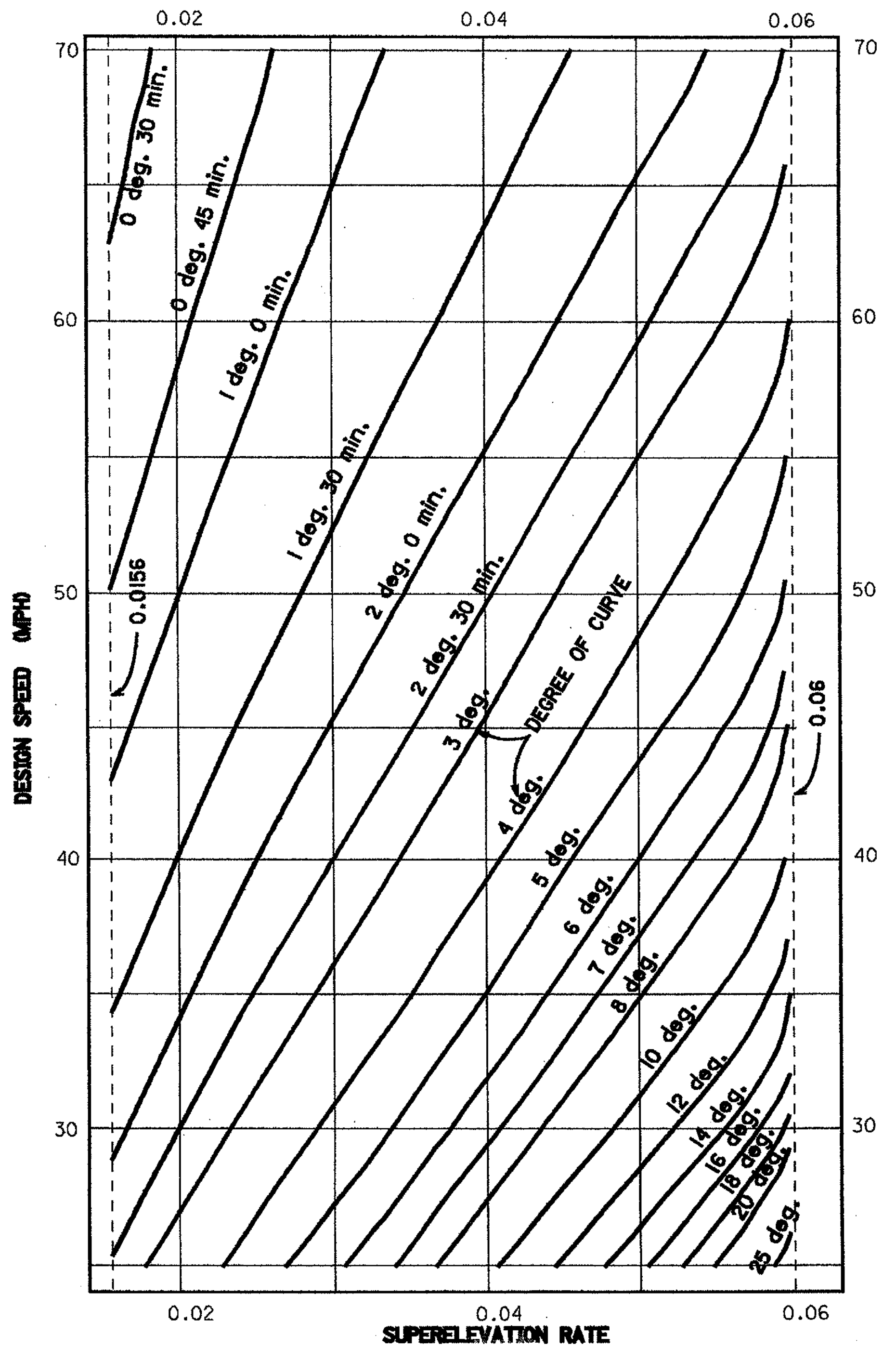
NOTE - Based on a maximum rate of 0.083 ft/ft and data contained on Figure 202-3.



DESIGN SPEED MET BY COMBINATION OF DEGREE OF CURVE AND SUPERELEVATION RATE FOR HIGH-SPEED* URBAN HIGHWAYS	**903-2**
	REFERENCE SECTION 903.2

NOTE - Based on a maximum rate of 0.06 ft/ft and data contained on Figures 202-4 and 202-10.

*Greater than 40 mph.



3R VALUES LANE AND GRADED SHOULDER WIDTHS

905-1

REFERENCE SECTION 905.11, .12

RURAL AREAS

DESIGN ADT	DESIGN SPEED	LANE WIDTH (A)		GRADED SHOULDER WIDTH (C)	
		<10% TRUCKS	≥10% TRUCKS	WITH GUARDRAIL (B)	W/O GUARDRAIL
LESS THAN 750	50 OR OVER	10′	10′	4′	2′
	LESS THAN 50	9′	10′	4′	2′
751 TO 2000	50 OR OVER	11′	12′	5′	3′
	LESS THAN 50	10′	11′	4′	2′
OVER 2000	50 OR OVER	11′	12′	8′	6′
	LESS THAN 50	11′	12′	8′	6′

URBAN AREAS

FUNCTIONAL CLASSIFICATION	LANE WIDTH (A)	CURBED SHOULDER WIDTH (NO PARKING)	PARKING LANE
ARTERIAL STREETS	11′ (D)	0′	8′
COLLECTOR STREETS	10′	0′	Comm./Ind. 8′ Residential 7′
LOCAL STREETS	10′	0′	7′

A. At least one 12′ lane in each direction must be provided on all Federal aid Primary projects.

B. Guardrail offset distances shall be the same as the values shown in the W/O guardrail column above.

C. Divided facilities shall have a minimum median graded shoulder width of 4′ W/O guardrail and 6′ with guardrail.

D. 10′ lane widths are acceptable on minor arterials.

CRITERIA FOR NON-FREEWAY BRIDGES TO REMAIN

905-2

REFERENCE SECTION 905.21

<table>
<tr><th rowspan="2">FUNCTIONAL CLASSIFI-CATION</th><th rowspan="2">DESIGN ADT</th><th colspan="2">MINIMUM LATERAL CLEARANCE (H)</th><th rowspan="2">MINIMUM VERTICAL CLEARANCE</th><th rowspan="2">MINIMUM DESIGN LOADING</th></tr>
<tr><th>ON BRIDGE (A)</th><th>UNDER BRIDGE (D)</th></tr>
<tr><td rowspan="2">EXPRESSWAYS AND ARTERIALS</td><td>>4000</td><td>6′ (B)</td><td rowspan="10">CURBED OR TREATED SHOULDER WIDTH PLUS BARRIER CLEARANCE (E)</td><td rowspan="2">14′</td><td rowspan="2">HS-20 (F)</td></tr>
<tr><td>≤4000</td><td>3′</td></tr>
<tr><td rowspan="4">COLLECTORS</td><td>>4000</td><td>6′ (B)</td><td rowspan="4">14′</td><td rowspan="4">HS-15</td></tr>
<tr><td>2001-4000</td><td>3′</td></tr>
<tr><td>750-2000</td><td>2′</td></tr>
<tr><td><750</td><td>0′</td></tr>
<tr><td rowspan="4">LOCALS</td><td>>4000</td><td>6′ (B)</td><td rowspan="4">14′</td><td rowspan="4">HS-15 (G)</td></tr>
<tr><td>2001-4000</td><td>3′</td></tr>
<tr><td>750-2000</td><td>2′</td></tr>
<tr><td><750</td><td>0′ (C)</td></tr>
</table>

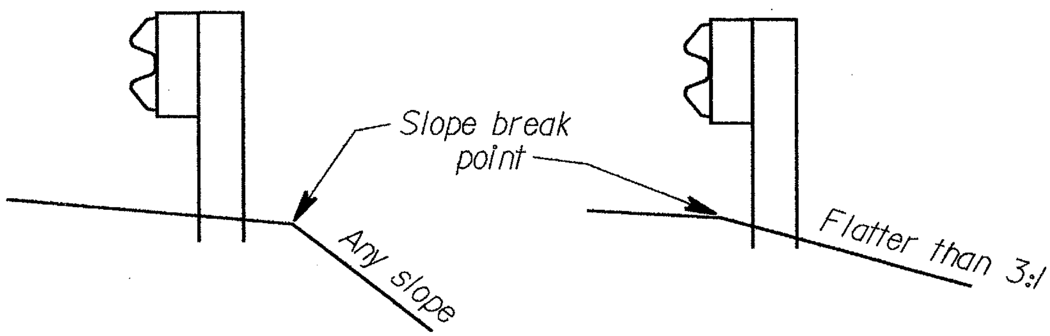
THIS TABLE IS APPLICABLE TO ALL NON-FREEWAY BRIDGES EXCEPT THOSE CONSIDERED NEW OR RECONSTRUCTED

A. Distance measured to curb or railing, whichever is less. In no case shall the minimum width be less than the approach pavement.
B. On mainline bridge having a length of 100′ or more, the minimum may be reduced to 3′
C. One lane bridges may have a total minimum width of 18′.
D. Distance measured to face of walls, abutments or piers.
E. See Figure 601-6 for minimum barrier clearance.
F. Existing bridges should be considered for ultimate replacement or strengthening if the operating rating capacity cannot safely service the system for an additional 20 years. The existing structure shall be capable of carrying at least 100% of the state's legal load at operating capacity.
G. Minimum loading may be H-10 if current ADT is 50 or less.
H. Divided facilities shall have a minimum of 3′ lateral clearance on the median side.

October 1992

GUARDRAIL POST LENGTH DETERMINATION	906-1
	REFERENCE SECTION 906.22

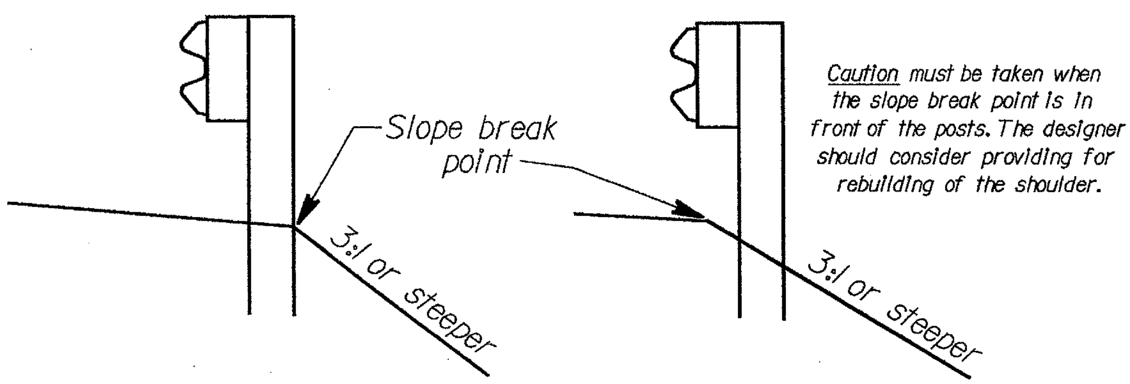
Standard post lengths may be used for the situations depicted below:
(6'-0" posts, 3'-5" min. embedment depth)



Locations where the slope break point is at or beyond the back of the posts.

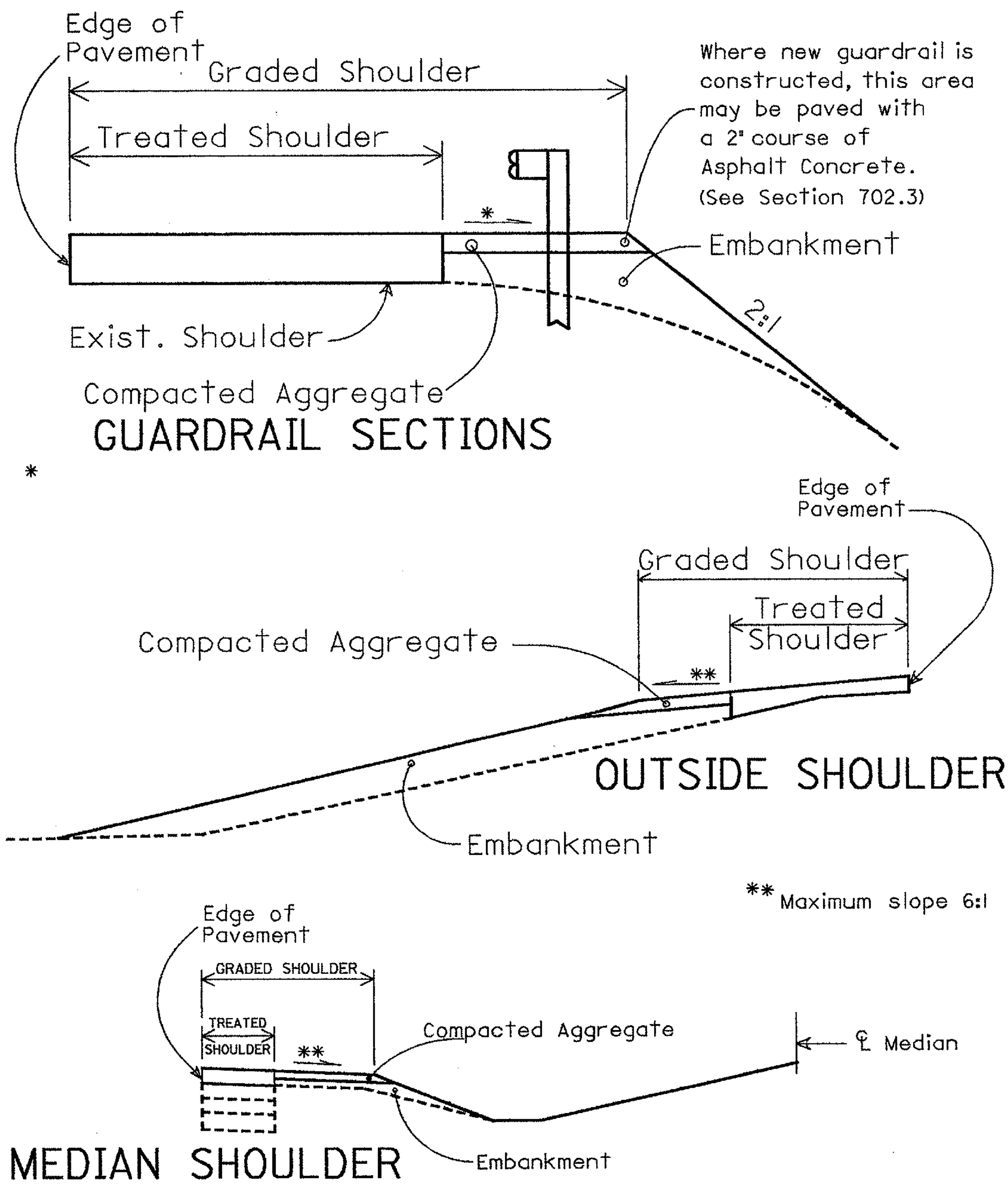
Locations where the foreslope is flatter than 3:1, regardless of location of slope break point.

Longer post lengths are required for the situations depicted below:
(9'-0" posts, 6'-5" min. embedment depth)



Any installation where foreslopes are 3:1 or steeper and the slope break point is at, or in front of, the back of the posts.

HEAVY OVERLAY SHOULDER TREATMENT	907-1
	REFERENCE SECTION 907.22



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900 Resurfacing, Restoration and Rehabilitation (3R) Projects

List of Metric Figures

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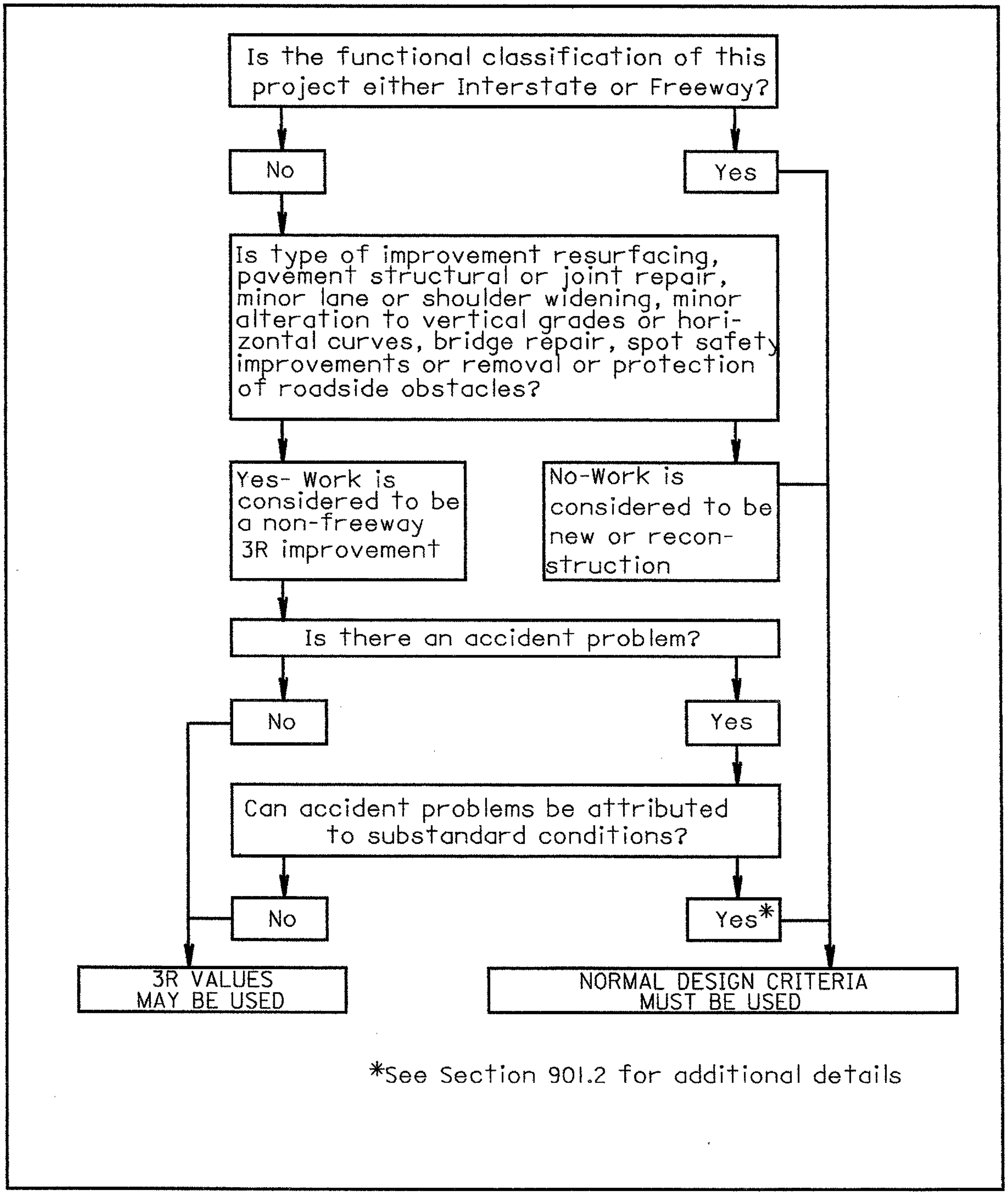
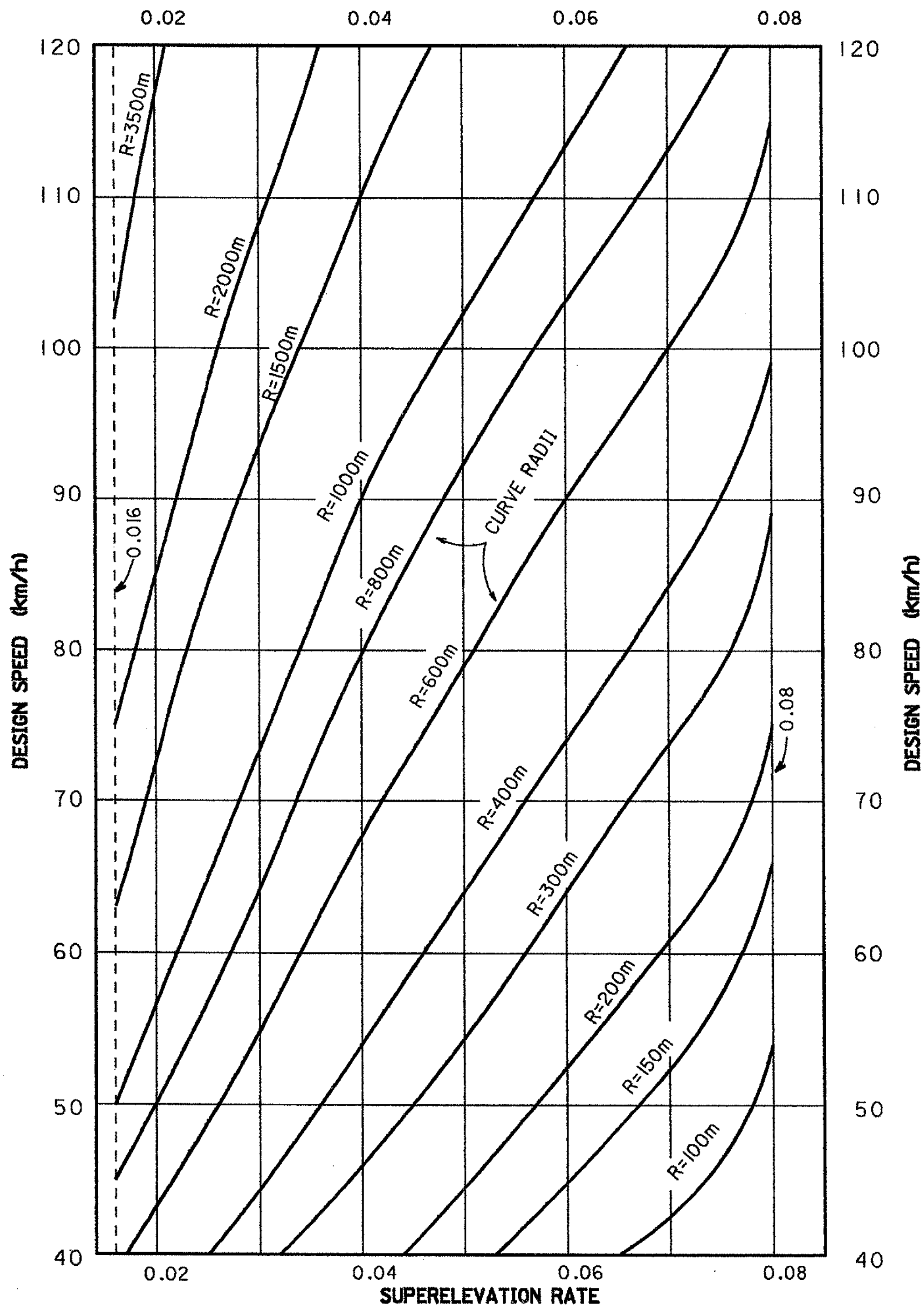
FLOW CHART TO DETERMINE USE OF 3R VALUES	901-1
	REFERENCE SECTION 901.2



DESIGN SPEED MET BY COMBINATION OF CURVE RADIUS AND SUPERELEVATION RATE FOR RURAL HIGHWAYS	903-1 REFERENCE SECTION 903.2

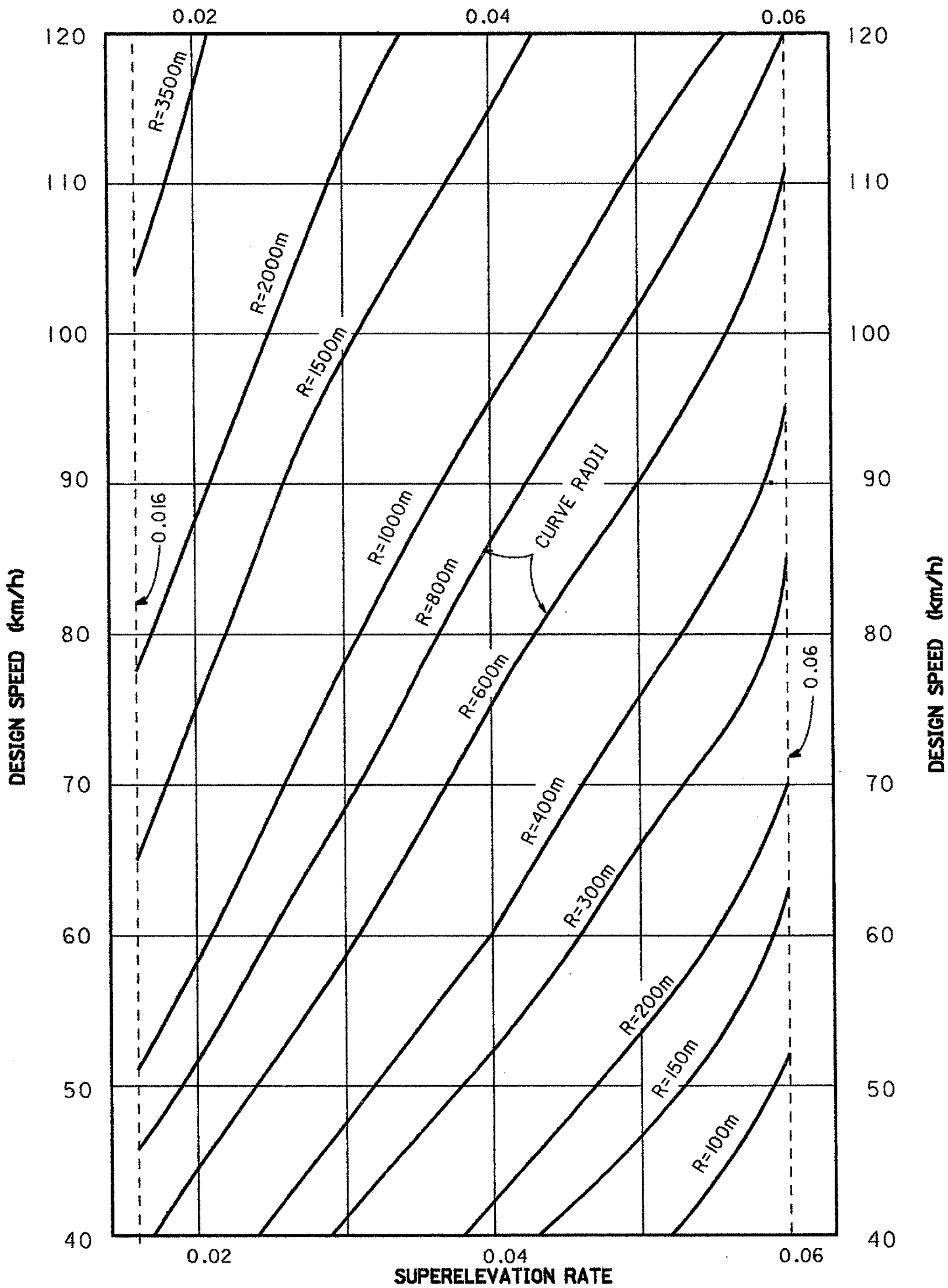
NOTE - Based on a maximum rate of 0.08 and data contained on Figure 202-3.



DESIGN SPEED MET BY COMBINATION OF CURVE RADIUS AND SUPERELEVATION RATE FOR HIGH-SPEED*URBAN HIGHWAYS	903-2
	REFERENCE SECTION 903.2

NOTE - Based on a maximum rate of 0.06 and data contained on Figures 202-4 and 202-10.

*Greater than 70 km/h.



3R VALUES LANE AND GRADED SHOULDER WIDTHS

905-1

REFERENCE SECTION 905.11, .12

RURAL AREAS

DESIGN ADT	DESIGN SPEED km/h	LANE WIDTH (A)		GRADED SHOULDER WIDTH (C)	
		<10% TRUCKS	≥10% TRUCKS	WITH GUARDRAIL (B)	W/O GUARDRAIL
LESS THAN 750	OVER 80	3.0 m	3.0 m	1.2 m	0.6 m
	80 OR LESS	2.7	3.0	1.2	0.6
751 TO 2000	OVER 80	3.3	3.6	1.5	0.9
	80 OR LESS	3.0	3.3	1.2	0.6
OVER 2000	OVER 80	3.3	3.6	2.4	1.8
	80 OR LESS	3.3	3.6	2.4	1.8

URBAN AREAS

FUNCTIONAL CLASSIFICATION	LANE WIDTH (A)	CURBED SHOULDER WIDTH (NO PARKING)	PARKING LANE
ARTERIAL STREETS	3.3 m (D)	0	2.4 m
COLLECTOR STREETS	3.0	0	Comm./Ind. 2.4 Residential 2.1
LOCAL STREETS	3.0	0	2.1

A. At least one 3.6 m lane in each direction must be provided on all National Highway System Federal-aid projects.

B. Guardrail offset distances shall be the same as the values shown in the W/O Guardrail column above.

C. Divided facilities shall have a minimum median graded shoulder width of 1.2 m W/O Guardrail and 1.8 m with guardrail.

D. 3.0 m lane widths are acceptable on minor arterials.

CRITERIA FOR NON-FREEWAY BRIDGES TO REMAIN

905-2

REFERENCE SECTION 905.21

<table>
<tr><th rowspan="2">FUNCTIONAL CLASSIFI-CATION</th><th rowspan="2">DESIGN ADT</th><th colspan="2">MINIMUM LATERAL CLEARANCE (H)</th><th rowspan="2">MINIMUM VERTICAL CLEARANCE</th><th rowspan="2">MINIMUM DESIGN LOADING</th></tr>
<tr><th>ON BRIDGE (A)</th><th>UNDER BRIDGE (D)</th></tr>
<tr><td rowspan="2">EXPRESSWAYS AND ARTERIALS</td><td>>4000</td><td>1.8 m (B)</td><td rowspan="10">CURBED OR TREATED SHOULDER WIDTH PLUS BARRIER CLEARANCE (E)</td><td rowspan="2">4.25 m</td><td rowspan="2">HS-20 (F)</td></tr>
<tr><td>≤4000</td><td>0.9</td></tr>
<tr><td rowspan="4">COLLECTORS</td><td>>4000</td><td>1.8 (B)</td><td rowspan="4">4.25</td><td rowspan="4">HS-15</td></tr>
<tr><td>2001-4000</td><td>0.9</td></tr>
<tr><td>750-2000</td><td>0.6</td></tr>
<tr><td><750</td><td>0</td></tr>
<tr><td rowspan="4">LOCALS</td><td>>4000</td><td>1.8 (B)</td><td rowspan="4">4.25</td><td rowspan="4">HS-15 (G)</td></tr>
<tr><td>2001-4000</td><td>0.9</td></tr>
<tr><td>750-2000</td><td>0.6</td></tr>
<tr><td><750</td><td>0 (C)</td></tr>
</table>

THIS TABLE IS APPLICABLE TO ALL NON-FREEWAY BRIDGES EXCEPT THOSE CONSIDERED NEW OR RECONSTRUCTED

A. Distance measured to curb or railing, whichever is less. In no case shall the minimum width be less than the approach pavement.
B. On mainline bridge having a length of 30 m or more, the minimum may be reduced to 0.9 m.
C. One lane bridges may have a total minimum width of 5.4 m.
D. Distance measured to face of walls, abutments or piers.
E. See Figure 601-6 for minimum barrier clearance.
F. Existing bridges should be considered for ultimate replacement or strengthening if the operating rating capacity cannot safely service the system for an additional 20 years. The existing structure shallbe capable of carrying at least 100% of the state's legalload at operating capacity.
G. Minimum loading may be H-10 if current ADT is 50 or less.
H. Divided facilities shall have a minimum of 0.9 m lateral clearance on the median side.

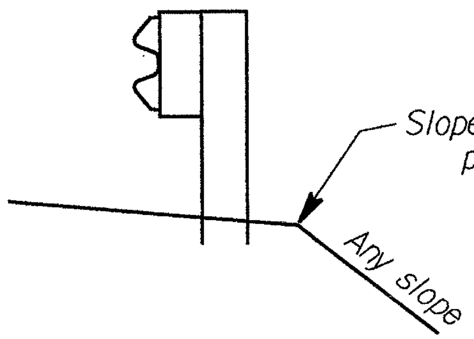
GUARDRAIL POST LENGTH DETERMINATION

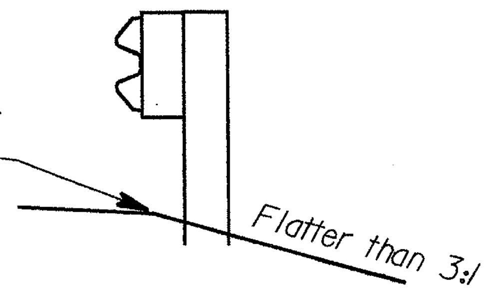
906-1

REFERENCE SECTION 906.22

Standard post lengths may be used for the situations depicted below:

(1.8 m posts, 1.0 m min. embedment depth)



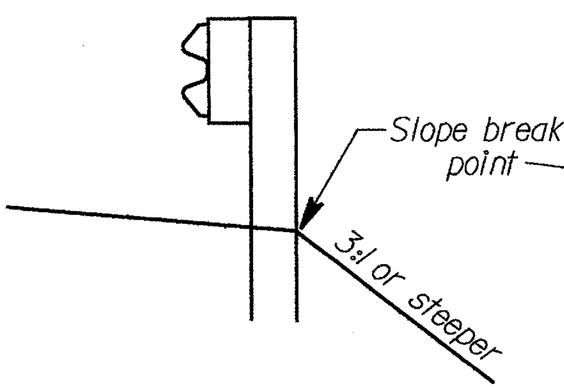


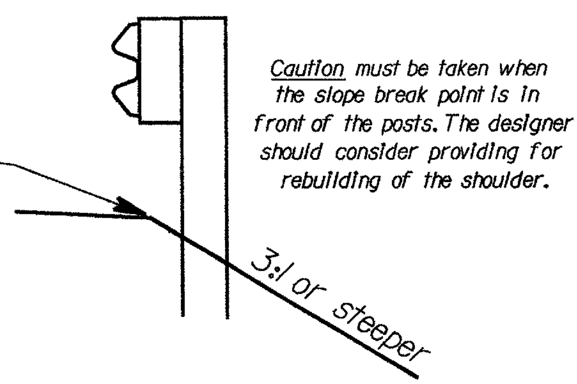
Locations where the slope break point is at or beyond the back of the posts.

Locations where the foreslope is flatter than 3:1, regardless of location of slope break point.

Longer post lengths are required for the situations depicted below:

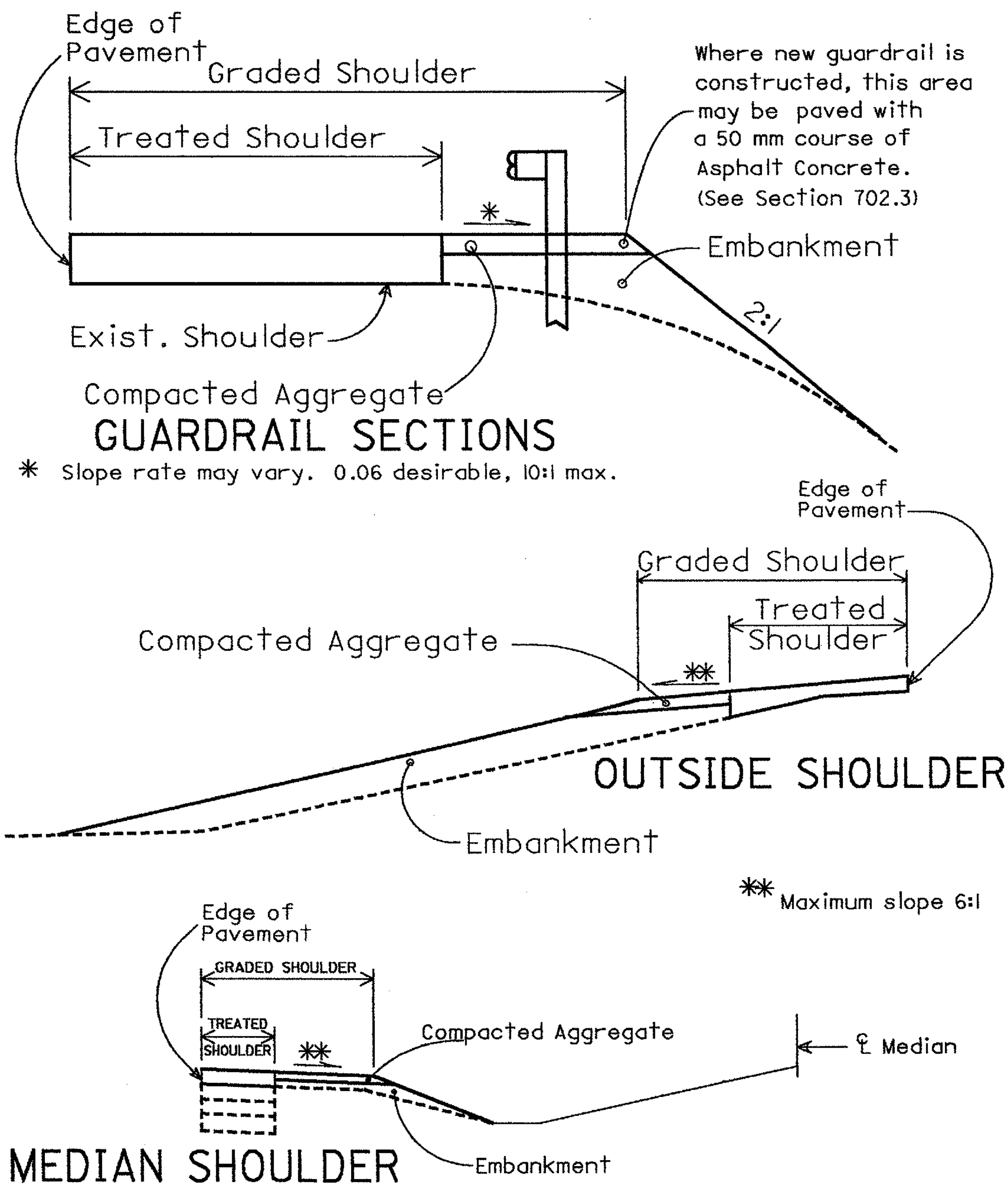
(2.7 m posts, 2.0 m min. embedment depth)





Any installation where foreslopes are 3:1 or steeper and the slope break point is at, or in front of, the back of the posts.

HEAVY OVERLAY SHOULDER TREATMENT	907-1
	REFERENCE SECTION 907.22



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References

Document	Date	Referenced Sections
Procedures for Developing Design Designations for Non-Interstate Bridge Replacement/Rehabilitation Projects	9/11/98	102.1
Development Process Policy: Local-Federal Projects	11/17/97	105.4

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PROCEDURES FOR DEVELOPING DESIGN DESIGNATIONS FOR NON-INTERSTATE BRIDGE REPLACEMENT/REHABILITATION PROJECTS

OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF TECHNICAL SERVICES

NOVEMBER 17, 1993
REVISED SEPTEMBER 11, 1998

PROCEDURES FOR DEVELOPING DESIGN DESIGNATIONS
FOR NON-INTERSTATE BRIDGE

REPLACEMENT/REHABILITATION PROJECTS

The procedures contained in this revised procedural manual are to be used to develop design designations for non-interstate bridge replacement/rehabilitation projects. Such bridge projects may be located on U.S. highways, state routes, county routes, township routes, or local streets. These procedures replace those found in the manual dated November 17, 1993.

Traffic forecasts for bridge projects on the Interstate System must continue to be provided or certified by the Office of Technical Services. For these bridges, the district offices may either forward design designations to Technical Services or request that the Technical Services provide them. Design designations for bridge projects that include more than simple replacement/ rehabilitation must also be provided by Technical Services. This would include bridges with major approach work, bridges on new alignments, or bridges that are part of major capacity addition projects.

Bridge projects within a metropolitan planning organization (MPO) area should be coordinated with the MPO. Since a bridge project involving federal funds must be included on the MPO's transportation improvement program (TIP), coordination should take place at the time the project is added to the TIP.

This responsibility was originally delegated to the district offices in November, 1993, based on approval from FHWA in a letter dated September 29, 1993 (see Appendix A). The original version of this manual was designed to provide a cookbook approach to developing design designations for bridge projects for use by the district offices. The changes are intended to make the projections more accurate by giving the district offices more flexibility in developing them.

The major changes in this edition of the manual are as follows:

- the elimination of generalized growth rates by county and their replacement with a statewide continuous range of rates to provide flexibility in the selection of an accurate rate specific to the site and the individual project;

- changes in the terminology used to refer to the year of construction from "Current Year" to "Opening Year" to eliminate confusing "current" with the current calendar year or with the year of the most recent count data;

- changing the Design Year to be either 12 or 20 years after the Opening Year, consistent with the draft Pavement Design Manual (paragraph 2.02.1.1);

- providing a range of values for the selection of the K factor, the calculation of the DHV on the worksheet, and the replacement in the design designation of K with the DHV;

- three choices for the D factor, depending on whether the bridge is within or outside an MPO's boundaries and whether the bridge is one-way or two-way;

- providing a “comments” section on the worksheet for use in documenting the selection of the growth rate, for substituting refined output from the MPO models, for noting more detailed available truck information (the “B” and “C” components), and/or for noting directional imbalances in the ADT such as those found on bridges on routes over freeways between ramp termini;

- dropping the request for forwarding completed design designations to Technical Services; and

- the update of terms to reflect current terminology in use in the department.

The worksheet, itself, is now larger, the equivalent of two 8 ½ by 11 inch sheets. However, the form can be reproduced as a two-sided 8 ½ by 11 inch form or side by side on an 11 by 17 inch sheet, etc.

Any comments or questions on the use of this manual, including the discovery of any errors or inconsistencies, should be directed to the Office of Technical Services at (614) 644-8195.

Worksheet Instructions (Note: the worksheet is found on pages 6 and 7.)

1A. Enter the PID.

1B Enter the County-Route-Log. If the project is not on the State System, enter an appropriate project identifier.

2A. Enter the Existing ADT. The ADT selected should be the most recent, accurate, seasonally adjusted 24-hour volume available. The most recent ADT may be obtained from the latest Traffic Survey Report (TSR) if the project is on the State System. Other data sources may be used (ODOT data obtained since the last TSR, count data from county engineers, MPOs, consultants, cities, etc.). Partial-day counts may be expanded to 24-hours using average values for the proportion of each hour in the daily total. Expansion tables and seasonal adjustment factors can be obtained from the Office of Technical Services' Traffic Monitoring Section. If the available count data is three (3) years or older, consideration should be given to obtaining a new count.

2B. Enter the 24-hour B&C volume (trucks). If no data is available, leave this box blank.

2C. Enter the Existing Year. This is the year the count was taken. For TSR data, assume this is the year of the report (e.g., for a report published in 1996, assume the data is from 1996) unless the specific ADT is known to come from a count taken in an earlier year.

3. Enter the Opening Year. The Opening Year is the year construction will be completed and the bridge will reopen to traffic.

4. Enter the Design Year. The Design Year is either 12 or 20 years after the Opening Year. This is determined by the scope and intent of the project and is unlikely to be an option available to the user of this manual. Most projects will have a 20-year life; a 12-year design year would occur only when the bridge is part of an overall 12-year pavement rehabilitation project.

5A. Enter the number of years from the Existing Year to the Opening Year. Enter the difference between the Opening Year and the Existing Year: **(3) - (2C).**

5B. Enter the number of years from the Existing Year to the Design Year. Enter the difference between the Design Year and the Existing Year: **(4) - (2C)**.

6. Select a growth rate. The growth rate is to be selected from the continuous range of rates shown on the worksheet. The range of rates for each category is subjective, as are the categories, themselves. Judgment must be used in selecting an appropriate rate. If the project lies within an MPO area, manually adjusted output from a travel demand forecasting model provided by the MPO may be used in place of the growth rate. A rate derived from a regression analysis of historical traffic volumes over at least a twelve year period (equivalent to three traffic survey reports–five preferred) may be used as a tool for selecting the growth rate. It is important to recognize that a high rate derived from a regression analysis, based on only a few data points may not be sustainable when projected 20 or more years into the future. The

implicit growth rate based on the Design Year ADT and the Existing Year ADT should be calculated and evaluated against the rates shown. The use of model output in place of the given rates should be noted in "Comments" (Section 15) of the worksheet.

7. Enter the Opening Year Factor. This factor is calculated as follows: **[(6) x (5A)] + 1**. Multiply the growth rate by the difference between the Opening Year and the Existing Year, then add 1.

8. Enter the Design Year Factor. This factor is calculated as follows: **[(6) x (5B)] + 1**. Multiply the growth rate by the difference between the Design Year and the Existing Year, then add 1.

9. Enter the Opening Year ADT. The Opening Year ADT is obtained by multiplying the Existing ADT by the Opening Year Factor: **(2A) x (7)**.

10. Enter the Design Year ADT. The Design Year ADT is obtained by multiplying the Existing ADT by the Design Year Factor: **(2A) x (8)**.

11A. Enter K. The K factor is selected from the chart on the worksheet. The volume groupings shown are subjective. When count data exists, it is possible to estimate K by dividing the peak hour volume by the ADT. However, K is to reflect the 30th highest hour of the year. For a count on a given day, there is no way to know how the peak hour for that day compares to the 30th highest hour, but "true" K would almost always be higher than this estimated K.

11B. Enter the DHV. The DHV (Design Hourly Volume) is obtained by multiplying the projected Design Year ADT by the K Factor: **(10) x (11A)**.

12. Enter the D factor. The D factor is assumed to be .55 for projects outside an MPO's boundaries and .60 for projects on or within an MPO's boundaries, except for a one-way bridge, in which case the D factor is always 1.00. The D factor, representing the directional distribution in the design hour, is used to calculate the Directional Design Hourly Volume (DDHV). Like the K factor, it can also be estimated from available count data.

    The directional distribution in the ADT is entirely different from D. In the ADT, the directional split is usually close to 50/50. If known to vary significantly from 50/50, such as between the ramps on a bridge on a roadway over a freeway, then the directional distribution should be noted in the "Comments" section of the worksheet.

13. Enter the T24 factor. T24 represents the proportion of B&C commercial vehicles in the ADT. T24 is calculated based on the Existing Year data and assumed to apply to the Design Year. Information is seldom available that warrants selecting a T24 value for the Design Year that differs from T24 as calculated from the Existing Year data. T24 is calculated as: **(2B)/(2C)**. If no count data exists, assume T24 = .03 or obtain new count data that provides truck data.

14. Enter the TD factor. TD is the proportion of B&C commercial vehicles in the design hour. If the number of trucks in the peak hour is included in any available count data, an estimate of TD can be calculated directly. However, TD is usually close to 60 percent of the T24 value, which an acceptable approximation for use here. TD is calculated as **(13) x .6**.

15. The comments section may be used for noting the substitution of MPO model output for volume estimates based on growth rates, the B and C components of the truck traffic, a significant departure from the expected 50/50 split in the daily directional distribution rate, or anything else the user wishes to document.

The Design Designation is summarized at the end of the worksheet from the above information. The design values (D, T24, and TD) are commonly listed as percents rather than decimal proportions. DHV is usually shown on the plans instead of K, although to assess the reasonableness of the DHV, it is usually easier to think in terms of K.

References:

1. Pavement Design and Rehabilitation Manual, Draft, Office of Materials Management, transmitted on August 10, 1998.

2. Guidelines for Developing Design Year Traffic on Local Roads and Streets, prepared by the Bureau of Technical Services, December, 1976.

3. Procedures for ODOT District Offices for use in Developing Design Designations for Non-Interstate Bridge Replacement/Rehabilitation Projects, Bureau of Technical Services, November 17, 1993.

4. Traffic Survey Reports prepared by the Bureau/Office of Technical Services, 1975-1998 (some in preparation, older reports exist).

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BRIDGE PROJECT DESIGN DESIGNATION WORKSHEET			
1A	Enter the PID:		1A
1B	Enter the County-Route-Log or other identifier:		1B
2A	Enter the Existing ADT (Total Vehicles):		2A
2B	Enter 24-hour B&C (commercial) volume if available:		2B
2C	Enter the Existing Year:		2C
3	Enter the Opening Year:		3
4	Enter the Design Year:		4
5A	Enter the number of years from the Existing Year to the Opening Year: **(3) - (2C) =**		5A
5B	Enter the number of years from the Existing Year to the Design Year: **(4) - (2C) =**		5B
6	Select a growth rate from the following range of rates: Stable .0025-.0050 Moderate .0100-.0200 Low .0050-.0100 High .0200-.0300		6
7	Enter the Opening Year Factor: **[(6) x (5A)]+1 =**		7
8	Enter the Design Year Factor): **[(6) x (5B)]+1 =**		8
9	Enter the Opening Year ADT: **(2A) x (7) =** Round to nearest 100 vehicles (nearest 10 vehicles if < 1000)		9
10	Enter the Design Year ADT: **(2A) x (8) =** Round to nearest 100 vehicles (nearest 10 vehicles if < 1000)		10
11A	Enter K, selected from the following table of Design Year ADT : < 1000 .12 5001 - 15000 .10 1001 - 5000 .11 15001 < .09		11A
11B	Enter the DHV: **(10) x (11A)**		11B
12	Enter the D Factor (for DDHV): within an MPO area: .60 outside an MPO area: .55 any one-way bridge: 1.00		12
13	Enter the T24 factor (the proportion of B&C vehicles in ADT): **[(2B)/(2A)]** or **.03** if (2B) is blank		13
14	Enter the TD factor (the proportion of B&C vehicles in the design hour): **(13) x 0.6**		14

BRIDGE PROJECT DESIGN DESIGNATION WORKSHEET		
15 COMMENTS		15
DESIGN DESIGNATION (summarized from above) PID		1A
County-Route-Log		1B
Opening Year ADT =		9
Design Year ADT =		10
K =		11A
D =		12
T24 =		13
TD =		14

Approved:

Jerry Wray
Director

Effective: November 17, 1997
Responsible Office: Project Management
Policy No.: 410-001

DEVELOPMENT PROCESS POLICY

LOCAL-FEDERAL PROJECTS

Policy Statement:

To the extent both practical and feasible, ODOT shall minimize its direct involvement in the design and delivery of those highway capital improvement projects that are funded with local and Federal monies, and which do not directly involve routes comprising the National Highway System.

Through this policy, it is the Department's objective to return the primary duties and responsibilities for local highway improvement projects to the Local Public Agency (LPA) having ownership and/or maintenance purview over the facilities involved, and in doing so, allow such improvements to be designed and constructed in accordance with existing design standards and other requirements adopted by that local government.

Authority:

-- Intermodal Surface Transportation Efficiency Act of 1991 (U.S. Public Law 102-240 specifically Section 1016(d)).

-- 23 USC Sections 112 and 109(p).

-- Ohio Revised Code, Section 5501.03(C), that allows ODOT to enter into contracts with other state agencies, local political subdivisions, boards, commissions, et.al., to administer the design, qualification of bidders, competitive bid letting, construction inspection and acceptance of any projects administered by the Department, provided that the local administration of such projects is performed in accordance with all applicable State and Federal laws and regulations with oversight by the Department.

References:

-- ODOT Transportation Development Process Manual

-- ODOT Design Manuals

-- ODOT Survey Manual

-- ODOT Real Estate Manual

-- ODOT Utilities Manual

Scope:

This policy is applicable to all Districts, Divisions and Offices of the Department that have heretofore been responsible for or otherwise involved in the design and/or delivery of Local-Federal Projects (LPA projects, Enhancement Program Projects, Local Safety Program Projects, etc.).

Background:

ODOT's former and existing policies, standards and practices regarding project design, construction and administration have been developed over the years to meet the specific needs of the Department. Generally, these policies, standards and practices have not heretofore sufficiently recognized nor accounted for the full potential of the various disciplines and levels of expertise in infrastructure development that exist within local governments or are available through their hired engineering and other professional services consultants. Additionally, ODOT requirements may have unintentionally contributed to unnecessary increases in a project's total delivery cost due to superfluous design criteria and the Department's many complex review and approval processes. Project time frames for completion have been significantly lengthened as well.

In recent years, the Ohio Public Works Commission (OPWC) has instituted a program for providing financial assistance to local government infrastructure projects. This program is widely regarded as being very effective in nearly all aspects, and is characterized as being highly efficient in catalyzing needed projects forward while keeping administrative requirements to a reasonable minimum. In doing so, OPWC has successfully relied on the integrity and competence of the licensed professional engineer who is responsible for the project, requiring him/her to "sign and seal" all significant documentation associated with the project's design and construction. Through this policy, ODOT will attempt to emulate OPWC to the extent possible by reducing the Department's administrative involvement and allowing LPAs to be accountable for their own projects.

Definitions:

Finalization Package shall mean the necessary documents required for closing out a construction project. Included in this package shall be the "Final" invoice and a form C-85 for Certified Acceptance (CAP) projects or a final inspection certificate in the case of Federal Oversight Review (FOR) projects.

Final Project Programming Package shall consist of all necessary documents required to "program" a project for inclusion within ODOT's listing of the State Transportation Improvement Plan (STIP). This package shall include such items as the original PDMS form, project location map, supplemental project information form, preliminary legislation, agreements, identification of funding resources, etc.

Initial Project Programming Package shall consist of a collection of information and pertinent documents that indicates the projects selection for Federal funding assistance, as well as provides sufficient information as to the intention and ability of an LPA to accept the responsibility of a project's development and delivery as outlined under this policy.

Local Public Agency (LPA) shall mean any other state agency, local political subdivision, board, commission, or other governmental entity identified under paragraph C of Section 5501.03 of the Ohio Revised Code as being eligible for assuming the administrative responsibilities for ODOT improvement projects.

LPA Project shall mean any highway improvement project or enhancement project that is funded primarily with monies from the Federal Highway Administration as are made available through the Department and matched with local resources.

MPO shall mean any of the recognized Metropolitan Planning Organizations that have participation in ODOT's Surface Transportation Improvement Program (STIP).

National Highway System shall mean those roads and highways defined by the National Highway System Designation Act of 1995 as signed into law on November 28, 1995.

Program Manager shall mean the designated organization that selects projects for Federal funding assistance made available to it through Federal requirements or at ODOT's discretion. For example, the Ohio County Engineers Association, or an individual MPO, shall be the program manager for the funds specifically allocated to it.

Project Engineer shall mean the licensed professional engineer who has been officially designated as the LPA's principal representative for attending to project responsibilities.

PS&E Package shall consist of all information needed to obtain Federal authorization prior to the advertisement of a project for construction bids. Its content shall include a copy of the Project Agreement, the Project Engineer's official detailed cost estimate, a copy of the plans, and a copy of the project specifications. Documentation as to the continuing validity of the project's environmental clearance and required permits shall also to be included.

STIP shall mean ODOT's Surface Transportation Improvement Program which sets forth all projects that have been approved for funding under the various programs administered by the Department.

TIP shall mean a Transportation Improvement Program issued by an MPO, comprising a listing of local projects to be funded, including those involving State and/or Federal funding programs.

Procedure Statement:

I. GENERAL PROVISIONS:

A. As are set forth in Sections II through VIII of this Policy Statement, LPAs may voluntarily assume the following project management tasks and/or responsibilities:

1. Preliminary development and environmental clearance activities;
2. Final detail design and development of construction plans and specifications;
3. Right of way acquisition and relocation, and utility relocation activities;
4. Advertising, competitive bidding, and contract award activities; and/or
5. Construction contract administration, materials testing, and inspection activities.

B. ODOT will retain all administration and management duties for the delivery of those projects which are part of the National Highway System (NHS).

C. All projects must be listed on the State Transportation Improvement Program (STIP).

D. If ODOT is to retain any activity relating to advertising, competitive bidding, contract award, or construction administration, project plans and specifications must be developed in metric units and otherwise follow ODOT's plan format requirements.

E. General funding parameters:

1. For projects over which ODOT is the program manager, the ODOT program manager shall determine any limitations on the use of Federal funding participation in the project. Total anticipated expenditures of Federal funds may not exceed 110 percent of the amount initially programmed for the

project. Should the lowest responsive construction bid push the project's costs beyond this limit, the final determination regarding the award of the construction contract will be made by ODOT's Awards Committee after consultation with the Program Manager, with the total awarded contract dollar amount being eligible for Federal funding participation.

2. For projects over which ODOT is not the Program Manager, the Program Manager having such purview shall determine any limitations on the use of Federal funding participation in the project.

3. No funding in excess of that set forth within the STIP will be paid by ODOT until approval of the amount in excess of the STIP amount has been confirmed by the Program Manager involved.

4. Each Program Manager shall identify a point of contact for ODOT from which approval of funds disbursement can be granted. Notice of funding increases can be given verbally to ODOT by the Program Manager with the conversation being documented by the Office of Project Coordination.

5. Any disbursement of Federal funds to reimburse the LPA for eligible expenses incurred for any activity shall be performed in accordance with the terms and conditions of the Project Agreement.

6. Proper invoices for the value of any work performed shall be prepared and certified by the Project Engineer, paid to the service provider, and submitted to ODOT for reimbursement to the LPA. Invoices may be submitted to the ODOT district office for reimbursement on a monthly basis, or other mutually agreeable time frame.

II. PROJECT INITIATION:

A. LPA responsibilities:

1. The LPA responsible for the project shall submit to the ODOT district office whose jurisdiction includes the LPA's project, an initial project programming package that provides evidence that the project is in the STIP and all preliminary information about the project and which information may have been used in selecting it. To be included in this package shall be a formal statement from the LPA involved as to its intentions and readiness to accept responsibility for the project's development and delivery. The LPA's statement in this regard shall also include detailed information about its

expertise, experience, practices and processes related to dealing with these responsibilities that will adequately and appropriately support a determination of competency to carry out the proposed project.

2. The LPA shall designate a fully qualified professional engineer to act as Project Engineer and serve as the LPA's principal representative for attending to project responsibilities.

3. If an LPA is to place reliance on the capabilities of consultant professional service providers for addressing any aspects of these project responsibilities, similar detailed information about the consultant(s) shall be submitted.

4. The LPA must demonstrate that in contracting with the consultant professional service providers to be used on the project, it utilized a quality-based selection process as required pursuant to Ohio Revised Code Sections 153.65 through 153.70 and the process must be approved by the FHWA. Information on how to secure FHWA approval can be obtained through ODOT's Office of Contracts.

B. ODOT responsibilities:

1. The ODOT district office whose jurisdiction includes the LPA's project, shall be the Department's point of contact regarding project issues and activities.

2. The ODOT district office shall designate a principal representative who will routinely provide guidance and coordination to the LPA throughout the project's entire development duration.

3. The ODOT district office shall receive and process the project programming package, review the LPA's credentials for administering the project (as well as those of its various consultants (if any)), and make a determination as to its (their) competency to perform the project.

   a. Once a determination of competency is made in behalf of a specific LPA, the ODOT district office shall decide the frequency that such related information must be updated and submitted for future projects, and is to be based on the district's on-going familiarity with the LPA and the quality of its project management activities.

   b. Only consultants that are prequalified with ODOT will be recognized as being eligible to provide services on a project.

4. The ODOT district LPA representative shall convene an initial meeting with the LPA and its consultants (if any), and the Program Manager. The purposes of this meeting are:

   a. To convey and review program requirements and expectations;

   b. To assure that an appropriate project scope has been defined and that it is reflective of the basis for the project's selection;

   c. To arrive at a common agreement on the design criteria; and

   d. To discuss the prospects and implications of the LPA performing the project's development and delivery responsibilities.

5. The ODOT district office shall prepare a Project Agreement to be executed by and between the Department and the LPA. The Project Agreement shall:

   a. Set forth all program requirements and expectations of the two parties relative to the development and delivery of the project; and

   b. Establish Federal funds committed to the project as determined by the Program Manager, with an approved dollar amount being based upon a fixed percentage sharing of eligible costs, but with a "not-to-exceed" dollar limitation. The LPA is expected to ensure that the project's development costs reasonably stay within budgeted resources.

   c. Set forth the budget for the project's development cost categories through its completion, and that also identifies the sources and status of all funds included. The LPA is expected to ensure that the project's development costs stay within budgeted resources.

6. The Project Agreement shall be forwarded to the LPA for its proper execution and return to ODOT for inclusion into the programming package for the project. The district office shall process the final programming package through ODOT's Office of Project Coordination, establishing the project's funding commitment and anticipated development schedule. The Director shall sign the Project Agreement and provide a fully executed copy to the LPA.

III. PRELIMINARY DEVELOPMENT:

A. General provisions:

Preliminary development involves those matters, activities and issues that are integral to satisfying the project's environmental clearance and associated permit requirements pursuant to the National Environmental Policy Act and various other Federal and State requirements related to the protection or enhancement of the environment and its resources.

B. LPA responsibilities:

1. The LPA's responsibilities will be limited to conducting the required public involvement events, and the preparation of all required documents, permit applications, reports and other supporting materials in accordance with guidelines established by ODOT's Office of Environmental Services as such items may be determined by that office to be necessary and appropriate for the project.

2. All preliminary development activities and required environmental documents shall be performed by fully qualified professionals in a thorough and expert manner.

3. LPA contact with regulatory agencies should be limited to seeking advice and guidance on requirements and procedures.

4. During project construction activities, and after its completion as may be necessary, the LPA shall be responsible for assuring compliance with all commitments made as a part of the project's environmental clearance and/or permit requirements.

C. ODOT responsibilities:

1. ODOT shall be responsible for the review of all required documents, reports and other supporting materials and will directly provide approved documents and any required certifications to the applicable regulatory agencies.

2. The ODOT district LPA representative shall actively track and facilitate project progress to the extent practicable, providing constructive assistance at the LPA's request.

3. Should the project not have achieved full approval of the appropriate environmental clearance documents prior to their undertaking, the ODOT district office will deny the project's eligibility for Federal funding participation in the costs of final detail design, right of way, and construction activities.

IV. FINAL DETAIL DESIGN:

A. LPA responsibilities:

1. Detail design, and the development of project construction plans and specifications, may be performed in accordance with generally accepted design standards and requirements usual and customary to the local government. All such activities shall be performed by or under the close direction of the Project Engineer.

2. A fully qualified licensed professional engineer shall sign and seal the completed plans and documents. Licensed professional engineers engaged in the development of the project must either be under the direct employment of the LPA or have been contracted by the LPA in accordance with the requirements of Sections 153.65 through 153.70 of the Ohio Revised Code.

B. ODOT responsibilities:

1. The ODOT district office shall constructively participate in defining the appropriate scope for the project to ensure that the improvement will be designed to meet the needs and expectations associated with the project's selection for funding.

2. ODOT will provide engineering design review services for a project only as may be requested by the LPA as agreed upon and stated within the Project Agreement, and provided that its plans and specifications have been developed in metric units and otherwise follow ODOT plan format requirements.

3. The district LPA representative shall actively track and facilitate project progress to the extent practicable.

V. RIGHT OF WAY:

A. General provisions:

1. Right of way acquisition and relocation activities shall be performed in accordance with the requirements of the Uniform Real Property Acquisition and Relocation Assistance Act of 1971 (Public Law 91-646).

2. All right of way acquisition activities, including title research, property valuation, negotiation, and relocation counseling activities, shall either be performed by ODOT real estate staff or by fully qualified real estate professionals who are experienced in the requirements of the Uniform Act and the associated policies of the FHWA.

3. Any required formal appraisals of real property shall be performed by ODOT staff appraisers or by licensed appraisers who possess the appropriate level of professional certification from the Ohio Department of Commerce and who are experienced in the requirements of the Uniform Act and the associated policies of the FHWA.

4. The costs of betterments to either private or public utility facilities accomplished in conjunction with their physical relocation as a consequence of the project shall not be eligible for Federal funding participation.

B. ODOT responsibilities:

1. To the extent surplus production capacity is available within its regional offices, ODOT's Office of Real Estate may provide right of way acquisition services to LPAs on a project by project basis. Alternately, ODOT shall provide an LPA with a list of professional real estate service providers who would be fully qualified to perform the required project real estate activities.

2. The ODOT Office of Real Estate shall review the credentials and determine the acceptability of all practitioners of real estate services proposed to work on the project. All such work shall be performed in a thorough and expert manner.

3. The ODOT Office of Real Estate, or fully qualified appraisers specifically approved by said office, shall be responsible for the review of all property value appraisal analyses for establishing fair market value.

4. The ODOT Office of Real Estate shall review right of way acquisition and relocation activities performed by the LPA and/or its consultant, and provide required compliance certifications to the FHWA.

5. The ODOT district LPA representative shall actively track and facilitate project progress to the extent practicable, providing constructive assistance at the LPA's request.

VI. COMPETITIVE BIDDING:

A. General provisions:

1. Only those contractors which are then currently prequalified by ODOT will be eligible to submit bids for the construction of projects addressed by this policy.

2. The project's contracting activities shall incorporate applicable Federal requirements including but not limited to civil rights, equal employment opportunity, and the payment of prevailing wages pursuant to the Davis-Bacon Act.

3. The process shall result in a contract award to the lowest responsible bidder submitting a responsive bid. In the event that the lowest responsive bid is in excess of the Project Engineer's official estimate of the project's construction costs, the LPA shall confer with the ODOT district office as to the appropriateness of any contract award. Any contract to be awarded in an amount exceeding the project's pre-bid budget must be concurred in by the applicable Program Manager.

4. There shall be no preferential treatment accorded any bidder based on the geographic location of its business offices.

B. LPA responsibilities:

1. Prior to any advertisement for construction bids, the LPA shall submit to ODOT a complete "PS&E" package. The PS&E package shall also contain:

a. The Project Engineer's official detailed estimate of the project's construction and right of way acquisition costs

b. An Environmental Consultation Form pursuant to 23 CFR 771.129, demonstrating the continuing validity of the project's environmental document, its impacts and commitments, and any required permits.

2. Advertising, competitive bidding, and contract award activities associated with the project's construction requirements shall be performed in accordance with applicable local bidding requirements and within the restrictions stated in Part A of this Section VI.

3. The LPA shall provide notification and the details of a contract award to ODOT's Office of Project Coordination within ten days of taking such action.

4. Noting that the project's Federal funding parameters are such that the approved amount is a fixed percentage sharing of eligible costs, but with a "not-to-exceed" dollar limitation, the LPA is expected to ensure that the project's design and construction costs reasonably stay within budgeted resources.

5. The LPA shall pay any and all costs in excess of those amounts set forth in the Project Agreement.

C. ODOT responsibilities:

1. ODOT will provide advertising, competitive bidding, and/or contract award activities associated with the project's construction requirements only as may be requested by the LPA, and provided that its plans and specifications have been developed in metric units and otherwise follow ODOT plan format requirements.

2. The ODOT district LPA representative shall actively track and facilitate project progress to the extent practicable, providing constructive assistance at the LPA's request.

VII. CONSTRUCTION CONTRACT ADMINISTRATION:

A. General provisions:

1. ODOT will only accept project construction contract administration responsibilities for projects for which it has performed the advertising, competitive bidding, and/or contract award activities.

2. Construction contract administration, materials testing, and inspection activities may be performed pursuant to the LPA's usual and customary practices as may have been determined to be adequate by the ODOT district office. At a minimum, these activities shall be sufficient to ensure that the construction contractor satisfactorily:

   a. Fulfills all the requirements of the contract in a timely and quality manner;

   b. That the construction materials utilized are in accordance with project plan specifications;

   c. That the applicable prevailing wages are paid to construction workers employed on the project;

   d. That adequate records of the work performed are made and maintained; and

   e. That proper invoices of the value of such work performed by the contractor are prepared and certified by the Project Engineer, paid to the contractor, and submitted to ODOT for reimbursement on a monthly basis or other mutually agreeable time frame.

B. LPA responsibilities:

1. Construction contract administration, materials testing, and inspection activities.

2. Change orders, resolution of disputes, and other matters of contract administration shall be the responsibility of the LPA.

3. Upon the completion of construction, the LPA shall notify the ODOT district office to secure its participation in final inspection activities and acceptance of the project from the contractor.

4. Within ninety days of the acceptance of the completed project, the LPA shall prepare and submit to the ODOT district office a project "finalization" package. This package shall consist of:

   a. The final billing estimate;

   b. All necessary administrative and technical certifications; and

c. The Project Engineer's signed and sealed statement that the project was developed and delivered in compliance with the terms, conditions, and requirements of the Project Agreement.

C. ODOT responsibilities:

1. ODOT will perform construction contract administration activities only as may be requested by the LPA, and provided that its plans and specifications have been developed in metric units and otherwise follow ODOT plan format requirements.

2. The district LPA representative shall actively track and facilitate project progress to the extent practicable.

3. ODOT's interests in performing a final inspection shall be limited to ensuring that the final product conforms to the project's defined scope and otherwise satisfactorily reflects the requirements of the construction contract.

4. The ODOT district office shall review the finalization package and proceed with project closeout activities as appropriate.

5. ODOT may, from time to time, perform quality and/or compliance monitoring activities regarding any aspect of a Local-Federal project administered by an LPA. The results of such monitoring efforts shall be communicated in writing by ODOT to both the LPA and FHWA. When corrective action is determined to be needed, ODOT shall provide the LPA with the appropriate advice and guidance to remedy the matter.

Training:

Training shall be developed and conducted for ODOT district office staff members who will serve as principal representatives to LPAs doing business with the Department. Such training shall focus on:

I. The overall project development process.

II. Review and competency determinations associated with an LPA's desire and intentions to accept responsibility for the project's development and delivery, particularly the review of detailed information about the LPA's (or its consultants') expertise, experience, practices and processes related to addressing these responsibilities.

III. Development of a Project Agreement for an LPA project under this policy that sets forth an accurate and appropriate project scope, and details the extent to which the Department will be involved in the delivery of the project.

IV. New and revised procedures that relate to ODOT's processing of project programming packages, PS&E packages, and finalization packages generated in support of Local-Federal projects as a result of this policy.

Additionally, ODOT will take the necessary steps to ensure that this policy is adequately and appropriately communicated to all LPAs seeking to do projects under this policy, as well as all Program Managers having programs affected by this policy.

Fiscal Analysis:

The scope of this policy has the prospect of significantly reducing the Department's administrative and technical involvement in approximately 200 Local-Federal projects each year. As a result, it is anticipated that ODOT will realize substantial savings in manpower that has heretofore been dedicated to developing such projects in behalf of the LPAs. Additionally, it is envisioned that this policy will have positive economic impact on the overall delivery costs of local highway projects, allowing these finite resources to be stretched further across awaiting demands.